NIELSON GL00855

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M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

PROJECT PLAN

PHASE I

IDENTIFICATION OF CANDIDATE GEOTHERMAL APPLICATIONS SYSTEMS

INTRODUCTION

This Project Plan outlines the work necessary to determine the feasibility of utilizing geothermal energy as a major alternative Renewable Energy System (RES) for the deployment of the M-X missile system in Nevada and Utah.

The Phase I Objectives Hierarchy for the overall M-X/RES Project Geothermal Task is illustrated in Exhibit I. This chart brings the planned Phase I geothermal activities into perspective with the M-X/RES Project objectives by providing a hierarchy that translates the top level Project objectives into specific geothermal objectives. The viability of the two Phase I Project objectives shown in the top box will be evaluated in the mid-1982 Decision Package, which in turn will be supported by the identification of feasible candidate RES systems including geothermal, solar, wind and others.

The Phase I objective is to provide data which will enable an assessment of the feasibility of meeting some or all of the M-X Missile System ground operating power requirements through the installation and operation of specific geothermal application facilities. This assessment can be made by characterizing appropriate geothermal resource sites and by determining the feasibility of use of these resources for power generation or direct application. Program elements to accomplish this objective have been tailored to satisfy the near-term schedule constraints of the M-X program while also addressing long-term commercial benefits and furthering the state of the art of geothermal exploration and assessment technology. Note that the objectives

for characterizing resources and determining technical/cost/schedule viability are compatible with M-X/RES Project Work Breakdown Structure (WBS) Elements 2.3 and 3.1, respectively. The sub-objectives shown to support these two geothermal objectives are also compatible with third and fourth level WBS elements of the Geothermal Assessment and Applications Development Task Plan.

M-X/RES PROJECT GEOTHERMAL TASK

PHASE 1 OBJECTIVES HIERARCHY

DEFINE INTEGRATED RES OPTIONS THAT COULD
- **PROVIDE RELIABLE POWER FOR M-X**
- **ACCELERATE RES COMMERCIALIZATION**

DEVELOP DECISION PACKAGE BY MID '82 TO SUPPORT USAF DECISIONS ON
- **RES MIX**
- **RES ACQUISITION STRATEGIES**
- **COMMERCIAL INCENTIVES**

IDENTIFY FEASIBLE CANDIDATE SYSTEMS FROM OTHER RES TECHNOLOGIES

IDENTIFY FEASIBLE GEOTHERMAL APPLICATIONS SYSTEMS : DETERMINE HOW , AT WHAT COST, AND ON WHAT SCHEDULE GEOTHERMAL ENERGY COULD BE DELIVERED TO M-X , WHILE BENEFITING THE COMMERCIAL COMMUNITY

CHARACTERIZE GEOTHERMAL RESOURCE SITES IN OR ADJACENT TO THE M-X DEPLOYMENT AREA (2.3)
- **EXPLORE, CONFIRM, AND DEVELOP CASE STUDIES FOR GEOTHERMAL RESERVOIRS**
- **PLAN PHASE II ACTIVITIES**

DETERMINE PLANT FEASIBILITIES AND RESERVOIR SPECIFIC DESIGNS FOR ELECTRICAL AND DIRECT HEAT APPLICATIONS (3.1)
- **DEFINE CONCEPT, APPROACH**
- **DETERMINE PLANT FEASIBILITY FOR CONFIRMED RESERVOIRS**
- **PLAN SYSTEMS IMPLEMENTATION**
- **IDENTIFY COMMMERCIALIZATION IMPACTS**
- **PLAN PHASE II ACTIVITIES**

MX-028

OBJECTIVES AND STRATEGY

The overall objectives of the work proposed herein are twofold, i.e.;

(1) To assess the feasibility and economics of utilizing geothermal energy as one of the possible alternative Renewable Energy Systems (RES) to provide electrical power and/or direct building space conditioning requirements for the M-X Missile System, and

(2) To accelerate the commercialization of geothermal energy systems.

The more specific responsibility of the Geothermal Assessment and Applications Development Task is to provide geothermal resource and application information for use by DOE/DOD in deciding if geothermal energy can be utilized to make a significant contribution to the proposed Nevada/Utah M-X system energy requirements.

This Task Management Plan outlines the strategy for achieving the objectives stated above. This strategy involves the participation of various federal agencies, research organizations and private sector companies and utilities. Due to the short time frame available for the completion of this task, DOE has decided to utilize participants and established procedures from its already existing geothermal programs to achieve the stated objectives and thereby make use of an in-place infrastructure to carry out the necessary M-X/RES geothermal tasks. Examples of existing DOE programs and technology development efforts that the participants have been performing are:

- Industry Coupled Program:

  Cost-shared exploration and drilling for high-temperature reservoirs

with companies working in Nevada and Utah.

- State Coupled Program:

  Low and intermediate-temperature geothermal assessment in Nevada and Utah.

- Exploration and Assessment Technology Program:

  Development of new techniques and improvement of existing techniques.

- User Coupled Drilling Program:

  Cost shared exploration and drilling for low- and intermediate-temperature reservoirs with private sector.

- Reservoir Engineering:

  Development of new techniques and application of existing techniques.

- Electric Applications:

  Design and construction of binary and flash demonstration plants and evaluation of loan guarantee applications from industry.

- Direct Heat Applications:

  Design and construction of direct heat demonstration projects with private sector.

- Industrialization Programs:

  Commercialization of geothermal energy.

FUNCTIONAL RELATIONSHIPS

Exhibit II illustrates the functional relationships among the M-X/RES Project Office and some of its contractors and DOE/DGE and some of its contractors. DOE/DGE will communicate with and report to the M-X/RES Project Office on all aspects of the Geothermal Assessment and Applications Development Task. The DGE Project Manager will receive staff assistance from a special group, the Joint Task Group (JTG), that is composed of personnel from the Idaho (DOE/ID) and Nevada (DOE/NV) Operations Offices of DOE. The JTG serves mainly in planning, coordinating, and communicating functions for DGE, and has no line responsibility over technical aspects of Task implementation.

Implementation will be accomplished by carefully coordinated effort of DOE/ID and DOE/NV and their contractors. ESL/UURI and EG&G will serve as the primary support contractors to DOE/ID and the JTG. ESL will have basic responsibility for determining strategy and reviewing progress and results for the Geothermal Assessment portions of the Task, as well as for performance of some of the technical work elements. ESL will also coordinate procurement of existing earth science data from Fugro and from industry and will develop and maintain the M-X/RES Geothermal Data Base. ESL will analyse commercialization impacts of the geothermal work jointly with EG&G.

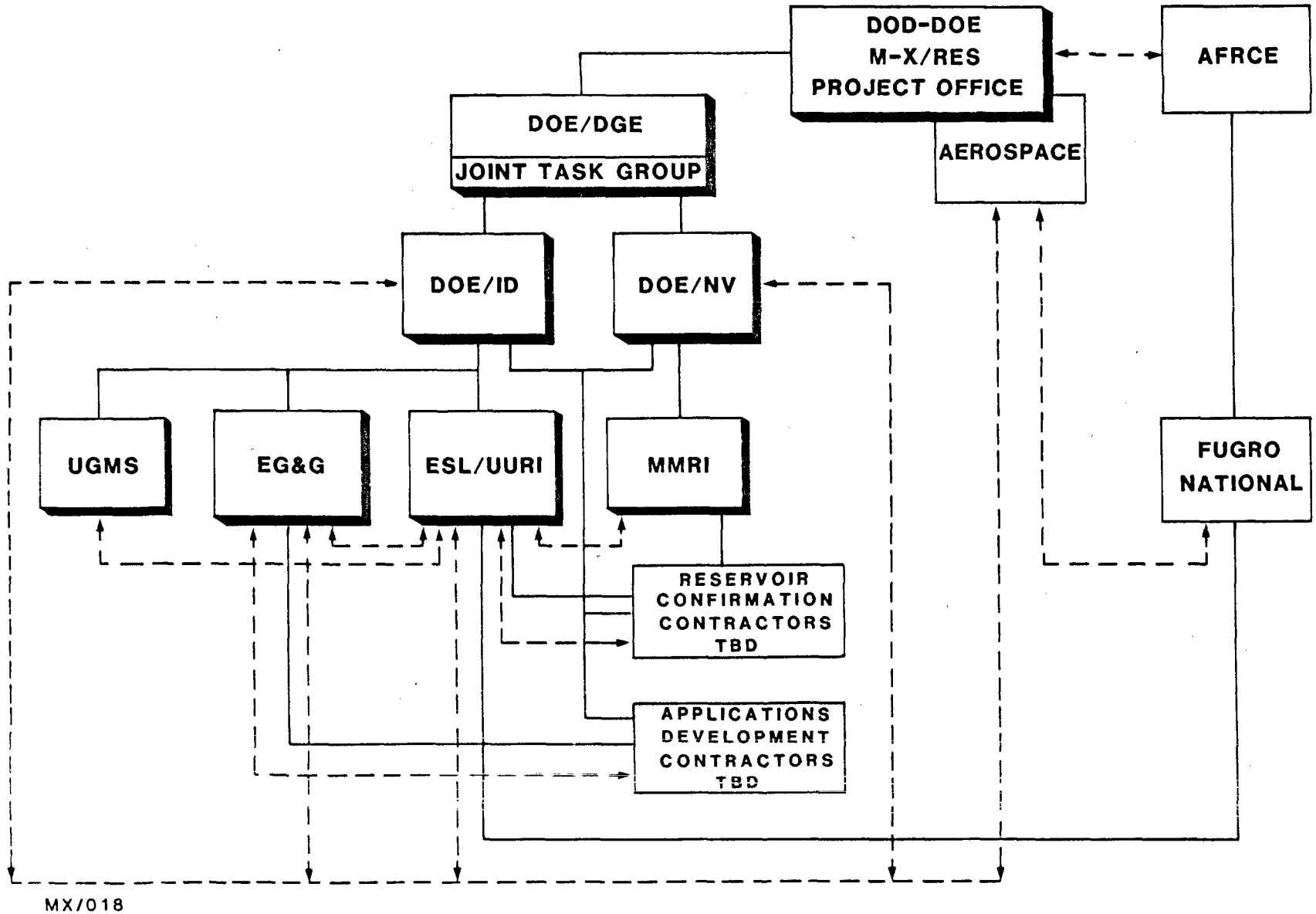
EG&G will bear basic responsiblity for the Geothermal Applications Development portion of the Task. They will perform generic feasibility studies and conceptual design for potential geothermal use from typical reservoirs of the type expected in and near the M-X development area. As

reservoir parameter data become more refined, EG&G will perform reservoir specific conceptual designs and systems specifications. They will also plan for implementation of geothermal utilization for Phase II. EG&G along with ESL will analyze commercial impacts of the M-X/RES geothermal data.

MMRI and UGMS will be the principal support contractors responsible for low- and intermediate-temperature geothermal assessment in the deployment area. They will also provide planning support for ESL and the JTG.

