DOE Idaho Operations Office

Enhanced Geothermal Systems

Solicitation for Financial Assistance # DE-PS07-02ID14264

Glass Mountain Enhanced Permeability Project

by

Calpine-Siskiyou Geothermal Partners LP

April 9, 2002

Required Forms and Documents

Form Number	Description
SF 242	Application for Federal Assistance
DOE Form 241.2	Notice of Energy RD&D Project
	Technical Proposal
	Cost Proposal Guidelines
	Benefits Analysis Data
	EPACT Certification
	Resumes
SF 424B	Assurances – Nonconstruction Programs
DOE Form 1600.5	Assurance of Compliance, Nondiscrimination, OMB Statement
	Certifications: Lobbying, Debarment and Drug-Free Workplace
	Environmental Checklist
SF-3881	ACH Vendor/Miscellaneous Payment Enrollment Form
	Bibliography of Published Papers

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TABLE OF CONTENTS

STANDARD FORM 424: APPLICATION FOR FEDERAL ASSISTANCE
COVER PAGE

1.0 EXECUTIVE SUMMARY 1-1
- 1.1 Proposed Project 1-1
- 1.2 Organizational Plan 1-2
- 1.3 Specialized Experience 1-3
- 1.4 Total Costs 1-3

2.0 CRITICAL REVIEW OF TECHNOLOGY STATUS 2-1
- 2.1 Technology Status of the Proposed EGS Concept 2-1
- 2.2 Scientific and Technical Feasibility of the Proposed Concept 2-1
- 2.3 Why the Domestic Industry has not Pursued the Proposed Concept 2-1
- 2.4 Halliburton Addendum 2-2

3.0 PROJECT DESCRIPTION 3-1
- 3.1 Introduction 3-1
- 3.2 Application of the Proposed EGS Concept 3-3
- 3.3 Proposed Unproductive Geothermal Resource Site and its Suitability 3-4
- 3.4 Barriers to be Overcome 3-5
  - 3.4.1 Technical Barriers 3-5
  - 3.4.2 Institutional/Financial Barriers 3-5
  - 3.4.3 Environmental Barriers 3-6
- 3.5 Benefits 3-6
  - 3.5.1 Benefits to US Industry 3-6
  - 3.5.2 Addressing Electricity Supply Needs 3-7
  - 3.5.3 Financial and Economic Benefits 3-7
  - 3.5.4 Environmental Benefits 3-7
- 3.6 Environmental Review related to NEPA 3-7

4.0 PROJECT PLAN 4-1
- 4.1 Statement of Objectives 4-1
- 4.2 Statement of Work 4-1
- 4.3 Work Breakdown Structure 4-1
- 4.4 Milestone Plan: Technical Targets, Decision Points, Go/No-go 4-2
- 4.5 Spending Plan 4-3
- 4.6 Sources of Financing 4-4

5.0 TECHNICAL CAPABILITIES 5-1

5.1 Key Personnel and Responsibilities 5-1
5.2 Related Experience 5-1
5.3 Facilities and Equipment Available 5-2
5.4 Justification for and Description of Needed Facilities and Costs 5-3

6.0 PROJECT MANAGEMENT PLAN 6-1
6.1 Project Organization and Responsibilities 6-1
6.2 Task Integration and Project Coordination 6-1
6.3 Project Management Structure 6-1
6.4 Management Philosophy 6-1

7.0 TECHNOLOGY TRANSFER AND COMMERCIALIZATION PLAN 7-1
7.1 Technology Transfer 7-1
7.2 Commercialization Plan 7-1

EGS BIBLIOGRAPHY

1.0 EXECUTIVE SUMMARY

1.1 Proposed Project and Why it is Appropriate for the Domestic Geothermal Industry

Numerous geothermal reservoirs worldwide, over a wide temperature range, contain zones of low permeability which limit the development potential and the efficient recovery of heat from these reservoirs. The cause of low permeability may be the natural condition of the reservoir rock, or formation damage incurred while drilling. Permeability in these zones may be enhanced through methods of well stimulation. Present geothermal stimulation technology includes well stimulation practices that were initially developed in the United States during the early 1980's and since have been successfully applied to remove production induced scale deposits from well bores and repair damage to the well bore as the result of drilling. Stimulation has also been use to bring marginal geothermal fields into commercial production outside the United States.

The Enhanced Geothermal System concept presented here is to further develop existing stimulation technology required to extract energy from the reduced permeability zones, focussing on the Fourmile Hill project in the Glass Mountain Known Geothermal Area, Siskiyou County, California. Calpine-Siskiyou Geothermal Partners LP proposes to develop a combination of stimulation technologies that could be used to enhance presently non-commercial or marginally commercial geothermal reservoirs. Improving permeability would decrease the number of production and injection wells required for a given plant size. This in turn would lower the cost and the environmental impact of development, resulting in more fields online and better economic benefits to power producers and consumers.

The potential of the concept was demonstrated in 1997 at the Mahanagdong sector of the Leyte Geothermal Power Project in the Philippines. Here, seven low permeability wells were initially capable of producing only 14 MWe for a newly constructed 60MWe power plant. After a large-scale stimulation program lasting only several months, these same wells were stimulated and enhanced to produce 64.3 MWe, enough to meet the full load requirements of the new power plant. The Glass Mountain geothermal reservoirs are geologically similar to the Mahanagdong field and Calpine-Siskiyou Geothermal Partners LP proposes a phased geothermal reservoir enhancement program here to develop the concept.

In the proposed Phase 1 program, the technologies to be tested include high-rate water injection, acidizing, and nitrogen lifting of the fluid column. In Phase 2, it is proposed to expand the technologies to include: a well drilled using techniques designed to optimize post-drilling stimulation opportunities; and completion of a forked production well with slotted liners in both legs. Both of these concepts are believed to be firsts in the geothermal world. In Phase 3 the results from the first two phases will be applied to stimulate wells as needed during the development of production and injection wells for a 50-mw development. In Phase 4, the long-term performance of the stimulated wells will be monitored, and the stimulation techniques will be applied to minimize make-up drilling requirements.

The Glass Mountain KGRA is an ideal site for a number of reasons:

- Technology developed at Glass Mountain will be applicable throughout the Western United States. Glass Mountain is a volcano-hosted geothermal reservoir system with underlying basement rocks influenced by Great Basin tectonics. Glass Mountain therefore is typical of other low permeability reservoirs in the Western United States.

- The Glass Mountain KGRA includes one proven high-temperature (>500°F) low-permeability resource known as Telephone Flat, and a second high-quality prospect located 5.5 miles away, known as Fourmile Hill. The three existing productive wells at Telephone Flat provide an opportunity to obtain baseline data and evaluate stimulation efforts applied there during the 1980's. At Fourmile Hill, the first deep exploration drilling is planned to begin in July 2002, and reservoir conditions similar to those at Telephone Flat are anticipated. Therefore, stimulating permeability at Fourmile Hill will be the focus of the EGS program. If successful, the exploration and EGS program will lead to development of a 50-mw steamfield and power plant scheduled to come online by the end of

2004. The facilities at Fourmile Hill will be available for demonstration and long-term operation of this stimulation project, and be totally integrated into the development and operation Fourmile well field and power plant.

- There are available water supply wells and injection wells at Telephone Flat which can be utilized for the initial testing and stimulation at both Telephone Flat and for Fourmile Hill. Calpine anticipates constructing temporary pipelines from Telephone Flat to Fourmile Hill as part of its exploration drilling plan for Fourmile Hill. Existing wells at Telephone Flat will be used to supply injection water for stimulation, and alternately to dispose of water produced by the testing of the stimulated wells. There is an existing supply of fresh water at Telephone Flat to supply water for both drilling and the initial stimulation experiments. During Phase 2 of the EGS project, water for stimulating wells will be obtained from nearby production wells and sumps.

- Acid stimulation of wells at Telephone Flat was applied in 1988 and was at least partially successful. It would also appear from temperature logs that deep fractures were inadvertently created, but never tested, during the disposal of cold water into one of the Telephone Flat wells. This existing work provides a track record and a "head-start" for the proposed EGS project.

- An EGS project at Fourmile Hill can add electrical power to the grid in the near term because Calpine-Siskiyou controls the geothermal leases, has obtained all necessary permits, and has an executed power sales agreement is in-place for a 50 MW plant. Moreover, a successful Fourmile Hill development will directly benefit the US government by providing royalties to Bureau of Land Management and green power to the Bonneville Power Agency.

- By decreasing the number of wells required, the EGS program could lessen the environmental impact of the Fourmile Hill project and thereby defuse opposition to further geothermal development at Glass Mountain and elsewhere.

1.2 Organizational Plan

The work proposed here will take place entirely on Federal leases held by Calpine Corporation, the parent company which owns 100% of Calpine-Siskiyou. Calpine is the nation's geothermal leader, operating steamfields and plants providing over 800 mw at the Geysers field. Calpine personnel have extensive experience drilling, developing and operating geothermal steamfields and power plants. However, much of the specialized expertise involved in well stimulation resides with service companies, some of which have already been identified and contacted with regards to the proposed EGS project. Project organization will therefore involve very close interaction between service company representatives and their counterparts from Calpine-Siskiyou. Calpine-Siskiyou staff will have the responsibility of supervising the activities of various subcontractors and maintaining fiscal control of the EGS project while integrating these activities with the simultaneous development of a well field and power plant.

This project will be organized by function Tasks will be the responsibility of a Calpine-Siskiyou functional manager described below and shown in the organizational chart in section 6. Each manager will be responsible for the timely completion of tasks falling within his/her functional responsibility, and will be expected to coordinate the various tasks with other members of the team and subcontractors.

Mr. Dennis Gilles, VP Geothermal, is an officer of Calpine-Siskiyou and has ultimate signatory authority on all aspects of this project.

Mr. Tom Box, VP Geothermal Resource Management, will provide overall guidance and executive responsibility. Reporting to Mr. Box will be three functional managers:

1. Mitch Stark, Senior Geoscientist, will be the day-to-day project manager and will coordinate with DOE on reporting and budgeting matters. Supporting Mr. Stark will be engineers, operators, consultants and subcontractors as needed to assemble and operate surface facilities, acquire and analyze data, and maintain data quality control.

