

DOE/OK/22088-4

*U.S. FISH AND WILDLIFE SERVICE*  
*Pacific Islands Office, Ecological Services*



**A SURVEY OF ENDANGERED WATERBIRDS ON MAUI AND O'AHU AND  
ASSESSMENT OF POTENTIAL IMPACTS TO WATERBIRDS FROM THE  
PROPOSED HAWAII GEOTHERMAL PROJECT TRANSMISSION CORRIDOR.**

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Final Report  
August 1994

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## SUMMARY

A survey of endangered waterbirds on Maui and Oahu was conducted during August and September 1993 to identify potential waterbird habitats within the general area of the proposed Hawaii Geothermal Project transmission corridor and to assess the potential impacts to endangered waterbirds of installing and operating a high voltage transmission line from the Island of Hawaii to the islands of Oahu and Maui. Annual waterbird survey information and other literature containing information on specific wetland sites were summarized. Literature describing impacts of overhead transmission lines on birds was used to evaluate potential impacts of the proposed project on endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl.

On Oahu, five wetland habitats supporting endangered Hawaiian waterbirds were identified within 2.5 miles of the proposed transmission line corridor. On Maui, three wetland habitats supporting endangered Hawaiian waterbirds were identified within the general area of the proposed transmission line corridor. Several of the wetlands identified on Oahu and Maui also supported resident wading birds and migratory shorebirds and waterfowl.

Endangered waterbirds, resident wading birds, and migratory birds may collide with the proposed transmission lines wires. The frequency and numbers of bird collisions is expected to be greater on Oahu than on Maui because more wetland habitat exists and greater numbers of birds occur in the project area on Oahu. In addition, the endangered Hawaiian goose and the endangered Hawaiian petrel may be impacted by the proposed segment of the Hawaii Geothermal Project transmission line on Maui.

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## INTRODUCTION

In 1993 the Department of Energy (DOE, Oak Ridge) contracted the U.S. Fish and Wildlife Service, Pacific Islands Office (Service) to conduct biological surveys as part of the environmental impact statement being prepared for the Hawai'i Geothermal Project. Service responsibilities in this agreement include conducting resource surveys to identify potential impacts of the proposed geothermal project on endangered and threatened species, migratory birds, and other fish and wildlife resources for which the Service has jurisdiction or special expertise. The contracted surveys covered waterbirds, plants, the Hawaiian bat, seabirds, the Hawaiian hawk, forest birds, and invertebrates. With the exception of waterbirds, all surveys were conducted in or near the three geothermal resource subzones on the island of Hawai'i.

The following document reports on the waterbird surveys, which were conducted within the general area of the proposed transmission corridor on the islands of Maui and O'ahu. In addition to the waterbird survey, a botanical survey of the proposed transmission corridor on Maui was undertaken and is included in this document. On the island of Hawai'i, wetland habitats for waterbirds were not thought to be a significant feature in the proposed geothermal subzones or proposed transmission corridors. Thus, surveys of waterbirds on Hawai'i were not undertaken. However, for completeness, file information on endangered and threatened species in or near the proposed transmission corridor on the island of Hawai'i are included in Appendix I (birds) and Appendix II (plants). The exact locations of the auxiliary, shoreside electrical facilities on Maui and O'ahu were not known. Thus, no surveys or evaluation of impacts to wetlands or endangered or threatened species were completed for these areas.

For all areas of the proposed transmission corridor, the National Wetlands Inventory maps do not provide useful information about the small wetlands areas of concern. In place of these maps, we have provided diagrammatic maps (Figures 2, 3, and 4) of wetlands in or near the proposed transmission corridor. Mapping the distribution of endangered waterbirds along the proposed transmission corridor was not undertaken because these birds regularly move between wetlands, making it difficult to record reliable information on distribution and abundance over the limited number of field days. Banding of waterbirds would be required to accurately map their distributions within the proposed transmission cable corridor.

The purposes of this study were to identify wetland habitats, to assess the value of these wetlands to Hawaii's federally-listed endangered waterbirds, and to use this information to conduct a preliminary assessment of the potential impacts of the proposed transmission line on wetlands and associated endangered waterbirds on Maui and O'ahu. The value of the project area wetlands to resident wading birds and migratory shorebirds and waterfowl was evaluated and the potential impacts of the proposed transmission line on these species were assessed.

## BACKGROUND

The proposed Hawai'i Geothermal Project would include installation and operation of a high voltage (300 kV), direct current, electrical transmission system capable of transmitting power from the geothermal resource subzones of the Kīlauea East Rift Zone on the Island of Hawai'i to the Island of Maui (50 MW net) and the Island of O'ahu (500 MW net). The proposed system would consist of a rectifier station to convert the alternating current produced from the geothermal resource to direct current, overhead transmission lines, submarine cables, a power tap to service a portion of Maui's demand, an inverter station on O'ahu to convert the current back to alternating current, and sea electrodes or a cable ground return to complete the electrical circuit (Krasnick and Mansur, 1987).

Several transmission corridors, including a proposed overhead line route (Fig. 1), were identified in the Hawai'i Deep Water Cable Program Environmental Assessment (State of Hawai'i, HDWCP EA) (Krasnick and Mansur, 1987). The proposed transmission line corridor is the only route the Service evaluated for the purposes of this study. The following description of the proposed transmission line corridor is taken from the HDWCP EA.

The proposed transmission line corridor (Fig. 1) would begin in Hawaii's Puna District where the alternating current (ac) electricity would be generated from the geothermal resource. Transmission lines from the geothermal plants would traverse north to a point near Kea'au and then head northwest to Kaūmana. The electricity would be transformed from ac into direct current (dc) at a rectifier station located at Puna, Kea'au, or Kaūmana. The dc transmission lines would then follow an existing power corridor across the middle of the island that leads to the Ke'āmuku substation in the northern portion of the North Kona District. The overhead lines would then follow a major road north to a point just south of Waimea, where they would turn to the west and follow another major road to the coast at Kawaihae Bay. The lines would travel up the coast, on the inland side of the road, from Kawaihae to Māhukona. The take-off site for the submarine cable is just northwest of Māhukona Harbor at Maka o Hule Point. A shoreside facility, 0.1 - 0.4 ha (0.25 - 1.0 ac) in size (Dames and Moore, 1982), would be required for transferring the electrical current from overhead lines to submarine cables.

The cables would extend across the shoreline and fringing reef to water depths of at least 30.5 m (100 ft) via trenching, conduits, or other undersea support structures. The cables would be oriented perpendicular to the bottom contours to a depth of about 149 m (490 ft) and then proceed northward along a terrace towards Upolu Point. The cables would then proceed northwesterly across the Alenuihāhā Channel and come ashore on Maui's southern coast, preferably at Huakini Bay. A two acre shoreside facility on Maui would include oil pressurization equipment and possibly a 50 MW tap for service to the Maui Electric Company grid. At Huakini Bay, the cables would again connect to overhead transmission lines and traverse the southern coast of east Maui to Āhihi Bay.

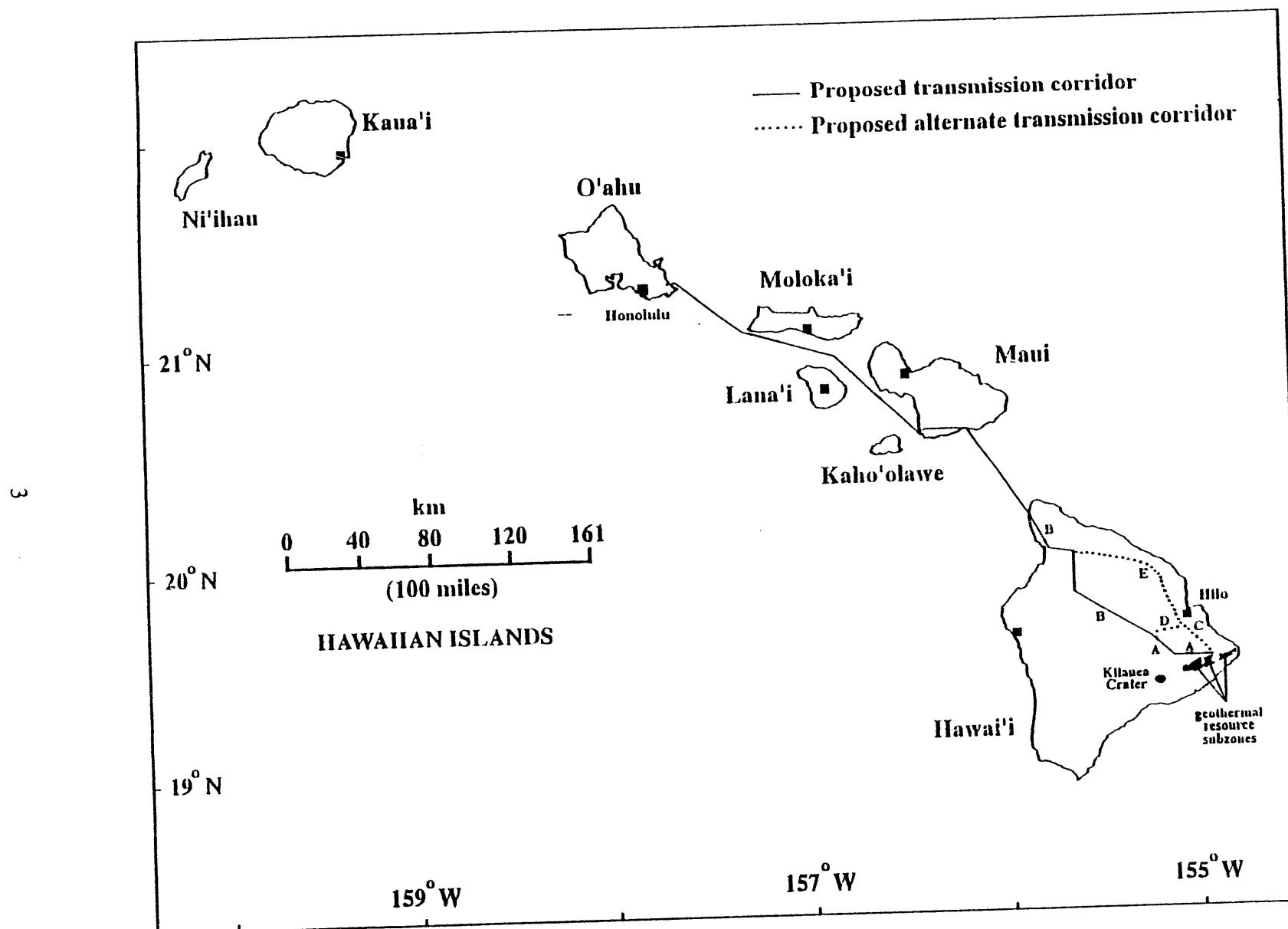


Figure 1. Proposed Hawai'i Geothermal Project transmission corridor.

