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DEVELOPMENT OPPORTUNITIES

FOR GEOTHERMAL SPAS IN THE STATE OF HAWAII

for

THE STATE OF HAWAII

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT AND TOURISM

Honolulu, Hawaii

by

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Richmond, California

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1. INTRODUCTION

The warm ground waters of Hawaii have long been enjoyed in natural springs, and wells in various parts of the State have encountered warm water underground. Direct use of these ground waters for spas has the possibility of broadening the State's economic base in a way that is sustainable and environmentally benign. The Japanese word for a warm ground-water spa is "onsen." The tradition of bathing in onsens is an important part of Japanese culture, and spas fed by thermal and mineral waters have attracted seekers of health and relaxation in many countries.

This report has been prepared on behalf of the Department of Business, Economic Development and Tourism (DBEDT) to assess opportunities for developing onsen facilities in Hawaii and to provide a convenient summary of information for potential onsen developers. General characteristics of geothermal spas are discussed in Chapter 2. Chapter 3 describes specific areas of the State with good prospects for onsen development based on the observed or inferred occurrence of warm ground water. Chapter 4 discusses marketing considerations and presents examples of approaches taken by a variety of spas around the world. Chapter 5 reviews State of Hawaii regulations that could affect spa development, and Chapter 6 discusses significant economic factors, including drilling costs and comparative prices for spa services. Chapter 7 presents a list of pertinent references.

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2. CHARACTERISTICS OF GEOTHERMAL SPAS

The word “spa” comes from the name of a town in southeastern Belgium where water from iron-rich springs has been used for bathing and drinking since the Middle Ages (Lund, 1996). In common usage, the term has been broadened to include any pool or bathing facility used primarily for health or relaxation. The distinguishing feature of an onsen, as used in this report, is that it is supplied by natural ground water, without the addition of chemicals. The water may be naturally warm (“thermal”), or it may be heated to obtain a comfortable bathing temperature. Typically, natural ground water contains certain minerals, which may be desirable for health reasons. A wide range of mineral constituents is acceptable for onsens; the minerals may or may not be in concentrations suitable for drinking. The ground water may flow to the surface in springs, or it may be produced from wells.

A traditional Japanese onsen is supplied by hot spring water. This is defined in Article 2 of the Japanese Hot Spring Act as mineral water with associated gases (excluding natural gas consisting mainly of hydrocarbon) that comes from the ground and that satisfies specified temperature and chemical criteria, as listed in Table 1 (Sekioka, pers. comm., 1999). Although Japanese onsens are characteristically very hot, this official definition of hot spring water actually extends to temperatures as low as 25°C (77°F). The definition is also very flexible with respect to chemical composition: the amount of total dissolved solids (TDS) must be at least 1,000 milligrams per liter (mg/l), and the water must meet or exceed the specified concentration for at least one of the eighteen chemical species listed. Depending on the dominant chemical species, hot spring waters are classified into nine basic categories, and they are further grouped according to temperature, osmotic pressure, acidity (pH), and hardness or softness (Grant Thornton, 1988).

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Thus, a wide variety of temperatures and chemical compositions can meet the Japanese definition for hot spring water. Individual onsens in Japan frequently post the compositions of their water to allow patrons to follow their own preferences. Table 2 shows some of the range of hot spring temperatures and chemical compositions in Beppu, one of Japan's most famous onsen areas. Clearly, these waters would need to be cooled before being suitable for bathing; the maximum tolerable temperature is generally considered to be around 43°C (110°F). It is also interesting that not all these springs satisfy the minimum TDS requirement of 1,000 mg/l for hot spring water, but they still seem to be acceptable for onsen use in Japan.

In general, spa developments using natural thermal or mineral water tend to fall within certain ranges of temperature, flow rate and chemical composition. Temperatures for bathing are typically in the range of 27 – 43°C (80 – 110°F). Hotter waters can be cooled or diluted with water from other sources (such as municipal water), and cooler waters can be heated to the desired temperature. Flow rates are typically in the range of 50 – 65 liters per second (l/s), equivalent to 800 – 1,000 gallons per minute (gpm). The concentration of TDS in the water is typically less than that of seawater; that is, less than about 34,500 mg/l.

High concentrations of certain chemical species may make ground waters unsuitable for spa development or may require special precautions. One such chemical is hydrogen sulfide (H_2S), which may make spa use unappealing because of its characteristic sulfurous smell, and which may require special ventilation in closed or low-lying areas to prevent dangerous accumulations. On the other hand, some believe in the curative power of sulfur in hot spring water, and therefore, do not object to the sulfurous smell. Other examples would include arsenic and mercury, which are not uncommon in thermal waters; the State of Hawaii Department of Health (DOH) has specified maximum contaminant levels for these two substances in potable water at 0.05 mg/l and 0.002 mg/l,

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respectively (§11-20-3, Hawaii Administrative Rules (HAR)). In addition, ground waters with high TDS can cause scaling, and a low pH can cause corrosion. Both of these conditions can increase the capital and operating costs of an onsen facility.

One consideration unique to Hawaii relates to the fact that any ground water at a temperature above 150°F (65.6°C) is considered a "geothermal resource" (Section 182-1 of the Hawaii Revised Statutes (HRS)). Permitting requirements are somewhat more complicated for drilling in areas where a geothermal resource may be encountered (as discussed further in Chapter 5). This tends to set a ceiling on the desirable temperature for the development of an onsen facility. However, most of the areas of warm ground water in the state are considerably below 150°F, so the permitting of wells to supply an onsen facility would normally be no different than for other water supply wells.

As a frame of reference, Tables 3 – 5 provide several examples of spas outside Japan that are supplied by thermal or mineral water. The U. S. examples (Table 3) show that spas have been developed in a variety of institutional settings, including resorts on private land, concessions within state and federal parks, and state-operated health facilities. The spas may be supplied either by springs or by wells, and the natural waters may be cooled, heated, or mixed with municipal water to achieve the desired temperatures. Facilities that do not chemically treat the ground water generally rely on once-through flow to maintain water quality; alternately, individual pools may be drained and re-filled after each use. Table 4 illustrates that the chemical composition of ground waters at U. S. spas varies over a wide range, including differences between individual springs in a resort area (such as Saratoga Springs, New York). Table 5 shows a similar range of chemical compositions for spas in Bohemia (Czech Republic).

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3. PROSPECTIVE LOCATIONS

Most areas of warm ground water in the Hawaiian Islands have been discovered only by drilling wells. The highly porous basalts that make up the islands allow rapid infiltration of rainfall. For most of the land mass, this results in deep water tables, except in coastal areas. At the same time, the volcanic origin of the islands suggests that pockets of residual heat are likely to exist and that warm ground water is likely to occur in volcanic structures such as calderas and rift zones. Several statewide geothermal resource assessments have presented detailed summaries of the technical evidence for elevated temperatures in certain areas, including areas suitable for direct use applications (DLNR, 1984 and 1992; GeothermEx, 2000).

The prospective locations discussed in this chapter focus on areas of warm ground water, based either on direct observations in wells and springs or on inferences about volcanic structures. However, areas that produce non-thermal mineral water may also be of interest, given that such water can be heated to desired temperatures for use in spas. In coastal areas of the Hawaiian Islands, it is common to find brackish ground water, which is a mixture of sea water and rain water. Some resorts in Hawaii offer pools and spas fed by pure sea water, on the premise that the natural sea salts make the water more attractive to some patrons. Thus, the brackish water of some coastal areas may also have potential use as a supply of natural mineral water for onsens. The coastal areas where such an approach might be taken are much more extensive and may have more land available for commercial development than the warm ground water areas described below.

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3.1 Hawaii (Big Island)

Four areas on the island of Hawaii have shown evidence of potential for onsen development (figure 1). The Pahoa and Pahala areas take their names from towns adjacent to the eastern and southwestern rift zones (respectively) of Kilauea volcano. The Kawaihae area is named after a coastal town on the southwest flank of Kohala volcano, and the area extends inland to near the town of Waimea. The Hualalai area encompasses the northern, southern, and northwestern rift zones of Hualalai volcano, as well as adjacent coastal areas.