2. Marc Steffen, Drilling Manager, will be responsible for all downhole operations and will negotiate contracts and supervise drilling service subcontractors. Supporting Mr. Steffen in this effort will be Calpine and contract drilling personnel who will implement the downhole work.

3. Charlene Wardlow, Manager of Development Permitting, will be responsible for obtaining required permits and verifying that the project remains in compliance with those permits. Support from Mr. Stark and Mr. Steffen will be required for this effort. Ms. Wardlow will also ensure that Calpine safety programs are integrated with all project operations, bringing in Calpine safety specialists as needed.

1.3 Specialized Experience

Calpine Corporation is the nation's largest geothermal energy provider. Calpine operates plants and geothermal fields at The Geysers, and has explored, developed and operated geothermal fields throughout the Western United States and Mexico. Its team of 10 key personnel assigned to this project, collectively bring more than 229 years of experience in all phases of geothermal development and operations at Glass Mountain, The Geysers and other geothermal projects in the US and around the world.

In addition to the experience of Calpine-Siskiyou personnel, service companies and contract consultants with specialties in well testing and stimulation will be used for this project. Discussions are presently underway with these specialists who will design and perform the stimulation programs, and testing. Each have more than 20 years experience in their respective fields and have collectively worked at virtually every geothermal field in the world doing stimulation and testing. This team of service companies and consultants have designed or applied the state-of-the-art simulation and testing technology worldwide.

Based in San Jose, Calif., Calpine Corporation is dedicated to providing customers with reliable and competitively priced electricity. Calpine is focused on clean, efficient combined-cycle, natural gas-fired generation and renewable geothermal energy. Calpine has launched the largest power development program in the United States. To date, the company has approximately 28,100 megawatts of base load capacity and 5,400 megawatts of peaking capacity in operation, under construction and in announced development in 27 states and Alberta, Canada. The company was founded in 1984 and is publicly traded on the New York Stock Exchange under the symbol CPN. In 1999, the company made the S&P500.

1.4 Total Costs and Non-Federal Cost-Share Commitments by Phase and By Budget

Table 1.1 below shows the anticipated Federal and non-Federal costs for this project.

Table 1.1. Planned EGS project costs ($000)

Phase	Dates	DOE Share	Calpine-Siskiyou Share	Total
1. Demonstration / application	7/02 - 9/03	$500	$256	$756
2. MEQ, purpose-drilled well, and fork.	10/03 - 9/04	$3,180	$2,120	$5.300
3. Development EGS	10/04 - 9/05	$2,000	$3,000	$5,000
4. Operations EGS	10/05 - 9/07	$1,000	$4,000	$5,000
Totals		$6,680	$9,376	$16,056

The Phases 1 and 2 spending plans are somewhat accelerated, compared with the guidelines suggested in the solicitation. This is because Calpine has scheduled the development drilling program for the calendar years 2003 and 2004, in order to meet its power sales contractual commitment. The EGS project phases are scheduled to coordinate with the development drilling program so as to maximize the benefit of EGS. The timing is discussed in more detail in Section 4 (Project Plan). Also, in accordance with Section V.I of the solicitation, we anticipate some pre-award costs to cover the period July 1 through September 6, 2002, again to coordinate the EGS schedule with Calpine-Siskiyou's scheduling. Written authorization will be requested for the pre-award costs, as specified in the solicitation.

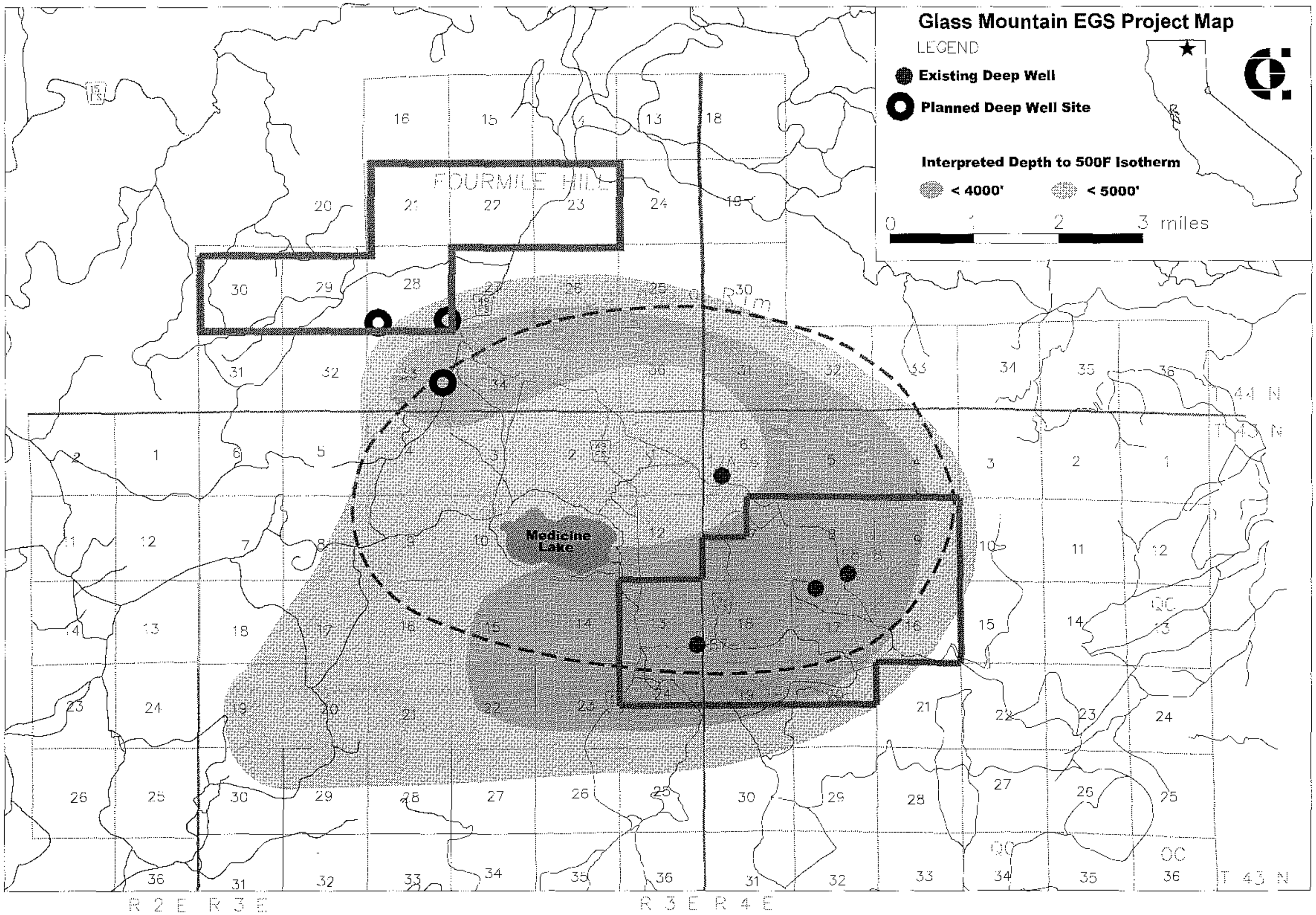

Figure 1. Glass Mountain area, showing thermal anomaly and key EGS project sites.

2.0 CRITICAL REVIEW OF TECHNOLOGY STATUS

2.1 Technology Status of the Proposed EGS Concept
Calpine intends to apply a combination of geothermal well stimulation technologies to develop low permeability geothermal reservoirs at Glass Mountain. Well stimulation is applied for the remediation of well problems. This proposal is to develop a combination of well stimulation technologies to initially bring low permeability geothermal reservoirs into production.

The technology of well stimulation by acid and cold water injection into geothermal wells has continued the to evolve in recent years since the early 1980's when DOE initiated its Geothermal Well Stimulation Program. Many successful jobs have been performed within geothermal fields in central and southern California, primarily on existing producing wells where production has diminished due to downhole scaling as the result of production or residual reservoir damage from drilling fluids.

A compelling example of geothermal well stimulation is provided from the Mahanagdong, Leyte Geothermal Power Project in the Philippines. Early in1997, this field had only 14 MWe available from seven production wells to supply a 60 MWe power plant scheduled for start-up in the middle of the year. In a three month period, these same seven wells were stimulated to produce 62.4 MWe using coiled tubing units, acidizing equipment, and a drilling rig. A Bibliography appended to the hard copy of this report provides this reference and numerous other publications related to stimulation technology. The wells at Mahanagdong were stimulated by acid treatment followed almost immediately by discharge testing. Gas lifting of the fluid column followed acidizing if a well failed to discharge. Once a well discharged it was tested for a sufficient length of time for it to heat-up the well bore.

2.2 Scientific and Technical Feasibility of the Proposed Concept
The geologic and drilling conditions of Mahanagdong are similar to Glass Mountain in three very important ways: they are in volcanic-hosted reservoirs; newly drilled wells show poor permeability (5,000 to 17,000 md-ft in both fields); and the wells respond positively to acid stimulation. In high-permeability reservoirs, the fractures intercepted by the well bore cannot easily be filled regardless of the amount of drill cuttings or lost circulation material they accept. But the smaller fractures typical of lower-permeability reservoirs are more susceptible to this kind of damage, so the lost permeability must be recovered and improved using permeability-enhancement techniques.

Remedial acid stimulation has become more popular and widespread as more geothermal fields have reached maturation and production declines become more severe. The current technology and methodology have progressed to utilize coiled tubing, various acids and inhibitor blends, and the use of injected nitrogen into the acid stream. This technique has enabled large sections of reservoir to be washed with enhanced penetration of acid stimulation into specific fractures due to the expansion characteristics of the nitrogen. The method can be equally successful in existing wells that are completed with a slotted liner, as the acid passes through to slots to attack skin damage formation at the well bore wall and beyond. There are several reputable and experienced service companies that possess the capability and technical expertise to perform acid stimulation into geothermal reservoirs.