M-X/RES GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK

FUNCTIONAL RELATIONSHIPS



RESPONSIBILITIES AND AUTHORITIES

The specific responsibilities and authorities for each working group of the Geothermal Assessment and Development Task are designated as follows:

1. DOE/DIVISION OF GEOTHERMAL ENERGY (DGE)

Task Manager: Robert A. Gray Alternate: Harry Giles

a) Provides overall guidance regarding policy, priorities, task direction, schedule and budget in accordance with M-X/RES Project Office requirements.

b) Assures effective and efficient implementation of the Geothermal Task Plan, of directions from the M-X/RES Project Office, and of applicable DOE orders and other Federal regulations.

c) Institutes planning activities and approves the Geothermal Task Plan and modification to the Plan.

d) Provides funding to the DOE/Idaho and DOE/Nevada field offices.

e) Approves release of data to the public from the M-X/RES Geothermal Data File.

f) Coordinates with other national-level geothermal programs of the DOE and the U.S. Geological Survey. Incorporates results that are of benefit to the M-X/RES Project.

g) Reports to and maintains communication with the M-X/RES Project Office. Provides periodic schedular and expenditure progress reports, topical reports, and briefings.

2. ID/NV JOINT TASK GROUP (JTG)

Principal Contact: Allen J. Roberts, DOE/NV Alternate: Leland L. Mink, DOE/ID

a) Coordinates efficient and effective implementation and management of the Geothermal Task Plan in accordance with directions from the DOE/DGE Task Manager.

b) Coordinates preparation of the Geothermal Task Plan and of modifications to the Plan.

c) Coordinates the preparation of monthly schedular and expenditure progress reports and of technical reports, submitting them to DOE/DGE.

d) Coordinates the establishment and maintenance of the M-X/RES

Geothermal Data File and makes appropriate recommendations to DOE/DGE for release of data to the public.

e) Provides planning, technical review and briefing assistance to DOE/DGE as requested.

3. DOE/ID FIELD OFFICE

Field Manager: Leland L. Mink Associate Field Manager: Russell D. Lease

a) Contracts for and directs day-to-day implementation of:

1) Work supporting field exploration for high- and low-to-intermediate temperature geothermal reservoirs and reservoir confirmation, including drilling for low- and intermediate-temperature reservoirs in the State of Utah (through ESL and UGMS).

2) Work supporting the conceptual definition of M-X geothermal applications, planning for implementation, and analysis of the impact on commercialization (through EG&G and ESL).

3) Technical planning and review assistance; data file development and management; monthly report review, consolidation, and submission (through ESL, EG&G, and UGMS).

b) Consolidates contractor monthly schedular and expenditure progress reports, develops a management assessment of status and/or problems and recommends solution. Implements those solutions after approval of the DOE/DGE.

c) Reviews technical reports and approves their submittal to DOE/DGE and to the M-X/RES Project Office.

4. DOE/NV FIELD OFFICE

Field Manager: Joseph N. Fiore Associate Field Manager: Allen J. Roberts

a) Contracts for and directs the day-to-day implementation of:

1) Work supporting field exploration for high- and low-to-intermediate temperature geothermal reservoirs and reservoir confirmation, including drilling for low- and intermediate-temperature reservoirs in the State of Nevada (through MMRI).

2) Industry cost-shared drilling activities associated with potential reservoirs of all temperatures in Nevada and Utah, utilizing ESL approved work scopes and activities (Contractor(s)

TBD).

3) Feasibility studies relating to the utilization of initial high-temperature rservoirs for the generation of electrical power, utilizing EG&G approved work scopes and activities (through Contractor(s) TBD).

b) Consolidates contractor monthly schedular and expenditure progress reports, develops a management assessment of status and/or problems and recommended solutions, and implements these solutions after approval of the DOE/DGE.

c) Reviews technical reports and approves their submittal to DOE/DGE and to the M-X/RES Project Office.

d) Schedules and coordinates all contact and communication with State of Nevada governmental entities relating to M-X/RES Geothermal Assessment and Applications Development.

5. EARTH SCIENCE LABORTORY DIVISION/UNIVERSITY OF UTAH RESEARCH INSTITUTE (ESL/UURI)

Project Manager: Dennis L. Nielson Alternate Contact: Phillip M. Wright

a) Contractor to DOE/ID.

b) Provides DOE/ID, DOE/NV and the Joint Task Group (JTG) primary technical planning and coordination assistance for the Geothermal Assessment portion of the M-X/RES Geothermal Task.

c) Implements assigned technical portions of Geothermal Task including:

1) development of exploration and reservoir confirmation strategies and data requirements;

2) detailed exploration and reservoir confirmation at initial and other high-temperature sites, in cooperation with industry lease-holders;

3) commercialization analyses, in conjunction with EG&G.

d) Assists DOE/ID, DOE/NV, and the Joint Task Group in technical review of exploration, reservoir confirmation, and drilling contractors, including UGMS, MMRI, and other contractors TBD.

e) Coordinates acquisition by other contractors of geoscience and related data from industry and private sectors.

f) Establishes a central data file for the storage of all M-X/RES

Geothermal data including properietary data. Organizes the release of non-proprietary data through public open-file with approval of the JTG.

g) Coordinates the flow of geothermal assessment data and analyses of those data, to GSE/I.

h) Schedules and coordinates all contacts and communication with State of Utah governmental entities relating to M-X/RES Geothermal Assessment and Applications Development Task.

6. EG&G, IDAHO, INC.

Project Manager: Thomas W. Lawford Alternate Contact: M. Ken Shane

a) Contractor to DOE/ID.

b) Provides DOE/ID, DOE/NV, and the Joint Task Group technical planning and coordination assistance on the Applications Development portion of the M-X/RES Geothermal Task.

c) Implements assigned technical portions of Geothermal Task, including:

1) development of candidate geothermal applications;
2) collection and analysis of Geothermal Applications data;
3) reservoir engineering at assigned sites; and
4) commercialization analysis in conjunction with ESL.

d) Assists DOE/ID, DOE/NV, and the Joint Task Group in technical review of applications development contracts.

e) Purchases applications development data after approval of the DOE/ID, and contracts for applications development studies by appropriate contractors.

f) Releases appropriate Geothermal Applications data through public open-file.

g) Provides applications data and analysis to GSE/I with copy to ESL for master data file.

7. MACKAY MINERALS RESEARCH INSTITUTE (MMRI)

Primary Contact: Dennis L. Trexler Alternate: James L. Bruce

a) Contractor to DOE/NV.

b) Provides technical proposals, planning to ESL and the Joint Task Group.

c) Performs assigned portions of task, including:

1) Geothermal assessment for low- and intermediate-temperature geothermal systems at candidate Operating Base sites in Nevada.

2) Reconnaissance and detailed exploration for other high-temperature geothermal systems in the deployment area of Nevada.

3) Collection, reduction, and analysis of data from the above efforts and transmittal of such data to ESL.

d) Publishes data and analysis as appropriate to benefit the commercialization of geothermal resources.

e) Purchases existing geoscience data and subcontracts for surveys after coordination with ESL and approval of DOE/NV.

8. UTAH GEOLOGICAL AND MINERAL SURVEY (UGMS)

Primary Contact: Robert Klauk Alternate Contact: Wallace Gwynn

a) Reports to DOE/ID.

b) Provides technical proposals and planning assistance to ESL and to the Joint Task Group.

c) Implements assigned portions of task, including:

1) Geothermal assessment for low- and intermediate-temperature geothermal systems at candidate Operating Base sites in Utah.

2) Reconnaissance and detailed exploration for other high-temperature geothermal systems in the deployment area of Utah.

3) Collection, reduction, and analysis of data from the above efforts and transmittal of such data to ESL.

d) Publishes data and analysis as appropriate to benefit the commercialization of geothermal resources.

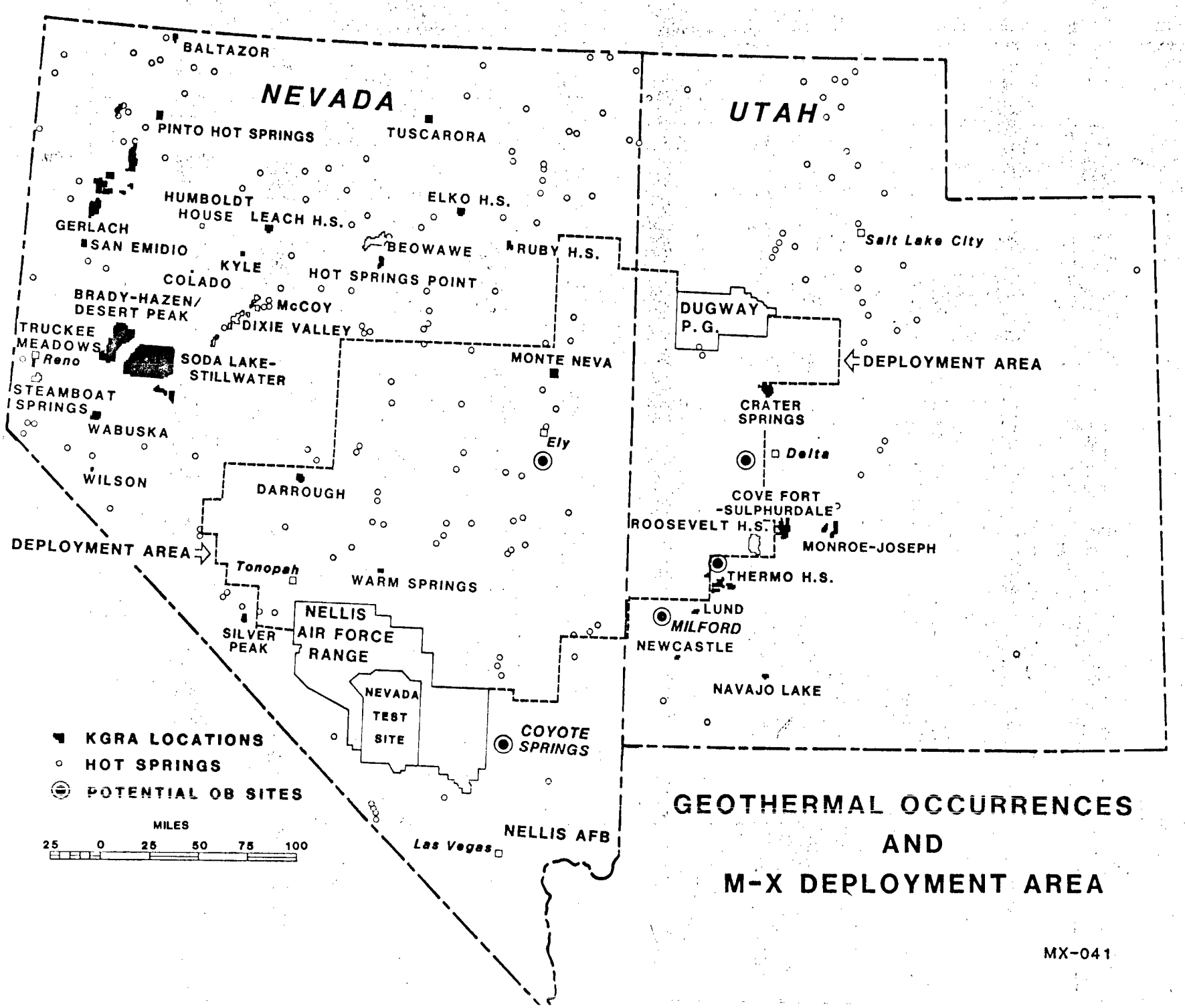
KNOWN GEOTHERMAL OCCURRENCES AND THE M-X DEPLOYMENT AREA

The following map, Exhibit III, shows the M-X deployment area and the candidate Operating Base sites along with locations of known geothermal reservoirs, hot springs and other occurrences. KGRAs are shown as blocks. These are generally areas where there is potential for occurrence of temperatures high enough to support electrical power generation ($T \geq 150°C$). The most important of these KGRAs in terms of electrical power potential for the M-X/RES Project are Roosevelt Hot Springs in Utah, and Dixie Valley, Steamboat Springs, Desert Peak, Humbolt House, and Beowawe in Nevada. In the presentation that follows, we will refer to these particular KGRAs as the "Initial High-Temperature Sites."

