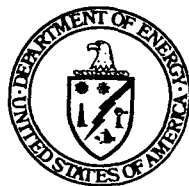


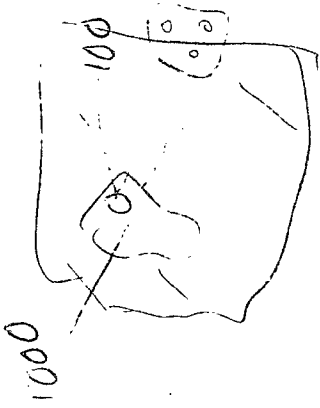
U. S.
DEPARTMENT OF ENERGY
DIVISION OF GEOTHERMAL ENERGY

STATE COUPLED PROGRAM

Future Forecasting



620079
B620079



STATE COUPLED PROGRAM

PURPOSE

- **TO COLLECT AND PUBLISH REGIONAL
AND AREAL GEOTHERMAL RESOURCE DATA**

JUSTIFICATION

- **TO FACILITATE SELECTION OF HIGH-QUALITY
SITES FOR FURTHER EXPLORATION BY
USERS AND DEVELOPERS**



STATE COUPLED PROGRAM

**BASIC COMPONENT OF
HYDROTHERMAL DIRECT
APPLICATIONS PROGRAM**



GOAL OF DIRECT APPLICATIONS PROGRAM

**TO STIMULATE COMMERCIAL USE OF A
VERY LARGE ENERGY RESERVE**



Today's Energy Picture in the U.S.

- 1) The U.S. Produces Only 3/4 of the Energy it Consumes.**
- 2) Approximately 1/2 of our Oil comes from Foreign Sources.
Many of these Sources have Unstable Governments.**
- 3) The Amount of Money being Spent in Foreign Markets has
a Detrimental Effect on U.S. Economy.**
- 4) Capital Costs Required to Develop and Utilize Alternate
Energy Sources are Very High.**
- 5) Energy Use Forecasts for the Year 2000 and Beyond
Indicate that all Feasible Alternative Energy Sources Plus
Conservation Measures will be Needed.**

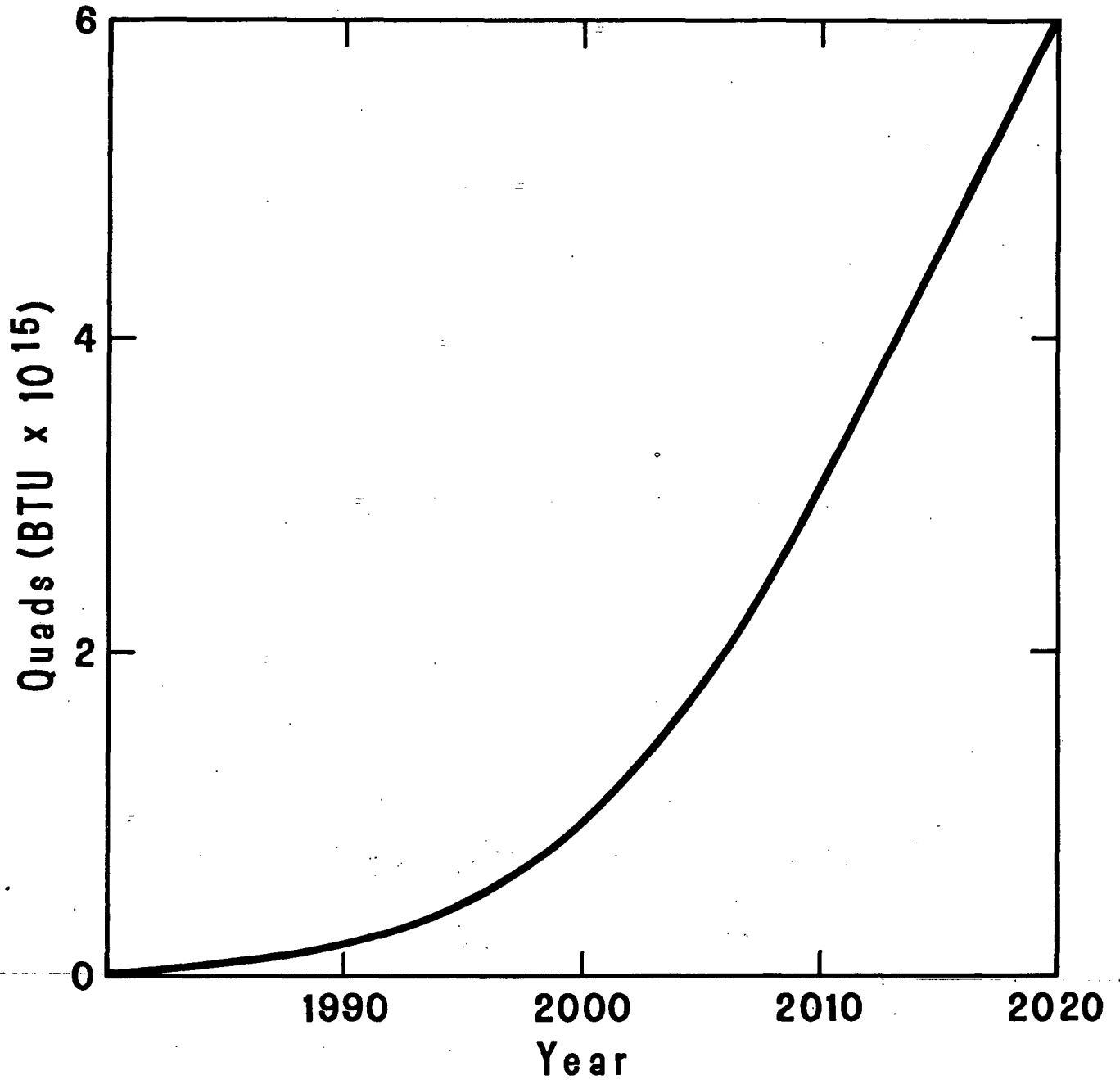
DOE GOAL FOR COMMERCIALIZATION OF GEOHERMAL DIRECT HEAT

| | <u>1985</u> | <u>2000</u> | <u>2020</u> |
|--------------------|----------------------|-----------------------|------------------------|
| GOAL | 0.1 Q/yr | 1.0 Q/yr | 6.0 Q/yr |
| PETROLEUM SAVED | 18 Million bbl/yr | 180 Million bbl/yr | 1080 million bbl/yr |