2.3 Why Domestic Industry has not pursued the proposed Concept
The use of this technology to stimulate a geothermal well before production begins has not been tested in the United States and is the focus of this proposal. This technology has not been tested in this application probably because it has been commercially developed only in the last few years during a period of diminished drilling activity in the geothermal industry. Also, high-rate injection and acidizing experience in a number of fields has been "hit-or-miss"; sometimes these methods do not improve well performance at all. By following the systematic approach outlined in this proposal, and implementing the innovations in Phase 2 to improve targeting of specific zones, it is hoped that better and more predictable well performance benefits can be realized. Publishing such results will encourage other geothermal operators to apply the technology elsewhere.

2.4 Addendum by Halliburton for Acidizing Well at Glass Mountain

Enclosed is Halliburton Energy service's cost estimate to acidize one well at Glass Mountain. As per our conversation we are assuming that we can cool this well down to 250 deg.F. We plan on pre-mixing all the acid on the fly. This will save a tremendous amount of money by not pre-blending in Bakersfield and hauling the acid to Glass Mountain.

Typical Glass Mountain Well Information

Casing Size	9.625 In.
Casing Depth	4000 Ft.
Slotted Liner Size	7 In.
Slotted Liner Depth	9000 Ft.
Open Hole Size	8.5 In.
BHST (est)	475 Deg.F

Halliburton Job Recommendation

7.5% HCI DETAILS: (2,000 gal)	
Base Fluid	7.5% Hydrochloric Acid
Mixing Fluid	Fresh Water
Iron Control	50 lbs/M Fe-2
Friction Reducer	1 gal/M FR-26LC
Corrosion Inhibitor	5 gal/M HAI-85M
SILICA SCALE ACID DETAILS:	(40,000 gal)
Base Fluid	12/3% SILICA SCALE ACID 14312
Mixing Fluid	Fresh Water
Iron Control	14 gal/M Fe-1A
Iron Control	50 lbs/M Fe-2
Friction Reducer	1 gal/M FR-26LC
Corrosion Inhibitor	5 gal/M HAI-85M
Surfactant	2 gal/M LOSURF-300

Halliburton Cost Estimate

Price Ref	Description	Qty	U/M	Unit Price	Total
	ACID AND ADDITVES				
201-004	HYDROCHLORIC ACID	7.5	%	$ 1.69	$ 1,859.00
		2000	GAL		
218-008	FE-2 100001615	2100	LB	6.40	7,392.00
312-340	FR-26LC	42	GAL	57.09	1,318.78
210-013	HAI-85M	210	GAL	95.33	11,010.62
209-029	SILICA SCALE ACID 14312	12.3	%	3.42	75,240.00
		40000	GAL		
218-016	FE-1A	560	GAL	20.29	6,249.32
218-703	LOSURF 300	80	GAL	53.50	2,354.00

STIMULATION SERVICES

Price Ref	Description	Qty	U/M	Unit Price	Total
300-111	MILEAGE FOR STIM EQUIP 3124	1300	MI	5.03	7,192.90
		2	UNT		
300-112	MILEAGE FOR STIM CREW 3125	1300	MI	2.96	2,116.40
		1	UNT		
300-112	MILEAGE PDR VAN	1300	MI	2.96	2,116.40

		1	UNT		
300-131	DELIVERY CHEMICALS	1300	MI	5.03	3,596.45
		1	UNT		
300-131	DELIVERY FE-1A	1300	MI	5.03	3,596.45
		1	UNT		
300-131	DELIVERY ACID TANKS	1300	MI	5.03	3,596.45
		1	UNT		
300-200	FOOD AND LODGING 3132	3	DAY	350.00	4,620.00
		8	MAN		
301-085	ACID PUMP CHG 1ST 2 HRS	2	HR	4,402.00	2,421.10
	(PER 2 HR)	1	PMP		
301-051	PUMPING TIME ADD HRS 21342	4500	PSI	3.92	3,566.91
		551.47	HHP		
		3	HR		
307-157	PRE-MIXING PROPORTIONING 3218	40000	GAL	0.08	1,760.00
307-793	PDR VAN 16214	1	DAY	1,784.00	981.20
307-108	TANK RENTAL 3214	1	DAY	200.00	220.00
		2	EA		
307-116	TANK CLEANING 3215	2	HR	200.00	220.00

COIL TUBING SERVICE

590-000	MILEAGE COILED TUBING 4084	1300	MI	5.03	10,789.35
		3	UNT		
590-000	MILEAGE COILED TUBING CRANE	1300	MI	5.03	3,596.45
		1	UNT		
590-005	MILEAGE CT CREW 16270	1300	MI	2.96	2,116.40
		1	UNT		
590-023	CT SUPERVISOR- LAND 16271	8	HR	131.00	786.00
		1	MAN		
590-032	CT OPERATOR- LAND 4091	8	HR	93.06	558.36
		1	MAN		
590-035	CT ASSISTANT - LAND 4092	8	HR	83.44	500.64
500-959	CRANE OPERATOR	8	HR	93.06	558.36
590-039	FOOD AND LODGING LAND 4421	3	DAY	350.00	2,887.50
		5	MAN		
590-059	CT UNIT SERVICE CHARGE 8 HOURS	2.375	IN	4,243.00	3,182.25
		1	DAY		
		1	UNT		
590-139	COILED TBG MIN CHG SEVERE SER.	2.375	IN	7,708.00	5,781.00
		1	EA		
590-601	HYDRAULIC PACKOFF 4237	1	DAY	268.00	201.00
590-141	HYDRAULIC CRANE 4122	1	DAY	863.00	647.25
500-959	WASH TIP WITH CHECK VALVE	1	EA	479.00	359.25
500-959	SIDEDOOR STRIPPER RUBBER	1	EA	625.00	468.75
590-928	HYDRAULIC STRIPPER RBBER 4376	1	EA	395.00	296.25
590-534	B.O.P. REDRESS CHG 4206	1	JOB	800.00	600.00

NITROGEN SERVICES

Price Ref	Description	Qty	U/M	Unit Price	Total
380-048	MILEAGE N2 ROUND TRIP 3567	1300	MI	5.03	3,596.45
		1	UNT		
381-401	CREW MILEAGE- ROUND TRIP 3587	1300	MI	2.96	2,116.40
		1	UNT		
381-115	FOOD AND LODGING 16263	3	DAY	350.00	1,155.00
		2	MAN		

380-006	N2 PUMPING 0-4000 SCF 1ST 2 HRS	4500	PSI	1,957.00	1,467.75
		1	UNT		
380-022	PUMP 0-4000 SCF ADD HR. 83157	4500	PSI	385.00	1,155.00
		4	HR		
		1	TRK		
380-014	NITROGEN CHARGE 3575 (PER 100 SCF)	1050	SCF	4.08	3,213.00
381-111	ENGINEER OR SUPER 3580	8	HR	131.00	786.00
381-095	OPERATOR N2 3578	8	HR	93.06	558.36

TOTAL AMOUNT	**$ 333,041.73**
DISCOUNT AMOUNT	144,236.98
DISCOUNTED TOTAL	**$ 188,804.75**

NOTE: Service Location - Bakersfield

3.0 PROJECT DESCRIPTION

Permeability enhancement has long been recognized as vital in improving the economic viability and decreasing the environmental impact of geothermal development. Although results are not always consistent, acidizing and cold-water injection techniques can often improve per-well steam flow or injection capacity by a factor of two or more, or turn wells that won't even flow into prolific producers.

Flowrate per well (both for production and injection wells) is a critical factor in the economic viability and environmental impact of geothermal fields. Typically, about half the cost of geothermal development is spent on wells and surface production and injection facilities, with the remaining half spent on the power plant. Doubling or tripling the flowrate per well can thus cut total development costs by 25% or more. Since drilling is a "front-end" development cost, minimizing drilling has a disproportionate effect on project economics and the ultimate cost of producing power. Economic advantages continue to accrue after plant start-up, because fewer make-up wells are needed to sustain generation. And throughout the cycle, drilling fewer wells is environmentally advantageous, resulting in fewer disturbances to the surrounding environment and less long-term land use.

The permeability enhancement program proposed here has the promise of being able to increase domestic production of geothermal energy from three fundamental standpoints.

- Promote development of low permeability resources, including those considered sub-commercial with current technology.
- In existing fields, stimulate expansion by tapping currently under-utilized low-permeability zones.
- Decrease the environmental impact of geothermal development by decreasing drilling requirements, thereby speeding public acceptance and permitting of new geothermal facilities.

Our concept will be refined and demonstrated at the Fourmile Hill site within the Glass Mountain KGRA, where permits and contracts are in place for a 50-mw well field and power plant (Figure 1). Presently the nearest well capable of commercial production is 5.5 miles from Fourmile Hill, in the Telephone Flat area. No deep exploration wells have been drilled in Fourmile Hill to date, but there is evidence of sufficient heat and fluid to support the 50-mw development.

In the short term, the proposed EGS will support the development of steam supply to a new power plant. In the longer term, it will promote the development of geothermal systems throughout the Western U.S. which presently have high heat flow (>100 mWm^{-2}). High-temperature, low permeability conditions have been detected at exploitable depths at a number of high-temperature hydrothermal sites, and the EGS technology developed at Fourmile Hill can be widely applied at other high heat flow sites, including previously identified candidate sites for Hot Dry Rock development and EGS.

3.1 Introduction

The Glass Mountain geothermal system is the largest known commercially producible but wholly undeveloped high-temperature geothermal resource in the United States. Estimates of its ultimate potential range as high as 1000 mw. It is explored by 26 intermediate-depth, thermal-gradient coreholes and four deep geothermal wells over the last 20 years, but development has been slowed due to a number of commercial and political obstacles. Those obstacles have largely been overcome in recent years, so the challenge now is to delineate and develop the resource in an efficient and environmentally responsible manner.

Geologically the Glass Mountain area is marked by extensive Quaternary bimodal volcanism as young as 900 years, an elliptical volcanic depression surrounding the lake, and a single weak fumarolic feature known as the Hot Spot. Temperature gradient holes and exploration wells drilled by Calpine and others show a thermal anomaly covering 40 square miles where measured and extrapolated temperatures of 500°F are to be found at depths of ≤ 4000 ft (Figure 1).

