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Public Utilities Commission

2

Docket No. 05-0145

3

O`ahu Power Plant

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Testimony of

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Dr. David Rezachek

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re: Sea Water Air Conditioning System

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2 My name is Dr. David Rezachek and my business address is 7 Waterfront Plaza, Suite 400, 500
3 Ala Moana Boulevard, Honolulu, Hawaii 96813. I am the Associate Development Director of
4 Honolulu Seawater Air Conditioning, LLC. I am a full-time consultant to Honolulu Seawater
5 Air Conditioning, LLC. Provide engineering consulting and project management services in all
6 phases of development of seawater air conditioning (SWAC) district cooling projects in Hawaii.
7

8 **Education**

9 Ph.D.1991. Ocean Engineering. University of Hawaii at Manoa. Dissertation Title:
10 “Development of a Solar Pond System Design Computer Model”
11 M.S.1980. Mechanical Engineering. University of Hawaii at Manoa. Thesis Title: “Application
12 of Heat Pumps to Residential Water Heating”
13 B.S.1976. Environmental Technology and Urban Systems. Florida International University
14 1973 U. S. Navy Nuclear Power School and Nuclear Power Plant Prototype (Nuclear
15 Engineering)
16 1972 Ensign. U. S. Navy Officer Candidate School
17 B.S. 1972. Chemistry (with distinction). University of Minnesota

18

19 **Awards & Professional Recognitions**

20 Won national Best Energy Education Program (BEEP) award in 1989 for Ka’ahale La (Tour of
21 the Sun) Interscholastic Photovoltaic-Powered Vehicle Competition

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1 Project leader for first high school solar car to complete the 1990 World Solar Challenge (a
2 1,900-mile solar car race from Darwin to Adelaide, Australia) in the second year of the Ka'ahale
3 La (Tour of the Sun) Interscholastic Photovoltaic-Powered Vehicle Competition
4 Registered professional mechanical engineer in the State of Hawaii for more than 21 years (No.
5 5485)

6 **Professional Affiliations**

7 American Society of Mechanical Engineers (ASME)

8 American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

9

10 I am a full-time consultant to Honolulu Seawater Air Conditioning, LLC. Provide engineering
11 consulting and project management services in all phases of development of seawater air
12 conditioning district cooling projects in Hawaii.

13

14 1993 – Present **OWNER/PRINCIPAL.** Rezachek & Associates. Energy and
15 environmental engineering consultants. Provide consulting and project management services in a
16 variety of renewable energy, energy efficiency, and environmental areas.

17

18 1987 – 2003 **ALTERNATE ENERGY SPECIALIST.** State of Hawaii - Department of
19 Business, Economic Development and Tourism - Energy Division - Alternate Energy Branch.
20 Conduct analyses of existing and proposed alternate energy programs and projects. Conduct the
21 planning, development and implementation of alternate energy demonstration and
22 commercialization projects. Project manager for more than fifty alternate energy- and energy-
23 efficiency-related projects.

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1980 – 1987 **ASSISTANT MECHANICAL ENGINEER.** Sugar Technology and Engineering Department, Hawaiian Sugar Planters' Association (HSPA). Alternate and conventional energy research and application, energy conservation and air pollution monitoring. Supervised two experimentalists for approximately 30 percent of their time.

1980 **GRADUATE RESEARCH ASSISTANT.** Hawaii Natural Energy Institute (HNEI), University of Hawaii at Manoa. Assisted in all phases of alternate energy research projects.

1979 – 1980 **JUNIOR RESEARCHER.** Hawaii Natural Energy Institute (HNEI), University of Hawaii at Manoa. Hawaii Ethanol from Molasses Project. Literature search team leader. Cost and energy analyses and preliminary process evaluation.

1978 – 1979 **GRADUATE RESEARCH ASSISTANT.** Center for Engineering Research (CER), University of Hawaii at Manoa. Various support services related to alternate energy and engineering research.

1976 – 1977 **GRADUATE RESEARCH ASSISTANT.** Department of Oceanography, University of Hawaii at Manoa. Research on the "Dissolution of Calcareous Nanoplankton Under Simulated Oceanic Conditions." Determined the dissolution rate of calcium-45 tagged coccoliths under ocean pressure and carbonate (pH) concentrations.

1 1974 – 1976 **ASSOCIATE QUALITY ASSURANCE ENGINEER.** Quality Assurance
2 Department, Design Group, Florida Power & Light Company, Miami, Florida. Responsible for
3 the quality assurance aspects of engineering activities performed throughout the life of a nuclear
4 power plant. Audit team leader for numerous quality assurance audits of groups and departments
5 associated with nuclear and environmental engineering.

6

7 1974 **PROJECT ENGINEER.** Advanced Reactors Division, Westinghouse Electric
8 Corporation, Madison, Pennsylvania. Coordinated projects in Liquid Metal Fast Breeder Reactor
9 (LMFBR) development with other Westinghouse and Nuclear Regulatory Commission (NRC)
10 projects.

11

12 1972 – 1974 **STUDENT/OFFICER.** United States Navy Nuclear Power Program. Officer
13 training; nuclear engineering education; and operation of, and supervision of enlisted operators
14 of, a nuclear power plant prototype.

15

16 **Publications, Reports, and Presentations**

17 Rezachek, David. 2006. "Seawater Air Conditioning System Performance," Honolulu Seawater
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19 Rezachek, David. 2006. "Energy Savings and Demand Reduction Potential of SWAC Systems,"
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- 4 Seawater Air Conditioning LLC, July 2006 (Pub)
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- 10 Association (AWWA), AWWA-Hawaii Conference, Honolulu, Hawaii, May 10, 2006 (Pre)
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- 13 Krasnick, George and Rezachek, David. 2005. "Honolulu Seawater Air Conditioning," Hawaii
- 14 Association of Environmental Professionals, Honolulu, Hawaii, August 25, 2005 (Pre)
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- 17 (Pre)
- 18 Rezachek, David. 2005. "Seawater Air Conditioning for Honolulu," Honolulu Seawater Air
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- 20 Rezachek, David. 2005. "Seawater Air Conditioning for Honolulu," Engineering Alumni
- 21 Association of the University of Hawaii, General Meeting, Honolulu, Hawaii, June 7, 2005 (Pre)
- 22

