

**Guam Hydrologic Survey
and
Comprehensive Water
Monitoring Program**

**FY 2025
Annual Report**

WERI

**WATER AND ENVIRONMENTAL RESEARCH INSTITUTE
OF THE WESTERN PACIFIC
UNIVERSITY OF GUAM**

October 2025

Intentional page

**Guam Hydrologic Survey
and
Comprehensive Water Monitoring Program**

**FY 2025
Annual Report**

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October 2025

Water & Environmental Research Institute
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Introduction

This annual report covers three main sections. The first section is about the Guam public laws Guam Hydrologic Survey (GHS, P.L. 24-247) and Comprehensive Water Monitoring Program (CWMP, P.L. 24-161). This section includes the WERI organization of tasks, responsibilities, data flow, and research assistants. The next section covers GHS hydrologic information management, research focus, and education/training and outreach activities. The last is the CWMP report, focusing on the expansion of observation sites, data collection and submission, and support.

Guam Public Laws 24-247 and 24-161

In 1998, the 24th Guam Legislature enacted Public Laws [24-247](#) and [24-161](#) as the Guam Hydrologic Survey (GHS) and the Comprehensive Water Monitoring Program (CWMP), respectively. These two laws were ratified in response to an El Niño event in 1998, resulting in a prolonged drought that advised water rationing practices. CWMP addresses the need for continued collection of hydrologic data and GHS to conduct more hydrologic and water resources research. WERI is charged with administering the annual legislative appropriations necessary to facilitate, direct, and implement the program's primary objectives. Both programs are now integral to the WERI water resources research, information dissemination, education, and training mission.

The foresight of the Guam Legislature in creating these two vital programs deserves special mention. Through their efforts and continued support, WERI advances in consolidating and interpreting several essential water resource information, constructing hydrologic information for Guam, and revitalizing the USGS water resource monitoring program. Our understanding of the complex physical, chemical, and biological processes that influence Guam's water resources has broadened, and the increase in graduate student research opportunities provided by the programs contributed to the number of highly trained water resource professionals in the island's workforce.

Guam Hydrologic Survey Program (GHS)

The purpose of GHS is to consolidate all of Guam's available hydrological data gathered by local and federal government agencies and consultants, and to conduct research on water-related issues of local importance. GHS also funds a variety of water resource educational programs in various formats, including guest lectures and seminars at UOG and in the community, informational and training workshops for teachers and professionals from other government agencies, field trips and talks for students, and the publication and distribution of educational posters, maps, and fact sheets. In addition, GHS also funds research assistants and associates who engage in CWMP activities, including fieldwork with USGS' observation well data collection, and phreatic groundwater and hydrologic data analyses.

For twenty-six years, WERI has continued to operate and administer the GHS Program. The GHS and CWMP Annual Reports are now available online on the GHS website:

<https://guamhydrologicsurvey.uog.edu>
[GHS Annual Reports](#)

WERI serves numerous island agency partners through the GHS Program, attending legislative hearings, providing research findings, sharing hydrologic and geologic maps, and advising on water resource concerns. Through the GHS Program, reliable research-based information can be achieved. Therefore, the Guam Legislature, Guam Environmental Protection Agency (GEPA), Guam Waterworks Authority (GWA), NAVFAC Marianas, and the Groundwater Resources Development Group (GWRDG) are more confident in determining management plans, actions, and regulations involving our water resources. WERI shared water research findings and advised agencies on wastewater issues, aquifer capacity, hydrogeologic assessments, surface hydrology, saltwater intrusion, and the new online data visualization products.

WERI provided GHS outreach to the Northern Guam Soil and Water Conservation District, GWA, the Legislature, Guam DOE, visiting universities, and the private sector with the Virtual Tour into the Northern Guam Lens Aquifer. Post social distancing protocols, in 2024 the GHS Program, with the services of Global Learning and Engagement (GLE UOG), WERI resumed the Northern Guam Lens Aquifer Virtual and Site Tour.

WERI continues to expand GHS interagency support through its online web products. Since developing the GHS website in 2016, WERI manages and produce new hydrologic reports, presentations, maps, and databases. WERI continues to develop new online data visualization products—a new means of sharing hydrologic data through interactive maps and graphs, such as WERI Web MApps and MAppFx.

Comprehensive Water Monitoring Program (CWMP)

The CWMP is the core of essential water information, through approved measurements and analytic methods, the basis of hydrologic research interpretations. The CWMP was created to gather data on saltwater intrusion and water lens profiles in Guam's sole source aquifer in the northern part of the island. Stream flow data and other parameters associated with surface waters are collected in the south. Moreover, the program collects rainfall data for hydrologic, meteorologic, and climatologic studies. These are essential for determining sustainability assessments and water supply capacities.

The CWMP rehabilitated data collection assets that fell into disrepair. CWMP allowed WERI to obtain services from USGS Pacific Island Water Science Center (PIWSC) to collect, organize, and manage hydrologic data from stream gages, rain gages, and observation wells. Government of Guam and USGS PIWSC funds the CWMP, restores the Federal/State Territory cost-sharing for continued hydrologic monitoring.

USGS PIWSC methods ensure that data are frequently and reliably collected, analyzed, and made widely available. Most data from USGS gages are readily accessible online. PIWSC collected hydrologic information for Guam are consolidated, quality is marked with provisional and approved, and made available online:

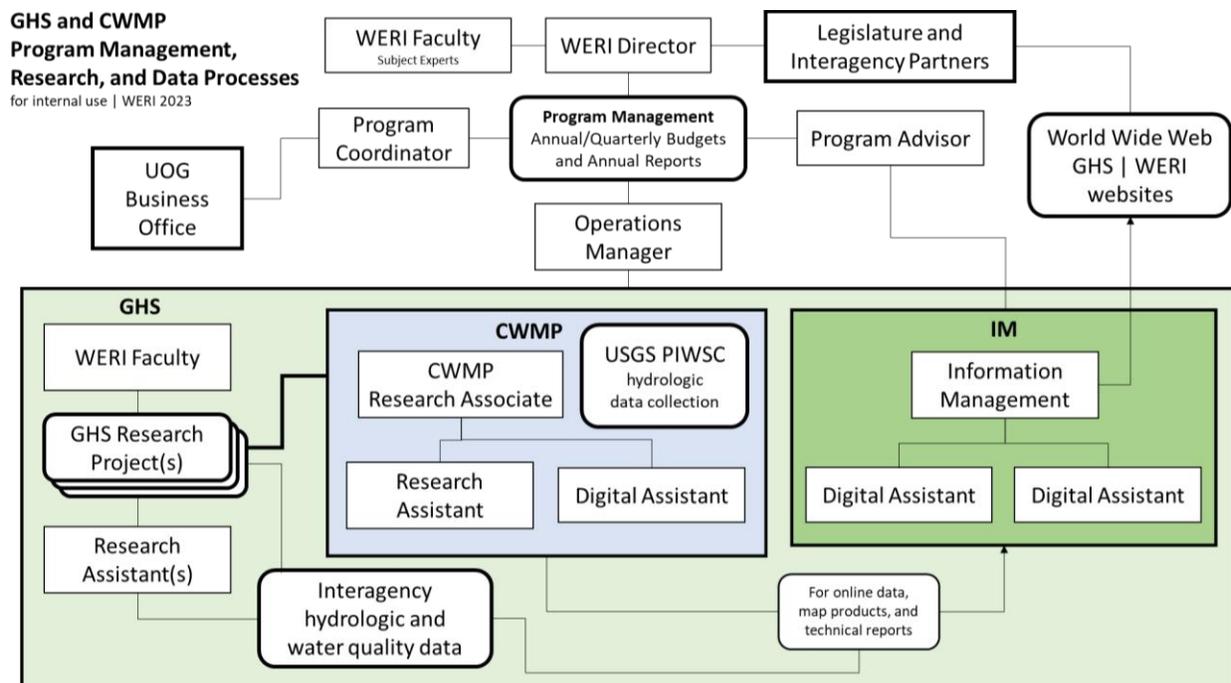
<http://hi.water.usgs.gov>

CWMP data is analyzed and interpreted. GHS employs research assistants and research associates to organize, analyze, and interpret CWMP data. CWMP is essential to GHS projects that processes and analyzes and interprets the collected data.

Organization and Operations

GHS and CWMP are organized by a program management team that involves the WERI Director and a support panel of WERI Faculty subject experts, the Program Coordinator, Operations Manager, and the Program Advisor. The WERI GHS and CWMP Program continue to improve and may also change the internal organizational structure yearly to streamline operations, management, processes, and product output. The organization is also crucial for determining the program's resource requirements, project focus, and annual budget. The figure below is an internal WERI GHS and CWMP personnel position and process diagram.

GHS analyzes water resource data for investigative research and the production of reports. WERI Faculty proposes GHS projects annually and selects the best available research assistants to conduct a GHS-related project. This opens opportunities for a research assistant to do a master's thesis through UOG's Environmental Science Program. GHS also has an Information Management team that oversees and develops both the WERI and GHS websites. The Operations Manager collects project summaries from faculty projects, CWMP projects and activities, and Information Management, and manages the organization and drafting of the GHS and CWMP Annual Reports.



Organization and operations

GHS Research Assistants

The following are GHS funded research assistants, educational level, and project focus.

Research Team

Mary Clare Snaer

Environmental Science Graduate Student

Hydrologic analysis of deep observation wells

CWMP digital and field Research Assistant

Risel Uludong

Environmental Science Graduate Student

Groundwater Protection Zone

Research Assistant

Nicole Mathews

Environmental Science Graduate Student

Landcover analysis

Research Assistant

Jovic Caasi

MS Mathematics

Groundwater Modeling Systems (GMS) groundwater model analysis

Research Assistant

Atasha Bautista

Undergraduate Chemistry and Biology

Groundwater solute transport model preparation and application, GIS spatial analysis, feature analysis, and data organization

Research Assistant

GHS Information Management Team

Dannika Kate U. Valerio

B.S. Computer Science and Communications, Information Manager

Lead GHS and WERI website management, design, programming, data visualization products development, and WERI News

Sydney M. Quintanilla

Undergraduate Computer Science, Digital Assistant

Assists with website designs, updates, and hydrologic data organization, programming, and data visualization product update

The GHS operations and administration has posted job announcements to fill a few more research assistant/associate positions in the information management (1 Digital Assistant) and CWMP (1 CWMP Research Associate and 1 Research Assistant) sections. Job announcement for Research Assistants for research (and thesis) projects are posted as well at the UOG website ([HRO Online Employment Portal](#)).

Guam Hydrologic Survey Report

The Water and Environmental Research Institute of the Western Pacific continues to operate and manage the Guam Hydrologic Survey (GHS) and Comprehensive Water Monitoring Program (CWMP). The following are data and research product report status of GHS and CWMP for FY 2025. GHS continues with the online information management systems and operations to organize and make hydrologic and water resources information available online. Information management includes development of online interactive data visualization products, MAppFx and Web MApps. GHS also has hydrologic research components and outreach programs. Hydrologic research investigates vulnerabilities, resilience, and sustainability of water resources under known environment and climate conditions. The research also focuses on data collection, organization, analysis, and interpretation for determining sustainable practices. Then the ongoing/completed scientific research recommendations are presented through WERI GHS outreach and educational services.

GHS Information Management

D.K.U Valerio, S.M. Quintanilla, and N.C. Habana

The Information Management (GHS IM) develops the GHS website, which is the worldwide interface for accessing Guam's available hydrologic information. The secure website is a UOG web domain, and the address is:

guamhydrologicsurvey.uog.edu

University of Guam's (UOG) Web Team, Office of Information Technology (OIT), manages the GHS website security and hosting. The content management system, development platform, is WordPress®. The GHS Program addresses an accountable task in public law—dissemination of Guam's pertinent hydrologic information.

WERI leads the island with an online hydrologic information system for local interagency partners and for anyone's interest worldwide. The effectiveness of the website is expressed by interagency partners who mention referencing the online information. The GHS website superiorly improved program management with data and information organization, improved information access, and reduced the need for printing. Other UOG research organizations are now interested in following WERI's lead in developing their own online database system. The GHS IM team organize, design, develop, and apply computer programming to the website's interface and online data visualization.

GHS Website Content and Navigation

In the Spring of 2025, OIT and GHS IM met to address the changing landscape of website securities and vulnerabilities. OIT had checked and concluded that the current template for the GHS website had ceased its security updates. To protect UOG's network, data systems, and server structure from cyber-attack vulnerabilities, WERI needed to update the entire GHS website into a new OIT approved Word Press template with the latest and continuous security updates. The new GHS website development is underway, and the current (old) version will be phased out soon—target is end of the year.

The GHS website stems from a modern version of the classic webpage design, including a traditional main menu bar. The menu bar lists: REO (Research,

Education and Outreach) Agendas; Sustainable Management; Groundwater | Hydrogeology; Hydrology; Climate | Weather; Wastewater | Toxicology; Library; and About GHS (see following figure). Each menu item has a dropdown list. A photo slider of essential content links on the home page is below the menu bar, followed by information on upcoming events, the latest news, sustainable management, annual reports, interagency partners, charters and agreements, and GHS and CWMP mission statements and goals. White papers and program reports are found in the REO Agendas and Sustainable Management tabs, respectively. The REO tab contains years of WERI white papers about REO. The Sustainable Management tab contains the Annual Reports, and unit organization and management of its operations. The following four tabs refer to components of the hydrologic cycle, beginning with groundwater and hydrogeology. Each of these hydrological menus contains pertinent, recent, and significant published WERI research work with technical reports, publications, maps, data visualization products, and databases. The GHS website is often presented at the annual Guam Advisory Council Meetings and in the Global Learning and Engagement WERI Workshop 2025. The workshop also unveiled and demonstrated the use of WERI's new online data visualization products, further discussed in the next section.



Guam Hydrologic Survey website homepage, phase out of this unsupported template is in progress

GHS Website Migration and Updates

As mentioned above, the GHS website is undergoing a migration to a more secure and reliable platform. This is to ensure there are no security vulnerabilities and that the site is compatible with modern website standards. At the same time, the GHS Information Management team is in the process of rolling out major updates to improve performance, reliability, website features, and cross-platform accessibility to enhance browsing experience. During this transition, users visiting the old GHS website may experience temporary interruption or limited functionality. Currently, a

message appears on the GHS website notifying users and visitors of the ongoing site construction.

The appearance of the new GHS website takes on a fresh look that is responsive to different devices, such as PC desktops, tablets, and mobile phones. In addition, dark mode is included as a feature to increase comfort and usability. It can be toggled through a switch found in the main menu bar on the top of the page.

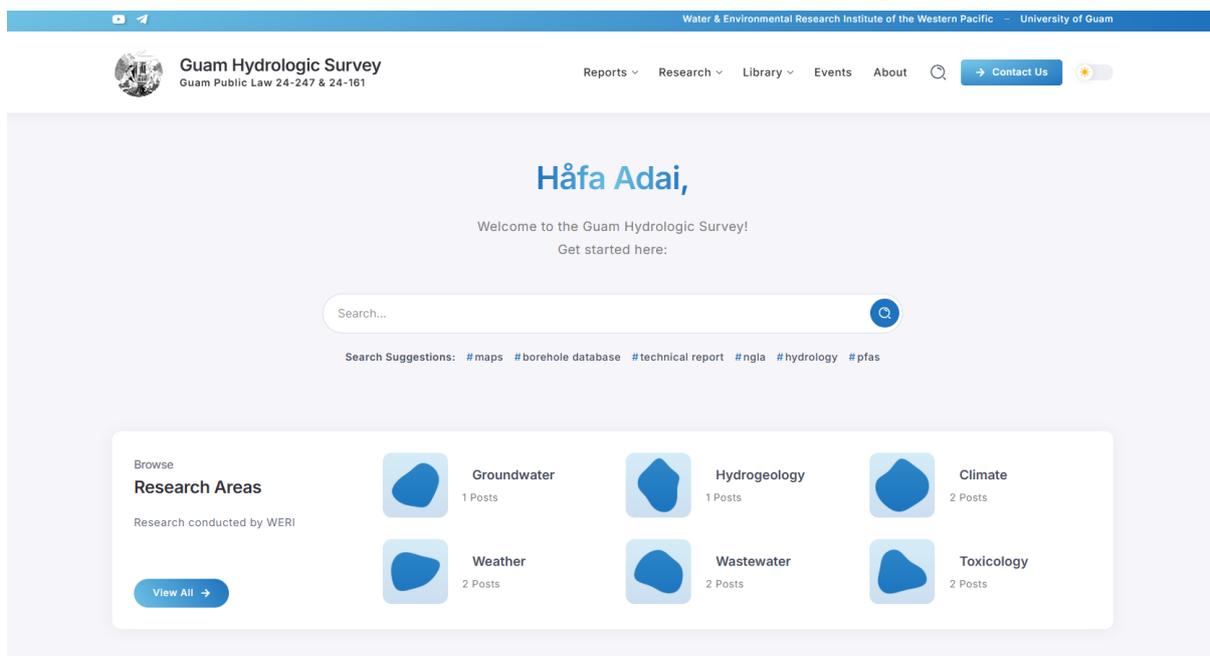
The new and improved GHS website will house the same content from the previous site, but the content and navigation adopt a different structure.