At Āhihi Bay, the cable would follow an underwater path to the northwest between Maui, Kaho'olawe and Lāna'i, pass to the south of Moloka'i, cross the Kaiwi Channel, and come ashore on O'ahu's eastern coast near Waimānalo Beach. In Waimānalo, the cables would connect to overhead transmission lines that would extend three miles inland to the Aniani inverter site where the electrical current would be converted from dc to ac and tied into O'ahu's electrical grid system.

## ENDANGERED WATERBIRDS SURVEY

### WETLAND HABITATS IN HAWAII

Endangered waterbirds that might be found in or near the proposed Hawai'i Geothermal Project transmission corridor on O'ahu and Maui are listed in Table 1. Endangered waterbirds and other endangered birds that might be found in or near the proposed Hawai'i Geothermal Project transmission corridor on the island of Hawai'i are listed in Appendix I.

**Table 1. Endangered waterbirds that could occur in or near the proposed Hawai'i Geothermal Project transmission corridor on O'ahu and Maui.**  
(See Figures 2 and 3 for the location of the transmission corridor and wetland habitat.)

Taxon	Common name	Location
<i>Anas wyvilliana</i>	Hawaiian duck, Koloa	O'ahu
<i>Fulica americana alai</i>	Hawaiian coot, 'Alae ke'o ke'o	O'ahu, Maui
<i>Gallinula chloropus sandvicensis</i>	Hawaiian moorhen, 'Alae 'ula	O'ahu
<i>Himantopus mexicanus knudseni</i>	Hawaiian stilt, Ae'o	O'ahu, Maui

The U.S. Fish and Wildlife Service has estimated that the area of coastal wetland habitat in the main Hawaiian Islands declined 31% between 1780 (9,096 ha=22,467 ac) and 1980 (6,262 ha=15,467 ac) (U.S. Fish and Wildlife Service, 1990a; total wetlands has decreased by about 12%, according to Dahl, 1990). Filling of coastal wetlands for commercial, residential, and resort and golf course developments and the draining of wetlands for agriculture are the primary causes for this decline. Encroachment of introduced plants, such as mangroves and weedy grasses, and runoff from industrial, agricultural and urban areas have degraded many coastal wetlands. The loss and degradation of Hawaii's coastal wetlands have been significant contributing factors to the decline of endemic waterbirds and wintering waterfowl in Hawai'i.

The coastal wetlands that remain are habitat for Hawaii's four federally-listed endangered waterbirds ( U.S. Fish and Wildlife Service, 1985) : the Hawaiian stilt (*Himantopus mexicanus knudseni*); the Hawaiian coot (*Fulica americana alai*); the Hawaiian moorhen (*Gallinula chloropus sandvicensis*); and the Hawaiian duck (*Anas wyvilliana*). Hawaii's wetlands also support one species of indigenous wading bird, the black-crowned night heron (*Nycticorax nycticorax hoactli*), and provide important wintering habitat for migratory shorebirds and waterfowl.

The estimated annual numbers of waterfowl wintering in Hawai'i have declined from an average of approximately 40,000 birds in the 1950's to 2,000 birds in 1990 (U.S. Fish and Wildlife Service, 1993). Northern shoveler (*Anas clypeata*), northern pintails (*Anas acuta*), American and Eurasian widgeons (*Anas americana* and *A. penelope*), green-winged teals (*Anas crecca*), and lesser scaup (*Aythya affinis*) make up 95% of the migratory species of waterfowl wintering in the Hawaiian Islands (Engilis, 1988). The most common species of migratory shorebirds wintering in Hawai'i are the lesser golden-plover (*Pluvialis dominica*), the ruddy turnstone (*Arenaria interpres*), the wandering tattler (*Heteroscelus incanus*), and the sanderling (*Calidris alba*).

The most important habitats for native and migratory bird species are lowland palustrine marshes and associated open water areas, montane streams, cultivated wetlands, and the shallow margins of brackish ponds, mudflats, and related estuarine wetlands. Due to the limited amount of natural waterbird habitat left in Hawai'i, endangered waterbirds, resident wading birds, and migratory waterfowl and shorebirds also take advantage of agricultural wetlands, drainage ditches, man-made reservoirs, sewage oxidation ponds, and aquaculture facilities (U.S. Fish and Wildlife Service, 1990b).

## **ENDANGERED WATERBIRDS**

Unless otherwise referenced, the following information on the status and habitat requirements of Hawaii's four endangered waterbird species is taken from the Hawaiian Waterbirds Recovery Plan (U.S. Fish and Wildlife Service, 1985) and the Draft Revised Hawaiian Waterbirds Recovery Plan (U.S. Fish and Wildlife Service, 1993).

### **Hawaiian Stilt (*Himantopus mexicanus kundseni*, Ae'o)**

The Hawaiian stilt is a highly gregarious and semi-colonial wading bird closely allied with the black-necked stilt of North America. Colonization in Hawai'i by stilts probably began with a few migrant individuals. Stilts are black above (except for the forehead) and white below and have distinctive pink legs. The Hawaiian subspecies differs from the mainland form in that the black area extends lower on the forehead and around to the sides of the neck, and the bill, tarsus, and tail are longer (Coleman, 1981). Males and females can be

distinguished by color of the back feathers and to a lesser extent by voice. Back feathers on the female are brownish; back feathers on the male are black. The voice of a female stilt is lower than the male's voice. The total length of Hawaiian stilts is about 40 cm (16 inches).

Stilts use fresh, brackish, and salt water habitats. Proposed habitats include early successional marshlands interspersed with areas of mudflat or shallow open water; shallowly flooded (< 15 cm=6 in), low-growing *Paspalum* sp. or *Batis maritima* flats; and exposed tidal mudflats. Stilts rarely occur in wetlands above 200 m (656 ft) elevation. Stilts may nest and forage in different wetland sites, and the birds will move between these areas daily.

Feeding habitat consists of shallow water areas. Stilts eat a wide variety of aquatic organisms including polychaete worms, crustaceans, aquatic insects, and small fish (Shallenberger, 1977). Loafing sites include open mudflats, *Batis* flats, and fresh or brackish water ponds.

Stilts nest on mudflats or adjacent to or on low-relief islands within bodies of fresh, brackish or salt water. Stilts prefer to place their nests on small, bare or sparsely vegetated islands in shallow ponds with stable water levels but will also use other dry, bare sites near shallow water. The nest itself is a simple scrape or depression on the ground. Nesting season in Hawai'i is March through August with a peak in May and June. Stilts lay three or four eggs that are incubated for approximately 24 days. The chicks leave the nest within one day of hatching but may remain with the parents for several months.

Many factors, including indiscriminate hunting, predation by introduced species, and most importantly, the loss of wetland habitat, contributed to the decline of the Hawaiian stilt. Historic population numbers of Hawaiian stilts are unknown. Munro (1960) suggested that the population had declined to about 200 birds by the early 1940's; however, this may have been an underestimation, since Schwartz and Schwartz (1949) estimated about 1,000 birds in the late 1940's. Population counts from 1960 to 1979 fluctuated from a low of 253 in 1960 to a high of 1,476 in 1977. Long-term population trends of the Hawaiian stilt indicate that statewide populations have been relatively stable, or slightly increasing for the last 20 years (Reed and Oring, in press). Since 1983, statewide surveys have documented 1,000 or more stilts in the islands. The majority of Hawaiian stilts are found on the islands of O'ahu, Maui, and Kaua'i. Engilis and Pratt (1993) estimate the current statewide population to be between 1,200 and 1,600 birds.

#### **Hawaiian Coot (*Fulica americana alai*, 'Alae ke'o ke'o)**

The Hawaiian coot is a subspecies of the American coot. This subspecies probably originated from a group of migrant coots from continental North America that remained as residents in the islands. The Hawaiian coot is smaller in body size but has a bulbous, white frontal shield that is distinctly larger than the shield of North American populations of American coots. A small percentage of Hawaiian coots have a red frontal shield and deep

maroon markings at the tip of the bill, similar to the mainland form. A third form has a full red frontal lobe. Adult coots have dark, slate-gray plumage and white undertail feathers that are conspicuous when swimming. Sexes are similar in appearance. Immature coots have a white throat and breast and a dark bill with a small frontal shield (Pratt *et al.*, 1989). Chicks are black with reddish orange heads.

Hawaiian coots use fresh and brackish water marshes and ponds where emergent vegetation is interspersed with open water. Hawaiian coots are typically found in coastal plain wetlands up to 400 m (1,312 ft) in elevation, but they are also known to use upland plunge pools (Kaua'i) and montane stock ponds (Hawai'i) at elevations up to 2,000 m (6,562 ft).

Coots typically forage in water less than 30 cm (12 in) deep but can dive in water up to 1.2 m (4.0 ft) in depth. Hawaiian coots prefer freshwater wetlands for feeding but also feed in brackish waters and rarely in saline waters. Food items include seeds and leaves of aquatic plants, small fish, and invertebrates including snails, crustaceans, and aquatic and terrestrial insects (Schwartz and Schwartz, 1949). Loafing sites include logs and rafts of vegetation, narrow dikes, mud bars, artificial islands, "false nests," and deep open bodies of water such as reservoirs.

Coots prefer areas with a 50:50 mix of open water and emergent vegetation for nesting. Nests are constructed of aquatic vegetation in open water or emergent vegetation. Open-water nests are typically floating or semi-floating and anchored to emergent vegetation. Nests placed within emergent vegetation are platforms constructed from buoyant stems of nearby plants (Byrd *et al.*, 1985). False nests may be constructed near the actual nest and are often used as loafing or brooding platforms. Nesting occurs mostly from March through September, although some nesting apparently occurs in all months of the year (Shallenberger, 1977). Water level fluctuation has been determined to affect nesting. Clutch size ranges from 3 to 10 eggs, with an average of 4.9 eggs (Byrd *et al.*, 1985). The incubation period ranges from 23 to 27 days, and chicks leave the nest soon after hatching.

Historically, coots occurred on all major Hawaiian islands except Lāna'i and Kaho'olawe, which apparently never had suitable waterbird habitat. In the first half of this century, Schwartz and Schwartz (1949) pointed out the decline and potential threat of extinction of the Hawaiian coot. Censuses from the 1950's to the late 1960's indicated a population of less than 1,000 birds. Currently, Hawaiian coots inhabit all main Hawaiian islands except Kaho'olawe. Engilis and Pratt (1993) estimate that coot populations fluctuate between 2,000 and 4,000 birds, depending on climatic conditions, with Kaua'i, O'ahu, and Maui supporting 80% of these birds.

