



Background

The Pacific Island Network (PACN) of the National Park Service Inventory and Monitoring Division performs long-term monitoring of terrestrial, marine, and aquatic resources within the national parks of Hawai‘i, Guam, Saipan, and American Samoa. One of our most important protocols performed in the national parks on west coast of the Island of Hawai‘i is water quality, which is implemented in numerous anchialine pools. Five sites at Kīholo in the Pu‘u Wa‘awa‘a ahupua‘a are part of water quality sampling along the Ala Kahakai National Historic Trail (ALKA).

Beginning in April 2008, two sites were sampled at Kīholo: the Hind Well and Upper Keanalele. Sampling continued at the Hind Well until May 2011, when the site was discontinued for safety concerns. Sampling continued at Upper Keanalele until December 2016, when the site was discontinued due to permitting and safety concerns. In 2018, staff from PACN and ALKA met with the Hui Aloha Kīholo board to present results and discuss adding additional sampling sites to support ongoing projects. In February 2020, PACN began sampling at the two pools at Waia‘elepī (hereafter referred to as Waia‘elepī and Waia‘elepī iki) and Lower Keanalele. Additionally, sampling resumed at the Hind Well because the site had been improved and no longer poses a safety concern.

Water quality sampling involves collection of water samples for nutrient analysis in the lab and measures of general water characteristics with a water quality instrument called a sonde (Table 1). Each measure was chosen for its importance in detecting changes related to human-induced disturbances or natural processes with significant impacts to the ecosystem.

Table 1. List of water quality parameters measured during quarterly sampling events.

Parameter	Definition	Affected by
Total dissolved nitrogen (TDN)	An essential nutrient, naturally very common	Erosion/run-off, fertilizers, animal waste, vegetation
Total dissolved nitrates + nitrites ($\text{NO}_3^- + \text{NO}_2^-$)	An essential nutrient, naturally very common	Erosion/run-off, fertilizers, animal waste, vegetation
Total dissolved phosphorus (TDP)	An essential nutrient, not naturally common	Erosion/run-off, fertilizers, detergents
Temperature	Kinetic energy of particles (expressed as heat)	Groundwater vs. seawater input, weather conditions, depth, stagnancy, long-term environmental change
pH	Measure of acidity (4=acidic, 7=neutral, 10=basic)	Chemical and biological processes
Salinity	Measure of dissolved salts	Groundwater vs. seawater inputs
Dissolved oxygen	Measure of oxygen level dissolved in water	Biological processes, stagnancy
Turbidity	Measure of suspended solids in water (clarity/cloudiness)	Erosion/run-off, invasive fish, surrounding vegetation, plankton, bacteria, suspended algae
Chlorophyll	Measure of the concentration of suspended algae	Increased nutrient levels can trigger algal blooms.



Monitoring Results

All water quality parameters measured in 2020 through 2023 were similar at the two subterranean sites, the Hind Well and Lower Keanalele, and there was little change in any parameter at the Hind Well compared to results previously reported for 2008 to 2011 (Table 2 and Figure 1). Water quality parameters were also similar at the two pools at Waia‘elepī. At all sites, nutrient levels were typical of other anchialine pools monitored along the west coast of the Island of Hawai‘i and were relatively stable. Temperature was cool and stable at the Hind Well and Lower Keanalele, ranging from 70.7 to 72.1°F (21.5 to 22.3°C). Temperature showed a seasonal pattern at the Waia‘elepī pools, ranging from 70.9 to 82.2°F (21.6 to 27.9°C). There was variation in pH among the sites, but pH was generally slightly basic and stable, averaging at 7.7 for the Hind Well, 8.2 for the Waia‘elepī pools, and 7.8 for Lower Keanalele. A pH between 6.5 and 8.5 is generally considered good water quality for freshwater systems. Salinity followed a predictable pattern of decreasing salinity with distance from the shoreline, but all sites were very fresh, averaging 2 parts per thousand (ppt). Freshwater usually has a salinity value around 0 ppt, and seawater usually has a value around 35 ppt. At the Hind Well and Lower Keanalele dissolved oxygen saturation was high and stable and turbidity (water clarity) and chlorophyll (algae concentration) were very low, indicating very clear water. At the Waia‘elepī pools dissolved oxygen, turbidity, and chlorophyll were more variable, reflecting observed algal blooms.