The menu bar towards the top of the bar still stands as the main form of user navigation with an updated look. Its content was condensed into five main sections: Reports, Research, Library, Events, and About. In addition, the search bar has been improved next to the Contact Us button.

Upon hovering over the Reports link in the menu bar, it reveals 4 sections: GHS Annual Reports; State of the Aquifer Reports; Research, Education, and Outreach Agendas; and Sustainable Management Reports. Below each of these sections, the most recent reports appear for convenience.

When hovering over the Research link in the menu bar, it reveals 4 research areas—Groundwater & Hydrogeology; Hydrology; Climate & Weather; and Wastewater & Toxicology. Below each of these sections, the most recent posts appear for users to browse through. The user can also click on the name of the research area, which will lead them to all the available posts for that research area.

Hovering over the Library, users will see the 5 different sections, which include the following: Sort & Search, a PDF library for WERI publications; Presentations, a library containing PDF and PowerPoint files from WERI workshops and advisory council meetings; Maps & Posters, a library containing historic maps and Google maps; Web MApps, which features interactive maps from WERI and interagency



Preview of the new GHS website's homepage as of October 2025. As updates continue, the appearance of the site is subject to change.

partners; and MAppFx, which are interactive maps and data visualizations created by WERI. Links to databases, such as the Borehole Database (BHDB) and Chloride and Production Database (CPDB), also pop up in this section for convenience.

The front page greets users with a convenient search bar to lookup available resources, a section highlighting the most recent research projects conducted by WERI, and sliders that spotlight the latest Web MApps and MAppFx projects available. Towards the bottom of the page are links to available resources—such as the extensive library, database, and reports. These items are also accessible in the main menu bar.

The new site is under active development, so styles and appearance of features may shift as the team experiments with design iterations. The content migration is expected to be complete by the end of this year, and refinements to the site's overall layout and design will continue into the next year.

More Online Data Visualization Products

Online data visualization is now of great interest with interagency partners for its organization, an interactive and intuitive interface, and reliable reference. WERI's development of MAppFx and Web MApps has made large data organization useful, modern, and practical. The WERI GHS IM team has presented MAppFx and Web MApps at conferences and meetings: University Council On Water Resources – National Institute of Water Resources (UCOWR-NIWR 2023), Guam Advisory Council Meeting (2023), National Groundwater Association (NGWA 2023), WERI-FCU Taiwan Exchange Event (2024), GLE-WERI Workshop (2024), AWWA Conference (2024), Guam Advisory Council Meeting (2024), WERI-CWNU G-LAMP South Korea Exchange Event (2025), UOG CIS Conference (2025), and GLE-WERI Workshop (2025). From samples shown in advisory council meetings for the Western Pacific, stakeholders from CNMI are now sharing nitrates and chloride data to help with data management. Showcased in the 2024 AWWA Conference (Hyatt, Tumon) for CNMI BECQ, Yap is now interested in having their data converted into a MAppFx product.

In 2023, WERI developed two MAppFx products: Ugum Watershed Stream Flow Duration Curves and Northern Guam Lens Aquifer Production Well Nitrates. WERI now expands and develops more online data visualization products on the GHS website. MAppFx products are also found in the link:

<https://guamhydrologicsurvey.uog.edu/index.php/mappfx/>

The following sections detail the new MAppFx projects and updates underway for existing MAppFx projects. These include the following: Northern Guam Lens Aquifer Production Well Nitrates; Southern Guam Watersheds: Streamflow Duration Curves; Chloride and Production; Deep Observation Wells; Production Well Nitrates and Chloride for Saipan, CNMI; Streamflow Duration Curves for Pohnpei and Kosrae, FSM; and a Geology Photo Gallery.

MAppFx: Northern Guam Lens Aquifer Production Well Nitrates

D.K.U. Valerio, M. W. Zapata, and N.C. Habana

[WERI Technical Report 180](#) | [GHS Online Summary Report](#) | [View MAppFx](#)

Many water resource researchers and agencies have longed for an interactive database map that is easy to access, especially in discussions and decisions for

water source protection and production management. Web development tools, namely JavaScript libraries and frameworks, offer a wide range of resources to create interactive map and graph platforms. With the availability of these tools, the WERI GHS IM team can pursue avenues for online hydrologic databases. This led the team to develop a data visualization interface that features a map of survey points, or areas within polygons or polyline boundaries, with historic data. To store the map's geographic metadata and data for the plot, a JSON (JavaScript Object Notation) file was used. As a result, the first data visualization product in the MAppFx series, which features an interactive map of Guam's production wells and nitrate data, which was based on a WERI research by J. Bulaklak and N.C. Habana (2021). Users can interact with the map through layer toggles, drawing tools for highlighting select areas or presentation purposes, and information panels detailing statistical analysis and time series plots of available nitrate data.

This MAppFx was completed in 2023, but updates to the nitrate data are in progress. The data updates are pending as onboarding and training for a new WERI GHS IM team member are currently underway for the transfer of information. Once training is complete, the latest data will be incorporated into the MAppFx's JSON database.

MAppFx: Southern Guam Watersheds – Streamflow Duration Curves

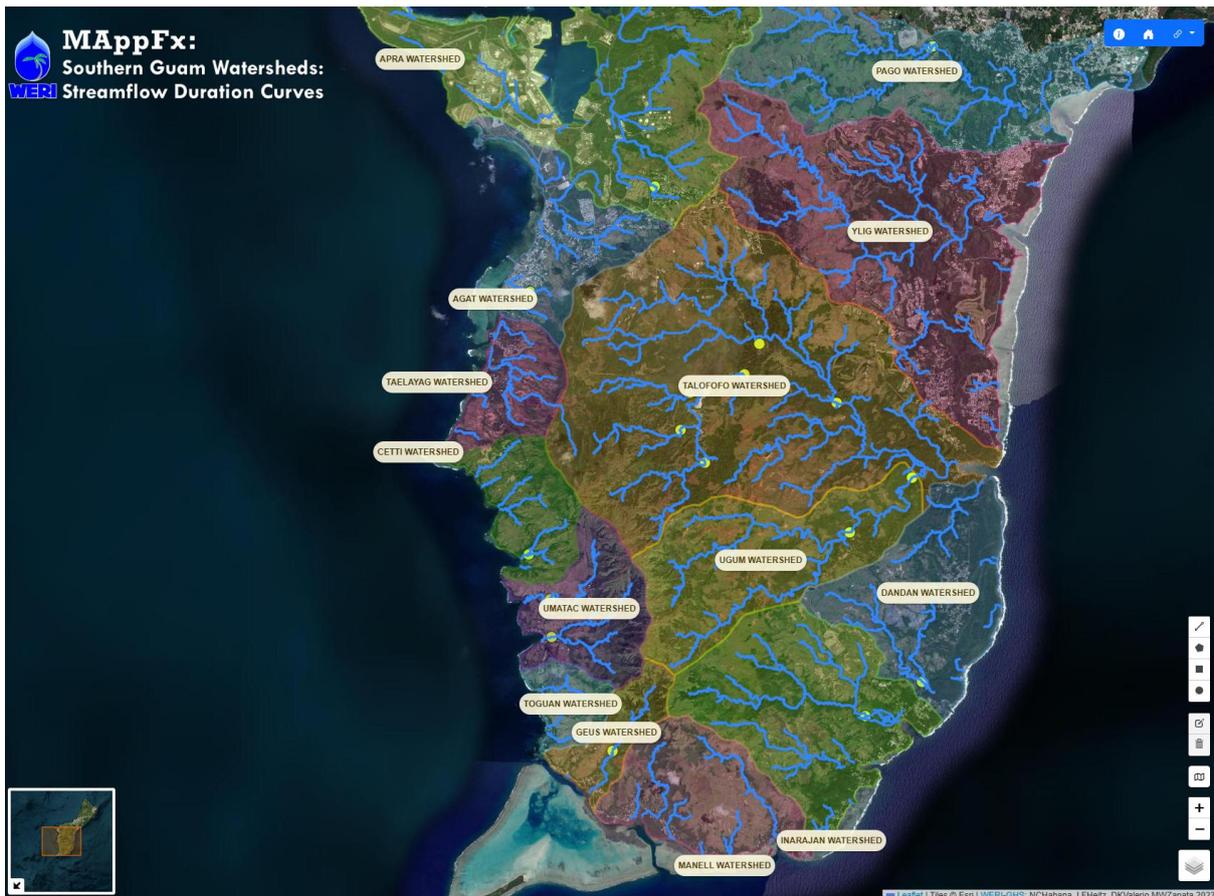
N.C. Habana, L.F. Heitz, D.K.U. Valerio

Southern Guam's watersheds and streams may have potential for energy and/or water supply development. Streamflow variability and flow duration analysis are useful information to determine such potential. Flow variability and flow duration curves were quantified directly from gaged sites and ungaged reaches, using inferential techniques (Heitz et al. 2016 and 2017, WTR 154 and 164, respectively). This project expands the MAppFx: Ugum Flow Duration Curves (Habana et al. 2023, WTR 181), into the entire southern Guam (14 watersheds and 19 stream gages). To obtain proper watershed and stream topology, the technique required modifying the GeoJSON file, expanding its data nesting configuration. All the assessed gaged streams in southern Guam are now available online. The use of the interactive web map and graph interface was demonstrated in the Guam Hydrologic Survey WERI Workshop in September 2024. More than 40 interagency employees learned about the use and access of MAppFx products in the WERI Workshop 2025. The technical report is underway.

MAppFx: Chloride and Production

M.W. Zapata, D.K.U. Valerio, and N.C. Habana

MAppFx production well chloride concentration is one of the latest WERI data visualization products. Chloride and production rate data visualization was developed soon after the MAppFx for production well nitrate level [Valerio et al. 2023, WERI Technical Report (WTR) 180]. Chloride is another very important production well constituent like nitrate, that chloride may also limit production. GWA tests wells for chloride concentration, since high levels of chloride is often a result of saltwater intrusion. Chloride translates to salinity, a water quality aesthetics concern, often a result of drawing excessively from a freshwater lens. The management of



MAppFx Southern Guam Watersheds: Streamflow Duration Curves

water quality and production includes the observation of changes in chloride of utility water production. Guam uses about 100 deep vertical wells to extract more than 38 MGD of utility water from the Northern Guam Lens Aquifer (NGLA). The MAppFx Chloride web interface opens with a layer version of the Northern Guam Lens Aquifer map (Habana and Jenson 2018) and Guam Waterworks Authority (GWA) production wells.

The JSON, JavaScript Object Notation (data form file), for this online application was configured for plotting chloride and production data over time (date). An Excel file is used to organize GWA data, and the Excel program generates the JSON file. This makes ease of managing chloride and production data that can be updated quarterly and serves as a state of the aquifer component.

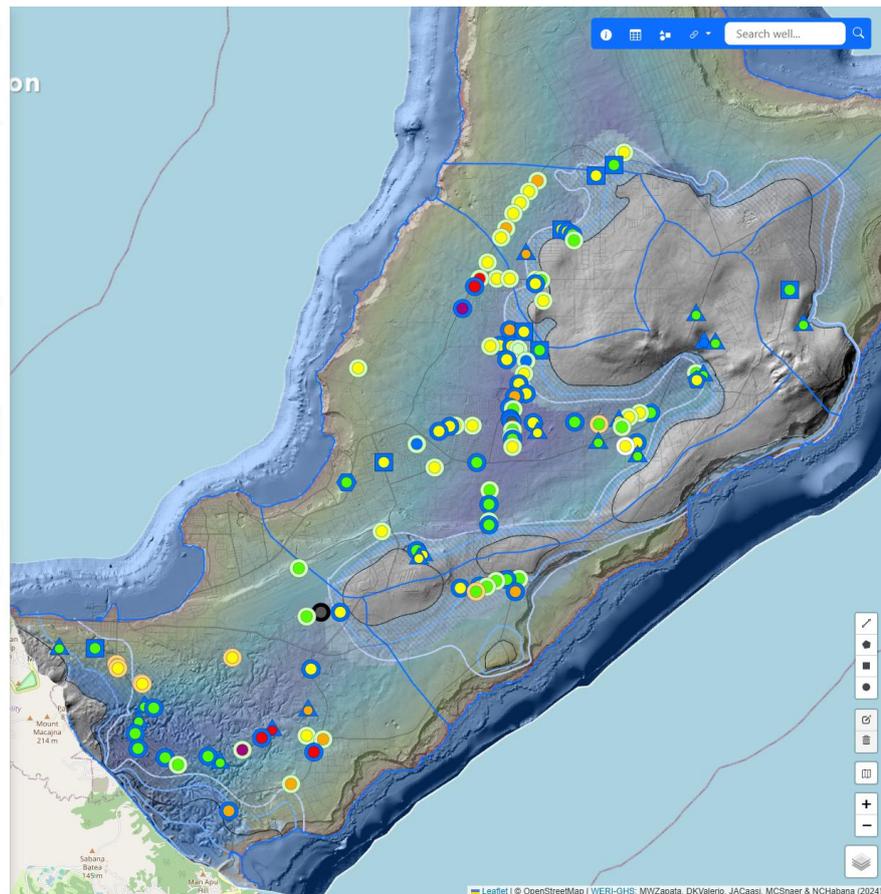
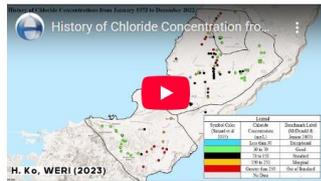
This data visualization product is coded to provide a summary interface of production weighted average chloride and total production for each aquifer basin in the NGLA. The well points on the interactive map utilize symbology based on the latest data chloride concentration (mg/L or ppm) and production rate (GPM). Side panel widgets are available as well for symbology and summary. The symbology panel is interactive that one can select to activate wells based on concentration and production rate. The summary panel is the annual production well rate (MGD) and production weighted average chloride concentration for each of the 6 aquifer basins in the NGLA. Selecting each aquifer basin in this panel expands to a last 10 years of annual summaries showing total production and weighted average chloride. Upon selecting a well point on the interactive map, an interactive double axis chart appears showing the historical positive concentration, production, and their respective trend

Summary

Basin	Production (MGD)	PWA Chloride (mg/L)	Inactive Wells	Active Wells
Machanao	0.9	73.2	0	2
Upi	1.1	67.4	0	2
Mangilao	1.7	78.1	1	6
Finegayan	5.1	97.7	0	16
Hagåtña	8.5	115.7	7	24
Yigo-Tumon	19.1	83.7	11	55
Totals	36.3	92.1	19	105

Click on a basin to view its history.

History of Chloride Concentrations from January 1973 to December 2022



MAppFx Chloride and Production

line. This MAppFx product was presented in September 2024 to the American Water Works Association, Hawaii Western Pacific Sub Section, and training for use was conducted at the Guam Hydrologic Survey WERI Workshop to interagency partners. The next task is to try to include the military wells. The technical report is underway.

Updates to the chloride and production data for this MAppFx are in progress. With a new WERI GHS IM team member aboard, these data updates will be available once the training for information transfer on the JSON database and MAppFx interface is complete. When the latest data becomes available on this MAppFx, users will see an updated statistical summary in the well's information pane as well as the chloride and production levels collected by GWA in the time series plot.

MAppFx: Southern Guam Flow Duration Curves

D.K.U. Valerio, N.C. Habana, L.F. Heitz

Southern Guam's watershed and stream may have potential for energy and/or water supply development. A useful information for determining such potential is streamflow variability and flow duration analysis. Flow variability and flow duration curves were quantified directly from gaged sites and ungaged reaches, using inferential techniques (Heitz et al. 2016 and 2017, [WTR 154](#) and [164](#), respectively). This project expands the *MAppFx: Ugum Flow Duration Curves* (Habana et al. 2023, [WTR 181](#)), into the entire southern Guam (14 watersheds and 19 stream gages).