The Pahoa area includes the Puna Geothermal Venture (PGV) project, an electrical generation plant that produces approximately 25 megawatts from a deep geothermal reservoir. The area also contains a number of shallower wells with warm ground water that is chemically distinct from the geothermal brine tapped by the PGV plant. Thermal springs occur along the coast in both the Pahoa and Pahala areas. Table 6 shows a representative sampling of temperatures and chemical compositions of ground waters from the wells and springs of these areas (excluding the deep geothermal brine) (Janik et al., 1994). Several different types of ground water can be distinguished (Sorey and Colvard, 1994), ranging from cold and dilute (in the Pahoa Battery 2A well) to hot and saline (in the Puna Thermal TH 3 well). The diversity of water types indicates that the aquifers in the vicinity of the east rift zone are highly compartmentalized. However, any of the warm or hot water types in Table 6 (types III to VI) could be suitable for onsen facilities, and the broad distribution of thermal springs along the coast suggests a widespread occurrence of warm ground waters in the Pahoa and Pahala areas.

Portions of both the Pahoa and Pahala areas are within the Hawaii Volcanoes National Park and are thus not available for commercial development. The portions outside the National Park consist primarily of agricultural and conservation districts, with

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minor amounts of urban land (Lynette & Associates, 1992; subsequent descriptions of land status and zoning are attributable to the same source).

The Kawaihae area southwest of the Kohala Mountains contains a number of warm wells, with reported temperatures as high as 36°C (Nance, pers. comm., 1999). Table 7 shows the temperatures and chemical compositions of warm ground water from selected wells in the area (Thomas, 1986). The area is somewhat anomalous in that it is not located on a rift zone; the warm ground water occurs at the junction of lava flows from the Kohala and Mauna Kea volcanoes. The area contains primarily zoned for agriculture, with a small amount of urban land.

The Hualalai area has been delineated primarily based on the geophysical evidence about the rift zone structure and the relatively young age of volcanism in the area. In addition, some wells in the northern portion of the area (north of Keahole Airport) have encountered slightly elevated temperatures in the range of 25 – 26°C (Nance, pers. comm., 1999). No detailed description of ground water chemistry is available for the area. The land is zoned about half conservation and half agricultural, with small urban areas.

Other areas on the island of Hawaii may also have potential for onsen development based on their proximity to rift zones. Such areas would include the southwest and northwest rift zones of Mauna Loa, and the northwest and east rift zones of Mauna Kea. The Mauna Kea northwest rift area includes one deep well at Waikii that encountered a temperature of 40ºC (104ºF) at a depth of 4,240 feet. However, in view of the depth of this well and a general lack of wells in the other areas, the possibility of onsen development at these locations is speculative at the present time.

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3.2 Maui

The island of Maui contains three areas with potential for onsen development: Lahaina, Olowalu and Ulupalakua (Figure 2). The Lahaina area encompasses a small region in the immediate vicinity of the city, where wells have encountered slightly elevated ground water temperatures (25 – 27°C). Prospects for significantly higher temperatures in the area are slim (Thomas, 1986). Still, chemical analyses (Table 8) show that the Lahaina ground waters meet the legal Japanese definition of hot springs water (Table 1). The Lahaina area would be a candidate for the method of heating natural mineral water to supply onsen developments. Because Lahaina has already undergone significant commercial development, land for a new onsen should be relatively available; alternatively, existing resorts could install onsens as expansions of their current facilities.

The Olowalu area has been delineated based on the presence of warm ground water in wells and tunnels near the coast, as well as geologic evidence of rift zones extending inland to the crest of the West Maui volcano. Ground-water temperatures as warm as 35ºC (95ºF) have been measured in the area, and again the chemistry of the water (Table 8) would satisfy the Japanese definition of hot spring water. The land falls within both agricultural and conservation districts.

The Ulupalakua area contains the lower-elevation portions of the southwest rift zone of Haleakala volcano. No wells have been drilled directly within the rift zone, and no warm ground waters have yet been encountered. Still, volcanic activity in the area is relatively recent (the last eruption was in 1790), and geologic evidence indicates a good chance that warm ground waters are present (Thomas, 1986). The land is roughly evenly divided between agricultural and conservation districts.

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The other rift areas of Haleakala (the northwest and east rift zones) are more speculative prospects for warm ground water at present. Wells in the northwest rift zone have not shown elevated temperatures, and there is a general lack of well data and other geologic information in the east rift zone.

3.3 Molokai and Lanai

The islands of Molokai and Lanai have two areas of warm ground water that may be suitable for onsen development (Figure 2). Water wells in the West Molokai area have encountered temperatures of up to 35.6°C (96.1°F), with total dissolved solids of up to 15,700 mg/l (not quite half the salinity of sea water) (Table 9). Water wells in the Palawai area of Lanai (including the Palawai Basin and the adjoining coastal area to the south) have reached temperatures of 40.3°C (104.5°F), with TDS in the range of 900 to 3,000 mg/l. Both areas have established resorts that could add onsens to their facilities. The eastern portion of Molokai represents a separate volcanic center, but there is virtually no information about the presence of warm ground water from geologic investigations or drilling, and most of this area is zoned for conservation. Therefore the potential of eastern Molokai for onsen development appears limited.

3.4 Oahu

The island of Oahu has two areas of identified potential for the occurrence of warm ground water: Waianae on the west and Waimanalo on the east (Figure 3). The Waianae area has three clusters of warm wells (Thomas, 1986) with temperatures in the range of 25 – 29°C (77 – 84°F) and TDS values in the range of 800 – 2,700 mg/l (Table 10). Land in the Waianae area (Lualualei Valley) is partly urban and partly agricultural. A federal naval reservation occupies much of the eastern part of the area. The Waimanalo area is on the southeast rift of the Koolau volcano. Several wells in the

Waimanalo area have encountered temperatures of up to 30°C (86°F) and total dissolved solids of up to approximately 3,400 mg/l (Table 10). The known area of warm wells is largely urban and partly within Bellows Air Force Base.

3.5 Kauai

In 1995 and 1996, several ground-water monitor wells drilled by the United States Geological Survey (USGS) discovered warm ground water in the Lihue Basin on Kauai (Gingerich and Izuka, 1997; Izuka and Gingerich 1997a, 1997b and 1997c) (Figure 4). The warmest well produced water with a maximum initial temperature of 34°C (93°F); this temperature declined to 27°C (81°F) in the course of a seven-day pump test. Three other wells produced water at steady temperatures in the range of 25 – 27°C (77 – 81°F) (Table 11). These temperatures are comparable to those observed at Lahaina and Waianae.

The four warm wells were drilled on the northern and eastern flanks of Kilohana volcano on agricultural land, roughly three miles northwest of the town of Lihue. Chemical analyses of the produced water are unavailable; from measurements of specific conductance, the total dissolved solids are estimated to be below 1,000 mg/l. Based on the results of these wells, the Lihue Basin appears to have potential for onsen development.

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4. MARKETING CONSIDERATIONS

The concept of onsens is based on traditional bathing practices in Japan, but it has potential attraction to a wide variety of people. If one interprets the onsen concept broadly to mean the use of natural ground waters for bathing, health, and relaxation, then the concept meshes well with several current trends in the marketing of spas. The following discussion summarizes these trends, drawing on descriptions in a recent spa guidebook (Fodor's, 1998), various journal and magazine articles (see references), and Internet web sites of a number of spa resorts (see Appendix). To illustrate these trends, Table 12 presents brief descriptions of a cross-section of spa resorts in the United States, Canada, and Mexico. The table compares the resorts in terms of amenities, activities, services and costs.

One trend that has been gaining popularity in the 1990s is a rekindling of interest in natural mineral waters. In part, this trend draws on nostalgia for a European tradition of "taking the waters" in grand resorts. It fits in with a general trend toward natural, unadulterated products that grew out of the counter-culture movement of the1960s (Keefer, 1995). It also follows a trend toward greater product differentiation: the appreciation of "waters" with specific origins and ingredients has some parallel in the increasing sophistication of tastes in tea, coffee, and beer. The Japanese practice of posting the chemical composition of particular onsens is quite compatible with this. The use of natural sea water in spas at the Ihilani Resort on Oahu (Table 12) illustrates that this marketing approach is already being used in Hawaii.

Another prominent trend in the marketing of spas is an emphasis on health and fitness. This harks back to a tradition in many cultures of using spas to cure specific ailments. The emphasis on health is evident in the offering of dietary programs, exercise equipment and various athletic activities at many spas. This can also include mental

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fitness or self-improvement seminars. A recent example of the promotion of spas for specific health benefits is the Blue Lagoon in Iceland, which promotes bathing in the discharge brine from a geothermal power plant as a cure for psoriasis, as well as for general recreation. The Blue Lagoon has proved to be tremendously popular with both native Icelanders and tourists, and it has recently opened an expanded facility, including a convention center (www.bluelagoon.is/).