#### **Hawaiian Moorhen (*Gallinula chloropus sandvicensis*, 'Alae 'ula)**

The Hawaiian moorhen is a nonmigratory, endemic subspecies of the common moorhen of North America (American Ornithologist's Union [A.O.U.], 1983). There are no distinct

plumage, soft body coloration, or measurement differences that can be used to distinguish Hawaiian moorhen from North American moorhen (Wilson and Evans, 1990.) Hawaiian moorhens superficially resemble Hawaiian coots, but moorhens are smaller, possess red shields over their red and yellow bills, and have white flank stripes (Schwartz and Schwartz, 1949). Moorhens are black above and slate blue below with white underwing coverts. Legs of moorhens are yellow with red "garters" above the ankles. Immature moorhens are olive-brown with dull-colored legs and bills (Pratt *et al.*, 1989). The sexes are similar in appearance.

Hawaiian moorhen habitat consists of fresh or slightly brackish water marshes with dense stands of robust, emergent vegetation interspersed with open water, taro patches, lotus fields, vegetated margins of stream and irrigation ditches, reservoirs, and wet pastures. An overall ratio of 50:50 between vegetation and open water is thought to be optimum (Weller and Fredrickson, 1973) with water depth less than 1 m (3 ft) deep. Hawaiian moorhens prefer coastal habitats less than 125 m (410 ft) in elevation and tend to remain close to cover. Nesting, feeding and loafing sites are generally in the same area.

Because of their secretive nature, Hawaiian moorhens prefer to forage in dense, emergent vegetation. They are opportunistic feeders, and their diet varies with the particular habitat used (Shallenberger, 1977). Documented food items consumed by this subspecies include algae, guava seeds, and other plant material and aquatic insects and mollusks (Schwartz and Schwartz, 1949; U.S. Fish and Wildlife Service, 1985).

Hawaiian Moorhens generally nest in areas with standing freshwater, normally less than 60 cm (24 in) deep. Most nests are inconspicuously placed within dense emergent vegetation over shallow water. The emergent vegetation is folded over into a platform nest (Shallenberger, 1977). If emergent vegetation is too sparse, nests may be constructed on the ground in areas with nearby tall cover.

Nesting occurs year-round, but most activity extends from March through August (Shallenberger, 1977). Nesting is influenced by water levels and vegetation growth (U.S. Fish and Wildlife Service, 1983), and high salinity is not tolerated. Chang (1990) found mean clutch size to be 4.9 eggs ( $n=87$  nests), which is less than the 5.6 eggs ( $n= 64$  nests) found by Byrd and Zeillemaker (1983). The incubation period is about 22 days. Chicks swim away from the nest shortly after hatching but remain close to and dependent on the parents for several weeks.

In 1891, Hawaiian moorhens were common on the main Hawaiian Islands except Lāna'i and Kaho'olawe (Munro, 1960). However, by the late 1940's, Schwartz and Schwartz (1949) considered the status of Hawaiian moorhens to be "precarious," especially on O'ahu, Maui, and Moloka'i. Because of its secretive nature, the Hawaiian moorhen is difficult to census. Censuses in the 1950's and 1960's estimated no more than 57 birds. The spread of aquaculture on Kaua'i and O'ahu from the late 1970's through the 1980's added to the available moorhen habitat and probably resulted in an increase in the numbers of these birds.

Hawaiian moorhens now exist only on Kaua‘i and O‘ahu. However, because of the inability to adequately survey moorhens, an accurate population estimate cannot be made. Some estimates place the statewide population of moorhens at 750 birds, with approximately 500 birds found on Kaua‘i and about 250 birds found on O‘ahu. Engilis and Pratt (1993) believe that estimates of the current population size are low based on the number of habitat areas that were missed during statewide surveys.

### **Hawaiian Duck (*Anas wyvilliana*, Koloa)**

The Hawaiian duck has been described as either a full species or a subspecies of either the mallard (*Anas platyrhynchos*) or the gray duck (*Anas superciliosa*) several times since it was first described in 1851 (Bostwick, 1982). The updated A.O.U. checklist maintains the Hawaiian duck as a full species (A.O.U., 1983). Recent genetic studies indicate that the Hawaiian duck is distinct at the species level and is related to the North American mallard complex (Browne *et al.*, 1993). The Hawaiian duck is a typical dabbling duck similar to the North American mottled duck. It is a small, drab-brown duck, with an emerald speculum quite distinctive from those of the mallard. The adults of both sexes resemble a dark, female mallard. However, males usually have darker head and neck feathers, are slightly larger, and their bills are more olive-colored than the orange tone found in females (Swedberg, 1967). Males also have brighter orange feet.

Historically, the Hawaiian duck used a variety of natural wetland habitats including freshwater marshes, flooded grasslands, coastal ponds, streams, mountain pools and bogs, and forest swamplands from elevations ranging from sea level up to 3,000 m (9,843 ft). Many of these lowland wetlands have been completely altered, destroying or severely limiting their value to Hawaiian ducks. Other lowland habitats currently used by Hawaiian ducks include irrigation ditches, flooded fields (taro patches), reservoirs, mouths of larger streams with outlets to the sea, and managed refuge lands.

The majority of Hawaiian ducks are found on Kaua‘i where they primarily inhabit montane streams. Hawaiian ducks in the Kohalā Mountain region of the Island of Hawai‘i use stock ponds, reservoirs, irrigation ditches, and mountain stream habitat (Paton, 1981). On O‘ahu, Hawaiian ducks use the managed impoundments at the James Campbell National Wildlife Refuge, the aquaculture ponds adjacent to the Refuge, and various marshes still supporting open water areas such as Punahoa‘olapa, Kawainui, and He‘eia.

Hawaiian ducks are opportunistic feeders and typically forage in shallow water of wetlands and streams, usually in areas 2-12 cm (0.8 - 4.7 in) in depth. Plant and animal matter used by Hawaiian ducks as food include snails, dragonfly larvae, grass seeds, rice, green algae, and seeds and leaf parts of wetland plants (Swedberg, 1967).

Hawaiian ducks are usually found alone or in pairs and are very wary, especially when nesting or molting. Hawaiian ducks nest on the ground near water. The breeding season

seems to be concentrated between May and December, with some nesting occurring all year (Swedberg, 1967). Clutch size ranges from two to ten eggs. Swedberg (1967) reported a mean clutch size of 8.3 eggs from nests found by various investigators. The incubation period is about 30 days, with most chicks hatching between April and June.

Like other Hawaiian waterbirds, Hawaiian ducks were historically found on all major Hawaiian Islands except Lāna‘i and Kaho‘olawe. There are no estimates of Hawaiian duck populations prior to recent years. Nevertheless, natural wetlands and agricultural wetlands developed by Hawaiians provided extensive amounts of waterbird habitat, and it is likely that the Hawaiian duck was once fairly common. The number of Hawaiian ducks declined noticeably early in this century, primarily due to alien predators, hunting, and loss of habitat from changes in agricultural practices and urban development. By 1949, only an estimated 500 ducks remained on Kaua‘i (unknown numbers on Ni‘ihau), and about 30 ducks remained on O‘ahu. They were considered only an occasional visitor to the Island of Hawai‘i and were extirpated on Maui and Moloka‘i (Schwartz and Schwartz, 1949).

Restoration efforts including captive breeding and release between 1958 and 1982 have been somewhat successful, and Hawaiian ducks are now found on Kaua‘i, O‘ahu, and Hawai‘i. The most current estimate of the statewide Hawaiian duck population is 2,500 birds, with approximately 2,000 birds found on Kaua‘i, 300 birds found on O‘ahu, and 200 birds found on Hawai‘i (Engilis and Pratt, 1993). Hybridization with mallards (especially on O‘ahu), predation by alien mammals, and habitat loss continue to limit local populations of Hawaiian ducks.

## EVALUATION METHODOLOGY

Determination of the area to be surveyed on Maui and O‘ahu was subjective because the exact location of the transmission line corridor is not known. Aerial photographs, U. S. Geological Survey topographic maps, and National Wetland Inventory maps were used to identify wetland habitats that potentially support endangered waterbirds within the general area of the proposed transmission line corridor on the Maui and O‘ahu. On O‘ahu, five significant wetland habitats within 2.5 miles of the proposed transmission line corridor were identified for study (Fig. 2). On Maui, three wetland habitats were identified from Mākena to Nu‘u, which is within the general area of the proposed transmission line corridor (Fig. 3).

On August 4, 1993, Service biologists conducted field surveys of the wetlands within Bellows Air Force Station on the Island of O‘ahu. Wetland habitats were evaluated as potential feeding and nesting habitat for endangered Hawaiian waterbirds based on the specific habitat requirements of each species. Endangered waterbirds present at the wetlands were identified and counted. Information on the various age classes (adult, juvenile, chick) of birds observed were recorded. Wetlands were also evaluated as potential habitat for other wetland-dependent birds. Resident wading birds and migratory species using the wetlands