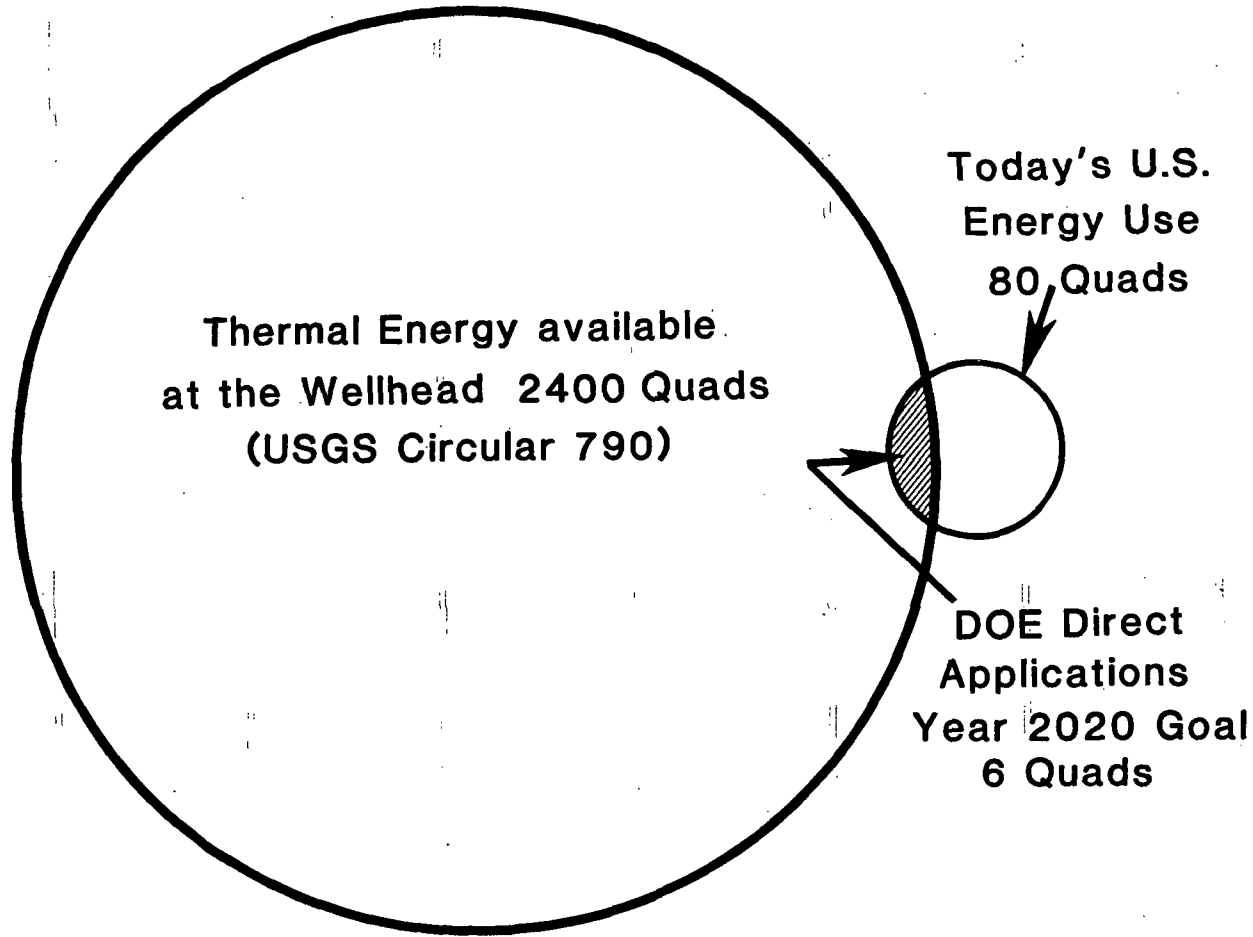
Today's U.S. Energy Use \cong 80 Quads/yr