A long-standing aspect of spa marketing emphasizes relaxation. This is related to the emphasis on health, in that spas are promoted as a way to reduce stress. It also fits a current demographic pattern of changing preferences in the "baby boomer" generation as they make a transition to less rigorous fitness programs (Wellner, 1998). At the luxury end of the resort market, this trend takes the form of a high degree of personal attention or "pampering" (Fodor's, 1998), including a wide assortment of massage and cosmetic services. At the budget end of the market, the emphasis on relaxation can translate into a preference for simple or rustic facilities, consistent with the emphasis on naturalness, discussed earlier.

Another trend worth noting in spa marketing is a focus on specific cultural traditions. The concept of onsens fits this trend, but it does not necessarily imply attracting primarily Japanese visitors. In many cases, spa marketing appeals to a desire for the exotic and unfamiliar. Thus, a Japanese style of spa may attract patrons precisely because it represents a different cultural tradition. This is the approach taken by a spa called Ten Thousand Waves in Santa Fe, New Mexico, which features onsen baths using heated municipal water (Fodor's, 1998). Other examples include the Kalani Oceanside Retreat in the Pahoa area (which blends Japanese and Hawaiian traditions); the Ka-Nee-Ta Resort in Warm Springs, Oregon (which focuses on the cultural traditions of Native Americans); and the Polynesian Spa of Rotorua, New Zealand. Web sites for these spas are included in the Appendix.

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A final point about the marketing of onsens in Hawaii concerns the distinction between natural warm ground water and geothermal resources. The term geothermal means "earth heat," and geothermal resources in a broad sense include warm ground water at the lower end of the temperature spectrum. However, the production of electrical energy from geothermal resources in Hawaii has not been viewed favorably by some members of the public. On the other hand, direct use of warm ground waters may be regarded more favorably. As noted earlier, State of Hawaii law specifically defines geothermal resources to be at a temperature above 150°F (thus excluding most of the warm ground waters of Hawaii). Therefore, from a marketing point of view, the difference between the direct use of warm ground water (such as for onsens) and the generation of electrical energy from geothermal resources should be noted.

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5. REGULATORY CONSIDERATIONS

The developer of an onsen resort would need to comply with the same set of regulations that would apply to any resort in Hawaii. This would include State and County regulations regarding land use and zoning, as well as various County permitting requirements, such as grading, grubbing, and stockpiling permits; building permits; electrical permits; and plumbing permits. This section focuses only on those regulatory considerations that may come into play specifically because of the onsen aspect of the project.

There are seven aspects of government regulations in Hawaii that an onsen developer should keep in mind:

1. the definition of a geothermal resource;
2. State land use districts, including Geothermal Resource Subzones;
3. County regulations;
4. drilling permits;
5. underground injection control (UIC);
6. air quality permits; and
7. pool permits.

5.1 Definition of a Geothermal Resource

As discussed briefly in Chapters 2 and 4, the definition of a geothermal resource is important because it distinguishes whether an onsen developer must comply with a rather complicated set of regulations applicable to geothermal resource developers. According to Section 182-1, HRS:

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> "Geothermal resources" means the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution of other products obtained from naturally heated fluids, brines, associated gases, and steam, in whatever form, found below the surface of the earth, **but excluding** oil, hydrocarbon gas, other hydrocarbon substances, and **any water**, mineral in solution, or other product obtained from naturally heated fluids, brines, associated gases, and steam, in whatever form, found below the surface of the earth, **having a temperature of 150 degrees Fahrenheit or less**, and not used for electrical generation. [emphasis added]

Since most warm ground waters likely to be used for onsens in the State of Hawaii are below 150°F (65.6°C), specific regulations regarding Geothermal Resource Subzones and geothermal drilling permits do not apply. However, these specific regulations are discussed in the following sections, because there are a few areas of the state (such as the Pahoa and Pahala areas) where ground-water temperatures above 150°F are quite possible.

5.2 State Land Use Districts

According to Section 205-2, HRS, all lands in the state of Hawaii fall into one of four land use districts: urban, rural, agricultural, and conservation. In addition, according to Section 205-5.1, HRS, the Board of Land and Natural Resources (BLNR) is charged with designating Geothermal Resource Subzones, which are the only areas in the State where geothermal development activities may be permitted. Geothermal development activities are defined as follows (Section 205-5.1, HRS):

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> "the exploration, development, or production of electrical energy from geothermal resources and direct use applications of geothermal resources; provided that within urban, rural, and agricultural land use districts, direct use applications of geothermal resources are permitted both within and outside of areas designated as geothermal resource subzones…"

From the point of view of an onsen developer, if ground water is hotter than 150ºF (and is therefore defined as a geothermal resource), it can be developed for a direct-use application (such as an onsen) regardless of Geothermal Resource Subzone boundaries, as long as the proposed development is located within an urban, rural, or agricultural land use district. Within a State conservation district, development of ground water above 150ºF can only take place within Geothermal Resource Subzone boundaries. This is not a very onerous constraint, because a commercial onsen development is unlikely to be proposed for a conservation district in any case.

5.3 County Regulations

If an onsen development is proposed outside of a State conservation district, County regulations would apply. For the County of Hawaii, a Geothermal Resource Permit may be required for development of ground water hotter than 150ºF. The County of Hawaii is the only county with the requirement of a Geothermal Resource Permit at the County level.

5.4 Drilling Permits

If an onsen developer is working with ground water that has a temperature of 150°F or less, then the permitting process for drilling a well is identical to any water well development. This would be handled through the Commission on Water Resource

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Management, within the Department of Land and Natural Resources (DLNR), pursuant to Chapter 174C, HRS.

If ground water hotter than 150°F is expected, then the developer would need to obtain a Geothermal Exploration Permit, pursuant to DLNR Administrative Rules, Chapter 13-183, HAR, "Leasing and Drilling of Geothermal Resources". If the results of exploration confirm the presence of a geothermal resource (ground water hotter than 150ºF), the developer would need to apply for a Geothermal Mining Lease pursuant to Chapter 182, HRS, and Chapter 13-183, HAR, and subsequently a Geothermal Well Drilling Permit pursuant to Chapter 13-183, HAR. In this situation, the developer would be interacting with the Engineering Branch of the land Division within DLNR, which has responsibility for geothermal development.

5.5 Underground Injection Control (UIC)

The Department of Health (DOH) is the State agency that regulates injection wells, pursuant to Chapter 340E, HRS, and the corresponding DOH Administrative Rules (Title 11, Chapter 23). Under these regulations, the injection water coming from an onsen would be considered sewage. The regulations classify the type of injection well depending on the total dissolved solids (TDS) content of the injection water with respect to the target injection zone. An onsen developer would need to obtain a UIC permit from the DOH in order to operate an injection well for the project.

5.6 Air Quality Permits

For most onsen developments, no specific air quality permit would be required. However, if the ground water contains significant quantities of hydrogen sulfide, then special ventilation may be required to prevent dangerous accumulations of this gas in

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enclosed or low-lying areas. This ventilation would need to be designed to avoid any violation of ambient air quality standards for the State under Chapter 342B, HRS, and the corresponding DOH Administrative Rules (Title 11, Chapters 59 and 60). Under these regulations, the limit for hydrogen sulfide in ambient air is 25 parts per billion, averaged over a 1-hour period. If there is any question about permissible levels of hydrogen sulfide emissions from an onsen facility, the developer should work with the DOH to obtain an Authority to Construct and a Permit to Operate, if necessary.

5.7 Pool Permits

The DOH regulates swimming pools in Hawaii under Title 11, Chapter 13 of its Administrative Rules. These regulations typically require chlorination and filtering of pool water, as well as control of pH and alkalinity. However, it is not clear whether these regulations would apply to an onsen, which is based on the concept of natural ground water untreated by chemicals. Many mineral water spas in other parts of the world maintain the purity of their water by allowing only once-through flow (no recirculation) and by taking periodic samples to check for possible contaminants. Other mineral water spas are designed so that individual pools are drained and re-filled after each use. Because there are no specific regulations in Hawaii governing the use of untreated mineral water in public bathing pools, an onsen developer would need to work with the DOH to establish in advance what regulations a proposed project would need to follow. Final guidelines may require a determination by the State Attorney General's office.

