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PROPOSAL
FOR
TECHNICAL ADVISORY SERVICES FOR GEOTHERMAL RESOURCE ASSESSMENT

submitted to

Mr. M. E. Towill, Director
Department of Business, Economic Development and Tourism
Attention: Energy Division
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APPENDICES

1. INTRODUCTION

The State of Hawaii Department of Business Development and Tourism (DBED) has requested a proposal (RFP) to provide technical advisory services for Hawaii's Geothermal Resource Assessment Program (GRAP). DBED will issue and administer the technical advisory services for the GRAP. Other State or County agencies involved in this work will be the Department of Land and Natural Resources (DLNR), ad-hoc inter-agency committees convened to facilitate discussion of resource assessment and management matters, the State Department of Health, and the County of Hawaii. Herein we will refer to the State of Hawaii as Hawaii or the State, and the island of Hawaii, as such. As we understand the RFP the objectives of the GRAP are to:

1. Determine the extent of geothermal resources in Hawaii;

2. Characterize these resources; and

3. Determine quantitatively, the geothermal resource potential in Hawaii.

Hawaii also wants to properly plan and implement geothermal development so the resource is not depleted prematurely either through excessive or improper exploitation.

To date, Hawaii has focused its assessment program on the East Rift Zone of Kilauea Volcano (KERZ) on the island of Hawaii. However, the location of future assessment work should not be limited to the KERZ, but rather evaluated on the basis of resource viability, land-use, environmental and socio-environmental factors and will be objectively determined on the basis of consideration of land-use, environmental and socio-economic factors.

The tasks in the Scope of Work presented in the DBED RFP are presented below along with our suggested modifications (in bold type) which we believe will significantly enhance the overall effectiveness of the GRAP given the heightened environmental concerns in Hawaii. These suggested modifications are proposed for DBED's consideration and acceptance. The Weiss Associates team will assist DBED and DLNR in:

1. Establishing priorities among available resource assessment methods in a technical and cost-effective manner.

2. Planning the direction and management of the Scientific Observation Hole (SOH) program.

3. Evaluating the SOH drilling methodology with cost-effectiveness being a major criterion.

4. Designing and planning appropriate well tests, surface and aerial surveys, and/or mapping projects.

5. Providing technical guidance to the geothermal\cable master plan and EIS being prepared by ERCE.

6. Providing technical guidance relative to the planning and design of the geothermal\cable project by the consortium to develop 500 megawatts of geothermal electrical power in the KERZ and the Hawaiian Electric Company.

7. Making reasonable judgements and to reach objective, scientifically supported conclusions about the extent and characteristics of geothermal resources.

8. Advise DBED and DLNR on well-field design and management practices to assist them in adopting appropriate policies, standards, and design criteria to avoid over-production and premature depletion of the geothermal resources.

Our experience working in Hawaii indicates that for all these tasks, it is critical to account for environmental, regulatory and policy concerns.

1.1 PROPOSAL ORGANIZATION

We have organized our response to the DBED RFP in the following manner. Section 2 presents the Weiss Associates team along with their qualifications and relevant work experience. This section also describes Weiss Associates, the company philosophy and company technical approach, and presents a summary of our qualifications. Section 3 highlights our technical approach to the GRAP addressing the RFP Scope of Work. Section 4 presents a discussion on project organization, accessibility and responsiveness, and project cost-effectiveness. It includes several recommendations on cost control, and discusses conflicts of interest. Section 5 presents the 1991 Schedule of Charges and Conditions for Weiss Associates and their subcontractors for this project. Appendix A presents the resumes for the Weiss Associates team. Appendix B presents an example of the recommended prioritization method.

2. THE TEAM

The success of this project will depend on the team members, communication with DBED and other State or County representatives, and the commitment of Weiss Associates and DBED to provide the team with the necessary support.

To provide the best possible geothermal technical advisory services for this effort, Weiss Associates has joined with a number of subcontractors to form a highly qualified team of specialists with the requisite scientific, engineering, drilling, technical, environmental, regulatory, policy and management experience. The Weiss Associates team brings over 200 years of cumulative experience to the GRAP, along with broad knowledge of the interrelationships between resource assessment methodologies and commercial geothermal development. The team is fully cognizant of the practical requirement for cost-effective programs, in that each and every aspect of the work task must be considered in light of the overall objective.

As requested in the RFP, the team is well versed in the disciplines of geology, geochemistry, geophysics, hydrology, reservoir engineering, well-field engineering, power plant design, and drilling operations. To ensure a comprehensive evaluation of the geothermal resources in Hawaii and complete project success, we recommend the addition of the following disciplines to the team: environmental, regulatory and policy, direct use applications, management and coordination, and quality control and quality assurance. Described below are our team qualifications and relevant work experience.

2.1 TEAM QUALIFICATIONS AND RELEVANT WORK EXPERIENCE

Weiss Associates offers DBED a team of specialized, highly experienced senior professionals whose component skills and expertise are complementary and complete. This section introduces the team members, highlights their qualifications and relevant work experience, and identifies their specific roles in the project. The team will be available for the length of the contract to assist DBED and DLNR in the Scope of Work defined in Section 1. A list of the team members by discipline is given in Table 1. Individual team member resumes are presented in Section 5.

Mr. Joe L. Iovenitti - Project Management and Coordination

Joe Iovenitti, our proposed project manager, has over 14 years of professional experience in geothermal exploration, development, and production programs. He is proficient in integrating geoscientific data into a comprehensive geothermal system model to optimize cost-effective exploration activities, reservoir development and production operations. Mr. Iovenitti has hands-on experience in project management, flow testing, regulatory, permitting and environmental issues, and is knowledgeable of drilling and completion practices, reservoir engineering, power plant and marketing issues. He has supported several resource evaluations with risk analysis to optimize technical and new business opportunities.

Mr. Iovenitti has specific work experience in evaluating geothermal systems in Hawaii, as well as in regional geothermal assessments. As the Senior Geologist for Thermal Power Company between 1982 and 1987, he was responsible for planning, executing and managing a board spectrum of geoscientific programs in all Thermal Power Company geothermal operations. He had direct geoscientific responsibility the Puna Geothermal Venture 25 MW project, which is currently being developed. He has conducted detailed evaluations of numerous exploration and development projects throughout the western United States, Indonesia and the Philippines. Highlights of Mr. Iovenitti's extensive experience with the geothermal system in the KERZ follow:

- *Kilauea East Rift Zone*: Recommended drill site locations and completion program for the SOH program.

- *Kilauea East Rift Zone*: Conducted a comprehensive geoscientific evaluation of the Puna geothermal system for Thermal Power Company, Ormat Energy Systems, and most recently, for ERCE in support of their work on the Geothermal/Cable Master Plan prepared for DBED; prepared, conducted and directed the work which resulted in the "Summary Report on the Geothermal Resources of the East Rift Zone, Kilauea Volcano, Hawaii" submitted by ERCE to DBED as Appendix A of the Geothermal/Cable Master Plan.

- *Kilauea East Rift Zone*: Provided a comprehensive Kilauea Volcano geothermal resource overview to two of the consortia which bid on the 500 MW development project in Hawaii.

- *Kilauea East Rift Zone*: Performed a geohydrochemical analysis of the southeastern portion of the island of Hawaii; published work on the shallow portion of the hydrological system.

- *Puna Geothermal Field*: Developed the conceptual program for injection of non-condensible gases.

- *Puna Geothermal Field*: Performed a detailed geochemical analysis of the Puna geothermal field and its relationships with the shallow hydrological system.

- *Puna Geothermal Field*: Performed the geoscientific data integration and interpretation for an internal Thermal Power Company report on the Puna geothermal reservoir. This report formed the basis for the 25 MW development program.

- *Puna Geothermal Field*: Prepared a geological, geochemical, geophysical, and hydrological program in support of the 25 MW development project.

- *Puna Geothermal Field*: Prepared technical plans for, managed and worked closely with geoscientific consultants on the summarizing and reinterpreting both the public domain and available private geophysical, hydrological and reservoir engineering data on the Puna geothermal field.

- *Puna Geothermal Field*: Conducted an comprehensive evaluation of the exploratory well results in the Puna field.

With respect to regionally-oriented geothermal resource assessment programs outside of Hawaii, Mr. Iovenitti conducted and was responsible for:

- *Central America:* An end-term review of the geothermal energy assessment program conducted by Los Alamos National Laboratory in that region between 1985 and 1981.

- *The Philippines*: A general reconnaissance of geothermal prospects and projects in the Philippines.

- *Indonesia*: A detailed geothermal reconnaissance of the islands of Java and Bali, Indonesia, and a comprehensive evaluation of the Dieng geothermal field in central Java. This work led to contractual negotiations between Thermal Power Company and Pertamina, the national oil company of Indonesia for geothermal development rights on over 5,000 acres at Dieng.

- *Cascade Province*: The evaluation of the entire High Cascade geothermal province for Thermal Power Company which led to the drilling of a 4,800-ft corehole in central Oregon in conjunction with Chevron Resources Company and US DOE under the DOE's Cooperative Drilling Program for Deep Thermal Gradient Drilling.

