

Table of Contents

EXECUTIVE SUMMARY	ii
SCOPE AND PURPOSE	ii
ACCOMPLISHMENTS AND RECOMMENDATIONS FOR PATH FORWARD	ii
OBJECTIVE #1: COMPREHENSIVE GROUNDWATER MONITORING	ii
OBJECTIVE #2: MAKE DATA PUBLICLY AVAILABLE	iii
OBJECTIVE #3 SPECIAL PROJECTS AND PROGRAM SUPPORT	iv
1. INTRODUCTION.....	1
1.1 WHAT IS THE GAMA PROGRAM?	1
1.2 GAMA MISSION AND OBJECTIVES.....	2
1.3 STRUCTURE AND APPROACH TO THIS PROGRAM EVALUATION	3
2.REVIEW OF WORK COMPLETED	4
2.1 GAMA PROGRAM PROJECTS.....	4
2.2 TECHNICAL HYDROGEOLOGIC AND DATA SUPPORT.....	13
2.3 GAMA TOOLS AND RESOURCES	14
2.4 CHEMICALS OF CONCERN GROUNDWATER INFORMATION SHEETS	16
2.5 WATER QUALITY IN DOMESTIC WELLS	17
2.6 REPORTS	17
2.7 RECENT GAMA PROGRAM ENHANCEMENTS	19
2.8 SUMMARY OF PROGRAM WORK COMPLETED TO DATE	19
3. STAKEHOLDER AND WATER BOARDS FEEDBACK RESULTS	22
3.1 SOLICITATION AND GROUPS SURVEYED	22
3.2 WEBSITE USAGE DATA.....	22
3.3 GAMA PAC RECOMMENDATION.....	22
3.4 SUMMARY AND COMPILATION OF FEEDBACK.....	23
4. NEXT STEPS: GOALS AND INITIATIVES.....	26
4.1 CONTINUE/INCREASE GAMA SUPPORT OF OTHER PROJECTS AND PROGRAMS	26
4.2 INCREASE ACCESS AND USE OF GAMA RESOURCES.....	28
4.3 INCREASE DATA AVAILABILITY AND ENHANCEMENT OF THE DATA INTERFACE	29

Executive Summary

Scope and Purpose

The State Water Resources Control Board (State Water Board) Groundwater Ambient Monitoring and Assessment (GAMA) Program began in 2000 due to a heightened awareness of groundwater quality and the need to assess groundwater statewide. The [Supplemental Report of the 1999 Budget Act](#) required the State Board to develop an ambient groundwater monitoring program and GAMA was created in 2000 as a result. Recognizing the need to comprehensively address groundwater, Assembly Bill 599 (AB 599, Liu) established the Groundwater Quality Monitoring Act of 2001 (Water Code Section 10781). The goal of AB 599 is to improve comprehensive groundwater quality monitoring and increase the availability of groundwater quality information to the public.

The GAMA Program has evolved to support numerous Water Boards programs by providing scientific review and reporting, online tools, and standardize databases. This report presents an evaluation of program work completed to date and presents recommendations for future GAMA program efforts based on the results of this evaluation.

Accomplishments and Recommendations for Path Forward

The core objectives of the GAMA Program are to:

- *improve statewide comprehensive groundwater monitoring (Objective #1) and*
- *increase the availability of groundwater quality information to the public (Objective #2).*
- *conduct special projects and data assessments to support programs involving groundwater quality in California (Objective #3).*

A summary of accomplishments and recommendations for continued work toward these goals is provided below. A more detailed description of these accomplishments and recommendations are provided in the main body of this report.

Objective #1: Comprehensive Groundwater Monitoring

Accomplishments

The GAMA Program met its core objective to monitor groundwater quality throughout California through the following projects:

- **Priority Basin Project** comprehensively monitors ambient groundwater quality statewide. Since its inception, over 2,300 wells have been sampled in 35 study units that represent 98 percent of groundwater resources in California.
- **California Aquifer Susceptibility, Domestic Well, and Special Studies Projects** characterized groundwater vulnerability, recharge processes, fate and transport, denitrification processes, and impacts to domestic well owners across California

Recommendations for Continued Work

- **Continue the Priority Basin Project** through assessments of shallow aquifers typically accessed by domestic wells and State Small water systems.
- **Continue to assess for trends** through strategic sampling of existing municipal supply wells.
- **Compile a state-wide snapshot of perfluoroalkyl substances (PFAS)** compound concentrations in ambient groundwater.

Objective #2: Make Data Publicly Available

Accomplishments

The GAMA Program met its core objective to make comprehensive groundwater quality data available to the public:

- **Publicly available GAMA Groundwater Information System** compiled, standardized, and georeferenced over 87 million analytical results
- **Publicly available online tools and models** to assess well proximity to nitrate and 1,2,3 TCP; groundbreaking tools to evaluate non-point source contamination through managed contracts with University of California Davis (UC Davis).
- **Stakeholder process** hosted over 100 public meetings and GAMA-led trainings with Water Boards staff, community members, and other stakeholders including Groundwater Sustainability Agencies (GSAs), non-governmental agencies, academia, and variety of other users of GAMA data that contact staff.

Recommendations for Continued Work

- Increase the quality and frequency of information exchange to better communicate the GAMA Program framework and services:
 - Increase stakeholder and Water Boards awareness of the GAMA Program, and the unique resources the program offers through consistent, increased outreach.
 - Communicate data findings through tools and infographic reporting to ensure program findings reach larger audiences
- Update GAMA program products, online interfaces and fact sheets to better support Water Boards and stakeholder efforts
 - Evaluate options for updating the GAMA Groundwater Information System to use an ESRI based platform
 - Evaluate options for creating a data submission portal to bring more statewide groundwater data into our online information systems
 - Make several specific improvements to the GAMA Groundwater Information System (outlined further on page 27)

Objective #3 Special Projects and Program Support

Accomplishments

The GAMA program provided evaluations of groundwater quality data and developed tools for the public to completed assessments of groundwater quality in support of several other programs involving groundwater quality issues, including:

- **Human Right to Water and Safe and Affordable Funding for Equity and Resilience (SAFER)** - analyzed available domestic well water quality as part of the Division of Drinking Water (DDW) Needs Assessment, partnered with the California Water Quality Monitoring Council to develop the Safe to Drink Portal
- **Sustainable Groundwater Management Act** - lead training for Groundwater Sustainability Agencies, developed groundwater age web-based application, collaborated with Lawrence Livermore National Laboratory and California State East Bay on groundwater age modeling study
- **Source Water Protection** - worked with DDW to develop source water protection initiatives, online data hub, and source water assessment tool

- **Recycled Water** – performed hydrogeological review of recycled water permit applications
- **Nitrate contamination** - provided hydrogeologic technical support to the office of enforcement
- **Salt and Nutrient Management Planning** – developed a website and data hosting tool for Salt and Nutrient Management Plans
- **California Water Plan updates and Well Standards** - provided hydrogeologic technical assistance and project review for Department of Water Resources (DWR)
- **Domestic well sampling, outreach, and education** - provided information to the public through multiple platforms and web applications (e.g., “Is My Well Near a Nitrate Impacted Well?”)

Recommendations for Continued Work

- **Continue to provide project specific groundwater technical and data support to other department programs and initiatives.**
 - Provide data support and tailored online tools to support ongoing projects.
 - Support efforts related to the Human Right to Water and SAFER Initiatives by collaborating and sharing data with Non-Governmental Organizations (NGOs) to help target efforts related to domestic wells
 - Provide data support and developed online tools to support ongoing projects under Sustainable Groundwater Management Act (SGMA)
 - Provide data tools and technical guidance to regional boards in support of basin evaluations associated with implementation of the Recycled Water Policy

GAMA Program Evaluation

1. Introduction

This report presents an assessment of the functions and work completed by the State Water Resources Control Board (State Board) Groundwater Ambient Monitoring and Assessment (GAMA) Program and provides recommended actions to further support program goals. This evaluation was conducted to assess the work that the program has performed, obtain and compile feedback from Water Boards staff and stakeholders, and outline recommendations for the future direction of the program.

1.1 What is the GAMA Program?

The GAMA Program was created in response to the need for a comprehensive statewide ambient groundwater quality monitoring program. California depends heavily on groundwater resources to meet its water supply needs, using more groundwater than any other state in the country (Foundation, 2017). During a typical year, groundwater supplies approximately 40 percent of the state's water supply, and supplies up to 60 percent during dry years (Board, 2018). Approximately 31 million Californians obtain at least part of their drinking water from a public water system that relies on groundwater (Board, 2018). Additionally, over 1.5 million Californians are served by domestic wells (Johnson and Belitz, 2015).