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6. ECONOMIC CONSIDERATIONS

The cost to construct and operate an onsen resort would be comparable to the cost of a spa resort that draws on municipal water, with the exception that an onsen in Hawaii would need to drill wells for the production and injection of the mineral water used in the spa. A full analysis of the economics of such a spa development is beyond the scope of this report; in practice, a spa is just one component of the amenities, which a resort would offer, and a detailed market analysis would be required to establish the incremental revenue attributable to spa facilities alone. The following discussion is intended to give a first order approximation to the cost of well drilling and to illustrate the range of prices that spa resorts typically charge for their services.

Commercial spa resorts typically use on the order of 800 – 1,000 gallons per minute (gpm). This would require a production well with 12- to 14-inch casing. Such a well in Hawaii would cost in the range of $500 per foot (including the cost to drill and case the well and to conduct a pump test). In addition, the cost of a pump for the well would be approximately $150,000 to 200,000. (Nance, pers. comm., 1999). Thus, for a 400-foot well, the capital cost would be on the order of $400,000. This assumes that the well would be drilled as a routine water well. If temperatures greater than 150°F are expected, then blowout prevention equipment may be required, which could add significantly to the well's cost. An onsen facility would typically require a spare production well and a spare injection well. Therefore, the cost of four wells would need to be factored into the economics of a proposed project, unless such wells already exist from earlier development efforts.

Current prices charged by a cross-section of spas in the United States, Canada, and Mexico are shown in table 12. The daily lodging prices are single-person, double-occupancy rates in high season. These prices span a large range, from approximately $50

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for rustic accommodations to over $500 for luxury resorts. Clearly, the prices charged by a proposed spa development will have to be tailored to the level of service that is expected to be provided.

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TABLES

Table 1. Onsen characteristics in Japanese Hot Springs Law (Article 2)

Temperature: 25°C (77°F) or greater (as measured at point of extraction from spring)

Chemical Constituents (hot springs water must satisfy at least one of the following):

Total dissolved solids (TDS) [a]	1,000	milligrams/liter or more
Sodium bicarbonate ($NaHCO_3$)	340	milligrams/liter or more
Free carbon dioxide (CO_2)	250	milligrams/liter or more
Meta-silicic acid (H_2SiO_3) [b]	50	milligrams/liter or more
Ferrous and/or ferric ion (Fe^{++} and Fe^{+++})	10	milligrams/liter or more
Manganous ion (Mn^{++})	10	milligrams/liter or more
Strontium ion (Sr^{++})	10	milligrams/liter or more
Barium ion (Ba^{++})	5	milligrams/liter or more
Meta-boric acid (HBO_2)	5	milligrams/liter or more
Bromide ion (Br^{-})	5	milligrams/liter or more
Fluoride ion (Fl^{-})	2	milligrams/liter or more
Hydro-arsenic acid ion ($HAsO_4^{--}$)	1.3	milligrams/liter or more
Meta-arsenious acid ($HAsO_2$)	1	milligram/liter or more
Hydrogen ion (H^+)	1	milligram/liter or more
Iodide ion (I^-)	1	milligram/liter or more
Lithium ion (Li^+)	1	milligram/liter or more
Total sulfur ($HS^- + S_2O_3 + H_2S$)	1	milligram/liter or more
Radium salt (as Ra)	1×10^{-8}	milligrams/liter or more
Radon (Rn)	20×10^{-10}	Curie units or more

[a] Excluding gaseous substances

[b] Equivalent to 1.3 X concentration of silica (SiO_2)

Data source: Mitsura Sekioka (personal communication)

Table 2. Temperatures and major chemical species of selected hot springs in Beppu, Japan

Area Name	Spring Name	Temperature (°C)	Temperature (°F)	Acidity (pH)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Estimated Total Dissolved Solids [a] (mg/L)
Kannawa	Ishimatsu	100.0	212.0	7.7	882	97.8	1.0	24.5	1,104	455	389	49	3,002
Kamegawa	Shinoyu	56.6	133.9	8.2	182	28.6	6.6	20.4	225	152	152	108	875
Old City	Kimura	55.6	132.1	7.4	170	14.1	33.2	47.5	107	53.4	194	504	1,123
Hotta	Hotta	75.5	167.9	6.2	26.78	3.438	12.22	17.91	17.88	66.05	86	76.25	307
Kankaiji	Jizouyu	50.0	122.0	6.9	30	5	12	57	3	45	96.8	188	437

[a] Total dissolveds solids estimated as sum of major species concentrations
mg/L = milligrams/liter
Data source: Taguchi et al., 1996

Table 3. Characteristics of selected U.S. spas supplied by thermal or mineral water

	Facilities	Temperature of Produced Water (^oC)	(^oF)	Current Rate of Use (L/s)	(gpm)	Comments
Calistoga, California	6 private spa resorts with mineral baths, steam baths, and mud baths; 1 public mineral-water swimming pool.	77-93	171-199	NR	NR	Supplied by wells about 60 feet deep. Produced water is cooled to 27-40^oC (81-104^oF) for use in pools and baths. Water is also bottled as mineral water for drinking.
Hot Springs, Arkansas	National Park, incl. 1 spa resort and 1 medical facility; 3 spa resorts and 1 arthritis hospital outside the park with soaking tubs and swimming pools.	60-62	140-144	41	650	Supplied by surface springs. A portion of spring water is cooled by heat exchangers to 32^oC (90^oF), then mixed with uncooled water to temperatures in the range of 32-40 ^oC (90-104^oF).
Hot Springs, Virginia	1 private resort (The Homestead) with 700 rooms. Sauna, steam baths, and mineral baths; mineral-water swimming pools.	39-41	102-106	63	1,000	Supplied by surface springs.
Hot Sulphur Springs, Colorado	Private resort with private mineral baths and 10 mineral-water pools.	40-44	104-112	9	140	Supplied by surface springs. Water is not re-circulated in pools. No chemicals are added.
Saratoga Springs, New York	Saratoga Spa is New York state park, with 2 bath houses, a hotel/convention center, and 2 swimming pool complexes. Private resort in city of Saratoga Springs offers mineral baths.	6-13	43-55	NR	NR	Supplied by surface springs. At state-run bath-houses, mineral water is heated to 37^oC (100^oF). At private resort, mineral water is mixed with heated tap water to reach desired temperature. Mineral water bottled for drinking.
Thermopolis, Wyoming	Hot Springs State Park, incl. bath house with private baths and central pool; boarding home; and physical rehab center. Private RV park with large mineral pool. Private greenhouse.	22-57	72-135	180	2,850	State park facilities are supplied by Big Horn Spring (120 L/s). Private facilities are supplied by Sacajawea well (flow rate 60 L/s, depth not reported).
Warm Springs, Georgia	Rehabilitation center operated by state, with 21m x 27m therapy pool.	31	88	53	845	Water is heated to 34-35^oC (93-95^oF) for therapy pool.
White Sulphur Springs, West Virginia	Private health resort (The Greenbriar) with indoor and outdoor mineral pools.	17	63	1.6	25	Water for mineral pools is heated to desired temperature.

L/s = liters per second; gpm = gallons per minute; NR = not reported
Data sources: Guilmette, 1996; Lund, 1996; Miller, 1992; web sites for specific spas and resorts

Table 4. Temperatures and major chemical species of selected U. S. spas

	Temperature (^oC)	Temperature (^oF)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Total Dissolved Solids (TDS) (mg/L)
Belknap Springs, Oregon	NR	NR	690	15	0.2	210	1,300	170	96	17	2,498
Desert Hot Springs, California	NR	NR	280	0.08	0.08	34	106	491	NR	NR	NR
Hot Springs, Arkansas	61	142	4	1.5	4.8	45	1.8	8	42	165	272
Hot Springs, Virginia	39-41	102-106	5.4	NR	NR	NR	1.4	160	NR	194	NR
Indian Springs, Colorado	NR	NR	520	82	38	150	NR	420	58	NR	NR
Saratoga Springs, New York	6-13 [a]	43-55 [a]									
Geyser	NR	NR	850	83	75	375	820	0	12	2,562	4,836
Hathorn	NR	NR	3,820	340	353	872	6,030	0	12	4,850	16,407
Hayes	NR	NR	3,025	333	277	724	4,500	0	11	4,550	13,539
Lincoln	NR	NR	1,150	219	171	348	1,538	0	51	2,608	6,166
Orenda	NR	NR	2,420	266	224	672	3,800	0	11	3,600	11,105
Polaris	NR	NR	560	80	95	370	1,000	0	17	2,130	3,260(?)
State Seal	NR	NR	2	0.15	4.4	32.2	4.8	22	5	104	175
Thermopolis, Wyoming											
Big Horn Spring	22-57	72-135	262	49	76	76	328	760	82	766	2,400
Sacajawea well	54	129	227	46	76	300	300	819	NR	741	NR
Warm Springs, Georgia	31	88	1.9	3.6	12	21	1.8	7.6	24	118	190
White Sulphur Springs, West Virginia	17	63	22	1.2	130	440	17	1400	17	210	2,237

