PROCEEDINGS

SECOND GEOPRESSURED GEOTHERMAL ENERGY CONFERENCE

VOLUME V

LEGAL, INSTITUTIONAL AND ENVIRONMENTAL

BY

JOHN H. VANSTON
DONALD B. ELMER
THOMAS C. GUSTAVSON
CHARLES W. KREITLER
KATHLENE LETLOW
SALLY COOK LOPREATO
MARIAN MERIWETHER
PAULA RAMSEY
KATHRYN E. ROGERS
JAMES K. WILLIAMSON

VOLUME V OF FINAL REPORT

UNITED STATES GULF COAST GEOPRESSURED GEOTHERMAL RESOURCES MANAGEMENT AND SCOPE-OF-WORK STUDY FOR GENERATION OF ELECTRIC POWER

SPONSORED BY

THE UNITED STATES ENERGY
RESEARCH AND DEVELOPMENT ADMINISTRATION
CONTRACT NUMBER E (40-1) 4900

FEBRUARY 23-25, 1976

THE UNIVERSITY OF TEXAS AT AUSTIN

DISCLAIMER

NOTICE

TABLE OF CONTENTS

PART 1

LEGAL

LEGAL ISSUES IN THE DEVELOPMENT OF GEOPRESSURED-GEOTHERMAL RESOURCES OF TEXAS AND LOUISIANA GULF COAST

DONALD B. ELMER

KATHRYN ROGERS

PHASE 0

SCOPE-OF-WORK AND MANAGEMENT STUDY

TABLE OF CONTENTS

PART 1

Page

LEGAL ISSUES IN THE DEVELOPMENT OF GEOPRESSURED GEOTHERMAL RESOURCES OF TEXAS AND LOUISIANA GULF COAST

SUMMARY

This report is divided into two major sections, Legal Scholarship and Legal Support. Scholarship is distinguished from support by concentration on abstract analyses of issues which include resource definition, ownership, taxation, and multistate reservoirs. Support is based entirely on those legal tasks called up by the technical work scheduled in the areas of Resource Assessment, Advanced Research and Technology, Institutional and Environmental, and Resource Utilization.

The report begins with the observation that it is rare that law has the opportunity to develop legal principles governing a resource at the same time that technology is beginning to make exploitation of the resource a reality. One important such area for legal scholarship is the definition of geothermal resources which will serve law in the field of regulation, in the settlement of ownership disputes, and in leasing provisions.

Resource definition begins with an examination of the different scope of science as compared to law. Definitions are used very differently by the two disciplines. Scientific descriptions aim at high levels of accuracy and detail, and serve a role as part of hypotheses about physical reality. Legal definitions serve the purpose of identifying the juridically important characteristics of juridically important entities in certain specific situations. This difference in thrust is visible in both case law and statutes, where rulings on the character of geothermal steam are made for the purpose of deciding an income tax issue, and arguments about ownership are settled by defining the resource as surface or mineral estate.

Resource definition examines the physical model of geothermal resources in general and geopressured resources in particular. This model outlines a system which consists of magmatic heat, intrusions of magmatic material into the near subsurface or a thinning of the surface, and the possibility of heat transfer mediums with attendant associated and solute minerals and gases. This model is compared to the model articulated by statutes and case law.

The thirteen western states, Texas and Louisiana, and the United States all have statutes which deal with geothermal resources in various manners.

The scope of many of these legislative provisions is limited to leases of state-owned lands and regulation of operation of wells and facilities on all lands. Few of the statutes define the resource so as to include all types of geothermal resource, with hot rock massifs and geopressured systems being most commonly left out. Few of the statutes define the resource so as to include the entire system as set out in the physical model.

There have been three major cases concerning geothermal resources: Union Oil, an action to settle a title dispute involving a federal mineral reservation on lands in The Geysers; Pariani, an action to settle a similar title dispute in lands subject to a state mineral reservation in lands in The Geysers; and Reich, an action which argued for application of the depletion allowance to geothermal steam wells at The Geysers.

Each of these cases sets out some legal model within a definition. Only one of the cases turns, however, on the model. The more important question in ownership disputes is characterization of the resource as surface or mineral estate. The tax dispute does explicitly turn on the definition of geothermal steam as a gas for income tax purposes.

The section on resource definition closes with a recommended definition in two versions. One form is extremely detailed and specific for all known types of geothermal systems. The other is compact, but it shares with the longer version the clear delineation of the complex physical structure of these resources.

Resource definition is followed by an analysis of the ownership complex. This area is intimately connected with the characterization process applied to resources which places a particular thing in one of two estates. These estates in land, the surface and the mineral, are different bundles of rights in property. The surface estate is concerned chiefly with domestic and agrarian uses of land, while the mineral estate is concerned exclusively with exploitation of commercially valuable commodities that can be severed from the subsurface and sold.

Geothermal resources are characterized by the statutes of some of the states, such as Idaho, Montana, and Washington, as unique resources called sui generis, that is, neither mineral nor water. Other states, such as Hawaii, explicitly label the resource as mineral. Most of the statutes only implicitly characterize the resource by virtue of less direct provisions, such as subordination of geothermal leases to either mineral law or water law. The case law, in the ownership disputes, argues both sides of this dichotomy. In one such case, Union Oil, the court does rule that geothermal resources are water and, therefore, part of the surface estate.

None of the cases articulates supporting analysis for the characterization that is incontravertible. This report suggests a different approach from the usual Alice in Wonderland animal-vegetable-mineral procedure which simply argues that this or that precedent said the thing was one of the three. The analysis attempted in the report is based on careful attention to the definition of the resource and to policies which inhere in the characterization of the entities and estates in land. This analysis concludes that geothermal energy systems ought to be viewed as part of the surface estate. The section concludes that legislative prerogatives and duties in policy making should not be passed on by default to other parties. It is recommended that both state and federal legislatures develop clear declarations of both the character and ownership of the resource; or that alternatively, state and federal regulations and statutes at least provide for a certificate of primary purpose which will permit clear ownership rights with regard to produced geothermal systems.

Problems associated with multistate and multinational reservoirs are examined by the report following the ownership section. There are reservoirs that cross the abstract lines of jurisdiction between Texas and Louisiana, between Texas offshore and the Federal Outer Continental Shelf (OCS), between Louisiana offshore and the Federal OCS, between Texas and Mexico, and those which are shared by Texas offshore, the Federal OCS, Mexico offshore and both Texas and Mexico onshore.

This complex of deposits and jurisdictions may give rise to problems and conflicts over different definitions, characterizations, ownership principles, or regulations. The section recommends that the states should create and join an Interstate Compact Commission on Geopressured and Other Geothermal Resources, which commission should also include both Mexico and the Federal government. The function of such a commission is to promote uniformity in treatment of the resource and to provide a forum for resolution of disputes. It is also recommended that the states establish an escrow system which would permit unit operation across jurisdictional boundaries while equitably preserving the rights of developers.

This report examines taxation on both state and federal levels. The states will be concerned, at least until specific geothermal taxation statutes are passed, largely with ad valorem taxes, and severance taxes on the solute natural gas which will be produced from geopressured systems. At the federal level, allowances for intangible drilling costs and the depletion allowance have been the subject of both litigation and legislation. Reich decided that geothermal steam wells are subject to the same percentage depletion as gas, and this ruling was later codified by the Tax Reduction Act of 1975. Unfortunately, this provision is severely limited by the narrowness of the requirement that the geothermal well must qualify as a gas well in order to take advantage of the allowance.

It is clear that geopressured resources are not brought under the depletion allowance by either the case or the legislation. Other precedent for cost depletion appears to apply to geopressured systems in the Texas water law case of Shurbet. In this case the court determined that taxpayers who were applying for a cost depletion on a depleting aquifer, the Ogallala, used for irrigation pumping and farming in the Texas/New Mexico panhandle were entitled to such an allowance. The court reasoned that the tax statute does not limit cost depletion to minerals alone, as the percentage depletion seems to. They argued further that the resource falls under the heading of other natural deposits in the act. This section outlines an argument that would make Shurbet effective for geopressured systems and allow at least a cost depletion. The section concludes with recommendations for statutory enactment at both state and federal levels. The chief thrust of such recommendations is the need for explicit and specific provisions covering severance, ad valorem, intangible expenses, and depletion.

Legal support functions are outlined by this report for the site selection portion of Resource Assessment. Site selection will require an analysis of the regulations covering that particular geographic area, as well as careful study of the ownership patterns for the areas. Advanced Research and Technology will introduce some potential environmental impacts through drilling program design and monitoring programs. In addition, the effect of statutes and regulations may be to impose specific requirements on the monitoring program. This possibility is subject to analysis by the legal section. Well design itself may raise questions related to hazard and bonding of the project to encompass such contingencies.

Institutional studies overlap legal studies in several areas. That section proposes to produce a detailed regulatory analysis of the particular site. This task will be shared with the Legal Section. Environmental tasks are intimately intertwined with legal research. The Legal Section has defined the significant variables for study and articulated the structure under which such findings become part of the decision-making process. The Legal Section also plans to work closely with social scientists to develop innovative local funding and management techniques.

Resource Utilization not only outlines a net energy analysis of the resource, but also develops various utilization alternatives. These proposals for use raise antitrust and monopoly issues in the case of an electric utility which would produce its own geothermal resources for consumption in a generating facility dedicated to that site. Such utilization options are also subject to both a taxation and an environmental analysis.

INTRODUCTION

> Seldom, if ever, has . . . [the] law had the opportunity to develop principles governing an important resource at precisely the same time that modern technology is beginning to make the utilization of those resources a reality.
>
> United States v. Union Oil of Calif., et al.
> No. 74-1574, U.S. Court of Appeals, Ninth Circuit, at 3,
> Brief of State of California by and through the State Lands Commission of the State of California as Amicus Curiae January 1974

The role of legal analysis in a resource assessment and management planning project is to identify important planning and policy constraints and goals. Technology is a tool used to achieve public and privately selected objects. It operates within the total environment of a particular society. This social environment derives many of its features from the structure and content of the legal system which places limits on the relationships of individuals to other persons, things, and institutions. Both technology and law are subject to policy decisions of government, and both reflect these decisions.

The policy which forms the backbone for the Geopressured-Geothermal Resource Management Project at the Center for Energy Studies at The University of Texas is the rapid and efficient development of this resource. The technological portions of this project have concerned themselves with an analysis of the nature and distribution of geopressured-geothermal deposits in Texas and Louisiana, with defining a drilling and testing program, and with development of models of resource utilization. The legal component was specifically charged with defining the resource; examining ownership, taxation questions, and problems with multistate reservoirs; and summarizing relevant law from federal, state, and international jurisdictions. In addition, the legal component was charged with analyzing the permitting requirements and acquisition problems associated with the test site.

These components were designed in the first instance to interact, in recognition of the real world interrelationships of technology and law. What became more apparent as the project developed was the unrecognized richness and diversity of interaction. The original charges were expanded and modified, and the new charges were presented to the project sponsor, ERDA, in An Interim Report: Phase 0 Legal Research, United States Gulf Coast Geopressured-Geothermal Resource Management Program submitted during a site visit. These new charges were later incorporated in a submission to ERDA for an extension to Phase 0. They included continuations of explicit tasks and definition of many legal support tasks related to specific technical functions to be executed during the development of the test site and regional laboratory.

LEGAL SCHOLARSHIP

LEGAL SCHOLARSHIP

Legal scholarship is distinguished from legal support in this project by virtue of its concern for conceptual problems of legal structure as contrasted with the practical problems of assisting particular technical understanding of the resource in the development of principles that will fulfill the policy goal of the project.

This section is explicitly philosophical. It raises important policy issues, not only concerning this resource, but also concerning the legal/policy process whereby technical or physical understanding passes into law. It examines resource definition, ownership, problems with multistate reservoirs, and taxation.

LEGAL SCHOLARSHIP

RESOURCE DEFINITION

Resource Definition.

SUMMARY

This part of the section on Legal Scholarship explores the interrelationships between physical and legal models of geothermal resources. The physical model includes geologic systems which feature abnormally high rates of heat flow from the earth's interior into regions of the surface or immediate subsurface where present or imminent technology can gain economical access to it. The heat is brought to the surface by means of heat transfer mediums, such as water, steam, or gas. These mediums may be present naturally or may be artificially introduced. The mediums may also carry solute minerals and gases.

The statutory legal models, contained in definitions in the acts of some fifteen states and the federal government, are largely based on the provisions of the Geothermal Steam Act of 1970 or the Geothermal Resources Act of 1967 [1]. The Steam Act legal model includes the heat and associated energy in certain formations. It also includes both natural and artificially introduced heat transfer mediums, and contaminants thereof under some circumstances [2]. The Steam Act fails to connect these elements into a coherent systemic whole that would comprehend all similar resources.

The California Code (Geothermal Resources Act of 1967) includes the heat of the earth, with no reference to extraordinary rates of heat flow. It also includes contaminants of heat transfer mediums, but apparently fails to include the mediums themselves [3].

Two states, Oregon and Washington, do not follow either the federal Steam Act or the California Code [4]. These states each emphasize the availability of the energy to do work. Oregon provides that geothermal resources must be hotter than 250°F. bottom hole temperature (bht). It further delimits the notion of "heat" by reciting that the heat must be available ". . . for the production of heat energy . . . ." Washington provides that the only heat resources that will be considered as part of the geothermal resource will be those from which ". . . it is technologically practical to produce electricity commercially . . . ." Washington

goes on to exclude from the resource those lower-temperature deposits useful chiefly for process heating of various sorts [5].

None of the statutory legal models considered articulates a clear comprehensive statement of the resource. Each such definition excludes one or more types of presently recognized geothermal resource. No consistency exists concerning the degree of availability of the heat to do work that will make a particular geologic system a geothermal system.

Case law also expresses a legal model. Three recent cases involved property and tax disputes which centered on The Geysers geothermal steam field in California. Geothermal resources were treated as water, for purposes of disputing a federal claim under a mineral reservation; as a gas, for purposes of a percentage depletion allowance on federal taxes; and as water, for purposes of disputing a State of California claim under a mineral reservation. Each such definition is restricted to the narrow scope of the fact situation. But each does express some sort of model of the physical nature of the resource.

This section concludes with two suggested legal models suitable for statutory enactment.

INTRODUCTION

> The fundamental legal and policy problems associated with geothermal resources arise primarily because of our inability to identify exactly what geothermal resources are. Geothermal energy as a resource is not a familiar commodity which readily fits existing resource categories. It has been described at various times as water, gas, and a hard mineral [6]

The United States Gulf Coast Geopressured-Geothermal Resources Management Project, AT-(40-1)-4900, specifically charges the legal section of the project with the task of analyzing definitions of geothermal resources which are contained in statutes and case law. Both statutory definitions and characterizations are reviewed for the thirteen western states and Texas and Louisiana, as well as for the federal jurisdiction. Discussion of various options for categorizing the resource is contained in the following section on ownership. Case law administrative proceedings are closely examined for those definitions that form a necessary part of the decision.

These legal models are compared to a physical model derived from technical literature. The differing perspectives and scope of definitions in the two different disciplines are discussed and analyzed. The section concludes with a look forward to the related subject of ownership and offers some recommendations for statutory legal models.

ANALYSIS: THE INTERRELATIONSHIP OF THE PHYSICAL AND LEGAL MODELS

Science concerns itself with accurate descriptions of reality. This goal involves labeling of the many sorts of entities and processes that we are aware of, or can predict on the basis of theories. The interests of science are all-encompassing. They range from the macrocosm and subjects such as pulsars, quasars, X-ray stars, and radio galaxies, to distances on the order of 10^{10} light years and times measured in billions of years [7]. Science incorporates the microcosm focusing on the structure of DNA and RNA in the genetic material of cells, and on the interaction of atomic particles at various energies and flux densities [8].

Law, in contrast, concerns itself with the relationship of persons to other persons, institutions, and things. The potential scope of law is, consequently, considerably more limited than the scope of science. Furthermore, the perspectives are very different. The law is concerned with actions of persons and institutions within the social, political, and ethical structure of a particular culture at a particular time and place.

This difference in scope and perspective has a decided impact on the way in which definitions are used by the two disciplines. Science defines, or describes, phenomena with the observer firmly incorporated in the description, by virtue of Heisenberg's Law and the special and general theories of relativity. Such definitions are usually treated as hypotheses, though the history of science makes it clear that such hypotheses are not lightly abandoned. They are, at any rate, subject to a continuing process of comparison to and verification by perceived reality.

Legal definitions are not of the same sort at all. They constitute declarations that this thing, or event, or the like, will be regarded as a member of this class of entities to which persons may lawfully (i.e., legitimately) have certain sorts of relationships of use and control, and so forth. Legal definitions, in other words, describe the place in the overall juridical system that certain juridically important things, institutions, persons, or events may have. The law and legal definitions also evolve, in response to changes in economics, political structure, and social conditions.

As a result of this difference in scope and perspective, law uses scientific definitions in ways that may seem strange to scientists, technicians, and engineers. What is good physics may be bad law. "[A] technical or scientific definition may not be satisfactory for a legal classification. The most productive resolution of the problem [of classifying geothermal resources] would be to classify geothermal energy only after considering the consequences of such classification" [9].

It is precisely this concern for the consequences that causes legal classifications and definitions to be carefully limited to certain specific contexts. For example, Reich v. Commissioner of Internal Revenue concludes that "steam is a 'gas' as that term is used in sections 611(a) and 613(b)(1)" (emphasis added throughout Resource Definition section) [10]. (Reich is a federal tax dispute over depletion allowances for geothermal steam wells in operation at The Geysers, a geothermal field north of San Francisco.) And in United States v. Union Oil Co. the district court clearly places the definition in context. "[T]he Government must press the contention that the main constituent of geothermal energy, namely superheated water (or steam) was a 'mineral' within the contemplation of Congress and the meaning of the mineral reservation in [sec.] 9" [11]. (Union Oil is an ownership dispute involving federal land grants and the rights of patentees of such lands and their successors to produce geothermal resources in spite of a mineral reservation on the grant.) The property involved is being used for geothermal steam production at The Geysers. The court there goes on to say that "the word 'mineral' is necessarily subject to interpretation by reason of its context and particular usage" [12].

The administrative tax court in Reich makes a definitive statement on the role of the judiciary in articulation of legal models and classification of physical resources:

> The question presented is a different case for a judicial body. It involves the resolution of geological and engineering disputes. It must be remembered that we are not sitting as a scientific forum. We are sitting as a court. We must accordingly decide the question for one party or the other [13].

The role of statutes passed by the legislatures of the various states and the federal government is, of course, quite different. These statutes, in general, do not purport to settle disputes [14]. They lay down rules of general application. However, even statutes have a clear context. The 1975 amendments to the Internal Revenue Code are a good example [15]. These amendments provide, at sec. 501(a) (modifying sec. 613A(b)(1)(C)) that "[t]he allowance for depletion under section 611 shall be computed in accordance with section 613 with respect to (C) any geothermal deposit . . . which is determined to be a gas well within the meaning of section 613(b)(1)(A)" [16]. This definition corresponds to the one articulated in Reich, but that is not as important here as the fact that it is an example of the highly specific nature of statutory definitions.

Another relevant example of the specificity of statutes is the Geothermal Steam Act of 1970 (cited herein at footnote 1) which applies only to

> . . . lands administered by [the Secretary of the Interior], including public, withdrawn, and acquired lands, . . . in any national forest or other lands administered by the Department of Agriculture . . . and in lands conveyed by the United States subject to a reservation . . . of the geothermal steam . . . therein [17].

In other words, a statute does not define or classify a given entity for all purposes, in all contexts. A statute states what the entity will be taken to be for purposes of this particular piece of legislation. Courts will on occasion extend the applicability of statutory definitions to areas which are related but which were not included in the statute [18].

It is because the law defines and characterizes in order to settle disputes and to establish the place of a thing, institution, or process in an overall juridical scheme that scientific and technical accuracy is not strictly adhered to. In Texas, ammonia gas is classified as a hydrocarbon gas for purposes of Railroad Commission administration of the articles on pipeline common carriers. In the Reich case the tax court reached the scientifically questionable conclusion that what was being consumed in the case of The Geysers was the steam [19]. The court reached this conclusion because of the policy analysis that argued that the reservoirs constituted a wasting asset perfectly similar in type to oil and gas for purposes of the depletion allowance. This is bad physics but it may be good policy, especially in terms of allowing additional financial incentive for development for development of this new resource.

This last example, taken from the subject of discussion, raises many important questions. The issues of the relationship of scientific fact and characterization to legal classification for purposes of the depletion allowance are carefully addressed in the section on taxation. It is clear, to this point, that the law has occasionally reiterated quite correct and complex scientific definitions. It is also clear that the statutes of the various states, the federal statutes, and the pronouncements of courts have <u>not</u> produced definitions that consistently agree with the best physical understanding of geothermal resources.

The structure that this physical understanding describes is set out in detail later in the physical model section. For purposes of discussion here a geothermal energy system can be taken to consist in a crustal thinning or an igneous intrusion from the interior into the region of the surface or near subsurface causing abnormally high rates of heat flow [20]. Heat transfer mediums may be present naturally or may be introduced into the system in order to gain access to the heat energy of the intrusion. The heat exchange mediums may express additional energy as pressure, and may contain in solution various sorts of minerals or gases. The value of such systems lies in the potential for work or heating of the available heat energy, though contaminants may add to the economic value [21].

The federal statute, the Steam Act, does not refer to this description. The detailed discussion of the act, set out in the section on legal models, indicates that <u>some</u> heat transfer mediums, <u>possibly some</u> contaminants of these mediums, and heat or other energy in certain formations <u>constitute geothermal energy systems</u>. The act lists only <u>some</u>, but not all, of the characteristics of <u>some</u> types of geothermal energy systems. The source of the heat, the igneous intrusions, are omitted; and consequently so are hot rock massifs. Geopressured reservoirs and the solute natural gas therein are omitted. Most importantly, the scientifically described structure is not there in the act.

The statutes of various states also articulate legal models. For example, both Texas and Louisiana statutes share with the Steam Act a format which does not define the structure of the resource, but only lists some attributes. Arizona and Colorado also share this format since their statutes are modeled on the Steam Act.

The California statutory provisions--and the statutes of New Mexico, Montana, Hawaii, Idaho, and Alaska, inasmuch as they reiterate the California Code--are more inclusive than the Steam Act. They involve the heat of the earth, but fail to distinguish the overall normal thermal gradient from the extraordinary heat flows associated with geothermal deposits. They include the contaminants of various heat transfer mediums, but may fail to include the mediums themselves. As a result of broader language these acts appear to include hot rock massifs and geopressured reservoirs, though they reiterate the language of exclusion concerning oil and natural gas. These statutes, therefore, suffer from the same lack of articulated structure that is inherent in the California Code.

Oregon comes closest to stating explicitly the physical structure of geothermal energy resources. It recognizes the anomalous nature of the heat sources, the igneous intrusions, by labeling them as "underground <u>reservoirs</u> of heat." The Oregon statute goes on to reinforce the notion of extraordinary heat flows and the necessary notion of availability of the energy when it speaks of "hot waters of less than 250 degrees Fahrenheit bottom hole temperature" [22] as being excluded from the resource. The act, however, omits heat transfer mediums, although it includes some contaminants thereof.

Washington carries the notion of availability one step further than does Oregon. The Washington statute provides that the heat energy of the earth is part of the geothermal resource if and only if it is both technologically and economically available to produce electricity [23]. The same statute provides that wells which can no longer provide enough heat for electricity and supply minerals can be converted to water wells [24].

Low-temperature uses, as for greenhouses and fish ponds, are not regulated by the geothermal law at all, but rather fall under state water law [25].

Washington's legal model still fails to distinguish the normal thermal gradient from those geologic structures which posses large enthalpy by comparison to normal gradient. The statutory definition does include, however, both heat transfer mediums and nonhydrocarbon solute and associated minerals. In every other respect, the act articulates a fairly broad systemic definition of the resource.

Nevada has opted for an extremely simple legal model. Geothermal resources means the heat or other associated geothermal energy found beneath the surface of the earth [26]. This definition articulates no structure at all. It omits any mention of heat transfer mediums and contaminants. The statute does, at a later point, mention and define by-products for royalty purposes but does not include such by-products in the definition of the resource [27]. In addition, the heat transfer mediums are declared part of water resources and subject to water law [28]. Utah, at this time, does not define geothermal resources by statute.

The definitions offered in litigation include that proposed in the amicus brief by the State of California in Union Oil and in Pariani, et al. v. The State of California [29]. (Pariani involves a similar dispute concerning state land grants and mineral reservations in the same area.) This definition does articulate a structure. In fact it describes the resource so as to include the igneous intrusion and the natural heat transfer mediums as well as their contaminants. The only important structural feature omitted is the concept of availability of the resource in terms not only of drilling capabilities, but also of sufficient temperature differential to do work. The court itself, in the Union Oil case, was satisfied to reiterate the extremely simple definition of the Resources Agency of the State of California, that geothermal energy is "the natural heat of the earth which can be extracted in the form of hot water and/or water vapor (steam)" [30]. This definition does not articulate a structure as did the amicus brief.

The administrative tax court in Reich included a detailed structural definition of the geothermal resource at The Geysers in the fact statement. This definition does include the concept of availability of the energy, the notion of igneous intrusions, the role and internal processes of heat transfer mediums, but leaves out contaminants except for silica and calcium carbonate. The court went on to rule that steam is more than heat and water, but also includes pressure. Unfortunately, the court then determined that the commercial product of The Geysers is steam rather than energy. This conclusion of law is bad physics, as earlier discussed, and reflects a failure to understand the physical system so carefully described in the findings of fact.

> To characterize geothermal resources as simply "superheated water, or steam" totally ignores the very technical and complicated "geothermal processes" and "geothermal formations" referred to in [the Steam Act] . . . . These geochemical and geophysical distinctions provide a basis in fact which demands that similar distinctions be made at law [31].

The amicus brief argues that the law must follow the scientific definition. Is the amicus correct? What consequences follow if the law ignores the best physical understanding of the resource in the formulation of statutes and in the judicial process?

One of the most important consequences of scientifically incomplete or invalid definitions arises in the area of leases, especially those under the statutes, for the exploitation of geothermal resources. If the definitions exclude hot rock massifs or geopressured resources, as the Steam Act appears to do, then no legal rights to exploit this resource can be acquired from the only authority with the right to make such leases.

Examples from the environment of geopressured resources can be drawn from the statutes of both Texas and Louisiana. In Texas confusion in the drafting of the definition of by-products leads, in the case of a total flow installation, to the bizarre situation where that part of the methane which is removed before the fluids are passed through the turbine is part of the resource, and that portion which exsolutes after passing through the turbine is not. The methane which does not qualify under the statute as part of the geothermal resource will become costly indeed. Under Texas law the geothermal lease operator will have to account to the mineral lessors for the full value of the excluded methane, without any deduction for operating and production costs [32].

The Louisiana statute covering leasing, SB 420, has explicit language in sec. (c) which incorporates dissolved natural gas into the resource. This seems to signal the inclusion of the geopressured-geothermal resources which do include solute methane. However, unlike the Texas statute, the Louisiana Act does not specifically provide in sec. (a) for geopressured resources. If the analysis previously explained is correct, then the Louisiana statute does not comprehend geopressured reservoirs and fluids at all [33]. This would have the result that geothermal leases for exploitation of the geopressured systems could not be obtained under this act.

There are important federal tax consequences. The availability of cost depletion for the geopressured resource depends a great deal on a convincing demonstration that such systems are, as in the Reich case, wasting assets. This subject will be discussed at great length in the section on taxation. It is important to indicate at this point the potential impact of scientific definition on this field.

Another area of great potential importance will arise during disputes between mineral leaseholders and geothermal leaseholders or lessors. A point of particular danger for both Texas and Louisiana is the solute methane. It is commercially feasible to exploit geopressured reservoirs for their solute methane content alone [34]. Unless there are good and justifiable scientific and policy arguments for including solute methane as part of the geothermal lease, the mineral leaseholders will demand compensation for the produced methane. The geothermal leaseholder will probably have to account for the value of the produced gas without any deductions for the cost of production [35].

It should be noted that statutory definitions are much less important in the case of leases between private parties. Here, or in any other dispute concerning ownership, the law turns to a different standard. Definitions are used only to support arguments concerning the characterization of the resource. The important question is "To which category does the entity belong?" rather than "What is it?" The two questions are frequently confused in such a fashion that an answer to what it is has reference to the category it belongs in. These issues are intimately related to questions of ownership. They will be addressed at greater length in that section.

PHYSICAL MODEL

Geopressured-Geothermal Resources.

The physical characteristics of geopressured-geothermal systems have been discussed elsewhere in these volumes, and in other publications and papers. It is useful to reiterate the basic definition here in order to compare it with the legal definitions of geothermal power that are available.

Bebout, in the Proceedings of the First Geopressured-Geothermal Energy Conference, stated that "[a] geopressured zone is commonly defined as one in which the subsurface fluid pressure significantly exceeds that of normal hydrostatic pressure. . . . An increase in the temperature and reduction of the salinity of the water in the sand reservoirs in the geopressured zone accompany this increase in pressure." Such reservoirs occur at great depths; in the case of the geothermal zone contained within the Frio Formation, ". . . it defines an irregular surface that varies in depth from 8,000 to 12,000 feet below sea level" [36]. "Reservoir depths generally vary from 5,000 to 20,000 feet, with corresponding temperatures from below 200° F. to above 300° F."

There is another critically important characteristic of geopressured-geothermal reservoirs. "Natural gas is presumed to exist at saturation levels in the reservoirs" [37]. The quantities of dissolved natural gas are economically significant, ranging from a low value of approximately 7 standard cubic feet per barrel of produced fluids, up to approximately 40 scf/bbl [38].

In summary, a geothermal water reservoir may be defined as a shale and sand structure at great depth in which the fluid pore pressure exceeds hydrostatic pressure reaching to several thousand pounds per square inch, which ranges in temperature from approximately 150° F to above 350° F, and which is saturated with methane gas in significant quantities [39]. The waters in the reservoir are of low salinity, but may have large amounts of dissolved solids [40].

Geopressured-geothermal systems differ substantially from vapor-dominated hydrothermal systems, such as The Geysers, and from other systems such as impermeable hot rock massifs, volcanic and magmatic deposits, and hypersaline brines such as the Imperial Valley and Cerro Prieto, Mexico [41]. The common factor that makes all such configurations geothermal deposits is their enthalpy or heat content.

Geothermal Resources Generally.

It is important to place geopressured-geothermal resources in context with the other major types of geothermal resources. All presently designated geothermal systems--i.e., dry steam, wet steam, hot water, geopressured fluids, and hot rock massifs--share one common feature: enthalpy. Enthalpy or heat content is a measure of molecular kinetic energy in matter, and is expressed on an arbitrary but fixed scale. But it is not heat alone which makes geothermal systems valuable. The energy must be available for use on the surface, to do work or to provide heat. Availability necessarily includes technological and economic factors.

Each of the denominated geothermal systems represents particular types of geologic formation that produce extraordinary heat flows from the interior of the earth's core into the lithosphere. They represent a special subcategory of geothermal processes in general. The overall category of geothermal processes includes subduction of the lithosphere, continental drift, exduction of magma at mid-ocean ridges, convection currents in the asthenosphere and the associated earthquakes, vulcanism, and other macroscopic activities [42]. On the microscopic level geothermal processes include thermochemical reactions which convert fossil organic matter present in sedimentary strata into coal or into oil and natural gas, and which cause diagenesis of clay strata at depths leading to hydrothermal tectonism [43].

On the macroscopic level, geothermal formations include continental land masses, oceanic basins, island arcs, oceanic trenches, and mountain chains [44]. In the microscopic category are found the resources that concern this project and other energy projects. This category, however, also includes coal deposits, oil and gas reservoirs, and mineral deposits of many other sorts [45].

All the the enumerated geothermal processes and geothermal formations are the products of the movement of the earth's internal heat. This heat is produced in several ways, including radioactive decay of uranium, thorium, and potassium; mechanically derived heat from stress induced by compression, tension, torsion, friction, and so forth; physiochemical heat due to phase changes in materials; and the latent heat of formation of the globe [46].

Within the subcategory of denominated geothermal resources, geopressured-geothermal resources are somewhat anomalous. Jones has argued that igneous intrusions are necessary to explain paleothermic evidence [47], but the role of magma as a carrier of interior heat is not as obvious here as it is in other geothermal systems [48]. Furthermore, the geopressured-geothermal systems have two other sorts of available energy: kinetic energy from the pressure differential and potential chemical energy in the natural gas.

A broad physical model of geothermal systems that are significant for their energy potential at this time would include the feature of abnormally high rates of heat flow from the earth's interior into regions of the surface or immediate subsurface where present technology can gain economical access to this energy. Mass transfer is involved in some systems--i.e., dry and wet steam systems--and may be invoked in others--hot water, hot brines, geopressured fluids, and hot rock massifs. The heat transfer mediums may also contain kinetic energy present as pressure differential from atmospheric pressure. The exchange mediums may also contain solute minerals or gases [49].

LEGAL MODEL

Introduction.

> [G]eochemical and geophysical distinctions provide a basis in fact which demands that similar distinctions be made at law.
>
> United States v. Union Oil Company of California, et al.
> No. 74-1574, U.S. Court of Appeals
> Ninth Circuit, at 12
> Brief of State of California by and through the State Lands Commissionas Amicus Curiae
> January 1974

This section sets out the definitions contained in the statutes of the thirteen western states, Texas and Louisiana, and the United States, as well as those contained in case law. These legal definitions and descriptions articulate a particular physical structure. They are, in a real sense, models of the physical system. (Table 1.1 summarizes the statutory material.)

The legal models articulated by the listed statutes and cases range in complexity from very simple to very detailed. Some cases equate geothermal resources and water, while others state a complete description of the physical system. All such definitions are strictly limited to the scope of the statute or the case in question; different definitions may serve different purposes.

Table 1.1

OVERVIEW
STATE LAWS AND REGULATIONS:
GEOTHERMAL RESOURCES

<u>Alaska</u>:	Definitions:	California Code and Steam Act.
	Characterization:	Unclean byproducts, probably mineral.
	Scope:	State lands 38.05.181 (c)(1 & 2).
	State Law:	38.05.181 (1971).
	Leasing Regulations:	11 AAC 84.700 to 84.720 (1974).
	Drilling Regulations:	11 AAC 94.730 (1974).
	Geothermal regulations refer to general mineral leasing procedure (Ch. 82). All regulations and law compiled in "Regulations and Statutes Pertaining to Coal and Other Leasable Minerals on Alaska Lands as Contained in the Alaska Administrative Code and the Alaska Statutes," Division of Lands, Department of Natural Resources, State of Alaska, September 1974.	
<u>Arizona</u>:	Definitions:	Steam Act.
	Characterization:	Unclear.
	Scope:	All lands in state, sec. 27-659.
	State Law:	Art. 4, sec. 27-651 to 27-666 (Ch. 152, Laws 1972).
	Leasing Regulations:	Land Department Regulations, Ch.5, Art. 21 (R12-5-801 to 811).
	Drilling Regulations:	"General Rules and Regulations Governing the Conservation of Geothermal Resources," Oil and Gas Conservation Commission (Title 27, Ch. 4, Art. 21), 1972.

Table 1.1 (cont'd)

California:	Definitions:	California Code.
	Characterization:	Not water, unclear as to mineral.
	Scope:	State Lands, sec. 6904 and all land in state sec. 3715.
	State Law & Leasing Regulations:	"Geothermal Resources Act of 1967" Public Resources Code, Div. 6, Part 2, Ch. 3, Art. 5.5 (Statutes of 1967, Ch. 1398) also Ch. 4, secs. 3714.5, 3723.5, and 3728.5 (1974).
	Drilling Regulations:	PRC, Div. 3, Ch. 4. California Laws for Conservation of Geothermal Resouces. (Oil and Gas Publication #PRC02).
	Leases and Permits:	2 Cal. Admin. Code 2250 et seq.
Colorado:	Definitions:	Steam Act.
	Characterization:	Not water or mineral.
	Scope:	All land. Sec. 100-10-109.
	State Law:	"Colorado Geothermal Resources Act" (1974), sec. 1, Ch. 100, Art. 10, Colorado Revised Statutes--1963 as amended.
	Leasing Regulations:	State Board of Land Commissioners a) "Special Rules and Regulations Relating to Geothermal Resources Leases" (Form #248-1) 1972. b) "Lease Form" (Form #248-2) 1972.
	Drilling Regulations:	(pending) Department of Natural Resources, Oil and Gas Conservation Commission.
Hawaii:	Definitions:	California Code.
	Characterization:	Mineral.
	Scope:	All lands, sec. 182-1, (3 & 4).
	State Law:	Ch. 182 (Government Mineral Rights) as amended (H.B. 2197-74).

Table 1.1 (cont'd)

	Leasing Regulations & Drilling Regulations:	"Regulation of Geothermal Mining on State Lands and Reserved Lands in Hawaii" (DRAFT).
Idaho:	Definitions:	California Code.
	Characterization:	Sui generis.
	Scope:	All wells in state sec. 42-4003, 42-4012 and state lands 47-1601.
	State Law:	"Idaho Geothermal Resources Act" (1972) sec. 42-4001 (amended 1974) 42-4015 and 47-1601 through 1611 (1972).
	Leasing Regulations:	"Rules and Regulations Governing the Issuance of Geothermal Resources Leases," Board of Land Commissioners, 1974.
	Drilling Regulations:	"Drilling for Geothermal Resources: Rules and Regulations and Minimum Well Construction Standards," Department of Water Resources, 1975.
Louisiana:	Definitions:	Steam Act.
	Characterization:	Not mineral.
	Scope:	State Lands sec. 802. All lands sec. 807.
	State Law:	Title 30, Ch. 7 (Act 735; 1975), Ch. 8 (Act 784; 1975).
	Leasing Regulations:	(pending) State Mineral Board.
	Drilling Regulations:	(pending) Department of Conservation.
Montana:	Definitions:	Idaho modification of California Code.
	Characterization:	Sui generis.
	Scope:	State lands sec. 81-2601.
	State Law:	81-2601 to 2613 (Ch. 111, L. 1974); HB 581 (1975); amends sec. 70-820; SB 79 (1975) amends sec. 60.

Table 1.1 (cont'd)

	Leasing Regulations:	"Geothermal Rules and Regulations," Ch. 6, Title 81, Montana Administrative Code, 1975.
	Drilling Regulations:	"Geothermal Investigation Reports," 36-2.8(14), Montana Administrative Code.
<u>Nevada</u>:	Definitions:	Only heat/energy.
	Characterization:	Not water, not mineral.
	Scope:	State lands AB 158. All lands SB 158.
	State Law:	Title 48, secs. 2 to 5, Nevada revised Statutes (S.B. 158; 1975); NRS 322.030 to .060 (A.B. 158; 1975).
	Leasing Regulations:	(leasing moratorium on state lands since 1967).
	Drilling Regulations:	(geothermal regulations pending) State Water Law and well drilling regulations.
<u>New Mexico</u>:	Definitions:	California Code.
	Characterization:	Not water.
	Scope:	All lands sec. 65-11-6. State lands 7-15-3.
	State Law:	"Geothermal Resources Act," 7-15-1 to 28 (Laws of 1967, Ch. 158); "Geothermal Resources Conservation Act" (Laws of 1975; Ch. 272); 72-20-5(D) (Laws of 1975; Ch. 289). Energy Resources Act (Laws of 1975; Ch. 289) 65-13-1 to 16 sec. 65-13-1 to 16. Sec. 63-18, Laws of 1967, Ch. 143 and Energy Research Development Act 65-12-1 to 8.

Table 1.1 (cont'd)

	Leasing Regulations:	"Rules and Regulations Relating to Geothermal Resources Leases," State Land Office, 1971. Also sec. 7-15-1 Laws 1973.
	Drilling Regulations:	"Geothermal Resources: Rules and Regulations," Oil Conservation Commission, 1974.
<u>Oregon</u>:	Definitions:	Unique.
	Characterization:	Not mineral, not water.
	Scope:	State lands Ch. 51, Sp. Sess. 1974, all lands 522.050(2).
	State Law:	Geothermal Resources Act 1971 secs. 522.010 through 522.990. H.B. 2040; 1975 (amending 1971 "Geothermal Resources Act"); H.B. 3185; 1975 (geothermal heating districts).
	Leasing Regulations:	"Geothermal Lease Regulations," 75-010 to 75-605, Division of State Lands (Revised 1975).
	Drilling Regulations:	"Geothermal Regulations," Ch.632, Div. 2 (200-005 through 20-170), <u>Oregon Administrative Rules Compilation</u>, 1972. (Department of Geology and Mineral Industries).
<u>Texas</u>:	Definitions:	Steam Act.
	Characterization:	None.
	Scope:	All lands SB 685 sec. (4)(a), State lands ibid at sec. (5)(a).
	State Law:	"Geothermal Resources Act of 1975" (S.B. 685; 1975).
	Leasing Regulations:	(pending) State Land Office, School Land Board.
	Drilling Regulations:	"Rules and Regulations Governing Drilling and Producing on Permanent Free School Lands," School Land Board, 1974. "Rules Having Statewide General Application to Oil, Gas, and

Table 1.1 (cont'd)

		Geothermal Resource Operations within the State of Texas," (051.02.02.000 to 051.02.02.080), Texas Railroad Commission, Oil and Gas Division, 1976.
Utah:	Definitions:	None.
	Characterization:	Water.
	Scope:	All land in state 73-1-20 (1).
	State Law:	Sec. 73-1-20 (Ch. 189; Laws of 1973).
	Leasing Regulations:	"Rules and Regulations Governing the Issuance of Mineral Leases," State Land Board, 1973. "Geothermal Steam Lease and Agreement" (1973) (The lease form contains the regulations).
	Drilling Regulations:	"Rules and Regulations of the Division of Water Rights for Wells Used for the Discovery and Production of Geothermal Energy in the State of Utah" (DRAFT, 1975).
Washington:	Definitions:	Unique.
	Characterization:	Sui generis.
	Scope:	All lands 79.76.060 and 070.
	State Law:	"Geothermal Resources Act" (Sub. H.B. 135; 1974).
	Leasing Regulations:	"Geothermal Leasing Policy," Department of State Lands (DRAFT, 1975).
	Drilling Regulations:	"Geothermal Rules and Regulations," Department of Natural Resources (DRAFT, 1975).

The Board of Natural Resources must approve all regulations.

Table 1.1 (cont'd)

<u>Wyoming</u>:	Definitions:	As water.
	Characterization:	Water resource.
	Scope:	All lands in state sec. 41-121(b).
	State Law:	Sec. 41-121 (1973): Geothermal steam and hot water a water resource.
	Leasing Regulations:	"Rules and Regulations Governing the Issuance of Geothermal Resource Permits and Leases," State Board of Land Commissioners, 1975.
	Drilling Regulations:	(pending) Oil and Gas Conservation Commission.
<u>Federal Statutes</u>:	Definitions:	Steam Act.
	Characterization:	May be mineral.
	Scope:	Federal lands sec. 1002.
	Federal Law:	Ch. 23: Geothermal Steam Act of 1970, 30 USC, secs. 1001 to 1025.

Based on "State Laws and Regulations Regarding Geothermal Resources" compiled by the

Renewable Energy Resources Project
National Conference of State Legislatures
1405 Curtis Street, Suite 2300
Denver, Colorado 80202

Alaska.

A. Definition: Exposition. The definition section of the Alaska Geothermal Resources Act of 1971, sec. 38.05.181 (q),(1) and (6) (A-D), carefully tracks at part (6) the language set out in the California Geothermal Steam Act of 1967 at sec. 6903. The act goes on, in part (6) (A-D), to set out the definition as contained in the Steam Act at sec. 1001, (c). Finally, in part (q) (1) the definition of byproducts as set out in the Steam Act in sec. 1001 (d) is included.

B. Definition: Analysis. The hybridization of the models contained in the Steam Act and the California Code gives Alaska a legal model which includes the heat source, heat transfer mediums, and contaminants. The heat source is not distinguished from the ordinary heat flow regime of the lithosphere. The heat transfer mediums do include artificially injected substances. And the contaminants do not include natural gas.

The situation with regard to "byproducts" is very confused. "Byproducts" are explicitly defined in sec. 38.05.181, (q),(1) in the exact fashion as they are in the Steam Act. The inclusion of the provisions of the California Code also provides for at least part of the listing from the Steam Act, but with a significant difference. Those minerals which are in solution (not including those only in association with) with the heat transfer mediums, without regard for value or producibility, are part of the resource under (q)(6). But the definition of "byproducts" includes such minerals in solution only if they meet tests of value and producibility. Further, such minerals, if they are to be byproducts, are in solution or in association with "geothermal resources," which already includes the same minerals. The confusion persists in other provisions of the act such as part (1)(1) which equates geothermal steam with other byproducts.

C. Characterization. The confusion which exists with regard to the definition of the term "byproducts" exists also with regard to the characterization of the resource. Part (e)(2) provides that if a byproduct is present in valuable amounts, the director or others may order its production. However, "the production or use of those byproducts is subject to the rights of holders of preexisting leases, claims, or permits covering the same land for the same minerals. This removes "byproducts" which would be part of the resource--assuming they pass the test set out in (q) (1)--and producible under a geothermal lease from the scope of the geothermal resource. Subordination to mineral leases may simply be equity, or it may signal that these valuable byproducts are part of the mineral estate.

Part (1)(5) provides that in cases where a geothermal lease is no longer producing paying amounts of geothermal resources--including byproducts--but can produce valuable amounts of byproduct minerals, it may be converted into a mineral lease. This section may imply a different intent than (q) (1) discussed above, since it clearly indicates that production of these minerals under a geothermal lease requires no additional mineral lease. However, it again recognizes equity or ranks the byproducts chiefly as minerals and part of that estate.

More direct sections, such as (e)(1), include geothermal resources with "other minerals." Section (c)(3)(F-G) treat a geothermal lease in the same manner as a mineral lease by providing surface easements and other similar requirements. Part (j)(5) reiterates this position. However, part (k)(1)(A-B) distinguishes steam, brines with minerals, and associated gases from minerals and chemicals for purposes of royalty payments. This would seem to imply a clear distinction between geothermal resources and the mineral estate [50].

D. Summary. The legal model applies to state lands and not to private lands. Geothermal resources in Alaska, under the provisions of this act, include the heat source with no distinction from normal thermal gradients; the heat transfer mediums; and some of the contaminants of said mediums under some circumstances. The geothermal resource seems to place byproducts squarely into the mineral estate without clearly identifying the character of the whole resource.

Arizona.

A. Definition: Exposition. The Arizona Geothermal Resources statute, Article 4 Sections 27-651 to 27-666(1972), follows the language of the Steam Act. It departs from this language in the title--Geothermal Resources --which is more inclusive than the federal title. It adds to part (5)(c) of -651, the phrase, "including any artificial stimulation or induction thereof." And the Arizona statute eliminates the "byproducts" section and substitutes part (5)(d) which includes as part of the resource "[a]ny mineral or minerals, exclusive of fossil fuels and helium gas, which may be present in solution or in association with geothermal steam, waters, or brines."

B. Definition: Analysis. The Arizona act, in part (5)(c), clearly means something other than fluid injection when it speaks of "stimulation or induction thereof." What is meant becomes clear by reference to sec. 27-651 (10) and 27-655; part (10) provides that the definition of wells includes wells "drilled for the purpose of stimulating the heat of a formation or for the creation of heat in a formation by nuclear or any other form of energy." Sec. 27-655 provides that the commission "shall have jurisdiction over any stimulation, induction or creation of a geothermal resource." Thus, the Arizona act adds to the model expressed by the Steam Act the notion that the heat for such a resource may be added to the system by artificial means. This is a unique provision and raises questions about the meaning of geothermal energy systems for this state. Such a provision means that a geothermal resource is not restricted solely to magmatic heat for its energy.

The Arizona act also eliminates the economically and technically complex definition of byproduct that is found in the Steam Act. It substitutes for this a simple inclusion of heat transfer medium contaminants, as long as they are minerals. This would seem to include natural gas, except for the provision for the exclusion of fossil fuels. The act would therefore not include the solute natural gas of the geopressured resources.

The act suffers further from the criticisms previously leveled at the Steam Act's failure to define geothermal formations. These formations are defined by reference to the named products of geothermal processes, none of which said products is characteristic of geopressured reservoirs. Hot rock massifs are also apparently left out.

C. Characterization. The only section of the act which seems to bear on the character of geothermal resources is sec. 27-652. This section, in parts (A-D), distinguishes geothermal fluids from water, both surface and subsurface. Part A provides that "contamination of any waters of the state . . . by waste from underground geothermal reservoirs" is to be prevented. Part B provides that "a well for geothermal resources underlying a usable groundwater aquifer shall be constructed so as to avoid contamination of such aquifer." Part C provides that "[D]isposal of water of brines from a geothermal well . . . shall not damage . . . underlying groundwater . . . or . . . surface water." Part D provides that "maintenance of the . . . geothermal resource, . . . maintenance of the quality of surface and other ground waters" may require commission action.

D. Summary. The legal model applies to all lands in the state. In as much as the Arizona statute follows the Steam Act it conveys the same type of legal model, i.e., heat (including exogenously supplied heat), heat transfer mediums, and some but not all contaminants. There is no clear description of the system or systems which are in fact involved in geothermal energy resources. The act fails to supply any clear-cut characterization. Parts of the section setting out powers of the commission seem to imply that geothermal resources are not water.

California.

A. Definition: Exposition. California enacted its geothermal statutes in 1967, predating the Steam Act. It chose to express a somewhat different legal model in its code provisions. These provisions are set out in full for analysis.

> Sec. 6903 "For purposes of this chapter, 'Geothermal Resources' shall mean the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substance."[5]

B. Definition: Analysis. This legal model begins with the central feature of geothermal systems, heat. It provides that the energy "in, resulting from, or created by, or which may be extracted from," heat is also part of the resource. This clearly covers pressure as well as heat, so pressure is part of the resource. This broad-based definition also clearly includes hot rock massifs and geopressured fluids because of the phrases "in whatever form" and "present in" and "resulting from." The energy or enthalpy of impermeable hot rock massifs is "present in" the massifs [52]. And geopressured fluids are those "resulting from" paleothermic reactions [53].

Solute minerals and other substances are part of the resource, but interestingly enough the heat exchange mediums themselves--i.e., the steam, brines, fluids, and gases--appear to be excluded. The statute reads "'geothermal resources' shall mean . . . heat of the earth, the energy . . . and all minerals . . . or other products obtained from . . . fluids, brines, . . . gases and steam." Note that the statute does not put an "and" in front of "fluids, brines, . . . gases and steam." This limits the resource to energy--heat and pressure--and to the contaminants of the heat transfer medium only, unless "other products" is interpreted to mean and include the heat transfer medium.

It should also be noted that the exclusion of hydrocarbon gas appears to leave the solute methane of the geopressured systems out of the resource model. In addition, the phrase "naturally heated fluids" may include heat transfer mediums whose source of heat is the ordinary thermal gradient rather than any near-surface intrusives. The phrases "natural heat of the earth" and "such natural heat" also fail to mention such intrusions and could be taken to refer to the same normal thermal gradient.

C. Characterization. Provisions covering leasing on all lands in the state appear to make a strong distinction between water resources and geothermal resources [54]. Sec. 3742.2 provides for certificates of primary purpose which create a rebuttable presumption of absolute title to geothermal resources from wells which are primarily for the purpose of producing said geothermal resources and "not for the purpose of producing water usable for domestic or irrigation purposes" [55]. Secs. 3714, 3716, 3718, 3740, 3741, and 3746 all make similar distinctions. Furthermore, Division 7 of the California Water Code, at sec. 13710(1967) clearly declares that water wells do not include "oil and gas wells, or geothermal wells." This seems to settle the matter that under California law geothermal resources are not water resources.

The case with regard to the mineral classification is not so clear. The acts do not appear to make any affirmative declarations concerning the character of the geothermal resources as minerals. Several articles juxtapose minerals and geothermal resources, though not always consistently. Sec. 6906 of the Public Resources Code recites that conflicts as between geothermal leases and "leases of the same lands for . . . other minerals" will be resolved on the basis of multiple use. This implies that geothermal resources are minerals. However, Sec. 6913, dealing with royalty rates, distinguishes royalties on steam, mineral laden brine, and associated gases from royalties on minerals and chemical compounds [56].

D. Summary. The legal model conveyed by the California Code provisions applies to both state and private lands. It includes the heat of the earth, though it fails to distinguish this from the extraordinary enthalpy of geothermal deposits; it includes the contaminants of the heat exchange mediums, but it appears to omit the heat transfer mediums themselves. The resource is characterized as not water, but it is not clear from the code provisions whether it is regarded as a mineral.

Colorado.

A. Definition: Exposition. The definition section of the Colorado Geothermal Resources Act (1974)[57] follows the general format of the Steam Act. Sec. 100-10-103 defines "Geothermal resources" and "Geothermal byproducts" in parts (6)(a and b), and (4) respectively. Part (10) of this section also defines "Pool" and part (7) defines "Geothermal Resource Zone."

"Geothermal Resources" (rather than "geothermal steam and associated geothermal resources" as in the Steam Act) means "geothermal heat and associated geothermal resources including but not limited to [58]

100-10-103(6)(a) (I) Indigenous steam, other gases, hot water, hot brine, and all other products of geothermal processes;
(II) Steam, other gases, hot water, hot brine, and all other products of geothermal processes resulting from water, brine, steam, air, gas, or other substances artificially introduced into subsurface formations; and
(III) Natural heat, steam energy, and other similar thermal energy in whatever form found in subsurface formations.

& (6)(b) For purposes of this article, such term shall not include thermal energy contained in mineral deposits (including deposits of coal, oil shale, crude oil, natural gas, and other hydrocarbon substances, and including other substances and materials associated and produced in connection with such minerals) which are explored for, developed, and produced primarily for the mineral value thereof and not primarily for the thermal energy contained therein.

& (4) "Geothermal By-product" means any substance which remains after thermal energy has been removed from geothermal resources, includbut not limited to cooled waters, solution minerals, chemical compounds, extractable salts, rare earths, and other mineral substances.

& (10) "Pool" means an underground reservoir containing an accumulation of geothermal resources.

& (7) "Geothermal resource zone" means the geologically identifiable portion of the earth from which a geothermal resource is obtained.

B. Definition: Analysis. The legal model articulated by this statute is similar to that of the Steam Act, because of the borrowed language and structure. This statute emphasizes the enthalpy of the resource in many different ways. Sec. (6)(a) opens with a change from geothermal steam to geothermal heat. Part (III) explicitly describes "natural heat" and "similar thermal energy." Sec. (6)(b) distinguishes the geothermal resource from other geologic deposits which, though they contain thermal energy, are produced for their value as commodities. Sec. (4) defines byproducts as those things left after the "thermal energy has been removed." Sec. (12) defines "waste" in terms of diminution of total recoverable thermal energy.

There is some question whether the energy contained in geothermal resources as pressure would be part of the resource under this definition. Pressure is not enumerated in Sec. (6)(a)(III) wherein the various forms of energy are listed. The term "steam energy" may include pressure. The administrative tax court in Reich [59] argued that " . . . steam is . . . heat and water combined in a way which results in tremendous pressure" [60]. Such a reading of "steam energy" might include pressure, in spite of the improperly drawn conclusion that steam always expresses energy as pressure. Sec. (6)(a) probably includes pressure by virtue of the saving phrase "but not limited to."

The statute recapitulates in Sec. (6)(a)(I) the heat transfer mediums listed in the Steam Act, but corrects an omission there of gases as possible mediums. Sec. (6)(a)(II) adds further to the list "other substances" and "air."

The Colorado statute substantially changes the listing of contaminants of heat transfer mediums. The byproducts section in the Steam Act identified said contaminants. This section of the Colorado statute adds to the list of things which may be found in the heat transfer mediums, one of the mediums itself. Sec. (4) includes "cooled waters," thus changing byproduct from a simple list of contaminants to a list of all those things left over after the "thermal energy" has been extracted [61]. Would solute natural gas be included as a "byproduct"? The saving phrase, "but not limited to" seems to include solute methane.

Interestingly enough, the section which defines byproducts is not unambiguously included in "Geothermal resources" by reference. This is, of course, a very important issue. The Steam Act unambiguously includes byproducts by listing them under "geothermal steam" and so forth as sec. 1001 (c)(iv) and (d). The Colorado statute does not include "byproducts" in the similar section (6)(a) and (b). Careful reading of the remainder of the statute identifies much internal contradiction. Sec. 100-10-103,(8) defines "Owner" as a person with rights over the "Geothermal resource." It leaves out any mention of "by-product." Sec. 112-3-13 on "Leases" mentions only "GEOTHERMAL RESOURCES" and omits "by-products." Sec. 112-3-15 does the same, as do secs. 112-3-16, 112-3-26, and 112-3-48. However, sec. 112-3-48, in part 2(b) provides for royalties on both the resource and its byproducts. Sec. 100-10-106,(1) also includes geothermal byproducts. It is therefore quite unclear whether "by-products" are explicitly included, though the saving phrase, "but not limited to" may have the effect of so including them.

Geopressured-geothermal resources and hot rock massifs appear to be included in the legal model, by virtue of the saving phrase "but not limited to." However, part 6(b) appears to provide that geopressured reservoirs which can be developed commercially for their solute natural gas content alone would not be part of the listed geothermal resources. This reading, if correct, would make it impossible for a prospective geothermal operator to perfect a lease for geopressured-geothermal resources in such a case, unless the operator also secured the mineral lease as well.

C. Characterization. The Colorado statute seems to characterize geothermal resources as something other than water or mineral. Sec. 100-10-106 extends the same powers of the commission to geothermal resources that it has over oil and gas. This seems to imply differing characters. Sec. 100-10-107 provides that existing water law requirements are not altered (see parts 1, 2, and 3). Part 4 of this section provides, however, that such required water law permits apply only where the geothermal operation would appropriate or use "ground waters" of the state. This may imply, depending on the exact meaning of "ground water," that most types of geothermal resource wells will not be considered water wells and that the resource itself is not considered water.

Sec. 112-3-13, on leases, provided for a clear distinction between geothermal resources and mineral resources. "If GEOTHERMAL RESOURCES OR stone, coal, oil, gas, or other . . .MINERALS" seems to convey the logical proposition that "geothermal resources" or minerals are the subject of the clause. An inclusion of geothermal resources with minerals would have read, "geothermal resources and minerals."

Sec. 112-3-15 provides that the state may join in development of "oil, gas, or geothermal resources." This seems to have the effect of distinguishing geothermal resources from oil and gas, traditionally regarded and leased as minerals. Sec. 112-3-26(1) reads to the same effect, and distinguishes geothermal from "coal, asphaltum, oil, gas, and other like substances." Sec. 118-6-21 explicitly recites that with regard to leases predating the act "it shall be presumed that reference to minerals or mineral rights does not include geothermal resources unless geothermal resources are specifically mentioned." And for leases antedating the act, "reference to minerals or mineral rights shall not include geothermal resources unless specifically mentioned." This expresses a clear policy which declares that geothermal resources are not minerals [62].

D. Summary. The legal model applies to all lands in the state. The Colorado Geothermal Resources Act of 1974 reiterates the general legal model of the Steam Act. It provides that heat transfer mediums, contaminants of those mediums (with some modifications), and heat energy are parts of the resource. The act appears to include natural gas, but to exclude some types of geopressured reservoirs which are valuable for the gas alone. The geothermal resource is characterized as not water and not mineral.

Hawaii.

A. Definition: Exposition. The Hawaii statute, Act 241(1974) amending Section 2, Part 182-1 Hawaii Revised Statutes, at Subsection (8), exactly reiterates the definition contained in the California Code at sec. 6903. It supplements this definition with a declaration, in subsec. (1), that "'Minerals' . . . means . . . all other mineral substances . . . including all geothermal resources."

B. Definition: Analysis. The legal model includes the natural heat of the earth, without reference to extraordinary heat flow; and the contaminants of the heat transfer mediums excepting oil, gas, and other hydrocarbons. It omits the heat transfer mediums themselves. The definition of geothermal resources as mineral is more germane to the question of characterization of the resource than it is to any legal model, as can be seen by considering the long list of substances contained in subsec. (1). It begins with hydrocarbons, technically not minerals, and goes on to include gaseous and liquid mineral deposits, as well as the geothermal resource.

C. Characterization. The Hawaii statute is quite clear on the point of characterization. Geothermal resources under subsec. (10) are minerals. Subsecs. (7-8) reinforce this definition by reference to mining operations and mining leases which place geothermal resources with mineral deposits. They are also the property of the state until severed [63].

D. Summary. The legal model applies to all lands in the state. It includes the heat and contaminants but leaves out the heat transfer mediums.

Idaho.

A. Definition: Exposition. The Idaho Geothermal Resources Act of 1972, in sec. 42-4002(c) and (e), defines geothermal resources in a manner that is clearly based on the California Code, with several important differences. In part (c) Idaho duplicates the California Code down to the words "'all minerals in solution or other products obtained from' the material medium of any geothermal resource." "Material medium" is defined by (e) in terms taken from the California Code. "'Material Medium' means any substance including, but not limited to naturally heated fluids, brines, associated gases, and steam, in whatever form" [64]. This section goes on to identify the function of a material medium as something "which contains or transmits the natural heat energy of the earth." It then goes on to exclude petroleum, oil, hydrocarbon gas, or other hydrocarbon[s] from this category.

B. Definition: Analysis. This is one of two statutes that explicitly recognize the function of heat transfer mediums [65]. In spite of this excellent definition of heat transfer mediums, it is clear that geothermal resources do not include such material mediums [66]. Part (c) reads "'Geothermal resource' means the natural heat energy . . . and all minerals in solution or other products" of material mediums; but it does not say "and" material mediums. The legal model is therefore precisely the same as California's, except that the impact of moving the exclusion of oil, gas, and so forth from minerals in solution to the definition of material mediums is to allow such substances into the resource as other products. The act only provides that they can not be "material mediums."

C. Characterization. Part (c) contains, in addition to the California Code provisions, a section that explicitly characterizes geothermal resources. "Geothermal resources are . . . sui generis, being neither a mineral resource nor a water resource, but they are . . . closely related to and possibly affecting and affected by water and mineral resources in many instances." This characterization is followed in later sections of the act. Sec. 42-4003(b) distinguishes geothermal waters from waters to be used for beneficial purposes other than as a material medium, mineral source, or energy source. See also secs. 4004(b)(2 and 5) and 4005(b and e) for similar provisions. The resource is also distinguished from minerals by the reservation clause of sec. 47-1602.

Confusion in one section may arise from an attempt to do equity in a grandfather clause. Sec. 42-4003(e)(1 and 2) provides that users of geothermal waters for low-grade heat who had a valid water permit before January 1, 1972 and who are not involved with other nonheating uses do not need a geothermal lease. This implies that low-grade heat uses move geothermal fluids from *sui generis* to water resources. There is no elaboration on this point.

D. Summary. The legal model applies to private lands and state lands. It includes the natural heat of the earth without distinction from normal thermal gradients, and it includes minerals and other substances carried or associated with heat transfer mediums. Natural gas appears to be included by this provision.

Louisiana.

A. Definition: Exposition. The close resemblance of the definition in HB 700 and SB 420 to that of the Steam Act again permits an identification of differences. Secs. 681.2 of HB 700, (1)(a-b), and 801 of SB 420, (1)(a and b), are identical to (c)(i) and (ii) of the Steam Act. Subsec. (1)(c) of both statutes contains a significant difference: "heat, dissolved natural gas, . . . " This has the effect of lumping the complex potential chemical energy of methane in with the thermal and kinetic energy of heat and pressure.

HB 700 simply omits sec. (d) of the Steam Act after repeating (c)(iv); thus, "byproducts" receives no definition here. For purposes of HB 700 there is a positive inclusion of methane through sec. (1)(c) and no exclusion of it in any byproducts section.

SB 420 greatly complicates the legal model by the structure of sec. 801(2), which reads:

> "Byproduct" means any mineral or minerals, excluding oil and natural gas, which are found in solution or in association with a geothermal resource and which have a value of less than seventy-five per centum of the value of the total geothermal resource if utilized [,] or [are] not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves or whose production would waste or not fully utilize the geothermal resource.

B. Definition: Analysis. The model set out by SB 420 is extremely difficult to clarify. Methane is a part of the geothermal resource under sec. (1)(c), yet it is not included as a byproduct derived from the resource by virtue of sec. (2). The restriction of sec. (1) of both acts to "Geothermal resources" rather than "geothermal steam and associated resources" under the Steam Act may be significant here. Yet SB 420 includes byproducts as part of the geothermal resource, by virtue of (1)(d). This means that methane, a part of the resource, can not be a "byproduct" (i.e., a part of the resource) by explicit exclusion. There are further textual difficulties with this statute [67].

Far more important, in light of the presence of geopressured-geothermal systems in Louisiana and in view of the implicit intention to include such systems signaled by listing natural gas in sec. (c), is the failure to explicitly name such systems under the category of products of geothermal processes. If the reasoning applied to the Steam Act is valid, then "geothermal formations" as found in sec. (c) are defined by looking to the named types of geothermal processes in sec. (a). Since sec. (a) fails to mention geopressure, this type of formation is not included in sec. (c). Therefore, neither heat, nor methane, nor associated energy from geopressured resources comes under the act. In addition, hot rock massifs appear to be omitted.

The rule that courts will construe a statute to support its intention may not be of much help here. Act 784, SB 420, fails to mention geopressure anywhere though sec. 801(c) does hint at it. Act 735, HB 700 does explicitly mention geopressure, not only in the title, The Louisiana Geothermal and Geopressure Energy Research and Development Act, but also in the findings clause. Unfortunately this act also in sec. 681.1(9) explicitly declares that its intention is to "provide the framework and guidelines for the state, through the State Department of Conservation, to <u>begin</u> concerted efforts." And sec. 681.3, which describes the powers and duties of the department, nowhere specifies leasing, though many different sorts of research and evaluation tasks are enumerated.

The inclusion of a reference in Act 784, the leasing act, sec. 807, to a grant of full regulatory authority "over all drilling and producing operations under a geothermal lease . . . [to] the state department of conservation" does not alleviate the problem since the new geopressure-geothermal research and development act, though part of the conservation statute, does not cover leasing. Thus the act that provides for leasing does not include geopressured deposits, while the act that does include such deposits does not cover leasing. Furthermore, sec. 808 of 784 provides that geothermal leases are subordinate to and may not interfere with oil, gas, or mineral leases. This section would have the impact of allowing gas leases for development of the geopressured reservoirs for <u>only</u> the solute natural gas. This production would take place under a gas lease and no geothermal lease could interfere with it. Clearly geopressured reservoirs with paying quantities of natural gas are <u>not</u> part of the geothermal resource.

<u>C. Characterization</u>. The Louisiana statutes do not explicitly recite any positive characterization of the geothermal resource. However, in

Act 784, at sec. 808, the act provides that geothermal leases are subordinate to and may not interfere with oil, gas, or mineral leases. This clearly indicates that geothermal resources are not mineral resources.

D. Summary. Louisiana, then, presents two distinct legal models, HB 700 and SB 420, which apply to state and private lands. HB 700 reiterates the model of the Steam Act with the exception that it omits any definition of "byproducts" and adds to the class of energies potential chemical energy in the methane. SB 420 carries out this same model, except that it reiterates from the Steam Act the definition of contaminants which will be considered part of the resource. The omission of explicit reference to geopressured fluids in sec. 1(a) appears to render inconsequential the inclusion of methane in sec. 1(c), since methane is found only in such geopressured reservoirs. But in any case geopressured systems seem to drop out of the model expressed by both acts [68].

Montana.

A. Definition: Exposition. Montana has two statutes bearing on geothermal resources [69]. The leasing statute, sec. 81-2601 to-2613, defines the geothermal resource in terms indentical to those used by Idaho at Section 47-1602. This is the California Code verbatim, down to "'or other products obtained from' . . . the material medium," and so forth. Unfortunately the act does not go on to define "material medium" as did Idaho at sec. 42-4002(e).

B. Definition: Analysis. This definition includes the heat energy, without regard for extraordinary thermal gradients; and the contaminants of the heat transfer mediums. If "material medium" can be interpreted by reference to the Idaho source, the legal model describes the role of the heat transfer mediums without including them.

C. Characterization. Montana characterizes the geothermal resource as "sui generis, being neither a mineral resource nor a water resource." This section explicitly repeals a provision of the Montana Water Use Act at sec. (3) which had included geothermal waters within the meaning of water. In addition, the act reserves, post facto and prospectively, all geothermal resources under any lease of state or school lands [70].

D. Summary. The legal model covers state lands. It includes the heat source and unspecified contaminants of the heat transfer mediums, but omits the mediums themselves. The resource is characterized as sui generis.

Nevada.

A. Definition: Exposition. Nevada has two statutes applying to geothermal resources [71]. The statutes share a common definition: "'Geothermal resource' means heat or other associated geothermal energy found beneath the surface of the earth" [72]. AB 158, ch. 366, which discusses royalties, includes a royalty on "byproducts." This provision is followed immediately by a definition of "byproduct" as "any tangible substance produced or extracted in the utilization of a geothermal resource."

B. Definition: Analysis. The legal model conveyed by the basic definition includes only the heat or energy content of geothermal systems. AB 158, ch. 366, for purposes of royalty payments on geothermal leases on state lands, introduces a notion of byproducts substantially more inclusive than any found in other statutes. Byproducts, as defined herein, would include any produced heat transfer mediums as well as contaminants of any sort. However, it is unclear that "byproducts" are part of the geothermal resource. Sec. 5 of SB 158, ch 416, provides that any water and steam encountered during geothermal exploration are subject to the appropriation procedures of the water acts [73]. Thus, water is not part of the geothermal resource, but it can be a byproduct. Therefore byproducts are not part of the resource, at least with respect to state lands.

C. Characterization. Neither act characterizes the geothermal resource explicitly. The above cited water law provision indicates that geothermal resources are not water, especially since the definition excludes water and other heat transfer mediums. Sec. 322.040 of AB 158, ch. 366, distinguishes geothermal resources from coal, oil, and gas. This section may imply that the resource is not mineral, especially when read with the above cited royalty provision for byproducts that comprehends all solute minerals.

D. Summary. Nevada defines geothermal resources so as to include only heat or energy. The resource is characterized as not water, and possibly as not mineral. The provisions cover both state and private lands.

New Mexico.

A. Definition: Exposition. New Mexico has at least five statutes which mention geothermal resources [74]. Of these, three define geothermal resources. The most complete definition is found in the Geothermal Resources Conservation Act (1975). This act provides in sec. 65-11-3(A) for reiteration of the California Code model. It further provides in part (F) for the definition of a "'low temperature thermal reservoir,' [which] means a geothermal reservior containing low temperature thermal water, . . . less than boiling at [that] altitude . . . [with] . . . value by virtue of the heat." The Geothermal Resources Act (1967), at sec. 7-15-1?,(A), also reiterates the California Code, but omits any mention of low temperature reservoirs [75]. The 1967 statute which requires reports defines the geothermal resource slightly differently. This act, at sec. 63-1-8(B)(1), is identical to the California Code only up to the phrase, "or which may be extracted from, this natural heat." It omits any mention of minerals or associated substances.

B. Definition: Analysis. The legal model differs slightly for each of these statutes. The Geothermal Resources Conservation Act, like the California Code, includes the normal heat of the earth (without distinction of extraordinary thermal gradients) and some of the contaminants of the heat transfer mediums. It omits the mediums themselves. The act adds to this a classification that divides said resources into two types, hot and warm. The Geothermal Resources Act includes only the California model; while the reporting act includes only the energy and heat content of the heat transfer mediums.

C. Characterization. None of the cited New Mexico statutes explicitly characterizes the geothermal resource. However, some of the provisions are indicative of characterization. Sec. 7-15-7 of the Geothermal Resources Act provides for different royalties for the brines with minerals intact, the steam, and associated gases as compared to minerals or chemical compounds [76]. In Part (A)(8) of the same section is a provision allowing renegotiation of royalties, except for minerals on lands under a mineral reservation. This section seems to say that minerals, which are contaminants of the heat transfer mediums in a geothermal system, are really part of the mineral estate and are controlled by reservations of the mineral estate. Yet, if such minerals are part of the geothermal resource, the implication would be that the entire resource falls under the mineral estate. The Resource Conservation Act provides further hints that geothermal resources are minerals in New Mexico. The entire structure of the act is based on oil and gas law, even to correlative rights, proration to market demand, and ratable taking [77].

D. Summary. The legal model applies to both state and private lands. The resource is not characterized explicitly, but appears to be regarded as a mineral by the acts. The legal model includes the natural heat and contaminants of the heat transfer mediums; but excludes the mediums themselves.

Oregon.

A. Definition: Exposition. Oregon has at least four statutes which speak to geothermal resources [78]. Two of these acts make virtually identical definitions of the goethermal resource [79]. Oregon, in sec. 522.010(4), defines "Geothermal resources" to mean "the natural underground reservoirs of heat that may be exploited for the production of heat energy, including but not limited to all minerals obtained from naturally or artifically injected fluid, brine or associated gas and steam in any form whatsoever, but excluding oil, hydrocarbon gas and other hydrocarbon substances and hot waters of less than 250 degrees Fahrenheit bottom hole temperature." Ch. 51 (HB 3324) sp. sess. 1974, sec. (3)(2) amending ORS 273.551 alters this definition by adding to "reservoirs of heat" the phrase "steam or hot water."

B. Definition: Analysis. The definition recited in both statutes focuses on the heat available for the production of heat energy. This idea goes directly to the notion of availability of energy for use or work. The idea is embodied not only in the provision that the reservoir must be so situated as to be exploitable for the production of heat energy, but also in the limitation to hot waters of greater than 250°F.

The legal model includes the "reservoirs" of heat, steam, and hot water. This model expresses the notion that geothermal energy systems are based on extraordinary heat flows beyond normal thermal gradient for that area. Contaminants of heat transfer mediums are also part of the model, but the mediums themselves are not. Furthermore, there is a strange restriction of these mediums to injected mediums.

C. Characterization. Sec. (3)(1) of Ch. 51 characterizes the resource as nonmineral. HB 2040 excludes geothermal resources from the Ground Water Act of 1965 and provides for certificates which establish a rebuttable presumption that the geothermal lease is not appropriating water. This act goes on to declare that the resource is the property of the surface owner, unless severed or reserved. The impact of this provision on characterization of the resource is not clear.

D. Summary. The legal model applies to state and private lands. It includes reservoirs of heat, steam, or hot water, and some contaminants of the heat transfer mediums. The acts characterize the resource as not water and not mineral.

Texas.

A. Definition: Exposition. The definition in the Texas statute, the Geothermal Resources Act of 1975, is so closely modeled on the Steam Act that it will suffice to point out the differences. SB 685 Ch. 243 in sec. (3) part (a)(1) mentions "and hot brines, and geopressured waters." This inclusion clearly recognizes the limitations of the corresponding sec. (c)(i) of the Steam Act.

Sec. (3)(b) defines byproduct quite differently from the Steam Act, and from the Louisiana statutes. It provides that "[t]he term 'by-product' means any element in a geothermal formation which when brought to the surface is not used in geothermal heat or pressure induc[ed] energy generation."

B. Definition: Analysis. This definition ties the nature of byproducts, not to economic values, but rather to physical processes of use of the heat transfer medium and its contaminants at the surface. The intent of the act, based on the history of its drafting and on the language as written, is to include as a "by-product" any contaminant which could be withdrawn from the heat transfer medium before the medium gave up its thermal and pressure energy in energy generation. To be more specific, "by-products" may include the solute natural gas mentioned in the section on the physical model of geopressured-geothermal resources if such natural gas "is not used in heat or pressure induc[ed] energy generation".

The model conveyed by the Texas statute describes heat in specific formations, now including geopressured reservoirs; and heat transfer mediums as enumerated in the Steam Act. It greatly changes the nature of contaminants admitted to status as part of the geothermal resource, allowing natural gas--or any other entity--to come in if it is not used in energy generation. Thus, substances, including natural gas, which were specifically excluded from the Steam Act are now potentially included in the resource.

The impact of the model's provisions on "by-products" is understandable in light of the widespread opinion that the newly defined geopressured-geothermal reservoirs will not be worth exploiting solely for their heat or pressure energy, but will require the added economic value of natural gas (at intrastate unregulated prices) [80]. This opinion may yield to later information, including work presented during the First Geopressured-Geothermal Energy Conference by investigators from Lawrence Livermore Labs (House et al.) which may show that the sale of methane is not absolutely necessary to exploitation of the resource.

Nevertheless, the definition of "by-products" introduces unnecessary complications. Several different systems for producing electrical energy from geopressured fluids have been explored by the Resource Utilization section of the Phase 0 project, and by investigators at Lawrence Livermore Labs. In at least one system of power generation, the total flow system favored by the staff at Livermore, the exsolution of methane would contribute to the kinetic energy input to the generator [81]. This process would lead to the rather bizarre result, under the model inherent in the statute, that natural gas is a byproduct in binary working fluid and other systems, but is not a byproduct in a total flow system (at least with respect to the methane that exsolutes in the turbine). In addition, nonelectric generation uses of the geopressured fluids, for district heating, and so forth, would class methane as a byproduct.

C. Characterization. The Texas statute does not characterize the resource explicitly. No implications can be drawn from any of the provisions of the act.

D. Summary. The legal model covers both public and private lands. It corresponds to the Steam Act, except for byproducts. It includes heat in specific formations (adding geopressured aquifers) heat transfer mediums, and any contaminant not used in heat or pressure induced energy generation.

Utah.

A. Definition: Exposition. In sec. 73-1-20 of the Utah Code Annotated, 1973 Supplement, Utah places "all wells for the discovery and production of water to be used for geothermal energy production" under the Division of Water Rights. The statute does not define the resource in any way.

B. Definition: Analysis. Utah enacted provisions which do not define but only characterize the resource for purposes of regulatory control. There is no visible impact on ownership or leasing within these provisions. However, the State Land Board has adopted a rule, Rule 30 of Rules Governing Issuance of Mineral Leases, allowing leasing of geothermal resources in state lands. Such leases, pursuant to Rule 30, will issue only for lands in which the state retains a complete fee simple interest, owning both surface and mineral rights.

C. Characterization. The statute clearly places geothermal resources, whatever they are, under water law for purposes of regulation. The rule, however, places the resource under mineral leasing law.

D. Summary. The State of Utah has chosen not to define geothermal resources. Regulation of the development of drilling programs for the entire state will proceed under the authority of the Water Rights Division. Leasing regulations for State lands have been issued which appear to characterize the resource as a mineral. The legal impact of this characterization embodied in a rule is not clear.

Washington.

A. Definition: Exposition. The Washington statute, the Geothermal Resources Act of 1974, cited as ch. 79.76.010-900, in sec. 030 defines geothermal resources in a unique fashion:

> "Geothermal resources" means only that natural heat energy of the earth from which it is technologically practical to produce electricity commercially and the medium by which such heat energy is extracted from the earth, including liquids or gases, as well as any minerals contained in any natural or injected fluids, brines and associated gas, but excluding oil, hydrocarbon gas and other hydrocarbon substances.

B. Definition: Analysis. This definition obviously ties the nature of the resource to one particular type of usage. Furthermore, it ties this usage to situations that are technically and economically feasible. This position is reiterated in sec. 79.76.100, which provides that "(1) [when] [i]t is not technologically practical to . . . produce electricity . . . and, (2) [when] [u]sable minerals cannot be derived . . . jurisdiction over the well may be transferred . . . [and] the well shall no longer be subject to the provisions of this chapter but shall be subject to . . . laws . . . relating to . . . ground water." Low temperature uses for greenhouses and similar situations are covered by water law according to sec. 79.76.060. The legal model also includes the heat transfer mediums and contaminants of same excepting oil, natural gas, and other hydrocarbon substances.

C. Characterization. The act at sec. 79.76.040 explicitly characterizes the resource as *sui generis*, being neither mineral nor water.

D. Summary. The legal model applies to public and private lands. The resource is restricted to use for electricity and incident mineral production. It includes the heat transfer medium and some contaminants. The resource is characterized as *sui generis*.

Wyoming.

A. Definition: Exposition. Wyoming, in sec. 41-121(b) of the 1973 Supplement, enacted a statute placing geothermal resources under the Wyoming Ground Water Act, Article 9 - Underground Water. This section now provides that "'Underground water' means any water, including hot water and geothermal steam, under the surface of the land" (emphasis in original). This section defines the resource for purposes of obtaining rights to use and exploit such hot water and steam.

B. Definition: Analysis. This definition firmly places geothermal resources, low and high temperature, within the scope of Wyoming water law. The definition fails to describe any structure for the geothermal energy resource itself, except perhaps by default. It would appear that in Wyoming geothermal resources are only the heat transfer fluids. No mention is made of byproducts, or of the heat or other energy itself.

C. Characterization. The geothermal resource is clearly characterized as water for purposes of ownership in Wyoming. The state owns all of the waters, surface and subsurface, under the constitution. This ownership is codified at section 41-2 (1957) of the Wyoming Statutes.

D. Summary. Geothermal resources are defined as water only. This definition therefore includes the heat transfer mediums and no other feature of the physical systems. The resource can be appropriated pursuant to Wyoming water law for private use, though it is the property of the state in the first instance.

Federal Statutes.

A. Definition: Exposition. The full text of the definition section of the Geothermal Steam Act of 1970 is set out to facilitate discussion of its model of geothermal systems.

Sec. 1001 Definitions
. . .(c) "geothermal steam and associated geothermal resources" means
(i) all products of geothermal processes, embracing indigenous steam, hot water and hot brines;
(ii) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations;
(iii) heat or other associated energy found in geothermal formation; and
(iv) any byproduct derived from them;
(d) "byproduct" means any mineral or minerals (exclusive of oil, hydrocarbon gas, and helium) which are found in solution or in association with geothermal steam and which have a value of less than 75 per centum of the value of the geothermal steam or are not, because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by themselves; [82]

B. Definition: Analysis. On its face, sec. (c)(i) is far too inclusive since all products of "geothermal processes" come in as members of the class "geothermal steam and associated resources." This class would include coal, oil and natural gas, most minerals, and other entities which are the results of the geothermal processes enumerated in the section on the physical model. This reading is not only too inclusive, but it would lead to internal contradictions as compared to sec. (d) where "byproducts" are defined to exclude oil and natural gas.

The law has its own peculiar rules for interpreting ambiguous and even sometimes perfectly clear language. The intent of the statute is controlling, and courts will rewrite or interpret the language so as to give effect to the intention [83]. The clear legislative intent of the Steam Act was to comprehend the known types of geothermal systems in 1970. These are enumerated in sec. (c)(i) as steam, hot water, and hot brine systems; probably roughly corresponding to The Geysers in California, to Cerro Prieto in Mexico, and to the Imperial Valley in California. Since the class denominated by sec. (c)(i) has thus been limited to these three types of systems, it is apparent that geopressured-geothermal systems are not included. Indeed, Barnea's testimony [84] makes it clear that this particular system was not understood until roughly two years after the Steam Act was passed.

It is important to note that thus far the legal model has discussed only the heat transfer mediums, and has limited this discussion to the class of fluids, ignoring the potential role of gases as heat exchange mediums. Sec. (c)(ii) expands this discussion to include those heat exchange mediums artificially introduced into the system.

Section (d) of the act discusses contaminants of the heat exchanger transfer mediums. It does so in a fashion that is analogous to the concept of available energy that is part of the notion of entropy. A byproduct of a geothermal resource is part of that resource only if it is not worth more than three fourths of the value of the geothermal steam, or if it is not worth extracting for itself without regard to the heat content of the fluid which contains it. This part of the legal model is avowedly economic in nature, but this is not troublesome since definitions of mineral deposits of all sorts are also economic [85].

What is troublesome are the provisions of a later section of the Steam Act, sec. 1008, which provides that:

> If the production, use, or conversion of geothermal steam is susceptible of producing a valuable byproduct or byproducts, including commercially demineralized water[,] for beneficial uses in accordance with applicable State water laws, the Secretary shall require substantial beneficial production or use thereof unless, in individual circumstances he modifies or waives this requirement in the interest of conservation of natural resources or for other reasons satisfactory to him. However, the production or use of such byproducts shall be subject to the rights of the holders of preexisting leases, claims, or permits covering the same land or the same minerals, if any.

The impact of this section is to make "Byproducts" were, under sec. subject to preexisting mineral leases. "Byproducts" were, under sec. 1001(d) part of the geothermal resource and subject to development under geothermal leases issued pursuant to this act. (Sec. 1022(b) provides that "[r]ights to develop and utilize geothermal steam and associated geothermal resources underlying lands owned by the United States may be acquired solely in accordance with the provisions of this chapter." See also secs. 1002, 1014(c), and 1020(b). This provision would seem to have the effect of making "byproducts" subject to two different legal classifications. This confusion is not helped by the provisions which recite that the byproducts covered herein must be "valuable," an adjective left undefined in spite of the values carefully laid out in the definition of "byproducts" in sec. 1001(d).

Only in sec. (c)(iii) does the Steam Act speak directly to the feature of geothermal systems that makes them valuable as sources of energy, namely their enthalpy or heat content. This section also includes pressure under the heading "associated energy." The troublesome part of this section is that it limits the energy covered by the act to "geothermal formations," without defining what these formations are. The courts would very possibly interpret the meaning of "geothermal formation" by reference to those geothermal systems that product steam, hot water, or hot brines. This circularity of referrent from sec. (iii) to sec. (i) leads to the exclusion of hot rock massifs as well as geopressured-geothermal reservoirs since neither was comprehended by the legislative intent expressed in sec. (i).

C. Characterization. The Steam Act does not explicitly characterize the resource. However, sec. 1020(b) provides for the attorney general to institute a judicial proceeding to quiet title of the United States to mineral reservation lands for purposes of geothermal leasing and ownership [86]. (A quiet title proceeding resolves two conflicting claims to ownership rights in property.) This section clearly implies that the resource is a mineral.