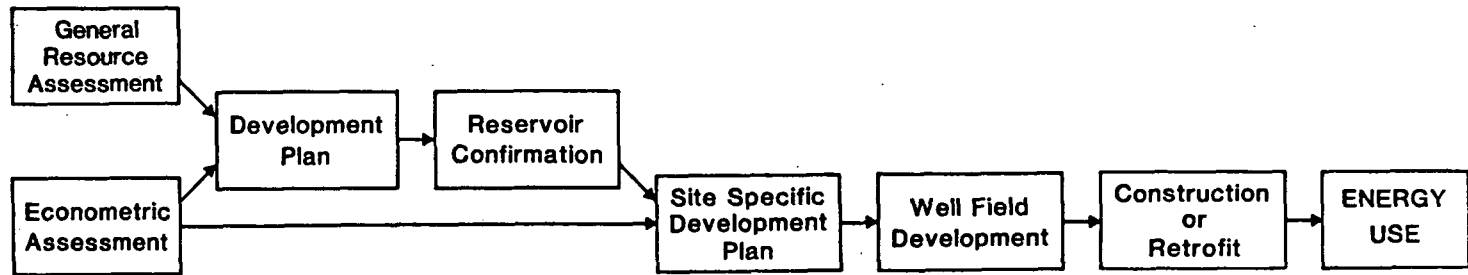
GOALS DIRECT ENERGY USE



Stimulate Commercial Use of A Very Large Energy Reserve



COMMERCIALIZATION SEQUENCE

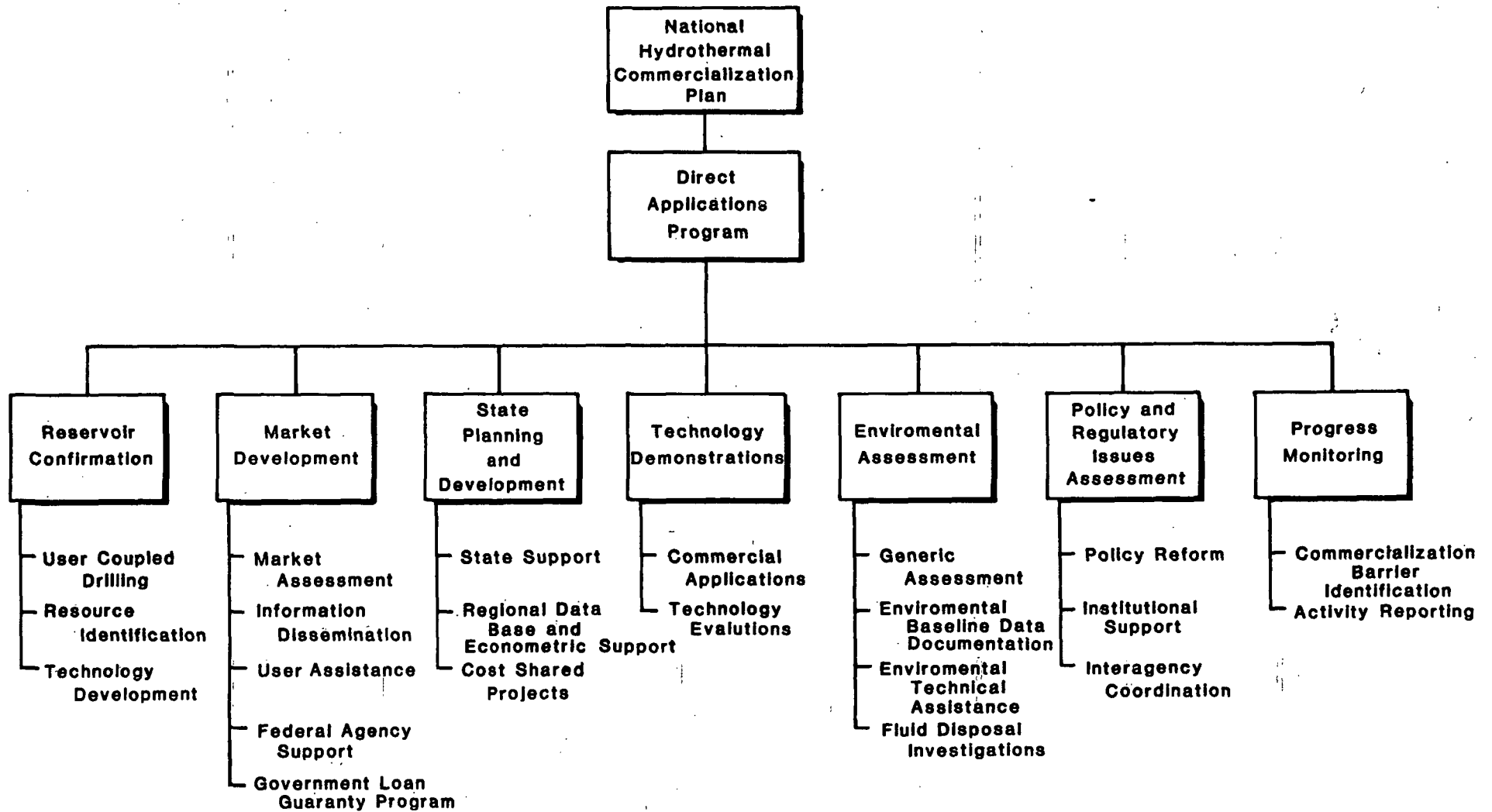


MAJOR BARRIERS TO COMMERCIALIZATION

- **Lack of defined resources**
- **Lack of an established industry**
- **Limited technical and economic data**
- **Policy and regulatory confusion**
- **Environmental impact uncertainties**



DOE PROGRAM WORK ELEMENTS



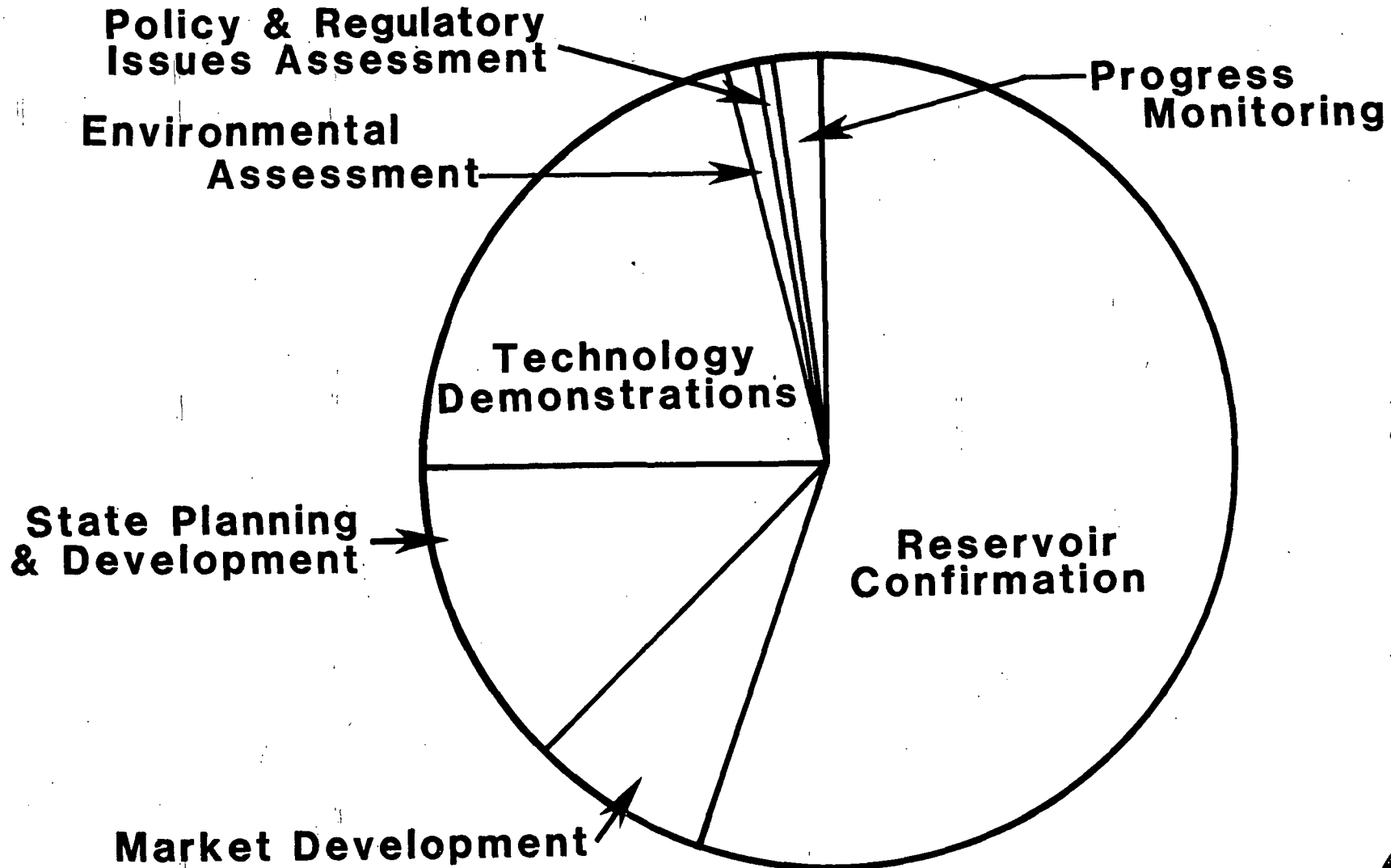
PROGRAM DEVELOPMENT MATRIX

| Barriers → Program Elements | Lack of Defined Resources | Lack of an Established Industry | Limited Technical Data | Policy and Regulatory Confusion | Environmental Impact Uncertainties |
|---|---------------------------|---------------------------------|------------------------|---------------------------------|------------------------------------|
| • Reservoir Confirmation | XX | XX | XX | X | X |
| • Market Development | | XX | X | | |
| • State Planning and Development | X | XX | X | XX | X |
| • Technology Demonstrations | | XX | XX | X | X |
| • Environmental Assessment | | X | X | XX | XX |
| • Policy and Regulatory Issues Assessment | | X | X | XX | X |
| • Progress Monitoring | X | X | X | X | X |

XX Primary Impact **X** Secondary Impact

BUDGET ALLOCATION

(FY 81 PROPOSED)