- 1 Krasnick, George and Rezachek, David. 2005. "Honolulu Seawater Air Conditioning Project,"
2 Presentation to the Downtown Neighborhood Board, Honolulu, Hawaii, June 2, 2005 (Pre)
- 3 Rezachek, David. 2005. "Seawater Air Conditioning for Honolulu," ASHRAE Hawaii Seminar,
4 Island Energy Solutions – "Surrounded by a Renewable Energy Resource," Honolulu Hawaii,
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- 6 Krasnick, George and Rezachek, David. 2005. "Honolulu Seawater Air Conditioning," State of
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- 8 Rezachek, David. 2005. "Seawater Air Conditioning – Cool, Green, and Clean," Technology
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10 http://www.hawaiihospitalityonline.com/past_issues/hh0305/tech_notebook.asp, March 2005
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18 Management Association, Honolulu, Hawaii, January 20, 2005 (Pre)
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6 Seawater Air Conditioning (SWAC) Integrated with Thermal Energy Storage (TES)",

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8 Rezachek, David. 2003. "Sea Water District Cooling Feasibility Analysis for the State of

9 Hawaii," Rebuild Hawaii Consortium Meeting, Honolulu, Hawaii, May 13, 2003 (Pre)

10 Rezachek, David. 2003. "Sea Water District Cooling Feasibility Analysis for the State of Hawaii

11 – Summary of Results," Innovative Energy Systems Workshop, Pagoda Hotel, Honolulu,

12 Hawaii, March 19, 2003 (Pre)

13 Rezachek, David (workshop organizer). 2003. "Innovative Energy Systems Workshop," March

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2 Export Promotion Plan for Hawaii," Department of Business, Economic Development, and
3 Tourism, State of Hawaii, (Draft) (Rep)
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5 Resource for Hawaii," Department of Ocean and Resources Engineering Seminar, University of
6 Hawaii at Manoa, Honolulu, Hawaii, March 6, 2002 (Pre)
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8 Resource for Hawaii," Department of Business, Economic Development, and Tourism, State of
9 Hawaii, February 2002 (Pub)
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11 of the Solar World Congress – ISES 2001, November 25 - December 2, 2001, Adelaide,
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21 Energy for Sustainable Tourism," Proceedings of the International Conference for Renewable
22 Energy and Energy Education – CIER 2001, CETER/ISPJAE, September 11-14, 2001, Havana,
23 Cuba (Pub)

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- 3 Solar Energy Association (HSEA)," State of Hawaii – Public Utilities Commission, Docket No.
- 4 00-0209, In the Matter of the Application Hawaiian Electric Company, Inc. For Approval of a
- 5 Residential Demand-Side Management Program, Recovery of Program Costs and Lost Margins,
- 6 and Consideration for Shareholder Incentives," September 7, 2001 (Rep)
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- 12 and Conservation in Hotels – Towards Sustainable Tourism," Proceedings of the 4th
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2 “Renewable Energy of the Sun,” Rizzoli International Publications, Inc., New, York, 192 pages
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6 Network,” in Proceedings of the First Green Enertopia International Forum, September 1-3,
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9 Takahashi, Patrick. 1997. “The Green Enertopia International Network,” in Proceedings of the
10 International Solar Energy Society (ISES) Solar World Congress, August 24-29, 1997, Taejon,
11 Korea (Pub, Pre)
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13 Hawaii,” Prepared by James E. Francfort, Idaho National Engineering Laboratory, for the U.S.
14 Department of Energy, DOE/ID-10430(HI), September 1996, 48 pages (Pub)
- 15 Rezachek, David A. 1996. “Hawaii Ocean Resources Management Plan - Energy. Presentation to
16 the Marine and Coastal Zone Management Advisory Group (MACZMAG),” June 7, 1996 (Pre)
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18 in Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference, Session
19 Sol-24 Terrestrial Photovoltaics, March 19-24, 1995, Lahaina, Hawaii (Pub, Pre, Invited Paper,
20 Award for Best Photovoltaic Paper)
- 21 Rezachek, David A. 1995. “Heat Pipes Control Humidity Without Moving Parts, Transitions,”
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2 Issue 48, May 1995, page 2 (Pub)
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4 the Hawaii Windpower Workshop, March 21-22, 1994, Honolulu, Hawaii (Pre)
- 5 Rezachek, David A. 1994. "1993 Pali Challenge and Hawaii EV 2010 Final Report," Submitted
6 to the National Renewable Energy Laboratory on behalf of the Electric Vehicle Association of
7 Hawaii (Rep)
- 8 Rezachek, David A. 1993. "Development of a Solar Pond System Design Computer Model," *in*
9 Proceedings of the 3rd International Conference PROGRESS IN SOLAR PONDS, University of
10 Texas - El Paso, May 27, 1993 (Pub, Pre)
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18 Roger A. Ulveling, Director, Department of Business and Economic Development, on behalf of
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2 Energy Development in Hawaii Workshop," July 26-27, 1989, State of Hawaii, Department of
3 Business and Economic Development, Energy Division, Honolulu, Hawaii, 215 pages (Pub)
- 4 Rezachek, David A. 1988. "Photovoltaic-Powered Water Pumping," Presented at the Hawaii
5 Water Works Association 1988 Annual Conference, October 24, 1988, Kahului, Hawaii (Pre)
- 6 Rezachek, David A. 1986. "Final Performance Source Emissions Survey of Hilo Coast
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8 January 13-15, 1986, Experiment Station, Hawaiian Sugar Planters' Association, 35 pages (Rep)
- 9 Rezachek, David A. 1986. "A Low-Cost, Portable, Isokinetic Stack Gas Particulate Sampling
10 System," Environmental Report 11, January 7, 1986, Hawaiian Sugar Planters' Association
11 (HSPA), Aiea, Hawaii (Rep*)
- 12 Rezachek, David A. 1984. "Increased Sugar Recovery Through Higrading," Paper No. 602 -
13 Journal Series of the Experiment Station, Hawaiian Sugar Planters' Association (HSPA), Aiea,
14 Hawaii (Pub)
- 15 Rezachek, David A. 1984. "Update on Fast Injection of Fertilizer into Drip Irrigation Systems,"
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- 18 Rezachek, David A. 1984. "Determining the Effectiveness of Fast Injection of Fertilizer Through
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2 Uniformity After Injection Into a Drip Irrigation System," Irrigation Report 84, Hawaiian Sugar
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- 4 Rezachek, David A. 1984. "Wind Energy for Irrigation Pumping," Volume 3 -
5 Wind/Ocean/Nuclear/Hydrogen *of* Proceedings of the Sixth Miami International Conference on
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9 the Performance of Solar Ponds," Volume 2 - Solar Applications/Waste Energy *of* Proceedings
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2 Hawaiian Commercial and Sugar Company - Paia Mill Bagasse Boiler Stack - Paia, Maui,
3 Hawaii," May 24-26, 1982, 48 pages (Rep)
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10 Plantation Company, Ltd. Number 2 Scrubber - Lihue, Kauai, Hawaii," conducted December 2,
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5 Company Bagasse Boiler Stack - Pahala, Hawaii," August 24-25, 1981 33 page, (Rep)
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7 pp, DOE/ET/23141-T2 (Pub)

