HYDROLOGY GROUP SUMMARY

9.16.25

I. Background

Fresh water in the Keauhou Aquifer System Area (KASA) exists in at least three groundwater bodies: a basal lens near the coast, a deeper confined groundwater body beneath the basal lens, and a high-level groundwater body farther inland. The connection among these groundwater bodies is not well understood. Nearshore and offshore groundwater-dependent ecosystems (GDEs) such as anchialine pools, fishponds, estuaries, and reefs, depend on natural discharge of fresh groundwater from the KASA. These GDEs are important sites for biodiversity and Native Hawaiian traditional and customary (T&C) practices which include, among others, food collection, water gathering, and bathing. The Commission on Water Resource Management (CWRM) is obligated to balance the withdrawal and use of groundwater with the protection of these T&C practices under the public trust doctrine.

In an effort to update the current understanding of Keauhou's hydrology, CWRM convened three initial meetings with hydrology experts Brytne Okuhata, Don Thomas, and Heidi Kāne. These meetings were led by CWRM staff Ryan Imata, facilitated by their consultant Peter Adler, with additional input from the Adaptive Management Plan (AMP) advisor Scot Izuka. Each meeting lasted about two hours and included other CWRM staff and AMP advisers who listened, observed, and participated in group discussions at the end of each meeting.

II. Initial Goals

The meetings were meant to be a comfortable consensus-seeking exchange of ideas with five aspirations:

- Identify and agree upon a general conceptual (prevailing) model for groundwater flow in the KASA and articulate underlying assumptions, including hypotheses of how groundwater moves through the aquifers;

- Identify possible specific AMP baseline-monitoring indicators to test these hypotheses;

- Articulate the current assumptions behind each recommended indicator;

- Design a preliminary monitoring program to accompany the AMP baseline-monitoring indicators, including what to monitor for, frequency of monitoring, and monitoring sites; and

- Prioritize a short list of specific additional future research projects and questions that will inform subsequent updates to the AMP.

III. Take-Aways from the Expert Discussions

A. **Keauhou is Enigmatic**. Though some of the hydrogeology in the KASA is known, some of its fundamental characteristics remain unknown. The water bodies within the KASA do not fit the single freshwater lens conceptual model that is the basis for most aquifers in Hawai`i and on which the Robust Analytical Model (RAM) is based. RAM is a simple model used to calculate sustainable yield in basal aquifers. Given the complexity of the KASA's hydrogeology and CWRM's need to assess the impacts of groundwater withdrawal for all current and prospective users of water from the Keauhou aquifers, there is a need to establish a new framework for managing all the groundwater aquifers in the KASA.

B. **Interconnectivity is not well understood.** The conceptual model for Keauhou groundwater currently includes: (a) a thin freshwater basal lens that extends from the shoreline into the flank of Hualālai by a yet undefined distance; (b) one or more deeper fresh groundwater bodies beneath confining geologic structures (and possibly underlain by deeper confining structures) that extend from the submerged flank of Hualālai into its interior, also by an undefined distance; and (c) a high-level groundwater body farther inland with a water table that is substantially higher than that in the coastal basal lens.

Based on constructed wells and water-level information, the high-level groundwater body extends to the north at least as far as the Kalaoa Well; farther north, water levels drop off sharply to those typical of a basal lens. Existing hydrogen- and oxygen-isotopic data indicate possible interconnectivity among the three groundwater bodies, but the locations and magnitudes of the connection(s), and how pumping from one body may affect flow in the others, are not fully understood.

The high-level and deep-confined water bodies have similar hydrogen- and oxygen-isotopic compositions – that are quite distinct from the compositions of the basal groundwater – and suggest a possibly close connection between the former two bodies. The isotopic compositions of the high-level and deep-confined water bodies indicate that they are likely recharged from the upper elevations of Hualālai, Mauna

Loa, and Mauna Kea, far outside the geographical region typically attributed to recharging the KASA. The isotopic composition of the basal lens waters is more similar to what would be expected for direct rainfall infiltration, but the isotopic and chloride data indicate some contribution from one or both of the other two water bodies.

C. **Future Rainfall and Recharge**. Projection of recharge rates to these aquifers into the future carry inherent uncertainty, but current studies indicate the possibility of statistically significant declines in rainfall into the future. Future recharge to the KASA may be reduced by rainfall decline. One estimate, for the mid-century (2041-2071) is that recharge may be reduced to 62 million gallons per day (MGD), representing a 38% decline from the current estimate for recharge. It should be noted that these estimates are predicated on the (possibly incorrect) assumption that recharge to the system area is confined to the geographic region defined by the KASA.

D. **GDE Indicators to Monitor**. Critical hydrologic indicators for benchmarking and monitoring at sentinel sites can, and should, build off existing data sources (e.g., currently approved production and monitoring wells, and data collected by the Natural Energy Laboratory of Hawaiʻi Authority, National Park Service's Kaloko-Honokōhau National Historical Park, and Queen Liliʻuokalani Trust).