To obtain proper watershed and stream topology, the technique required modifying the GeoJSON file, expanding its data nesting configuration. All of the assessed



MAppFx: Southern Guam Flow Duration Curves

gaged streams in southern Guam are now available online.

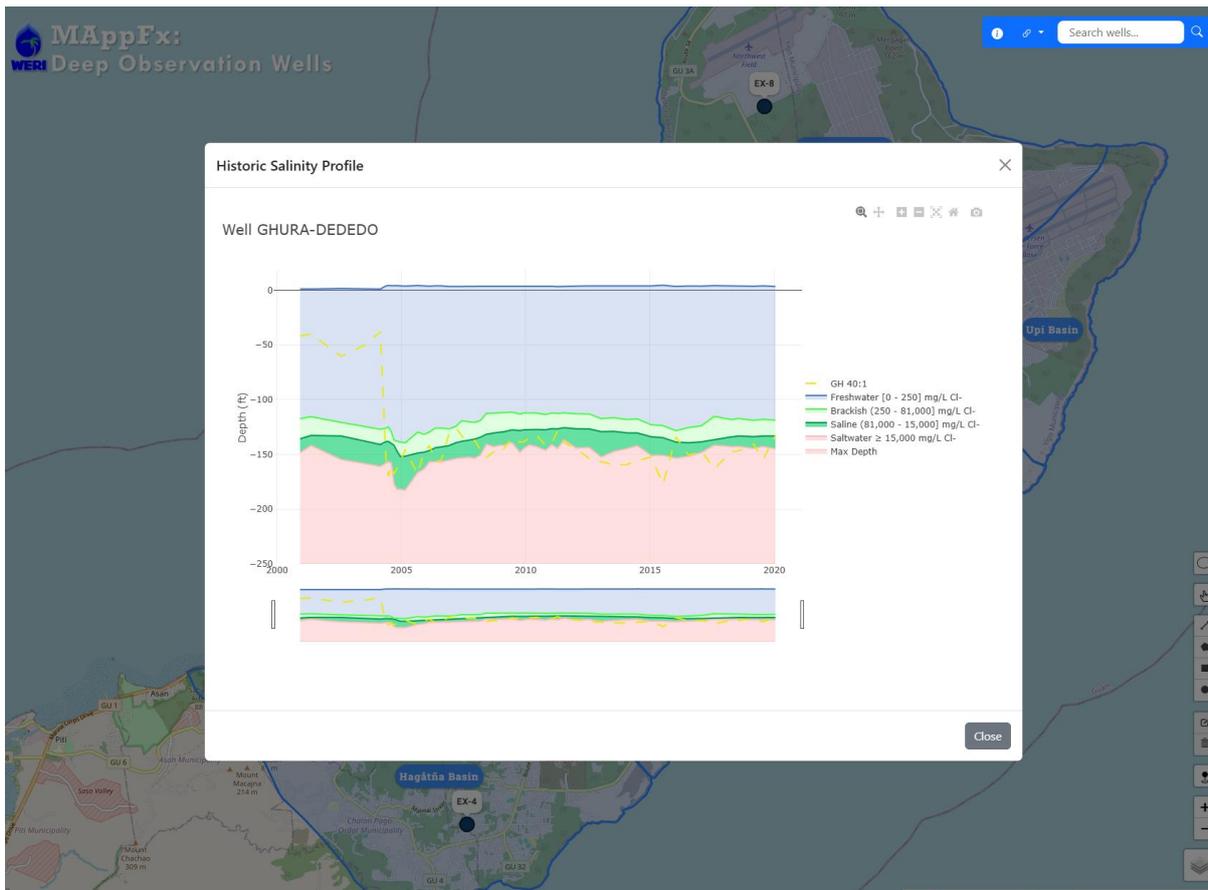
[MAppFx: Southern Guam watershed streamflow duration curves](#)

The use of the interactive web map and graph interface was demonstrated in the Guam Hydrologic Survey WERI Workshop in September 2024. More than 40 interagency employees learned about the use and access of MAppFx products in the WERI Workshop 2024. The technical report is underway.

MAppFx: Deep Observation Wells

M.W. Zapata, M.C. Snaer, D.K.U. Valerio, and N.C. Habana

Deep observation wells (DOWs) are phreatic access ports for conducting salinity profiles in the NGLA. A DOW is a vertically positioned tubular structure that extends down a borehole with perforation below the saturated zone, penetrating the freshwater lens, extending into the saltwater zone. This allows for a depth and conductivity analysis that translates into a salinity profile. The salinity profile sampling is done at least twice a year. This operation was conducted as part of the WERI-USGS data collection under the CWMP. Dougher et al. (2019, WTR 168) developed the first historic graphing of salinity profiles for three DOWs in the Tomhom Aquifer, NGLA. The report defines the phreatic zone of freshwater, transition zone, and saltwater. Dougher’s research revealed the capacity and durability of the aquifer that went through a major recharge event from typhoons, followed by a 6-year drought. In 2024, the WERI GHS IM team started developing



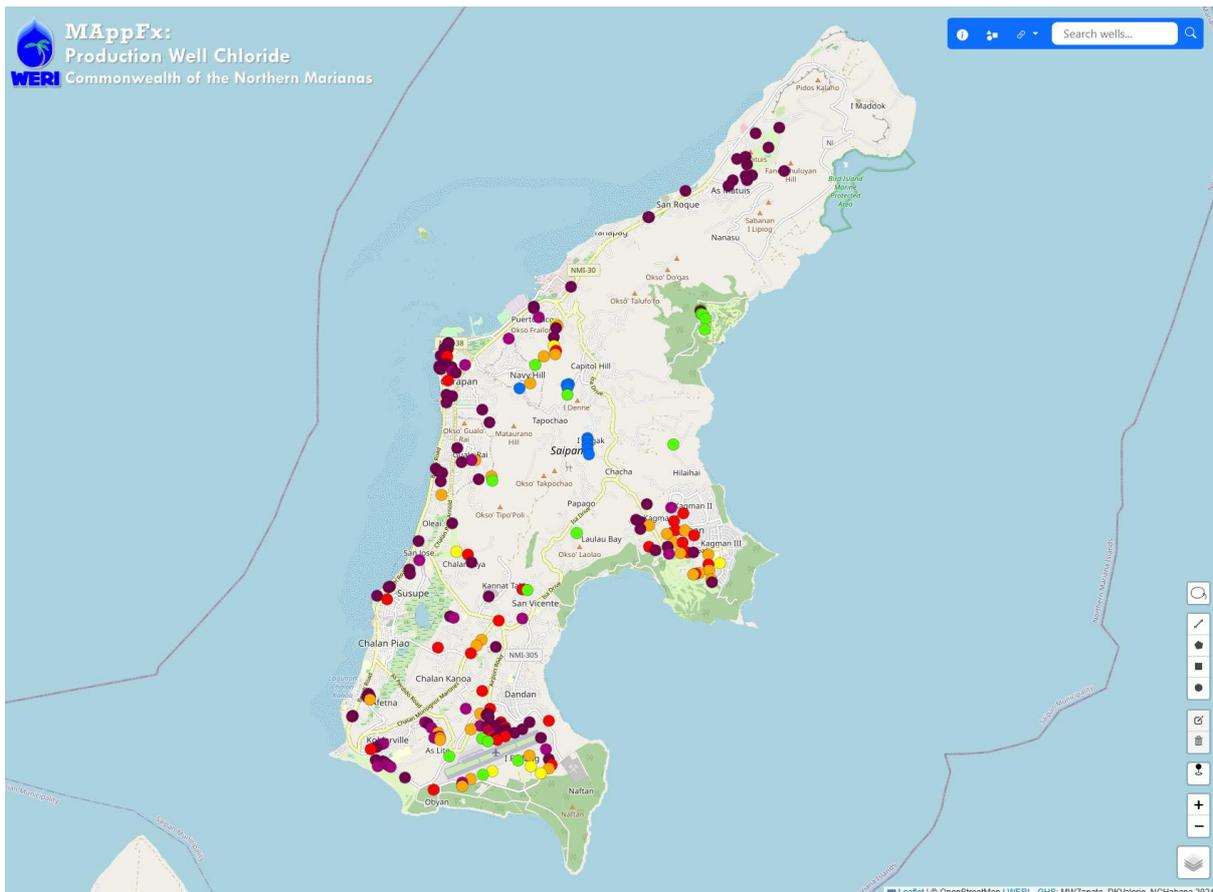
MAppFx: Deep Observation Wells (DOWs)

the historic graph of phreatic zone for the DOWs as a component of the MAppFx web app. On the MAppFx interface, users see 8 DOW historic profiles that began in 2001. In the future, it will include the newly installed DOWs of both GWA and Military. The WERI GHS IM team was able to create a workflow that converts the raw Excel data to MAppFx's input and database file, JSON. This system is easy to manage and update when new data is received. DOW salinity profiles alone are difficult to analyze and present in such a way that could be well understood. Historic salinity profiles provide a better and valuable insight for determining the status of the aquifer, showing changes in freshwater lens thickness in response to drought and ample recharge. MAppFx makes this easier to visualize and support with the management of the island's major water resource.

MAppFx: Saipan, CNMI – Production Well Nitrates and Chloride

M.W. Zapata, D.K.U. Valerio, and N.C. Habana

Two MAppFx products were created for Saipan, CNMI using the production well nitrates and chloride data, respectively. The WERI GHS IM team developed a system to organize the raw data, an Excel file, and convert it into a JSON file as an input into the MAppFx interface. The map features an interactive map of Saipan with production wells as the points of survey. Each well is color coded based on a system of values provided by the Saipan BECQ team and can be toggled on and off through the map's legend and layer control widget. Its graphs display available data for the site that users can also interact with.



MAppFx for Saipan, CNMI on Production Well Chloride

It essentially takes on the same codebase as the Chloride and Production MAppFx for Guam, but with a new selection feature, which was requested by the Saipan BECQ team. This selection tool allows for the user to select multiple wells and view all the graphs in one pane. Having this view helps provide a summary when comparing data between select wells in different regions. To trigger this tool, the user would select the lasso widget towards the bottom right of the screen. This MAppFx was presented at the WERI Advisory Council Meetings and was met with positive reception from the audience.

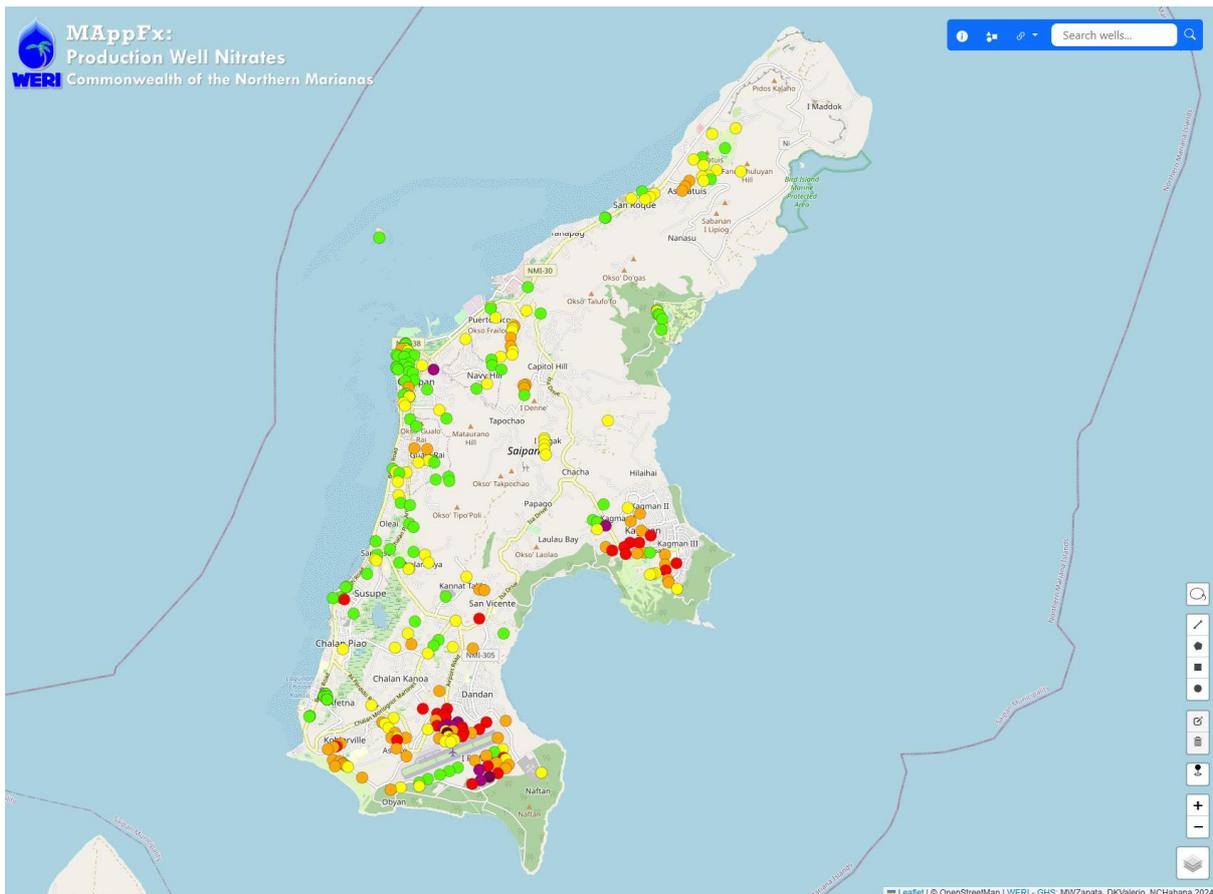
Updates to the existing nitrate and chloride data for this MAppFx are pending. Training is in progress for a new WERI GHS IM team member to ensure a smooth transition of the data process between Excel and the MAppFx platform. Upon the completion of training, users should see the latest nitrate and chloride data available of the respective MAppFx products for Saipan.

MAppFx: Pohnpei and Kosrae, FSM – Streamflow Duration Curves

N.C. Habana, L.F. Heitz, and D.K.U. Valerio

[View MAppFx](#)

A MAppFx was created for FSM, namely Pohnpei and Kosrae, which features streamflow duration curves. After showing the Saipan, CNMI MAppFx projects at the 2024 AWWA Conference (Hyatt, Tumon), Yap representatives expressed their interest in converting their data into a MAppFx product. Earlier this year, the WERI



MAppFx for Saipan, CNMI on Production Well Nitrates

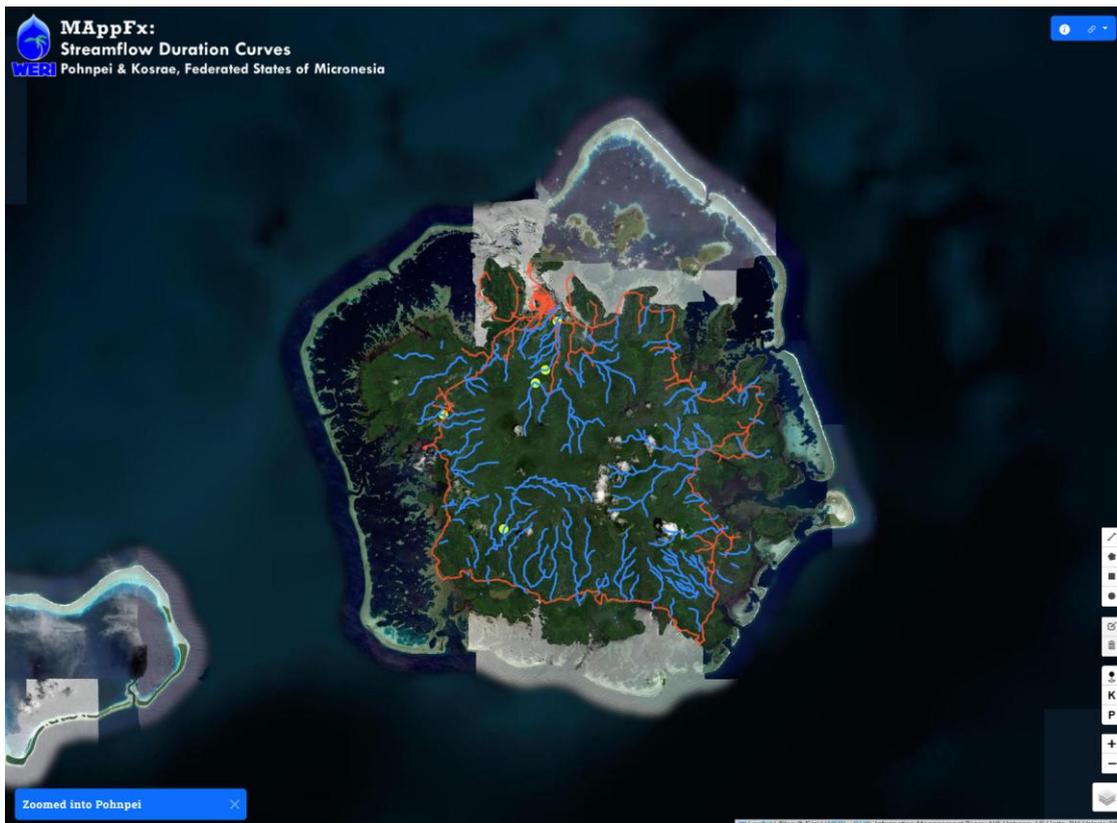
GHS IM team completed this MAppFx for the FSM. When the page first loads, the map zooms out to have a view of the two islands—Pohnpei and Kosrae. The user can click on one of the islands to get a zoomed in view. Another option to “fly” between the two islands is by using the navigation widget located on the bottom right of the interface. The button labelled as “K” zooms into Kosrae, and the button labelled as “P” zooms into Pohnpei. At its core, this MAppFx maintains the same code as the one for the Southern Guam Watersheds Streamflow Duration Curves but has been refreshed with reusable code blocks and functions.