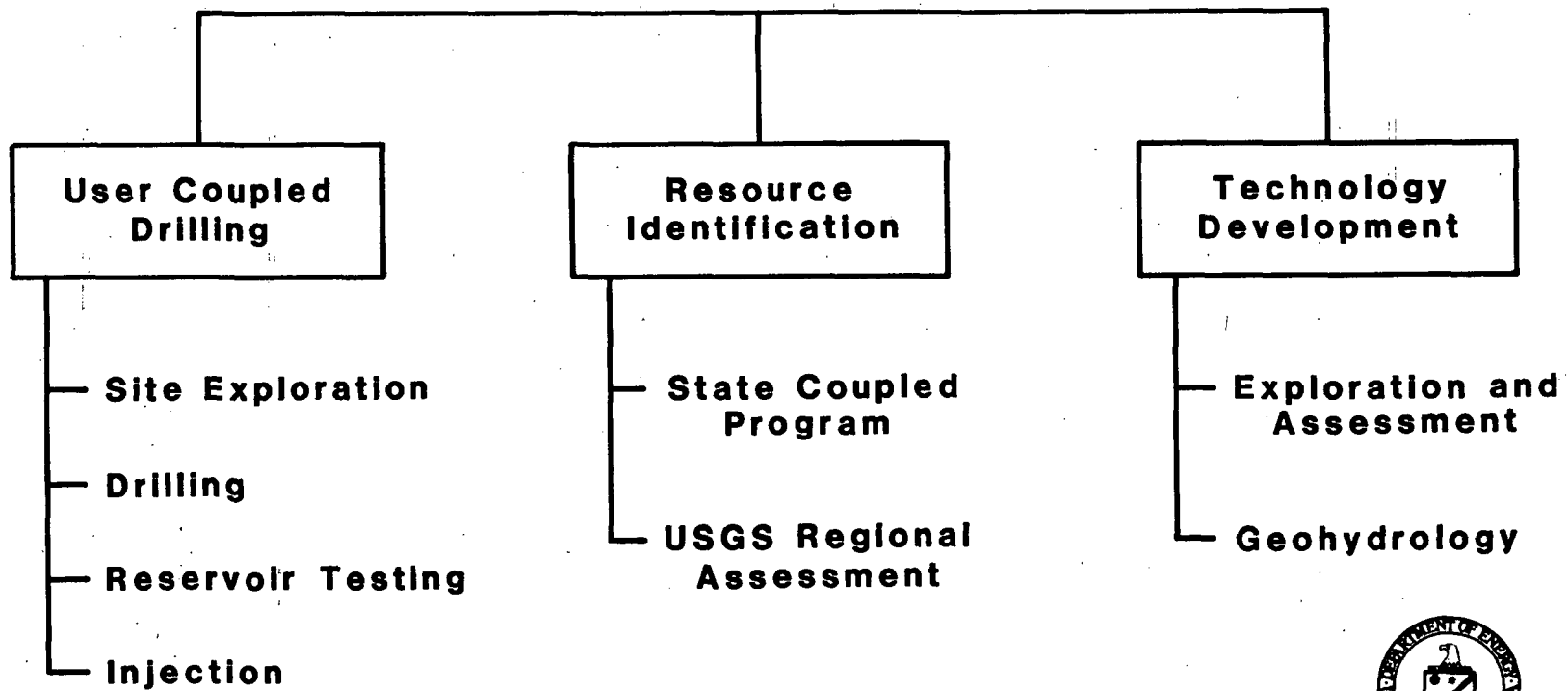
STATE COUPLED PROGRAM

AND PRODUCT
A GOAL-ORIENTED PROGRAM TO
COLLECT AND PUBLISH REGIONAL
AND AREAL GEOTHERMAL DATA

- TO ASSIST USGS IN RESOURCE
INVENTORY (Circular 790 Update)
- TO ENCOURAGE DEVELOPMENT BY
PROSPECTIVE USERS



RESERVOIR CONFIRMATION

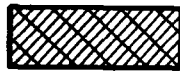
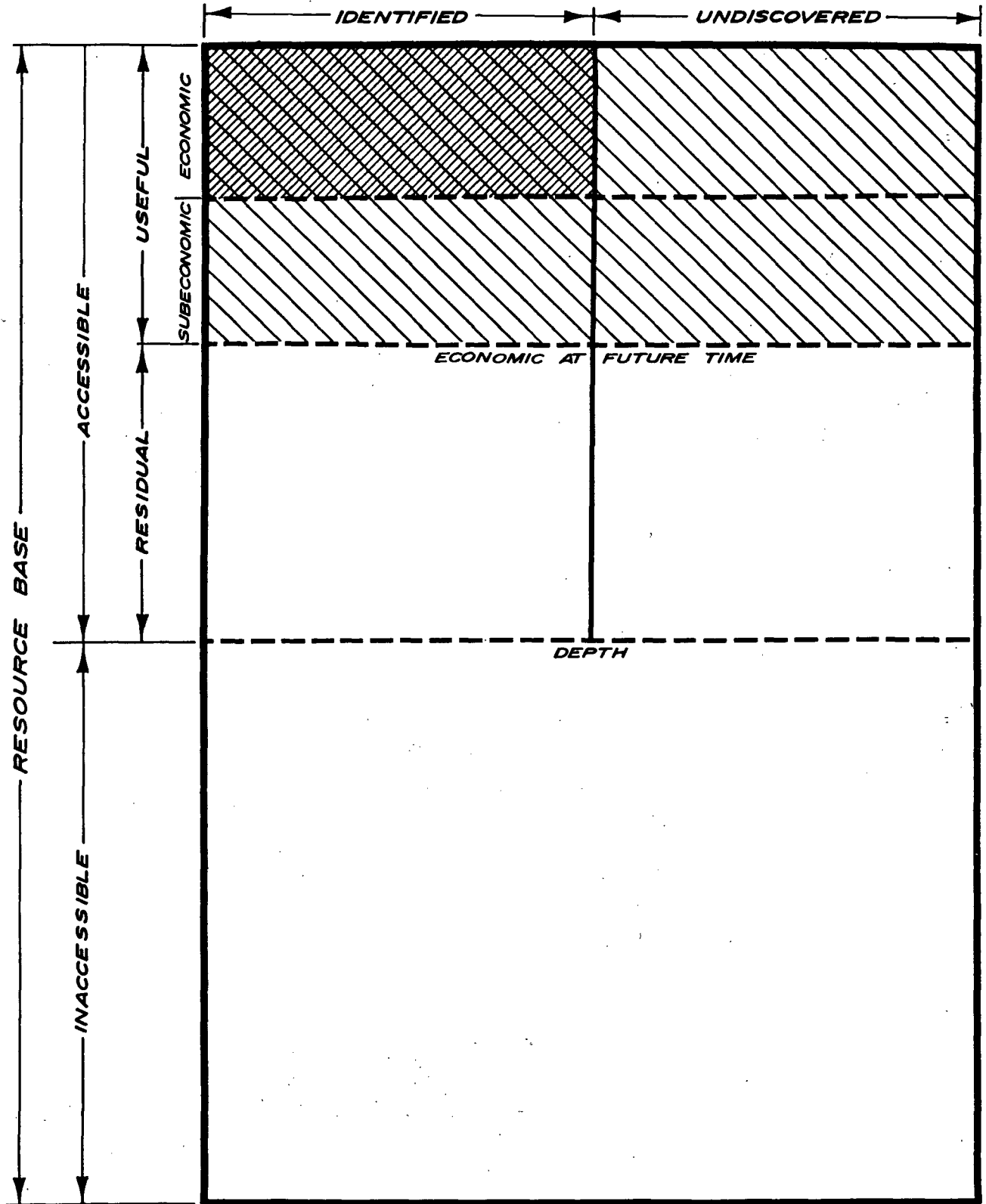