[a] Temperature of Saratoga Springs is not reported for individual springs
mg/L = milligrams per liter
TDS values are measured for Sarasota Springs; other TDS values are estimated as sum of concentrations of major chemical species.
NR = Not reported (does not necessarily mean species is absent)
Data sources: Woodruff, 1987; Lund, 1996

Table 5. Temperatures and major chemical species of selected spas in Bohemia, Czech Republic

Town	Source	Temperature (°C)	Temperature (°F)	Acidity (pH)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Total Dissolved Solids (TDS) (mg/L)
Karlovy Vary	Mlýnský Spring	52.1	125.8	6.7	1,713.0	98.0	37.3	135.9	607.7	1639.0	54.1	2163.0	6,500
Teplice	Pravrídlo Spring	39.0	102.2	6.8	231.8	11.9	9.5	43.0	50.1	125.4	69.7	560.0	1,000
Jáchymov	HG-1 Well	34.2	93.6	8.1	144.7	11.1	4.4	17.0	7.2	15.2	63.1	390.5	700
Hájek	Císarský Spring	15.0	59.0	7.5	1,575.0	37.1	24.3	71.1	594.6	1769.0	100.3	1469.3	5,600
Konstantinovy Lázne	BV-11 Well	13.3	55.9	5.3	101.0	12.8	37.1	38.1	42.6	11.5	58.2	593.1	900
Františkovy Lázne	Glauber III Well	12.5	54.5	6.2	3,221.0	63.5	41.3	185.3	1306.0	3975.0	64.6	1939.0	10,100

mg/L = milligrams/liter
Data source: Albu et al., 1997 (Table 14.1)

Table 6. Temperatures and major chemical species of selected wells and springs in Pahoa and Pahala areas, Hawaii

Sample Location	Well Depth (feet)	Water Type (defined below)	Temperature (°C)	Temperature (°F)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Calculated Total Dissolved Solids (TDS) (mg/L)
Pahoa Battery 2A well	755	I	24.3	75.7	16.4	3.32	2.48	3.65	4.49	13.5	57.3	45.6	124
Keauohana 1 well	802	II	24.3	75.7	50.2	3.65	3.25	8.43	75.9	16.2	50.5	34.3	225
Puna Geothermal MW-1 well	720	III	43.9	111.0	63	11.2	13.1	24.6	19.6	195	104.0	36.0	449
Allison well	140	IV	37.8	100.0	216	10.8	15	13.4	281	69	24.1	132.0	694
Puna Thermal TH 3 well	690	V	89.4	192.9	3,390	292	205	261	6,042	565	220.0	28.4	11,000
Lighthouse Spring	-	VI	28.0	82.4	1,050	43.1	119	63.2	1,818	304	64.0	46.4	3,490
Burgess Pool	-	VI	32.5	90.5	1,530	62.5	166	78.2	2,729	457	72.3	50.8	5,130
Campbell Spring	-	VI	37.4	99.3	2,040	102	203	95.5	3,505	509	93.1	51.9	6,590
Pohoiki Spring	-	VI	35.0	95.0	1,740	74	190	93.1	3,011	452	98.2	52.5	5,700
Opihikau Spring	-	VI	38.0	100.4	NR	NR	NR	NR	4,800	NR	NR	NR	NR
Puu Elemakule Spring	-	VI	41.5	106.7	4,770	183	569	197	8,365	1,323	65.9	171.0	15,600
Seawater	-	-	-	-	10,500	390	1,350	410	19,000	2,700	6.4	142.0	34,500

mg/L = milligrams/liter
NR = Not reported (does not necessarily mean species is absent)
Data sources: Janik et al., 1994; Sorey and Colvard, 1994

Water types (after Sorey and Colvard, 1994):

I	**Cold** (25°C or less) and **dilute** (chloride 10 mg/L or less)
II	**Cold** (25°C or less) and **brackish** (chloride about 75-300 mg/L)
III	**Warm** (about 40°C) and **dilute** (chloride about 20 mg/L)
IV	**Warm** (about 40°C) and **brackish** (chloride about 100-800 mg/L)
V	**Hot** (50-100°C) and **saline** (chloride 1,000 mg/L or greater)
VI	**Warm** (30-40°C) and **saline** (chloride 1,000 mg/L or greater)

Table 7. Temperatures and major chemical species in warm ground water from selected wells in Kawaihae area, Hawaii

Sample Location	Well Depth (feet)	Maximum Measured Temperature (°C)	(°F)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Estimated Total Dissolved Solids [a] (mg/L)
Well 6147-01	1,046	31.0	87.8	100	12.8	8.5	23	171	9	51.33	105	481
Well 5548-01	849	28.0	82.4	334	23.8	49	30	23	93	68.44	140	761
Well 6148-01	620	27.0	80.6	210	16.3	36	28	352	118	74.86	82	917
Well 5745-02	1,231	26.5	79.7	35	4.4	10.4	8.3	28	28	70.58	100	285

[a] Total dissolveds solids estimated as sum of major species concentrations
mg/L = milligrams/liter
Data source: Thomas, 1986

Table 8. Temperatures and major chemical species in warm ground water from selected wells on Maui

Sample Location	Well Depth (feet)	Maximum Measured Temperature (°C)	(°F)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Bicarbonate HCO_3 (mg/L)	Estimated Total Dissolved Solids [a] (mg/L)
Lahaina Area												
Well 5240-01	39	26.82	80.3	465	17.0	119	123	1,030	144	64.4	194	2,156
Well 5340-01	27	25.20	77.4	413	13.4	174	166	1,180	240	51.4	150	2,388
Well 5240-03	31	24.93	76.9	406	16.2	132	164	1,040	134	5.9	246	2,144
Olowalu Area												
Well 4835-01	44	35.0	95.0	202.2	28.2	18.8	53.3	393.4	50.6	51.2	340	1,138
Well 4937-01	300	25.6	78.1	255.0	11.9	78.0	112.0	669.0	76.0	73.5	141	1,416

[a] Total dissolveds solids estimated as sum of major species concentrations
mg/L = milligrams/liter
Data source: Thomas, 1986

Table 9. Temperatures, flow rates and salinities of selected warm wells on Molokai and Lanai

Sample Location	Well Depth (feet)	Maximum Measured Temperature (°C)	(°F)	Maximum Measured Flow Rate (l/s)	(gpm)	Chloride Cl (mg/L)	Total Dissolved Solids (mg/L)
West Molokai Area, Molokai							
Well 0815-01	409	35.6	96.1	14.2	225	4,500	8,600
Well 0715-01	401	35.4	95.7	15.1	240	4,400	8,300
Well 0715-02	387	33.9	93.0	17.4	276	7,000	15,700
Palawai Area, Lanai							
Well No. 9 (4854-01)	1,450	38.3	100.9	22.7	360	400	920
Well No. 10 (4555-01)	1,455	40.3	104.5	2.9	46	1,400	>2,920
Well No. 12 (4552-01) [a]	620	35.0	95.0	12.0	190	707.5	1,030

[a] Well no. 12 is located in Kaluakapo Crater, south of rim of Palawai Basin.
mg/L = milligrams/liter
Data source: DLNR completion reports and well files; Nance, 1993.