8 **Note: The above list does not include numerous nuclear quality assurance audit reports,**
9 **project progress reports, and other technical reports.**

10 Key:

11 Pre Presentation

12 Pub Publication

13 Rep Report

14

15 My testimony will describe Sea Water Air Conditioning. A typical Seawater Air Conditioning
16 (SWAC) system is quite simple, and is illustrated below. Cold seawater is pumped up from the
17 bottom of the sea (i.e., a depth of 1,600 to 3,000 feet in Hawaii). This cold seawater is passed
18 through a heat exchanger where it cools chilled water that is circulated to buildings.

19

20 Basic components include:

21

22 A seawater supply distribution system including the pipeline, pumps, and discharge pipe;

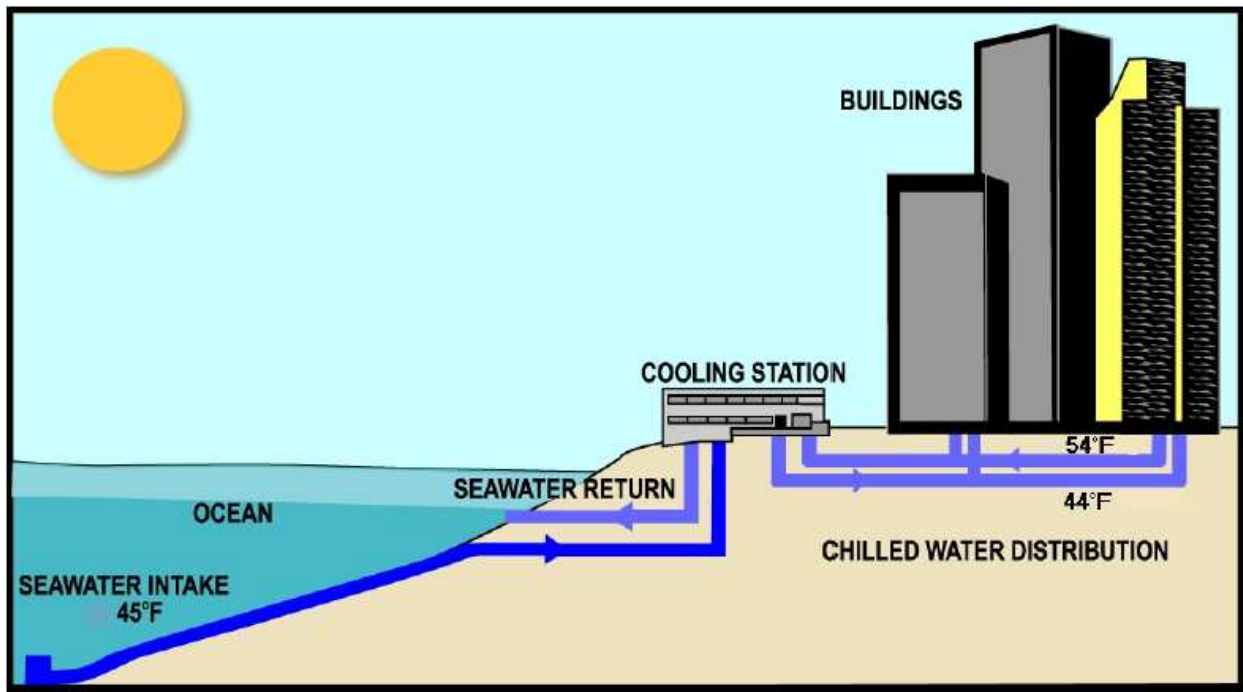
23 A fresh water circulation distribution network, including pumps. This network provides chilled

1 water that circulates through each building; and
2 Heat exchangers that transfer heat from the fresh water circulation distribution loop to the
3 seawater.

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5 These basic components are optimized for each specific location, climate, and building.

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An Elevation of a Basic Seawater Air Conditioning System.

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10 Applications of Seawater Air Conditioning in Hawaii

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12 As a tropical island state, Hawaii has a year-round, relatively-uniform need for air conditioning.

13 Air conditioning systems are energy intensive and represent 35% to 45% of energy use in typical

14 office and hotel buildings in Hawaii. Hawaii also has some of the highest electricity rates, and air

15 conditioning costs, in the country. And, Hawaii relies on expensive imported fossil fuels for

1 more than 90% of its energy needs. At the same time, all islands have some shorelines that have
2 good access to deep, cold seawater used in a SWAC system.

3
4 SWAC is suitable for coastal developments with large air conditioning demand and reasonable
5 access to deep, cold seawater. Notable areas are southern Kauai, several areas of Oahu, and the
6 southern 60% or more of the Big Island.

7
8 A number of studies have been conducted to evaluate the potential of SWAC in Hawaii, and
9 there is an operating system at the Natural Energy Laboratory of Hawaii Authority (NELHA) at
10 Keahole Point, Hawaii. These studies all show that there is significant potential for SWAC in
11 Hawaii. More recent studies show that combining SWAC with thermal energy storage and
12 auxiliary chillers increases the cost effectiveness and applicability of such systems.