To access this MAppFx product, a new section for FSM was created on the GHS website. From the menu bar, hover over Library > MAppFx. On the MAppFx page, click on the FSM link to scroll down to the map. A technical report for this project is underway.

MAppFx: Geology Photo Gallery

D.K.U. Valerio and N.C. Habana

One of the latest MAppFx projects underway is the MAppFx Geology Photo Gallery. Compared to the other web maps in the MAppFx series, this one takes on an entirely new approach in its database system. While a JSON file is still used to store the geographic data for the map, this MAppFx utilizes JavaScript API (Application Programming Interface) calls between the backend—the server and data store—and the user interface (frontend) parts of the app that communicate the user’s selection from the map and the metadata for the set of photos to be presented onscreen. In



View of Pohnpei in MAppFx Streamflow Duration Curves for FSM

in addition, the backend is organized through a directory system. This approach will be easy to manage with future photo collections. Any updates would be a simple drag and drop of photos in their respective folder. The premise of this MAppFx is to have survey points, either a singular site or region represented by polygons. When a user clicks on a map feature, they'll be able to access photos related to that site. These photos will be displayed as a gallery of geologic samples or site visits that the user can browse through. Currently, there is a working demo of its two core features—the map and the photo gallery components. However, there are some major challenges in developing a secure backend access to the photo directory and sending the photo set back to the MAppFx interface. The WERI GHS IM team is actively working with the UOG Web Development team to set up secure data endpoints and ensure there are no vulnerabilities where this MAppFx will be hosted, which is the GHS website. Developments to the photo directory structure are ongoing and will continue into the next year. Refinements to the overall design and appearance of the MAppFx will take place in tandem to ensure a smooth experience for the user. Once this MAppFx reaches production-ready status, that is, where it is live online and users will be able access it through the GHS website, training will be done for WERI GHS IM members to maintain the photo database and API endpoints in the JavaScript code.

Web MApps: Hydrologic Map of Guam Watersheds

N.C. Habana, D.K.U. Valerio, M.C. Snaer, and L.F. Heitz

A high-resolution surface hydrologic map is invaluable for watershed planning, environmental and water resources protection, preservation, and determining strategies for sustainable development. With the success of producing a high-resolution map of the surface hydrology of northern Guam's limestone plateau

(Habana et al. 2022), stake holders expressed the need to include the terrain and hydrologic spatial analysis for southern Guam. The northern Guam surface hydrology techniques were applied to southern Guam, using the latest 2020 DEM, and the results are astounding, resulting in a high-resolution watershed map of southern Guam. The final product is complete and is the most comprehensive surface hydrology map ever produced. Intricate details include runoff paths, enhanced terrain texture, internal watershed features, size categorized watersheds, fill areas or surface depressions, and coastal watershed feature details. This map is now available on the Guam Hydrologic Survey website:

The map will continue to improve, now undergoing selection of place names, and proper naming/spelling of watersheds and geographic features through the Kumisión I Na'an Lugåt Guåhan (Commission of Place Names, Guam). A large map plate and accompanying technical report is in progress as well, and once complete may be distributed to stakeholders in the Watershed Planning Committee, Bureau of Statistics and Plans, the Guam Coastal Management Program, the Guam Environmental Protection Agency, and Department of Education. The Island have seen the recent uploaded hydrologic map product (10th Assembly of Planner's Symposium, 2025) and have expressed great interest and are anticipating the map's update with place names in 2026.

The current map results are in use with interagency partners. Another phase plan for surface hydrology is to repeat the process on the latest Guam DEM (2020) to combine north and south, into an extra-large map as the Surface hydrology of Guam.

Guam Hydrologic Survey Research

WERI Researchers continue to observe and study the island's water source. They focus on advancing hydrologic data-based research, going in depth into the components of Guam's hydrologic cycle. This section covers the year's research endeavors, organized along the componential lines of the hydrologic cycle, utility water production and water quality, and towards model development.

Climate and Weather

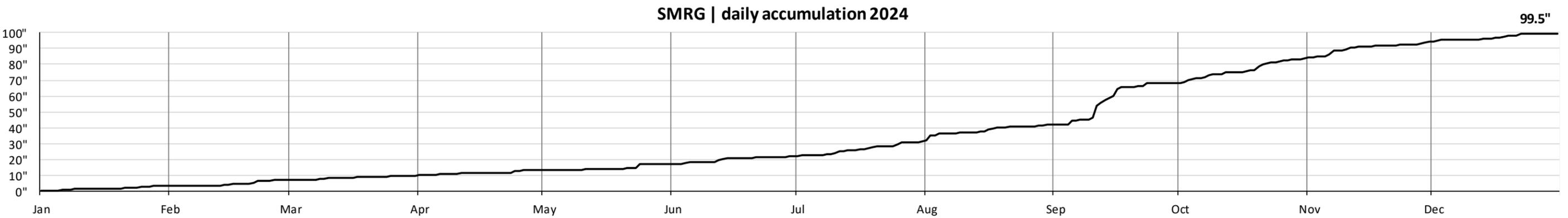
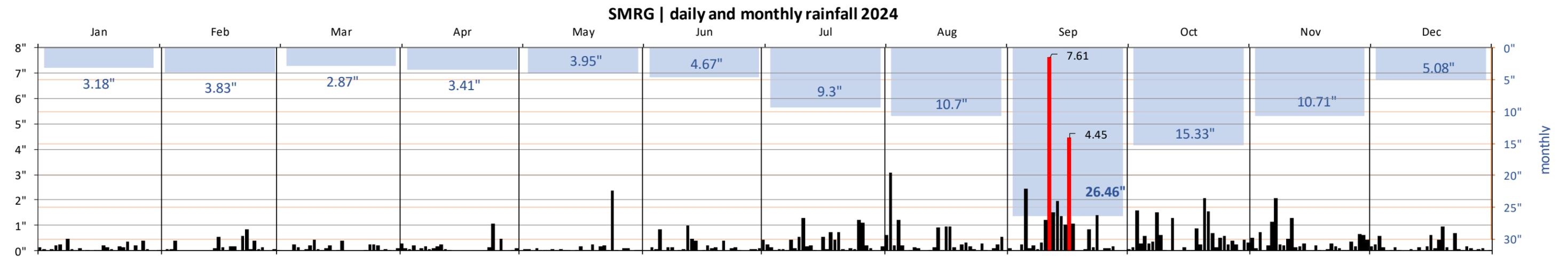
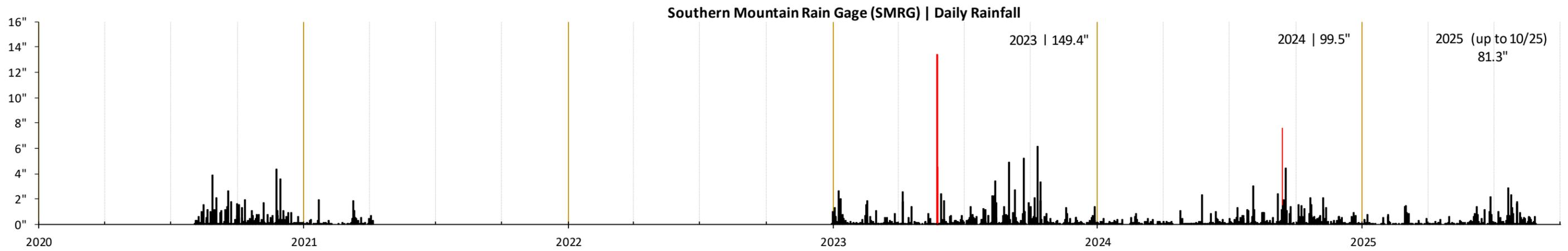
C. Simpson, I. Cruz, and N.C. Habana

NWS field team of Simpson and Cruz continue a monthly trek to the late Dr. Lander rain gage at the top of the Humåtac Watershed, called the Southern Mountain Rain Gage (SMRG). Habana processes the rain data for analysis. In 2023, the year of Typhoon Mawar, the SMRG logged more than 149 inches of rainfall, which may be one of the highest annual recorded rainfalls in Guam (see graph, next 2 pages). The following year had about a 100" of annual rainfall. In 2025, up to October 25, the SMRG total was 81 in. In 2024, the highest monthly rainfall recorded was 26.5 in, in September. That month had two daily rainfalls greater than 4 in (red bars).

WERI GHS Program (Habana) compiles a multi-graph history of ENSO and rainfall, providing a valuable resource for hydrologic studies over 55 years. Spanning two large pages, the visualization covers the period from 1970 through October 10, 2025. The graph's structure is organized by year, marked by major vertical gridlines, and further delineated into quarters by minor gridlines. The top panel plots the Oceanic Niño Index (ONI), sourced from the [NOAA NWS Climate Prediction Center](#), illustrating positive (El Niño) and negative (La Niña) values.



Hydrologic Map of Guam Watersheds (2025), a large format (6' x 8') high resolution map. This map is currently in pdf format and is now available for viewing and download at the GHS website.



Southern Mountain Rain Gage 2020-2025, and 2024 (NWS - Simpson, Cruz, and WERI - Habana)

ENSO strength is visually categorized using a clear color scheme:

- **El Niño strengths:** Weak [0.5, 1), Moderate [1, 1.5), Strong [1.5, 2), and Super (≥ 2) are colored in increasing intensities of yellow, orange, and red.
- **La Niña strengths:** Weak [-0.5, -1), Moderate [-1, -1.5), Strong [-1.5, -2), and Super (≤ -2) use a progression of light to dark blue and purple.
- **ENSO neutral** is defined by ONI values between -0.5 and 0.5.

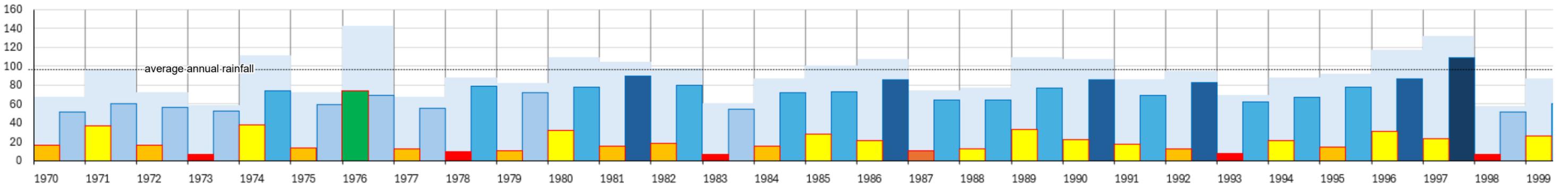
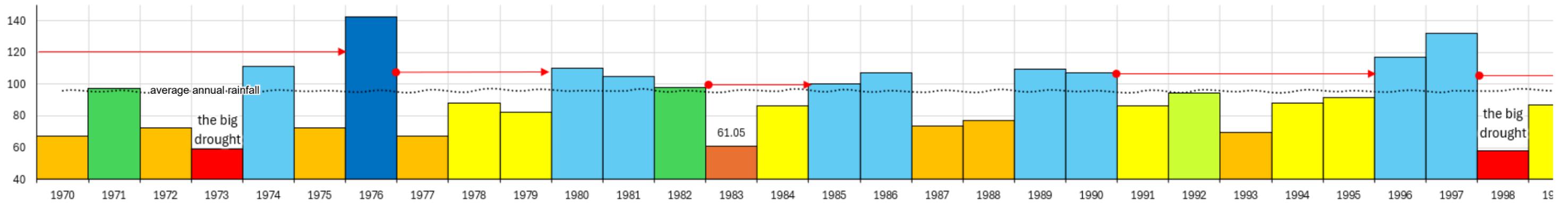
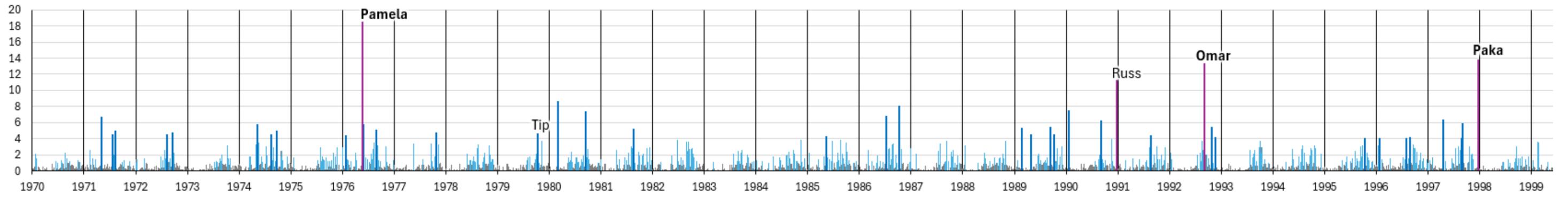
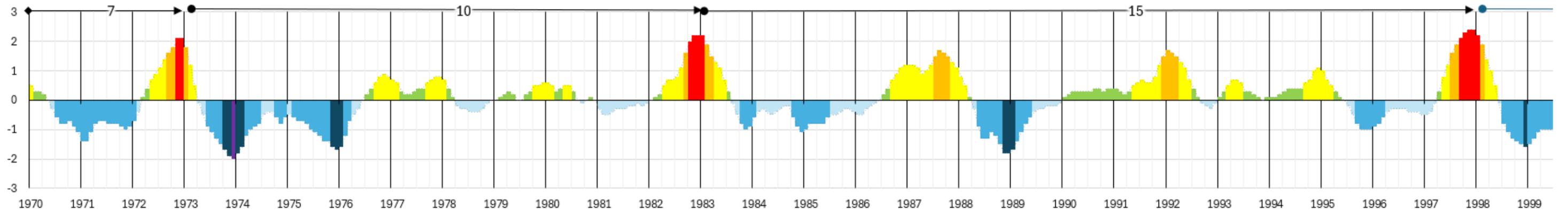
Below the ONI plot, three aligned panels illustrate rainfall data from the NAS rain gauge:

- **Daily rainfall** is depicted using bars colored by intensity, ranging from gray (0–1 inch) to purple (over 10 inches). Notable typhoons, such as Pamela (18.5 inches) and Pongsona (19.7 inches), are labeled next to their corresponding rainfall spikes.
- **Annual rainfall** is shown with a color-graded backdrop, indicating drought conditions (red, <60 inches) through periods of high rainfall (dark blue, >100 inches). Four years recorded near or above 140 inches, while significant droughts occurred in 1973 and 1998, with the latter leading to the CWMP and GHS legislation.
- **Seasonal rainfall** (dry: Jan–Jun; wet: Jul–Dec) is also color-coded using the ROYGB scheme.