- *Nevada*: The State of Nevada geothermal resource evaluation program for Chevron Resources Company. His geoscientific work created the foundation for geothermal discovery at Soda Lake, and led directly to the 16 MW geothermal development at Beowawe.

Dr. Steven Vonder Haar - Geologist

Steven Vonder Haar, our proposed geologist, has over 15 years of professional experience in applied geosciences. He has conducted geological, geophysical and reservoir assessments in such geothermal areas as Cerro Preito, Mexico; Valles Caldera, New Mexico; Krafla, Iceland and Imperial Valley, California.

Dr. Vonder Haar was also involved in the 1982 assessment of geothermal energy in Hawaii. This was a comprehensive geothermal assessment of all the islands in Hawaii. He also was part of a team that included scientists from US DOE, Lawrence Berkeley Laboratory, University of Hawaii, and the State of Hawaii. Not only did he perform an historical assessment of published literature, but also reinterpreted existing data, particularly at one site in Oahu, and three sites on the island of Hawaii. He is also familiar with the assessed energy requirements of the State of Hawaii, and the inherent difficulties in transmitting power from the KERZ to Oahu. Dr. Vonder Haar brings to the GRAP a technical understanding of modeling of fracture flow, and the impact of mineral precipitation from geothermal fluids.

Dr. Robert F. Corwin - Geophysicist

Robert F. Corwin, our proposed geophysicist, has been involved in the application of geophysical techniques to geothermal investigations since 1972. He has broad experience integrating the results of electrical, magnetic, gravity, and seismic geophysical studies with hydrogeologic and geochemical data in support of geothermal resource evaluations. He has performed theoretical, laboratory, and field research in a number of areas of geothermal interest, and has authored several publications describing the results of these studies.

Dr. Corwin has conducted field geophysical investigations throughout the western United States and in Hawaii, Alaska, Mexico, and Iceland. Examples of high-temperature study areas include Roosevelt Hot Springs, Utah; Cerro Prieto, Mexico; Unalaska Island (Aleutians), Alaska; East Mesa and Medicine Lake, California; Steamboat Hills, Nevada; and others. Low-temperature geothermal resource areas studies by Dr. Corwin include White Pine, Nevada; Sierra Valley, Byron Hot Springs, Desert Hot Springs, and Sonoma, California; and others. Both

the Desert Hot Springs and the Sonoma, California investigations provided successful geophysical results from developed urban areas where cultural conditions generally have adverse impacts on geophysical surveys.

Dr. Carter D. Hull - Geochemist

Carter D. Hull, our proposed geochemist has over 14 years of professional geothermal resource evaluation experience focused on geothermal and geological processes. He has been involved with the planning and development of regional geothermal resource assessments of the Upper Santa Ana River Basin region of California, and in the South San Bernardino, Harlem Hot Springs, and Arrowhead Hot Springs Known Geothermal Resource Areas of California. He has conducted assessments to identify and develop geothermal resource for the Cities of San Bernardino, Riverside, Highland, Loma Linda, and Colton, California. He participated in geothermal resource assessment projects for the Salton Trough, Coso Hot Springs, and The Geysers regions of California, and the Crater Lake, central Cascades, and Newberry Volcano regions of Oregon. He has also made contributions to resource assessments of Cerro Prieto, Riito, Laguna Salada, Los Humeros, and Los Azufres geothermal fields in Mexico. His technical experience includes:

- Collection of water and gas samples from geothermal wells in hot water, two-phase, and steam reservoirs, as well as from hot springs, fumaroles, gas vents. He is also experienced in sampling soils.

- Collection and interpretation of temperature, seismic, electrical, and chemical data for geothermal resource assessment projects. Design of well logging programs and interpretation of electrical and temperature logs for geothermal wellbores.

- Identification of hydrothermal mineral assemblages in well cores, cuttings, and petrographic thin-sections and interpretation of such mineral assemblages.

- Production and interpretation of a number of fluid inclusion studies of geothermal areas.

- On-site geologist in charge of numerous geothermal drilling and coring projects. He is also familiar with various drilling techniques.

Dr. Hull's research for his M.S. from the University of California, Riverside focused on the identification and assessment of geothermal resources. This work delineated, characterized, and evaluated four geothermal resource areas in the San Bernardino Valley region of southern California. These systems are cumulatively the largest currently exploited direct-heat

geothermal region in North America. He received Ph.Ds in geological science and chemistry from the University of Oregon. Honors received consist of

- Research Fellowship at ESS-1 - Geothermal group, Los Alamos National Laboratory where his work concentrated on identification and assessment of the geothermal systems in the Salton Trough region of southern California.

- Stearns Fellowship and the Outstanding Merit for Research Awards from the Geological Society of America in 1989-1990 for geothermal assessment work at Carter Lake, Oregon.

- Postdoctoral research in the Geochemistry Laboratory, University of Southern California concentrated on the evolution of geothermal systems.

- Nominated in 1990 and 1991 as a Fulbright Scholar for research on geothermal systems of Iceland. Alternate Fulbright candidate for geothermal research in Iceland in 1991-1992.

Robert A. Ferry - Hydrologist

Robert A. Ferry, our proposed hydrologist, has over seven years experience in contaminant hydrogeology, including project management, site assessment, remedial investigation and design, aquifer testing, ground water flow models, monitoring and extraction well design, construction, development, as well as geotechnical subsurface investigations. Mr. Ferry has published a paper in the Journal of Geodynamics (1985) on modeling the thermal evolution of the active geothermal system at Monotombo, Nicaragua. In addition to his hydrology skills he brings an understanding of the thermal disequilibria generated when steam and/or hot water invade shallower and cooler permeable horizons.

Herman Dykstra - Reservoir and Well-Field Engineering

Herman Dykstra, our proposed reservoir engineer, has 48 years of professional experience in reservoir engineering. He is one of the world's leading experts in geothermal reservoir assessment, and has published several papers on geothermal reservoirs including a detailed reservoir assessment of the Geysers geothermal field in California. Mr. Dykstra has also evaluated the Puna geothermal field for Thermal Power Company and submitted a report assessing the potential for generating 25 KW of electrical power from that field. Mr. Dykstra's extensive engineering experience will also be utilized in well field engineering. Highlights of his work include:

- *Monotombo, Nicaragua*: Flow test analysis of the geothermal reservoir in this field, as well as the designing, obtaining, and analyzing an interference test.

- *Imperial Valley, California*: Prepared isotherms for three geothermal reservoirs in Imperial Valley, based on well temperature surveys. Determine heat-in-place and estimated reserves.

- *Steamboat Springs, Nevada*: Obtained and analyzed flow test data from two wells in this field.

- *Coso Hot Springs, California*: Analyzed flow test data in all wells in this field up to the time first plant was being installed. Prepared isotherm contours based on temperature surveys in wells, determined heat in place and estimated reserves.

- *Dixie Valley, Nevada*: Analyzed flow test data on wells in this field and analyzed interference test data.

- *Puna, Hawaii*: Analyzed flow test data on two Puna geothermal venture wells. Estimated electrical generating capacity of the field.

- *California*: Extensive analysis of the Geysers Field for the California Division of Oil and Gas. Estimated heat in place and megawatts of reserves. Also performed economic evaluations for several royalty interests. Analyzed the potential of a lease in the Geysers Field, and prepared a well development schedule to maintain productivity.

Dr. Glen E. Coury - Well-Field Engineering and Power Plant Design

Glen E. Coury, our proposed well-field and power plant design engineer, has 23 years of professional engineering experience. He is a chemical engineer with extensive achievements in project management, geothermal energy designs and testing, pollution control in water and air streams, process development, economic analysis, and heat transfer systems. Accomplishments include power plant design and operation, process equipment design, and field tests of two-phase flow in pipelines, production wells and injection wells.

Geothermal projects include: 1) overall cycle analysis and process design to select optimum power plant type and operating conditions based on resource conditions, geothermal fluid chemistry, and environmental factors, 2) pipeline and separator design for flashing flow of steam and brine to minimize pressure loss while avoiding dangerous slug flow, 3) safe disposal of gas and hot brine, including combined reinjection, 4) vacuum system design, and 5) design of binary systems, including selection of fluid and of operating temperature and pressure.

Dr. Coury has specific Hawaii experience as a member of a team led by Stone & Webster, which assisted a private party in their due diligence, as they evaluated the possibility of joining the Puna Geothermal Venture project as a major partner of Ormat.

Dr. Coury's role in the Stone & Webster scope of work was to 1) meet with several members of the Ormat staff and their reservoir engineering and geochemist consultant, 2) review reports prepared for Ormat, as well as reports prepared by Thermal Power Company, the previous company on the project, 3) visit the site, as well as the HGP-A facility, 4) interview the technical director of the HGP-A project, and 4) prepare written and oral reports for the private party, including reports presented to its Board of Directors.