Table 10. Temperatures and major chemical species in warm ground water from selected wells on Oahu

Sample Location	Well Depth (feet)	Maximum Measured Temperature (°C)	Maximum Measured Temperature (°F)	Sodium Na (mg/L)	Potassium K (mg/L)	Magnesium Mg (mg/L)	Calcium Ca (mg/L)	Chloride Cl (mg/L)	Sulfate SO_4 (mg/L)	Silica SiO_2 (mg/L)	Carbonate + Bicarbonate $CO_3 + HCO_3$ (mg/L)	Estimated Total Dissolved Solids [a] (mg/L)
Waianae Area												
Well 2508-02	175	29.0	84.2	126	9.6	108	41	382	25	89	313	1,094
Well 2808-01	535	26.7	80.1	120	3.2	28	66	160	222	63	97	759
Well 2709-08	190	26.0	78.8	92	2.6	9.6	11	147	22	165	NR	449
Well 2409-07	73	25.5	77.9	680	18.2	61	96	1,410	232	172	NR	2,669
Well 2508-07	58	25.5	77.9	380	12.8	81	127	1,330	59	186	NR	2,176
Waimanalo Area												
Well 2043-01	537	30.0	86.0	28.0	1.1	2.8	14.0	25.0	5.4	22.0	84	182
Well 2042-05	450	30.0	86.0	NR	NR	NR	NR	NR	NR	NR	NR	NR
Well 2142-03	41	26.1	79.0	NR	NR	NR	NR	NR	NR	NR	NR	NR
Well 2043-02	280	25.0	77.0	36.0	1.0	6.8	12.0	27.0	10.0	35.6	148	276
Well 2042-13	160	25.0	77.0	920.0	36.0	110.0	150.0	1,700.0	220.0	26.0	224	3,386

[a] Total dissolveds solids estimated as sum of major species concentrations
mg/L = milligrams/liter
NR = Not reported (does not necessarily mean species is absent)
Data source: Thomas, 1986

Table 11. Temperatures and flow rates of warm wells in Lihue Basin, Kauai

Well Name	State Well Number	Well Depth (feet)	Maximum Measured Temperature (°C)	Maximum Measured Temperature (°F)	Maximum Measured Flow Rate (l/s)	Maximum Measured Flow Rate (gpm)
Northwest Kilohana Well	2-0126-01	1,004	34.0	93.2	20.5	325
Northeast Kilohana Well	2-0124-01	1,047	25.2	77.4	20.7	328
Pukaki Well	2-0023-01	1,147	27.0	80.6	19.4	308
Hanamaulu Well	2-5923-08	1,002	25.9	78.6	5.2	83

Data sources: Gingerich and Izuka, 1997; Izuka and Gingerich, 1997a, 1997b, and 1997c

Table 12. Comparison of marketing themes and costs for selected resorts and health centers with mineral water spas

	Amenities	Activites	Services	Weekly Cost (All-Inclusive)	Daily Lodging	Specific Services or Spa Use
Hawaiian Locations						
Ihilani Resort and Spa, Kapolei, Oahu (west coast of Oahu)	Luxury resort designed for upscale travelers and members of Ko'Olina Golf Club. Opened in 1993. Ocean-water spas, exercise equipment, ocean beach, swimming pools, jacuzzis; 640-acre grounds.	Health and fitness classes, tennis, golf, snorkeling, Boccie ball, croquet, water sports, aerobics.	Massage, hydrotherapy, aromatherapy, thalassotherapy, body wraps and scrubs; personal fitness trainers.	$2,834-$3,646	$295-$575	NA
Kalani Oceanside Retreat, Island of Hawaii (Pahoa area)	Back-to-nature retreat with emphasis on Hawaiian spirituality and culture. Advertises nearby thermal springs as one of its attractions. Opened in 1982. Japanese-style spa, 25-m pool, sauna, jacuzzis, weight room, reading room. Accommodations in lodge, single cabins or campsites	Health-oriented work-shops, including yoga, hula, tai-chi; basketball, volleyball, surfing, kayaking, fishing, swimming with dolphins.	Massage services, including underwater shiatsu massage.	$660-$940	$95-$110	NA
Locations Outside Hawaii						
Alamo Springs Spa at Menger Hotel, San Antonio, Texas	Spa fed with heated mineral water from Edwards aquifer. Menger Hotel is directly across from the Alamo. Spa opened in 1993. Includes sauna and steam rooms, exercise equipment, swimming pool.	Personalized training regimens.	Massage, body scrubs and wraps, hydrotherapy, thassalotherapy, facials, reflexology.	NA	$132-$142	NA
Calistoga Spa Hot Springs, Calistoga, Californiia	Mineral baths, steam baths, and mud baths fed by natural hot water from wells; three swimming pools; exercise equipment.	Aerobics classes.	Massage, blanket wraps.	NA	$87-$132	$44-$88
Carson Hot Mineral Springs Resort, Carson, Washington	Mineral baths fed by natural hot spring water; accommodations in hotel (built in 1897) or rustic cabins.	Fishing, hiking, golf.	Massage, blanket wraps.	NA	$35-$50	NA

Table 12. Comparison of marketing themes and costs for selected resorts and health centers with mineral water spas

	Amenities	Activites	Services	Weekly Cost (All-Inclusive)	Daily Lodging	Specific Services or Spa Use
The Greenbriar, White Sulphur Springs, West Virginia	Two-hundred-year-old resort, with spa fed by heated mineral water from Alvon spring. Indoor and outdoor pools; exercise equipment. Accomodations in hotel or cottages.	Golf, tennis, biking, bowling, fishing, aerobics classes, horseback riding, carriage rides, skeet- and trap-shooting, croquet; dancing, movies, food-and-wine weekends.	Massage, herbal wraps, facials; spa therapy in conjunction with health examinations at nearby private clinic; personal fitness trainers.	$2,650-$3,495	$160-$281	NA
Harrison Hot Springs Hotel, Harrison Hot Springs, British Columbia, Canada	Lakeside resort with indoor and outdoor pools fed by natural warm spring water. Exercise equipment.	Bike rental, cross-country skiing, tennis, volleyball, swimming. Horseback riding and golf nearby. Dinner dances.	Massage.	NA	US$83-$120	NA
The Homestead, Hot Springs, Virginia	Historic hot springs spa resort. Bath House built in 1892, renovated 1994-1997. Georgian-style hotel with modern conference facilities. Indoor and outdoor pools; exercise equipment.	Golf, tennis, horseback riding, fishing, archery, falconry, hiking, biking, skiing, ice skating, skeet- and trap-shooting, movies carriage rides, dancing.	Massage services, aromatherapy, facials, body wraps and scrubs, therapeutic whirlpool.	NA	$132-$235	$25-$115
Hotel Ixtapan, Ixtapan de la Sal, Mexico	Hot springs health resort. Indoor and outdoor pools. Art Deco hotel opened in 1942. Private marble-walled baths; exercise equipment.	Golf, tennis, horseback riding, volleyball, badminton; folkloric ballet.	Massage, reflexology; acupuncture; mud packs, facials.	$784-$825	$68-$105	NA
Kah-Nee-Ta Resort, Warm Springs, Oregon	Hot springs resort owned and operated by confederation of Native American tribes. Swimming pools and bathhouses. Accommondations in guest lodge.	Tribal ceremonies, salmon bake, drumming; hiking, biking, horseback riding; gambling casino.	Massage, aromatherapy, reflexology, mud wraps.	NA	$120-$215	$6 (pool)

Table 12. Comparison of marketing themes and costs for selected resorts and health centers with mineral water spas

	Amenities	Activites	Services	Weekly Cost (All-Inclusive)	Daily Lodging	Specific Services or Spa Use
Lodge at Potosi Hot Springs, Pony, Montana	Natural hot spring pools. Accommodations are in rustic cabins, meals are family-style in central lodge.	Hiking, mountain biking, fishing, horseback riding.	Massage.	NA	$250	NA
Safety Harbor Resort and Spa, Safety Harbor, Florida	Health resort with pools and jacuzzis fed by natural thermal springs. Exercise equipment.	Fitness evaluation; lectures on health-related subjects; golf and tennis instruction; cooking demonstrations.	Massage, body wraps and scrubs, facials.	$1,667-$2,298	$86-$103	$15-$110
Spa Hotel and Casino, Palm Springs, California	Natural hot springs supply 2 outdoor mineral water pools and hydrotherapy center. Owned and operated by Agua Caliente band of Native Americans.	Nearby access to golf, hiking, horseback riding, tennis. Pool swimming. Gambling casino.	Massage, aromatherapy, body scrubs, mud wraps, facials.	NA	$159-$229	NA
Ten Thousand Waves, Santa Fe, New Mexico	Japanese-style onsen baths fed by artificially heated water. Resort emphasizes Japanese motif, including kimonos for guests and rooms with futons or tatami mats.	Hiking, horseback riding; skiing and rafting nearby.	Massage, salt rubs, herbal wraps, facials.	NA	$119-$204	$18-$25

NA = Not applicable or information not available.
Data sources: Fodor's Travel Publications, Inc., 1998; internet web sites for individual resorts.

