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Sonoma Valley Groundwater Management Program

Five-Year Review and Update
FINAL REPORT

March 2014

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ABBREVIATIONS AND ACRONYMS

AB	Assembly Bill
AF	Acre-feet
bgs	Below Ground Surface
BMO	Basin Management Objective
CCR	California Code of Regulations
City	City of Sonoma
CoCoRaHS	Community Collaborative Rain, Hail & Snow
CUWCC	California Urban Water Conservation Council
DPH	California Department of Public Health
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
EIR	Environmental Impact Report
EPA	United States Environmental Protection Agency
ET	Evapotranspiration
GIS	Geographic information system
GMP	Groundwater Management Program
gpm	Gallons per minute
GPS	Global Positioning System
IRWMP	Integrated Regional Water Management Plan
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
mg/L	Milligrams per liter
mgd	Million gallons per day
MOU	Memorandum of Understanding
□g/L	Micrograms per liter
msl	Mean Sea Level
□□WA	North Bay Watershed Association
NMFS	National Marine Fisheries Services
PANEL	Basin Advisory Panel
Plan	Sonoma Valley Groundwater Management Plan
PRMD	Sonoma County Permit & Resource Management Department
Program	Groundwater Management Program
RCD	Southern Sonoma County Resource Conservation District
RWQCB	Regional Water Quality Control Board
SAP	Sampling and Analysis Plan
SB	Senate Bill
SDC	Sonoma Developmental Center
SEC	Sonoma Ecology Center
SVCSD	Sonoma Valley County Sanitation District
SVGMP	Sonoma Valley Groundwater Management Program

SVRWP	Sonoma Valley Recycled Water Project
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TDS	Total dissolved solids
ug/L	Micrograms per liter
us/cm	microSiemens per centimeter
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
VOMWD	Valley of the Moon Water District
Water Agency	Sonoma County Water Agency
Water Code	California Water Code

1.0 Introduction

This Five Year Review and Update presents a summary on the progress of the Sonoma Valley Groundwater Management Program (GMP) since initiation in 2008. The Sonoma Valley GMP is being implemented in accordance with the Sonoma Valley Groundwater Management Plan (Plan), which was completed in 2007 by a broad coalition of local stakeholders. The Plan was prepared to inform and guide the Sonoma County Water Agency (Water Agency), as the lead agency, as well as stakeholders and other interested parties for the purpose of maintaining a sustainable, high-quality groundwater resource for the users of the groundwater basin underlying the Sonoma Valley (Figure 1-1).

This report covers the activities and data collected during implementation of the Sonoma Valley GMP and focuses on evaluating data collected during Water Years 2009 through 2013 (the five complete water years following adoption of the Plan). The report is organized as follows:

- Section 1 provides the purpose of this annual report and background information on the Plan, including the GMP organization and structure.
- Section 2 presents a summary of activities conducted between 2008 and 2013, and an assessment of accomplishments relative to the basin management objectives.
- Section 3 provides an updated assessment of the water resource setting and conditions in Sonoma Valley with a focus on hydrologic conditions during Water Years 2009 through 2013.
- Section 4 provides a summary of progress toward implementing Plan component actions and recommendations for future actions.
- Section 5 provides an overview of GMP activities planned for the next five years.

1.1 Purpose of the Five Year Review and Update

The purpose of this Five Year Review and Update is: (1) to summarize and document the activities conducted and accomplishments achieved during the first five years of GMP implementation (2) to provide an overview of groundwater conditions, and monitoring results and trends during this time period; (3) to continue to assess whether management activities are achieving basin management objectives; and (4) to present a summary of planned future management activities. This Five Year Review and Update is also intended to be a tool for updating and obtaining feedback from stakeholder constituency groups and other interested parties on various aspects of the Sonoma Valley GMP, including the progress made to date on Plan implementation and plans for the future.

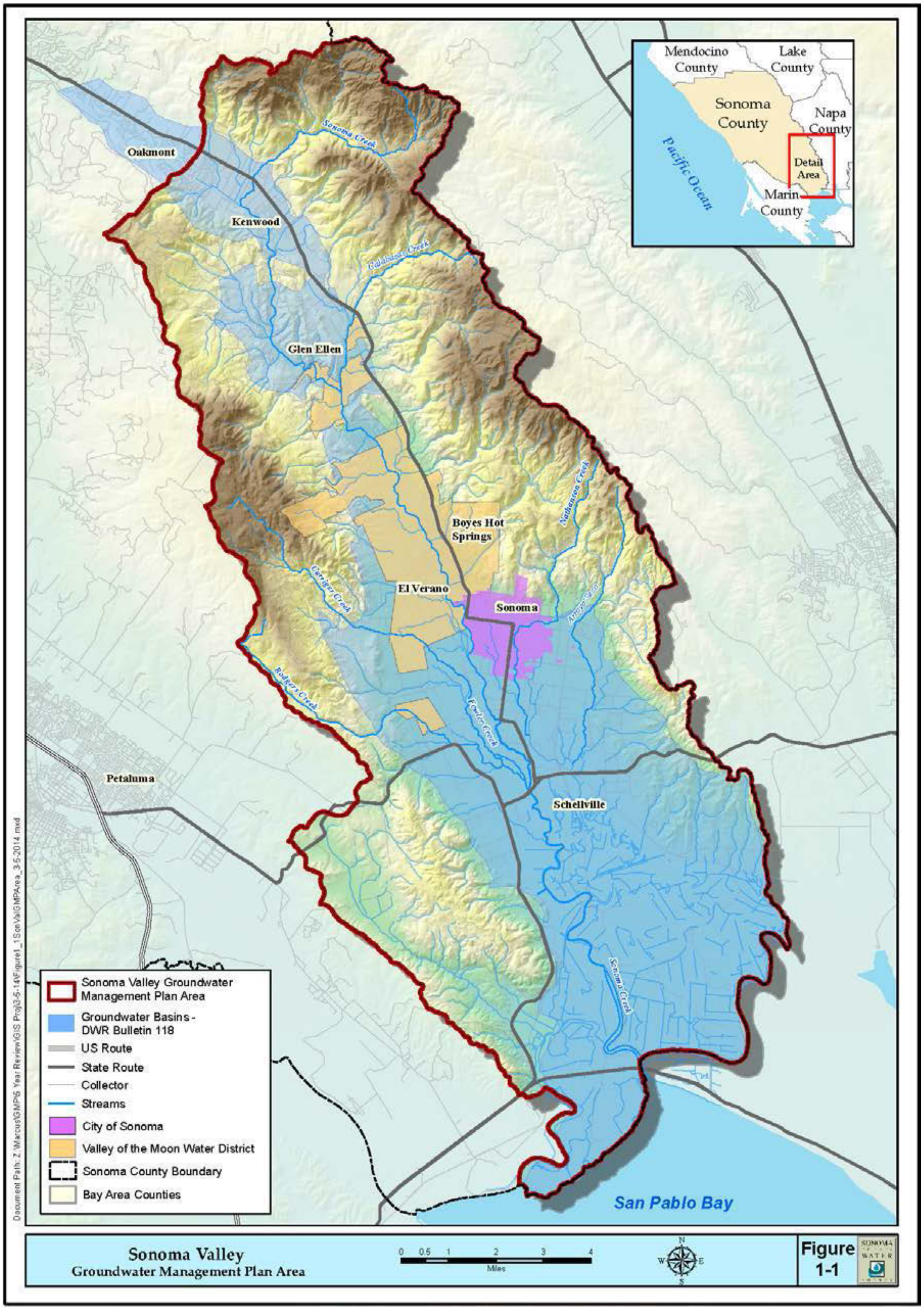


Figure 1-1 Sonoma Valley Groundwater Management Plan Area

1.2 Overview of Sonoma Valley Groundwater Management Plan

1.2.1 Description of Plan Area

The area subject to the Plan and GMP is shown in Figure 1-1, and lies within the San Francisco Bay Hydrologic Region. The GMP area encompasses the Sonoma Creek Watershed and includes the Sonoma Valley and the southern portion of the Kenwood Valley, designated groundwater basins 2-2.02 and 2-19, respectively, as determined by the California Department of Water Resources (DWR). For the purposes of this report, the GMP Area is the Sonoma Valley and includes the City of Sonoma and communities of El Verano, Boyes Hot Springs, Glen Ellen, Kenwood, and the southernmost portions of Oakmont.

1.2.2 Background of Plan

Groundwater has long played a key role in the development, growth and sustainability of the Sonoma Valley, with more than half the water demand in a given year met by local groundwater resources. With increasing demand on finite local groundwater supplies, stored groundwater in the Sonoma Valley has been and will continue to be depleted without appropriate actions being taken in the near future. Recognizing this need, the Plan was developed in coordination with the Water Agency, the Valley of the Moon Water District (VOMWD) and the City of Sonoma (City) under a collaborative and cooperative process that included a broad range of 20 stakeholders participating on the Basin Advisory Panel (Panel). The Panel consists of representatives from local agriculture, dairies, government, private business enterprises, environmental groups, and domestic well users. The Plan was adopted by the Water Agency, City, VOMWD, and the Sonoma Valley County Sanitation District in late 2007. Additionally, letters of support and endorsement for the Plan were received from the Sonoma Valley Vintners & Growers Alliance, the Sonoma Ecology Center, the Mission Highlands Mutual Water Company, and the Sonoma County Water Coalition. The Plan identifies a range of water management options, including enhanced groundwater recharge, conjunctive use of surface water and groundwater, increased conservation, and greater use of recycled water to help balance water demand with water supply.

The Plan was prepared under the authority of the Groundwater Management Act, California Water Code (Water Code) § 10750 *et seq.*, originally enacted as Assembly Bill (AB) 3030 in 1992 to encourage voluntary, non-regulatory groundwater management at the local level.

1.2.3 Lead Agency, Basin Advisory Panel and Technical Advisory Committee

The Water Agency is the lead agency and is responsible for managing GMP activities and progress. The lead agency directs and is responsible for all GMP studies, projects, and programs it directly or indirectly finances. The lead agency coordinates with Sonoma Valley stakeholders through the Panel, who provide input and direction to the lead agency in implementing the GMP. The VOMWD and the City, in coordination with the lead agency and the Panel, also undertake actions identified in the Plan. In addition, a Technical Advisory Committee (TAC) provides technical support to the Panel and the Water Agency.

1.2.4 GMP Goal, Basin Management Objectives, Management Components and Actions

The stated goal of the Sonoma Valley GMP, as presented in the Plan is:

> *To locally manage, protect, and enhance groundwater resources for all beneficial uses in a sustainable, environmentally sound, economical, and equitable manner for generations to come.*

The purpose of the GMP is to serve as the initial framework for integrating the many independent groundwater management activities to meet this goal.

As part of the Plan, Basin Management Objectives (BMOs) were developed by the Panel to provide measurable and verifiable accomplishments for meeting the overall goal of the Plan. The following ten BMOs provide the foundation for achieving the Plan's goal:

- **BMO-1** Maintain groundwater elevations for the support of beneficial uses of groundwater and to protect against inelastic land subsidence.
- **BMO-2** Improve water use efficiency and conservation.
- **BMO-3** Identify and protect groundwater recharge areas and enhance the recharge of groundwater where appropriate.
- **BMO-4** Manage groundwater in conjunction with other water sources.
- **BMO-5** Protect groundwater quality for beneficial uses including minimizing saline intrusion.
- **BMO-6** Protect against adverse interactions between groundwater and surface water flows.
- **BMO-7** Improve the community's awareness of groundwater planning, water resources, and legal issues.
- **BMO-8** Improve the groundwater database and basin understanding through consistent monitoring and additional surveys, and improve basin analytical tools including the groundwater simulation model.
- **BMO-9** Manage groundwater with local control.
- **BMO-10** Explore, identify and maximize non-regulatory approaches to manage the groundwater resource.