His primary responsibilities on the Puna geothermal resource assessment were to: 1) evaluate brine chemistry and its impact on both plant performance and on the environment, 2) evaluate methods for disposal of hydrogen sulfide and, in particular, evaluate the applicability of simultaneous reinjection of brine and hydrogen sulfide to the reservoir at Puna, 3) evaluate, and assist the party in the understanding of the reservoir analysis report, and 4) review some aspects of the Poser plant process design. Other relevant work experience consists of:

- *Taiwan*: Evaluated the performance of a three MW plant, and discovered the problems limiting its output. He designed retrofit systems to bring the plant back to its design power output, and designed a new energy recovery system to use the hot water more efficiently and almost double power output.

- *The Philippines*: Evaluated a gas handling system and designed a more efficient approach which allowed higher power output rates from the turbine-generator and also increased resource life. He conducted an extensive training program for the staffs of the Philippine National Oil Company and the National Power Company.

- *Coso Geothermal Area, California*: Developed, tested, and designed a new and cost-saving procedure for disposal of waste gases by reinjection into the geothermal reservoir.

- *Proprietary*: For another U.S. geothermal power project that was operating below design levels, he has redesigned the brine and steam systems to provide more steam at a higher pressure to the turbine, tested and revised the brine disposal system, and assisted in the design of a binary power plant to recover additional electric power from the waste hot brine stream.

Herbert E. Wheeler, Jr. - Drilling Operations

Herbert E. Wheeler, Jr. is a petroleum engineer who we propose oversee drilling operations in conjunction with Buddy Bowden, described below. Mr. Wheeler has 39 years of professional engineering experience. He has consulted for a number of different geothermal energy projects including those for the World Bank, Bechtel, Thermal Power Company and Ormat Energy Systems, Inc. For the latter two companies, he provided engineering consultation on well design and drilling operations in the Puna geothermal field. In addition to work in Hawaii, Mr. Wheeler has also consulted on drilling volcanic geothermal systems in the Azores, Taiwan, Ethiopia, Romania, Philippines and California.

Royce B. Bowden - Drilling Operations

Royce B. Bowden, in conjunction with Mr. Wheeler oversee drilling operations. Mr. Bowden has over 35 years of professional drilling experience. He and Herbert Wheeler compliment each other in that Mr. Bowden has considerable field expertise while Mr. Wheeler has both the theoretical and practical experience. Mr. Bowden is proposed for this project because of his capabilities and understanding of drilling issues in Hawaii. He was the Thermal Power Company drilling supervisor for the drilling, completion and testing of Kapoho State-1, Kapoho State-2, and Kapoho State-1A. Total footage drilling in the KERZ exceeds 20,000 ft.

He is familiar with the slim-hole drilling methodology. Mr. Bowden supervised the drilling and coring of a 4,800-ft hole in a young volcanic terrain in central Oregon. He is also a co-author on the SOH Program Report completed by R. A. Patterson & Associates (1991) and submitted to DBED.

Nicki A. Norman - Environmental, Regulatory and Policy

Nicki A. Norman, is proposed for environmental, regulatory and policy issues. This is an optional position in that it was not called for in the DBED RFP, however, given the environmental sensitivities in Hawaii, we believe such a person would be useful for the successful completion of the GRAP.

Ms. Norman, has been providing environmental services to independent energy developers, large engineering corporations and regulatory agencies for over 14 years. These services have include permit acquisition, community relations, regulatory revision, policy

analysis, and legislative liaison. She has considerable experience in the environmental issues, agency regulations and people involved in geothermal development in Hawaii having served as the Environmental Manager for the Puna Geothermal Venture from January 1983 to July 1984. During that period she acquired drilling permits from the County of Hawaii and DLNR, assisted the State Department of Health in the development of air quality and ground water regulations, held community meetings and conducted a geothermal bill through State Legislature.

Ms. Norman's consulting practice has provided services to project developers pursuing permits and minimizing impacts, regulatory agencies interested in improving or defining regulations, and international agencies trying to promote environmentally responsible development. Her perspective of pursuing commercial goals with a development regulatory context, and her Hawaiian experience make Ms. Norman ideally suited to provide the environmental input to the Technical Advisory Team.

John W. Lund - Direct Use Applications

John W. Lund, is proposed for direct use applications. This is also an optional position in that it was not requested in the DBED RFP. However, we believe that a direct use application expert will benefit the project if the GRAP identifies resources of low to moderate temperatures and commercially viable for direct use applications.

Dr. Lund is Professor of Civil Engineering Technology at Oregon Institute of Technology, Klamath Falls, Oregon. Research Associate with the Geo-Meat Center, Oregon Institute of Technology. He is a registered professional engineer in California and Oregon, a Member of the Oregon State Board of Engineering Examiners.

John Lund was co-chairman for the International Geothermal Conference devoted to direct use applications and co-editor of the Proceedings. Co-chairman of the First Sine/U.S. Geothermal Resources Conference in Chine and editor of the Proceedings. Geothermal consulting work performed in China, India, U.S.S.R., Yugoslavia, Hawaii and several other sates. Presented numerous papers and involved in research and consulting on direct thermal applications of geothermal energy since 1974. Involved in teaching courses and training sessions in geothermal energy in New Zealand, Iceland, Italy, China, Japan, Yugoslavia, U.S.S.R., Hungary, Czechoslavakia and India.

He is a member of the Board of Directors for the Geothermal Resources Council, Davis California and a former member of the Advisory Committee on Geothermal Energy for the U.S. Department of Energy.

Regional geothermal assessment work consists of:

- *Klamath Falls, Oregon*: Utilization of geothermal energy in Klamath Falls, Oregon, 1974-1978 (including resource assessment, pumping tests, corrosion testing, hydrology and geochemistry analysis).

- *Oregon*: A geotechnical evaluation of costs and benefits of adaptation of geo-heating to the agri-business industry in the Klamath and Snake River Basin, Oregon (USDOE) - 1978-1979.

- *Market Assessment*: Geothermal potential within the Bonneville Power Administration marketing area, 1980-1981.

- *Northern India*: Recommendation of direct geothermal utilization, (UNDP) - 1982.

- *United States*: Geothermal direct use development in the United Sates with emphasis on geothermal heat pumps - 1988.

- *United States*: Analysis of the current status of geothermal direct use development in the United States - updated for 1985-1990 (GRC), 1990.

Richard B. Weiss - Quality Control/Quality Assurance

Richard B. Weiss is proposed for quality control/quality assurance. He is founder and President of Weiss Associates. Mr. Weiss has over 20 years of geohydrological experience and extensive experience in various phases of geothermal resource assessment and utilization. His relevant work experience includes:

- *Puna Geothermal Field, Hawaii*: Compiled and synthesized geologic, hydraulic, chemical and geothermal data for a detailed summary report of the hydrology of the lower East Rift Zone.

- *"Hot Dry Rock" Geothermal Exploration Program, Idaho*: Designed and implemented an exploration program including a hydrologic survey with emphasis on water chemistry and heat flow in the Snake River Plain.

- *Regional Assessment, Honduras*: Planned and implemented a reconnaissance geothermal ground water survey.

- *Rose Valley, California*: Conducted ground water and surface water resource evaluation involving water supply availability for potential geothermal development.

- *Coso Hot Springs, California*: Performed a comprehensive geologic and hydrologic environmental study for geothermal development.

- *Geothermal Waste Control Technology*: Managed, organized and edited a report on geothermal waste control technology, including sections on injection, alternatives to injection, and air pollution control.

- *Geothermal Ground Water Monitoring Guidelines*: Developed a six-step planning and evaluation procedure for the US EPA. Evaluated fluid properties and flow regimes that geothermal reservoir production and injection may induce on cooler ground and surface water flow and quality.

- *Regional Assessment*: Compiled and synthesized geologic, hydrologic and geothermal data for numerous sites in the western U.S., including specification of the following geothermal resource areas and leases in EPA Region VIII.

  - Imperial Valley, California
  - Geysers Geothermal Field, California
  - Klamath Falls, Oregon
  - Rio Grande Rift Zone, New Mexico.

2.2 ABOUT WEISS ASSOCIATES

Weiss Associates is a geological and environmental consulting firm based in Emeryville, California. Founded in 1980, Weiss Associates has over 70 engineers, hydrogeologists, environmental scientists, regulatory specialists, and support staff. The company provides industrial clients, government facilities and environmental law firms with a full range of consulting services including:

- Geothermal resource assessment;

- Soil and ground water contamination investigation;

- Hydrogeologic characterization;

- Remedial action plan design and implementation;

- Regulatory compliance support; and

- Expert witness testimony.

Several of our staff have extensive geothermal resource evaluation experience including R.B. Weiss, founder and President of Weiss Associates, and J.L. Iovenitti, Principal Geologist. For the DBED RFP, we have assembled a team of highly specialized, highly experienced geothermal scientists and engineers (see Section 2.1 and Table 1). In the area of ground water contaminant hydrology, Weiss Associates is recognized as one of the state's most experienced Superfund consultants, involved in remediation of seven of the 31 Superfund sites in the San Francisco Bay Area. The firm works closely with federal, state and local regulatory agencies to assure client compliance during all phases of environmental projects. We are proud of the fact that we assist Lawrence Livermore National Laboratory in their ground water characterization studies at their two Superfund sites, and most recently, we have been selected by Lawrence Berkeley Laboratory for their ground water characterization studies.