13
14 Benefits to be derived from the use of cold, deep seawater resources include: (1) air
15 conditioning, (2) auxiliary cooling for industrial facilities and cooling systems, (3) cool and cold
16 water aquaculture and agriculture, and (4) water quality improvement.

17
18 SWAC systems eliminate the need for cooling towers and, as a result, reduce potable water use,
19 toxic chemical use, and the production of sewage.

20
21 Exhaust seawater can be used for cold water aquaculture and agriculture. Lack of land
22 availability would likely prevent this for any urban Honolulu SWAC systems, but it may be
23 feasible for neighbor island systems (if sufficient adjacent land is available). This dual-use

1 application may also help to make these generally smaller systems more cost effective.

2

3 Finally, SWAC system exhaust seawater is unpolluted and pathogen-free. Its discharge into
4 various receiving water bodies (e.g., the Ala Wai canal, Honolulu Harbor, and Pearl Harbor)
5 could contribute to water quality improvement.

6

7 **History of Sea Water Air Conditioning**

8 Seawater Air Conditioning (SWAC) is a category of deep water cooling which can use deep
9 seawater or freshwater as a cooling source.

10

11 The feasibility of using cold seawater to directly cool buildings has been studied and analyzed
12 for many years. In 1975, the U.S. Department of Energy funded a program entitled "Feasibility
13 of a District Cooling System Utilizing Cold Seawater." Several locations were studied and the
14 two most favorable sites were Miami/Ft. Lauderdale and Honolulu. The study, however, noted
15 that one of the limiting technical factors was the inability to deploy large diameter pipelines to
16 depths of 1,500 feet and more.

17

18 The Natural Energy Laboratory of Hawaii Authority (NELHA) began as "NELH" in 1974 when
19 the Hawaii State Legislature created the Natural Energy Laboratory of Hawaii on 322 acres of
20 land at Keahole Point. NELH was mandated to provide a support facility for research on the
21 ocean thermal energy conversion (OTEC) process and its related technologies.

22

23 A 12-inch diameter pipeline was installed to a depth of 2,000 feet in 1981 off Keahole Point,

1 Hawaii. In spite of its "temporary" design life of 2 years, it survived many major storms
2 including a hurricane and was operational for over twelve years. A number of additional deep (to
3 >3,000 feet) seawater pipes have since been deployed at NELHA.

4

5 In 1986, the Natural Energy Laboratory of Hawaii Authority, Keahole Point, Hawaii began the
6 successful utilization of SWAC in their main laboratory building. Deep-water pipelines were
7 already installed to provide cold, nutrient rich, seawater for research purposes in alternate energy
8 and aquaculture. Since a cold water supply was already incorporated into the infrastructure, it
9 was decided to utilize the cold water for cooling. The use of SWAC has been expanded to a new
10 administration building and a second laboratory.

11

12 In 1986, a joint project between the Canadian government and Purdy's Wharf Development, Ltd.
13 demonstrated the use of ocean water as a source for building cooling to a 350,000 square ft.
14 office complex along the waterfront in Halifax, Nova Scotia. Due to the geographic conditions
15 and annual low water temperatures, a small diameter pipeline was deployed to a depth of less
16 than 100 ft. This was a major factor in limiting the overall expense of installing the cooling
17 system. Total investment for this project was \$200,000. The project was very successful and
18 savings were identified in the following areas: a saving of \$50-60,000 per year in avoided
19 electrical cost, fewer maintenance staff, reduction in fresh water, savings in water treatment, and
20 savings in cooling tower maintenance and replacement. The financial result in terms of a simple
21 payback period was two years. Today, Purdy's Wharf continues to successfully utilize an
22 expanded seawater air conditioning system for their waterfront properties.

23

1 In 1990, the US Department of Energy funded a study entitled: "Waikiki District Cooling
2 Utility." The purpose of this brief study was to evaluate whether it was economically and
3 technically feasible to utilize seawater air conditioning as a means to provide cooling to the
4 hotels in Waikiki and to create a Waikiki Cooling Utility. Waikiki was targeted because of the
5 high density of hotels, high electrical consumption and a large demand for air conditioning. It
6 was estimated by Hawaiian Electric Company that of the 107 Megawatts consumed in Waikiki,
7 51.4 Megawatts were used for air conditioning. This study concluded that economically and
8 technically, Waikiki could be cooled by utilizing seawater air conditioning. Hindering progress
9 on this concept is the difficulty of installing the distribution system throughout a high-tourist
10 region.

11
12 In 1995, Stockholm Energy started supplying properties in central Stockholm with cooling from
13 its new district cooling system. Most of the cooling is produced by using cold water from the
14 Baltic Sea. The temperature of the cooling water leaving the plant is 43°F or lower and the return
15 temperature from the distribution grid is 61°F at high load and a few degrees lower at low load.
16 The district cooling system is designed for a maximum load of ~1,500 tons.

17
18 A lake source cooling project at Cornell University, replaced central campus refrigeration based
19 chillers with a new source based on the cold deep waters of nearby Cayuga Lake. Since its start-
20 up in July 2000, the project has averaged greater than 85 percent reduction in energy use
21 delivered to the buildings.

22
23 A deep lake water cooling system was installed by the Enwave Energy Corporation in Toronto,

1 Ontario. This system became operational in August 2004. It draws water from Lake Ontario
2 through pipes extending 3 miles into the lake, reaching to a depth of 270 feet. The lake-bottom
3 water is at 39°F year-round even at the height of summer, when the surface water is warm. The
4 cooler denser water remains near the bottom. The deep lake water cooling system is part of an
5 integrated district cooling system that covers Toronto's financial district, and has a cooling
6 capacity of 59,000 tons.

7

8 The cold water drawn from Lake Ontario's deep layer in the Enwave system is not
9 returned directly to the lake, once it has been run through the heat exchange system. The Enwave
10 system only uses water that is destined to meet the city's domestic water needs.