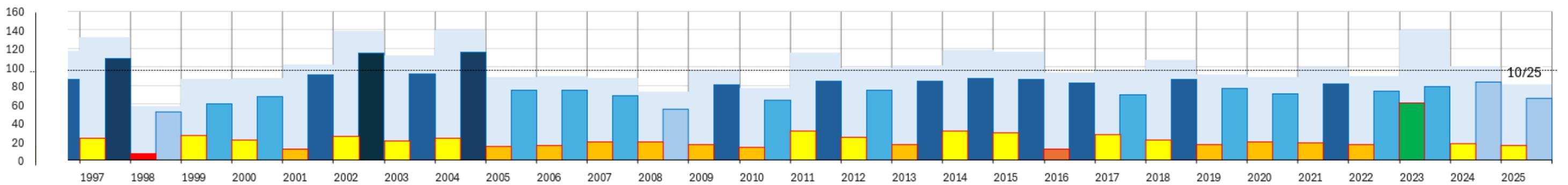
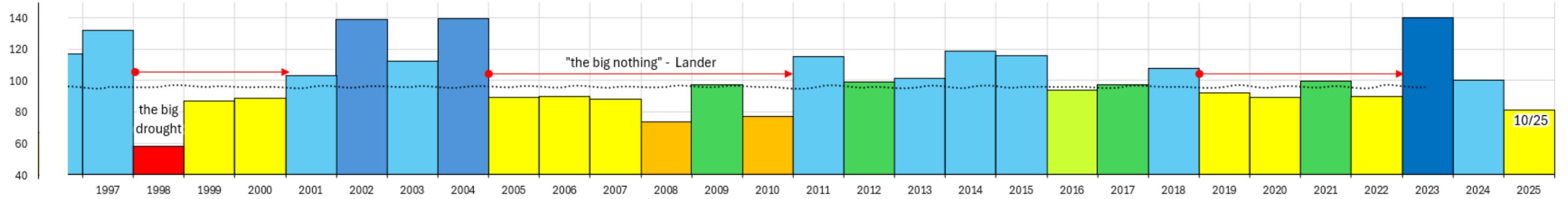
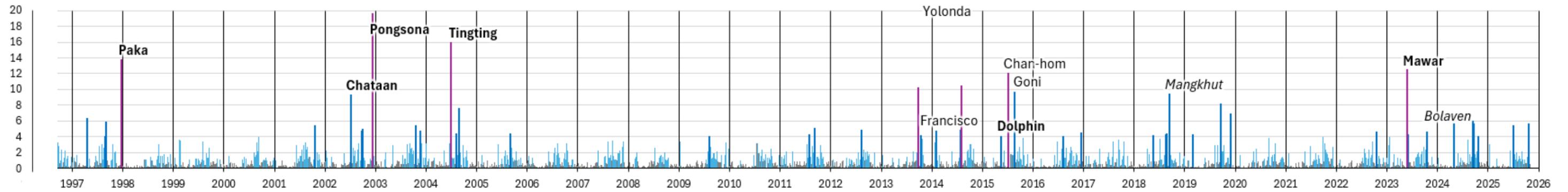
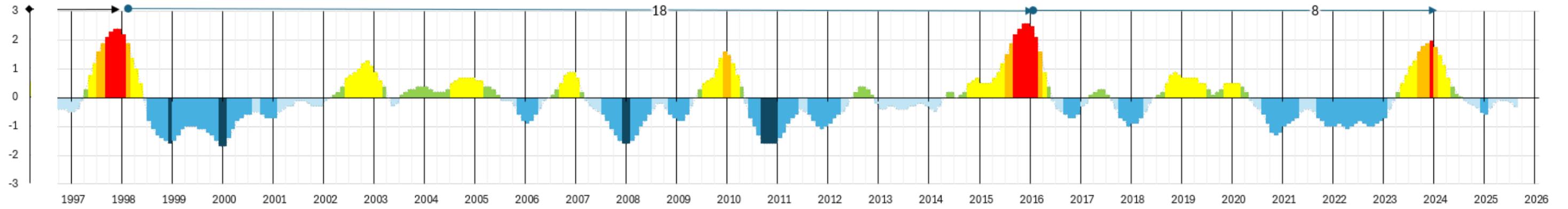
This historical data provides a robust visual reference for understanding the relationship between ENSO and rainfall patterns on Guam.

An analysis of rainfall data from 1970 to 2023 reveals distinct decadal shifts in Guam's precipitation patterns. Between 1970 and 1998, the dry season recorded less than 10 inches of rainfall five times, a frequency that has not been replicated in the decades since. The early 2000s marked a particularly wet period, with four consecutive years (2000–2004) receiving over 100 inches of annual rainfall, including two years exceeding 140 inches. This was succeeded by a sustained period of low rainfall from 2005 to 2010. Noted by researcher Lander as "the big nothing," this six-year stretch saw no daily rainfall totals exceeding 5 inches. Annual totals remained below 100 inches during this time, with two years dropping below 80 inches. The island's climate shifted again after 2010, entering an eight-year period where annual rainfall consistently reached or surpassed 100 inches. A subsequent drying trend was observed from 2019 to 2022, with three out of four years falling below the 100-inch mark. The pattern was dramatically reversed in 2023, which saw a major deluge, potentially rivaling the extreme rainfall amounts recorded during Typhoon Pamela.

During fiscal year 2025, the El Niño–Southern Oscillation (ENSO) cycle was a dominant factor in Guam's climate. The year began with the waning of a **2023–2024 Super El Niño** event, which was followed by a transition to La Niña conditions. After a period of neutrality, the system is now indicating a shift back into a La Niña phase. This transition is consistent with historical patterns since 1970, which show that major Super El Niño events are typically followed by a multi-year La Niña phase. As the most important driver of interannual climate variation in the region, ENSO has a profound influence on Guam's rainfall, sea levels, and tropical cyclone activity.



The Big Picture: ENSO ONI and Rainfall History (1970-2025) daily, annual, and seasonal (1970-1999...)



Continued... ENSO ONI and Rainfall History (1970-2025) daily, annual, and seasonal (...1997-10/25/2025)

Water Quantity and Quality

Water resource quantity may be limited by quality. In the Northern Guam Lens Aquifer, sustainable production can be influenced by both hydrology and quality. WERI studies both the quality and quantity of its water resources that may provide insight to improving its production capacity and contribute to advanced studies such as groundwater model development. The researched hydrologic information through the GHS and CWMP Program is centered on these studies.

Chloride and Production Study

H. Ko, Y. Wen, J. Jenson, D. Cabrera, G. Badowski, and N.C. Habana

Hazelle Ko, a graduate student in the Environmental Science Program at the University of Guam (UOG), supported by GHS Program, [successfully defended her master's thesis](#) in November 2024. Her comprehensive research focused on 49 years of chloride trends within nine wells in the Yigo-Tumon Basin of the Northern Guam Lens Aquifer. By evaluating the impacts of natural factors like ENSO, rainfall, and sea level, alongside well production rates, she determined that increasing chloride concentrations were influenced by well pumping, design, and saltwater intrusion. Though more recent data suggests a potential reversal in trends, the overall long-term increase underscores the critical need for sustainable groundwater management.

Beyond her thesis, Ko's contributions to environmental science at UOG have been significant. Before enrolling in the graduate program in 2022, she began her collaboration with Dr. Yuming Wen in 2021, focusing on the hydrological characteristics of the Finegayan Basin. She continued this work, including on a federally funded project concerning salinity trends in the Northern Guam Lens Aquifer. Her exceptional performance earned her UOG's "Outstanding Graduate Award" in May 2023. Additionally, Ko has presented her work at several national and international conferences, receiving "Best Presentation" at the 14th International Conference on Environmental Science and Development in Xiamen, China. Her research provides vital insights into the sustainability of Guam's primary water source. WERI UOG and the GHS Program graduates an outstanding environmental scientist.



Hazelle Ko receives her master's degree in environmental science, UOG's Graduate Studies Program, with support from WERI and the GHS Program

Comparisons of Patterns and Trends of Salinity in Basins, NGLA

H. Ko, N. Mathews, and Y. Wen

This project presents an updated assessment of chloride concentration trends and production patterns in the Finagua'yok, Tomhom, Hagåtña, and Mangilao Basins, building upon the findings of four previous technical reports. The primary objective is to provide a consistent, basin-scale evaluation of recent data, highlighting changes over the past decade and ongoing patterns in groundwater quality and well production. The analysis integrates updated decadal statistics, spatial mapping of chloride trends, updated statistical analysis (Mann-Kendall and STL decomposition), and evaluation of pumping practices relative to Northern Guam Lens Study (NGLS) recommendations. By comparing the most recent decade with the preceding decade, this research identifies wells that have maintained stable conditions as well as those indicating changes in chloride concentrations or production rates. Summary tables and maps are used to support these assessments, providing a clear view of temporal and spatial patterns that may inform water management decisions. The Mann-Kendall and STL Decomposition results for Finagua'yok Basin are shown in Tables 1 and 2. The updated evaluation is intended to serve as a reference for ongoing monitoring, management planning, and decision-making in the Northern Guam Lens Aquifer, complementing the prior reports while emphasizing recent trends and emerging areas of concern.

Mann-Kendall Summary for Finagua'yok Aquifer Basin (left table), and Decomposition Summary for Finagua'yok Aquifer Basin (right table)

Well	z	p-value	Direction	Significant	Well ID	Seasonal Strength	Trend Class
D22A	-0.79692923	4.25E-01	Decreasing	No	D22A	0.012	Weak or negligible seasonality
D24	1.290890847	1.97E-01	Increasing	No	D24	0.009	Weak or negligible seasonality
F01	11.79088732	4.35E-32	Increasing	Yes	F10	0.029	Weak or negligible seasonality
F02	10.78964261	3.85E-27	Increasing	Yes	F11	0.037	Weak or negligible seasonality
F03	6.805609359	1.01E-11	Increasing	Yes	F12	0.052	Weak or negligible seasonality
F04	9.795911587	1.17E-22	Increasing	Yes	F13	0.04	Weak or negligible seasonality
F08	13.10466372	3.10E-39	Increasing	Yes	F15	0.07	Weak or negligible seasonality
F10	7.862089838	3.78E-15	Increasing	Yes	F16	0.008	Weak or negligible seasonality
F11	6.133009488	8.62E-10	Increasing	Yes	F17	0.009	Weak or negligible seasonality
F12	4.073635341	4.63E-05	Increasing	Yes	F18	0.016	Weak or negligible seasonality
F13	0.008934932	9.93E-01	Increasing	No	HGC2	0.203	Moderate seasonality
F15	2.195947493	2.81E-02	Increasing	Yes			
F16	2.537858216	1.12E-02	Increasing	Yes			
F17	-3.147863698	1.64E-03	Decreasing	Yes			
F18	1.346738248	1.78E-01	Increasing	No			
HGC2	4.116009329	3.85E-05	Increasing	Yes			

Water Quality Monitoring of Agana Swamp on Guam

Y. Kim, I. Snively, and A. Ludwig

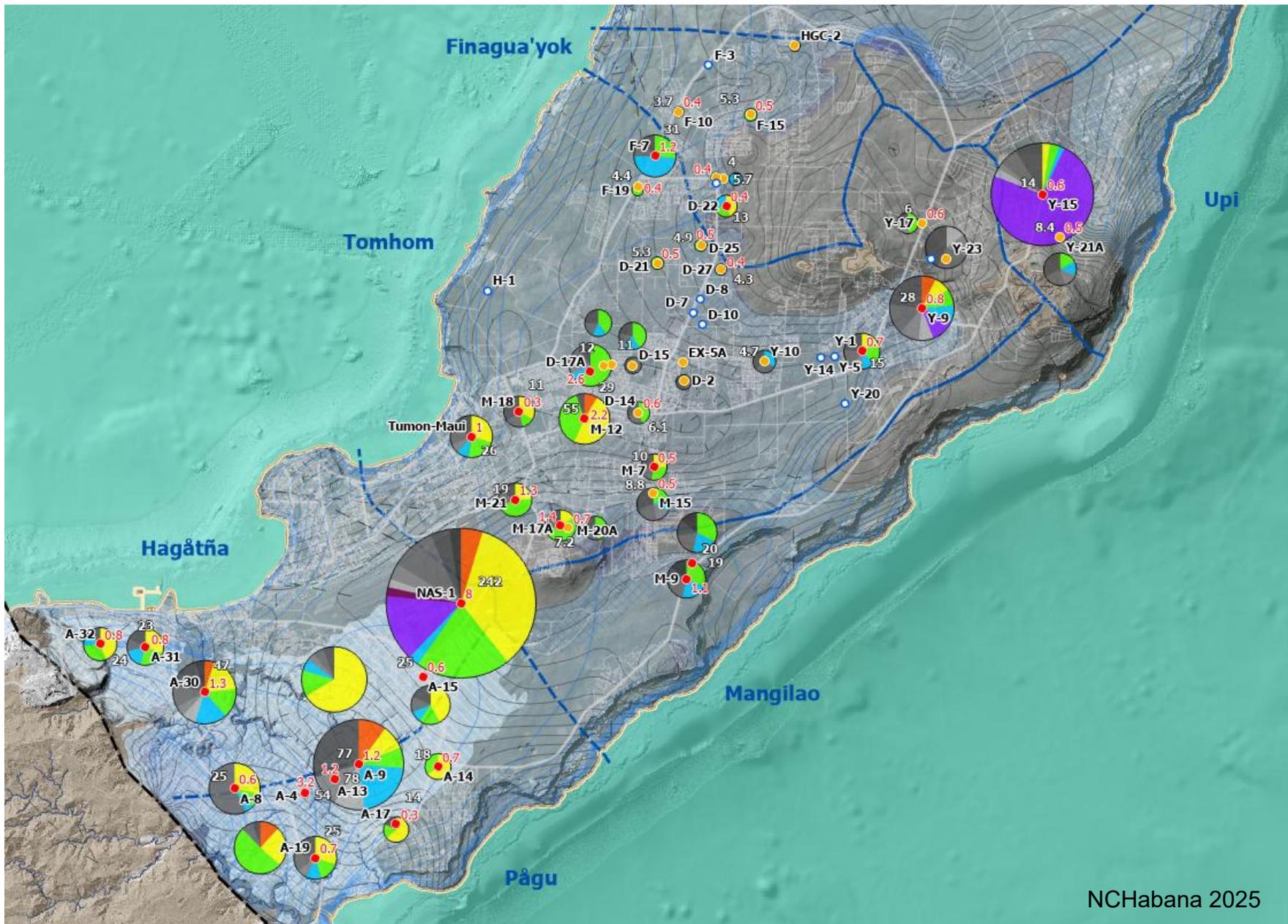
Agana Swamp, located near the village of Hagåtña, provides important ecological functions by intercepting runoff and storing or transforming potential pollutants. However, elevated contaminant levels can adversely affect both benthic organisms and overall water quality. In this study, we selected three monitoring sites: (a) Agana Spring — the source of the Agana River, (b) Agana Swamp — located in the middle of the wetland, and (c) the downstream section of the Agana River. Agana Spring, which originates from groundwater, flows toward Agana Swamp; thus, its water quality data provide insight into how conditions change as water flows downstream. The Agana River originates from Agana Spring and passes through Agana Swamp, so sampling downstream of the river helps assess variations in water quality within the swamp. Over a one-month period, we monitored temperature, pH, dissolved oxygen, total nitrogen, total phosphorus, nitrate, nitrite, ammonia, orthophosphate, total dissolved solids, and conductivity. In Agana Swamp, nitrate/nitrite–nitrogen levels were below the detection limit (<0.010 mg/L-N), indicating that the swamp plays a role in reducing water pollutants. Chloride concentrations in Agana Spring water ranged from 80 to 190 mg/L, which were relatively higher than those in Agana River water collected at the Agana Bridge near the ocean.