In the late 1990s, public concern raised awareness within the Legislature of groundwater contamination from methyl tertiary butyl ether (MTBE), perchlorate, and other emerging chemicals. The [Supplemental Report of the 1999 Budget Act](#) required the State Board to develop an ambient groundwater monitoring program and GAMA was created in 2000 as a result.

Recognizing the need to comprehensively address groundwater, [Assembly Bill 599 \(AB 599, Liu\)](#) established the Groundwater Quality Monitoring Act of 2001 (Water Code Section 10781). The goal of AB 599 is to improve comprehensive groundwater quality monitoring and increase the availability of groundwater quality information to the public. AB 599 requires the State Board, in coordination with an Interagency Task Force (ITF) and public advisory committee (GAMA PAC), to integrate existing monitoring programs, take advantage of and incorporate existing data whenever possible, design new program elements as necessary, prioritize groundwater basins that supply drinking water, design a database that provides public access to groundwater quality information, and to submit a report to the Legislature.

The 2003 Report to the Governor and Legislature, [A Comprehensive Groundwater Quality Monitoring Program for California](#), details the groundwater quality monitoring program. United States Geological Survey (USGS) prepared a plan entitled [Framework for a Ground-Water Quality Monitoring and Assessment Program for California](#), was included in the State Board's Report to the Legislature.

Since 2000, GAMA has extensively monitored California's groundwater resources by sampling over 2,300 wells in groundwater basins that account for 98 percent of groundwater use in California. Ambient groundwater quality results collected from these basins are provided to the public online. This has allowed Water Boards staff, water managers, state decision makers, and the public to better manage California's groundwater resources. In 2013, GAMA began to assess the remaining 2 percent of groundwater resources used for domestic and small system drinking water supplies.

In 2001, the GAMA program annually received \$1.3 million for contracts from the Waste Discharge Permit Fund (WDPF). From 2003 to 2012, program funding was supplemented from Proposition 50 bond sale revenues by \$5 million per year (average). In 2012, when Proposition 50 Bond funding ceased, the Governor's budget increased WDPF annual funding to \$4.34 million. The GAMA public advisory committee (GAMA PAC) includes several WDPF fee-paying members and is involved in making program decisions. Feedback from the GAMA PAC has helped guide the decision to increase data products and was used to develop future program goals and initiatives discussed in this report.

1.2 GAMA Mission and Objectives

The GAMA Program mission is to provide data, information, and tools to enable the public and decision makers to better assess ambient groundwater quality and understand groundwater quality changes throughout the state. The primary objectives of the GAMA Program are to:

1. Improve statewide comprehensive groundwater monitoring
2. Increase the availability of groundwater quality information to the public

Program objectives are met through interagency collaboration with the State and Regional Water Boards (Water Boards), Department of Water Resources (DWR), Department of Pesticide Regulation (DPR), USGS, Lawrence Livermore National Laboratory (LLNL), EcoInteractive (contractor for GAMA Groundwater Information System), and University of California Davis (UC Davis). In addition, the GAMA PAC, Interagency Task Force (ITF), Non-Governmental Organizations (NGOs), local water agencies, and well owners are essential stakeholders to the program.

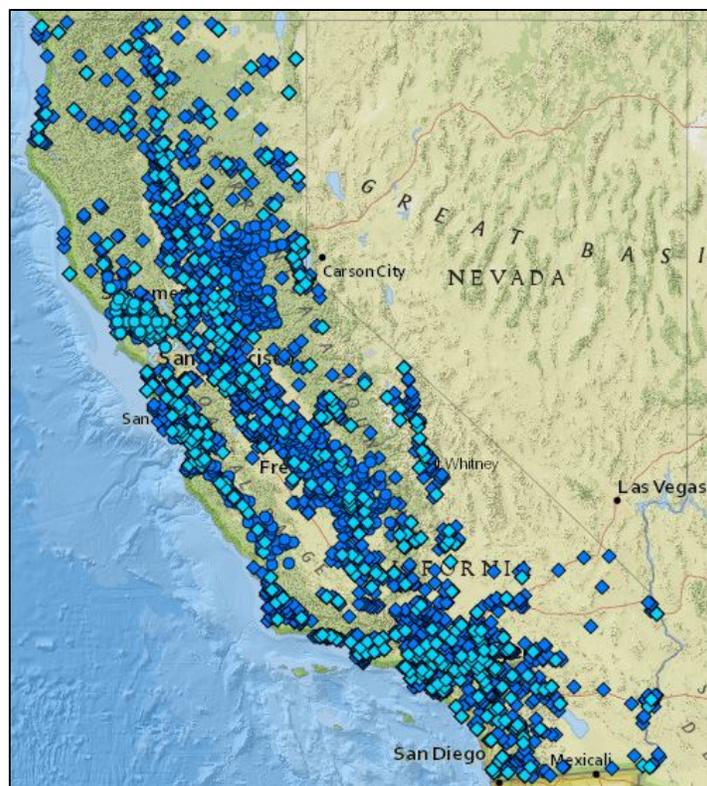


Figure 1. Groundwater wells sampled as part of the GAMA Program Priority Basin Project

1.3 Structure and Approach to this Program Evaluation

GAMA Program staff and managers from the State Board conducted this internal evaluation through completion of the following tasks:

1. Engage in discussions and administer written surveys to gather feedback with the following groups: State Board Deputy Management Coordinating Committee (DMC)/Management Coordinating Committee (MCC); Regional Water Boards; GAMA PAC; and several Water Board divisions and programs.
2. Evaluate the program in the following ways, and describe in this document:
 - a. Review and summarize the work completed by the program (section I of this document).
 - b. Synthesize feedback received from Water Board staff and stakeholders. Evaluate this information along with the work completed to determine whether statutory requirements and program mission, vision, and goals are being met (section II).
 - c. Use feedback and summary results to recommend future program efforts (section III)

2.Review of Work Completed

2.1 GAMA Program Projects

2.1.1 California Aquifer Susceptibility (CAS) Assessment

As a result of the initial Supplemental Report to the 1999 Budget Act, the GAMA Program began by analyzing existing groundwater data from public water system wells in areas of high population density and vulnerability to contamination. This analysis was implemented by studies contracted to LLNL and USGS for groundwater age dating and low-level VOC analysis. This groundbreaking study was called the [California Aquifer Susceptibility \(CAS\) Assessment](#), that was carried out from 2000 to 2003.

Table 1:California Aquifer Susceptibility Project Highlights

GAMA CALIFORNIA AQUIFER SUSCEPTIBILITY (CAS) ASSESSMENT	
PROJECT DETAILS	
<ul style="list-style-type: none"> • 850 public drinking water wells sampled in 8 study areas from the Santa Ana Watershed in Southern California to the Northern Sacramento Valley • Nine reports published 	
PROJECT BENEFITS	
<ul style="list-style-type: none"> • Established the list of most common contaminants in different areas and hydrogeological conditions • Served as a pilot study that helped to develop the GAMA Priority Basin Project 	
PROJECT SUCCESSES	
<ul style="list-style-type: none"> • Age dating analysis provided information on the presence of young groundwater as a proxy for susceptibility to land-use activities • Low-level VOC results were used as a hydrogeologic tracer to help understand complex groundwater flow dynamics 	
WEBSITE: http://www.waterboards.ca.gov/water_issues/programs/gama/cas.shtml	

2.1.2 Priority Basin Project

The [Priority Basin Project](#) provides a comprehensive statewide assessment of the ambient groundwater quality. Since 2002, over 3,000 public, small-system, and domestic wells that represent 98 percent of the groundwater resource have been sampled to create a statistically unbiased analysis of ambient groundwater quality statewide. USGS, as the technical lead on the project, also monitors for any groundwater quality changes over time (trends) by re-sampling a subset of the sampled wells every five years. Publications for each study unit details the study unit and summarizes data collected, and a simultaneously released factsheet, which provides this information in brief, illustrative terms.