11 More recently, the Intercontinental Resort and Thalasso Spa Bora Bora opened May 1,
12 2006 and features a number of unique attributes. The innovative, eco-friendly, air-conditioning
13 system deploys a 7,874 -foot pipe (the deepest ocean pipe in the world) to a depth of 3,000 feet
14 off the reef of Bora Bora. The pipe pumps ice cold, deep-sea water through a titanium heat
15 exchanger, transferring the cold into the fresh water circuit that then powers the air conditioning
16 throughout the hotel.

17

18 **World use cold water to cool buildings**

19

20 Cornell University, Ithaca, NY: 20,000 tons (freshwater)

21 Toronto, Canada: 58,000 tons (freshwater)

22 New Brunswick, Nova Scotia: 1,000 tons (seawater)

23 Sweden: 80,000+ tons (seawater and freshwater)

1 Hawai'i (NELHA): 30-50 tons (seawater)

2 Tahiti: 450 tons (seawater)

3 Curacao: 1,200 tons * (seawater)

4 Korea: 2,000 tons * (seawater)

5 * under development

6

7 **Mechanics of Sea Water Air Conditioning System**

8 Cold, deep seawater is pumped through a distribution pipeline to a cooling station on the shore.

9 The intake pipe is located at a depth where the water temperature is 39°F-45°F year round. The
10 cooling station transfers the seawater's coldness to water circulating in a closed loop pipe system
11 (district cooling system) that provides air conditioning service to customer buildings. The
12 cooling station ensures that the seawater and fresh water never mix. SWAC uses only the cold
13 from the seawater, not the actual water. Warmed seawater is returned to the sea through a
14 diffuser located at a much shallower depth where zone of mixing requirements are satisfied. (See
15 also Question 6, above)

16

17 **Piping Requirements**

18 The seawater supply and return distribution network will use high density polyethylene (HDPE)
19 pipe. The chilled water distribution network will use plastic coated (insulated) steel pipe.

20

21 **Efficiency**

22 **Energy Efficiency and Demand Side Management Benefits.** Energy savings with SWAC
23 systems are 75%, or more, compared to conventional A/C.

1

2 * Each ton of SWAC eliminates the need for more than 3,400 kWh/year of energy use.

3 * 100,000 tons of SWAC will save more than 344 million kWh per year. This is equivalent to
4 more than 123,000 residential solar water heating systems.

5 * Each ton of SWAC eliminates the need for up to 0.63 kilowatts of new (likely-to-be-fossil-
6 fueled) generation capacity.

7 * 100,000 tons of SWAC will eliminate the need for nearly 63 megawatts of new generation.
8 This is equivalent to nearly 86,000 residential solar water heating systems.

9 * This reduced demand for new energy generation is equivalent to about four years of HECO's
10 projected load growth.

11 * The reduced need for expensive new electricity generation capacity will help to keep electric
12 rates lower for longer.

13

14 **Reduced Oil Dependence.** Hawaii is more than 90% dependent on imported fossil fuels, most
15 of this is oil. A SWAC system can significantly reduce the use of crude oil.

16 100,000 tons of SWAC will reduce crude oil use by more than 777,000 barrels per year.

17 **Renewable Energy Use.** SWAC uses an infinite, 100% renewable energy resource - cold,
18 deep seawater.

19 SWAC will greatly help the State of Hawaii, and HECO, meet new Renewable Portfolio
20 Standard (RPS) Standards.

21 More than 90% of the energy savings from SWAC are due to the use of an indigenous, infinite
22 renewable energy resource – cold, deep seawater.

23 With limited land area and high electrical demand, Oahu will have the greatest challenge in

1 meeting RPS Standards. SWAC is the renewable energy technology that can provide the greatest
 2 benefits to Oahu in the near term.

3

4 100,000 tons of SWAC will provide renewable energy benefits equal to:

5 187 MW of photovoltaics (at a Capacity Factor [CF] = 0.21);

6 123 MW of wind (at a CF = 0.32); or

7 60 MW of MSW or biomass combustion (at a CF = 0.65).

8

20	77,	94,	86,	83,	15,	15,	15,	15,	342,0	1,628,	
16	36	83	10	75	68	68	68	68	56	185	62,749
	4	6	0	6	7	7	7	7			
20	77,	94,	86,	86,	15,	15,	15,	15,	344,4	1,972,	
17	36	83	10	10	68	68	68	68	00	585	62,749
	4	6	0	0	7	7	7	7			
20	77,	94,	86,	86,	15,	15,	15,	15,	344,4	2,316,	
18	36	83	10	10	68	68	68	68	00	985	62,749
	4	6	0	0	7	7	7	7			
20	77,	94,	86,	86,	15,	15,	15,	15,	344,4	2,661,	
19	36	83	10	10	68	68	68	68	00	385	62,749
	4	6	0	0	7	7	7	7			
20	77,	94,	86,	86,	15,	15,	15,	15,	344,4	3,005,	
20	36	83	10	10	68	68	68	68	00	785	62,749
	4	6	0	0	7	7	7	7			

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Notes:

DH - Downtown Honolulu currently under development (first delivery date – December 2008; consists primarily of office buildings with hospital and some residential; 4,058 annual full load utilization hours)

W1 - Waikiki 1 in planning stages (first delivery date – January 2011; consists primarily of hotels and residential; 25% more [i.e., 5,073] annual full load utilization hours than Downtown Honolulu)

W2 - Waikiki 2 in very preliminary planning stages (first delivery date – January 2013; hotels, residential, University of Hawaii; intermediate [i.e., 4,565] annual full load utilization hours)

PAH - Pearl Harbor/Airport/Hickam in very preliminary planning stages (first delivery date – January 2015; military + airport; intermediate [i.e., 4,565] annual full load utilization hours)

Energy savings of Waikiki 2 and Pearl Harbor/Airport/Hickam are assumed to be intermediate between Downtown Honolulu and Waikiki 1

Systems ramp up from 18,000 tons at startup to 25,000 tons eighteen months later

Ocean Thermal Energy Conversion (OTEC)

OTEC, or Ocean Thermal Energy Conversion, is an energy technology that converts solar radiation to electric power. OTEC systems use the ocean's natural thermal gradient—the fact that the ocean's layers of water have different temperatures—to drive a power-producing cycle. As

1 long as the temperature between the warm surface water and the cold deep water differs by about
2 20°C (36°F), an OTEC system can produce a significant amount of power.