Areas of occurrence of thermal springs and/or wells are shown on the map by circles. These thermal wells or springs verify the existence of low- and moderate-temperature geothermal resources within the deployment area and help to indicate the potential for direct applications of geothermal energy for M-X/RES purposes. In addition, there is believed to be potential for discovery of high-temperature resources at depths under many of these thermal wells and springs.

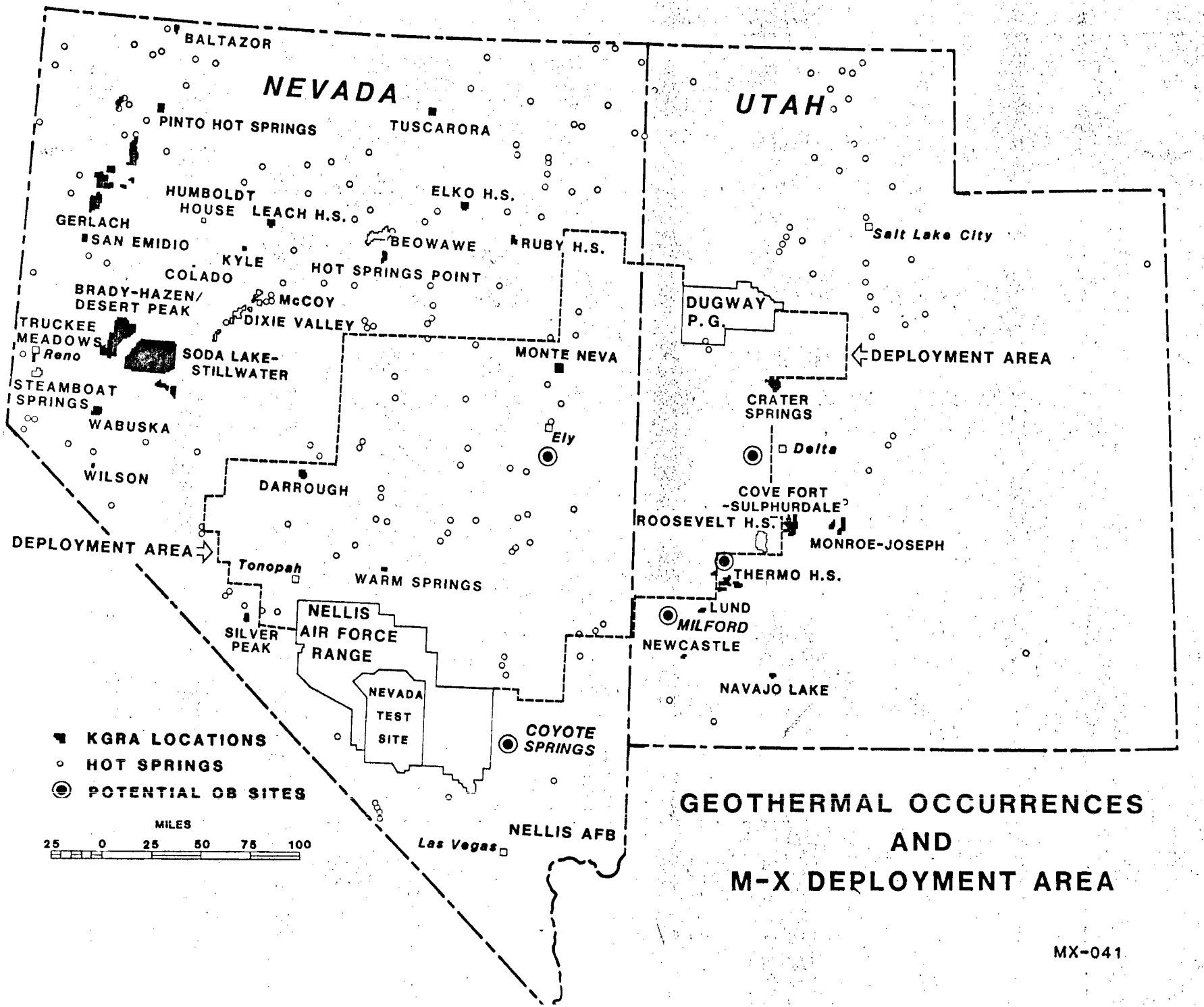
Industry's exploration activities have not been as intensive within the deployment area as they have been immediately outside of the deployment area. Industry has, quite naturally, explored first in those areas where surface evidence of high-temperature geothermal reservoirs is most obvious. More intensive industry exploration work is predicted within the deployment area over the next 10 years. This work, along with the exploration work that will

be carried out for the M-X/RES Project, will result in discovery and characterization of resources that are unknown today.



GEOTHERMAL OCCURRENCES AND M-X DEPLOYMENT AREA

MX-041



GEOTHERMAL OCCURRENCES AND M-X DEPLOYMENT AREA

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M-X/RES GEOTHERMAL TECHNICAL APPROACH OVERVIEW (PHASE I)

Three major concurrent and independent geothermal activity paths are emphasized in the strategy shown on the accompanying chart, Exhibit IV. These activity paths are differentiated mainly on resource considerations. The greatest potential for electrical power generation exists at known geothermal sites outside of the deployment area. Path 1 is designed to investigate M-X/RES applications at these sites. At the same time, there is potential for discovery of currently unknown resources within the deployment area that could be used for electrical power generation, and Path 3 will investigate these possibilities. Several of the candidate Operating Base sites lie near known geothermal occurrences, mostly of low to intermediate temperature. Use of these resources to provide space conditioning will be investigated in Path 2. But because it is not economic to pipe low-temperature fluids for direct application more than 5 to 10 miles, low- to intermediate-temperature exploration activities will be confined to these distances from the candidate Operating Bases.

The activity paths are designed to support the M-X/RES Decision Package of mid-1982. Strategies are being developed to specify in detail the activities in each path while making maximum use of existing information and state-of-the-art geothermal technologies. The activities in these three paths will be supplemented by generic plant studies, implementation planning, and commercialization analyses to provide close compatibility with other RES candidate system development efforts. Details of the three activity paths follow below.

The top path (1) is one of high confidence level and should assure a role for geothermal energy in M-X/RES. It emphasizes electrical power generation, although use of direct thermal energy through cascading will also be investigated. The 6 sites in the "Initial High-Temperature Sites" category (Roosevelt Hot Springs, Steamboat, Beowawe, Desert Peak, Dixie Valley and Humboldt House) are reasonably well known. Recent dicussions have uncovered the fact that plant design data which M-X/RES may be able to purchase have been developed by consortia for some of the sites. It remains to: (1) screen the 6 sites by using both resource data and the results of generic parameterizations and consortia studies to select the 1 or 2 highest priority sites for cost-shared drilling/testing, (2) perform drilling and testing, and (3) translate the results into specific high-temperature candidate geothermal system design(s)/specification(s).

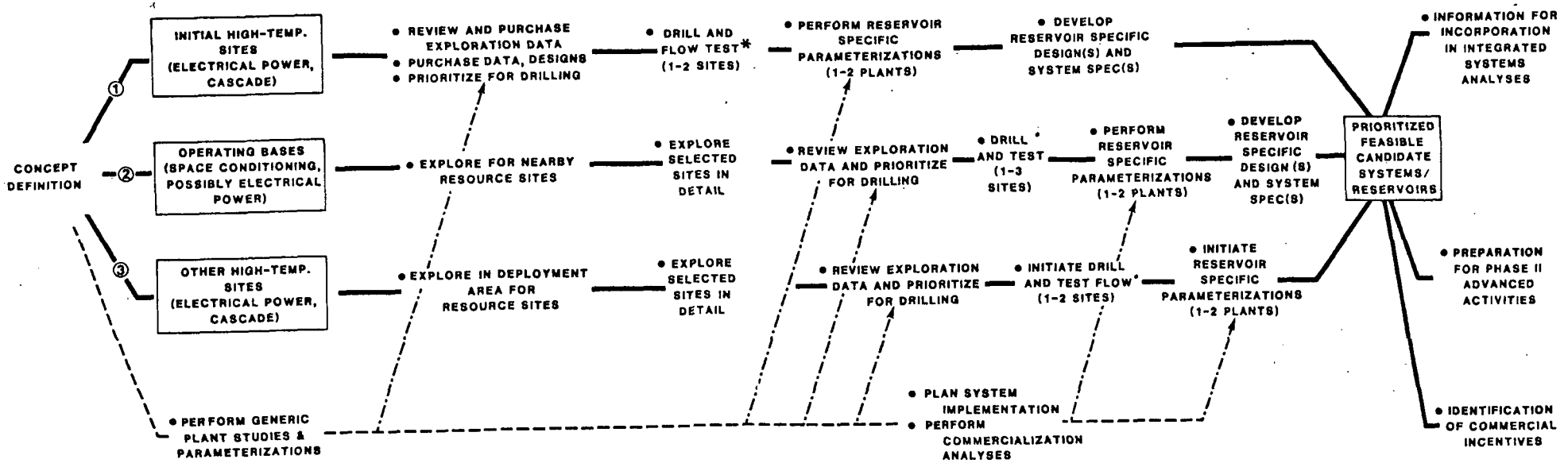
The middle path (2) pertains to exploration for reservoirs near 2 candidate Operating Base Sites. This path is also likely to result in an M-X application. At present the Milford and Beryl candidate OB sites are known to be associated spatially with a geothermal resource, and potential for discovery at other OB sites is high. It is most likely that lower temperature fluids would be found at these sites that would restrict application to space conditioning, although electrical power generation will be investigated. The Milford Candidate OB site, in particular, appears to have potential for electrical power generation. The activities along Path 2 begin with exploration and screening prior to conducting activities similar to those called for in Path 1. The results will be 1 or 2 OB reservoir specific system design(s) and system specification(s).

The lower path (3) involves exploration in the deployment area for high-temperature sites that are now unknown. It is anticipated that 1 to 2 sites will evolve from this path that will provide backup in the event that those applications in Path 1 yield lesser capability than required. Also, this category (a) has fewer associated transmission problems, (b) could support the option of an M-X/RES dedicated plant, (c) increases the likelihood of available geothermal power, and (d) provides a head-start for follow-on activities. The activities will lag those of the first two paths mainly because of funding restrictions. Accordingly, the corresponding parametrization studies will culminate later in Phase I and will be less refined than for the upper two paths; i.e., they will be provided as reservoir specific parameterizations rather than system designs/specifications. Design activities would therefore be continued into Phase II, along with appropriate extensions of the upper two paths.

Generic and parametric studies of electric power plants and space conditioning systems will be performed early in Phase I to provide direction and guidance for each of the three paths. This guidance will be in the form of engineering, economic feasibility, schedular, commercialization, and socio-institutional considerations.

Phase II activities for the three activity paths will involve drilling for reservoir testing, production drilling, detailed reservoir specific applications designs, and construction and start-up of geothermal utilization systems.