D. Summary. The legal model applies to federal lands. It describes heat and other energy in specific formations, i.e., steam, hot water, hot brine; and heat transfer mediums as enumerated above. These entities, and possibly the contaminants of the heat transfer mediums under certain economic conditions, are geothermal resources for purposes of the Steam Act. Apparently omitted are those other geothermal systems, the hot rock massifs and the geopressured reservoirs [87]. The act fails to characterize the resource but it implies that the resources are minerals. In sum, the act fails to state exactly what a geothermal energy system is. It only lists some, but not all, of the attributes of such systems as recognized in 1970.

Case Law: UNION OIL.

The State of California acting by and through the State Lands Commission submitted an amicus curiae brief in the case of United States v. Union Oil Co., et al. No. 74-1574 U.S. Ct. of App. for the 9th Circuit [88]. The state defined geothermal resources as

> "compound resources, necessarily consisting of magma (molten rock), frozen rock to conduct the heat from the magma upward, and often including silica, calcium carbonate, or other impermeable mineral deposits, and sometimes (but not always) occurring with heated, toxic, noxious water or steam of high mineral content under great pressure, existing below the surface of the earth in unique configurations" [89].

This declaration conveys an interesting legal model. It reaches deeper, in material terms, than any of the statutory definitions, because it begins the definition with the geologic source of geothermal processes and formations--the interior heat of the globe. It even discusses the mechanisms of mass transfer of igneous material from the interior to the near subsurface when it speaks of frozen rock (i.e., igneous material). It identifies certain associated mineral deposits. The model concludes by clearly indicating that the heat transfer mediums and associated contaminants are not a necessary part of the resource though they may occur with it.

This definition introduces the notion of a two part heat and mass transfer. The first stage involves the movement of igneous matter from the interior to the near subsurface, and the second stage involves (only sometimes) the additional movement of heat transfer fluids from this mass of igneous matter to the surface. The definition clearly comprehends the possibility of injecting "working" fluids by not tying the resource in any necessary way to naturally occurring heat transfer fluids. It also clearly comprehends both hot rock massifs and geopressured fluids. The definition identifies certain subsurface mineral deposits as often associated with the geothermal resource. These heat transfer fluids and their contaminants, i.e., toxic and noxious compounds, and minerals, are also part of the resource.

This definition is only offered in a brief by a party whose interests are aligned with one of the parties to the litigation. It is not part of the opinion of the United States Court of Appeals in this case which opinion still had not been issued by December of 1975. The memorandum of decision of the district court in this case before appeal [90] does recite a definition of the resource, at least of a part thereof.

The district court first establishes that the resource will be defined for purposes of the quiet title action under the mineral reservation section of the Stock Act [91]. This procedure means that the "definition" will consist in the ruling that geothermal resources are, or are not, minerals. The court begins by arguing that the United States must mean that "the main constituent of geothermal energy, namely the superheated water (or steam) was a 'mineral' within the contemplation of Congress and the meaning of the mineral reservation in sec. 9" [92]. The court then argues that tests based on usage [93] and case law [94] and the expressed opinions of the Solicitor's Office of the Department of Interior [95] all indicate that water is not a mineral. The court finds on these bases that geothermal resources are not minerals under the Stock Act mineral reservation.

It is important to note that this "definition" states only that the resource, for purposes of the act in question, is not a mineral. The court in passing, does quote the definition from the Steam Act and a more succinct definition issuing from the State of California Resources Agency. Geothermal energy is "the natural heat of the earth which can be extracted in the form of hot water and/or water vapor (steam)" [96]. The court, however, in accepting the opinion of the solicitor's office as to the nature of the geothermal steam must, as a matter of logic, accept the definition of the resource upon which this opinion bases the classification. The solicitor recites that "Geothermal steam is essentially just subterranean water heated to a high temperature" [97]. This is, of course, an extremely simple model. It is, however, a logically necessary part of the opinion, unlike the reference to the Steam Act which appears earlier in the recitation. The court may therefore be taken as adopting this definition.

Case Law: REICH.

Arthur E. Reich, a case before the tax court (an administrative body), argued for application of the depletion allowance for geothermal steam production in The Geysers fields [98]. The tax court ruled in petitioner's favor on depletion and on the issue of intangible drilling costs [99]. This ruling was later upheld by the U.S. Court of Appeals for the 9th Circuit [100]. The case sets out a lengthy explanation and definition of geothermal resources [101].

> The center of the earth consists of a solid iron core surrounded by a molten iron outer core with approximate temperatures of 7000 degrees Fahrenheit. From this molten iron core located thousands of miles below the surface of the earth, the temperature decreases rather regularly toward the surface of the earth where at a depth of some 120 miles the temperatures approximate 3000 degrees Fahrenheit. While the earth thus contains an enormous supply of heat at depth, this supply is inaccessible and cannot be utilized from the surface.
>
> Most of the earth's mantle at a depth below 120 miles is at its melting temperature. From time to time small parts of the mantle melt, or bodies of melt accumulate, and move upward towards the surface. This molten rock, or magma, moving up from depth can pour out of the earth's surface as lava flow or volcanic activity or can freeze off in the crust of the earth near the surface.
>
> In order to have a geothermal system it is necessary not only to have a penetration of magma near the surface of the earth but also to have above this heat source a zone of fractured rock containing a supply of water. Heat from the freezing magma is transmitted upward through a zone of essentially solid rock to the zone of fractured rock by conduction, an extremely slow process.
>
> The heat source at The Geysers consists of such a body of magma which penetrated close to the surface of the earth and then commenced to freeze. Heat over a period of many years was transmitted upward by conduction through a solid layer of rock to heat the fractured rock containing the supply of water.
>
> The water contained in the zone of fractured rock is meteoric in origin. The steam zones at the Geysers are physically separated from the magma below, from the surrounding areas containing ground water under normal hydrostatic pressure, and from the surface of the earth by impermeable zones. The impermeable boundaries were caused by the filling of fractures and fissures in the following manner: The heat from the magma was conducted upward to the zone of fractured rock bearing meteoric water, and as the water became heated, a convective system was generated. In this convective

> system, the hot water and steam flowed upward and outward while cold water moved into the now heated fractured rock, and in turn, became heated and flowed upward and outward. The hot water and steam caused dissolution of silica from the rocks and the silica was borne upward and outward by the hot water and steam until colder regions were reached where the silica was deposited. The cold water moving into the area of heated rock carried calcium carbonate which was deposited as the water heated. This convective system gradually built a tight impermeable seal around the area of heated fractured rock by virtue of the deposition of silica and calcium carbonate in, and thus sealing, the fractures in the rocks surrounding the central area.
>
> The isolation of the central area by a zone of impermeable rock has resulted in formation of a sealed off, isolated, irregularly shaped reservoir of steam with relatively uniform internal pressures differing significantly from the hydrostatic pressures of the normal ground water environment outside the reservoir.

It must be understood that all of the quoted material consists in a statement of fact and not a ruling on the definition of geothermal resources. The administrative tax court is here merely reiterating the physical facts as it is acquainted with them by virtue of the declarations of fact as found in the arguments of the opposing parties, or by virtue of its own research or knowledge. The administrative tax court in this case <u>does</u> explicitly rule, at a later point, on the nature of the geothermal resources in question here, namely steam. But the ruling does not "define" the entire system; it only categorizes steam itself [102].

The court in <u>Reich</u> refuses to accept an argument by the Internal Revenue Service that

> the commercial product of the wells is the internal heat of the earth . . . [Respondent] begins with the premise that steam is nothing more than . . . heat and water . . . [Respondent] points out that at the The Geysers electrical generating plants the water in the steam is discarded after the steam is used to turn the turbines . . . [Respondent] concludes that of the two elements in steam, only the heat is commercially useful because the water is thrown away. Thus . . . the water serves only as a conductor to carry the earth heat to the turbines.
>
> [The court does] not agree . . . For purposes of the commercial enterprise at The Geysers, steam is much more than heat and water. It is heat and water combined in a way that results in tremendous pressure. And it is the pressure of the steam which drives the turbines. Heat alone would not drive them. <u>It follows that the commercial product of the wells at The Geysers is steam, not heat</u> [103].

The court follows this ruling with a ruling that "steam is a 'gas' as that term is used in sec. 611(a) and 613(b)(1)" [104]. The statutes referred to are the Allowance of Deduction for Depletion and Percentage Depletion sections of the Internal Revenue Codes. The definition argues bad physics. Certainly it is the pressure drop across the turbine that is transformed into usable mechanical rotational energy. But this pressure itself is the result of the heat content or enthalpy of the steam or water vapor in the particular environment of sealed subterranean reservoirs. The heat content of the steam could be extracted by running it through a heat exchanger with a lighter weight working fluid to absorb the heat. This system, a binary working system, transfers the heat of the primary fluid to a secondary working fluid, creating resultant pressure in the secondary fluid. This secondary fluid would then expand through a turbine, producing a drop in pressure and resultant mechanical work [105]. The heat content of the steam could also be extracted by means of thermoelectric converters, or by physio-thermo-chemical means. All of these processes indicate that the energy which the geothermal system expresses in the steam is heat energy.

The overall legal model in Reich can be taken to consist in the description contained in the statement of facts and the conclusions of law that for geothermal steam wells in The Geysers, geothermal steam is a gas for purposes of the Internal Revenue Code. This definition is legally complex, since part of it consists of "dicta", though these dicta are necessary for interpretation of the opinion, and part consists of "conclusions of law" upon which the decision in the case turns. It describes the magmatic heat source, the mass transfers of igneous material to the near subsurface, the associated minerals, the occasional heat transfer fluids and their contaminants, and the legal status of the available steam, in these dry steam reservoirs, as gas for certain purposes. It applies to The Geysers or very similar fact situations.

Case Law: PARIANI.

Pariani, et al. v. State of California, et al. is a summary judgment action to quiet title in lands which plaintiff's predecessors had received under patents from the state and which were subject to a mineral reservation [106]. Plaintiffs had a lease agreement with various companies producing geothermal steam and hot water from the said leases, which companies also had lease agreements with the state under the mineral reservation [107].

Plaintiffs claim that geothermal resources are heat and water, and not minerals. They do not advance a detailed definition of the resource, but rather distinguish the resource from mineral deposits [108]. Defendants here reiterate the definition employed by the state in Union Oil [109]. Since the argument in the case concerns a mineral reservation, the state concentrates on demonstrating that geothermal resources are part of the mineral estate.

The court, in a ruling in May 1974, rejects both parties' motions for summary judgment. This ruling recognizes that there are matters of disputed fact which need to be resolved in a full-fledged trial. Even though this case carries no definitive court ruling on the nature of the resource, it is still instructive with regard to the legal model.

The influence of the legal setting is decisive. This is no scientific advancement of hypothesis and experimentation to prove or disprove the model. It is an action to determine whether or not the resource is a "mineral" for purposes of a mineral reservation in a land patent. Pariani argues that the geothermal resources are water, because the water rights are part of the surface estate. Because the state retains the mineral estate on the lands, the state argues that the resources are minerals, or at least attributes of minerals.

RECOMMENDATIONS

> [A] correct definition or characterization of geothermal resources is . . . complicated.
>
> Amicus at pg. 17

A legal definition is suggested herein that corresponds to physical characterizations of the various sorts of recognized geothermal systems. This definition would be suitable, in the first instance, for incorporation into a statutory format. It would also be suitable for judicial use in resolution of disputes arising out of the character of the geothermal systems.

Geothermal Energy Resources

1. Shall include dry and wet steam systems, hot water and hot brine systems, geopressured systems, hot rock massif systems, magma systems, and other unspecified natural systems displaying rates of magmatic heat flow greater than normal thermal gradient for that area, and which are due to crustal thinning, igneous intrusion, distortion of the lithosphere, or other natural heat-producing mechanisms; and

2. The enumerated geothermal energy resource systems are characterized as follows [110]:

   A) (1) Dry and wet steam systems consist in magmatic heat, abnormally large rates of heat flow, zones of heat conduction, boiling water, dry and wet steam, geologic strata to conduct water into the system, relatively impermeable overlying geologic strata which confine the system, hydrothermal convection; and

   (2) Such systems may include unspecified amounts of associated gases, unspecified amounts of solute minerals in the liquid phase, if any; and

   (3) The energy expressed in such systems consists in both heat and pressure; and

   (4) The dry and wet steam serves as the secondary heat transfer mediums.

   B) (1) Hot water and hot brine systems consist in magmatic heat, abnormally large rates of heat flow, zones of heat conduction, boiling and overpressured waters, geologic strata to conduct water into the system, hydrothermal convection; and

(2) Such systems may include unspecified amounts of associated gases and solute minerals in various concentrations, while concentrations and types of minerals chiefly distinguish water from brine systems; and

(3) The energy expressed in such systems consists in both heat and pressure; and

(4) The water and brines serve as the secondary heat transfer mediums.

C) (1) Geopressured systems consist in magmatic heat, high heat content of fluids within the reservoir, geopressured aquifers, water, relatively impermeable geologic strata which confine the system, growth faults; and

(2) Such systems may include unspecified amounts of associated gases, and unspecified amounts of solute minerals; and

(3) The energy expressed by the system consists in both heat and pressure; and

(4) The water and gases serve as the heat transfer mediums.

D) (1) Hot rock massifs consist in magmatic heat, high heat content of low porosity rock in the near subsurface; and

(2) Such systems require artificial introduction of heat transfer mediums; and

(3) The energy expressed by the system consists in heat and pressure, if any, induced in the working fluid; and

(4) Water, or light-molecule working fluids, or gas can serve as heat transfer mediums.

E) (1) Magma systems consist in magmatic heat, liquid or near liquid rock at temperatures ranging from 600 to 1500 degrees Centigrade; and

(2) Such systems require artificial introduction of heat transfer mediums; and

(3) The energy expressed by the system consists in heat, and resultant pressure, if any, induced in the working medium; and

(4) Heat transfer mediums are as yet unspecified.

The detailed definition of geothermal energy resources set out herein may by substantially condensed and still preserve the structural validity derived from the scientific characterization.

> GEOTHERMAL ENERGY RESOURCES ARE AND INCLUDE ANY AND ALL GEOLOGIC STRUCTURES, SYSTEMS, OR CONFIGURATIONS WHICH POSSESS LARGE AMOUNTS OF HEAT ENERGY AT TEMPERATURES SIGNIFICANTLY HIGHER THAN ORDINARY THERMAL GRADIENT IN SURROUNDING GEOLOGIC STRUCTURES; AND ARE SO SITUATED THAT THE ENERGY OF THE SYSTEM IS AVAILABLE TO DO WORK OR PROVIDE HEAT; AND WHICH MAY INVOLVE COMPLEX THERMAL CONDUCTION/CONVECTION SYSTEMS WHICH CONTAIN NATURAL OR ARTIFICIALLY INTRODUCED HEAT TRANSFER MEDIUMS; AND WHICH MEDIUMS MAY CONTAIN ASSOCIATED GASES AND SOLUTE MINERALS; AND WHICH EXPRESS ENERGY AS HEAT AND/OR PRESSURE.

The highly compressed character of this definition raises the distinct possibility that judicial readings of the statue could construe the definition in a fashion contrary to the policy intentions of the enacting legislature. This possibility strongly suggests that the definition should be supplemented by a clear policy statement that the definition means to comprehend all presently recognized geothermal systems and any newly recognized ones which share the same characteristics.

The policy statement should go on to indicate that the definition means to encompass only those systems that represent available heat energy at higher levels than surrounding thermal gradients [111]. The definition is also meant to include all of the fluids, vapors, gases, or solids which function as heat transfer mediums, and any minerals or gases which are in solution or are associated with these mediums.

These statutes do not make any recommendations with regard to the classification of the resource. They do make it clear that the entire system must be considered and that various commodities play different roles within these geothermal systems than they do elsewhere. Such a systemic definition will have the laudable effect of making it difficult blindly to place the geothermal resource into a traditional category by reference to only one part of the actual physical system.

The policy issues of classification for purpose of ownership will be taken up in the next section. It should be noted that the classification of the resource might vary according to the field of law or polity involved. What makes fine policy sense for a taxation problem like Reich probably will not make the same sense as a regulatory principle by an environmental agency.

LEGAL SCHOLARSHIP

OWNERSHIP

Ownership.

SUMMARY

The geothermal statutes of Texas and Louisiana apply only to leasing of state lands and regulation of private development. They do not apply to private ownership. Even if the courts were to use the definition contained in the statutes for the question of ownership, it does not appear that solute natural gas would always be part of the resource in Texas, or that it would ever be part of the resource in Louisiana.

Ownership analysis of the geothermal resource based on the systemic description contained in the recommended legal models places these resources in the surface estate. Analysis based on the component parts of the resource system places the fluids in the surface estate and the natural gas in the mineral estate. The lack of any clear characterization or declaration on ownership can lead to dual ownership. This situation can be resolved by means of an accounting as between the cotenants in the resource.

It is recommended that the states incorporate into the statutes a declaration of both the character and ownership of geothermal resources. It is recommended that in the alternative the state provide a certificate of primary purpose to establish a rebuttable presumption of absolute ownership of the resource in the producer of same. It is also recommended that logical inconsistencies in the statutory definitions which would have the effect of excluding solute natural gas be corrected.

INTRODUCTION

Legal theories of ownership in America derive from ancient Norman and English jurisprudence, with its roots deep in feudal systems of complex social obligations and relationships. The basic concept of ownership is the fee simple absolute, the characteristics of which were expressed in Latin as "cujus est solum, ejust est usque ad coelum et ad inferos." The fee simple owner owns from the sky to the depths, without limit [112]. Modern case law has somewhat abridged the rights of ownership in the air space above the property, but has done little to modify the rule with regard to ownership of the subsurface [113], at least concerning stationary entities such as ore deposits.

This absolute ownership of the land from the surface down to the center of the earth can be separated into two legal entities called the surface and mineral estates. The fee owner can sell to another person the legal right to use certain features of the subsurface, thus creating two estates in that piece of land, surface and mineral. These legal rights constitute a more or less limited form of ownership that allows mineral estate owners to explore, develop, produce, and sell certain commodities found underground. The relationships possible between these two estates in land are extremely complex and arcane and are more properly the subject of legal treatises or texts.

The net effect of these legal categories is that often it is more important to know <u>whose it is</u>, than to know <u>what it is</u>. Indeed the answer to the former question is often proposed as the answer to the latter. Such issues are, however, critically important to potential investors in geothermal leases or sales. This classification process is especially important for newly recognized and largely uncategorized resources such as geopressured aquifers.

Ownership questions are further complicated by the <u>noncommodity</u> nature of geothermal power. The migratory nature of oil and gas has caused legal dilemmas and straining after gnats for many years, but at least these <u>substances</u> can be separated from the earth and sold [114]. In the case of geothermal deposits, energy itself is the salient feature of such resources. Gases, minerals, and heat transfer mediums are produced during the process of gaining access to this energy, but they are incidental to the real value [115]. Traditional legal doctrines, such as the Rule of Capture and the Theory of Ownership in Place, all become complicated in the extreme when applied without careful analysis to this new resource [116].

Some authorities argue that theories of ownership will prove irrelevant.

> Of what usefulness then are the theories of ownership of oil and gas which have been adopted in the various states? . . . [T]heories, such as qualified ownership of the common source of supply and ownership of the exclusive right to drill and produce, have not helped in the case of oil and gas in analyzing legal problems and determining legal consequences. We can expect even less from theories of ownership in the case of geothermal resources [117].

Indications that this pessimistic position may not be warranted can be found in litigation which has developed since the article was written. The parties and the court in Union Oil spend much effort in attempts to show that geothermal steam belongs in or does not belong in the mineral estate. Pariani, a related action in state court, argues precisely the same issues with regard to a reservation of the mineral estate under state land grants. The animal-vegetable-mineral distinction made in these court cases is closely paralleled by the following passage from Alice in Wonderland:

> "Very true;" said the Duchess: "flamingoes and mustard both bite. And the moral of that is--'Birds of a feather flock together.'"
>
> "Only mustard isn't a bird," Alice remarked.
>
> "Right, as usual," said the Duchess: "what a clear way you have of putting things!"
>
> "It's a mineral, I think," said Alice.
>
> "Of course it is," said the Duchess, who seemed ready to agree to everything that Alice said; "there's a large mustard-mine near here. And the moral of that is--'The more there is of mine, the less there is of yours.'"
>
> "Oh, I know!" exclaimed Alice, who had not attended to this last remark. "It's a vegetable. It doesn't look like one, but it is."

"I quite agree with you," said the Duchess; "and the moral of that is--'Be what you would seem to be'--or, if you'd like it put more simply--'Never imagine yourself not to be otherwise than what it might appear to others that what you were or might have been was not otherwise than what you had been would have appeared to them to be otherwise.'"

"I think I should understand that better," Alice said very politely, "if I had it written down: but I can't quite follow it as you say it."

"That's nothing to what I could say if I chose," the Duchess replied, in a pleased tone.

Lewis Carroll, Alice in Wonderland
(Steadman edition, 1973) ch.9, at 79.

In both the cases mentioned, the moral of the arguments seems to be, "The more there is of mine, the less there is of yours." Perhaps this environment is a necessary one for cases disputing ownership and attempting to fit the resource into one or the other of the recognized estates.

Statutes as well as case law may articulate a characterization of the resource and on occasion may simply declare to the real issue by defining ownership [118].

By and large, both case law and statutes adhere to traditional analysis based on characterization and consequent ownership under the different estates in land. This section of the report addresses the threshold issue of characterization. The resource is examined under the definitions contained in the Geothermal Resources Act of 1975 and in terms of its constituent parts, according to case law and statutes applicable to the different entities. Characterization and ownership are submitted to a policy analysis.

STATUTORY PROVISIONS

Neither Texas nor Louisiana makes any explicit declarations concerning characterization of the resource or ownership in the geothermal statutes passed during the summer of 1975 [119]. Indications that the two states may feel quite differently about the resource can be found in the structure of the Texas act as compared to provisions found in the Louisiana act which subordinate geothermal leases to leases for oil, gas, or minerals [120]. The impact of this subordination is the clear indication that Louisiana does not regard geothermal resources as minerals. Texas, however, chooses to place regulation of the resource in the hands of the traditional state agencies for regulation of oil and gas and leasing of same on state lands, the Railroad Commission and the Land Commissioner. This choice may reflect the belief that geothermal resources are closely related to and part of the class of minerals. Texas offers no explicit hint beyond this [121].

There is a further problem beyond the lack of characterization. Both the Texas and Louisiana statutes are designed to empower the state to <u>lease state lands</u> for geothermal development and to <u>regulate drilling</u> on public and on private lands. The definition of the resource in terms of ownership is directly applicable to leases of the <u>state lands</u> but <u>not</u> directly applicable to leases of <u>private land</u> [122].

However, even if the definitions contained in the acts are held to apply to private transactions, a serious question would exist about the potential retroactive impact of such a ruling. In Texas, case law holds that retroactive laws are <u>not</u> considered constitutional [123] when they operate to impair vested rights. Rights under a lease are just such vested rights. Texas has also held that a retroactive law is unconstitutional if it takes away vested rights, creates new obligations, imposes new duties, or adopts new liabilities in respect to past transactions [124]. Such a ruling would also be open to attack under the constitutional prohibition against impairment of contracts [125].

The net effect of these considerations is that the question of whether or not existing oil and gas leases have vested any rights is open to dispute and litigation. The Texas and Louisiana statutes, even if held to apply to private transactions for purposes of defining the resource and determining ownership, could not apply to leases or sales already executed at the time of enactment.

There remains the question of the impact of the definition on private transactions through the mechanism of the statewide regulation of the resource under the Railroad Commission. Such regulatory authority has been used by other regulatory agencies to affect ownership interests [126]. A recent Texas case has held that the Railroad Commission specifically does not have authority to determine ownership of oil and gas in the process of regulating these resources [127]. This same principle would surely be applied to the geothermal resource. It seems reasonable to believe that the Railroad Commission will not be able to impose the definition contained in the statute on private property transactions concerning leases for geothermal resources.

Some of the states with geothermal legislation have chosen to characterize the resource explicitly. Idaho and others have declared the resource to be sui generis [128]. This characterization means that it is not a mineral, nor is it water. Hawaii has declared the resource to be a mineral [129]. The remaining states have implied a position on the characterization of the resource by virtue of various passages within the legislation that lump the resource with minerals or water, often both in the same statute [130]. In addition, some states, Wyoming among them, have statutory provisions vesting ownership of the resource in the state.

ANALYSIS

Introduction.

The relationship of the characterization in legislation and case law to the question of ownership of the resource by private parties is extremely complex. Characterization of an entity as a mineral may place it in the mineral estate, assuming that no valid reservations of the mineral entity took place in the chain of title. Characterization of an entity as water will not automatically move the resource into the control of the surface estate, the traditional owner of surface and subsurface waters. The mineral estate owner has the right to use the attributes of the surface estate in a reasonable fashion for the development of the mineral estate [131]. This use may amount to ownership in point of fact.

In both Texas and Louisiana the statutes covering geothermal resources are silent with regard to characterization and with regard to ownership in private lands. Case law will serve as the source of authority in the absence of statutes and will be applied by judicial bodies in resolving disputes over ownership. Several basic approaches can be used to analyze the ownership complex. The courts can deal with the resource as a systemic whole, according to a legal model more or less similar to that proposed in the Recommendations section of Resource Definition; or the courts can deal with the various component parts of the resource. In the former case they will be marking new territory and will be required to undertake a serious policy inquiry more properly germane to the legislature [132]. If the courts proceed with the latter approach, they can choose from among the many components of the resource and subsume the whole resource under that component in order to achieve a particular choice in ownership. Neither technique "reveals" the law, as Blackstone believed [133].

Systemic.

If the courts were to approach an ownership analysis from the point of view of a systemically defined resource, they would not be restricted to the definition found in the Texas act, nor to any legal definition as such. Rather, they would be concerned with the technical character of the resource. The administrative tax court in Reich offers an excellent example of this latitude.

In the case of Texas and Louisiana the courts would have to select the definition most germane to geopressured-geothermal resources. (These resources are discussed in detail in the first part of the Physical Model section of Resource Definition.) Geopressured-geothermal resources are composed of overpressured aquifers at moderate to great depth whose waters possess abnormally high temperatures. These waters are presumed to be saturated with natural gas in solution and may have moderately high mineral content. In terms of geologic structure, such aquifers are overlain by relatively impermeable strata and can only be made available for use by means of a well or wells [134].

This description makes it clear that geopressured-geothermal resources are not commodities in the same sense that oil and gas are. The hydrocarbons can be severed from the soil and shipped great distances to be used not only as fuels, but also as chemical feedstocks for manufacturing. The hot geopressured fluids are brought to the surface in order to extract the heat and pressure content, as well as the solute gas content [135]. The fluids themselves will be reinjected or disposed of on the surface according to the judgment of the environmental agencies of the respective states.

The resource consists in a particular configuration of geologic structure which contains heat and pressure energy as well as solute chemicals of various sorts in waters of antique origin. It is the energy contained in these systems that makes the resource so difficult to classify [136]. The proper line of inquiry into ownership should ask which estate in land should own the resource, and why. It should eschew the categorization of the resource under traditional labels [137].

What attributes distinguish the surface and mineral estates, beyond their simple physical situs?

> [Severing] the entire mineral estate from the surface estate . . . . leav[es] the owner of each with definite incidents of ownership enjoyable in distinctly different manners. The manner of enjoyment of the mineral estate is through extraction of valuable substances, and the enjoyment of the surface is through retention of such substances as are necessary for the use of the surface, and these respective modes of enjoyment must be considered in arriving at the proper subject matter for each estate . . .
>
> Applying this intention, the severance should be construed to sever from the surface all substances presently valuable in themselves, apart from the soil, whether their presence is known or not, and all substances which become valuable through development of the arts and sciences, and that nothing presently or prospectively valuable as extracted substances would be intended to be excluded from the mineral estate.
>
> . . . [S]ince its [i.e., oil and gas] retention is not necessary to the enjoyment of the surface estate, i.e. its removal does not deplete the soil for surface purposes, nor does its extraction destroy the surface nor remove subjacent support, oil and gas . . . . should . . . be considered to be within a general mineral grant . . . The only interference with the surface enjoyment is in the exersize of the right of access (emphasis added) [138].

This lengthy quotation was used by the State of California in Pariani not only to lay out the differences between the two estates, but also to provide the basis for an analogy to geothermal resources. The state cites numerous cases to demonstrate the reliance courts have placed on this article [139].

The distinction drawn between the estates is based on an implicit market economy environment. The mineral estate is an exploitive estate whose sole purpose for existence is to provide parties with property rights in substances which are valuable in a market economy. Thus, the mineral estate is enjoyed by extracting and selling more or less discrete entities which can be taken from the earth.

By contrast, the surface owner is restricted to agrarian uses, or other uses which are chiefly domestic. This restriction is chiefly visible in the reservation to the surface estate of subterranean waters usable for irrigation or domestic consumption [140].

Does this analysis prove useful when applied to geopressured-geothermal resources? The threshold problem under the assumption that the resource will be considered as a systemic whole is that it is not a substance. Geopressured-geothermal resources involve substances (i.e., water and natural gas, as well as mineral salts) and geologic strata in peculiar configurations. The resource, as a system, represents potential energy available to do work or provide heat.

Assuming, for the sake of argument that this hurdle can be passed, the next inquiry should focus on the notion of severance. Can the resource system be severed from the soil in the same fashion that oil and gas can be? It does not appear so. Oil and gas can both be withdrawn and sent great distances, and there be used in all of the same ways that it can be at the point of severance from the soil. Geothermal resources cannot be removed from the wellhead any substantial distance before the heat content of the fluids decreases to a point where no useful work can be extracted from the thermal differential.

The inquiry into severance highlights a critical distinction in the notion of value. What is the value of oil, gas, coal, silver, gold, and other common mineral substances? It consists in the physical/chemical characteristics of the substances. The complex hydrocarbon molecules of oil, gas, and coal make these substances valuable. The hydrocarbons readily oxidize and give up great amounts of heat in doing so. They also will accept various ions and can be easily made into polymers, or otherwise manipulated as a feedstock for the manufacture of different compounds. Silver and gold and other metallic minerals are valuable because the properties of their atomic structure, such as ductility, resistance to corrosion, conductivity, and so forth are useful in commerce.

Geothermal fluids are valuable for quite different reasons. These fluids are rather ordinary substances, largely water, which are in a certain condition because they are part of a geothermal system which moves or traps large amounts of magmatic heat as compared to neighboring geologic structures. The value, for purposes of commerce, lies in the work which may be extracted from the condition of the fluids, rather than in the fluids themselves.

An analogy to the value of geothermal fluids exists in the surface structures--such as high valleys and escarpments--which, when combined with available water as a working fluid, can take advantage of gravity to generate electricity in a hydroelectric facility such as a dam. Here the potential energy of the fluids is the vertical distance through which specific volumes of fluid per unit time can be moved. The hydrological head which supplies the motive force to turn the turbines and generators is potential energy in the same sense that the thermal "head" in geopressured fluids is the potential energy of those systems.

Assuming further that geopressured-geothermal resources can be severed and have the same sort of commercial value as minerals generally, there still remains the significant question of the impact on the surface estate of exploitation of this resource. One of the criteria previously articulated is that mineral estate enjoyment does not unduly interfere with surface enjoyment. Oil and gas can be readily severed from the soil without greatly encumbering the surface. The mineral estate has an easement or right to use the surface in a reasonable fashion. However, no mineral estate would comprehend complex processing plants on the surface as part of the implied easement of reasonable use.

Geothermal resources require precisely such complex processing plants on the surface, usually electrical generators, to convert the latent heat of the fluids into commercial commodities such as electricity. Even direct uses, such as system heating, will require surface facilities above and beyond the wellhead and gathering equipment. These requirements impose a much greater burden on the surface owner unprepared for such use than any oil and gas easement could.

It appears that geopressured-geothermal resources are highly dissimilar to minerals which are ordinarily part of the mineral estate. They can not be severed and transported in the same ways minerals can. They are not valued for the same reason. And the required use of the surface estate is significantly greater than any implied use available to oil and gas, and other mineral leaseholders [141].

Geopressured-geothermal resources do not fit the criteria proposed as attributes of the mineral estate. Nonetheless, the State of California in Pariani argued that "a natural and unavoidable attribute of all minerals at great depth . . . is . . . heat energy . . . . Said heat, in whatever form, is part and parcel of the minerals of which it is an attribute and therefore belongs to the owner of the mineral estate" [142].

The state is correct in asserting that heat energy is characteristic of all materials at depth [143]. The argument confuses materials with minerals. A mineral lease does not convey the soil itself, only those substances within the soil that are valuable in themselves [144]. Not all things under the surface are minerals. The heat inherent in materials at depth is an attribute of the soils and geologic structure. Geothermal heat is clearly an attribute of part of the surface estate (i.e., the soil) and is therefore itself part of this same estate.

This last distinction is a hybrid which begins to cross over into the traditional discussion based on the classification system of animal, vegetable, mineral. This road leads directly to Alice In Wonderland situations since the categories are largely manufactured post facto according to the result desired. The real purpose of inquiring into the distinction between the surface and mineral estates is to discover policy purposes for so distinguishing. The available legal criteria express a policy choice for free alienability of commodities and land in a market economy. They do not tell us why this should be so. Such an inquiry is probably beyond the scope of this work.

Nevertheless, application of the ordinary legal distinctions between the estates clearly demonstrates that geopressured-geothermal resources, and probably geothermal resources in general, are properly part of the surface estate. Are there other good and significant reasons why this conclusion should be supported? Perhaps the freely exersized right to sever the mineral estate is the chief argument in support of this conclusion. Many hundreds of thousands of mineral leases have been executed on property throughout the Gulf Coast area. These leases, by and large, did not contemplate any additional compensation to surface owners for rights to "extract" geothermal resources. If the resource were held to be part of the mineral estate under ordinary oil and gas leases, the present leaseholders would receive an enormous windfall benefit. The state would lose an opportunity to impose any sort of severance tax on the leases and consequently would lose potential revenue.

More importantly, the state would have lost the opportunity to make a policy decision concerning the disposition of the resource. Ownership of the resource by mineral owners is not a foregone conclusion. Nor is private ownership of the geopressured resources the only alternative. The state could claim the resources underlying all lands in the state, with the possible exception of the ancient land grants areas. Regardless of the merits of state ownership of the resource, that option would be effectively eliminated by any holding that the resource was part of the mineral estate.

There may be some good policy reasons not to place the geothermal resource within the surface estate. Texas has retained title to all or part of the minerals in nearly 8 million acres, of which 7.4 million acres are Relinquishment Act lands [145]. The Relinquishment Acts released some interest in the state's mineral rights to surface holders [146]. It might therefore be in the interests of the state for geothermal resources of all kinds to be within the mineral estate. They would be leasable and therefore a source of income [147].

This income, however is required by law and constitutional provision to be expended for the benefit of education [148]. On the other hand, the income from a severance tax on leases of surface rights in geothermal resources would yield funds which could be expended on other pressing matters. The decision is one which ought to be subject to definitive policy judgment by the legislatures of the respective states.

In addition, a close resemblance exists between exploration and exploitation technology for oil and gas, and that proposed for geothermal development in Texas and Louisiana. Gas wells have been routinely completed in and near the geopressured zones for some years. The techniques proposed for well drilling for geopressured-geothermal resources are standard practice, and the states have recognized this resemblance in their placement of regulatory authority with the agencies that regulate oil and gas.

However, resemblance in terms of development is not identity of resource. Good arguments for regulation are not necessarily good arguments for deciding questions of ownership. These matters are uniquely within the province of legislative authority and duty and ought to be decided on the basis of detailed policy analyses.

Component.

The courts can, as mentioned earlier, choose to analyze geothermal resources in terms of their component parts. In Union Oil and Pariani disputants and adjudicators both spent much time on characterizing the resource as one of its constituent parts. The court in Union Oil for instance, ruled that geothermal resources were water. This section analyzes the geopressured-geothermal resources according to the constituent parts. The geopressured resource is broken down, for this purpose, into water, heat, pressure, and solute minerals and analyzed without regard for the geothermal statutes [149].

Water: Surface and Subsurface. In Texas, surface and ground waters are treated according to different sets of rules. Surface waters are reserved to the state and held in trust for the people generally [150]. Their use is subject to two different sets of legal principles, riparian rights and appropriation under regulation [151]. Surface water users of flowing water must apply to the Texas Water Rights Commission for a permit granting the right to specific quantities of water from a definite source [152]. Riparian rights simply entitle landowners contiguous to a body of water to make reasonable use thereof [153]. Both of these sets of legal principles govern use only: the ownership remains in the state.

In contrast, the surface owner owns ground water as part of the surface estate [154]. In fact, this incident of surface ownership can be severed and sold [155], and the owner of this right in land can produce virtually unlimited amounts of water for commercial as well as domestic uses [156].

It seems clear that under Texas law, geothermal resources which were regarded simply as water (as the court in Union Oil so regarded them) could be used by the surface owner. Louisiana held a similar judicial standard of unlimited production of ground water by the surface estate until the enactment of LRS. 38:3091-3094. This statute now regulates production of ground waters in excess of 50,000 gallons per day. It also provides that no orders pursuant to the act will issue with respect to waters from strata producing oil or gas. Although the statute introduces uncertainty, it appears that if geothermal resources were regarded simply as water they could be used by the surface owner in Louisiana as well.

The recent case of Robinson v. Robbins Petroleum Corp. settles the question of the ownership of salt water in Texas [157]. The owner of the surface estate owns the subsurface salt water. This ruling would supplement the previous holdings on ownership of water and is applicable to geothermal fluids which would otherwise have been distinguishable from water by virtue of the solute minerals [158].

Heat and Pressure. Heat and pressure have proved to be highly elusive legal entities. Careful research has revealed numerous tort and contract cases which discuss heat and/or pressure as an incidental matter to the decision [159]. The only case law really focusing on the issue of heat and pressure is Reich, discussed in the Resource Definition section herein.

Under Reich the steam is characterized for tax purposes and not with regard to ownership, so that this ruling is little help. There does not appear to be any analysis of the incidents of ownership in these two forms of energy, in spite of the contentions of California in Pariani.

It appears that in Texas the surface owner would own the heat content of geopressured or geothermal fluids. The head inheres in an entity which is clearly part of the surface estate and is a characteristic of it. The right, which is part of the mineral estate, to use and dispose of such fluids is only the right to use the fluids to assist in production of the minerals, not the right to waste any valuable characteristic therof.

Solute Minerals. The ownership of solute minerals is a particularly knotty problem in the case of geopressured reservoirs. The waters of this resource are likely to contain significant amounts of solute natural gas and perhaps some economically significant minerals of other sorts. The natural gas, in the absence of any statute or case law defining ownership within the geopressured-geothermal system, is the property of the mineral estate owner in Texas. In Louisiana, where the rule is that no one owns minerals in place, leaseholders obtain only a right to produce the minerals, rather than an estate in land [160].

These interests give the mineral estate holder a claim to the solute natural gas contained in geopressured reservoirs. Gas wells produce natural gas from geopressured strata today in great quantities. The ownership interest of the mineral estate in the gas is in clear conflict with the ownership interest of the surface owner in the subsurface waters. This situation will be resolved, most probably, on the basis of accounting [161].

Mineral estate holders are, or course, entitled to a reasonable use of the surface in order to produce oil and gas [162]. Thus, the mineral estate owners could produce the geothermal fluids incident to producing the natural gas. The unresolved question concerns the measure to be used in accounting for the value of the geothermal fluids. This value can be computed with and without the worth of the fluids' heat energy for electrical production or process heat. A valuation that does not reflect the nature of the fluids as geothermal will probably deprive the surface owner of property without compensation. Texas law ordinarily does not require compensation for use of water by the mineral estate. However, it is clear that heat energy wasted by such production is an inherent and valuable feature of the water and is therefore an incident of the surface estate.

PROBLEM AREAS

The problem area of first importance is the lack of statutory guidance with regard to ownership of the resource. Both statutes speak to the resource only for purposes of leasing from state lands, and for purposes of regulation. This lack of statutory authority must be set in the context of geopressured reservoirs which contain natural gas in commercial quantities. This gas, in the absence of legislative declaration or judicial interpretation, is presently the property of the mineral estate owner, usually holders of oil and gas leases.

The lack of statutory declaration of ownership is further complicated by the fact that the definition employed in the statutes is also not binding on private parties. The courts may look to the statutory definition for guidance, but they are in no wise bound to it for purposes of adjudicating ownership disputes. There is likewise no legislative declaration on the character of the resource.

Systemic analysis of the resource may lead to the conclusion that the geothermal resources of the Gulf Coast properly belong to the surface estate. This decision, even though probably correct, produces accounting problems as between the surface and mineral holders. If the statutory definition is applied, the mineral estate holder has no claim to solute natural gas so long as it falls under the geothermal definition. In Texas, solute natural gas may or may not be part of the geothermal resource according to use made of the fluids at the surface. In Louisiana, solute natural gas does not appear to be part of the geothermal resource, largely because of the subordination of geothermal leases to mineral leases. The net effect of these complications is that it is extremely difficult to ascertain whether solute natural gas is or is not accountable to the mineral estate.

In the absence of a statutory declaration the courts are likely to find that the fluids are in the surface estate and the solute natural gas is in the mineral estate. Such a ruling, though highly likely, does not alleviate the accountability problem. The mineral owner must now account to the surface owner for the heat energy of the produced fluids, since such energy is an incident of the surface ownership of the fluids. What value should be placed on this energy is highly speculative and would be completely dependent on type of use, proximity to likely users, and so forth.

RECOMMENDATIONS

The following suggestions are options for meeting some of the problem areas which have been identified.

1. The legislatures of the respective states should make a clear declaration of the character and ownership of geothermal fluids, after conducting careful public analysis of the policy reasons for so assigning the resource.

2. The legislatures should provide by statute for a procedure for a certificate of primary purpose [163]. This certificate establishes a rebuttable presumption that the operator of a geothermal lease has absolute title to the geothermal resources which are produced. The impact of such a certificate is to allow the state to set some standards of resource definition and ownership with regard to lease transactions in the private sphere. It encourages statewide uniformity in these matters while avoiding the problems attendant on legislating private contractual rights.

3. Defects in drafting which tend to leave out part of the resource, such as solute natural gas, should be corrected. Louisiana should clarify its position with regard to geopressured resources in general, and Texas should clarify its position on byproducts.

4. Use of labels to settle disputes should be avoided. "Surface" and "mineral" are too often used as terms to preclude discussion of decisions already reached. However, if such labeling is deemed necessary, the states should label the resource as *sui generis*. This action would permit the necessary policy review.

LEGAL SCHOLARSHIP

MULTISTATE AND INTERNATIONAL RESERVOIRS

Multistate and International Reservoirs.

SUMMARY

This section identifies areas where potential geothermal resources of several types overlap the state boundaries of Texas, Louisiana, and New Mexico. In addition it identifies overlapping among the state offshore areas, the federal Outer Continental Shelf, and the offshore of Mexico. Jurisdictional differences are examined, with attention given to differences in definition, characterization, and scope of legislation.

The need for federal action is based on constitutional requirements with regard to interstate compacts and agreements, treaty powers, and provisions of the National Environmental Policy Act. Problems arise with nonuniform statutory provisions, differences in ownership under law, and burdens on interstate commerce.

The section recommends establishment of a study commission with representatives from all parties involved. The study commission should be followed by creation of a permanent Interstate Compact Commission on Geopressured and Other Geothermal Resources and by passage of uniform and reciprocal legislation. The federal governments of the United States and Mexico should be included on the commission. Intermediate steps should be taken by the states to provide for equitable resolution of potential conflicts.

INTRODUCTION

> The growing interdependence of regional interests calling for regional adjustments, has brought extensive use of compacts. A compact is more than a simple device for dealing with interests confined within a region. . . . [I]t is also a means of safeguarding the national interest.
>
> Mr. Justice Frankfurter
> Speaking in West Virginia ex rel. Dyer v. Sims
> 341 U.S. 22 (1951).

This section examines legal and administrative problems arising out of shared geothermal resources. It does not restrict itself solely to consideration of geopressured reservoirs, but considers as well the Trans-Pecos hot rock systems and hot water systems that Texas shares with New Mexico. (Figures 1.1 to 1.6 illustrate the areas discussed in this section.)

A careful summary of the chief statutory differences among the various jurisdictions is included. It discusses the potential problems arising out of these and related areas.

The section concludes with a proposal of several policy options which would enable a state to deal effectively with such problems.

PHYSICAL DISPOSITION

Texas and Louisiana.

Figure 1.3 indicates that potential geopressured-geothermal fairways overlap the state boundaries of Texas and Louisiana inland of the Gulf. The caption identifies this deposit as Cenozoic.

Texas and New Mexico.

Figure 1.6 indicates that there are areas of high heat flow along the Rio Grande Valley from New Mexico into Texas In his testimony before the House Energy Crisis Committee, Dorfman identifies the area as the Rio Grande Rift System. This system is not a geopressured system, but it does raise similar jurisdictional question. In the same report, Dorfman discusses the Trans-Pecos Hot Rocks which are being tested in the Jemez Mountains of New Mexico. He indicates that "certain areas of west Texas north of the Big Bend National Park contain similar rocks." This type of geothermal resource may also be shared with New Mexico.

Texas and Mexico.

Figure 1.1 indicates that the geopressured-geothermal fairway of southeastern Hidalgo, western Willacy, and western Cameron counties extends into Mexico.

Texas Offshore and Federal Outer Continental Shelf (OCS).

Texas has retained ownership of the waters, bed, and shore of the Gulf of Mexico out to the 3-league, or 12-mile, limit [164]. The federal government claims ownership and control of lands in the area of the Outer Continental Shelf [165]. Both Figures 1.1 and 1.2 indicate potential geopressured-geothermal fairways offshore of Kenedy and Matagorda counties. These deposits may extend into the federal OCS.

Louisiana Offshore and Federal OCS.

Figure 1.4 demonstrates that geopressured-geothermal deposits extend from Louisiana offshore into the federal OCS. In the case of United States v. State of Louisiana, it was determined that the state owns and controls

Figure 1.1

Potential Geothermal Fairways
Frio Formation
South Texas

Three major Frio sand depocenters are delineated:

1. Southeastern Hidalgo, western Willacy, and western Cameron Counties. The highest sand ratios occur in the lower Frio in thick sand bodies (100 to 600 feet thick) that are primarily dip oriented. These sand bodies were deposited as high-destructive deltas.

2. Eastern Kenedy and Kleberg Counties. A high-sand occurs in the upper Frio, where sand bodies 10 to 100 feet thick are separated by thin shale intervals. These sand bodies are oriented in strike direction and accumulated mainly as strandplain deposits.

3. North-central Nueces County. In the middle Frio a high ratio of sand occurs at the northern part of the study area. Preliminary work farther north indicates that these sand bodies thicken considerably in that direction.

Temperatures of 250^{o}F and greater occur at depths of 10,000 feet or deeper. For the Frio formation, this includes parts of the lower three correlation units. In order to delineate prospective areas, the 250^{o}F and 300^{o}F isotherms have been added to their respective sand-percentage maps for the above tree units. This combination has resulted in the recognition of several prospective areas in Hidalgo, Cameron, Willacy, and Kenedy Counties for which more detailed, local studies must be made. Not taken into consideration at this stage are other critical factors such as areal distribution and thickness of individual sand bodies, porosity, and permeability.

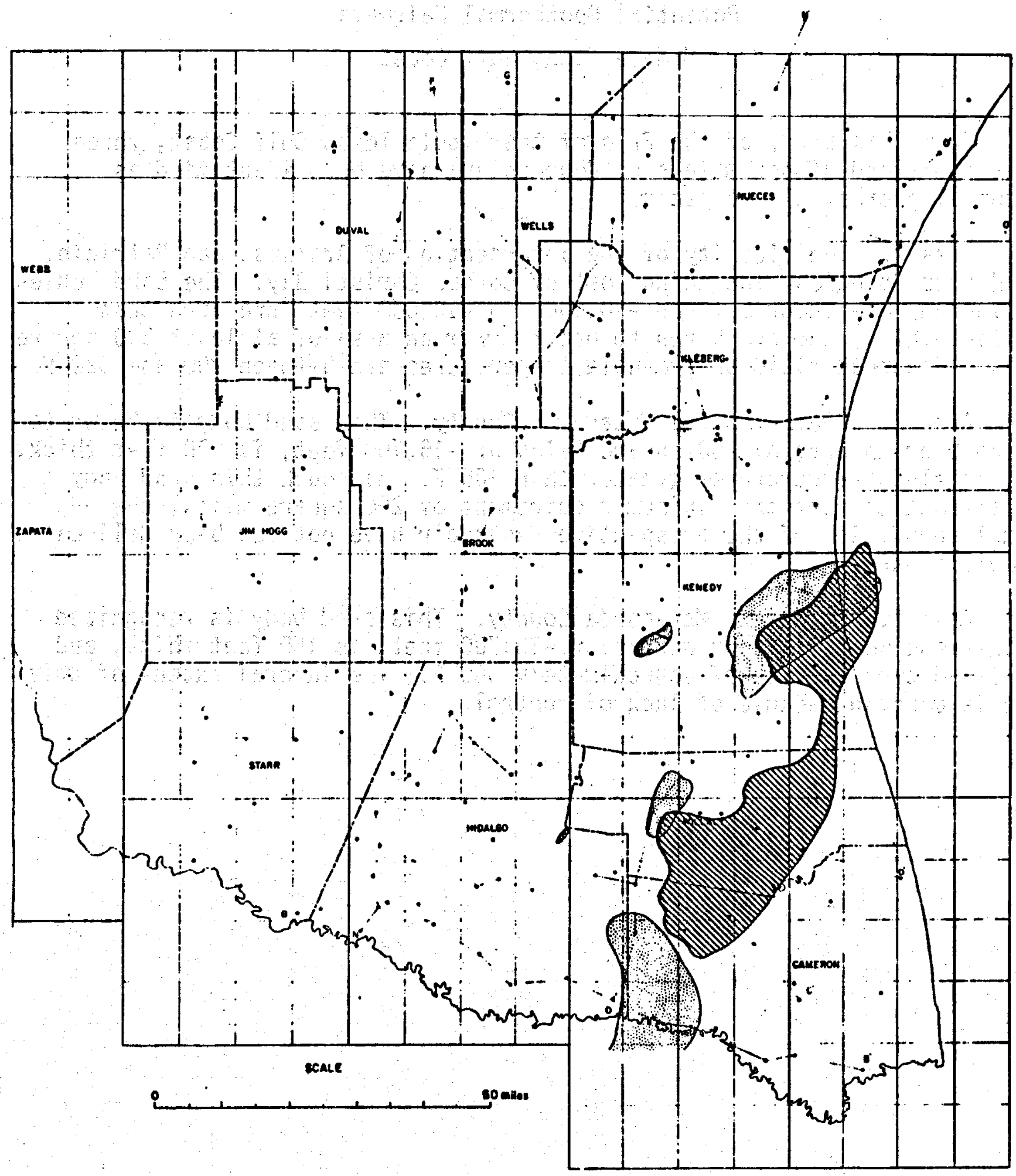

WEBB
DUVAL
WELLS
NUECES
KLEBERG
ZAPATA
JIM HOGG
BROOK
KENEDY
STARR
HIDALGO
CAMERON
SCALE
0
50 miles

Figure 1.1

Figure 1.2

Potential Geothermal Fairways
Middle Texas Gulf Coast

From this study of the Frio of the Middle Texas Gulf Coast, three areas (gulfward of the main sand depocenter) have been identified as potential geothermal prospects.

Area 1. The vicinity of the intersection of Aransas, San Patricio, and Nueces Counties, including most of Corpus Christi Bay. The sand bodies considered here occur between -10,000 and -16,000 feet, are more than 500 feet thick, and are known to occur over an area of at least 200 square miles. Recorded fluid bottom-hole temperatures are between 300 and 320°F.

Area 2. South-central Matagorda County. This sand body is known to extend over an area of 100 square miles at -15,700 feet, is 200 feet thick, and has fluid temperatures greater than 300°F. Although this sand body appears not to meet the minimum requirement of 200 square miles, the actual boundaries of the prospective reservoir have not yet been delineated by well control.

Area 3. Northeast Matagorda County. This sand body is recognized in only one well where it occurs at -13,700 feet, is 150 feet thick, and has fluid temperatures of approximately 300°F. The lateral extent of this sand is unknown because of lack of control.

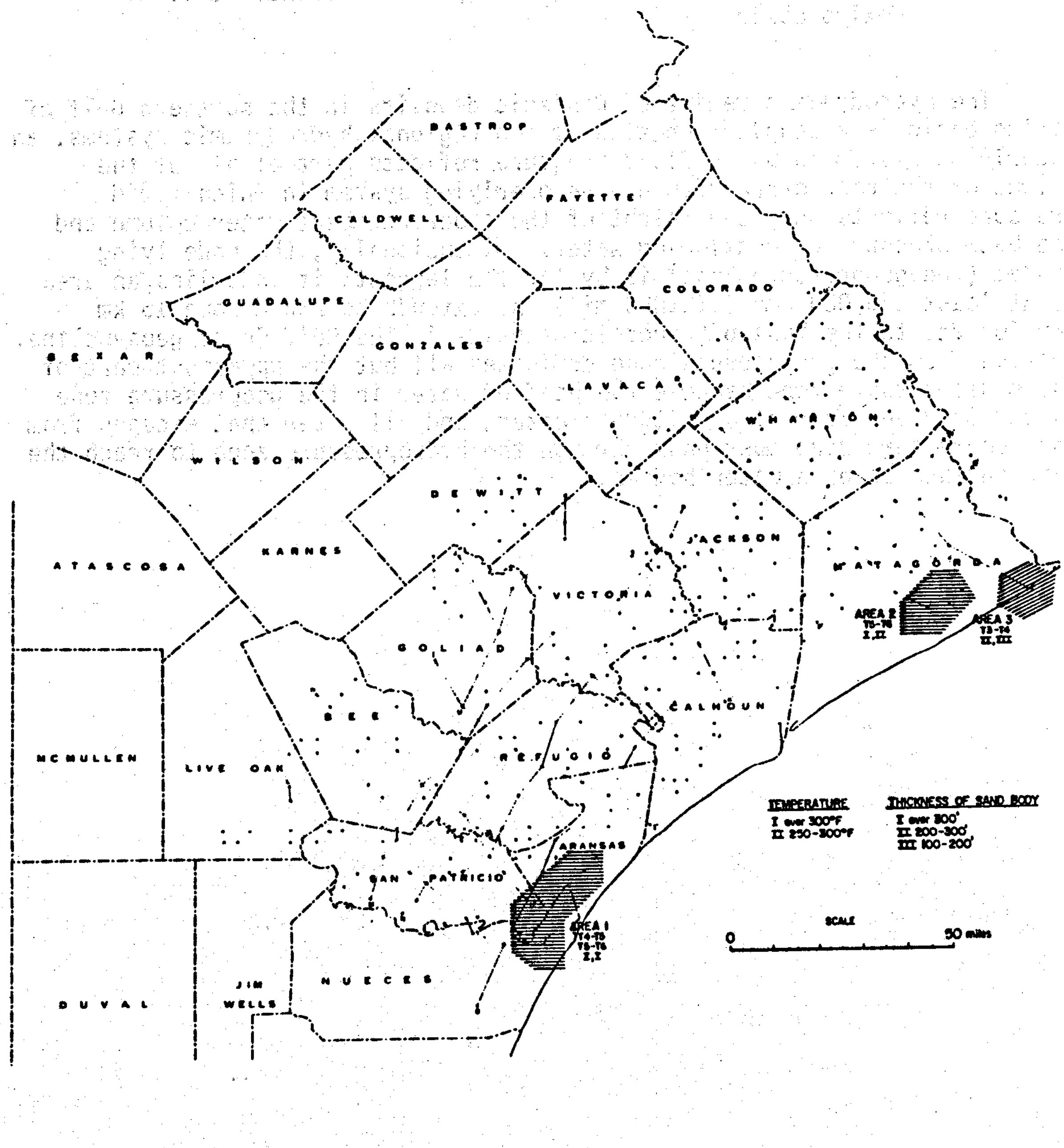

BASTROP
FAYETTE
CALDWELL
GUADALUPE
COLORADO
BEXAR
GONZALES
LAVACA
WHARTON
WILSON
DE WITT
JACKSON
ATASCOSA
KARNES
MATAGORDA
VICTORIA
AREA 2
AREA 3
T3-T4
GOLIAD
BEE
CALHOUN
MCMULLEN
LIVE OAK
REFUGIO
TEMPERATURE
I over 300°F
II 250-300°F
THICKNESS OF SAND BODY
I over 300'
II 200-300'
III 100-200'
ARANSAS
SAN PATRICIO
AREA 1
T4-T5
T5-T6
SCALE
0
50 miles
NUECES
JIM WELLS
DUVAL

Figure 1.2

Figure 1.3 Geopressured zone in Eocene deposits, northern Gulf of Mexico basin.

Figure 1.4 Geopressured zone in Neogene deposits, northern Gulf of Mexico basin.

The hydrodynamic regime of Cenozoic deposits in the northern Gulf of Mexico basin is a coupled function of two regional hydrodynamic systems: an underlying system in which fluid pressure reflects part of all of the weight of the rock overburden and an overlying system in which fluid pressure reflects only the weight of the superincumbent water column and the back pressure of outflowing water. Dimensionally, the underlying system (the geopressure zone) is by far the largest; it underlies an area of at least 375,000 km^2 (150,000 mi^2) and extends downward some 15 km (50,000 ft) to the base of Cenozoic deposits in the Gulf Coast geosyncline. Leakage from the geopressure zone dominates all but the uppermost part of the hydropressure zone because the head of water in the geopressure zone is commonly an order of magnitude greater, and all water that escapes from the geopressure zone must pass through the hydropressure zone to reach the land surface or open water bodies.

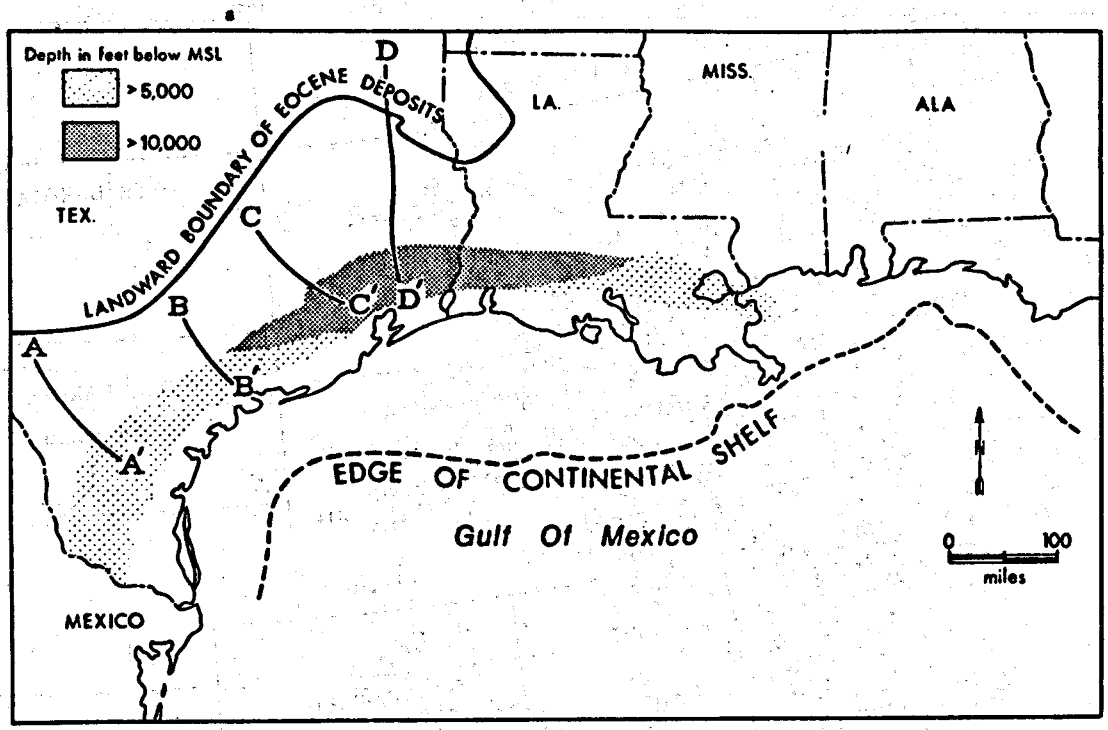


Figure 1.3

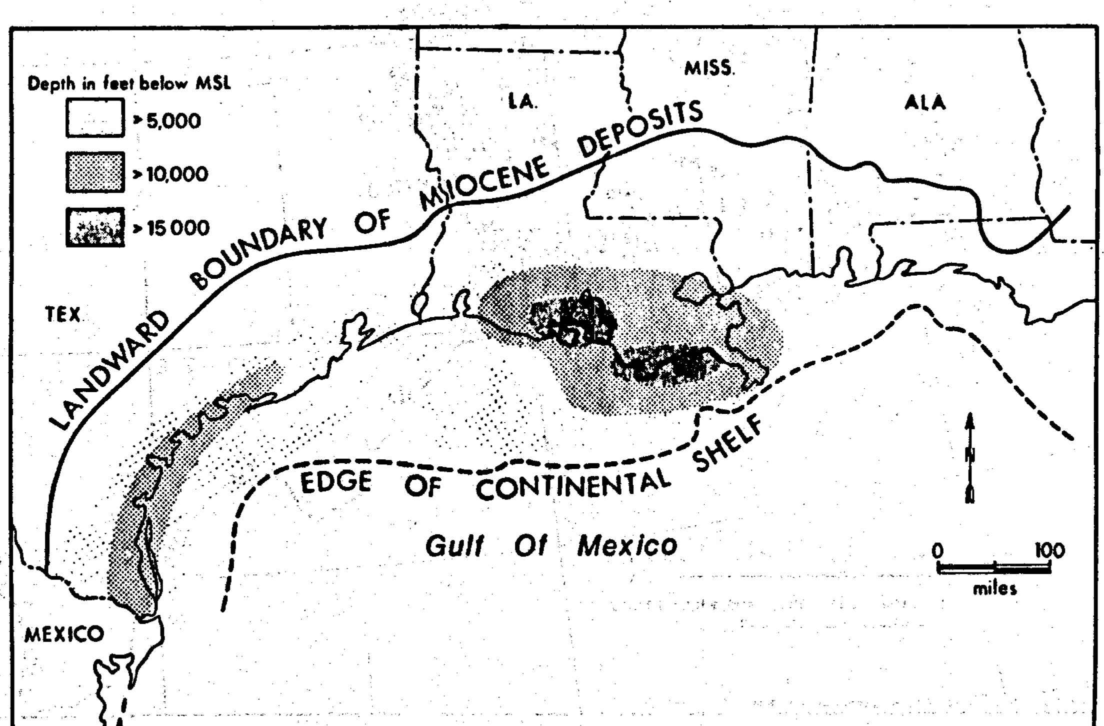


Figure 1.4

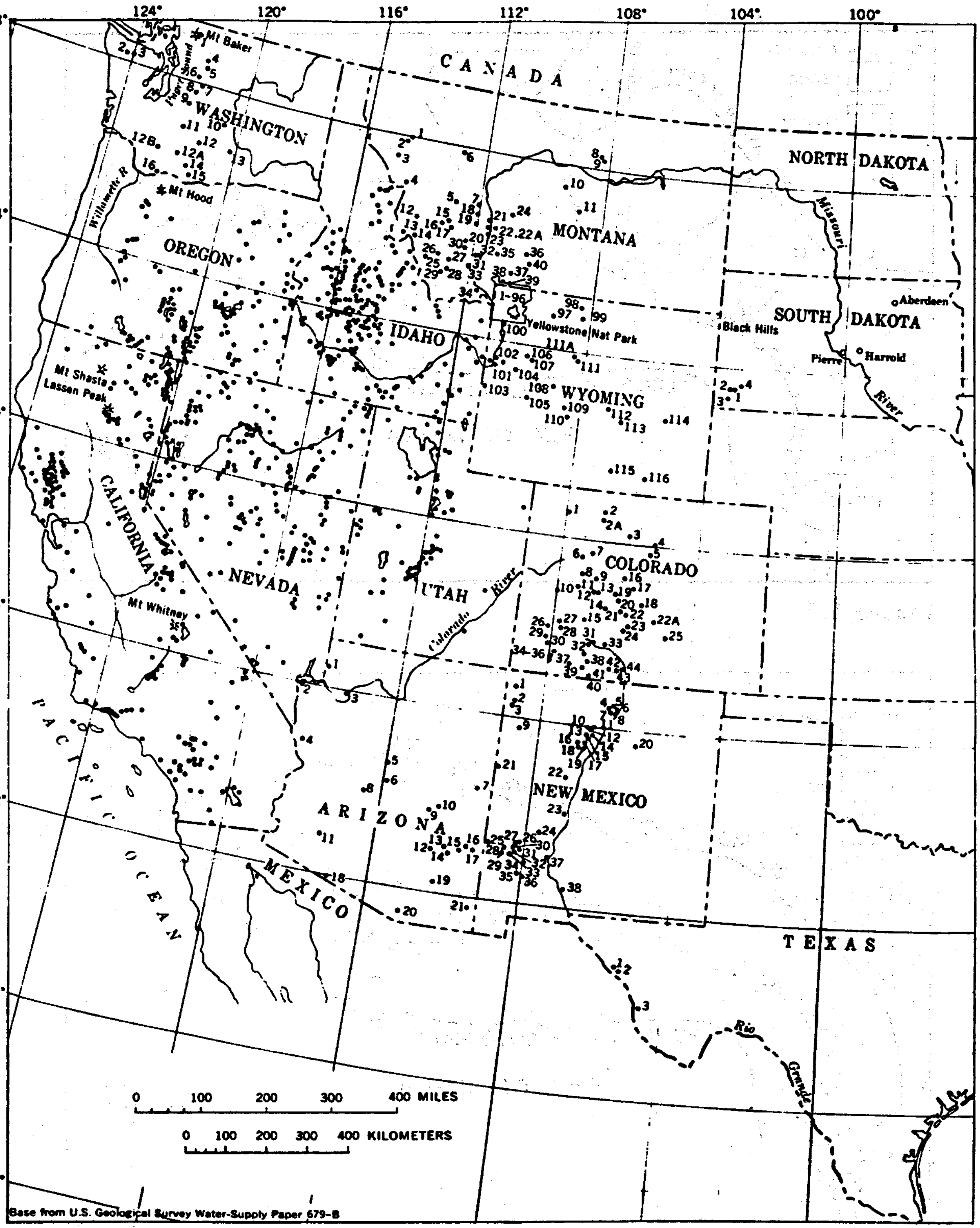
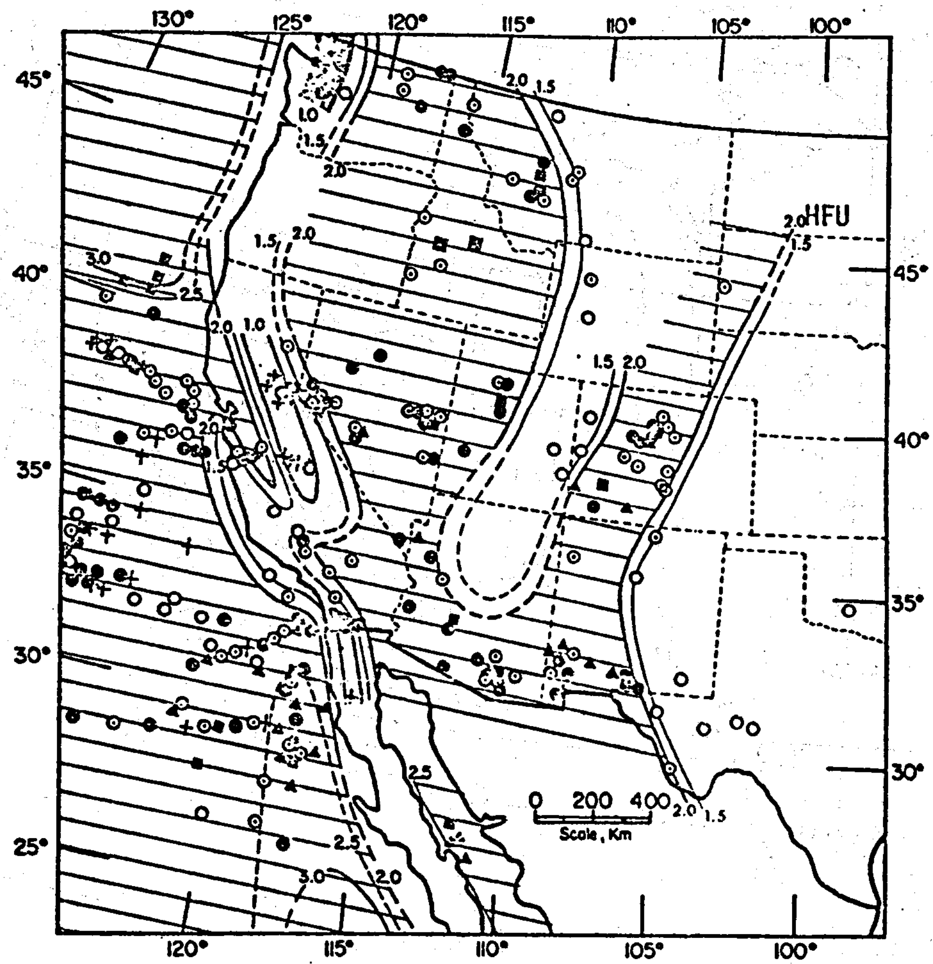


Figure 1.5 Thermal Springs of the United States
Source: Thermal Springs of the United States and Other Countries of the World. U.S.G.S.


96°
92°
88°
84°
80°
76°
72°
68°
48°
44°
40°
36°
32°
28°
24°
CANADA
NEW YORK
MASS
PENNSYLVANIA
Long Island
WEST VIRGINIA
VIRGINIA
NORTH CAROLINA
MISSOURI
OKLAHOMA
ARKANSAS
GEORGIA
FLORIDA
Mississippi River
Missouri
River
ATLANTIC OCEAN
GULF OF MEXICO



HFU = Heat flow unit = 10^{-6} cal/cm^{2}sec

+ = 0 - 0.99 HFU ● = 2.0 - 2.49

○ = 1.0 - 1.49 ▲ = 2.5 - 2.99

⊙ = 1.5 - 1.99 ■ = > 3.0

Figure 1.6. Heat flow in the western U.S. Taken from Systems Study for the Use of Geothermal Energies In The Pacific Northwest, Oregon State University RLO-2227-T19-1.

the area offshore out to three miles [166].

<u>Texas Offshore, Federal OCS, and Mexico Offshore</u>.

Figure 1.4 indicates that the geopressured-geothermal deposits in the Willacy and Cameron county areas may extend into both the Texas and Mexico offshore. If these deposits also extend into the federal OCS at the right position, they could underlie all three jurisdictions.

JURISDICTIONS

Texas.

Texas provides for regulation of drilling on all lands and for leasing of state lands [167]. It defines geothermal resources so as to include geopressured reservoirs and bases the definition on the model in the federal Steam Act. It does not characterize the resource.

Louisiana.

Louisiana provides for regulation of drilling on all lands and for leasing of state lands [168]. It defines geothermal resources so that it is unclear if geopressured reservoirs are included. The definition is based on the federal Steam Act. The statute does not explicitly characterize the resource, but it does imply that geothermal resources are not minerals.

New Mexico.

New Mexico provides for regulation of drilling on all lands and for leasing of state lands [169]. It defines geothermal resources so as to exclude geopressured resources, but so as to include hot rock systems. It bases its definition on the California Code. The statute implies that geothermal resources are not water, though the byproducts may be part of the mineral estate.

United States.

The United States provides for leasing and regulation of drilling on federal lands [170]. It defines geothermal resources so as to exclude geopressured reservoirs. The statute does not explicitly characterize the resource, but it does strongly imply that it is part of the mineral estate.

Mexico.

Mexico provides for development of geothermal resources through the agency of the Comisión Federal de Electricidad and the Department of Geothermal Resources of the Division of General Management of Planning and Program [171]. These agencies are divisions of the federal government of Mexico and operate pursuant to federal grants of authority. This project has no information on the definition, characterization, or ownership status of the resource in Mexico.

FEDERAL ACTION

Several different sorts of federal action are implied by the existence of geothermal resources which cross jurisdictional boundaries. Agreements between states, such as Texas and Louisiana, are governed by both constitutional and statutory provisions. Article 1, Section 10, of the United States Constitution provides that "[n]o State shall, without the Consent of Congress, . . . enter into any Agreement or Compact with another State, or with foreign Powers"

Agreements between the United States and a foreign nation, such as Mexico, are subject to the federal constitutional treaty power [172]. Texas is prevented from entering directly into treaties with Mexico by art. 1 sec. 10 and by the Supremacy Clause, which makes the laws of the United States the supreme law of the land [173].

Agreements among the various states and the federal government will proceed under constitutional and statutory authority similar to that already outlined. Therefore, any agreement involving Texas and Louisiana offshore and federal OCS must be made pursuant to these authorities.

Since development of geothermal resources will have an impact on the environment, agreements permitting large-scale leasing in such multi-jurisdictional areas may therefore have significant environmental impacts [174]. Recent rulings in the case of <u>Natural Resources Defense Council v. Morton</u> [175] have required an Environmental Impact Statement on the Bureau of Land Management's leasing operations. This and similar rulings may require an Environmental Impact Statement for any of the agreements or treaties requiring federal action [176].

PROBLEM AREAS

"The problem remains as to who will be responsible for management of single geothermal resources which lie under lands controlled by separate jurisdictions." [177]. Conflicting statutory provisions with respect to resource definition and implicit characterization will be a source of potential problems for development of geopressured-geothermal reservoirs shared by Texas and Louisiana. For lands which may not be subject to the leasing provisions of the statutes, but which involve such reservoirs, there will be the differences introduced by both case law and common law.

A good example of such potential conflicts lies in the area of "byproducts" in the case of unit operators of a reservoir underlying both Texas and Louisiana. "Byproducts," under Texas law, may or may not include natural gas according to the use of the geopressured fluids at the surface. In Louisiana, natural gas may not be included in the resource at all because geopressured resources themselves are omitted. Moreover, in Louisiana geothermal leases are subordinate to mineral leases. Thus, operators of such units could face three different problems with obtaining clear and absolute title to the solute natural gas. The differences in water law will raise potential problems of ownership and accountability similar to the problems with natural gas.

Differences in commercial regulation and taxation exist with regard to the two states, the federal jurisdiction, and Mexico. Application of state tax statutes to resources shared with the federal jurisdiction may raise significant problems with regard to the Commerce Clause, which gives the federal government the sole right to regulate interstate commerce [178].

Substantial confusion may arise with regard not only to regulatory authority, but also to the content of said regulations. The rules under the Steam Act and other federal statutes which affect reservoirs in both the states offshore and the federal OCS will differ substantially from the rules of the states. For example, neither Texas nor Louisiana has a feature similar to sec. 1008 of the Steam Act which gives the Secretary of the Interior the right to order production of valuable byproducts.

RECOMMENDATIONS

Consideration of issues raised in this section leads to several policy options included as recommendations:

1. The legislatures of all of the involved states and countries should participate in a joint study project to examine issues and structural techniques for resolving such issues.
2. The states individually and collectively should establish an escrow account and an escrow program so that unit drilling in overlapping areas may progress promptly, while preserving the equitable rights of the parties pending resolution.
3. The states should create and join an Interstate Compact Commission on Geopressured and Other Geothermal Resources. The federal government of the United States and that of Mexico should be full partners in such an organization [179]. This commission will require a supplementary treaty agreement.
4. The states and nations involved in the commission should enact uniform and reciprocal legislation.
5. This organization, or any other similar such entity, should strive to generate uniform definitions, characterizations, and regulations of the shared resources.
6. States should enact provisions permitting geothermal regulatory agencies to cooperate with the geothermal regulating agencies of other states [180]. (Some states already have such provisions.)

LEGAL SCHOLARSHIP

TAXATION

Taxation.

SUMMARY

State ad valorem taxes will be applicable to geothermal resource development. There are serious problems with valuation and timing of application. The value of geothermal resources lies chiefly in the energy which is available from such systems. This report recommends that the legislature undertake a thorough policy examination of ad valorem taxation as it applies to geothermal resources and implement its findings in new statutes which articulate valuation principles and timing principles for the application of the tax.

State severance taxation laws on natural gas will, if applied separately, have the effect of treating a component part of the geopressured-geothermal systems as a separable entity. The state should undertake a similar policy analysis on the nature of severance taxes as applied to this new resource. The legislature should implement its findings in statutes which carefully define the resource in terms which correspond to physical reality and which clearly delineate both the basis and percentage of taxation.

The federal taxation code and regulations do not now contain any explicit provisions which are applicable to geopressured resources. Present provisions for a percentage depletion allowance for geothermal steam wells which qualify as gas wells are derived from the Reich case, which applies only to the geothermal deposits at The Geysers in California. Present percentage depletion allowances for natural gas would have the same impact on geopressured resources that state gas severance tax provisions do.

Case law provides the opportunity for bringing geopressured-geothermal resources under the cost depletion provisions. Shurbet, a case allowing a cost depletion allowance for farmers drawing irrigation water from the Ogallala aquifer, may be applicable to geopressured reservoirs.

This report recommends that Congress, after proper deliberation, enact statutes explicitly recognizing the application of cost or percentage depletion allowances and intangible expensing to geopressured-geothermal resources. Such provisions should apply to injection wells and other necessary equipment, such as surface disposal equipment or installations.

Taxation.

INTRODUCTION

> We admit . . . the acknowledged power of a State to tax its own citizens, or their property within its territory . . . to be sacred.
>
> Justice Marshall in
> Brown v. Maryland, 12 Wheat 419, (1827)

> The Congress whall have Power To lay and collect Taxes . . .
>
> Article I, Section 8 of the
> United States Constitution

The development of geopressured-geothermal resources in the Gulf Coast area of Texas and Louisiana will, in part, be a function of tax policy and application. This section explores the present taxation picture for producers of geopressured reservoirs under state law and under federal law.

State taxation is concerned primarily with ad valorem taxes on property and severance/occupation taxes on production of minerals (See Figures 1.7 and 1.8). Federal tax is important chiefly in the areas of intangible drilling costs and depletion allowance. The importance of this area of federal law in underlined by the litigation arising out of geothermal development in California at The Geysers.

The litigation referred to, the Reich case, has had an impact on the legislation. New amendments to the Internal Revenue Code issued in 1975 depend on that case for the operative determination of the nature of the resource. These amendments, and two proposed amendments, must be carefully examined in order to determine their projected impact on geopressured resource development.

This section concludes with recommendations which would have the effect of providing badly needed incentives for investment in the development of this unique resource.

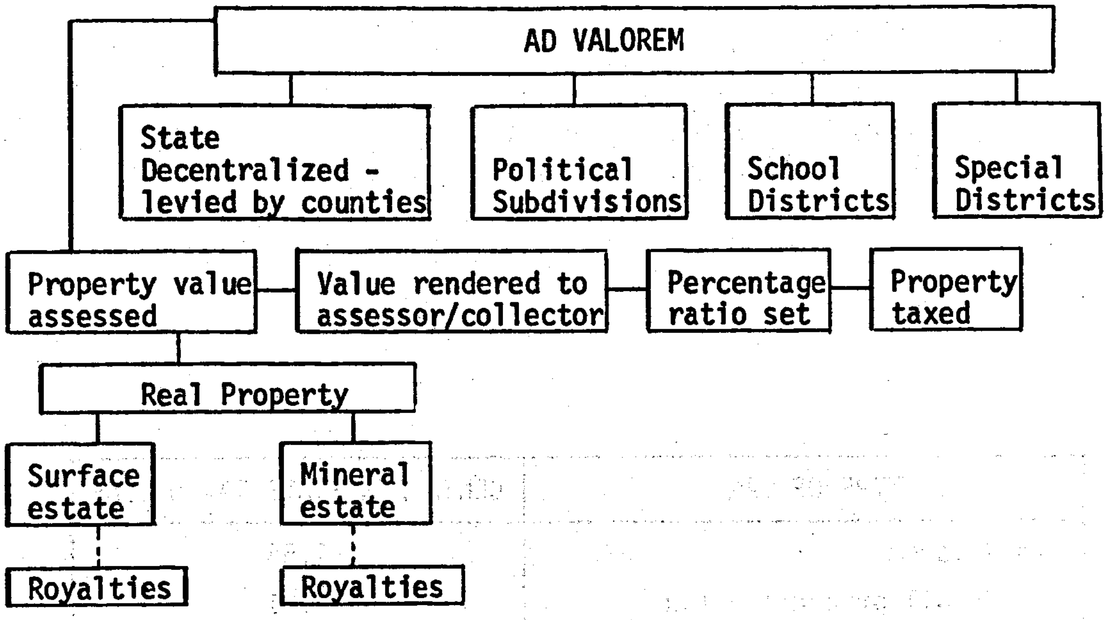


Figure 1.7.A

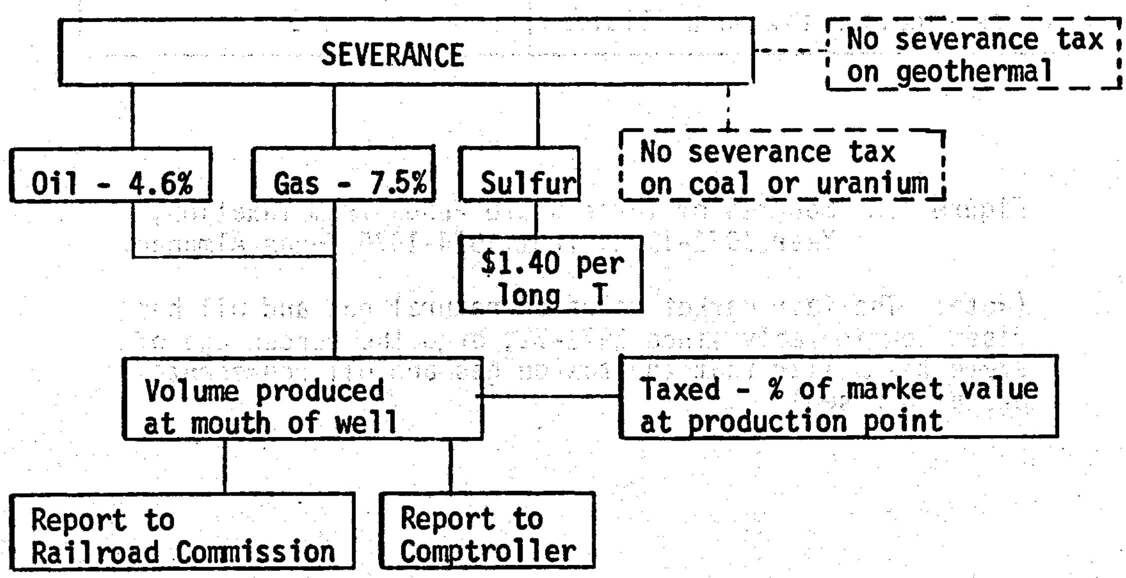


Figure 1.7.B

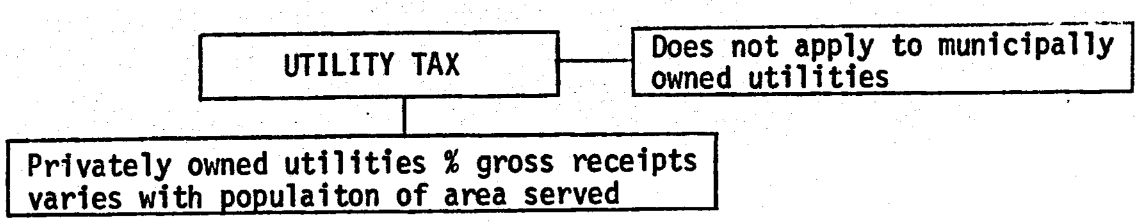


Figure 1.7.C

TYPE OF TAX	CENTS PER STATE TAX DOLLAR
Ad Valorem	1.54
Crude oil production tax	4.81
Natural gas production tax	2.85
Sulfur production tax	0.12
Gross receipts tax on utilities	0.56

Figure 1.8 Sources of Texas State Funds from Taxation, Year 1971-1972, from 1974-1975 Texas Almanac.

(Note: The fair market value of natural gas and oil has risen considerably since 1971-72, ergo the percentage of state tax dollar that the tax on gas and oil represents has also risen).

STATE TAX

The geothermal statutes of Texas and Louisiana do not mention taxation. No taxation statute in these states explicitly includes the resource.

Ad Valorem.

Historically, Texas has depended upon a property or ad valorem tax to provide funds for the operation of the government (see Figure 1.7.A). For this purpose all property, whether real or personal, tangible or intangible, is to be assessed and taxed at some ratio of its value. For many years the state's ad valorem rate was 35¢ per every $100 valuation for the general revenue fund (abolished in 1951), 35¢/$100 for the Confederate pension fund. Throughout this century, however, state dependence on the ad valorem tax has decreased steadily. This situation has resulted promarily from the discovery of major oil fields in Texas and the ever-increasing industrialization of the state, events which have provided large amounts of taxable income. In the years 1971-72, state ad valorem taxes represented only 1.54¢ of every dollar (or $1.54 of every $100.00) of state taxes collected (Figure 1.8). As of January 1, 1976, only 12¢/$100 valuation will go to the state, composed of 10¢ for the College Building Fund and 2¢ for the Confederate pension. Eventually, only the 10¢ College Building Fund tax will survive.

Although the importance of ad valorem taxes to the state has dwindled, these same taxes are the financial basis of many political subdivisions of the state, including counties, cities, towns, hospital districts, school districts, drainage and irrigation districts, and countless other special districts. The 254 counties are the decentralized collectors for the state ad valorem tax, which each county assessor pays to the state comptroller. Texas has approximately 3000 taxing districts, and over 1500 assessment offices. No one knows how many special districts exist in Texas because those that are organized under general law provisions need never report their existence to the state. One source estimates that there are 1001 special districts in Texas [181]. Not all districts have the power to levy ad valorem taxes, ane the tax rates among districts having this power vary widely [182].