3 The economic evaluation of OTEC plants indicates that their commercial future lies in floating
4 plants of approximately 100 MW capacity for industrialized nations and smaller plants for small-
5 island-developing-states.

6

7 Estimated costs for a 100 MW plant-ship in Hawaii are \$5,000 to \$6,000 per kilowatt in 2006\$.

8 Assuming a 20-year book life, 10% interest, 1% O&M, the cost of energy produced is 9.1 to 10.9
9 cents/kWh. This is equivalent to the avoided energy cost for oil at \$60 to \$72/barrel. However,
10 since OTEC is a base-load power plant, it will also receive a capacity credit of 2 – 3 cents/kWh.

11

12 Advanced power conversion cycles, such as the Kalina cycle, have already been demonstrated on
13 a commercial scale. The biggest challenge seems to be the development of the very large
14 diameter (10 to 17 feet) pipes required. However, it may be possible to use smaller OTEC
15 modules and bundles of off-the-shelf HDPR pipe bundles.

16

17 (Source: Appendix F4 of Rezachek, David. 2002. "Renewable Energy Research, Development,
18 Commercialization, and Export Promotion Plan for Hawaii," Department of Business, Economic
19 Development, and Tourism, State of Hawaii)

20

21 Wave Energy

22 Waves are generated by the force of the wind acting on the surface of the ocean. The wind
23 imparts a portion of its energy to these waves. The energy of these waves is then converted,

1 through various devices, to a rotary or oscillating motion or to movement of a working fluid
 2 (such as air, seawater or hydraulic fluid) which can be used to drive an electrical generator.
 3 The following table shows estimated costs (in 2006\$) for WECS at various sites in Hawaii. A
 4 number of sites on all islands are close to being economically feasible at avoided energy costs of
 5 \$75/barrel (Makapuu, Oahu) to \$101/barrel (Pepeekeo, Hawaii).

6

7

Island	Location	Life (Yrs)	Capacity (MW)	Capital Cost Per kW	Capacity Factor	Production (MWh/yr)	Cost of Energy (cents/ kWh)
Kauai	Anahola	30	30	\$3,250	0.377	98,947	13.5
	Barking Sands	30	30	\$3,440	0.197	51,793	27.1
Oahu	Makapuu	30	60	\$3,060	0.427	224,378	11.3
	Kahuku Point	30	60	\$3,070	0.402	211,197	12.0
	NE Coast 2A	30	30	\$3,190	0.395	103,704	12.7
	NE Coast 2C	30	30	\$3,170	0.388	101,831	12.9
	Mokapu Point	30	30	\$3,210	0.373	97,966	13.6
	Waimanalo Bay	30	30	\$3,170	0.339	88,957	14.7
Maui	Opana Point	30	60	\$3,090	0.403	211,984	12.1
	Lower Paia	30	60	\$3,090	0.388	203,974	12.5
	Waiehu Point	30	30	\$3,320	0.385	101,256	13.3

Hawaii	North Kohala	30	30	\$3,620	0.354	93,084	16.7
	Honokaa 2A	30	10	\$3,620	0.384	33,612	14.7
	Pepeekeo 2E	30	10	\$3,630	0.370	32,389	15.3

1

2

3 (Source: Appendix F9 of Rezachek, David. 2002. “Renewable Energy Research, Development,
4 Commercialization, and Export Promotion Plan for Hawaii,” Department of Business, Economic
5 Development, and Tourism, State of Hawaii)

6

7 **Power Saved**

8

9 SWAC primarily replaces intermittent and peaking power.

10

11 Oahu experiences two peaks during the work week. The daytime peak is broader and is created
12 to a large extent by air conditioning. A SWAC system in Downtown Honolulu (where businesses
13 typically operate primarily from 7 a.m. to 6 p.m., Monday through Friday) will help to reduce
14 this broad daytime peak.

15

16 The evening peak is sharper, is larger than the daytime peak during some months (e.g., October)
17 and is primarily due to residential and hotel use. Waikiki has many hotels and high rise
18 residential buildings (Downtown Honolulu also has some high rise residential buildings). The
19 Waikiki SWAC system will help to reduce this evening peak. Other SWAC systems proposed
20 for Honolulu are also expected to beneficially impact these peak use periods.

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Global Warming

Environmental Benefits. Reduced use of fossil fuels provides for significant reductions in greenhouse gas emissions and other air and water pollutants. SWAC systems greatly reduce the use of harmful chemicals (refrigerants) used in conventional cooling systems.

100,000 tons of SWAC will reduce the production of pollutants from fossil fuel combustion by up to the following amounts:

Carbon Dioxide (CO ₂) Emissions	370,000 tons/year
Volatile Organic Compounds (VOC) Emissions	23 tons/year
Carbon Monoxide (CO) Emissions	121 tons/year
Particulate Matter under 10 microns (PM ₁₀) Emissions	81 tons/year
Nitrogen Oxides (NO _x) Emissions	736 tons/year
Sulfur Oxides (SO _x) Emissions	719 tons/year

Cost of SWAC System

As with most renewable energy systems, SWAC systems are capital intensive (~\$4,800/ton vs \$1,050/ton for conventional air conditioning systems), but have significantly lower operating costs. Life-cycle costs for SWAC systems are expected to be significantly less than for conventional air conditioning systems.

1 HSWAC has conducted a comparative analysis of more than 40 buildings in the Downtown
2 Honolulu area. In every case, building owners will save money the first year by converting to
3 SWAC. At an initial oil price of \$60 per barrel, average first year savings are nearly 8%. Oil is
4 presently more than \$72 per barrel. At this initial oil price, first savings will be more than 12%.

5
6 Furthermore, SWAC provides more stable cooling costs and each of these building owners will
7 save millions of dollars over a 25-year period. At an initial oil price of \$60 per barrel, lifetime
8 savings average more than \$7,300/ton. At an initial oil price of \$72 per barrel, lifetime savings
9 average more than \$9,400/ton.