The Plan includes a variety of components that are required by Water Code § 10753.7, recommended in DWR Bulletin 118 California's Groundwater (DWR 2003), and identified as optional programs under Water Code § 10753.8. These components are grouped into five general categories termed Plan Component

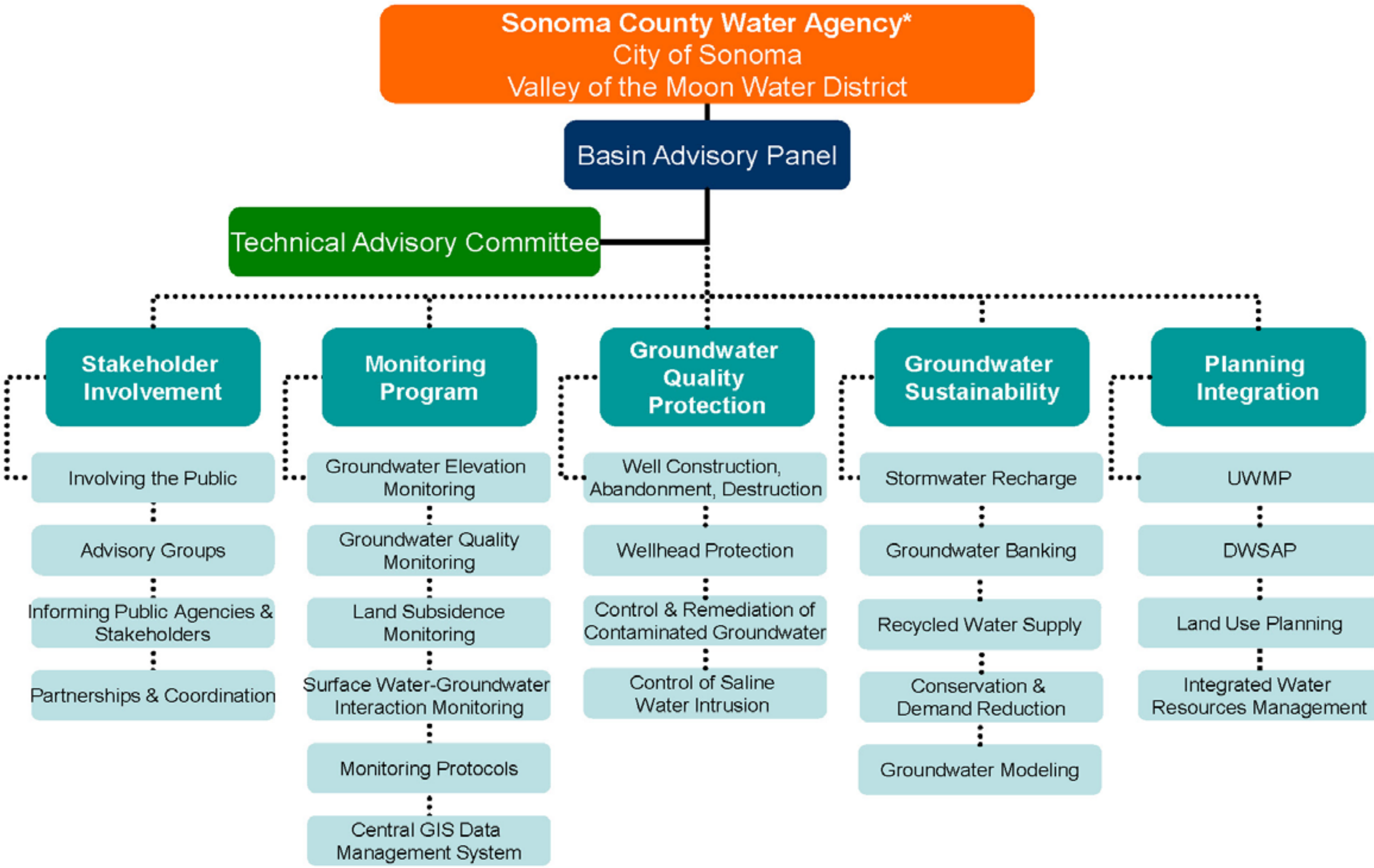
Actions, and how these management components meet the BMOs is summarized in Table 1-1:

1. Stakeholder Involvement
2. Monitoring Program
3. Groundwater Resource Protection
4. Groundwater Sustainability
5. Planning Integration

Management actions for each Plan Component Action form the foundation for meeting the BMOs and goal. Management actions, management components, and the Sonoma Valley GMP organization are illustrated in Figure 1-2. Details on the GMP actions are provided in the Plan, which is available for review at http://sonomacountywater.org/projects/svgroundwater/. For further information, contact Marcus Trotta, SCWA (707) 547-1978, mtrotta@scwa.ca.gov.

Basin Management Objectives	BMO No.1 Maintain groundwater elevations for the support of beneficial uses of groundwater, and to proctect against inelastic land subsidence.	BMO No.2 Increase water use efficiency and conservation.	BMO No.3 Identify and protect groundwater recharge areas and enhance the recharge of groundwater where appropriate.	BMO No.4 Manage groundwater in conjunction with other water sources.	BMO No.5 Protect groundwater quality for beneficial uses including minimizing saline intrusion.	BMO No.6 Protect against adverse interactions between groundwater and surface water flows.	BMO No.7 Improve the community's awareness of groundwater planning, water resources, and legal issues.	BMO No.8 Improve the groundwater database and basin understanding through consistent monitoring and additional surveys, and imrove basin analytical tools including the groundwater simulation model.	BMO No.9 Manage groundwater with local control.	BMO No.10 Explore, identify and maximize non-regulatory approaches to manage the groundwater resource.
Component No.1 Stakeholder Involvement										
Involving the Public	√		√			√	√		√	√
Advisory Groups	√		√			√	√		√	√
Informing Public Agencies & Stakeholders	√		√			√	√		√	√
Partnerships & Coordination	√		√			√	√		√	√
Component No.2 Monitoring Program										
Groundwater Elevation Monitoring	√	√	√	√	√	√		√	√	
Groundwater Quality Monitoring	√		√	√	√	√		√	√	
Land Subsidence Monitoring	√					√		√	√	
Surface Water-Groundwater Interaction Monitoring	√					√		√	√	
Monitoring Protocols	√	√	√	√	√	√		√	√	
Central GIS Data Management System	√	√	√	√	√	√		√	√	
Component No.3 Groundwater Quality Protection										
Well Construction, Abandonment & Destruction			√		√				√	
Wellhead Protection			√		√				√	
Control & Remediation of Contaminated Water			√		√				√	
Control of Saline Water Intrusion			√		√				√	
Component No.4 Groundwater Sustainability										
Stormwater Recharge	√	√	√	√	√	√			√	√
Groundwater Banking	√		√	√	√	√			√	√
Recycled Water Supply	√			√		√			√	√
Conservation/Demand Reduction	√	√		√	√	√	√	√	√	√
Groundwater Modeling	√	√	√	√	√	√	√	√	√	√
Component No.5 Planning Integration										
Urban Water Management, Land Use Planning, DWSAP Program	√	√	√	√	√	√	√	√	√	√

Table 1-1 Summary of Basin Management Objectives and Management Components



Notes:
*Lead agency
UWMP – Urban Water Management Plan
DWSAP – Drinking Water Source Assessment and Protection Program
The Technical Advisory Committee (TAC) will include members from the Basin Advisory Panel (BAP) and other entities and will report to the BAP.

Figure 1-2 Groundwater Management Program Implementation Organization Chart

2.0 2008-2013 Sonoma Valley Groundwater Management Program Activities and Progress

This section presents a summary of Sonoma Valley GMP activities conducted and accomplishments achieved since the program was initiated at the beginning of 2008. These activities are grouped and described according to the five Plan Component Actions described in Section 1.2.4, above, and listed in Table 2-1.

2.1 Component 1 - Stakeholder Involvement

Active stakeholder involvement forms the foundation for a continued, successful collaborative process of decision-making and actions during GMP implementation. Stakeholder interests represented on the Panel include economic, agricultural, environmental, local agencies with jurisdiction in Sonoma Valley, land use, residential groundwater users, and special districts, with a broad geographic distribution across the Sonoma Valley. A public outreach plan was developed in 2008 by the Center for Collaborative Policy and is periodically updated to guide the process by which stakeholders stay informed about and provide input on the implementation of the GMP, share information through briefings and the media, and inform the community and other interested parties on GMP implementation. Stakeholder involvement activities completed during 2008-2013 were conducted pursuant to the outreach plan and are summarized below.

- **Outreach and briefings** – In addition to quarterly Panel meetings and monthly TAC meetings, targeted briefings, focused outreach, and informational talks at events and conferences were conducted annually, including the following:
    - Sonoma Ecology Center's Water Wisdom Workshops in Sonoma
    - Sonoma Valley Vintners and Growers Alliance's Quality Conference
    - Wine Country Water summit in Rohnert Park
    - Water Conservation Field Days at Kunde Vineyard
    - Presentations at Water and Groundwater Conferences

Additionally, the following organizations received annual informational briefings on the GMP:

- City of Sonoma
- County of Sonoma Board of Supervisors
- North Bay Watershed Association
- Sonoma Ecology Center
- Sonoma County Water Coalition
- Sonoma Ranch Homeowners Association
- Sonoma Valley Citizens Advisory Commission
- Southern Sonoma County Resource Conservation District
- Valley of the Moon Alliance
- Valley of the Moon Water District

2008-2013 Accomplishments	Basin Management Objectives									
	BMO No.1 Maintain groundwater elevations for the support of beneficial uses of groundwater, and to proctect against inelastic land subsidence.	BMO No.2 Increase water use efficiency and conservation.	BMO No.3 Identify and protect groundwater recharge areas and enhance the recharge of groundwater where appropriate.	BMO No.4 Manage groundwater in counjunction with other water sources.	BMO No.5 Protect groundwater quality for beneficial uses including moinimizing saline intrusion.	BMO No.6 Protect against adverse interations between groundwater and surface water flows.	BMO No.7 Improve the community's awareness of groundwater planning, water resources, and legal issues.	BMO No.8 Improve the groundwater database and basin understanding through consistent monitoring and additioonal surveys, and improve basin analytical tools including the groundwater simulation model.	BMO No.9 Manage groundwater with local control.	BMO No.10 Explore, identify and maximize non-regulatory approaches to manage the groundwater resource.
Component No.1 Stakeholder Involvement										
Developed, updated periodically, and implemented Public Outreach Plan		√	√				√		√	√
Regular, periodic communications including periodic reporting, fact sheets, and annual updates to stakeholders		√	√				√		√	√
GMP coordination and policy decisions through Basin Advisory Panel quarterly meetings		√	√				√		√	√
Technical review and input on program activities via Technical Advisory Committee monthly meetings		√	√				√		√	√
Focused outreach and briefings to expand volunteer monitoring program		√	√				√		√	√
Conducted local technical presentations and briefings		√					√		√	√
Produced a video highlighting key elements of the Sonoma Valley GMP		√					√		√	√
Stakeholder visits to possible Sonoma Valley sites for stormwater retention/groundwater recharge projects						√	√		√	√
Sponsored public meetings on the Stormwater Management/Groundwater Recharge Scoping Study						√	√		√	√
Sponsored public meetings on the Salt and Nutrient Management Plan			√			√	√		√	√
Component No.2 Monitoring Program										
Developed a Sampling and Analysis Plan for monitoring well data collection	√				√	√		√	√	√
Semi-annual measurement of water levels were coordinated with DWR, VOMWD, the City of Sonoma, SCWA and local trained volunteers	√				√	√		√	√	√
Expanded the groundwater level monitoring program by 81 additional wells bringing the total number of voluntary wells to 141.	√				√	√		√	√	√
Installed two multi-depth wells with a $250K grant.	√				√	√		√	√	√
Instrumented select wells for automated groundwater level monitoring	√				√	√		√	√	√
Installed one new stream gage on Sonoma Creek and initiated stream gage monitoring	√				√	√		√	√	√
Conducted stable isotope testing to assess age and flowpaths in parts of the Sonoma Valley	√				√	√		√		√
Developed plan for a volunteer rainfall monitoring program	√						√	√		√
Monitoring data compiled into a GIS database, evaluated and reported on annual basis	√				√	√		√		√
Developed work plan for the California Statewide Groundwater Elevation Monitoring Program and submitted groundwater level data to DWR	√				√	√		√	√	√
Prepared and distributed the Annual Reports and Data Transmittals	√				√	√	√	√	√	√
Component No.3 Groundwater Quality Protection										
Preparation and distribution of a private wells owners guide ("WELLness – A Guide to Your Water Well")			√		√		√		√	√
Conducted groundwater recharge mapping under a $20,000 grant received			√	√	√			√	√	√
Additional groundwater quality sampling in southern Sonoma Valley for salinity			√		√			√	√	√
Assembled and compiled additional Department of Public Health groundwater data on wells in the valley	√		√	√	√			√	√	
Assembled and compiled additional GeoTracker cleanup site groundwater data on wells in the valley			√		√			√	√	
Component No.4 Groundwater Sustainability										
Conducted unincorporated area water conservation audit and prepared a report under a $25,000 grant	√	√		√			√		√	√
Distributed and publicized the "Slow It, Spread It, Sink It" guidebook as a resource for property owners to implement stormwater retention and groundwater recharge projects	√	√		√			√		√	√
The SVGMP Panel developed and gives Annual Conservation Awards	√	√		√			√		√	√
Provided input on stormwater capture/groundwater recharge and groundwater banking feasibility studies	√			√					√	√
Updated the groundwater flow model to better simulate groundwater recharge distribution	√			√	√			√	√	√
Component No.5 Planning Integration										
Coordinated funding and participation by Lead and Cooperating Agencies in the SVGMP				√					√	√
Conducted coordinated efforts to pursue funding for additional groundwater monitoring and conservation projects that resulted in the award of two AB303 Grants and one water conservation audit grant				√	√				√	√
Developed and continued coordinated monitoring in the Sonoma Valley				√	√				√	√
Participation and input on the recycled water project and development of the Salt and Nutrient Management Plan for Sonoma Valley				√	√				√	√
Participation in the CUWCC Memorandum of Understanding (MOU) for water conservation		√		√	√				√	√
Conduct periodic constituent briefings for information dissemination, to receive input and continue looking for additional opportunities to integrate future planning and program efforts				√			√		√	√

Table 2-1 Accomplishments and BMOs

- **Communications** - Communications have included sending out announcements and supporting materials in advance of regular meetings to stakeholders, maintaining email distribution lists of stakeholders, and updating the project website (http://sonomacountywater.org/projects/svgroundwater/). In addition, a clip from a ten-minute video featuring the Sonoma Valley GMP and many Panel members was part of an Assembly Water, Parks, and Wildlife Committee hearing on groundwater.