Agana Springs, Agana Swamp, and Agana River – downstream, respectively

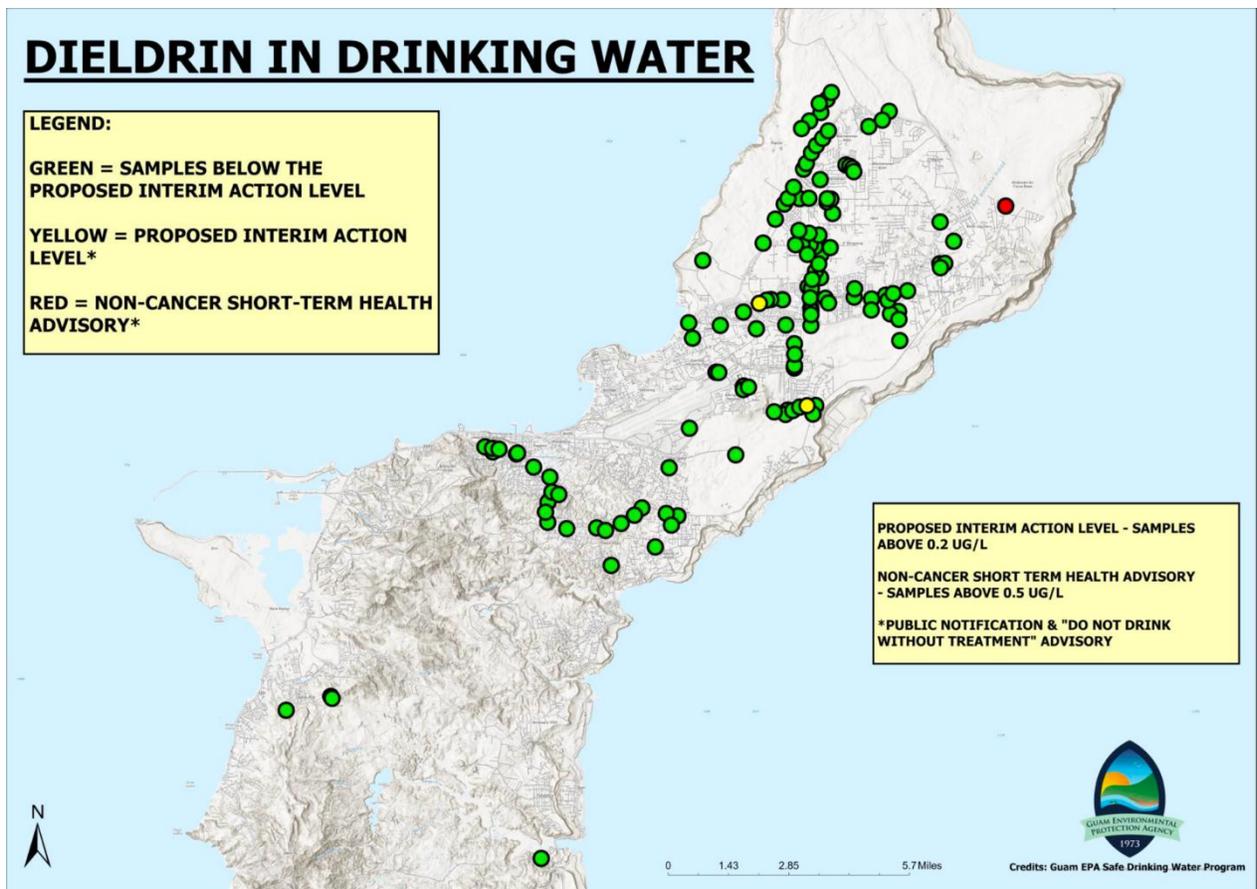
Contaminants – PFAS and Dieldrin

Other than chloride (saltwater) that can limit or even terminate/halt utility water production, Per- and polyflouroalkyl substances (PFAS) and Dieldrin are now in the headlines for contaminants of concern ([PDN](#), [GDP](#)). PFAS is manufactured mainly for its special properties that the chemical is both hydrophobic and oleophobic – repels water and oil. PFAS is a health concern as the chemicals are found to accumulate in the body. In a WERI study, a form of PFAS was found present in every site tested ([Duenas et al. 2023](#)). USEPA data for Guam maps the PFAS in production wells. Dieldrin on the other hand is a banned pesticide (1987) and is classified as a probable human carcinogen, according to USEPA. Guam EPA provides a map of production wells with levels of Dieldrin for notification and response (next two pages).



NCHabana 2025

Production wells and PFAS (USEPA UCMR5)



GEPA production wells and dieldrin map (GEPA 2024)

Hydrology, Hydrogeology, and Groundwater Protection Zone

Two projects focus on managing the Northern Guam Lens Aquifer (NGLA). One uses a GIS-based model with the DRASTIC index to update Groundwater Protection Zones, assessing aquifer vulnerability to human activities. The other analyzes long-term Deep Observation Well data to understand how rainfall and other factors impact the freshwater lens' thickness.

Establishing a GIS-based Model for Updating Groundwater Protection Zones in Guam

R. Uludong and Y. Wen

The research is conducted to update Guam's Groundwater Protection Zone (GPZ) by assessing the aquifer's groundwater protection zone (GPZ) and establishing a GIS-based Model to update the GPZ. The island's aquifer, also known as Northern Guam Lens Aquifer (NGLA) is comprised of nearly half of the island's geography. Most of the island's anthropogenic activities, infrastructures, waste and wastewater transmission are situated atop of the aquifer. There are ongoing and continuations of anthropogenic activities (developments) that are drawing concerns to aquifer vulnerability. With advanced geospatial technologies it is possible to assess and evaluate the vulnerability of GPZ so that the sustainability of the island's water resources and ecosystem can be addressed. The use of the DRASTIC index method while incorporated with GIS can be

applied to evaluate the GPZ's vulnerabilities. The project focuses on hydrogeologic settings, while implementing the calculation of weights and ratings for the DRASTIC parameters. The data for the seven parameters of DRASTIC Depth to water table, net Recharge, Aquifer media, Soil media, Topography (Slope), Impact to the vadose zone, and hydraulic Conductivity need to be collected and processed so that they can be incorporated into the DRASTIC model for calculation of the DRASTIC index to evaluate the vulnerabilities for GPZ in ArcGIS. This project will provide a visual result level of areas of susceptibility to groundwater contamination in the NGLA. The final DRASTIC Index (DI) is a weighted linear combination of the model's parameters and is calculated using the following equation:

$$DI = DrDw + RrRw + ArAw + SrSw + TrTw + Irlw + CrCw$$

where *D*, *R*, *A*, *S*, *T*, *I* and *C* stand for the parameters while *w* and *r* represent the weight of each parameter and the corresponding rating, respectively.

Deep Observation Wells

M.C. Snaer, N.C. Habana, Y. Kim, and L. Aquino

Deep Observation Wells (DOWs) are vertical ports used to obtain detailed salinity profiles of the phreatic zone within the Northern Guam Lens Aquifer (NGLA), which contains a freshwater lens supplying about 90% (42 of 45 MGD) of Guam's utility water. The bottom of NGLA's freshwater lens has a transition zone that grades with depth from brackish, to saline, and saltwater.

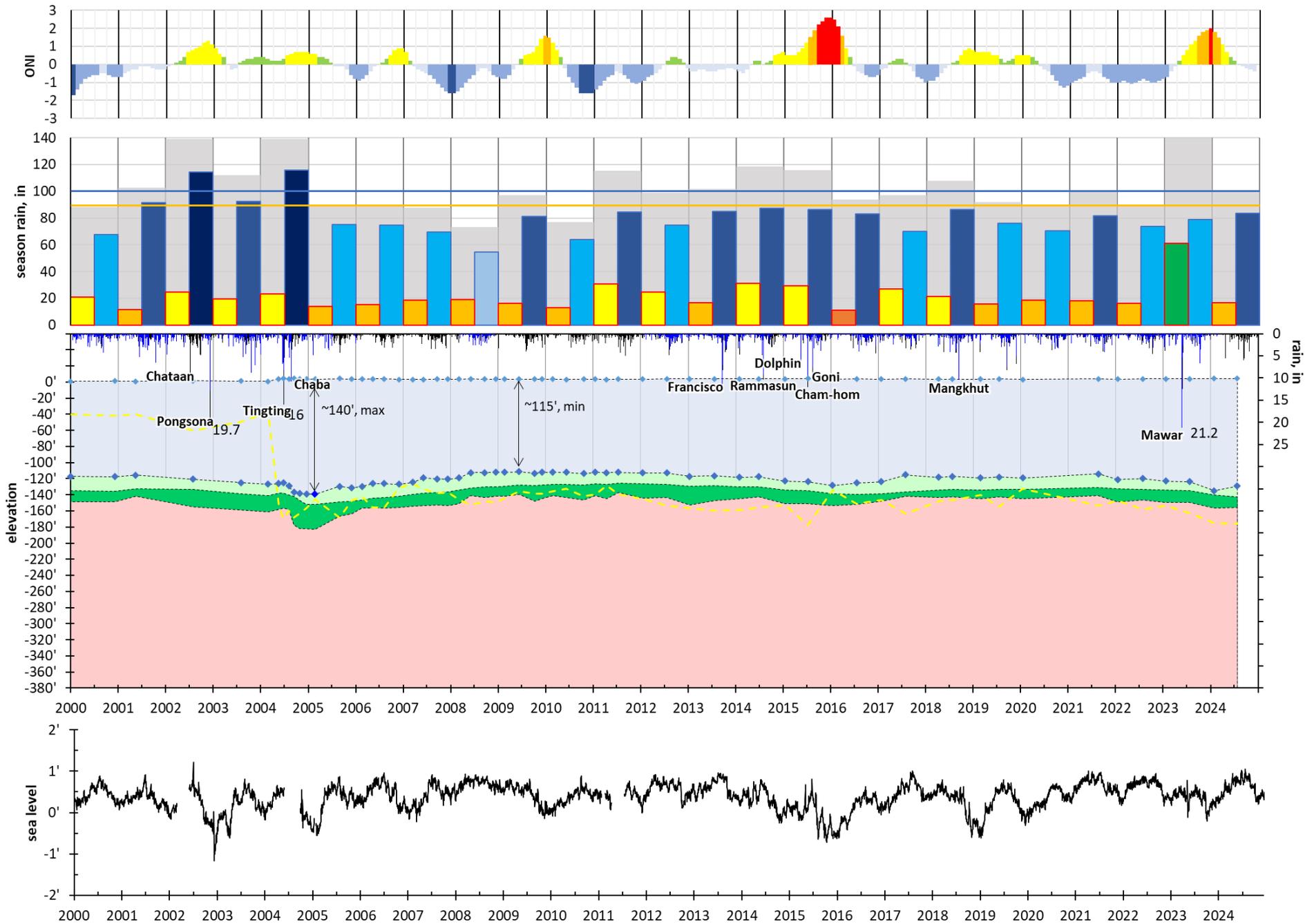
Eight DOWs distributed across northern Guam, each with over twenty years of data, extend into the saltwater portion of the phreatic zone. Conductivity, temperature, and depth (CTD) transducers are lowered into the DOWs semi-annually to collect long-term records of water levels, freshwater lens thickness, transition zone fluctuations, and saltwater interface position. These historic datasets reveal changes in conductivity(salinity), lens position, and thickness that reflect both climatic and hydrologic variations over time.

This study analyzes how rainfall, tides, and climate phenomena such as El Niño and La Niña influence freshwater lens thickness. Multi-variable hydrographic analyses integrate the Oceanic Niño Index (ONI), rainfall, sea level, and DOW historic salinity profile data to illustrate the aquifer's response to climatic and hydrologic conditions. At the GHURA-Dededo DOW, for example, lens thickness fluctuates with drought and recharge periods, including major [typhoon rainfall events](#) such as Pongsona (2002), Dolphin (2015), Mangkhut (2018), and Mawar (2023).

These long-term observations are essential for evaluating aquifer resilience to drought and recharge efficiency across different areas within the aquifer. They also help refine groundwater model parameters, improve understanding of freshwater lens dynamics, and support the sustainable management and development of Guam's water resources.

Groundwater Modeling

All the studies mentioned above are key components for ultimately developing a useful model of the island's sole source aquifer. Research provides important hydrologic and



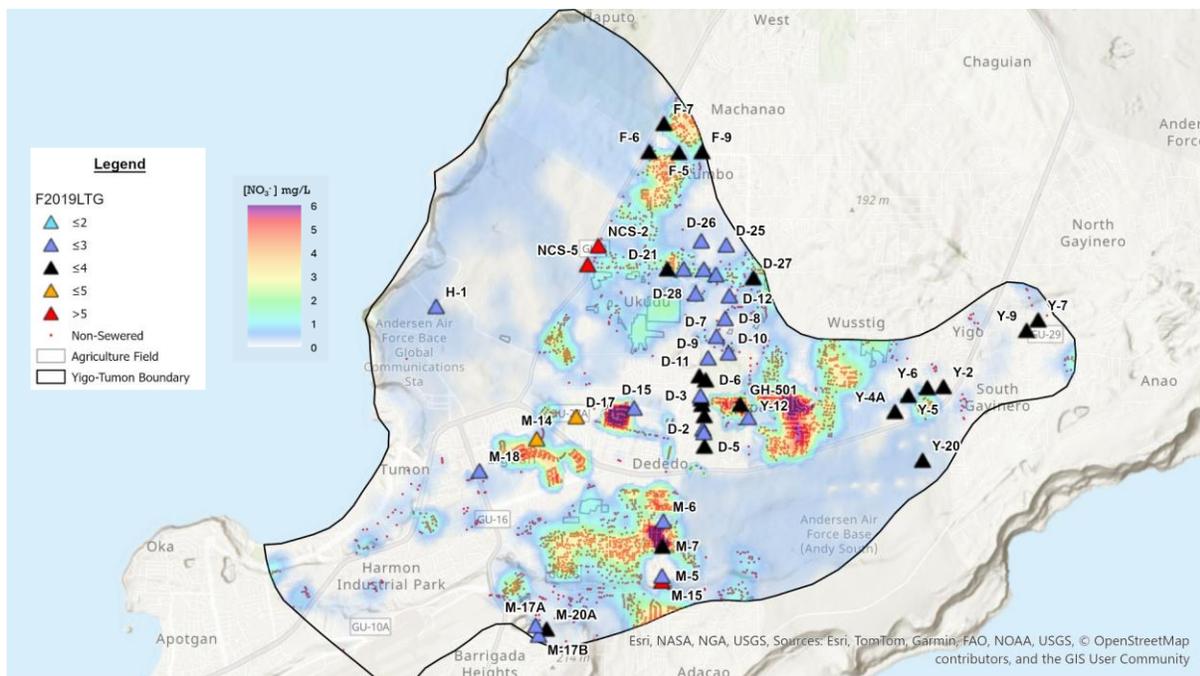
Multi-variable hydrographic analysis of the GHURA-Dededo DOW

statistical information that is key to building a reliable model. Groundwater models can run an acceptable representation on a computer, simulating and testing scenarios for optimum development. Hydrologic models have limitations vs reality; however, they provide insight into capacities and vulnerabilities, and may help with determining sustainable development and water resources management strategies, including enacting appropriate regulations/laws for protecting the aquifer.

Nitrate-N Solute Transport of the Tomhom Aquifer Basin

A. Bautista, J.A. Caasi, T. Wood, and N.C. Habana

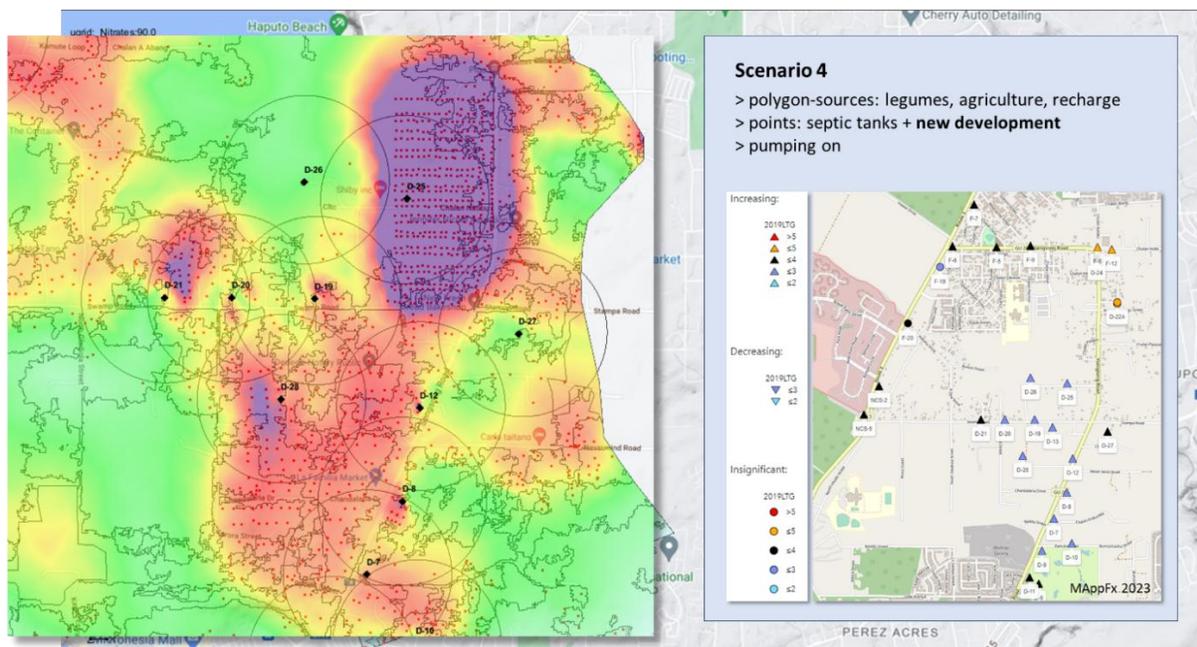
This study builds upon the Swamp Road pilot model by applying a similar modeling approach to the Tomhom Aquifer Basin, the most productive groundwater basin within the NGLA. The model was constructed using Esri ArcGIS Pro and [Aquaveo GMS](#), [MODFLOW USG](#), which provided the framework for compiling and refining spatial datasets, as well as simulating groundwater flow and solute transport. Three scenarios were formulated to represent different conditions, including on/off pumping and varying nitrate-nitrogen inputs, to evaluate nitrate migration toward production wells. Among the model simulations, one scenario identified nitrate hotspots in areas containing existing septic tank systems, suggesting potential plume migration toward nearby production wells. These findings emphasize the importance of proper wastewater management and land-use planning to protect the quality of Guam’s primary drinking water resource. This research was presented at the 2025 WERI–GLE Guam Hydrologic Survey (GHS) Workshop, and a technical report will be produced to further document and analyze the results of this study.