Weiss Associates senior professionals are published scientists with graduate degrees from leading environmental sciences schools, including Stanford University, University of California/Berkeley, Massachusetts Institute of Technology, New Mexico Institute of Mining and Technology, and Purdue University.

2.3 COMPANY PHILOSOPHY

Weiss Associates enjoys a reputation for integrity, personalized service, competitive costs, and attention to detail, which is acknowledged by our clients, government agencies -- and even our competitors. Since our founding, our policy has been steady growth through solid science, responsiveness to client and regulatory needs, and attention to budgetary concerns. We continuously update and expand services, maintaining state-of-the-art proficiency in an increasingly complex field. Equally important to us is cultivating a work environment which nurtures innovation and personal development in our employees.

Many companies provide the services we do. Weiss Associates distinguishes itself by setting consistently high standards for quality work -- and then meeting them. We take special pride in putting forth extra effort in every element of a project.

2.3.1 Company Technical Approach

Weiss Associates' technical approach is driven by a simple concept. The most critical aspect of a project is careful, concerted, conscientious analysis of data by experienced professionals. To achieve our technical goals efficiently, accurately, and safely, we place a high premium on using the most sophisticated technology available, providing adequate and appropriate senior supervision, monitoring and guidance to our staff, and providing thorough staff safety training.

3. TECHNICAL APPROACH

The major goal of the GRAP is to quantify the geothermal resource potential in Hawaii that is available for commercial exploitation. To achieve this goal, the extent and nature of the geothermal resources in the State must be characterized.

The DBED RFP Scope of Work called for, among other things, establishing priorities among available resource assessment methodologies, and planning the direction and management of the SOH program (see Section 1). In addition, there are several parts of the RFP that refer to the environmental and regulatory setting that affect geothermal development. Commercial potential and sustainability of geothermal use are impacted by the regulations, environmental setting, and community attitudes. The exploration phase of geothermal development can set the stage for future opposition or acceptance by agencies and the community. Weiss Associates highly recommends including environmental compliance and coordination within the resource assessment methodology to minimize the risk of future opposition, focus limited economic resources on the most commercially viable geographic areas, and coordinate agency interaction to assist in exploration activities.

Described below are the specifics of the RFP Scope of Work, and our recommended approach to achieve them. The following recommended programs are subject to discussion with, and approval by DBED and DLNR. In all the following recommended programs, Weiss Associates strongly urges full participation by DBED, DLNR and other agencies in the development of an enhanced understanding of the technical data and overall evaluation process. This will promote information exchange and participation of regulatory agencies involved in geothermal exploration and development, *such that specific agency concerns can be incorporated into the resource assessment program at the onset to maximize the cost-effectiveness and the utility of the GRAP at completion.*

3.1 PRIORITIZE RESOURCE ASSESSMENT METHODS

To establish the priorities among various available resource assessment methodologies, we must first define the areas where assessments should be done. To this end, we recommend

the following three-step approach.

Step 1 - Review State of Hawaii Geothermal Resource Data

The initial step in any resource assessment is the review of all available data. In this process, Weiss Associates has a distinct advantage in that:

- Mr. Iovenitti is intimately familiar with all the geoscientific data from the KERZ. He was the Senior Geologist responsible for the Puna Geothermal Venture from 1982-1988.

- Dr. Vonder Haar was involved in the 1982 geothermal resource assessments conducted in Hawaii. He was directly responsible for the reinterpretation of four resource areas in the state.

- Mr. Dykstra is familiar with the reservoir conditions encountered in the KERZ. He critically evaluated the Kapuho State-1 and Kapuho State-2 flow test results, and along with the HGP-A performance data, Mr. Dykstra estimated the producing capacity of the explored portion of the Puna geothermal field which is now in development.

- Dr. Coury is similarly familiar with the geothermal resource in the KERZ. He performed due diligence on the Puna geothermal field for a party considering joining the Puna Geothermal Venture as a major partner.

- Messrs. Wheeler and Bowden are intimately familiar with the drilling issues in Hawaii and the KERZ. Mr. Bowden has drilled over 20,000 ft in the KERZ with assistance from Mr. Wheeler.

- Ms. Norman has considerable experience with environmental issues, agency regulations, and concerns of the public in Hawaii. She served as the Environmental Manager for the Puna Geothermal Venture.

Additionally, our team of senior professionals can readily synthesize the data, draw conclusions regarding its validity, interpret its significance, and recommend additional work, if required.

Step 2 - Prioritize Geothermal Resource Areas

Following the data review, we recommend prioritizing the known or suspected geothermal resource areas using the following two steps.

- Initial prioritization: We recommend a simple, easily applied method to rank the resource areas. A relative priority for each resource area can be assigned by calculating a numerical value based on the potential type of resource (ranging from high temperature electrical generation to low temperature direct use) and a probability estimate of finding the indicated resource, both of which are based on the sum total of information available at the time of this prioritization. Different inherent values (or weights) can be assigned to the type of resource to reflect their relative degree of importance. For example, a high temperature resource capable of electrical generation may be considered by DBED and DLNR significantly more important than a low temperature resource. Consequently, the high temperature factor may have a higher value assigned to it. An algorithm can then be developed and used to initially rank the resource areas on a technical basis. DBED, DLNR and the appropriate agencies are recommended to be involved in this process. The highest resource area with highest calculated numerical value will have the highest initial technical ranking.

- Final Prioritization: The initial technical prioritization should be coupled to factors such as environmental, land-use, potential impacts or other issues. It is important to consider such factors because there is little point in establishing a high priority on a particular resource area if a regulatory or environmental issue may prevent or impede its exploration and development. For example, it would be inappropriate to highly rank a resource area within the Hawaii Volcanos National Park. Each of these factors would be assigned a value which is determined by the relative importance of each factor. The algorithm used in the final prioritization should consider all the factors that Weiss Associates, DBED, DLNR, and other agencies deem important. The factors and values assigned to them would be developed with the assistance of DBED, DLNR and other appropriate agencies.

This methodology can be successfully employed to develop a final priority listing of geothermal resource areas which addresses not only technical, but also the environmental, institutional and regulatory issues in Hawaii. Mr. Iovenitti has successfully used this approach to rank resource opportunities in the Cascade geothermal province and Indonesia. These analyses are proprietary, but Mr. Iovenitti did conduct a similar type of analysis for Lawrence Livermore National Laboratory (LLNL) which is in the public domain. In that case, he prioritized over 350 sites of possible hazardous materials releases for the purpose of allocating limited resources to investigate the subsurface nature and extent of contamination. This analysis is presented in Appendix B.

Step 3 - Establish a Characterization Program

The final priority list developed above, of geothermal resources in the State provides a starting point for DBED and DLNR to focus their attention and funding. The Weiss Associates team can then assist DBED and DLNR in establishing priorities among the available resource assessment methodologies as they may specifically pertain to the prioritized resource

areas (and budget). Undoubtedly, there will be some areas that will require additional surface and/or aerial surveys, while immediate drilling at other sites may be appropriate to critically investigate the resource.

Quantification of a geothermal resource, as requested by DBED in their RFP (Section 1) requires drilling boreholes that can be used for flow tests, fluid sampling, and interference testing, if possible. However, the acquisition and synthesis of basic site data such as the geology, geochemistry and geophysics, for example, are critical for siting the boreholes to confirm the resource, and if present, to delineate its extent and characteristics.

The prioritization scheme must be re-examined as new information is developed on a resource area (or new regulations, etc. are established) which may either increase or decrease its relative priority. This three step program will provide DBED with a cost-effective approach to the GRAP by 1) prioritizing the resource areas through objective parameters and focussing available funding only on highly ranked resource areas, 2) considering environmental, regulatory and policy issues to minimize potential impacts, and 3) allowing the use of the appropriate resource assessment methodology for each resource area.

3.2 DIRECTING AND MANAGING THE SOH PROGRAM

After the geothermal resource areas in the State are prioritized, we recommend that the SOH program focus on those high priority resource areas that are ready for drilling. The objective of the SOH program will be focused on the quantification of Hawaiian geothermal resource potential for commercial exploitation, considering all the factors involved in bringing a geothermal resource to development in Hawaii. Detailed planning and execution of the SOH program depends largely on the specifics of the site geology, hydrology, geophysics, etc. As mentioned earlier, Mr. Iovenitti prepared a report entitled, "Recommendations for the State of Hawaii Scientific Observation Hole Program" for Harrison Engineers which was the prime geoscientific contractor for Ormat Energy Systems, Inc. This report presents the technical considerations required to plan the program.

Past events in Hawaii speak loudly and clearly that management of this program cannot move ahead effectively without addressing environmental, regulatory and policy concerns. The coupling of geoscientific geothermal resource evaluation techniques such as drilling methodology, borehole evaluation methodology (lithologic logging of cores and cuttings,

geophysical logging, temperature and pressure logging, flow test, etc.) with environmental, regulatory and policy issues will make for a successful, cost-effective, highly respected SOH program within the scientific community. Possibly more important in Hawaii, this approach would result in a highly respected program by the public, and State and County agencies.