Assessment of property in Texas has traditionally been unpredictable. There is no specified statewide formula for this assessment. The state is currently trying to develop a single system for its 1100 school districts, but all other taxing districts will remain free to set their own procedures. This means that the valuations will continue to differ from district to district, along with the percentage of the value which is taxed, and the amount of tax imposed per $100 valuation.

Texas Const., art. 8 sec. 20

> No property of any kind in this State shall ever be assessed for ad valorem taxes at a greater value than its fair cash market value.

Texas Const., art. 8 sec. 1

> Taxation shall be equal and uniform. All property in this State, whether owned by natural persons or corporations, other than municipal, shall be taxed in proportion to its value, which shall be ascertained as may be provided by law.

The term "fair cash market value" in the constitutional mandate has created problems in regard to assessment of property value. Tax assessors are rarely experts at evaluation of all forms of taxable property. To assess oil or gas property, leaseholds, or wells requires some expertise in the field of petroleum engineering which county assessors rarely have. In some instances, assessment engineers are called in to value the well for ad valorem taxation purposes. However, there is no uniform procedure, and each assessor devises unique methods.

Many wells are simply taxed at a given rate, such as $4,000. This procedure circumvents the "uniformity" called for in the constitution, and also makes it possible to tax a well for a value <u>greater</u> than the fair cash market value. But neither the legislature nor the petroleum industry has sought reforms for the inequity. The assessment procedures vary from district to district, and any specific oil or gas well would have to be examined through the existing practices in that locale.

In addition, there are variances as to what percentage of the "fair cash market value" will be used for the property valuation base. If all property in the district is valued at 80 percent of its true value, a type of uniformity will be obtained. However, this is not usually the case, and some property (such as houses) will be valued at its fair cash market value, while other property (personal property) may not be rendered at all. Although the ad valorem taxation processes in use in Texas are obviously products of a ninteenth century ideology, they are not likely to be changed in the near future.

The requirement for valuation at "fair cash market value" introduces substantial complications. The "fair cash market value" of a geothermal resource will depend entirely on the type of use, the statutory character of the user, the transportation burden, and other imponderables. If heat is the real value of a geothermal resource, should value be measured with regard to the worth of comparable Btu? This scheme is employed for the setting of rates in The Geysers by Pacific Gas and Electric [184].

The Resource Utilization section of the Phase 0 Project has calculated that the probable cash flow from a geopressure-operated electrical generating system will be split between electricity and natural gas in the ratio of 1 to 2. With due regard for the thermal inefficiency of converting Btu to kilowatts of electrical power, and for the extraordinary intrastate prices for natural gas, it is still clear that some large portion of the value of the resource lies in the byproducts. Will these byproducts be valued with or without setoffs or cost-sharing of the production facilities with electrical generation?

Valuation of a complex resource must itself be complex. Geopressured-geothermal resources will be expressed at the surface in the form of fluids with a certain heat content, pressure content, and dissolved mineral and gas content. All of these items have value, including the fluid and the pressure. They may not have a discoverable "fair cash market value."

The timing for valuation is also critical. Geothermal production is characteristically a long-lead-time endeavor. There may be a period of from three to five years before a given reservoir has passed through from exploration and development to full production. The valuation should wait until the utilization system has also developed and engaged with production. Only at this point can the "fair cash market value" of the resource be ascertained.

Who should pay the ad valorem tax, the lessor or the lessee? In oil and gas tax practice, the lessee renders the value of the well at the time of production and pays the taxes. Geothermal lessees will register the wells with the Railroad Commission during expolration and development. The value of the well or reservoir may reach the assessor at this time. If the assessor follows oil and gas practice, the lessee, who owns the estate in the resource as an interest in property, will pay the tax.

Severance and Occupation.

Oil and gas production (severance) taxes, which are levied pursuant to statutory provisions [184], are not easily applicable in theory to goethermal resources (Figure 1.7.B). These occupation taxes are set on the fair cash value of the product as it emerges from the mouth of the well. In the case of natural gas, the tax is 7.5 percent of this value. Oil is taxed at 4.6 percent of its fair cash value before any refining. These fuels can be appraised and assigned values and volumes in terms of barrels or cubic feet. The actual energy of these commodities will not be utilized until the respective fuels are burned. Their actual byproduct value will not be realized until after refinement. However, geothermal energy will emerge at the mouth of the well, for the most part, in the form of pressure and heat carried by water and gas in solution.

It is hypothesized that the major worth of the Gulf Coast geothermal fluids will be the initial burst of power into the turbines as soon as they reach the ground level. Consequently, a unique taxation theory may be necessitated by the unique nature of the resource. It would be difficult to tax the fluids strictly by volume produced, as the heat and pressure of each reservoir will differ. The theory of severance taxes as applied to oil and gas would obviously be difficult to apply to geothermal resources.

The presence of methane gas in the geothermal fluids is presumed by most reports. The amount of gas suspended in the geopressured fluids has not been determined, although 40 cubic feet per barrel is the standard estimate. Extraction of this gas from the fluids during the several processes before and during power generation will result in taxable gas being produced. Geothermal leaseholders will be liable for a gas tax if the resource is held to include the gas. Removal of additional minerals from the fluids will necessarily raise similar questions of state and federal taxation.

One policy function of severance and occupation taxes is to obtain some economic benefit for the state from commodities destined to be sold outside the state. An argument against imposing this same severance and occupation tax structure on geothermal production is that such production is not exportable. This argument does not take into account the displaced energy use which makes available for consumption elsewhere every Btu of geothermal energy consumed. It also overlooks the solute natural gas which will be available for sale to either the intrastate or interstate markets.

FEDERAL TAX

Intangibles.

Under one section of the existing federal tax law regarding oil and gas, I.R.C. sec. 263(c), the taxpayer's capital expenditures for exploration and intangible drilling and development costs of oil and gas wells may be either deducted as expenses or capitalized and depreciated over a long period of time. If these costs are expensed, the immediate deduction can help the developer, who has large expenditures in the early stages of development, but very little, if any, income. The practical effect is similar to an accelerated depreciation and is worth twice the value of normal depreciation of capital assets [185]. Once the choice is made, the taxpayer is bound to continue using the chosen deduction not only for that well, but for ensuing projects. If no choice is indicated, the IRS presumes that the taxpayer has chosen to capitalize. If I.R.C. sec. 263(c) is applied to geothermal development, the developer will be able to expense or capitalize the early capital expenditures. However, at present, sec. 263(c) is not automatically applicable to geothermal resources. It has been allowed in some instances to apply to the intangible drilling and development costs of geothermal exploration, yet the tax commission continues to challenge taxpayers using this deduction [186].

Depletion.

There are two sorts of depletion allowances under the Internal Revenue Code. Sec. 611 provides for cost depletion, and sec. 613 provides for percentage depletion. The provisions of sec. 613 were modified by the Tax Reduction Act of 1975 so as to reduce the allowance for oil and gas from 27½ percent to 22 percent. (Both sections are set out in full in appendix). Percentage depletion allows a greater write-off than cost, and is not tied to the basis in property. The percentage depletion can return the value of the original basis many times over [187].

Two important cases have construed these provisions and/or those on intangibles: Reich and Shurbet. They are taken up in a following section.

Statutory Provisions.

Tax Reduction Act of 1975. This legislation inserts the word "geothermal into the Internal Revenue Code for the first time. In amending section 613A, one of the gas well exemptions is expanded as follows:

> Sec. 613A LIMITATIONS ON PERCENTAGE DEPLETION IN CASE OF OIL AND GAS WELLS . . . .
>
> (b) EXEMPTION FOR CERTAIN DOMESTIC GAS WELLS.--
>
> (1) IN GENERAL.--The allowance for depletion under section 611 shall be computed in accordance with section 613 with respect to-- . . .
>
> (C) any geothermal deposit in the United States or in a possession of the United States which is determined to be a gas well within the meaning of section 613(b)(1)(A), and 22 percent shall be deemed to be specified in subsection (b) of section 613 for purposes of subsection (a) of that section.

This demonstration of congressional concern for giving a tax incentive to the geothermal industry is patterned after the decision in Reich. Only the I.R.C. section regarding the depletion allowance is altered, not the section on deductions for intangible drilling and development costs, which is of equal importance. In Reich, the court's main discussion was on the depletion allowance, and the issue of intangible drilling deductions was thought to be decided by the former. Secondly, the Reich definition of which geothermal wells will qualify for the depletion allowance is employed: any geothermal well which "is determined to be a gas well."

Why the definition of geothermal resources from the Geothermal Steam Act of 1970 was not utilized is not apparent. The result of this amendment is only short-term and limited relief for the geothermal industry as a whole. First, it will allow the tax commissioner to continue challenging on a case-by-case basis the characteristics of each geothermal well, to determine if each is a "gas" well. Second, this amendment will allow for preferred tax treatment of dry steam geothermal resource developments, while the geothermal fluid resources will have even more problems to grapple with. They are now as much as excluded from the Internal Revenue Code since a geothermal well of steam and fluids will not qualify as a "gas" well, and because of the everpresent problem of I.R.C. sec. 613 (b)(7)(A), which specifically excludes water from the percentage depletion provisions.

Because I.R.C. sec. 263 (c) is not amended, it is at least possible that deductions for intangible drilling costs will not be allowed even if the depletion allowance is permitted. In Dunnigan Enterprises, Inc., Docket number 657-74, the Internal Revenue Service is challenging a New Mexico taxpayer's deduction for intangible drilling and development costs in geothermal exploration [188]. Because many such cases are settled out of court, it is difficult to know how frequently the Internal Revenue Service is challenging these previously mentioned deductions. However, one thing is clear: the Tax Reduction Act of 1975 amendments to the code will have little impact upon geothermal wells that are primarily fluid in nature rather than dry steam. The problem is that of statutory wording, since "gas" can apply to dry steam geothermal resources, yet cannot be used to describe geopressured-goethermal deposits. It is difficult to imagine why Congress would desire dry steam geothermal resources to enjoy a tax preference that geopressured-geothermal fluid resources were prohibited from.

H.R. 6238 (Proposed). H.R. 6238 was introduced into the House on April 22, 1975, less than one month after the Tax Reduction Act of 1975 went into effect. This bill was referred to the House Ways and Means Committee, where it remains for lack of support. This Bill would clear up some of the previously outlined problems created by the earlier legislation. The depletion allowance sec. 613A(b)(1)(C) would be amended to read, "(C) any geothermal deposit in the United States or in a possession of the United States which is determined to be producing geothermal steam and associated resources as defined in the Geothermal Steam Act of 1970." In addition subsec. (c) of sec. 263 would read as follows:

> (c) INTANGIBLE DRILLING AND DEVELOPMENT COSTS IN THE CASE OF OIL AND GAS WELLS, OR GEOTHERMAL DEPOSITS. -- Notwithstanding subsection (a), regulations shall be prescribed by the Secretary or his delegate under this subtitle corresponding to the regulations which granted the option to deduct as expenses intangible drilling and development costs in the case of oil and gas wells . . . and such regulations shall be extended so as to apply in the case of wells drilled for geothermal steam and associated resources as defined in the Geothermal Steam Act of 1970.

If this bill is passed, it will define the tax status of geothermal developments with the definition used in the Geothermal Steam Act of 1970. Although this move will make the federal geothermal statutes in toto more uniform, how it will affect the Gulf Coast geopressured-geothermal fluids is still in question. As previously pointed out, none of the existing statutes or litigation has touched upon geopressured fluids per se, dealing instead almost solely with dry steam deposits. In fact, careful analysis of the definition contained in the Steam Act, found herein in Resource Definition, indicates that the Steam Act does not include geopressured-geothermal resources. Until these legal mechanisms deal specifically with the Gulf Coast geothermal deposits, the potential developers of these fluid resources must continue to employ arguments from and conclusions based upon both Reich and Shurbet in trying to obtain the tax benefits that have been received in those cases.

S. 2608 (Proposed). This bill, submitted by Fannin to the Senate Finance Committee in November, 1975, would modify depletion and intangible provisions of the code. It would allow a 25 percent depletion allowance on resources defined according to the Geothermal Steam Act, as in H.R.6238 (Proposed). This proposed bill also allows the option to deduct intangible drilling and development costs on geothermal wells in the same fashion as for oil and gas wells (see Appendix for full text).

The fact that S. 2608 adheres to the Steam Act definition is an unfortunate limitation because it operates to exclude not only geopressured resources but also hot rocks. If it were not for the limitations inherent in the definition, geopressure might otherwise qualify for the 25 percent depletion allowance.

Another shortcoming of this proposed bill, as remedial legislation, is that it does not provide intangible expensing for the entire geothermal system. Intangibles are included, in sec. 189(c)(1), but only for wells drilled for geothermal steam and associated resources. This omission leaves out production wells for geopressured resources and injection wells.

Case Law.

Arthur E. Reich 52 T.C. 700 (1969), aff'd 454 F.2d 1157 (9th Cir. 1972) is one of the very few litigated cases having to do with the federal income taxation of geothermal resources and their development.

This is one of the very few litigated cases having to do with the federal income taxation of geothermal resources and their development. The commissioner challenged the California taxpayers' contention that they be allowed (1) to treat intangible drilling and development costs of a geothermal well as if they were incurred drilling an oil or gas well, therefore enabling the taxpayers to expense these costs; and (2) to claim a 27½ percent depletion allowance deduction, since the geothermal well produced steam and steam is a gas, for the purpose of qualifying for favorable tax treatment.

The administrative tax court decided in favor of the taxpayer who had taken both the deduction for intangible drilling and development and the depletion allowance. This ruling was appealed by the commissioner and was affirmed by the Ninth Circuit Court of Appeals in 1972. The tax court made these findings: (1) Steam, not heat, is the product of the wells; (2) Steam is held to be a gas, since in the common commercial usage of the geothermal industry, it is regarded as such; (3) The Geysers is a natural resource that is capable of depletion, and is, in fact, being depleted. Accordingly, the depletion allowance was permitted. The commissioner in his brief had stipulated that if the depletion allowance was applicable in this case, the issue of intangible drilling costs also would be decided in favor of the taxpayers. Consequently, the intangible drilling deduction was allowed with little discussion. The companion case, George D. Rowan, was decided in reliance on Reich, and Rowan was allowed deductions for intangible drilling and development costs [189]. In both of these cases the geothermal wells were producing steam, which qualified them as "gas wells" for the purpose of the statutory language of the I.R.C. The commissioner admitted that "gas wells" could apply to nonhydrocarbonaceous gases (i.e., not methane gas); however, the government is not necessarily bound by this statement and could now assert the opposite.

Reich really turned on a long production history and clear evidence of decreasing steam pressure [190]. This feature of long-term evidence is common to Shurbet [191]. Reich is effectively limited in application to other wells at The Geysers. Its applicability to geopressured development is extremely marginal. Geopressured resources are not steam. Furthermore, there is no long productive history to show a decline in any parameter of the resource.

In the case of United States v. Shurbet, the United States Court of Appeals for the Fifth Circuit affirmed the ruling the the Ogallala water reservoir of the Southern High Plains was a "natural deposit" for purposes of the cost depletion allowance in I.R.C. sec. 611. The U. S. District Court, where the case originated, compiled an impressive finding of fact upon which the ruling in Shurbet is largely based. The appeals court and the I.R.C. Regulations both limit the finding to facts similar to those in Shurbet [192].

The decision turns on several main points of decided interest to taxation analysis for geopressured reservoirs. Total recoverable water in the reservoir was diminished from 1938 to 1962 by 40 million acre feet [193]. Average 24-year recharge and discharge are roughly balanced at 3/20ths of an inch per year [194]. Both the water table and the saturated thickness of the reservoir have declined [195]. The reservoir is being mined and once drained "will require more than 4000 years to refill and will be lost insofar as Plaintiffs and immediate succeeding generations are concerned" [196]. The ground water is being exhausted, and the reservoir will be predictably exhausted [197].

The court goes on to conclude that ground water in the Ogallala "is a mineral and a natural deposit within the meaning of the federal tax statutes and regulations governing deductions for cost depletion" [198].

Some subtle differences in reasoning exist between the court of appeals and the district court. The appeals court opens by stating that it agrees with the district court that "Ground water in the Ogallala . . . is a mineral and a natural deposit within the meaning of . . . cost depletion" [199].

The appeals court then begins to distinguish "natural deposit" from "mineral." It indicates that the term "natural deposit" must be measured by the policy purposes of Congress in allowing depletion. The court recites legislative history and concludes, in sec. 4, that

"the legislative history . . . means no more than that Congress intended depletion as a means of allowing an annual deduction to represent the capital exhausted in the taxpayer's business operations . . . The language of the . . . provisions . . . do[es] not convey any such meaning [i.e., that natural deposits are minerals,] and it seems to us inconsistent with the purpose and rationale of cost depletion" [200].

The court then points out that "water" is excluded only from the sections defining and setting out percentage depletion. The court cites a prior case involving another excluded element, sod, in which the exclusion of sod from percentage depletion was held not to impact cost depletion [201].

Finally, the court points out that the treasury regulations strongly imply that "some minerals may be subject to cost depletion which are not subject to percentage depletion" [202]. ". . .'Minerals' . . . includes but is not limited to all . . . minerals and other natural deposits subject to depletion based upon a percentage of gross income" [203]. The court holds, therefore, that substances excluded from percentage depletion by I.R.C. sec. 613(b)(6): "(s)oil, sod, dirt, turf, water, or mosses," are "natural deposits" open to cost depletion.

Analysis.

Geothermal resources are not now taxed by the state as separate entities under severance or occupation taxes. The venerable ad valorem tax is applicable by its terms to any type of property, real or personal, which has value. Geopressured-geothermal resource development will certainly be subject to these ad valorem taxes.

The constitutional requirement of fair cash market value will be the chief stumbling block. Assuming for the sake of argument that county tax assessors are equipped to conduct and understand a complicated scientific investigation of the particular installation, it is not clear which information will be relevant and what criteria ought to be applied. A geothermal reservoir will be evaluated by potential users with a specific use in mind. The value of the reservoir to that user is precisely its ability to meet certain needs. Thus, a reservoir may be rejected by electrical-generation users because of insufficient heat content, but may be acceptable to process-heat users.

Geothermal reservoirs could conceivably be classified according to the type of use to which each reservoir would most likely be put. Each class of users presently pays a certain price for that resource for which geothermal resources would substitute. It seems at least conceptually feasible to specify by statute or regulation an ad valorem classification system based on use and reservoir capability over lifespan.

Geopressured-geothermal resources are clearly not covered by any federal statutory provisions presently in force, nor by any under consideration in Congress. The Tax Reduction Act of 1975 is limited by its terms to geothermal steam wells which can qualify as gas wells under the test in Reich. The Reich case itself appears strictly limited in direct application to The Geysers steam field in California.

Case law may provide a precedent for a depletion allowance for geopressured resources. Though geopressured reservoirs do not resemble The Geysers, they do resemble the ground water aquifers of the Ogallala which were the subject of Shurbet. The Ogallala structure developed during the Pliocene, a more recent epoch than that which saw the sand and shale bodies of the geopressured reservoirs develop. Both systems are permeable, and waters can move through the materials. The Ogallala is extremely shallow, at 50 to 250 feet below the surface. The geopressured reservoirs generally occur at depths greater than 7000 feet below the surface. The Ogallala is under normal hydrostatic pressure, while geopressured reservoirs are under hydrostatic overpressure. Both systems are reservoirs whose main component is water. Geopressured reservoirs contain enthalpic water which is under pressure and contains natural gas.

Resemblance is not enough to bring geopressured reservoirs under the rule in Shurbet, especially in light of the court's statement that the "case is not meant to furnish a precedent as to the allowance of cost depletion for ground water, except under the peculiar conditions of the Southern High Plains" [204].

What are the peculiar conditions of the Ogallala? The court indicates that the most important such condition is the depletability of the reservoir. The fact situation, as developed in the district court, depends heavily on the accumulation of data showing a decline in the water table for the period 1938 to 1961. These data were supplied by the United States Geological Survey. No similar data exist for geopressured reservoirs since no controlled and monitored production for geothermal energy purposes has yet taken place. It will take significant production history to begin to approach the data base used in Shurbet.

At present, the Phase 0 Project has only theoretical considerations upon which to base an argument for depletion. Waters present in geopressured reservoirs are fossil waters and not of recent meteoric origin. The reservoirs are sealed off by impermeable zones and are under an extraordinary hydraulic head. Both of these factors eliminate inflow from other strata as possible major sources of recharge. The waters present are both the product of thermal metamorphosis of the clays and the interstitial waters of deposition. The impact of production on the reservoirs will be to extract these fluids without introducing replacement fluids. This situation seems to make the geopressured reservoir more depletable than the Ogallala, which, given an annual average precipitation in excess of 3/20ths of an inch, will eventually recharge after production ceases. There are no such expectations for the geopressured reservoirs. However, proof of the depletion will be a major hurdle.

Unfortunately, depletion of the water in the Ogallala aquifer is not precisely parallel to depletion of a geopressured reservoir. The waters of such reservoirs are not being produced as a commodity, as are those in Shurbet. Nor do they form the value of the resource in the same sense that water does in that case [205]. Water is only a heat transfer medium in these reservoirs. Its presence, however, is the limiting factor on availability of the magmatic heat. Geopressured-geothermal resources are unique among geothermal resources generally in that there is no recharge of fluids. It is not economically feasible to reinject fluids into these aquifers in order to recover more heat or pressure. The enthalpy is a measure of the heat content of the fluids. Therefore the geopressured resource will be exhausted as an energy resource, when the heat transfer fluids are exhausted.

However, it is conceptually possible that such reservoirs will suffer other sorts of depletion first. The temperature and pressure content of the waters could easily decrease long before the fluid output dropped significantly. In this contingency, the analogy to Shurbet and its reliance on decrease in total commodity production seems inappropriate. Reich seems more to the point with its concern for the decrease in the pressure of the available steam, rather than for total steam production.

Even if depletability can be established, geopressured reservoirs must still face the Shurbet rulings which hold that water is a mineral and a natural deposit. This study has argued that geopressured resources in particular and geothermal resources generally are not simple commodities. They have, in contrast, been defined and described as complex geologic systems. It is important, therefore, to determine whether the ruling of the court can be read in such a fashion as to include geopressured resources under the heading of "natural deposit" without having to include such resources under the heading of "water."

The appeals court in Shurbet affirms the district court holding that "[g]roundwater . . . is a mineral and a natural deposit within the meaning of the federal tax statutes." The government argues that water is not a natural deposit because it is not a mineral. The court states that the term "natural deposit" explicitly includes entities which are not minerals. The court does not argue that water is a mineral.

This distinction in argument within the opinion of the court is significant for geopressured resources. It does not appear necessary to contravene the best scientific understanding and argue that geopressured resources are only water. It also does not seem necessary to attempt to show that water is a mineral. It will suffice to show that the term "natural deposit," as used in the Internal Revenue Code, will comprehend geopressured-geothermal resources.

The court in United States v. Shurbet, convincingly demonstrates that neither legislative history nor present regulation limits the provision within cost depletion sections of the law. The various limitations and exclusions are in fact parts of percentage depletion. The court's analysis in Shurbet can be supplemented by reference to I.R.C. secs. 611(a) and 613(a), reproduced in full in the appendix.

Sec. 611(a) provides that "[i]n the case of mines, oil and gas wells, other natural deposits, and timber, there shall be allowed . . . a deduction." But sec. 613(a) provides that "[i]n the case of the mines, wells, and other natural deposits listed in subsection (b), the allowance for depletion . . . shall be the percentage . . . specified." This is clear support for the court's conclusion that the exceptions apply only to percentage depletion.

Are geopressured resources such natural deposits? It seems that they may be. They are at least "deposits," defined by the Oxford English Dictionary as a layer of precipitated matter or a natural accumulation. The geopressured reservoirs are identifiable underground structures of natural origin that can be "mined" for the heat and pressure content of the contained fluids. This is true of all geothermal systems, so long as they are defined in terms of extraordinary heat content or heat flow. The natural and diffuse normal thermal gradient would not so qualify.

Therefore, if geopressured reservoirs can be shown to be depletable, it appears that they may come under the rule in Shurbet, as least with regard to the heat transfer medium. This route to a depletion allowance is fraught with uncertainty and needs a degree of analysis beyond the scope of this paper.

PROBLEM AREAS

Two broad categories of problems are dealt with in this section: problems within state taxation and problems within federal taxation.

State Taxation.

With regard to state taxation it is clear that substantial clarification is needed in order to provide the ad valorem tax structure with criteria on valuation and timing. The impacts of inadequate decision making, or of no decision making, may be to restrain somewhat the development of geothermal resources in Texas and Louisiana.

Severance and occupation taxes on the production of geothermal resources should also be examined by the states. The precise subject of these state taxes needs to be carefully defined.

Present potential conflicts between taxes on natural gas from ordinary gas wells and on the solute natural gas present in geopressured fluids need resolution. The geopressured resource must not be treated in terms of its components and subjected to multiple rules of law.

Potential conflicts arising out of the large subsurface area of the reservoirs also need a forum for resolution, other than the judiciary. Reservoirs cross the jurisdictional lines of various sorts of governmental entities, such as school districts, water districts, cities, counties, and underground water conservation districts. The opportunities for confusion and multiple tax burdens are rife.

Federal Taxation.

The chief problem area with regard to federal taxation is the lack of any clear statutory basis for rational tax planning in the development of the resource. No present federal tax statute comprehends geopressured resources. Case law which led to the depletion provisions contained in the Tax Reduction Act of 1975 is limited to geothermal steam production in The Geysers in California.

There is some persuasive precedent, the Shurbet case, for arguing that geopressured reservoirs should qualify for cost depletion under the provisions covering natural deposits. However, the establishment of any definitive judicial decision represents a costly burden on development and an uncertainty which hinders investment.

Major problems will exist in attempting to qualify geopressure under the Shurbet rule. That case depends on a long production history which shows a decline in the water table. In the case of geopressure, there is no such production history. Furthermore, it is not clear that the water flow will decrease as dramatically as the heat content of the liquids or their pressure content.

A further problem arises out of unresolved taxation rules on the solute natural gas. Present I.R.C. regulations permit different taxation rules to apply to different parts of a resource. Under this rule the solute natural gas would presently be eligible for a 22 percent depletion allowance. While this might envourage investment, in the absence of rational policy planning and amendment of the regulations and code, it has the deleterious impact of treating a common resource as if it were not a system, but rather, only a collection of discrete entities.

RECOMMENDATIONS

This report makes the following specific recommendations in the area of taxation:

1. Legislatures for the respective states should formulate rules and statutes directly applicable to ad valorem and severance taxes on geothermal resources. Such rules should specify the general principles for valuation and timing of application of ad valorem taxes. The laws should also specify the nature of the severance tax and the exact character of the application of the tax to the various different kinds of geothermal energy resources.

2. State legislatures must also resolve jurisdictional problems that arise out of the very large geothermal reservoirs. Such reservoirs will underly many different sorts of taxing entities. Rational development policy would clarify such difficulties and establish a single taxation entity for geothermal resources. Such an entity could then distribute pro rated shares of the taxes to the other taxing entities.

3. The federal government should establish one clear uniform and comprehensive provision to cover all types of geothermal resources. This provision should allow intangible expensing for production and injection wells, as well as other types of surface disposal equipment.

4. The federal government should allow either a cost or a depletion allowance to encourage development of the resource. Such depletion allowances should be tied to reinvestment in the further development of geothermal or renewable energy resources. The provision should also resolve potential conflicts with present taxation rules on natural gas and other entities by providing that such elements in geopressured systems should be taxed as part of the geothermal resource and not as a separate entity.

LEGAL SUPPORT

LEGAL SUPPORT

Summary.

This section summarizes the results of a cursory examination of the technical tasks proposed under Phases 0 and 1. It details some areas where such technical tasks generate a requirement for legal analysis either because they create potential conflicts with regulations or rules, or because they require legal assistance for completion of the outlined work. Four areas of technical work--Resource Utilization, Advanced Research and Technology, Institutional and Environmental, and Resource Utilization--all require such analysis by the Legal Section. Such an analysis was not undertaken in Phase 0.

This section recommends that a detailed funded study be undertaken to identify and plan for such legal work as is required by the technical tasks implemented during Phases 0, 1, and 2.

Introduction.

The Legal Support section of this report is distinguished from Legal Scholarship by virtue of its close and dependent association with the technical tasks within Phase 0 of the project. This is not the same sort of dichotomy as that between abstract and practical because all of the work done in the section on legal scholarship is highly practical in the context of policy planning for resource utilization. The scholarship section will not, however, answer questions about the legal impact of various tasks which the technical planners wish to implement during this project. It is also distinguished by the fact that none of these things have been done at this time but are planned for execution during the next phases of the project.

The Legal Support section is divided into four sections that exactly correspond to the division of labor among the technical tasks. They are Resource Utilization, Advanced Research and Technology, Institutional and Environmental, and Resource Utilization. Each section includes legal tasks that will examine potential obstacles to completion of that task, or potential involvements of that task with governmental regulatory structure (see Figure 1.9). The Legal Section will, in the future, make recommendations and implement procedures designed to assist in the rapid and orderly development of the resource.

PERT CHART: DISCUSSION

The attached PERT Chart (Program Evaluation Review Techniques) is an abbreviated graphic representation of the complex of legal tasks which must be undertaken in order to carry out the policy purposes of the Geopressured-Geothermal Project. It displays two sorts of information: time-dependent linear progression of tasks and interconnection of legal and technical tasks. The analysis which serves as the substrata for the PERT Chart and the chart itself have revealed important but heretofore ignored tasks.

An example of an unidentified task is the apparent necessity for the development of an Environmental Impact Assessment and the possibility that this assessment will lead to an Environmental Impact Statement for both the Well Drilling and Regional Laboratory Tasks in Phases 1 and 2. This requirement will impact allocation of resources within the various phases. It will also substantially alter the schedules. It is likely to impose a public hearing situation on the project.

The PERT Chart also expresses the implied interconnections which were not fully articulated in the Phase 0 proposal. Indeed, many of these interconnections had to wait until implementation had begun in order to become visible. An example of this is the identification of legal, economic, and environmental constraints on the Resource Utilization Task and its development of scenarios.

The PERT Chart carries the display of implied tasks into Phases 1 and 2. An example of this is the impact of the legal environmental analysis on the design of both the test well and the regional lab. The state permitting requirements and the problems of site acquisition are clearly implied by the technical projects. The general legal environmental research can run parallel to the well design and regional lab design, but the specific analysis must wait on the output of the technical tasks.

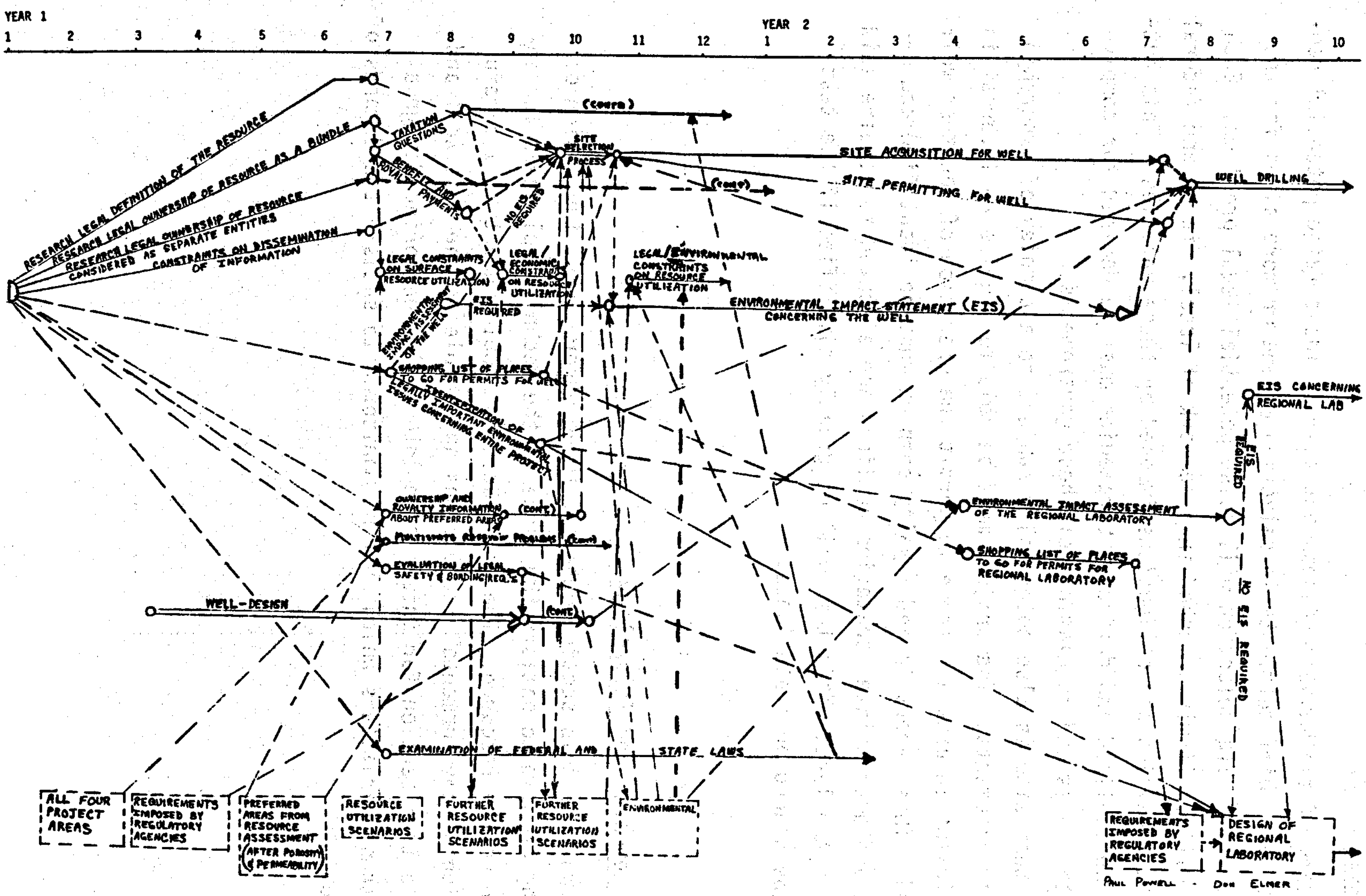


Figure 1.9 PERT chart for sequencing of legal scholarship and support tasks.

Resource Assesment.

The work of the Resource Assessment team in identifying potential geothermal fairways will culminate in selection of one or more sites for the test well. This site selection will raise potential legal problems. Each such site will be firmly enmeshed in a network of local, state, and federal governmental entities and obligations imposed by these entities. This network must be outlined and defined. Strategies must be devised for complying with the rules and regulations of these governments.

Each test site is also potentially subject to a complex of ownership and royalty interests. The project must be able to acquire an interest in land sufficient in area and scope to permit the operation of the test well as planned. This ownership and royalty complex must be identified and delineated, and appropriate strategies outlined and executed to acquire said interest in the land. This task will be greatly simplified if the test site can be placed on state lands.

Advanced Research and Technology.

The work of this section entails, among other tasks, the design of a monitoring program to satisfy the needs of the technical planners for information on the resource. The Legal Section should undertake a careful examination of environmental regulations applicable to the test well and present to this section for integration into their monitoring design a list of those parameters which must be monitored to satisfy the demands of regulation.

Institutional and Environmental.

The institutional tasks undertaken during Phase 0 and those planned for Phase 1 present an opportunity for innovative legal work. An example of this may be found in social and institutional analysis which argues for a greater degree of local control of development of the resource than would normally occur in a situation with outside investors. The Legal Section can provide information on the possibility of municipal operation of a geothermal site to produce fluids for district heating. The Legal Section can uncover other valid mechanisms for implementing the policy articulated by social and institutional research. Local financing of an industrial park centered on a geothermal site is a possibility under Texas law, in spite of constitutional provisions against the lending of credit.

The Institutional Section also proposes to undertake a detailed investigation of regulations which may impact both the test well and the proposed regional laboratory. This task is naturally one in which the Legal Section will participate. Examination of the statutes will not be sufficient to outline the final scope of such regulations. A careful examination of case law and precedent will be necessary.

The Environmental Section has undertaken preliminary establishment of base line information for the geothermal fairways and plans a detailed analysis of the proposed test sites. These technical analyses must be based on the pattern of requirements imposed by state and federal environmental regulations. The information must be arrayed in a fashion that fits the regulations and statutes. Decisions must be reached at certain stages in the planning based on this information.

A typical pattern for a federally sponsored project would entail a detailed site inspection and the generation of an Environmental Impact Assessment. This assessment would be followed either by a Negative Declaration or by the generation of an Environmental Impact Statement. Extraordinary impacts of such a process on project planning and implementation are always a possibility, and the Legal Section has a clear role in planning for and anticipating such results.

Resource Utilization.

Resource Utilization developed options for utilization of the geopressured fluids. These options range from electrical generation to district heating and process heat applications. Each such option has unique legal consequences.

Examples of the differing impacts of these options may be found in taxation. This report suggested earlier that ad valorem taxation may be based on a valuation system that is tied to the use made of the particular reservoir. Each use option will also have different consequences under both state and federal antitrust provisions. An electric utility which plans to produce its own fluids from a geopressured reservoir may come under the provisions of the antitrust statutes. A city which plans to utilize the fluids for district heating and which produces its own fluids, may not.

Recommendations.

This report recommends that a careful study of the proposed work plan for Phase 1 of the Resource Management Project be funded and undertaken. This study would examine the work plan in order to identify those technical tasks that will require legal assistance for their completion, or those tasks which present potential problems under law. This study should culminate in a work plan to complement the technical tasks and support their proposed approaches to their goals. There is a clear need for continuing legal analysis and planning in order to achieve rapid and efficient development of the resource.

NOTES

NOTES

1. Geothermal Steam Act of 1970, 30 U.S.C. sec. 1001 et seq. (1970); Geothermal Resources Act of 1967, CAL. PUB. RESOURCES CODE sec. 6902 et seq. (Supp. 1975). See Table 1.1, infra, State Laws and Regulations Regarding Geothermal Resources (as adapted from a compilation of the same name by Renewable Energy Resources Project, National Conference of State Legislatures, 1975) [hereinafter cited as State Laws Summary].
2. See discussion infra of Geothermal Steam Act of 1970.
3. See discussion infra of CAL. PUB. RESOURCES CODE sec. 6902 et seq. (Supp. 1975).
4. See ORE. REV. STAT. sec. 522.010 et seq. (1971), as amended [1975] Ch. 552, H.B. 2040, Digest of Oregon Laws 1975. See WASH. REV. CODE sec. 79.76.010 et seq. (1974).
5. WASH. REV. CODE secs. 79.76.060, 79.76.100 (1974).
6. Allen, Legal and Policy Aspects of Geothermal Resource Development, 8 WATER RESOURCES BULL. 250, 252 (1972).
7. See generally 78 TECH. REV. 2 at 26-69 (Dec. 1975).
8. Id.; also see SCI. AM. 4 at 44-57, 80-95 (April 1975).
9. Bjorge, The Development of Geothermal Resources and the 1970 Geothermal Steam Act--Law in Search of a Definition, 46 U. COLO. L. REV. 1, 23 (1974).
10. Arthur E. Reich, 52 T.C. 700, 711 (1969), aff'd Reich v. Comm'r, 454 F.2d 1157 (9th Cir. 1972).
11. United States v. Union Oil Co., 369 F. Supp. 1289 (N.D. Calif. 1973), appeal docketed No. 74-1574, 9th Cir., Jan. 11, 1974.
12. Id.
13. Arthur E. Reich, supra note 10, at 711-12.
14. Special statutes focusing on private disputes are discouraged, occasionally by constitutional provisions against special legislation, but they are far from rare.

15. Tax Reduction Act of 1975, Pub. L. No. 94-12, 89 Stat. 26 (codified in scattered sections of 26 U.S.C.), at sec. 501, which modifies 26 U.S.C. sec. 613a Limitations on Percentage Depletion in Case of Oil and Gas Wells (c).

16. See Arthur E. Reich, supra note 10.

17. 30 U.S.C. sec. 1002, see also secs. 1014(c), 1020(b), 1022(b) (1970).

18. There are occasionally holdings that extend definitions into cases that were never covered by the Acts. See, e.g., OP. ATT'Y GEN. OF TEX. M-175 (1967), which classifies ammonia as a hydrocarbon gas for purposes of Railroad Commission regulation pursuant to the pipeline safety act, TEX. REV. CIV. STAT. ANN. art. 6023 (1962).

19. Arthur E. Reich, supra note 10.

20. The heat transfer mechanism may include crustal thinning. See PROCEEDINGS OF THE FIRST GEOPRESSURED GEOTHERMAL ENERGY CONFERENCE 151-52 (R. Deller and M. Dorfman eds. 1975) [hereinafter cited as 1975 PROCEEDINGS].

21. "The release of geothermal energy is more an event or occurrence than a thing." Olpin, The Law of Geothermal Resources, 14 ROCKY MT. MIN. L. INST. 123, 131 (1968).

22. See ORE. REV. STAT. sec. 522.010 et seq. (1971).

23. WASH. REV. CODE sec. 79.76.030 (1974).

24. WASH. REV. CODE sec. 79.76.100 (1974).

25. WASH. REV. CODE sec. 79.76.060 (1974).

26. NEV. REV. STAT. secs. 322.030 -.060 (Supp. 1975).

27. Id.

28. Id.

29. Brief for State of Cal. as Amicus Curiae at 12, United States v. Union Oil Co., 369 F. Supp. 1289 (N.D. Cal. 1973), appeal docketed No. 74-1574, 9th Cir., Jan. 11, 1974; Pariani v. California, No. 657-291 (Super. Ct., City and County of San Francisco, filed May 1974).

30. The Resources Agency had entered this ruling previous to the passage of the Geothermal Resources Act of 1967, in order to bring such wells under the authority of the State Water Board.

31. Brief for State of Cal. as Amicus Curiae, supra note 29.

32. This would fall under the Texas cases concerning drilling by a wrongful claimant. See Right of Way Oil Co. v. Gladys City Oil, Gas & Mfg. Co., 157 S.W. 737 (Tex. 1913), which provides for liability for gross value if the trespass is intentional--and for net value--if it is not intentional. But the burden of proof is on the trespasser. But see Gulf Oil Corp. v. Marathon Oil Co., 152 S.W.2d 711 (Tex. 1941), which holds that if the land is already under lease the lessor is only entitled to his royalty interest under the lease. And see Keeton & Jones, Tort Liability and the Oil and Gas Industry, II, 39 TEXAS L. REV. 253 (1961).

33. See Table 1.1, infra, Louisiana.

34. See Jones, Open Discussion of Session I, in 1975 PROCEEDINGS 96. Eight thousand gas wells were already in the geopressured zone in Louisiana in 1972.

35. Guffey v. Stroud, 16 S.W.2d 527 (Tex. Comm'n App. 1929, opinion adopted).

36. Agagu, Bebout, Dorfman, Regional Sand Distribution of the Frio Formation, South Texas--A Preliminary Step in Prospecting for Geothermal Energy, in 1975 PROCEEDINGS 114.

37. House, Johnson, Towse, Potential Power Generation and Gas Production from Gulf Coast Geopressured Reservoirs, in 1975 PROCEEDINGS 283.

38. See Culberson and McKetta, Phase Equilibria in Hydrocarbon-water Systems III--The Solubility of Methane in Water at Pressures to 10,000 psia, 3 J. PETR. TECH. 223 (1951).

39. M. Dorfman, G. Underhill, Resource Utilization Working Papers, 1975 (unpublished papers delivered at meeting 1975).

40. Jones, Open Discussion of Session I, in 1975 PROCEEDINGS 96; and see FUTURES GROUP, A TECHNOLOGICAL ASSESSMENT OF GEOTHERMAL RESOURCE DE-

VELOPMENT, NSF-RA-X-75-011, 38-41 (April 1975); see also HOUSE COMM. ON SCIENCE AND ASTRONAUTICS, 93d Cong., 2d Sess., REPORT FOR SUBCOMMITTEE ON ENERGY 15-16 (Comm. Print, May 1974) [hereinafter cited as 1974 SUB-COMM. REPORT].

41. P. Kruger (ERDA), Development of the Nation's Geothermal Energy Resources, May 12, 1975 (address at Second Energy Technology Conference, Washington, D.C.). See generally Hearings on H.R. 8628 and H.R. 9658 Before the Subcomm. on Energy of the House Comm. on Science and Astronautics, 93d Cong., 1st Sess., No. 21 at 46-47 (1973) [hereinafter cited as 1973 Hearings].

42. See Toksoz, The Subduction of the Lithosphere, 233 SCI. AM. No. 5 at 89 (Nov. 1975).

43. Jones, supra note 40 at 37, 59, 63, 68, 77-80, 85.

44. Toksoz, supra note 42.

45. Jones, supra note 40; STATE OF CAL., FOURTH PROGRESS REPORT, sec. I, at 11-25, pursuant to S. Res. 301, SENATE FACT-FINDING COMMITTEE ON NATURAL RESOURCES (1967).

46. Toksoz, supra note 42 at 89-91; Jones, supra note 40 at 21-40, 91-94, 149-54.

47. Jones, supra note 40 at 91-94, 149-54.

48. Supra, note 41.

49. 1974 SUBCOMM. REPORT, supra note 40, at 3, 12, 14-18.

50. Note the consistent tendency to regard minerals which are byproducts but which become severed from the heat transfer mediums as part of the mineral estate. See ALASKA STAT. 38.05.181 (1971), secs. (e)(5), (J)(1), (K)(1)(A & B), herein.

51. See CAL. PUB. RESOURCES CODE sec. 3701 (1972).

52. Dorfman, Potential Geothermal Resources in Texas, Tech. Mem. ESL-TM-3, College of Engineering, U. of Tex. at Austin (Dec. 1974).

53. Kruger, supra note 41.

54. CAL. PUB. RESOURCES CODE sec. 3700-76 (1972).

55. Note the omission of waters for commercial or industrial use. Perhaps this distinction arises out of surface estate rights under California water law.

56. See Alaska statute, supra note 50, for similar provisions.

57. Colorado Geothermal Resources Act, COLO. REV. STAT. ANN. sec. 100-10-101 (1963) as amended (Supp. 1974).

58. All new or changed material with reference to the Geothermal Steam Act of 1970, 30 U.S.C. sec. 1001(c), (d) is underlined with a solid line.

59. See Reich, supra note 10.

60. See Reich, supra note 10 at 709. This reading of "steam energy" is given more plausibility by reference to (6)(a)(I) which says ". . . steam, other gases." This is a fairly clear reference to the Reich case, which holds that geothermal steam, in The Geysers, is a gas for the purposes of the depletion sections of the Internal Revenue Code of 1954.

61. Note that pressure is not included here, so that the listed commodities would not be byproducts in the case where the heat content of a geopressured reservoir was not used but the hydraulic head was.

62. But see COLO. REV. STAT. ANN. sec. 112-3-16, royalty provision which lumps geothermal resources with other minerals.

63. See HAWAII REV. LAWS sec. 182-1(3) as amended, Act 241, H.B. No. 2197-74, 7th Legislative Session (1974); U. OF HAWAII, HAWAII GEOTHERMAL PROJECT PRELIMINARY REPORT 20 n.24, 21 n.28 (1974).

64. Bracketed material is taken directly from CAL. PUB. RESOURCES CODE sec. 6903 (1972).

65. Montana uses the phrase "material medium" in its statute where it repeats all of (c). See MONT. REV. CODES ANN. sec. 81-2602 (Supp. 1974). It fails to go on to define "material medium" in the manner of Idaho.

66. See also IDAHO CODE sec. 47-1602 (1972), as it defines geothermal resources for purposes of leases of state land. This section does

not define "material mediums" and corresponds to 4002(c) with the addition of a mineral reservation clause.

67. ". . . if utilized" has two clear potential referents--geothermal resource or byproduct--but the byproducts are part of the resource by virtue of (1)(d)∴ contradiction. ". . . or whose production etc. . . ." has one clear referent--methane--but this is specifically excluded by language earlier in (2). However, see Jones in 1975 PROCEEDINGS 96. There are more than 8,000 natural gas wells in the geopressured zone in Louisiana.

68. Both statutes should include explicit references to geopressured systems and hot rock masses. Remedial amendments for S.B. 420 could strike "dissolved natural gas" in sec. 801(1)(c) or strike "and natural gas" in sec. 801(2) in order to perfect the statute. "If utilized" needs a clearer referent, and lack of legislative history or evidence of legislative intent prevents second-guessing the Louisiana Legislature. H.B. 700 should give clear referents for sec. 681.2(1)(d), "byproducts."

69. a) MONT. REV. CODES ANN. secs. 60-127, 60-144, 145, 148 (Supp. 1975).
    b) MONT. REV. CODES ANN. sec. 81-2601 - 2613 (1974).
    c) Montana Water Act, ch. 452, Mont. Sess. Laws of 1973, apparently repealed at sec. (3) by MONT. REV. CODES ANN. sec. 81-2602 (1974).

70. MONT. REV. CODES ANN. sec. 81-2602(1) (1974).

71. a) NEV. REV. STAT. secs. 322.030 - .060 (1975).
    b) NEV. REV. STAT. Title 48, secs. 2-5 (1975).

72. NEV. REV. STAT. Title 48, sec. 2 pt. 1 (1975); Nev. Ass. B. 158 sec. 4, ch. 266 [1975] amending NEV. REV. STAT. sec. 322.0300.060 (1973).

73. See NEV. REV. STAT. sec. 533.025, surface and ground waters belong to state. NEV. REV. STAT. sec. 534.030, ground waters are public property.

74. a) N.M. STAT. ANN. secs. 65-12-1 to 8 (1975).
    b) N.M. STAT. ANN. secs. 65-11-1 to 24 (1975).
    c) N.M. STAT. ANN. secs. 7-15-1 to 28 (1967).
    d) N.M. STAT. ANN. sec. 63-1-8 (1967).
    e) N.M. STAT. ANN. secs. 65-13-1 to 16 (1975).

75. See Royalties section, N.M. STAT. ANN. sec. 7-15-13 (1967), for provision allowing reinjecting of geothermal resources. The intent seems to be to cover fluids by this provision, but fluids are not included as part of the resource.

76. See N.M. STAT. ANN. sec. 7-15-7(A)(1 & 2) (1967).

77. See N.M. STAT. ANN. secs. 65-11-3(c), 65-11-5(C & D) (1975). See also secs. 65-11-10 & 13, which even retain the phrase "divided mineral ownership."

78. a) ORE. REV. STAT. secs. 522.010 to .090 (1971).
    b) H.B. 2040 (1975).
    c) H.B. 3185 (1975).
    d) H.B. 3324 (Sp. Sess. 1974).

79. ORE. REV. STAT. sec. 522.010(4) (1975); H.B. 3324 sec. 3(2), Ore. Sp. Sess. 1974.

80. Wilson, House, in 1975 PROCEEDINGS 267, 283, 299.

81. House, in 1975 PROCEEDINGS 288, fig. 5.

82. 30 U.S.C. sec. 1001 (1970).

83. See, Moor v. County of Alameda, 411 U.S. 693, 709 (1973); United States v. Stewart, 311 U.S. 60 (1940) for this following principle from Tidewater.

> Words are inexact tools at best . . . and here it is essential that we place the words of a statute in their proper context by resort to legislative history.

Tidewater Oil Co. v. United States, 409 U.S. 151, 157 (1972).

84. 1973 Hearings, supra note 41, at 30-31.

85. Cook, The Depletion of Geologic Resources, 77 TECH. REV. No. 7 at 5-27, esp. 25-27 (June 1975); see also FUTURES GROUP, supra note 40, at 75-76, for discussion of byproducts.

86. United States v. Union Oil Co., supra note 11, is a case where such a try title action is taking place.

87. These are omitted because of the inherent circularity of referent involved in interpreting the statute--both are omitted from f(c)(i).

88. United States v. Union Oil Co., supra note 11.

89. United States v. Union Oil Co., supra note 11, record at 18.

90. United States v. Union Oil Co., supra note 11.

91. This was a trespass to try title or quiet title action undertaken by the United States pursuant to sec. 21(b) of the Geothermal Steam Act of 1970, 30 U.S.C. sec. 1020(b) (1970), which directs the United States Attorney General "to institute an appropriate proceeding in the U.S. District Court . . . to quiet title of the United States in such resources." The title claimed that the mineral reservation clause (sec. 9) of the Stock Raising Homestead Act, 43 U.S.C. sec. 299 (1916), includes "geothermal resources." The total amount of land affected exceeds 35 million acres; see Bjorge, The Development of Geothermal Resources and the 1970 Geothermal Steam Act--Law in Search of Definition, 46 U. COLO. L. REV. 1, 8-24, for a thorough discussion of the case.

92. United States v. Union Oil Co., supra note 11, record at 16.

93. United States v. Union Oil Co., supra note 11, record at 17.

94. United States v. Union Oil Co., supra note 11, record at 18-19.

95. United States v. Union Oil Co., supra note 11, record at 20-21.

96. STATE OF CAL. RESOURCES AGENCY, ENERGY IN CALIFORNIA 38 (Jan. 1973).

97. Letter to Gilmore, 3 CODE CONG. & ADM. NEWS 5126, 91st Cong., 2d Sess. (1970); letter to Capaccioli, supra at 5128; letter to Rep. Aspinall, supra at 5121.

98. 52 T.C. 700 (1969).

99. Arthur E. Reich, 52 T.C. 700, 715 (1969).

100. Reich v. Comm'r, 454 F.2d 1157 (9th Cir. 1972).

101. Arthur E. Reich, supra note 99, at 704.

102. It should be clear that the definition that the state of California urges in Union Oil is derived quite properly from Reich as the latest ruling at that time.

103. Arthur E. Reich, 52 T.C. 700, 709 (1969).

104. _Id._ at 711. INT. REV. CODE OF 1954 secs. 611(a), 613(b)(1).

105. Wilson, in 1975 PROCEEDINGS 271, 273.

106. Pariani v. California, No. 657-291 (Super. Ct., City and County of San Francisco, filed May 1974).

107. Brief for Plaintiff at 2-4, Brief for Defendant at 3-5, _supra_ note 106.

108. Brief for Plaintiff at 10, _supra_ note 106.

109. United States v. Union Oil Co., _supra_ note 11, record at 18.

110. _See_ 1974 SUBCOMM. REPORT, _supra_ note 40, at 14-18.

111. However, see 208 POP. SCI. No. 1 at 55 (Jan. 1976), for an example of the use of low-grade heat ("geothermal heat") of the _normal_ thermal gradient used to de-ice highways. Does this qualify as a geothermal energy resource? It probably should not since it is a feature of all soils in areas outside of the polar regions.

112. BLACK'S LAW DICTIONARY 453 (4th ed. 1951). _See_ Pyramid Coal Corp. v. Pratt, 229 Ind. 648, 652, 99 N.E.2d 427, 429 (1951) citing Keiper v. Klien, 51 Ind. 316, 323 (1875).

113. _See generally_ Thornburg v. Port of Portland, 233 Or. 178, 376 P.2d 100 (1962).

114. _See_ Westmoreland & Cambria Natural Gas Co. v. DeWitt, 130 Pa. 235, 18 A. 724 (1889); Townsend v. State, 147 Ind. 624, 47 N.E. 19 (1897), where the courts applied rules derived from feudal law on wild birds and animals--_ferriae anima_.

115. _See_, however, economic analysis in other volumes of this report.

116. _See_ Prairie Oil & Gas Co. v. State, 231 S.W. 1088 (Tex. Comm'n App. 1929), defining the Rule of Capture as meaning the owner of a piece of land owns all oil and gas produced from wells on that land regardless of the origin of said oil or gas. And _see_ Stephens County v. Mid-Kansas Oil & Gas Co., 254 S.W. 290 (Tex. 1923), which defines

the concept of ownership in place, which gives the surface owner title to all underlying oil and gas, the same as for other minerals.

117. Olpin, The Law of Geothermal Resources, 14 ROCKY MT. MIN. L. INST. 123, 131 (1968), citing WILLIAMS & MEYERS, OIL & GAS LAW sec. 204.9 (1964).

118. See IDAHO CODE sec. 42-4001 (Supp. 1974); MONT. REV. CODES ANN. sec. 81-2601 (1974); WASH. REV. CODE sec. 79.76.010 et seq. (1974).

119. TEX. REV. CIV. STAT. ANN. art. 5421s; LA. REV. STAT. secs. 30.681.1-5, 30.800-08 (1975).

120. LA. REV. STAT. sec. 30.808.

121. Another hint is the fact that the proposed new statewide rules for the Railroad Commission on oil/gas/geothermal simply insert the phrase "geothermal" into the former statewide rules without any other substantial change.

122. "It cannot be contended . . . that when a legislature has defined by statute an otherwise ambiguous term as it relates to matters affecting state lands that the statutory definition will likewise apply to contracts and conveyances between private parties who use the same words." Holland, Is Helium Covered by Oil and Gas Leases?, 41 TEXAS L. REV. 408, 412-13 (1963).

123. TEX. CONST. art. I sec. 16, e.g. Turberville v. Gowdy, 272 S.W. 559 (Tex. Civ. App.--Fort Worth 1925, no writ); McCain v. Yost, 155 Tex. 174, 284 S.W.2d 898 (1955); McGinley v. McGinley, 295 S.W.2d 913 (Tex. Civ. App.--Galveston 1956, no writ).

124. International Security Life Insurance Co. v. Maas, 458 S.W.2d 484 (Tex. Civ. App.--Houston [1st Dist.] 1970, writ ref'd n.r.e.).

125. U.S. CONST. art. I, sec. 10.

126. See Boyd, Legal Aspects of State Owned Oil and Gas Energy Resources, L/R 5, Texas Governor's Energy Advisory ouncil, pt. II, at 42-44 (1974), which describes the large role the Land Commissioner plays in management of Relinquishment Act lands, including the right to forfeit the lease and agency.

127. Railroad Comm'n v. Austin, 524 S.W.2d 262, 267-68 (Tex. 1975).

128. See IDAHO CODE sec. 42-4001 (Supp. 1974); MONT. REV. CODES ANN. sec. 81-2601 (1974); WASH. REV. CODE sec. 79.76.010 et seq. (1974).

129. See HAWAII REV. LAWS sec. 182.1 as amended Act 241, H.B. No. 2197-74, Seventh State Legislative Session (1974).

130. ORE. REV. STAT. sec. 215.213 (1973) as amended [1975] Ch. 552, H.B. 2040, Digest of Oregon Laws (1975).

131. Sun Oil v. Whitaker, 483 S.W.2d 808 (Tex. 1972); Stradley v. Magnolia Petroleum, 155 S.W.2d 649 (Tex. Civ. App.--Amarillo 1949, writ ref'd).

132. At least according to the dominant political structural myths, the legislature makes "policy" decisions and the courts simply implement the law. This attitude is probably unrealistic and simplistic, but it is firmly embedded in doctrines of legislative intent.

133. See Olpin, supra note 21 at 128-30. See also Levy, Realistic Jurisprudence and Prospective Overruling, 109 U. PA. L. REV. 1 (1960).

134. See Dorfman, Oral Presentation in App.

135. See Underhill, Model Resource in App. See also Olpin, supra note 21 at 130-31.

136. See Bjorge, supra note 9 at 21-24.

137. "It must be realized that in . . . law . . . the easy path is to copy the conceptualism and decisions of others without much probing," Cohen, Property Theories Affecting the Landowner in a New Oil and Gas State, 10 U. ALA. L. REV. 323 (1958).

138. Kuntz, The Law Relating to Oil and Gas in Wyoming, 3 WYO. L. REV. 107, 112-13 (1949).

139. Pariani v. California, supra note 106, record at 18.

140. See Fleming Foundation v. Texaco, Inc., 337 S.W.2d 846, 851-52 (Tex. Civ. App.--Amarillo 1960, writ ref'd n.r.e.).

141. Texas has consistently held that coal does not pass under an oil and gas lease precisely because the use of the surface estate is so vastly different from that recognized by lessor/lessee in oil and gas leases. See Acker v. Guinn, 464 S.W.2d 348, 352 (Tex. 1971).

142. Brief for Defendant at 28, Pariani v. California, supra note 106.

143. They fail to distinguish the extraordinary enthalpy of geothermal systems that make such systems available to do work.

144. See Banbauer v. Menjoulet, 214 Cal. App. 2d 871, 873 (1963) as cited in Brief for Defendant at 13, Pariani v. California, supra note 106. See also State ex rel. State Highway Comm'n v. Trujillo, 82 N.M. 694, 487 P.2d 122 (1971).

145. See generally Texas General Land Office, HISTORY AND DISPOSITION OF THE TEXAS PUBLIC DOMAIN (1942); STORY OF TEXAS PUBLIC LANDS (1973).

146. See TEX. REV. CIV. STAT. ANN. arts. 5367-5379 (1962) for the 1919 Act; TEX. REV. CIV. STAT. ANN. art. 5368a (1962) for the 1931 Act.

147. Most Relinquishment Act lands are in West Texas and would not involve areas with geopressured resources. See Walker, The Texas Relinquishment Act, SW. LEGAL FOUNDATION 1st INST. ON OIL & GAS LAW & TAX 245, 247 n.117 (1949).

148. See TEX. CONST. art. VII secs. 2, 11; TEX. REV. CIV. STAT. ANN. art. 5367-79 (1962).

149. See Edwards, Impact of State and Federal Law on the Development of Geothermal Resources in Texas, L/R 9, Texas Governor's Energy Advisory Council, 307 (1974), which this section closely tracks [hereinafter cited as L/R 9].

150. See TEX. WATER CODE ANN. sec. 5.021 (1972).

151. See Motl v. Boyd, 116 Tex. 82, 286 S.W. 458 (1926).

152. See L/R 9, supra note 149; TEX. WATER CODE ANN. secs. 5.023, .025, .026, .030 (1972).

153. See L/R 9, supra note 149; W. HUTCHINS, THE TEXAS LAW OF WATER RIGHTS (1961).

154. TEX. WATER CODE ANN. secs. 5.339, 21.004, 52.002-3 (1972).

155. Texas Co. v. Burkett, 117 Tex. 16, 296 S.W. 273 (1927); Evans v. Ropte, 128 Tex. 75, 96 S.W.2d 973 (Tex. Comm'n App. 1936, opinion adopted).

156. See Corpus Christi v. Pleasanton, 154 Tex. 289, 276 S.W.2d 798 (1955). The Texas Supreme Court held that the permitting article, TEX. REV. CIV. STAT. ANN. art. 7602 (1962) later TEX. WATER CODE ANN. sec. 5.205 (1972), limited only unlawful production. See L/R 9, supra note 149. See also Acton v. Blundell, 112 M & W 324, 152 Eng. Rep. 1223 (Ex. 1843); Houston & T.C. Ry. Co. v. East, 98 Tex. 146, 81 S.W. 279 (1904).

157. 501 S.W.2d 865 (Tex. 1973).

158. Note, Robinson v. Robbins, 42 TEXAS L. REV. 781 (1974); Hudson, Salt Water Is a Mineral: Ownership of a Natural Resource, 50 TEXAS L. REV. 488 (1972). Hudson must be unhappy with this ruling.

159. See a) Williams v. Pipe Traders Indus. Prop. of Ariz., 409 P.2d 720 (Ariz. 1966), heat is a transfer medium.

b) Bristol v. Municipal Light, 200 N.E. 260 (Mass. 1964); Seaton Mt. Electric, Light, Heat, Power v. Idaho Springs Co., 111 P. 834 (Colo. 1910), technical descriptions of steam heat.

c) Detroit Edison Co. v. State, 298 Mich. 259, 298 N.W. 525 (1941), plaintiff contends sale of steam heat is sale of heat, but court disagrees, says sale is of steam. And see State ex rel. Wash. Univ. v. Pub. Serv. Comm'n, 272 S.W. 971 (Mo. 1925) to the same effect.

d) Reynolds v. Wash. Real Estate (S. Ct. R.I. 1901), discusses relationship of pressure of steam to contract for "power." And see Reiss v. N.Y. Steam, 128 N.Y. 103, 28 N.E. 24 (1891); Roddy v. U.S. Fidelity, 288 F. Supp. 315 (1968); Beunk v. Valley City Desk Co., 128 Mich. 562, 87 N.W. 793 (1901); Muller v. A.B. Kirschbaum Co., 148 A. 851 (Pa. 1930); 21 A.L.R. 664 (1920); 26 A.L.R.2d 129 (1950).

160. See Cohen, supra note 137, at 336-37 for an example of such analysis.

161. See Burnham v. Hardy Oil Co., 147 S.W. 330 (Tex. Civ. App.--1912); Murphy v. Benson, 245 S.W. 249 (Tex. Civ. App.--1922); Jenkins v. Pure

Oil Co., 53 S.W.2d 497 (Tex. Civ. App.--1932); Greer v. Stanolind Oil & Gas Co., 200 F.2d 920 (10th Cir. 1952). And see Guffey v. Stroud, 16 S.W.2d 527 (Tex. Comm'n App.--1929, opinion adopted).

162. See Sun Oil v. Whitaker, 483 S.W.2d 808 (Tex. 1972); also Stradley v. Magnolia Petroleum, 155 S.W.2d 649 (Tex. Civ. App.--Amarillo 1944, writ ref'd). See Guffey v. Stroud, supra note 161, for discussion of accounting. See also L/R 9, supra note 151 at 16-17, for discussion drawing opposite conclusion.

163. See CAL. PUB. RESOURCES CODE sec. 3742.2 (1967), and similar passages in statutes of other states.

164. See TEX. REV. CIV. STAT. ANN. arts. 5415, 5415a (1962).

165. See Outer Continental Shelf Lands Act, 43 U.S.C. sec. 1331 et seq. (1970); Submerged Lands Act, 43 U.S.C. sec. 1301 et seq. (1970).

166. 363 U.S. 1 (1960).

167. See TEX. REV. CIV. STAT. ANN. art. 5421s secs. 4, 5 (1975).

168. LA. REV. STAT. secs. 30.802, 803, 807 (1975).

169. N.M. STAT. ANN. secs. 65-11-2 (1975), 7-15-5 (1967).

170. 30 U.S.C. secs. 1002, 1023 (1970).

171. See 1973 Hearings, supra note 41, at 175.

172. U.S. CONST. art. VI, cl. 2.

173. "This Constitution, and the Laws of the United States which shall be made in Pursuance thereof; and all Treaties made, or which shall be made, under the Authority of the United States, shall be the Supreme Law of the Land" (U.S. CONST. art. VI).

174. See Coastal Zone Management Act, 16 U.S.C. secs. 1451-64 (1973). See National Environmental Policy Act of 1969, 42 U.S.C. sec. 4332(2)(c) (1970), "significantly affecting . . . the environment." See Comment, 87 HARV. L. REV. 1050 (1974).

175. See Natural Resources Defense Council, Inc. v. Morton, 458 F.2d 827 (D.C. Cir. 1972).

176. See also Scientists' Institute for Public Information v. AEC, 481 F.2d 1079 (D.C. Cir. 1973); Comment, 87 HARV. L. REV. 1050 (1974).

177. Allen, Legal and Policy Aspects of Geothermal Resource Development, 8 WATER RESOURCES BULL. 250, 254 (1972).

178. U.S. CONST. art. I, sec. 8.

179. See Grad, Federal-State Compact: A New Experiment in Co-Operative Federalism, 63 COLUM. L. REV. 825 (1963), which discusses the Delaware River Basin Compact in which the United States is a full participant.

180. See N.M. STAT. ANN. sec. 65-13-8 (1975); IDAHO CODE sec. 42-4010(h) (1972). See also 43 U.S.C. sec. 1334(a)(1) which directs the Secretary of the Interior to cooperate with state conservation agencies.

181. TAX FOUNDATION, INC., Facts and Figures on Government Finance 14 (1971).

182. Yudof, The Property Tax in Texas, 51 TEXAS L. REV. 885, 888 n.22 (1973).

183. The state utility commission has allowed the company to charge on the books as if it were buying fuel oil or natural gas of equivalent Btu value.

184. TEX. TAX.--GEN. ANN. arts. 3.01, 4.02.

185. See McDonald, Distinctive Tax Treatment of Income from Oil and Gas Production, 10 NAT. RESOURCES L.J. 100 (1970).

186. See Arthur E. Reich, supra note 10 at 715. See Eisenstat, Tax Treatment of Exploring and Developing Geothermal Resources, 22 OIL & GAS TAX Q. 76, 80 (Sept. 1973).

187. Calculations indicate that the 22% deduction is really equal to 15% depreciation. See Olpin, supra note 21, for an excellent though dated discussion of tax problems.

188. See Eisenstat, Reducing the Risks in Geothermal Exploration: A Tax Update, 3 GEOTH. ENERGY MAG. No. 5 at 93 (May 1975).

189. 28 T.C. 797 (1969).

190. "Thus, the pressure decline in the 32-year period from 1926 through 1957, the date when commercial operations began, was at least 20 pounds per square inch." ". . . [D]uring this 11-year period [1957-1967] there was a (further) decline in static pressure . . . of 50 pounds per square inch." Arthur E. Reich, _supra_ note 10, at 704.

191. United States v. Shurbet, 347 F.2d 103 (5th Cir. 1965) _aff'g_ Shurbet v. United States, 242 F. Supp. 736 (N.D. Tex. 1961). Also, _see_ Olpin, _supra_ note 21, for discussion. And _see_ Don C. Day, 54 T.C. 1417 (1970).

192. United States v. Shurbet, _supra_ note 191, at 109. And _see_ 26 C.F.R. 1.611.2; Rev. Rul. 65-296, 1965-2 CUM. BULL. 181.

193. Shurbet v. United States, 242 F. Supp. 736, 742 sec. 5.13(d) (1961).

194. _Id_. at 743 secs. 5.15(d), 5.16(d).

195. _Id_. at 744 sec. 5.18(a-d).

196. _Id_. at 744 sec. 5.20(a), (b).

197. _Id_. at 744 sec. 5.20(c).

198. _Id_. at 744 sec. VI, 6.01.

199. United States v. Shurbet, _supra_ note 191, at 107[2].

200. _Id_. at 108[4].

201. _Id_.; Flona Corp. v. United States, 218 F. Supp. 354, 356 (S.D. Fla. 1963), _appeal docketed_ No. 20981, _appeal dismissed per curiam_ (April 14, 1964).

202. United States v. Shurbet, _supra_ note 191, at 108[5].

203. Treas. Reg. sec. 1.611-1(d)(5) (1973).

204. United States v. Shurbet, _supra_ note 191, at 104.

205. Shurbet v. United States, _supra_ note 193, at 738 secs. II, III, for argument that water--for irrigation--was the value of the reservoir.

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ACKNOWLEDGMENTS

The authors wish to thank Katie Nesbitt, Don Peters, and D. Cheryl Wilkins, who expended great effort on editing this material; and Maxine Fowler, Linda Davis, Kathryn Hughes, Karen Burk, Jacquelin Cobb, and others who typed it.

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APPENDIX

POTENTIAL GEOTHERMAL RESOURCES IN TEXAS

(Oral Presentation)*

Myron Dorfman

The Gulf Coast Geothermal Sands

Unlike the other two systems already discussed, which depend upon high heat flow at shallow depth, the Gulf Coast geothermal sands develop at moderate to great depth. Due to a unique combination of factors involving the accumulation and compaction of great quantities of sands and muds in the Texas Gulf Coast area, overpressured aquifers, usually referred to as geopressured zones, have been created. The waters in these zones possess abnormally high temperatures. In Texas the principal geothermal zones are long, linear, high-volume aquifers extending from Laredo to Beaumont. They occur in successive parallel bands southward into the Gulf of Mexico. The top of the zone begins at depths of about 8,000 feet to 10,000 feet, and temperatures as high as 520^{o}F. have been recorded in Matagorda County, Texas. These abnormally pressurized geothermal zones have usually been considered a nuisance while drilling for petroleum. However, future research may prove that they are more widespread than petroleum and perhaps as valuable. The very high temperature waters are essentially fresh water, with salinities as low as 1,000 ppm. This compares favorably with city water in Austin, Texas. Upon reaching atmospheric conditions a portion of the water will flash to steam which can be used to generate electric power. Present technology is available to allow us to drill for and produce this water by processes that are standard in the petroleum industry. In addition, observations have indicated that Gulf Coast geothermal waters contain significant quantities of natural gas in solution. This natural gas will also be released at surface conditions and can be separated from the other fluids and added to our present supply of this valuable fuel. Laboratory studies indicate that approximately 40 cubic feet of natural gas may be dissolved in each barrel of water.

*Federal Energy Administration, Houston, Texas, September 16-19, 1974.

This means that production of every 50,000 bbl. of geothermal water will release 2 MMcf of natural gas. In addition, after extraction of heat from the geothermal fluids, the comparatively fresh water can be used for irrigation or consumption in the arid areas of the Valley in South Texas. Preliminary calculations indicate that the major Gulf Coast geothermal sands have the capability of producing at least 22,000 mw. of power for 50 years along coastal Texas. Independent studies in progress by U.S. Geological Survey scientists suggest that reserves for the generation of electricity may be twice this figure. What is needed now is a rapid research program to demonstrate the feasibility of this resource.

RESOURCE MODEL EMPLOYED BY GARY K. UNDERHILL FOR THE RESOURCE UTILIZATION SECTION OF PHASE 0 STUDY

Well Head Conditions:

Pressure	=	2,000 psia	Flow	=	40,000 BBL/D (per well)
Temperature	=	325°F			
Gas Content	=	40 SCF/BBL	Salinity	≅	10,000 ppm TDS

Plant Fence Conditions:

Pressure	=	300 psia	Flow	≅	40,000 BBL/D (per well)
Temperature	=	320°F			
Gas Content	≅	3 SCF/BBL	Salinity	≅	10,000 ppm

Reinjection Conditions:

Pressure	=	300 psia	Flow	≤	40,000 BBL/D (per well)

(Pressure head required for other uses supplied by that user.)

Salinity Profile:

Silica	~ 550 ppm (Saturated)
Na^+	3,500
Cl^-	5,000
HCO_3^-	1,000
$SO_4^=$	75
K^+	50
Mg^{++}	25
I^-	15
Li^+	7
Rb^+	0.7

EXCERPTS FROM

FEDERAL INCOME TAX REGULATIONS: INTANGIBLE DRILLING AND DEVELOPMENT COSTS: SECTION 1.263(c)

SEC. 263. CAPITAL EXPENDITURES.

(a) General Rule.—No deduction shall be allowed for—

(1) Any amount paid out for new buildings or for permanent improvements or betterments made to increase the value of any property or estate. This paragraph shall not apply to—

(A) expenditures for the development of mines or deposits deductible under section 616,

——— o ———

(c) Intangible Drilling and Development Costs in the Case of Oil and Gas Wells.—Notwithstanding subsection (a), regulations shall be prescribed by the Secretary or his delegate under this subtitle corresponding to the regulations which granted the option to deduct as expenses intangible drilling and development costs in the case of oil and gas wells and which were recognized and approved by the Congress in House Concurrent Resolution 50, Seventy-ninth Congress.

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§ 1.263(c)-1 (T.D. 6313, filed 9-16-58: republished in T.D. 6500, filed 11-25-60.) Intangible drilling and development costs in the case of oil and gas wells.

For rules relating to the option to deduct as expenses intangible drilling and development costs in the case of oil and gas wells, see § 1.612-4.

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§ 1.612-4 (T.D. 6836, filed 7-14-65.) Charges to capital and to expense in case of oil and gas wells.

(a) *Option with respect to intangible drilling and development costs.* In accordance with the provisions of section 263 (c), intangible drilling and development costs incurred by an operator (one who holds a working or operating interest in any tract or parcel of land either as a fee owner or under a lease or any other form of contract granting working or operating rights) in the development of oil and gas properties may at his option be chargeable to capital or to expense. This option applies to all

expenditures made by an operator for wages, fuel, repairs, hauling, supplies, etc., incident to and necessary for the drilling of wells and the preparation of wells for the production of oil or gas. Such expenditures have for convenience been termed intangible drilling and development costs. They include the cost to operators of any drilling or development work (excluding amounts payable only out of production or gross or net proceeds from production, if such amounts are depletable income to the recipient, and amounts properly allocable to cost of depreciable property) done for them by contractors under any form of contract, including turnkey contracts. Examples of items to which this option applies are, all amounts paid for labor, fuel, repairs, hauling, and supplies, or any of them, which are used—

(1) In the drilling, shooting, and cleaning of wells,

(2) In such clearing of ground, draining, road making, surveying, and geological works as are necessary in preparation for the drilling of wells, and

(3) In the construction of such derricks, tanks, pipelines, and other physical structures as are necessary for the drilling of wells and the preparation of wells for the production of oil or gas.

In general, this option applies only to expenditures for those drilling and developing items which in themselves do not have a salvage value. For the purpose of this option, labor, fuel, repairs, hauling, supplies, etc., are not considered as having a salvage value, even though used in connection with the installation of physical property which has a salvage value. Included in this option are all costs of drilling and development undertaken (directly or through a contract) by an operator of an oil and gas property whether incurred by him prior or subsequent to the formal grant or assignment to him of operating rights (a leasehold interest, or other form of operating rights, or working interest); except that in any case where any drilling or development project is undertaken for the grant or assignment of a fraction of the operating rights, only that part of the costs thereof which is attributable to such fractional interest is within this option. In the excepted cases, costs of the project undertaken, including depreciable equipment furnished, to the extent allocable to fractions of the operating rights held by others, must be capitalized as the depletable capital cost of the fractional interest thus acquired.

(b) *Recovery of optional items, if capitalized.* (1) Items returnable through depletion: If the taxpayer charges such expenditures as fall within the option to capital account, the amounts so capitalized and not deducted as a loss are returnable through depletion insofar as they are not represented by physical property. For the purposes of this section the expenditures for clearing ground, draining, road making, surveying, geological work, excavation, grading, and the drilling, shooting, and cleaning of wells, are considered not to be represented by physical property, and when charged to capital account are returnable through depletion.

(2) Items returnable through depreciation: If the taxpayer charges such expenditures as fall within the option to capi-

tal account, the amounts so capitalized and not deducted as a loss are returnable through depreciation insofar as they are represented by physical property. Such expenditures are amounts paid for wages, fuel, repairs, hauling, supplies, etc., used in the installation of casing and equipment and in the construction on the property of derricks and other physical structures.

(3) In the case of capitalized intangible drilling and development costs incurred under a contract, such costs shall be allocated between the foregoing classes of items specified in subparagraphs (1) and (2) for the purpose of determining the depletion and depreciation allowances.

(4) Option with respect to cost of nonproductive wells: If the operator has elected to capitalize intangible drilling and development costs, then an additional option is accorded with respect to intangible drilling and development costs incurred in drilling a nonproductive well. Such costs incurred in drilling a nonproductive well may be deducted by the taxpayer as an ordinary loss provided a proper election is made in the return for the first taxable year beginning after December 31, 1942, in which such a nonproductive well is completed. Such election with respect to intangible drilling and development costs of nonproductive wells is a new election, and, when made, shall be binding for all subsequent years. Any taxpayer who incurs optional drilling and development costs in drilling a nonproductive well must make a clear statement of election under this option in the return for the first taxable year beginning after December 31, 1942, in which such nonproductive well is completed. The absence of a clear indication in such return of an election to deduct as ordinary losses intangible drilling and development costs of nonproductive wells shall be deemed to be an election to recover such costs through depletion to the extent that they are not represented by physical property, and through depreciation to the extent that they are represented by physical property.

(c) *Nonoptional items distinguished.* (1) Capital items: The option with respect to intangible drilling and development costs does not apply to expenditures by which the taxpayer acquires tangible property ordinarily considered as having a salvage value. Examples of such items are the costs of the actual materials in those structures which are constructed in the wells and on the property, and the cost of drilling tools, pipe, casing, tubing, tanks, engines, boilers, machines, etc. The option does not apply to any expenditure for wages, fuel, repairs, hauling, supplies, etc., in connection with equipment, facilities, or structures, not incident to or necessary for the drilling of wells, such as structures for storing or treating oil or gas. These are capital items and are returnable through depreciation.

(2) Expense items: Expenditures which must be charged off as expense, regardless of the option provided by this section, are those for labor, fuel, repairs, hauling, supplies, etc., in connection with the operation of the wells and of other facilities on the property for the production of oil and gas.

(d) *Manner of making election.* The option granted in paragraph (a) of this section to charge intangible drilling and development costs to expense may be exercised by claiming intangible drilling and development costs as a deduction on the taxpayer's return for the first taxable year in which the taxpayer pays or incurs such costs; no formal statement is necessary. If the taxpayer fails to deduct such costs as expenses in such return, he shall be deemed to have elected to recover such costs through depletion to the extent that they are not represented by physical property, and through depreciation to the extent that they are represented by physical property.

(e) *Effect of option and election.* This section does not grant a new option under paragraph (a) of this section or new election under paragraph (b) of this section. Section 3 of the Act of October 23, 1962 (Public Law 87-863, 76 Stat. 1142) granted any taxpayer who had exercised an option to capitalize intangible drilling and development costs under Regulation 111, § 29.23(m)-16 (1939 Code) or Regulation 118, § 39.23 (m)-16 (1939 Code) a new option for the first taxable year ending after October 22, 1962, to deduct such costs as expenses. Unless he has exercised the new option granted by such Act, any taxpayer who exercised an option or made an election under the regulations described in the preceding sentence is, by such option or election, bound with respect to all intangible drilling and development costs (whether made before January 1, 1954, or after December 31, 1953) in connection with oil and gas properties. See section 7807(b)(2). Any taxpayer who has not made intangible drilling and development expenditures in any taxable year beginning after December 31, 1942, prior to his first taxable year beginning after December 31, 1953, and ending after August 16, 1954, must exercise the option granted in paragraph (a) of this section in the return for the first taxable year in which the taxpayer pays or incurs such expenditures. If such return is required by law (including extensions thereof) to be filed before November 1, 1965, the option under paragraph (a) of this section, or the election under paragraph (b) of this section, may be exercised or changed not later than November 1, 1965. The exercise of or change in such option or election shall be effective with respect to the earliest taxable year to which the option or election is applicable in respect of which assessment of a deficiency or credit or refund of an overpayment, as the case may be, resulting from such exercise or change is not prevented by any law or rule of law on the date such option is exercised or such election is made. Any such option or election shall be binding upon the taxpayer for the first taxable year for which it is effective and for all subsequent taxable years.

INTERNAL REVENUE CODE OF 1954:

SECTIONS 611, 612, 613

DEPLETION ALLOWANCES

SEC. 611. ALLOWANCE OF DEDUCTION FOR DEPLETION.

(a) General Rule.—In the case of mines, oil and gas wells, other natural deposits, and timber, there shall be allowed as a deduction in computing taxable income a reasonable allowance for depletion and for depreciation of improvements, according to the peculiar conditions in each case; such reasonable allowance in all cases to be made under regulations prescribed by the Secretary or his delegate. For purposes of this part, the term "mines" includes deposits of waste or residue, the extraction of ores or minerals from which is treated as mining under section 613(c). In any case in which it is ascertained as a result of operations or of development work that the recoverable units are greater or less than the prior estimate thereof, then such prior estimate (but not the basis for depletion) shall be revised and the allowance under this section for subsequent taxable years shall be based on such revised estimate.

(b) Special Rules.—

(1) Leases.—In the case of a lease, the deduction under this section shall be equitably apportioned between the lessor and lessee.

(2) Life tenant and remainderman.—In the case of property held by one person for life with remainder to another person, the deduction under this section shall be computed as if the life tenant were the absolute owner of the property and shall be allowed to the life tenant.

(3) Property held in trust.—In the case of property held in trust, the deduction under this section shall be apportioned between the income beneficiaries and the trustee in accordance with the pertinent provisions of the instrument creating the trust, or in the absence of such provisions, on the basis of the trust income allocable to each.

(4) Property held by estate.—In the case of an estate, the deduction under this section shall be apportioned between the estate and the heirs, legatees, and devisees on the basis of the income of the estate allocable to each.

Last amendment.—Sec. 611(b)(4) appears above as amended by Sec. 35 of Public Law 85-866, Sept. 2, 1958 (qualified effective date rule in Sec. 1(c)(1) of Public Law 85-866, Sept. 2, 1958). Sec. 611(b)(4) as it read before this amendment is in P-H Cumulative Changes.

(c) Cross Reference.—

For other rules applicable to depreciation of improvements, see section 167.

SEC. 612. BASIS FOR COST DEPLETION.

Except as otherwise provided in this subchapter, the basis on which depletion is to be allowed in respect of any property shall be the adjusted basis provided in section 1011 for the purpose of determining the gain upon the sale or other disposition of such property.

SEC. 613. PERCENTAGE DEPLETION.

(a) **General Rule.**—In the case of the mines, wells, and other natural deposits listed in subsection (b), the allowance for depletion under section 611 shall be the percentage, specified in subsection (b), of the gross income from the property excluding from such gross income an amount equal to any rents or royalties paid or incurred by the taxpayer in respect of the property. Such allowance shall not exceed 50 percent of the taxpayer's taxable income from the property (computed without allowance for depletion). For purposes of the preceding sentence, the allowable deductions taken into account with respect to expenses of mining in computing the taxable income from the property shall be decreased by an amount equal to so much of any gain which (1) is treated under section 1245 (relating to gain from disposition of certain depreciable property) as gain from the sale or exchange of property which is neither a capital asset nor property described in section 1231, and (2) is properly allocable to the property. In no case shall the allowance for depletion under section 611 be less than it would be if computed without reference to this section.

Last amendment.—Sec. 613(a) appears above as amended by Sec. 13(e) of Public Law 87-834, Oct. 16, 1962, effective (Sec. 13(g) of Public Law 87-834, Oct. 16, 1962) for taxable years beginning after Dec. 31, 1962. Sec. 613(a) as it read before this amendment is in P-H Cumulative Changes.