M-X/RES GEOTHERMAL TECHNICAL APPROACH OVERVIEW (PHASE I)



AVAILABILITY OF FUNDS WILL LIMIT TOTAL NUMBER OF DEEP WELLS TO 2-3 DURING FY 1981 AND 3 TO 4 DURING FY 1982

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SUGGESTED HIGH-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

The high-temperature hydrothermal exploration strategy shown in Exhibit V is a generalized approach that is followed by many exploration groups although the specific mix of techniques used varies from group to group. The approach is designed to locate hidden hydrothermal systems in the Great Basin. It starts with a literature study and data compilation for large areas of 1,000 to 10,000 sq mi. From analysis of these data the exploration effort can be progressively concentrated to a district scale of 100 to 1000 sq mi and then down to a prospect scale of perhaps 10 sq mi. In addition, the strategy uses less expensive exploration activities in the early phases of exploration and the more expensive drilling and geophysical surveys in the latter phases.

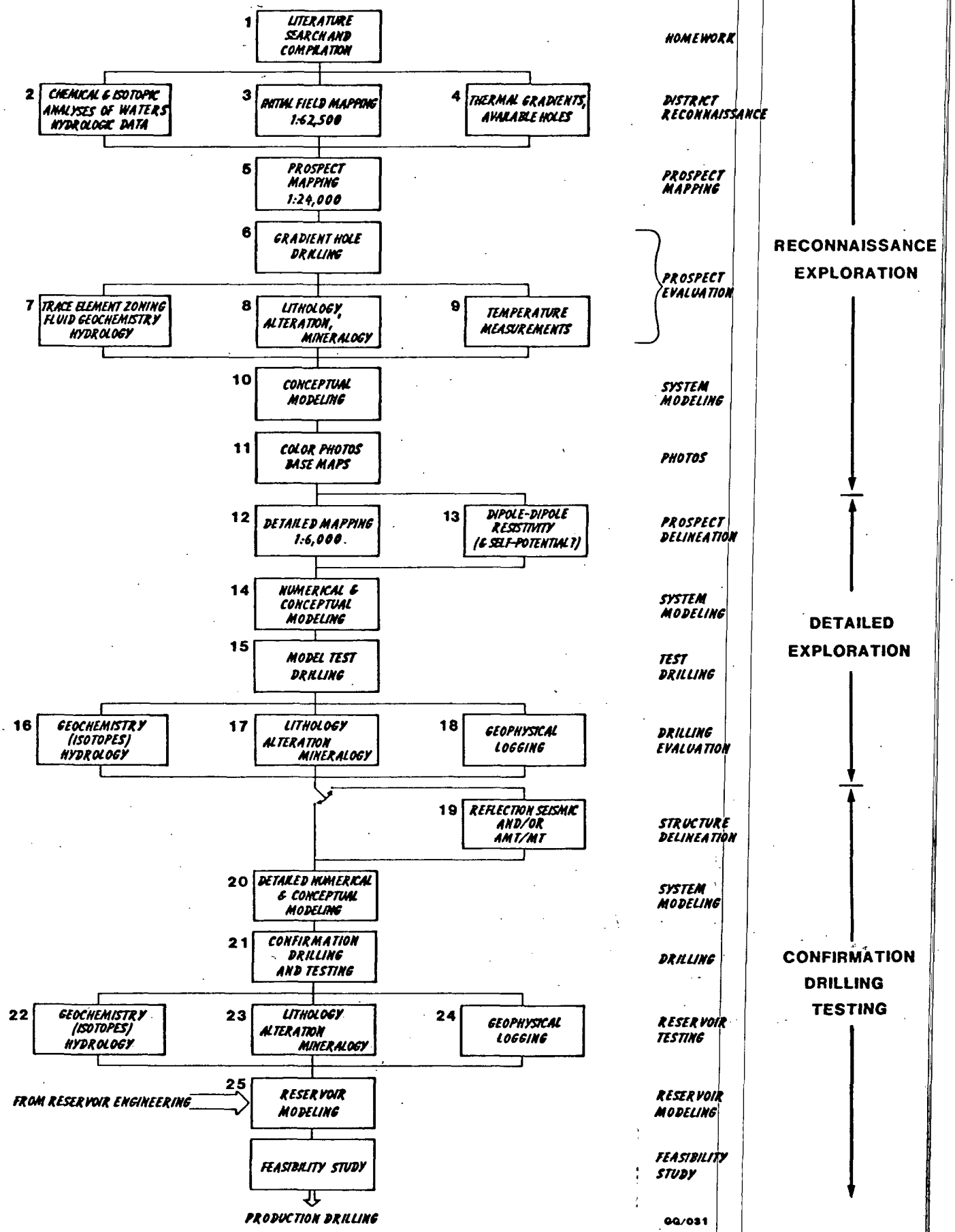
The strategy is based on the formulation and testing of conceptual models of the hydrothermal systems being sought. In any specific exploration effort, some steps in the sequence may be skipped, and many times it becomes necessary to add surveys not shown here to answer specific problems.

Progression through all twenty-five steps shown in the high-temperature strategy may take a year or more depending upon the commitment of the organization involved, availability of survey and drilling crews, competition, and weather, as well as other variables.

The initial activity in the geothermal assessment portion of the M-X/RES Geothermal Assessment and Applications Development Task is to refine the strategies for application to the Initial High-Temperature Sites, the Operating Base sites, and other high-temperature sites.

For the Initial High-Temperature Sites work can begin well into the strategy (approximately step #20) because for these sites much has been accomplished already through industry's exploration efforts, and first results can be expected in a time frame of several months.

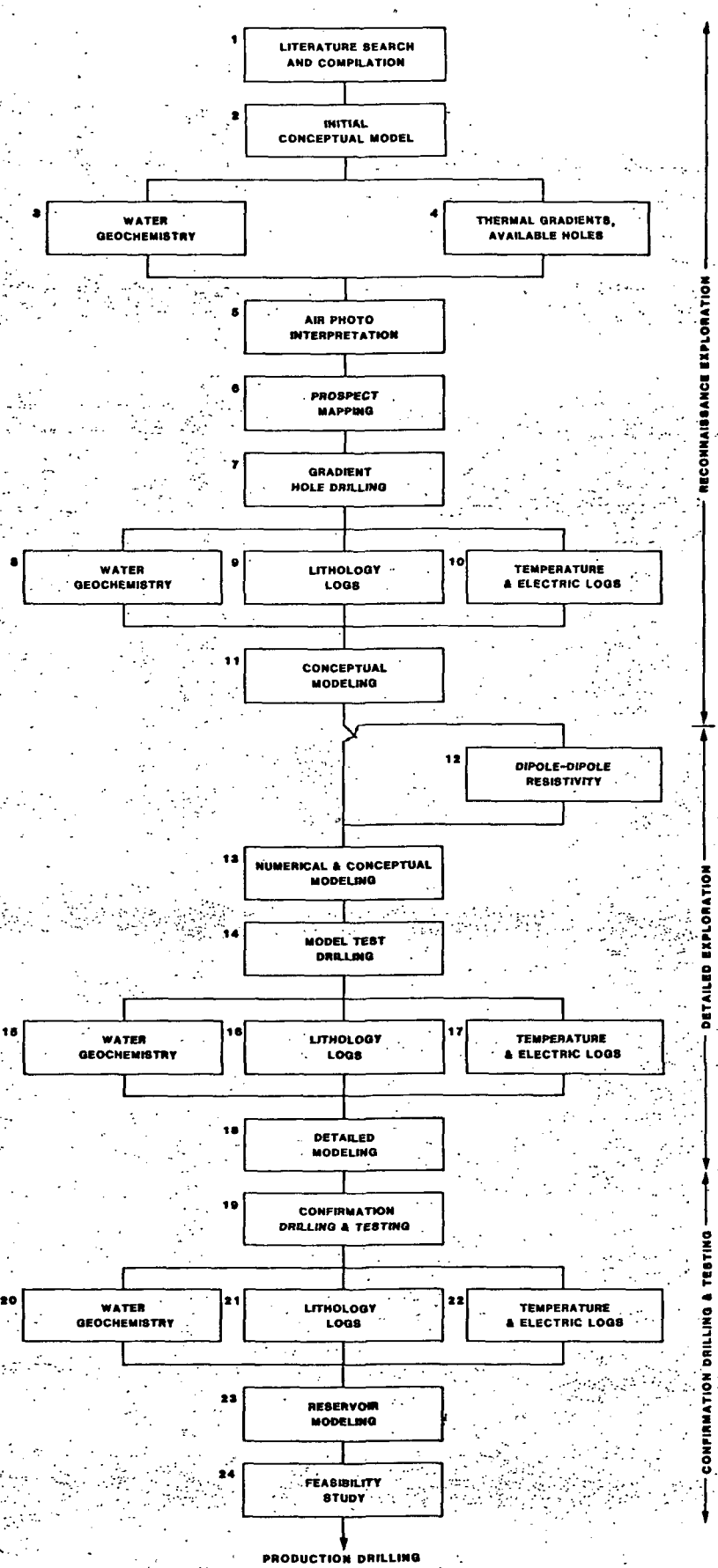
SUGGESTED HIGH TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY



SUGGESTED LOW- AND INTERMEDIATE-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

The low- and intermediate-temperature exploration strategy shown in Exhibit VI is similar to that shown for high-temperature systems. The same approach is used: starting with large areas, we narrow attention to prospects that have the best evidence of a viable reservoir, and work from the less expensive to the more expensive exploration procedures. The conceptual model approach is also applied, and steps in the exploration procedure may be skipped or new procedures added to solve specific problems.

Exploration in the vicinity the OB sites is site-specific. That is, instead of exploring large areas for the best geothermal systems, the exploration areas are predetermined. Thus many of the exploration procedures designed to narrow the area of search can be eliminated, and, if favorable evidence is found, detailed exploration can be quickly implemented. In addition, measurement of temperatures in geothermal holes being drilled by Fugro will speed up the exploration process at the OB sites, thereby allowing work to begin at step #7.



SUGGESTED LOW-AND INTERMEDIATE-TEMPERATURE HYDROTHERMAL EXPLORATION STRATEGY

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WORK BREAKDOWN STRUCTURE

The Work Breakdown Structure for elements of the assigned task are as follows;

Exhibit VII illustrates the position of the Geothermal Assessment and Geothermal Applications Development work elements relative to the top-level M-X/RES Project work breakdown structure. Taken together, Geothermal Assessment (WBS 2.3) and geothermal Applications Development (WBS 3.1) constitute what we have termed the "M-X/RES Geothermal Task."