WHAT IS A GEOTHERMAL RESOURCE

**FLUIDS ABOVE MEAN SHALLOW GROUNDWATER
TEMPERATURE**

- FLUIDS DOWN TO GROUNDWATER TEMPERATURE
ARE USEFUL**
- THE HOTTER THE BETTER**

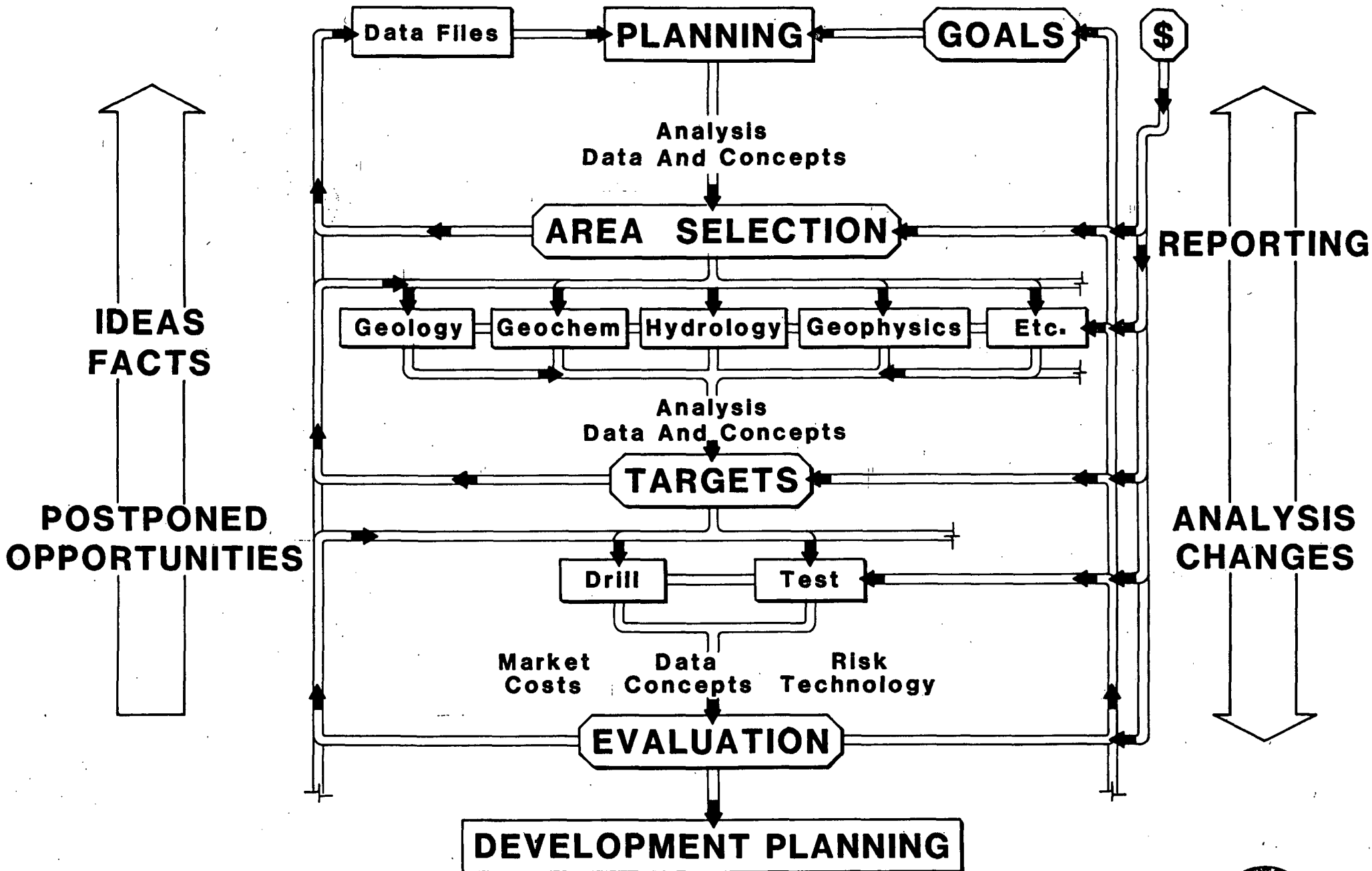




RESERVE

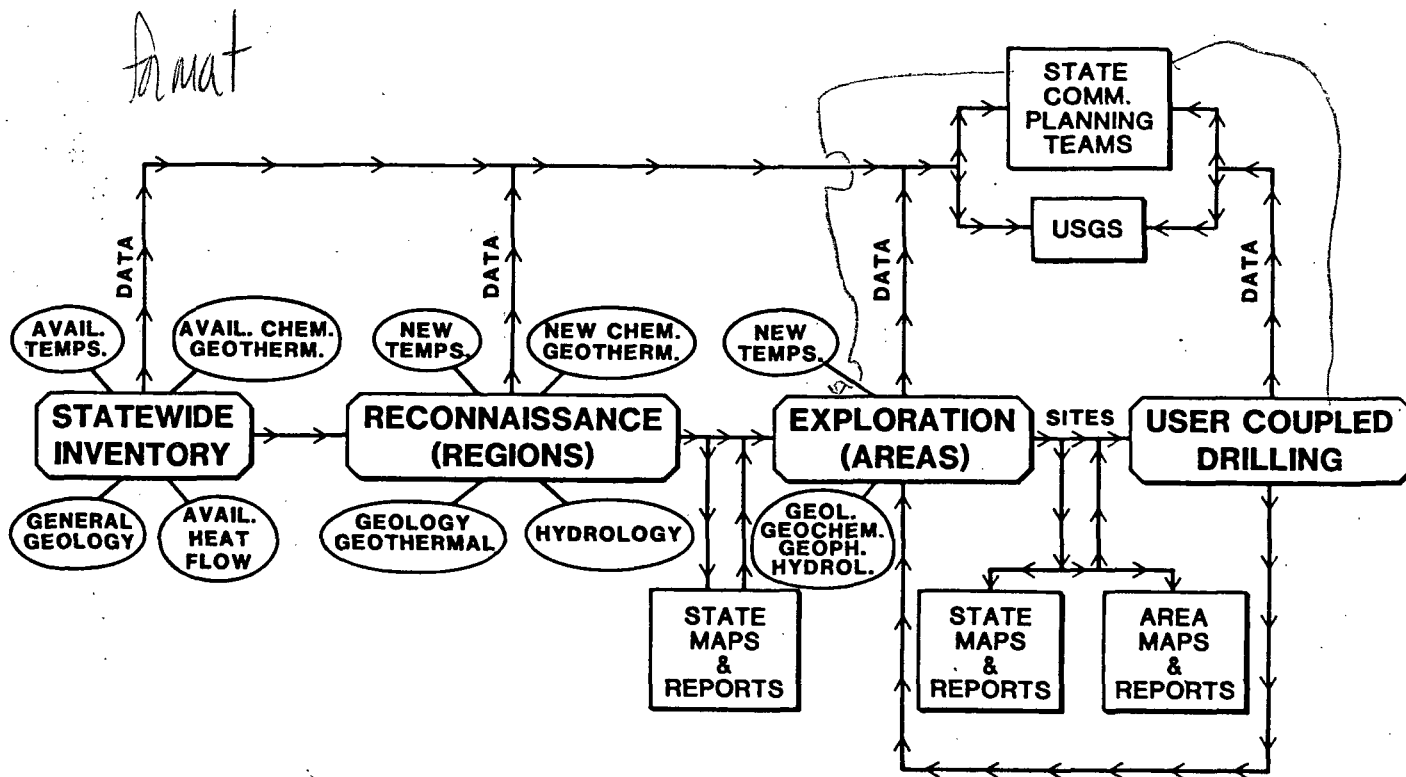


RESOURCE



STATE COUPLED PROGRAM

add planning teams



EXPLORATION STAGES

- STATEWIDE INVENTORY
 - RECONNAISSANCE 1,000-
LARGE REGIONS 10,000 Sq. mi.
 - AREA EXPLORATION 100-
SELECTED AREAS 1,000 Sq. mi.
 - SITE EXPLORATION less than
SELECTED SITES 10 Sq. mi.
 - TEST AND PRODUCTION
WELL DRILLING
- STATE
COUPLED
PROGRAM
- USER
COUPLED
DRILLING
PROGRAM

STATEWIDE INVENTORY

PURPOSE - TO OBTAIN AN OVERVIEW OF RESOURCES

- **RECONNAISSANCE AREA SELECTION**
- **SETTING PRIORTIES**

METHODS - COMPILATION AND ANALYSIS OF AVAILABLE DATA

- **WELL AND SPRING TEMPERATURES**
- **HEAT FLOW**
- **CHEMICAL GEOTHERMOMETRY**
- **GEOLOGY**

**PRODUCTS - RECONNAISSANCE REGIONS DEFINED AND
PRIORITIZED**



RECONNAISSANCE

**PURPOSE – TO SELECT AREAS FOR MORE
DETAILED STUDY**

**METHODS – MEASUREMENT OF TEMPERATURE,
WATER QUALITY, PRODUCTIVITY
IN WELLS & SPRINGS**

(PRIORITY 1)

**– ANALYSIS OF ALL DATA TO LOCATE
GOOD GEOTHERMAL ENVIRONMENTS**

**PRODUCTS – PRELIMINARY STATE MAP & REPORT
– STUDY AREAS DEFINED & PRIORITIZED**

AREA EXPLORATION

PURPOSE - TO ENABLE USERS AND DEVELOPERS TO
SELECT SITES FOR DETAILED EXPLORATION
AND DRILLING

METHODS - DIRECT TEMPERATURE MEASUREMENT IN ALL
WELLS AND SPRINGS

(PRIORITY 1)

- APPLICATION OF INDIRECT EXPLORATION
METHODS

- GENERAL GEOLOGICAL & HYDROLOGICAL
CHARACTERIZATION OF RESOURCES

PRODUCTS - STATEWIDE MAP AND REPORT

- AREA MAPS AND REPORTS

- SITES LOCATED



DIRECT VS INDIRECT DETECTION

**DIRECT METHOD - TEMPERATURE MEASUREMENT
SPRINGS AND WELLS**

INDIRECT METHODS - HEAT FLOW STUDIES
- GRADIENT EXTRAPOLATION
- CHEMICAL GEOTHERMOMETRY
- GEOLOGIC MAPPING
- GEOPHYSICAL SURVEYS
- GEOCHEMICAL SURVEYS
- HYDROLOGIC STUDIES



DIRECT DETECTION OF THERMAL WATERS

(HIGH PRIORITY)

- NO COMPLETE DATA COMPILATION EXISTS**