- **Media** – GMP staff, Panel members, and local stakeholders worked with local media to provide press releases on key events and milestones for the GMP. Press releases have focused on publication of Annual Reports, solicitation for additional groundwater level measurement volunteers, announcement of Sonoma Valley GMP Water Conservation Award Winners, and description of groundwater recharge efforts being undertaken through the GMP.

2.2 Component 2 - Monitoring Program

The long-term groundwater-level monitoring program for the GMP was developed in the 2007 Plan, initially implemented at the beginning of 2008, and has expanded in terms of the number of monitored wells. Expansion of the program has been accomplished mainly through public outreach and education to private well owners who have volunteered to be monitored. The majority of wells monitored in the program are voluntary private domestic and agricultural wells, with a smaller but significant portion of publicly-owned water supply wells. The groundwater-level monitoring program is a critically important component of the GMP and serves as a foundation to develop and improve decision-analysis tools, identify and forecast trends and guide the design, implementation and monitoring of groundwater management and protection programs. Approximate locations of wells included in the monitoring program are shown on Figure 2-1.

The monitoring program was formed in 2007 from previously existing groundwater-level monitoring programs in Sonoma Valley, comprising a total of 55 wells monitored by DWR (10 wells as of 2007), the City (12 wells as of 2007), and VOMWD (34 wells as of 2007). Since its initiation, 86 voluntary private wells were added to the Sonoma Valley groundwater level monitoring program bringing the total number of wells included in the voluntary groundwater-level monitoring program to 141.

- ### Coordinated Groundwater Level Data Collection

  The coordination of groundwater level data collection was initiated at the beginning of 2008 and continues today. The coordinated collection of groundwater-level data from these various monitoring efforts includes performance of synchronized groundwater-level monitoring events in the Spring

(April) and Fall (October/November) when groundwater levels are typically at their highest and lowest, respectively. The groundwater monitoring events were

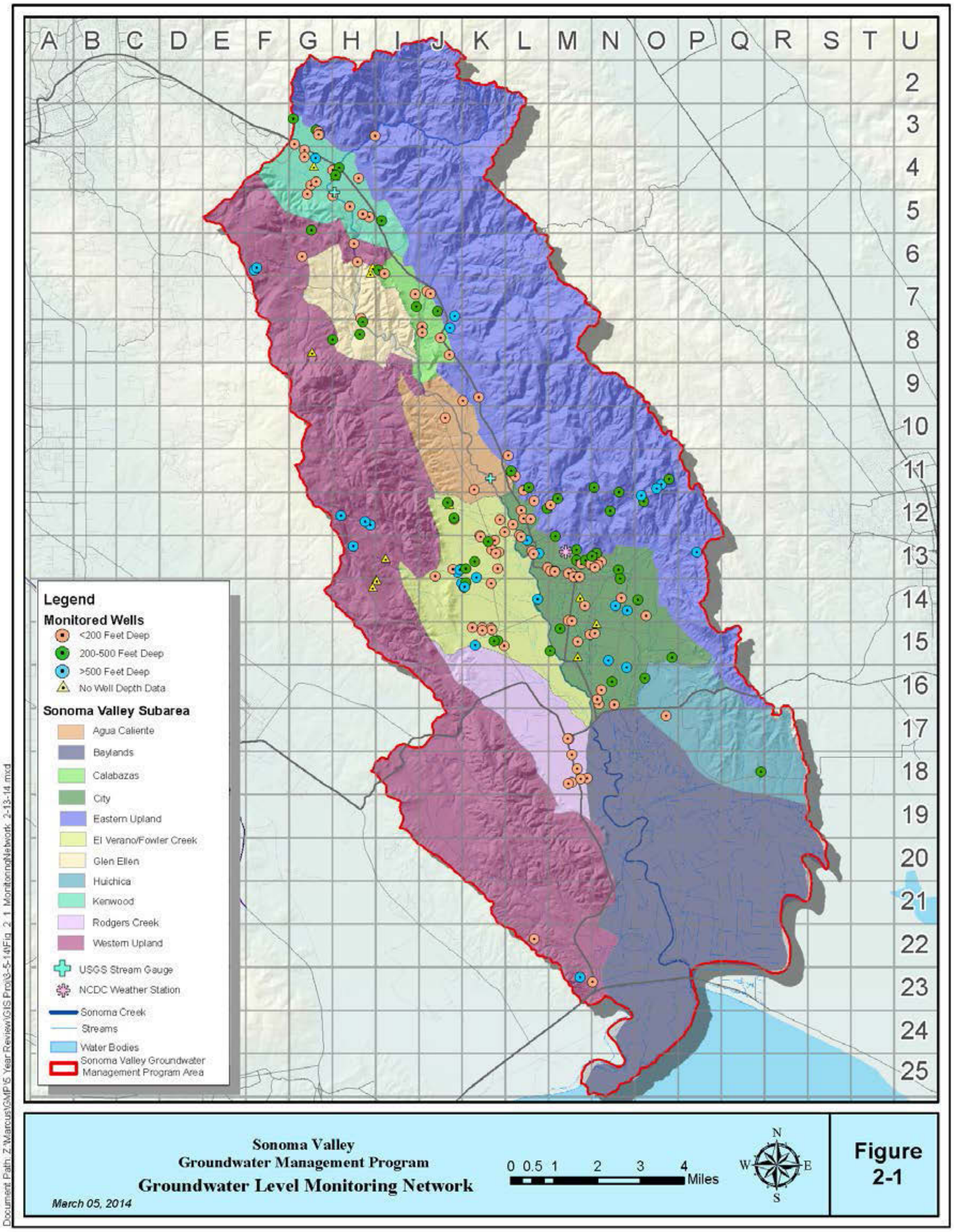


Figure 2-1 Groundwater Level Monitoring Network

conducted by DWR, the City, VOMWD, the Water Agency and trained private volunteers.

- **Sampling and Analysis Plan**

  The Sampling and Analysis Plan (SAP) was developed to establish monitoring protocols to ensure the adequacy and consistency of data collected, and to provide a framework and format for data collection and maintenance. The SAP includes information on the current monitoring network and identifies areas where additional wells are needed, data quality objectives, sampling and analysis procedures, quality assurance/quality control, data management and reporting. The SAP also includes a standard operating procedure for water level measurements and equipment sanitization.

- **Additional Evaluation of Available Well Construction and Location Information**

  Available groundwater-level monitoring program well construction information was reviewed and assessed to assist in the evaluation of groundwater-level data collected from different depths (and aquifer zones). Wells were subdivided according to well-screen depth or well total completion depth into the following three categories: (1) less than 200-feet deep; (2) 200 to 500 feet deep; and (3) greater than 500 feet deep. These categories are used to graphically display groundwater-level trends and groundwater flow patterns, as described in Section 3.3. Additionally, volunteers used Global Positioning System (GPS) equipment loaned to the program by the Sonoma Ecology Center to survey the approximate horizontal locations of wells included in the Voluntary Groundwater-Level Monitoring Program

- **High-Frequency Groundwater-Level Monitoring**

  High-frequency groundwater-level data has been collected utilizing Water Agency pressure transducers at a number of private, mutual water company and City of Sonoma wells over the past several years. Pressure transducer data is collected automatically for periods of days to weeks or longer, at high-frequency collection intervals of seconds, minutes or hours, and the data is transformed into groundwater level data. The data is collected to analyze issues that require more robust datasets to evaluate, for example, well performance and aging, time for water level recovery after pumping, affects of nearby pumping, and surface water-groundwater interaction. Findings from groundwater-level monitoring using pressure transducer data are summarized in Section 3.3.3.

- **Stream-Gaging of Sonoma Creek**

  Monitoring and evaluation of streamflow data for Sonoma Creek has been conducted and reported in annual reports since 2007. This includes data collected from the Agua Caliente Gage, which existed prior to the plan adoption, as well as installation of a new stream gage in Kenwood. Stream gaging of Sonoma Creek includes obtaining a continuous record of stage (height of water at the gage location), obtaining periodic measurements of discharge rate (quantity of water passing through the gage), and using these measurements to estimate streamflow at the gaging stations.

- **Streamflow/Groundwater Interaction Monitoring**

  Seepage runs were conducted by the USGS and Water Agency in 2010 during the spring and fall (generally coinciding with groundwater-level measurement events). Seepage runs consist of instantaneous stream discharge measurements within Sonoma Creek and several tributaries to better understand the interaction of surface water and groundwater within the Sonoma Creek watershed and to assist in quantifying recharge of groundwater in the Sonoma Valley. Results of the seepage runs are summarized in Section 3.2.

- **Volunteer Rainfall Monitoring**

  A plan was developed for a volunteer rainfall monitoring program for the SVGMP. Rainfall distribution varies widely in the Plan area and it is important to know how the water enters the watershed and how much total water falls as precipitation for water budgeting purposes. The plan proposes to add basic rainfall monitoring through volunteer locations using the general approach taken in the Community Collaborative Rain, Hail & Snow network (CoCoRaHS) www.cocorahs.org. The plan also proposes to add a number of automated rainfall stations to capture rainfall intensity in key areas of the Plan area.

2.3 Component 3 - Groundwater Quality Protection

Groundwater quality protection is a key component for ensuring a sustainable groundwater resource in the Sonoma Valley. As described in the Plan, groundwater quality protection includes both the prevention and minimization of groundwater quality degradation, as well as measures for the mitigation of groundwater contamination. The primary focus of the work in this component, as described below, is the continued monitoring of potential saline intrusion, planning for a long-term water quality monitoring program, and development of a private well owner's guide.

- **Development of Long-Term Water Quality Monitoring Program**

  To address water quality issues identified as potential concern in the 2006 USGS SIR report, including salinity intrusion from San Pablo Bay in the southern portions of Sonoma Valley and localized geothermal water upwelling, a long-term groundwater quality monitoring program has been implemented. A water quality monitoring program formerly performed by DWR is being resumed and expanded. Staff and TAC members coordinated with DWR representatives to identify the 12 wells in Sonoma Valley that were historically monitored for water quality (on a periodic basis) and recommended additional wells to include in the program (primarily in southern Sonoma Valley). Additionally, staff obtained limited existing water quality data collected by public water suppliers (the City, VOMWD), small water systems, and mutual water companies which has been incorporated into the program.

- **Development of Well Owner's Guide**
  A well owner's guide, *WELLness – A Guide to Your Water Well*, was developed and distributed to private well owners. The guide was originally developed by the Sonoma County Division of Environmental Health Services, and was updated with input from the County of Sonoma Permit and Resource Management Department, Sonoma County Water Agency, and the Sonoma Valley Groundwater Management Program TAC. The guide includes well owner responsibilities, information on well construction and well maintenance, water quality protection, water quality sampling and treatment. The guide also provides resources and contact information for local, state and federal agencies, analytical laboratories, and private organizations for additional well-related information and assistance. The well guide is a compilation of existing well-related documents and is customized for the local stakeholders.

2.4 Component 4 - Groundwater Sustainability

To ensure a long-term, viable, sustainable supply of groundwater, the GMP seeks to increase the amount of groundwater in storage in the Sonoma Valley over the long term. As part of the Plan analysis, several conceptual water management options were considered using the Sonoma Valley groundwater model developed by the U.S. Geological Survey including stormwater recharge, groundwater banking, increased recycled water use, and increased conservation. Results of the modeling indicate that each of these water management options is necessary for increasing the amount of groundwater storage in Sonoma Valley. To improve the sustainability of water resources in the Sonoma Valley, the Agency, VOMWD and the City have continued to pursue and investigate appropriate water management options that include additional surface water supplies, implementation of the California Urban Water Conservation Council (CUWCC) water conservation elements, conjunctive use opportunities, agricultural conservation and increased use of recycled water.