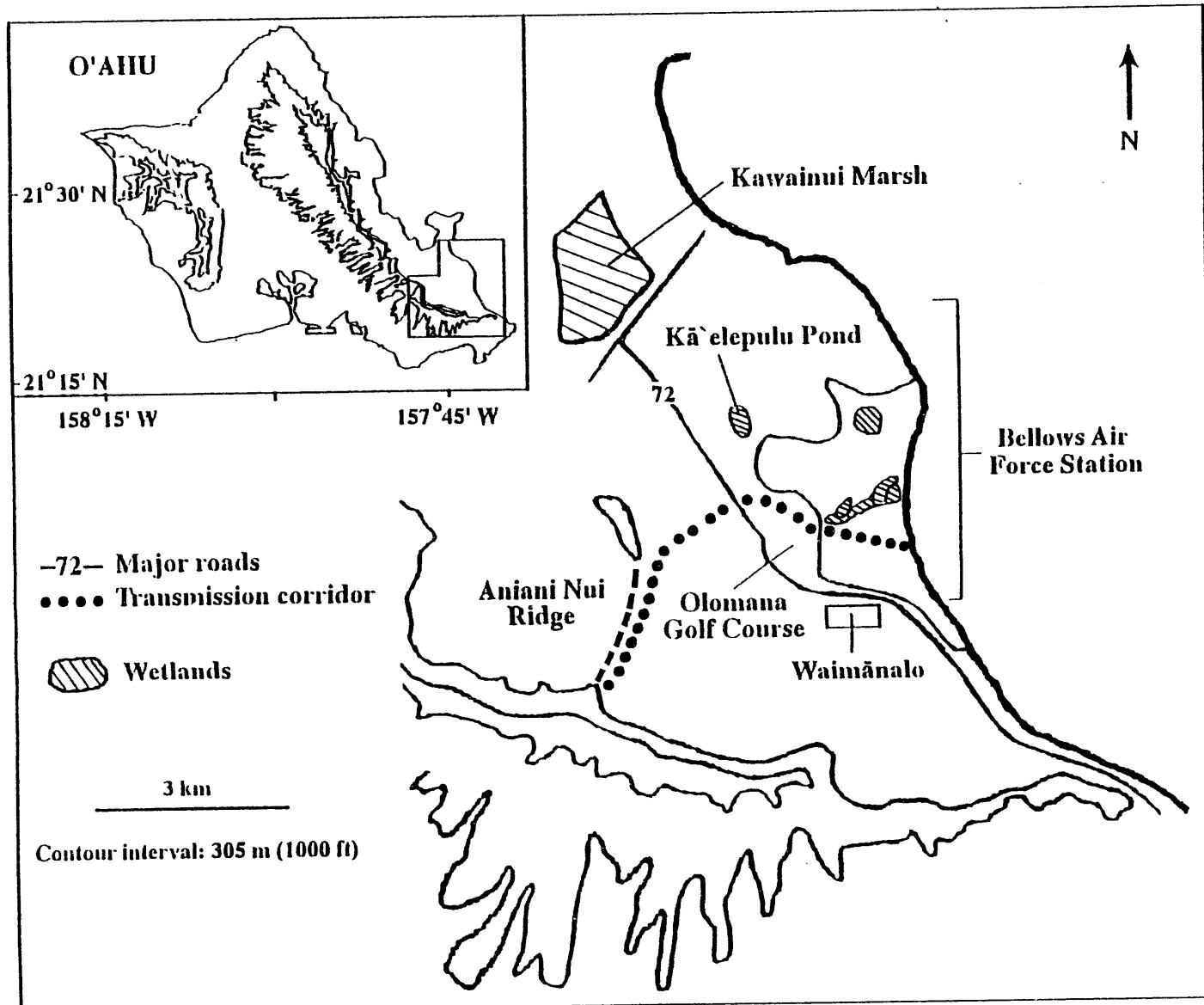


Figure 2. Proposed Hawai`i Geothermal Project transmission corridor on O`ahu.

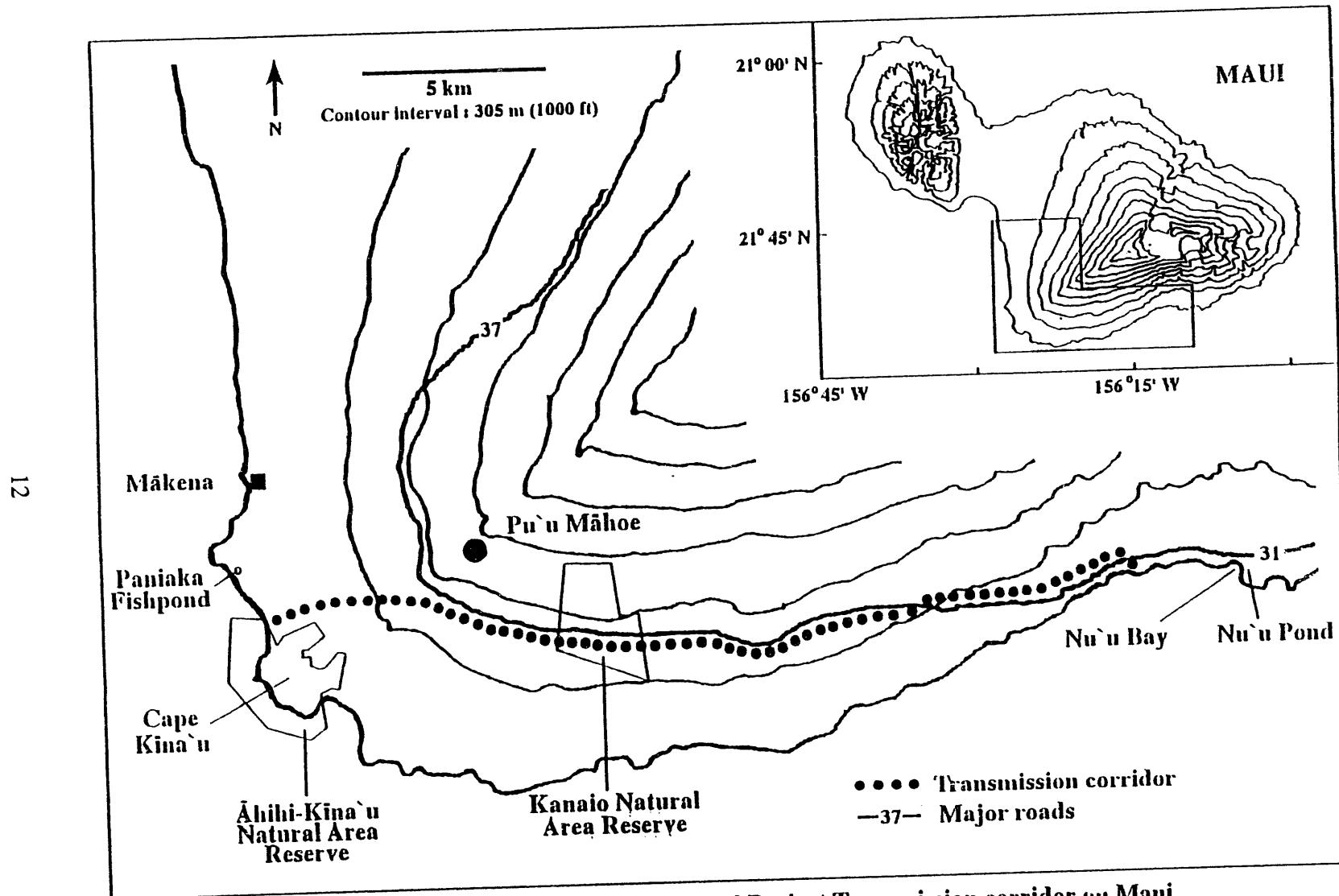


Figure 3. Proposed Hawai'i Geothermal Project Transmission corridor on Maui.

were identified and counted. The remaining wetlands in the project area on O'ahu had been visited by Service biologists on many occasions prior to this survey and were not revisited. On September 21, 1993, Service biologist conducted similar field surveys of all of the wetland habitats identified within the general project area of the proposed transmission line corridor on Maui.

Annual waterbird survey information from the State of Hawai'i, Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW), and the Nature Conservancy's Hawai'i Heritage Program database were reviewed to confirm and augment information gained during the field surveys. State waterbird counts are conducted twice annually, including a winter count during the month of January and a summer count during the month of June. For the purposes of this report, "small numbers of birds" is defined as "less than 10 individual birds" of each species reported from the State waterbird surveys.

Literature containing information on specific wetland sites was reviewed and summarized. DOFAW biologists, Hawai'i Natural Area Reserve (NAR) staff, and other persons with knowledge pertaining to the surveyed wetlands were contacted for additional information on sightings of endangered waterbirds in the general project area. Literature describing impacts of overhead transmission lines on birds was reviewed and summarized and used in evaluating potential impacts of the proposed project on endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl.

## **RESULTS AND DISCUSSION**

### **Waterbird habitats within the project area on O'ahu**

#### **1. Waimānalo Stream and adjacent wetlands**

Waimānalo Stream originates near the base of the Ko'olau Mountains. The stream flows through agricultural and rural areas of Waimānalo, crosses the Kalaniana'ole Highway, passes through Bellows Air Force Station, and exits to the ocean at Bellows Beach.

Waimānalo Stream is channelized below the Kalaniana'ole Highway. Portions of the stream within Bellows Air Force Station are bordered by mangrove trees in the lower reaches and disturbed areas of upland in the upper reaches. Several shallow mudflat areas occur along the upper reaches of the channelized portion of the stream. An old oxbow exists along the lower reaches of the stream near its outlet to the ocean. The oxbow has filled in with sediment and formed a small (less than 1 ha=2.5 ac) wetland consisting of mangrove trees and a *Batis* flat (Fig. 2).

The mangrove wetlands and adjacent shallow stream areas provide suitable foraging and loafing sites for black-crowned night herons and migratory shorebirds. The mudflat areas in the upper reaches of the channelized stream provide loafing and feeding habitat for Hawaiian

stilts, herons, and migratory shorebirds. During the August 1993 survey of the area, Service biologists observed four wandering tattlers, one black-crowned night heron, two Hawaiian stilts, and 13 lesser golden plovers foraging on mudflats within the stream.

The *Batis*-dominated portion of the oxbow wetland is generally overgrown and too dense to provide year-round habitat for endangered waterbirds or wintering habitat for migratory waterfowl. However, several small pockets of open water occur within the wetland, and these areas are likely used by stilts, black-crowned night herons, and shorebirds for feeding. No birds were observed within the *Batis* or mangrove portions of the oxbow wetland during the August 1993 survey.

## 2. Bellows Air Force Station wetland

A 4-ha (10-ac) isolated, freshwater marsh occurs adjacent to the abandoned air field in the northern section of the Bellows Air Force Station (Fig. 2). This seasonally-flooded marsh is currently choked with para grass (*Brachiaria mutica*) and probably provides habitat for endangered waterbirds only after major storm events that generate enough rainfall or stormwater runoff to create ponded areas of open water within the marsh. The marsh is identified as a potential wildlife enhancement area in the Fish and Wildlife Plan (Plan) and the corresponding EA for the Bellows Air Force Station (U.S. Air Force, 1975a and 1975b). In 1992, the Service, the U.S. Air Force, and DOFAW signed a Memorandum of Understanding to update and implement the Plan.

The marsh is not surveyed during the annual State waterbird surveys and the Hawai'i Heritage Program does not have occurrence records for any waterbirds in this area. No endangered waterbirds, resident wading birds, or migratory shorebirds or waterfowl were observed within this marsh by Service biologists during the August 1993 survey.

## 3. Olomana Golf Course

Olomana Golf Course lies west of Bellows Air Force Station in Waimānalo (Fig. 2). A few of the golf course water hazards and detention ponds provide habitat for endangered Hawaiian waterbirds. During 1992, Service biologists observed Hawaiian coots and Hawaiian moorhens at the golf course ponds. The ponds at Olomana Golf Course are included in the annual State waterbird surveys. The State waterbird surveys for the years between 1988 and 1992 confirm that small numbers of Hawaiian coots, Hawaiian moorhens, and Hawaiian stilts use the golf course ponds. Other birds observed at the ponds during the State waterbird surveys include black-crowned night herons, mallards, and domestic ducks (Hawai'i Department of Land and Natural Resources, 1993).