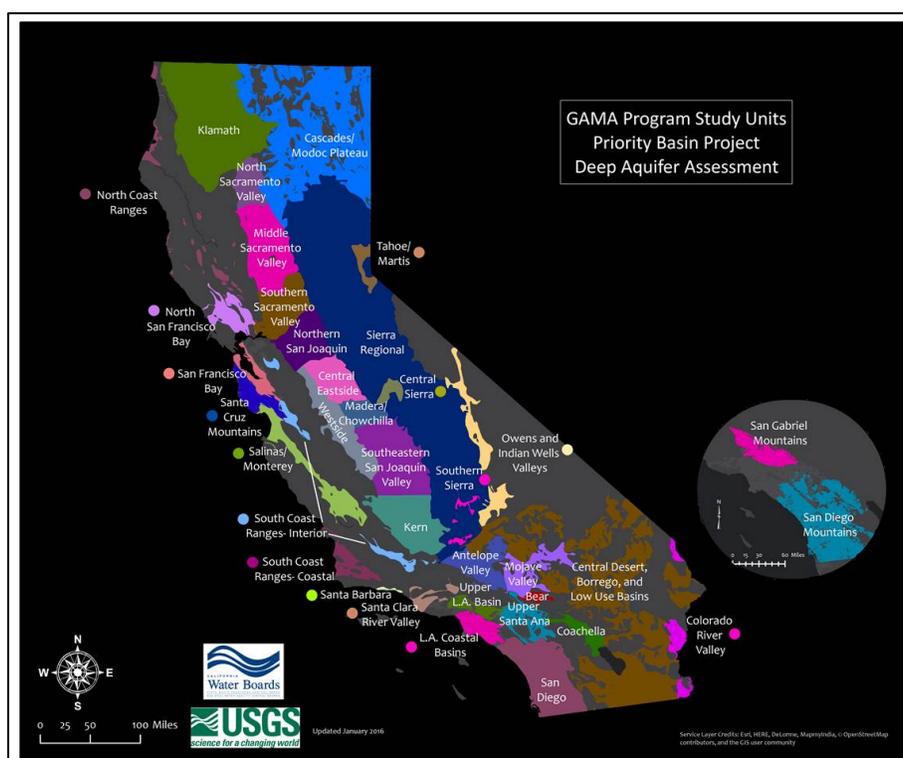


Figure 2. GAMA Priority Basin Project Study Units

Following the data reporting, an assessment report (Scientific Investigation Report) characterizes ambient groundwater quality conditions and assesses natural or human factors that affect them. A fact sheet is simultaneously released with the assessment report as well. In addition, USGS GAMA staff have published several scientific research papers in leading hydrogeologic journals. All data resulting from the Priority Basin Project is uploaded to the GAMA Groundwater Information System and all publications are posted on the State Board and USGS [GAMA Publications](#) web pages.

Table 2. GAMA Priority Basin Project Highlights

GAMA PRIORITY BASIN PROJECT	
PROJECT DETAILS	
Public Water System Wells (Baseline)	
<ul style="list-style-type: none"> • 2,300 wells sampled in 35 study units that represent 98 percent of groundwater resources in California • 35 Data Series (DS) Reports/28 Scientific Investigation Reports (SIR)/28 Fact Sheets/14 scientific papers have been published 	
Public Water System Wells (Trends)	
<ul style="list-style-type: none"> • 224 public water system wells sampled in 34 study units • 3 Data Series Reports have been published 	
Shallow Aquifer Assessment (Baseline)	
<ul style="list-style-type: none"> • 484 domestic wells sampled in 5 study units • 5 Data Series Reports have been published/ 5 Fact Sheets/1 Scientific Investigation Report 	
PROJECT BENEFITS	
<ul style="list-style-type: none"> • Establishes a baseline for tracking changes in groundwater quality at basin scales • Describes why observed water quality patterns exist and what natural process and human activities are responsible for constituent concentrations • Provides more robust information about water quality in groundwater resources used for drinking water supply than traditional drinking water quality source assessments • Identifies constituents in the groundwater present at concentrations near or above drinking-water quality benchmarks 	
PROJECT SUCCESSES	
<ul style="list-style-type: none"> • Isotopic compositions of certain elements and noble gas concentrations help to determine groundwater sources and recharge conditions, thus evaluating aquifer potentials, the source and potential impacts. • Results help to develop groundwater monitoring programs and preventive actions in areas where groundwater is affected by either anthropogenic or naturally occurring chemicals. For example, data available in the GAMA Groundwater Information System provide invaluable source/information for development of the Salt and Nutrient Management Plans. • Results intended for use by drinking water suppliers, entities managing groundwater under the Sustainable Groundwater Management Act and other local programs, help support evaluations of regulatory programs being implemented by the Water Boards. • The Priority Basin Project measures groundwater chemical concentrations at detection levels at 10 to 100 times lower than required by the Division of Drinking Water, allowing water managers to identify trends in ground-water quality in their region and respond before concentrations can exceed drinking water standards 	
WEBSITE: http://www.waterboards.ca.gov/gama/priority_basin_projects.shtml	

2.1.3 GAMA Groundwater Information System

The [GAMA Groundwater Information System](#) makes groundwater quality data and information available to the public. It houses GAMA Program related data, and integrates, standardizes, and displays groundwater quality data from several other sources on an interactive map interface. Analytical tools and reporting features help users assess groundwater quality information and identify potential groundwater issues statewide. The user interface was upgraded in 2020 and improvements and additions are continually developed as system needs change.

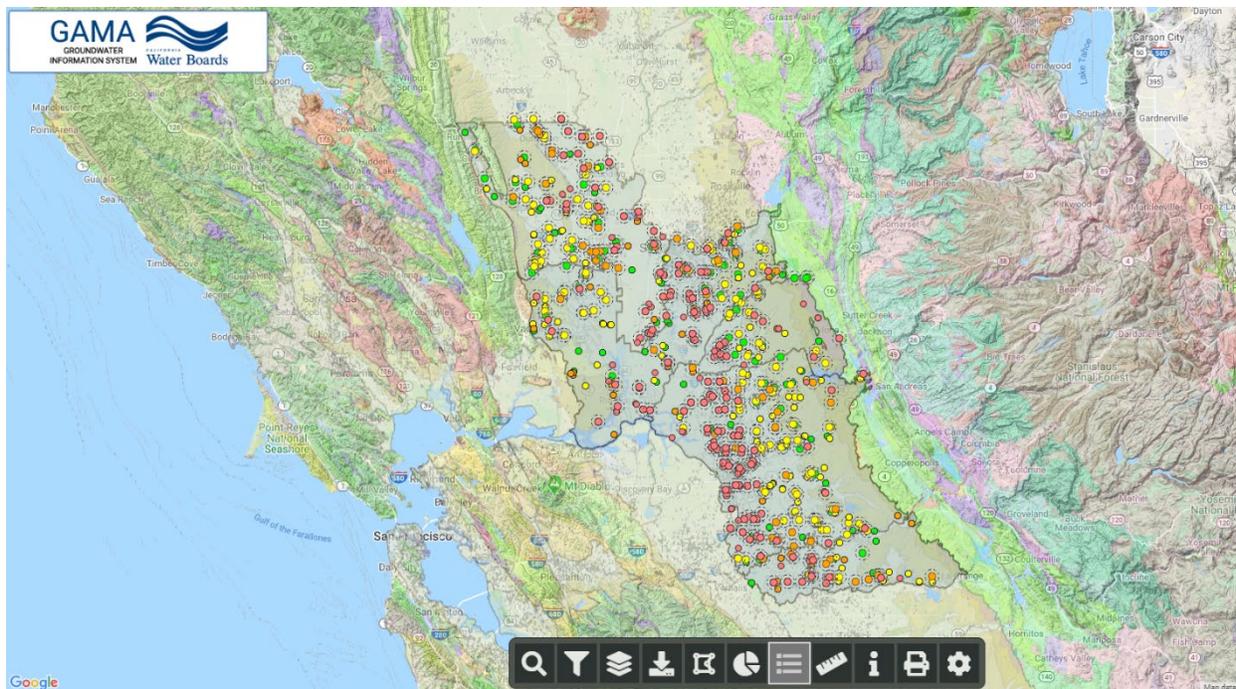


Figure 3. GAMA Groundwater Information System

Table 3. GAMA Groundwater Information System Highlights

GAMA GROUNDWATER INFORMATION SYSTEM	
PROJECT DETAILS	
<ul style="list-style-type: none"> • Publicly accessible online groundwater data repository • Contains approximately 87 million standardized analytical test results from over 291,000 wells • Contains more than 3.9 million depth-to-water measurements from Water Boards cleanup sites and the DWR water level data • Contains more than 137,000 environmental boring logs with well construction information • Contains more than 956,000 DWR well logs (available to regulators) • Contains 258 standardized chemicals 	
PROJECT BENEFITS	
<ul style="list-style-type: none"> • Standardized datasets from multiple sources including: DWR, DPR, National Water Information System, public water system wells, LLNL, USGS, Water Boards regulated sites and domestic well sampling data • Data categories (well locations, chemical data, depth to water, and elevation data) can be easily filtered and displayed within multiple map coverages. • Data can be easily exported for use in other programs • Groundwater information is constantly updated 	
PROJECT SUCCESSES	
<ul style="list-style-type: none"> • Custom data query options assist in locating potential impacts by displaying concentration results using chemical contaminant thresholds • Various water quality summary functions provide generalized groundwater quality information providing quick access to county wide chemical issues • Available Trends Graphs display chemical concentrations versus time to show likely trends in specified wells 	
WEBSITE: http://geotracker.waterboards.ca.gov/gama/gamamap/public	

2.1.4 Special Studies Project

LLNL was the project technical lead of the [Special Studies Project](#), which focuses on detailed groundwater quality studies using state-of-the-art laboratory analytical techniques and geochemical data analysis. Since 2004, study topics have included nitrate fate and transport, distinguishing agricultural and septic contamination signatures in groundwater, and groundwater age and recharge sources. These studies have used tracers such as stable isotopes, radiometric isotopes, noble gasses, and trace organic compounds such as pesticides, pharmaceuticals, and personal care products. All publications are available on the [GAMA Publications](#) web page. The Special Studies Project ceased in order to direct resources to Priority Basin Project Shallow Aquifer Assessment studies.