The best information on the nature of the resource comes from three exploration wells drilled in the 1980's by Unocal, along the southeastern margin of the volcanic depression in an area known as Telephone Flat. These wells produced sufficient steam for 3 to 4 MW each, with dilute, neutral chemistry and low non-condensable gas concentrations (Table 3.1). Interpreted reservoir temperatures ranged from 470°F to 515°F.

Table 3.1. Key drilling and testing results, Telephone Flat wells

	68-8	31-17	87-13
Total depth (ft)	8,417	8,787	6,935
Max. Temp. (°F)	556	542	549
Fluid entry depths (ft)	4,900 & 5,700	3,800	2,600
Total mass flow (kph)	270	340	270
Steam flow (kph @ 90 psig)	54	52	53
Enthalpy (btu/lb)	480	435	475
kh (md-ft)	4,800	8,470	17,500
Non-condensable gas (wt % in steam)	0.15%	0.07%	0.12%
Total Dissolved Solids (ppm)	2,713	3,028	2,335

These three wells, drilled during the 1980's, all encountered high-temperature (>500°F) geothermal reservoirs, with thick sections of propyllitic alteration indicative of geothermal reservoir conditions (Figure 4). All three produced two-phase reservoir fluids to the surface, although various stimulation methods were needed to get two of them to flow. But steam flow rates were only sufficient for an estimated 3 to 4 mw per well, compared with values an order of magnitude greater at the world's best fields. The main reason for that difference is permeability. Permeability-thickness (kh) values for the three Telephone Flat wells range from 4,800 to 17,500 millidarcy-feet, compared with values two to four times higher observed in the better fields.

There are several possible reasons for the low permeability zones within the reservoir(s) at Glass Mountain: lithologic properties, the natural "self sealing" minerals deposited in mature reservoirs, and permeability damage sustained during drilling due to cuttings and lost circulation materials plugging up fractures.

Because the Telephone Flat wells are over five miles from the approved Fourmile Hill project area, it is uncertain whether a resource accessible from Fourmile Hill would share these same characteristics. However, we do anticipate that similar zones of low permeability beneath more shallow productive zones are likely at Fourmile Hill as at Telephone Flat because of similar geology and temperature-depth profiles.

Geologic relationships throughout the Medicine Lake Volcano are lithologically and hydrologically complex. There is ample evidence from recent age dating that there have been multiple periods of silicic intrusion within the caldera within the last 300,000 years. There is also geological, geochemical and geophysical evidence that previous geothermal systems have occupied different parts of the caldera at different times within both the overlying rocks and these silicic intrusive rocks. At Telephone Flat there are large differences in the temperature-depth profiles that may be due to explained by either the wells being either in different reservoirs, or complex flow patterns. These factors offer possible explanation why some parts of the reservoir are low permeability and may be partially self-sealed.

When hydrothermal systems cool naturally, fracture form first in the high temperature zone, then the ductile zone and subsequently in the magmatic zone as cooling progresses downward. The cooling process allows fractures to form and water to circulate in formerly impermeable hot rock. This appears to be the case at Telephone Flat where the GMF 17A-6 and 31-17 wells are drilled into granodiorite with an age of approximately 300,000 years. The granodiorite has undergone potassic alteration in a weak porphyry-copper hydrothermal system. Hornfelsed volcanic rocks are present

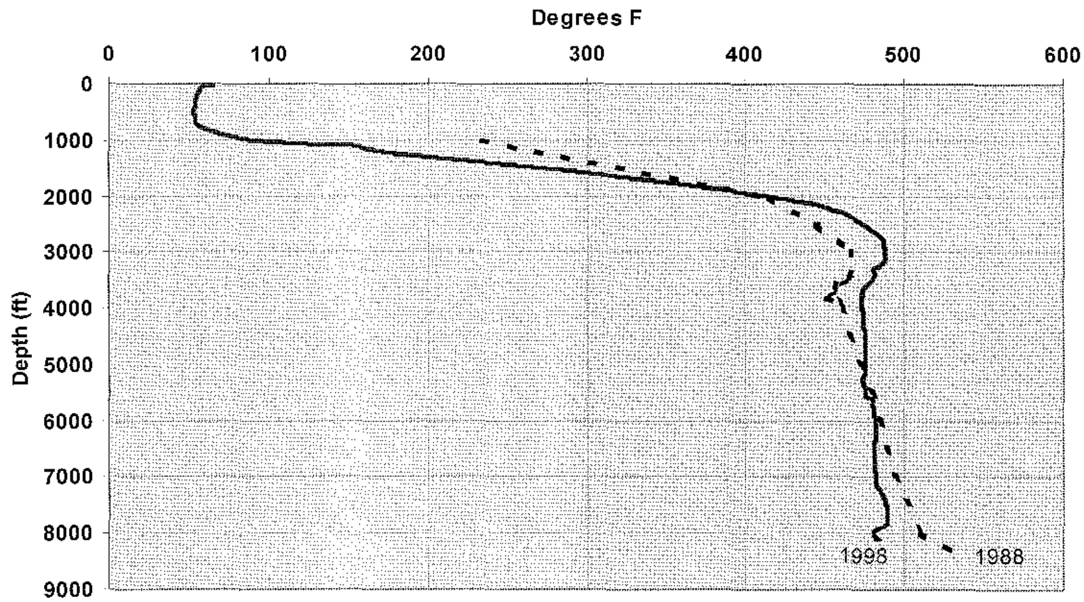

Figure 2. GMF 31-17 temperature profiles

at the margin of the granodiorite and the current geothermal reservoir is within a zone of propylitic alteration. Fluid inclusion studies show that 600+ degF hydrothermal fluids formed vein minerals in the reservoir rock that is now occupied by a 500+ degF resource. The 500+ degF reservoir has deposited additional vein minerals. This together with the fact that minor amounts of calcite veining are present deep within the reservoir is strongly suggestive that at least two geothermal systems have existed within the reservoir volume penetrated by GMF 31-17 and there has been partial self-sealing.

As a fundamental concept, we should be able to engineer and, as a result, accelerate the natural processes of fracture formation and fluid in zones of low permeability. This has been accomplished by several technologies in several places throughout the world.

3.2 Application of the Proposed EGS Concept

The project will develop an Enhanced Geothermal System (EGS) reservoir in hot, low-permeability areas at Calpine's Fourmile Hill Project. This will be accomplished by using a variety of permeability enhancement techniques, such as acidizing and cold water injection, to extend and increase the connectivity of existing, but poorly connected fractures within saturated, low permeability rock. It is anticipated that the fractures will enlarge and propagate through thermal contraction, mineral dissolution and decrease in effective stress. This will, in turn, allow flow paths within incipient fractures or partially plugged flow paths to develop between the convecting portion of the reservoir and the low permeability zones. Ample water supplies will be available from existing sources and eventually from new production wells.

At GMF 31-17, there is evidence that cold-water injection to this well stimulated fracturing at or above the granodiorite and the surrounding hornfelsic zone. Dr. Colin Williams of the U.S. Geological survey believes that water at, and below the shallow production zone between 3500 and 3800 ft. depth, has been moving down the annulus of the well liner and has continued to cool the bottom of the well from 525°F to 480°F. The fact that the formation is still taking water is indicative that it is connected to the natural fracture system (Figure 2).

After GMF 31-17 was completed in 1988 and tested in 1989, it was known that permeability was lacking below 3800' because of spinner tests. The temperature-depth profile in 1988 shows an almost isothermal section below 3800' with a conductive-appearing temperature profile below 7500' that indicates formation temperatures increase from 500°F to 525°F near the total depth of 8787'. Although the precise documentation is lacking, it is believed that cold sump water was disposed of in GMF 31-17 sometime in 1990 because the well at this time was reported as "static". Temperature logs made in 1990, 1992, and 1998 all show that the apparent formations in this "static" well were reduced by 40°F to

80°F and remained so after 8 years. This is why we think that GMF 31-17 was inadvertently stimulated by cold-water injection and connected to the natural fracture system.

We intend to test our concept of cold-water injection and fracturing in GMF 31-17 at Telephone Flat by first logging the bottom of this well to determine if interzonal flow is occurring. Then we intend to lift the fluid column with a sufficient volume of nitrogen or air to allow fluid at the bottom of the well to flash and flow to the surface. Flow from the bottom of the well will heat up the well bore and allow testing of this deep zone. A 30-day flow test is planned to allow sufficient time to heat the well bore, obtain representative samples of reservoir fluids, and evaluate well performance. The test fluids from GMF 31-17 will be flowed to an existing sump and then pumped through a temporary pipeline for injection into the nearby GMF 87-13 (see Figure 1).

Following the 31-17 flow test, 68-8 will be flow tested, sampled and logged in a similar manner. The 68-8 fluids will be injected into 31-17, and the injectivity of 31-17 will be monitored to see if permeability is further enhanced.

Based on the flow test results from both wells, either GMF 31-17 or GMF 68-8 will be selected for acid stimulation. Halliburton, an oilfield service company with many years experience with acid stimulation of geothermal wells, has already provided a price quote for this job (attached), and will probably be selected to carry out the work.

Once we have tested these permeability enhancement concepts at Telephone Flat we will attempt to demonstrate the concepts at Fourmile Hill.

3.3 <u>Proposed Unproductive Resource Site and its Suitability for the Proposed EGS Concept</u>
In the Fourmile Hill area the thermal anomaly is shallowest in southeast corner of Section 28 (Figure 1). The zone of high temperature is believed to deepen to the northwest across the Fourmile Hill area. Calpine-Siskiyou's plan is to drill a combination of deep vertical wells within Section 28 and slant wells directed southward from Section 28 to access enough of the hypothesized reservoir to support the 50 MW development. The drilling program is planned to begin in the summer of 2002.

The Fourmile Hill thermal anomaly is best defined by Temperature Gradient Hole 88-28, where temperatures of 454 degF are measured at a depth of 3100 ft (Figure 3). The temperature profile shows approximately 20 degrees of temperature reversal between 3100 ft and the total depth of 4417 feet. Figure 4 shows in cross Section (location shown on Figure 1) how the high temperature gradients in the Fourmile Hill area fit with the generally high gradients found around the rim of the volcanic depression.