FIGURES

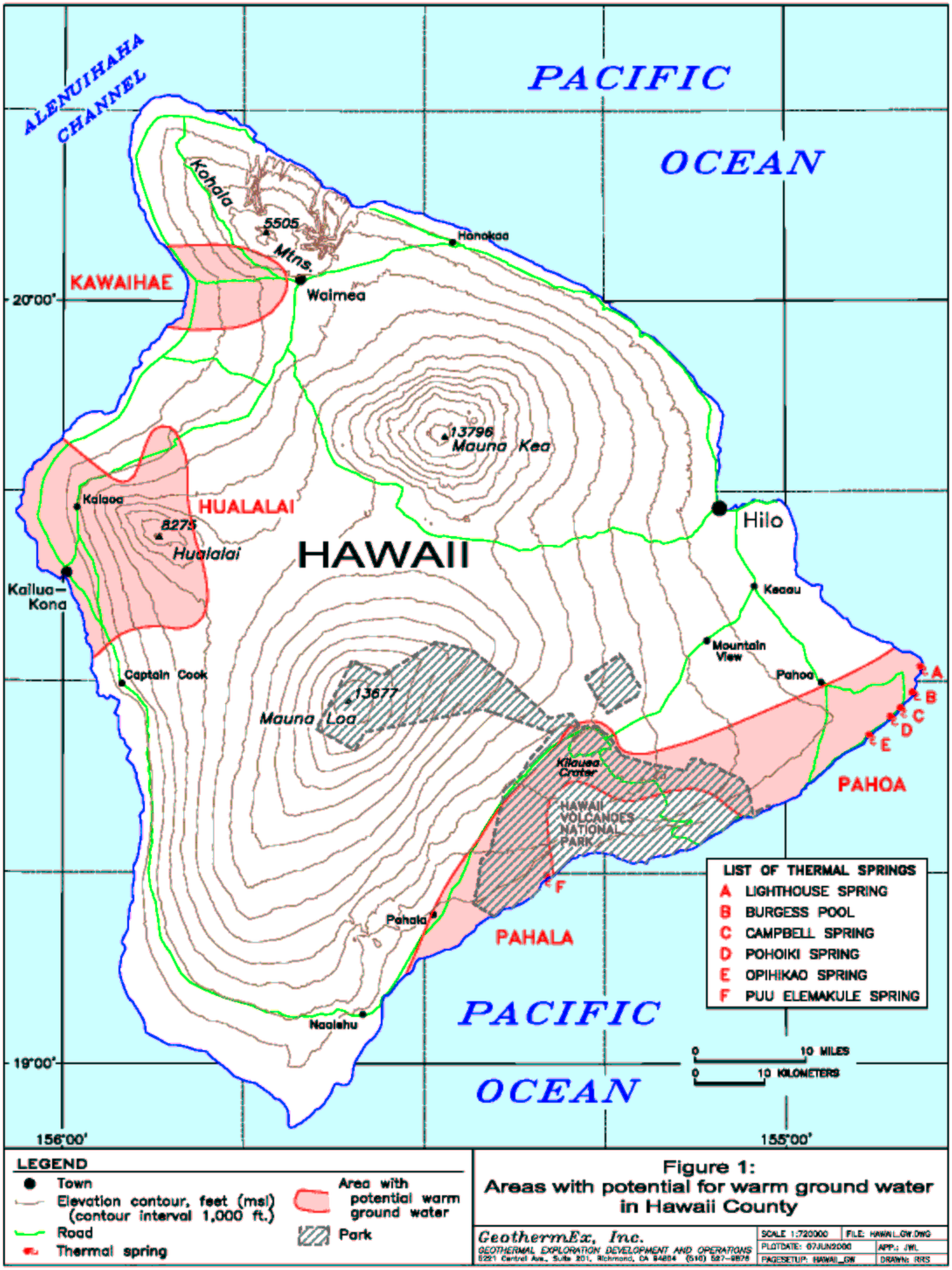

Figure 1:
Areas with potential for warm ground water in Hawaii County

GeothermEx, Inc.
GEOTHERMAL EXPLORATION DEVELOPMENT AND OPERATIONS
5221 Central Ave., Suite 201, Richmond, CA 94804 (510) 527-9876

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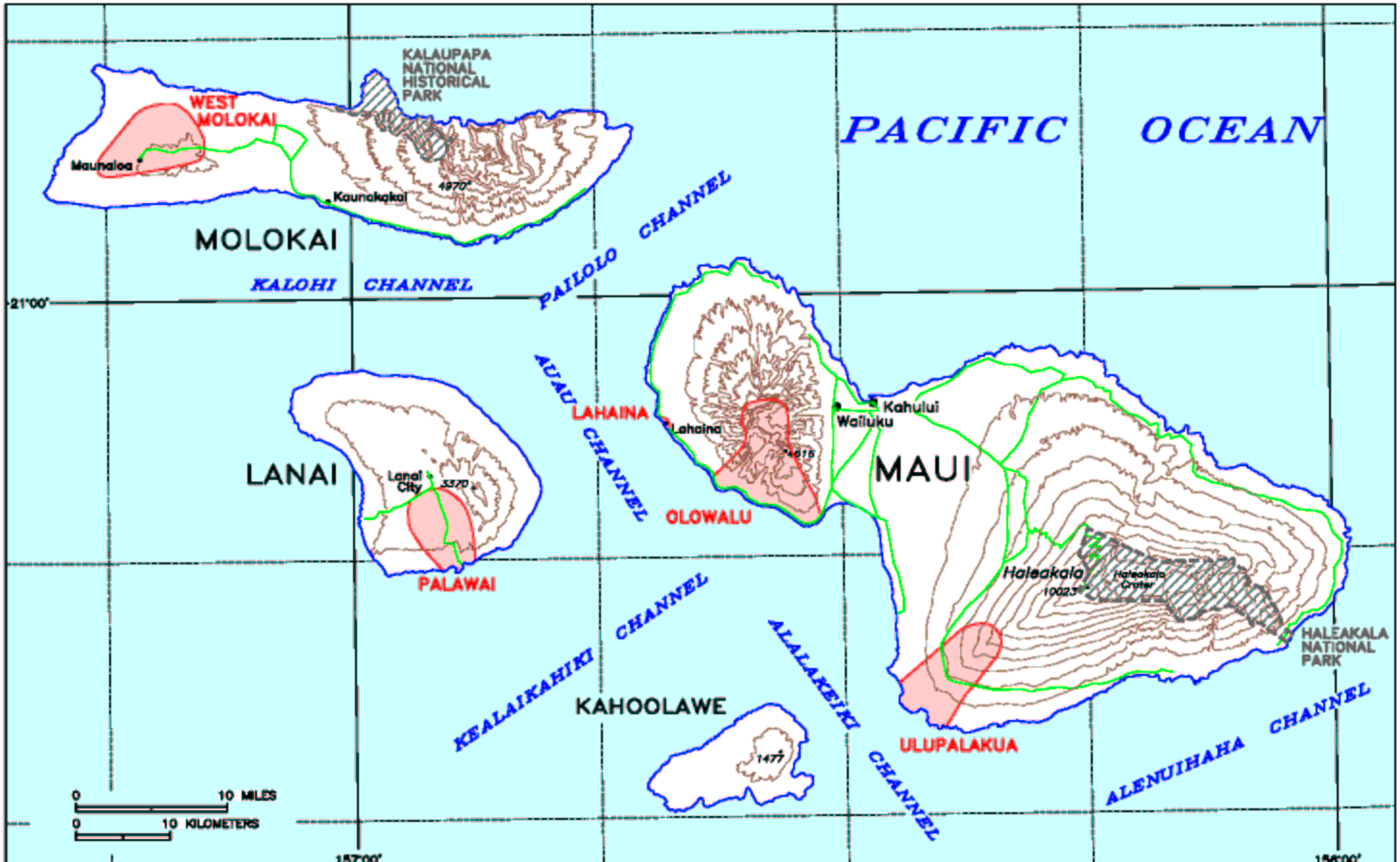

Figure 2: Areas with potential for warm ground water in Maui County

GeothermEx, Inc.
GEOTHERMAL EXPLORATION DEVELOPMENT AND OPERATIONS
5221 Central Ave., Suite 201, Richmond, CA 94804 (510) 527-9876