Salinity monitoring is important for anchialine pools, as some coastal species that reside in these pools require specific brackish conditions, but not much is known about the salinity thresholds under which different species thrive. There are natural fluctuations of water and salinity levels attributed to tides and seasonal changes. Monitoring water levels and salinities in these GDEs, as well as biota counts, in conjunction with the collection of well pumpage, rainfall changes, salinity profiles, and tides can help assess the impacts of changes in fresh water influx related to both groundwater use by humans and climate change.

Another valuable parameter to monitor is the hydrogen and oxygen isotopic compositions at multiple points in the water column to: (1) gain insights into the relative contributions of the different source water bodies supplying the GDE and nearshore groundwater on which the GDE depend; and (2) enable CWRM to monitor changes in the relative contributions from the three water bodies as a result of changes in groundwater withdrawal as well as long-term climate impacts. Analyzing stable isotopes will help to determine (1) where [at what altitude] the recharge occurs and (2) if and how water from different recharge areas may have mixed to shed light on possible interconnectivity of the various fresh groundwater bodies.

CWRM does not currently collect groundwater hydrogen and oxygen isotopic data from their deep monitor wells. Rather, salinity profiles and water levels are collected on a quarterly basis. Additionally, there are wells where water levels are measured in the high-level and the basal water bodies. In conjunction with salinity profiles, these help to assess the health of the aquifer bodies.

E. Placement of Future Monitoring Wells

The Hawai`i State legislature has appropriated four million dollars for a pilot study for Keauhou. This funding was estimated based on two new undefined monitoring wells. Discussion among the group of how to best utilize these funds yielded a few possible projects.

One suggestion was to drill a new well into the deep-confined fresh groundwater body and determine whether a bottom confining layer is present that would limit its volume or discharge rate. If a bottom confining layer did not exist, and there was a transition zone in the sub-basal deeper confined water body, the Ghyben-Herzberg principal would apply and therefore the transition zone for this confined aquifer could be monitored in the same way that CWRM monitors a typical basal lens. While this would be valuable information, it could also be very expensive. One, possibly more cost-effective, suggestion was to deepen an existing monitoring well, although doing so has challenges of its own that need to be further explored.

Water-level data under non-pumping conditions are seldom, if ever, collected or reported from production wells. Requiring these measurements as a condition for future permits would document the impacts of pumping on local water levels (heads) and might tie directly into the AMP's goal of informing pumping permit decisions and helping expand indicators into possible conditions for permits.

Piezometers—a specific type of monitoring well with a relatively short, specified “open” interval—could provide valuable insight to the hydraulics of the different fresh groundwater bodies in the KASA and how interconnected they may be. For example, one piezometer could be installed to monitor the basal lens and another installed to monitor the deep confined body. Data from these piezometers could help determine whether new pumping from the high-level groundwater body causes changes in the basal lens, the confined body, or both, and to what degree. The alternative—a single monitoring well that is open to both groundwater bodies—will only provide a less-informative average of the hydraulics.

Another common monitoring approach is to conduct periodic synoptic water-level surveys. These surveys consist of nearly simultaneous water-level measurements in multiple wells over a specified area. If done periodically, successive surveys can be compared to assess changes in the shape of the water table in response to pumping, climate change, or other related processes.

F. Different Aquifer Management Strategies

It is recognized that the single-aquifer sustainable yield management approach (a) does not account for the multiple fresh groundwater bodies in the KASA; (b) does not account for the impacts to GDEs; and (c) is probably not realistic given the geographic regions that potentially recharge the multiple fresh groundwater bodies. Given these shortcomings, an alternative approach to management of the KASA is needed.

Among the alternatives considered were the assignment of individualized sustainable yields to each of the three water bodies, and management of withdrawals from each based on managing salinity thresholds, or by some combination of managing other indicators that are associated with contributions by each water body to the GDE. In the immediate term, valuable information can be gained by increasing the data recovered from future wells into any of these aquifers. In particular, requiring careful measurement of water levels before drilling resumes each day would allow the identification of perched or confined water bodies during drilling. With a properly designed AMP, the management approach can be modified as more is learned about the KASA from future monitoring and research.

G. **Future Studies**.

To further study the boundaries, interconnections, health, and discharge of the aquifers, the following investments could yield insights:

- Additional submarine groundwater discharge (SGD) surveys can be done to understand both the location of the discharge of groundwater, as well as possible changes over time.

- Monitor the head and the salinity profile in the basal lens and in the deeper confined fresh groundwater body (if it does not have a bottom confining unit).

- Analyze historical Keauhou pumpage records, rainfall data, and anchialine-pool data to observe any possible correlations and trends.

- Undertake surface-based geophysical surveys (e.g. aeromagnetics or seismic reflection) to potentially identify large-scale features that may be causing the enigmatic high-level groundwater body

- Conduct core drilling along upper highway to establish the geology of the high-level groundwater body.

- Conduct studies using natural or artificial tracers to analyze the movement and interconnectivity among the fresh groundwater bodies.