Nitrate- N Solute Transport of Swamp Road

A. Bautista, J.A. Caasi, T. Wood, and N.C. Habana

The freshwater source in the NGLA is vulnerable to the island's wastewater system. Ongoing urban growth, aging established residential areas, and wastewater discharge above the water source via septic tanks and leaky/overflowed sewer mains have long posed risks to groundwater quality. Nitrate analyses of production wells have found many wells with an increased trend in nitrate-N concentrations ([The Guam Daily Post 2020](#)). This study applied a solute transport model in the Swamp Road area to evaluate current regulations governing residential septic tank density and distances between buildings to production wells. The model results revealed the extent of contaminant plumes near production wells, which may support refined regulations for development near production wells. This research continues to make model refinements of nitrate-N sources and scenarios in a planned residential area near the Swamp Road production wells. The model examined septic tank use within a planned high-density residential area, revealing intensified nitrate plume formation. Findings from this study have been presented to various island agencies and at multiple venues, gaining significant attention from the Guam Legislature. It serves as a pilot study for future research on groundwater contaminant transport across the island. A technical report detailing the study's findings and implications is expected to be completed by the end of the year.



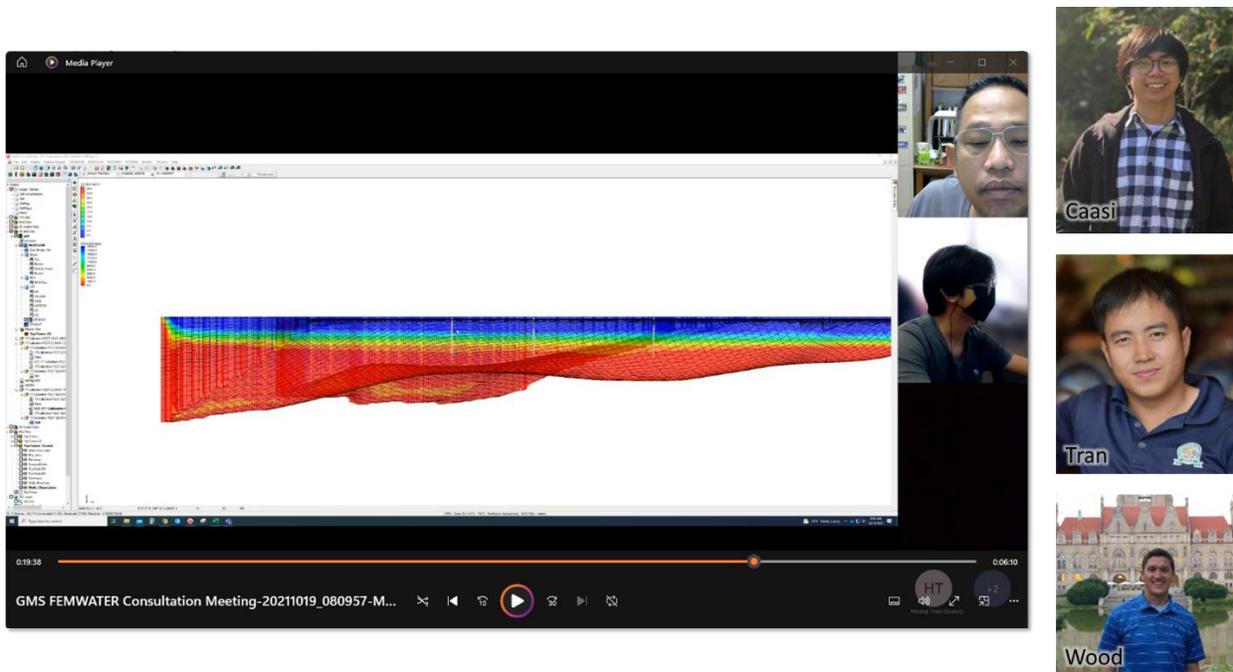
Nitrate-N solute transport model results of development density scenario

Groundwater Model of the Tomhom Aquifer

J.A. Caasi, N.C. Habana, B. Railey, T. Wood, and H. Tran

WERI GHS groundwater model research team and Aquaveo® GMS produced a SEAWAT phreatic model of the Tomhom Aquifer, NGLA. The Tomhom Aquifer supplies nearly 20 MGD, about half of the total utility water from the NGLA. The model was created to test a GWA Master Plan, well relocation option, which terminates and moves

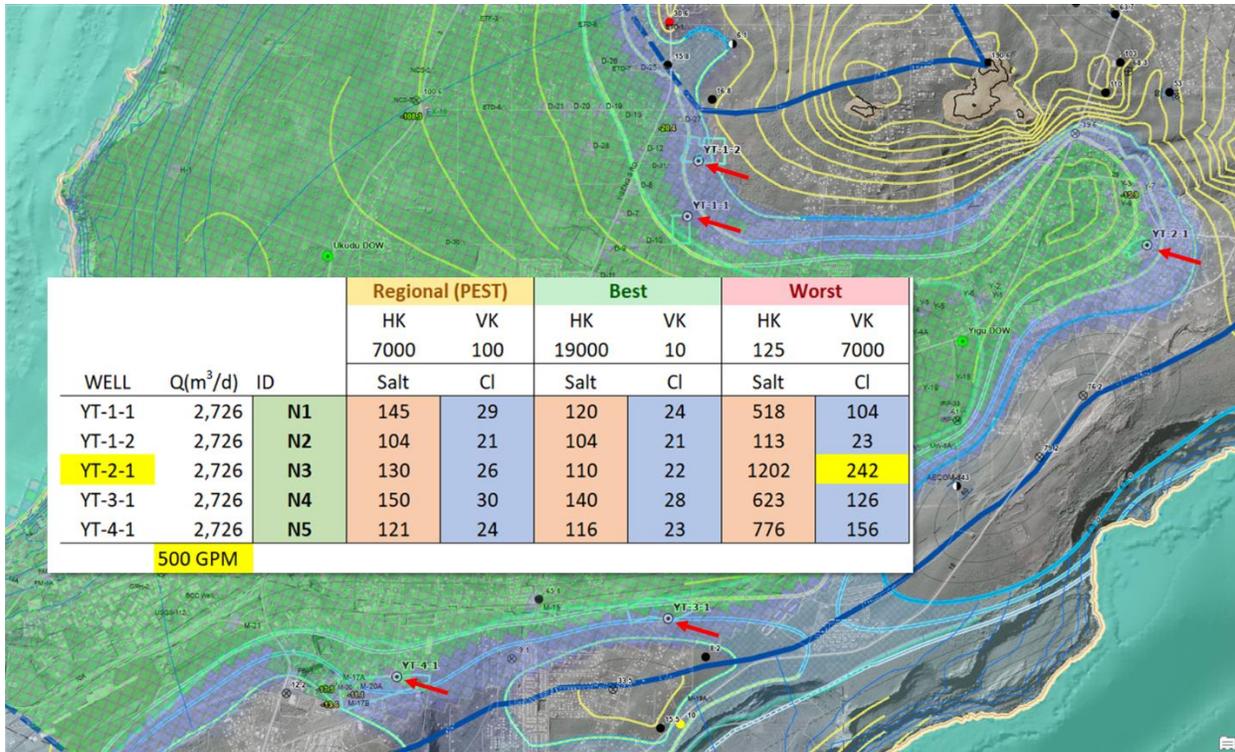
the poor performing production wells to the aquifer “sweet spot,” also known as the parabasal zone. Production wells in the parabasal zone are less susceptible to saltwater intrusion (McDonald 2003, WTR 98), and may allow increased production rate. The poor performing production wells are low pump rate that is limited by chloride (saltwater) updraw. Five wells were chosen, based on GWA production well chloride and pump rate data. And five relocation sites in the parabasal zone were selected. The model was “calibrated,” local hydraulic conductivity (vertical and horizontal) was adjusted to match the well chloride concentration, using the latest pump rate for each well. Then, the existing parabasal wells were analyzed with the model hydraulic conductivities, in search for the hydraulic conductivities of its worst and best performing wells in the zone. The regional hydraulic conductivities were included in the test as well. Pumping each relocated well at 500 gpm, model results showed that in each case of hydraulic conductivities, the chloride concentration was below 250 mg/L in each well. A technical report needs to be produced for this GHS research work.



WERI and Aquaveo, **3-D SEAWAT** phreatic model of the Tomhom Aquifer, showing the freshwater lens (dark blue), transition zone (green-yellow), and saltwater (red)

Guam Hydrologic Survey Outreach - Presentations, Tours, Workshops, Conferences, Symposiums, and Meetings

WERI includes education and outreach programs to government and private sector employees and stakeholders, and to educators as well. In this fiscal year, WERI and Global Learning and Engagement (GLE, UOG) brought back the Northern Guam Lens Aquifer Tour and The GHS WERI Workshop, including educational outreach activities through an international collaboration workshop and special days for our public-school students. WERI also presented their GHS research work and products in the local and



Model results for the relocation of 5 production wells in select parcels over the parabasal zone

national stage. The full news/events story are available on the WERI website. The WERI Guam Hydrologic Survey Program continues to make local and national impact.

Aquifer Tour, Workshop, and Educational Outreach

The following are WERI GHS outreach stages where WERI shared their works in tours and workshop and educational outreach to our public-school students. The following are links to the events/news and full story on the WERI website:

- 2025 [WERI International Collaborative Research Workshop with Changwon National University's \(CWNU\) Global Learning and Academic Research Institution for Master's, PhD students and Postdocs \(GLAMP\)](#)
- 2025 [Career Day – J.Q. San Miguel Elementary School](#)
- 2025 [Guam Rocks! \(Ritidian's National Wildlife Refuge\)](#)
- 2025 [Career Day – J.Q. San Miguel Elementary School](#)
- 2025 [WERI's Northern Guam Lens Aquifer Tour](#)
- 2025 [WERI-GLE GHS Workshop](#)

The WERI-GLE GHS Workshop is the GHS Outreach Program's along the Guam Advisory Council Meeting is one of the most sought-after outreach the island stakeholders in government, military, and private sectors look forward to attending. This year's workshop was attended by 14 important stakeholder-agencies on the island.

Workshop Attendees:

- Bureau of Statistics and Plans, Guam Coastal Management Program
- Department of Land Management
- Guam Department of Agriculture
- Guam Environmental Protection Agency
- Gutteridge Haskins & Davey Inc.
- Guam Housing and Urban Renewal Authority
- Guam Waterworks Authority
- HDR, Inc.
- Guam Legislature (Senator Perez's Office)
- Naval Facilities Engineering Systems Command Marianas
- Northern and Southern Guam Soil and Water Conservation District
- National Weather Service, Weather Forecast Office
- University of Guam: SENG, CLASS/DEAL, CNAS, WERI
- US Geological Survey, Pacific Islands Water Science Center

Workshop presentations that were presented and submitted are now available on the GHS website:

[GHS Workshop Presentations](#)

Conference/Symposium/Meeting Presentations

Into FY 2025, the following were outreach stages where GHS projects and products were presented in a Conference/Stakeholder's Meeting. The following are links to the events/news on the WERI website:

- 2024 [WERI CNMI Advisory Council Meeting](#)
- 2024 [WERI Guam Advisory Council Meeting](#)
- 2024 [National Groundwater Association \(NGWA\), Annual Groundwater Week](#) (Snaer awarded the Farvolden Scholarship)
- 2025 [Watershed Planning Committee Meeting](#)
- 2025 [Southern Guam Soil and Water Conservation District – Guam Educators Conservation Summit](#)
- 2025 [University of Guam's Conference on Island Sustainability](#)
- 2025 [UCOWR/NIWR Annual Water Resources Conference, University of Minnesota](#)
- 2025 [Watershed Planning Committee Meeting](#)
- 2025 [Northern Guam Soil and Water Conservation District – Educator's Symposium](#)
- 2025 [10th Assembly of Planners Symposium](#)
- 2025 [Worldwide Meteorological Organization/United Nations Economic and Social Commissions for Asia and the Pacific's \(WMO/UNESCAP\) Typhoon Committee Conference](#)

Local News

Following news headlines during FY 2025 concerning the presence of PFAS and Dieldrin in Guam's utility water, WERI took an active role in public engagement. WERI faculty provided numerous presentations and disseminated information to address community issues and concerns related to the contaminants. The contamination received coverage in multiple news outlets, including the *Guam Daily Post* and the *Guam Pacific Daily News*, prompting WERI to provide expert commentary and clarification.

- 2025 Dieldrin: [Guam Daily Post](#) | [WERI News](#)
- 2025 PFAS: [Guam PDN Instagram](#) | [Guam Daily Post](#) | [WERI](#)

Comprehensive Water Monitoring Program Activities

USGS-PIWSC continues hydrologic data collection under the CWMP. New DOWs have been constructed to improve phreatic modeling, historic profile assessments, and understanding of freshwater availability. However, the addition of new wells increases gaging and sampling, requiring additional operational and logistical support. In accordance with Public Law 24-247, the Government of Guam funds 50% of the CWMP cost share with USGS-PIWSC. This fiscal year, USGS-PIWSC completed four field visits to Guam. The most recently approved and published data are current through January 2025.

USGS-WERI Observation Well Data Collection

CWMP data collection was conducted in FY 2025. Due to the Federal Government shutdown, USGS PIWSC field team and administration are currently on furlough, thus USGS' CWMP activities summary cannot be provided at this time.



USGS Field Team and WERI GHS Research Assistant measuring water level at EX-9 DOW

The USGS field team conducted hydrologic measurements and retrieved logger data during the following periods:

- October 21–30, 2024 – All observation wells
- January 4–18, 2025 – CTD measurements, all observation wells
- April 13–22, 2025 – All observation wells
- July 10–27, 2025 – CTD measurements, all observation wells

CTD measurements are scheduled semi-annual, in months of January and July.

USGS operates 37 hydrologic gaging sites—24 within the aquifer and 13 within watersheds. A table lists these gaging stations alongside corresponding maps of the aquifer and watershed areas, with a link to the USGS online Mapper (see next four pages).

GHS-funded WERI Research Assistant and UOG Environmental Science graduate student Mary Clare Snaer joined the USGS field team for most DOW site visits. Snaer is conducting a hydrologic analysis of the phreatic zone (see *Deep Observation Wells* section above).

CWMP Observation Wells: latest data available, based on USGS' [Mapper](#) and [GeoLog Locator](#). Observation wells in the gray area are in the USGS maps, but have no recent hydrologic data.