Specific activities that have been conducted since 2009 that can contribute to groundwater sustainability include:

- **Development of Stormwater Management Guide**
  A homeowner's guide, *Slow It. Spread It. Sink It. – A Homeowner's & Landowner's Guide to Beneficial Stormwater Management*, was developed and provided in various public meetings and settings. The guide was compiled and written by Southern Sonoma County Resource Conservation District with input from the BAP and TAC, and was adopted from a guidebook originally developed by the Resource Conservation District of Santa Cruz County. The guide provides basic information and examples of best management practices (BMPs) that landowners can implement to minimize the effects of stormwater runoff,

including things such as rain barrels for temporary storage and reuse for landscaping watering, rainfall galleries and gardens, and low impact development practices.

- **Groundwater Recharge Mapping**
  The Sonoma Valley recharge mapping project was completed as part of a grant awarded for AB303 funds through the California Department of Water Resources. The recharge mapping effort was conducted by the Sonoma Ecology Center and involved input from a variety of geologic experts and included several TAC members. The recharge mapping study identifies area of relative higher and lower recharge potential based on soil type, geology, slope and underlying geology. The recharge mapping report is available online at http://www.scwa.ca.gov/files/docs/projects/svgw/svgw-docs-0411/Sonoma_Valley_GWR_Final_Report.pdf.

- **Site Visit of Graywater Facility**
  The Panel members toured a graywater (i.e., water reuse) facility, which is the first legally permitted graywater system in Sonoma County, at a housing complex in Sebastopol and are now exploring the possibility of a project in the Sonoma Valley. Graywater is wastewater from hand sinks, showers, washing machines, etc.; this non-industrial wastewater comprises an estimated 50 to 80 percent of residential wastewater.

- **Site Visits of Potential Groundwater Recharge Projects**
  Groundwater recharge at individual properties was the subject of numerous TAC site visits and discussions. Site visits included ranches and vineyards and private residences to look at current practices for surface water drainage management controls, water retention, rainfall harvesting, soil erosion issues and possible recharge options.

- **Rural Area Water Conservation Assessments**
  A pilot program to evaluate water conservation programs for areas within the Sonoma Valley that currently do not have formal conservation programs (primarily rural areas outside the service areas of VOMWD and the City) was completed under a $25,000 grant obtained by the Agency from the North Bay Watershed Association (NBWA). The pilot program includes conducting residential and agricultural site assessments involving water use surveys to educate private well users (residential and agricultural water users) regarding water conservation practices. The site assessments provide information that can be used to develop future water conservation and efficiency programs and incentives for well users throughout the NBWA service area. Conservation materials will also be developed for distribution at local events within unincorporated areas to educate residents and businesses about the need for and benefits of water conservation. Results of the activities will be used to

identify future grant funding opportunities to encourage and incentivize conservation practices.

- **Water Conservation Awards Program**
  The Panel has provided Water Conservation Awards that recognized members and groups from Sonoma Valley for extraordinary levels of water conservation. Six Sonoma Valley projects were recognized for extraordinary levels of water conservation by the Sonoma Valley Groundwater Management Basin Advisory Panel. Among the winners are several Sonoma Valley residents, Sonoma businesses, the community center, the high school and a homeowner's association:
  - Several residential homeowners (Russell Goodman family, Larry Arnold, Robert Castillo, James Deely, and John and May Field), Mission Village Homeowners, Ramekins Culinary School, and Sonoma Valley High School for irrigated turf replacement with drought-tolerant landscaping, providing a model for visitors and other Sonoma Valley businesses.
  - Sonoma Ecology Center for public education efforts on water conservation through the Water Wisdom series of tours, lectures, workshops, and demonstrations.
  - Several wineries and vineyard managers (Benziger Family Winery, Clarence Jenkins, Deerfield Ranch Winery, and Gundlach Bundschu Winery) for water treatment and reuse, groundwater recharge, and water-use efficiency efforts.

- **Recycled Water**
  The increased use of recycled water is one of the primary strategies identified in the GMP for sustaining groundwater supplies in Sonoma Valley. The Sonoma Valley Recycled Water Project (SVRWP) is intended to reduce the discharge of treated wastewater to surface waters and provide a reliable alternative source of water for agricultural and urban use in Sonoma Valley. The SVRWP will reduce reliance on other regional water supplies, including groundwater, by utilizing tertiary treated recycled water from the SVCSD wastewater treatment facility that would otherwise be discharged into San Pablo Bay. Activities have included substantial completion of a financial/economic feasibility analysis for the project and construction of the first segment of the proposed recycled water trunk main (extending from the Sonoma Valley Treatment Plant to the vicinity of Watmaugh Road) and recycled water storage pond.

- **Stormwater Management/Groundwater Recharge Scoping Study**
  A study was initiated to identify and assess stormwater management and groundwater recharge opportunities in the Sonoma Valley. The key objective of the study was to identify stormwater management/groundwater recharge projects that will provide regional flood mitigation and groundwater recharge benefits within the Sonoma Valley. The study was conducted by a consultant team under contract to SCWA, with the City of Sonoma and Valley of the Moon Water District as partners. The scoping phase of the study resulted in the

identification of several projects for further feasibility analysis in the future, funding dependent. The City Watersheds Project, which includes a stormwater detention and recharge component, was awarded a $1.9 Million grant in 2013 and is currently in the initial phases of design. Outreach to stakeholders was conducted through the Sonoma Valley TAC and BAP.

- **Groundwater Banking Feasibility Study**
  A groundwater banking feasibility study was conducted to identify and assess opportunities to improve long-term water supply reliability in Sonoma County. The study was conducted by a consultant team under contract to SCWA with several partner agencies including the City of Sonoma and Valley of the Moon Water District. A primary objective of the study was to identify groundwater banking projects in the Sonoma Valley and Santa Rosa Plain that could better utilize the SCWA Russian River supplies and existing conveyance infrastructure to meet dry year water needs and summer water shortages while meeting instream flow requirements. The feasibility study resulted in the identification of several projects for further feasibility analysis and several pilot projects for implementation in the future, funding dependent. Outreach to stakeholders was conducted through the Sonoma Valley TAC and BAP.

- **Groundwater Flow Model Update**
  As part of a Master of Science Thesis for the Department of Geological and Environmental Sciences at Stanford University, an update to the Sonoma Valley Groundwater Flow model was completed. The update was performed by Jacob Bauer who received guidance and input on the groundwater flow model update from the USGS. The primary updates to the model included development of a new recharge model based on a soil moisture budget model and extension of the area of recharge to the MODFLOW model to encompass entire Sonoma Creek Watershed. Mountain-front recharge in the Sonoma Creek Watershed originating in the highland areas outside the model domain was added to the model and accounted for separately from aerial recharge within the model domain. Additionally, the calibration time-period was extended to 2006 and baseflow in tributaries to Sonoma Creek were added to the model.

2.5 Component 5 - Planning Integration

Planning integration involves making decisions and taking actions while considering multiple viewpoints of how groundwater and other related resources should be managed in the Sonoma Valley. Such integration also promotes resource enhancements and reliability, operational efficiency, cost savings, and in some cases generates larger system and environmental benefits. The Water Agency, VOMWD and the City, are implementing integrated management in the region through cooperation to manage Russian River surface water resources, participation and joint funding of a Groundwater Banking Feasibility Study Program, participation in the CUWCC Memorandum of Understanding (MOU) for water conservation, the recycled water program, and implementation of this GMP. Additionally, continued efforts and discussions at the GMP Panel, TAC, outreach meetings and focused briefings facilitate opportunities for all stakeholders in Sonoma Valley to provide input on these integrated planning programs.

2.6 Program Funding

The GMP has been funded through a variety of sources. A Cooperative Funding Agreement was entered into between the Water Agency, the City, VOMWD, the Sonoma Valley County Sanitation District, the Sonoma County Agricultural Preservation and Open Space District, and the County of Sonoma to fund the GMP. Cooperative funding agencies also provide in-kind services through participation of representatives on the Panel and TAC. Additional, the Water Agency provides a Project Manager and other staff as needed for technical analysis and preparation and production of meeting materials and reports, working with the GMP Technical Consultant.

Several individuals, representing rural well owners, environmental organizations, and mutual water companies, provide voluntary in-kind services in the form of groundwater-level data collection and reporting.

Stakeholder involvement included participation in the Panel and TAC meetings and briefings, as well as water-level monitoring, field investigations, and development of future demonstration projects, all through voluntary contributions of their own time and resources for the benefit of the overall program.

Finally, several grants have been applied for and received by the GMP:

- One grant was received from the NBWA for $25,000 for unincorporated area water conservation audits
- Two AB303 grants were applied for and received:
  - $250,000 for the installation of two multi-screened monitoring wells and conducting a groundwater recharge mapping project in 2009
  - $168,000 for the installation of two groundwater wells in 2013-14
- Additionally, the Water Agency applied for and received a grant from DWR for $1.9 Million for the City Watersheds Project, which includes a stormwater detention and recharge component.

3.0 Water Resources Setting and Conditions

This section provides a summary of water resources conditions in the Sonoma Valley, and is focused on data collected over the past five years since the GMP was implemented. Subsections cover climate and surface water hydrology, groundwater level and quality trends, water supplies and demands. A summary of findings is provided at the end of the section, along with an assessment of primary data gaps.

3.1 Climate

The climate of the study area is Mediterranean, with moderate temperatures and distinct wet and dry seasons. About 90 percent of the annual precipitation typically occurs during the months of November through April. Precipitation is highly affected by atmospheric rivers, which concentrate rainfall and runoff along narrow bands. Nearly 50% of the precipitation in the Sonoma County area is due to atmospheric rivers (Dettinger, et al, 2011). Mean annual precipitation at Sonoma averaged 29.2 inches during the 60-year period from 1953 through 2012 (Figure 3-1), as calculated from rainfall measurements collected at the Climate Station SONOMA.C (NCDC #8351, Sonoma). This station is located approximately 0.5 miles northwest of the Sonoma Post Office at latitude 38°17’55” N, longitude 122°27'43"W, elevation 97 ft (NGVD 29). Seven of the last 10 years exhibited below average annual rainfall.

While the rainfall pattern is generally consistent, rainfall amounts can vary considerably throughout Sonoma Valley based on elevation and geographic location within the valley. Estimates of mean annual precipitation for the period 1981 through 2010, obtained using the Parameter-elevation Regressions on Independent Slopes Model (PRISM; Daly and others, 2004), were used to indicate the spatial and temporal distribution of precipitation in Sonoma Valley. The PRISM model provides an estimate of spatial and temporal variability in precipitation in response to distance from moisture sources, average storm track, aspect of land surface in relation to storm tracks, and the effect of elevation (Daly and others, 2004). The average annual rainfall distribution for the Sonoma Valley Watershed for 1981 through 2010 estimated using the PRISM model is presented in Figure 3-2. Annual rainfall varies from a low of 23 inches on the valley floor to up to 54 inches in the highest areas of the Sonoma and Mayacamas Mountains.

Evapotranspiration (ET) in Sonoma Valley varies spatially and temporally due to differences in land cover, potential ET, plant rooting depths, and soil moisture storage. Estimates for ET in the vicinity of Sonoma Valley derived for the Sonoma Valley Groundwater Model range from approximately 1 inch per month in the winter months to approximately 6 inches per month in the summer months (Bauer, 2008).