- MANY REPORTED TEMPERATURES ARE INACCURATE**
- MANY WELLS LACK MEASURED TEMPERATURES**
- DIRECT DETECTION IS A QUICK AND INEXPENSIVE WAY TO LOCATE RESOURCE AREAS**



FINDING WELLS

State Geological Surveys

Advertise for
Thermal Wells in
Local Papers

State Water Divisions

State Oil &
Gas Commissions

Universities

Petroleum
Information Corp.

USGS - Water
Resources Div.
Computer File
WATSTOR

Industry Contracts

Agricultural Agencies

correct
spelling

TEMPERATURE VS HEAT FLOW

- **GEOHERMAL RESOURCES = ELEVATED TEMPERATURES**
- **HIGH HEAT FLOW DOES NOT ALWAYS MEAN HIGH TEMPERATURE**
- **HIGH TEMPERATURE DOES NOT ALWAYS MEAN HIGH HEAT FLOW**

Heat Flow = Thermal Conductivity x Temperature Gradient

$$Q = K \frac{\Delta T}{\Delta Z}$$

- **THEREFORE IN GEOHERMAL EXPLORATION**
 - **TEMPERATURE DATA ARE OF PRIMARY IMPORTANCE**
 - **HEAT FLOW DATA ARE OF SECONDARY IMPORTANCE**
- **SIMPLE TEMPERATURE DATA ARE QUICK AND INEXPENSIVE**
- **HEAT FLOW DATA ARE SLOW AND EXPENSIVE**



TEMPERATURE MEASUREMENT

- **BOTTOM HOLE TEMPERATURE TO NEAREST 1°C
0.1°C FOR GRADIENTS**
- **INSTRUMENTS MUST BE CALIBRATED**
- **PORTABILITY AND SIMPLICITY NECESSARY**
- **CAN BE DONE BY TECHNICIANS, STUDENTS**
- **GOOD FIELD NOTES A MUST**



PUBLIC MAPS

BASE DATA

◇ SPRING

○ WELL

RED > 50 °C

BLUE < 50 °C

| | |
|------|-------|
| TEMP | FLOW |
| TDS | DEPTH |

TOPO., DRAINAGE

CULTURE, POLITICAL BOUND.,

TOWNSHIP, RANGE, SECTION,

FOREST, WILDERNESS,

INDIAN, MILITARY

GEOHERMAL DATA

THERMAL SPRINGS AND WELLS

TEMP., FLOW, DEPTH, TDS

FAVORABLE AREAS

FEDERAL, STATE KGRAs

SQUIBS



SCIENTIFIC MAP DATA

BASE DATA - AS ON PUBLIC MAP

GEOHERMAL DATA - AS ON PUBLIC MAP

OTHER DATA SETS: (SHOPPING LIST)

HEAT FLOW

SPRING DEPOSITS

FAULTS/LINEMENTS

EARTHQUAKE EPICENTERS

Hg, As, U, S DEPOSITS/PROSPECTS

WATER QUALITY

AQUIFER PRODUCTIVITY

GEOCHEMICAL THERMOMETRY

HIGH T

MODERATE T

LOW T

**AREAS AND INTERPRETATIONS (INCLUDE BUT
DISTINGUISH POTENTIAL AREAS)**

IGNEOUS SYSTEMS

VOLCANIC CENTERS AND FLOWS (YOUNG)