DOW OWL	Owner	Data updated to latest field visit July 2025	Latest posted data on USGS website	Observation	Mapper ¹ WL	GeoLog Locator ² CTD
A-16	GG	Yes (Y)	Active Logger (AL)	OWL**	WLAL**	
M10-A	GG	Y	AL	OWL	WLAL	
A-20	GG	Y	7/23/2025	OWL	WL	
NCS-A	Mil	Y	7/19/2025	OWL	WL	
BPM-1	GG	Y	7/18/2025	OWL	WL	
MW-2	Mil	Y	7/16/2025	OWL	WL	
Yigo-1	GG	Y	7/16/2025	OWL new	WL	
EX-4	GG	No (N)	7/23/2024	DOW*	WL	CTD
GHURA-Dededo	GG	N	1/11/2025	DOW	WL	CTD
EX-9	GG	N	1/9/2025	DOW	WL	
EX-8	Mil	N	7/26/2024	DOW	WL	CTD
EX-10	GG	N	7/22/2024	DOW	WL	CTD
EX-1	GG	N	7/15/2024	DOW	WL	CTD
EX-7A	GG	N	1/16/2025	DOW new	WL	CTD
NCSF-1 DOW	Mil	N	1/10/2025	DOW new	WL	CTD
NCSF-2 DOW	Mil	N	7/18/2024	DOW new	WL	CTD
AAFB-1	Mil	N	No data available (NDA)	DOW new	WL	CTD, not yet posted
Marbo-1 DOW	Mil	N	NDA	DOW new	WL	CTD, not yet posted
NCSB-1	Mil	N	NDA	DOW new	WL	CTD, not yet posted
NWF-1	Mil	N	NDA	DOW new	WL	CTD, not yet posted
EX-6 (no longer observed)	GG	Y	9/17/2008	DOW		CTD, but closed 9/17/2008
EX-7 (no longer observed)	GG	Y	7/28/2017	DOW		CTD, but closed 7/28/2017
NCS-3 (no longer observed?)	Mil	N	NDA	?		comp. log, no CTD, no WL
AECOM-3	Mil	N	4/19/2024	OWL	WL	composite log, no CTD
AECOM-1	Mil	N	NDA	?		comp. log, no CTD, no WL
AECOM-6	Mil	N	NDA	?		comp. log, no CTD, no WL
AECOM-7	Mil	N	NDA	?		comp. log, no CTD, no WL
AECOM-11	Mil	N	NDA	?		comp. log, no CTD, no WL

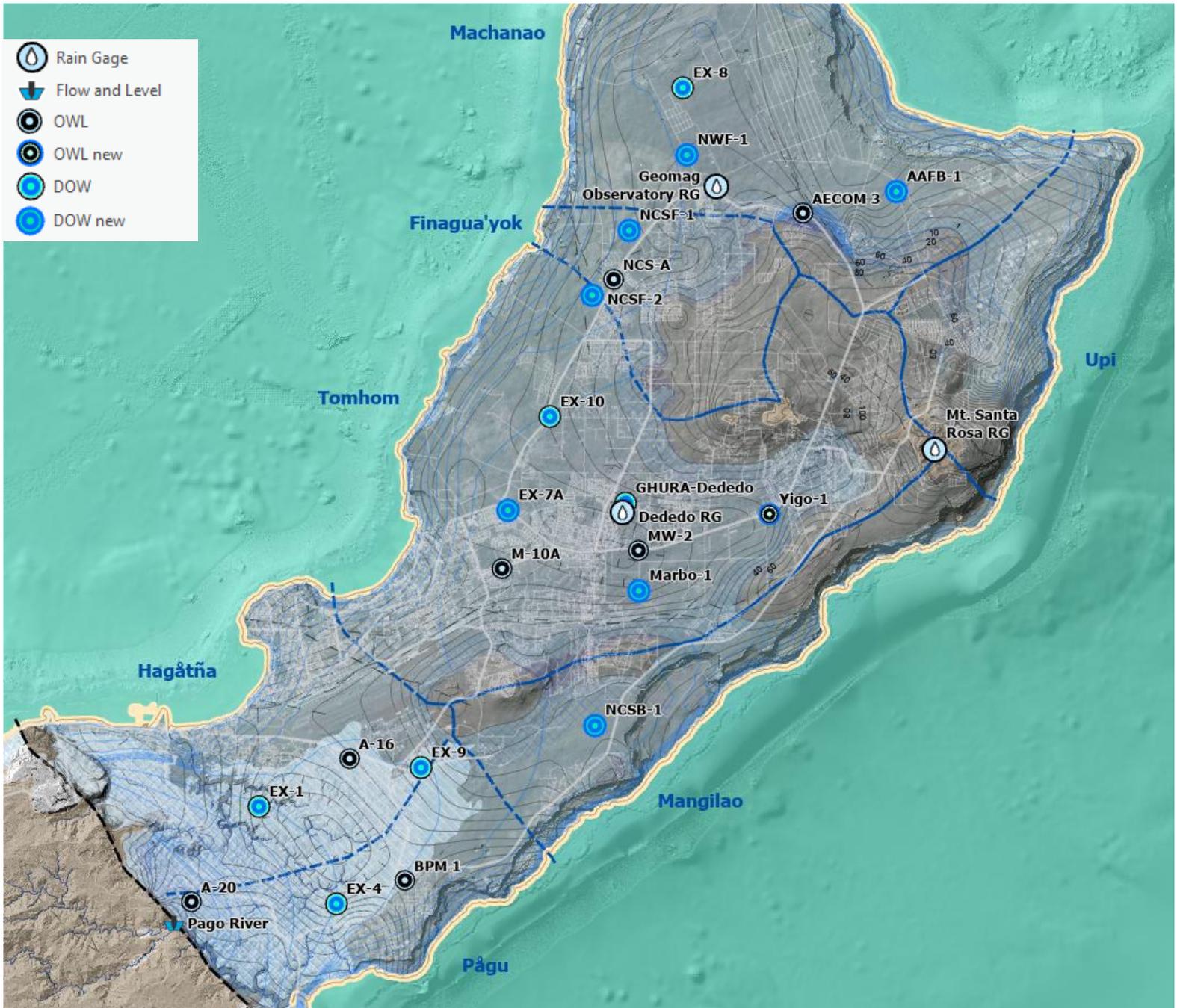
*Deep Observation Well - CTD and WL (WL is measured upon visits)

** OWL - Observation Water Level - WL only | WLAL - Water level active logger

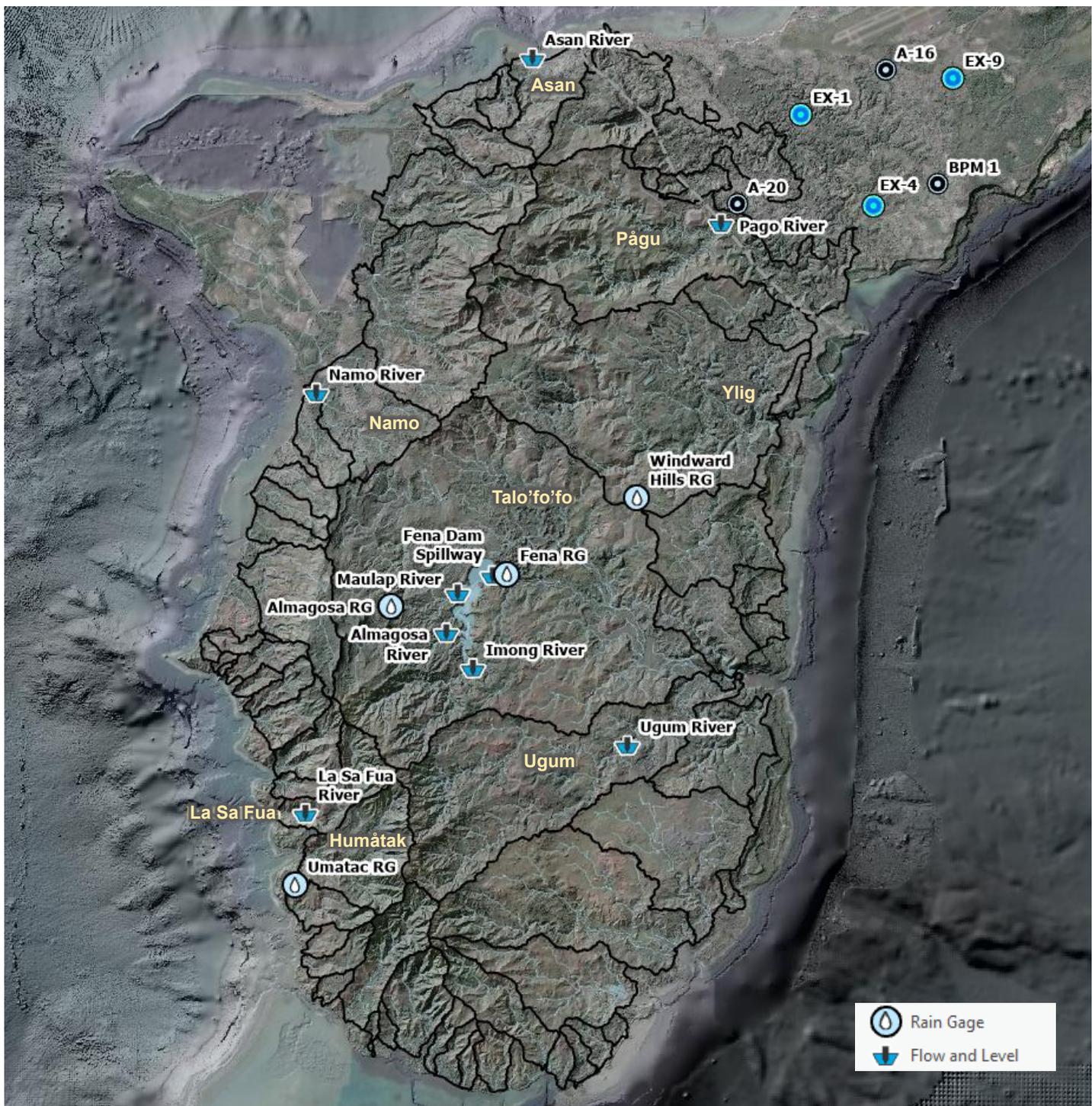
Hydrologic Observation Stations on Guam. Blackened coordinates were advised by NAVFAC for security.

	Station ID	USGS Site Number	Gage	Hydrologic Class	Observation	Aquifer/ Watershed	Village	nearby Landmark/Facility/Road	Land Property	Lat	Lon	USGS Data Site
Northern Guam Aquifer	AAFB-1	133519144542201	DOW new	GW	CTD, WLML*	Machanao	Yigo	Andersen AFB, 5th Street	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133519144542201
	EX-7A	133121144493101	DOW new	GW	CTD, WLML	Tomhom	Dededo	Rt. 1, between Rt. 3 & Calle De Fatima	GG GWA	13.522542	144.825278	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133121144493101
	NCSB-1	132843144503801	DOW new	GW	CTD, WLML	Mangilao	Barrigada	NCS Barrigada	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132843144503801
	NCSF-1	133448144510101	DOW new	GW	CTD, WLML	Finagua'yok	Dededo	NCS Finegayan	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133448144510101
	NCSF-2	133400144503301	DOW new	GW	CTD, WLML	Finagua'yok	Dededo	NCS Finegayan	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133400144503301
	NWF-1	133545144514401	DOW new	GW	CTD, WLML	Machanao	Dededo	Pott's Junction, Rt. 3A	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133545144514401
	EX-1	132736144461671	DOW	GW	CTD, WLM*	Hagåtña	MTM	J.Q. San Miguel Elementary School	GG GWA	13.461389	144.773611	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132736144461671
	EX-4	132626144471771	DOW	GW	CTD, WLM	Pågu	Mangilao	Father Duenas Memorial School	GG GWA	13.441583	144.790028	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132626144471771
	EX-9	132806144481871	DOW	GW	CTD, WLML	Hagåtña - Pågu	Barrigada	P.C. Lujan Elementary School	GG GWA	13.469667	144.807528	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132806144481871
	EX-10	133224144495271	DOW	GW	CTD, WLML	Tomhom	Finegayan	Swamp Road, Rt. 3	GG GWA	13.541833	144.833889	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133224144495271
	EX-8	133628144513271	DOW	GW	CTD, WLML	Machanao	Dededo	Northwest Field	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133628144513271
	GHURA-Dededo	133120144505471	DOW	GW	CTD, WLML	Tomhom	Dededo	GHURA 501, GICC	GG GWA	13.524250	144.849917	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133120144505471
	Marbo-1	133023144511001	DOW new	GW	CTD, WLML	Tomhom	Dededo	Marbo, UC Training Facility	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133023144511001
	Yigo-1	133120144524801	OWL new	GW	WLML	Tomhom	Yigo	Yigo Fire Station	GG GWA	13.522239	144.880122	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133120144524801
	A-16	132813144472771	OWL	GW	WLML	Hagåtña	Barrigada	Canada Toto Loop Rd	GG GWA	13.471361	144.792528	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132813144472771
	A-20	132624144452771	OWL	GW	WLML	Hagåtña - Pågu	Ordot - Chalan Pago	Judge Sablan St, Chalan Vicente C Blas, and Ramirez Dr.	GG GWA	13.441750	144.759639	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132624144452771
	AECOM 3	133502144531101	OWL	GW	WLML	Machanao	Dededo	Andersen AFB, Route 9, AAFB Gate	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133502144531101
	BPM 1	132644144480871	OWL	GW	WLML	Pågu	Mangilao	Abing St.	GG GWA	13.446528	144.804333	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132644144480871
	M-10A	133032144491871	OWL	GW	WLML	Tomhom	Dededo	Harmon Loop School	GG GWA	13.510611	144.824139	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133032144491871
	MW-2	133047144510171	OWL	GW	WLML	Tomhom	Yigo	Marbo, Rt. 1	GG GWA	13.514556	144.852722	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133047144510171
NCS-A	133412144504901	OWL	GW	WLML	Finagua'yok	Finegayan	Noyes St., Rt. 3, NCS	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133412144504901	
Dededo RG	133100144504966	Rain Gage	Rain	RF*	Tomhom	Dededo	GICC Golf Course, D-4	GG GWA	13.522250	144.849306	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133100144504966	
Geomag Observatory RG	133522144520601	Rain Gage	Rain	RF	Machanao	Dededo	Pott's Junction	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133522144520601	
Mt. Santa Rosa RG	133209144545301	Rain Gage	Rain	RF	Tomhom	Tomhom-Upi	Comm Dome	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=133209144545301	
Southern Guam Watersheds	Asan River	16807600	Flow and Level	River/Stream	PSF*	Asan	Asan	National Asan Park	GG	13.472639	144.713556	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16807600
	Namo River	16808120	Flow and Level	River/Stream	PSF	Namo	Agat - Santa Rita	Rt. 2A, Namu River	GG	13.398917	144.665944	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16808120
	La Sa Fua River	16809600	Flow and Level	River/Stream	SFL	La Sa Fua	Humåtak	Rt. 2, La Sa Fua River	GG	13.306944	144.664417	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16809600
	Imong River	16847000	Flow and Level	River/Stream	SFL	Talo'fo'fo	Talofoto	South Fena Reservoir, Imong River	GG	13.339000	144.701528	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16847000
	Almagosa River	16848100	Flow and Level	River/Stream	SFL	Talo'fo'fo	Hågat	South-east Fena Reservoir, Almagosa River	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16848100
	Maulap River	16848500	Flow and Level	River/Stream	SFL	Talo'fo'fo	Hågat	East Fena Reservoir, Maulap River	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16848500
	Fena Dam Spillway	16849000	Flow and Level	River/Stream	SFL	Talo'fo'fo	Santa Rita	Fena Reservoir dam spillway	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16849000
	Ugum River	16854500	Flow and Level	River/Stream	SFL	Ugum	Talofoto - Inarajan	Talofoto Falls	GG	13.322417	144.736139	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16854500
	Pago River	16865000	Flow and Level	River/Stream	SFL	Pågu	Ordot - Chalan Pago	Lonfit and Sigua Rivers junction, Pago River	GG	13.436806	144.756028	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=16865000
	Umatac RG	131729144393766	Rain Gage	Rain	RF	Humåtak	Humåtak	Umatac Fire Station	GG	13.291778	144.662194	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=131729144393766
Almagosa RG	132105144405166	Rain Gage	Rain	RF	Talo'fo'fo	Hågat	High Road, trail	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132105144405166	
Fena RG	132132144422366	Rain Gage	Rain	RF	Talo'fo'fo	Santa Rita	Pump Station, Fena Researvoir	Military			https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132132144422366	
Windward Hills RG	132234144441966	Rain Gage	Rain	RF	Ylig	Yona	Windward Hills Country Club, Fairway Dr.	Private	13.377167	144.737806	https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=132234144441966	

* CTD = Conductivity, Temperature, Depth | WLML = Water Level Measured, Logger | WLM = Water Level Measured | RF = Rainfall Logger | PSF = Peak streamflow | SFL = Streamflow and Level logger



Northern Guam aquifer observation well and rain gage stations – OWL (Observation Water Level) and DOW



Southern Guam watersheds, stream and rain gage stations

Pertinent Hydrologic Data

Building on existing collaboration, GWA provides WERI with monthly chloride and production data, which has been instrumental in developing MAppFx data visualization products and advancing research on groundwater flow, salinity, and nitrate transport. To produce a more robust and comprehensive annual aquifer report, a formal data-sharing protocol is needed. The protocol would ensure continuous and timely submission (at least quarterly) of observation well CTD, water level, and other regulated species data from all major agencies, including GWA, GEPA, and the military. Addressing and overcoming the challenges of acquiring sensitive utility information, often hindered by public water quality concerns, is a priority. By formalizing data submission, agencies can improve transparency, build public trust, and ensure that pertinent hydrologic data is consistently available for analysis, ultimately strengthening Guam's water protection strategies.

Intentional page