For example, Mr. Iovenitti conducted exactly this type of operation in Oregon in 1985 where he was responsible for the permitting, drilling, completion, evaluation and testing of a deep corehole (4,800-ft total depth) under the US DOE Cooperative Drilling Program for Deep Thermal Gradient Drilling. It was the first geothermal deep corehole drilling operation of its type in the State, which was sited near the axis of the High Cascades an extremely environmentally sensitive area. Mr. Iovenitti successfully interacted with all Federal, State and County agencies (which included the US Forest Service, and Oregon Department of Water Resources) to obtain the necessary permits and approvals to conduct this type of program. Near the close of the drilling operation, forest fires in eastern Oregon were so severe that forest fire fighters from western Oregon were also mobilized. As a consequence, the entire forest in western Oregon was closed to industrial operations. Consequently the operation was totally shut-down and standby charges were incurred. Once informed of the situation, Mr. Iovenitti contacted the Forest Service and successfully negotiated an agreement whereby the drilling operation could proceed. This drilling operation was the only approved industrial operation in the forest in which the corehole was located. Mr. Iovenitti was able to obtain permission from the US Forest Service to continue drilling because of his excellent working relationships with USFS personnel.

The Weiss Associates team will also assist DBED and DLNR in evaluating appropriate drilling methods for the SOH program. The extensive drilling experience of Messrs. Wheeler and Bowden coupled with Mr. Iovenitti's and Dr. Vonder Haar's knowledge of the subsurface geology, hydrology, and expected fluid chemistry will be invaluable in defining the most cost-effective methodology. For example, in considering the most appropriate drilling methodology such factors as the high permeability of the subaerial basalts, the occurrence of lava tubes, brecciated tops of lava flows, the occurrence of faults and numerous fractures in the subsurface, the presence of vigorous ground water flow, among other factors, must be taken into account. Mr. Bowden having drilled three deep exploratory wells (cumulative drilled depth exceeds 20,000 ft) in the lower KERZ, has an intimate knowledge of drilling conditions in Hawaii. He also drilled and completed a 4,800-ft corehole in young volcanoes in Oregon using the "slim-hole" technology. Mr. Wheeler has similar experience with Thermal Power Company for the drilling operation in the Puna Geothermal Field. Messrs. Bowden and Wheeler

are intimately familiar with all geothermal drilling methodologies and have proven abilities to successfully complete drilling programs on budget.

3.3 DESIGN AND PLAN APPROPRIATE EVALUATION METHODS

As described above, once the high priority geothermal resource areas have been defined, the Weiss Associates team can assist DBED and DLNR in designing and planning the appropriate resource evaluation methodologies. With the experience of our team, we are in an unique position to assist DBED and DLNR in this task and assure that a scientifically-justifiable, practical and cost-effective program will be developed. It should be noted that in the design of any resource evaluation methodology, the complete, accurate and comprehensive integration of all available data is most critical to project success. Each geoscientific discipline (e.g., geology or reservoir engineering) has a specific role in delineating the nature and extent of the geothermal resource. Geology can not delineate by itself, the size of the geothermal resource, but it can indicate where to site a borehole or well to test the resource. Reservoir engineering, without a basic understanding of the geology, is similarly incomplete. Additionally, the evaluation method must be tailored for the particular resource site and the stage of exploration or development at a site.

We have included on our team an expert in direct-use application, Dr. Lund, to further enhance this task. This will allow us to further assist DBED and DLNR in conducting a more comprehensive assessment which will further the benefits of geothermal resources in the state.

3.4 GEOTHERMAL/CABLE MASTER PLAN AND EIS

The breadth and depth of experience of the Weiss Associates team (Sections 2 and 5) will be a tremendous asset to DBED and DLNR by providing technical guidance to the geothermal/cable master plan and EIS. We have proposed a senior professional team versed in all the relevant geoscientific disciplines (geology, geochemistry, geophysics, hydrology, reservoir engineering) and drilling operations, as well as in surface production facilities (well-field engineering and power plant design). We believe that our experience in environmental, regulatory and policy will also be especially useful in successfully completely this task. We will work closely with DBED and DLNR to:

1) Discuss which issues in the geothermal/cable master plan and project require technical guidance;

2) Prioritize the potential resource areas;

3) Formulate a specific scope of work which reflects the prioritization scheme; and

4) Establish a time-table for delivery of a report.

Our team capabilities and experience are sufficiently diverse to allow us to effectively respond to virtually any issue associated with this component of the RFP.

3.5 EXTENT AND CHARACTERISTICS OF THE GEOTHERMAL RESOURCES

The collective experience of the team provides the basis to effectively assess all types of geothermal systems ranging from high temperature electrical generating candidates to low temperature direct use types. We have assembled a senior professional team well versed in the subsurface geothermal resource assessment, and in the defining surface facilities, such as well-fields and power plants. We believe that our experience in environmental, regulatory and policy areas will also be especially useful in successfully completely this task.

We will assist DBED and DLNR in making educated, reasoned judgements as to the extent and characteristics of the geothermal resources based on the total information available during the course of this project. Certainly, borehole information (e.g., flow test results, interference tests, geothermal fluid chemistry, borehole temperature and pressure conditions) coupled with the results of geological, geophysical and hydrochemical surveys provide the most definitive determination of resource extent and characteristics. However, this information is not always available.

Without the borehole information described above, the nature and extent of the geothermal resource can only be approximated on the basis of available geological, geochemical, geophysical and hydrological data. Standard geochemical techniques can reasonably define the type of geothermal resource based on the chemical characteristics of the subsurface waters and gases. Geological, soil geochemical and geophysical techniques can be used to define the extent of the resource. However, because of the inherent limitations of these techniques and the manner in which they are employed (e.g., reconnaissance or detailed surveys), the extent of the

resource can be only approximated without the benefit of a borehole.

3.6 ADVISE ON WELL-FIELD DESIGN AND MANAGEMENT PRACTICES

We can effectively assist DBED and DLNR in adopting appropriate well-field management practices, policies, standards and design criteria. For example, premature depletion of a geothermal resource can be caused by the improper development of a field. This can result from insufficient well spacing and/or over-development by too many wells such that cumulative production interferes with individual wells. Mr. Dykstra's 48 years in reservoir engineering, his work at the Geysers geothermal field, as well as experience in other geothermal and oil/gas fields are an invaluable asset in assisting DBED and DLNR to efficiently develop the well-field. Dr. Coury's work in two-phase flow in pipelines, and his work in reinjection of non-condensible gases at the Coso geothermal field will also be invaluable to Hawaii, given that reinjection of gases, is the disposal option to be employed by the Puna Geothermal Venture. Ms. Norman's work in addressing environmental, regulatory and policy issues while serving as the Environmental Manager for Thermal Power Company, and her subsequent experience will be very appropriate for dealing with issues of policy, standards and design criteria.

Additionally Mr. Iovenitti and Dr. Coury are working with a California-based company which has a methodology to process geothermal non-condensible gases and generate methanol and reagent to agricultural grade sulfur, to evaluate the cost-competitiveness of this technique. The developers have conducted a pilot test on a geothermal well and found the process to work effectively and in their opinion, every cost-effectively.

4. PROJECT ORGANIZATION AND MANAGEMENT

In this section we discuss the Weiss Associates approach to project organization and management. Four components are especially important to assure the success of this project:

- Experience and capability of the project team,
- An efficient and effective project organization,
- Clear communication with DBED and other appropriate agencies; and
- A carefully structured and sound management plan.

Below we discuss our proposed project organization, accessibility and responsiveness, project cost effectiveness, and any conflicts of interest.

4.1 PROJECT ORGANIZATION

Table 1 presents the team personnel. Mr. J. L. Iovenitti will manage the day-to-day activities of the project, coordinate activities with DBED and the Weiss Associates team, and provide technical oversight of all aspects of the project. His extensive experience in Hawaii will significantly enhance the project's cost-effectiveness. The individual team members list in Table 1 will lead the effort in their respective discipline and report to Mr. Iovenitti. Weiss Associates staff will be used as appropriate to increase cost-effectiveness. Mr. R. B. Weiss will provide quality control/quality assurance and have project oversight responsibility. Project direction will be defined by DBED, and we are prepared to assist in any manner required to facilitate the GRAP.

4.2 ACCESSIBILITY AND RESPONSIVENESS

All Weiss Associates team members are committed to providing the services described in the RFP and in this document. Team members will be available for meetings and other

activities in Hawaii as required, given reasonable notice. All reports will be prepared according to a schedule developed in discussions with DBED.

4.3 COST EFFECTIVENESS

Weiss Associates provides premium technical expertise, excellent project management and personal client relations at competitive fees. Almost 90% of our work comes from repeat business, a full two-thirds of these clients have worked with us for over five years. These statistics emphasize that we consistently and dependably meet our client's needs, and they in turn establish long lasting relationships with us. We are commonly asked by new clients to complete work started by others, and these initial contacts often become long-term associations. In this way, WA's steady growth is directly attributable to our effectiveness at providing responsive quality service and excellent value.