(b) **Percentage Depletion Rates.**—The mines, wells, and other natural deposits, and the percentages, referred to in subsection (a) are as follows:

(1) 22 Percent—

(A) sulphur and uranium; and

(B) if from deposits in the United States—anorthosite, clay, laterite, and nephelite syenite (to the extent that alumina and aluminum compounds are extracted therefrom), asbestos, bauxite, celestite, chromite, corundum, fluorspar, graphite, ilmenite, kyanite, mica, olivine, quartz crystals (radio grade), rutile, block steatite talc, and zircon, and ores of the following metals: antimony, beryllium, bismuth, cadmium, cobalt, columbium, lead, lithium, manganese, mercury, molybdenum, nickel, platinum and platinum group metals, tantalum, thorium, tin, titanium, tungsten, vanadium, and zinc.

Last amendment.—Sec. 613(b)(1) appears above as amended by Sec. 501(b)(2)(A) of Public Law 94-12, Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974.

Prior amendment.—Sec. 613(b)(1) was previously amended by Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969. Sec. 613(b)(1) as so amended is in P-H Cumulative Changes.

(2) 15 Percent—if from deposits in the United States—

(A) gold, silver, copper, and iron ore, and

(B) oil shale (except shale described in paragraph (5)).

Last amendment.—Sec. 613(b)(2) appears above as amended by Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969.

Prior amendments.—Sec. 613(b)(2) was previously amended by the following:

Sec. 207(a)(1) of Public Law 89-809, Nov. 13, 1966, Effective (Sec. 207(b) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.*

6(a) of Public Law 88-571, Sept. 2, 1964, effective (Sec. 6(b) of Public Law 88-571, Sept. 2, 1964) for taxable years beginning after Dec. 31, 1963.*

* Sec. 613(b)(2) as so amended is in P-H Cumulative Changes.

(3) 14 Percent—

(A) metal mines (if paragraph (1)(B) or (2)(A) does not apply), rock asphalt, and vermiculite; and

(B) if paragraph (1)(B), (5), or (6)(B) does not apply, ball clay, bentonite, china clay, sagger clay, and clay used or sold for use for purposes dependent on its refractory properties.

Last amendment.—Sec. 613(b)(3) appears above as amended by Sec. 501(b)(2)(B) of Public Law 94-12, Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974.

Prior amendment.—Sec. 613(b)(3) was previously amended by:

Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969.*

Sec. 207(a)(2) and 209(a)(2) of Public Law 89-809, Nov. 13, 1966, effective (Sec. 207 (b) and Sec. 209(c) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.*

Sec. 302(a)(1) of Public Law 86-564, June 30, 1960 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960, which amended Sec. 302(c) of Public Law 86-564, June 30, 1960).*

* Sec. 613(b)(3) as so amended is in P-H Cumulative Changes.

(4) 10 percent—asbestos (if paragraph (1)(B) does not apply), brucite, coal, lignite, perlite, sodium chloride, and wollastonite.

Last amendment.—Sec. 613(b)(4) appears above as amended by Sec. 501(b)(2)(B) of Public Law 94-12, Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974.

Prior amendment.—Sec. 613(b)(4) was previously amended by Sec. 510(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969. Sec. 613(b)(4) as so amended is in P-H Cumulative Changes.

(5) 7½ percent—clay and shale used or sold for use in the manufacture of sewer pipe or brick, and clay, shale, and slate used or sold for use as sintered or burned lightweight aggregates.

Last amendment.—Sec. 613(b)(5) appears above as amended by Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969. Sec. 613(b)(5) as it read before this amendment is in P-H Cumulative Changes.

Addition.—Sec. 613(b)(5) was added by Sec. 209(a)(1) of Public Law 89-809, Nov. 13, 1966, effective (Sec. 209(c) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.

(6) 5 percent—

(A) gravel, peat, pumice, sand, scoria, shale (except shale described in paragraph (2)(B) or (5)), and stone (except stone described in paragraph (7));

(B) clay used, or sold for use, in the manufacture of drainage and roofing tile, flower pots, and kindred products; and

(C) if from brine wells—bromine, calcium chloride, and magnesium chloride.

Last amendment.—Sec. 613(b)(6) appears above as amended by Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969.

Prior amendments.—Sec. 613(b)(6) was previously amended by the following:

Sec. 208(a)(1), 209(a)(1), (3) and (4) of Public Law 89-809, Nov. 13, 1966, effective (Sec. 208(b) and Sec. 209(c) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.*

Sec. 302(a)(2) of Public Law 86-564, June 30, 1960 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960) which amended Sec. 302(c) of Public Law 86-564, June 30, 1960).*

*Sec. 613(b)(6) as so amended is in P-H Cumulative Changes.

(7) 14 percent—all other minerals (including, but not limited to, aplite, barite, borax, calcium carbonates, diatomaceous earth, dolomite, feldspar, fullers earth, garnet, gilsonite, granite, limestone, magnesite, magnesium carbonates, marble, mollusk shells (including clam shells and oyster shells), phosphate rock, potash, quartzite, slate, soapstone, stone (used or sold for use by the mine owner or operator as dimension stone or ornamental stone), thenardite, tripoli, trona, and (if paragraph (1)(B) does not apply (bauxite, flake graphite, fluorspar, lepidolite, mica, spodumene, and talc (including pyrophyllite), except that, unless sold on bid in direct competition with a bona fide bid to sell a mineral listed in paragraph (3), the percentage shall be 5 percent for any such other mineral (other than slate to which paragraph (5) applies) when used, or sold for use, by the mine owner or operator as rip rap, ballast, road material, rubble, concrete aggregates or for similar purposes. For purposes of this paragraph, the term "all other minerals" does not include—

(A) soil, sod, dirt, turf, water, or mosses;

(B) minerals from sea water, the air, or similar inexhaustible sources; or

(C) oil and gas wells.

For purposes of this subsection, minerals (other than sodium chloride) extracted from brines pumped from a saline perennial lake within the United States shall not be considered minerals from an inexhaustible source.

Last amendment.—Sec. 613(b)(7) appears above as amended by Sec. 501(b)(2)(B), (C) of Public Law 94-12 Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974.

Prior amendments.—Sec. 613(b)(7) (formerly (b)(6) was previously amended by the following:

Sec. 501(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 501(b) of Public Law 91-172, Dec. 30, 1969) to taxable years beginning after Oct. 9, 1969.*

Sec. 208(a)(2), Sec. 209(a)(1), (5) of Public Law 89-809, Nov. 13, 1966, effective (Sec. 208(b) and Sec. 209(c) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.*

Sec. 6(a)(1) of Public Law 88-571, Sept. 2, 1964, effective (Sec. 6(b) of Public Law 88-571, Sept. 2, 1964) for taxable years beginning after Dec. 31, 1963.*

Sec. 302(a)(3) of Public Law 86-564, June 30, 1960 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960, which amended Sec. 302(c) of Public Law 86-564, June 30, 1960).*

* Sec. 613(b)(7) (formerly (b)(6)) as so amended is in P-H Cumulative Changes.

(c) **Definition of Gross Income From Property.**—For purposes of this section—

(1) **Gross income from the property.**—The term "gross income from the property" means, in the case of a property other than an oil or gas well, the gross income from mining.

(2) **Mining.**—The term "mining" includes not merely the extraction of the ores or minerals from the ground but also the treatment processes considered as mining described in paragraph (4) (and the treatment processes necessary or incidental thereto), and so much of the transportation of ores or minerals (whether or not by common carrier) from the point of extraction from the ground to the plants or mills in which such treatment processes are applied thereto as is not in excess of 50 miles unless the Secretary or his delegate finds that the physical and other requirements are such that the ore or mineral must be transported a greater distance to such plants or mills.

Last amendment. — Sec. 613(c)(2) appears above as amended by Sec. 302(b)(1) of Public Law 86-564, June 30, 1960 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960, which amended Sec. 302(c) of Public Law 86-564, June 1960). Sec. 613(c)(2) as it read bef this amendment is in P-H Cumulat Changes.

(3) **Extraction of the ores or minerals from the ground.**—The term "extraction of the ores or minerals from the ground" includes the extraction by mine owners or operators of ores or minerals from the waste or residue of prior mining. The preceding sentence shall not apply to any such extraction of the mineral or ore by a purchaser of such waste or residue or of the rights to extract ores or minerals therefrom.

(4) **Treatment processes considered as mining.**—The following treatment processes where applied by the mine owner or operator shall be considered as mining to the extent they are applied to the ore or mineral in respect of which he is entitled to a deduction for depletion under section 611:

(A) In the case of coal—cleaning, breaking, sizing, dust allaying, treating to prevent freezing, and loading for shipment;

(B) in the case of sulfur recovered by the Frasch process—cleaning, pumping to vats, cooling, breaking, and loading for shipment;

(C) in the case of iron ore, bauxite, ball and sagger clay, rock asphalt, and ores or minerals which are customarily sold in the form of a crude mineral product—sorting, concentrating, sintering, and substantially equivalent processes to bring to shipping grade and form, and loading for shipment;

(D) in the case of lead, zinc, copper, gold, silver, uranium, or fluorspar ores, potash, and ores or minerals which are not customarily sold in the form of the crude mineral product—crushing, grinding, and beneficiation by concentration (gravity, flotation, amalgamation, electrostatic, or magnetic), cyanidation, leaching, crystallization, precipitation (but not including electrolytic deposition, roasting, thermal or electric smelting, or refining), or by substantially equivalent processes or combination of processes used in the separation or extraction of the product or products from the ore or the mineral or minerals from other material from the mine or other natural deposit;

(E) the pulverization of talc, the burning of magnesite, the sintering and nodulizing of phosphate rock, the decarbonation of trona, and the furnacing of quicksilver ores;

(F) in the case of calcium carbonates and other minerals when used in making cement—all processes (other than preheating of the kiln feed) applied prior to the introduction of the kiln feed into the kiln, but not including any subsequent process;

(G) in the case of clay to which paragraph (5) or (6)(B) of subsection (b) applies—crushing, grinding, and separating the mineral from waste, but not including any subsequent process;

(H) in the case of oil shale—extraction from the ground, crushing, loading into the retort, and retorting, but not hydrogenation, refining, or any other process subsequent to retorting: and

(I) any other treatment process provided for by regulations prescribed by the Secretary or his delegate which, with respect to the particular ore or mineral, is not inconsistent with the preceding provisions of this paragraph.

Last amendment.—Sec. 613(c)(4) appears above as amended by Sec. 2(a) of Public Law 93-499, Oct. 29, 1974, effective (Sec. 2(b) of Public Law 93-499, Oct. 29, 1974) for taxable years beginning after Dec. 31, 1970.

Prior amendments.—Sec. 613(c)(4) was previously amended by the following:

Sec. 502(a) of Public Law 91-172, Dec. 30, 1969, effective (Sec. 502(b) of Public Law 91-172, Dec. 30, 1969) with respect to taxable years beginning after Dec. 30, 1969.*

Sec. 209(b) of Public Law 89-809, Nov. 13, 1966, effective (Sec. 209(c) of Public Law 89-809, Nov. 13, 1966) with respect to taxable years beginning after Nov. 13, 1966.*

Sec. 302(b)(2) of Public Law 86-564, June 30, 1964 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960) which amended Sec. 302(c) of Public Law 86-564, June 30, 1960).*

* Sec. 613(c)(4) as so amended is in P-H Cumulative Changes.

(5) **Treatment processes not considered as mining.**—Unless such processes are otherwise provided for in paragraph (4) (or are necessary or incidental to processes so provided for), the following treatment processes shall not be considered as "mining": electrolytic deposition, roasting, calcining, thermal or electric smelting, refining, polishing, fine pulverization, blending with other materials, treatment effecting a chemical change, thermal action, and molding or shaping.

Addition.—Sec. 613(c)(5) was added by Sec. 302(b)(2) of Public Law 86-564, June 30, 1960 (qualified effective date rule in Sec. 4 of Public Law 86-781, Sept. 14, 1960, which amended Sec. 302(c) of Public Law 86-546, June 30, 1960). Sec. 613(c)(5) as it read before this amendment is in P-H Cumulative Changes.

(d) **Denial of Percentage Depletion in Case of Oil and Gas Wells.**—Except as provided in section 613A, in the case of any oil or gas well, the allowance for depletion shall be computed without reference to this section.

Last amendment.—Sec. 613(d) appears above as amended by Sec. 501(b)(1) of Public Law 94-12, Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974. Sec. 613(d) as it read before this amendment is in P-H Cumulative Changes.

Implied amendment of Sec. 613(d) was made by Sec. 36(b) of Public Law 85-866, Sept. 2, 1958.

Addition.—Sec. 613(d) was added by Sec. 36(a) of Public Law 86-866, Sept. 2, 1958, (qualified effective date rule in Sec. 39(b) of Public Law 85-866, Sept. 2, 1958).

SEC. 613A. LIMITATIONS ON PERCENTAGE DEPLETION IN CASE OF OIL AND GAS WELLS.

(a) General Rule.—Except as otherwise provided in this section, the allowance for depletion under section 611 with respect to any oil or gas well shall be computed without regard to section 613.

(b) Exemption for Certain Domestic Gas Wells.—

(1) In general.—The allowance for depletion under section 611 shall be computed in accordance with section 613 with respect to—

(A) regulated natural gas,

(B) natural gas sold under a fixed contract, and

(C) any geothermal deposit in the United States or in a possession of the United States which is determined to be a gas well within the meaning of section 613(b)(1)(A),

and 22 percent shall be deemed to be specified in subsection (b) of section 613 for purposes of subsection (a) of that section.

(2) Definitions.—For purposes of this subsection—

(A) Natural gas sold under a fixed contract.—The term "natural gas sold under a fixed contract" means domestic natural gas sold by the producer under a contract, in effect on February 1, 1975, and at all times thereafter before such sale, under which the price for such gas cannot be adjusted to reflect to any extent the increase in liabilities of the seller for tax under this chapter by reason of the repeal of percentage depletion for gas. Price increases after February 1, 1975, shall be presumed to take increases in tax liabilities into account unless the taxpayer demonstrates to the contrary by clear and convincing evidence.

(B) Regulated natural gas.—The term "regulated natural gas" means domestic natural gas produced and sold by the producer, before July 1, 1976, subject to the jurisdiction of the Federal Power Commission, the price for which has not been adjusted to reflect to any extent the increase in liability of the seller for tax under this chapter by reason of the repeal of percentage depletion for gas. Price increases after February 1, 1975, shall be presumed to take increases in tax liabilities into account unless the taxpayer demonstrates the contrary by clear and convincing evidence.

(c) Exemption for Independent Producers and Royalty Owners.—

(1) In general.—Except as provided in subsection (d), the allowance for depletion under section 611 shall be computed in accordance with section 613 with respect to—

(A) so much of the taxpayer's average daily production of domestic crude oil as does not exceed the taxpayer's depletable oil quantity; and

(B) so much of the taxpayer's average daily production of domestic natural gas as does not exceed the taxpayer's depletable natural gas quantity;

and the applicable percentage (determined in accordance with the table contained in paragraph (5)) shall be deemed to be specified in subsection (b) of section 613 for purposes of subsection (a) of that section.

(2) Average daily production.—For purposes of paragraph (1)—

(A) the taxpayer's average daily production of domestic crude oil or natural gas for any taxable year, shall be determined by dividing his aggregate production of domestic crude oil or natural gas, as the case may be, during the taxable year by the number of days in such taxable year, and

(B) in the case of a taxpayer holding a partial interest in the production from any property (including an interest held in partnership) such taxpayer's production shall be considered to be that amount of such production determined by multiplying the total production of such property by the taxpayer's percentage participation in the revenues from such property.

In applying this paragraph, there shall not be taken into account any production of crude oil or natural gas resulting from secondary or tertiary processes (as defined in regulations prescribed by the Secretary or his delegate).

(3) Depletable oil quantity.—

(A) In general.—For purposes of paragraph (1), the taxpayer's depletable oil quantity shall be equal to—

(i) the tentative quantity determined under the table contained in subparagraph (B), reduced (but not below zero) by

(ii) the taxpayer's average daily secondary of tertiary production for the taxable year.

(B) Phase-out table.—For purposes of subparagraph (A)—

In the case of production during the calendar year:	The Tentative quantity in barrels is
1975	2,000
1976	1,800
1977	1,600
1978	1,400
1979	1,200
1980 and thereafter	1,000

(4) Daily depletable natural gas quantity.—For purposes of paragraph (1), the depletable natural gas quantity of any taxpayer for any taxable year shall be equal to 6,000 cubic feet multiplied by the number of barrels of the taxpayer's depletable oil quantity to which the taxpayer elects to have this paragraph apply. The taxpayer's depletable oil quantity for any calendar year shall be reduced by the number of barrels with respect to which an eltction under this paragraph appliès. Such election shall be made at such time and in such manner as the Secretary or his delegate shall by regulations prescribe.

(5) Applicable percentage.—For purposes of paragraph (1)—

In the case of production during the calendar year:	The applicable percentage is:
1975	22
1976	22
1977	22
1978	22
1979	22
1980	22
1981	20
1982	18
1983	16
1984 and thereafter	15

(6) Oil and natural gas resulting from secondary or tertiary processes.—

(A) In general.—Except as provided in subsection (d), the allowance for depletion under section 611 shall be computed in accordance with section 613 with respect to—

(i) so much of the taxpayer's average daily secondary or tertiary production of domestic crude oil as does not exceed the taxpayer's depletable oil quantity (determined with regard to paragraph (3)(A)(ii); and

(ii) so much of the taxpayer's average daily secondary or tertiary production of domestic natural gas as does not exceed the taxpayer's depletable natural gas quantity (determined without regard to paragraph (3)(A)(ii)); and 22 percent shall be deemed to be specified in subsection (b) of section 613 for purposes of subsection (a) of that section.

(B) Average daily secondary or tertiary production.—For purposes of this subsection—

(i) the taxpayer's average daily secondary or tertiary production of domestic crude oil or natural gas for any taxable year shall be determined by dividing his aggregate production of domestic crude oil or natural gas, as the case may be, resulting from secondary or tertiary processes during the taxable year by the number of days in such taxable year, and

(ii) in the case of a taxpayer holding a partial interest in the production from any property (including any interest held in any partnership) such taxpayer's production shall be considered to be that amount of such production determined by multiplying the total production of such property by the taxpayer's percentage participation in the revenues from such property.

(C) Termination.—This paragraph shall not apply after December 31, 1983.

(7) Special rules.—

(A) Production of crude oil in excess of depletable oil quantity.—If the taxpayer's average daily production of domestic crude oil exceeds his depletable oil quantity, the allowance under paragraph (1)(A) with respect to oil produced during the taxable year from each property in the United States shall be that amount which bears the same ratio to the amount of depletion which could have been allowable under section 613(a) for all of the taxpayer's oil produced from such property during the taxable year (computed as if section 613 applied to all of such production at the rate specified in paragraph (5) or (6), as the case may be as his depletable oil quantity bears to the aggregate number of barrels representing the average daily production of domestic crude oil of the taxpayer for such year.

(B) Production of natural gas in excess of depletable natural gas quantity.—If the taxpayer's average daily production of domestic natural gas exceeds his depletable natural gas quantity, the allowance under paragraph (1)(B) with respect to natural gas produced during the taxable year from each property in the United States shall be that amount which bears the same ratio to the amount of depletion which would have been allowable under section 613(a) for all of the taxpayer's natural gas produced from such property during the taxable year (computed as if section 613 applied to all of such production at the rate specified in paragraph (5) or (6) as the case may be) as the amount of his depletable natural gas quantity in cubic feet bears to the aggregate number of cubic feet representing the average daily production of domestic natural gas of the taxpayer for such year.

(C) Taxable income from the property.—If both oil and gas are produced from the property during the taxable year, for purposes of subparagraphs (A) and (B) the taxable income from the property, in applying the 50-percent limitation in section 613(a), shall be allocated between the oil production and the gas production in proportion to the gross income during the taxable year from each.

(D) Partnerships.—In the case of a partnership, the depletion allowance in the case of oil and gas wells to which this subsection applies shall be computed separately by the partners and not by the partnership.

(E) Secondary or tertiary production.—If the taxpayer has production from secondary or tertiary recovery processes during the taxable year, this paragraph (under regulations prescribed by the Secretary or his delegate) shall be applied separately with respect to such production.

(8) Business under common control; members of the same family.—

(A) Component members of controlled group treated as one taxpayer.—For purposes of this subsection, persons who are members of the same controlled group of corporations shall be treated as one taxpayer.

(B) Aggregation of business entities under common control.—If 50 percent or more of the beneficial interest in two or more corporations, trusts, or estates is owned by the same or related persons (taking into account only persons who own at least 5 percent of such beneficial interest), the tentative quantity determined under the table in paragraph (3)(B) shall be allocated among all such entities in proportion to the respective production of domestic crude oil during the period in question by such entities.

(C) Allocation among members of the same family.—In the case of individuals who are members of the same family, the tentative quantity determined under the table in paragraph (3)(B) shall be allocated among such individuals in proportion to the respective production of domestic crude oil during the period in question by such individuals.

(D) Definition and special rules.—For purposes of this paragraph—

(i) the term "controlled group of corporations" has the meaning given to such term by section 1563(a), except that section 1563 (b)(2) shall not apply and except that "more than 50 percent" shall be substituted for "at least 80 percent" each place it appears in section 1563(a),

(ii) a person is a related person to another person if such persons are members of the same controlled group of corporations or if the relationship between such persons would result in a disallowance of losses under section 267 or 707(b), except that for this purpose the family of an individual includes only his spouse and minor children,

(iii) the family of an individual includes only his spouse and minor children, and

(iv) each 6,000 cubic feet of domestic natural gas shall be treated as 1 barrel of domestic crude oil.

(9) Transfer of oil or gas property.—

(A) In the case of a transfer (including the subleasing of a lease) after December 31, 1974 of an interest (including an interest in a partnership or trust) in any proven oil or gas property, paragraph (1) shall not apply to the transferee (or sublessee) with respect to production of crude oil or natural gas attributable to such interest, and such production shall not be taken into account for any computation by the transferee (or sublessee) under this subsection. A property shall be treated as a proven oil or gas property if at the time of the transfer the principal value of the property has been demonstrated by prospecting or exploration or discovery work.

(B) Subparagraph (A) shall not apply in the case of—

(i) a transfer of property at death, or

(ii) the transfer in an exchange to which section 351 applies if following the exchange the tentative quantity determined under the table contained in paragraph (3)(B) is allocated under paragraph (8) between the transferor and transferee.

(10) Special rule for fiscal year taxpayers.—In applying this subsection to a taxable year which is not a calendar year, each portion of such taxable year which occurs during a single calendar year shall be treated as if it were a short taxable year.

(11) **Certain production not taken into account.**—In applying this subsection, there shall not be taken into account the production of natural gas with respect to which subsection (b) applies.

(d) **Limitations on Applications of Subsection (c).**—

(1) **Limitation based on taxable income.**—The deduction for the taxable year attributable to the application of subsection (c) shall not exceed 65 percent of the taxpayer's taxable income for the year computed without regard to—

(A) depletion with respect to production of oil and gas subject to the provisions of subsection (c),

(B) any net operating loss carryback to the taxable year under section 172, and

(C) any capital loss carryback to the taxable year under section 1212.

If an amount is disallowed as a deduction for the taxable year by reason of application of the preceding sentence, the disallowed amount shall be treated as an amount allowable as a deduction under subsection (c) for the following taxable year, subject to the application of the preceding sentence to such taxable year. For purposes of basis adjustments and determining whether cost depletion exceeds percentage depletion with respect to the production from a property, any amount disallowed as a deduction on the application of this paragraph shall be allocated to the respective properties from which the oil or gas was produced in proportion to the percentage depletion otherwise allowable to such properties under subsection (c).

(2) **Retailers excluded.**—Subsection (c) shall not apply in the case of any taxpayer who directly, or through a related person, sells oil or natural gas, or any product derived from oil or natural gas—

(A) through any retail outlet operated by the taxpayer or a related person, or

(B) to any person—

(i) obligated under an agreement or contract with the taxpayer or a related person to use a trademark, trade name, or service mark or name owned by such taxpayer or a related person, in marketing or distributing oil or natural gas or any product derived from oil or natural gas, or

(ii) given authority, pursuant to an agreement or contract with the taxpayer or a related person, to occupy any retail outlet owned, leased, or in any way controlled by the taxpayer or a related person.

(3) **Related person.**—For purposes of this subsection, a person is a related person with respect to the taxpayer if a significant ownership interest in either the taxpayer or such person is held by the other, or if a third person has a significant ownership interest in both the taxpayer and such person. For purposes of the preceding sentence, the term "significant ownership interest" means—

(A) with respect to any corporation, 5 percent or more in value of the outstanding stock of such corporation,

(B) with respect to a partnership, 5 percent or more interest in the profits or capital of such partnership, and

(C) with respect to an estate or trust, 5 percent or more of the beneficial interests in such estate or trust.

(4) **Certain refiners excluded.**—If the taxpayer or a related person engages in the refining of crude oil, subsection (c) shall not apply to such taxpayer if on any day during the taxable year the refinery runs of the taxpayer and such person exceed 50,000 barrels.

(e) **Definitions.**—For purposes of this section—

(1) **Crude oil.**—The term "crude oil" includes a natural gas liquid recovered from a gas well in lease separators or field facilities.

(2) **Natural gas.**—The term "natural gas" means any product (other than crude oil) of an oil or gas well if a deduction for depletion is allowable under section 611 with respect to such product.

(3) **Domestic.**—The term "domestic" refers to production from an oil or gas well located in the United States or in a possession of the United States.

(4) **Barrel.**—The term "barrel" means 42 United States gallons.

Addition.—Sec. 613A was added by Sec. 501(a) of Public Law 94-12, Mar. 29, 1975, effective (Sec. 501(c) of Public Law 94-12, Mar. 29, 1975) Jan. 1, 1975 and applies to taxable years ending after Dec. 31, 1974.

"PROPOSED BILL S 2608"

Introduced by Fannin

Nov. 4, 1975

S. 2608

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) (1) part VI of subchapter B of chapter 1 of the Internal Revenue Code of 1954 (relating to itemized deductions for individuals and corporations) is amended by adding at the end thereof the following new section:

"SEC. 189. EXHAUSTION OF GEOTHERMAL STEAM AND GEOTHERMAL RESOURCES.

"(a) IN GENERAL.—There shall be allowed as a deduction, under regulations prescribed by the Secretary or his delegate, an amount equal to 25% of the gross income from a geothermal steam and geothermal resources property for the taxable year.

"(b) LIMITATION.—The deduction allowed under subsection (a) may not exceed 50% of the taxpayer's taxable income from the geothermal steam and geothermal resources property for the taxable year, computed without regard to the deduction allowed by this section.

"(C) SPECIAL RULES.—

"(1) LEASES.—In the case of a lease, the deduction allowed under subsection (a) shall be equitably apportioned between the lessor and lessee.

"(2) LIFE TENANT AND REMAINDERMAN.—In the case of property held by one person for life with remainder to another person, the deduction under this section shall be computed as if the life tenant were the absolute owner of the property and shall be allowed to the life tenant.

"(3) PROPERTY HELD IN TRUST.—In the case of property held in trust, the deduction allowed under subsection (a) shall be apportioned between the income beneficiaries and the trustee in accordance with the pertinent provisions of the instrument creating the trust, or in the absence of such provisions, on the basis of the trust income allocable to each.

"(4) PROPERTY HELD BY ESTATE.—In the case of an estate, the deduction under this section shall be apportioned between the estate and the heirs, legatees, and devisees on the basis of the income of the estate allocable to each.

"(d) DEFINITIONS.—For purposes of this section—

"(1) GEOTHERMAL STEAM AND GEOTHERMAL RESOURCES PROPERTY.—The term 'geothermal steam and geothermal resources property' means property from which the taxpayer extracts any product included in geothermal steam and associated geothermal resources, as defined in subsection 2(c) of the Geothermal Steam Act of 1970 (30 U.S.C. 1001).

"(2) GROSS INCOME FROM THE PROPERTY.—The term 'gross income from the property' means the gross income from extracting geothermal steam and associated geothermal resources from the property.

"(3) PROPERTY.—The term 'property' has the same definition it has under section 614. For purposes of applying such section 614 with respect to this section, a well producing geothermal steam and associated geothermal resources shall be considered to be a gas well.

"(e) APPLICATION WITH SUBCHAPTER I.—No deduction shall be allowed under section 611 with respect to exhaustion of geothermal steam and associated geothermal resources if a deduction is allowable under this section with respect to such exhaustion."

(2) The table of parts for such part VI is amended by adding at the end thereof the following new item:

"SEC. 189. EXHAUSTION OF GEOTHERMAL STEAM AND ASSOCIATED GEOTHERMAL RESOURCES."

(3) Section 57(a)(8) of such Code (relating to items of tax preference) is amended by inserting immediately after "section 611" the following: "or the deduction for exhaustion allowable under section 189."

(4) Section 62(6) of such Code (relating to definition of adjusted gross income) is amended by striking out "and the deduction allowed by section 611." and inserting in lieu thereof a comma and "the deduction allowed by section 189, and the deduction allowed by section 611.".

(c) Section 263(c) of such Code (relating to deduction for intangible drilling and development costs in the case of oil and gas wells) is amended—

(1) by adding at the end thereof the following new sentence; "Such regulations shall also grant the option to deduct as expenses intangible drilling and development costs in the case of wells drilled for geothermal steam and associated geothermal resources, as defined in section 2(c) of the Geothermal Steam Act of 1970 (30 U.S.C. 1001), to the same extent and in the same manner as such expenses are deductible in the case of oil and gas wells.", and

(2) by amending the caption of such section to read as follows:

"(c) Intangible Drilling and Development Costs in the Case of Oil and Gas Wells and Geothermal Wells.".

(d) Section 613A(b)(1) of such Code (relating to limitations on percentage depletion in case of oil and gas wells) is amended—

(1) by inserting immediately after the comma in subparagraph (A) the following: "and",

(2) by striking out "and" in subparagraph (B), and

(3) by striking out subparagraph (C).

(e) Section 617(a)(1) of such Code (relating to deduction and recapture of certain mining exploration expenditures is amended by striking out "is not allowable under section 613." and inserting in lieu thereof "is not allowable under section 613 or section 189.".

(f) The amendments made by this Act apply to taxable years beginning after December 31, 1975.

PART 2

INSTITUTIONAL

THE DEVELOPMENT OF GEOTHERMAL ENERGY IN THE GULF COAST: SOCIO-ECONOMIC, DEMOGRAPHIC, AND POLITICAL CONSIDERATIONS

KATHLENE LETLOW
SALLY COOK LOPREATO
MARIAN MERIWETHER
PAULA RAMSEY
JAMES K. WILLIAMSON

PHASE 0

SCOPE-OF-WORK AND MANAGEMENT STUDY

TABLE OF CONTENTS

PART 2

CHAPTER I.

THE NATURE OF THE REGION: BASELINE SOCIAL AND DEMOGRAPHIC DATA

Sally Cook Lopreato
Marian Meriwether
Paula Ramsey

INTRODUCTION

An important aspect of planning for major technological changes or innovations, such as the development of geothermal energy, is consideration of impacts on, and consequences for, individuals in the areas and communities where changes occur. Local and regional factors determine, in large measure, the success of technological developments, and absorb, too, many of the direct and indirect costs of the developments. Early attention to the interrelationships among the technological requirements for, and possible uses of, an innovation or expansion with such variables as local skill levels, wages, tax base, and social infrastructure (e.g., transportation, schools, housing, hospitals) can help in alleviating some of the burdens of development on local communities, and help insure optimal utilization of a resource within a given region. The Phase 0 Scope-of-Work study on geothermal development in the Gulf Coast attempts to identify possible effects of geothermal research, development, and utilization on the area and its inhabitants.

Chapters I and II address key socioeconomic and demographic variables. The present chapter provides an overview of the area where the resource is located. Major data are presented which can be used to establish a baseline description of the region for comparison over time and to delineate crucial areas for future study with regard to geothermal development. Several other more detailed descriptions of the Gulf Coast are available (e.g., Pan American University, 1973; Governor's Office of Information Services, 1974). The present chapter merely highlights some of the variables which reflect the cultural nature of the Gulf Coast, its social characteristics, labor force, and services in an attempt to delineate possible problems with and barriers to the development of geothermal energy in the region.

The following chapter focuses on the local impacts of geothermal wells and power-generating facilities using data on such variables as size and nature of construction and operating crews. Note is taken of changes which have occurred in areas of California and New Mexico where geothermal-geopressured resources have already undergone development. Tentative projections of local impacts applicable to the Coastal Zone are set forth, and a methodology is developed for future work.

At the conclusion of Part II data from the areas studied--baseline descriptions and regional problems, local impacts of drilling and production--are brought together and summarized in terms of identified problems with geothermal resource development in the region. Included in that list of research also are recommendations from Chapter III on political and institutional considerations. A flow chart is utilized to describe research which is needed in order to exploit the resource as quickly and effectively as possible. Areas of interface among various parts of the research are identified and described. These will include joint research tasks and exchange of data between the social-cultural group and the institutional, legal, environmental, and resource utilization groups.

Definition of the Study Region.

The geothermal zone along the Gulf Coast is embodied in a geographic area with rather erratic boundaries. The study region has been delineated in county units and includes most of the area within the zone. Figure I.1 shows the 36 county area described in this report overlaid on a map of the geothermal configuration of the region. As can be seen from the map, the geothermal resource stretches the entire length of the coastline. At the present stage of study, no definite decision has been made as to test-well sites, although several potential site areas are designated in Figure I.1. The present volume, therefore, attempts to describe the entire Texas Gulf Coast, noting special problems or characteristics in different areas.

The geothermal zones continue across the Louisiana coast, as can be seen from the Phase 0 Resource Assessment report. The present volume focuses on the Texas Gulf Coast, however, for two major reasons. First,

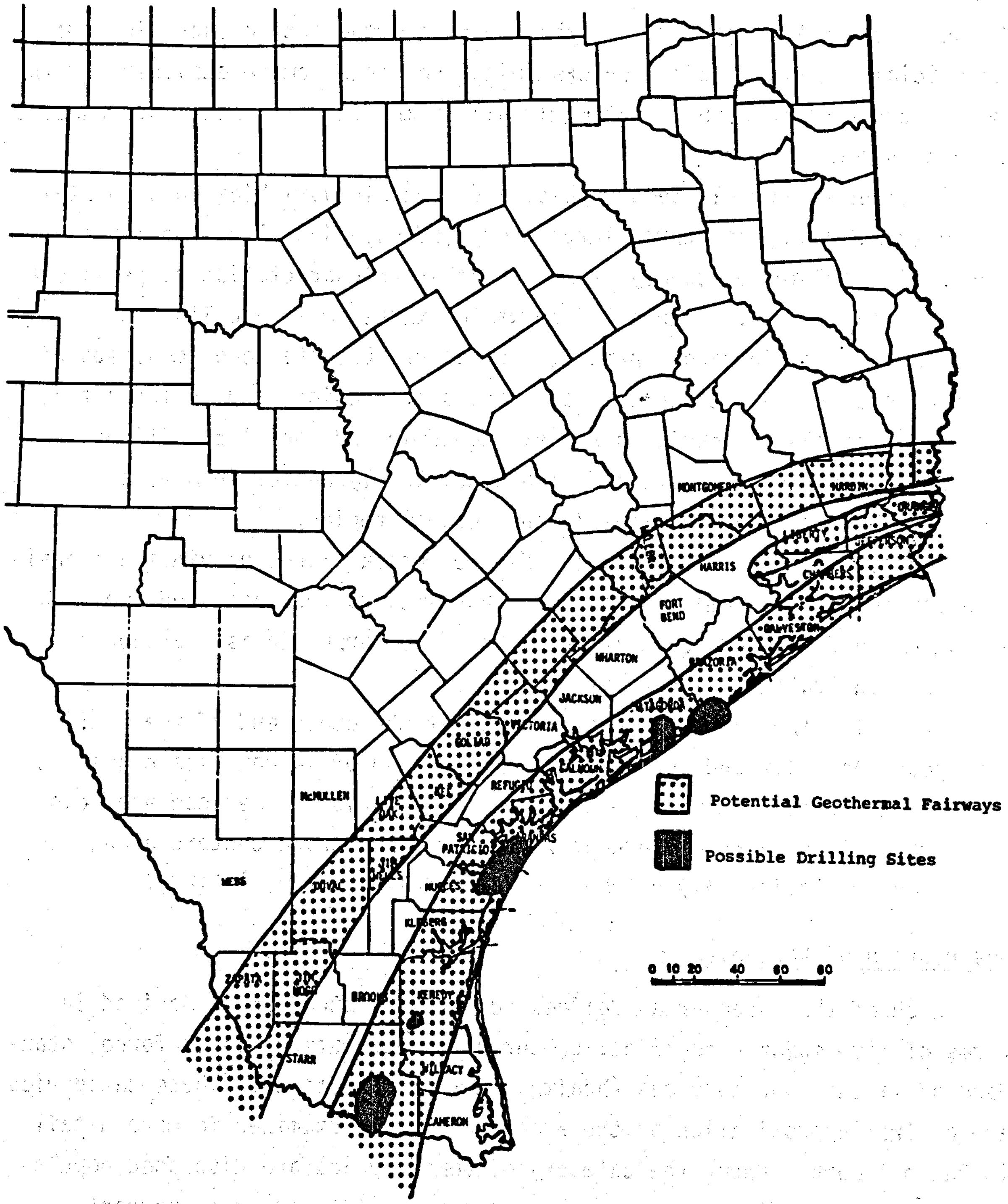


Figure I.1 The Study Area.

a decision was made to cover in detail at least a part of the Gulf Coast in the scope-of-work project rather than to review the entire coast in a more superficial manner. Second, by examining one state comprehensively a methodology could be developed that would allow immediate movement into Phase 1 for both states.

A number of social, demographic, and economic variables on a county-by-county basis suggest three large groups of counties along the Texas coast which differ noticeably from each other in characteristics pertinent to the present study. Figure I.2 shows the three areas and lists the counties included in each. Area I, the Eastern Coastal Zone, consists of the eleven eastern-most counties of the coastal region, and includes three census-designated metropolitan areas. Economic and social conditions, as defined by the variables studied, are consistently better in Area I counties than in other counties in the coastal region.

The eleven county Area II, the Middle Coastal Zone, provides a transition between the economically active urban area to the east, and the rural, economically depressed southern counties. The Corpus Christi Standard Metropolitan Statistical Area is in Area II.

Area III, the Southern Coastal Zone, at the other end of the scale both geographically and economically, is made up of 14 counties closest to the Mexican border. A high percentage of population is Mexican American. The area is largely rural, except for a few urban trade centers along the border and coastline (see Appendix C for detail on area clusters).

Description of Variables.

Each of the three areas delineated for this study are described in terms of five major categories: demographics, education, labor force, standard of living, and services (health and transportation). These categories are a first approximation of the area and must be examined in more detail in Phase 1 work. Under the category of demographics are discussed population size and density, percent urban versus rural residences, percent Black and Mexican American in the population. "Black" in this report is the same as the Census term "Negro" and refers to those who reported their race as Negro or Black in the 1970 Census Survey. The terms "Spanish Heritage" and "Mexican American" are used interchangeably in this report and

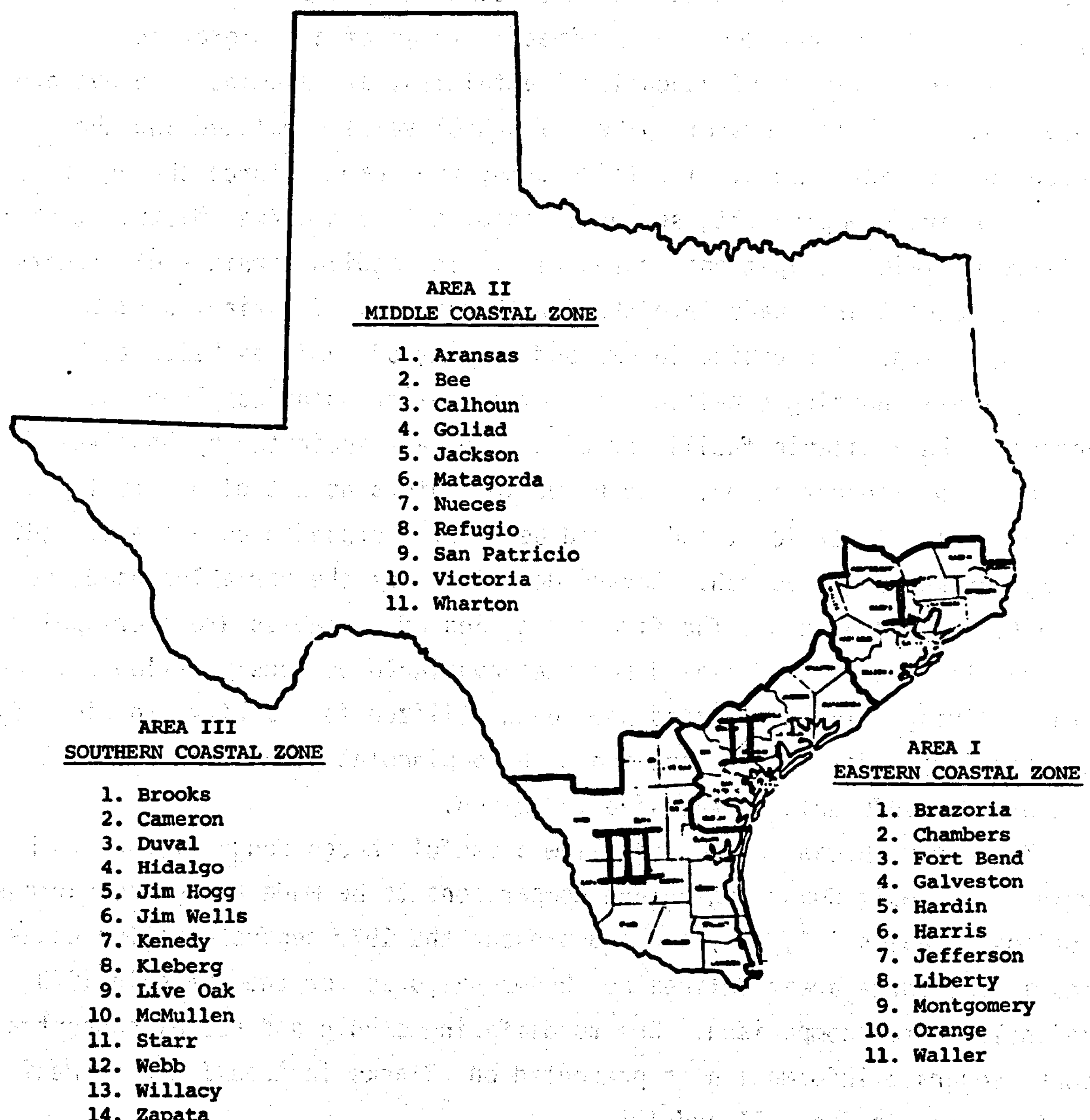


Figure I.2 Texas Counties.

consist of census counts of persons of Spanish language and/or Spanish surname. Those counts no doubt under-report the numbers of Mexican Americans for several reasons; for example, women who marry Anglo men and no longer have a Spanish surname, and Mexican Americans who prefer to "pass" as Anglos. Population changes are examined in terms of net migration.

Under the category of educational attainment are examined the average educational level in terms of number of school years completed and the present school enrollment. The third category--labor force characteristics--covers unemployment, seasonal employment, and worker distribution in terms of major occupational categories. The median earnings of workers in those occupations leads into the fourth category of variables--standards of living. Per capita income and percent of families below the poverty level, housing conditions and extent of crowding complete that section. The available facilities of an area are indicated by hospital services and transportation. These two indicators do not give a full picture of regional services, and should be greatly expanded as a set of indicators for Phase 1 research. Census definition of the variables used are presented in Appendix A. The five categories of variables are overlapping; for example, the type of health services available obviously reflects standard of living. The categories have been utilized for clarity, to simplify the description for the reader, and to help pinpoint problem areas. All data are for 1970 unless otherwise indicated.

These five broad categories allow a useful though rough picture to be drawn of the Gulf Coast region and comparisons to be made among the various sections. Tables I.1, I.2, and I.3 present the 1970 census data for counties in the three areas delineated above. Figures for the state in 1970 are included for comparison. Due to differing ethnic and racial concentrations, separate information is presented on Blacks in Area I and on Mexican Americans in Areas II and III.

AREA I. THE EASTERN COASTAL ZONE

Demographics.

Three Standard Metropolitan Statistical Areas (SMSA) are located in Area I, as can be seen from Figure I.3. The Houston SMSA covers Harris, Liberty, Montgomery, Waller, Ft. Bend, and Brazoria Counties. Galveston County contains the Galveston-Texas City SMSA. Hardin, Jefferson, and Orange Counties constitute the Beaumont-Port Arthur-Orange SMSA. Of the eleven counties in Area I, then, only Chambers County has not yet been included officially in one of the major metropolitan areas. Chambers is, however, 46.4% urban (Waller, by contrast, is only 28.1% urban despite its inclusion in the Houston SMSA). The entire Eastern Coastal Zone is a highly developed urban-industrial center, and constitutes one of the 25 urban regions projected to hold 85% of the total American population by the year 2000 (Pickard, 1972: 143). The region is heavily populated and much of it is densely settled, from a high in Harris County of 1,011 population per square mile to a low in Chambers with 20 people per square mile. Seven of the eleven counties report population densities higher than the state average.

The Eastern Coastal Zone attracts migrants because of the employment opportunities generally associated with urban areas (Fig. I.4). Only Jefferson and Liberty Counties reported more people moving out than moving in during the 1960 to 1970 period. Montgomery County, by contrast, showed a positive net migration of nearly 76% over the decade. Adjoining Harris County, Montgomery has experienced "spill-over" from the Houston suburban growth, evidenced by number of new residential developments (Barnstone, et al., 1974: 39).

The Mexican American population is relatively small in Area I, ranging from 1.3% of the population in Liberty County to 26.6% in Ft. Bend. Area I, on the one hand, contains proportionately fewer Mexican Americans than does the state as a whole. Blacks, on the other hand, represent a sizeable portion of the population in Area I, making up nearly 20% of the total compared to 12.5% for the state population. Because it is the largest minority in Area I (see Figure I.5), we have included separate figures on the Black population in Table I.1.

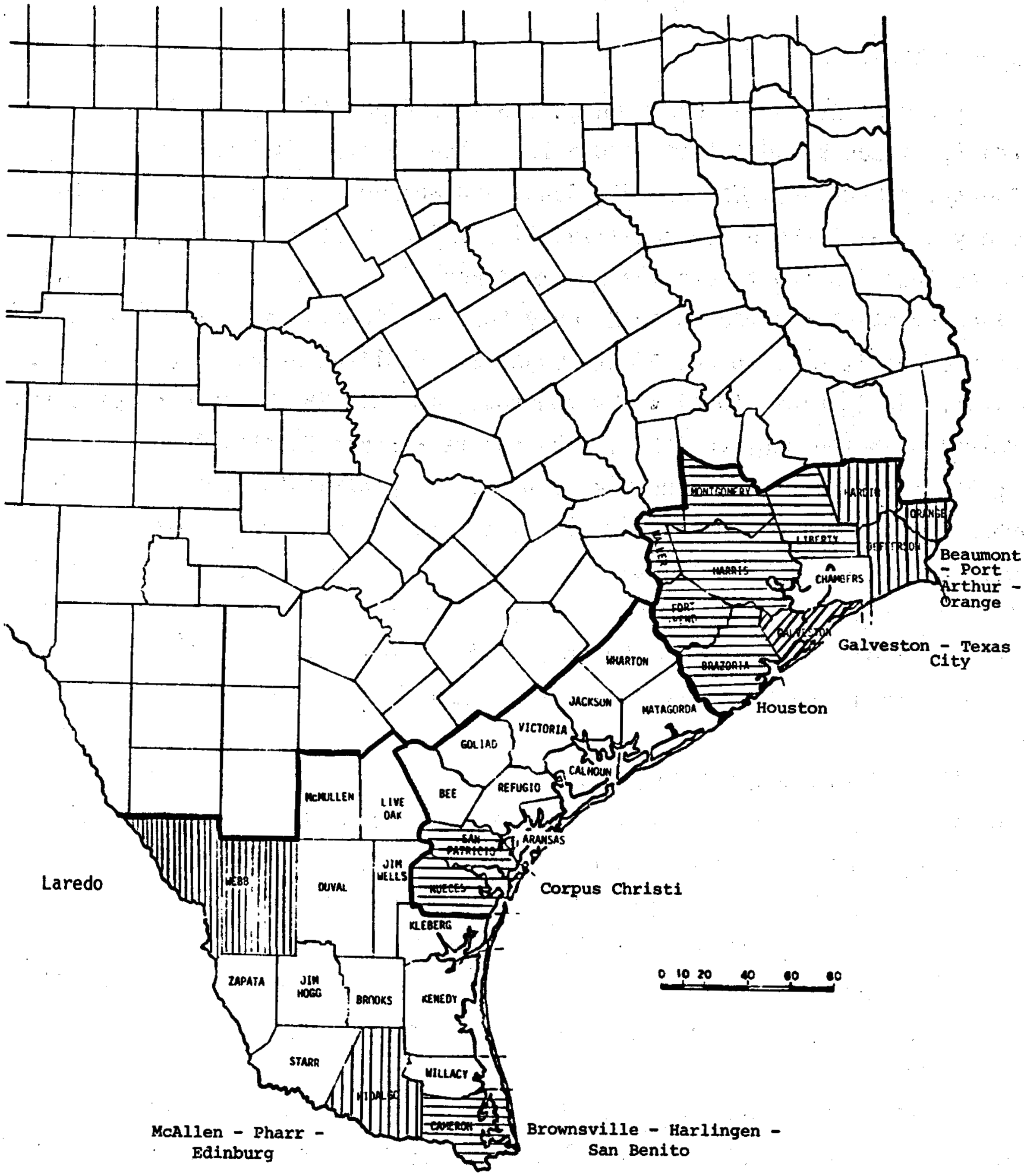


Figure I.3 Standard Metropolitan Statistical Areas.

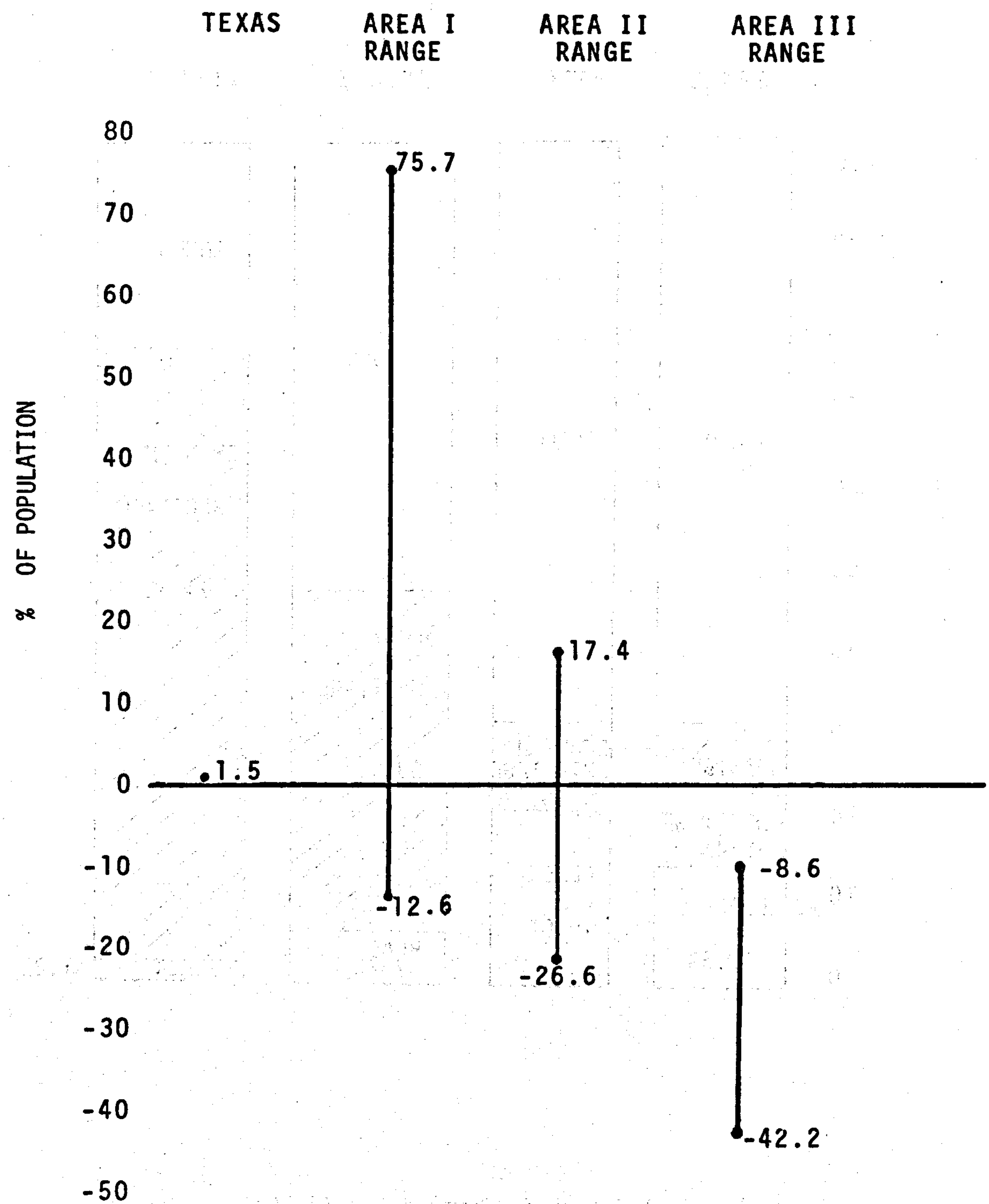


Figure I.4 Net Migration 1960-1970.

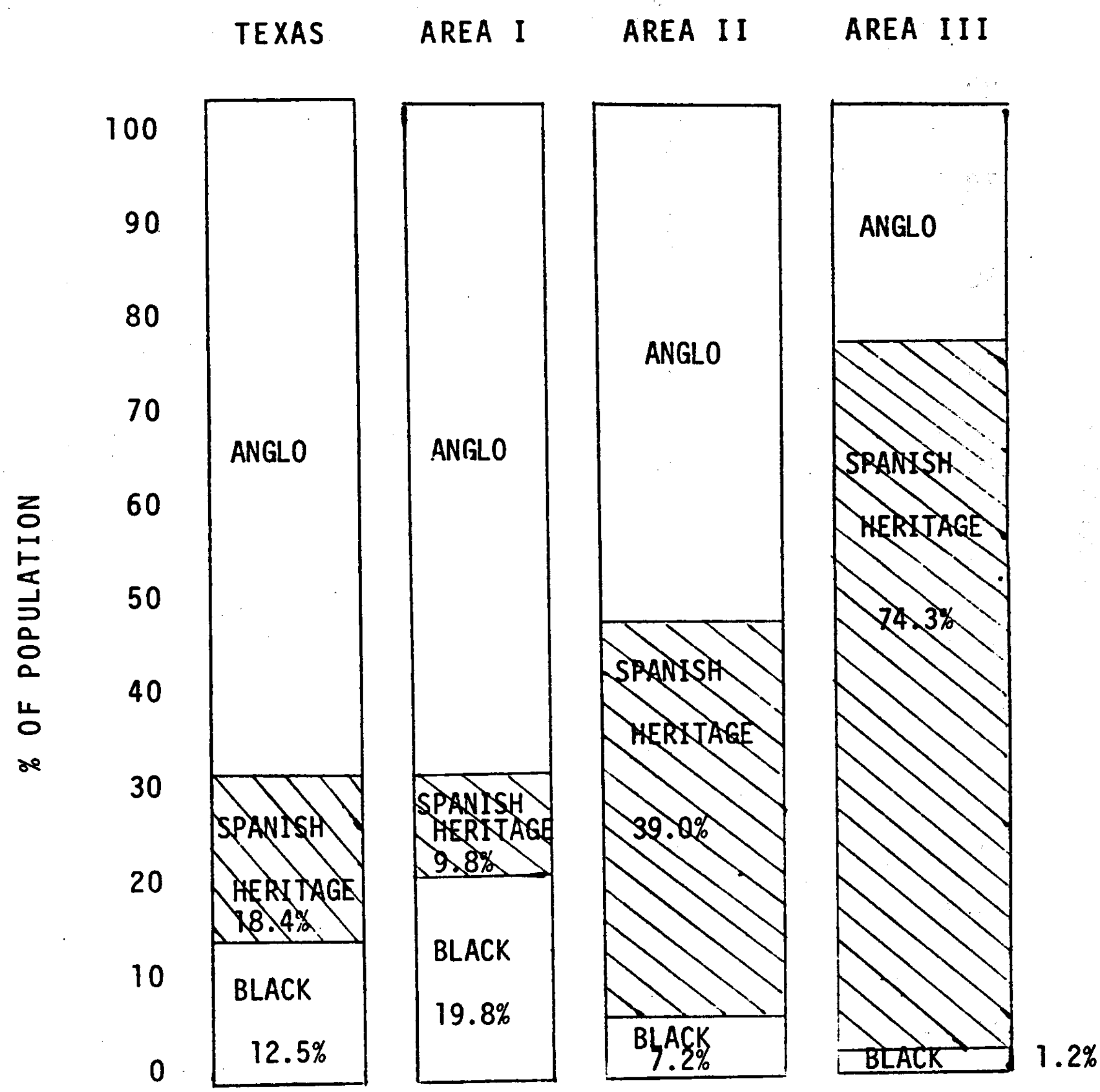


Figure I.5 Ethnic Composition (1970).

Education.

In terms of the median number of school years completed, Area I falls slightly behind state averages for both Blacks and the total population (Fig. I.6). Most counties in Area I, however, rank slightly higher than the state average of 52.1% for total population age 3 - 34 enrolled in school, ranging from 49% to 66.7%. The same is true for the Black population, with a range of 47.5% to 76.6% enrolled, compared to the state average of 53% (Fig. I.7).

Labor Force.

Area I had, in 1970, unemployment rates for total population and Blacks that were slightly higher than state averages. (Fig. I.8: in July, 1975, however, seven of the eleven counties in Area I reported unemployment rates considerably lower than the state figure of 6.5 [Texas Employment Commission, 1975]). Employment in Area I appears to be somewhat steadier than in the state as a whole since the part-time labor force (those working 26 weeks or less in a year) is smaller. Blacks represent less than their proportionate share of the labor market with approximately 18% of the total employed compared to 20% of the total population.

The labor force structure in Area I closely approximates the over-all state distribution, with some slight upward shift toward the top three categories in Figure I.9. The urban industrial nature of Area I is clearly demonstrated in the low rates of agricultural employment. Despite the over-all trend, several counties in Area I are still heavily based on agriculture. Conspicuous here are Brazoria and Ft. Bend Counties which have extensive rice cultivation.

Standard of Living.

As might be expected from the occupational distribution, Area I has higher median earnings than the state average. This comparison does not hold for Blacks, but that is primarily due to the particularly low median earnings reported for Blacks in Waller County. Waller is 52.6% Black, and unlike the area as a whole, shows a high degree of part-time Black employment. Agriculture claims many of these workers, with 6.7% of the Black labor force in farm-related work compared to 1.1% for Area I. Over

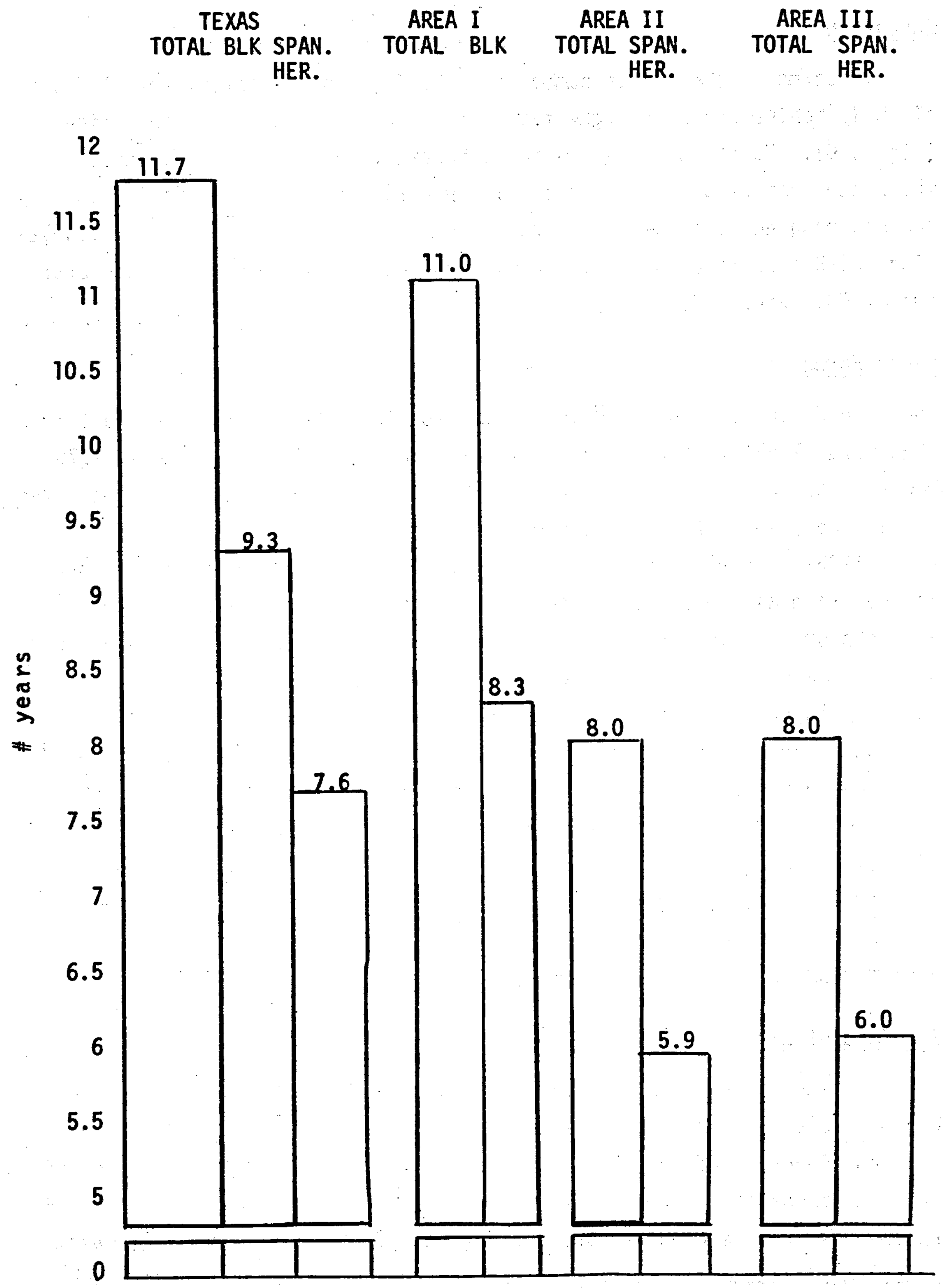


Figure I.6 Median school years completed (males 25 & older in 1970).

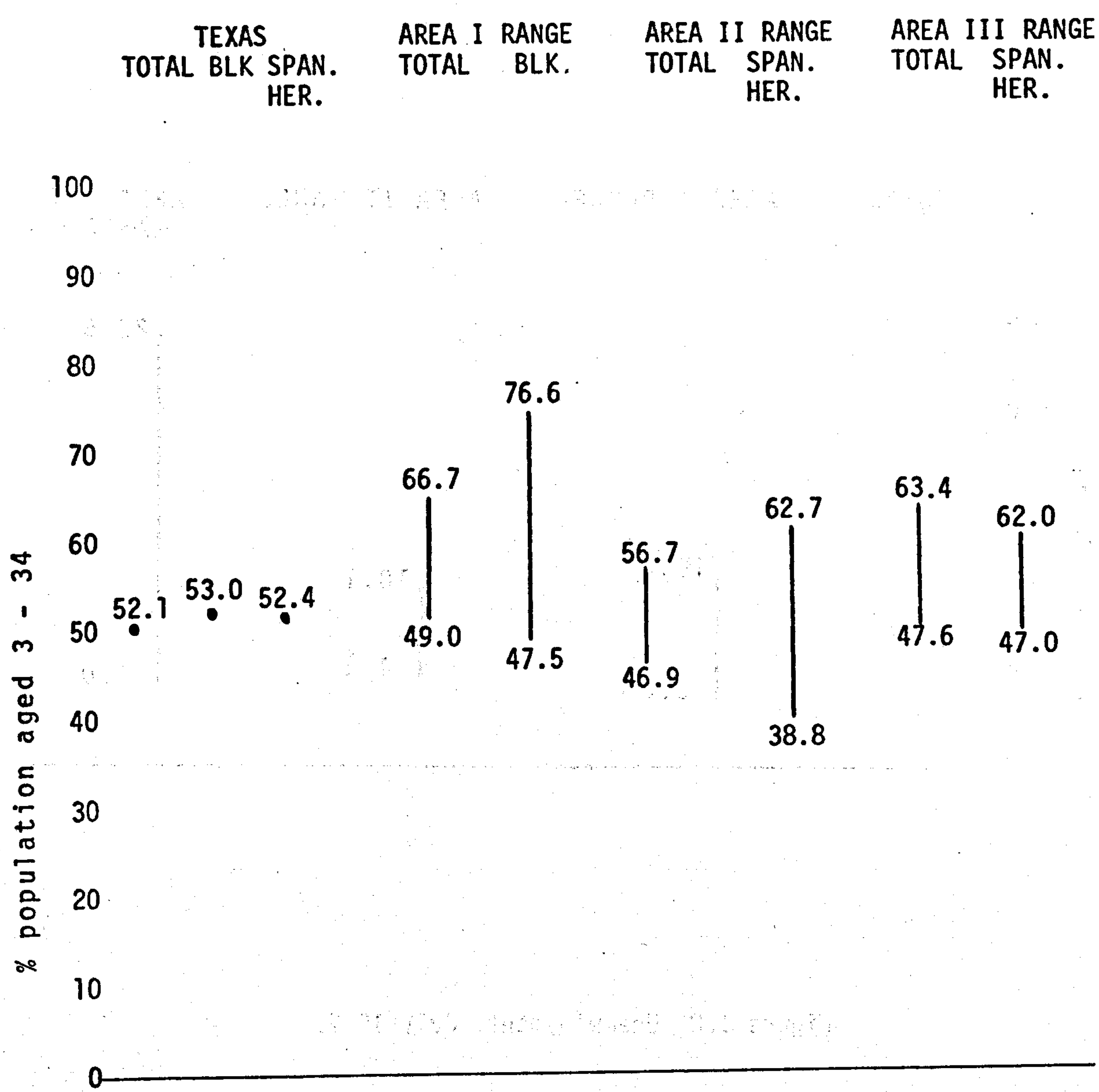


Figure I.7 Population age 3-34 enrolled in school.

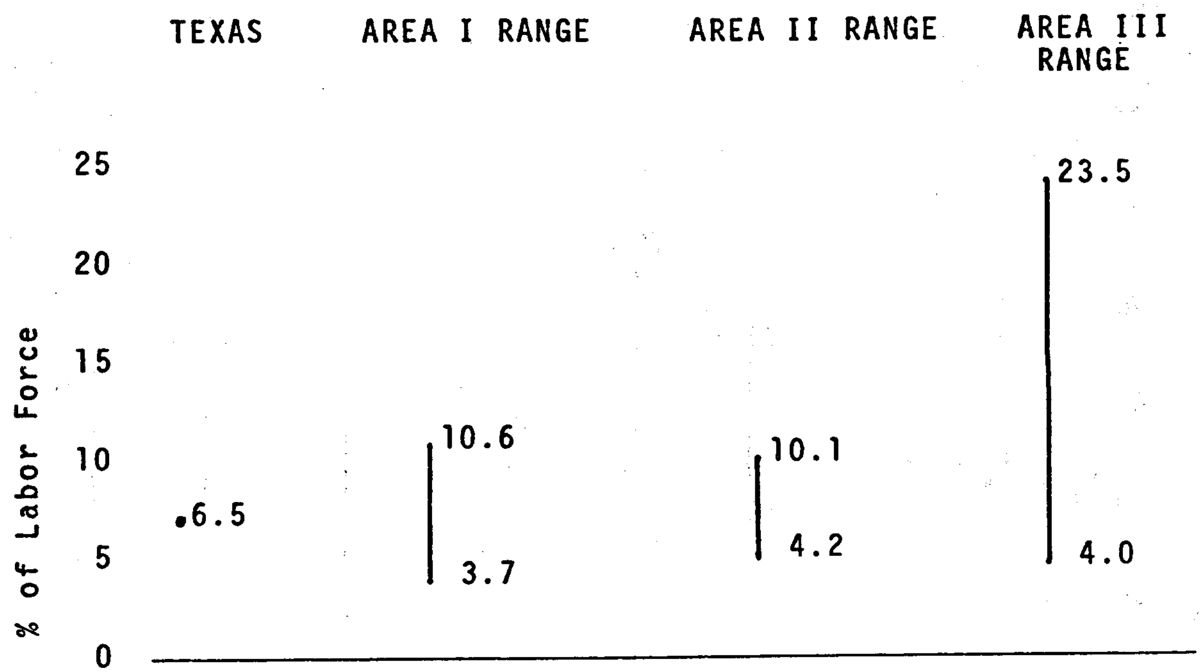
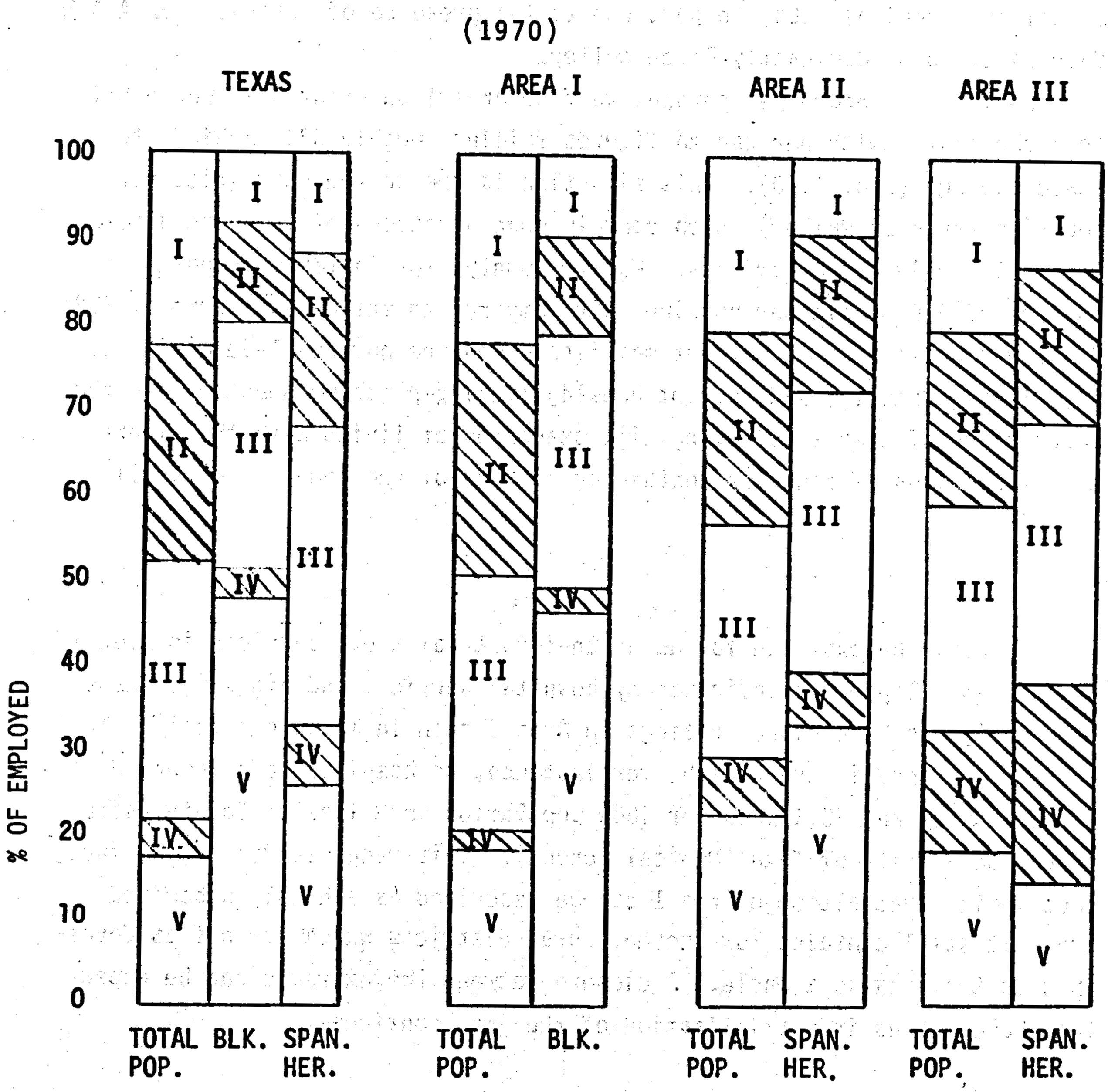


Figure I.8 Unemployment, July 1975.



I. Professional, Technical, Managerial, Administrative
II. Clerical, Sales
III. Craftsmen, Foremen, Operatives, Transport
IV. Farmers, Farm Managers, Farm Labor and Foremen
V. Laborers, Service Workers, Private Household Workers

Figure I.9 Occupational Distribution (1970).

twenty-three percent of Blacks employed in Waller County are in professional or technical jobs, in part due to the presence of Prairie View A & M University, a predominantly Black college.

Looking at income per person, we find Area I substantially worse off than the state, with per capita figures falling roughly $200 behind the state average (Fig. I.10). This situation is due to the statistics for counties (such as Waller) which contain concentrations of low-paid Blacks with relatively large families. Waller County, for instance, reports an average of 3.9 people per housing unit compared to the Texas figure of 3.2. Other variables such as percent families below the poverty level (Fig. I. 11), living density, and percent housing lacking plumbing substantiate the description of Area I as having high standards of living with the important exceptions of counties containing pockets of the low-income racial minority.

Services.

As would be expected for an urban-industrial area, services in Area I are well-developed, as indicated by hospital services and highway mileage. Both variables have higher ratings in Area I than in Texas generally. The intra-area range is great with, for instance, no hospital beds reported in Waller County and 10.1 beds per 1000 population in Galveston County (site of the University of Texas Medical School). This range is due to the fact, once again, that although Area I can be described as a highly urbanized area, it still contains low-income, rural districts which are not as developed as the area as a whole. A closure between the extremes can be expected, however, as industrialization of the area continues.

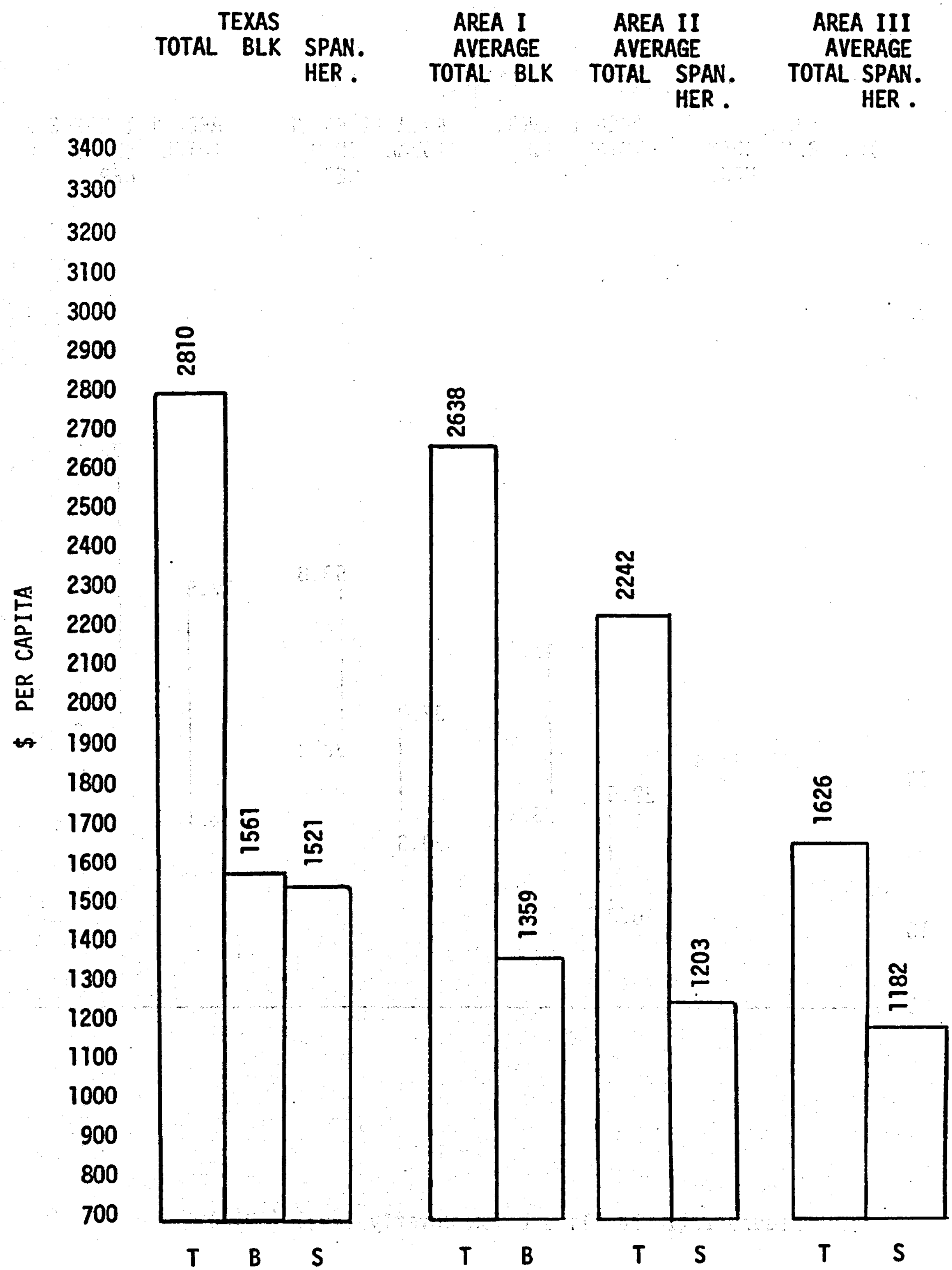


Figure I.10 Per capita income (1970).

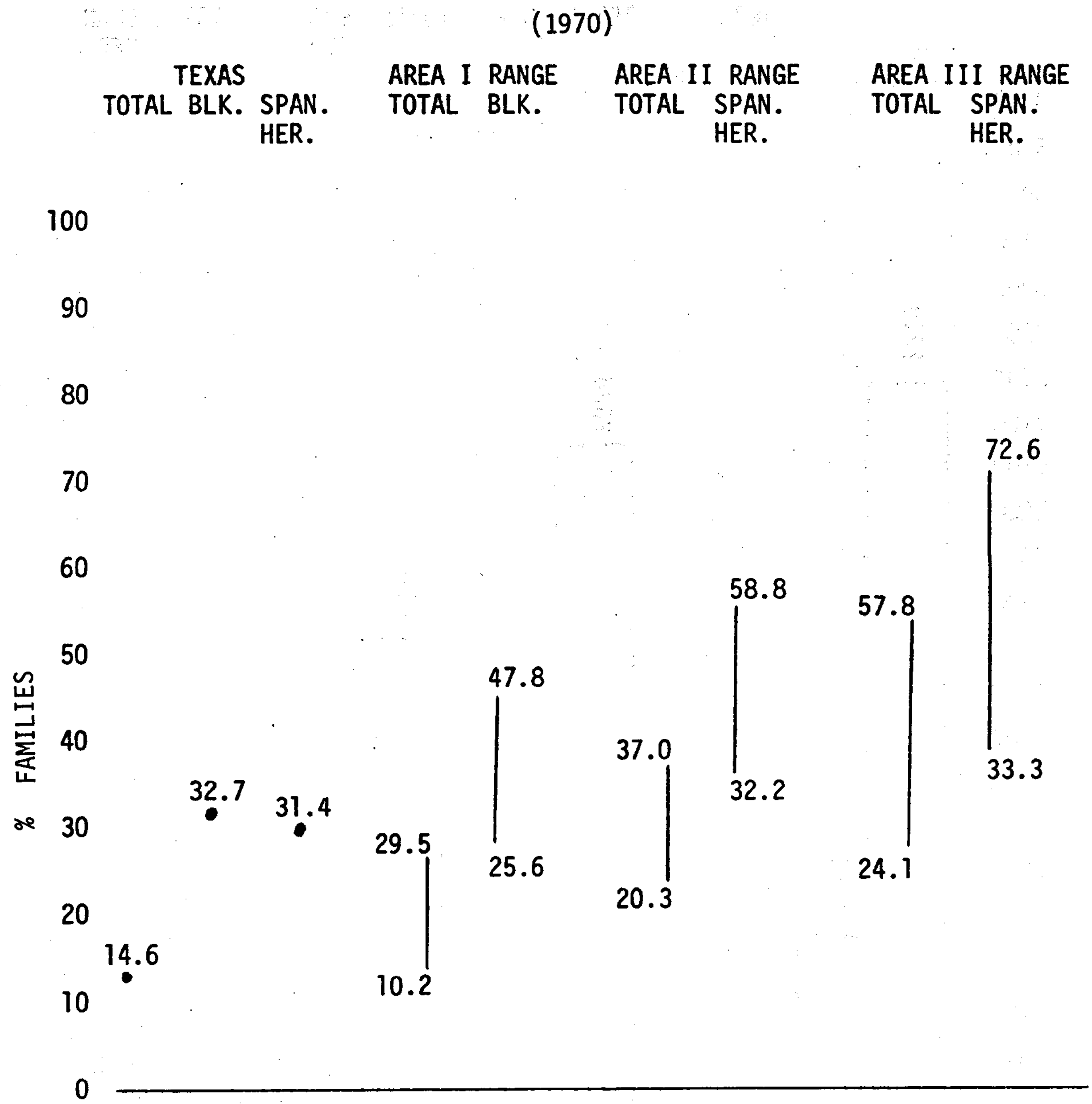


Figure I.11 Families below poverty level (1970).

Table I.1

AREA I. EASTERN COASTAL ZONE

	TEXAS	AREA I	BRAZORIA	CHAMBERS	FT. BEND	GALVESTON	HARDIN	HARRIS	JEFFERSON	LIBERTY	MONTGOMERY	ORANGE	WALLER
I. Demographic													
Population Total	11,195,431	2,527,308	108,312	12,187	52,268	169,812	29,996	1,741,912	244,817	33,014	49,479	71,226	14,285
Population per square mile	43		76	20	60	426	33	1,011	259	28	45	198	28
% Urban	79.8		61.3	46.4	55.3	89.9	25.7	95.5	95.0	45.5	24.2	66.3	28.1
% Net Migration (1960-1970)	1.5		10.4	6.1	8.9	7.8	8.9	21.6	-12.6	-9.7	75.7	1.0	10.6
Birth Rate	19.3		19.3	19.0	19.6	18.1	19.2	21.6	16.9	20.9	16.4	18.9	14.7
Death Rate	8.5		5.8	8.9	6.5	8.5	9.2	6.9	8.9	11.8	8.7	7.1	9.5
% Spanish Heritage	18.4	9.8	9.9	3.8	26.6	12.0	1.6	10.7	4.5	1.3	3.3	3.1	3.5
% Black	12.5	19.8	9.9	20.4	16.9	19.6	15.2	20.2	24.9	21.1	12.4	9.2	52.6
II. Education													
% Population 3-34 enrolled													
Total population	52.1		52.6	49.9	49.0	55.5	49.9	51.9	58.3	50.1	49.7	53.0	66.7
Black population	53.0		48.9	49.0	51.4	58.1	55.5	52.4	57.2	56.2	47.5	56.2	76.6
Median School Years Completed													
All Males	11.7		12.1	10.5	9.5	11.4	10.6	12.2	11.8	9.8	11.4	11.5	10.5
Black Males	9.3		8.7	6.4	8.1	9.2	8.1	9.9	8.4	7.1	7.6	8.6	8.9
All Females	11.6		12.1	10.5	9.8	11.6	10.8	12.1	11.5	10.3	11.3	11.2	11.3
Black Females	10.0		8.8	8.6	8.4	10.2	9.3	10.6	9.4	8.6	9.0	9.2	10.2
III. Labor Force													
% Civilian Work Force Unemployed 1970													
All Males	3.0		2.0	3.1	2.0	3.2	3.7	2.4	3.3	3.2	2.4	3.5	4.6
All Females	4.7		4.9	3.9	3.5	4.7	7.8	4.0	6.4	5.5	3.2	7.9	4.1
Black Males	4.9		4.4	6.5	3.8	4.8	5.4	3.8	7.3	7.3	3.1	7.8	7.5
Black Females	7.0		12.1	5.3	5.6	8.1	11.4	6.2	11.6	11.9	5.3	9.5	4.7
% Unemployed, July 1975	6.5		4.4	3.7	3.8	5.6	10.6	5.3	9.3	6.0	4.0	10.3	6.7
Male Workers, weeks worked in 1969													
Total # Workers	3,088,769	697,938	30,870	3,394	1,389	47,195	7,606	495,942	67,293	8,355	12,984	19,133	3,777
Total # Black Workers	314,950	114,672	2,252	573	1,878	7,466	848	82,554	13,306	1,411	1,153	1,316	1,915
% Working 27-52 Weeks													
All Workers	87.2	88.6	88.2	86.3	85.4	87.2	91.0	89.0	87.9	87.5	90.2	89.6	68.5
Black Workers	84.7	85.7	73.6	83.6	77.8	83.4	88.7	87.0	86.8	87.3	90.2	82.6	49.7
% Working 26 weeks or less													
All Workers	12.8	11.4	11.8	13.7	14.6	12.8	9.0	11.0	12.1	12.5	9.8	10.4	31.5
Black Workers	15.3	14.3	26.4	16.4	22.2	16.6	11.3	13.0	13.2	12.7	9.8	17.4	50.8

Table I.1 (cont'd.)