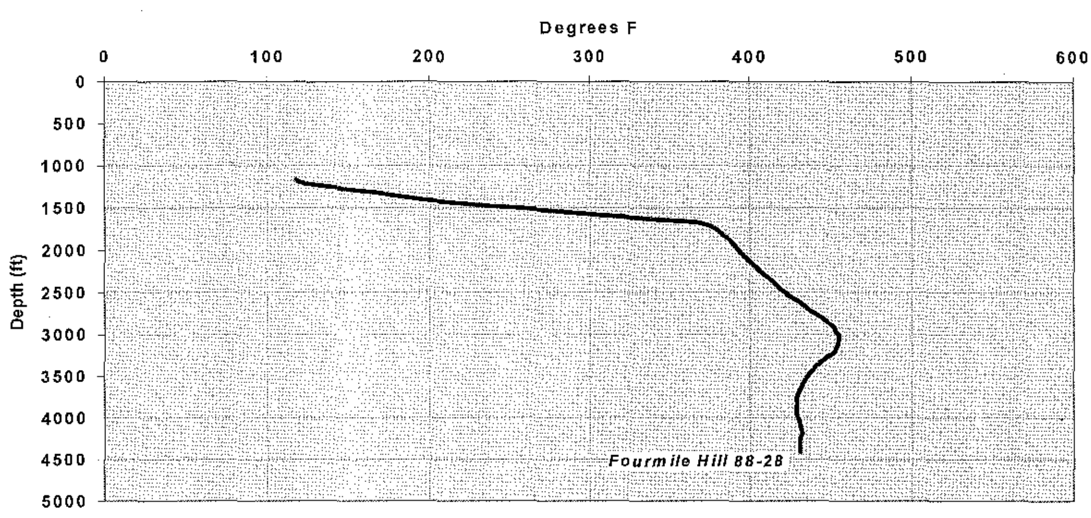

Figure 3. GMF88-28 Temperature Gradient

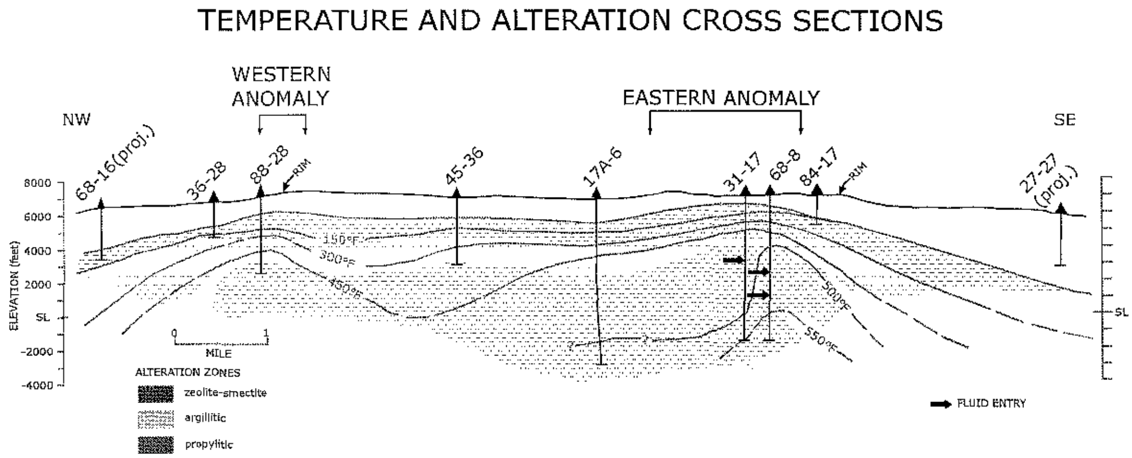

Figure 4. Temperature and alteration profile through Fourmile Hill ("western anomaly") and Telephone Flat ('eastern anomaly")

The simplest interpretation of the temperature reversal in 88-28 is lateral flow of a 455°F fluid at a depth of about 3100'. Given the decreasing temperatures to the north and west, it is likely that the source of this fluid is a hotter reservoir located south and/or east of 88-28. This will be the target of the 2002 Fourmile Hill drilling program.

As discussed above, it is anticipated that Fourmile Hill reservoir conditions will be similar to the conditions known at Telephone Flat. Therefore we propose to select one of the new wells to be drilled at Fourmile Hill for permeability enhancement, applying the results learned from the Telephone Flat flow tests, injection stimulations and acid stimulation. After completing this work, all the data and results will be thoroughly analyzed, completing Phase 1 work.

EGS Phases 2, 3 and 4.will take place entirely at the Fourmile Hill area, as the drilling moves into development for the 50-mw plant. As outlined in Sections 1 and 4, Phase 2 will move from evaluation of known technologies to innovating new ones, i.e.:

- Drilling a new "purpose-drilled" well with the expectation of having to use permeability enhancement right after drilling. This would involve applying drilling measurement and wireline logs to identify specific zones for permeability enhancement, and using specialized drilling tools to target those zones for acid stimulation.
- Adding a fork to an existing production well, completing it with liners in both legs.
- Acquiring microearthquake and tracer data to analyze the results of these efforts.

In Phases 3 and 4, the results from the Phases 1 and 2 will be applied during the development drilling and field operations to optimize the overall resource production scheme.

3.4 Barriers to be Overcome

3.4.1 Technical Barriers

- Unknowns: Fourmile Hill is an exploratory project with no history of deep wells. The Telephone Flat wells are over five miles away, so the experience there can only be generally applied to Fourmile Hill.
- The Phase 2 "purpose-drilled" well will require drilling and stimulation techniques rarely used in geothermal drilling. These include logging-while- drilling, parasitic air strings, and open-hole packers.
- The Phase 2 forked well may require permeability enhancement. In previous geothermal forked completions, re-entry into a specific leg is not assured. It may be advisable to use more sophisticated completions that allow tools to be directed into either leg. This will allow existing low production wells to be economic by increasing their permeability-thickness product, where the effective thickness is increased by multiple penetrations and the permeability is increased by stimulation of low permeable zones.

3.4.2 Institutional/Financial Barriers

A complex set of regulations by the Forest Service that manages the project surface, the Bureau of Land Management that regulates the resource, the CA Regional Water Quality Control Board that regulates impacts to both surface and subsurface water quality, and cultural sensitivity to Native American tribes, local residents and recreational users proscribe a narrow range of permitted activities at Fourmile Hill. The institutional barriers directly related to the proposed EGS project follow:

- Well drilling and field development are limited to a few environmentally acceptable and permitted sites. Therefore, it is critical that every well's production be maximized through stimulation because the option of moving the Fourmile Hill well field to more geologically favorable locations is severely restricted.
- USFS approval of the precise route for the temporary water pipeline that will connect the existing well(s) at Telephone Flat to Fourmile Hill is required. This temporary pipeline must be removed from the project area at the end of the first season of drilling (end of 2002).
- Strict control of air emissions from well drilling and testing activities is required. Calpine is currently developing special test separation equipment that will meet the requirements of the Air Pollution Control Board.
- No use of surface water and only limited use of subsurface fresh water are permitted. Therefore in the long term, water for this project is anticipated to primarily come from the geothermal fluids produced by production wells.
- Interference with multi-use activities permitted in the National Forest such as snowmobiling restricts the placement of pipelines, etc. Access for trucks transporting the heavy drilling, testing and stimulation equipment to Fourmile Hill and Telephone Flat is limited to specific Forest Service Roads to prevent conflicts with recreational users of the Forestlands around Medicine Lake.

3.4.3 Environmental Barriers

Waste Discharge Orders are required from the Regional Water Quality Control Boards that regulates water quality in the Project Area related to water quality. This order requires approval of all construction activities related to the engineering, construction and operation of drilling pads and sumps in addition to meeting Geothermal Resource Order No. 4 of the Bureau of Land Management. The disposal of geothermal fluids produced during testing, and the control of all stimulation materials to the sump and geothermal reservoir is mandatory.

All drilling and testing operations need to be in compliance with the Geothermal Resource Orders. Prior to drilling, testing and stimulating well Sundry Notices need to be submitted to the BLM office in Ukiah, CA. Drilling programs will be submitted to the BLM for each new well or fork, and a Permit to Drill is required from the BLM.

The drilling and testing of the EGS wells will also require permits from the Siskiyou County Air Pollution Control District. Prior to drilling, estimates of diesel emissions must be submitted for the particular drilling rig to be used. Flow line emissions of carbon dioxide, ammonia, and hydrogen sulfide are required while drilling. Emission controls on hydrogen sulfide will require that special separator and abatement equipment be fabricated.

Winter weather conditions on Medicine Lake Volcano severely restrict access and outdoor activities. The elevation of the project is approximately 7000' with maximum snow depths exceeding 10 ft. and average daily minimum of less than 20 degF. As a consequence, during Phase 1 the drilling, testing and stimulation of wells will be restricted to approximately May through December with peak activities being concentrated in summer months. Therefore, the scheduling and coordination of the proposed field activities in each project Phase must be coordinated with the Federal Fiscal Year Budgets.

3.5 Benefits

3.5.1 Benefits to US Industry

- Successful resource development at the Fourmile Hill area of Glass Mountain will stimulate additional development throughout the Glass Mountain area, which is believed to have geothermal reserves capable of producing 500 to 1,000 MW.
- No commercial electrical geothermal plants have constructed in the United States during the last ten years for a variety of reasons, most being related to competitive forces. Successful development at Glass Mountain could

stimulate geothermal developers to revisit other geothermal prospects throughout the United States that have not been developed because of perceived problems with public acceptance or commercial viability. Glass Mountain being the largest undeveloped geothermal resource in the United States will serve as a new flagship for the development of liquid-dominated geothermal resources throughout the Western United States.

3.5.2 Addressing Electricity Supply Needs

1. The Fourmile Hill project will provide clean, renewable capacity to the western power grid, thereby contributing to lower market prices and improved reliability. Price fluctuations of natural gas, a major fuel for the generation of electricity, make it difficult for energy suppliers to commit to long-term electricity contracts at low fixed rates. Because the cost of geothermal energy is not tied to the cost of natural gas, this form of energy is more conducive to long term fixed price contracts once the total cost of development is known.
2. Alternative energy portfolio requirements of electrical suppliers will be increased.