Summary and Recommendations

Water quality measured at the Hind Well in 2020 through 2023 were very similar to measurements at Lower Keanalele and past measurements at the Hind Well and Upper Keanalele, indicating that water quality in the subterranean habitat is relatively stable. Water quality at the Waia‘elepī pools showed seasonal variation in temperature, dissolved oxygen, turbidity, and chlorophyll, which is expected and well within the normal range of these parameters in anchialine pools of west Hawai‘i. The presence of invasive fish in these two pools poses concern for ecosystem health because they predate the native shrimp and damselfly larvae, however, there is no indication that they are influencing the water quality condition currently. All sites monitored at Kīholo were very fresh with salinity values around 2 ppt. At all sites, nutrient concentrations for total dissolved nitrogen (TDN), total dissolved phosphorus (TDP), and nitrates plus nitrites (NO₃+NO₂-) were well within the normal range measured in the anchialine pools of west Hawai‘i. Several factors could influence nutrient concentration in the pools including erosion and runoff; the use of fertilizers, detergents, and other chemicals around or upslope of the area; local vegetation; and animal waste. We continue to monitor water quality at these locations and will provide updates as certified data become available.

More Information

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Program reports, protocols, and data products:

<https://irma.nps.gov/DataStore/Reference/Profile/2238112>



Summary of Water Quality Monitoring at Kīholo 2008-2023

Table 2. Average water quality values by year for Kīholo anchialine sites. The detection limit for turbidity was 0.10 FNU and the detection limit for chlorophyll was 0.10 µg/l. Any values that were recorded below the detection limit are replaced with the detection limit for reporting.

Site	Year	NO ₃ ⁻ +NO ₂ ⁻ (mg/l)	TDN (mg/l)	TDP (mg/l)	Chlorophyll (µg/l)	Dissolved Oxygen Saturation (%)	Salinity (ppt)	Temp. (°C)	Turbidity (FNU)	pH (None)
Hind Well	2008	0.66	0.64	0.06	0.1	94.0	2.0	21.5	0.1	7.6
Hind Well	2009	0.74	0.79	0.06	0.1	95.1	2.1	21.5	0.1	7.5
Hind Well	2010	0.79	0.85	0.06	0.1	95.1	2.0	21.6	0.3	7.7
Hind Well	2011	0.93	0.89	0.07	0.1	95.7	2.0	21.4	0.1	7.4
Hind Well	2020	0.98	1.10	0.09	0.1	96.7	1.9	21.8	0.5	7.6
Hind Well	2021	0.89	1.04	0.07	0.1	95.6	2.0	21.7	0.1	7.8
Hind Well	2022	0.89	1.03	0.07	0.2	95.4	2.0	21.6	0.1	7.8
Hind Well	2023	0.76	0.87	0.07	0.1	95.2	2.0	21.7	0.1	7.7
Lower Keanalele	2020	0.77	0.89	0.07	0.1	96.4	2.3	21.9	0.1	7.7
Lower Keanalele	2021	0.69	0.75	0.06	0.1	95.8	2.4	21.8	0.1	7.8
Lower Keanalele	2022	0.73	1.02	0.06	0.1	95.2	2.4	21.8	0.1	7.8
Lower Keanalele	2023	0.67	0.82	0.06	0.1	95.2	2.3	21.7	0.1	7.7
Upper Keanalele	2008	0.56	0.53	0.05	0.1	94.4	1.8	21.5	0.1	7.7
Upper Keanalele	2009	0.63	0.69	0.05	0.1	95.7	1.9	21.5	0.5	7.6
Upper Keanalele	2010	0.68	0.78	0.06	0.1	94.7	1.8	21.6	0.3	7.8
Upper Keanalele	2011	0.70	0.73	0.06	0.1	95.1	1.9	21.4	0.1	7.7
Upper Keanalele	2012	0.67	0.70	0.06	0.1	94.9	1.9	21.4	0.1	8.1
Upper Keanalele	2013	0.69	0.73	0.06	0.1	95.1	1.9	21.6	0.1	7.6
Upper Keanalele	2014	0.77	0.77	0.06	0.1	94.9	2.3	21.5	0.3	7.5
Upper Keanalele	2015	0.71	0.75	0.06	0.1	95.2	2.0	21.4	0.1	7.8
Upper Keanalele	2016	0.75	0.87	0.06	0.1	95.8	1.7	21.6	0.1	7.6
Waia'elepī	2020	0.58	0.70	0.05	8.5	131.6	2.1	24.0	1.4	8.0
Waia'elepī	2021	0.45	0.56	0.04	3.5	159.3	2.1	24.9	1.7	8.4
Waia'elepī	2022	0.55	0.76	0.04	3.8	128.3	2.2	25.3	1.8	8.3
Waia'elepī	2023	0.42	0.54	0.03	2.1	122.0	2.2	24.8	1.4	8.1
Waia'elepī iki	2020	0.47	0.59	0.05	3.4	109.3	2.2	24.1	0.9	8.0
Waia'elepī iki	2021	0.19	0.30	0.02	4.8	142.0	2.2	24.2	3.0	8.5
Waia'elepī iki	2022	0.61	0.80	0.04	5.2	86.0	2.2	24.2	1.6	7.9
Waia'elepī iki	2023	0.33	0.45	0.02	4.1	102.9	2.3	24.6	2.7	8.0