#### 4. Kā'elepulu Pond

Kā'elepulu Pond is an urban wetland located within the town limits of Kailua on the windward side of O'ahu (Fig. 2). Kā'elepulu Pond and its associated wetlands once provided highly productive habitat for all four of Hawaii's endangered waterbirds and valuable wintering habitat for migratory shorebirds and waterfowl. Incremental filling of the shallow wetland habitats along Kā'elepulu Pond for urban development has decreased the habitat available to these species. Nevertheless, the remaining wetlands of Kā'elepulu Pond still support small numbers of all four endangered waterbirds and migratory shorebirds and waterfowl. During 1993, Service biologists observed Hawaiian coots, Hawaiian moorhens, and Hawaiian stilts at Kā'elepulu Pond. Kā'elepulu Pond is included in the State's annual waterbird surveys, and all four endangered waterbirds have been consistently observed in small numbers during the surveys over the past ten years. Small numbers of lesser golden plovers, sanderlings, ruddy turnstones, wandering tattlers, and Northern shovelers have been sighted occasionally at the pond during these surveys (Hawai'i Department of Land and Natural Resources, 1993).

#### 5. Kawainui Marsh

Kawainui Marsh is a 750-acre (303-ha) freshwater wetland located on the windward coast of O'ahu between Kailua Bay and the base of the Ko'olau Mountains (Fig. 2). The marsh is densely vegetated and areas of open water are limited to the center of the marsh. Kawainui marsh provides essential nesting, feeding, and loafing habitat for all four endangered waterbirds. All four species are considered permanent residents of the marsh.

Kawainui Marsh also provides habitat for resident wading birds and migratory shorebirds and waterfowl. Migratory waterfowl are found within the open water areas during winter months. Migratory waterfowl reported from Kawainui Marsh include Northern pintail, Northern shovelers, mallards, lesser scaup, green-winged teal, and American widgeon (Engilis, 1988). Migratory shorebirds reported from Kawainui Marsh include the lesser golden plover, ruddy turnstone, sanderling, and wandering tattler (Shallenberger, 1977; Conant, 1981; and Engilis, 1988). Black-crowned night herons are commonly seen foraging along the edges of the open-water areas and potholes within the marsh. Kawainui Marsh is included in the State's annual waterbird surveys. Records of the surveys over the past 10 years generally confirm the above information (Hawai'i Department of Land and Natural Resources, 1993).

### **Waterbird habitats within the project area on Maui**

#### 1. Paniaka Fishpond

Paniaka Fishpond is located adjacent to Big Beach along the ocean side of the Mākena-Keone'ō'io Government Road just south of Mākena (Fig. 3). The wetland is approximately

0.4 ha (1.0 ac) in size and is owned by the State of Hawai‘i. The pond consists of a shallow depression of slightly brackish water with sparse emergent vegetation growing within and along the edges of the pond. Kiawe trees (*Prosopis pallida*) dominate the surrounding upland.

The Service has observed Hawaiian stilts feeding at the pond on several occasions. The highest number of stilts recorded at the pond during visits by Service biologists was six stilts in 1992. During the most recent count conducted by Service biologists on September 21, 1993, three Hawaiian stilts were observed at the pond. Two of these birds were juveniles and the other was an adult. The Hawai‘i Heritage Program does not have occurrence records for any endangered Hawaiian waterbirds or migratory shorebirds or waterfowl at Paniaka Fishpond. Paniaka Fishpond is included in the State’s annual waterbird counts. Two Hawaiian stilts and one golden plover were observed during the 1993 winter waterbird count at Paniaka Fishpond (Hawai‘i Department of Land and Natural Resources, 1993).

## 2. Āhihi-Kīna‘u Natural Area Reserve (NAR) anchialine ponds

The Āhihi-Kīna‘u NAR is the site of the most recent lava flow on the island of Maui and contains anchialine pools known for their high diversity of rare Hawaiian shrimp and a unique lava tube community that provides habitat for native Hawaiian cave fauna (Hawai‘i Heritage Program, 1989). Anchialine pools are distributed along the Cape Kīna‘u peninsula seaward of the Mākena-Keone‘ō‘io Government Road, at varying distances from the sea between Nuku‘ele Point on the Cape and La Perouse Bay (Wong, 1975). Maciolek (1986) separated the pools into 12 groups in order to describe the pools in terms of distribution, basin character, water quality, and aquatic biota. Each group consisted of a few to many pools in close proximity, the groups being separated by either considerable distance, lava of high relief, or a combination of both features. Individual pools vary in surface area from less than 1 m<sup>2</sup> to 3,000 m<sup>2</sup>, most of them being very small. Total water surface area of the groups ranges from a few square meters to more than 2,000 m<sup>2</sup>. Most pools are less than 0.5 m (1.6 ft) deep with the exception of Hā‘ula Pond, which exceeds 5 m (16.4 ft) in depth. Water surface area and depth of the pools are affected by tides, and many of the shallower pools are temporarily drawn down at low tide (Maciolek, 1986).

The two most prominent anchialine pools at Āhihi-Kīna‘u NAR, Hā‘ula Pond and Kauhioaiakini Pond, were surveyed for the purposes of this study (Fig. 4). Kauhioaiakini Pond is actually a series of pools within a large depression that is the single, largest open area of little physical relief on the Cape Kīna‘u peninsula (Wong, 1975). Emergent vegetation, including small rush (*Juncus* sp.), sea purslane (*Sesuvium portulacastrum*), and pickleweed (*Batis maritima*), occurs along the edges of the pond. Widgeon grass (*Ruppia maritima*) and several species of blue-green and red algae are abundant in the pond (Wong, 1975; Maciolek, 1986).

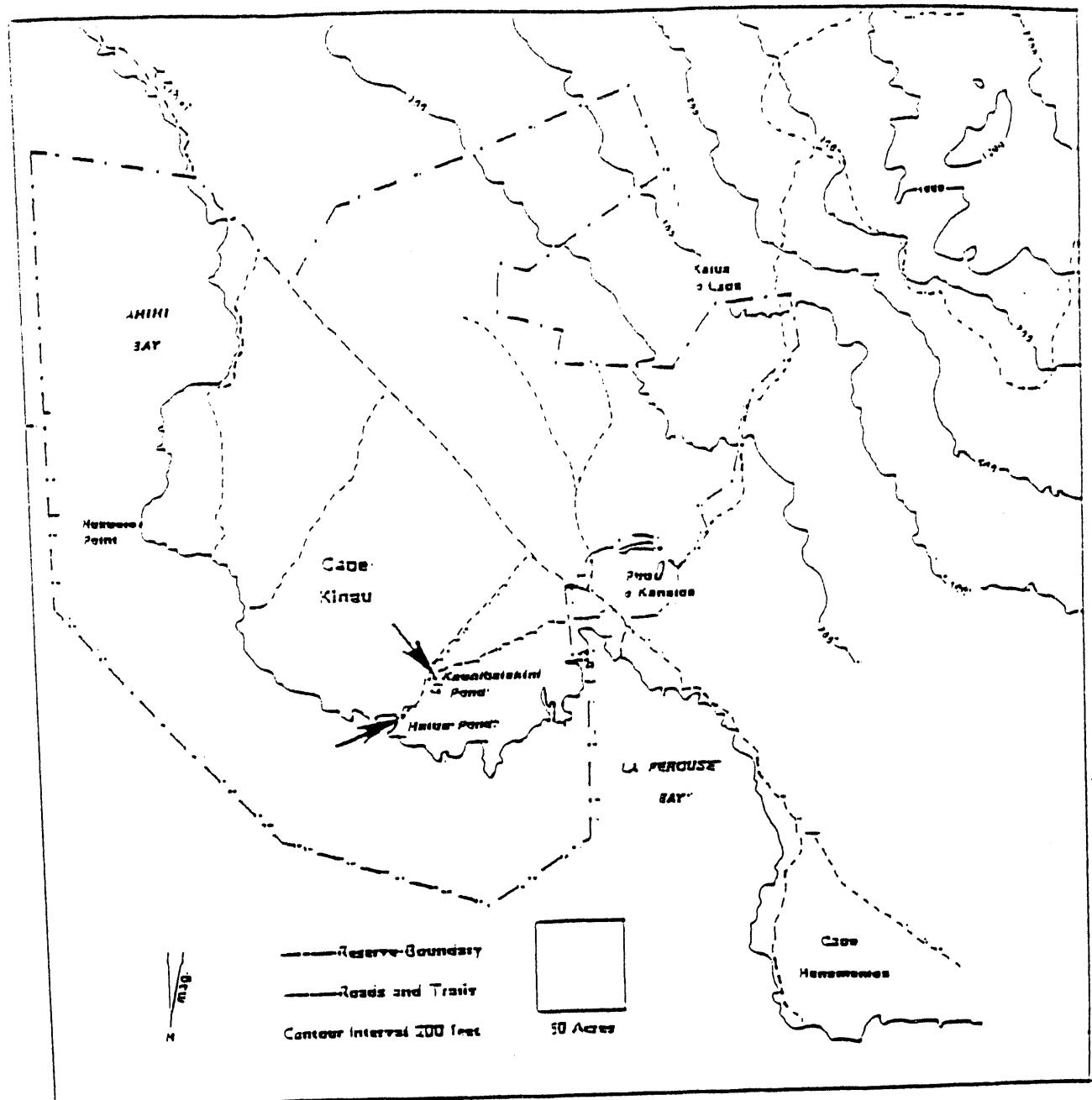


Figure 4. Locations of anchialine pools surveyed at Āhihi-Kīna'u Natural Area Reserve.

Three adult Hawaiian stilt, three wandering tattlers and four ruddy turnstones were observed foraging along the banks of Kauhioaiakini Pond by Service biologists on September 21, 1993. The Hawai'i Heritage Program conducted resource surveys of the Āhihi-Kīna'u NAR in order to assist the State in preparing an inventory and management plan for the reserve. During these surveys, Hawai'i Heritage Program staff recorded two occurrences of Hawaiian stilts at Kauhioaiakini Pond. Five stilts were observed on May 2, 1987, and two stilts were observed on March 3, 1988, foraging at the edges of Kauhioaiakini Pond. Wandering tattlers and ruddy turnstones were also recorded during these surveys. The State waterbird surveys do not currently include Kauhioaiakini Pond. However, during the winter waterbird count on Maui in 1981, five Hawaiian stilts were observed at Kauhioaiakini Pond (Hawai'i Heritage Program, 1993b). According to the NAR's staff, it is common to see three to five stilts foraging at the pond, but no observations of stilt nesting activity have been recorded.

Hā'ula Pond is the single largest water exposure on Cape Kīna'u (Wong, 1975). Several small patches of pickleweed and rush are found along the shallow-water edges of the pond. A few kiawe trees are found along the ocean shoreline of the pond. Large areas of Indian marsh fleabane (*Pluchea indica*) dominate the inland shoreline of the pond. Macroflora of the pond is dominated by green and blue-green algae (Maciolek, 1986). Widgeon grass occurs on crust-covered rocks protruding into the water (Wong, 1975).

No endangered waterbirds or migratory shorebirds were observed at Hā'ula Pond by Service biologists during the September 1993 survey. The Hawai'i Heritage Program has no records of endangered waterbirds or migratory shorebirds at the pond. The State waterbird surveys do not include Hā'ula Pond.