M-X/RES PROJECT
WORK BREAKDOWN STRUCTURE

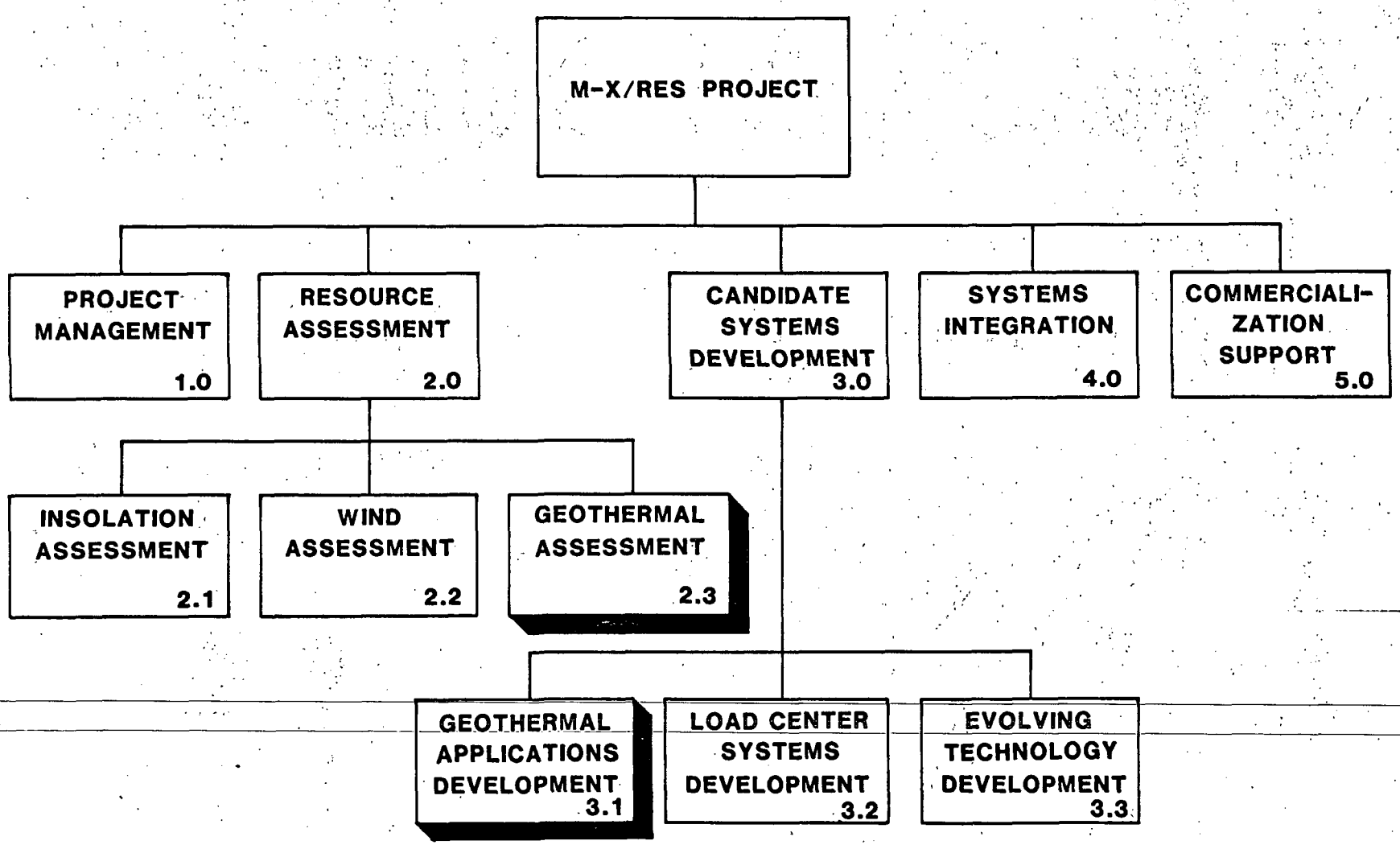

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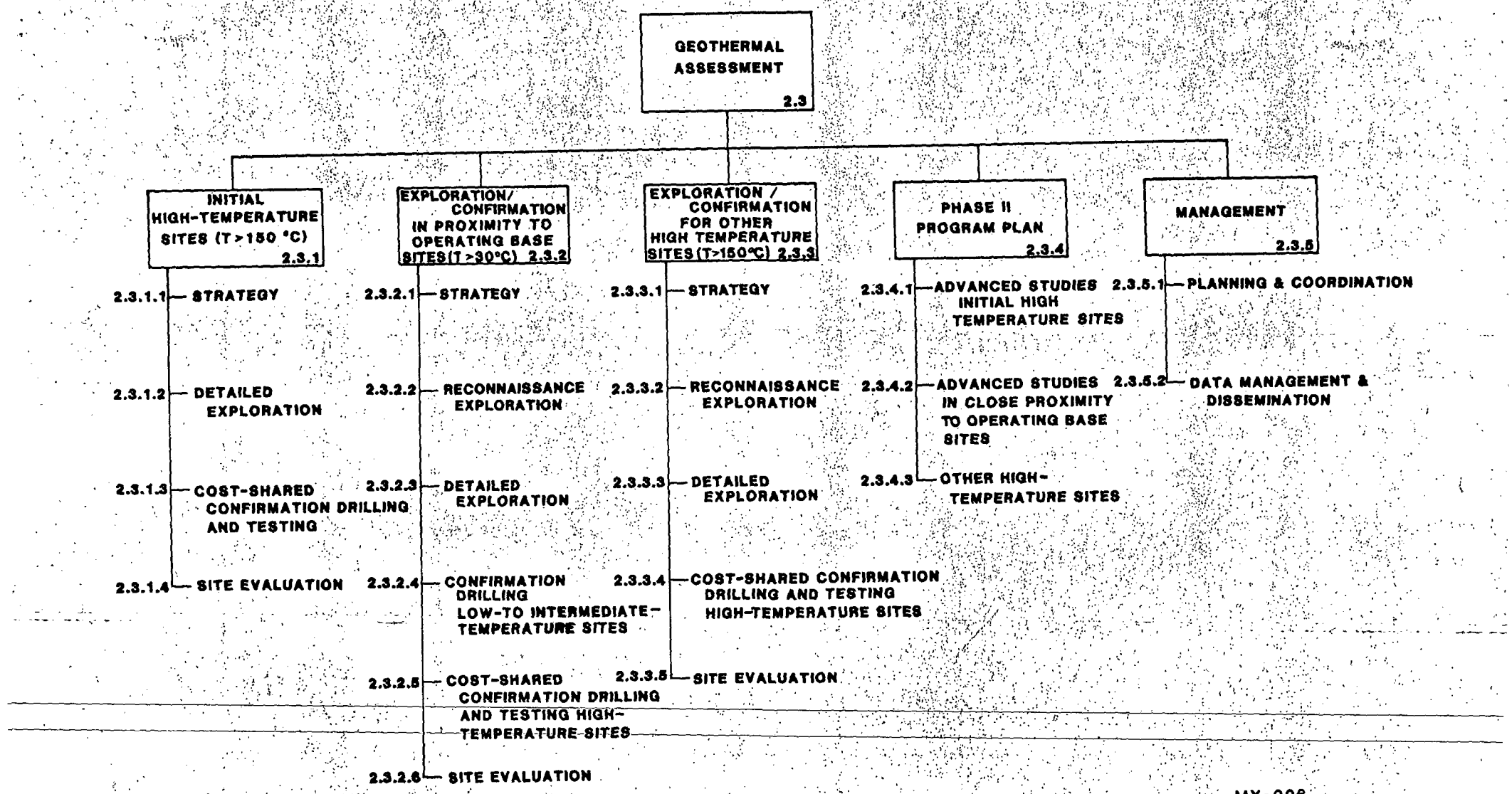
Exhibit VIII shows the third-level of the WBS pertaining to Geothermal assessment. Elements 2.3.1, 2.3.2, and 2.3.3 reflect the three main elements of the strategy, i.e. the three separate activity paths as previously discussed on the technical approach overview.

PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE



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PHASE I GEOTHERMAL ASSESSMENT WORK BREAKDOWN STRUCTURE

The Phase I work breakdown structure for Geothermal Assessment follows from the objectives of the M-X/RES Project and the Geothermal Assessment and Applications Development Task. Geothermal Assessment will be concentrated in three areas: 1) Initial High-Temperature Sites, 2) Operating Base Sites, and 3) Other High-Temperature Sites.

WBS 2.3.1 Initial High Temperature Sites (T>150°C).

The Initial High-Temperature Sites are those that have been identified as being in the advanced stages of exploration and which show promise of being able to contribute electrical power to the M-X system. These areas are Roosevelt Hot Springs, Utah, and Dixie Valley, Steamboat Springs, Desert Peak, Humbolt House, and Beowawe in Nevada. As industry exploration proceeds, other sites could be added to this list. Large amounts of exploration data are presently available for these areas and it is thought that additional information could be readily purchased from companies that are exploring there. Formulation of optimum exploration and reservoir confirmation strategies will proceed after all available data have been collected and analyzed, companies have been contacted, and priorities have been established. Following the formulation of strategies, the DOE will contract with the companies who hold the land leases for detailed exploration or confirmation drilling and testing on a cost-shared basis. ESL will assist in this effort. This will both aid in the confirmation of these reservoirs and provide data that will be used in the M-X/RES Data Base Book and released to the geothermal community, if appropriate. The last element (2.3.1.4), termed "Site

Evaluation," provides for a retrospective analysis of the program. During this portion, case studies of the procedures will be developed and advances in geothermal exploration and assessment technology will be evaluated and communicated to the geothermal exploration community.

WBS 2.3.2 Exploration/Confirmation in Proximity to Operating Base Sites (T>30°C).

The exploration and confirmation in proximity to the Operating Bases will follow the same general procedure as outlined for the Initial High-Temperature Sites. Differences are: 1) the activities will concentrate in the vicinity of the Operating Base sites, 2) the exploration targets will be both high-temperature systems suitable for electric power generation and low- to intermediate-temperature systems which could be applied to both space conditioning and process heat, and 3) the entire exploration procedure for low- to intermediate-temperature resources and the initial stages of the high-temperature exploration will be performed by the resource teams of Nevada (MMRI) and Utah (UGMS). The procedure will begin with an evaluation of the strategy to be employed, both from the standpoint of the prioritization of the sites and in terms of the procedures to be employed. In general, the reconnaissance exploration and some of the detailed exploration will be done by MMRI and UGMS. However, if evidence of a high-temperature geothermal resource is found, attempts will be made to induce private industry to pick up the exploration under a cooperative agreement with the government. This could lead to cost-shared confirmation drilling and testing at favorable sites. The activity is divided in this fashion because high-temperature geothermal

exploration expertise generally resides with private industry whereas appropriate exploration expertise for low- and intermediate-temperature systems rests with MMRI and UGMS, and because industry will likely be involved through lease holdings and through production of electrical power from any high-quality reservoirs found.

WBS 2.3.3 Explortion/Confirmation for other High Temperature Sites (T>150°C).

The component of the WBS that addresses exploration and confirmation for other high-temperature sites is based on the philosophy that most high-temperature exploration has been concentrated in areas of Nevada and Utah adjacent to the deployment area, leaving the deployment area itself much less thoroughly explored. The initial effort will be to work out a strategy and establish priorities in light of limited funds and the importance of the Initial High-Temperature Sites and the Operating Base Sites. The exploration under this element will be initiated by MMRI and UGMS. If indications of high-temperature geothermal systems are discovered, attempts will be made to attract companies to participate with the government in cost-shared exploration. At favorable sites this will lead to cost-shared confirmation drilling and testing. The final step will be a site evalution where case studies will be developed and improvements in exploration and assessment technology will be evaluated and transferred to industry.

WBS 2.3.4 Phase II Program Plan.

This element provides for the planning of activities to be done under Phase II of the Task, those which will follow the June, 1982 M-X/RES decision.

This planning will address advanced studies at the Initial High-Temperature Sites and at the Operating Base Sites. In addition, the status of the Other High-Temperature Sites will be evaluated and recommendations for additional studies made.

WBS 2.3.5 Management.

This element addresses the management of the Geothermal Assessment portion of the Task. The specifics of management are addressed under the authorities and responsibilities of the individual participants and shown on functional relationships charts previously presented in Exhibit II.