3.5.3 Financial and Economic Benefits

Calpine-Siskiyou has expects the Fourmile Hill project to generate property taxes of about $1.4 million per year, Federal royalties to BLM of over $1 million per year, and substantial Federal and state income taxes from the project and employees' salaries.

Developing the 49.9 MW Fourmile Hill project would also yield economic benefits to the local area and region. Combining the in-house economic analyses done for the Fourmile Hill EIR and a study of economic effects done for a similar-sized project in Deschutes County, Oregon (a county similar in size and demographics to Siskiyou County), the following economic and employment benefits are estimated:

1. During construction (33 months): Up to 160 temporary jobs, of which up to 50% would be filled by local residents. The multiplier effect would lead to additional local job creation of up to 154 jobs in the areas of household goods and services, construction supplies, education, and government services.
2. During operation (20 years): Approximately 19 permanent jobs, of which residents of the region would fill 12. The multiplier effect would lead to additional local job creation of up to 130 jobs in the areas of household goods and services, education, and government services. From time to time, temporary jobs would be created to support such cyclic activities as make-up drilling and major plant maintenance.

3.5.4 Environmental Benefits

The increase in production by well stimulation technologies wills directly decrease the number of needed wells for the Fourmile Hill project, and avoids the additional land disturbance created by new wells and pipelines. All geothermal projects will benefit by the well stimulation technologies.

Moreover, bringing new geothermal power online will lessen our dependence on other sources of energy, thereby reducing greenhouse gas emissions.

3.6 Environmental Review

An Environmental Check list is appended for initial reference to this solicitation response. Each of the items checked as been thoroughly addressed in one or more of the environmental documents referenced below.

As a result of review under the National Environmental Policy Act (NEPA), the US Forest Service, Bureau of Land Management and the Bonneville Power Administration issued a positive Record of Decision in May 2000. The Environmental Impact Statement and Environmental Impact Report, a document required under the California Environmental Quality Act (CEQA) addresses the development of a 49.9-MW steamfield, power plant and transmission line facility. This includes surface occupancy rights in Sections 21, 22, 23, 28, 29, and 30 of Township 44N, Range 3E, MD B&M Siskiyou County, California.

Additionally, an Environmental Assessment/Initial Study, EA #CA027-EA 95-11, in compliance with NEPA and CEQA covered the exploration wells to be drilled at Fourmile Hill project area in the summer of 2002 Calpine-Siskiyou Geothermal Partners LP for which this solicitation is requesting support in testing and stimulating.

All federal permits have been received for drilling program except a Sundry Notice from the BLM for a water line to be used for delivering fresh water to the location for the drilling rig and to deliver produced fluids to a well for injection back into the geothermal reservoir. Additionally, the existing Geothermal Drilling Permit is being modified for a smaller hole program.

The air permits issued by the Siskiyou County Air Pollution Control District (APCD) for the drilling of the first five wells in the Fourmile Hill project area are in place and we plan to drill up to three during 2002. These permits also cover the flow testing of these wells once they are completed. Additional permits for the flow testing of the Telephone Flat wells will be obtained as needed from the Siskiyou County APCD.

The Waste Discharge Orders that cover the discharge of drill cuttings and reservoir fluids to lined sumps at each well location will be issued in May 2002 by the North Coast Regional Water Quality Control Board (RWQCB). There are existing Waste Discharge Orders from the Central Valley RWQCB for the testing activities at Telephone Flat.

Because exploration overlaps with development activities we are also working on permit applications and submittals related to drilling wells beyond the exploration phase and activities associated with power plant development.

4.0 PROJECT PLAN

At this point, we have a broad outline and technical concept for all four phases of the proposed EGS program. However detailed project planning has been accomplished for Phase 1 only, so sections 4.3 and 4.4 do not cover the later phases. The details subsequent to Phase 1 will be accomplished in each successive Phase.

4.1 Statement of Objectives

The overall objective is to apply known and new well permeability enhancement techniques to reduce the number of wells needed for the 50 mw Fourmile Hill project, and demonstrate the applicability of the techniques to other undeveloped or under-developed fields.

4.2 Statement of Work

Phase 1: 7/02 -- 9/03

- Use existing productive wells at the Telephone Flat area to demonstrate and quantify the benefits of known permeability enhancement and well bore stimulation techniques such as high-rate injection, acidizing, and gas lift.
- Apply the known techniques to one of the new wells to be drilled in 2002 by Calpine-Siskiyou in the Fourmile Hill area.

Phase 2: 10/03 -- 9/04

- Install a microearthquake (MEQ) network to monitor the distribution of fractures created or stimulated due to permeability enhancement operations.
- Drill a new well in Fourmile Hill using techniques such as measurement-while-drilling, spot coring, mini-frac tests and Formation Micro Scanner logging to quantify permeable zones, partially filled fractures, and damaged permeability. Then use best available downhole technology to focus permeability enhancement on zones specifically targeted, and demonstrate the benefits of this purpose-drilled approach compared with the less focused methods previously used in geothermal stimulation.
- At a Fourmile Hill well, which does not respond sufficiently to permeability enhancement efforts, drill and complete a fork, finishing with slotted liner in both legs. This will demonstrate an alternative approach to development of low-permeability reservoirs.

Phase 3: 10/04 -- 9/05

- Based on the Phase 1 and 2 results, apply permeability enhancement techniques as appropriate during the 50-mw development drilling program.

Phase 4: 10/05 -- 9/07

- After 50-mw plant is online, monitor performance of all production and injection wells, applying remedial stimulation where performance has been compromised by formation bridging or scaling. Conduct tracer testing and continue MEQ monitoring to determine possible flow paths.
- Continue to use permeability enhancement technology on makeup wells to minimize costs and maximize production.

4.3 Work Breakdown Structure

At this time, the Work Breakdown Structure has been completed only for Phase 1. The work is broken down into five tasks, as shown below. Note that Tasks 1 and 2 are scheduled prior to the anticipated award date of September 6, 2002. These pre-award costs will be treated in accordance with Section V.I of the solicitation.

Task 1: Flow test well 31-17

Dates: 7/1/02 -- 7/30/02

Well 31-17 was drilled in 1988 to a TD of 8,787' and only flowed after a matrix acid stimulation. The flow test was about two days duration and never produced pure reservoir fluids uncontaminated by drilling and injected fluids. There is evidence that additional deeper permeability may have been created by injection, but there have been no flow tests since 1988.

A 30-day flow test is proposed for this well, using nitrogen lift as needed to get the deeper zone to flow. Calpine-Siskiyou's test separator will be installed, and liquid will be flowed to the existing sump at the site. From there it will be pumped via temporary pipeline for disposal in a neighboring Telephone Flat well. A flow test of approximately 30 days duration is planned, and well performance and chemistry will be monitored. Following the flow test, water produced from a neighboring well will be injected into 31-17. Injectivity will be monitored to determine if permeability changes during this time. Pressure-temperature spinner (PTS) logs will be acquired with the well shut-in, producing and injecting.

Task 2: Flow test well 68-8

Dates: 8/1/02 -- 8/30/02

Well 68-8 was drilled in 1985 to a TD of 6,991' and deepened in 1988 to a TD of 8,417'. After gas lift, it flowed on its own for a short term (~2 days) flow test and never produced pure reservoir fluids uncontaminated by drilling fluids. A 30-day flow test is proposed for this well. The flow test, sampling and logging programs will be similar to the program outlined above for 31-17.

Task 3: Acid stimulation of Telephone Flat well

Dates: 9/9/02 -- 9/23/02

Depending on the flow testing results, either 31-17 or 68-8 will be chosen for acid stimulation. The formulation and program will be planned carefully with an experienced service company to maximize the chances of success. Most likely a coiled tubing unit will be used to carry out the job. The plan includes a 10-day flow test afterwards, with PTS logging and chemical sampling, in order to evaluate the success.

Task 4: Acid stimulation of Fourmile Hill well

Dates: 11/1/02 -- 11/15/02

By this time there should be two wells completed at Fourmile Hill. Of these, one will be chosen for acid stimulation, based on all the previous Phase 1 results. The formulation and program will be planned carefully with an experienced service company to maximize the chances of success. Most likely a coiled tubing unit will be used to carry out the job. The plan includes a 10-day flow test afterwards, with PTS logging and chemical sampling, in order to evaluate the success.

Task 5: Analyze Phase 1 results, prepare for Phase 2

Dates: 12/1/02 -- 9/30/02

All the technical and operational data gathered will be analyzed and interpreted, leading to a more precise work plan and budget estimate for Phase 2.

4.4 Milestone Plan

The Phase 1 technical targets are defined in the five tasks outlined above in Section 4.3. Completion of each task marks a milestone. Key Phase 1 decision points are:

9/1/02: Decide which Telephone Flat well to stimulate. The criteria for this decision will be the flow test results from 68-8 and 31-17.

11/1/02: Decide which Fourmile Hill well to stimulate. By the time of this decision point there should be two Fourmile Hill wells completed and at least partially tested. The decision criteria will be the drilling and flow test data, as well as the preliminary results from the Telephone Flat stimulation.

5/1/03: Decide whether to go ahead with Phase 2 as planned, modify the Phase 2 program, or cancel the EGS effort. This decision will be based on all the Phase 1 data and analysis, as well as the overall Fourmile Hill drilling results.

4.5 Spending Plan

This proposal has been structured with the intent of scheduling the project Phases in accordance with the timing guidelines suggested in the solicitation. However, Calpine-Siskiyou faces a contractual deadline to bring power online at Fourmile Hill. To meet that deadline, the resource must be delineated and the economics of development drilling must be reasonably well understood by mid-2003. This means that Phases 1 and 2 must be accelerated, relative to the solicitation guidelines, in order to synchronize the EGS program with the development drilling program and thereby maximize the benefits of EGS. Therefore we propose to begin the Phase 1 work July 1, 2002, incurring pre-award costs of $200,000 (in accordance with Section V.I of the solicitation), and that Phases 1 and 2 be completed in approximately two years total, rather than the four to five "budget periods" suggested in the solicitation. Assuming continued success, Phase 3 could then be accomplished in one year, per solicitation guidelines, coinciding with the latter stages of development drilling. Finally, Phase 4 would begin shortly after the plant comes online, consistent with its stated purpose of applying EGS after startup, and would continue for approximately two years. Overall, this proposal envisions EGS funding distributed over five to six fiscal years, consistent with the solicitation guidelines, but the phases are "front-loaded" compared with the guidelines.