4.3.1 Reporting Systems and Scheduling

Weiss Associates maintains computerized billing and budget tracking of all our projects. Time and expense reports for each project are reviewed monthly by project managers, or more often if necessary, to ensure that projects are within budget. Project status summaries are supplied to clients on request. In addition to formal monthly technical meetings of all our project managers, we maintain a unique, continuously updated tracking system, accessible to all staff, to schedule upcoming work company-wide and resolve logistical issues. The subcontractors on this project will be required to complete Weiss Associates time sheets and expense reports and submit them to Mr. Iovenitti.

Quality assurance procedures are a regular part of the Weiss Associates project management process and include:

1) Periodic communication between project managers and team personnel; frequency is dictated by the specific tasks;

2) Periodic review of technical progress;

3) Strict documentation of all personnel contacts and meetings involved in the technical or budgetary scope and direction;

4) Strict documentation and summary of all research materials, technical rationale and basis for technical decisions;

5) Close coordination with the client or their authorized representative(s);

6) Internal senior review of all draft and final reports prior to client submittal;

7) Periodic review of goals and schedules to insure adequate time to fully implement the above quality assurance procedures.

We have found this combination of technical and quality control review extremely effective in producing technically superior products on schedule and within budget.

Our communications with all outside parties are thoroughly documented. All telephone conversations, including those with Weiss Associates field personnel, are documented in writing, including date, time, person called/calling, and salient points of the conversation. All other materials leaving the office, such as equipment and supplies, are accompanied by transmittal letters. Copies of all written material sent from our office, including transmittal letters, are retained in a chronological file.

4.3.2 Cost Control

The state-wide nature of this project, its location, and expressed concern by DBED about budget, warrants very strict cost control measures on every aspect of this work. Weiss Associates recommends that prior to initiation any of the subtasks in this project, DBED and Mr. Iovenitti, formulate a specific Scope of Work and cost estimate for each subtask, in as much detail as practical. A clear time-table for deliverables should also be defined. The RFP indciates a general time-table for the interim draft, draft annual report, and final resource assessment report, but more specific time-tables for the subtasks are strongly recommended.

Weiss Associates also recommends that DBED control all trips to Hawaii by providing written approval. Additionally, all meetings should be carefully reviewed for cost-effectiveness.

The single, largest cost component on this project may be for meetings and field visits by the Weiss Associates team. To minimize these expenditures, we propose that DBED and Mr. Iovenitti, define to the degree possible, at the earliest convenient time, the type and number of times that such meetings and trips will required. We should also identify the appropriate

team members to attend. This determination should be flexible since changes will occur as the project develops. We also recommend using video-tape, and video or audio teleconferences in lieu of in-person meetings whenever appropriate to reduce costs while maintaining technical integrity and good communication between Weiss Associates and DBED.

Where appropriate, Weiss Associates will use staff with a lower billing rate for appropriate work. These staff members will have appropriate education and experience, and will work under the appropriate Weiss Associate Senior team member. This approach will provide additional cost savings to DBED. Similarly, if additional expertise is required beyond the Weiss Associates team, we would seek approval from DBED to bring the appropriate expert into the team.

4.4 DISCLOSURE OF ANY CONFLICTS OF INTEREST

The Weiss Associates team is not aware of any real or potential conflicts of interest for this project. None of the team members have any work in progress or recently completed and are under contract with any private firms involved in geothermal exploration or development in Hawaii. However, many of our team members have worked for the various firms involved in geothermal development in Hawaii. Mr. Iovenitti prepared detailed geoscientific reports for Ormat Energy Systems, Inc., for their 25 MW development project in the lower KERZ, and for ERCE in support of the Geothermal/Cable Master Plan prepared for and submitted to DBED, as well presenting work on the geothermal resource associated with the KERZ to the Kilauea Energy Partners, and California Energy Company. Our drilling experts, Messrs. Wheeler and Bowden have consulted for Ormat Energy Systems, Inc. in Hawaii and elsewhere. Mr. Bowden is currently consulting for California Energy Company.

The geothermal industry is relatively small. We believe that our relationships in the past, present and future with the industry do not create any conflicts of interest. If any potential conflicts should develop during the course of the work performed for DBED, we will notify DBED.

5. 1991 SCHEDULE OF CHARGES AND CONDITIONS

A new schedule of charges is issued at the beginning of each year. Unless other arrangements have been made via a proposal for a specific scope of work, charges for all work *including projects initiated in the prior year* will be based on the new schedule of charges.

5.1 PERSONNEL

Personnel charges are for any technical, clerical and/or administrative work performed on behalf of the client, including geologic and engineering functions as well as report preparation and project-related correspondence and administration. Direct charges are not made for secretarial service, office management, accounting and maintenance, as these items are included in overhead. Personnel overhead costs include direct payroll costs, payroll taxes, vacation, holidays, sick leave, employee insurance, and other benefits. Current personnel rates are as follows:

PROFESSIONAL SERVICES	HOURLY RATE
President and Principal Hydrogeologist (R. B. Weiss)	$120
Principal Geologist (J. L. Iovenitti)	110
Senior Project Hydrogeologist (R. A. Ferry)	85
Senior Project Geologist	85
Project Geologist, Hydrogeologist or Engineer	75
Senior Staff Geologist, Hydrogeologist or Engineer	65
Staff Geologist, Hydrogeologist or Engineer	55
Field Operations Manager	55
Geologic/Environmental Technician	45
Graphics/Draftsperson	45
Word Processing	40
Administrative Managers	60
Clerical	33
Senior Associate Geologist, Geochemist or Geophysicist	100

Charges for professional services are in increments of one quarter-hour. Minimum charge is four hours. Actual hourly rates depend on the individual assigned to a job, but will be in the range for their job category. Prices are subject to change.

Depositions/legal testimony are charged portal-to-portal, at 150% of standard rates, with a four-hour minimum charge. *The estimated fee must be paid prior to commencement of testimony.* Preparation for court cases is charged on a time-and-materials basis as outlined in this schedule.

The rates for personnel assigned to work outside the conterminous United States may be subject to premiums. Time spent in travel in the interest of the client will be charged at hourly rates except that no more than eight hours of travel time will be charged in any day. When it is necessary for an employee to be away from the office overnight, actual costs of, or a negotiated rate for, living expenses will be charged.

5.2 OUTSIDE EXPENSES

Outside expenses related to each job are charged at cost plus ten percent. This includes expenses such as subcontractors described below, auto/field vehicle rental, drilling and backhoe services, laboratory analysis fees, water sampling equipment rental, airfare and other travel expenses, lodging, meals, telephone, maps, field supplies, graphic reproduction, etc.

SUBCONTRACTOR PROFESSIONAL SERVICES	HOURLY RATE + 10%
Herman Dykstra	$176
Glen E. Coury	85
Herbert E. Wheeler, Jr.	95
R. B. Bowden	55
N. A. Norman	110
J. W. Lund	85

5.3 INVOICES

Invoices are rendered monthly, either as a final or progress billing, and are *payable upon receipt* unless prior arrangements have been made. Interest of 1-1/2% per month, or the maximum rate allowed by law, is due on accounts not paid within 30 days. *Any attorney's fees, consultants' time or other costs incurred in collecting any delinquent amount shall be paid by the Client.* Reports and other work prepared by us remain our property until all fees for such reports and other work have been paid.

5.4 CONDITIONS

Weiss Associates warrants that our services are performed, within the limits prescribed by our Clients, with the usual thoroughness and competence of the geotechnical profession. No other warranty or representation, either expressed or implied, is included or intended in our proposals, contracts, or reports.

For damage on account of any error, omission, or other professional negligence, our liability will be limited to a sum not to exceed $50,000 or our fee, whichever is more. In the event that the Client does not wish to limit our professional liability to this sum, we will waive this limitation upon the Client's written request provided that the Client agrees to pay for this waiver an additional consideration of 10% of our total fee or $1,000, whichever is greater. Client further agrees to notify any contractor and subcontractor who may perform work in connection with any design, report or study prepared by us of such limitation of professional liability for design defects, errors, omissions, or professional negligence, and to require as a condition precedent to their performing their work a like indemnity and limitation of liability on their part as against Weiss Associates.

We maintain General Liability insurance for bodily injury and property damage with an aggregate limit of $1,000,000 per occurrence and we will furnish certificates of such insurance at the Client's request. Our liability to the Client for bodily injury or property damage arising out of work performed for the Client for which legal liability may be found to rest upon us, other than for professional errors and omissions, will be limited to our General Liability Insurance coverage.

In the event that the Client makes a claim against Weiss Associates, at law or otherwise, for any alleged error, omission or other act arising out of the performance of our professional services, and the Client fails to prove such claim upon final adjudication, then the Client shall pay all costs incurred by Weiss Associates in defending itself against the claim, including but not limited to, personnel-related costs, attorney's fees, court costs and other claim-related expenses.