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT
WORK BREAKDOWN STRUCTURE

Exhibit IX shows the third-level of the WBS pertaining to Geothermal Applications Development. Plant feasibility studies are planned for the three activity paths previously discussed on the technical approach over-view. System implementation planning will be performed at specific reservoir sites that are confirmed as a result of Geothermal Assessment activities. Commercialization analyses will be performed on all data and communicated to the geothermal community.

WBS 3.1.1 Concept Definition

3.1.1.1. Scenario/Technology Tradeoff and Strategies

Develop scenarios for the utilization of geothermal energy for electrical power for the overall system and for space conditioning of several OB sites, as well as a cascaded electrical power/space conditioning option for one OB site.

3.1.1.2 Generic Parameterization

Develop generic performance and cost parameters for three types of electric power production and for space conditioning at typical OB sites, as functions of resource temperature, fluid chemistry and average well flow rates. Special consideration will be given to conceptual development of special binary and hybrid flash-steam-binary power plants to mitigate shortages of cooling water, and floating power concepts to mate with the generation characteristics of other renewable energy sources. Conceptual work on combination space-water heating and space cooling systems for the OBs will be carried through preliminary cost estimates and economics. This data is to be used for selection of the most promising electric generating and OB sites. Consideration of dry or hybrid cooling for electric power generation will also be evaluated.

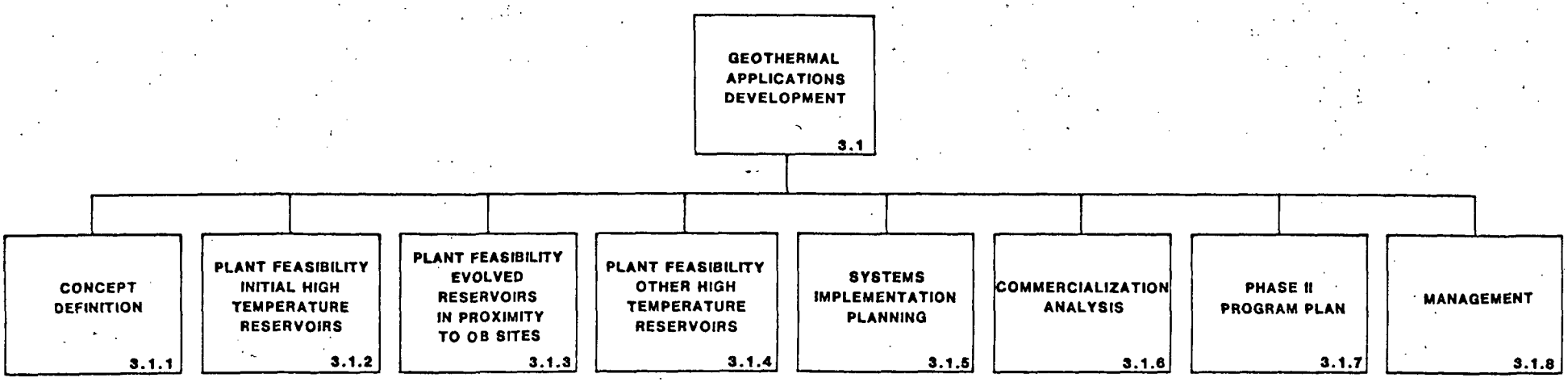
3.1.1.3 Socio-Institutional Issues

Develop a generic list of the environmental concerns, permitting problems and political-legal ramifications appropriate for electric generating and space conditioning applications in the areas of interest. Evaluate each of the items and its potential impact on construction schedules.

M-X/RES PROJECT

GEOTHERMAL TASK

PHASE I GEOTHERMAL APPLICATIONS DEVELOPMENT WORK BREAKDOWN STRUCTURE



MX-065

3.1.1.4 Commercialization Issues

Scope the potential commercialization issues associated with development of large scale geothermal applications. Consider development of the infrastructure necessary for low to intermediate geothermal applications, the market for geothermal components and the demonstration of large scale applications. Demonstration of ways to cut through the barriers to geothermal utilization will also be significant to commercialization. This task will be coordinated with DOE-DGE commercialization programs.

WBS 3.1.2 Plant Feasibility - Initial High Temperature Reservoirs

3.1.2.1 Reservoir Specific Parameterization

Contract with Northern Nevada Consortium and Utah Power and Light to buy reservoir and plant study data and transmission line studies (DOE/Nevada Operations Office). Review and evaluate their studies.

3.1.2.2 Prioritize Reservoirs

Prioritize the studied reservoirs on the basis of lowest power costs, technical feasibility, environmental and socio-institutional issues, commercialization aspects and strategic location. Produce a final report.

3.1.2.3 Reservoir Specific Designs

Based upon Tasks 3.1.2.1 and 3.1.2.2 above, and Task 3.1.1.2, develop a plant conceptual design, if not produced in 3.1.2.1 above. Subcontract with an A-E firm for a Title I design study. Review the Title I design and produce a final report package for M-X/RES consideration.

WBS 3.1.3 Plant Feasibility - Evolved Reservoirs in Proximity to Operating Bases

3.1.3.1 Analysis of Cascaded Systems

Working from the Generic Parameterizations of element 3.1.1.2, scope cascaded electric generation/space conditioning systems for the OB sites.

3.1.3.2 Initial Applications Evaluation

Using the generic data from tasks 3.1.1.2 and 3.1.3.1, and initial reservoir data, evaluate the potential systems appropriate for application at the OB sites.

3.1.3.3 Applications Design Development

Using updated reservoir data, the generic data, and the initial evaluations above, select the appropriate system concepts. Perform a conceptual system design. Place a subcontract with an AE firm for a Title I design.

WBS 3.1.4 Plant Feasibility of Other High Temperature Reservoirs

Following the discovery and preliminary assessment of a new high temperature reservoir, the initial estimates of fluid temperature, flow rate per well, and water quality will be used to determine the electrical generation capacity and economics of the site.

3.1.4.1 Reservoir Specific Parameterization

The electric generation generic parameterization developed in Task 3.1.1.2 will be adjusted to the characteristics of the specific reservoir.

3.1.4.2 Reservoir Specific Designs

As further reservoir definition becomes available, the parametrics of Task 3.1.4.1 will be refined and the economics of the site development will be evaluated. If the analysis proves favorable, an AE will be contracted to develop a reservoir-specific design. Given the site and resource characteristics, the AE will develop preliminary layouts and equipment sizes, and estimate the plant and equipment capital costs, O&M, and energy production.

3.1.4.3 Prioritize Reservoir Applications

After all of the preliminary designs have been completed and reviewed, the designs will be evaluated with respect to economics, energy impact, and commercialization impact. The designs will be prioritized with the initial resource sites (Tasks 3.1.2.3 & 3.1.3.3) to aid in the selection of the optimum electric generation configuration. This will consist of a combined effort of UURI and EG&G.

WBS 3.1.5 Systems Implementation Planning

3.1.5.1 Operations Planning

Operating plans will be developed for the plant concepts that cover system operation, plant maintenance and SO testing. Support facilities, equipment, personnel requirements and training programs required for operation and maintenance of the plants will be identified.

3.1.5.2 Environmental and Safety Analysis

The potential environmental impacts and health and safety risks associated with the plant concepts for installation, operation and maintenance of the plant will be identified and assessed. Special procedures required to comply with Federal, State, and local standards will be identified.

3.1.5.3 Systems Acquisition Planning

A plan that covers all items commencing with Phase II activities and culminating with the operational availability of the plant concepts will be prepared that reflects necessary design, development, prototype testing, CC tests, installation and checkout activities.

3.1.5.4 Risk Management

Finally, areas of possible risk shall be identified that address performance, cost, and schedule for the various concepts that might commence with Phase II activities. Causative factors will be discussed, and plans developed for minimizing the risks.

WBS 3.1.6 Commercialization Analysis

3.1.6.1 Market Identification

Existing and future markets for geothermal electric generation plants and district space conditioning systems will be identified and used in the data dissemination phase of Task 3.1.8.

3.1.6.2 Characterization of Deterrents or Barriers

The deterrents and barriers to the development of geothermal utilization will be identified from past and projected geothermal projects. Issues such as permitting, licensing, rights of way, project infrastructure and capital formation will be covered. These issues will be cross-referenced to the quantity and scheduling of systems procured and demonstrated by M-X/RES applications.

3.1.6.3 Commercial Applications Configuration and Demonstration

The impact of the proposed M-X/RES project designs and demonstrations on the acceleration of geothermal commercialization will be assessed.

3.1.7 Phase II Program Plan

The Phase II Program Plan contains work that will be performed after June 1982. On or about that date, decisions will be made regarding the contributions to be made by geothermal energy systems to the overall MX-RES project, and the ongoing work will be selected from work proposed in the Phase II Program Plan.

Subtasks that will be covered in the plan are: advanced activities at initial high temperature sites and in close proximity to base sites, and activities at other high temperature sites that are not colocated with operating bases.

WBS 3.1.8 Management

3.1.8.1 Planning and Coordination

This task will develop project objectives, finalize work breakdown structure, acquire necessary resources, schedule work and assure that schedules and fiscal constraints are met. The plan will be revised as necessary to keep it current.

3.1.8.2 Data Management and Dissemination

This task will assure that report and briefing schedules are met and that data is distributed to both other project teams and the commercial sector as appropriate.

PHASE I GEOTHERMAL ASSESSMENT TASK AND MILESTONE SCHEDULE

The milestone schedule for Phase I of the Geothermal Assessment Task reflects the deliverables required by the M-X/RES Project. This schedule is compatable with the schedule developed for the Geothermal Applications Development portion of the Task. The due dates are also compatable with those established for the solar and wind evalutions.

The timing of the several activities reflects the need for early confirmation at one or more of the Initial High-Temperature Sites since these are the sites that have the highest probability of providing electrical power to the M-X system. Exploration and reservoir confirmation in the vicinity of the Operating Base sites is also a high priority activity. Reconnaissance exploration for this effort is scheduled to start in January, 1981 and will be run simultaneously with activities at the initial high-temperature sites. As mentioned previously, this work can be expedited by preservation of and temperature measurements in holes now being drilled by Fugro National at the candidate OB Sites, and by use of data previously collected by Fugro as part of the M-X site evaluation.