10

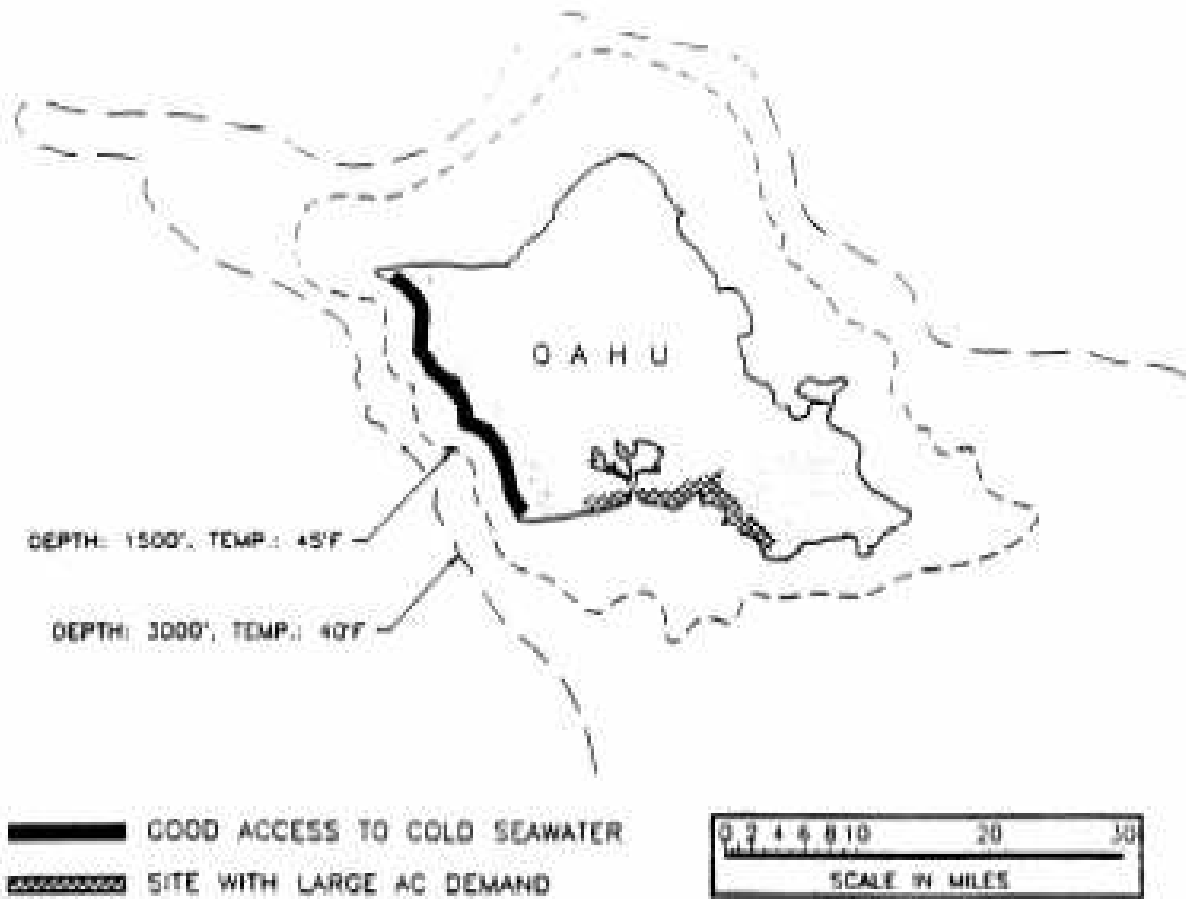
11 First year, and lifetime, savings are projected to be even greater for Waikiki buildings owing
12 to the greater number of utilization hours.

13

14 **SWAC Systems for Oahu**

15 There are a variety of sites on Oahu where SWAC could be built. The following diagram shows
16 technically feasible areas.

17



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Downtown SWAC system

The Downtown Honolulu SWAC system is being designed to provide cooling to the following service area. The actual service area may vary somewhat from this diagram.



1

2

3 Seawater will be brought in to a cooling station sited makai of the 677 Ala Moana Building (old
4 Gold Bond building). Chilled (fresh) water will be distributed from the cooling station to
5 areas in western Kakaako Mauka, downtown Honolulu, and to Queens hospital.

6

7 The design system capacity is 25,000 tons (~40 customer buildings). The project is economically
8 viable at 20,000 tons.

9

10 Forty-one of 90 potential customers in the Downtown service area (Kakaako Makai to
11 Downtown Honolulu) have been contacted. Customer response has been very favorable. These
12 customers represent nearly 24,000 tons, or 50% of the total air conditioning demand of more
13 than 48,000 tons. This potential tonnage is expected to increase with the on-going development
14 of properties in the Kakaako area.

1
2 Conceptual designs of the seawater distribution system, the chilled water distribution system, and
3 the cooling station have been completed. Final designs of these system components have
4 begun.

5
6 A Permit Manager has been obtained. Discussions have been held with all affected federal, State,
7 and City & County of Honolulu agencies. Permit requirements have been identified. The
8 preliminary scoping process has begun, with presentations to numerous government agencies,
9 and energy, environmental, technical and public groups. A preliminary Draft Environmental
10 Impact Statement has been prepared and several surveys to support the completion of this
11 document have been completed.

12
13 The State of Hawaii has authorized \$80 million in tax-exempt Special Purpose Revenue Bonds
14 and has granted seawater air conditioning district cooling systems an exemption from Public
15 Utilities Commission regulation. Act 95 (Renewable Portfolio Standard), of the 2004 State
16 legislature, has defined seawater air conditioning as an eligible renewable energy technology.
17 The State of Hawaii – Department of Taxation has provided HSWAC with a comfort letter
18 stating that these projects qualify for Act 221/215 tax benefits under the renewable energy
19 classification. A business plan has been prepared and negotiations are underway for an
20 additional \$24 million in equity capital and \$16 million in additional bond funding.

21
22 Negotiations for a cooling station site are nearly complete. Once this site has been acquired, the
23 permitting process will be geared up.