	TEXAS	AREA I	BRAZORIA	CHAMBERS	FT. BEND	GALVESTON	HARDIN	HARRIS	JEFFERSON	LIBERTY	MONTGOMERY	ORANGE	WALLER
Occupational Categories Total Employed	4,141,529	995,871	39,811	4,291	17,887	65,011	10,061	711,749	89,848	10,884	17,090	24,428	4,811
Black Employed	475,660	178,176	2,871	785	2,476	11,862	1,221	131,372	19,447	1,999	1,780	2,150	2,213
Black as % of Total Employed	11.5	17.9	7.2	18.3	13.8	18.2	12.1	18.5	21.6	18.4	10.4	8.8	46.0
Professional, Technical % of All Employed	14.3	16.1	13.6	12.9	10.2	17.3	11.6	16.9	14.5	9.0	12.8	12.7	19.0
% of Black Employed	7.2	7.8	4.4	2.2	2.9	8.4	2.5	8.0	6.4	3.1	5.1	4.7	23.6
Managers, Administrators % of All Employed	8.7	8.5	7.7	6.8	7.2	7.4	7.6	8.9	7.9	7.4	10.2	6.7	6.5
% of Black Employed	2.1	2.3	3.0	1.5	3.1	1.6	3.3	2.3	2.3	3.7	.6	1.4	2.6
Sales Workers and Kindred % of All Employed	7.8	8.0	4.8	5.7	5.5	6.3	5.6	8.7	6.9	5.4	6.6	6.5	4.4
% of Black Employed	1.9	2.3	.5	2.4	2.5	2.2	.5	2.5	2.0	.8	.3	1.7	.6
Clerical Workers & Kindred % of All Employed	17.4	18.0	12.3	10.3	12.7	16.7	10.5	19.5	14.9	11.9	13.6	12.7	13.5
% of Black Employed	8.8	10.1	2.4	2.2	4.8	8.0	3.8	11.4	6.9	5.3	2.8	4.1	12.7
Craftsmen, Foremen % of All Employed	14.3	15.8	21.5	17.8	16.9	17.1	22.3	14.6	17.5	17.9	21.1	25.4	10.4
% of Black Employed	8.8	9.5	7.5	8.3	8.2	7.6	10.7	9.8	9.7	8.6	8.1	8.0	5.6
Operatives (excl. Transport) % of All Employed	11.1	10.5	13.4	11.4	14.8	10.4	16.7	9.6	12.7	13.0	10.5	15.1	7.0
% of Black Employed	14.3	12.0	10.8	11.2	13.4	9.4	16.5	12.3	12.4	9.6	9.9	11.6	6.4
Transport Equipment Operatives % of All Employed	4.0	3.9	3.5	3.4	3.6	3.1	4.6	4.0	3.8	6.6	5.6	3.1	3.1
% of Black Employed	6.9	8.4	6.7	3.9	6.4	6.0	6.6	9.0	6.9	9.5	10.6	2.8	2.8
Laborers (excl. Farm) % of All Employed	4.9	5.3	5.8	6.0	7.3	6.4	8.3	4.9	6.6	8.9	6.2	5.9	6.2
% of Black Employed	11.3	13.1	18.4	11.2	15.2	15.8	21.1	13.5	16.3	20.8	16.6	21.3	10.2
Farmers, Farm Managers % of All Employed	2.0	.5	1.1	5.1	4.4	.2	.5	.2	.3	2.3	.7	.4	5.4
% of Black Employed	.4	.2	.4	--	2.0	.1	--	.2	.1	1.0	.2	.2	1.3
Farm Laborers, Foremen % of All Employed	2.0	.4	1.1	6.2	3.5	.3	.3	.2	.4	3.4	1.6	.3	6.2
% of Black Employed	2.3	.9	4.8	19.5	6.7	.8	.9	.4	1.1	4.6	4.6	1.0	5.4

Table I.1 (cont'd.)

	TEXAS	AREA I	BRAZORIA	CHAMBERS	FT. BEND	GALVESTON	HARDIN	HARRIS	JEFFERSON	LIBERTY	MONTGOMERY	ORANGE	WALLER
Service Workers													
% of All Employed	11.1	10.7	10.5	11.0	11.0	12.8	9.5	10.5	11.9	10.6	9.0	9.4	13.4
% of Black Employed	23.8	23.5	22.6	21.9	18.9	31.5	19.2	22.9	24.9	17.6	22.0	28.0	18.9
Private Household													
% of All Employed	2.2	2.1	2.2	3.4	3.0	2.0	2.4	2.0	2.5	3.7	2.2	1.6	5.0
% of Black Employed	12.1	10.0	18.5	15.7	15.8	8.7	15.0	9.4	10.4	15.8	17.8	15.0	9.9
IV. Standard of Living													
Median Earnings													
For All Males	6,824		8,853	7,550	6,576	8,024	7,557	7,981	7,860	6,794	7,738	8,311	4,964
Black Males	4,518		4,708	3,490	4,141	4,765	4,847	5,252	5,009	4,611	3,845	4,860	2,738
Earnings--Males in Selected Occupations													
Professional, Managerial													
Total	10,106		11,364	9,402	9,504	11,342	8,846	11,645	10,653	8,852	10,627	10,043	9,049
Black	6,681		6,810	...	...	6,382	...	7,284	6,759	...	...	...	3,556
Craftsmen, Foremen													
Total	7,260		9,558	8,641	7,634	8,650	8,099	8,192	8,629	7,532	8,023	9,195	6,606
Black	5,137		6,141	...	5,917	5,300	5,739	5,659	5,647	5,974	4,310	5,758	5,208
Operatives, Transport													
Total	5,956		8,631	7,944	6,336	7,596	7,591	6,788	7,616	6,698	6,940	7,957	5,105
Black	4,950		4,946	...	4,733	4,773	5,585	5,573	5,372	4,605	3,877	5,649	3,625
Laborers (excl. Farm)													
Total	3,636		4,351	3,853	4,205	4,644	4,271	4,302	4,482	3,926	3,714	5,031	2,143
Black	3,955		4,338	...	4,391	4,703	3,793	4,620	4,687	4,303	3,836	4,329	1,747
Farmers, Managers													
Total	4,705		5,367	6,167	3,673	7,192	...	5,235	5,417	3,420	6,600	...	4,275
Black	1,198		...	--	...	...	--	2,602	...	...	...	--	...
Farm Laborers, Foremen													
Total	2,607		3,024	3,008	2,544	2,441	...	2,832	2,542	3,485	1,957	...	3,313
Black	2,003		2,548	2,821	1,750	...	...	2,385	2,271	...	...	...	3,029
Median Earnings													
For All Females	3,241		3,202	2,433	2,922	3,239	2,823	3,637	2,885	2,594	3,066	3,002	1,711
Black Females	2,182		1,225	1,493	1,809	2,225	1,534	2,443	1,707	1,342	1,213	1,526	988

Table. I.1 (cont'd.)

	TEXAS	AREA I	BRAZORIA	CHAMBERS	FT. BEND	GALVESTON	HARDIN	HARRIS	JEFFERSON	LIBERTY	MONTGOMERY	ORANGE	WALLER
Earnings--Females in Selected Occupations													
Clerical													
Total	3,879		4,022	3,667	4,003	3,761	3,681	4,324	3,597	3,539	3,722	3,632	2,429
Black	2,951		...	...	...	2,628	...	3,144	2,497	...	...	...	722
Operatives, Transport													
Total	3,142		2,736	...	3,176	2,847	3,054	3,162	2,219	2,750	2,678	2,787	785
Black	3,026		...	...	....	2,314	...	2,726	1,638	...	...	...	...
Per Capita Income													
Total Population	2,810		2,903	2,584	2,227	3,023	2,365	3,391	2,887	2,276	2,663	2,740	1,955
Black Population	1,561		1,243	1,158	1,144	1,655	1,315	1,785	1,544	1,190	1,315	1,339	1,262
% Families Below Poverty													
Total Population	14.6		10.2	21.8	21.3	14.0	18.7	12.2	15.4	22.6	17.4	12.3	29.5
Black Population	32.7		35.0	46.4	42.1	29.3	36.1	25.6	32.6	42.1	47.8	34.0	38.8
Housing													
Persons Per Unit	3.2		3.5	3.1	3.7	3.2	3.2	3.2	3.2	3.1	3.3	3.4	3.9
% with 1.01 + per Room	11.1		10.9	10.5	17.7	9.6	11.5	9.6	9.1	11.8	10.5	11.3	12.1
Rooms Per Unit	4.8		4.9	4.9	4.9	4.7	4.9	4.9	5.0	4.7	4.8	4.9	4.8
% Lacking Plumbing	6.0		4.9	12.3	14.6	3.0	11.4	1.8	3.1	13.3	11.6	3.1	20.5
V. Services													
Hospital Beds per 1000	3.5		2.3	6.2	2.6	10.1	3.4	4.8	5.2	3.5	2.0	2.8	0.0
State Highway Mileage	256.5		393.1	234.3	330.3	245.6	229.7	558.1	271.2	349.1	358.5	178.9	206.5

AREA II. THE MIDDLE COASTAL ZONE

As mentioned earlier, the Middle Coastal Zone is an area of transition between the eastern urban area and the economically depressed counties to the south.

Demographics.

The Middle Coastal Zone is neither particularly densely populated, nor is it a highly urbanized area. Only three counties surpass the state average population density. Nueces County, which contains the only major metropolitan center in Area II--Corpus Christi (estimated population 215,000 as of April, 1973)--is the most densely settled county in this part of the coastal zone and is the only county more urbanized than the state average. Nueces and San Patricio Counties constitute the Corpus Christi SMSA. Neighboring Live Oak, Jim Wells, and Aransas Counties are influenced by the metropolitan activities of the Corpus SMSA, but the entire Middle Coastal Zone remains predominantly agricultural.

In contrast to Area I, the Middle Coastal Zone has been characterized by a significant degree of out-migration. Only one county, Aransas, gained population through migration during the period 1960 to 1970. The Middle Coastal Zone population is more than one-third Mexican American and only 7.2 percent Black. The Black population is concentrated in the eastern counties and becomes proportionately less in the southern counties of this area. The Mexican American population, on the other hand, increases as one looks down the coast. These minority distributions reflect the transition from the Eastern Coastal Zone which supports a high percentage of Blacks to the Southern Coastal Zone with a majority of Mexican Americans. Data in Area II are given for the population as a whole and for the Mexican American minority.

Education.

The Middle Coastal Zone lags somewhat behind state averages of school years completed, both for the total population and the Mexican American sub-group. In terms of present population enrolled in school, however, the figures for Area II are roughly the same as state figures.

Labor Force.

Unemployment in the Middle Coastal Zone varies substantially by county. Total male unemployment in 1970 was less than two percent in Jackson and Calhoun Counties, while it was nearly five percent in Goliad County. Mexican American male unemployment is consistently higher, ranging from 2.3 percent in Jackson to 9.1 percent in Goliad. Female unemployment for both the total and the Spanish Heritage populations is higher than for males and considerably higher than state figures. July, 1975, unemployment rates ranged from 4.2% in Wharton County to 10.1 in Calhoun County. The more industrialized Corpus Christi area (Nueces and San Patricio Counties) also reported higher rates than the 6.5 state figure. Part-time employment is less in Area II than for Texas as a whole.

The occupational distribution in the Middle Coastal Zone is more heavily skewed toward the lower end compared to the Eastern Coastal Zone, and this trend is even more pronounced in Area III, as will be seen. Professional, managerial, as well as skilled labor jobs grow fewer down the coast, with semi-skilled and unskilled labor, and, in particular, farm-related occupations increasing.

Almost a third of the employed in Area II are Mexican American, with those workers being disproportionately represented in lower-level occupations. For example, approximately 22 percent of the Area II labor force are in professional and managerial occupations and 18 percent are in labor and service jobs. Roughly 11 percent of all Mexican American workers are employed in professional and managerial positions, while over one-fourth are in service and labor occupations. Over five percent of the active labor force are in farm-related work, compared to a state average of four percent and an average of less than one percent in the neighboring Eastern Coastal Zone. The incidence of farm employment among Mexican Americans is particularly notable, with a high of 27 percent in Goliad County. Only in the two most urbanized counties, Nueces and Victoria, has Mexican American farm labor declined significantly below the state average. (Aransas County has a substantial fishing business, and shows negligible employment in agriculture).

Standard of Living.

The occupational distribution is reflected in median earnings. Area II counties lie below state averages, both for the population as a whole (except Calhoun County) and for the Spanish Heritage population (except Calhoun and Nueces Counties). Even more interesting, perhaps, is to note the drop from the male median earnings figures ranging from $4,964 to $8,853 in Area I, to a range of $3,852 to $7,230 in Area II. Earnings of the Mexican American population are consistently lower than for the total population for both males and females.

Per capita income is substantially lower than state figures, with a total population range from $1,997 to $2,585 and a Spanish Heritage range from $872 to $1,473. As might be expected then the incidence of poverty is high: from 20.3 to 37 percent of all families in Area II counties fall below the census-defined poverty level, compared to the state average of 14.6 percent; from 32.2 to 58.8 percent of Spanish Heritage families are so classified compared to the Texas figure of 31.4 percent.

The low incomes in the Middle Coastal Zone are reflected in housing quality. Housing in this area is overcrowded when compared to state averages. In Texas, slightly more than 11 percent of all units house more than an average of one person per room; all Area II county percentages are higher than this, up to 21 percent in San Patricio County. Moreover, a significant portion of Area II housing is substandard, as indicated by percent units lacking some or all plumbing: as high as 26.6 percent in Goliad County, compared to the state figure of 6 percent.

Services.

From the rice-farming counties bordering Area I to the agricultural land which encircles Corpus Christi, Area II has a farm-based economy. Oil and gas production significantly supplement agricultural production. The industrial developments in Corpus Christi mark a turn, however, toward a manufacturing-oriented base. As the Middle Coastal Zone develops in that direction, services in the area increase. In terms of state highway mileage, for example, the area appears to be generally as well served as the rest of the state. Personal services are also developing; medical care, measured in terms of the number of hospital beds for each 1000 population, is on a par with the state, although some counties appear to be individually lacking in hospital services.

Table I.2

AREA II. MIDDLE COASTAL ZONE

	TEXAS	AREA II	ARANSAS	BEE	CALHOUN	GOLIAD	JACKSON	MATAGORDA	NUECES	REFUGIO	SAN PATRICIO	VICTORIA	WHARTON
I. Demographic Population Total	11,195,431	479,940	8,902	22,737	17,831	4,761	12,975	27,913	237,544	9,494	47,288	53,766	36,729
Population per square mile	43		32	27	34	6	15	24	282	12	69	60	34
% Urban	7.8		0	58.7	58.5	0	41.1	55.5	94.0	48.2	64.5	76.9	44.8
% Net Migration (1960-1970)	1.5		17.4	-24.6	-14.8	-16.3	-17.9	-6.2	-12.7	-26.6	-15.0	-2.8	-15.2
Birth Rate	19.3		17.2	25.4	20.6	14.8	14.4	16.9	23.3	11.6	22.5	19.8	17.3
Death Rate	8.5		10.8	7.9	6.3	13.3	9.9	7.2	7.1	6.4	7.0	8.2	9.0
% Spanish Heritage	18.4	39.0	26.6	39.1	33.4	38.5	17.7	18.5	46.3	38.0	49.1	31.5	18.8
% Black	12.5	7.2	4.6	2.7	4.7	12.0	12.8	19.4	4.7	9.8	2.4	8.0	19.9
II. Education													
% Population 3-34 enrolled													
Total population	52.1		56.7	46.9	52.3	51.8	52.3	53.9	52.6	55.2	55.7	52.3	53.7
Spanish Heritage	52.4		62.7	54.4	51.3	45.7	54.2	51.1	53.3	53.2	54.7	38.8	49.6
Median School Years Completed													
All Males	11.7		10.9	10.7	11.3	8.0	9.5	10.1	12.0	9.9	10.0	11.1	9.4
Spanish Heritage Males	7.6		5.4	5.2	7.3	5.3	5.5	5.6	8.1	5.2	4.9	7.2	5.7
All Females	11.6		11.5	10.6	11.5	8.9	10.3	10.9	11.7	10.2	10.1	11.3	9.9
Spanish Heritage Females	7.0		6.0	4.4	6.6	5.6	6.5	6.0	7.2	5.3	4.2	6.8	5.5
III. Labor Force													
% Civilian Work Force Unemployed 1970													
All Males	3.0		4.1	3.3	1.9	4.8	1.6	3.1	3.5	4.6	4.3	3.1	2.1
All Females	4.7		3.5	6.7	7.2	6.0	4.3	7.7	5.5	3.3	5.0	6.7	5.6
Spanish Heritage Males	4.7		5.7	3.5	2.8	9.1	2.3	3.2	4.7	5.3	4.4	5.3	2.6
Spanish Heritage Females	6.8		6.0	8.2	15.5	15.8	9.9	6.6	7.1	3.7	6.3	8.7	9.9
% Unemployed, July 1975	6.5		4.3	5.2	10.1	5.2	4.3	6.1	8.1	4.7	8.6	5.9	4.2
Male Workers, weeks worked in 1969 Total # Workers	3,088,769	125,060	2,158	6,545	4,593	1,296	3,484	7,221	61,867	2,560	11,792	13,863	9,681
Total # Spanish Heritage	464,226	39,536	386	1,881	1,250	430	603	1,239	22,689	870	4,762	3,810	1,616
% Working 27-52 Weeks													
All Workers	87.2	88.7	80.1	91.0	92.0	78.9	87.0	84.9	90.2	84.6	84.6	89.9	86.6
Spanish Heritage Workers	85.9	88.0	84.2	90.0	93.0	85.3	85.1	81.2	90.2	81.1	79.6	87.8	87.0
% Working 26 weeks or less													
All Workers	12.8	11.3	19.9	9.0	8.0	21.1	13.0	15.1	9.8	15.4	15.4	10.1	13.4
Spanish Heritage Workers	14.1	12.0	15.8	10.0	7.0	14.7	14.9	18.8	9.8	18.9	20.4	12.2	13.0

Table I.2 (cont'd.)

Occupational Categories	TEXAS	AREA II	ARANSAS	BEE	CALHOUN	GOLIAD	JACKSON	MATAGORDA	NUECES	REFUGIO	SAN PATRICIO	VICTORIA	WHARTON
Total Employed	4,141,529	162,974	2,845	6,345	5,835	1,548	4,529	9,679	81,305	3,471	14,947	19,356	13,114
Spanish Heritage Employed	600, 425	51,003	569	2,359	1,553	511	706	1,498	30,078	1,202	5,530	4,973	2,024
Spanish Heritage as % of Total Employed	14.5	31.3	20.0	37.2	26.6	33.0	15.6	15.5	37.0	34.6	37.0	25.7	15.4
Professional, Technical													
% of All Employed	14.4	13.2	8.2	12.2	12.3	11.1	10.8	11.8	14.6	9.0	11.2	13.7	11.8
% of Spanish Heritage	7.6	6.2	3.7	3.2	3.9	3.1	1.6	5.4	7.5	.1	4.9	5.8	4.0
Managers, Administrators													
% of All Employed	8.9	8.8	15.3	8.2	7.8	7.5	4.9	8.9	9.6	6.0	10.2	7.2	6.3
% of Spanish Heritage	5.8	4.7	9.5	5.0	3.1	0	3.5	8.4	5.1	.1	4.4	3.4	2.8
Sales Workers and Kindred													
% of All Employed	7.8	7.0	9.9	8.1	4.0	2.8	5.6	4.0	7.8	6.2	5.9	8.0	5.4
% of Spanish Heritage	5.7	4.7	5.3	4.4	1.4	2.7	5.1	1.0	5.2	6.1	2.7	5.4	5.8
Clerical Workers & Kindred													
% of All Employed	17.4	14.8	13.5	14.7	10.9	9.7	9.0	11.4	16.8	12.2	13.0	13.8	13.1
% of Spanish Heritage	13.7	11.0	6.9	8.4	3.7	5.1	3.8	7.1	13.4	5.5	6.9	11.1	6.4
Craftsmen, Foremen													
% of All Employed	14.3	16.0	15.5	15.5	17.8	15.4	17.8	15.3	16.1	15.1	17.0	16.7	13.7
% of Spanish Heritage	15.0	16.1	13.5	18.4	11.5	18.6	16.3	11.6	17.0	9.4	14.7	16.7	14.4
Operatives (excl. Transport)													
% of All Employed	11.1	10.0	8.1	7.4	17.3	8.6	15.7	12.6	8.9	11.3	9.2	11.3	11.0
Transport Equipment Operatives													
% of All Employed	4.0	4.0	3.8	3.3	3.0	3.1	3.2	4.0	4.1	3.6	3.6	4.6	4.8
% of Spanish Heritage	5.3	6.4	8.3	5.6	6.1	6.7	5.8	6.7	6.6	5.8	6.0	6.9	4.1
Laborers (excl. Farm)													
% of All Employed	4.9	6.8	42.2	5.5	8.3	8.5	5.5	7.7	5.7	8.4	8.0	5.3	5.5
% of Spanish Heritage	8.7	11.4	13.7	11.3	16.9	11.9	15.0	14.5	10.2	18.1	15.2	10.0	9.4
Farmers, Farm Managers													
% of All Employed	2.0	2.4	.8	4.1	2.5	13.0	7.9	4.1	.9	2.2	3.2	2.0	7.3
% of Spanish Heritage	.7	.6	---	1.2	1.0	1.8	---	---	.3	---	1.2	.6	1.7
Farm Laborers, Foremen													
% of All Employed	2.0	2.9	.9	4.5	2.6	11.5	6.4	4.5	1.2	6.3	5.6	2.0	6.9
% of Spanish Heritage	5.8	6.2	---	8.1	6.7	25.2	6.2	8.0	2.8	11.0	12.8	2.9	15.7

Table I.2 (cont'd.)

	TEXAS	AREA II	ARANSAS	BEE	CALHOUN	GOLIAD	JACKSON	MATAGORDA	NUECES	REFUGIO	SAN PATRICIO	VICTORIA	WHARTON
Service Workers													
% of All Employed	11.1	11.3	11.8	12.7	11.8	11.5	9.1	11.4	11.6	14.0	10.0	11.7	9.5
% of Spanish Heritage	13.8	16.1	16.0	19.8	16.7	14.7	11.0	16.3	16.2	20.6	14.6	16.7	12.7
Private Household													
% of All Employed	2.2	3.3	3.7	3.8	1.8	5.4	1.7	4.3	2.9	6.0	3.1	3.5	4.9
% of Spanish Heritage	2.5	4.8	19.2	7.6	3.5	7.2	6.5	4.4	3.5	12.0	6.7	5.1	5.2
IV. Standard of Living													
Median Earnings													
For All Males	6,824		5,893	4,946	7,230	3,852	6,168	6,332	6,771	5,671	6,116	6,566	5,297
Spanish Heritage Males	4,599		3,895	3,283	5,127	2,726	4,544	4,551	4,885	3,437	3,870	4,167	4,152
Earnings--Males in Selected Occupations													
Professional, Managerial													
Total	10,106		8,242	8,480	9,546	6,824	7,911	8,382	10,209	8,551	8,625	9,443	8,250
Spanish Heritage	7,698		...	4,712	...	---	...	...	6,213	...	6,250	7,167	...
Craftsmen, Foremen													
Total	7,260		6,639	5,926	8,837	4,364	7,190	7,350	7,232	7,307	7,270	6,924	6,053
Spanish Heritage	5,466		...	3,831	6,232	...	4,463	4,600	5,634	...	4,935	4,726	5,261
Operatives, Transport													
Total	5,956		5,883	5,007	7,588	3,652	6,831	6,585	5,884	6,807	6,054	6,320	5,272
Spanish Heritage	5,466		...	3,740	5,867	...	4,788	5,436	5,284	4,231	5,078	4,396	5,219
Laborers (excl. Farm)													
Total	3,636		3,756	3,135	3,895	4,541	5,286	3,903	3,455	3,576	3,541	3,343	3,622
Spanish Heritage	3,448		...	3,039	4,208	...	5,145	3,731	3,392	3,479	3,529	3,496	3,456
Farmers, Managers													
Total	4,705		...	3,338	8,028	...	4,182	6,275	6,037	...	6,914	3,731	3,754
Spanish Heritage	3,323		0	...	...	2,192	0	0	2,667	0	...	....	...
Farm Laborers, Foremen													
Total	2,607		...	2,005	2,366	...	2,167	2,877	2,454	2,870	2,008	2,581	2,768
Spanish Heritage	2,493		0	2,096	...	2,194	...	3,947	2,379	2,521	2,139	2,305	2,805
Median Earnings													
For All Females	3,241		3,034	2,306	2,789	1,819	2,237	2,549	3,220	2,534	2,582	2,613	2,323
Spanish Heritage Females	2,515		1,635	1,552	1,831	1,231	994	1,441	2,447	2,450	1,316	1,688	1,633

Table I.2 (cont'd.)

	TEXAS	AREA II	ARANSAS	BEE	CALHOUN	GOLIAD	JACKSON	MATAGORDA	NUECES	REFUGIO	SAN PATRICIO	VICTORIA	WHARTON
Earnings--Females in Selected Occupations													
Clerical													
Total	3,879		3,413	2,879	3,504	...	2,511	3,467	3,891	3,420	3,278	3,341	3,320
Spanish Heritage	3,229		...	1,536	...	...	...	...	3,068	...	2,433	3,127	...
Operatives, Transport													
Total	3,142		...	...	1,856	...	...	2,306	2,703	...	2,100	1,994	1,957
Spanish Heritage	2,700		0	...	1,870	...	...	...	2,640	...	...	1,440	...
Per Capita Income													
Total Population	2,810		2,585	2,015	2,302	1,997	2,207	2,260	2,527	2,284	2,039	2,332	2,111
Spanish Heritage	1,521		1,031	947	1,261	872	1,468	1,234	1,473	1,238	1,064	1,338	1,305
% Families Below Poverty													
Total Population	14.6		21.3	29.3	20.3	37.0	26.2	24.4	21.5	25.5	32.6	21.8	30.6
Spanish Heritage	31.4		41.3	53.9	32.2	58.8	35.8	39.0	34.7	45.3	54.3	39.7	37.9
Housing													
Persons Per Unit	3.2		3.0	3.5	3.6	3.1	3.2	3.2	3.5	3.3	3.7	3.4	3.3
% With 1.01 + per Room	11.1		12.0	14.0	17.0	13.5	12.0	11.6	15.9	15.4	21.0	14.1	14.3
Rooms Per Unit	4.8		4.4	4.7	4.7	4.8	4.9	4.7	4.8	4.8	4.6	4.9	4.9
% Lacking Plumbing	6.0		3.5	12.9	5.6	26.6	10.8	11.9	4.8	11.4	18.1	7.5	16.2
V. Services													
Hospital Beds per 1000	3.5		0.0	3.2	4.0	7.0	3.8	0.0	5.4	4.2	2.8	6.3	6.0
State Highway Mileage	256.5		73.1	270.6	170.3	238.4	262.3	300.4	407.5	184.3	299.1	231.6	369.5

AREA III. THE SOUTHERN COASTAL ZONE

Long-standing social and economic problems, such as the underdevelopment of human resources in terms of levels of education and job training, language and cultural differences stemming from close proximity to Mexico, remoteness from centers of economic activity, and scarcity of fresh water, have been barriers to economic development in South Texas. Due in large measure to the lagging nature of South Texas development, numerous studies are available describing the area and its problems. The most pertinent of those studies are referenced at the end of the present volume. In the present chapter only an overview of the area is given, as was done for the Eastern and Middle Coastal Zones.

Demographics.

The fourteen-county Southern Coastal Zone is predominantly a rural, farm and ranch area. Population densities are extremely low. Only two counties exceed the state average figure for population per square mile: Cameron and Hidalgo. Cameron County contains the Brownsville-Harlingen-San Benito SMSA, and Hidalgo is the present extent of the McAllen-Pharr-Edinburg SMSA. Both of these SMSA counties rely heavily on agribusiness and some food processing industries. The Laredo SMSA encompasses Webb County. While Area III as a whole appears from census statistics to be somewhat heavily urbanized, this pattern is due to the tendency for the population to cluster in small villages and towns. That the area is not, in fact, urbanized can be seen from the population densities, which reach a low in McMullen County of one person per square mile.

The Southern Coastal Zone has a high degree of out-migration among the population. In the decade 1960 to 1970 the counties in the area experienced population loss through migration of from 8.6 to 42.2 percent. As would be expected of the border region, Area III counties consist largely of Mexican Americans and have small percentages of Blacks. U.S. Census reports for 1970 show from 40 to 98% persons of Spanish Heritage for all counties in the area except Kleberg. As a whole, the Southern Coastal Zone population is nearly three-fourths Mexican American. Language and cultural differences of this segment of the population add to the social and economic problems of the area, especially in the areas of labor and education. The already predominant Mexican language and culture are constantly reinforced by immigration, both legal and illegal, across the border. Mexican immigration to the U.S. from 1964 to 1973 numbered 475,409. It is impossible to know how many Mexicans enter illegally each year, but at least 78,981 were apprehended and deported in the same 10 year span (Immigration and Naturalization Service, 1973). Some estimates place the number of detected and undetected illegal immigrants at one million annually (Portes, 1974). This influx of immigrants places an added strain on the employment and educational situation.

Heaviest out-migration occurs among Anglos, with nearly a fifty percent loss between 1960 and 1970 (Pan American University, Division of Business and Economic Research, 1973). Significant population loss is witnessed, too, in the younger age groups (20-29) among Mexican Americans. As the younger and better educated population leaves the area, the result is an increasing concentration of older, unskilled or semi-skilled workers. A "vicious cycle" is evident as productive growth industries experience this population change as a deterrent to southern location, and the lack of industrial development in turn spurs further out-migration.

The high birth rates and relatively low death rates (Fig. I.12) mean, however, that the area continues to grow in population due to natural increase. State population projections show that even with continued population loss through migration, the Southern Coastal Zone population will increase by roughly 30 percent from 1970 to 1990 (Governor's Office of Information Services, 1974).

Education.

Educational attainment (median school years completed) in South Texas is far below standard for the state. This pattern holds for the total population as well as the Spanish Heritage population, for males and females. Low educational attainment among Mexican Americans stems partially from the fact that, historically, this group has not been able to place a great deal of emphasis on education, as poor economic conditions often forced students to drop out of school early to enter the job market and help support the family. The problem was further compounded by the language

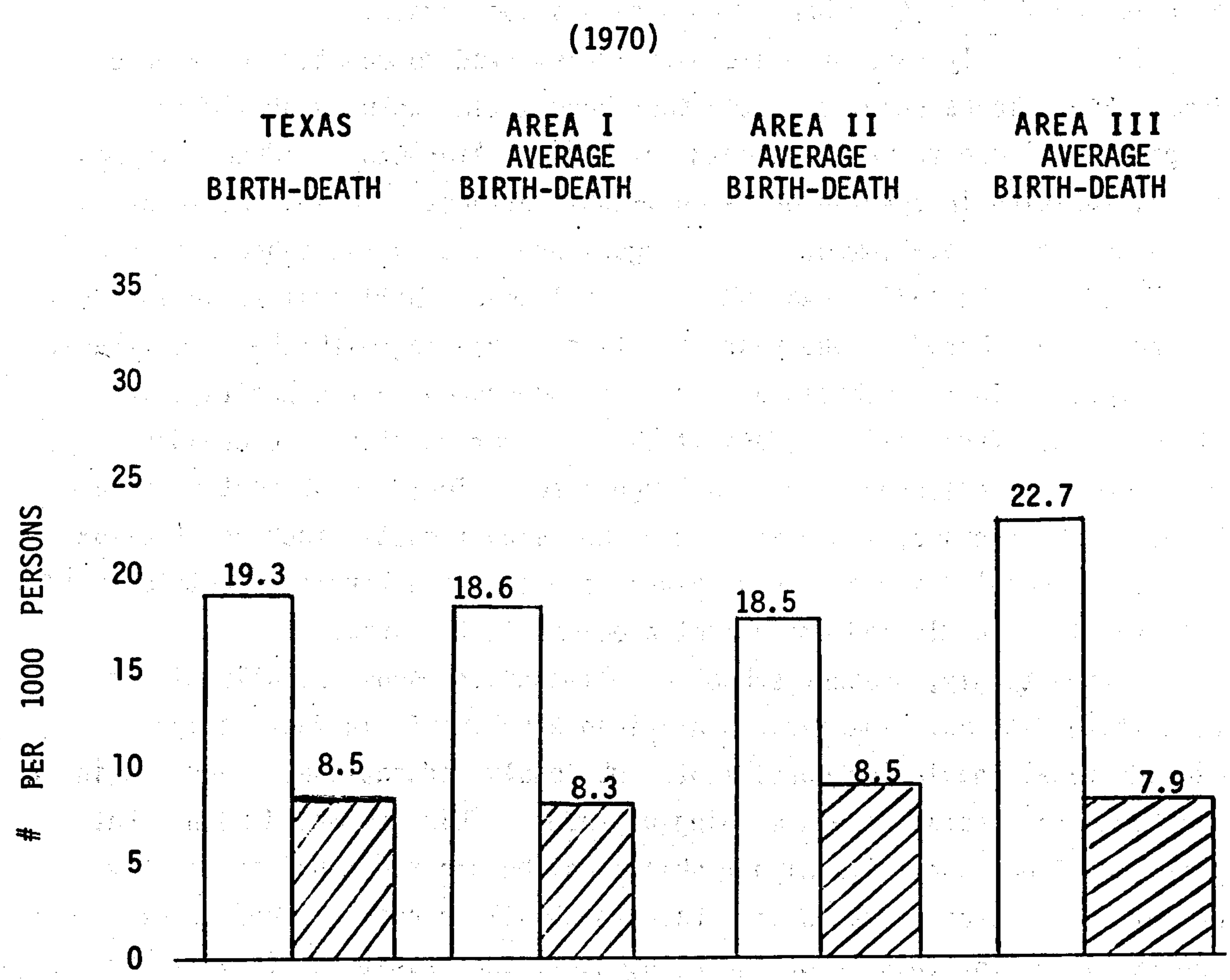


Figure I.12 Birth and death rates (1970).

barrier, including the lack of basic English skills. Inability to understand what is going on in a classroom causes students to lose interest quickly and fall farther behind with each school grade.

Only recently have programs been implemented to counter these problems. South Texas schools in the past have often excluded or limited programs designed to meet the needs of Mexican American children. In many cases, speaking in Spanish was a punishable offense. Today, the emphasis is switching to development of bilingual programs in the schools (see Moore, 1970). In 1972, Texas HB 121 established a bilingual education program to be phased in one year at a time, beginning with the first grade.

Problems in the schools are further compounded by the constant influx of immigrants from Mexico. Facilities in border counties are crowded. Most immigrant children require bilingual education, and dropout rates are high. In most cases, immigration does not significantly increase the tax base of a school district. Educational and language barriers contribute to the overall economic and employment problems in the area.

Interestingly, present school enrollments are substantially higher than state figures. The Mexican American enrollment, in fact, slightly exceeds total population enrollment. Obviously, educational standards in the Southern Coastal Zone are being upgraded. This new trend means that a potential labor pool with higher skills may be created. Unless the development of the area proceeds at a rate which will provide occupational opportunities for this labor force, however, the result is likely to be increased out-migration. The better educated population is the first to leave the area in order to find suitable jobs. In another vein, it is this better educated population which provides a source of possible leadership for political organization. The development of education without the development of a suitable market place for skills learned has, then, several unintended consequences, among which are population dislocations and/ or a volatile political situation.

Labor Force.

A surplus of unskilled labor is one major factor in the lagging economic development of South Texas. The problem developed as agriculture, historically the major industry of the region, became more mechnaized, leaving many workers unemployed and without salable skills needed in the labor force. Thousands of South Texans joined the migrant labor stream with its low wages and poor working conditions. Others remained unemployed in the region.

The seasonal nature of agricultural work and the large numbers of displaced farm workers, are contributors to the high percentages of part-time employment. Texas data shows that 12.8 percent of all male workers age 16 and over and 14.1 percent of Mexican American workers were employed half the year or less during 1969. For Area III, however, the percentage was 17.2 for the total male work force, and 18.9 for Mexican Americans. Part-time employment rates are highest (32.2%) in Starr County, which also has the highest percentage of persons of Spanish Heritage (97.9%).

Census data for 1970 showed male unemployment in Area III counties substantially above the Texas rate of 3.1%. Kenedy County, with 2.7%, is the only county with a lower rate than the state; others range from 3.7% (Kleberg) to 7.5% (Starr). Unemployment in the Spanish Heritage population is generally higher than that for the total population. Total unemployment had increased sharply by July, 1975, reaching a high of nearly a quarter of the labor force in Starr County (see Figure I.8).

Area III is heavily dependent on farm employment, with over 12 percent of the employed population in farm occupations compared to a state total of 4 percent. Among Spanish Heritage workers, nearly 20 percent are involved in agricultural work. As can be seen from Table I.3, median earnings for Mexican Americans are exceedingly low in those occupations. At least part of this low reported income is due to the semi-feudal nature of a large part of the Southern Coastal Zone. Many workers receive much of their sustenance commodities in kind from the large ranches and farms which employ them. They live in ranch-furnished houses, receive food from ranch-backed stores, and in some cases are entitled to ranch-based medical services.

The area differs from the state less substantially in other categories. If we combine the top two categories, Professional and Technical, and Managers and Administrators, we find that 20.6% of Area III workers fall in this high category, compared with 23.3% of Texas workers. Mexican American workers, however, are better represented in Area III (14.3%) than in the state (12.6%) for these categories. Sales and clerical workers comprise 21.6% of the total Area III working population and about 20% of all Mexican American workers--again above state percentages. The Craftsmen and Foreman category, indicating skilled labor, is under-represented in Area III, as are Operative professions. Mexican Americans in the area fall further behind the state average in these two categories than does the total population.

Standard of Living.

Median earnings for both males and females in both the total and Mexican American populations fall substantially below state median. Median earnings (1970) in Texas are $6,824 for the total population and $4,599 for Mexican Americans. Area III counties range from $1,966 (Kenedy County) to $5,731 (Jim Wells) for the entire population and from $1,938 (Kenedy) to $4,593 (McMullen) for population of Spanish Heritage. Generally speaking, median earnings in all occupational categories in Area III are lower than the median for Texas, and the median earnings for Mexican Americans are below those for the total population.

A large influx of legal and illegal immigrants from Mexico constantly reinforces the already large surplus of unskilled labor, and commuters who live in Mexico and work in Texas add to the competition in the job market. This large scale immigration and border commuting contributes not only to the displacement of Texas workers and the depression of wages in the area, but also to the concentration of a large, unskilled Mexican American population in South Texas. This group has the added problems of cultural and language differences which are additional barriers to entrance to the labor market.

The main reason for the large number of immigrants and commuters is the economic discrepancy between the U.S. and Mexico. Mexico has a high unemployment rate, a lower wage scale, and one of the highest population growth rates in the world, which are added incentives for taking advantage of higher wages and better living conditions in the U.S. through immigration.

Some Mexican workers enter the country illegally; others obtain permits to live in Mexico and commute across the border to work, thus taking advantage of higher wages in Texas and lower living expenses in Mexico. Often they work for lower wages than American workers. Before an employer is allowed to hire these "Greencarders", he is required to certify that a shortage of American workers in that particular occupation exists. Nevertheless, commuters still constitute competition for U.S. citizens in the job market.

The effects of immigration and commuting from Mexico on the labor market and the economy of South Texas are important. The major impacts are in competition for jobs, especially low-skilled jobs, and the resulting depression of the wage scale. On the one hand, immigrants pay little or no taxes, but add to the need for human services such as health, education and welfare. Commuters and immigrants often send money earned in the area back to relatives in Mexico, creating a drain on the economy. On the other hand, immigrant workers usually fill only the lowest paying jobs, live in the poorest conditions, and are often exploited in the U.S. market in terms of wages and working conditions.

Special trade agreements between the U.S. and Mexico also have an effect on the South Texas economy. Products produced by U.S. firms can be exported for assembly and re-enter the U.S. if the condition of the parts has not changed. Duty is assessed only on the value added, which is equal only to the wages paid to workers. The result is a growing number of U.S. manufacturing plants positioned just across the border in Mexico, where wages are one-third of the U.S. minimum wage. Again, the victims are Mexican American and other semi-skilled workers in Texas. Also, the plants attract more Mexican workers to the border than are needed, with the result that many cross over to Texas seeking work.

The high birth rate discussed earlier, and the educational and economic situation in South Texas, contribute to a very low per capita income. All counties in Area III have 1970 per capita incomes well below the figure for Texas ($2,810); the lowest being Starr County with $1,123, and the highest, Kleberg, with $2,149. In all counties, the per capita income for the Spanish Heritage population is lower than for the total population. The state figure for Spanish Heritage per capita income is $1,521, and Area III counties range from $880 (Willacy County) to $1,768 (McMullen).

Percentage of families below poverty level in Area III counties for 1970 are extremely high, especially for the Mexican American population. Less than 15% of Texas families are below poverty level; the lowest figure in this area is 24.1% in McMullen County, while the highest is 57.8% in Zapata County. Percentages for Mexican American families range from 28.9% in McMullen County to 72.6% in Willacy; the state figure is 31.4%.

Poverty is also evident when quality of housing is examined. In Texas, the median number of rooms per housing unit is 4.8, and only 6% of the units lack some or all plumbing facilities. Area III counties have from 4 to 4.6 rooms per unit, and, in all but Kleberg County, more than 13% of the units lack at least some plumbing facilities. In Starr County, 46.4% of all units have inadequate plumbing. Housing in Area III is also more crowded than in the state as a whole. In Texas, an average of 3.2 persons live in each year-round housing unit, and 11.1% of the units are occupied by more than one person per room. All Area III counties are equal to or above the state figure in average number of persons per unit, and substantially higher than the state on percent of occupied units with 1.01 or more persons per room, the highest again being Starr County with 36.5%.

Services.

Eight of the thirteen counties (1970) have 0 hospital beds per 1,000 population. Of the remaining counties, all except Jim Wells (3.5) and Klebert (4.0) are below the state average, which is 3.5 per 1,000 persons. State highway mileage is exceedingly low in this area, with eight counties falling far below the state average (Kenedy County is at the bottom with 46.7 miles of state highway compared to the state average of 256.5).

Table 1.3

AREA III. SOUTHERN COASTAL ZONE

	TEXAS	AREA III	BROOKS	CAMERON	DUVAL	HIDALGO	JIM HOGG	JIM WELLS	KENEDY	KLEBERG	LIVE OAK	McMULLEN	STARR	WEBB	WILLACY	ZAPATA
I. Demographic																
Population Total	11,195,431	521,647	8,005	140,368	1,722	181,535	4,654	33,032	752	33,166	6,697	1,233	17,707	72,854	15,570	4,352
Population per square mile	43		9	157	6	118	4	39	7.5	39	6	1	15	22	26	5
% Urban	79.8		83.8	77.6	58.4	74.1	92.5	72.0	-	86.2	-	-	32.1	96.2	52.5	-
% Net Migration (1960-1970)	1.5		-27.0	-32.1	-29.0	-25.4	-23.9	-23.3	-39.5	-13.9	-26.2	-8.6	-23.9	-17.8	-42.2	-22.9
Birth Rate	19.3		20.5	29.3	21.0	31.2	18.3	22.9	15.7	26.7	16.9	9.7	30.8	31.3	24.8	18.2
Death Rate	8.5		9.6	7.7	10.0	7.3	10.1	7.8	5.7	5.6	10.8	5.5	6.7	6.9	7.2	9.7
% Spanish Heritage	18.4	74.3	79.9	76.2	84.5	79.1	91.9	64.0	70.7	12.2	40.4	60.3	97.9	85.6	76.8	91.5
% Black	12.5	1.2	1.3	1.0	0.2	0.8	1.0	1.2	0.0	4.4	1.4	0.6	0.5	1.7	0.7	0.2
II. Education																
% Population 3-34 enrolled																
Total population	52.1		58.9	55.6	56.7	57.6	47.6	51.5	51.2	55.5	53.3	63.4	53.4	53.5	59.7	59.8
Spanish Heritage	52.4		58.1	55.4	56.8	57.5	47.0	51.7	57.8	59.2	57.9	60.6	53.8	56.4	58.4	62.0
Median School Years Completed																
All Males	11.7		8.3	8.7	7.6	7.6	6.5	9.1	5.3	12.1	8.9	9.7	5.9	8.1	7.7	6.2
Spanish Heritage Males	7.6		6.3	6.0	6.9	5.2	6.1	6.2	3.7	7.9	4.6	8.3	5.7	7.0	4.4	5.3
All Females	11.6		8.5	8.4	7.9	7.0	6.7	9.5	5.8	11.5	10.1	10.2	5.9	7.1	7.3	5.7
Spanish Heritage Females	7.0	-	6.8	5.7	7.1	4.9	6.5	6.7	3.8	7.0	5.1	5.4	6.0	6.5	4.5	5.0
III. Labor Force																
% Civilian Work Force Unemployed 1970																
All Males	3.0		5.4	6.1	4.1	5.1	5.9	5.3	2.7	3.7	5.8	4.5	7.5	6.6	6.1	6.5
All Females	4.7		2.8	7.3	3.9	7.2	3.7	5.1	-	8.4	2.8	...	3.7	7.1	9.7	0
Spanish Heritage Males	4.7		5.5	6.6	4.4	6.3	5.9	7.4	4.5	4.9	5.7	6.8	9.1	6.9	6.6	7.7
Spanish Heritage Females	6.8		4.0	9.4	2.7	8.6	3.1	6.5	-	8.7	4.2	...	4.1	7.6	12.0	-
% Unemployed, July 1975	6.5		8.1	11.2	5.3	12.0	6.2	6.7	4.0	4.4	6.0	5.4	23.5	16.7	8.9	14.7
Male Workers, weeks worked in 1969																
Total # Workers	3,088,769	118,993	1,913	29,403	2,666	39,418	1,093	7,944	251	10,269	1,694	357	3,760	15,914	3,416	895
Total # Spanish Heritage	464,226	82,396	1,488	20,712	2,189	28,826	1,013	4,452	194	3,616	55	195	3,609	12,391	2,341	819
% Working 27-52 Weeks																
All Workers	87.2	82.8	76.3	83.2	90.1	82.0	89.5	87.2	82.1	80.7	86.5	86.8	67.8	85.7	81.1	87.5
Spanish Heritage Workers	85.9	81.1	73.3	80.8	89.2	80.3	87.8	86.5	81.4	82.8	84.6	86.2	66.9	84.3	77.6	86.6
% Working 26 weeks or less																
All Workers	12.8	17.2	23.7	16.8	9.9	18.0	10.5	12.8	17.9	19.3	13.5	13.2	32.2	14.3	18.9	12.5
Spanish Heritage Workers	14.1	18.9	26.7	19.2	10.8	19.7	12.2	13.5	18.6	17.2	15.4	13.8	33.1	15.7	22.4	13.4

Table I.3 (cont'd.)

	TEXAS	AREA III	BROOKS	CAMERON	DUVAL	HIDALGO	JIM HOGG	JIM WELLS	KENEDY	KLEBERG	LIVE OAK	McMULLEN	STARR	WEBB	WILLACY	ZAPATA
Occupational Categories																
Total Employed	4,141,529	150,477	2,233	40,178	3,462	52,073	1,510	10,453	298	9,656	2,070	403	4,016	18,974	4,168	983
Spanish Heritage Employed	600,425	105,232	1,792	27,927	2,937	37,340	1,389	5,404	248	4,091	637	200	3,922	16,379	2,887	916
Spanish Heritage as % of Total Employed	14.5	69.9	80.3	69.5	84.8	71.7	92.0	51.7	83.2	42.4	30.8	49.6	97.7	86.3	69.3	93.2
Professional, Technical																
% of All Employed	14.4	11.5	11.1	10.9	8.8	11.3	7.7	11.0	2.7	19.1	10.7	5.7	14.1	10.9	10.4	13.1
% of Spanish Heritage	7.6	7.8	7.8	7.1	8.8	7.0	6.8	5.5	4.0	9.5	3.5	-	15.5	9.7	5.3	9.5
Managers, Administrators																
% of All Employed	8.9	9.1	6.0	9.8	7.3	8.5	6.4	9.1	1.7	7.8	8.1	11.9	8.5	11.4	8.0	9.0
% of Spanish Heritage	5.0	6.5	2.7	6.6	4.1	5.3	6.3	5.2	-	5.6	1.1	8.0	8.1	10.3	6.3	10.7
Sales Workers and Kindred																
% of All Employed	7.8	7.6	6.7	7.6	4.7	7.7	2.5	6.5	-	5.0	4.3	2.7	6.0	9.9	4.8	39.8
% of Spanish Heritage	5.7	6.9	6.8	6.7	4.9	6.9	1.2	6.8	-	5.0	5.2	-	6.5	10.1	2.9	.8
Clerical Workers & Kindred																
% of All Employed	17.4	14.0	11.1	14.9	11.0	12.3	14.2	13.2	7.7	14.8	11.3	6.2	12.6	19.5	9.4	12.2
% of Spanish Heritage	13.7	12.9	12.4	13.6	11.3	10.2	14.1	11.0	11.7	9.5	4.2	4.0	13.1	20.6	8.1	9.5
Craftsmen, Foremen																
% of All Employed	14.3	11.3	12.0	12.3	15.5	9.5	12.3	14.9	-	14.1	15.6	5.7	8.3	10.5	9.7	10.6
% of Spanish Heritage	15.0	11.2	12.4	12.4	12.5	9.8	11.4	15.9	-	16.7	17.7	3.5	7.4	10.5	7.7	13.3
Operatives (excl. Transport)																
% of All Employed	11.1	10.4	9.3	10.4	11.6	11.8	14.8	12.4	7.7	9.1	9.3	6.9	6.6	6.3	8.4	19.3
% of Spanish Heritage	16.3	12.0	8.1	13.3	11.7	14.0	16.1	12.0	8.1	10.1	11.5	6.5	6.8	6.4	12.5	17.5
Transport Equipment Operatives																
% of All Employed	4.0	5.1	7.5	4.1	5.1	5.8	4.5	5.2	3.4	3.7	5.3	3.7	4.1	6.3	3.4	3.1
% of Spanish Heritage	5.3	6.3	9.8	5.1	6.4	7.4	4.6	7.2	3.2	5.2	10.8	3.5	5.0	6.6	4.5	4.4
Laborers (excl. Farm)																
% of All Employed	4.9	6.5	6.4	7.6	7.8	6.0	6.9	6.2	-	4.4	3.8	9.4	5.6	7.1	4.1	5.8
% of Spanish Heritage	8.7	8.0	6.7	9.7	8.8	7.1	7.6	10.3	-	7.8	5.2	18.5	6.1	7.7	5.4	7.5
Farmers, Farm Managers																
% of All Employed	2.0	2.5	1.7	2.2	4.0	2.7	3.6	2.8	2.7	1.2	8.7	1.8	3.0	.6	6.8	7.1
% of Spanish Heritage	.7	1.6	.7	1.2	3.8	1.8	4.5	2.2	-	-	1.6	9.5	2.2	.6	2.3	7.1
Farm Laborers, Formen																
% of All Employed	2.0	9.8	12.9	6.8	7.7	13.7	10.5	4.8	45.3	3.7	10.9	21.6	20.8	4.9	25.1	8.6
% of Spanish Heritage	5.8	12.6	14.2	8.9	8.8	17.6	10.5	7.1	42.3	7.4	25.1	27.0	20.0	5.2	32.5	9.0

Table I.3 (cont'd.)

	TEXAS	AREA III	BROOKS	CAMERON	DUVAL	HIDALGO	JIM HOGG	JIM WELLS	KENEDY	KLEBERG	LIVE OAK	McMULLEN	STARR	WEBB	WILLACY	ZAPATA
Service Workers																
% of All Employed	11.1	10.2	11.8	11.2	12.9	8.7	14.6	10.5	18.8	13.7	9.0	2.2	9.4	10.3	7.5	10.9
% of Spanish Heritage	13.8	11.2	13.4	12.8	14.0	10.1	15.3	11.2	21.0	17.3	7.7	5.5	8.3	9.9	9.3	10.4
Private Household																
% of All Employed	2.2	2.4	3.8	2.2	3.7	2.0	2.1	3.4	10.1	3.2	2.9	6.0	.01	2.3	2.3	.004
% of Spanish Heritage	2.5	3.0	4.9	2.6	4.8	2.7	1.6	5.8	9.7	5.9	6.4	6.0	.9	2.4	3.2	.4
IV. Standard of Living																
Median Earnings																
For All Males	6,824		3,571	4,117	3,947	3,681	3,547	5,731	1,966	5,615	5,221	4,324	3,076	3,834	3,394	3,842
Spanish Heritage Males	4,599		3,055	3,472	3,545	3,134	3,536	4,255	1,938	4,114	3,537	4,593	2,982	3,654	2,741	3,619
Earnings--Males in Selected Occupations																
Professional, Managerial																
Total	10,106		8,000	7,822	6,913	7,785	5,932	8,845	-	9,623	9,800	...	6,549	8,032	8,054	4,879
Spanish Heritage	7,698		...	6,642	6,378	5,990	6,091	7,188	-	6,379	...	...	6,244	7,388	6,300	6,308
Craftsmen, Foremen																
Total	7,260		4,045	4,474	5,621	4,187	3,750	5,668	...	6,740	6,759	...	3,750	3,981	4,401	3,700
Spanish Heritage	5,466		3.535	3,868	4,182	3,792	3,400	4,466	...	5,738	6,571	-	3,863	3,694	3,702	2,842
Operatives, Transport																
Total	5,956		4,020	3,655	4,257	3,484	3,829	5,391	...	3,478	4,756	...	3,484	3,458	2,777	4,264
Spanish Heritage	5,466		3,450	3,451	3,963	3,330	3,566	2,170	...	3,951	4,159	...	3,454	3,387	2,578	4,048
Laborers (excl. Farm)																
Total	3,636		2,900	2,681	2,941	2,662	2,038	3,350	-	3,400	...	...	2,362	2,716	1,925	...
Spanish Heritage	3,448		2,750	2,583	2,930	2,359	1,966	3,327	-	4,067	...	...	2,467	2,613	1,688	...
Farmers, Managers																
Total	4,705		...	4,224	1,971	4,452	...	7,458	...	5,500	9,200	...	2,667	...	7,667	...
Spanish Heritage	3,323		...	2,548	2,305	3,134	...	3,921	-	-	-	...	...	...	...	...
Farm Laborers, Foremen																
Total	2,607		2,037	2,038	1,844	1,848	2,673	2,914	1,708	2,087	2,820	...	1,840	1,735	2,308	...
Spanish Heritage	2,493		1,710	2,071	1,799	1,859	2,396	3,131	1,623	1,961	2,358	...	1,489	1,599	2,292	...
Median Earnings																
For All Females	3,241		2,448	2,385	1,840	2,024	1,478	2,557	...	2,631	2,409	...	1,735	2,647	1,868	1,955
Spanish Heritage F.	2,515		2,061	2,082	1,557	1,692	1,528	1,945	...	1,897	1,427	...	1,721	2,666	1,361	1,775

Table I.3 (cont'd.)

	TEXAS	AREA III	BROOKS	CAMERON	DUVAL	HIDALGO	JIM HOGG	JIM WELLS	KENEDY	KLEBERG	LIVE OAK	McMULLEN	STARR	WEBB	WILLACY	ZAPATA
Earnings--Females in Selected Occupations																
Clerical																
Total	3,879		2,929	3,117	2,483	2,656	1,700	3,299	...	2,386	3,180	...	1,240	3,139	2,659	...
Spanish Heritage	3,229		2,736	2,770	2,364	2,293	1,775	2,947	...	2,194	...	...	1,265	3,245	2,762	...
Operatives, Transport																
Total	3,142		...	1,810	...	1,686	...	2,132	...	1,521	...	...	...	1,681	...	...
Spanish Heritage	2,700		...	1,882	...	1,648	...	...	-	...	...	-	...	1,673	754	...
Per Capita Income																
Total Population	2,810		1,518	1,577	1,458	1,482	1,366	1,940	1,775	2,149	2,038	2,113	1,123	1,547	1,404	1,276
Spanish Heritage	1,521		1,123	1,091	1,258	1,006	1,190	1,311	1,411	1,298	932	1,468	1,102	1,352	880	1,121
% Families Below Poverty																
Total Population	14.6		44.7	46.0	49.0	49.8	49.8	31.5	43.9	29.4	26.4	24.1	54.9	44.7	57.2	57.8
Spanish Heritage	31.4		50.9	54.6	53.7	57.1	51.7	46.0	33.8	47.5	52.2	23.9	56.9	49.2	72.6	67.8
Housing																
Persons Per Unit	3.2		3.6	3.9	3.5	4.1	3.7	3.6	4.3	3.7	3.2	3.4	4.3	4.0	4.0	3.6
% With 1.01 + per Room	11.1		28.8	28.7	22.5	33.0	25.3	22.3	31.0	15.4	18.1	26.2	36.5	31.4	30.9	23.3
Rooms Per Unit	4.8		4.5	4.4	4.5	4.4	4.4	4.6	4.0	4.6	4.5	4.5	4.3	4.3	4.4	4.1
% Lacking Plumbing	6.0		27.0	21.3	29.9	25.1	26.0	16.3	14.9	5.7	13.4	24.0	46.4	16.7	30.1	37.0
V. Services																
Hospital Beds per 1000	3.5		0.0	0.0	2.5	2.1	0.0	3.5	0.0	4.0	0.0	0.0	12.	3.4	0.0	0.0
State Highway Mileage	256.5		116.6	510.2	293.2	649.1	143.0	256.3	46.7	141.3	325.2	139.5	217.0	308.0	209.0	106.4

AREA PROBLEMS RELEVANT TO GEOTHERMAL RESEARCH

Suggestions of broad regional differences in social and demographic characteristics arise from the preceding area descriptions. Comparisons and contrasts of the areas in terms of some variables of possible relevance to geothermal development and utilization will therefore help provide a regional outline to direct more intensive investigations of the area in which the test site is eventually located.

The population of southern and coastal Texas exhibits greatest concentration in and around the major urban areas of Houston and Galveston, Beaumont, Corpus Christi, and Brownsville. The total land area is smaller in relation to the size and spread of these urban areas in Areas I and II, i.e., the Eastern Coastal Zone is far more densely populated and less rural than central and south Texas. These differences are further heightened by the rapid migration out of South Texas, which is extremely high in all of Area III and in much of Area II. The evidence suggests that many residents formerly dependent upon agricultural occupations have moved to urban areas in search of employment.

One major population difference between the areas is their ethnic composition with the Mexican American proportion high in Area III, the Black percentage comparatively high in Area I, and Area II overlapping at each end. Some counties in the middle of Area II have roughly equal proportions of Black and Mexican American residents.

Educational attainment is lowest in Area III and highest in Area I, where school completion approached the overall Texas level. Current enrollment figures in all three areas indicate educational upgrading for the total populations and for the ethnic minorities within them.

Unemployment exceeds the state level in the majority of counties in all three areas. Again, the most widespread and severe unemployment is in Area III, decreasing somewhat in Area II, and while still high, decreasing more in Area I. The incidence of seasonal work bears out the same trend but to a more subtle degree, and (with the exception of one county) in Area I full-time workers account for a larger share of the employed population than in Texas as a whole.

Examination of the distribution of the working population among the occupational categories reveals basic conformity in all three areas with the state's occupational patterns. The major exception is in farm occupations, however, where the three areas differ considerably. Texas workers in these occupations account for 4% of all workers; half (2%) being farmers and managers and half (2%) laborers and foremen. In contrast, 0.7% of Area I workers and 5.7% of Area II workers are in farming. In Area III, 12.3% of all workers are in farming, and almost four-fifths of those are laborers and foremen.

It is not immediately obvious from an analysis of the crude data just what the labor force situation means for geothermal development. For instance, high unemployment and seasonal participation rates may be viewed either as an economic problem or as a promising manpower resource. Further research and analysis is needed to pinpoint the specific relationships and potentials implied, before decisions are made as to which types of resource utilization should be encouraged.

Whatever the nature of the contributing factors, the major part of the Texas Coastal Zone is economically and socially depressed. Areas II and III compare quite unfavorably with Texas figures in such key variables as per capita income and percentage of families below the poverty level. On both variables, 32 of the 36 counties in this study evidence poverty relative to the state as a whole; the four exceptions are Area I counties. Other measures of the standard of living in the region confirm these patterns. Crowding in dwelling units and inadequate plumbing facilities characterize most Area II and III counties. The percentage of crowded dwellings in Area III is roughly 2 to 3 times the percentage for Texas, and inadequate plumbing is 2 to 7 times as evident. Further, the most recent Bureau of Economic Analysis (U.S. Dept. of Commerce, 1974) projections show the south Texas area continuing as a no-growth region--and as the least prosperous part of Texas--to at least 1990. Interestingly enough, the only contingency mentioned as possibly mitigating the projections would be the development of new resources in the area.

As we have seen, the economic depression of South Texas is a circular phenomenon: the surplus of unskilled labor, together with language and cultural barriers to education and employment, discourage investments, and the lack of sufficient capital, in turn, depresses the occupational/wage structures. Several programs have been initiated to stimulate development in the area. A number of labor training and vocational education programs in secondary schools have been set up by the U.S. Office of Education, Adult Continuing Education Programs of the Texas Education Agency provide high school equivalency training, and Health and Rural Manpower Training programs are financed by federal funds. A major industrial training program is the Industrial Start-up Training Program, a cooperative effort of the Texas Industrial Commission and the Texas Education Agency. This latter program hopefully will attract new industry to the area at the same time that it improves the skill level of the South Texas labor base. The program trains workers for specific jobs in industry entering or expanding in the area. Area III is characterized by growing political awareness and activity of the Mexican American population. As this large segment of the population gains access to the decision making processes, more programs and more changes are apt to develop. Some of the major programs or studies now underway are listed below.

A. Governmental Coordination

<u>Greater South Texas Cultural Basin Commission</u>
Established by the Legislature in 1973 and implemented by Governor Dolph Briscoe in June, 1974 for the purpose of "stimulating orderly economic and socially desirable development." Decision-making commission composed of representatives of local citizenry, COGs, and state and federal agencies. Authorized to prepare legislative and other recommendations with respect to long and short range programs.

<u>Interstate Compact</u> (House Concurrent Resolution 135)
Signed by the Texas Governor in summer, 1975, this compact expresses state willingness to work with California, Arizona, and New Mexico on joint efforts to overcome problems generated by their location on the Mexican border.

<u>HUD Project</u>
HUD funds awarded to Greater South Texas Cultural Basin Commission (GSTCBC) through the Governor's Office Division of Planning Coordination to improve planning and coordination of government

services in the basin area.

Regional Human Resource Development Project

HEW grant to GSTCBC to develop greater capacity at the state and regional levels for planning and management of human service programs.

B. Education and Job Training

Texas Education Agency Grant to GSTCB Commission

Under provision of the Comprehensive Employment and Training Act (CETA) of 1973. To examine needs of adults qualifying for CETA assistance and to examine coordination between CETA and other adult education programs to determine their effectiveness.
Jan. 1 - June 30, 1975.

Bilingual Education Program

Established in 1972 (Texas H.B. 121) to provide linguistic training to school aged children. Program being phased in one grade each year, beginning with the first grade.

Vocational Education Program

Made up of 8 major categories set up by the U.S. Office of Education to provide vocational education curriculum in secondary schools. Texas Education Agency and Texas Advisory Commission on Vocational Education.

Adult and Continuing Education Program

Texas Education Agency. Provides basic and high school equivalency training. Funding by state (40%) and federal government. Budget of $4.8 million in Texas in 1974, 26% ($1.3 million) of which was allocated to South Texas.

National Comprehensive Employment and Training Act of 1973

Federal funds to help develop health services and rural manpower training. 23.7% of its $63.5 million budget in 1975 allocated to South Texas.

Industrial Start-up Training Program

Cooperative effort between Texas Industrial Commission and Texas

Education Agency. Provides training to qualify citizens for jobs created by new or expanding industries in the area. Program director from TIC works with industry to identify training needs; local institutions (schools, colleges, technical institutions) provide facilities and instructors; special equipment and training wage provided by industry.

Texas Department of Community Affairs Grant to GSTCB Commission

Granted Nov., 1974. Project to identify basic problems and barriers to employment and economic growth and to recommend solutions. Phase I to be completed June 30, 1975, and Phase II a year later.

C. Economic Development

Rural Development Loan Program

Administered by Texas Industrial Commission. Provides businesses with establishment and operating loans at low interest rates.

Texas Water Development Plan

Research of necessary actions to provide South Texas with supplementary water supplies. Texas Water Development Board.

U.S. Department of Commerce, Economic Development Administration Grant to GSTCB Commission

To develop information useful to industrial and economic developers in South Texas.

Texas Economic Action Program

Contract with Governor's Office, Division of Planning Coordination, to provide technical assistance and to coordinate the South Texas portion of the State economic development plan.

EDA Development Grant

To GSTCB Commission to develop a program for the mitigation of unemployment caused by plant closures and layoffs, base closings, reduced federal expenditures, and border problems. To be funded under provisions of Title IX of the Economic Adjustment Act.

D. Health

<u>Early and Periodic Screening, Diagnosis and Treatment</u>
Amendment in 1967 to Title XIX of the Social Security Act, an addition to Medicaid. Effective 1972; administered in Texas by department of Public Welfare through interagency contract with State Department of Health. Screening, diagnosis, and treatment of health problems of children in low income or medically indigent families.

E. Migrant Programs

<u>National Migrant Worker Program</u>
1971; to help workers make transition from migrant work to stable non-agricultural employment. Dept. of Labor.

<u>Texas Migrant Education</u>
1962; to meet special education needs of migrants (for further descriptions see Marshall et al., 1974).

A more detailed review of the above programs would be helpful in understanding the effects on South Texas relevant to geothermal development. These comparisons suggest the need for further research along several lines, depending on the site chosen for geothermal development. Additional technical information will be required regarding specific uses of the geothermal resource, and thus what type industries might be attracted to the area. Possible effects of these industries on each area, especially on the labor force, could then be studied. Several further research needs must be given preliminary consideration. A closer analysis of the unemployed labor force is needed to see what types and levels of skill characterize the workers available for employment in new or expanding industries. More research into migration patterns and their relationship to the labor force is needed. Exploring the possibility that the high degree of out-migration from Area III is related to high in-migration in Area I would be valuable, as this would affect both the numbers and skill levels of available workers in both areas.

All three areas include counties which are inconsistent with the others on some variables. Kleberg County in Area III, for instance, has an extremely low percentage (12.2%) of Mexican Americans, in comparison to the rest of the area. Another example is Aransas County in Area II, in which 42.2% of the work force is in non-farm labor occupations (the total area percentage is 6.8%), but which does not differ significantly from the rest of the area in other ways. This figure is due to the fishing-based economy of Aransas County. The county, or counties, involved in the geothermal site should be examined for their individual characteristics in more detail, so that future developments can be planned within their particular needs and resources for growth. Appendix C describes one method which would be helpful in such work. Specific research tasks are discussed at the end of the three chapters constituting this part of the volume.

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CHAPTER II

LOCAL IMPACTS OF DRILLING, DEVELOPMENT, AND PRODUCTION

Sally Cook Lopreato
Kathlene Letlow

INTRODUCTION

The question of the impacts of technological change on social institutions and behavior has been addressed by numerous students of societal processes, including such scholars as William F. Ogburn (1950) and Leslie A. White (1949). Unfortunately, however, the precise relationships between different kinds of technological innovation and resultant social change have yet to be systematically investigated. The purpose of this chapter is to consider possible effects of the development of geothermal resources upon nearby communities.

The first section of the chapter reviews two studies which address similar questions for the coal and nuclear power industries. Drawing from the methodology as well as the theoretical foundations of these studies, an attempt is made to establish a perspective from which community change can be viewed. The results of these studies are used to help suggest ways of estimating possible consequences of geothermal development.

After the discussion of general factors determining development consequences, the methodology section describes an approach to the analysis of technological impact and ensuing community changes. The analysis section utilizes a case study approach based on aggregate census data and field-gathered material. Limitations of existing data sets are noted, and, based on those limitations, a plan is developed for analysis which could be used in planning for and developing additional geothermal resources.

COMMUNITY IMPACT STUDIES: A REVIEW

Research reports relevant to the potential of geothermal resources focus almost exclusively upon geological and technical factors. The major shortcoming of such reports is that they fail to answer the persistent question--What are the sociological consequences at the community level of specific types of energy exploration and development? The first step for our purposes is to determine how much of what we know about local impacts of expansion or development in other energy-related fields can be generalized to the area of geothermal exploration. In that line we examine below two pioneer local-impact studies for the coal mining and nuclear power industries.[1]

Underground Mining.

A recently completed Electric Power and Research Institute (EPRI, 1975) report on underground coal mining attempted to assess the ability of local communities to absorb and manage large-scale, unforeseen, erratic, and perhaps temporary growth. The method of analysis involved extrapolating from a case study of one "boom" town situation which arose following expansion in an underground extraction industry to another area which would be experiencing expanded coal mining.

The case study was carried out for Sweetwater County, Wyoming, which contained 10,429 square miles with a population of 18,400 in 1970. Historical mainstays of the county's economy were railroads and coal mining, interdependent activities which had declined since World War II. The county was sustained by activities such as the construction of a dam, oil and gas production, and the mining of trona (natural soda ash), which uses processes very similar to those of underground coal extraction. By no means, however, could it be said that the county was thriving; it had realized, for example, an 8.5 percent population loss over the 1960-1970 decade (EPRI, 1975:9).

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[1]Several additional studies are discussed and summarized elsewhere (see Univ. of Denver Research Institute, 1975). The methodologies, problem areas pinpointed, and conceptual frameworks of community impact works to date are extremely similar.

The beginnings of a boom were experienced by Sweetwater County in 1970 as a result of business decisions to invest large amounts of capital in trona plant and mining operations and in construction of a power plant. As one might have predicted, the most notable changes generated by these activities occurred in the labor force. From 1971 to 1974, mining employment increased 73 percent, from 1530 to 2650 workers. An increase in construction employment resulted both from the opening of new mines and construction activity at the power plant, which in turn led to secondary construction in the community. Employment in the construction sector spiraled from 400 to 4800 employees. Local and state government employees, including school teachers, increased from 880 to 1300. Available employment for women did not increase proportionately to total employment, and wives and daughters of newcomers reportedly sought jobs and could not find them. In sum, total employment in the county from 1970-74 more than doubled, from 7230 to 15,225 employees (EPRI, 1975: 5-6).

Demographic impacts were evidenced almost immediately with county population doubling between 1970 and 1974, a growth rate of 19 percent per year. This boom in population growth was exclusively attributed to in-migration of mine workers and their families. The population increase involved labor force groups specific to mining and construction activity. Most notable growth occurred in young adult male and children categories, resulting in a decrease in overall median age.

It is clear that the social infrastructure was inadequate to support the increased population. "The financial viability of municipalities and school systems deteriorated through a lack of both capital and operating funds" (EPRI, 1975: 5). Waste collection was unsatisfactory. Local sewerage treatment could not meet modern standards, and the development of new housing was encumbered with costs of additional treatment facilities. Educational and recreational facilities also proved too limited to meet the demands of a rapidly growing and increasingly younger population. The additional assessed tax valuation from new homes, even at inflated prices, did not cover the related demands made on municipal revenues (EPRI, 1975: 7).

Although the study failed to supply precise measures of density per housing unit or density per room, it asserted that crowding was an obvious social problem. One of the most serious shortages the county experienced occurred in the housing and land market. Not only was the housing industry unable to respond rapidly to sudden demand, but much of the county land was owned by the government and a few large owners and was not opened for development. A "seller's market" ensued, and housing was subsequently priced far too high for workers, who joined the growing ranks of mobile home dwellers (EPRI, 1975: 5).

One effect of the rapid growth in the community was social disorganization, which eventually manifested itself even in the mining industry. Productivity declined substantially from 1972 to 1973. Trona tonnage obtained per work shift dropped 60 to 75 percent. Employee turnover increased to 35 percent in some companies, and in others rose to 100 percent. Recruitment efforts failed to bring in new workers. In spite of attractive competitive wages, labor supply could not catch up to demand. (EPRI, 1975: 7). The report concluded that the industry whose expansion had stimulated the process of community growth was in turn adversely affected by unplanned, unmanaged social change.

Instead of general hypotheses regarding community change, the study pinpointed major problem areas: health and safety, environment, labor, transportation, competitive sources, and the need for coordinated planning. Extrapolating from the analysis of Sweetwater County, possible impacts were then discussed for two West Virginia counties where rapid expansion of underground coal mining might occur. Major directions of community change in periods of rapid development are summarized in Figure II.1, which has been adapted from the EPRI report.

Nuclear Plants.

A second investigation of local consequences of development in energy-related industry is the community impact study of nuclear plant sitings carried out by Frisbie and Letlow (1974). In their initial specification of the broad dimensions of social change which would be studied, the authors differentiated between the short term effects of the construction phase of siting and the more permanent impacts of long term operation of the nuclear facility. For each time period four broad categories of variables were examined: demographic, socioeconomic, political/

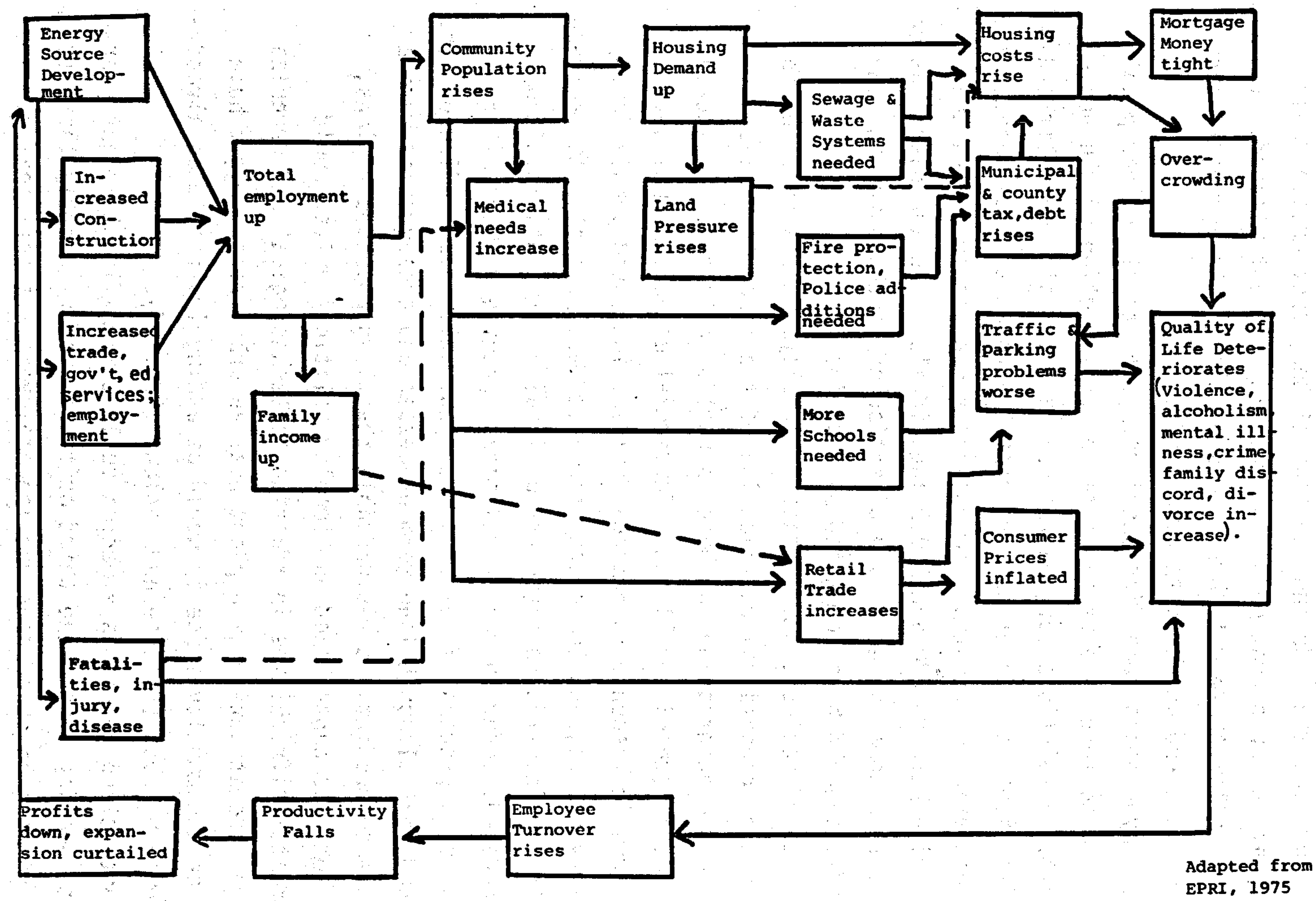

Figure II.1 Possible Community Impacts of Resource Development administrative, and social psychological. Any indicator of community change under these dimensions would ideally be measured at three points in time--prior to siting, during the peak of the construction phase, and several years after operation of the facility was established. The study tried to follow these data parameters by using both aggregate census data where possible and an in-depth case study.

The major hypotheses regarding short term effects of nuclear plant siting were related to choice of the site and construction of the nuclear complex itself. Predictions for the demographic dimension were limited to population distribution. Counties were expected to experience substantial waves of in-migration of construction workers and engineers, with the project employing between 600 and 2,000 individuals. The age distribution was predicted to become skewed in the direction of youth, since in many instances workers would be accompanied by families.

In the area of socioeconomic impacts, unemployment was expected to decrease, and the occupational distribution of the labor force was expected to show concentration in the construction category. An increase was anticipated in school enrollment. Commercial establishments were expected to grow in response to demands from the increased population. Wages, property values, and the county tax base were predicted to increase.

Since the administrative structure of local governments is often relatively underdeveloped in more rural areas, precisely where siting is likely to occur, a process of political reorganization was predicted. The authors argued that although long term processes and consequences were at best difficult to predict, it was probable that less populous regions, administered by less centralized and complex political units, would encounter greater difficulties in adapting to technological and organizational change. Construction of a plant near an urban center might have less impact on a community since it would be adding impetus to an already-existing growth process (Frisbie and Letlow, 1975: 17).

The construction phase was expected to last from five to eight years with activity peaking around the third or fourth year. Shortly thereafter, a stream of out-migration of construction employees was anticipated. Incoming permanent operating staff would be limited to a group of 100 or 200, consisting primarily of technical and professional workers. The major long term demographic effect was predicted to result from new or expanded industrial activity in the area, which would produce another wave of in-migration.

Long term socioeconomic predictions included increased size of labor force, upgraded occupational distribution, and higher employment rates, wages, and disposable family income. The administrative infrastructure would continue to expand. In the social psychological dimension, as workers migrate into the community, a lack of shared values with the present population can lead to latent or open hostility. Change of any sort is always met with resentment from some individuals. These attitudes can be expressed in many forms, including the development of special interest groups.

An attempt was made to examine the extent to which the above predictions could be supported by aggregate data gathered from census publications. Units of analysis were eighteen counties in which nuclear power plants were in operation by 1970. Unfortunately, since the plants' start-up dates ranged from 1957 to 1970, and since census data are gathered at ten-year intervals, it was not possible to measure the variables for each of the counties precisely at the three desired points in time, i.e., before construction, during construction, and after plant operation had begun. Thus, census statistics for many of the counties did not show impacts of the construction phase of growth as differentiated from more permanent effects. What could be discerned from the data was a general picture of the counties both before and after siting. The great variety in the geographic location of the sites, and in the type and capacity of the reactors installed, forced the researchers to be extremely tentative in their interpretation of results.

Briefly, the results of the aggregate data analysis were as follows: Given the national tendency for rural populations to decline between 1960 and 1970, the siting of a nuclear power plant was felt to have converted what might otherwise been population-loss counties to population-gain counties. For the four counties in which the construction phase could be differentiated from other effects by an overlap with the 1960 census, an increase in population was observed. This population growth rate, thought to be in part due to in-migration of construction workers, was indeed temporary, as 1970 data then evidence a decrease in growth rates. Positive relationships were also discovered between siting of nuclear power plants and both employment rates and personal and community affluence.

A detailed case study of one community in which nuclear facilities had been in operation for sixteen years was carried out. Results of this analysis were similar to the findings in the aggregate analysis. The county's population growth consisted primarily of families of child-bearing age. Shortly after the plant began operation, the county gained several additional industries, resulting in a substantial increase in percent of the labor force employed in manufacturing.

Construction employment increased by 1800 workers during the peak years of 1957 and 1958. Permanent employees, while fewer in number, had grown to 400 by 1975. Nearly all of the employees became or already were residents of the community or the neighboring community to the east. Unemployment decreased, while the demand for skilled laborers increased. Land values soared, resulting in a tax boost for the county. Since the industrial and economic base of the county was practically stagnant before construction of the power plant, it was concluded that in this case the effects of nuclear plant siting were significant and positive.

Case study comparison.

Conclusions of the nuclear and coal studies are dissimilar. The study of trona mining impacts on a relatively undeveloped area and subsequent generalizations to the coal industry explicated negative community impacts of great magnitude. It was found that growth occurred so rapidly that the community was unable to adjust its services to meet the demands of the incoming population. Social disorganization occurred to such an extent that mining activities almost came to a standstill. The nuclear impacts study, on the other hand, indicated that large development projects can help stimulate a dragging economy and impact local communities in a positive way. The variable which appears most influential in explaining the difference is the ability of the community to absorb incoming workers.

Although neither of the studies dealt with the development of geothermal resources per se, they are both directly relevant to this research since the point of interest is identical to the purpose of this chapter--to address the question of community impacts of development in an energy industry. These case studies demonstrate the nature of the effects which can be expected when large-scale construction projects are placed in relatively under-developed, rural regions. These analyses can be used to gain insights into analogous activities along Texas coasts. Of course, that is not to say that people who now live in the latter areas will react in the manner of persons who live in other parts of the country where major mining or nuclear construction projects have occurred. However, researchers can use those previous studies as a point of reference for collecting information which can be used to make more precise estimates for specific cases.

In terms of the methodology employed, the coal mining report is an example of a case study in which impacts of development in the trona mining industry on one community were generalized to impacts on other communities in a different part of the country by expansion in the coal mining industry. Naturally, there are serious problems inherent in this type of study. To begin with, the use of a single case for analysis of a complex issue is at best a risky procedure. The fact that the case of Sweetwater County was an extreme sample has both advantages and disadvantages. By choosing a county in which change occurred at an unprecedented pace and magnitude, the investigators guaranteed their ability to actually pinpoint specific kinds of community impacts. Unfortunately, "boom" towns are the exception rather than the rule in times of expansion within a particular industry, so the generalizability of the impacts which they identified is in doubt.

Another shortcoming of the coal mining study is that impacts which resulted from expansion in one industry were assumed likely to result from expansion in a different industry. It is true that trona mining and coal mining are both extraction industries, and that similar technologies are required for both processes. On the other hand, the actual chemical content of trona and coal is different, indicating that, at a minimum, health hazards and environmental impacts may not be similar. The generalizability of impacts of one extraction industry to another is at best hypothetical and untested.

A final drawback of the coal study is found in its cross-regional assumptions. By extrapolating from one county in Wyoming to counties in West Virginia, the investigators take gross liberties with their data. The study pointed out the need to control for the size of the county populations, for the rural concentration of the populations, and for population density. Yet the three counties were not truly comparable on these measures, not to mention a score of other variables which tend to vary dramatically with region of the country.

The nuclear power report drew generalizations from available case studies of community consequences of the siting of generating plants, but there were at least two major drawbacks to that approach. First, much of the literature appeared to be biased in perspective. The studies were not, typically, the endeavor of a team of social scientists interested in technology and social change. Naturally, each of the communities examined had experienced a degree of conflict as to the pros and cons of locating a nuclear plant in the vicinity. The resulting reports were often the product of an individual or group of individuals who already had taken a stand either for or against the industry. A second problem encountered in the analysis of case study reports was that even though several communities had been investigated, each case study was singular in the impacts which it deemed important. Thus, it was not possible to derive from the available literature one conceptual framework or model within which to measure community impacts. In general, however, some broad dimensions for assessment of community impacts were uncovered.

In the nuclear impacts report, the analysis of aggregate statistics for eighteen communities which had nuclear generators in operation was perhaps the most valuable contribution. Unfortunately, an analysis based on data of this type is limited to description. Even with a good conceptual framework and a vast amount of published data available at the county level, the conclusions were extremely tentative because of a serious time-lag problem. Nuclear power plants were being constructed and put into operation at various points in time from 1958 through 1970. Because census data are collected every ten years, in one county the data were measured three years after the installation went into operation, and in another county the measures were taken seven years after initial impact. The need for data measured <u>before</u> onset of development, <u>during</u> the development period, and <u>after</u> start-up of active production could not be exactly met. In contrast the geothermal project has great potential for allowing more precise measurements. Despite shortcomings, however, the two community impact studies reviewed here suggest some basic hypotheses which will be useful in predicting and gauging the impacts of geothermal development.

ESTIMATES OF COMMUNITY IMPACTS

The above review points out two major factors which, in combination, can be used for a first-cut estimate of community impacts of a development. First are the size and requirements of the development, in terms of such factors as number of workers required, transportation facilities used, land taken, and so on. A subcategory here should be the relative attractiveness of the development for other industrial activities. This factor is essential in determining the range and time span of community impacts. A coal mining operation, for example, may rate low in attracting other industries to the same area, whereas a geothermal field could rate high since some byproducts are useful only in close proximity to the wells (e.g., process heat generated by high temperature water). For the coal operation the short-term impacts on the community infrastructure would be greater than long-term impacts (leaving out of consideration at this point environmental and occupational health issues). The geothermal field would be associated with more long-term than short-term impacts.