Exploration and confirmation at Other High-Temperature Sites will utilize present DOE contractors during its initial phases, but when evidence of a high-temperature geothermal system is found, efforts will be made to get private industry involved. In Utah these activities are scheduled to begin after emphasis is first placed on exploration around the Milford, Beryl, and Delta candidate OB Sites, where geothermal manifestations are known to occur. In Nevada no geothermal manifestations are known near either the Coyote/Kane

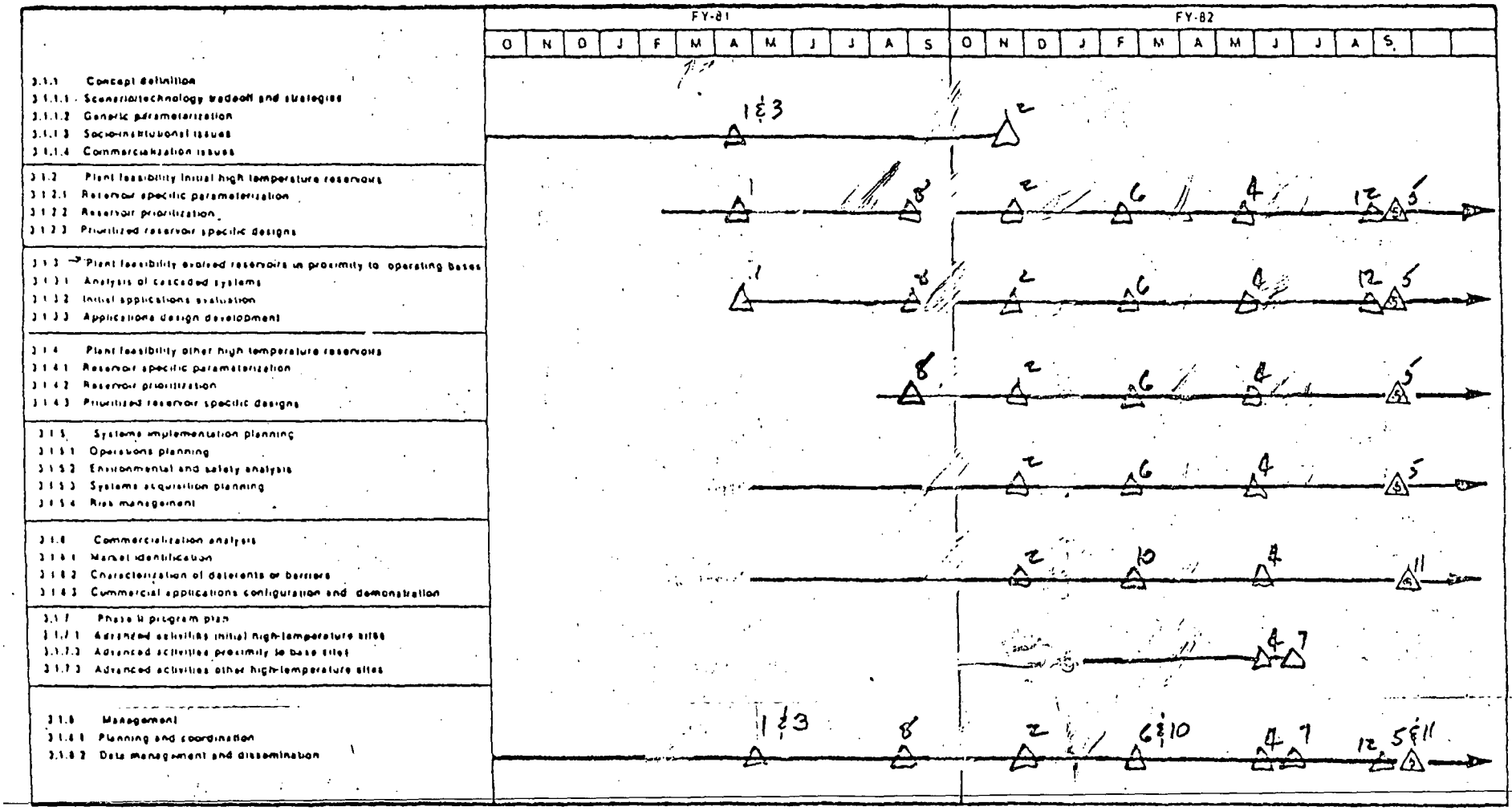
or Ely candidate OB Sites, so that exploration at these sites will likely be concluded sooner and exploration for other high-temperature sites can begin earlier.

PHASE I GEOTHER

WBS No.	TASK	D	J
2.3.1	INITIAL HIGH-TEMP SITES		
2.3.1.1	STRATEGY		
2.3.1.2	DETAILED EXPLORATION		
2.3.1.3	COST-SHARED CONFIRMATION D&T		
2.3.1.4	SITE EVALUATION		
2.3.2	EXPL/CONF-O.B. SITES		
2.3.2.1	STRATEGY		
2.3.2.2	RECONNAISSANCE EXPLORATION		
2.3.2.3	DETAILED EXPLORATION		
2.3.2.4	CONF. DRILLING-LOW TO INTERMEDIATE-T SITES		
2.3.2.5	COST-SHARED CONF. D&T-HIGH-TEMP. SITES		
2.3.2.6	SITE EVALUATION		
2.3.3	EXPL/CONF-OTHER HIGH-TEMP. SITES		
2.3.3.1	STRATEGY		
2.3.3.2	RECONNAISSANCE EXPLORATION		
2.3.3.3	DETAILED EXPLORATION		
2.3.3.4	PREPARE FOR COST-SHARED CONF. D&T		
2.3.3.5	SITE EVALUATION		
2.3.4	PHASE II TASK PLAN		
2.3.4.1	ADVANCED STUDIES-INITIAL HIGH-TEMP SITES		
2.3.4.2	ADVANCED STUDIES-O.B. SITES		
2.3.4.3	ADVANCED STUDIES-OTHER HIGH-TEMP. SITES		
2.3.5	MANAGEMENT		
2.3.5.1	PLANNING & COORDINATION		
2.3.5.2	DATA MANAGEMENT & DISSEMINATION		

1/ Strategy Presentation For Integrated Systems Analysis
2/ Preliminary Task Briefing
3/ Delivery Of Reservoir Data - Path 1
4/ Detailed Task Briefing
5/ Final Report
6/ Preliminary Assessment Report
7/ Phase II Task Plan
8/ Interim Assessment and Plant Feasibility Report
9/ Delivery Of Reservoir Data - Status For Paths 2 and 3, Update Pa

Geothermal Applications Development Milestone Chart



Milestones

1. - Strategy presentation for integrated systems analysis to Aerospace, Inc.
2. - Preliminary task briefing to MX-RES project office
3. - ~~Survey of evolving reservoir sites~~ Initial Applications Complete
4. - Detailed task briefing
5. - Final report (draft)
6. - Preliminary ~~assessment report~~ applications development report
7. - Phase II task plan
8. - ~~Interim commercialization report~~ Plant feasibility report
9. - ~~Final commercialization report~~
10. - Interim ~~report on plant feasibility studies~~ commercialization report
11. - ~~Reservoir specific specifications~~ Final commercialization report
12. Reservoir specific system specifications

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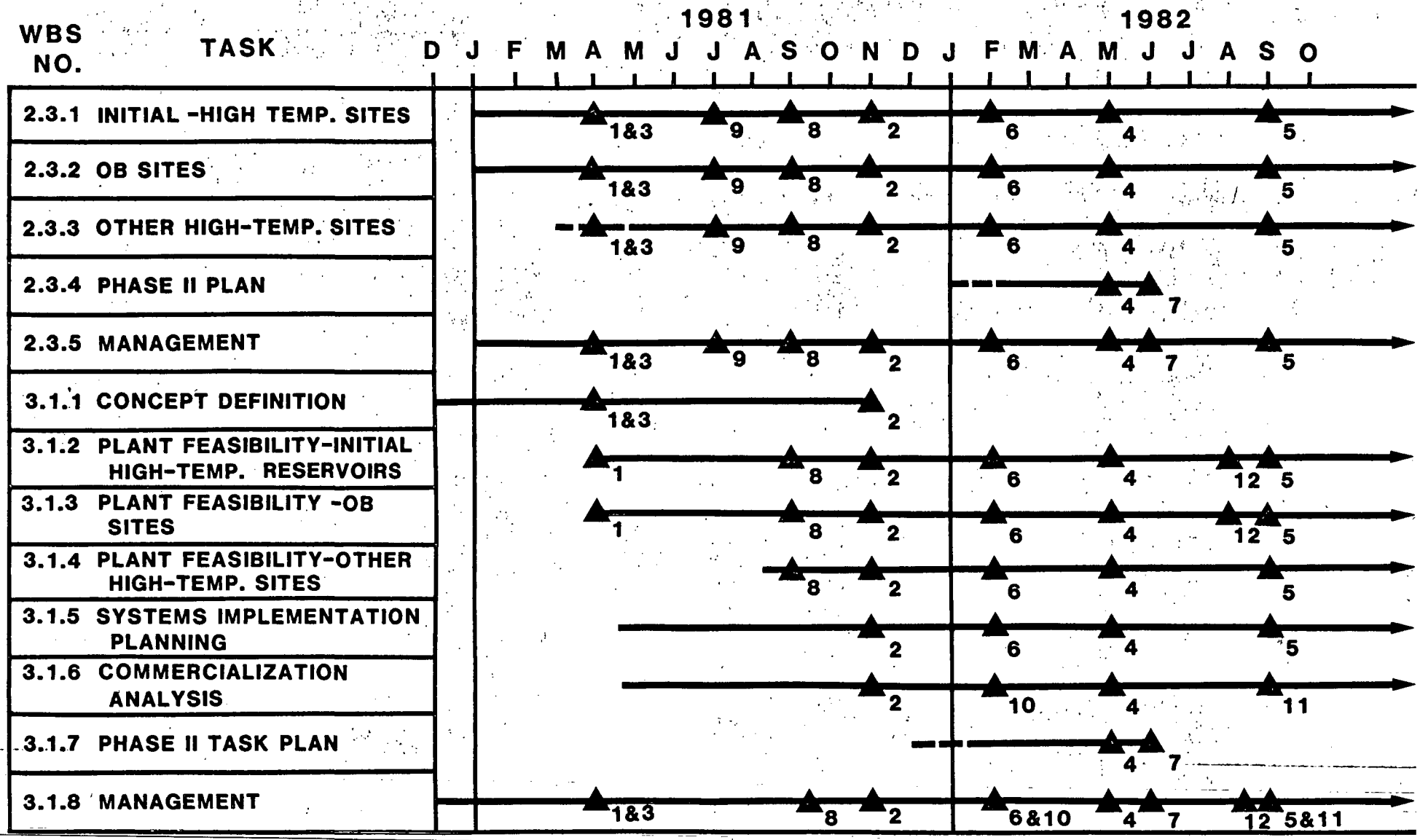
MASTER SCHEDULE AND

EXPENDITURES SECTION

MASTER SCHEDULE



MILESTONES

1/ Strategy Presentation For Integrated Systems Analysis
2/ Preliminary Task Briefing
3/ Delivery Of Path I Reservoir Data & Initial Applications Concepts
4/ Detailed Task Briefing
5/ Final Report - Draft
6/ Preliminary Assessment & Applications Development Report
7/ Phase II Task Plan
8/ Interim Assessment & Plant Feasibility Report
9/ Delivery Of Reservoir Data (Path 2 & 3)
10/ Interim Commercialization Report
11/ Final Commercialization Report
12/ Reservoir Specific System Specifications

CONCENTRATED ACTIVITY

PHASING IN & OUT AS APPROPRIATE

MX-027a
Rev. 1/81

FY 1981 EXPENDITURE PLAN

This chart identifies planned expenditure by contractor and WBS element during FY 1981. It assumes the initial availability of cost and obligational authority equal to or exceeding that requested by memorandum dated 27 October 1980 (A. J. Roberts to R. A. Gray - titled Near-Term Funding Requirement/MX Geothermal Assessment and Applications Task).

Contained within the estimates for UGMS and MMRI is funding to drill a combined total of forty 500-feet deep holes to assess the temperature gradients at sites in proximity to the candidate Operating Base locations and at several potential Other High-Temperature Sites. Additionally, allowance has been made for the initiation of several 1500-feet deep holes to analyze the stratigraphy of potential geothermal sites identified as a result of the gradient hole drilling.