While the Consultant will take reasonable precautions to minimize any damage to the property, it is understood by Client that in the normal course of work some damage may occur, the correction of which is not part of this agreement. Plus, we will not be liable for damage or injury arising from damage to subterranean structures (pipes, tanks, telephone cables, etc.) which are not called to our attention and correctly shown on the plans furnished us, in connection with work performed by us.

If hazardous conditions are encountered that may threaten the health and safety of our personnel, required safety equipment will be supplied by the Client or by Weiss Associates and charged to the client. If it is necessary for our personnel to work while wearing safety equipment, field time and equipment charges may increase by as much as 200% to 300% or more and such costs will be added on a time-and-materials basis, as required, to the original contract amount.

All reports, boring logs, field data, field notes, laboratory test data, calculations, estimates and other documents prepared by the Consultant, as instruments of service, shall remain the property of the Consultant. Client agrees that all reports and other work furnished to the Client or his agents, which are not paid for, will be returned upon demand and will not be used by the Client for any purpose whatsoever.

Table 1. Team Personnel

DISCIPLINE	TEAM MEMBER	WEISS ASSOCIATES	SUBCONTRACTOR
Management & Coordination	J.L. Iovenitti	X	
Geology	S. Vonder Haar	X	
Geochemistry	C.D. Hull	X	
Geophysics	R.F. Corwin	X	
Hydrology	R. Ferry	X	
Reservoir Engineering	H. Dykstra		Independent Consultant
Well-field Engineering	H. Dykstra/ G.E. Coury		Independent Consultant/Coury and Associates, Inc.
Power Plant Design	G.E. Coury		Coury and Associates, Inc.
Drilling Operations	H.E. Wheeler, Jr./R. Bowden		Independent Consultants
Environmental, Regulatory and Policy*	N.A. Norman		Future Resources Associates, Inc.
Direct Use Applications*	J.W. Lund		Geo-Heat Center, Oregon Institute of Technology
Quality Control/Quality Assurance	R.B. Weiss	X	

* Optional team member; see text for explanation.

APPENDIX A

APPENDIX A

RESUMES

APPENDIX B

APPENDIX B

EXAMPLE PRIORITIZATION METHOD

APPENDIX B

EXAMPLE PRIORITIZATION METHOD

Presented is an example of the prioritization methodology described in Section 3.1. Geothermal resource area prioritizations conducted by Mr. Iovenitti are proprietary. We present however, a hazardous waste case performed by him for Lawrence Livermore National Laboratory.

PRIORITIZATION OF POTENTIAL SOURCES

A total of 356 potential sources have been identified at LLNL to date (Figs. 12 and 14) based on studies conducted by Dreicer (1985), the EPA (Zelikson, 1988), and the LLNL Ground Water Project. The sources vary widely in size, significance, and even likelihood of existence. For our initial evaluation, we have included as a potential source any area where hazardous material might have entered the subsurface. Our potential sources range from known, intensively studied areas, such as the Building 403 fuel leak, to areas included only on the basis of an anecdotal report of mishandled material. Because of this wide range in certainty regarding whether a site is a potential source, and because there are many sites, we developed an objective method of ranking the sources to prioritize future investigation.

For the initial prioritization, we chose a simple, easily applied method to rank the sources. A relative priority for each potential source was assigned by calculating a numerical value incorporating readily available and quantifiable information. Potential sources were ranked only with respect to VOCS, and several simplifying assumptions were made. Nevertheless, when the approach was tested on 10 fairly well characterized potential sources, it produced results that were both reasonable and useful as a first approximation. The method is described below.

A potential source investigation prioritization score (PSIPS) was assigned to each possible source according to the following equation:

$$PSIPS = 2\,(GW + POM) + HVZ \quad . \qquad (2)$$

In this equation, the value of GW (ground water) reflects the concentration of VOCs in ground water near the potential source, as follows:

Total VOC Concentration in Ground Water (ppb)	GW Score
<1	0
1-9	4
10-99	6
100-999	8
> 1,000	10

Total VOC concentration in ground water was determined from a total VOC isoconcentration map for November-December 1987 (Webster-Scholten and Hall, 1988). This map was contoured using concentrations from all wells, regardless of depth, and this simplification may result in some mis-assigned high scores in our initial prioritization.

POM (potential for offsite migration) values vary from 0 to 2, reflecting the likelihood that any VOCs released at a source may have migrated west of Vasco Road or south of East Avenue since U. S. Navy occupied the LLNL site in 1942. Based on the magnitude and direction of the ground water gradient, and an average VOC advection rate of about 70 ft/yr, we estimated that potential sources west of line AB in Figure 7 could be sources of VOCs in ground water west of Vasco Road, and were thus assigned a value of 2. Because VOCs from potential sources south of line BC would migrate much more slowly (based on present knowledge of the hydrogeology), and onto DOE-owned rather than onto private property, these sources were given a POM score of 1. All other potential sources were given a POM score of 0.

History-Vadose Zone (HVZ) values vary from I to 6; they are the sum of two factors. Each site is initially assigned an HVZ value of 1, 3, or 5, indicating the likelihood of its being a threat to the subaerial environment. This score reflects a subjective judgment, based on historical research, and takes into account the nature of the activity that took place at the location, the magnitude of reported spills, if any, and the reliability of the source of the information. One point is then added to the score if vadose zone soil chemistry data are available to objectively substantiate the historical portion of the score.

The prioritization scheme was applied to all 341 recognized potential sources. A histogram showing the resulting distribution of PSIPS values is presented in Figure 15. Although two scores, 15 and 19, predominate, the distribution of PSIPS values is otherwise fairly even. The dominance of "moderate" scores indicates that a more detailed, second-order method may be needed to differentiate these sources.

With the potential sources initially prioritized, we plan to continue our work by critically evaluating those sources that fall at either end of the horizontal axis on Figure 15. Those sources at the high end are considered most likely to be significant sources of VOCs in soil and/or ground water, and most likely to require remedial action. Those at the low end are probably not subaerial hazardous material release sites, and therefore may be readily eliminated from further consideration.

Taken from Yukic, F.A., M.D. Dresen, J.L. Iovenitti, I. Flaschka, E.M. Nichols, R.O. Devany, B. Qualheim, G. Howard, P. Cedewall, and W. I. Isherwood: LLNL Ground Water Project Monthly Progress Report, August 15 - September 15, 1988, Lawrence Livermore National Laboratory, Livermore, California (UCAR-10160-88-10).

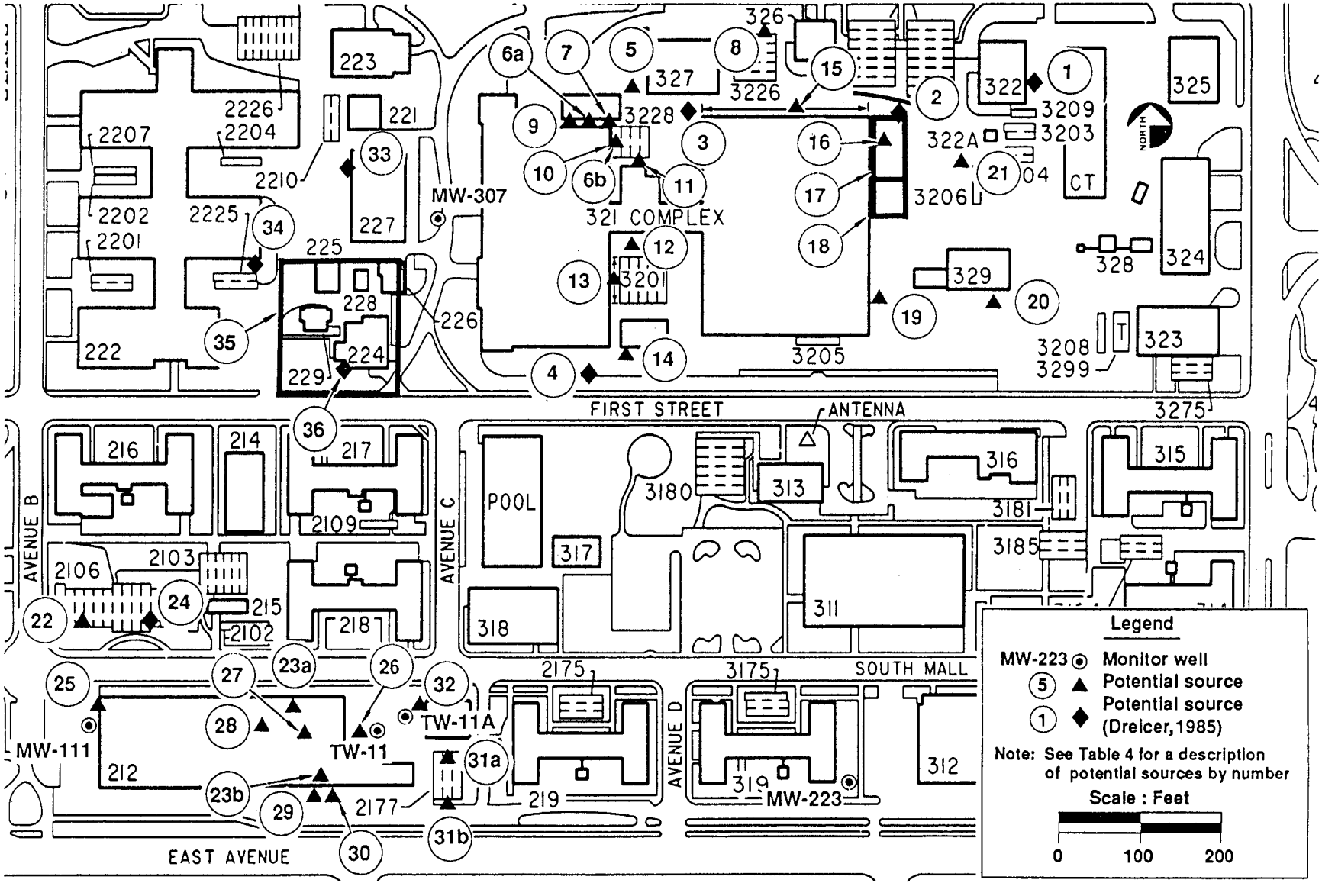

Figure 12. Potential sources in the Building 321 complex, Building 212 area, and Building 225/227 area.