The second major factor is the social and economic overhead capacity of the community; that is, the degree to which the area can absorb the development and support growth. Variables of importance here would include the nature of the local work force and levels of employment, the state of housing, schools, hospitals, and other services, the nature of existing land use, and so on. Perhaps the key component of community adaptability, however, is the attitude on the part of the population toward the development; is the community willing to commit itself to expansion in services, to adjustment of zoning laws, to some short-term crowding of facilities, and to potential growth in general? It is frequently stated that the smaller the community--by which is meant the more rural--the greater the impacts of any given development. That type of statement is over-simplistic to the point of being wrong. Impacts, in the first place, can be positive or negative, and they must be identified as short-term or long-term. In the second place, it is essential to differentiate between utility of the community and utility for the community.

Utility of the community refers to the degree to which the community as a social organization benefits from something. Utility for the community refers to the degree to which individuals or categories of individuals in the community benefit (see Pareto, 1935). The two utilities are related, but they are quite distinct and frequently are in conflict. A given development (whether it be a geothermal field, a petrochemical plant, a manufacturing plant, or whatever) may strengthen the community as a unit (through added tax revenues, for instance) and be detrimental to parts of the citizenry (if, for example, sections of residential land drop in value due to air pollution).

Rural areas can be more flexible than urban areas in terms of such variables as available land, population density, pollution levels, labor supply, and type of economic investment. The impacts of initiating automobile manufacturing in Philadelphia would be greater, and more negative, than locating such manufacturing in Round Rock, Texas. Traditional values which might impede development are often associated with rural residents (we return to this point below), but the attitudes of urban dwellers can be a greater barrier as they fight what they see as "excessive" growth of their city.

From a planning perspective, too, it should be easier to align the utility of a small rural community and the utility for its inhabitants than those of a major urban center and for its diverse residents. At any rate, the particular development and its needs must be studied in relation to the specific community and its capabilities before any exact estimation of impacts--positive or negative--can be made.

METHODOLOGY

Large-scale development projects induce or alter processes of change in the demographic and socioeconomic structures of the proximate communities. The perspective from which this process of change will be approached in the present study is that of systems analysis. A system in sociological work is thought of as a complex or network of interrelationships among social structures. A system is composed of identifiable parts which are bound together in mutually interdependent relationships. The parts of a system are assumed to be identifiable and the boundaries to it delimited such that a system may be analyzed as separate or "closed" for research purposes. In reality, no system is closed, but is interdependent with other systems at the same level as well as being included in systems at a higher level.

One of the most important characteristics of this type of analysis is its emphasis upon the concept of equilibrium. The properties or dimensions of a system are assumed to exist in a state of "balance" with each other. As a modification to a system is imposed from the outside, disequilibrium results, and some degree of predictability is lost. Although a system may undergo some modifications and alterations without visible effects, it is assumed that abrupt and drastic changes produce observable social disorganization, as the various parts are influenced and strive to regain an equilibrium line. The goal of a systems analysis is to develop a model in which the important structures are identified and measured, and the hypothesized interrelationships within the system empirically tested and tied to larger systems.

Partial modeling, or a first approximation, is the most practical approach to a system analysis when previous research is sparse. A partial model can describe a system in several ways. It may be limited to a small portion of the interrelationships which would ultimately be included in the analysis, or it may be focused on only a single level of the system (Pareto, 1935). It is important to note that where a partial model is used, specific hypotheses or precise predictions of change in one variable given change in another variable are premature and difficult to formulate. Research based on a first approximation is essentially exploratory, and results of such a study must be fed back into the model to further refine it.

The first step in investigating the community as a social system is to identify major structures or dimensions constituting its organization or interdependencies. Various attempts have been made to empirically determine the dimensions along which communities vary by using a factor analytic technique on a large number of community variable measures available in official statistical reports (Jonassen and Peres, 1960; Hadden and Borgatta, 1965; Bonjean, Browning, and Carter, 1969). These studies show that community change can be studied in terms of conceptually distinct dimensions which can be labeled socioeconomic status, residential mobility, urbanism, poverty status, family life cycle, manufacturing concentration, commercial center, educational center, and foreign born concentration.

While most community studies produce some commonality of dimensions, by no means can it be said that the analyses produced identical results. The scheme of community dimensions which was defined by Bonjean, Browning, and Carter (1969) will be utilized in this analysis for several reasons. First, Jonassen and Peres (1960) limited their study to counties in only one state, while the Bonjean, et al. article included all U.S. counties. Hadden and Borgatta (1965) on the other hand, limited their work to cities. Factor analyses are typically not generalizable to different units of analysis, such as from city to county--the unit to be used here. The Bonjean, et al. study also appears to encompass most of the variables brought to light in our previous review of community impact studies. The dimensions of community change, along with the names and computation procedures of the highest loading variables in each dimension, are as follows:

<u>Differentiating Dimensions of Community Impacts</u>

(Factors and Variables)

I. Socioeconomic Status

Median family incomes*

*Unless otherwise specified, variable is direct from County and City Data Books.

Dwelling condition - % Of homes not dilapidated
% Housing units with telephone
Poverty - % Families with income < $3000
Per capita income
High school education - % Persons 25 years and older with high school education
Well-to-do - % Families with income > $10,000
School years completed
Home value - Median value, owner-occupied, single-family
% White collar workers
Median rent - Median gross rent, renter-occupied

II. Age Composition or Family Life Cycle

% 21 and over**
Median age
% Under 5 years
% Population of school age
Kindergarten and elementary enrollment
Population per unit
% 65 years and over
Crude birth rate
Mean family size - Total population/total number of families
% Non-white

III. Governmental Revenues and Expenditures

Local expenditures per Expenditures/Active population 21-65 years
Local revenues - Revenues/Active population 21-65 years
Local expenditures for education per Education Expenditures/ Active population 21-65 years
Local tax revenue per pupil - revenue x percent tax/ expenditures/number pupils

IV. Residential Mobility

Dwelling newness - % Increase in units in last ten years
% Migrants from a different county
% Occupied units moved into in last 2 years before census
% Population increase
% Net migration

V. Urbanism

Heterogeneity - % Foreign-born plus three times % non-white
Population size
Population density - Persons per square mile

**For 1970, the item is 18% and over.

VI. Manufacturing Concentration

% Employed in manufacturing
Per capita value added by manufacturing
Industrial Bureaucracy - % Manufacturing establishments with < 100 employees

VII. Commercial Center

% Employed working outside county of residence
% Employed in wholesale and retail trade
Per capita retail sales - All retail sales/population

VIII. Unemployment

% Unemployed
% Employed in agriculture
% Population living on farms
% Active population employed - Total employed/active population

The first part of the analysis utilizes an on-site case study. Data are limited primarily to manpower and division of labor statistics which were gathered from direct observations of geothermal operations by a member of the research team. Interspersed with personal observations are statistics gleaned from telephone interviews and second-hand verbal reports. Although the data are crude and at best preliminary, they are included because of the dearth of published information shedding light on the issue.

The second part of the analysis utilizes as closely as possible the conceptual scheme previously designated. Data are computed from 1960 and 1970 County and City Data Book publications. Two counties which have experienced geothermal exploration--Imperial County, California, and Sandoval County, New Mexico--will be described at each of the two time periods in an attempt to approximate a longitudinal analysis describing changes in community dimensions over time. It should be noted that even if dramatic change in some of the dimensions can be demonstrated, the change cannot be directly attributed to geothermal development since no control group of similar counties without geothermal development are included in this limited study.

Speculation as to whether geothermal development has indeed fostered consequences for the few communities in which it has occurred, as well as speculation as to the potential magnitude of the changes which might be expected for future areas of development, is premature without a systematic investigation of the data which are now available. The Phase 0 project attempts to outline how such an investigation could be carried out. The descriptive approach utilized here is lacking in statistical analysis, but it demonstrates a methodology and initiates the work that is needed to determine community level impacts of geothermal development.

ANALYSIS

One example of private-sector geothermal resource development is found in an area known as the Geysers, located in Sonoma County, California. Since that county has undergone substantial geothermal research and development (with 41 wells drilled between 1955 and 1965 alone), it would be thought to be a prime target for the kind of secondary data analysis which this study undertakes. A brief glance at the 1960 and 1970 census data for Sonoma County, however, indicates that it is not a good candidate for such an analysis. Located only 75 miles north of San Francisco, the tremendous growth experienced in the last twenty years is in large part an effect of overflow from the bay area. Many workers commute to the San Francisco area. Since a census description of the county could not differentiate between effects of the urbanization process due to its proximity to San Francisco and effects of geothermal development, more detailed information on its geothermal facilities were gathered by on-site observations of a member of the Phase 0 research team.

The actual production of electricity at the 25,000 acre Geysers site is in the hands of Pacific Gas and Electricity, a San Francisco power company. The on-site observer noticed that with eleven units producing a total of 550 MW, there were surprisingly few workers. For the day shift there could be observed five or six inspectors, four machinists, three electricians, and two plant engineers. At night control was consolidated to one central watch with only two or three additional staff. The entire operation appeared to require no more than nineteen men.

The drilling of new wells at the Geysers is contracted out to Union Magma Thermal Drilling Company. Manpower requirements for this activity were small at the time of the on-site visit. New drilling was estimated to require three operators, five men on the rig, one or two managers, and two to five truck drivers. Drilling activity, lasting up to six months, utilized a maximum of fifteen workers.

Two kinds of construction activities occur at the Geysers. First, as new wells are drilled, constructors are hired to build new pipelines. The observer indicated that eight to ten employees would be required for a period of three to four months to produce two miles of new pipeline. Of these workers, only two or three would be unskilled. A more extensive construction process has occurred at the site as new generating units have been added to the facility. For a new unit and cooling tower, a maximum of twenty-five to thirty workers can be expected to be hired at one time. Over a period of thirteen to fifteen months, it would be reasonable to expect thirty pipefitters, twelve electricians, four to six boilermakers, twenty carpenters and steelworkers, and two to three laborers working on the site. Even with these limited data it can be observed that maximum geothermal activity in Sonoma County in the areas of construction, drilling, and electricity production requires less than one hundred workers. Given the growth already underway in the region, it is unlikely that labor force impacts of geothermal development can be shown to be at all significant.

Other than the jobs which geothermal activity creates directly, the most obvious local impact is upon the tax structure. Since taxes are levied on the estimated present value of the geothermal resource rather than the amount of the resource which is recovered and used for generation during any one year, the county has experienced a tremendous tax boost.

The approach specified in the methodology section may give more information based on two less urbanized counties which have experienced geothermal resource development. Results of the data compilation appear in Table II.1. Since the counties are quite disparate in population size, region of the country, and type of geothermal resource, each county will be described separately. Where change or difference is described, it refers to change in one specific variable for one specific county over the ten year period, 1960-1970.

Imperial County, California, is agricultural, isolated from major urban centers, and made up of small towns. The county has had a long history of geothermal exploration with two wells drilled as early as 1927. The county is now the location of at least two major test sites for geothermal development. The East Mesa test site, under the jurisdiction of the U.S. Bureau of Reclamation, consists of four or five experimental wells and a desalination laboratory. It is not expected that the site will ever be used to produce electricity for commercial purposes. The Niland test site is owned by San Diego Gas and Electricity, and plans have been made for generation of electricity in the near future (see El-Ramly, Peterson and Seo, 1974: 31-38 for well sites and drilling dates to 1973).

On the whole, the socioeconomic status of Imperial County showed slight positive gains between 1960 and 1970. Median family income increased from $5507 to $8256, and the proportion of families with less than $3000 annual income decreased from 21% to 11.5%.[2] The more affluent group--families with more than $10,000 annual income--increased from 15.4% to 38.5%. As home values and monthly rent increased, dwelling condition was upgraded to nearly 100% undilapidated.

The population grew younger as the proportion of school age increased from 26.1% to 33.9%. The proportion of the population under five years of age, however, decreased from 12.4% to 9.8%, consistent with a decrease from 27.7 to 22.4 births per one thousand women.

Local governmental revenues per person in the active population increased from $819 to $1242, and expenditures increased from $820 to $1181. Not only do these figures indicate an increase in community services, but they also demonstrate that the incoming funds more adequately met necessary expenditures. Both educational expenditures and local tax revenue per pupil also increased.

No consistent direction of change occurred among the residential mobility variables. Movement within the county between housing units increased, but construction of new dwellings slowed from 18% to 9.4%. The county showed a net migration of -11.8% in 1960, a trend which continued through 1970 when there were 15% more migrants going out of the county than there were moving into it. This net out-migration is also reflected in the slowing of population growth from 14.5% to 3.3%. During the last decade the county showed little evidence of urbanization, with relatively small changes in population size and density.

Manufacturing concentration remained very low in the county, and the proportion of the population employed in manufacturing activities increased only 1.1%. Per capita value added by manufacturing decreased slightly by 1970. Although manufacturing activities did not increase, the

[2]Income figures are not given in constant dollars. The change in terms of real purchasing power is not as great as may first appear.

county did meet more of its own commercial needs, evidenced by increases in the proportion of those employed in wholesale and retail trade as well as by per capita retail sales. The proportion of employees traveling outside the county for work increased. As might be expected from an area with a large net out-migration, the proportion of the population actively employed decreased from 77.4% to 62.2%. The size of the farm population also declined sharply.

One conclusion from the preceding analysis which can be stated unequivocably is that Imperial County can by no stretch of the imagination be considered in the midst of a "boom". In general, it can be said that the county is depressed economically. If rapid out-migration continues, the county is likely to resemble even more closely the bleak picture of "population loss" counties. This case study indicates almost no impacts from geothermal research and initial development. It should be remembered, however, that until very recently the only geothermal development in the county was limited to government-sponsored research on a small scale. Any major impacts would be unlikely to surface in census data until 1980. Also, labor force effects of temporary or short-term construction activity could be realized in the next couple of years, as geothermal development increases, and then be missed entirely by 1980 census data.

A second example of an area with an active geothermal drilling program is Sandoval County, New Mexico, where Bacca Land and Cattle Company first initiated drilling around 1960, and renewed their efforts in the early 1970's. Bacca now has an estimated fifty wells on its private land to explore the potential for geothermal development. If plans are being made for electricity generation, they are still unannounced.

Some slight gains in community economic status were evidenced between 1960 and 1970 by increases in median family income and the proportion of families with less than $3,000 annual income. Dwelling condition improved from 66.8% dilapidated to 65.7% undilapidated. The population grew older, evidenced by an increase in the median age from 18.6 to 21.2. The elderly population increased from 5.9% to 7.1%, as younger people migrated out. The crude birth rate declined sharply from 32.4 to 27.0 births per thousand women.

It is quite unlikely that community services expanded at all, due to insignificant changes in the county revenues and expenditures. More new dwelling units were being constructed, however, and more occupied units moved into in recent years. More importantly, net out-migration slowed from -14.1% to -1.9%.

The county experienced only slight evidence of urbanization. Manufacturing concentration remained almost nonexistent. The county became even less of a commercial center, as the proportion of employed working outside the county increased from 29.9% to 43.8%. Unemployment remained unusually high. It can be concluded that Sandoval County is even more depressed economically than Imperial County.

The following points summarize the brief two-county analysis attempted here.

1. Socioeconomic status improved slightly in both areas over time, but the data cannot be interpreted to show to what extent, if any, geothermal development contributed to that improvement.

2. While one of the counties demonstrated a trend toward a younger age structure, the age pyramid for the other county shifted dramatically toward an older population. The aging was clearly the result of out-migration in younger age categories.

3. Governmental revenues did increase for Imperial County, but for the more rural and depressed Sandoval County, both revenues and expenditures remained virtually stationary.

4. Residential mobility increased for both counties, but the data are unable to demonstrate if any of the increase is due to geothermal activity.

5. Neither of the counties showed marked signs of urbanization.

6. Manufacturing activities were limited and remained stable.

7. Wholesale and retail trade increased only slightly for Imperial County. Sonoma County became even less of a commercial center over the ten-year period.

8. Employment was nearly unchanged for both counties.

These findings are not definitive in any way, but we will tentatively advance one generalization: geothermal research and exploration in early stages will produce few impacts, positive or negative, on communites where they are carried out. Manpower, equipment, and construction required are negligible in comparison to other types of energy developments, such as a nuclear plant or coal mining operation. Existing community services probably will support the few incoming personnel. Still, surveys of housing availability, school enrollments, and so forth would help insure that the community would not suffer from crowding in its various facilities. Temporary housing and health facilities could be planned in advance to allow rapid accomodations if needed. Phase 1 research should detail all areas of possible impact and outline strategies for dealing with those impacts, including community, private industry, state and federal government cooperative efforts.

Communities should be advised on what to expect from the geothermal development in terms of the numbers and types of people who would be joining the community, and how long such people would be in the community. Resources should be available, both monetary and professional planning personnel, for the community to call on. In addition, the community should gain wherever possible from the development. Local labor, for example, should be exploited to fill jobs created by the resource exploration. Additional tax revenues from the resource facilities ideally would be distributed among the communities which actually bear the "costs" of the development. Early community involvement and continued dissemination of information to the community are required. With these conditions met, few negative community impacts of the resource development would be projected.

While goethermal exploration and development activities are predicted to produce minimal impacts at the local level, the same is not necessarily true of commercial production stages. The same methodology and hypotheses sketched out in this report are applicable to production of the geothermal resource. The major criterion is scale, or size of development. Let us clarify by way of example. Assume that four wells are producing 25 megawatts of electricity. The wells are positioned around town _X_, population 2,500. The electricity produced is used to supply power to an urban area of 50,000 people located 50 miles away, and the spent water is reinjected into abandoned oil reservoirs near the geothermal wells. In this situation, town _X_ probably would experience only increased traffic during the time of drilling and connecting to a grid. The local cafe might experience a short-lived "boom" in lunch business. Suppose, however, that the water could be used for process heat before reinjection. Two industrial factories, employing a total of 250 people, locate just outside the city limits of _X_. The town itself furnishes 50 workers. Additional workers benefit briefly from the construction period. 200 workers migrate to the town from neighboring counties. These workers are accompanied by young families, average size - 3.53[3] - for a total added population of 706. Town _X_ has grown in size by roughly 28 percent.

It should be obvious that local utilization of geothermal energy or its byproducts can quickly turn a "no impact" situation into a "substantial impact" one. It has been estimated that a major geothermal field can create, directly or indirectly, from several hundred to a few thousand jobs (Grabbe and Kamins, 1975: 5). In general, the smaller the community and the greater the utilization of the resource, the larger the impacts.

Although the results of the present analysis were often in the opposite direction of predicted findings, it must be stressed that the hypotheses were not disproved. Arguments presented in the methodology section and supported in the analysis of the data emphasize the primitive nature of investigations of this type. The more important contribution of the analysis is the development of a framework for future analyses. Suggestions for needed research on community impacts of geothermal development emerge from the work presented up to this point, and will be discussed following the final chapter of Part II.

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[3]Average size of the U.S. family in 1972, taken from the Statistical Abstract of the U.S., U.S. Bureau of the Census, 1973.

Table II.1

TWO U.S. COUNTIES WITH GEOTHERMAL DEVELOPMENT

Differentiating Factors and Variables	Imperial County, California 1960	Imperial County, California 1970	Sandoval County, New Mexico 1960	Sandoval County, New Mexico 1970
I. SOCIOECONOMIC STATUS				
Median family income ($)	5507	8256	2409	5465
Dwelling condition	58.3	94.5	33.2	65.7
% Units with telephones	65.9	74.3	24.0	49.1
Poverty	21.0	11.5	58.3	28.1
Per capita income	1623	2459	704	1543
High school education	33.8	43.1	22.0	39.4
Well-to-do	15.4	38.5	4.6	22.0
Median school years completed	9.0	10.8	8.1	10.3
Median home value ($)	9900	13838	5000	9815
% White collar workers	30.0	43.0	25.3	41.2
Median rent	61	89	38	74
II. AGE COMPOSITION				
% 21 and over	57.2	58.2	46.0	55.0
Median age	26.4	23.9	18.6	21.2
% under 5 years	12.4	9.8	15.9	11.3
% Population of school age	26.1	33.9	33.3	33.9
Kinder. and element. enrollment	14251.	16915.	3431	4098
Population per unit	3.6	3.5	4.5	4.2
% 65 and over	7.0	7.5	5.9	7.1
Crude birth rate	27.7	22.4	32.4	27.0
Mean family size	4.7	4.3	5.3	4.7
% Non-white	7.9	6.1	42.0	39.8
III. GOVERNMENTAL REVENUES AND EXPENDITURES				
Local expenditures per person ($)	820	1181	322	413
Local revenues per person ($)	819	1242	323	425
Education expenditures per person($)	275	402	286	373
Local tax revenue per pupil ($)	610	692	31	42

Table II.1 (cont'd)
pg.2

Differentiating Factors and Variables	Imperial County, California 1960	Imperial County, California 1970	Sandoval County, New Mexico 1960	Sandoval County, New Mexico 1970
IV. RESIDENTIAL MOBILITY				
Dwelling newness	18.0	9.4	12.0	44.3
Net migration (%)	-11.8	-15.1	-14.1	-1.9
% Occupied units moved into	42.9	57.7	23.8	41.2
% Population increase	14.5	3.3	14.2	23.2
V. URBANISM				
Heterogenity	60.1	56.0	128.2	125.0
Population size	72105	74492	14201	17492
Population density	17.	18.	4.	5.
VI. MANUFACTURING CONCENTRATION				
% Employed in manufacturing	5.6	6.7	14.2	14.9
Per capita value added ($)	357	295	D	74
Industrial bureaucracy	.04	.18	.11	--
VII. COMMERCIAL CENTER				
% Employed outside county	1.9	3.7	39.9	43.8
% Employed wholesale & retail trade	17.9	24.6	15.9	14.4
Per capita retail sales	1945	2081	266	308
VIII. UNEMPLOYMENT				
% Unemployed	6.2	7.0	9.9	9.0
% Employed in agriculture	38.8	NA	7.1	NA
% Population farm	7.6	2.3	4.5	3.9
% Active population employed	77.4	62.2	44.6	46.9

D = withheld to avoid disclosure
- = zero
NA = not available

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CHAPTER III

A POLITICAL AND INSTITUTIONAL SURVEY AND ANALYSIS OF THE DEMONSTRATION AND DEVELOPMENT OF GEOPRESSURED-GEOTHERMAL ENERGY ALONG THE TEXAS GULF COAST

INTRODUCTION

The concern of this chapter of the Phase 0 report is the interests of various institutions in the demonstration and development of geopressured-geothermal energy along the Texas Gulf Coast, and the potential for those institutions by virtue of those interests to significantly affect the development of the resource. Little formal methodology is available to researchers attempting to determine which governmental agencies and special interests will ultimately become involved in the development of a new energy resource. A list of the various divisions of government potentially concerned with the development of geopressured-geothermal energy was compiled by examining studies of other development or assessment projects (Texas Coastal Management Program, 1975; National Commission on Water Quality, 1975) and by surveying available directories of governmental agencies and responsibilities (United States Government Manual, GPO 1975; Guide to Texas State Agencies, 4th ed., Bureau of Government Research, L. B. J. School of Public Affairs, 1972). (This compilation is found in Appendix D.) The first section of this chapter examines the coastal area generally. A case study of a potential demonstration site surveys local politics and institutions in the second section. Major federal and state agencies as well as issues of local concern gained from the case study are examined in the final issues section.

THE TEXAS COASTAL AREAS

Suspected geopressured-geothermal resources underlie roughly thirty-six counties along the Texas Gulf Coast and extend approximately sixty miles into the Gulf of Mexico. (See Chapter 1 for description and boundaries of areas.) Coastal prairies and Gulf Coast marshlands or wetlands are the prevalent physical features of the coastal counties. The coastal prairie is a nearly level, slowly drained plain, usually less than 150 feet in elevation, characterized by grasslands which support farming and ranching, as well as slow moving rivers, creeks, bayous and sloughs. The wetlands are areas of low wet marsh found surrounding a complex system of bays, lagoons, and estuaries, interspersed with dunes (Suter, 1971).

The ownership of these lands, where the demonstration of geopressured-geothermal energy is most feasible, is of importance due to legal uncertainties surrounding ownership of the resource. Sites on state-owned lands offer the fewest impediments to demonstration of the resource. The state owns approximately 16%, or 4,156,735 acres in the coastal area. Of these, 3,858,522 acres are submerged lands or islands. Figure III.1 indicates the location of the state-owned lands along the coast. (The figures are courtesy of the Coastal Management Program, Division of Planning Coordination, Office of the Governor. While the inland boundaries shown on the figures are not those of the coastal study area of the present project, land ownership patterns along the coast are applicable.)

Figure III.2 shows the location of federally owned land along the coast. The federal government owns approximately 2%, or 450,532 acres in the form of parks, refuges, military installations, and properties of the U.S. Corps of Engineers.

Local governments, including counties, municipalities, and special districts, own another 1.5%, or 388,803 acres along the Texas Gulf Coast. These lands are shown in Figure III.3. However, these governments often affect much more land through jurisdictions of watersheds, navigation, municipal water supplies, city boundaries, and extra-territorial authorities.

The number and types of special districts existing in Texas is indicative of the local nature of government in the state. General governments, i.e. counties and municipalities, are constitutionally constrained, especially in the areas of finance, administration, and geographic jurisdiction, giving rise to an increase in reliance upon special districts (Thrombley, 1959). Such districts are usually created to perform a utility function which a general government cannot provide and are authorized to tax and/or incur debt to provide these services. While the increase in reliance upon nonschool special districts is not limited to Texas, the state ranks fourth in the numbers of special districts, preceded by Illinois (2,407), California (2,223), and Pennsylvania (1,777). Texas has 1,215 districts (U.S. Bureau of Census, 1972).

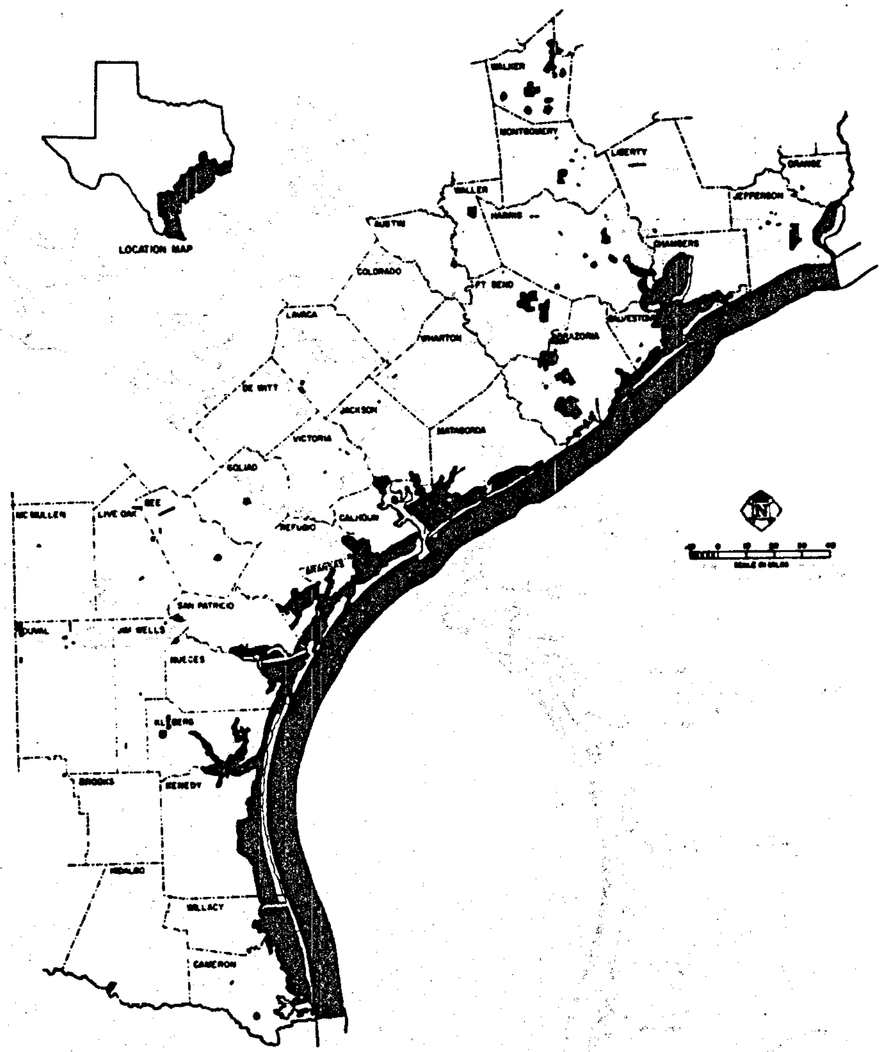

Figure III.1 State Land Ownership.

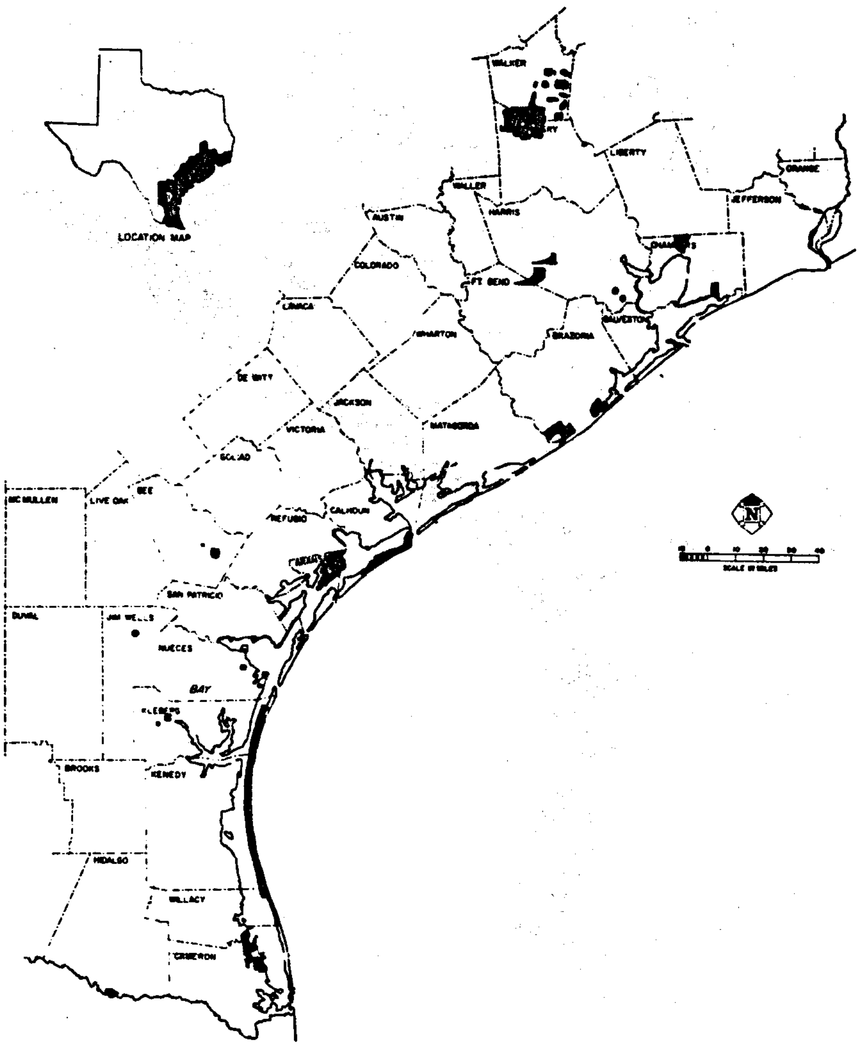

Figure III.2 Federal Land Ownership.

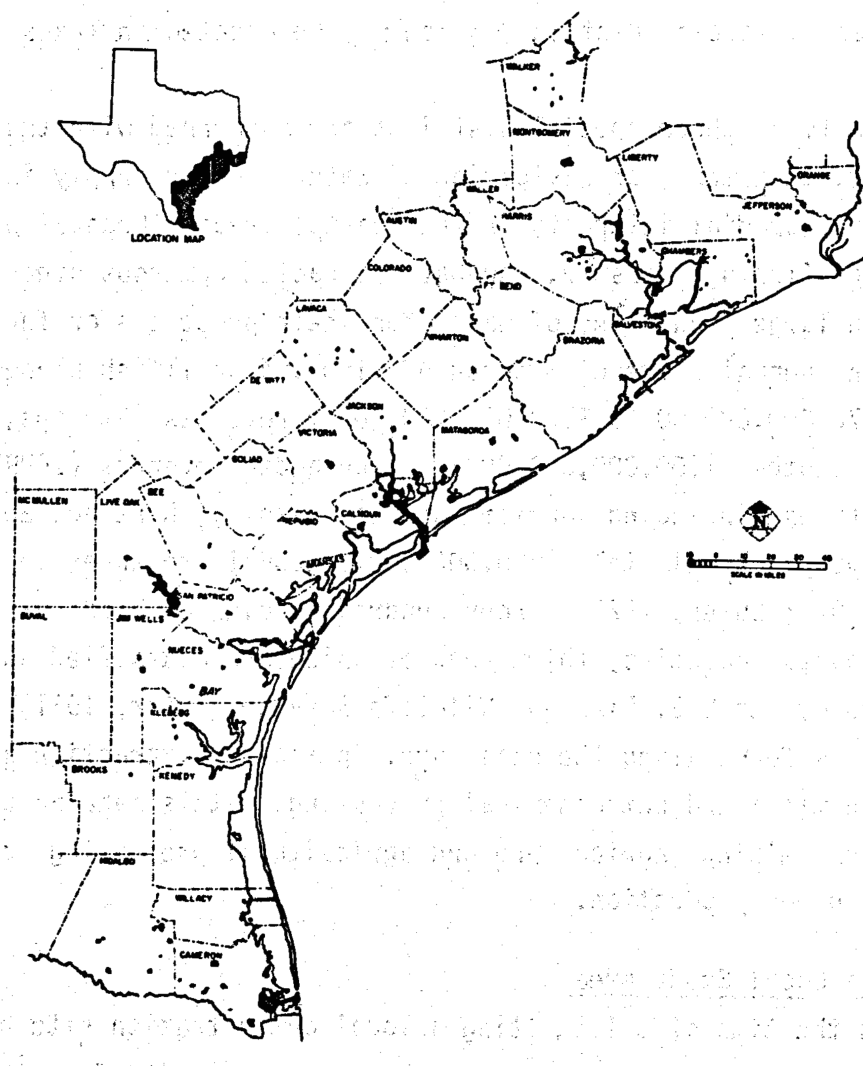

Figure III.3 Local Land Ownership.

The counties of Harris, Galveston, Brazoria, and Chambers, for example, have experienced a pronounced increase in the number of water districts required to supply water to fringe areas of Houston. In 1940, three water districts existed in the four-county area. In 1950, the number had increased to seven. By 1960, there were twenty-five. Today there are more than 300 water districts (L. B. J. School of Public Affairs, 1975). A list of the different types of special districts which may be created in Texas is found in Appendix E.

The majority of these special districts are concerned with the conservation, supply, treatment, or navigation of water. Water supply is also a major concern of special interests in the coastal areas. Coastal waters support a large fishing industry, and have attracted numerous other industries dependent upon large quantities of water for their processes or for transportation. The annual commercial catch of fish and shellfish along the coast ranges from $70,000,000.00 to $100,000,000.00 in revenues (Stevens, 1976) and generates another $100,000,000.00 in value-added revenues (ICNRE,1970). Leisure industries, including tourism, sports, fishing, hunting, and bird watching, produce approximately $290,000,000,000.00 in revenues in the coastal area (ICNRE, 1970; Suter, 1971). Four hundred species of birds have been seen in the coastal counties, thirty-one of which are classified as rare and endangered by the U.S. Fish and Wildlife Service (Suter, 1971). Other major industries found along the coast are: petroleum extraction and refinement, chemical and petrochemical processing, metals manufacturing and fabrication, mining, agriculture and agricultural processing, shipping, ranching, and power production.

Selection of a Local Study Area.

Since at the time of this writing a local demonstration site had not been selected, researchers were free to choose a local site from those initially selected for resource appraisal which would best fit the needs of a political and institutional survey. Four areas were initially selected by the Resource Assessment groups: Matagorda County; Aransas, Nueces, and San Patricio Counties; Kenedy County; and Cameron, Hidalgo, and Willacy Counties.

Matagorda County, situated in the upper Coastal Bend area of the coast, is predominantly rural, containing approximately 30,000 persons, one-half of whom live in the county seat of Bay City. The farming of rice in the marshy areas of the county is a major source of income, as is the production of petroleum, sulphur, and other mineral resources. These industries are spread throughout the county. Special interest group activity in the county has been limited to the activities of farming interests. The Matagorda County Rice Farmers Cooperative was the only group to appear at public hearings concerning the planned construction of a 2,500 Mw nuclear plant in the county (Speaker, 1975). Matagorda County is situated approximately 90 miles from Houston, the largest population center in the state.

Aransas, Nueces, and San Patricio Counties, located in the Coastal Bend of the Texas Gulf Coast, are a mixture of urban and rural populations, agrarian, manufacturing, mineral, and fishing interests. Industry in the area is centered around Corpus Christi Bay, a potential geothermal demonstration site. Represented are chemical and petrochemical manufacturing, metals manufacturing and fabrication, mining, agricultural product processing, shipping, fishing, and tourism.

The largest city in the three-county area is Corpus Christi, with approximately 205,000 persons. The corporate offices of Central Power and Light Company, the electric utility serving all four of the areas initially selected, are located in Corpus Christi. The public in the area appears highly organized in trade, professional, civic, and environmental groups. The three counties are part of an Economic Development District designated by the Economic Development Administration of the U.S. Department of Commerce.

Kenedy County, situated near the lower end of the Texas Gulf Coast, is one of the least populated counties in Texas. Petroleum production and ranching are the principal income producers for the county's 699 people. Sarita, the largest town in the county, contains only 185 people. The remainder are housed on large ranches in the county.

Cameron, Hidalgo, and Willacy Counties are located in the southernmost tip of Texas, along the Mexican border. Cameron and Hidalgo Counties are heavily populated, with the majority of the population found in small but densely occupied towns scattered throughout the counties.

Industry is concentrated in the cities of Brownsville, Harlingen, San Benito, Edinburg, McAllen, and Weslaco, and includes limited gas refining, steel fabrication, and chemical production. Other industries present in the area include fruit and vegetable processing, clothing manufacturing, beef production, milk products production, and seafood processing. The three counties, like Aransas, Nueces, and San Patricio Counties, have been designated an Economic Development District.

CASE STUDY: ARANSAS, NUECES, SAN PATRICIO COUNTIES

The Aransas, Nueces, and San Patricio Counties area was selected for the local political and institutional survey because of a concentration of potential electrical and nonelectrical uses of geopressured-geothermal resources and because of the existence of large numbers of special interests in the area.

The three counties cover 1,801 square miles of coastal plains, wetlands, and waters. Approximately 311,000 persons live in the three counties, concentrated generally around Corpus Christi Bay. County government in the area is similar to that found elsewhere in Texas. Aransas County is thought to be more environmental-minded due to dependence upon fishing and tourism. and the existence of a large federal wildlife refuge in the county. Nueces County and the City of Corpus Christi maintain close relationships as evidenced by a movement towards combining the two institutions' jail facilities and other essential services. The City of Corpus Christi (population 204,525; 1970) lies on the west and south of the bay in Nueces County. Corpus Christi, a home-rule city governed by a council-manager administration, has one of the most stable administrations in the state. The present city manager has held his position for eleven years. Using the powers of a home-rule city, Corpus Christi has maintained an active annexation program primarily northwest, south, and southeast of the city. The city, in a two-part program beginning in 1950, annexed Nueces Bay, Corpus Christi Bay, and approximately five miles of the Laguna Madre to control petroleum extraction, gathering, and transportation in the waters surrounding the city. Those submerged lands, shown on the accompanying map of the three-county area, are owned by the State of Texas and administered for the state by the General Land Office.

Petroleum activity on those lands is now declining. The city's Department of Petroleum Inspection administers the city's ordinances governing petroleum activity in the submerged and land areas controlled by the city. The department inspects wells annually. There are 315 wells currently producing in the submerged lands regulated by the city, down from a peak of 434 in 1970. There are approximately 300 land-situated wells producing in

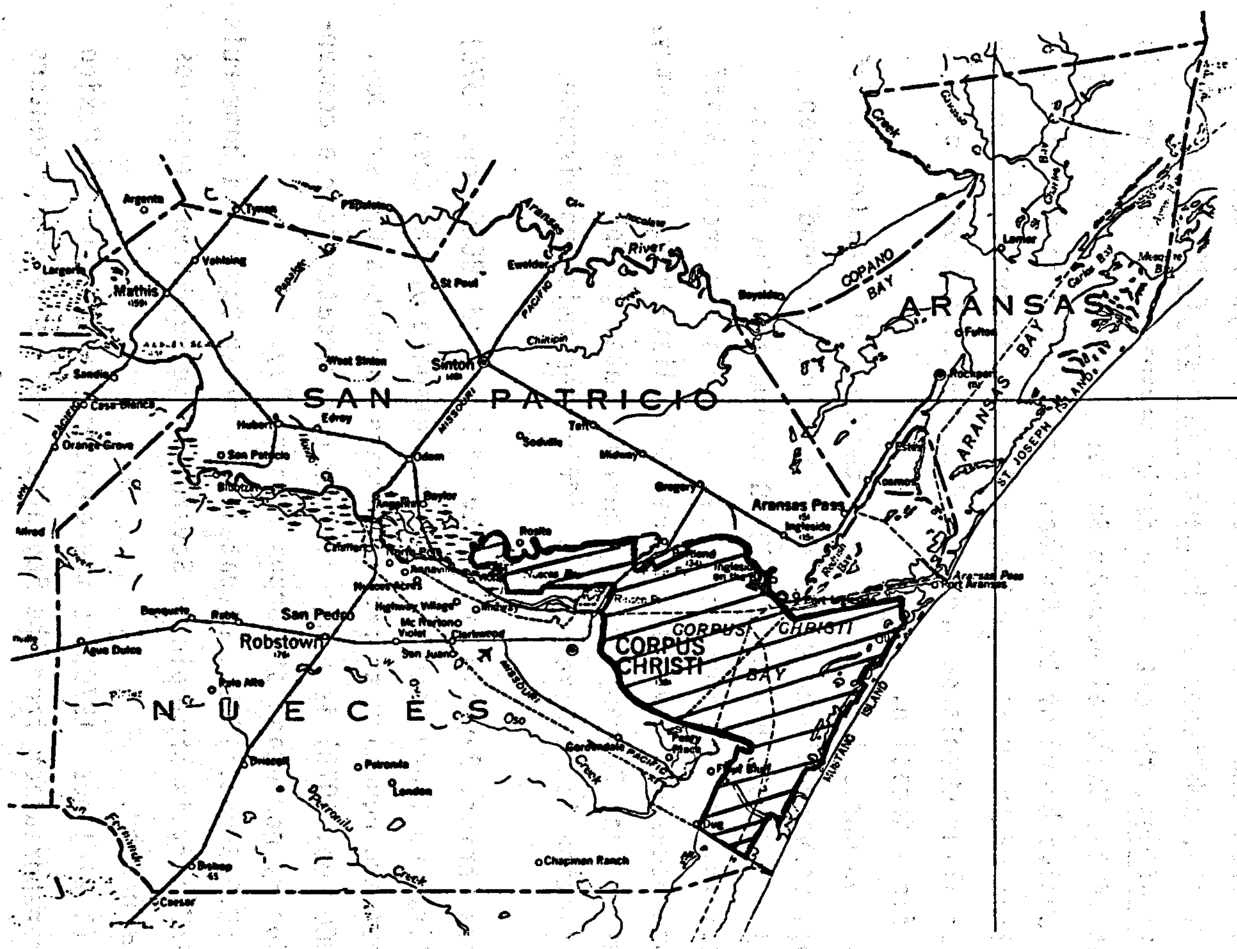

Figure III.4 Three-county case study area indicating submerged areas annexed by the city of Corpus Christi.

the city, down from 619 in 1967 (Conn, 1975). Figure III.5 traces the production of oil and gas inside the city limits from 1968 to the present.

Exceptions to the city's regulations are referred to the Bay Drilling Committee, created by the same ordinances. The committee is made up of six members, one-half nominated by industry and approved by the mayor, one-half from nonpetroleum industries appointed by the mayor. The current chairman is Edward Harte, publisher of the Corpus Christi Caller and Corpus Christi Caller-Times, the city's two daily newspapers. Mr. Harte is also past President of the National Audubon Society, currently serving as Chairman of the Executive Board of the Audubon Society, and is a member of the Steering Committee of the Goals for Corpus Christi Program. Recommendations of the Bay Drilling Committee are passed to the City Council of Corpus Christi for final decision.

The city of Corpus Christi is the home of the Coastal Bend Council of Governments (CBCOG), serving eleven counties of the coastal bend region, shown in Figure III.6. Membership of the CBCOG includes twelve cities, seven special districts, and the three counties of the study area. Staff of the CBCOG, on one occasion, have been forced to mediate between industry, E. I. DuPont de Nemours and Company, and an environmental group, the Coastal Bend Conservation Association, in an effluent-permitting dispute (Buckner, 1975).

North of Corpus Christi Bay lies the city of Portland (8000 pop. 1970). Also a home-rule city, Portland annexed a small rectangle of bay area adjacent to its southern boundary to provide access to Corpus Christi Bay.

Ingleside (4000 pop. 1970) is a general law city located near a concentration of new industry northeast of Corpus Christi Bay.

Aransas Pass (5,923 pop. 1970), situated on Redfish Bay, is a home-rule city whose major industry is shrimping. Several large petroleum companies maintain tank farms nearby.

Port Aransas (1,218) pop. 1970) is the entrance to the Gulf of Mexico for water-bound transportation from the Bay area. Marine research centers of the University of Texas and agencies of the federal government are housed within the city limits.

Other cities and towns and their respective populations located in the three-county area include:

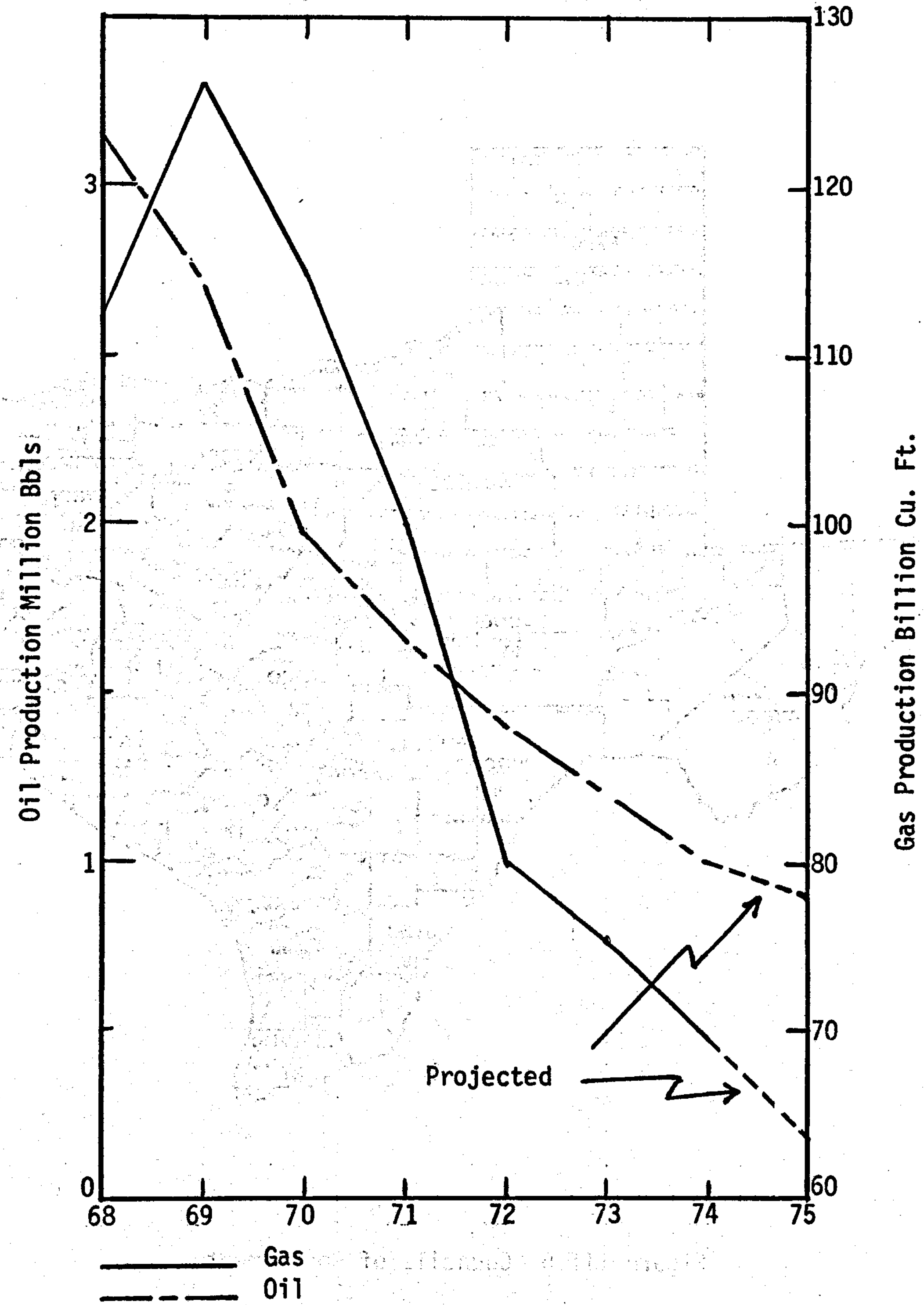

Figure III.5 Annual oil and gas production inside city limits. From Dept. of Petroleum Inspection, City of Corpus Christi, Mar. 13, 1975.

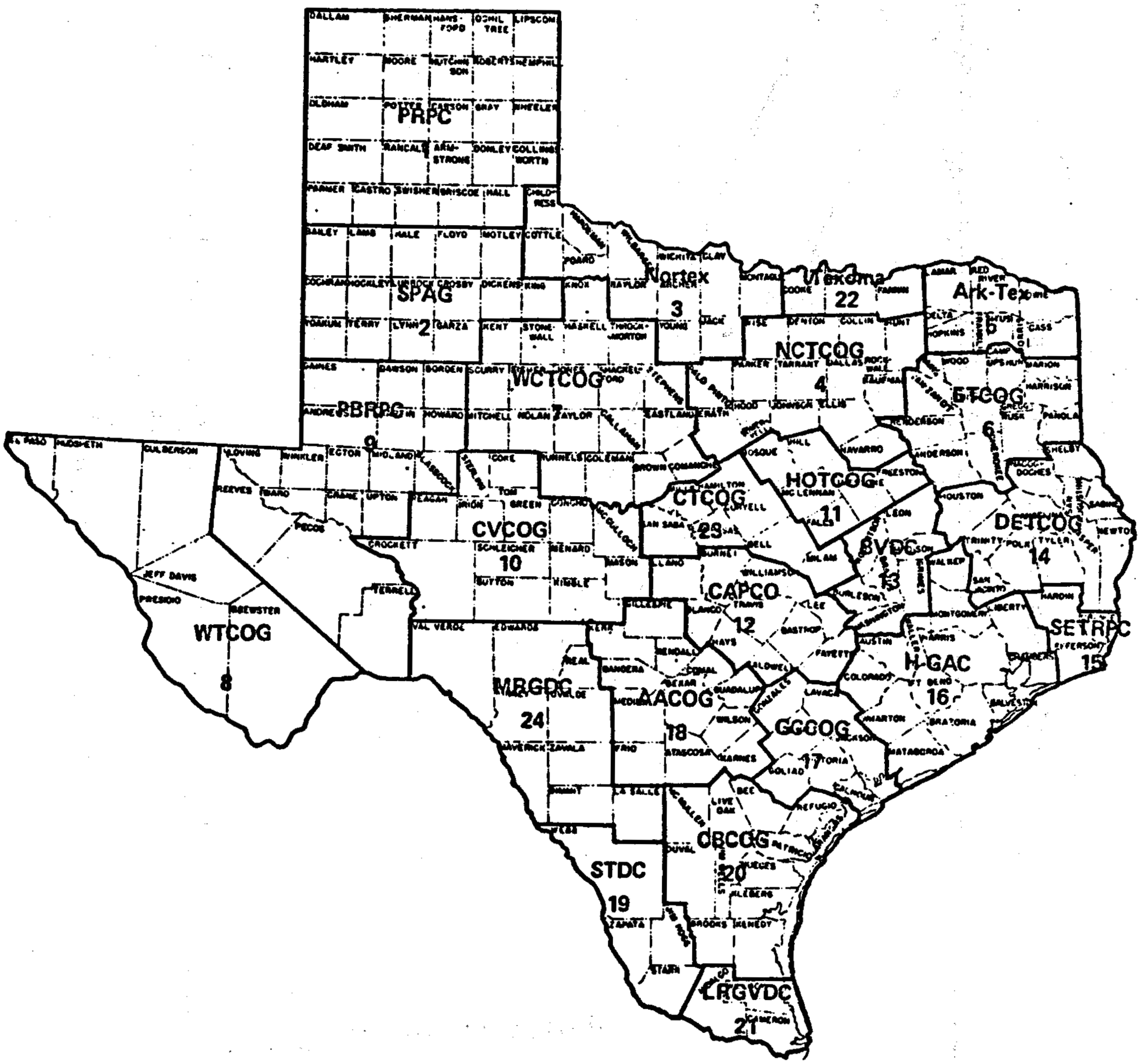

Figure III.6 Councils of Government.

COUNTY	CITY	POPULATION
Aransas County	Rockport	4007
	Fulton	1141
	Lamar	150
Nueces County	Robstown	16394
	Bishop	4000
	Agua Dulce	742
	Driscoll	626
	North San Pedro	2229
	South San Pedro	3065
San Patricio County	Sinton	5940
	Gregory	2300
	Mathis	5625
	Odem	2200
	Taft	3300
	Taft S.W.	2050

Approximately fifteen special districts exist in the three-county area. The last compilation was made in 1971 by the CBCOG. Since that time several have merged and several more have been created. The numbers and types of special districts in the area are listed in Appendix F. Two districts demand special attention. These are the Nueces County Navigation District No. 1 and the Lower Nueces River Authority. The navigation district owns and operates the Port of Corpus Christi and promotes the development of industry through its ability to issue revenue bonds to finance certain industrial improvements, notably environmental control facilities. The process also works to allow the Navigation District to build facilities based upon the credit of its supporting industries.

The Port of Corpus Christi is currently working toward developing a multipurpose deep-draft inshore port, a controversial undertaking. The Nueces County Navigation District, like other such districts in the state, was formerly able to buy surplus state lands and lease these lands for industrial sites. Criticism caused the Texas Legislature to terminate this practice in 1973. Navigation districts may still lease state lands for navigation purposes.

The Lower Nueces River Authority (LNRA) is the only district in the three-county area with a multicounty jurisdiction, including Nueces and San Patricio Counties. The LNRA is not as powerful as some river authorities, lacking ad valorem taxing authority. Its potential as a prominent institution in the area is derived from authorities concerning pollution control planning and abatement within its basin; supply and distribution of water; and generation of power.

Industry.

A strong supporter and likely large, direct user of geopressured-geothermal energy in the local study area is Central Power and Light Company (CP&L), an investor-owned electric utility serving an area which includes all four possible demonstration sites described previously. CP&L currently relies on natural gas for boiler fuel. Only one of the company's plants is equipped to burn oil on a permanent basis. In October 1975 company officials expressed fear that a cutback or cutoff of gas as a boiler fuel would soon be ordered by the Railroad Commission of Texas (Speaker, 1975). A first step toward that cutoff came in December 1975, when the commission ordered a halt to new long-term gas contracts for the use of gas as a boiler fuel (R.R.C. Gas Utilities Docket No. 600, December 17, 1975). While the company is currently investing heavily in a cooperative effort in a nuclear plant in Matagorda County and in coal-fired electricity generation facilities elsewhere, officials suggest that those two resources will serve only 45 percent of customers' needs in 1985 (Speaker, 1975). A successful demonstration of geopressured-geothermal energy would help alleviate the utility's struggle to supply electricity to its franchise area. CP&L maintains a AA rating with Moody's Bond Rating Service. While many utilities, including some in Texas, fell in their bond ratings as the energy crisis progressed, CP&L continued in a strong financial position despite serious problems with fuel supplies.

CP&L's willingness to increase its investment in geopressured-geothermal energy along the Texas Gulf Coast in either the demonstration plant or later developments will, of course, depend upon the cost per kilowatt generating capacity of a plant utilizing the resource. Currently investors are considering utility ventures in plants of up to $1000 per kw capacity (Davis, 1975). No firm cost figures are yet available for geopressured-geothermal development, but members of the Phase 0 Resource Utilization Group have suggested that geopressured-geothermal costs may approximate those of a nuclear venture (currently $650-$750 per kilowatt-generating capacity).

Other possible large direct users of geopressured-geothermal energy are large chemical companies which might use the resource for in-house electricity generation, as Dow Chemical in Freeport, Texas is contemplating doing; or as raw materials; or for a combination of uses. Many large companies concentrated along the shipchannel in Corpus Christi have power requirements large enough to suggest that they may eventually invest in the resource, pending a successful demonstration.

Petroleum companies experiencing declines in petroleum production in fields in and around Corpus Christi Bay may also become large direct users of geopressured-geothermal fluids for increased recoveries in those fields. The largest declining field in the immediate area is the Mustang Island field, operated by Atlantic Richfield Corporation and others. Located across the mouth of the bay, the field contained approximately eighty gas wells in 1966. The opportunity for the formation of consortia of companies able to use the resource either for electricity production or process heat or raw material will certainly exist. Speculation of such users has run from space heating and cooling of buildings to shrimp and oyster farming (see the Resource Utilization volume of the Phase 0 Report for a more detailed discussion of possible uses of the geopressured-geothermal resources). A large supportive industry, including drilling firms, well-logging firms, mud and tool suppliers exists in the area.

Industry, professions, and trades in the area are represented by chambers of commerce and numerous other groups. A partial list of these groups is found in Appendix G. The Area Development Committee of the Corpus Christi Chamber of Commerce and the Board of Trade/Port of Corpus Christi are two of the most active and influential groups concerned with industrial development.

<u>Civic Groups</u>.

The term "civic groups" describes those groups whose purpose is to increase participation in government, usually by informing the public. Such a group, entitled "Goals for Corpus Christi" was created and funded by the Area Development Committee of the Corpus Christi Chamber of Commerce to assist the City of Corpus Christi in gathering public opinion to create a new comprehensive plan for the city. Approximately 140 persons were selected to represent the city and communities surrounding the bay in formulating questions of public concern. Questions were raised in the areas of population and economy, recreation and culture, design of the city and land use, transportation, education, local government, housing, the environment, health and social welfare, and crime. Results of an informal voting process thus far indicate an overwhelming desire for economic development in the area, including support of a deep-draft inland port. However, the program is controversial and its impact on local planning is uncertain (Lewis, 1975).

Another large civic group in the area is the League of Women Voters. Active in following developments in politics and environmental matters, the group on one occasion initiated a city referendum concerning the form of local government for Corpus Christi. Other civic groups in the area with more narrowly defined interests include: Concerned Neighbors, originally concerned with forced busing; the Good Government League; Familias Unidas, an arm of La Raza Unida, located in Robstown; G.I. Forum, originally concerned with the affairs of minority veterans, now with broader concerns; and LULAC, concerned with gaining representation of Mexican Americans in the community, state, and nation. LULAC was originally established in Corpus Christi in 1929. LULAC and G.I. Forum each have approximately 200 active members (Bonilla, 1976). Familias Unidas is reported to be in a state of disorganization at this time. LULAC and G.I. Forum, as opposed to Familias Unidas, are basically nonpolitical groups, but this fact is obscured by intensive political activity on the part of individual members of the groups. Mexican American office holders in the area include one state representative, one Nueces County commissioner, and two Corpus Christi city council members. Mexican Americans are heavily represented in the city councils and mayorships in some smaller cities in the area, such as Mathis, Robstown, and Driscoll.

The mayor of Corpus Christi, Jason Luby, now in his second term, is familiar with the Mexican American culture and speaks fluent Spanish. His support generally comes from recently annexed areas of the city and from the Mexican American population of the city. The mayor is often in opposition to the majority of the council (observations are from 1974 during the mayor's first term).

Mexican American leaders in Corpus Christi have often found themselves at odds with what they term a provincial establishment in the city. The latest controversy surrounds the location of a Mexican American Cultural Center. Mexican Americans desire the center to be constructed in the downtown area by the bay so that tourists and others can gain from it. Proposals from other groups suggest that it be constructed in a large Mexican American section of the city (Bonilla, 1976). Many labor union leaders in the area are Mexican American, and are often members or leaders in a Mexican American group, leading observers to associate the interests of labor and Mexican American Affairs.

Eleven neighborhood groups have also been created in Corpus Christi, primarily in Mexican American and Black sections of the City, to improve neighborhoods and impact the political processes of the city. Planning, zoning, and capital improvements are the major interests of these groups.

Environmental Groups.

The largest environmental group in the area is the Coastal Bend Conservation Association, with membership in excess of 600 residents of the bay area. The association grew out of opposition surrounding an effluent permit application by E.I. DuPont de Nemours and Company, a large chemical concern then completing construction near the City of Ingleside. The company had requested a permit allowing them to discharge effluents their processes did not produce, in amounts in excess of their needs. Area residents, enraged over the application, formed the association, and with the mediatory efforts of staff of the CBCOG, achieved a compromise with the chemical company, resulting in an effluent permit reflecting the company's actual needs (Buckner, 1975). In another dispute, the association worked to prevent approval of an application for a solid waste disposal permit for a site near the Nueces River by a disposal firm from Houston (Frishman, 1976). The current president of the association is Steve Frishman, a marine geologist turned publisher of the South Jetty, a weekly newspaper in Port Aransas. The association's attention is now turned toward the deep-draft inland port.

An environmental group historically active in issues of bay-front construction, now concerned with broader issues of clean water, open spaces, and regulated growth is the Organization for the Preservation of an Unblemished Shoreline (OPUS). The group, numbering 150-200 active members, is politically oriented, having recently successfully lobbied the City Council of Corpus Christi to halt growth around the Cayo del Oso, a large estuary in the city (Suter, 1976). Other concerns of the group are regulating bay-front signs, limiting development on Padre and Mustang Islands, rehabilitating the city's downtown area, limiting industry's use of water, and the proper placement of spoils from port dredging (Corpus Christi Caller Times, November 13, 1975).

Two groups of Audobon members are also active in the area. The Audubon Club of Corpus Christi, an associate of the National Audubon Society, has a membership of 200, including: Dr. Hans Suter, a professor at the local community college and writer of an environmental column for the Corpus Christi Caller and Times; Pat Suter, current president of the club; and Edward Harte, Chairman of the Executive Board of the National Audubon Society and publisher of Corpus Christi's two daily newspapers. A local chapter of the National Audubon Society, the Coastal Bend Audubon Society, also exists in the area, with a membership in excess of 100. Overlap in membership of the two organizations is placed at one-third (Suter, 1976). A chapter of Ducks Unlimited also exists in the area but holds only annual meetings (Corpus Christi Caller, October 31, 1975).

Several recreational navigation groups, the Corpus Christi Sailing Club and the Corpus Christi Yacht Club, are interested in matters of bay area construction and activity. The Yacht Club was a large part of a controversy surrounding the placement of petroleum facilities in the bay. In 1965, following passage of ordinances extending the Corpus Christi city limits and imposing restrictions on petroleum activities in the bay, a petroleum operator asked that city ordinances be revised to allow the construction of a production platform in the bay. The navigation groups, interested in sailing in the bay, became concerned that "blanket permit" practices of the U.S. Corps of Engineers would allow such platforms to be constructed on each of the eighty-eight tracts of submerged lands in the bay, provided only that construction did not interfere with commercial shipping. The controversy created a "mass hysteria" according to one observer, resulting from a lack of understanding on the part of the public and a failing on the part of the petroleum companies to inform the public (Hutchinson, 1966). As the controversy progressed, tourism and city beautification interests joined the controversy on the side of the navigation interests, now facing all the petroleum companies of the area. The Bay Drilling Committee, discussed earlier in this report, was created and eventually recommended that joint operation of clustered production platforms be required of bay operators, among other restrictions. The recommendations of the committee were adopted by the City Council of Corpus Christi in June of 1966.

State and national environmental groups also appear at local forums in the area. Among these are the Sierra Club, Lone Star Chapter, and the Texas Environmental Coalition (TEC), representing 126 diverse member organizations across the state. Member groups and friends of the coalition includes The Sportsmans' Club of Texas, the Outdoor Writers Association, the Texas Society of Architects, the Nature Conservancy, the Texas State Farm Bureau, the Texas and Southwestern Cattle Raisers Association, the Texas Tourist Council, the Audubon Society, and the Sierra Club (Stewart, 1976). State and national organizations such as these require a local foothold to have a significant impact on local issues. Representatives of the TEC were present at hearings concerning the South Texas Project, the nuclear plant in Matagorda County, but because of a lack of local controversy did not make any remarks (Stewart, 1976). Affiliate groups present in the three-county study area could provide such a foothold. In addition, a local chapter of the Sierra Club was recently formed in the area. No information is yet available concerning its membership or goals.

ISSUES

Federal, State, and Local Regulation.

Participants in a conference called by staff of the Coastal Management Program of the General Land Office (Corpus Christi, Dec. 9, 1975) claimed that the permitting processes of federal regulators, chiefly the U.S. Corps of Engineers, were largely responsible for retarding new plant construction along the Texas Gulf Coast. Only expansions of existing facilities had been undertaken by industry in the last several years. An attempt by Mobil to construct a new polyethylene plant in Beaumont had been delayed three years, according to these industrial representatives. This was verified by Coastal Management Program staff in telephone conversations with Mobil officials (Jeffery, 1975). Phase 0 researchers found that two Texaco petrochemical plants are under construction at this time in the Port Arthur-Port Neches area of the upper coast. Conference participants specifically complained of the review process for construction permit applications, suggesting that a single exception to an application could delay the process up to eight months (Martin, 1975).

The potential for such exceptions to occur with regard to the demonstration of geopressured-geothermal energy is high, given the uniqueness of the project, the publicity certain to accompany the demonstration of the resource, and the large number of governmental and nongovernmental institutions potentially concerned with development of the resource.

A new development in the regulatory arena occurred with the passage of the Coastal Zone Management Act of 1972 (16 U.S.C.A. 1451-64.). This act, administered by the National Oceanographic and Atmospheric Administration for the federal government, provides that all federal agencies except the EPA conform their activities in or affecting coastal areas to federally approved state coastal management plans. Texas is currently in the process of devising such a plan, with recommendations to go before the legislature in January, 1977. The Texas Coastal Management Program, administered by the General Land Office of Texas, has held public hearings throughout the coastal area in an effort to determine the residents' desires for use of the coastal areas. These efforts have, to date, culminated in the nomination of "Areas of Particular Concern" by the member agencies of the Interagency Council on Natural Resources and the Environment and others, including environmental groups. Such areas include Air Quality Maintenance Areas, Forest Areas, water quality Stream Segments, "Section 208" Water Quality Planning areas, historical coastal waters, and coastal waters of particular environmental concern. These areas will be scrutinized at further public hearings before being finalized (Jones, 1975). A permitting process allowing multiple uses of the coastal areas is expected to be created in the zone. The zone covers most of the counties included in the suspected geothermal band following the coastline.

A large number of state agencies concerned with water appropriation and conservation may also impact the demonstration and eventual development of geopressured-geothermal energy either directly, through regulation, or indirectly, through delay caused by jurisdictional disputes. One jurisdictional dispute may occur between the Texas Water Development Board (TWDB) and the Railroad Commission of Texas. The TWDB has indicated a claim for jurisdiction over the amount of water withdrawn from geothermal wells in the state. The Railroad Commission of Texas, on the other hand, is charged with regulating the disposal of brines from oil and gas wells and with regulating geothermal energy production generally. Officials of the commission suggest that the power to regulate the withdrawal of fluids from geothermal wells is the power to regulate the production of those wells.

Another potential conflict may arise between the Railroad Commission of Texas and the Texas Water Quality Board. As previously mentioned, the Railroad Commission regulates the disposal of brines and other nuisances from oil and gas wells. The Texas Water Quality Board regulates effluent disposal generally. Conflict between the two agencies has existed regarding this arrangement since the passage of the Texas Water Quality Act which created it. Jurisdiction of disposal from geothermal wells has not been firmly established at this time, and disposals differ greatly from brine disposal from oil and gas wells, suggesting the TWQB might move to regulate geothermal disposals. Added to these potential conflicts is a reorganization process initiated by the Texas Legislature in 1975. The Joint Advisory Commission on Government Operations, created for that purpose, is reviewing the authorities and jurisdictions of all state agencies, and has determined that the abundance and overlap of the water-related agencies are among its greatest concerns (Haynie, 1975).

The General Land Office and the School Land Board will also be deeply involved in the regulation of geopressured-geothermal energy along the coast. The Geothermal Resources Act of 1975 requires those agencies to promulgate rules and regulations governing certain activities regarding the resource on state lands. At this time, no rules or regulations have been written. Delay in promulgating rules may cause demonstration and development to be slowed, since a lengthy period is required for writing and hearing of rules. The two agencies also face the problem of the lack of a model upon which to base their rules. The School Land Board may find itself in conflict with the Railroad Commission since both are given regulatory powers over production from geothermal resources.

Historically, however, the state agencies of Texas, including those mentioned in the preceding statements, have been able to resolve most jurisdictional conflicts through "gentlemen's agreements." Nor is the lack of rules and regulations of the General Land Office and the School Land Board expected to result in a delay for demonstration of geopressured-geothermal energy. Staff of the General Land Office and its elected commissioner suggest that demonstration can occur without extensive regulation.

Any difficulties would be handled in the terms of a lease (Hill 1975; Armstrong, 1975).

Another promising feature of Texas state government was noted while the institutional survey was being compiled. A number of advisory and administrative boards and commissions concerned with geopressured-geothermal energy development are generally made up of the same officials. For instance, the commissioner of the General Land Office serves on the General Land Board, the School Land Board, the Board for Lease of University Lands, the Antiquities Commission, the Interagency Council on Natural Resources and the Environment, and the Governor's Energy Advisory Council. The governor, lieutenant governor, the attorney general, the comptroller, members of the Railroad Commission, and other officials also serve on multiple boards and commissions. The "overhead democracy," those elected and appointed officials pursuing the public's interest in Texas, is smaller than is readily apparent, potentially serving to speed the processes of government and the demonstration project.

Local regulation is another matter. Many of the special districts in the state were created by special legislation of the Texas Legislature. Others were created by actions of the Texas Water Development Board. Still others were created by county commissioners' courts and municipalities. Their powers, policies, and interests differ even when created by the same authority. Municipalities, while having authorities similar to one another, differ in the use of those authorities.

Public Expectations of the Resources.

Admittedly speculative, but demanding of serious attention, is the possibility that the public along the Texas Gulf Coast has come to expect great economic benefits in the form of lower utility bills to accrue from the development of geopressured-geothermal energy. For a number of reasons, that expectation is probably greater in the Corpus Christi area than elsewhere in the state. Activities designed to promote interest in alternative sources of power, especially geopressured-geothermal energy, by members of the CES organization; research activities in the area by the Phase 0 political and institutional study group; and the presence of a private sponsor of the geopressured-geothermal energy project in Corpus Christi have increased the public's knowledge of the existence of the resource. Additionally, the legislative sponsor of the state's Geothermal Resources Act of 1975, Senator Mike McKinnon, represents the senatorial district encompassing the area. Newspaper articles accompanied the introduction and passage of the act.

While the information distributed by these sources was optimistic, it was not misleading. But optimistic reports of geopressured-geothermal energy, coupled with public discontent with rising utility bills, may have led to overexpectation of the energy resource. Current and projected residential electric rates are shown in Figure III.7. As demonstration of the resource progresses, public expectations will probably increase. Visible drilling operations and continued coverage by the news media will tend to strengthen expectations.

Continued public support is necessary to the success of the project, but that support must be well founded. A sudden loss of confidence caused by the public's finding that geopressured-geothermal energy will not lower utility bills; or that an influx of people into an area will overcrowd a school system; or that environmental hazards are much greater than anticipated could easily turn public sentiment against the project and its sponsors.

FUTURE RESEARCH NEEDS

The interrelationships among technological innovation, industrial development, and social change have been the recipients of both popular and scholarly attention, but it has unfortunately been the case that most observations are made from an a posteriori perspective. In the area of energy resource development, the few sociological studies previously conducted have been case studies, primarily based on after-the-fact conclusions using inadequate data (see, however, the recent report by Stoloff and Stoloff, 1975, for a different approach--referenced in Chapter II). The possible development of geothermal resources in the Coastal Zone can provide a rare opportunity for social scientists to plan for, monitor, and evaluate the impacts on specific areas of a major development process. The approach outlined here for consideration of community change is based on the assumption that data-gathering and analyses will be conducted systematically at several points in time to insure that conclusions describe a longitudinal

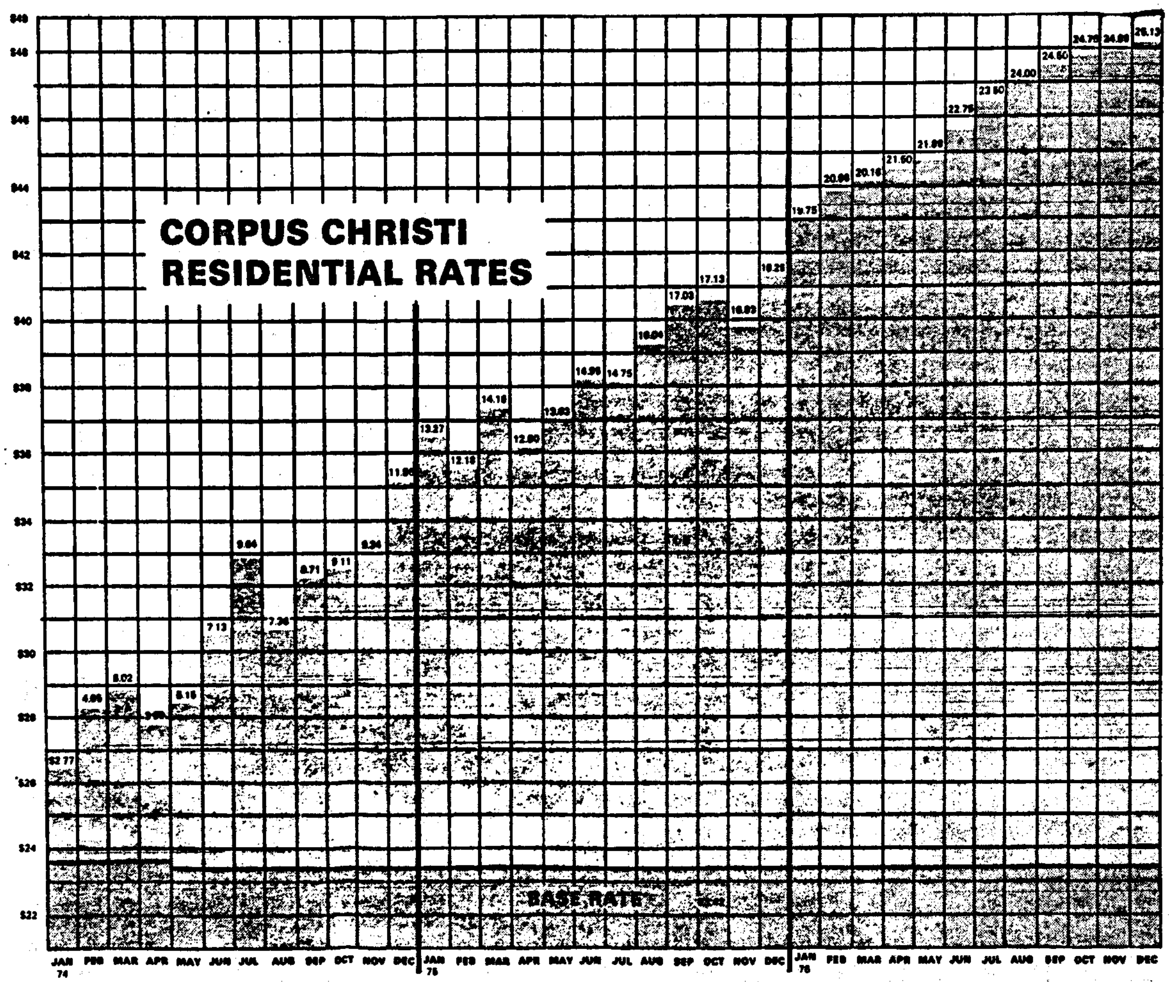

Figure III.7 Chart illustrates impact of fuel adjustment clause on basic residential bill, based on 1,000 kilowatt hours a month. Reprinted from Corpus Christi Caller-Times, Oct. 28, 1975.

process. Several key research tasks can be distinguished from the work reported in this chapter and the preceding one (see Figure III.8).

Many of the research recommendations which emerge from the work done in these three chapters are subject to a "sliding time scale" because needs will vary depending on decisions to require an Environmental Impact Assessment or an Environmental Impact Statement for the initial test well. It is important, however, that some tasks be completed before the first well is drilled--some even before the final announcement of site selection is made--in order to assure full credibility of results. The following items are listed in order of temporal priority.

1. Local Baseline Analysis.

An in-depth look at the chosen site area should be carried out along the lines suggested in Chapter II. Requirements for drilling and testing would be evaluated against the local service capabilities. Numbers of incoming workers--resident and commuting--amount of traffic, health hazards, and so on would be compared to the housing, transportation, and health facilities available, for example. Both positive and negative impacts would be considered and evaluated through a form of cost-benefit matrix. Consideration must be given to both utility for and utility of the community as discussed above in Chapter II.

The analysis should be carried out in cooperation with the legal and environmental research. For instance, it will be important, as legal problems of property rights in geopressured-geothermal resources are resolved, to study who in the local areas will be beneficiaries. If the situation should arise that local farmers, for instance, do not own property rights in the resource that is being developed, but are encroached upon as construction takes place, then resistance can be expected.

The local study should begin investigation of various types of industrial development which might accompany the geothermal activity. It would be shortsighted indeed to examine community adaptability for the geothermal drilling only--particularly since that activity may well entail relatively few incoming workers. As has been frequently stressed in this report, for this particular resource development and utilization must be studied and planned for concurrently.

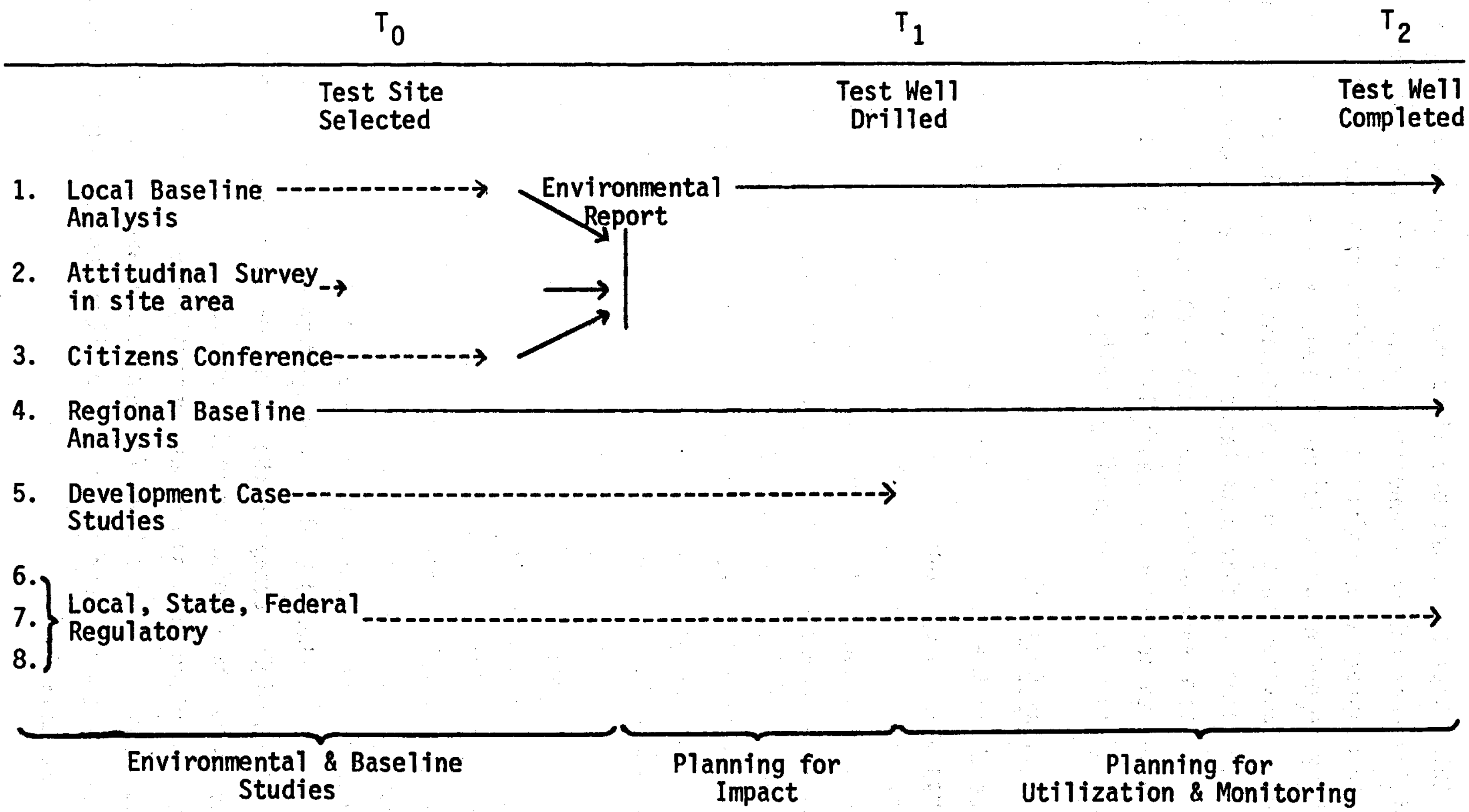

Figure III.8 Phase 1 Research Tasks

This work would form an essential part of any environmental report required. Analysis is expected to take 8-12 months and should be completed before the first well is drilled, although there will be ongoing components of the research.

2. Attitudinal Survey at Site.

Before the test-bed site is finally determined, a random sample survey of citizens in the potential site area should be conducted. This survey would identify attitudes toward and expectations of the resource development. Public expectations of great economic benefits at little environmental cost could impede continued demonstration of geopressured-geothermal energy if the public comes to feel at some point that it has been misled. The public must understand the beneficial and the detrimental aspects of the development of this alternative energy resource, including the range of possible environmental hazards. The only credible means of knowing public perception is through survey analysis.

Cultural values are expressions of that which is considered desirable in social life processes. The cultural values common to rural residents and those prevalent among urban dwellers differ, and these differences show up in the ways in which values influence behavior. Kahl (1968:6; Chapter II references) notes that "traditional values are compulsory in their force, sacred in their tone . . . They call for fatalistic acceptance of their world as it is . . . Modern values are rational and secular, permit choice and experiment, glorify efficiency and change, and stress individual responsibility." In general, traditional values, associated with rural life, could be expected to reinforce the status quo, while modern, urban values would be more amenable to change. Although, as pointed out above, this theoretical polarization of values may not hold up under the actual data, it hopefully indicates the importance of examining cultural values.

Questions on the survey should cover a range of subjects: from abstract queries regarding the relationship between man and his environment to specific questions regarding the willingness to adapt community services to accomodate the demands of growth, the expectation of financial benefit, and attitudes toward "outsiders" entering the community. This attitudinal analysis would, together with the aggregate data analysis discussed above, complete the initial process of modeling relationships within these communities which may be affected by geothermal development. Identical data-gathering and analyses should be conducted at two additional times: following the drilling and construction phase, and after geothermal development has been completed and commercial production has been underway for several years.

In addition to the random sample, which would be gathered through mail questionnaires, personal interviews would be conducted with representatives of affected sectors in the community, e.g., industry, labor, finance, services, special interest groups, and local government. The data could be used to provide a more comprehensive environmental report, and they would allow planners to understand better the needs and orientations of the community and the constraints and limitations within which development will occur. It is absolutely essential that an initial survey be conducted before announcement is made of definite site selection.

Following the initial baseline survey, a series of additional samples would be drawn to determine changing public perceptions as the resource is developed. Estimated time requirement for initial survey is 6 months.

3. Citizen Conference.

During the period when an environmental report is being conducted for the test site, a Citizens' Conference on Geothermal Development should be held in the area. All geothermal research groups might be involved as informants, with the sociocultural and institutional groups working most closely on conference organization with the citizens. A variety of interest groups should be represented, and the conference should be open to the area public. The conference would provide a mechanism for disseminating information to the public body likely to be most affected by early resource development and would offer an opportunity for input from the populace. Professional input should be energetic and yet simple enough for the layman to grasp basic technical, legal, and institutional issues surrounding the potential development An educated and involved public will be less likely to respond negatively to an innovative energy resource than would an uninformed group.

A similar conference was held in November, 1975 in Galveston, Texas. "Citizen's Look at Galveston Bay" conference was funded by the Department of Health, Education and Welfard, under the Environmental Education Act of 1970. The conference was developed by The Citizens'Environmental Coalition Educational Fund, Inc., which is composed of 40 area groups, ranging from the

Allied Civic Clubs of Houston to the Harris County AFL-CIO Council. (Similarly, a geothermal conference should be the prime responsibility of local citizens' groups.) The conference was well attended by people from various social strata--from industrial executives, to senior citizens, to congressmen. The professional and technical presentations provoked a substantial exchange of ideas with the citizens present. Such conferences can be extremely valuable in allowing citizens an opportunity to participate in the utilization and management of their natural resources. Input from citizens could become an integral part of the project's environmental report. The conference should be held <u>after</u> data is collected in the attitudinal survey (see item 2 above). Funding for the conference <u>per se</u> should be solicited by involved citizens' groups from various government and perhaps private industry sources (e.g., HEW in line with the Environmental Education Act of 1970).

4. <u>Regional Baseline Description</u>.