### 3. Nu'u Pond

Nu'u Pond or Salt Pond is a privately owned pond located inland of Nu'u Bay along the southern coastline of East Maui (Fig. 3). The pond is permanently flooded and is apparently used as a cattle stock pond, which limits the growth of wetland vegetation within and along the edges of the pond. The pond is approximately 1.0 ha (2.5 ac) in size.

Service biologists observed three adult Hawaiian stilts, 17 adult Hawaiian coots, and eight Hawaiian coot chicks in Nu'u pond on September 21, 1993. One Hawaiian coot nest with eggs was observed. The Hawai'i Heritage Program does not have any records of endangered waterbirds or migratory shorebirds or waterfowl at Nu'u Pond. The annual State waterbird counts include information on Nu'u Pond for the winter and summer counts of 1992 and the summer count of 1993. During the 1992 winter count, 56 Hawaiian coots, six Hawaiian stilts, fourteen Northern pintails, four ruddy turnstones, and one wandering tattler were observed at Nu'u Pond. During the summer count at the pond in the same year, 44 Hawaiian coots and five Hawaiian stilts were observed. During the 1993 winter count, 28 Hawaiian coots, three Hawaiian stilts, two lesser golden plovers, one ruddy turnstone, and three wandering tattlers were observed at the pond (Hawai'i Department of Land and Natural

Resources, 1993). Nu'u Pond is identified in the Service's Draft Revised Hawaiian Waterbirds Recovery Plan as an area where long term protection through a cooperative effort with the landowner should be explored.

### **Impacts of overhead transmission lines on avian species**

Specific studies and general observations on the impacts of power lines on avian species are focused on the issues of electrocution, electromagnetic effects, and collisions. Electrocution causes direct mortality by electrical shock. Electromagnetic effects include possible navigational disorientation resulting from birds passing through electric fields. Collisions include mortality and crippling of birds that collide with overhead wires and wire support structures.

Electrocution is primarily a problem for large birds of prey with large wingspread. The incidence of electrocution of bald and golden eagles and other raptors is well documented. Studies have shown that most lines that electrocute raptors are distribution lines where the distances between individual conductors or between conductors and ground wires are close enough to allow large birds to simultaneously touch two wires. Over the past two decades, design modifications of distribution lines have largely corrected the problems associated with raptor electrocutions. Most transmission lines do not cause electrocution of birds because of the relatively greater distances between wires (Olendorf *et al.*, 1981). Presumably, the electrocution of waterbirds will be low or none.

Fewer studies address the electromagnetic effects of power lines on avian navigational disorientation. Some studies indicate that orientation of birds may be affected slightly when local magnetic fields are disrupted by electrical currents (Southern, 1975; Larkin and Southerland, 1977; and Moore, 1977). Other studies suggest that corona noise and electric and magnetic fields detected by birds may provide location information during periods of reduced visibility (Lee and Griffith, 1977). Whether this helps birds avoid collisions with power lines is undetermined.

Observations of birds colliding with overhead utility wires are documented in the literature as early as 1876 (Coues, 1876). Since then, there have been many reported observations in the United States and abroad of birds colliding with power lines, various types of towers, and other man-made structures (Scott *et al.*, 1972; Avise and Crawford, 1981).

Many studies have documented the effects of television and radio towers on birds, especially migrating passerines. However, the reported incidence of actual bird collisions with self-supporting, high-voltage transmission line towers are few. The fact that birds generally do not collide with this type of structure relates to several factors, including the height of the transmission line support structures (relatively low when compared to television and radio towers), size and visibility of the support structures, the absence of vertical guy wires, and

the fact that these structures are not equipped with lights, which tend to attract or disorient migrating birds.

Birds do collide with distribution and transmission line wires. Many early reports simply documented observed mortality of avian species due to collisions with power lines. Siegfried (1972) reported his observations of ruddy ducks colliding with overhead wires in Minnesota and Manitoba. Stout and Cornwell (1976) summarized information on the nonhunting mortality of waterfowl from available literature. Total collision mortality was estimated as 0.1 %, and 65% of the reported collisions were with utility wires.

More recently, specific long term studies have been conducted to determine the flight behavior of birds at transmission line sites, in particular the rate at which birds collide with these lines, and the biological and social significance of bird mortality due to these collisions (Rusz *et al.*, 1986; Anderson 1978; Faanes, 1987; Lee, 1978). Results of these studies reveal several common factors that appear to influence the probability of wire strikes. These factors include:

1. Number of birds in the area, both locally and seasonally. Studies suggest that peak mortality is correlated with peak numbers of birds in the area. Therefore, more collisions can be expected where local concentrations of birds are high or at stopover feeding and resting sites during spring and fall migration periods.
2. Local weather conditions. Many of the reported collisions were observed during periods of good visibility. However, most studies suggest that more collisions occur during periods of inclement weather, especially fog, gusty winds, and heavy rain. These conditions either reduce visibility or cause birds to fly lower, thereby increasing the probability of collision. The chance for a catastrophic loss increases significantly when inclement weather causes large flocks of migrating birds to fly at low elevations.
3. Location of the lines. Location of the lines near high waterbird concentration areas such as open water or wetlands increases rates of collision. Collision rates are high where lines cross feeding areas or separate feeding and roosting areas and where lines cross natural flight lines such as drainageways.
4. Design of the towers and lines. Birds tend to avoid the airspace within 50 m (165 ft) of the towers, flying over the wire near the mid-span region. Self-supporting towers present less hazard to birds than towers supported with guy wires. Conducting lines with a horizontal configuration are less hazardous than a vertical array of wires. Due to their larger diameter, conducting wires are more visible than ground wires. The majority of the observed collisions were with ground wires.
5. Physical characteristics of the birds. Most reported or observed collisions involved species of waterfowl, shorebirds, gulls, herons, pelicans, cranes, or other large birds

possessing low maneuverability. Dabbling ducks collided more often than diving ducks. Raptors rarely collided with wires due to their great visual acuity and maneuverability. Young birds collided more often than adult birds.

6. Bird behavior. Studies suggest that many species are susceptible to collision when suddenly alarmed, engaged in courtship flights, searching for food while flying, escaping from predators, or inattentive to where they are going. Resident birds can learn the location of transmission lines. This may affect local flight patterns such that some birds avoid using habitat adjacent to transmission lines. Resident birds, therefore, are less likely to collide than transient birds. Collisions are more likely to occur during low-level feeding flights rather than migration flights which usually occur at high elevations. Flocking behavior during migration increases the chances for collisions at stopover sites.

## CONCLUSIONS AND RECOMMENDATIONS

Based on our review of the literature describing the impacts of overhead transmission lines on avian species, we do not believe that the potential impacts associated with the proposed transmission line project with regard to electrocution, electromagnetic effects, or collisions with wire support structures (towers) constitute a significant threat to endangered Hawaiian waterbirds, resident wading birds, or migratory shorebirds and waterfowl. Therefore, our assessment of the potential impacts of the proposed overhead transmission line on these species is focused on potential bird collisions with the transmission line wires and potential losses of wetland habitat associated with the construction of support structures or auxiliary facilities located onshore.

The Service identified three wetland areas supporting waterbirds within the project area of the proposed transmission line corridor on Maui and five wetland areas supporting waterbirds within the proposed transmission line corridor on O'ahu. The Service believes that endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl may collide with the proposed transmission line wires. The frequency and numbers of birds colliding with the transmission line wires may be higher on O'ahu because more wetland habitat exists within the project area on O'ahu and greater numbers of endangered waterbirds and migratory birds occur in the project area on O'ahu. The Service determined from the surveys that two other federally-listed birds, the endangered Hawaiian goose (*Nesochen sandvicensis*, nene) and the endangered Hawaiian petrel (*Pterodroma phaeopygia sandwichensis*, 'ua'u), may be impacted by the proposed segment of the Geothermal Transmission Line on Maui.

## **Preliminary assessment of the potential impacts of the proposed transmission line on wetlands and associated avian species on Maui**

No wetlands are found within the proposed transmission line corridor on Maui. Therefore, the Service does not anticipate direct impacts to wetlands from the construction or maintenance of the Maui segment of the Hawai'i Geothermal Project transmission line. Direct impacts to wetlands would generally include the loss or degradation of habitat by placement of the transmission line support structures in wetlands.

According to the project description, the exact location of shoreside facilities required on Maui are not known. Thus, we cannot assess the direct impact of these facilities on wetland habitats on Maui. However, based on the results of our preliminary botanical surveys, the Service believes that ample areas of non-sensitive, upland habitats are available within the project area for locating these facilities.

Wetland habitats supporting endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl were documented on Maui within the general area of the proposed transmission line corridor. Small numbers of endangered Hawaiian stilts and migratory shorebirds are supported at the Fāniaka fishpond and the Āhihi-Kīna'u NAR anchialine ponds.

The most significant wetland for endangered waterbirds in the project area on Maui appears to be Nu'u Pond. Significant numbers of Hawaiian coots have been reported from this small wetland. The area is used as both a nesting and feeding habitat by Hawaiian coots. Small numbers of Hawaiian stilts have also been observed foraging at the pond. Based on our assessment of the habitat values of the pond during this survey, the Service believes that the pond may support two to four pairs of Hawaiian stilts during the nesting season. Migratory shorebirds and waterfowl also use Nu'u Pond during winter months.

Hawaiian stilts may move between the wetlands at Mākena, Cape Kīna'u, and Nu'u depending on daily (Cape Kīna'u) or seasonal water level fluctuations and the corresponding availability of food. Some birds may fly along the coastline avoiding the proposed transmission line corridor. However, the possibility exists that stilts may take a more inland route when moving between these wetlands or to other larger wetlands on Maui. Stilts taking a more inland route may collide with the transmission line wires.

It is likely that at least some of the Hawaiian coots observed at Nu'u Pond are permanent residents of the pond. Nevertheless, coots using Nu'u Pond may disperse to other wetlands on Maui or Moloka'i depending on rainfall patterns, which may affect water levels in the pond and the corresponding availability of suitable foraging and nesting habitat. As with Hawaiian stilts, Hawaiian coots may fly along a coastal route and avoid the transmission line corridor. However, coots flying along a more inland route may collide with the transmission line wires. Resident wading birds and migratory shorebirds and waterfowl wintering in Hawai'i that use Nu'u Pond or the other small wetlands within the project area may be

subject to the same hazards as they move between these wetlands or to other larger wetlands on Maui or Moloka'i.