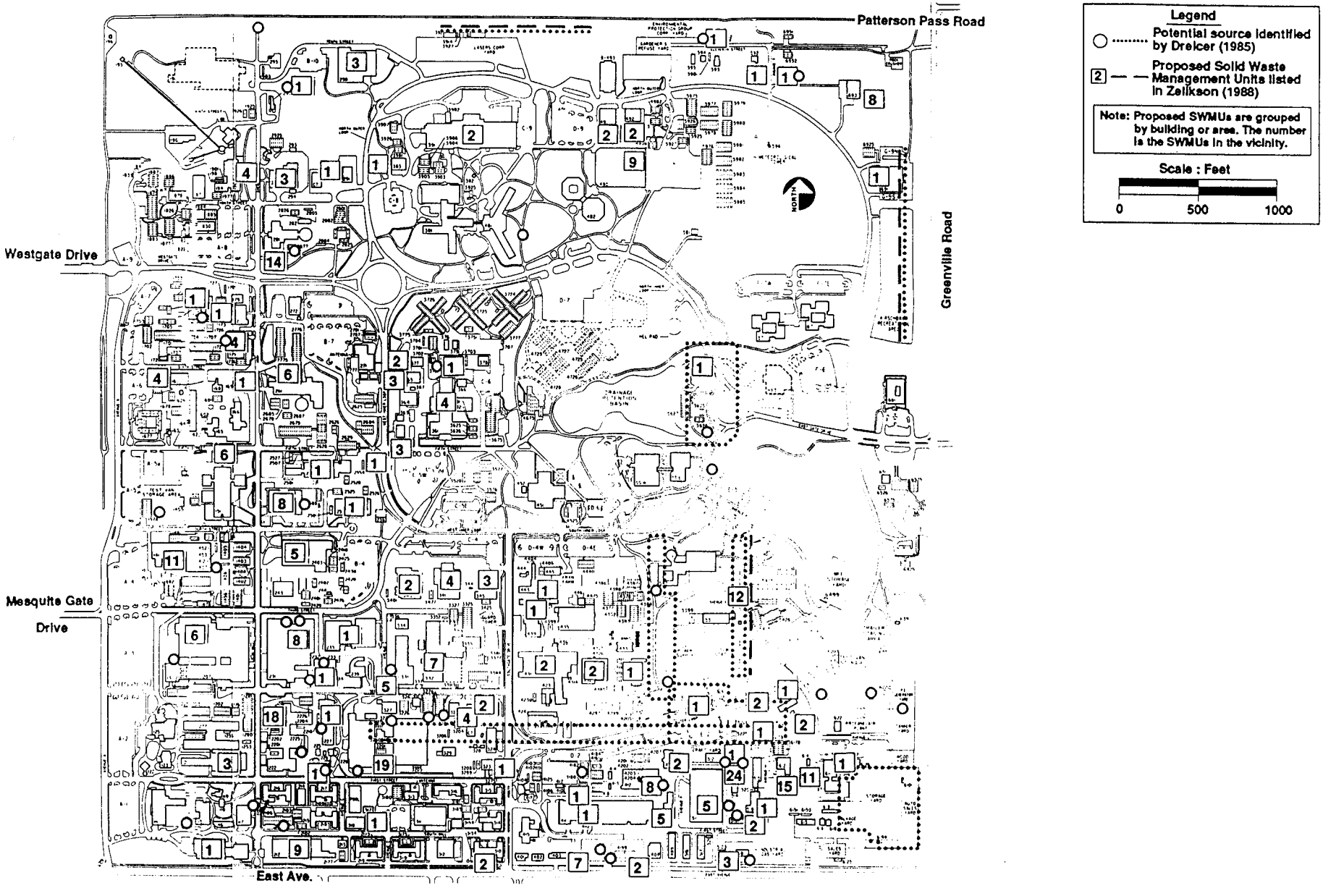

Figure 14. Potential sources of hazardous materials, from Dreicer (1985) and Zelikson (1988).

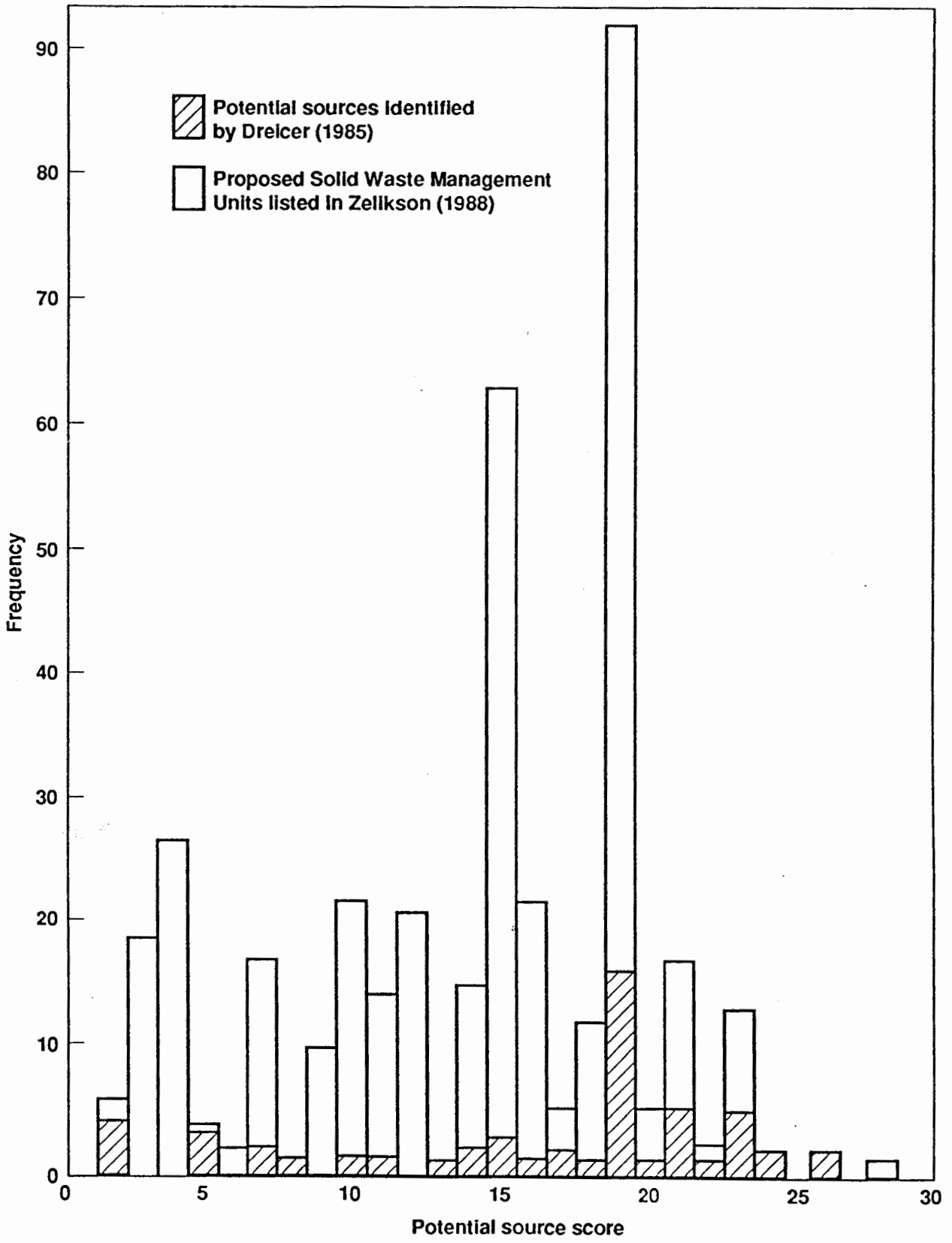

Figure 15. Distribution of potential source scores for Dreicer (1985) sources and SWMUs.