Before the geothermal development process can be evaluated, the structure of the region before the time of impact must be known. Using 1970 census statistics on each of the geopressured zone counties as baseline data, a regression model could be developed to predict per capita income, community revenues, and other key indicators of community status from specified independent variables. This analysis would be important in planning for the location of future geothermal-geopressured sites, particularly commercial production facilities. Planning for resource utilization would be based in large part on this baseline data. Trends in such factors as population movements, educational standards, work force distribution, and so forth, set parameters on the optimal type of development in a region. A regional input-output model is a good supplementary tool to use in work (see General Land Office, 1975; Bender and Coltrane, 1975; Haynes, 1975--references in Chapter II). Coordinated research with Louisiana should be organized for analysis of border areas. Estimated time: on-going; initial analysis complete in 15 months.

5. <u>Development Case Studies</u>.

Comparison of development projects in Texas would be extremely useful in developing a method to analyze the local economic and social impacts of major investments and a theory of the system relationships involved. Such theory and methods would help guide public sector planners and decision makers as they approach similar problems. Economic effects and population descriptions before and after investments are made provide some information and would be used as data, but the actual processes of change must be studied in order to be able to predict impacts. While unique problems with regard to geothermal-geopressured resources do exist--for instance, the issue of property rights--and preclude a definitive prediction of impacts of development in that resource from impacts of other kinds of projects, certain aspects of even highly diverse activities are comparable. The installation of refineries, nuclear power plant construction, and other industrial developments could be studied to great advantage in attempting to understand the social impacts of development. Local level analysis as described above in item 1 should be carried out on several projects already completed, or nearing completion, in Texas. Three possible candidates are: (a) a major dam construction project, e.g., Toledo Bend in East Texas; (b) nuclear power plant construction, e.g., Allen's Creek in the Middle Coastal Zone; and (c) natural gas drilling and production, e.g., recent Laredo discoveries.

6. Federal Regulatory Analysis.

Phase 0 research indicates substantial delays in permitting construction projects and effluent disposal by federal regulators, resulting in a lack of new plant construction in the Texas coastal areas. It is recommended that a detailed analysis of regulators--their interests, policies, and activities--be commissioned in a Phase 1 effort to be coordinated with the requirements of other components of the geopressured-geothermal project. A minimum of two carefully selected case studies should be sufficient to gain a working knowledge of federal regulatory activities. These case studies should examine the activities of regulators surrounding the preconstruction, construction, and early operational phases of (1) a new power plant situated on the coast and (2) a new or significantly altered chemical, petrochemical, or metals manufacturing plant situated on the coast. Such activities must have occurred within the last two years to measure fully the impacts of regulations. The study should be complete within eight months.

7. State Regulatory Analysis.

The passage of the Geothermal Resources Act of 1975 (Vernon's Ann. Cov. St. art. 5421 Sec 1-5), required that regulations governing geothermal activity be established by the Railroad Commission of Texas. The commission has issued eighty state-wide rules in accordance with that act. Regulations of other state agencies, such as the Texas Air Control Board, the Texas Water Development Board, and the Texas Water Quality Board are likely to be issued during or following demonstration of the resource. The rules issued by the Railroad Commission of Texas and any others subsequently issued by the commission or other agencies should be examined for their impacts upon the demonstration of geopressured-geothermal energy as well as for their consistency with existing regulation. Engineering, environmental, and legal expertise will be solicited as required from other components of the CES organization. The project is expected require one year.

8. Local Political and Institutional Survey and Analysis.

Following the selection of a demonstration site, regional and local institutions must be identified and their jurisdictions, policies, and procedures surveyed and analyzed, much as in the Phase 0 case study of the Aransas, Nueces, and San Patricio Counties area but in far greater depth. Significant political factors must be identified and an ongoing relationship established to ensure acceptance of the project. Special attention will be given to the special districts of the area selected, since each district is unique. The study requires a six-month time frame.

Summary.

These Phase 1 tasks would, in sum:

1. Provide aggregate socioeconomic data on the communities most susceptible to geothermal impacts
2. Describe attitudinal data for communities proximate to one or more possible sites
3. Establish documentation of potential political/institutional conflicts and barriers
4. Establish a broader theoretical understanding regarding the impacts of geothermal development

At the completion of Phase I, predictions of impacts on specific communities could be made and site-specific analyses continued, based on the conceptual framework and methodology developed and tested in Phases 0 and 1. The baseline data and attitudinal surveys should be done in Louisiana using the same approach followed in Texas. Findings could then be compared across states, with the goal of furthering joint planning programs where needed.

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APPENDIX A

EXPLANATION OF DATA

EXPLANATION OF DATA

Spanish Heritage.

Includes persons of Spanish language combined with persons of Spanish surname. Spanish language includes persons of Spanish mother tongue and all others in families in which the wife or head of family reported Spanish as mother tongue. Spanish surnames were from a list compiled by Naturalization and Immigration Service and updated by the Bureau of the Census.

Percent Black.

Percent who identified themselves as Negro or Black.

Urban Population.

Includes all persons living in places of 2,500 inhabitants or more, incorporated or unincorporated by cities or towns, and those living in other territory included in urbanized areas.

Net Migration.

Difference between number of persons moving into an area and number moving away. Net migration is estimated by subtracting natural increase from the total population change. Our tables express net migration as a percentage of the 1960 population; positive figures represent in-migration and negative figures out-migration.

Unemployed: 1970, 1975.

Expressed as the percent of the civilian labor force (16 years and older, employed, and unemployed, excluding armed forces) who were not working at the time of the census, who had been looking for a job during the preceding four weeks, or who reported that they were available to accept a job or were waiting to be called back to a job from which they had been laid off. 1975 figures from Texas Employment Commission.

Number Weeks Worked.

Number of weeks during which a person did any work, full or part-time (including vacation and sick leave) for pay or profit, or worked without pay for a family farm or business.

Occupational Categories.

Derived from a list of 441 specific occupations reported grouped into 12 major groups.

Median Earnings.

Given for several of the major occupational groups. Earnings refers to income before deductions for income tax, Social Security payments, union dues, etc.

Per Capita Money Income.

Computed by dividing aggregate money income by the total population.

Families Below Poverty Level.

Percentage of families falling below poverty levels set by the Social Security Administration and Federal Interagency Committee. Poverty level refers to a range of incomes adjusted by family size, sex of family head, number of children under 18, and farm and non-farm residence. (Figures are computed on a national basis and are not corrected for state and regional characteristics). Poverty level for a non-farm family of four headed by a male, for example, was $3,745 in 1969.

School Enrollment.

Refers to percentage of the population age 3 to 34 enrolled in a regular school or college, full or part-time. Vocational, trade, and business schools are not included.

Average Persons Per Unit.

Average number of people in occupied year round-units.

Median Number of Rooms Per Unit.

Includes whole rooms used for living purposes in all units, vacant and occupied, intended for year round use.

Occupied Units with 1.01 or More Persons Per Room.

Number of persons divided by number of rooms for each occupied unit.

Occupied Units Lacking Some or all Plumbing Facilities.

Percent of occupied units lacking one or more of such facilities as piped hot or cold water inside, flush toilet, shower or bath, and those units in which toilet and bathing facilities are used by occupants of other units.

Birth and Death Rates.

Ratios per 1,000 persons estimated from state certificates.

Hospital Beds per 1,000.

Data for year ending, September 30, 1969. Data on number of beds is from the American Hospital Association.

APPENDIX B

ORGANIZATIONS CONTACTED

ORGANIZATIONS CONTACTED

Bureau of Business Research, University of Texas at Austin

Bureau of Natural Resources and Environment, University of Texas at Austin

Central Power and Light, Inc.

Council for South Texas Economic Progress

General Land Office, Coastal Zone Management Program

Greater South Texas Cultural Basin Commission

Governor's Office of Information Service

Governor's Office of Planning and Coordination

L.B.J. School of Public Affairs, University of Texas at Austin

Rice Center for Community Design and Research

South Texas Research Institute

Texas Education Agency

Texas Employment Commission

Texas Industrial Commission

APPENDIX C

STATISTICAL CLUSTERING OF TEXAS COASTAL COUNTIES

STATISTICAL CLUSTERING OF TEXAS COASTAL COUNTIES*

The three coastal zone areas described in Chapter I were arrived at by visual perusal of the data presented in Tables I.1, I.2, and I.3. The sociocultural group undertook a more rigorous approach to area delineation during the Phase 0 extension period. The primary task was to use statistical techniques in clustering the 36 counties based upon socioeconomic similarities and to compare the results with the three areas described in the body of the text.

A computer-assisted procedure was used to cluster counties into groups with maximum homogeneity within groups and maximum heterogeneity between groups with respect to social and economic data. The procedure was applied to two data sets. First, counties were clustered according to their similarity on all 77 variables (standardized) in the original data tables. Second, the clustering technique was applied to a reduced set of 16 selected variables in order to examine the effects of weighting factors. The county groups resulting from these analyses were then compared with the areas delineated for discussion in Chapter I (see Figure I.2).

Method.

The clustering procedure used is a statistical technique for modeling data. The cluster program is an exploratory device to assist in a systematic search for regularities in large sets of unstructured data. It is designed to be used in discovering natural associations among variables, natural groups among counties, and category structures.

The process clusters counties at 25 levels of similarity. The first level groups those most similar on all dimensions; counties clustering at the second level are somewhat less similar, and so on. The resulting output includes a statistical "tree" which visually represents "families" of similar counties.[1] The measurement of similarity between data points

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*This analysis was carried out by Paula Ramsey, with programming assistance from CES staff members Jerry Avey and William Lesso, Jr.

[1]See Figure C.1

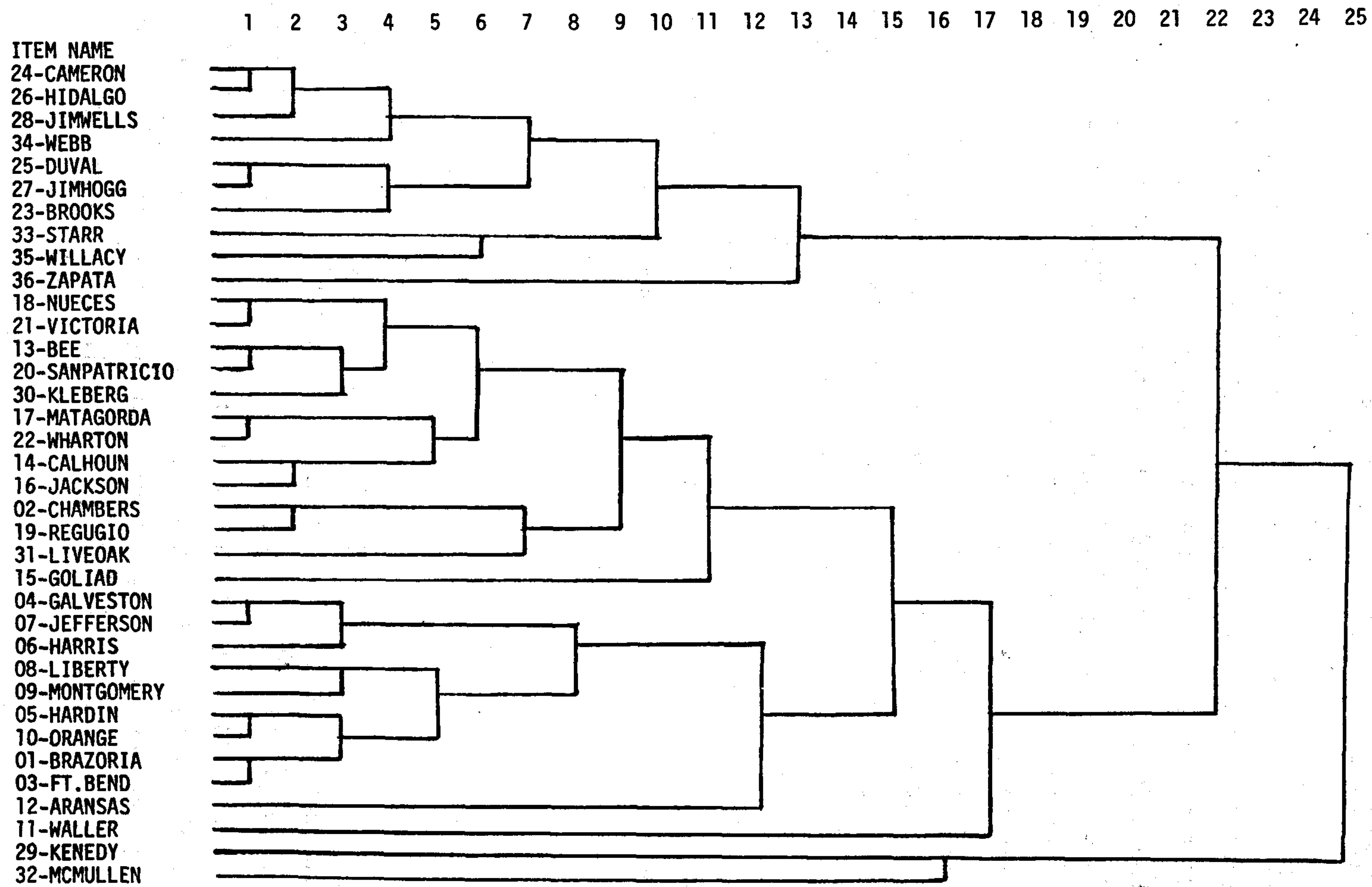


Figure C.1 Texas Coast County Cluster - Standardized. Mean within group sum of squared deviation in the new cluster is minimum. Print criterion is the total within groups sum of squared deviation.

(counties) may be based upon various mathematical criteria. The county data in the present study were analyzed numerous times, each time using a different criterion.

The data set was then reduced in order to see what effects weighting had upon the clustering, as well as to provide a more manageable set of indicators for future analysis. Elimination of redundent data was accomplished through two steps. The first step was examination of a correlation matrix in which correlation coefficients[2] were computed for each pair of variables in the original data set. Groups of highly correlated variables ($r \geq .80$) were distinguished from other variable groups which appeared to yield relatively independent information about the county populations. A factor analysis of the data was then checked for similarities of components; the results reinforced the conclusions drawn from the correlation matrix. Within each independent variable group identified, the measure most strongly associated with the others was selected to represent the group (dimension). In this manner fifteen indicators emerged for the major components of variation among populations. This precedure, in effect, reduced the weighting within the data to approximately equal values for each major independent component of variation.

Additionally, an index was constructed by which each county could be assigned a single "score" on occupational level. This index provided a sixteenth variable in the reduced list, and was computed as the sum of the following occupational categories using the indicated weight factor.

OCCUPATIONAL CATEGORIES	WEIGHT FACTOR
% Professional & Technical	x 6
% Managerial	x 5
% Craftsmen & Farmers	x 4
% Clerical & Sales & Operatives & Transport Operatives	x 3
% Service Workers	x 2
% Laborers & Farm Laborers & Private Household Workers	x 1

[2]Pearson Product Moment Correlation.

The following list shows the original categories from which the measures were taken, as well as the dimensions for which they are now indicators.

Original measure		Dimension
A. Demographic		
1.	% net migration	
2.	Birth rate	(1) Demographic
3.	Death rate	
4.	% Spanish Heritage	(2) Ethnicity
5.	% Black	
B. Education		
6.	% pop. in school	(3) Education
7.	Med. school years completed by ethnic males	(4) Ethnic Status
C. Labor Force		
8.	% all males unemployed	(5) Unemployment
9.	% all females unemployed	
10.	% full-time workers	(6) Seasonal/full-time work
11.	Occupational level (constructed index)	(7) Occupational level
D. Standard of Living		
12.	Med. earnings-ethnic males	
13.	Med. earnings-ethnic females	(8) Ethnic incomes
14.	Per capita income-ethnic pop.	
E. Services		
15.	Hospital beds per 1000	(9) Services
16.	State highway miles	

The reduced data set was analyzed by the same cluster procedure as was the 77 variable set.

Findings.

The more complete 77 variable data set clustered the counties with a high degree of consistency across trials using different criteria. The map in Figure C.2 shows the three major county groups. As can be seen in

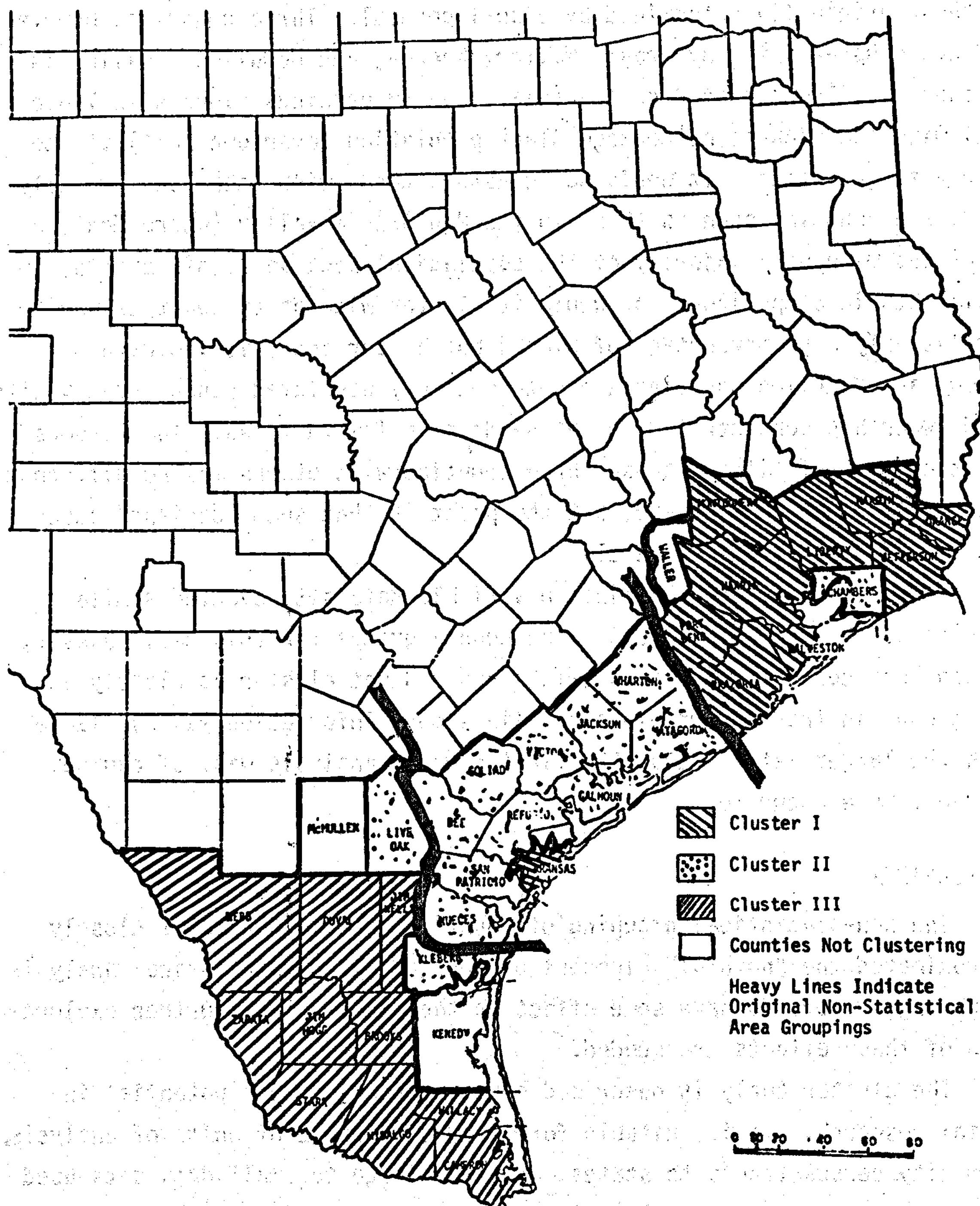


Figure C.2 Clusters on 77 variables.

the map, the area boundaries derived from cluster analysis are very similar to those originally determined by visual perusal. Three counties, however, did not cluster into any area: Waller, Kenedy, and McMullen. Waller is an economically depressed county (viz., median earnings figures in Table I.1) with the highest percentage Black population (over one half) of the thirty-six counties. It would not cluster, then, with other economically depressed counties such as those in the Rio Grande Valley (where Mexican Americans make up a majority of the population) because of differences in racial/ethnic compositon, nor would it cluster with other counties having a relatively high percentage of Blacks but better economic indicators. Kenedy and McMullen Counties are both sparsely populated ranch country with land ownership concentrated in the hands of a few families. The reasons for the "lack of fit" of these three counties with others may be different from the ones suggested here, but the point is that such "deviant" cases can often be analyzed separately.

The clustering for the sixteen variable data set revealed similar results as shown in Figure C.3. The county groups for this set, however, showed less consistency across trials and did not cluster as closely as the groups in the 77 variable set. Since more information was available with the larger set of data, the first cluster analysis was, of course, somewhat more accurate.

Conclusion.

The non-statistical grouping of counties used in Chapter I closely approximated the "natural" clusters discovered by the statistical analysis. Weighting factors do have some effect on the results, and further exploration of these effects are needed.

The cluster analysis described here has considerable potential in social research. It is suitable for study of a range of units of analysis, from city census tracts to states, and from large to small data sets used for various purposes. Small variable sets (four or five measures) could be used to cluster regions on specific social conditions for more detailed analysis. Further, these could be weighted differently to highlight changes in certain social conditions hypothesized to follow particular technological developments. Perhaps most interesting, further, would be

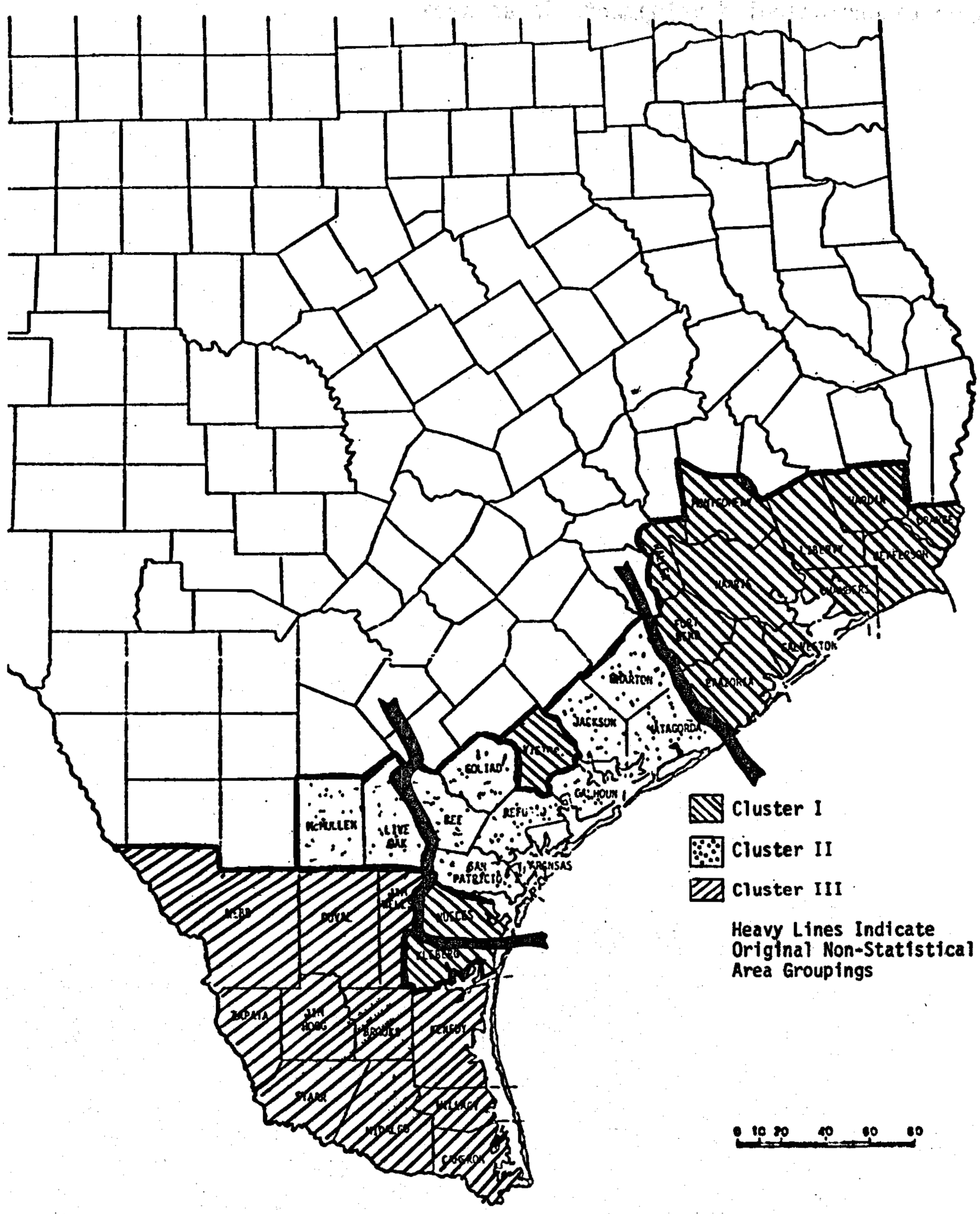


Figure C.3 Clusters on 16 variables.

the use of the technique to map "before" and "after" patterns involving major technological developments in an area.

APPENDIX D

SURVEY OF GOVERNMENTAL INSTITUTIONS

SURVEY OF GOVERNMENTAL INSTITUTIONS

FEDERAL INSTITUTIONS

Atomic Energy Commission.

Conducts and promotes research in specialized areas of geothermal energy. Activities assumed by ERDA and NRC.

Department of Agriculture. (Excluding Forest Service)

Conducts surveys, investigations, and research relating to the character of soil erosion and the preventive measures needed;

May undertake emergency measures for run-off retardation and erosion prevention as may be needed to safeguard lives and property from floods and erosion on watersheds suddenly impaired by fire or natural force;

Furnishes financial aid to persons or agencies to take preventive measures against soil erosion;

Assists local organizations technically or financially in preparing and carrying out plans for works of improvement (flood prevention, conservation, development, utilization, and disposal of water; or conservation and proper utilization of land);

May make loans to state and local public agencies and designated local nonprofit organizations to conduct research relating to land conservation and land utilization;

Provides technical and financial assistance to rural communities for the installation of measures and facilities for water quality management, control of agriculture-related pollution, and for disposal of solid wastes.

Department of Commerce.

Economic Development Administration. (79 Stat. 552; 42 USC 3121) as amended.

Carries out provisions of the Public Works and Economic Development Act of 1965, by aiding in the development of public facilities and private enterprise through public works grants and loans, business loans, and technical assistance to areas designated as Redevelopment Areas within Economic Development Areas. Additional funds are made available to Growth Centers within the Redevelopment Areas.

National Oceanographic and Atmospheric Administration.

Administers the Coastal Zone Management Act of 1972;

May designate marine sanctuaries on the continental shelf for the purpose of preserving or restoring areas for their conservation, recreational, ecological, economical or esthetic values;

Regulates activities within marine sanctuaries;

Conducts programs to develop ports and port facilities.

Department of Defense.

Generally: investigates the application of geothermal resources to defense needs.

Department of the Army.

Corps of Engineers.

Must approve any improvement of obstruction to be built in or on navigable waters;

Constructs flood control and navigation projects;

Has power of condemnation;

Repairs flood control works threatened or destroyed by flood;

Issues permits for the dumping of dredged material into navigable waters;

Establishes harbor lines;

Assists in the construction of works for the restoration and and protection of shores;

Must give full consideration to the recreational and fish and wildlife benefits of its water projects; and must operate its facilities to enhance these values if it can reasonably do so;

Provides technical services to state and local governments;

Holds public hearings.

Department of Housing and Urban Development.

Administers the Flood Insurance Program;

Administers the Community Development Grant Program under the Housing and Community Development Act of 1974.

Department of Interior.

Bureau of Land Management.

Leases public lands and the Outer Continental Shelf.

Bureau of Mines.

Carries on research into processes of geothermal extraction, processing, use, reuse, and disposal.

Bureau of Outdoor Recreation.

Develops a nationwide outdoor recreation plan;

Assists states in developing outdoor recreation plans;

Reviews Environmental Impact Statements on federally assisted public works projects.

Bureau of Reclamation.

Undertakes research and develops plans for the regulation, conservation, and utilization of water and related land resources;

Locates, constructs, operates, and maintains works for the storage, diversion, and development of waters for the reclamation of arid and semiarid lands in the western states;

Builds dams and reservoirs, canals, and distribution systems;

Builds power plants and transmission lines;

Has condemnation power through the Secretary of the Interior;

Sells electric power and energy generated at most of its projects;

Reviews Environmental Impact Statements for proposed federal water resource projects;

Provides loans to the irrigation districts within its projects to rehabilitate and improve the irrigation facilities;

Provides grants for construction of water resource programs.

National Park Service.

Concerned with the impact of any potentially harmful industry or project upon national parks and refuges.

U.S. Fish and Wildlife Service.

Enforces game and fish laws;
Manages and protects wildlife refuges;
Conducts research on fish and wildlife;
Protects certain marine mammals;
Makes studies to determine the probable effect of federal and other water use projects on the fish and wildlife resources of the area affected;
Reviews Environmental Impact Statements.

U.S. Geological Survey.

Enforces departmental regulations applicable to oil, gas, and other mining leases, permits, licenses, development contracts, and gas storage contracts;
Supervises the operations of private industry on mining and oil and gas leases on public domain, acquired, Indian, Outer Continental Shelf, and certain Naval Petroleum Reserve lands to prevent waste and to limit environmental damage and pollution;
Collect royalties;
Performs surveys, investigations, and research covering topography, geology, and the mineral and water resources of the United States;
May condemn land for Geological Survey use through the department;
Administers an exploration program for the discovery of domestic minerals by private industry with federal assistance.

Office of Water Resources Research.

Sponsors research in priority areas.

Department of Transportation.

U.S. Coast Guard.

Detects, prevents, and controls pollution on and adjacent to the

navigable waters of the United States;
Licences deepwater ports.

<u>Department of the Treasury</u>.

<u>Internal Revenue Service</u>.

Taxes income from investment in energy production, ownership;
Provides for tax incentives for energy investment as directed by congress and the president;
Decides issues regarding taxation, incentives through administrative hearings.

<u>Energy Research and Development Administration</u>.

Encourages and conducts research and development programs respecting all energy sources;
Collects and distributes data concerning the manufacture or development of energy and its efficient extraction, conversion, transmission, and use;
Encourages and conducts research into energy conservation;
Has power of condemnation to provide facilities necessary for its operation;
Provides loans and makes contracts for the conduct of research with public or private institutions or persons;
Subsidizes the construction and operation of reactors and other facilities for educational activities;
Coordinates research and development programs for all energy resources.

<u>Environmental Protection Agency</u>.

Regulates disposal of dredged material in navigable waters in U.S. and offshore;
Promulgates guidelines for solid waste recovery, collection, separation, and disposal systems;
Regulates noise pollution;
Conducts research on causes, effects, and prevention of air and water pollution;
Approves or disapproves state air plans and institutes its own plan

if a state fails to act;

Sets standards of performance for new stationary sources of air pollution;

Sets emission standards for hazardous air pollutants;

Approves or disapproves water quality standards if the state fails to act;

Issues permits for effluent discharges;

Publishes a list of toxic pollutants and effluent limitations for these substances;

Sets limitations for thermal discharges;

Has inspection powers;

Reviews Environmental Impact Statements in its areas of expertise.

<u>Federal Energy Administration</u>.

Makes plans related to the production, conservation, use, control, distribution, rationing, and allocation of all forms of energy;

Collects data on energy sources and use;

Has enforcement powers;

Coordinates federal energy programs and policies with those of the states.

<u>Federal Power Commission</u>.

Regulates electric and gas utilities engaged in interstate commerce;

Issues licenses for construction, operation, and maintenance of project works necessary or convenient for the development of navigation and power on streams congress has jurisdiction over;

Participates with other agencies in coordinating development of national land and water resources.

<u>Securities and Exchange Commission</u>.

Registers and regulates sales of securities;

Maintains competitive conditions among securities issuers;

Refers proceedings to Department of Justice.

STATE INSTITUTIONS

Texas Air Control Board.

Plans for the proper control of air resources;
Establishes levels of quality;
Promulgates and enforces rules and regulations;
Inspects and monitors air resources quality;
Causes legal proceedings to be instituted through the Attorney General's Office.

Antiquities Commission.

Designates State Archeological Landmarks;
Enforces the Antiquities Code of Texas.

Attorney General.

Gives legal advice to state agencies upon request in the form of opinions;
Represents state in civil and some criminal proceedings.

Texas Commission on Interstate Cooperation.

Promotes cooperation among Texas and other state governments;
Recommends adoption of compacts, uniform and reciprocal statutes and administrative rules.

Texas Coastal and Marine Council.

Assists in the planning, coordination, and assessment of marine-related affairs.

Comptroller of Public Accounts.

Oil, Gas, and Utilities Division.

Administers state taxes on oil, gas, sulfur, cement, telegraph companies, electric light, power, or water companies, others presumably including producers and users of geothermal energy.
Maintains field offices throughout the state.

Texas Historical Commission.

Administers the National Historical Preservation Act of 1966(16 U.S.C.A.

470 *et seq.*)

Interagency Council on Natural Resources and the Environment.

Composed of representatives from the General Land Office, the Governor's Office, Air Control Board, Department of Agriculture, Department of Parks and Wildlife, Department of Highways and Public Transportation, Texas Railroad Commission, Texas Soil and Water Conservation Board, Texas Water Development Board, Texas Water Quality Board, Texas A&M University, Texas Water Rights Commission, UT Bureau of Economic Geology, Historical Commission;

Coordinates natural resources development in Texas, including activities of member agencies regarding the Coastal Zone Management Program.

Office of the Governor.

Division of Planning Coordination.

Reviews proposed projects and grant applications of State agencies regional commissions;

Conducts economic impact analyses.

Governor's Energy Advisory Council.

Charged with creation of a state energy policy;

Will coordinate this policy with other state agencies.

Greater South Texas Cultural Basin Commission.

Promotes economic and social progress in forty counties of South Texas.

Railroad Commission of Texas.

Promulgates rules and regulations concerning the development of geothermal energy on private lands;

Regulates drilling, production, and maintenance of wells on state lands;

Charged with conserving the resource, physically and economically;

Protects correlative rights;

Sets production rates;

Prevents or abates water pollution;

Enforces its orders through shutoff process.

State Department of Health.

Designates shellfish producing areas as polluted and unacceptable for industry;

Certifies water and wastewater treatment operators;

Monitors coastal waters;

Reviews and approves water and wastewater treatment systems;

Supports work of the Air Control Board by monitoring air quality throughout the state.

Department of Highways and Public Transportation.

Coordinates matters involving the Intracoastal Canal;

Participates in A-95 Review procedures.

Department of Parks and Wildlife.

Maintains a comprehensive plan for outdoor recreation;

Develops and maintains comprehensive plans for fish and wildlife;

Exercises police power over fish and game, commercial fishing and pollution, ground water withdrawals;

Issues sand, shell, gravel, and marl permits;

Maintains extensive field structure.

General Land Office.

Issues licenses, leases, permits for use of state lands, including those belonging to the School Land Board, and the Board for Lease of University Lands. The Commissioner of the General Land Office is also a member of the several commissions handling land held by other institutions;

Collects rents and royalties;

Reviews Environmental Impact Statements involving activities on state lands including activities by navigation districts;

Leads state efforts to develop a Coastal Zone Management Program for the state.

Gulf States Marine Commission.

Develops a multistate program for the protection of gulf fisheries.

Member states include: Florida, Alabama, Mississippi, Louisiana, and Texas.

Texas Industrial Commission.

Locates and attempts to attract new industries;
Promotes expansion of existing industries;
May make loans to Industrial Development Agencies.

State Soil and Water Conservation Board.

Administers the state's responsibilities under the Federal Watershed Protection and Flood Prevention Act (16 U.S.C.A. 165a-4);
Assists and coordinates the activities of Soil and Water Conservation Districts;
Mandated to secure the cooperation and assistance of the U.S. and any of its agencies and of agencies of Texas in the work of the districts.

Texas Public Utilities Commission.

Will regulate affairs of most public utilities in Texas beginning September 1, 1976.

Texas Water Development Board.

Maintains a comprehensive state water plan for all water resources available to the state;
Maintains programs for desalination of brines;
Conducts studies regarding the economic value of water used for municipal, industrial, irrigation and recreational purposes;
Samples water resources of the state;
Maintains liaison with U.S. Bureau of Reclamation and Corps of Engineers.

Texas Water Quality Board.

Maintains principal authority in the state on matters relating to water quality;
Establishes water quality criteria for state waters;
Regulates the operation of wastewater treatment facilities;
Administers most of the requirements of the National Pollution Dis-

charge Elimination System through agreement with the Environmental Protection Agency;

Monitors and enforces state effluent discharge permits;

Maintains a field structure.

Texas Water Rights Commission.

Grants or rejects applications to take or divert public surface waters;

Creates and regulates certain types of water districts, including underground water districts;

Maintains field structure.

The University of Texas at Austin.

Center for Energy Studies.

Serves as the university's clearinghouse of energy information;

Coordinates numerous research efforts related to energy through a cooperative multidisciplinary organization.

Bureau of Economic Geology.

Participates in research coordinated by Center for Energy Studies;

A quasi-state agency serving as the state's geological survey.

Marine Science Institute.

Maintains extensive field facilities located in Gulf cities of Galveston and Port Aransas;

Maintains programs in Marine Environmental Quality, Physiology and Ecology of Marine Organisms, Geological and Physical Coastal Processes, Nearshore Living Resources, Planetary Seismology, Submarine Geology, Submarine Geophysics.

Texas A&M University.

Principally through Sea Grant College: Identifies and assesses needs in marine resources;

Carries out research and other projects responsive to those needs;

Trains personnel in marine related fields;

Fosters public awareness.

LOCAL INSTITUTIONS

Councils of Government.

Multicounty jurisdiction;

Composed of or responsible to locally elected officials;

Adopt plans in concert with other institutions in areas of housing, health, public works, economic development, waste disposal systems, manpower, transportation, others;

Review certain federally funded projects through OMB Cir. A-95 procedures.

Counties.

Governed by four elected commissioners, representing different geographical areas, presided over by a county judge, elected at large;

Levy and collect taxes up to $.85 per $100 valuation.

Combined city-county health departments may file pollution suits;

May construct and operate wastewater collection and treatment systems, other water quality management functions;

May control land usage in potential flood areas through zoning, flood plain management programs;

Can pass and enforce ordinances for Gulf beaches.

Municipalities.

Pass ordinances;

Issue bonds;

Make and enforce building codes and subdivision regulations;

Grant and regulate franchises;

Annex and acquire land;

Construct water supply and waste disposal systems.

General Law Cities. (5000 or less)

Annex territory contiguous to the city and one-half mile or less in width following majority approval of the territory's inhabitants;

May tax up to 1.5% of its taxable property annually.

<u>General Law Cities.</u> (5000 or more)

Annex territory within one mile of the city following majority approval of the territory's inhabitants;

May tax up to 1.5% of its taxable property annually.

<u>Home-Rule Cities.</u>

Annex adjacent land without consent;

May tax up to 2.5% of its taxable property annually;

May make and enforce building and subdivision regulations within five miles of its boundaries through Extra-Territorial Jurisdiction.

<u>Special Governments.</u>

Established by authorization of certain state agencies, by special legislation by the legislature, by petition to and approval by a county commissioners' court, and authorization by the city to be served by the proposed district. All methods require a confirmation election by landowners within proposed district boundaries.

Most special governments may issue bonds, fix and collect charges for services, levy <u>ad valorem</u> taxes, own and construct facilities, levy maintenance taxes, approve certain land use restrictions.

APPENDIX E

TYPES OF SPECIAL DISTRICTS CREATED IN TEXAS

TYPES OF SPECIAL DISTRICTS CREATED IN TEXAS

TYPE	PURPOSE
Water	
Water Control and Improvement	Supply and Irrigation
Water Improvement	Irrigation
Drainage	Control
Levee Improvement	Flood Control
Navigation	Navigation and Port
Fresh Water Supply	Urban Supply
Municipal Water	Urban Supply
Water Supply	Supply and Development
River Authority	Multipurpose
Watershed Authority	Conservation and Supply
Underground Water	Conservation
Conservation and Reclamation	Multipurpose
Water Power Control	Supply and Power
Sanitation	Wastewater Treatment and Disposal
Improvement	Supply and Control
Flood Control	Control
Soil Conservation	Soil Conservation
Hospital	Medical Care
Housing Authorities	Public Housing
Urban Renewal Authorities	Municipal Redevelopment
Rural Fire Prevention	Fire Fighting
Noxious Weed Control	Weed Control
Airport	Airports

In addition to the above, there are several combination districts created by the Texas Legislature. Examples of these include a subsidence district in the Houston area, and the Gulf Coast Waste Disposal Authority, also in the Houston area. (Thrombley, 1959, adapted by Williamson)

APPENDIX F

SPECIAL DISTRICTS IN THE CASE STUDY AREA

SPECIAL DISTRICTS IN THE CASE STUDY AREA

TYPE	NUMBER
River Authority	1
Drainage District	2
Soil and Water Conservation District	1
Navigation District	3
Municipal Water District	1
Conservation and Reclamation District	1
Water Supply District	1
Fresh Water Supply District	1
Water Control and Improvement District	3
Airport District	1
Total	15

In addition to the above nonschool special districts, there are eighteen school districts and one MHMR district.

APPENDIX G

PROFESSIONAL AND TRADE ORGANIZATIONS

PROFESSIONAL AND TRADE ORGANIZATIONS

Advertising Federation of Corpus Christi
Altrusa Club
American Association of Cost Engineers, South Texas Section
American Businesss Women's Association, Sparkling City Charter Chapter
American Chemical Society, South Texas Section
American Institute of Chemical Engineers, Coastal Bend Section
American Society of Civil Engineers
American Society of Safety Engineers
Associated General Contractors of America, Inc., South Texas Chapter
Auxiliary to the Nueces Chapter of Professional Engineers
Board of Trade-Port of Corpus Christi
Business and Professional Women's Club of Corpus Christi
Central Business District Association
City Council of Beta Sigma Phi
City Federation of Women's Clubs
Coastal Bend Agri-Business Council
Coastal Bend Archeological Society
Coastal Bend Chapter, National Secretaries Association
Coastal Bend Genealogical Society
Coastal Bend Personnel Association
Coastal Bend Retail Lumber Dealers Association
Coastal Bend Society of Texas Osteopathic Medical Association
Coastal Bend Veterinary Medical Association
Coastal Bend Warehouse and Transfer Association
Coastal Educational Secretaries Association
Consumer Credit Association of Corpus Christi
Corpus Christi Apartment Association
Corpus Christi Association of Independent Insurance Agents
Corpus Christi Association of Life Underwriters
Corpus Christi Association of Petroleum Landmen
Corpus Christi Board of Realtors
Corpus Christi Business and Estate Council
Corpus Christi Chamber of Commerce

Corpus Christi Chapter of American Society of Chartered Life Underwriters
Corpus Christi Chamber of Commerce Women's Committee
Corpus Christi Chapter, American Institute of Architects
Corpus Christi Chapter of National Association of Women in Construction
Corpus Christi Chapter, Texas Society of Certified Public Accountants
Corpus Christi Claims Association
Corpus Christi Council of Hospital Auxiliaries
Corpus Christi District Retail Grocers Association
Corpus Christi Firefighters Association, Local #936
Corpus Christi Franchised New Car Dealers Association
Corpus Christi Geological Society
Corpus Christi Hotel-Motel Association
Corpus Christi Independent Garagemen's Association
Corpus Christi Ministerial Alliance
Corpus Christi Press Club
Corpus Christi Principals Association
Corpus Christi Rental Property Association
Corpus Christi Restaurant Association
Corpus Christi Sales And Marketing Executives Association
Corpus Christi Traffic Association
Desk and Derrick Club of Corpus Christi
Downtown Business and Professional Women's Club
Gulf Coast Chapter, American Institute of Banking
Gulf Coast Florists Association
Gulf Coast Life Member Club--Telephone Pioneers of American
Gulf Coast Purchasing Management Association
Insurance Women of Corpus Christi
Licensed Vocation Nurses Association, Division #7
Little Theatre Corpus Christi
National Association of Corrosion Engineers
National Defense Transportation Association
Negro Business and Professional Women's Club of Corpus Christi
Nueces Chapter of Texas Society of Professional Engineers
Nueces County Bar Association
Nueces County Medical Society

Nueces County Pharmaceutical Association
Nueces Valley District Dental Society
PBX Club of Corpus Christi
Pilot Club of Corpus Christi
Sierra Club of Corpus Christi
Society of Professional Well Log Analysts
Society of Real Estate Appraisers
South Texas Division of the Texas Hospital Association
South Texas Marine Dealers Association
Southwest Texas Section, Society of Petroleum Engineers of AIME
Texas Chiropractic Association, District 12
Texas Hairdressers and Cosmetologists Association
The Byliners of Corpus Christi
Zonta Club of Corpus Christi

PART 3

ENVIRONMENTAL

GEOTHERMAL RESOURCES OF THE TEXAS GULF COAST-- ENVIRONMENTAL CONCERNS ARISING FROM THE PRODUCTION AND DISPOSAL OF GEOTHERMAL WATERS[1]

C. W. KREITLER
T. C. GUSTAVSON

BUREAU OF ECONOMIC GEOLOGY
THE UNIVERSITY OF TEXAS AT AUSTIN

PHASE 0

SCOPE-OF-WORK AND MANAGEMENT STUDY

1. PUBLISHED WITH THE PERMISSION OF THE DIRECTOR.

INTRODUCTION

Data from oil and gas wells in the Cenozoic sediments of the Gulf Coast indicate that waters of abnormally high temperature occur below the top of the geopressured zone. The geopressured zone, a zone of abnormally high pore-fluid pressure, occurs at depth where fluids contained within incompletely compacted and dewatered sediments support some of the weight of the rock overburden. In the Texas Gulf Coast, depth of the geopressured zone increases with the age of the sediments. Geopressured Frio Formation sediments occur generally at depths of 2 kilometers (6,600 ft) or more while geopressured Pleistocene sediments on the continental shelf occur at depths of approximately 1 kilometer (3,300 ft).

Dissipation of heat at the earth's surface occurs at a mean rate of 1.5 microcalories/cm^2/sec. Heat dissipation has resulted in a geothermal gradient in the Earth's surficial rocks such that mean rock temperature increases approximately 25°C (77°F) per km of depth. Where the insulating properties of rocks at depth are high, the geothermal gradient increases markedly. The undercompacted or geopressured zones of the Gulf Coast apparently act as effective heat insulators slowing the dissipation of heat to the surface (Jones, 1969; Lewis and Rosi, 1969). As a result, high temperatures are generally present in rock and pore-water below the top of the geopressure zone, locally exceeding 288°C (520°F).

The Frio Formation is the youngest of three formations on the Texas Gulf Coast--Wilcox, Vicksburg, and Frio--that are currently being investigated for geothermal energy. Bebout and others (1975a, 1975b) have identified several areas (fig. 1) along the Gulf Coast where thick, laterally extensive sands containing water with temperatures of 149°C (300°F) or more occur within the geopressured zone of the Frio Formation. Hot water produced from these geothermal sources has considerable potential energy stored as heat, a portion of which could be converted to electrical energy. For example, House and others (1975) have estimated the recoverable electrical energy from geothermal resources, including in-place methane, to be 5,990 MW-centuries for the Texas and Louisiana Gulf Coast. Dorfman and Kehle (1974) have estimated the exploitable electrical energy potential of the Frio Formation alone to be 7,000-MW centuries.

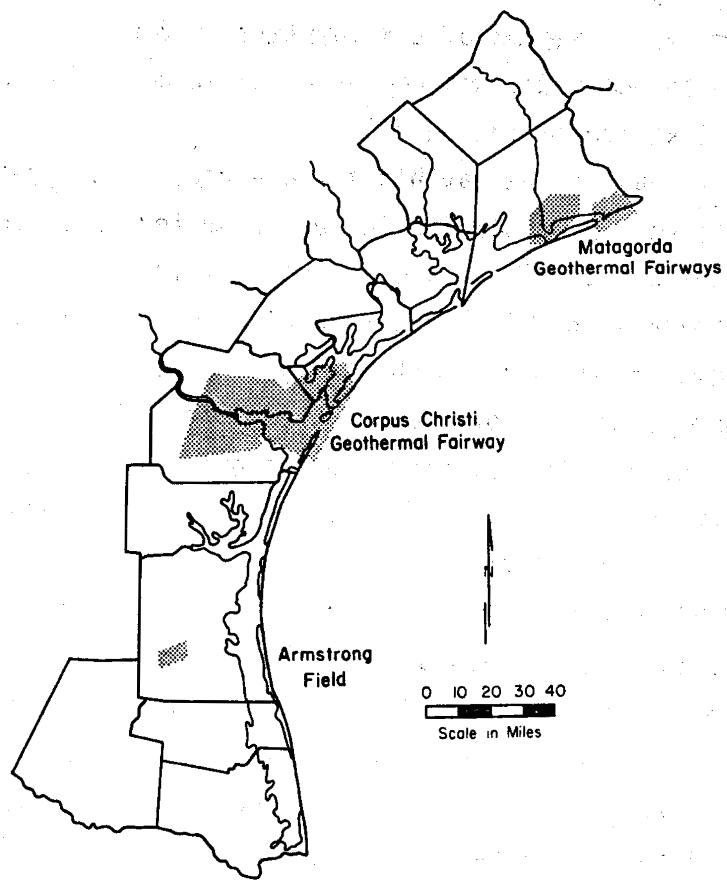


Fig. 1. Location of geothermal fairways along the southern Gulf Coast of Texas.

This report is an attempt to foresee areas of general environmental concern that will arise during exploration for and development of geopressured-geothermal resources on the Texas Gulf Coast (fig. 1). Disposal of hot saline water and potential subsidence and faulting of the land surface which may result from geothermal-water production are of paramount concern and have been recognized as such by others (Herrin and Goforth, 1975; Papadopulos, 1975; Moseley, 1975).

GEOTHERMAL FLUID DISPOSAL

Selection of disposal sites and methods of disposal for the enormous volumes of hot saline water that will result from geothermal production are two of the most perplexing problems that have arisen in the planning for geothermal resource development. Commercially viable generating facilities will have to be supplied by 5 to 10 wells, each capable of producing 3.8 m^3 per minute (1,000 gal) or about 5,500 m^3 (34,000 bbls) per day (approximately 170,000 to 340,000 bbls per day for a single generating facility). Although geothermal waters may be used by other industries for other purposes after passing through the generating facility, the problem of disposal is not lessened. The responsibility for disposal is simply transferred to others.

Questions requiring immediate answers include: (1) What are the physiochemical characteristics of geopressured fluids, (2) What are the characteristics of the environments that will come in contact with geothermal fluids through their disposal, storage, or transportation, and (3) What is the regulatory framework in which disposal must be considered.

Physiochemical Characteristics of Geothermal Fluids

Water Chemistry

Analyses of water samples from below the top of the geopressured zone are available from only seven wells throughout Aransas, Nueces, Refugio, and San Patricio Counties, and from 15 wells in Kenedy County (Taylor, 1975). For the samples from Aransas, Nueces, Refugio, and San Patricio Counties, total dissolved solids (TDS) ranges from a minimum of 8,000 ppm to a maximum of 72,000 ppm (fig. 2). Chloride concentration ranges from 3,500 to 46,000 ppm and sodium-plus-potassium concentration ranges from

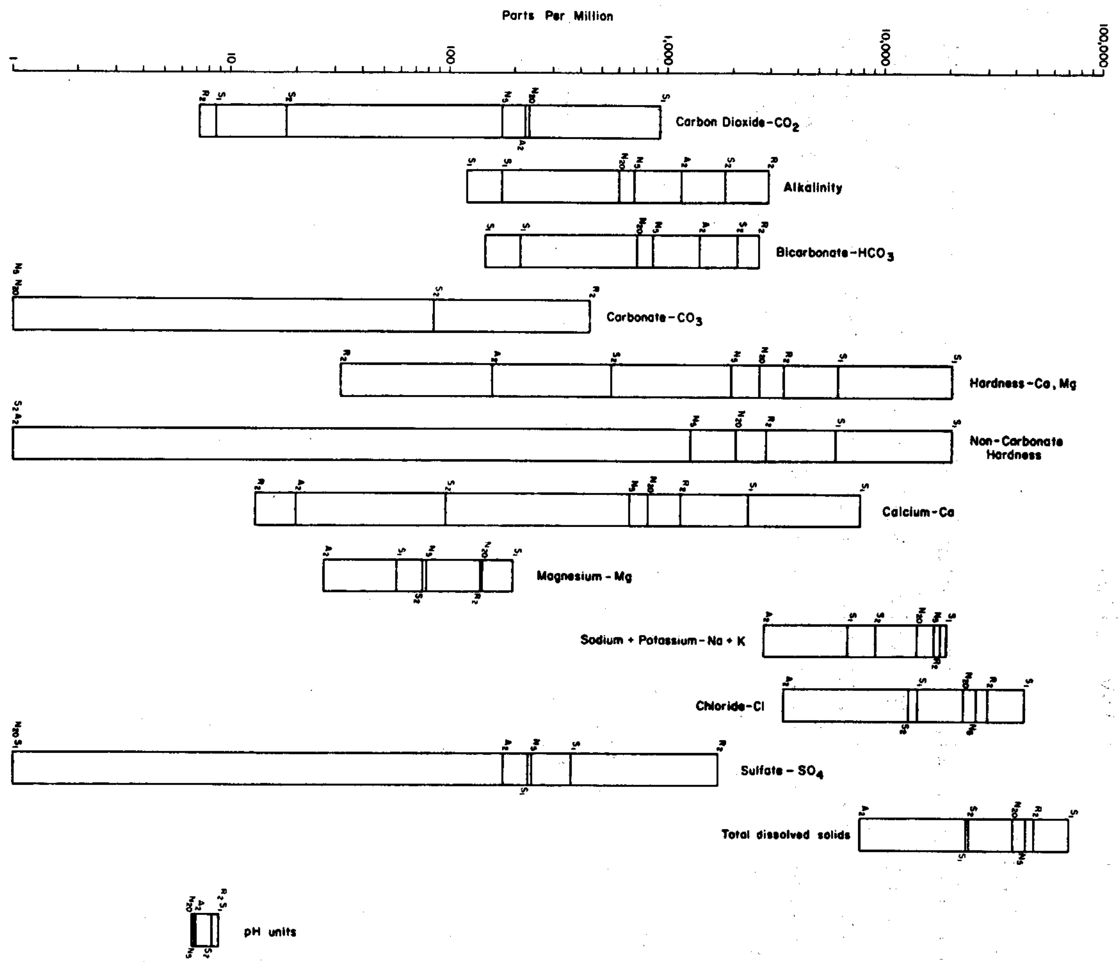


Fig. 2. Analyses of water from within the geopressured zone, Aransas (A), Nueces (N), Refugio (R), and San Patricio County (S) (see figure 4 for location) (Taylor, 1975).

5

2,000 to 20,000 ppm. For the samples from Kenedy County, TDS ranges from 18,000 to 40,000 ppm (fig. 3). For these same waters, pH varies from 4.9 to 10. Analyses for toxic trace elements such as boron are not available. If these water samples, all taken within 1 kilometer (3,500 ft) of the top of the geopressured zone (figs. 4, 5), are representative of geothermal fluid salinities within the geopressured zone, then produced geothermal waters will vary from moderately saline to brines.

Based on interpretations of electrical logs, Dorfman and Kehle (1974) suggest that salinities of geothermal reservoirs are comparatively fresh (TDS < 5,000 ppm) and could be used for irrigation and general use with minor desalination treatment. Burst (1969) and Dorfman and Kehle (1974) maintain that diagenetic changes of montmorillonite to illite in deep Gulf Coast sediments allow up to 15 percent of the waters contained in the muds to be expelled as fresh water, decreasing the salinity of adjacent sandy aquifers.

In Louisiana, geopressured waters of the Manchester field are moderately saline (16,000-26,000 mg/l TDS), but less saline than overlying normally pressured waters (600-180,000 mg/l TDS) (Schmidt, 1973). In Hidalgo County in South Texas, the average salinity for a geopressured reservoir is about 25,000 mg/l TDS (Papadopulos, 1975). Until actual samples of geothermal resource fluids are analyzed, however, the questions of salinity and possible toxic trace elements remain incompletely answered. For the purposes of this report, geothermal waters are considered to have moderate to high salinities.

Geothermal Fluid Temperatures

The temperature distribution of fluids within the geopressured zone is at best imprecisely known. Data are usually limited to a single bottom-hole temperature for each well. Isothermal maps of the middle and southern Gulf Coast (see Bebout and others, 1975a, 1975b) are generally conservative because of the common practice of well-bore cooling, or even icing, prior to logging to protect temperature-sensitive electronic components of electrical logging sondes. Reported fluid temperatures in geothermal fairways, nevertheless, are generally in excess of 149°C (300°F). Maximum recorded bottom-hole temperatures for the Texas Gulf Coast exceed 288°C (520°F).

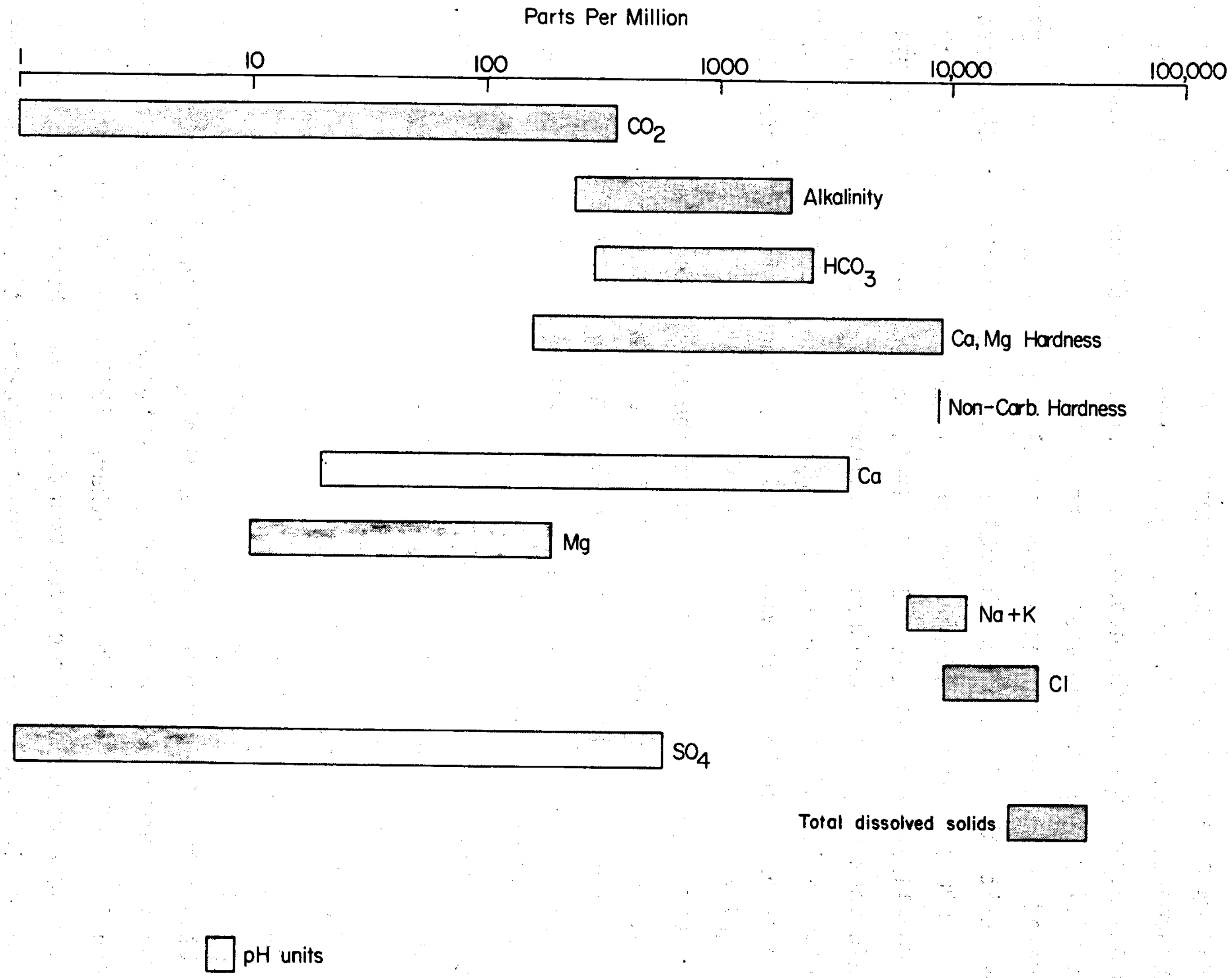


Fig. 3. Analyses of water from within the geopressured zone, Kenedy County (see figure 6 for location) (Taylor, 1975).

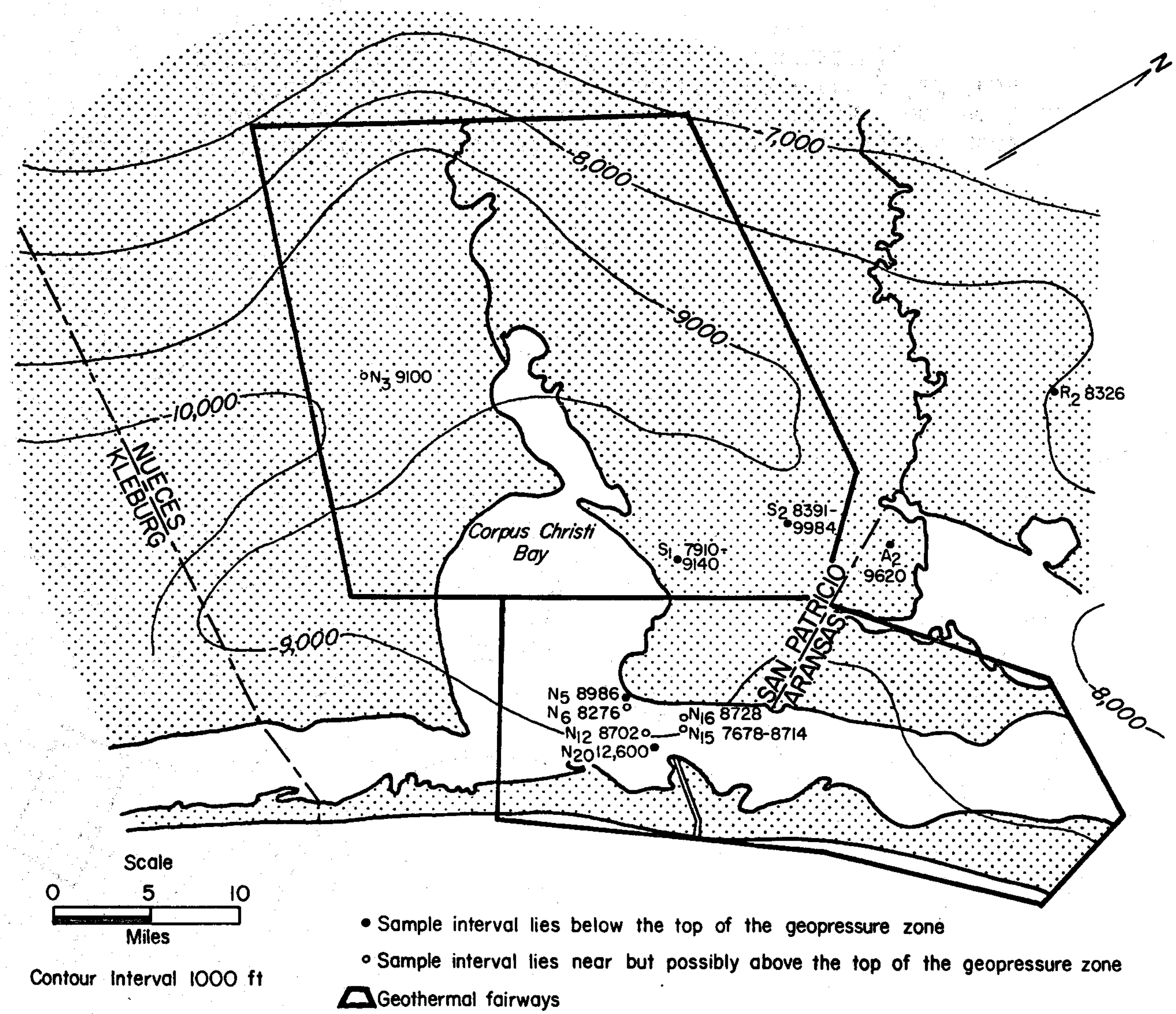


Fig. 4. Structure contour map of the top of the geopressured zone with locations and depths of water analyses (after Bebout and others, 1975a; 1975b).

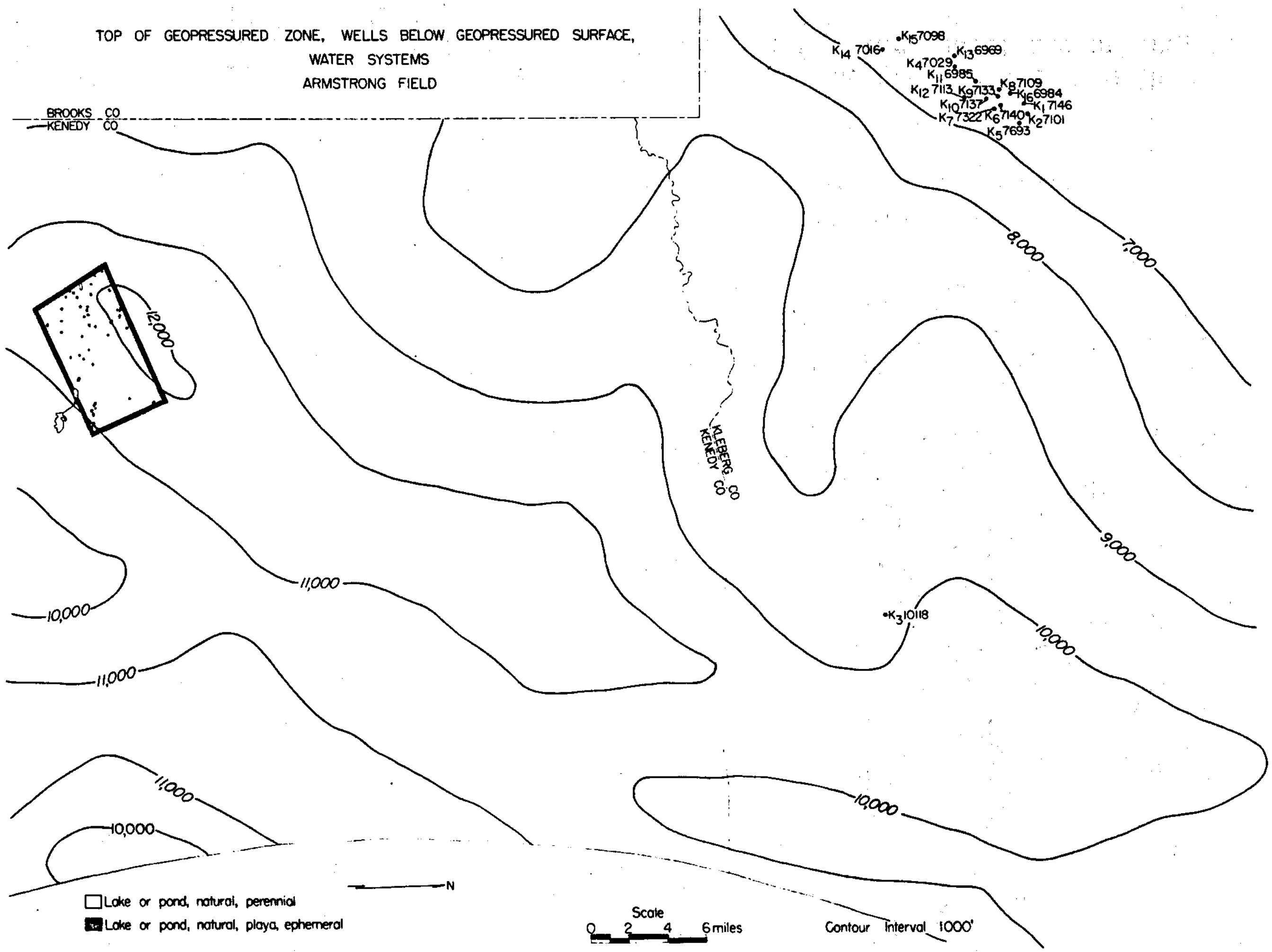


Fig. 5. Structure contour map of the top of the geopressured zone, natural water systems of the Armstrong fairway, and locations and depths of water analyses Kenedy County (compiled from Bebout, 1975b, and Brown and others, in press b).

Geothermal fluids will probably lose only a moderate amount of their heat energy while passing through the generating facility. They will probably retain temperatures of at least 100°C (212°F) when the process of waste water disposal begins.

Physiochemical Properties of Surface Water

In the processes of developing geothermal resources, care must be taken to prevent contamination of fresh water by hot saline geothermal fluids. In order to recognize the distribution of fresh-water resources, maps of the distribution of surface water, lakes or ponds, sloughs, drainage or irrigation ditches or canals, and artificial reservoirs were compiled for the Corpus Christi and Matagorda County fairways and for the Armstrong field in Kenedy County (figs. 5, 6, and 7). The major fresh-water streams are the Nueces River, Oso Creek, and Chiltipin Creek in the Corpus Christi area and the Colorado River and Big Boggy Creek in Matagorda County. The lower reaches of these streams and other minor streams may be influenced by wind or astronomical tides resulting in fluctuations in salinity.

Water analyses and discharge rates from the Nueces River, Oso Creek, and the Colorado River (U. S. Geological Survey, 1974) indicate that these waters are usable for irrigation and that the water of the Nueces River is suitable for human consumption after treatment. Total dissolved solids generally are less than 500 ppm for the Nueces River and less than 300 ppm for the Colorado River.

Disposal of saline oil-field waters has polluted surface waters in several areas of the Texas Coastal Zone. Chiltipin Creek lies east of the Nueces River and drains a small basin into Copano Bay (fig. 7). Creek waters contain high concentrations of calcium, magnesium, sodium, and chlorine ions, with TDS as high as 39,000 ppm (fig. 8). Salinities of the creek waters, which vary inversely with discharge, are high during periods of low discharge and low during periods of high discharge; rainwater dilutes the salt concentration of waters that are apparently percolating into the stream. The pollutants in Chiltipin Creek are attributed to salt-water disposal associated with petroleum production. The sulfate is consistently low while the chloride content fluctuates inversely with discharge suggesting that the sulfate is a natural product of the basin soils and that chloride content is a contaminant (Shafer, 1968). The only

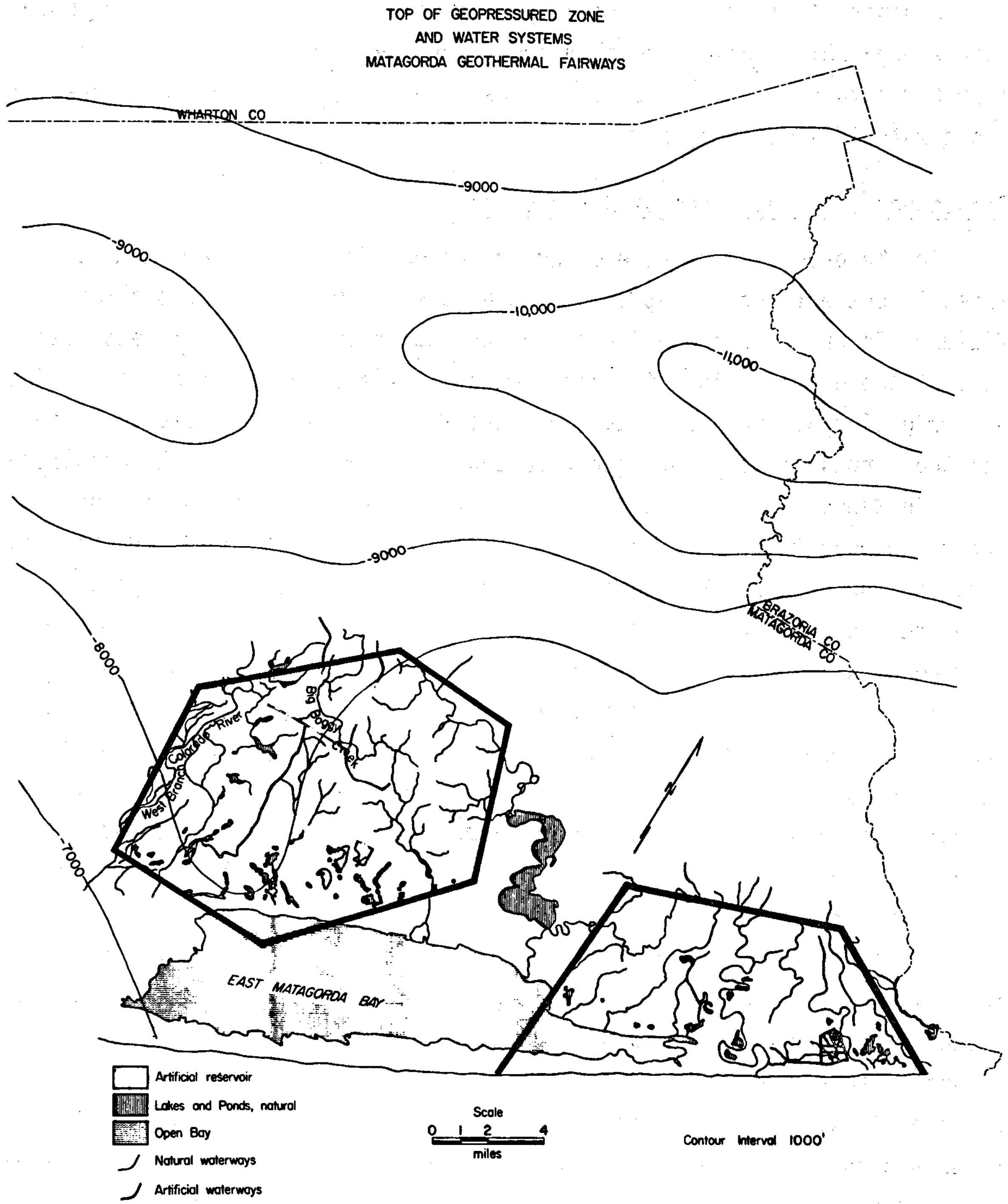


Fig. 6. Structure contour map of the top of the geopressured zone and surface-water systems (compiled from Bebout and others, 1975a, and McGowen and others, in press).

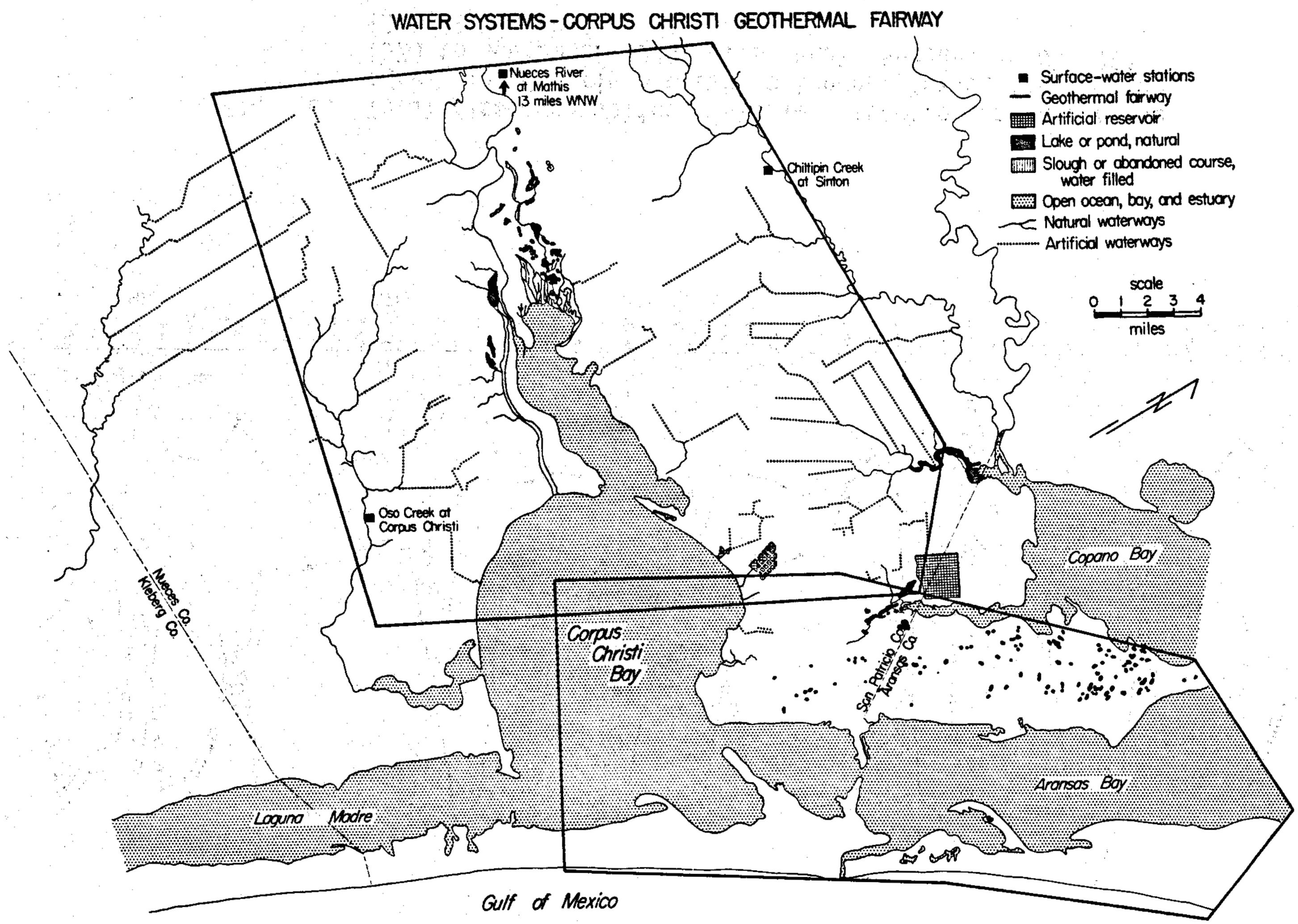


Fig. 7. Surface-water systems (compiled from Brown and others, in press a) and surface-water sample stations.

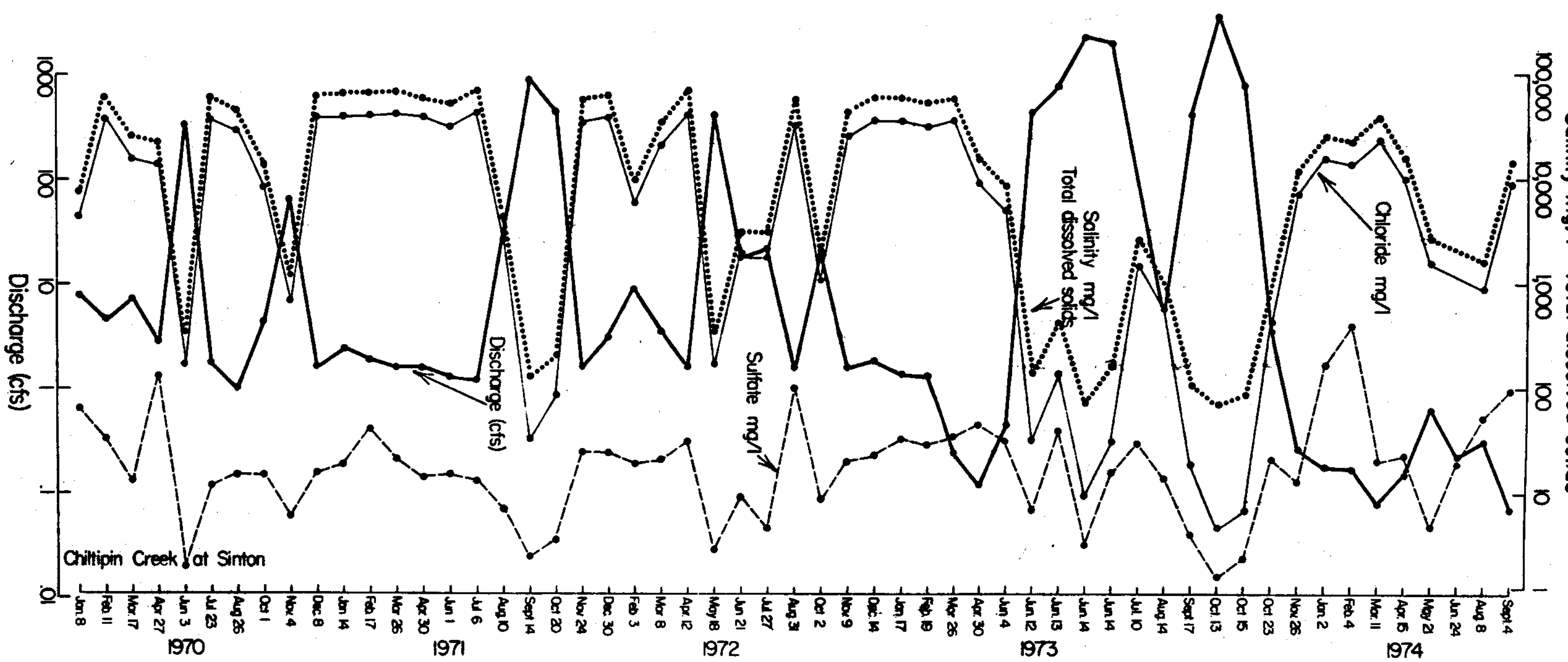


Fig. 8. Total dissolved solids, chloride, sulfate, and discharge curves for Chiltipin Creek at Sinton, Texas, from January 1970 to September 1974 (U. S. Geol. Survey, 1970b, 1971, 1972, 1973, 1974).

recognizable source of chloride ion is abandoned salt-water evaporation pits that lie in the Chiltipin Creek drainage basin. Although the use of evaporation pits to dispose of salt water has been disallowed by the Texas Water Quality Board since January 1, 1969, water pollution has continued for 6 years since the pits were abandoned.

Other incidences of pollution of shallow ground water and streams from salt-water evaporation pits have been observed in Matagorda County (Hammond, 1969) and in the Hamlin, Texas, area (William Trippet, personal communication, 1975). The impervious material lining these pits did not prevent percolation of large volumes of salt water into the substrate.

Disposal Areas

The Gulf of Mexico, coastal bays, estuaries, or lagoons, and saline aquifers are potential sites for disposal of hot saline water. The major environmental concerns in these areas are the effects of temperature and salinity of produced waters on surface water bodies. The salinity of the geothermal waters will probably approach that of normal seawater, although it is possible that salinity will be substantially less.

Coastal Bays, Estuaries, and the Gulf of Mexico

The salinity of produced geothermal waters does not preclude their disposal into marine waters of the Gulf of Mexico or into certain coastal waters. Coastal waters are characterized by highly variable salinities, ranging from fresh water to hypersaline (Parker, 1960; Brown and others, in press a, b; McGowen and others, in press). The presence of oyster reefs throughout most of the coastal bays and lagoons suggests that they are normally brackish. If saline fluids were adequately mixed in coastal water, they would have little effect on the overall salinity of the bays, lagoons, or estuaries because of the vastly greater volume of bay, lagoon, or estuarine water. Furthermore, periodic freshening of bays and estuaries by flood waters would not be significantly diminished by geothermal fluid disposal.

The temperature of geothermal waters will probably be in excess of 95°C (200°F) when discharged from the generating facility. These waters will require extensive cooling if they are to be disposed of into coastal waters or the Gulf of Mexico. If geothermal waters are cooled to temperatures such that the maximum temperatures and temperature differentials attributable to the heated effluent remain within the regulatory guidelines, then environmental impact will be minimized. South Texas river, bay, estuarine, and Gulf waters are characteristically warm during the summer months. Surface water temperatures can reach 43°C (111°F) in Laguna Madre and 35°C (95°F) in bays, lagoons, and estuaries (Parker, 1960). Natural temperatures of these waters equal or exceed the maximum ambient temperatures suggested by the National Technical Advisory Committee for water quality standards 32°C (90°F) and by the Texas Water Quality Board for tidal river reaches, bay, and Gulf waters 35°C (95°F). High ambient air temperatures such as in the Corpus Christi fairway which has a mean maximum July air temperature of 34.5°C (94°F) (Dallas Morning News, 1974) will increase the difficulty of cooling saline geothermal waters during summer months. High ambient temperatures for coastal waters, at times already in excess of maximum temperatures suggested by regulatory agencies, will make it difficult, if not impossible, to dispose of hot saline fluids into coastal waters unless they have been cooled to 35°C (95°F) or less.

Saline Aquifers

The Texas Railroad Commission permits well operators to dispose of saline water by injection into formations that contain mineralized water unfit for agricultural or general use and that do not contain oil, gas, or geothermal resources. Injection of spent geothermal fluids into saline aquifers is in theory the ideal method of salt-water disposal. This method limits environmental hazards to the immediate areas of the geothermal wells, injection wells, and generating facility. As long as the geothermal fluids are adequately contained and insulated, hazards to plant and animal life would be minimal.

In the Coastal Zone the depth to the base of fresh (less than 1,000 ppm TDS) to slightly saline (less than 3,000 ppm TDS) ground water zone is relatively shallow (figs. 9, 10, and 11), so that the depth of injection wells need not be great. The geometry and occurrence of sand bodies suitable for disposal of large volumes of spent geothermal fluids in the shallow subsurface of the Texas Coast, however, is at best incompletely known. Furthermore, essentially no data is available with which to evaluate the hydrologic characteristics of shallow salt-water aquifers as disposal sites for geothermal waters.