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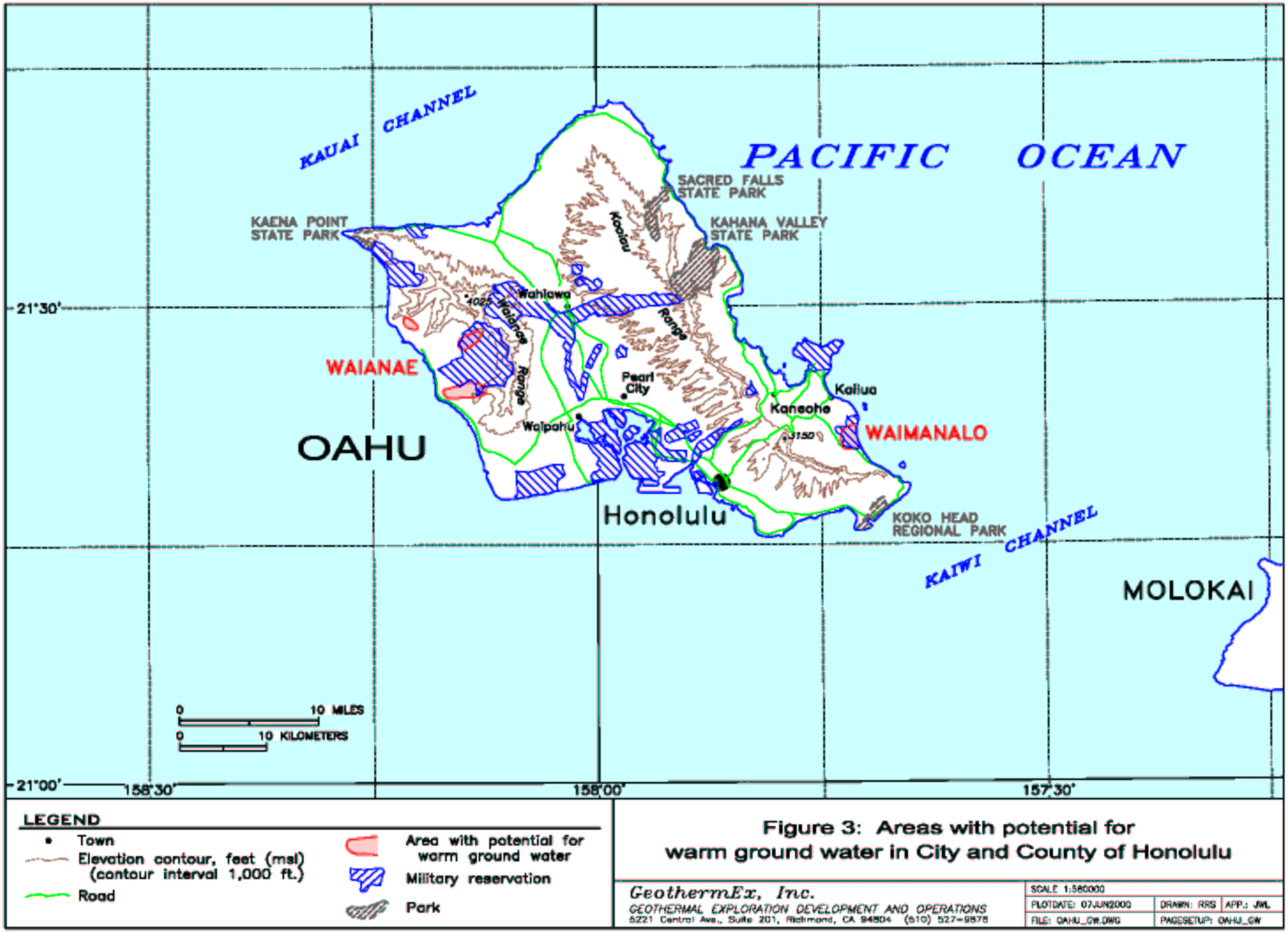

Figure 3: Areas with potential for warm ground water in City and County of Honolulu

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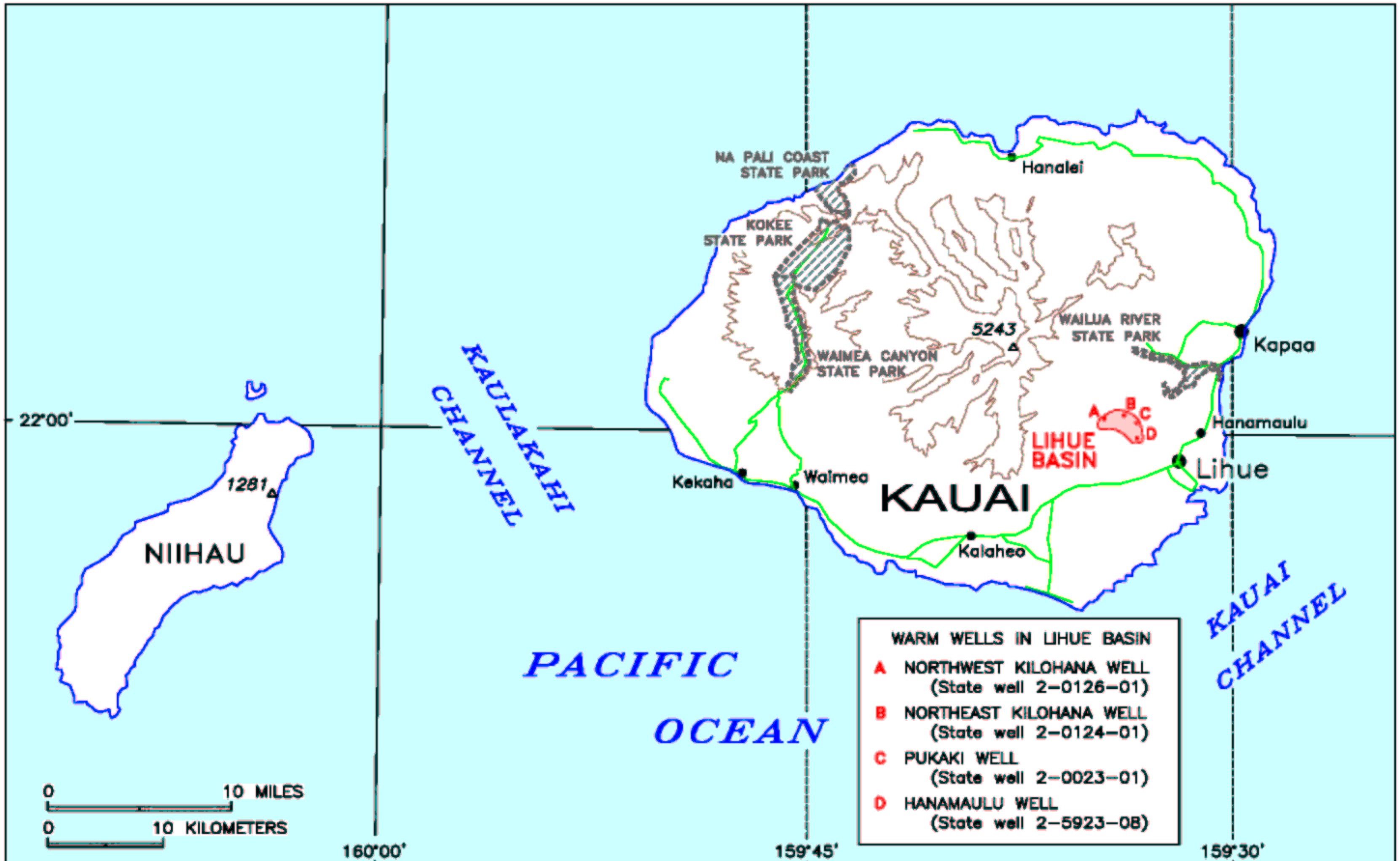

LEGEND

- Town
- Elevation contour, feet (msl) (contour interval 2,000 ft.)
- Road
- Area with potential for warm ground water
- Park
- A. Warm well

Figure 4:
Area with potential for warm ground water in Kauai County (Lihue Basin)

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PLOTDATE: 06JUN2000	DRAWN: RRS APP.: JWL
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APPENDIX

SELECTED WEB SITES RELATED TO GEOTHERMAL SPAS

About.com Spas website	http://spas.about.com
Blue Lagoon, Iceland	http://www.bluelagoon.is
Hot Sulphur Springs Resort, Hot Sulphur Springs, Colorado	http://www.hotsulphursprings.com
Kah-Nee-Tah Resort, Warm Springs, Oregon	http://www.kah-nee-taresort.com
Polynesian Spa, Rotorua, New Zealand	http://polynesianspa.co.nz
Safety Harbor Resort and Spa, Tampa Bay, Florida	http://www.safetyharborspa.com
Spa Hotel and Casino, Palm Springs, California	http://www.desertresorts.com/spa
State of Hawaii	
Department of Business, Economic Development and Tourism (DBEDT) - Energy Resources and Technology Division	http://www.hawaii.gov/dbedt/ert
Department of Land and Natural Resources	http://www.state.hi.us/dlnr