As identified earlier, a major activity in resource verification is deep well drilling. Present estimates indicate that the drilling and testing of one 6,000-feet deep geothermal well results in the expenditure of from $1.25 million to $1.5 million. Past experience in sharing drilling and testing costs with industry indicates that they might be induced to incur as much as 40% to 50% of the cost. This experience implies that planned FY 1981 funding will provide for as few as one or two deep holes, a circumstance determined to be quite inadequate as discussed further below.

The parallel approach of investigation planned for the task provides for simultaneous concentration on three regions of potential geothermal resource as detailed previously. This multipath approach was chosen to increase the likelihood of successful identification by June 1982 of resources that would generate electrical power of significant proportions in relation to M-X System requirements. It would be quite reasonable to plan for the drilling of wells associated with each of the investigative paths.

Funding for drilling of one to two deep holes does not allow complete support of the multipath approach. An alternative solution to this problem could of course be the provision of additional funding in FY 1981.

Please note at the bottom of the chart that both the DOE field offices and DOE/DGE are planning the use of Task funding for travel and per diem expenditures.

FY 1981 EXPENDITURE PLAN

MX GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT PLAN

($000's)

WBS ELEMENT	DOE/ID CONTRACTORS ESL	EG&G	UGMS	DOE/NV CONTRACTORS MMRI	COST-SHARED DRILLING	INITIAL ELEC FEAS	FY 1981 TOTAL
2.3 GEOTHERMAL ASSESSMENT	660	75	1280	1270	1425		4760
2.3.1 INITIAL HI TEMP SITES	315	25	-	-	750	-	1090
2.3.2 OPERATING BASE SITES	135	25	715	636	250	-	1761
2.3.3 OTHER HI TEMP SITES	130	25	547	608	475	-	1785
2.3.4 PHASE II TASK PLAN	30	-	-	-	-	-	30
2.3.5 MANAGEMENT	50	-	18	26	-	-	94
3.1 APPLICATIONS DEVELOPMENT	200	665	-	-	-	350	1215
3.1.1 CONCEPT DEFINITION	-	225	-	-	-	-	225
3.1.2 PLANT FEAS - INIT HI TEMP SITES	-	60	-	-	-	350	410
3.1.3 PLANT FEAS - O/B SITES	-	38	-	-	-	-	38
3.1.4 PLANT FEAS - OTH HI TEMP SITES	-	22	-	-	-	-	22
3.1.5 SYST IMPLEMENT PLANNING	200	108	-	-	-	-	308
3.1.6 COMMERCIALIZATION ANALYSIS	-	86	-	-	-	-	86
3.1.7 PHASE II TASK PLAN	-	-	-	-	-	-	-
3.1.8 MANAGEMENT	-	126	-	-	-	-	126
SUBTOTAL	860	740	1280	1270	1500	350	5975
FIELD OFFICE TRAVEL & PER DIEM	-	-	8	-	-	8	16
DOE/DGE TRAVEL & PER DIEM	-	-	-	-	-	-	9
TOTAL							6,000

FY 1982 EXPENDITURE PLAN

Planned FY 1982 expenditures by contractor and WBS element are identified on this chart. The plan provides for continuity of the preceding year's exploration and confirmation and an escalation in drilling and applications development activities. Plans anticipate the performance of several site specific conceptual designs relating to electric power generation from identified reservoirs. Current estmates indicate that such efforts would require approximately $800K per site. EG&G's plan carries the funding for these activities in each of the three paths of approach. The division of this effort along each of the paths may not be supported by resource identification and therefore is at this time only representative of the possibility of provision of electricity from utility and/or DOD-owned generating plants located near an operating base as well as in the deployment area.

Estimates for cost-shared deep drilling allow from four to six holes to be completed in FY 1982. This would be an aggregate of five to eight deep wells, provided that all were performed on a cost-shared basis with industry. Difficulties in obtaining the participation of industry would result in a reduction in the number of holes that could be drilled and hence the number of sites for whch reservoir analysis could take place. Drilling estimates have been distributed among the three paths of approach for consistency with the applications developent funding.

FY 1982 EXPENDITURE PLAN

MX GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT PLAN

($000's)

WBS ELEMENT	DOE/ID CONTRACTORS ESL	DOE/ID CONTRACTORS EG&G	DOE/ID CONTRACTORS UGMS	DOE/NV CONTRACTORS MMRI	DOE/NV CONTRACTORS COST-SHARED DRILLING	DOE/NV CONTRACTORS INITIAL ELEC FEAS	FY 1982 TOTAL
2.3 GEOTHERMAL ASSESSMENT	850	0	1200	1200	4400		7650
2.3.1 INITIAL HI TEMP SITES	200	-	0	0	1600	-	1800
2.3.2 OPERATING BASE SITES	350	-	550	350	800	-	2050
2.3.3 OTHER HI TEMP SITES	200	-	580	775	2000	-	3555
2.3.4 PHASE II TASK PLAN	50	-	50	50	-	-	150
2.3.5 MANAGEMENT	50	-	20	25	-	-	95
3.1 APPLICATIONS DEVELOPMENT	200	3120	0	0	-	-	3320
3.1.1 CONCEPT DEFINITION	-	50	-	-	-	-	50
3.1.2 PLANT FEAS - INIT HI TEMP SITES	-	800	-	-	-	-	800
3.1.3 PLANT FEAS - O/B SITES	-	1000	-	-	-	-	1000
3.1.4 PLANT FEAS - OTH HI TEMP SITES	-	800	-	-	-	-	800
3.1.5 SYST IMPLEMENTATION PLANNING	100	170	-	-	-	-	270
3.1.6 COMMERCIALIZATION ANALYSIS	100	100	-	-	-	-	200
3.1.7 PHASE II TASK PLAN	-	50	-	-	-	-	50
3.1.8 MANGAGEMENT	-	150	-	-	-	-	150
SUBTOTAL	1050	3120	1200	1200	4400	-	10970
FIELD OFFICE TRAVEL & PER DIEM	-	-	-	-	-	-	20
DOE/DGE TRAVEL & PER DIEM	-	-	-	-	-	-	10
TOTAL							11,000

PROPOSED FUNDING REVISION

This chart proposes a revision in planned fiscal year funding for FY 198 and FY 1982. The inadequacy of FY 1981 funding for drilling has been previously indicated. While funding during the total three year period appears adequate as of this stage of planning, it would be desirable to shift approximately $2,000K in funding from FY 1982 to FY 1981 for use in deep well drilling.

Since completion of the drilling and testing of as many as four or five wells in FY 1981 is somewhat unlikely, the funding revision request is an over simplification of a requirement for more obligating authority (B/A). Sufficient B/A would be needed to enter into contracts for that drilling, but quite likely cost authority (B/O) of the same magnitude would not be needed.

PROPOSED FUNDING REVISION
M-X GEOTHERMAL ASSESSMENT AND APPLICATIONS DEVELOPMENT TASK
($000)

WBS ELEMENT	PLANNED FUNDING			PROPOSED REVISED FUNDING		
	FY 1981	FY 1982	FY 1983	FY 1981	FY 1982	FY 1983
2.3 GEOTHERMAL ASSESSMENT	4760	7650	4010	6760	5650	4010
3.1 APPLICATIONS DEVELOPMENT	1215	3320	4960	1215	3320	4960
DOE TRAVEL	25	30	30	25	30	30
TOTALS	6,000	11,000	9,000	8,000	9,000	9,000

MX-083

GLOSSARY OF TERMS

BINARY PLANT - A plant in which the vapor of a secondary working fluid, such as an organic solvent is used to generate electricity and heat for vaporizing the secondary fluids provided by geothermal fluids.

CASCADING - Using the same geothermal fluid successively in more than one application.

CONFIRMATION DRILLING - Drilling in a geothermal resource area for purposes of establishing the occurrence of thermal fluids sufficient in temperature, quality and quantity for economic application.

CONFIRMED RESERVOIR - A discovery site at which drilling and flow testing have proven a sufficient resource to support economic use.

CONVECTIVE HYDROTHERMAL SYSTEM - A geothermal system in which there is heating and convection of naturally occurring fluids.

DISCOVERY - A site at which a successful well has been drilled and flow tested.

DISCOVERY HOLE - An exploration hole that intersects fluids of sufficient temperature and flow rate to suggest an economic resource.

EXPLORATION - Use of geology, geochemistry, geophysics, hydrology, and drilling for resource discovery (reconnaissance, detailed).

EXPLORATORY DRILLING - Drilling in a prospective geothermal resource area primarily for geologic information that bears on the nature of the resource.

FLASHED STEAM PLANT - Plant in which generators are powered by steam formed (flashed) directly from high temperature geothermal water.

GEOTHERMAL APPLICATIONS - Use of the energy in geothermal fluids produced from a geothermal reservoir.

GEOTHERMAL ASSSESSMENT - Exploration, drilling, flow testing and reservoir engineering activities designed to discover, confirm and obtain production from a geothermal reservoir.

GEOTHERMAL ENERGY - Natural heat from the earth.

GEOTHERMAL OCCURRENCE - A documented expression of the existance of a geothermal system such as a hot spring or a well containing warm water.

GEOTHERMAL PROSPECT - A site that has geothermal indications such as a thermal spring or well, favorable chemical geothermometers, anamolous geothermal graident or heat flow, or favorable geology.

GEOTHERMAL RESOURCES - Stored heat in the earth, both identified and undiscovered, that is recoverable using current or near-current technology, regardless of cost.

GEOTHERMAL RESOURCE TEMPERATURES -

LOW-TEMPERATURE GOETHERMAL RESOURCE - A geothermal resource whose temperature is in the range ($5^{o}C$ above mean ambient air temperature $\leq$ 90^{o}).

INTERMEDIATE-TEMPERATURE GOETHERMAL RESOURCE - A geothermal resource whose temperature is in the range ($90^{o}C \leq T \leq 150^{o}C$).

HIGH-TEMPERATURE GEOTHERMAL RESOURCE - A geothermal resource whose temperature is ($T > 150^{o}C$).

HYBRID SYSTEM - An application where part of the energy is geothermal and part is from another source such as coal or solar.

KNOWN GEOTHERMAL RESOURCE AREA (KGRA) - An area legally designated by the U.S. Geological Survey to be of interest and have high potential for development of geothermal resources, especially high temperature resources.

MWe - Megawatts of electrical energy.

MWt - Megawatts of thermal energy.

LIQUID DOMINATED - Geothermal reservoir which contains liquid as the dominant fluid. Temperatures may be in excess of $300^{o}C$.

PRODUCTION DRILLING - Drilling of geothermal wells in a confirmed reservoir for purposes of developing geothermal fluids in sufficient quantity for application. This usually requires large diameter wells (7-12") that have been fitted with appropriate well head equipment and liners.

REINJECTION - Returning of the geothermal fluids to the reservoir after their use in electrical power generation or beneficial heating.

RESOURCE ASSESSMENT - Geoscientific work including exploratory drilling done for the purpose of (1) determining the nature of a particular geothermal reservoir, (2) the best sites for drill testing, and (3) defining reservoir parameters.

RESERVOIR ASSESSMENT - Application of reservoir engineering techniques for analyzing flow test data and determining fluid temperature, producibility, fluid quality and reservoir life.

RESERVOIR ENGINEERING - Prediciton of reservoir temperature, production scenario and lifetime, based on analysis of temperature, pressure and flow rate data obtained during flow testing.

VAPOR DOMINATED - Geothermal reservoir which contains steam as the dominant fluid. Temperatures are typically around $240^{o}C$.