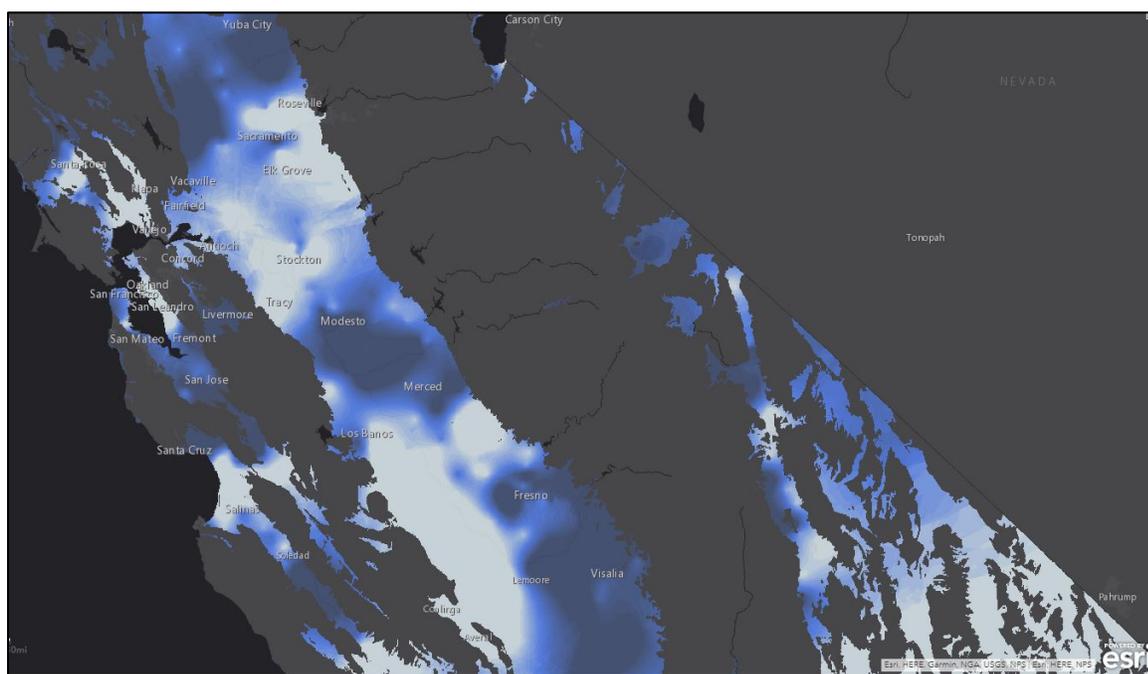


Figure 4. GAMA Online Tool: Groundwater Vulnerability Using Age Dating Data

Table 4. GAMA Special Studies Project Highlights

GAMA SPECIAL STUDIES PROJECT	
PROJECT DETAILS	
Nitrate sources, fate and transport	
<ul style="list-style-type: none"> • Groundwater from approximately 360 wells analyzed for multiple components; 10 reports were produced 	
Groundwater Age Dating	
<ul style="list-style-type: none"> • Over 2,500 groundwater samples were analyzed to evaluate groundwater age, recharge conditions, and sources of contamination; 10 reports were produced 	
Isotopic Compositions for water, nitrate, and other isotopic tracers	
<ul style="list-style-type: none"> • Hundreds of wells for Special Studies Project, Priority Basin Project and Domestic Well Project were tested to determine potential sources of nitrate, and source of recharge and transport conditions; 6 reports were produced 	
Noble Gases; neon, krypton, xenon, argon, helium	
<ul style="list-style-type: none"> • Over 2,500 samples were tested for noble gas concentrations to determine groundwater recharge conditions, source of recharge; a summary geostatistical report and 6 noble gas interpretative reports were produced 	
PROJECT BENEFITS	
<ul style="list-style-type: none"> • Developed new instruments to measure noble gas concentrations • Developed new analytical methods to measure wastewater indicators/tracers at nanoscale concentrations • Developed methods to measure stable isotopes • Improved methodology to trace the source(s) of nitrate in groundwater • Applied statistical methods and computer modeling to correlate groundwater geochemical parameters with groundwater source, age, and sources of contaminants 	
PROJECT SUCCESSES	
<ul style="list-style-type: none"> • Studies helped with the determination of potential nitrate sources in groundwater and fate and transport under different hydrogeological conditions and land use. • Studies provided information on the conditions under which nitrate in groundwater can be denitrified, and where its concentrations may increase and threaten drinking water sources. • Studies helped with the determination of groundwater age. Groundwater age and recharge conditions help to predict groundwater vulnerability to contamination and response to potential drought conditions. • Studies helped to evaluate how fast and what direction recharged water is moving, helping groundwater supply agencies to better manage aquifer recharge with treated wastewater or surface water runoff, without impacting groundwater quality. • Studies provided information on how surface precipitation percolate to groundwater and subsequently how prolonged drought conditions may affect aquifer storage in the future. 	
WEBSITE: http://www.waterboards.ca.gov/water_issues/programs/gama/special_studies.shtml	

2.1.5 Domestic Well Project

Domestic wells are not regulated like public water system wells. Each well owner is responsible for maintaining their well, including testing water quality. Well owners are oftentimes unaware of any potential contaminants in their well water.

Between 2002 and 2011, State Board GAMA Program staff sampled over 1,100 domestic wells for commonly detected chemicals in six California counties: Yuba, El Dorado, Tehama, Tulare, San Diego, and Monterey. The study was implemented by county based on domestic well use, participant interest, and availability of well records. The well owners volunteered to have their well sampled at no cost and received analytical results and fact sheets to inform them of any contaminants in their well water. A report summarizing domestic well results was produced for each county and is available on the [GAMA Publications](#) web page, and all data is accessible on the GAMA Groundwater Information System. Groundwater quality associated with domestic wells is currently being assessed by the Priority Basin Shallow Aquifer Assessment Project.