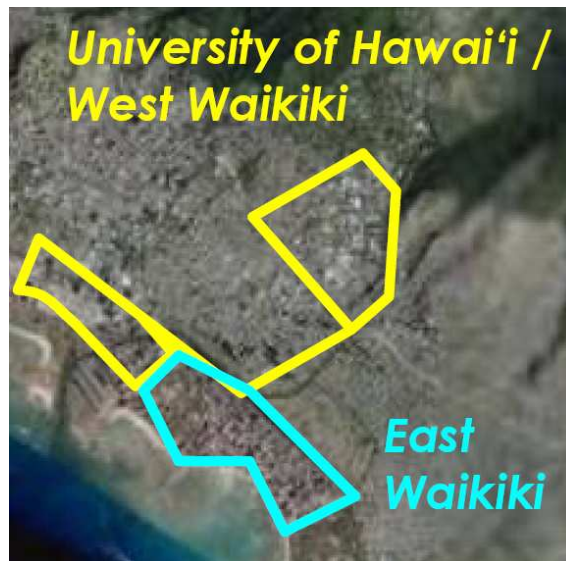
1
2 Draft customer contracts have been provided to representatives of 40 buildings, representing
3 more than 24,000 tons of cooling. First delivery date for cooling for this system is scheduled to
4 be December 1, 2008.

5

6 **East Waikiki SWAC system**

7 Nine of 36 potential customers in the Waikiki service area have been contacted. These customers
8 represent 13,000 tons of the total air conditioning demand of nearly 27,000 tons. The potential
9 tonnage in this service area expected to increase with the on-going development of properties
10 in the Waikiki area. The service area for the planned East Waikiki and Waikiki/University of
11 Hawaii SWAC systems are shown in the following diagram.

12



13

14

15 Preliminary evaluations of the seawater distribution and the chilled water distribution systems
16 are being made. Potential cooling station sites are being identified. Several potential

1 customers have suggested potential sites for the cooling station, including some situated on the
2 customers' sites and incorporated into existing or planned facilities.

3

4 There are a number of synergies between the Downtown Honolulu and Waikiki Projects that
5 may help to reduce the development time for both projects (e.g., similar permitting requirements,
6 similarities in design of seawater distributions systems, etc.)

7

8 This system is identified as W1 in the table for "Energy Savings and Demand Reduction
9 Potential of SWAC Systems" on page 17. Planned first delivery date for this system is January
10 2011.

11

12 **University of Hawaii/West Waikiki/ SWAC system**

13 Three customers totaling 20,000 tons in the University of Hawai'i/West Waikiki service area
14 (West Waikiki to Ala Moana to the University of Hawai'i) have been contacted. Additional
15 customer buildings along the distribution route from Waikiki to the University of Hawaii will
16 further increase the potential customer load.

17

18 Presentations have been made to the University of Hawai'i regarding providing SWAC service
19 as part of a concentrated SWAC project for Waikiki. A Capital Improvements Project (CIP)
20 request has been submitted to the University of Hawaii at Manoa for their review and
21 consideration. Funding for a feasibility analysis and business plan development has been
22 requested for the Planning phase of this CIP request.

23

1 This system is identified as W2 in the table for “Energy Savings and Demand Reduction
2 Potential of SWAC Systems” on page 17. Planned first delivery date for this system is January
3 2013.

4

5 **Hickam/Airport/Pearl Harbor SWAC system**

6

7 A preliminary feasibility analysis for providing district cooling to Pearl Harbor has been
8 completed by Ocean Engineering & Energy System (OCEES) International Ltd. HSWAC is
9 working with OCEES to evaluate the potential for a 20,000+ ton SWAC system to serve the
10 Pearl Harbor/Hickam/Honolulu Airport area. The service area for this project is shown in the
11 following diagram.

12



1

2

3 This system is identified as PAH in the table for “Energy Savings and Demand Reduction
4 Potential of SWAC Systems” on page 17. Planned first delivery date for this system is
5 January 2015.

6

7 **Kaka`ako SWAC system**

8 At present, central Kakaako does not have sufficient cooling density to warrant development of a
9 separate SWAC system. However, the Downtown Honolulu (including west Kakaako Mauka

1 and Kakaako Makai) service area has a potential cooling load of 48,000 tons. The Downtown
2 Honolulu SWAC is limited to 25,000 tons. The balance of the potential in the Downtown
3 Honolulu service area, plus new developments in Kakaako, are likely to be sufficient to justify a
4 separate 25,000-ton SWAC system for this area.

5
6 HSWAC plans to evaluate the feasibility, benefits, and costs of interconnecting the Downtown
7 Honolulu, Kakaako, University of Hawai'i/West Waikiki, and East Waikiki SWAC systems to
8 provide system redundancy and reliability.

9

10 **Ko Olina SWAC system**

11

12 In 1992, the State of Hawaii requested that Makai Ocean Engineering conduct an analysis of the
13 technical and economic feasibility of using deep cold seawater for cooling in Hawaii.

14 Makai's study concentrated on West Beach, Oahu, an emerging resort with good access to deep
15 cold water (40°F water can be obtained at the same distance as 45°F water in Honolulu) and a
16 lack of existing infrastructure (roads and other utilities had not yet installed which would make
17 it easier and less costly to install water supply and distribution piping and a cooling station).

18

19 Also, because this was an area with new development, conventional air conditioning systems had
20 not yet been installed (this would make SWAC systems more cost effective for such buildings
21 because they would not have to expend their capital for conventional air conditioning systems).

22

23 Preliminary analyses showed that SWAC systems greater than 2,500 tons could be cost-

1 effectively installed under these conditions. However, at this time, Hawaii was experiencing the
2 detrimental effects of a recession caused by the 1991 Gulf War and development in this area had
3 slowed considerably.

4

5 A more recent evaluation of this area showed that cooling demand density was not yet sufficient
6 to warrant a SWAC system, at this time. However, as this area develops further this will be
7 reevaluated. HSWAC believes that this will be an excellent area for future development, but has
8 not assessed the ultimate cooling demand potential of this area.

9

10 **Kaneohe Marine Air Corps Station SWAC system**

11 Preliminary estimates show that this area has a potential demand of ~2,500 tons. This area does
12 have relatively good access to deep cold water in the Molokai Channel. However, the relatively
13 small demand, and HSWAC's other project commitments, have not made this a priority project.

14