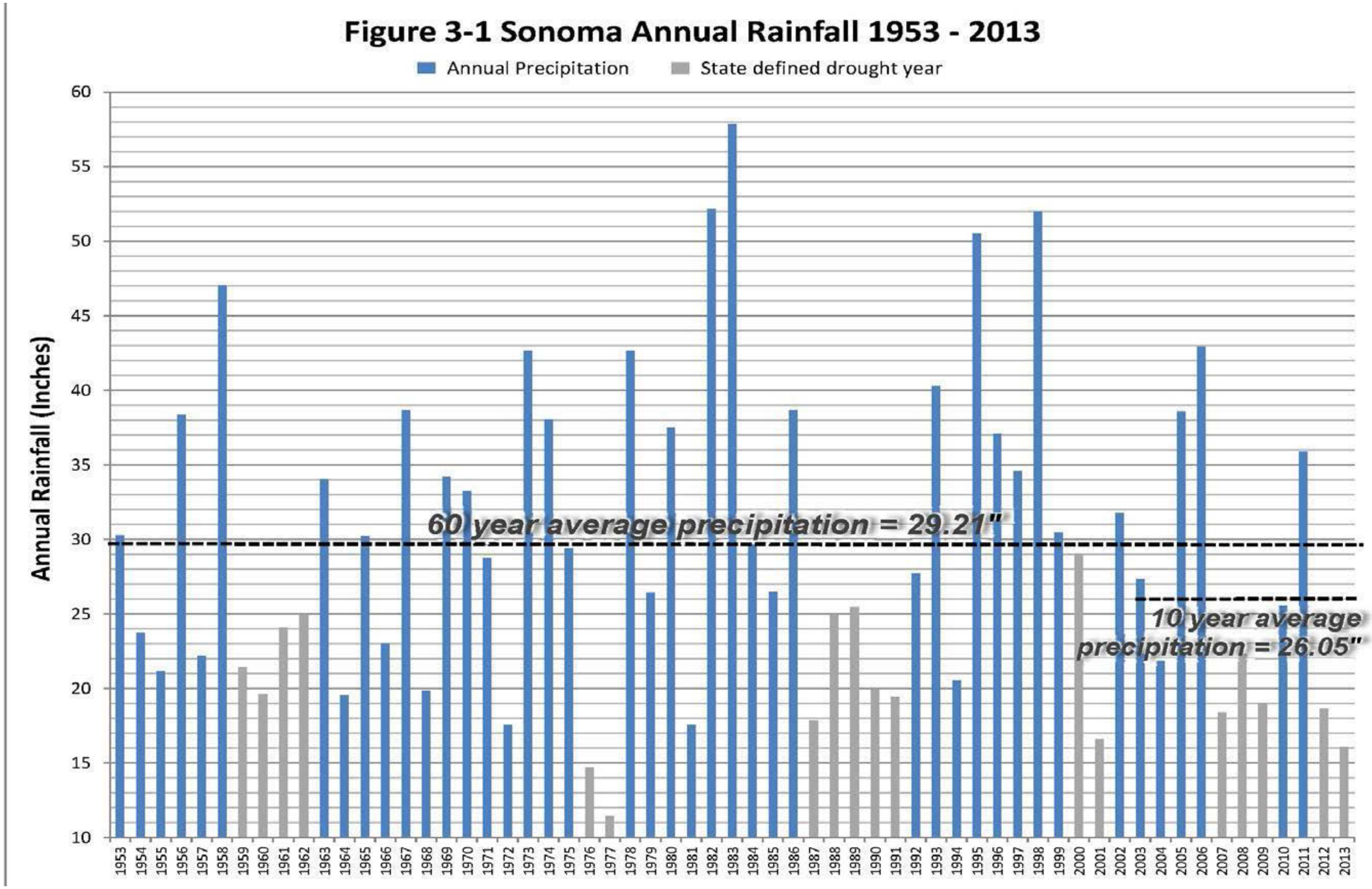


Figure 3-1 Sonoma Annual Rainfall 1953-2013

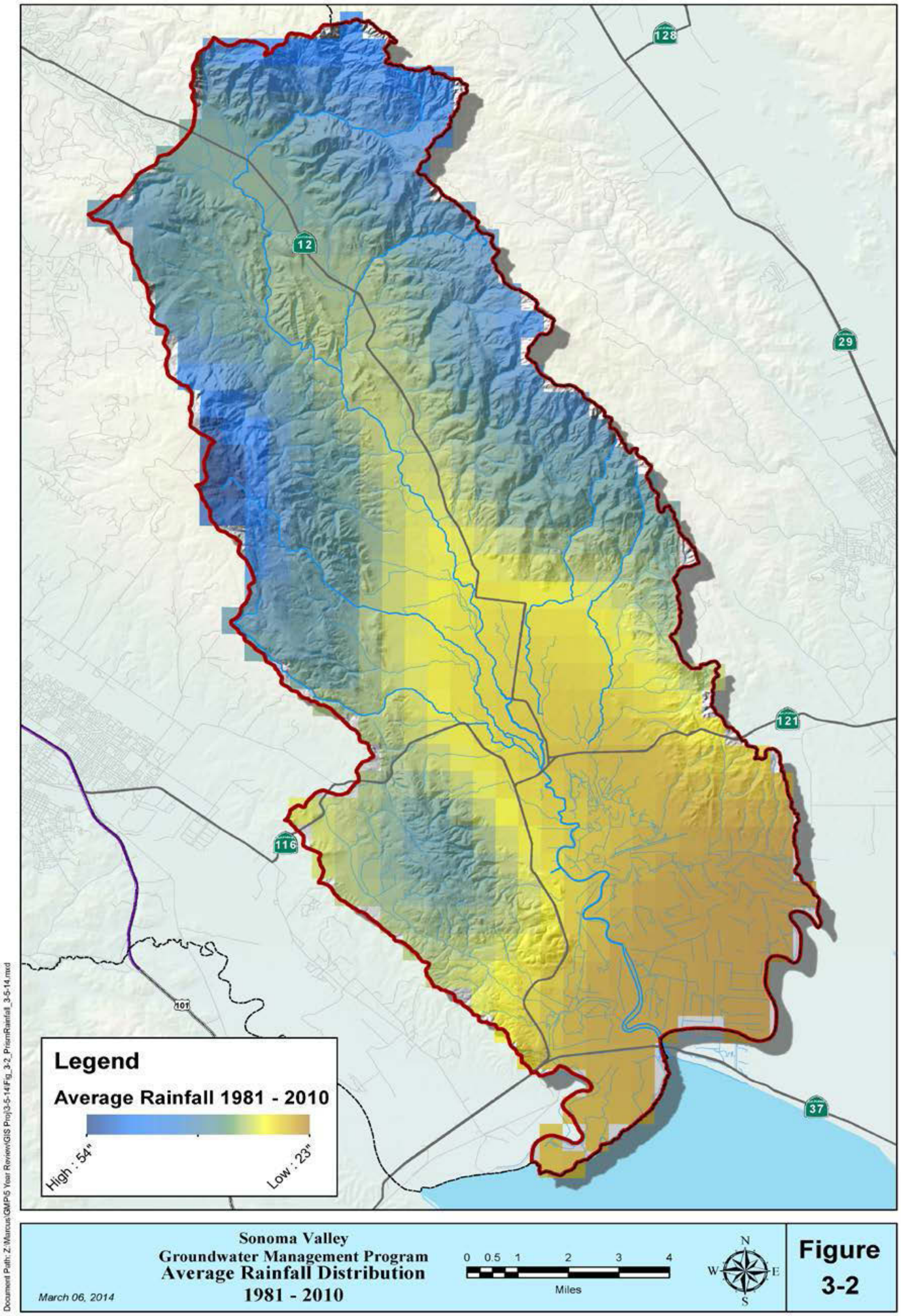


Figure 3-2 Average Rainfall Distribution 1981-2010

Climate Change

The San Francisco Bay Area has experienced a warming trend over the 20th century, and monthly maximum temperatures have increased approximately 1°C between 1900 and 2000 (Flint and Flint, 2012). A regional study of how climate change affects water resources and habitats in the San Francisco Bay area conducted by the US Geological Survey relied on historical climate data and future climate projections, which were downscaled to fine spatial scales for application to a regional water-balance model (Flint and Flint, 2012). Changes in climate, potential evapotranspiration, recharge, runoff, and climatic water deficit were modeled for the San Francisco Bay area, including detailed studies in the Russian River Valley.

Results indicated large spatial variability in climate change and the hydrologic response across the region. Although the model results indicate warming under all projections, potential precipitation change by the end of the 21st century differed depending on the model details. Hydrologic models predicted reduced early and late wet season runoff at the end of the century under both wetter and drier future climate projections, suggesting extended dry seasons. Summers are projected to be longer and drier in the future than in the past regardless of precipitation trends. Water supply could be subject to increased variability (and resultant reduced reliability) due to more variable precipitation. Additionally, the study found that water demands are likely to steadily increase because of increased evapotranspiration rates and climatic water deficit during the extended summers. The study concluded that extended dry season conditions and the potential for drought, combined with increases in precipitation variability, could serve as additional stressors on water quality and habitat.

3.2 Surface Water

Surface water discharge in Sonoma Creek is gaged near the middle part of the valley at the Agua Caliente Avenue bridge near Agua Caliente (USGS station number 11458500), and near Kenwood (USGS station number 11458433) (as shown in Figure 2-1). The Kenwood stream gage was installed in the fall of 2008 and is a fairly short-term record.

The Agua Caliente gage operated from 1955 through 1981 and was then temporarily discontinued until 2001 when it was restarted. Discharge measured at the Agua Caliente gage varies considerably annually, as shown in the graph of total annual discharge in acre-feet. The mean annual discharge of Sonoma Creek at the Agua Caliente gage (Figure 3-3) is 50,836 acre-feet (AF), on the basis of records for water years 1956–81 and 2002–13 (1 acre foot = 43,560 cubic feet = 325,900 gallons which is enough water to cover a football field with one foot of water). A maximum annual discharge of 123,402 AF was measured in 2006, and a minimum discharge of 1,002 AF was measured in 1977. For the last five years (Water Years 2009 through 2013, as shown if Figure 3-4), the annual discharge of Sonoma Creek measured at the Agua Caliente gage has ranged from approximately 22,460 AF in Water Year 2009 to approximately 74,330 AF in Water Year 2011 and has been