The proposed Phase 1 spending plan amounts to $755,500, of which $500,000 is the DOE share and $255,500 is the Calpine-Siskiyou share. The Phase 1 spending plan is broken down by task in Table 4.1, and by calendar year and fiscal year in Table 4.2.

Table 4.1. Phase 1 spending plan per task

Task	DOE Share	Calpine-Siskiyou Share	Total
1. Flow test 31-17	$10,000	$90,000	$100,000
2. Flow test 68-8	$100,000	$0	$100,000
3. TF stimulation	$150,000	$75,500	$225,500
4. 4MH stimulation	$240,000	$60,000	$300,000
5. Data analysis	$0	$30,000	$30,000
Totals	$500,000	$255,500	$755,500

Table 4.2. Phase 1 spending plan per year

	DOE Share	Calpine-Siskiyou Share	Total
CY2002	$500,000	$225,500	$725,500
CY2003		$30,000	$30,000
FY2002	$110,000	$90,000	$200,000
FY2003	$390,000	$165,500	$555,500

For the overall EGS project, table 4.3 shows the consolidated Phase 1 spending plan, followed by rough cost estimates for Phases 2, 3, and 4. As discussed above, the work plans and budgets for these phases will be refined based on the Phase 1 results.

Table 4.3. Spending plan per phase ($000)

Phase	Dates	DOE Share	Calpine-Siskiyou Share	Total
1. Demonstration / application	9/02 - 9/03	$500	$256	$756
2. MEQ array, purpose-drilled well, and fork.	10/03 - 9/04	$3,180	$2,120	$5.300
3. Development EGS	10/04 - 9/05	$2,000	$3,000	$5,000
4. Operations EGS	10/05 - 9/07	$1,000	$4,000	$5,000
Totals		$6,680	$9,376	$16,056

4.6 Sources of Financing

All the Calpine-Siskiyou funds and personnel allocations for this work will be provided by its 100% parent company, Calpine Corporation. Calpine is a Fortune-500 company publicly traded on the New York Stock Exchange. Calpine's Investment Committee has already approved funds for the 2002 Glass Mountain resource evaluation plan, including the drilling of up to three wells to prove up the resource at Fourmile Hill.

5.0 TECHNICAL CAPABILITIES

The following are brief descriptions of the personnel involved with this project. Detailed resumes accompany these brief descriptions.

5.1 and 5.2 Key Personnel And Related Experience

Mr. Tom Box is the Vice President, Geothermal Resource Management and has more than 28 years of broad experience in the geothermal industry including exploration, development, and operations. Relevant experience includes management of a team of resource and drilling professionals involved in the development and management of geothermal fields at the Geysers and Cerro Prieto, Mexico. He initiated a successful deep drilling program at Cerro Prieto and an enhanced injection program at the Geysers. He also participated in the development and stimulation of natural gas wells in the Sacramento Valley. Mr. Box has been a member of numerous DOE industry advisory boards over the years providing advice on the direction of the DOE geothermal program. Mr. Box is responsible for the exploration program at Glass Mountain and has been involved in this project since 1985.

Mr. Mitch Stark is Senior Geoscientist with more than 22 years experience in geothermal exploration and development. Three of those years were in a position of management responsibility for well stimulation efforts at the Mak-Ban and Tiwi fields, Philippines, which included the first acid stimulation at Mak-Ban using a coil tubing unit instead of a rig, and the successful forking of an injection well at Tiwi. Other relevant experience includes nearly 20 years acquiring and analyzing microearthquake data in geothermal fields. During the last 2 years Mr. Stark has been the principal industry liaison for DOE cost-shared projects: a Geysers EGS project, and a Glass Mountain Geothermal Resource Exploration Definition (GRED) project.

Dr. Joe Beall is Senior Geologist with thirty years experience in geothermal exploration, development and operation throughout the Western United States and Mexico. He has supervised the exploration efforts at Glass Mt. for Calpine and its predecessors for more than 20 years. In addition he has specialized in geochemical applications and tracer technology development at operating geothermal field, and has published extensively.

Mr. Mark Walters is a Consulting Geologist with more than 22 years experience in geothermal exploration, development and operations throughout the Western United States. Recently, he participated in a proposal for the Creation of an Enhanced Geothermal Reservoir at The Geysers. He initiated studies of permeability and tracer flow paths within injection – production well pairs at Coso and worked with the USGS in the identification of candidate Enhanced Geothermal Systems sites throughout the Great Basin.

Dr. Keshav Goyal, is Senior Reservoir Engineer with 24 years of geothermal experience in vapor dominated, two phase and liquid dominated geothermal fields including The Geysers, CA, Cerro Prieto, Mexico, Puna HI, Roosevelt UT, and Desert Peak, NV. Dr. Goyal has modeled East Mesa, CA, Cerro Prieto, Roosevelt, Desert Peak and Wairakei, NZ geothermal fields. He has evaluated the effect of injection on well performance, and at the Puna KS-1A, he participated in stimulating this well from zero flow to an induced flow from the two-phase reservoir. Dr. Goyal has over 40 publications in referenced journals and proceedings to his credit.

Mr. Marc Steffen, Drilling Manager, has 8 years of oil and gas experience and over 19 years of experience in geothermal drilling and workover operations. His geothermal experience has been concentrated in The Geysers as Manager of drilling and downhole operations, but also has included project management responsibilities in geothermal fields in Utah and Mexico. He has been involved in all facets of drilling, completion, and remedial activities including hydraulic fracturing and acid stimulation of oil and gas wells. As chairman of the recently disbanded Geothermal Drilling Organization, he has been actively involved in identifying, selecting, and participating in cost shared projects in conjunction with Sandia Labs and the Department of Energy. In his present capacity as Drilling Manager, he will oversee all drilling, completion, and remedial well operations in the Glass Mountain project.

Mr. Tim Smith, Drilling Superintendent, has more than twenty years experience supervising geothermal drilling operations. He has provided on-site supervision and coordinated the drilling, logging, testing, and stimulation of more than 120 geothermal wells throughout the Western United States and Mexico, including Glass Mountain.

Mr. Clarence Reams, Wireline Supervisor, has 35 years of experience in the drilling industry with approximately eleven years drilling, completing, and working over oil and gas wells, and 24 years drilling, completing and reworking geothermal wells in California and Mexico. He supervises drilling crews, contractors, and Calpine's wireline crew.

Ms. Charlene Wardlow is Project Environmental Manager with more than 20 years experience in all phases of geothermal development, advancing from Reservoir Engineer to EHS Manager. She initiated her career as a stimulation engineer and is presently the manager of the permitting and EHS programs at Glass Mountain KGRA.

Tim Conant, holds licenses as a Mechanical and a Civil Engineer in the State of California. He has over 20 years of experience in Geothermal plants and fields. He has worked mainly at The Geysers on the development of new projects and in the maintenance and operation of existing plants and fields, and also at Cerro Prieto, Mexico and the Sacramento Valley gas fields. Most recently he has worked on the initial plant layout for Fourmile Hill at Glass Mountain.

5.3 Facilities And Equipment Available

Environmental review and permits are available for the construction of a 50 MW power plant at the Fourmile Hill project where this EGS project is proposed for demonstration. Roads and drilling pads are presently under construction. One existing water well and three existing production wells at Telephone Flat are available for both the supply of drilling and testing water, and the disposal of brines from testing and well stimulation. Calpine is assembling the hardware for a long-term 2-phase flow test facility, including a high-pressure separator, piping, metering, sampling ports, and flash vessel. This assembly will be moved from well to well to accomplish the flow testing envisioned in the permeability enhancement program. Calpine will construct a temporary pipeline early in the summer of 2002 between the Fourmile Hill and Telephone Flat projects to accomplish both the delivery of water to Fourmile Hill and the disposal of brines from new production wells. There will also be sufficient additional piping to allow transport of fluid between pairs of wells at Telephone Flat or Fourmile Hill. If the Fourmile Hill drilling campaign is successful, as many as three new production wells will be available to this project for the proposed testing and stimulation beginning in the fall of 2002.

An extensive subsurface database and library is available for use by the project team that includes data and logs from 4 deep exploratory wells, and 26 deep temperature core holes. There are also several hundred documents related to the reservoir at Telephone Flat, and the geology, geochemistry and geophysics of Medicine Lake Volcano and the surrounding Medicine Lake Highlands.

Calpine has donated core and samples totaling about 100,000 ft. from its Glass Mountain project to a core library at the Energy and Geoscience Institute in Salt Lake City, Utah. An estimated 70,000 of core and cuttings are from temperature gradient holes and 30,000 from the deep exploratory wells are available testing for future research.

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5.4 <u>Justification For And Description Of Needed Facilities And Estimated Costs</u>

Calpine is providing the main facilities required for Phase 1 for the purposes of this EGS project, as described above in Section 5.3. For Phase 2 and beyond, few facilities are needed for the EGS project at Fourmile Hill that are not already planned by Calpine for its 50-mw development. The main such facility envisioned is a microearthquake (MEQ) monitoring array, planned to be installed during Phase 2. The monitoring of MEQ's is an established method of delineating the fractures that develop in response to wells being stimulated by injection. MEQ monitoring together with tracers allow the tracking of fluid movement and the identification of fracture and reservoir flow paths. The cost of a microearthquake system at Fourmile Hill is estimated at $800,000.

For Phase 1, more than half of the total estimated cost is for the two acid stimulation jobs planned. These costs are based on a written quote from a service subcontractor with many years experience doing acid stimulation of geothermal wells. The remaining Phase 1 costs are based on Calpine's own calculations and estimates. Proposed costs for Phase 2 and beyond are rough estimates only, and will be refined when and if the project approaches those budget periods.