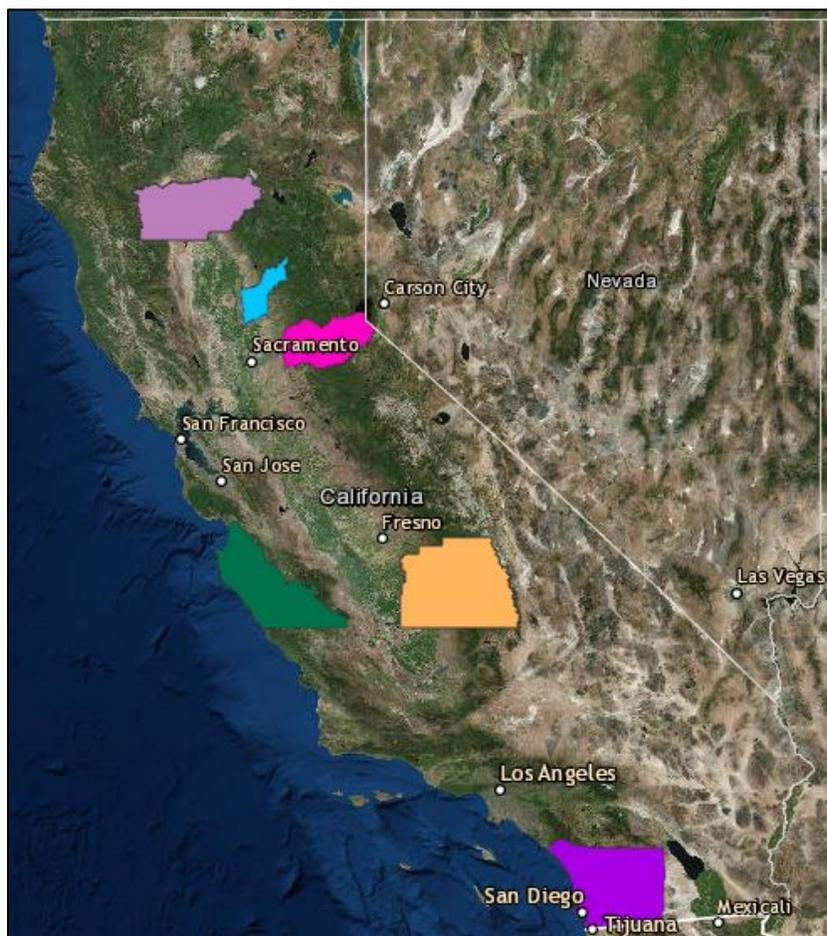


Figure 5. GAMA Domestic Well Project Study Units

Table 5a: GAMA Domestic Well Project Sampling information

GAMA DOMESTIC WELL PROJECT		
County (Sampling Date)	Number of Wells tested	Percentage of wells with results above MCL
Yuba County (2002)	128 wells	Total Coliform 22
El Dorado County (2003-04)	398 wells	Total Coliform 28
Tehama County (2005)	223 wells	Total Coliform 25, arsenic 14
Tulare County (2006)	181 wells	Total Coliform 33, nitrate 41
San Diego County (2008-09)	137 wells	Total Coliform 25, nitrate 18
Monterey County (2011)	79 wells	Total Coliform 14, nitrate 11

Table 5b: GAMA Domestic Well Project Highlights

GAMA DOMESTIC WELL PROJECT
PROJECT BENEFITS
<ul style="list-style-type: none"> • Provided information on groundwater quality to the well owners and the public (through the GAMA Groundwater Information System). • Identified potential impacts to shallow groundwater
PROJECT SUCCESSES
<ul style="list-style-type: none"> • Helped the state to evaluate the overall quality of the shallow groundwater used by domestic wells. • Provided well sampling and analysis, and information, to well owners at no charge
WEBSITE: http://www.waterboards.ca.gov/gama/domestic_well.shtml

2.2 Technical Hydrogeologic and Data Support

The GAMA Program also provides technical hydrogeologic support to other statewide programs when needed. GAMA program staff have provided technical hydrogeologic review, and assistance through the GAMA Groundwater Information System to the following groups:

- Water Boards:
 - State Water Boards' Divisions and Units - high level GIS support
 - Division of Drinking Water (DDW) - hydrogeologic analyses and public water system well aquifer tests to find new drinking water sources.
 - Office of Enforcement - actions involving groundwater.
 - DWQ Statewide Policies and Planning Unit –management of the contract with UC Davis to produce groundwater nonpoint source research and tools. Includes funding a portion of the contract.
 - DWQ Oil and Gas Unit - statewide groundwater monitoring and aquifer exemption reviews.
 - Central Coast and Central Valley Regional Water Board - Central Coast and Central Valley Regions Irrigated Lands Programs and grant projects.
 - San Diego Regional Water Board - analysis for the Santa Ana Region Poseidon Huntington Beach desalination project.
- Community Water Center -groundwater quality data and technical assistance for developing standard operating procedures for grant projects.
- Flood MAR- work as part of water quality subcommittee to develop research priorities and finalize flood-MAR Report
- Department of Water Resources (DWR) – developing geothermal heat exchange well and water well standards.

2.3 GAMA Tools and Resources

The GAMA Program provides maps, tools, and groundwater information to enable the public and decision makers to better assess groundwater quality. GAMA Program staff created the [GAMA Online Tools page](#) to house the links to new and existing data tools. A link to this tools page is embedded within the Department of Water Resources Sustainable Groundwater Management Act (SGMA) Data Viewer the GAMA Groundwater Information System resides on the on-line tools page, as well as:

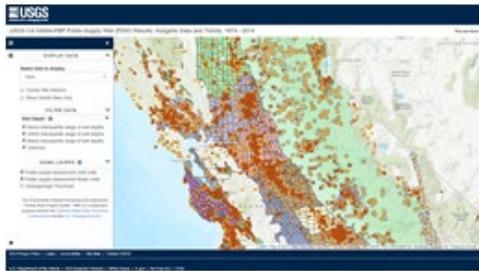
- GAMA Groundwater Publications Web map
- Is My Property Near a 123 TCP-Impacted Well?
- Is My Property Near a Nitrate-Impacted Well?
- Groundwater Vulnerability Using Age Dating Data
- USGS GAMA Groundwater Quality Mapping Tool
- Salt and Nutrient Management Plans Web map
- Digitized Well Completion Reports (Coming Soon)
- Source Water Protection Data Hub (Coming Soon)
- USGS GAMA Trend Analysis Tool (Coming Soon)



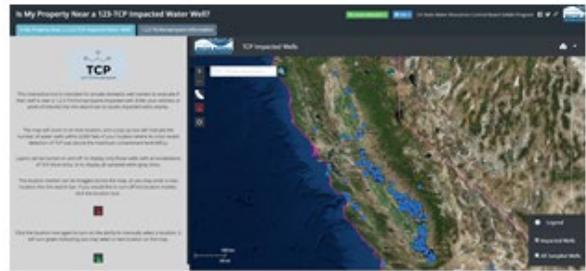
Groundwater Information System



Groundwater Vulnerability Using Groundwater Age



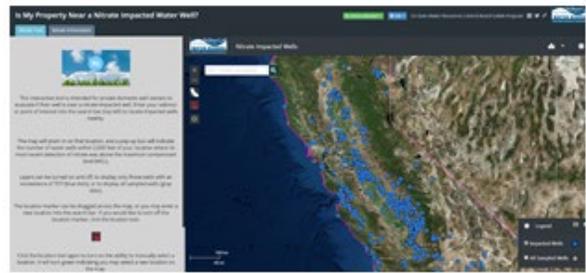
Trend Analysis Tool



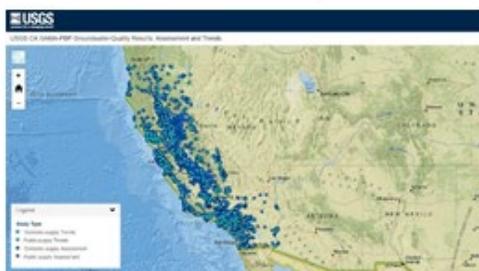
Is My Property Near a 123-TCP-Impacted Well?



Domestic Well Water Quality Tool



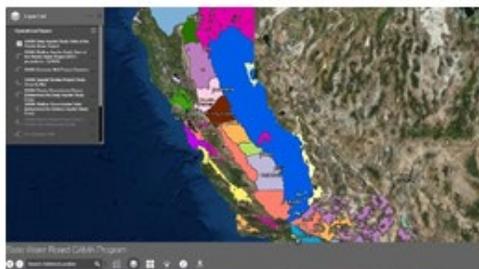
Is My Property Near a Nitrate-Impacted Well?



USGS Groundwater Quality Mapping Tool



Salt and Nutrient Management Plans Map



GAMA Groundwater Publications Webmap

Figure 6. GAMA Program Online Tools Webpage

2.3.1 Hydrogeologically Vulnerable Areas (HVA) Map

In 2000, DWQ staff created a map that identified hydrogeologic conditions that indicate a potential “vulnerability” groundwater to contamination sources (Figure 7). These HVAs are available as a GIS shapefile, available on the GAMA Groundwater Information System.