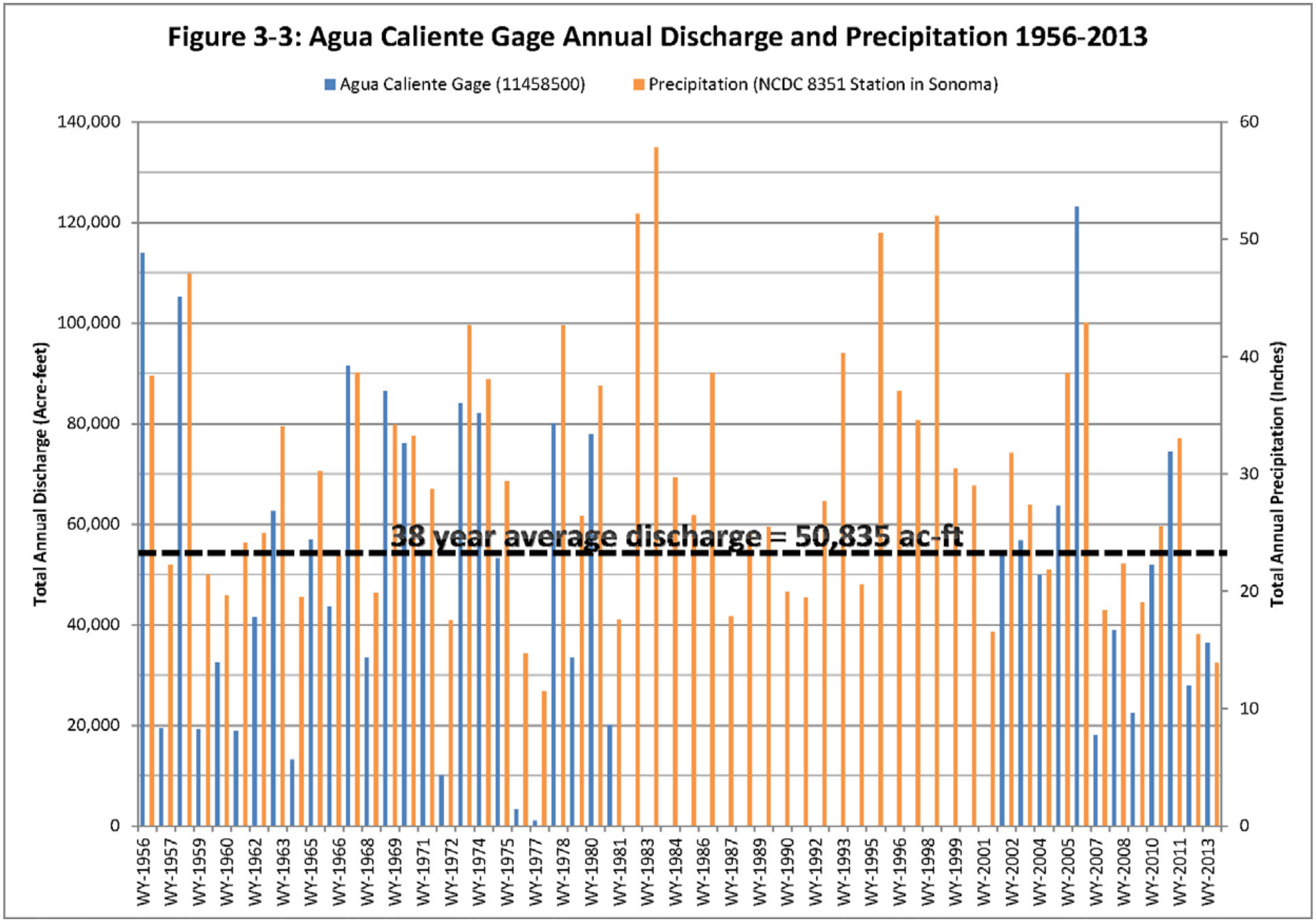


Figure 3-3 Agua Caliente Gage Annual Discharge and Precipitation 1956-2013

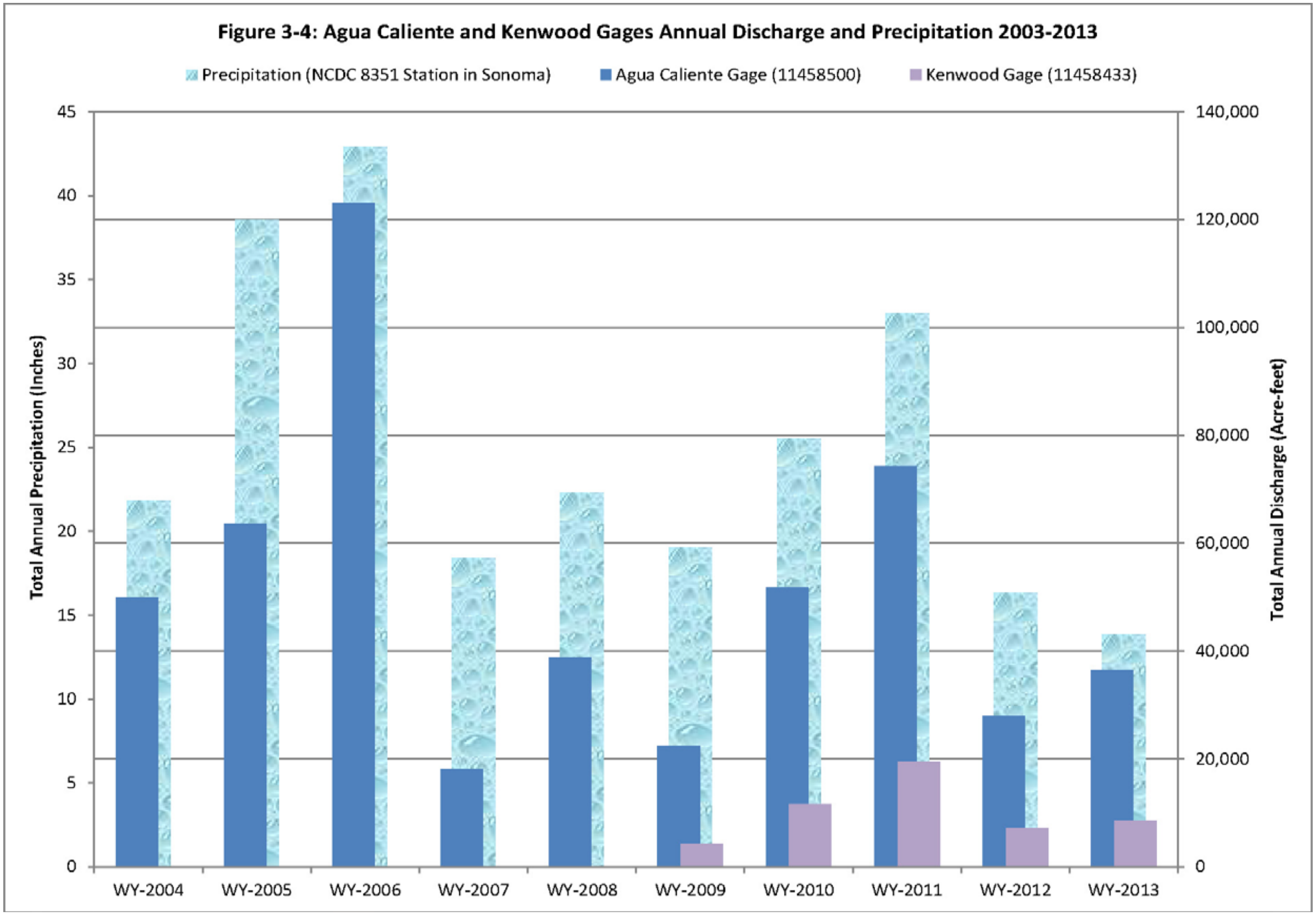


Figure 3-4 Agua Caliente and Kenwood Gages Annual Discharge and Precipitation 2003-2013

below the mean annual discharge of 50,836 AF in three of those five water years (Water Years 2009, 2012 and 2013).

The mean annual discharge of Sonoma Creek at the Kenwood gage (Figure 3-4) for the five years it has been operating is approximately 10,225 AF, ranging from approximately 4,283 AF in Water Year 2009 to approximately 19,495 AF in Water Year 2011. Between the two gauges, Sonoma Creek gains an annual average of approximately 32,000 AF, likely from a combination of tributary inflows and groundwater seepage between the two gauge locations.

In most water years, daily discharge does not increase significantly until November or December, after which it begins to rapidly decrease in April or May in response to the normal annual cycle of precipitation (Figure 3-5). Figure 3-5 also indicates that, precipitation and stream discharge shifted to a shorter and earlier period in the two most recent years (Water Years 2012 and 2013).

3.2.1 Streamflow-Groundwater Interaction

The discharge measured in Sonoma Creek contains two primary components, runoff and baseflow. The baseflow component is primarily derived from groundwater, which seeps into the stream's bed and banks through adjacent shallow aquifers. In order to assess the amount of baseflow entering Sonoma Creek above the Agua Caliente gage, hydrograph separation techniques were used to estimate the ratio of baseflow (groundwater discharge) to total streamflow, termed the baseflow index (BFI). The BFI may be thought of as a measure of the proportion of the stream runoff that comes from groundwater discharge into streams. Streams which exhibit a higher BFI generally indicate that shallow aquifers are relatively permeable and contain shallow groundwater levels that can sustain streamflow during periods of dry weather.

Previous estimates for BFI were derived for Sonoma Creek at the Agua Caliente gage for Water Years 1970 to 2006 and indicated that baseflow was approximately 50% of the total streamflow (Bauer, 2008). The BFI was extended to the total period of record for the Agua Caliente Bridge (1956 to 2013) and is provided in (Figure 3-6). For the data gap from 1981 to 2001, the BFI was estimated using linear regression (Bauer, 2008). The BFI for 1956 through 2013 was estimated to range from approximately 0.45 to 0.62, with an average of approximately 0.50. This indicates that in an average year approximately 50 percent of the flow of Sonoma Creek at Agua Caliente Bridge (approximately 25,000 AF) is derived from groundwater discharging from shallow aquifers upstream of the Agua Caliente gage.

Annual precipitation is also plotted on Figure 3-6 and shows that historically the BFI was highest (greater than 0.55) during the drier years (e.g., 1957, 1972, 1976 and 1977), which indicates that in years when precipitation and total flow are low, the baseflow component of streamflow is proportionally higher. The overall long-term trend of baseflow over time appears relatively stable, which is consistent with the relatively stable groundwater levels observed in wells completed within the shallow

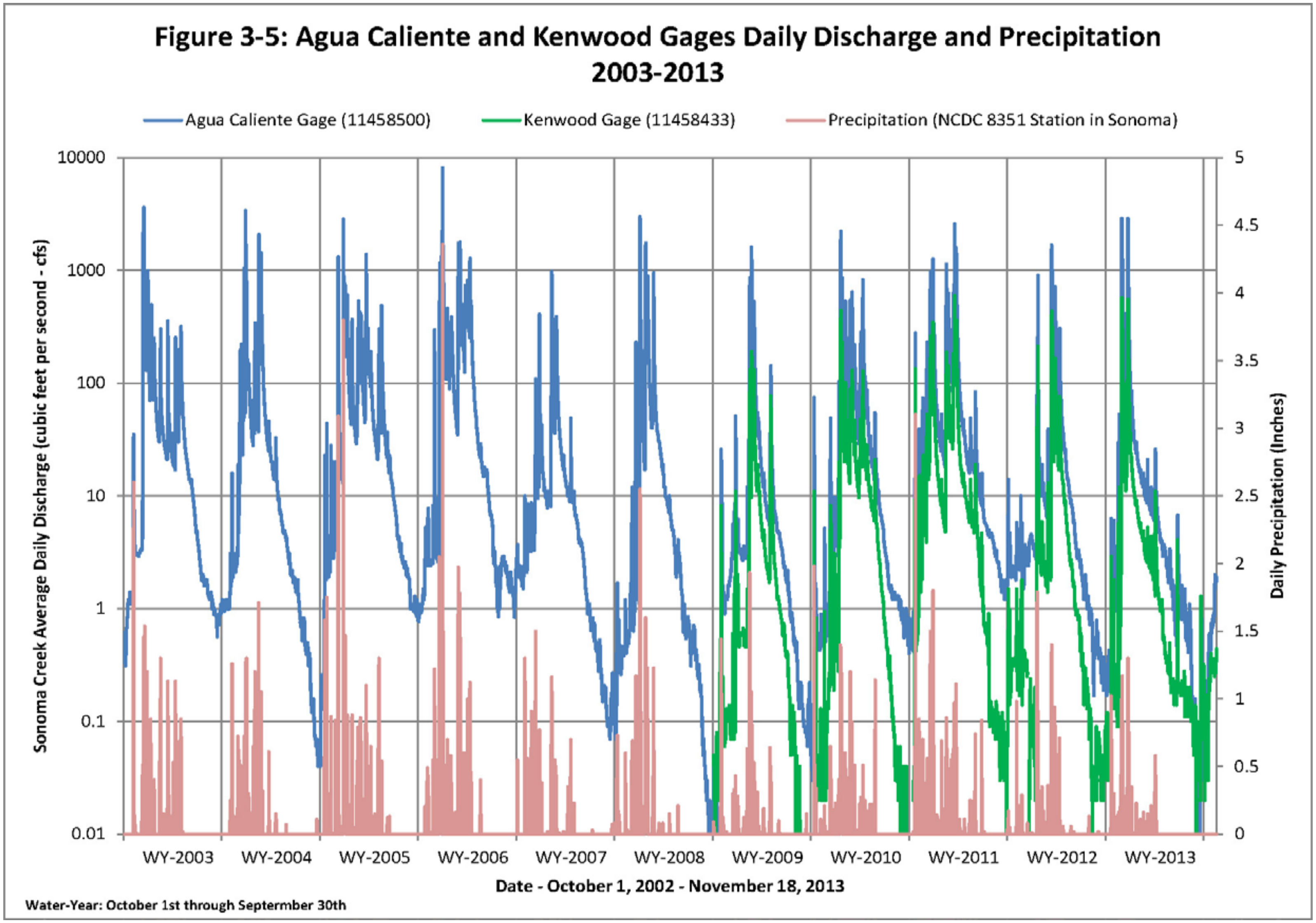


Figure 3-5 Agua Caliente and Kenwood Gages Daily Discharge and Precipitation 2003-2013

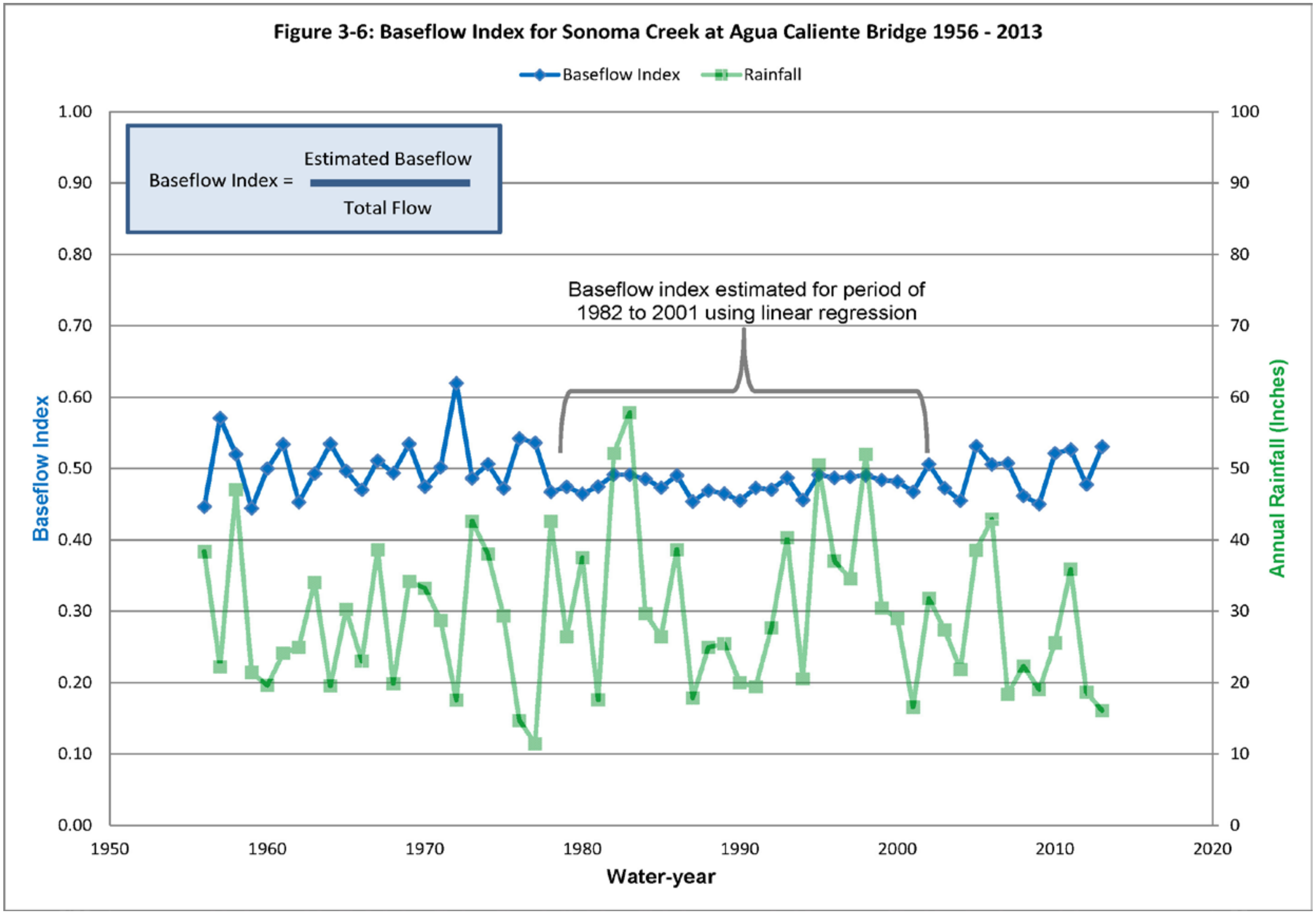


Figure 3-6 Baseflow Index for Sonoma Creek at Agua Caliente Gage 1956-2012

aquifers in Sonoma Valley, as further described below in Section 3.3. However, in more recent dry years (e.g., Water Years 2008, 2009 and 2012) the BFI has been proportionally lower (less than 0.50). This may indicate that historically groundwater levels were maintained slightly higher in shallow aquifers and provided a larger component of baseflow in comparison with more recent years.