Based on the common factors that influence avian collisions with overhead transmission lines, the Service does not anticipate that large numbers of endangered waterbirds or resident wading birds will collide with the transmission line wires on Maui. This preliminary assessment is based on the fact that the proposed transmission line corridor will not cross wetland or open- water habitats and the overall numbers of endangered waterbirds and resident wading birds in the general project area are relatively low. Nevertheless, we believe the potential exists for some birds to collide with the transmission line wires. In accordance with section 7 of the Endangered Species Act of 1973, as amended, (Act) and the interagency consultation regulations found at 50 CFR Part 402, the Service recommends that any biological assessment prepared for the Hawai'i Geothermal Project include an evaluation of the potential for endangered Hawaiian coots and Hawaiian stilts to collide with the transmission line wires on Maui. The effect of these collisions on Hawaiian coot and Hawaiian stilt populations should be comprehensively addressed during the interagency section 7 consultation.

To the best of our knowledge, the proposed transmission line corridor on Maui will not cross a major flyway for migratory shorebirds or waterfowl wintering in Hawai'i. However, as with resident wading birds and endangered waterbirds, the Service believes that the potential exists for migratory species to collide with the transmission line wires. The potential for such collisions to occur will be higher during spring and fall migration periods and during inclement weather. Potential impacts of the proposed transmission line segment on Maui to species afforded protection under the Migratory Bird Treaty Act of 1918, as amended, (MBTA) should also be evaluated and comprehensively addressed in the Draft HGP EIS.

#### **Preliminary assessment of the potential impacts of the proposed transmission line on wetlands and associated avian species on O'ahu**

The exact location of the transmission line corridor on O'ahu has not been determined. Therefore, the Service cannot evaluate direct impacts on wetlands within the transmission line corridor on O'ahu. Of particular concern to the Service is the protection of the Bellows Air Force Station Wetlands, which have been identified as potential endangered waterbird enhancement areas in the interagency Memorandum of Understanding between the Service, State of Hawai'i Division of Forestry and Wildlife, and the United States Air Force.

All of the wetland habitats identified within the general area of the proposed transmission line corridor on O'ahu are considered important habitats for endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl. All four of Hawaii's endangered waterbirds are still found on O'ahu and intra-island movement between wetlands in response to available foraging and nesting habitat is well documented. Therefore, all four species of endangered waterbirds may be exposed to the hazards of colliding with the transmission line

wires on O'ahu. Likewise, resident wading birds and migratory species may collide with the transmission line wires as they move between wetland areas within the project area or to other wetlands on O'ahu.

Based on the common factors influencing bird collisions with overhead transmission lines, the Service believes the numbers of bird collisions with the proposed transmission line wires may be higher on O'ahu than on Maui. Within the O'ahu project area, there are greater number of wetlands, and three of these wetlands are significantly larger than any of the wetlands located within the Maui project area. Correspondingly, greater numbers of endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl are expected to use the O'ahu wetlands and be exposed to the hazards of colliding with the transmission line wires. The biological assessment for the Hawai'i Geothermal Project should address the potential for all four endangered waterbird species to collide with the transmission line wires on O'ahu. The effect of these collisions on endangered waterbird populations in Hawai'i should be comprehensively addressed during the interagency section 7 consultation. Potential impacts of the proposed transmission line segment on O'ahu to species protected under the MBTA should also be evaluated and comprehensively addressed in the Draft HGP EIS.

#### **Additional concerns identified during the survey**

This study did not evaluate the wetland habitats within the proposed transmission line corridor on the Island of Hawai'i. The endangered Hawaiian coot, Hawaiian stilt, and Hawaiian duck are found on the Island of Hawai'i. Wetlands within the general project area of the proposed transmission line corridor on the Island of Hawai'i should be identified and surveyed to assess habitat values to endangered waterbirds, resident wading birds, and migratory shorebirds and waterfowl. The biological assessment should address impacts of the proposed transmission line on Hawaiian waterbirds, the endangered Hawaiian goose (*Nesochen sandvicensis*, nene), the endangered Hawaiian hawk (*Buteo solitarius*, 'io) and other endangered and threatened species identified by the Service as occurring within the Hawai'i Geothermal Project transmission line corridor on the Island of Hawai'i.

Potential nene habitat exists within the proposed transmission line corridor on Maui. The Hawaiian petrel (*Pterodroma phaeopygia sandwichensis*, 'ua'u) nests on the upper slopes and within the crater of Haleakala. Adult petrels transiting to and from nesting burrows and fledglings leaving nesting grounds for the first time may collide with the proposed transmission line wires. The biological assessment should also address potential impacts of the proposed transmission line on these two endangered species.

## ENDANGERED AND THREATENED PLANTS SURVEY

### INTRODUCTION

The proposed Hawai'i Geothermal Project transmission corridor extends from the Island of Hawai'i to O'ahu. The transmission corridor has overland segments that traverse the Island of Hawai'i, cross the dry southern slopes of Haleakala, Maui and extend inland from the windward shore at Waimānalo, O'ahu (Fig. 1). The specific site of the actual transmission line has not as yet been determined. The botanical survey covered in this report was limited to the Maui segment of the transmission corridor. This preliminary survey and should not replace more complete on-the-ground surveys of the transmission corridor when its exact location is established.

The dryland forests of the Hawaiian Islands contain the richest diversity of tree species of all vegetation types in the islands (Rock, 1913). This vegetation zone has also been most highly disturbed by humans (Hawai'i Heritage Program, 1991). The south slope of Haleakalā, Maui, has long been recognized as a dramatic example of both species richness and high disturbance in a dryland forest. Much of the dryland forest zone of Haleakalā has been converted to cattle pasture, and was already seriously degraded by browsing cattle and goats in 1910 (Rock, 1913).

Remnant pockets of native taxa remain in small gullies and other areas inaccessible to cattle and goats, or as mature or dying trees that are no longer reproducing. The understory is frequently composed of introduced taxa, typically range grasses (Medeiros *et al.*, 1986). Many rare and endangered taxa are found in this zone. The proposed Hawai'i Geothermal Project transmission corridor on Maui (Fig. 3) traverses through the lower portion of the dryland forest zone, and passes through areas where four listed endangered taxa and nine proposed endangered taxa (to be listed within the year) are known to occur (Table 2). Two of the endangered taxa (*Alectryon macrococcus* var. *auwahiensis* and *Lipochaeta kamolensis*) and one of the proposed endangered taxa (*Melicope adscendens*) are known only from one location each.

The windward, low elevation area designated as the transmission corridor on O'ahu (Fig. 2) extends from the shore near Waimānalo up to the an inverter sited at the eastern base of Aniani Nui Ridge (Krasnick, 1986). A search of the Hawai'i Heritage Program (1993a) database did not show any endangered or threatened plants in this area. Final alignment of the transmission corridor should include a botanical survey to identify endangered or rare plants that should be avoided or protected during construction or operation programs.

The proposed transmission corridor on the Island of Hawai'i was not surveyed. However, a list of endangered and threatened species that may be found along this transmission corridor (and proposed alternative corridors; Fig. 1) was obtained from the Hawai'i Heritage Program (1993a) database and is presented in Appendix II.

**Table 2. Endangered plants that could occur in the proposed Hawai'i Geothermal Project transmission corridor on Maui. (See Figure 3 for location of the transmission corridor.)**

Taxon	Common name	Status	Comments
<i>Alectryon macrococcus</i> var. <i>auwahiensis</i>	Māhoe	endangered	only known location
<i>Bonamia menziesii</i>	-----	proposed endangered*	
<i>Capparis sandwichiana</i>	Maiapilo	category 2*	
<i>Clermontia lindseyana</i>	‘Ōhā wai	proposed endangered	not seen since 1975
<i>Flueggea neowawraea</i>	Mēhamehame	endangered	
<i>Lipochaeta kamolensis</i>	Nehe	endangered	only known location
<i>Melicope adscendens</i>	Alani	proposed endangered	only known location
<i>Melicope knudsenii</i>	Alani	proposed endangered	not seen since 1975
<i>Melicope mucronulata</i>	Alani	proposed endangered	
<i>Neraudia sericea</i>	Ma‘aloa	proposed endangered	not seen since 1975
<i>Nototrichium humile</i>	Kulu‘ī	endangered	
<i>Santalum freycinetianum</i> var. <i>lanaicense</i>	‘Iliahi	endangered	
<i>Sesbania tomentosa</i>	‘Ohai	proposed endangered	
<i>Zanthoxylum hawaiiense</i>	-----	proposed endangered	

\* See text for definitions of "proposed endangered" and "category 2".

## METHODS

The area that was surveyed extends 24 kilometers along Highway 31 from Nu‘u Bay to Pu‘u Māhoe, and continues 3.5 kilometers along the western edge of the 1750 lava flow from Pu‘u Māhoe down to the ocean at Āhihi Bay near Kanahena (Krasnick, 1986). The botanical field survey was conducted on September 21 and 22, 1993. The area covered by the survey was limited to approximately 50 meters on either side of the survey route. The route along Highway 31 was driven by a three-person team on September 21, stopping at locations where endangered plants were known to occur or at locations where fairly intact native vegetation was found and endangered species were likely to occur. The route from Pu‘u Māhoe to Kanahena was walked by a two-person team on September 22. The types of vegetation and the degrees of disturbance along the route were noted. Since most of the rainfall in the lower dryland forest zone of Maui occurs from November through April, some of the native species were dormant and easy to overlook at this time of year.

Data on endangered and proposed endangered taxa are supplied from U.S. Fish and Wildlife Service (Service) maps and from the Hawai‘i Heritage Program (1993a) database, and encompass a one-mile radius on either side of the proposed transmission corridor. The botanical survey was not part of the original project, but was included by the Service since important botanical resources are known from the general area. This botanical survey was

not intended to be an in-depth survey, and should not take the place of on-the-ground surveys of the HGP transmission corridor on Maui. Once the exact route for the corridor has been determined, botanists should conduct a thorough survey of each transmission pole location, roadways, or any other area of impact to ensure that endangered species are not adversely affected.

## RESULTS AND DISCUSSION

### Native vegetation

While the lower portion of the dryland forest zone of East Maui has been drastically affected by humans and much of it has been converted to pasture, several pockets of native dry shrubland and dryland forest were observed during the field survey. The native vegetation types observed included *Wikstroemia monticola* ('Akia) Lowland Dry Shrubland, *Dodonaea viscosa* ('A'ali'i) Lowland Dry Shrubland, and *Erythrina sandwicensis* (Wiliwili) Lowland Dry Forest. These patches of native lowland vegetation are scattered throughout the area, and are all that remains of the original vegetation of the lower dryland zone of East Maui. Joseph Rock observed in the early 1900s that *Erythrina sandwicensis* was declining in number (Rock, 1913), and it has continued to do so since that time.

A portion of the proposed transmission corridor passes through the State of Hawai'i Department of Land and Natural Resources' Kanaio Natural Area Reserve (NAR). This NAR was created to protect the lower dryland forest vegetation of East Maui.