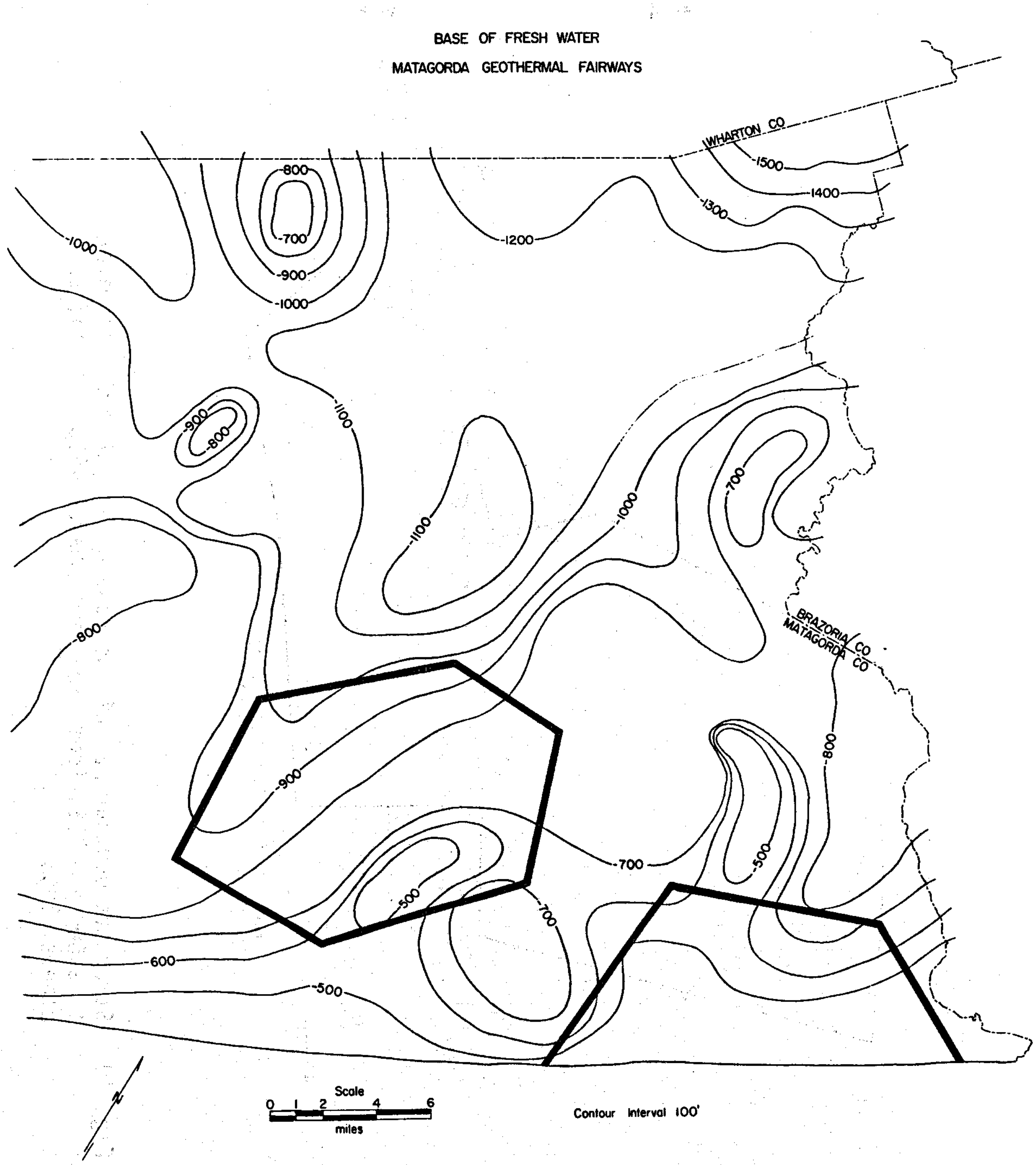


Fig. 9. Structure contour map of the base of fresh water (< 1,000 ppm TDS) (compiled from Hammond, 1969).

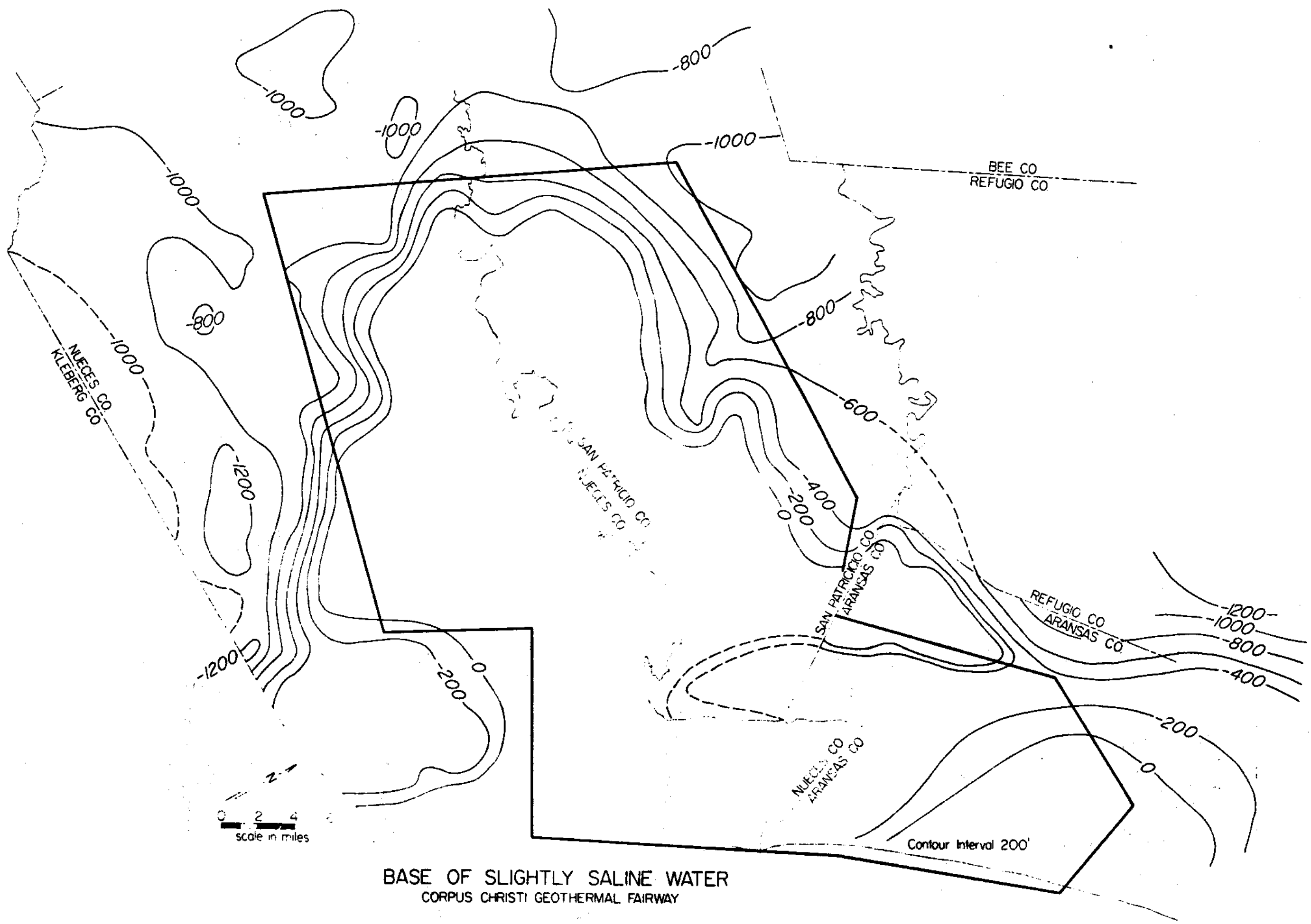


Fig. 10. Structure contour map of the base of slightly saline water (< 3,000 ppm TDS) (compiled from Shafer, 1968 and Wood and others, 1963).

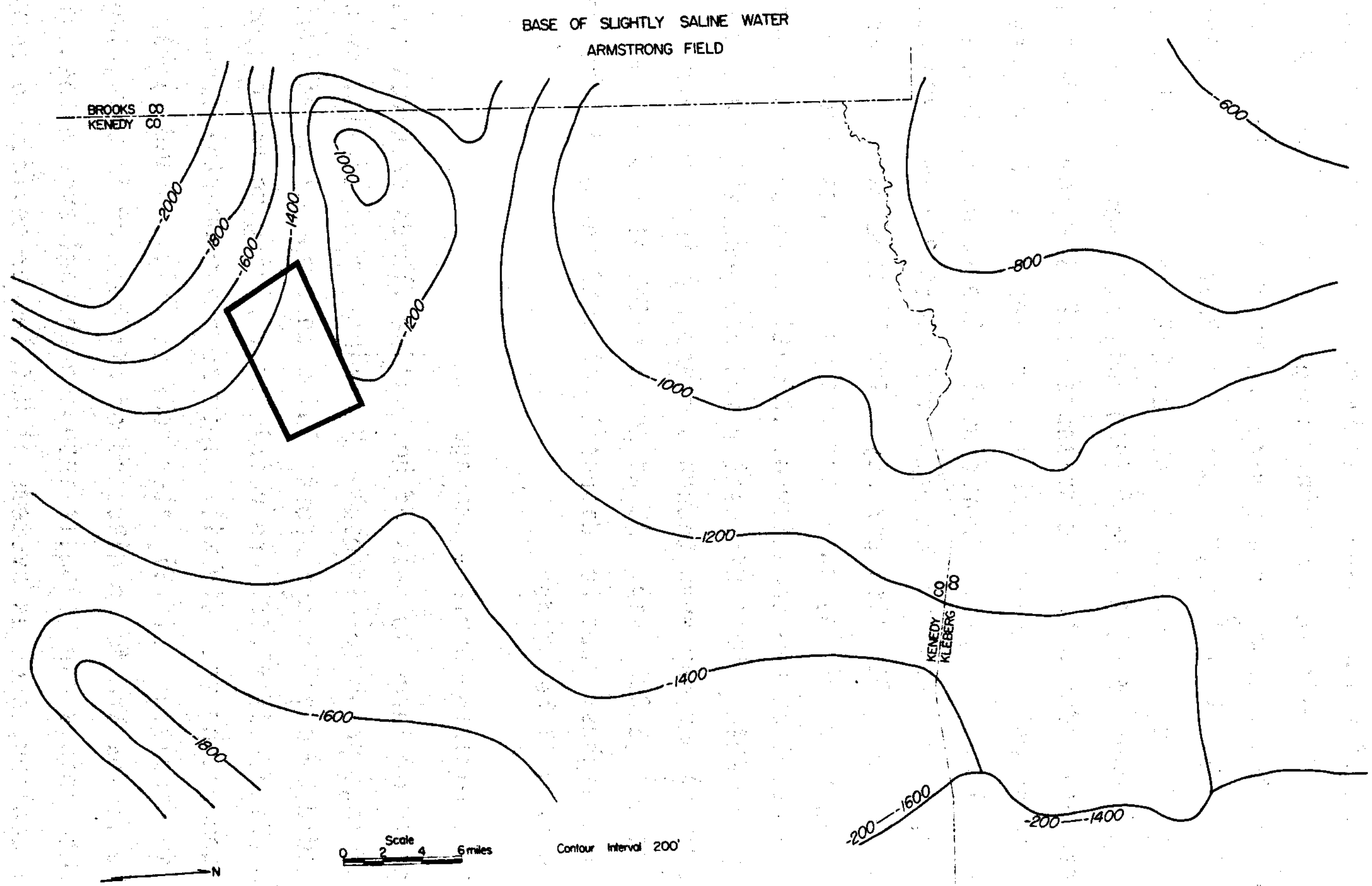


Fig. 11. Structure contour map of the base of slightly saline water (< 3,000 ppm TDS) (compiled from Wood and others, 1963).

In 1961, 93 percent or approximately 2,381,000 m^3 (15,000,000 bbls) of saline oil-field waters produced in Matagorda County was disposed of by deep subsurface injection wells (Hammond, 1969). This is approximately the projected monthly production for a single geothermal electrical generating site. Injection zones for 43 wells in the county ranged from 451.2 m to 2165.3 m (1,480 to 7,102 ft) below land surface with injection pressures ranging from 0 (gravity flow) to 70.4 kg/cm^2 (1,000 psi). Of these 43 wells, only two have high rates of disposal: one at a rate of 952.4 m^3 (6,000 bbls) per day under a surface pressure of 56.3 kg/cm^2 (800 psi) and another at 1,587.3 m^3 (10,000 bbls) per day under a surface pressure of 21.1 kg/cm^2 (300 psi). Many of the injection wells require high surface pressures to dispose of relatively small volumes of water. For example, the #1 J. B. Beld injection well (Hammond, 1969) requires surface pressures of 56.3 kg/m^3 (800 psi) to dispose of only 23.8 m^3 (150 bbls) per day. The limited data that are available regarding rates of injection and the surface pressures required for injection suggest that the capacity of formations to take up disposed fluids is highly variable. Most disposal rates are generally less than 158.7 m^3 (1,000 bbls) per day even though surface pumping pressures range upward to 70.4 kg/cm^2 (1,000 psi). At disposal rates of 1,587.3 m^3 (10,000 bbls) per day, the highest reported disposal rate, 20 to 40 disposal wells per generating site will be needed.

Fluid Transport Mechanisms--Surface Storage

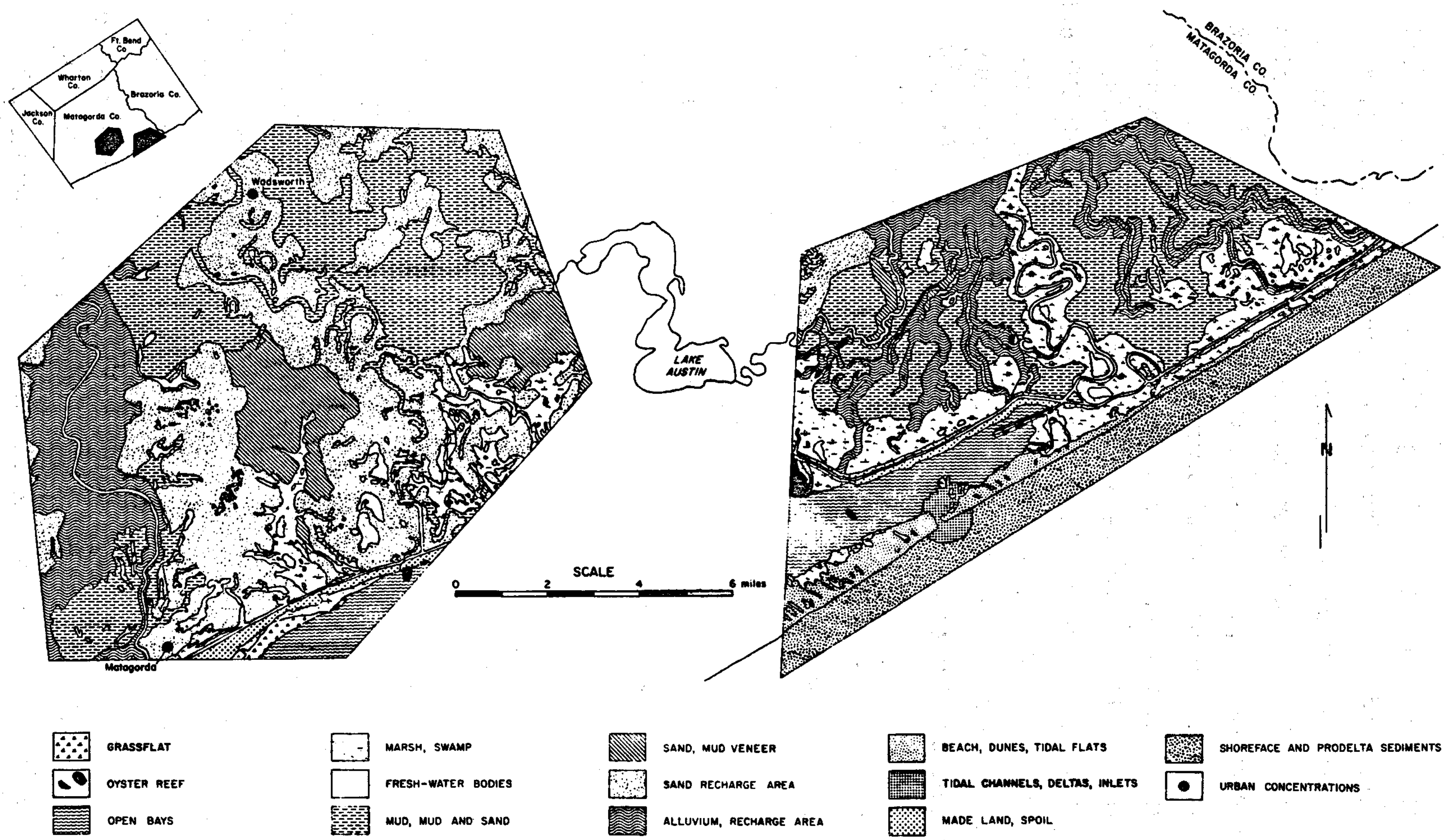
The production of large volumes of hot saline fluids requires transportation and storage prior to disposal. Pipelines, open canals, or natural water courses could be used to transport fluids to disposal sites (Railroad Commission Rule 8C1c). If fluids are reinjected, piping to the disposal wells from the generating facility will minimize environmental impact.

Transport in canals or natural water courses (figs. 5 and 7) may be desirable if the fluids are to be disposed of offshore or in bays, lagoons, or estuaries. Mechanisms can be built into the channel system that will enhance natural cooling, such as systems of baffles or devices to increase turbulence and mixing. Open channel flow, however, increases markedly the possibility of environmental problems. Channels, whether they are canals or natural water courses, will have to be lined and sealed with impervious material to prevent leakage of saline water into the surface sands and alluvium that are recharge areas for shallow aquifers (figs. 12, 13, and 14). For the same reason, temporary storage pits and pits to retain accidental spills in the production and generating areas must also be lined and sealed with impervious material. The effectiveness of seals used in the past is questionable. Ground water, apparently contaminated by salts derived from old evaporation pits, is still draining into Chiltipin Creek 6 years after salt-water evaporation pits were abondoned.

Additional problems that will arise from the use of an open channel to transport geothermal fluids are the effects on wildlife and plants. Plant and animal life that cannot tolerate salt water will probably die off in the immediate vicinity of channels. They could be replaced by salt-tolerant species, perhaps some of the same species that presently occur along tidal channels or marshes of the Texas Coast. Because of the high temperature of the fluids, water courses transporting geothermal fluids would probably contain neither plant nor animal life, with the possible exception of salt- and temperature-tolerant algae. The channels will be relatively narrow, but they will form an effective barrier to wildlife. Wildlife, especially smaller species, will probably not attempt to cross through the hot water carried in the open channels. If geothermal fluids are put into natural streams they will be diluted, but their environmental impact may not be diminished.

Regulations Governing the Production and Disposal of Saline and/or Geothermal Fluids

Several state and federal agencies including the Railroad Commission of Texas, the Texas Water Quality Board, the Texas Air Control Board, the Texas Water Development Board, and the Environmental Protection Agency, have regulatory responsibilities that will directly or indirectly influence development of both a geothermal test well and, subsequently, a geothermal energy production/generation facility. Only those regulations that affect the production and disposal of saline water will be considered here. The Texas Air Quality Board is charged under the amended Texas Clean Air Act of 1967 with safeguarding the "air resources of the state from pollution by controlling or abating air pollution and emissions of contaminants..." (Texas Legislature, 1967). At this time, it is not known if geothermal fluids will contain any potential air pollutants.



ENVIRONMENTAL MAP, MATAGORDA GEOTHERMAL FAIRWAYS

Fig. 12. Map of environmental biologic, geologic, and process units (compiled from McGowen and others, in press).

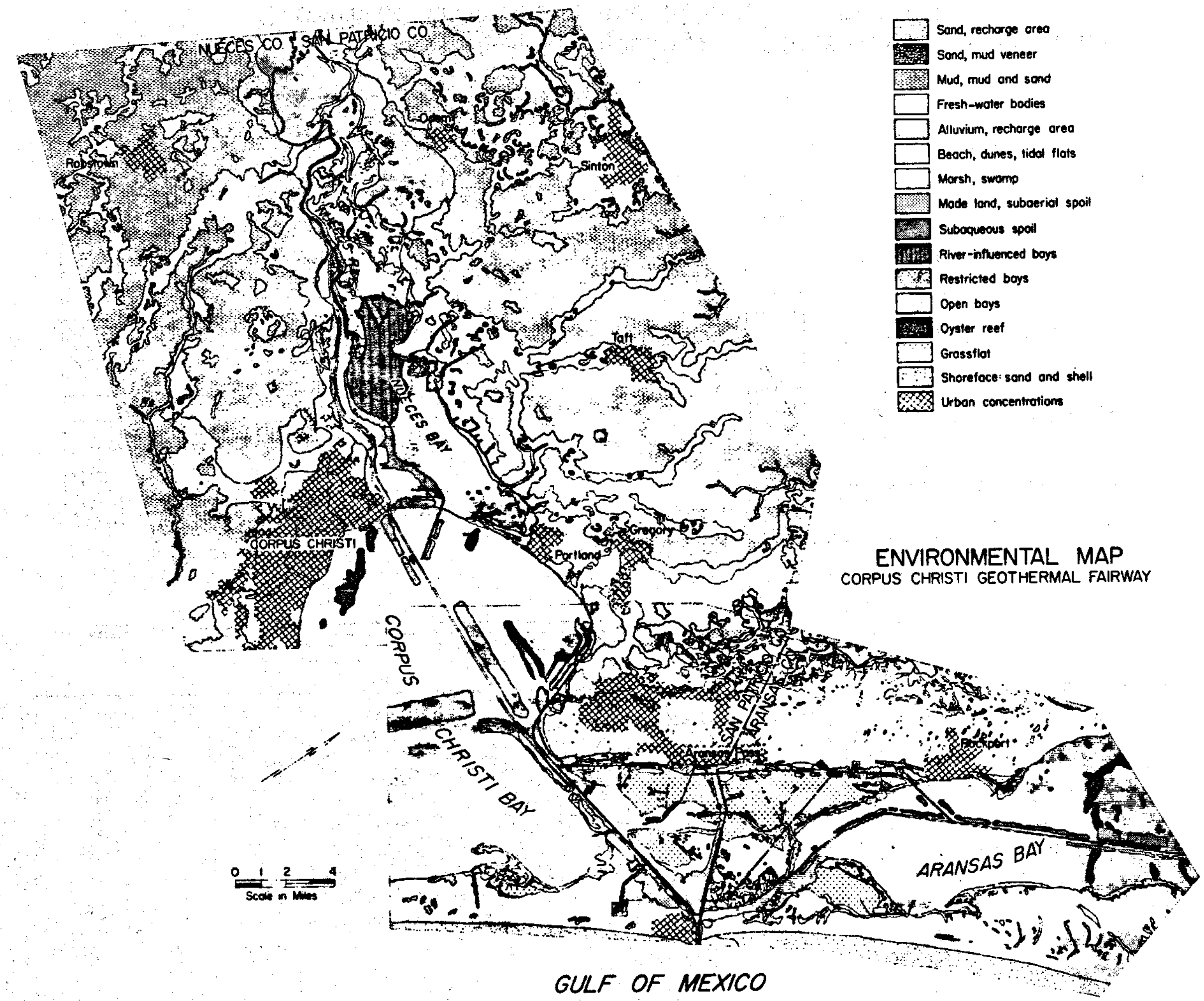


Fig. 13. Map of environmental biologic, geologic, and process units (compiled from Kier and others, 1974).

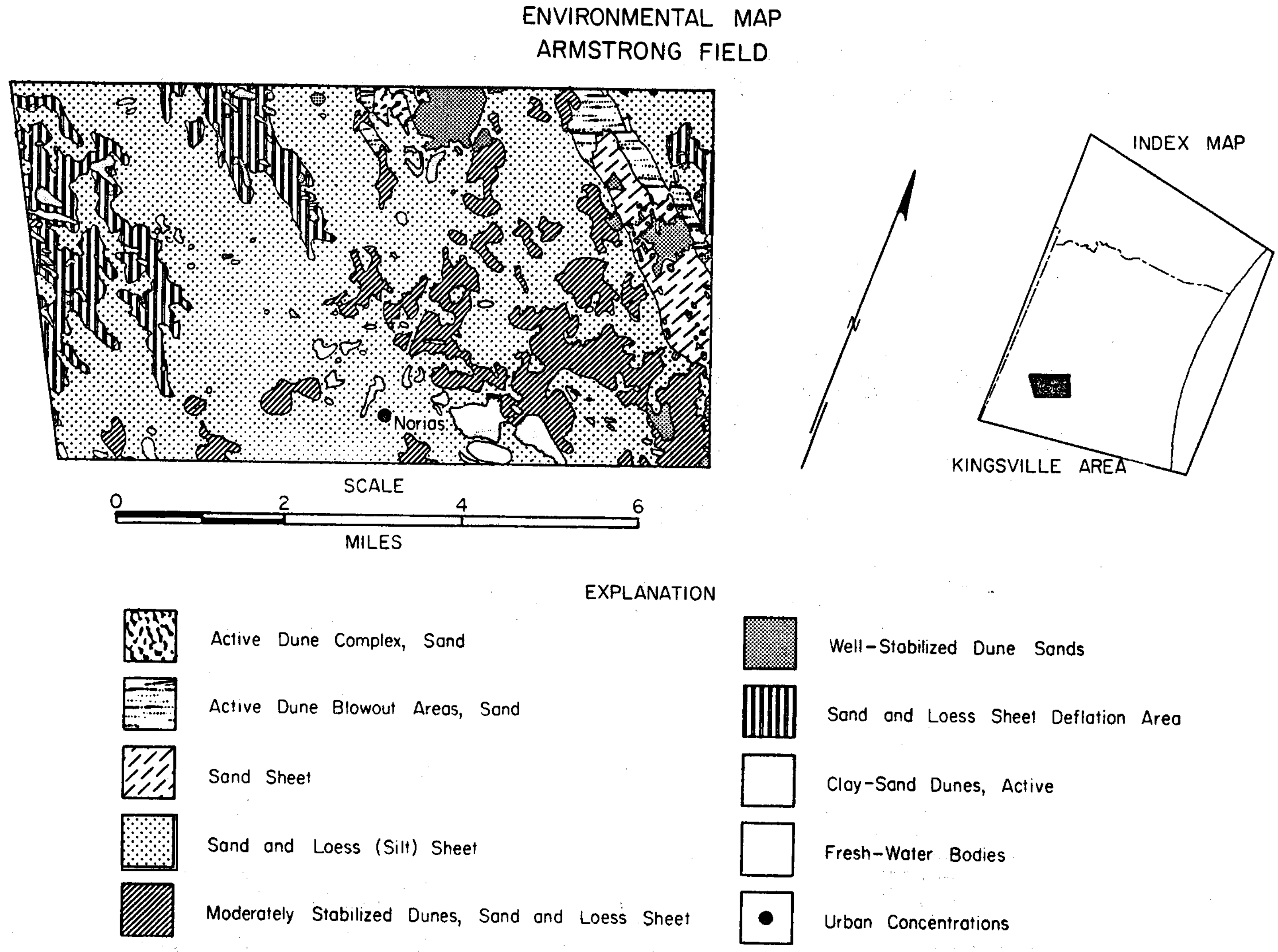


Fig. 14. Map of environmental geologic and geologic process units (compiled from Brown and others, in press b).

The primary environmental concern of the Texas Railroad Commission and the Texas Water Quality Board with respect to geothermal development is the impact of the disposal of hot saline geothermal fluids. The Railroad Commission of Texas (1975) will regulate the drilling and operation of geothermal resource wells and the disposal of fluids from geothermal resource wells. Under Rule 8(A), "Fresh water, whether above or below the surface, shall be protected from pollution . . . ."

(B) The operation of each ". . . geothermal resource well or well drilled for exploratory purposes . . . shall be carried on so that no pollution of any stream or water course of this state, or any subsurface waters, will occur as the result of the escape or release or injection of geothermal resource or other mineralized waters from any well."

(C) (1) All operators conducting ". . . geothermal resources development and production are prohibited from using salt water disposal pits for storage and evaporation of . . . geothermal resource waters . . . ."

(C) (1) (b) "Impervious collecting pits may be approved for use in conjunction with approved salt water disposal operations . . . ."

(c) "Discharge of . . . geothermal resource waters into a surface drainage water course, whether it be a dry creek, a flowing creek, or a river, except when permitted by the Commission is not an acceptable disposal operation and is prohibited."

(D) (1) "The (well) operator shall not pollute the waters of the Texas offshore and adjacent estuarine zones (salt water bearing bays, inlets, and estuaries) or damage the aquatic life therein."

(2) ". . . geothermal resource well drilling and producing operations shall be conducted in such a manner to preclude the pollution of the waters of the Texas offshore and adjacent estuarine zones."

(a) "The disposal of liquid waste material into the Texas offshore and adjacent estuarine zones shall be limited to salt water and other materials which have been treated, when necessary, for the removal of constituents which may be harmful to aquatic life or injurious to life or property."

The Texas Railroad Commission (1975) also regulates the injection of saline water. Under Rule 9 (A), "Salt water . . . unfit for domestic, stock, irrigation, or other general use may be disposed of . . . by injection into the following formations:

(1) "All non-producing zones of oil, gas or geothermal resources bearing formations that contain water mineralized by processes of nature to such a degree that the water is unfit for domestic, stock, irrigation, or other general uses."

Water quality standards developed by the Texas Water Quality Board were approved by the Environmental Protection Agency in October 1973 and were amended in 1975 (Texas Water Quality Board, 1975). These standards are in compliance with the Federal Water Pollution Control Act Amendments of 1972 (P. L. 92-500, U. S. Congress, 1973). Under these standards, "it is the policy of the state . . . to maintain the quality of water in the state consistent with the public health and enjoyment, the propogation and protection of aquatic life, the operation of existing industries and the economic development of the state . . . ." Furthermore, " . . . no waste discharges may be made which will result in the lowering of the quality of these waters unless and until it has been demonstrated to the Texas Water Quality Board that the change is justifiable as a result of desirable social or economic development (Texas Water Quality Board, p. 1).

The suggested limitation to thermal pollution as outlined in the Texas Water Quality Standards is of interest:

1. 2.75°C (5°F) rise over ambient temperature for fresh-water streams.
2. 1.65°C (3°F) rise over ambient temperature for fresh-water impoundment.
3. 2.2°C (4°F) rise or a maximum temperature of 52.5°C (95°) in fall, spring, and winter, and .85°C (1.5°F) rise or a maximum temperature of 52.5°C (95°F) in summer for tidal reaches of rivers and bay and Gulf waters (Texas Water Quality Board, 1975).

The Texas Water Quality Board recognizes that salinities of estuaries are highly variable and that the dominant factor affecting salinity variations is the weather. Salinity standards are presently incompletely defined but are under study.

The preceding review of the regulations and policies of Texas agencies that apply to the disposal of salt water indicates that:

1. Temporary salt-water collecting or storage pits are permitted.
2. Salt water treated to remove harmful constituents may be released into bays, estuaries, and the Gulf of Mexico.
3. Under certain circumstances, the discharge of salt water into natural water courses is permitted.
4. The reinjection of salt water into saline aquifers is permitted.
5. The lowering of standards for certain water bodies is permitted if sufficient need for economic development can be demonstrated.

POTENTIAL SUBSIDENCE AND FAULT ACTIVATION

Production of geothermal water from geopressured zones in Tertiary Gulf Coast sediments has potential for causing land subsidence and for activating surface faults. Though geothermal fluids are not now being produced from geopressured reservoirs, estimates of potential faulting and land subsidence can be made from simple mathematical models and by drawing analogies with subsidence and faulting attributed to production of oil, gas, and shallow ground water elsewhere in the Gulf Coast.

The environmental impact of geopressured-geothermal production is dependent upon the geographic location of the reservoir as well as the hydraulic and geologic characteristics of the reservoir. Faulting and subsidence in urbanized areas close to sea level will have a more adverse impact than will faulting and subsidence in rural inland areas.

Geopressured Sediments and Reservoir Compaction

Geothermal waters of the Gulf Coast will be produced from sediments of the geopressured zone where pore water pressures are abnormally high in comparison to pore water pressures in other sediments that occur at equal depths. Rapid deposition and burial of sands and muds have prevented complete compaction and dewatering of the sediments. Under normal conditions muds or mudstones undergo a decrease in porosity from greater than 50 percent at deposition to as little as 4 percent following burial, dewatering, and compaction. Porosity decreases logarithmically with depth under normal hydrostatic conditions (fig. 15). Partly compacted and dewatered muds and mudstones may retain porosities as high as 15 to 30 percent at depths in excess of 3,600 meters along the Gulf Coast. (Dickinson, 1953; Rubey and Hubbert, 1959; Bredehoeft and Hanshaw, 1968; Dickey and others, 1968; Chapman, 1972; Rieke and Chilingarian, 1974; Magara, 1975).

The high porosity of geopressured mudstones creates the potential for surface subsidence and fault activation. Production of large quantities of water from geopressured sandstones may permit depressuring of intercalated or surrounding geopressured mudstones and a subsequent decrease in mudstone porosity. If this occurs, the reservoir will undergo some compaction. Some of this compaction may be translated to land subsidence.

The lateral extent of reservoir compaction and land subsidence needs to be considered. Where there are no lateral barriers to a geothermal reservoir, ground-water production may lead to reservoir compaction and subsequent land subsidence over an extensive area. Most geothermal reservoirs, however, will probably be located between major growth faults that may act as lateral permeability barriers. Ground-water production and subsequent pressure declines may be confined to reservoirs within fault blocks. Differential compaction of sediments within a fault block may then cause fault movement and differential subsidence at land surface.

In considering the environmental impact of land subsidence and fault activation from geothermal production, four questions need to be addressed: (1) How much compaction of the reservoir will occur; (2) How much of the reservoir compaction will be translated to the land surface in the form of land subsidence; (3) What is the potential for fault activation; and (4) What will be the impact on present and future land use of the area being affected.

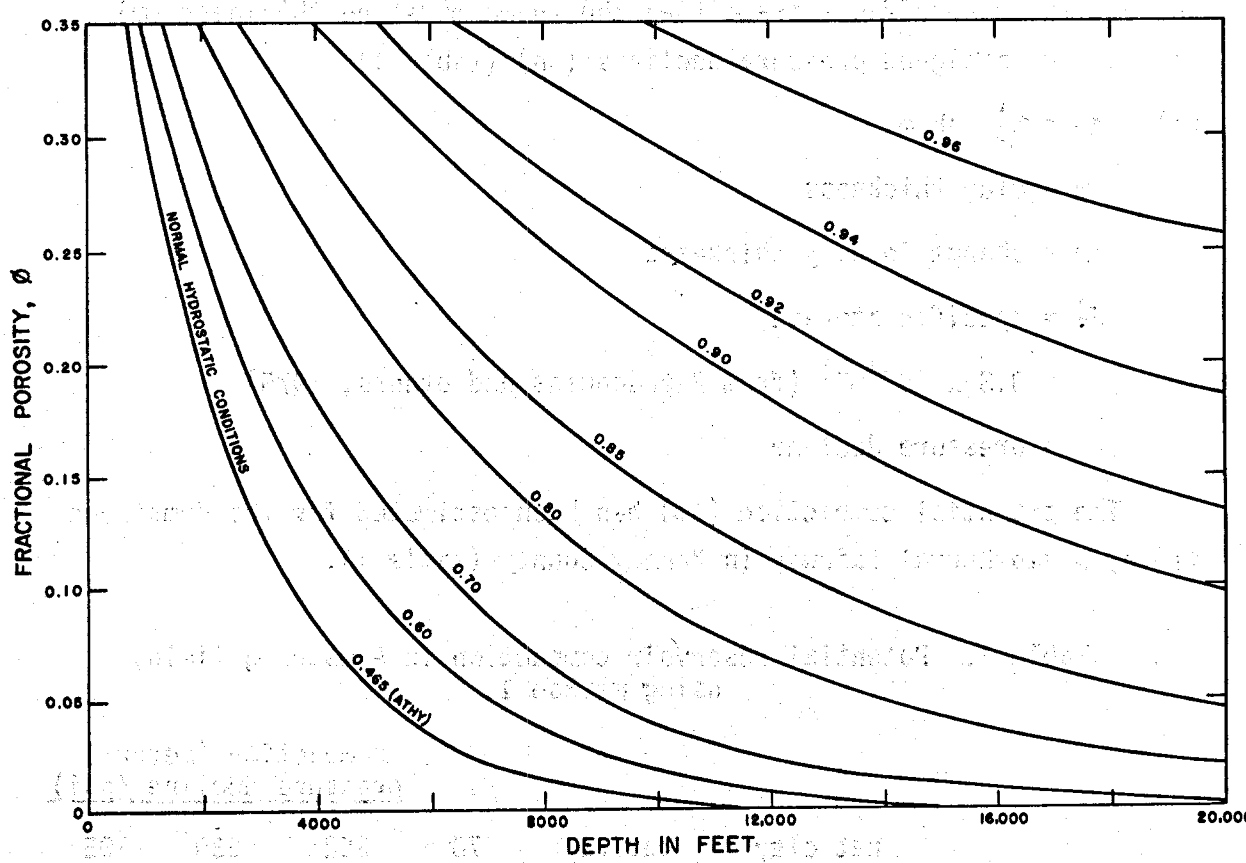


Fig. 15. Relationship between porosity and depth of burial for various values of λ (fluid pressure/overburden pressure ratio) for an average shale or mudstone. Athy's curve (λ = 0.465) is assumed to represent "compaction equilibrium" condition. (After Rubey and Hubbert, 1959, fig. 4, p. 178. Courtesy of the Geological Society of America Bulletin.).

Potential For Reservoir Compaction

Potential for reservoir compaction has been evaluated using two different approaches. The first method estimates the probable compaction of reservoir mudstones (Δm) using equation (1) (modified from Domenico, 1972, p. 234). For the potential geothermal reservoir in the Armstrong field probable mudstone compactions are calculated as the products of the estimated specific storage (S_s') the known mudstone thickness (m) and various assigned pressure declines (Δh) (table 1).

(1) $\Delta m = S_s' \; \Delta h \; m$

m = clay thickness

Δm = change in clay thickness

S_s' = specific storage

= $3.3 \times 10^{-4} m^{-1}$ (from Papadopulos and others, 1975)

Δh = pressure decline

The potential compaction (Δm) has been estimated for the Armstrong field, a geothermal fairway in Kenedy County (table 1).

Table 1. Potential reservoir compaction in Armstrong field, using method 1.

Well No.	net clay (m)	meters / psi	70 / 100	352 / 500	530 / 908	705 / 1000
			compaction (meters) pressure decline (psi)			
Armstrong 5	70		1.6	8.1	14.7	16.0
Armstrong 7	113		2.6	13.0	23.9	26.0
Armstrong 22	146		3.4	17.0	30.8	34.0

The specific storage was assumed to be $3.3 \times 10^{-4} m^{-1}$ (from Papadopulos and others, 1975). Compaction values are also based on the assumption that pore pressures in the mudstone will reach equilibrium with the sandstones; diffusivity, therefore, has not been considered. Similarly, compressibility of water and the producing sandstones has been ignored.

The net thickness of mudstone in tables 1, 2, 3, and 4 is from the area of maximum sand in the Armstrong reservoir. Maximum reservoir thickness is 370 m. Pressure losses have been varied from 70 meters of hydraulic head (100 psi) to 704 meters of hydraulic head (1,000 psi). Papadopulos (1975) predicted an average pressure loss of 640 meters for a hypothetical geothermal field that has had 20 years of production. From table 1, 1.6 to 31 meters of compaction might be expected from these pore pressure losses. With greater pressure declines and increased thickness of mudstone, there will be an increase in reservoir compaction.

The second approach in estimating potential compaction of geopressured mudstone is to multiply the thickness of mudstone in a reservoir by the long-term decrease in porosity caused by a decline of pore pressures (equation 2).

(2) $\Delta m = \Delta\phi\ m$

m = clay thickness

Δm = change in clay thickness

$\Delta\phi$ = change in porosity

At depths greater than 3,600 meters (12,000 ft.) within the Armstrong field, the fluid pressure/overburden pressure ratio (λ) is 0.85. For pressure reductions of 100 psi (70 m), 500 psi (352 m), and 1000 psi (705 m), λ would be reduced to 0.84, 0.83 and 0.77, respectively. From Figure 15, porosities would be reduced from 13 to 12 percent ($\Delta\phi$ = 1%), from 13 to 11 percent ($\Delta\phi$ = 2%), and from 13 to 8 percent ($\Delta\phi$ = 5%), respectively. Using these porosity decreases, the mudstone thickness for the Armstrong wells and equation 2, the calculated vertical compaction for the mudstone in the Armstrong reservoir varies from 0.7 to 7 m. (table 2).

Table 2. Potential reservoir compaction in Armstrong field, using method 2.

Well No.	net clay (m)	porosity change (%) / pressure decline (psi)	compaction (m) 1 / 100	2 / 500	5 / 1000
Armstrong 5	70		.7	1.4	3.5
Armstrong 7	113		1.1	2.2	5.7
Armstrong 22	146		1.5	3.0	7.3

Geothermal ground-water production will probably cause mudstone compaction within geopressured reservoirs. Approaches 1 and 2 predict significantly different amounts of compaction because of differences in the initial assumptions used in the calculations. Papadopulos (1975) estimated the compaction of a geopressured reservoir to be approximately 1 meter by determining sandstone compressibility and mudstone compaction. Mudstone compaction was based on Hantush's (1960) leaky aquifer theory. This provides a third, different estimate of reservoir compaction. A more accurate estimate for reservoir compaction will be known only when mudstone compressibilities can be determined experimentally with actual core material from a geopressured-geothermal reservoir. The different approaches, however, suggest that some mudstone compaction should be expected when pore pressures are lowered significantly within the reservoir.

Potential For Surface Subsidence

The methods for estimating potential reservoir compaction are not directly applicable for estimating land subsidence because the translation of compactional strain at depth to land subsidence has not been considered. The resultant strain from reservoir compaction may be partially absorbed by overlying sediments. Geertsma (1973) and Finol and Farouq Ali (1975) have shown that for equal amounts of reservoir compaction, land subsidence will diminish as reservoir depths increase and as lateral dimensions of the reservoir decrease. Geothermal reservoirs, though they are deep, are expected to have extensive lateral dimensions. The potential for land subsidence, therefore, needs to be considered.

Geertsma (1966, 1973) quantified the interaction of an isolated shrinking inclusion, the reservoir, and the overlying sediments. With Geertsma's (1966) theory of poroelasticity and Geertsma's (1973) tables, approximate values for land subsidence as a result of reservoir compaction can be calculated (tables 3, 4). For the Armstrong field, assumed

Table 3. Potential land subsidence over Armstrong field, using method 1 (table 1).

			subsidence (m) pressure decline			
Well No.	net clay (m)	meters psi	70 100	352 500	640 908	705 1000
Armstrong 5	70		.6	3.0	5.4	5.9
Armstrong 7	113		1.0	4.8	8.8	9.6
Armstrong 22	146		1.3	6.3	11.4	12.6

Table 4. Potential land subsidence over Armstrong field, using method 2 (table 2).

			subsidence (m) pressure decline		
Well No.	net clay (m)	meters psi	70 100	352 500	705 1000
Armstrong 5	70		0.3	0.5	1.3
Armstrong 7	113		0.4	0.8	2.1
Armstrong 22	146		0.6	1.1	2.7

to be a disk-shaped reservoir with a radius of 4.8 kilometers, approximately 37 percent of the compaction at the center of the reservoir could be translated into subsidence. The potential land subsidence (tables 3,

4) can be evaluated by multiplying the reservoir compaction (approaches 1 and 2) by this translation percentage. Land subsidence could vary from 0.3 m. to over 10 m.

One location where surface subsidence has been associated with oil and gas production from geopressured sediments is the Chocolate Bayou field on the Gulf Coast (fig. 16). There has been over 30 cm of subsidence in the Chocolate Bayou oil and gas field, where production is from relatively deep formations (-2,438 to -3,962 m). Oil production has been from normally pressured horizons, whereas gas production has been from the geopressured zone. Periods of maximum rates of annual subsidence do not coincide with periods of maximum oil production but rather with periods of maximum gas production from geopressured horizons (fig. 17). If subsidence is due to oil production, then there is a lag period during which strain is transmitted from the producing horizon (-2,438 to -3,962 m) to the surface. On the other hand, subsidence over the Wilmington oil field in California occurred concomitantly with oil production with no apparent lag period (Mayuga and Allen, 1969). Sediment compaction from gas production from the geopressured horizons appears to be a more logical cause of the land subsidence. Land subsidence over the Chocolate Bayou oil and gas reservoir further suggests that subsidence can be expected from geopressured-geothermal ground-water production.

Potential For Fault Activation

Tertiary and Quaternary sediments of the Gulf Coast are extensively faulted. Extensive ground-water production from geothermal reservoirs may activate the growth faults that intersect the geothermal horizons.

Subsurface faults do not die out in the upper Cenozoic sediments but in many cases extend to the land surface. Their natural rate of movement, however, is so slow that their surficial expression is evident only through subtle geomorphic features such as lineations and rectilinear stream drainage networks (Kreitler, in press). Structural control of stream drainage is particularly evident in the Houston-Galveston

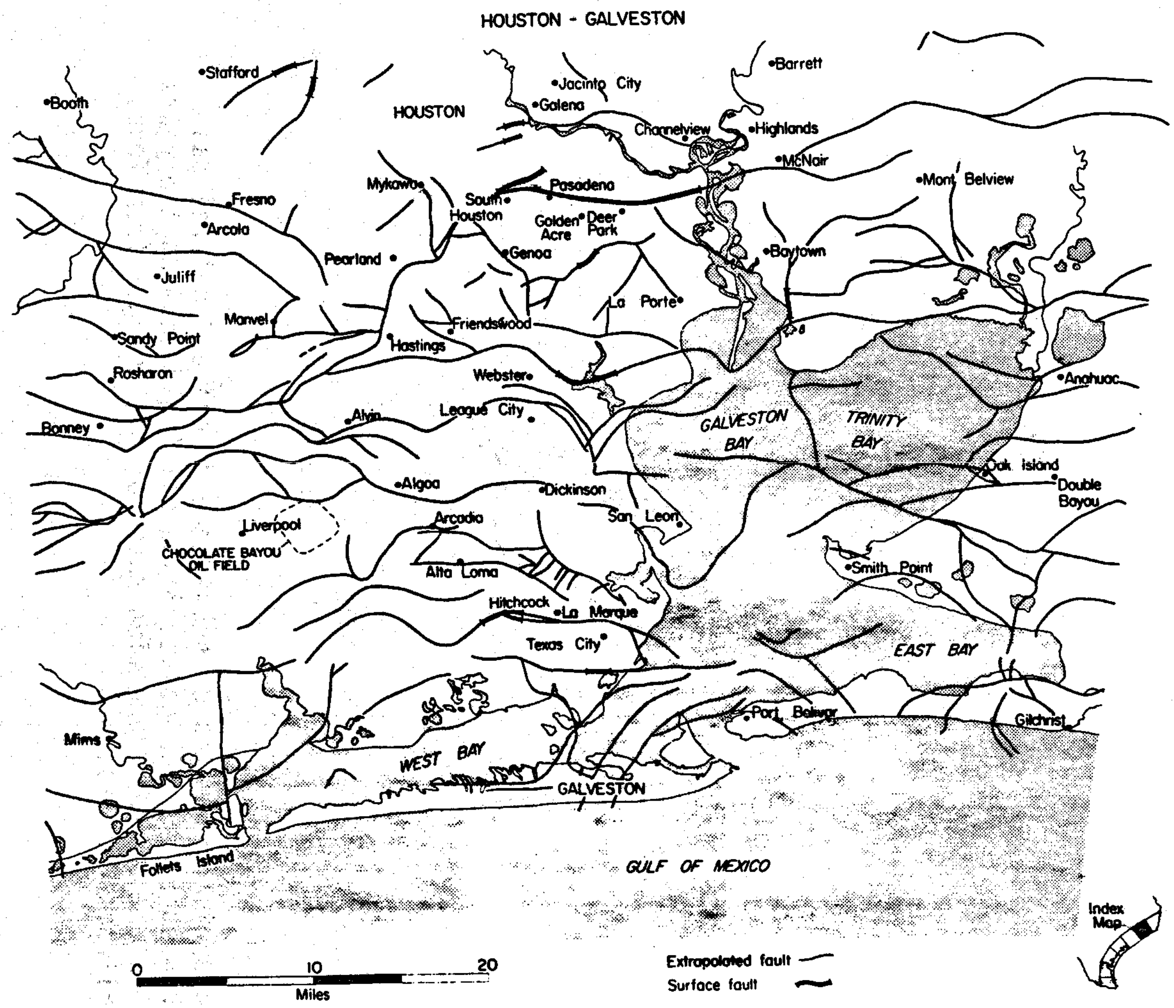


Fig. 16. Coincidence of active surface faults with surface traces of extrapolated subsurface faults, Houston-Galveston area. Note location of Chocolate Bayou oil and gas field.

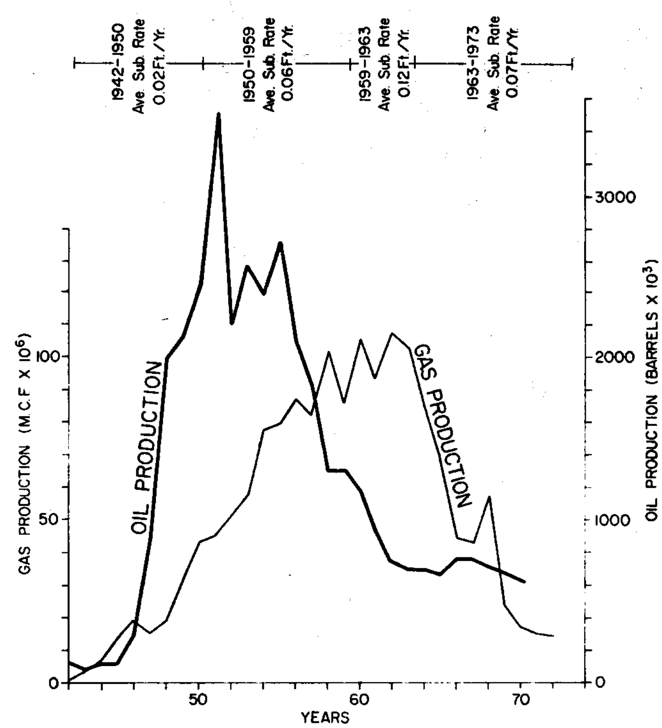


Fig. 17. Comparison of rates of subsidence to oil and natural gas production from Chocolate Bayou oil field between the years 1942 and 1973. Production rates of oil and gas from Texas Railroad Commission.

area. Active faults appear to control sections of Buffalo Bayou, Clear Creek, Highland Bayou, and Cypress Creek.

The Houston area has over 240 kilometers of active faults, making it the most active area for faulting in the Coastal Zone. The surface traces of many faults extrapolated from the subsurface are commonly coincident with active surface faults (fig. 16). Active surface faults, therefore, are not strictly surface or near-surface phenomena but are probably related to subsurface faults occurring in older Gulf Coast sediments. Van Siclen (1967) has documented this relationship in detail for the extension of subsurface faulting in the Addicks oil field to the Addicks fault, an active surface fault. Woodward-Lundgren and Associates (1974) has established through seismic profiling the surface extension of a subsurface fault in the Pasadena, Texas, area. Several fault extrapolations are also coincident with rectilinear stream drainage networks where no apparent fault escarpment exists (e.g., sections of Buffalo Bayou and Cedar Bayou).

Faults appear to act as complete or partial barriers to fluid migration. When production is only on one side of a fault, pore pressure declines and sediment compaction is greater on the producing side of the fault than on the other side. This subsurface differential compaction is manifested at the surface as fault movement or differential subsidence across the surface trace of the fault.

Tilt meters across the Eureka Heights fault and the Long Point fault, in western Houston, show excellent correlation between fault movement and the decline of the piezometric surface (water level) in the shallow artesian Chicot aquifer (fig. 18). As the piezometric surface declines, the downthrown side of the Eureka Heights fault drops but as the piezometric surface rises, there is a slight rebound of the downthrown side.

In the Saxet field west of Corpus Christi, a six-foot scarp has appeared along a segment of the surface extrapolation of a regional growth fault (fig. 19). The active segment of this fault lies almost exclusively within the Saxet oil and gas field; fault movement has occurred since the onset of production, (W. A. Price, personal communication, 1975). Leveling profiles across the Saxet field show rapid

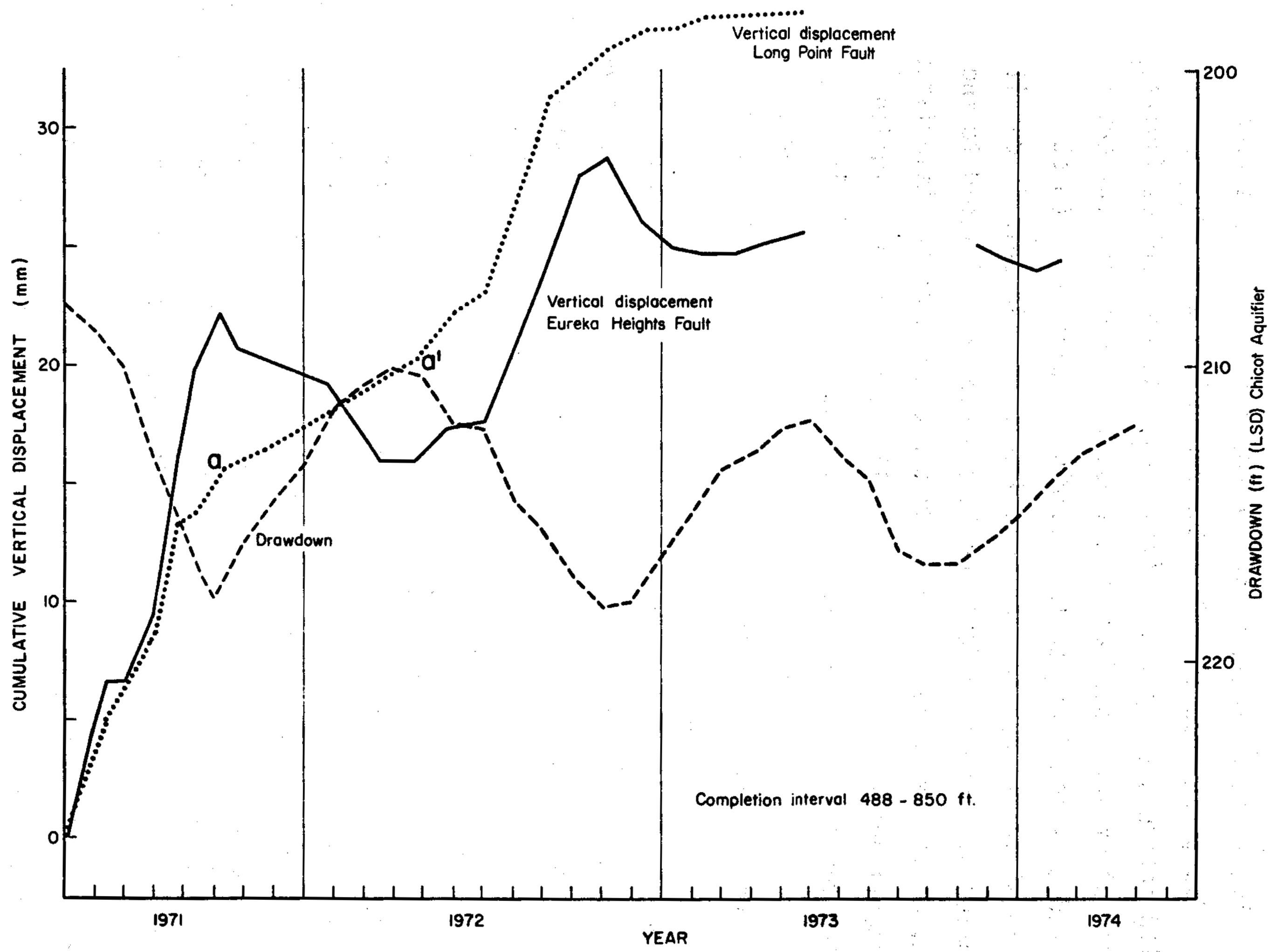


Fig. 18. Cumulative vertical displacement on Long Point and Eureka Heights faults in western part of Houston compared to drawdown of piezometric surface of Chicot aquifer. Displacement data for April 1971 to April 1972 from Reid (1973); displacement data for May 1972 to January 1974 and drawdown data for federal observation well L-J-65-13-408 from R. Gabrysch (personal communication, 1974).

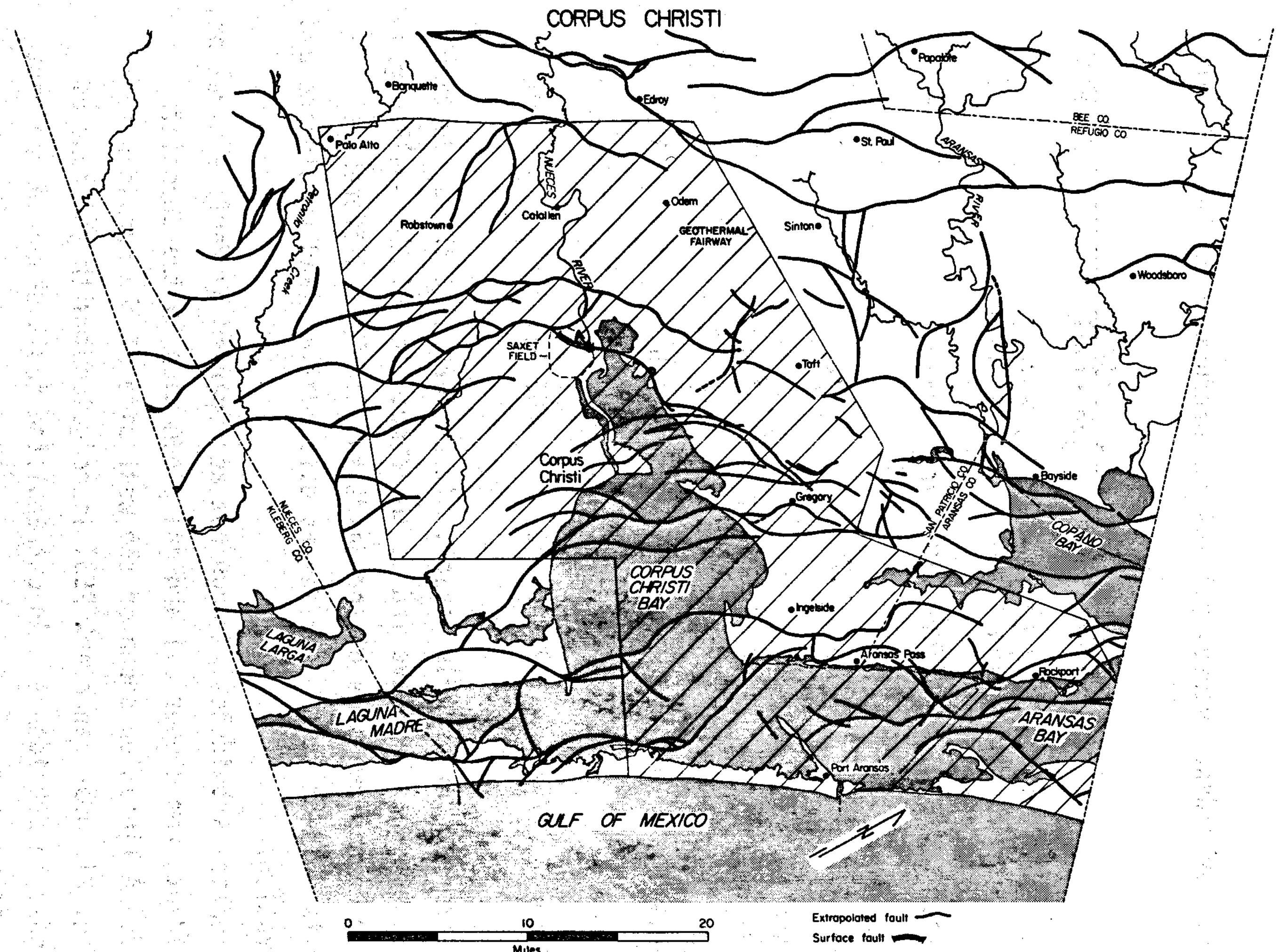


Fig. 19. Location of Corpus Christi geothermal fairway in relationship to surface traces of extrapolated subsurface faults. Note location of active fault in Saxet oil and gas field. Base map from Corpus Christi Sheet, Environmental Atlas Series.

increases in subsidence at the fault (fig. 20). Subsidence rates from 1950 to 1959, 7 cm/yr (.22 ft/yr), are approximately twice the rates from 1942-1950, 4 cm/yr (.14 ft/yr). A rapid increase in gas production from shallow sands occurred from 1950 to 1959 (table 5). Oil production,

Table 5. Subsidence versus oil and gas production in Saxet field.

	Time 1942-1950	1951-1959	1960-1974
Annual subsidence rate	4 cm/yr (.138 ft/yr)	7 cm/yr (.22 ft/yr)	--
Gas production	(MCF x 10^6) yr	--	--
Upper sand (300-900 m.)	7.7	19.1	5.2
Middle sand (900-1,524 m.)	12.8	7.0	3.4
Lower sand (1,524-2,440 m.)	5.3	1.5	3.3
Total	26.1	27.6	11.8
Oil production (bbl/yr)	2,086,672	765,541	576,891

however, decreased during this period. It appears that the production of high-pressured gas may have led to the compaction of the shallow gas sands on the downthrown side of the Saxet fault. This differential compaction is evident at the surface as differential land subsidence and fault activation.

Differential subsidence, though not accompanied by fault activation, is also evident from deeper oil and gas production in the Chocolate Bayou field. A lineation shown on the west side of the subsidence profile (fig. 21, near benchmark P53) is coincident with the zone of rapid increase in subsidence. An extrapolated fault shown on the east side of the field, between benchmarks N691 and M691, is coincident with a sharp increase in subsidence. No obvious escarpment exists at this

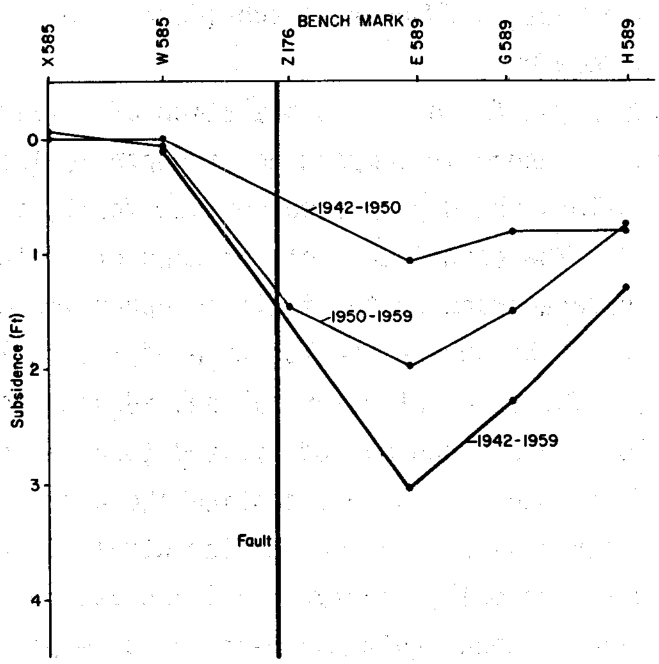


Fig. 20. Land subsidence over Saxet oil and gas field, Corpus Christi, Texas. Benchmark 589 over the center of the field. Note fault control of subsidence (between B. M. W585 and Z176). See fig. 19 for field location.

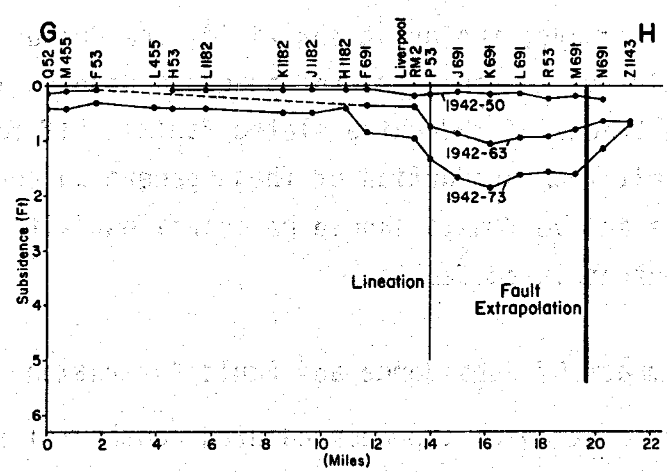


Fig. 21. Land subsidence over Chocolate Bayou oil and gas field. Note coincidence of differential subsidence with lineation and surface trace of extrapolated subsurface fault (see fig. 16 for field location).

locality, but with continued differential subsidence, an active fault would be expected to develop.

In the Chocolate Bayou field, the translation of strain from regions of differential reservoir compaction at depth to the land surface apparently follows the dip of a subsurface fault; it does not occur directly upward. The coincidence of the zone of differential subsidence and the surface trace of the fault is approximately 2.4 km (1.5 miles) northeast of the subsurface location of the fault at depth of 2.4 km (8,000 ft). The areas of potential subsidence resulting from geothermal exploitation, then may be limited to areas bounded by the surface traces of growth faults that confine the geothermal reservoir. If fault activation occurs as a result of differential compaction of geopressured reservoirs, normally pressured oil and gas reservoirs or shallow artesian aquifers, then fault movement can be expected to occur along the surface traces of fault extrapolations.

Fault extrapolations are made from subsurface structure maps using one or two datum surfaces in the Frio Formation. Where two surfaces are available the angle of the fault extrapolation is based on the dip of the faults between these two surfaces. Where only one subsurface datum is available, then the dip of the fault extrapolation is assumed to be 45 degrees. Figures 19, 22, and 23 show the location of four geothermal fairways, the Armstrong field, the Corpus Christi fairway, and two fairways in southeastern Matagorda County, in relationship to the surface traces of the extrapolated faults. If fault activation does result from production of these geopressured-geothermal reservoirs, then the active faults should be coincident with the surface traces of extrapolated faults.

The Environmental Impact Of Subsidence and Fault Activation

The geographic location of the geopressured-geothermal reservoir controls the magnitude of certain aspects of the environmental impact of geothermal energy development. Subsidence and fault activation are not critical problems until they adversely affect the quality of the present

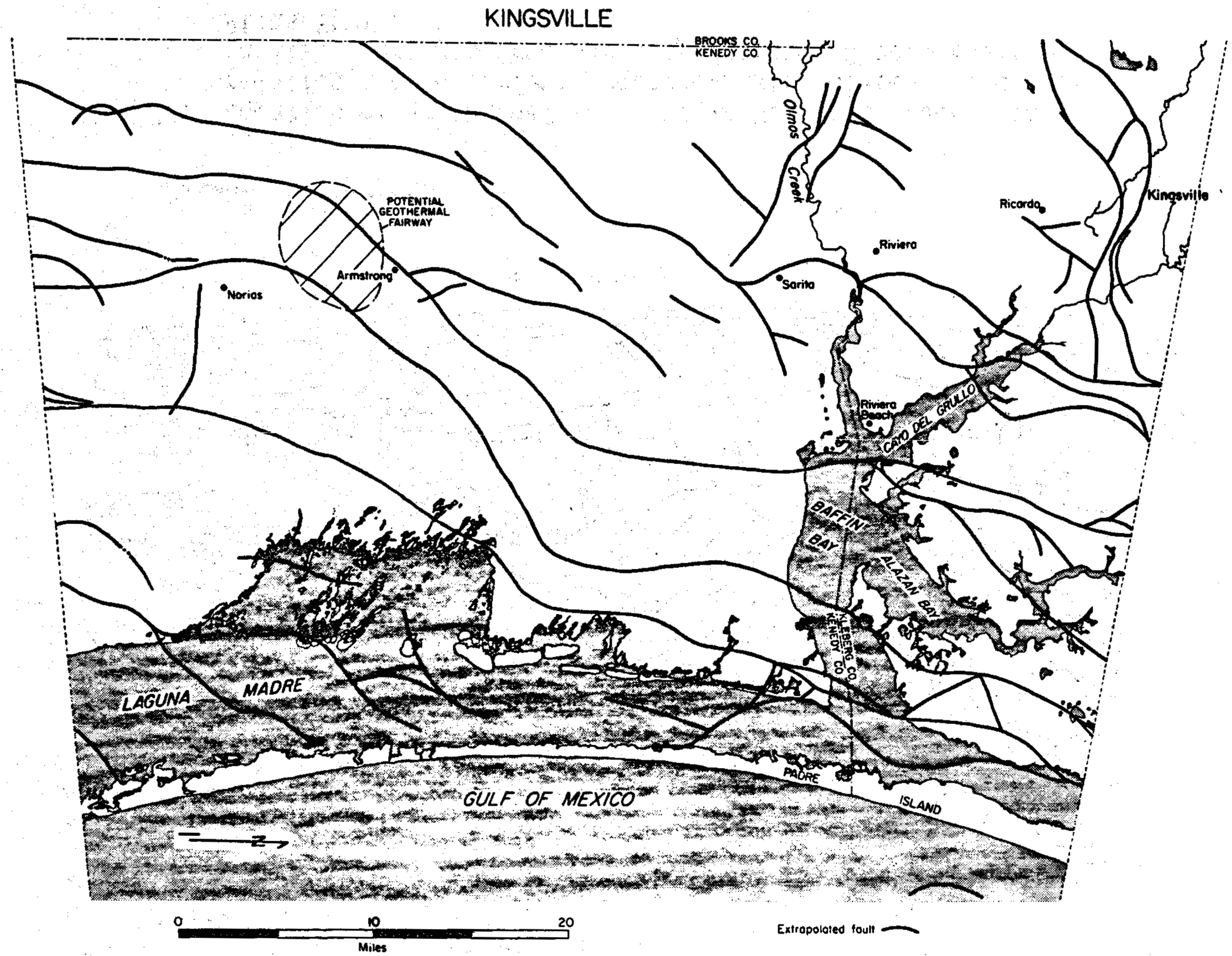


Fig. 22. Location of Armstrong geothermal fairway in relationship to surface traces of extrapolated subsurface faults. Base map from Kingsville Sheet, Environmental Atlas Series.

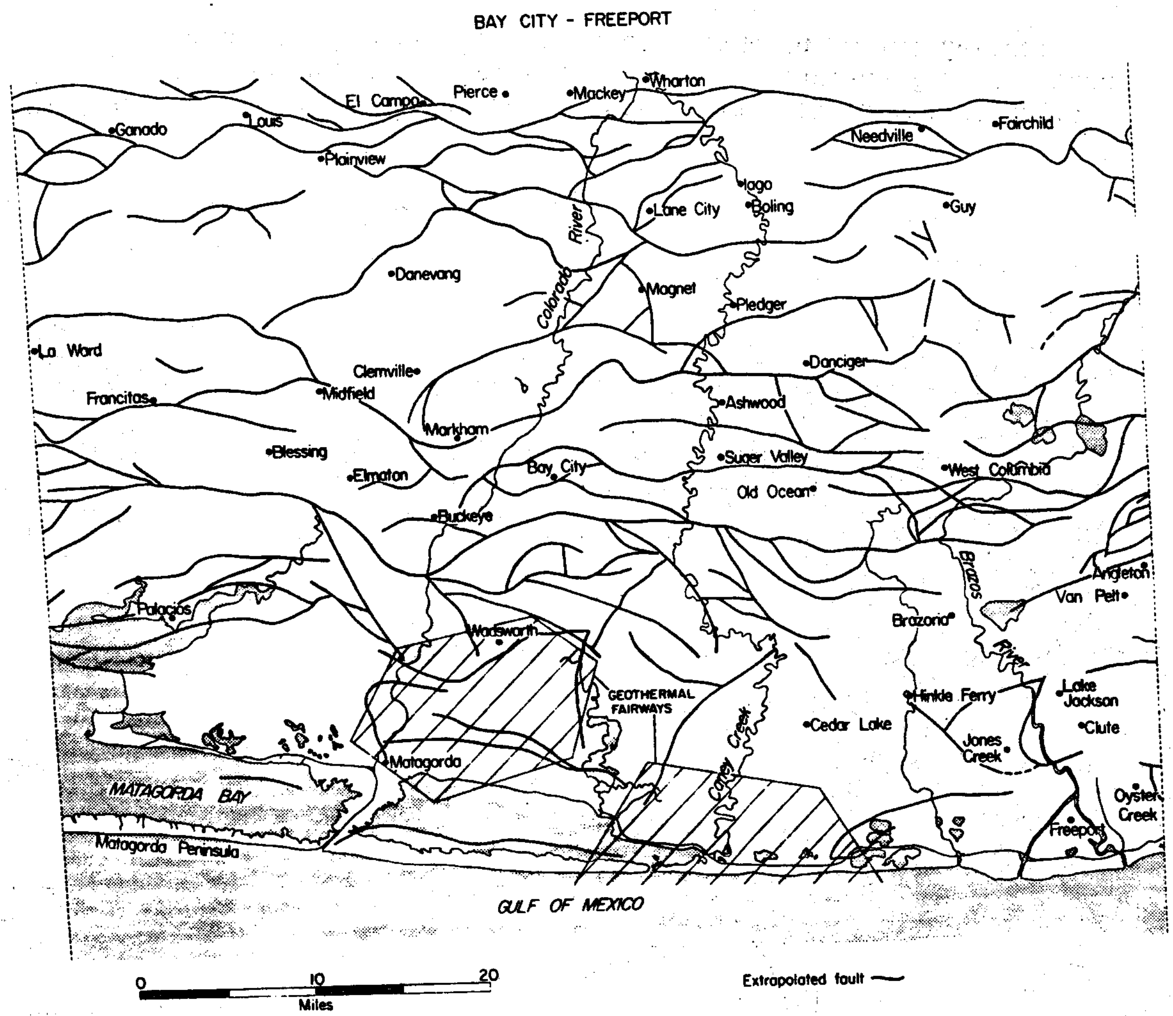


Fig. 23. Location of geothermal fairways in Matagorda County in relationship to surface traces of extrapolated subsurface faults. Base map from Bay City-Freeport Sheet, Environmental Atlas Series.

or future land use of a particular area. This is especially true in Harris and Galveston Counties where fluid production has caused extensive land subsidence and has activated over 240 kilometers (150 miles) of surface faults. These faults intersect two airports, interstate highways at 11 different locations, and railroad tracks at 28 locations and pass through 11 communities where over 200 houses show evidence of fault damage. Land subsidence in Harris and Galveston Counties has greatly increased the area which may be affected by future hurricane flooding. In the Galveston Bay area, the flood surge from Hurricane Carla (1961) inundated 314 square kilometers (123 square miles). With the subsidence that has occurred since Hurricane Carla, an additional 64 square kilometers (25 square miles) of land can be expected to be flooded (an increase in the flooding area of about 20 percent) in the event of a hurricane of the same magnitude and characteristics of Carla. The environmental impact of faulting and subsidence in Harris and Galveston Counties is high because of its population density, low elevation, and proximity to the Gulf of Mexico.

The Armstrong field, the Corpus Christi fairway, and two fairways in Matagorda County are being considered as potential reservoirs (fig. 1). In the event of geothermal fluid production from any of the fairways, it is necessary to assume that a certain amount of subsidence and/or fault activation could occur. Under these circumstances, predictions of the relative intensities of certain environmental effects can be made.

The primary land use for the Armstrong field is unimproved rangeland (Brown and others, in press b). The elevation of the land is approximately 9.1 kilometers (30 feet) and the area is 24 kilometers (15 miles) from the coast. Fault activation in the vicinity of this field could rupture a major gas transmission line. Land subsidence would not increase the area affected by hurricane salt-water flooding. The Armstrong area, however, was inundated by fresh-water flooding during Hurricane Beulah (U. S. Army Corps of Engineers, 1968) and land subsidence would probably increase the depth and extent of fresh-water flooding.

The Corpus Christi geothermal fairway underlies Corpus Christi Bay and the greater Corpus Christi area. Major land uses in the area include agriculture and suburban, urban, and industrial development (Brown and others, in press a). The area includes Corpus Christi Bay and a portion of the Gulf coastline. The elevation for most of downtown Corpus Christi is above 7.6 meters (25 feet); flooding here would probably be minimal. Much of the residential area southeast of Corpus Christi, however, is below 7.6 meters (25 feet) elevation. Subsidence in this area could increase the area affected by hurricane flooding. Similarly, industrial development along Nueces Bay could be affected by land subsidence. Fault activation would probably cause significant structural damage regardless of where it occurred in the greater Corpus Chrisit area. Land subsidence and surface faulting induced by geothermal water production could have a major negative environmental impact on the Corpus Christi area.

Geothermal fairways in Matagorda County in general underlie rangeland and cropland. The fairways are relatively close to the coast; therefore, subsidence could increase the area of potential salt water flooding induced by hurricane surges.

A nuclear power plant (South Texas Project) is to be sited on the edge of one of the two Matagorda fairways. Land subsidence could cause fresh-water flooding problems from the Colorado River at the plant site. Fault activation at the plant site could cause structural damage to the nuclear power plant. Further evaluation of specific areas for a geothermal reservoir in Matagorda County may indicate that the potential field is nowhere near the proposed nuclear power plant site and that the potential for flooding and faulting at the plant site will not be increased. Until that question is resolved the potential impact of subsidence and faulting on the nuclear power plant must be considered.

Of the three geothermal fairways briefly discussed, the potential environmental impact in the Armstrong area would be far less than the potential impact of faulting and flooding in the Corpus Christi and Matagorda County areas.

NATURAL HAZARDS OF THE GEOTHERMAL FAIRWAYS

Several natural hazards exist for the geothermal fairways including shoreline erosion, stream flooding, hurricane flooding and winds, and expansive soils. Hazards and mitigations are discussed in detail by Brown and others (1974) and Gustavson (1975). None of these hazards result from the production of geothermal fluids. They are hazards, however, that have the potential for causing structural damage to geothermal production facilities that could, in turn, result in massive leaks of hot saline fluids. They are considered then as potential ancillary causes of temporary but possibly catastrophic environmental impacts.

The major streams within the fairways are the Nueces and Colorado Rivers. The Colorado River has completely covered its floodplain nine times since 1913, about once every 9 years while the Nueces River has completely covered its floodplain 13 times in the past 56 years or approximately once every 4.25 years (Patterson, 1965; U. S. Geological Survey, 1970a, 1975a). Many of these floods result from the passage of tropical cyclones across the Gulf Coastal Plain. Since 1912, 12 storms with hurricane force winds (119.4 kilometers per hour (74 mph) or greater) have made landfall in the vicinity of the Armstrong field, and the Corpus Christi and Matagorda fairways. Hurricane Carla (1961) brought 241.9 kmh (150 mph) winds to portions of these fairways, and Celia (1970) contianed 282.3 kmh (175 mph) winds when it made landfall in the Corpus Christi area and caused extensive wind damage. Hurricane Beulah (1967) produced 141 tornadoes including 11 within the vicinity of the Corpus Christi fairway (Novlan and Gray, 1974). Fresh water from the heavy rains of Hurricane Beulah flooded much of the Armstrong field area. Storm surge as high as 6.7 m (22 ft) was created when Carla struck Matagorda Bay, causing extensive salt-water flooding. The environmental geologic maps (figs. 12, 13, 14) illustrate those areas that are flood prone--areas of recent alluvium, marsh, swamp, and in the Armstrong field portions of active dune blowout areas, sand sheets, and sand and loess sheets. Hurricane-aftermath flooding resulting from heavy rainfalls is also a serious problem; approximately 76.8 centimeters (30 inches) of rain accompanied Hurricane Beulah.

Coastal erosion is a continuing problem along the Texas Gulf Coast. Approximately 55 percent of the coast, including coastal areas of both the Matagorda and Corpus Christi fairways, is presently undergoing erosion. Erosion rates exceed 3 m (10 ft) per year locally.

Sediments of the Texas Coastal Plain with high clay content develop expansive clay loam soils. The dominant clay mineral of coastal plain sediments is montmorillonite which has the capacity of adsorbing water and expanding when water is available. Conversely, montmorillonite contracts when it dries out. When clays and muds adsorb water and expand they can develop pressures in excess of 142 metric tons per square meter on buried foundation members (Mielenz and King, 1955). This process results in moderate to severe limitations to construction in areas of predominately mud or interbedded mud and sand (figs. 12, 13). Engineering and construction techniques are available for at least partial mitigation of stresses resulting from expansive clay soils (Gustavson, 1975).

SUMMARY

The major environmental problems that could arise from geopressured-geothermal water production will result from the disposal of spent geothermal fluids and from surface subsidence and faulting.

Water from within the geopressured-geothermal zone of the Corpus Christi fairway is moderately to highly saline (8,000-72,000 ppm TDS). Disposal of hot saline geothermal water in subsurface saline aquifers will present the least hazard to the environment. It is not known, however, whether the disposal of as much as 54,000 m^3 (310,000 bbls) of spent fluids per day into saline aquifers at the production site is technically or economically feasible. An alternative method of disposal is to move geothermal fluids from the generating site by open water courses or canals for disposal into coastal bays or the Gulf of Mexico. This method must be considered if saline aquifers adequate for fluid disposal cannot be found. Overland transport of geothermal fluids may cause the following environmental impacts:

1. Salt may accumulate in the sediments underlying geothermal water courses.

2. Shallow ground-water recharge areas may be contaminated by salt water.
3. Non-salt or temperature-tolerant vegetation and animal life adjacent to geothermal-water courses may decline or die.
4. Accidental spills or discharges, or flooding could damage agricultural lands adjacent to salt-water courses.
5. Animal life will not be able to cross hot saline-water courses.
6. The ecological balance of portions of bays or estuaries or the Gulf of Mexico could be upset.
7. Air pollution could occur from toxic gases within the geothermal fluids.

Geothermal resource production facilities on the Gulf Coast of Texas could be subject to a series of natural hazards: (1) hurricane or storm induced flooding, (2) winds from tropical storms, (3) coastal erosion, or (4) expansive soils. None of these hazards is generated by geothermal resource production, but each has potential for damaging geothermal production and disposal facilities that could, in turn, result in leakage of hot saline geothermal fluids.

Production of fluids from geopressured-geothermal reservoirs will result in reservoir pressure declines and subsequently in compaction of sediments within and adjacent to the reservoir. The amount of compaction is dependent on pressure decline, reservoir thickness, and reservoir compressibility. At present, these parameters can only be estimated. Reservoir compaction may be translated in part to surface subsidence. When differential compaction occurs across a fault, fault activation may occur and be manifested as differential subsidence across the surface trace of the fault or as an actual rupture of the land surface.

The magnitude of environmental impact of subsidence and fault activation varies with current land use; the greatest impact would occur in urban areas, whereas relatively minor impacts would occur in rural, undeveloped agricultural areas.

RECOMMENDATIONS

Baseline environmental studies of the test well site, production, generating, and disposal areas and areas of potential subsidence and faulting must be initiated and should be completed prior to initiation of a test well or construction of production/generating facilities. Baseline studies are needed to determine the condition of the environment prior to testing and development. Such studies are necessary for recognition of any environmental changes that may result from the activities of geothermal resource exploration and exploitation. Predictions of the impacts of geothermal resource development on land use may then be made. Certain studies should continue to monitor environmental characteristics throughout the life of the test well or production/generating facility.

Recommended environmental studies should include:

1. Precise large-scale mapping of the affected areas. Detailed mapping is needed to aid in predicting possible effects to aspects of the environment resulting from geothermal resource development. Mapping should include: (1) environmental geologic, (2) climate and air quality, (3) active geologic processes and natural hazards, (4) slope or topographic, (5) biotope, (6) current land use, and (7) materials and soils;
2. Precise leveling surveys of production sites. Leveling surveys should be continued to be made to determine if or at what rate subsidence is occurring;
3. Seismic monitoring surveys of production sites. Seismic surveys should be continued throughout the duration of production to determine if or at what rate or intensity seismic events occur;
4. Strain gauge observations that will indicate instantaneously minute movements (subsidence) of the test or development area;
5. Modification of existing computer models developed by the Texas Water Development Board for water circulation in coastal bays and lagoons to indicate dispersion rates and paths for point sources of both chemical and thermal pollution;
6. Sampling of surface-water courses within the areas of interest on a monthly or semimonthly basis for water chemistry analysis, temperature, suspended material, and discharge. Sampling and

analyses should be continued throughout the duration of production to detect if or to what extent surface water contamination has occurred;

7. Sampling of shallow ground water within the areas of interest on a monthly or semimonthly basis for water chemistry, temperature, and regional ground-water movement. Sampling and analysis should be continued throughout the duration of production to detect if or to what extent ground-water contamination has occurred;
8. Precise three-dimensional mapping of subsurface structural elements from the base of geothermal production horizons to the surface. Predictions of the location, potential for, and degree of surface faulting within production areas can be made using these data;
9. Determination of the coefficients of compressibility for mudstones from presently available cores taken within the geopressured zone and from cores from the geothermal test well or geothermal development wells should be made. Using these data, predictions of reservoir compaction can be made;
10. Ground-water monitoring. If natural water courses, canals, or storage pits are used to transport or contain spent geothermal fluids, a system of ground-water monitoring wells must be employed to determine the extent or rate of infiltration of the fluids;
11. Biological surveys, including species distribution and analyses of critical and endangered species. If spent geothermal waters are introduced into surface waters, then repeated biological surveys must be made to determine if or to what extent the endemic biota have been affected;
12. Air quality surveys. During the processes of producing, using, or disposing of geothermal waters, air quality surveys must be made to determine if or to what extent air pollution is occurring.

ACKNOWLEDGMENTS

The authors wish to thank the following members of the Bureau of Economic Geology Staff for their contributions to this report. Karen A. Cortes and Dawn G. McKalips assisted in the preparation of the report. Thomas J. Evans, Charles G. Groat, Robert A. Morton, and E. G. Wermund reviewed the manuscript. Kelly Kennedy and Karen M. White edited the manuscript. Figures were prepared by the cartographic staff under the direction of James W. Macon. The manuscript was processed and typed by Susann V. Doenges and Elizabeth T. Moore.

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