Synoptic streamflow measurements (seepage runs) have also been conducted on Sonoma Creek and its tributaries in May 2003, May 2010 and October 2010. These seepage runs consist of a series of streamflow measurements made at several sites over a short time period (e.g., single day to several days) along Sonoma Creek and its tributaries to quantify streamflow gains and losses for a specific time period. Results from the seepage measurements for May 2010 (the most extensive dataset) are provided on Figure 3-7. Consistent with the May 2003 seepage runs (USGS, 2006), the results from May 2010 indicate that the majority of the mainstem of Sonoma Creek is gaining (groundwater is discharging into the creek) in the springtime. Losing reaches are limited to: (1) the upper reach near Kenwood where Sonoma Creek leaves Adobe Canyon and crosses over its alluvial fan upstream of Highway 12; (2) a section of the upper reach downstream of Lawndale Road and upstream of Randolph Road in Kenwood; and (3) possibly, a downstream reach between Leveroni and Watmaugh Road. Tributaries which exhibit losing reaches include: (1) the majority of Carriger Creek from Grove Street to its confluence with Sonoma Creek; (2) a short segment of Felder Creek; (3) a short reach of Calabazas Creek downstream of Highway 12; (4) Nathanson Creek upstream of Napa Road; and (5) Arroyo Seco upstream of Napa Road. The remaining tributaries which were monitored are primarily gaining, including the majority of Calabazas Creek and Mill Creek and the lower reaches of Nathanson Creek and Arroyo Seco Creek.

Since the majority of the reaches of Sonoma Creek and tributaries are gaining water and flows from groundwater, it is important that groundwater levels in the shallow aquifer be maintained to sustain streamflows. This is especially important during summer months, when rainfall runoff diminishes. Sustaining such streamflows contributes to maintaining healthy riparian habitat and aquatic ecosystems. The proportion of baseflow to total streamflow, estimated at approximately 50% at the Agua Caliente bridge on Sonoma Creek, may have been relatively higher during historic dry water years in comparison with more recent dry years. Additional streamflow (seepage) measurements during different times of the year will help to understand how reaches of Sonoma Creek and tributaries may change seasonally in terms of gaining or losing and how much of the stream baseflow comes from groundwater.

3.3 Groundwater

The current understanding of the groundwater resources in the basin comes primarily from: (1) a study conducted by the United States Geological Survey (USGS) which was co-funded by the Water Agency to evaluate the ground water resources

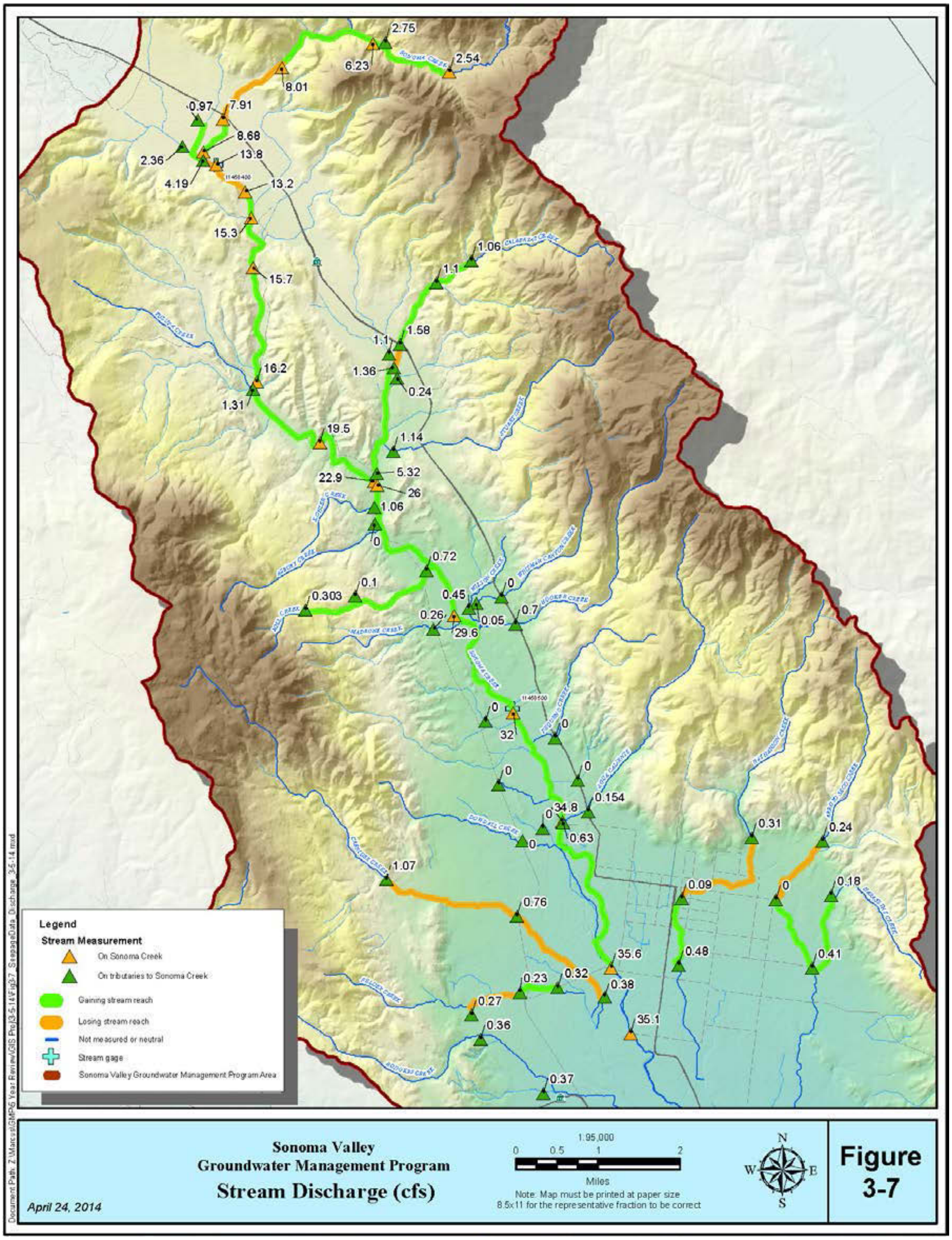


Figure 3-7 Stream Discharge

of the Sonoma Valley (USGS, 2006); and (2) subsequent studies and monitoring associated with implementing the GMP.

- The USGS study updated the hydrogeologic characterization of the basin and provided a current assessment of hydrologic conditions, including a description of historical groundwater levels and water quality changes. A groundwater flow model was also developed as part of the study that was used to evaluate conjunctive water management options during development of the GMP.

- Studies and monitoring incorporated into this section that have been conducted following development of the GMP (as summarized in Section 2) include: groundwater level data collection, water quality sampling, streamflow monitoring, groundwater recharge mapping, construction and monitoring of nested groundwater monitoring wells, updating of the groundwater flow model, and a groundwater banking feasibility study.

This section presents the results of the groundwater level and water quality monitoring program in the Sonoma Valley performed as part of the GMP (see Section 2.2). To maintain consistency with the approach utilized in the 2006 USGS report, wells were subdivided according to their well-screen depth or total depth into the following three categories: (1) shallow - less than 200-feet deep; (2) intermediate - 200 to 500 feet deep; and (3) deep - greater than 500 feet deep. As indicated on Figure 2-1, 73 monitoring wells are less than 200-feet deep, 40 monitoring wells are between 200 to 500 feet deep, and 22 monitoring wells are greater than 500 feet deep. Due to the limited number of wells that are greater than 500 feet deep, for the purposes of preparing depth-specific groundwater-level hydrographs and groundwater-level contour maps, wells were grouped into two categories: (1) less than 200-feet deep – shallow wells; and (2) greater than 200-feet deep – deep wells.

3.3.1 Geologic and Hydrogeologic Framework

Sonoma Valley is located within a geologically complex region(see Geologic Map, Figure 3-8). The entire watershed is underlain by basement rocks consisting of metamorphic, igneous and metasedimentary rocks of the Jurassic/Cretaceous-aged Franciscan Complex, Coast Range Ophiolite, and Great Valley Sequence. A mixture of younger (Tertiary and Quaternary-aged) volcanic and sedimentary rocks and unconsolidated sediments overlies these basement rocks. In general, groundwater flows from recharge areas in the mountains and uplands surrounding the Sonoma Valley toward the valley axis and in a generally southern direction towards San Pablo Bay. Several faults have been mapped in these mountains and one northwest-striking fault has been mapped along the eastside of the valley floor. This fault, referred to as the Eastside Fault, may act as a hydrologic barrier to horizontal groundwater flow conduit for the upward circulation of deeper thermal waters in the Sonoma area, and may restrict groundwater flow (USGS, 2006). It appears that

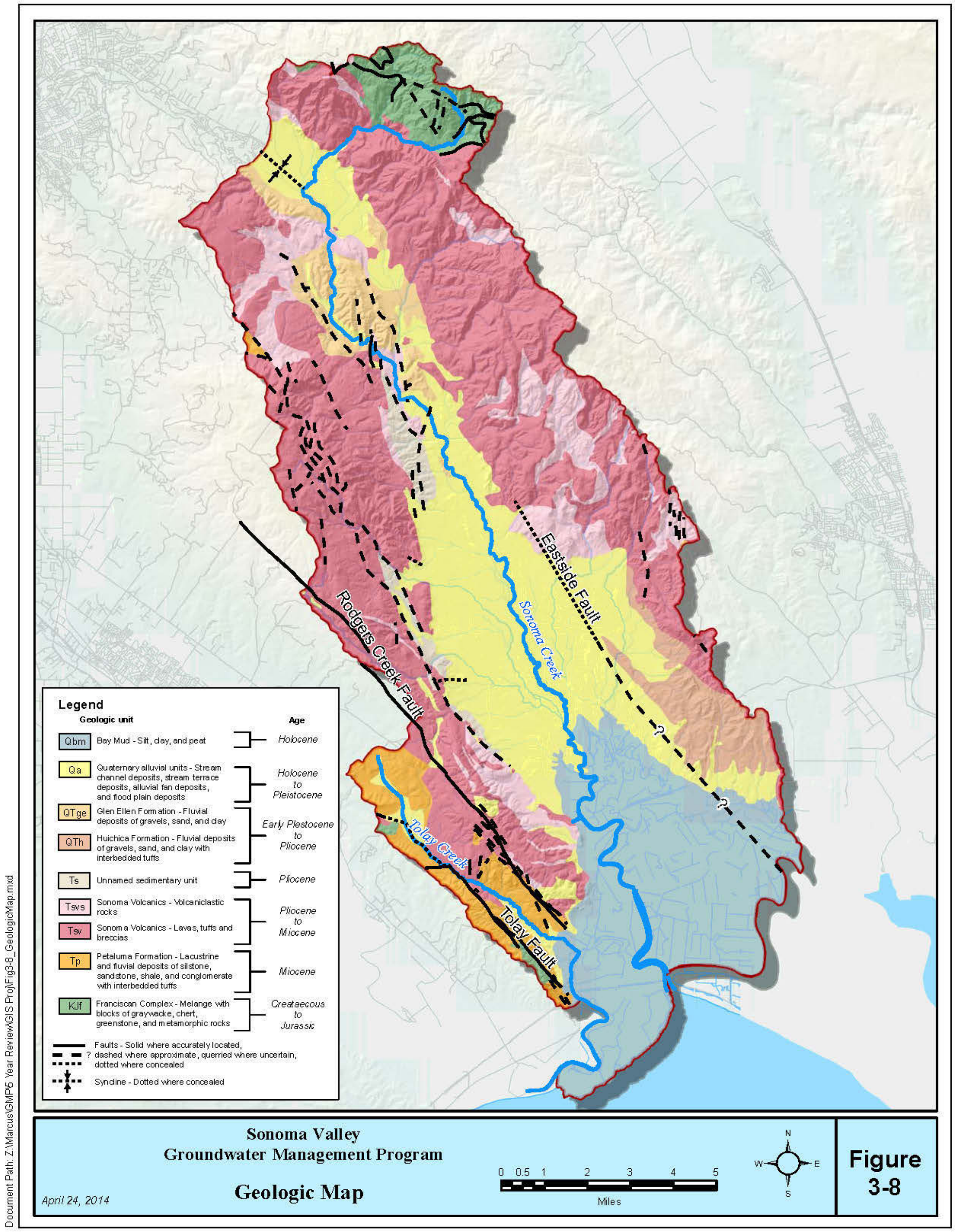


Figure 3-8 Geologic Map

the fault has offset aquifers, however additional groundwater level data is needed to further assess the fault's effect on groundwater flow.