12 PTS
@ 10 K / apiece
3 on 85-28 also PT
2/3 for each Telephone Flat wells
50 K.
20 K
5 K each

6.0 Project Management Plan

6.1 Project Organization and Responsibilities
The Glass Mountain Permeability Enhancement Project will be completed by Calpine-Siskiyou using the existing Calpine organization shown in 6.3. This organization focuses on Calpine's drilling, resource, and environmental management teams to develop and implement the technology to successfully stimulate geothermal wells at the Fourmile Hill and Telephone Flat project areas at Glass Mountain.

Calpine's geothermal Drilling Manager, Marc Steffen, will supervise a team of very experienced drilling supervisors in the development and implementation of a well stimulation program. We expect to work closely with Halliburton on completing this project. Calpine owns and operates a wireline unit capable of obtaining Pressure-Temperature-Spinner and other logs using memory tools. This equipment will be used in the evaluation phase of the project.

Calpine's Senior Geoscientist, Mitch Stark, will supervise a team of senior geologists, reservoir engineers and production engineers that will evaluate the geology and fracture characteristics of the Glass Mountain reservoir and design, implement, and evaluate the impact of various stimulation activities through a well testing and logging program.

Calpine's Manager of Development Permitting, Charlene Wardlow, has the primary responsibility to insure Calpine-Siskiyou's compliance with all permit and regulatory requirements. Given the sensitivity of operations in this area on local, Native American and environmental interests, all development activities on the Glass Mountain project will require the constant vigilance of all parties to maintain the highest standard of compliance and safety during the activities associated with this project.

6.2 Task integration and Project Coordination
Calpine intends to conduct a drilling and testing program in the Fourmile Hill and Telephone Flat area during the summer and fall of 2002. The activities associated with this proposal will be conducted in conjunction with our on-going operation in the area. The planned program consists of the drilling and completing one temperature gradient and 3 full size production wells in the Fourmile Hill area. Additionally, each of the three existing Telephone Flat wells will be production tested for approximately 30 days during this year. Injection lines will be constructed to allow flashed brine and/or groundwater to be moved between Fourmile Hill and Telephone Flat areas or between wells within the areas. The proposed stimulation activity will be planned and coordinated with these on-going activities.

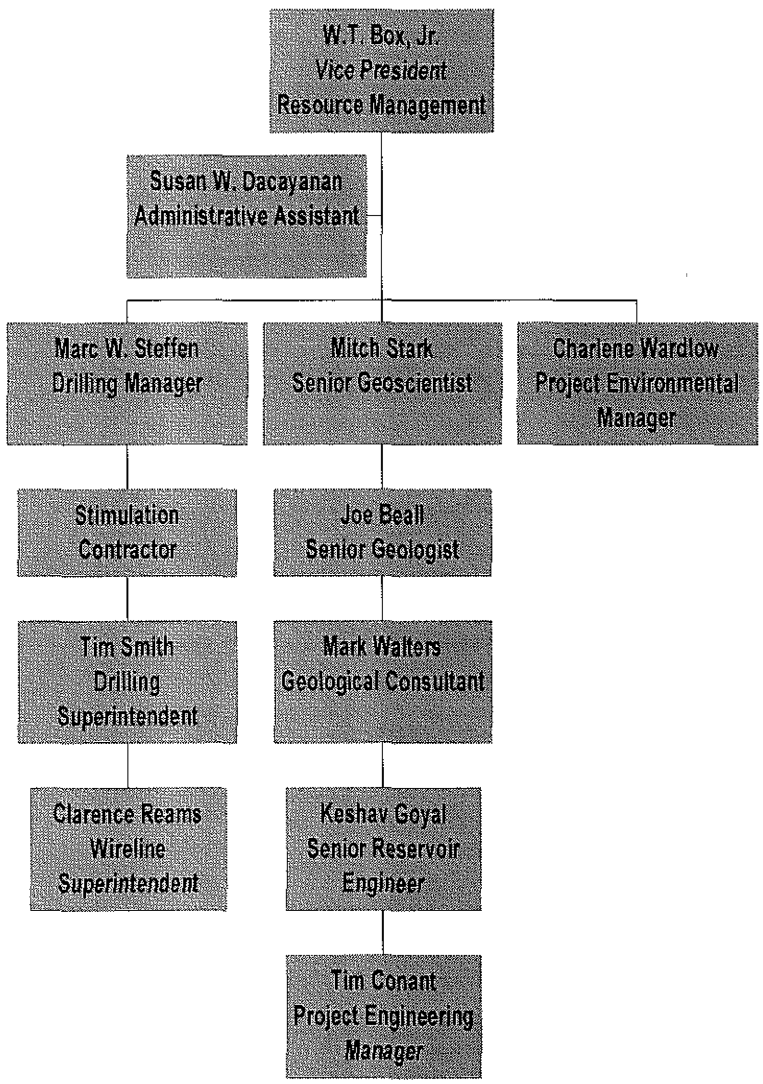
6.3 Project Management Structure Including Implementation and Monitoring of the Project – See attached organizational chart.

6.4 Management Philosophy
This proposed project is designed to build on the substantial existing database and worldwide experience regarding geothermal well stimulation. The development of additional, successful techniques to improve the permeability of non-commercial geothermal systems will be useful for developers working in both high and low enthalpy systems. Calpine's management style will allow individuals responsible for the various aspects of this proposal to call upon the expertise and experience of anyone on the team or to retain contractors and/or consultants for specific measurable tasks. The majority of the members of this group are well known to the Department of Energy geothermal program staff and are familiar with the capabilities of, particularly, Sandia Laboratory to assist in the design and implementation of various stimulation experiments.

Finally, Calpine intends to make available all drilling, logging stimulation, and well test data developed on the wells in Glass Mountain, either existing or planned, for use by the scientific community to understand the reservoir conditions and the results developed from this project.

Glass Mountain Permeability Enhancement

Project Team



7.0 Technology Transfer and Commercialization Plan

7.1 Technology Transfer

Technology transfer to the end-user industry on this project and its follow-on development phases will involve four approaches:

1. Periodic reports to DOE as required under this program. These will be industry-standard reports and will be completed within three months following each Phase of the project.
2. Topical technical reports will be published as papers at conferences such as the annual meeting of the Geothermal Resources Council or the Stanford Reservoir Engineering Workshop.
3. Calpine will make data collected during all project phases, available for study by other research organizations and collaborators such as the US Geological Survey, Sandia National Laboratory, and EGI. In addition, Calpine will provide previously collected data about the reservoir and its geology, geophysics and geochemistry to these research organizations.

It is Calpine's intent to distribute the project results and findings to the widest audience possible at the earliest time practical. Calpine has a long history of excellent cooperation with DOE to make proprietary technical data available in a timely manner for public-domain scientific research. Calpine also committed to releasing internally available reports and information to other collaborative investigators working at the Medicine Lake Volcano.

Calpine maintains close contact with the US Geological Survey's Geologic Hazards Group and Sandia National Laboratories' Geothermal Research Department, and intends to create partnering strategies when funds are available for these institutions to conduct their intended work at Glass Mountain.

7.2 Commercialization Plan

Calpine has no expectations of licensing any of the technologies developed by this project. Calpine's sole goal in this project is to decrease the costs and environmental impact of developing geothermal resources for electric power generation.

Solicitation No. DE-PS07-02ID14264
Attachment 1

OMB Approval No. 0348-0043

APPLICATION FOR FEDERAL ASSISTANCE

2. DATE SUBMITTED: **April 8, 2002**		Applicant Identifier:
1. TYPE OF SUBMISSION: *Application* ☐ Construction ☒ Non-Construction; *Preapplication* ☐ Construction ☐ Non-Construction	3. DATE RECEIVED BY STATE:	State Application Identifier:
	4. DATE RECEIVED BY FEDERAL AGENCY:	Federal Identifier:

5. APPLICANT INFORMATION:

Legal Name: **Calpine Siskiyou Geothermal Partners Limited Partnership**	Organizational Unit:
Address (*give city, county, state, and ZIP code*): **10350 Socrates Mine Road, Middletown, CA 95461**	Name and telephone number of the person to be contacted on matters involving this application (*give area code*): **W. Tom Box Jr. (707) 431-6106**

6. EMPLOYER IDENTIFICATION NUMBER (EIN):
77-0397029

7. TYPE OF APPLICANT (*enter appropriate letter in box*): **M**
A. State H. Independent School District
B. County I. State Controlled Institution of Higher Learning
C. Municipal J. Private University
D. Township K Indian Tribe
E. Interstate L. Individual
F. Intermunicipal M. Profit Organization
G. Special District N. Other (Specify):

8. TYPE OF APPLICATION:
☒ New ☐ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es): ☐ ☐

A. Increased Award C. Increase Duration
B. Decrease Award D. Decrease Duration
Other (Specify):

9. NAME OF FEDERAL AGENCY:
OFFICE OF ENERGY EFFICIENCY CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: **81.087**
TITLE: **Renewable Energy Research and Development**

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:
Glass Mountain Permeability Enhancement Project

12. AREAS AFFECTED BY PROJECT (*cities, states, etc.*):
Siskiyou County, CA

13. PROPOSED PROJECT:

Start Date	Ending Date
September 9, 2002	**January 1, 2005**

14. CONGRESSIONAL DISTRICTS OF:
a. Applicant **1** b. Project **2**

15. ESTIMATED FUNDING:

a. Federal	**$500,000**
b. Applicant	**$255,500**
c. State	$
d. Local	$
e. Other	$
f. Program Income	$
g. TOTAL	**$755,500**

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?
a. Yes. This Preapplication/Application was made available to the State Executive Order 12372 Process for Review on (date) ____________
b. No. ☐ Program is not covered by Executive Order 12372
☒ Or Program has not been selected by State for Review

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes. If yes, attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT. THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.

a. Typed Name of Authorized Representative	b. Title	c. Telephone Number
Dennis J. Gilles	Vice President, Geothermal	**(707) 431-6058**
		e. Date Signed **April 8, 2002**