mg/L = milligrams per liter

µg/L = micrograms per liter

FNU = Formazin Nephelometric Units

ppt = parts per thousand



Summary of Water Quality Monitoring at Kiholo 2008-2023

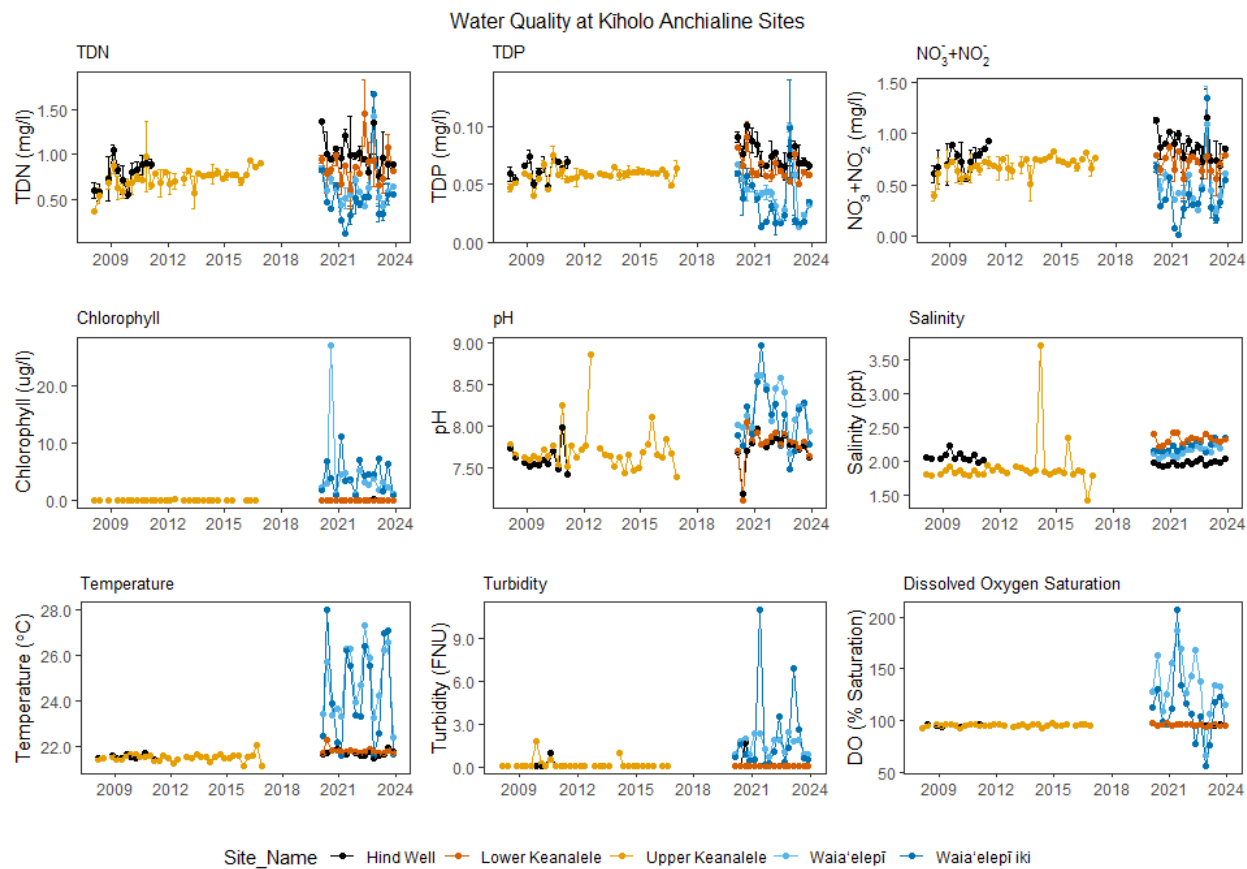


Figure 1. Water quality results at the anchialine pool sites at Kiholo for 2008 to 2023.