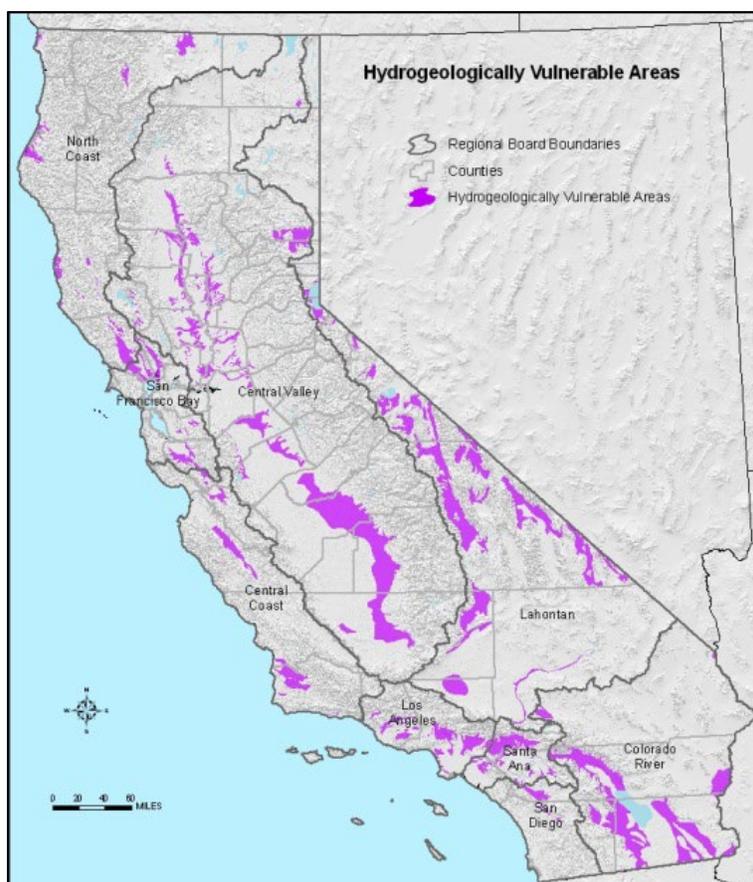


Figure 7. Hydrogeologically Vulnerable Areas (HVA)

2.3.2 Is My Property Near a Nitrate-Impacted Water Well?

In 2014, the GAMA Program created an interactive online map interface that displays locations of wells with known test results above the nitrate MCL to help domestic well owners evaluate if their well is near a nitrate-impacted well.

2.4 Chemicals of Concern Groundwater Information Sheets

The GAMA Program compiles technical information on Chemicals of Concern (COCs), which are chemicals that may pose a threat to groundwater quality in the State. Groundwater Information Sheets for each COC are available on the GAMA Program

website and are periodically updated to reflect developments in knowledge and treatment technologies and understanding of emerging COCs. Groundwater Information Sheets include the following for each chemical:

- chemical formula, aliases, and identification numbers
- regulatory and water quality concentration levels
- summary information pertaining to detection in California's groundwater
- analytical test methods, regulatory testing requirements, and known analytical limitations
- discussion of anthropogenic and natural COC sources
- environmental fate and transport characteristics
- history of occurrence
- remediation/treatment technologies
- adverse health effects
- key references

2.5 Water Quality in Domestic Wells

In California it is the responsibility of domestic well owners to assess whether their well water is safe. As such, GAMA staff created an online resource to provide well owners with information about maintaining a domestic well and how to maintain groundwater quality ("[Well Owner Guide](#)"). Additionally, fact sheets and frequently asked questions are provided on the [website](#), with links to important information such as certified laboratories, well sample collection methods and analytical tests, current state and federal maximum contaminant levels (MCLs), and approximate cost information associated with sampling domestic wells.

2.6 Reports

2.6.1 Public Accessibility to Information about Groundwater Conditions

In 2008, Assembly Bill 2222 (AB 2222, Caballero) required the State Board to prepare two reports. The first [Report to the Legislature](#), submitted in December 2010, recommended ways to enhance public accessibility of groundwater information and potential funding options to continue the GAMA Program.

2.6.2 Communities that Rely on Contaminated Groundwater

The second [Report to the Legislature](#) required by AB 2222, the submitted January 2013, identified 1) communities in California that relied on contaminated groundwater as a primary source of drinking water; 2) the principal groundwater contaminants and other constituents of concern; and 3) potential solutions and funding sources to clean up or treat groundwater or provide alternative water supplies.

2.6.3 Recommendations Addressing Nitrate in Groundwater

In February 2013, the State Board prepared a [Report to the Legislature](#), submitted in compliance with Chapter 1 of the Second Extraordinary Session of 2008 (SBX2 1, Perata). This legislation required the State Water Board to develop pilot projects focusing on nitrate in groundwater in the Tulare Lake Basin and Salinas Valley and to submit a report to the Legislature on the scope and findings of the pilot projects, including recommendations, within two years. The report detailed the scope and findings of the UC Davis pilot study projects in those areas. The Report to the Legislature made 15 recommendations to address the issues associated with nitrate contaminated groundwater, focusing on these key areas: 1) providing safe drinking water, 2) monitoring, assessment, and notification, 3) nitrogen tracking and reporting, and 4) protecting groundwater.

2.7 Recent GAMA Program Enhancements

Recent enhancements to the GAMA Program include:

- Increased data collected under the GAMA Priority Basin Project Shallow Aquifer Assessment, enhancing the groundwater quality dataset of the domestic and small-system drinking-water resource.
- Collected well construction data and integrated that data into online GAMA Groundwater Information System.
- The GAMA PAC reached consensus to begin developing online tools to assist those required to submit Groundwater Sustainability Plans under the new statewide SGMA regulations. State Board and USGS GAMA Program staff have initiated the development of new online tools.
- Developed and implemented a ticketing system for GeoTracker and the GAMA Groundwater Information Systems to prioritize tasks when changes or improvements to the system are requested. This has resulted in a more efficient feedback loop for system users.
- Designed a data upload system to facilitate collection of additional groundwater quality data from a variety of stakeholders.
- Managing a contract with the University of California, Davis to develop methods, models, and tools to analyze nonpoint sources of contamination of groundwater quality and to model groundwater quality changes associated with changes in overlying land use. Tools developed will be available on the GAMA Program website.
- Managing a contract with California State University East Bay and the Lawrence Livermore National Lab, who has teamed with the Butte County Department of Water Resources and Conservation to develop a groundwater age as a tool for sustainable groundwater management.
- Developing an online map-based Source Water Protection Data Hub to centralize data supporting source water protection (both ground and surface water) with the capability to download data and create source water assessments for newly permitted drinking water sources (as required by the Safe Drinking Water Act).

2.8 Summary of Program Work Completed to Date

The Priority Basin Project Phase I (comprehensive statewide assessment of resource used by 98 percent of water users) and Phase II (shallow aquifer assessment, domestic well users) have provided a foundation for establishing ambient groundwater quality on a basin/sub basin wide scale. Assessment reports generated by the USGS, LLNL, and CSU East Bay demonstrate the utility of the data collected through these GAMA projects in understanding the status of groundwater quality in California. The GAMA Groundwater Information System and online tools provide easy public access to groundwater quality data.

Table 6 summarizes the projects described in the preceding section that fulfilled the core GAMA objectives. These projects were completed in cooperation with the technical leads of the USGS and LLNL.

Table 6. Projects completed within the GAMA Program's core objectives

PRIORITY BASIN PROJECT	<ul style="list-style-type: none"> • Characterized ambient groundwater quality by sampling and analyzing groundwater in 98 percent of resource used • Published over 110 fact sheets and publications • Analyzed over 8,000 groundwater samples for diverse suites of chemicals, including Tritium/He, low level VOCs, isotopes, chemicals of concern, trace elements, bacteria, and noble gasses • Performed continued trend monitoring • Characterized the shallow groundwater resource used for domestic drinking water supply
CALIFORNIA AQUIFER SUSCEPTIBILITY, DOMESTIC WELL, AND SPECIAL STUDIES PROJECTS	<ul style="list-style-type: none"> • Characterized groundwater vulnerability and groundwater recharge processes; assessed groundwater age, fate and transport, denitrification studies, and impacts to domestic well users across California • Published over 50 reports and articles
GROUNDWATER INFORMATION SYSTEM	<ul style="list-style-type: none"> • Compiled, standardized, and georeferenced over 87 million analytical results from over 291,000 wells in California • Provided data to the public
ONLINE TOOLS AND MODELS	<ul style="list-style-type: none"> • Online Tools web page provides a growing set of tools for online users to better understand groundwater issues • Developed online tools for the public to assess well proximity to nitrate and 1,2,3-TCP • Groundbreaking tools, methods, and models in progress to evaluate non-point source contamination through managed contracts with UC Davis
STAKEHOLDER AND WATER BOARD FEEDBACK PROCESS	<ul style="list-style-type: none"> • Hosted over 100 meetings and GAMA-led trainings with State and Regional Board (Water Boards) program staff, community members, and stakeholders to report groundwater quality results, direct the development of GAMA Program tools, solicit feedback for improvement, and increase program awareness

The GAMA Program also provides technical support to many programs at the Water Boards, the Department of Water Resources, and a wide range of public audiences. Table 7 summarizes the projects described in the preceding section that provided technical support to a variety of initiatives and programs.