THERMAL GRADIENTS

OTHER SELECTED GEOLOGY AND GEOPHYSICS

AREAS OF PRESENT USE

HEAT CONTENTS

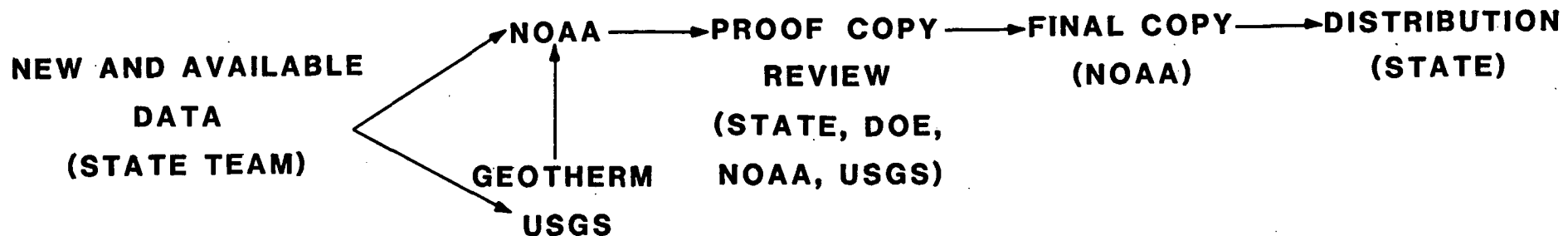
DEPTH TO RESOURCES

SQUIBS



MAP PRODUCTION

NOAA WILL HELP PREPARE MAPS



MAPS WILL BE PART OF STATE PUBLICATIONS



NOAA CAN HELP WITH

- **COMPUTER PLOTTING**
 - **LIMITED DIGITIZING**
- **MAP STANDARDIZATION**
 - **MAP PRODUCTION**
- **EDITORIAL ASSISTANCE**

**PLAN TO TAKE ADVANTAGE OF NOAA'S EXPERTISE
IT'S FREE**

REPORTS

NEEDS OF PROSPECTIVE USERS ARE PARAMOUNT

- **RESOURCE DESCRIPTION**

**LOCATION, TEMPERATURE, DEPTH,
WATER QUALITY, PRODUCTIVITY**

- **GEOLOGIC CHARACTERIZATION**

- **DISCOVERY POTENTIAL**

- **SOURCES OF FURTHER INFORMATION**

- **SUPPORTING SCIENTIFIC DATA**

PERIODIC REPORTS ALSO REQUIRED BY DOE



PROPOSALS

(SUGGESTED % EFFORT)

STATEWIDE INVENTORY

REGIONAL RECONNAISSANCE

AREA EXPLORATION

MAP PRODUCTION

REPORTING

USER ASSISTANCE

USGS INTERFACE

COMMERCIALIZATION PLANNING SUPPORT

DOE REQUESTS FOR DATA

| | YEAR | | | OUT-YEARS |
|---|-----------|-----------|-----------|-----------|
| | 1 | 2 | 3 | |
| STATEWIDE INVENTORY | 30 | 5 | 5 | 5 |
| REGIONAL RECONNAISSANCE | 25 | 25 | 10 | 5 |
| AREA EXPLORATION | 5 | 20 | 20 | 25 |
| MAP PRODUCTION | 10 | 10 | 10 | 5 |
| REPORTING | 5 | 5 | 10 | 5 |
| USER ASSISTANCE | 5 | 10 | 25 | 35 |
| USGS INTERFACE | 10 | 10 | 5 | 5 |
| COMMERCIALIZATION PLANNING SUPPORT | 5 | 10 | 10 | 10 |
| DOE REQUESTS FOR DATA | 5 | 5 | 5 | 5 |

PROGRAM PARTICIPANTS

DOE - HEADQUARTERS (WASHINGTON)

Program Planning, Guidance, Priorities

DOE - OPERATIONS OFFICES

Program Implementation, Contracting, Management

STATE CONTRACTORS

Performance of State Project

UNIVERSITY OF UTAH RESEARCH INSTITUTE (UURI)

LOS ALAMOS SCIENTIFIC LABORATORY (LASL)

GRUY FEDERAL

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY (VPI)

Management Assist. to DOE, Exploration, and Tech. Dev.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

Publishing State Resource Maps

U.S. GEOLOGIC SURVEY (USGS)

U.S. Resource Assessment and Computer Storage

Move slide up
in order?



COMPANION PROGRAMS

- COMMERCIALIZATION PLANNING
- USER COUPLED DRILLING
PONS+PRDAS
- USER ASSISTANCE
- USGS REGIONAL ASSESSMENT



GEOHERMAL COMMERCIALIZATION PLANNING

PURPOSE

**TO ASSIST STATES IN DEVELOPMENT OF
INDIGENOUS GEOHERMAL PLANNING AND
PROJECT IMPLEMENTATION**

STATE CP TEAMS

- **COMMERCIALIZATION PLANNING TEAM IN EACH STATE**
 - STATE EMPLOYEES, FEDERAL FUNDS
- **DOE FUNDING REMOVED IN STAGES AS STATE FUNDING TAKES OVER**
- **TEAMS DEVELOP AND COMMUNICATE:**
 - STATEWIDE DEVELOPMENT PLANS
 - SITE SPECIFIC DEVELOPMENT PLANS
 - ECONOMIC PLANNING CAPABILITY
 - TECHNICAL ASSISTANCE CAPABILITY
 - INFORMATION PROGRAMS



SUPPORT FOR COMMERCIALIZATION PLANNING

- **STATE RESOURCE TEAM**
 - **FURNISHES DATA TO CP TEAM**
- **NEW MEXICO ENERGY INSTITUTE (NMEI)**
 - **ECONOMIC MODELS, AGGREGATE REGIONAL DATA BASE**
- **EG&G, OREG. INSTITUTE TECH. (OIT), WESTERN ENERGY PLANNERS**
 - **ENGINEERING SUPPORT, MANAGEMENT ASSISTANCE**



USER COUPLED DRILLING PROGRAM

- OBJECTIVES** - TO DEVELOP INFRASTRUCTURE IN PRIVATE SECTOR
- TO DEMONSTRATE VIABILITY OF DIRECT HEAT

JUSTIFICATION - DEVELOPMENT LAGS BECAUSE OF:

LACK OF RESOURCE KNOWLEDGE: RESERVOIR LIMITS, DEPTH,
TEMPERATURE, PRODUCTIVITY, LONGEVITY

INABILITY OF SMALL DEVELOPERS TO SPREAD HIGH RISKS
AND COSTS

GOAL - TO FOSTER INFRASTRUCTURE CAPABLE OF DEVELOPING 2300
MWt-YR/YR



GEOHERMAL COMMERCIALIZATION

- **EXPLORATION NEEDED AT 500 SITES PER YEAR TO REACH YEAR 2000 GOAL OF 1 QUAD**
- **DEVELOPMENT OF THIS MAGNITUDE REQUIRES PRIVATE SECTOR PARTICIPATION**
- **WIDESPREAD DIRECT APPLICATION REQUIRES FAVORABLE ECONOMICS**



USGS GEOHERMAL RESEARCH PROGRAM

(FY 80)