### Endangered and proposed endangered taxa

Four endangered plant taxa and nine proposed endangered taxa have been reported within a one-mile radius of the proposed HGP transmission corridor on Maui, but were not observed during this survey (Table 2). Taxa listed as "proposed endangered" have been recommended for formal endangered status but await final approval from the Washington, D.C. office of the U.S. Fish and Wildlife Service. Two of the endangered taxa (*Alectryon macrococcus* var. *auwahiensis* and *Lipochaeta kamolensis*) and one of the proposed endangered taxa (*Melicope adscendens*) are known only from one location each. *Lipochaeta kamolensis* (Nehe) is restricted to several hundred individuals in one location that falls directly in the path of the proposed transmission corridor at Kamole Gulch. This taxon was not found during the survey, but is difficult to recognize during the dry season when the survey was conducted. The area should be surveyed for this plant during the rainy season. *Melicope adscendens* (Alani) and *Alectryon macrococcus* var. *auwahiensis* (Māhoe) are known from only one population each, which fall within the one-mile radius of the proposed transmission corridor.

The remaining endangered and proposed taxa are known from the general area of the proposed transmission corridor. They include the endangered taxa *Nototrichium humile* (Kulu‘ī), and *Santalum freycinetianum* var. *lanaiense* ('Iliahi) and the proposed taxa *Bonamia menziesii* (no common name), *Flueggea neowawraea* (Mēhamehame), *Melicope mucronulata* (Alani), *Sesbania tomentosa* ('Ohai), and *Zanthoxylum hawaiiense* (no common name). None of these taxa were observed during the survey. The three remaining proposed taxa, *Clermontia lindseyana* ('Ōhā wai), *Melicope knudsenii* (Alani), and *Neraudia sericea* (Ma‘aloa), have not been seen in the proposed transmission corridor area in the last fifteen years, but may still occur there.

One Category 2 candidate species, *Capparis sandwichiana* (Maiapilo) was observed during the survey. A Category 2 species is a species for which the Service has information indicating the species may be threatened and declining in number, but more information and surveys are needed to determine whether to list the species as endangered or threatened. A population of hundreds of *Capparis sandwichiana* plants is located on and near the boundary of the 1750 lava flow along the route between Pu‘u Māhoe and Kanahena.

## CONCLUSIONS AND RECOMMENDATIONS

### Native vegetation

The native dryland vegetation of the southern slope of East Maui has a rich diversity of tree species and is also one of the vegetation types most highly impacted by humans (Hawai‘i Heritage Program, 1991; Rock, 1913). Very few large expanses of intact native forest remain in the lower elevations of East Maui. For this reason, it is critical to maintain what little native vegetation remains.

Many small groves of *Erythrina sandwicensis* (Wiliwili) still remain on the south slope of Haleakalā. These groves are but a remnant of what was once an extensive component of the dryland forest (Rock, 1913). Since the amount of *E. sandwicensis* has declined and is restricted to isolated pockets, groves of this tree should be avoided in the construction of the proposed transmission corridor.

A portion of the proposed transmission corridor passes through or near the State of Hawai‘i Department of Land and Natural Resources' Kanaio Natural Area Reserve (NAR). The NAR protects a significant section of the dryland forest vegetation. Construction in the NAR would additionally fragment the remaining patches of dryland forest and increase the degradation of this vegetation. Any activity that negatively affects this rare dryland forest should be avoided. The State of Hawai‘i should be consulted on these plans as soon as possible and certainly before the development of construction plans for this area.

### **Endangered and proposed endangered taxa**

The rich diversity composing the dryland forest in Hawai'i also leads this vegetation type to have a large number of endangered species. Four endangered plant taxa and nine proposed endangered taxa have been reported in the general area of the proposed transmission corridor on Maui, and many more endangered taxa are found beyond the one-mile radius of the corridor. Three of these taxa have single-site distributions. Any corridor construction should particularly avoid the areas where these species occur. It is also critical to avoid construction in areas directly upslope of populations of these species since it could cause erosion that affects populations downslope.

Since this botanical survey was not part of the original project and was not extensive, it is likely that more endangered and proposed endangered plant taxa are located directly in or adjacent to the proposed transmission route. The transmission corridor should be surveyed and marked with an experienced Hawaiian botanist present once the exact route has been determined. Any location of endangered or proposed endangered taxa in the area should be avoided as locations for poles or any other type of construction. In addition, it is possible to avoid the candidate taxon, *Capparis sandwichiana* (Maiapilo), by placing the transmission route adjacent to the 1750 lava flow in the non-native vegetation rather than on the open lava field.

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**Appendix I. Endangered birds that could occur in or near the proposed Hawai'i Geothermal Project transmission corridor on the island of Hawai'i. (See Figure 1 for the location of the transmission corridor sections.)**

Taxon	Common name	Location	Comments
<i>Buteo solitarius</i>	Hawaiian hawk, 'Io	Hawai'i, corridor section A	
<i>Hemignathus munroi</i>	'Akia'pola'au	Hawai'i, corridor section A	
<i>Loxops coccineus coccineus</i>	Hawai'i 'Akepa	Hawai'i, corridor section A	
<i>Nesochen sandvicensis</i>	Hawaiian goose, Nene	Hawai'i, corridor section A	
<i>Oreomystis mana</i>	Hawai'i creeper	Hawai'i, corridor section A	
<i>Psittirostra psittacea</i>	'O'u	Hawai'i, corridor section A	
<i>Buteo solitarius</i>	Hawaiian hawk, 'Io	Hawai'i, corridor section B	
<i>Hemignathus munroi</i>	'Akia'pola'au	Hawai'i, corridor section B	
<i>Loxioides bailleui</i>	Palila	Hawai'i, corridor section B	
<i>Nesochen sandvicensis</i>	Hawaiian goose, Nene	Hawai'i, corridor section B	
<i>Oreomystis mana</i>	Hawai'i creeper	Hawai'i, corridor section B	
<i>Anas wyvilliana</i>	Hawaiian duck, Koloa	Hawai'i, corridor section C	
<i>Buteo solitarius</i>	Hawaiian hawk, 'Io	Hawai'i, corridor section C	
<i>Himantopus mexicanus knudseni</i>	Hawaiian stilt, Ae'o	Hawai'i, corridor section C	
<i>Fulica americana alai</i>	Hawaiian coot, 'Alae ke'o ke'o	Hawai'i, corridor section C	
<i>Psittirostra psittacea</i>	'O'u	Hawai'i, corridor section C	last seen in 1975
<i>Buteo solitarius</i>	Hawaiian hawk, 'Io	Hawai'i, corridor section D	
<i>Corvus hawaiiensis</i>	Hawaiian crow, Alala	Hawai'i, corridor section D	last seen in 1975
<i>Hemignathus munroi</i>	'Akia'pola'au	Hawai'i, corridor section D	
<i>Loxioides bailleui</i>	Palila	Hawai'i, corridor section D	last seen in 1975
<i>Loxops coccineus coccineus</i>	Hawai'i 'Akepa	Hawai'i, corridor section D	
<i>Nesochen sandvicensis</i>	Hawaiian goose, Nene	Hawai'i, corridor section D	
<i>Oreomystis mana</i>	Hawai'i creeper	Hawai'i, corridor section D	

continued

**Appendix I. Continued.**

Taxon	Common name	Location	Comments
<i>Psittirostra psittacea</i>	'O'u	Hawai'i, corridor section D	last seen in 1975
<i>Anas wyvilliana</i>	Hawaiian duck, Koloa	Hawai'i, corridor section E	
<i>Buteo solitarius</i>	Hawaiian hawk, 'Io	Hawai'i, corridor section E	
<i>Corvus hawaiiensis</i>	Hawaiian crow, Alala	Hawai'i, corridor section E	last seen in 1975
<i>Hemignathus munroi</i>	'Akiapola'au	Hawai'i, corridor section E	last seen in 1975
<i>Loxops coccineus coccineus</i>	Hawai'i 'Akepa	Hawai'i, corridor section E	last seen in 1975
<i>Oreomystis mana</i>	Hawai'i creeper	Hawai'i, corridor section E	

**Appendix II. Endangered plants that could occur in or near the proposed Hawai'i Geothermal Project transmission corridor on the island of and Hawai'i. (See Figure 1 for the locations of the transmission corridor sections.)**

Taxon	Common name	Location	Status	Comments
<i>Cyanea copelandii</i> ssp. <i>copelandii</i>	Hāhā	Hawai'i, corridor section A	proposed endangered*	not seen since 1975
<i>Cyrtandra giffardii</i>	Ha'iwale	Hawai'i, corridor section A	proposed endangered	
<i>Asplenium fragile</i> var. <i>insulare</i>	Kihi	Hawai'i, corridor section B	proposed endangered	not seen since 1975
<i>Clermontia pyrularia</i>	'Ōhā wai	Hawai'i, corridor section B	proposed endangered	not seen since
<i>Haplostachys haplostachya</i>	-----	Hawai'i, corridor section B	endangered	not seen since
<i>Isodendrion hosakae</i>	Aupaka	Hawai'i, corridor section B	endangered	
<i>Lipochaeta venosa</i>	Nehe	Hawai'i, corridor section B	endangered	
<i>Plantago hawaiiensis</i>	Laukahi kuahiwi	Hawai'i, corridor section B	proposed endangered	
<i>Silene hawaiiensis</i>	-----	Hawai'i, corridor section B	proposed endangered	
<i>Solanum incompletum</i>	Pōpolo	Hawai'i, corridor section B	proposed endangered	not seen since
<i>Tetramolopium arenarium</i> ssp. <i>arenarium</i>	-----	Hawai'i, corridor section B	proposed endangered	not seen since 1975
<i>Ischaemum byrone</i>	Hilo ischaemum	Hawai'i, corridor section C	proposed endangered	not seen since
<i>Argyroxiphium kauaense</i>	Ka'ū	Hawai'i, corridor section D	endangered	
<i>Clermontia peleana</i> ssp. <i>peleana</i>	'Ōhā wai	Hawai'i, corridor section D	proposed endangered	
<i>Cyrtandra giffardii</i>	Ha'iwale	Hawai'i, corridor section D	proposed endangered	not seen since
<i>Clermontia lindseyana</i>	'Ōhā wai	Hawai'i, corridor section E	proposed endangered	not seen since
<i>Clermontia peleana</i> ssp.	'Ōhā wai	Hawai'i, corridor section E	proposed endangered	
<i>Cyrtandra giffardii</i>	Ha'iwale	Hawai'i, corridor section E	proposed endangered	not seen since
<i>Cyrtandra tintinnabula</i>	Ha'iwale	Hawai'i, corridor section E	proposed endangered	not seen since
<i>Lycopodium manii</i>	Waswae'iole	Hawai'i, corridor section E	endangered	

\* See text for a definition of "proposed endangered".