Table 7. Technical support to other divisions and programs provided by the GAMA Program

HUMAN RIGHT TO WATER/ SAFE AND AFFORDABLE FUNDING FOR EQUITY AND RESILIENCE	<ul style="list-style-type: none"> • Characterization of shallow aquifers used for domestic wells • Analysis of available domestic well water quality and remedies to provide clean drinking water as part of the Division of Drinking Water Needs Assessment • Partnership with the California Water Quality Monitoring Council to develop the Safe to Drink Portal
SUSTAINABLE GROUNDWATER MANAGEMENT ACT	<ul style="list-style-type: none"> • Training for Groundwater Sustainability Agencies (GSAs) • Development of a groundwater age web application • Collaboration with LLNL and California State East Bay on a groundwater age modeling study
DIVISION OF DRINKING WATER	<ul style="list-style-type: none"> • Development of source water protection initiatives, online data hub, and assessment plan tool. • Hydrogeological review of recycled water permit applications
OFFICE OF ENFORCEMENT	<ul style="list-style-type: none"> • Hydrogeological technical support in areas of nitrate contamination
SALT AND NUTRIENT MANAGEMENT PLANNING	<ul style="list-style-type: none"> • Website development and data hosting • Interactive reference application located on the GAMA online tools webpage
DEPARTMENT OF WATER RESOURCES	<ul style="list-style-type: none"> • Hydrogeological technical assistance and project review for Bulletin 118 and California Water Plan Updates • Development of well standards
GENERAL PUBLIC	<ul style="list-style-type: none"> • Sampling of domestic wells in several counties, which included outreach, education, and communication of groundwater quality results • Development of web applications (e.g., "Is My Well Near a Nitrate Impacted Well?")

3. Stakeholder and Water Boards Feedback Results

GAMA staff collected feedback from Water Boards staff stakeholders through facilitated presentations and discussions with State Board management groups (DMC/MCC), Regional Boards, State Board divisions and programs, and the GAMA PAC to complete this program evaluation. In addition, staff reviewed website usage data to better understand how the GAMA Program's online resources were being accessed and used.

3.1 Solicitation and Groups Surveyed

From 2016 to 2018, GAMA Program Staff collected user feedback in several formats from key user groups. This feedback was solicited in order to evaluate the utility of the GAMA program to Water Boards staff and stakeholders overall, and to assess whether the data in the GAMA program is usable and accessible to the public and groundwater community. Most of the key feedback was obtained during presentations and group discussions with DMC/MCC, Regional Boards, GAMA PAC, and other State Board divisions and programs. GAMA staff attended over 70 face-to-face meetings, webinars, data fairs, conferences, and roundtables throughout the state and received feedback on how the GAMA Program is beneficial and what could be improved. A GAMA Program Survey was also provided to meeting participants; approximately 32 surveys were completed.

3.2 Website Usage Data

During 2018, the GAMA webpage received an average of 1,658 public users per month and 52 regulatory users per month (survey based on unique IP addresses). The number of public users per month ranged from 1,500 to 1,956. An average of 1,271 data exports were made per month (all users) ranging from 619 to 2,578 exports. The data show GAMA Program stakeholders and Water Boards staff are consistently accessing the program website and using the data year-round. Several indicators suggest that the general public make up the majority of GAMA webpage users. For every state employee user from March to June 2019, ten public users accessed the GAMA system. GAMA program staff indicate most web support calls received are from general public users seeking assistance.

3.3 GAMA PAC Recommendation

GAMA PAC members met with staff on August 1, 2018 for a program update. The findings outlined in this document were described and discussed. A consensus was reached to direct funding for the USGS to create spatial web applications, and statistical analyses of GAMA Program data, including trends data. This recommendation is consistent with the GAMA PAC direction that the GAMA Program should provide technical support to SGMA efforts across the state. It was agreed that funding for these new efforts would be sourced from a 20% decrease in funding for the shallow aquifer assessment effort.

3.4 Summary and Compilation of Feedback

3.4.1 Summary of Feedback

Many Water Boards staff and stakeholders would like the GAMA program to continue with its current platform of ongoing, collaborative groundwater monitoring and high-quality trends analysis.

Water Boards staff and stakeholders are supportive of the GAMA Program continuing periodic groundwater sampling and groundwater studies to characterize chemicals of concern, identifying trends in groundwater quality, and centralizing the availability of groundwater information to better protect our groundwater resources. Water Boards staff indicated they would like to see the GAMA program staff continue to provide hydrogeologic technical support and enhanced collaboration with other California groundwater initiatives and State Board priorities. Feedback was received for the GAMA program to continue to:

- Support the USGS in collecting water quality data to assess groundwater resources throughout California
- Create online data tool and hubs
- Review technical documents
- Participate in workgroups
- Provide data analysis
- Generate online tools that support regulators and the public.
- Provide data support to users accessing GAMA-hosted groundwater data

3.4.2 Compilation of Specific Feedback

Table 8, below, provides a bulleted list of feedback and suggestions received during the evaluation period. Staff grouped the feedback and suggestions compiled in Table 8 into the following 3 broad goals for the program:

1. Continue/Increase GAMA Support of Other Projects and Programs;
2. Increase Access and Use of GAMA Resources; and
3. Increase Data Availability and Enhancement of the Data Interface.

Staff recommendations for the GAMA Program presented in Section 4.0 are organized by these three over-arching goals.

Table 8. Compilation of Water Boards and stakeholder feedback results

WATER BOARDS AND STAKEHOLDER FEEDBACK RESULTS
Continue/Increase GAMA Support of Other Projects and Programs
<ul style="list-style-type: none"> • Add more online tools and data hubs that support Water Boards and stakeholder projects and regulatory programs • Tools should be created to support efforts under the Sustainable Groundwater Management Act, Human Right to Water and Safe and Affordable Drinking Water. • Add more shallow groundwater data in drought zones. Facilitate collaboration between Regional and State Boards to ensure that groundwater data and project findings are shared • Address data needs of the Groundwater Sustainability Agencies due to SGMA requirement, on the GAMA Groundwater Information System
Increase Access and Use of GAMA Resources
<ul style="list-style-type: none"> • Some stakeholders unaware of the program’s existence • Frequent confusion about how the GAMA program relates to the GAMA Groundwater Information System (e.g. unaware that the GAMA program offers other technical hydrogeological and program support) • Frequent confusion that GAMA is synonymous with GeoTracker. Many stakeholders were unaware that GeoTracker is a case management database, while the GAMA program is based upon monitoring and assessing ambient groundwater quality and hosts a separate groundwater data and information system (GAMA Groundwater Information System), as well as a suite of online tools.

Table 8 continued on next page

Table 8 (continued).

WATER BOARDS AND STAKEHOLDER FEEDBACK RESULTS (CONTINUED)	
Increase Data Availability and Enhancement of the Data Interface	
<ul style="list-style-type: none"> • Provide additional data download options in GAMA Groundwater Information System Streamline functions and condense information presented provide chemical constituent grouping on the GAMA Groundwater Information System, (conventional, inorganics, metals, microbiological, nutrients, organics, PAHs, PCBs, pesticides, pyrethroids, and VOCs) • Provide ability to download data from a user drawn polygon in GAMA Groundwater Information System • Add depth filter function into the GAMA Groundwater Information System • Provide automated data updates and shapefiles from data residing within the GAMA Groundwater Information System • Incorporate additional data sources into GAMA Groundwater Information System such as the Department of Toxic Substances Control (DTSC), US EPA-led cleanup sites, and historical DDW and DWR data • Increase available shallow groundwater quality data • Collect historical data in paper/microfiche format from Regional Boards to include in the GAMA Groundwater Information System • Provide first encountered groundwater information • Provide well construction information including depths and screen intervals • Link well completion reports to well locations • Link the groundwater wells sampled under the GAMA Program to the duplicate public water system wells in the DDW dataset and provide the well IDs • Increase scope of water quality assessment tools • Remove obscuring filter to facilitate accurate well location analyses • Provide clear descriptions of GAMA Groundwater Information System functions • Add functionalities currently only available for GAMA staff: set specific value of chemical for query; query by date; allow statewide queries • Add depth filter function into the GAMA Groundwater Information System • Add ability to query for active, inactive, and destroyed public water system wells 	

4. Next Steps: Goals and Initiatives

This section presents staff recommendations for goals and initiatives for the GAMA Program. These goals and initiatives were developed based in large part in response to the stakeholder feedback presented in Section 3.0, and are organized by the three overarching goals introduced in Table 8:

1. Continue/Increase GAMA Support of Other Projects and Programs:
2. Increase Access and Use of GAMA Resources; and
3. Increase Data Availability and Enhancement of the Data Interface.

Recommendations to implement each of these goals are presented below. A description of how the recommended action aligns with priorities and actions in the [State Water Board Strategic Work Plan](#) is provided when applicable.

4.1 Continue/Increase GAMA Support of Other Projects and Programs

As new statewide policies are developed, the GAMA Program has an opportunity to support new efforts that align with the purpose and intent of the Program. Some of these efforts include the Sustainable Groundwater Management Act, Human Right to Water Act, Safe and Affordable Drinking Water Fund (Senate Bill 200, Monning, statutes of 2019), and Source Water Protection. The following sections list specific initiatives to support this goal.