- **NATIONAL AND REGIONAL RESOURCE INVENTORY**
- **EXPLORATION AND ASSESSMENT TECHNOLOGY**
- **RESOURCE CHARACTERIZATION**
- **GEOLOGIC CONTROLS OF SUBSURFACE POROSITY
AND PERMEABILITY**
- **GEOENVIRONMENTAL EFFECTS OF PRODUCTION**

PROGRAM COORDINATOR -- WENDELL A. DUFFIELD



USGS REGIONAL ASSESSMENT

- **USGS BEARS RESPONSIBILITY FOR US RESOURCE ASSESSMENT**
 - **CIRC. 726, CIRC. 790**

- **STATE COUPLED TEAMS COOPERATE WITH USGS**
 - **DATA GOES TO FILE *GEO THERM***
 - **STATE-LEVEL CONTACTS**



USGS

LOW TEMPERATURE INVENTORY

- **WILL INVOLVE STATE COUPLED RESOURCE TEAMS
AND WATER RESOURCES DIVISION**
- **TO BE COMPLETED IN SEPT. 81**
- **SYSTEMS OF INTEREST 20°C (where applicable) to 100°C**
- **WILL DETERMINE
GRADIENTS
TEMPERATURES AT 1 km DEPTH
RECOVERABLE HEAT**
- **NOAA WILL PRINT MAPS**
- **COORDINATED BY MARSHALL REED**

USER ASSISTANCE

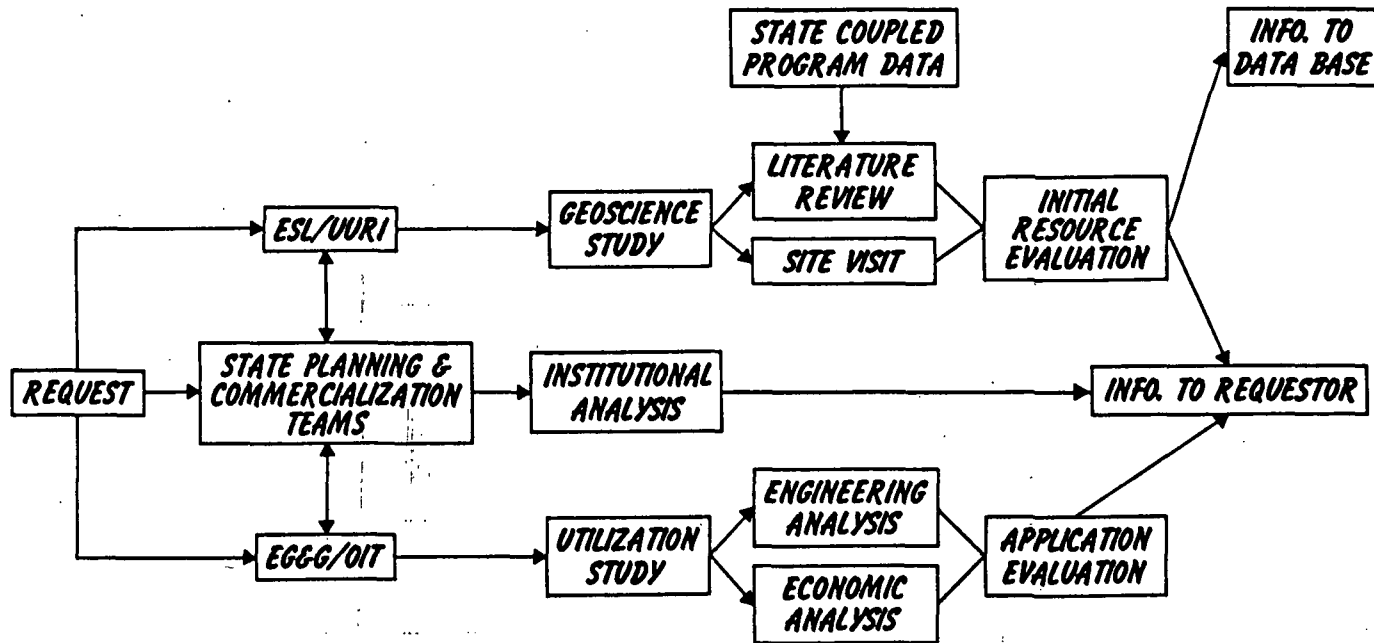
PURPOSES

**TO STIMULATE COMMERCIAL GEOTHERMAL DEVELOPMENT
BY PROVIDING USERS WITH:**

- Technical Information**
- Preliminary Resource Assessment**
- Preliminary Engineering & Economic Analyses**
- Institutional Analysis**

TO ACT AS KINDLING TO GET USER STARTED IN RIGHT DIRECTION

USER ASISTANCE PROGRAM WORK FLOW



INTERFACING

STATE COUPLED AND USER ASSISTANCE PROGRAMS

- STATE COUPLED TEAM RESOURCE DATA
- COORDINATION OF USER SPECIFIC STUDIES
- TRANSFER OF REQUESTS AS DESIRED

STATE COUPLED TEAMS



USER ASSISTANCE PROGRAM



USER PROBLEMS

- **INABILITY TO SPREAD RISK AND COST**
 - **Large Resource Companies Spread Risk and Cost**
Over Many Projects
- **INABILITY TO COLLECT REGIONAL AND AREAL DATA**
NEEDED FOR SITE SELECTION
- **LACK OF ENOUGH EXPERIENCED CONSULTANTS, CONTRACTORS**
- **LACK OF ECONOMIC DATA ON EXPLORATION, DEVELOPMENT,**
OPERATION

RESPONSIBILITIES

STATE COUPLED RESOURCE PROGRAM

1. REGIONAL GEOTHERMAL
DATA COMPILATION
2. IDENTIFICATION OF
RESOURCE AREAS
3. PUBLICATION OF MAPS
AND REPORTS
4. AREA SPECIFIC
EXPLORATION

USER COUPLED DRILLING PROGRAM

1. SITE SPECIFIC EXPLORATION
- GEOLOGICAL , GEOCHEMICAL,
GEOPHYSICAL, HYDROLOGICAL
2. DRILLING AND TESTING
3. ENGINEERING STUDIES



IMPLEMENTATION

- **DOE COMPETITIVE PROCUREMENT**

PROPOSALS FROM PRIVATE SECTOR, STATE
AND LOCAL GVTS.

- **COST-SHARE CONTRACT WITH USER OR DEVELOPER**

SPECIFIES - EXPLORATION PROGRAM
- CRITERIA TO DEFINE SUCCESS
- COST-SHARE BASIS

- **LOAN FROM BANK**

TO FINANCE PROJECT

- **WHEN WELL IS DRILLED AND TESTED**

- DEGREE OF SUCCESS DETERMINED
- DOE PAYS COST SHARE

STATE RESOURCE TEAMS INVOLVEMENT IN USER COUPLED DRILLING

OPTIONS (UNDER DISCUSSION)

- 1. MANAGEMENT ASSISTANCE TO DOE
PROPOSAL REVIEW, CONTRACT MONITORING**
- 2. SUBMIT PROPOSALS FOR SITE-
SPECIFIC EXPLORATION AND DRILLING**

COMMENTS INVITED