4.1.1 Provide data support and tailored online tools to support ongoing projects.

Tools slated for continued development include: The Source Water Protection Tool, The USGS GAMA Program Trends Analysis Tool, The Digitized Well Completion Reports Viewer, The Non-Point Source Contamination Tool created for the GAMA Program by UC Davis.

Timeframe

Ongoing. The non-point source tool is scheduled for development over the next two years.

Alignment with State Water Board 2020 Strategic Work Plan The Source Water Protection Tool supports priority 2: “protect and restore watersheds....”. Providing the public with an on-line tool to show the relationship between water intakes that supply our drinking water supply and the watersheds that support those intakes will raise awareness on the importance of protecting watersheds. Similarly, the tool supports priority 3.4.1: “Promote sustainable forest health conditions that protect water quality.....”, by raising awareness of the linkage between forest and watershed health and the drinking water supply.

The Non-Point Source Contamination Tool supports Work Plan Goal 3.4.2: “Assist Regional Boards as they implement the Irrigated Lands Program.”.

Feedback items from Table 8 that fit initiative 4.1.1

- Add more online tools and data hubs that support stakeholder projects and regulatory programs.

4.1.2 Support efforts related to the Human Right to Water Initiative by collaborating and sharing data with NGOs to help target efforts related to domestic wells.

The GAMA Program is developed the Domestic Well Water Quality Tool in 2019 and providing domestic well water quality estimate information to NGOs including the Water Equity Science Shop (WESS). GAMA also is leading the effort to develop a state-wide aquifer risk map to characterize aquifers at potential risk of containing contaminants above safe drinking water pursuant to SB-200.

Timeframe

The domestic water quality tool will be updated annually. The aquifer risk map is scheduled for completion by the end of 2020, with annual updates ongoing.

Alignment with State Water Board 2020 Strategic Work Plan

These efforts support priority 1.1: "...Californians reliant on unregulated water systems ("state smalls" and private wells) know the quality of their water". The Domestic Well Water Quality Tool and the aquifer risk map will increase public awareness of locations where state small and domestic well water quality may be impaired, which will help direct monitoring and assessment in these areas.

Feedback items from Table 8 that fit initiative 4.1.2

- Tools should be created to support efforts under the Sustainable Groundwater Management Act and Human Right to Water.

4.1.3 Provide data support and tailored online tools to support ongoing projects under SGMA

The GAMA Program will develop data tools that will aid Groundwater Sustainability Agencies and the Department of Water Resources when fulfilling requirements under the Sustainable Groundwater Management Act. These applications will provide data and information needed by Sustainable Groundwater Agencies for Sustainable Groundwater Management Act requirements and utilize the GAMA Program's expertise.

Timeframe

Ongoing. The current 4-year contract with the USGS includes several data assessment tasks regarding groundwater quality on a basin/sub basin scale pursuant to SGMA evaluations.

Alignment with State Water Board 2020 Strategic Work Plan

This recommendation supports priority 3.3.2 "Provide tools and resources to groundwater sustainability agencies to encourage long-term drinking water and

water quality planning...”. The Trends Analysis Tool is an example of such a resource.

Feedback items from Table 8 that fit initiative 4.1.3

- Add more shallow groundwater data in drought zones. Facilitate collaboration between Regional and State Boards to ensure that groundwater data and project findings are shared
- Address data needs of the Groundwater Sustainability Agencies due to SGMA requirement, on the GAMA Groundwater Information System

4.1.4 Provide data tools and technical guidance to regional boards in support of basin evaluations associated with implementation of the Recycled Water Policy

The GAMA Program will provide technical support and outreach to regions to assist with basin-wide evaluations. This includes reviewing Recycled Water Permits, reviewing basin evaluations, and providing data to support basin evaluations through online resources such as the Source Water Protection Data Hub and the USGS trend tool.

Timeframe

Ongoing. GAMA staff allocate workload around this project on an ad-hoc basis as project needs arise.

Alignment with State Water Board 2020 Strategic Work Plan

This recommendation supports priority 3.2.2 “Implement the Recycled Water Policy”, which is part of the priority 3: “Increase statewide water resiliency by expanding and integrating California’s water supply portfolio”.

Feedback items from Table 8 that fit initiative 4.1.4

- Add more online tools and data hubs that support stakeholder projects and regulatory programs

4.2 Increase Access and Use of GAMA Resources

When GAMA Program data and tools are used by the regulatory and research community, it is important that these groups are also informed about the broader scope and mission of the program. This will help more groups to access the full breadth of resources the program offers.

The following sections list specific initiatives to support this goal.

4.2.1 Increase stakeholder awareness of the GAMA Program, and the unique resources the program offers through consistent, increased outreach.

Announce program enhancements in groundwater association publications and provide additional training (online and in person) to Water Boards staff and stakeholders on using online data tools.

Timeframe

Ongoing.

4.2.2 Communicate data findings through tools and infographic reporting to ensure program findings reach larger audiences.

GAMA program staff will generate a series of summary publications and tools, using their technical background and knowledge of the program-supported studies. GAMA Program staff will also create zonal maps displaying estimated locations of top groundwater contaminants statewide.

Timeframe

Two- to three-year timeframe.

Feedback items from Table 8 that fit initiative 4.2.2

- Some stakeholders unaware of the program's existence
- Frequent confusion about how the GAMA program relates to the GAMA Groundwater Information System (e.g. unaware that the GAMA program offers other technical hydrogeological and program support)
- Frequent confusion assuming GAMA is synonymous with GeoTracker. Stakeholders were often unaware that GeoTracker is a case management database, while the GAMA program is based upon monitoring and assessing ambient groundwater quality and hosts a separate groundwater data and information system as well as a suite of online tools.

4.3 Increase Data Availability and Enhancement of the Data Interface

The datasets and tools in this category will support all the initiatives listed above, and numerous other Water Boards and stakeholder efforts.

4.3.1 Evaluate options for updating the GAMA Program Groundwater Information System to use an ESRI based platform

Updating the GAMA online platform will help facilitate program staff to update data more quickly and create new online tools independently. This also allows our collaborators to work with us on tool concept innovation and refinement.

Timeframe

Significant enhancements completed in early 2020. Further enhancements ongoing.

Feedback items from Table 8 that fit initiative 4.3.1

- Provide additional data download options in GAMA Groundwater Information System
- Streamline functions and condense information presented
- Provide constituent grouping on the GAMA Groundwater Information System, (conventional, inorganics, metals, microbiological, nutrients, organics, PAHs, PCBs, pesticides, pyrethroids, and VOCs)
- Provide ability to download data from a user drawn polygon in GAMA Groundwater Information System
- Provide automated data updates and shapefiles from data residing within the GAMA Groundwater Information System

4.3.2 Evaluate options for creating a data submission portal to bring more statewide groundwater data into our online information systems.

Increasing the amount of groundwater data standardized by the GAMA Program aligns with the ongoing directives of the Groundwater Quality Monitoring Act of 2001. A data upload portal would make receiving data much easier by broadening the formats of data accepted. This would allow for efficient receipt and review of groundwater data from county water districts, local and state government programs, universities, historic governmental reports, and consulting reports. Staff are currently working to develop a framework and test this portal.

Timeframe

Initial data portal completed in late 2019. Refinements ongoing.

Feedback items from Table 8 that fit initiative 4.3.2

- Incorporate additional data sources into GAMA Groundwater Information System such as DTSC, US EPA-led cleanup sites, and historical DDW and DWR data
- Increase available shallow groundwater quality data
- Collect historical data in paper/microfiche format from Regional Boards to include in the GAMA Groundwater Information System

4.3.3 Make Improvements to the GAMA Groundwater Information System.

GAMA staff has initiated and is continuing to work on the following list of suggested improvements to the GAMA Groundwater Information System. Continued improvements like those listed below is an ongoing task for the GAMA program as staff become aware of new users and uses for GAMA program data.

- Provide first encountered groundwater information
- Provide well construction information including depths and screen intervals

- Link well completion reports to well locations
- Link the groundwater wells sampled under the GAMA Program to the duplicate public water system wells in the DDW dataset and provide the well IDs
- Increase scope of water quality assessment tools
- Remove obscuring filter to facilitate accurate well location analyses
- Provide clear descriptions of GAMA Groundwater Information System functions
- Add functionalities currently only available for GAMA staff: set specific value of chemical for query; query by date; allow statewide queries
- Add depth filter function into the GAMA Groundwater Information System
- Add ability to query for active, inactive, and destroyed public water system wells

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