All geologic formations in the Sonoma Valley contain groundwater; however the water-bearing properties and wells yields of the formations vary significantly. Four geologic units are identified that are of greatest importance for groundwater supply within Sonoma Valley (USGS, 2006). These geologic units are described in order of increasing age.

Quaternary Alluvial Units – lenses of interbedded cobbles, sand, silt, and clay interlaced with coarse-grained stream channel deposits near the Sonoma Creek and tributaries, including alluvial fan deposits. These deposits form a broad blanket in the lower valley, a narrower band and discontinuous patches through the hilly middle valley, and a wide blanket in the upper valley. Where these deposits are thick and saturated, they are the highest yielding aquifers in the valley, with well yields of more than 100 gallons per minute (gpm).

Glen Ellen Formation - clay-rich stratified deposits of poorly sorted sand, silt, and gravel interbedded with minor beds of conglomerate and volcanic tuffs. This unit interfingers with the Huichica Formation and lies on top of the Sonoma Volcanics in some regions and on the Franciscan Complex in other regions. The well yields are significantly lower in this formation than in the Quaternary alluvial deposits, with well yields generally less than 20 gpm, and often only 1 to 2 gpm.

Huichica Formation – thick silt and clay with interbedded lenses of sands, gravels and tuff beds; this unit overlies and is interbedded with the Sonoma Volcanics; like the Glen Ellen Formation, well yields are low, typically 2 to 20 gpm, however, in some areas, the lower part of this formation can be higher yielding.

Sonoma Volcanics – thick sequences of volcanic rocks interbedded with sedimentary deposits derived from volcanic rocks and lake beds. This unit overlies the Franciscan Complex or other basement rock. This formation has the highest variability in water-bearing properties in the valley. Yields generally range between 10 and 50 gpm and occasionally as much as several 100 gpm.

As outlined above, the Sonoma Valley contains complex patterns of sediment deposition, which provides a complex aquifer system. The Glen Ellen and Huichica Formations were predominantly deposited in an east-west direction, perpendicular to the current valley. Much of the Quaternary Alluvium and Bay Muds were deposited in a north-south direction longitudinally along the axis of the current valley, with the exception of alluvial fan deposits that exhibit localized east-west orientations.

The shallow portions of the Quaternary alluvial deposits are commonly unconfined, while deeper portions of the Quaternary alluvial deposits, the Glen Ellen Formation, Huichica Formation, and Sonoma Volcanics are commonly confined to semiconfined. These geologic units overly the basement rocks of the Franciscan Complex, which for the most part acts as a barrier to flow, but can yield water near fault zones or where heavily fractured (USGS, 2006).

For the most part, the shallow aquifer system appears to be more continuous than and hydraulically isolated from the underlying deeper aquifer system. The shallow aquifer system is locally connected to Sonoma Creek, based on the results of seepage runs that indicate gaining stream flows along the majority of the mainstem. Recharge to aquifers in the Sonoma Valley occurs through streambed recharge along portions of Sonoma Creek and its tributaries, as well as through direct infiltration of precipitation and along the margins of the valley areas (mountain front recharge).. The shallow aquifer system receives most of this recharge. Recharge that reaches the deeper aquifer zones is more poorly defined and likely comes from a combination of leakage from overlying shallow aquifers and mountain front recharge along the margins of the valley.

Two aquifers (intermediate and deep) are present in the Glen Ellen Formation, but their lateral continuity has locally been disrupted and compartmentalized by Sonoma Volcanic lava flows and, possibly fault zones in the El Verano and Agua Caliente areas.

In the southern portion of the Sonoma Valley, there are thick sequences of clay generally present between approximately 100 and 350 feet below ground surface (bgs) that form an effective aquitard generally limiting hydraulic communication between shallow and deeper aquifer zones. The shallow and deep aquifer zones and clay aquitard zones identified in the southern Sonoma Valley correlate reasonably well and may be laterally continuous.

Groundwater level trends in the northern portion of the valley and generally within the shallow aquifer system indicate a pattern of overall stability. Based on groundwater levels in the intermediate and deep aquifers, there are two pumping depressions that have existed for several decades and appear to be growing. These pumping depressions are located west of El Verano and southeast of the City of Sonoma.

Results of studies conducted and reported in 2006 (USGS, 2006) indicated over the 25-year period ending in 2000, annual groundwater pumping increased from approximately 6,100 AF to 8,400 AF per year. Results of modeling the change in groundwater pumping versus inflow suggest a loss in storage of approximately 17,000 AF over the 25-year period (approximately 680 AF per year). More recent refinements to the groundwater flow model indicate that storage loss is approximately 1,400 AF per year (Bauer, 2008). Based on the groundwater levels and contours it appears most of the decrease in storage is in the intermediate and deep aquifers in the pumping depressions west of El Verano and southeast of the City of Sonoma.

The extent of both areas of depression is poorly defined. A screening-level estimate of the amount of available storage was developed by: (1) assuming an average groundwater-level decline of 40 feet over an area of approximately 3.5 miles long by 1.5 mile wide; and (2) applying a range of specific yields of 3 to 7 percent to this volume. Screening-level estimates of the currently available storage in the pumping depression southeast of the City of Sonoma are about 4,000 to 9,400 AF (GEI, 2013). For the El Verano area, a screening-level estimate of the amount of available storage was developed by: (1) assuming an average groundwater-level decline of 20 feet over an area of approximately about 2 miles long by 0.8 mile; and (2) applying a range of specific yields of 3 to 7 percent to this volume. Screening-level estimates of the currently available storage in the El Verano area are about 600 to 1,400 AF (GEI, 2013). Collectively the storage capacity estimates for these two areas represents approximately 4,600 to 10,800 AF, which represents a large portion of the total estimates of storage losses.

3.3.2 Subareas

Sonoma Valley has been divided into eleven subareas for the purposes of delineating groundwater conditions by geographic area. Subareas previously developed for Sonoma Valley have been refined and expanded to encompass the entire Sonoma Valley watershed (and Plan Area). The subareas were selected in consultation with the TAC based on hydrology, geography, geology and scientific judgment. These subareas were developed for management purposes and are not hydrologically distinct and groundwater and surface water flows between subareas. However, dividing Sonoma Valley into subareas enables GMP activities and programs to more accurately address the water use and hydrologic characteristics of each subarea. The subareas are shown in Figure 3-9 and a brief description of each is provided below.

Kenwood Subarea

The Kenwood subarea is located in the northern part of Sonoma Valley and has an approximate area of 5,140 acres (about 5% of Sonoma Valley). The Kenwood subarea is the southern half of the Kenwood Valley Groundwater Basin and is primarily a valley area comprised of alluvial deposits, stream channel, and terrace surficial deposits. These alluvial deposits are fairly thin in many portions of the subarea and many wells produce groundwater from the underlying Sonoma Volcanics.

Calabazas Subarea

The Calabazas subarea is located in the northern part of Sonoma Valley and has the smallest area at approximately 1,347 acres (about 1% of Sonoma Valley). The subarea is located south of Kenwood and is drained by Calabazas Creek. Primary geologic formations within the subarea include alluvial, stream and terrace surficial deposits, Glen Ellen Formation and Sonoma Volcanics. The subarea locally contains areas of thermal groundwater and flowing wells.

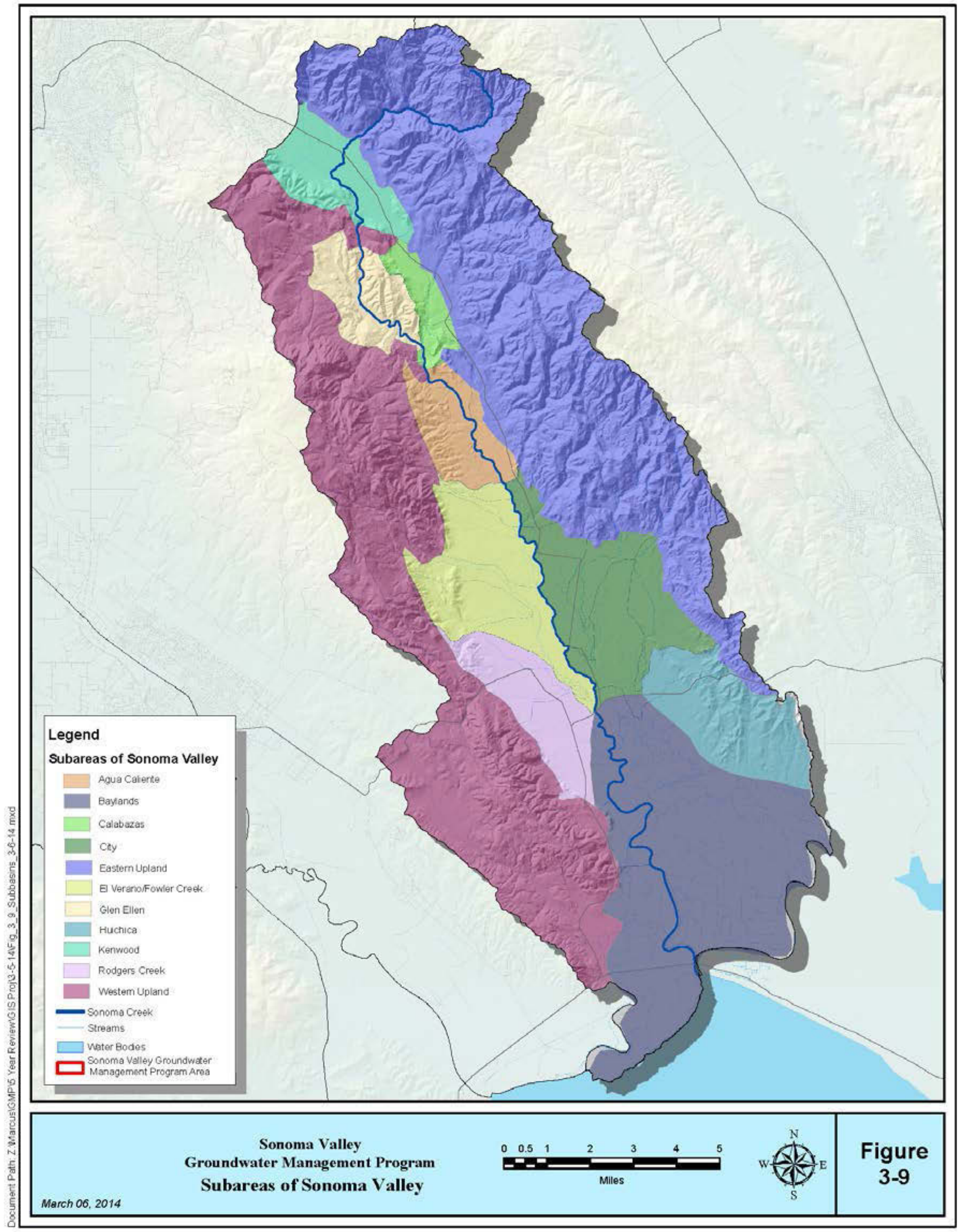


Figure 3-9 Subareas of Sonoma Valley

Glen Ellen Subarea

The Glen Ellen subarea is located in the northern part of Sonoma Valley and has an approximate area of 2,778 acres (about 3% of Sonoma Valley). The subarea is comprised of an area of moderate topographic relief incised by Sonoma Creek in the vicinity of Warm Springs Road. Primary geologic formations include the Glen Ellen Formation, alluvial, stream and terrace surficial deposits.

Agua Caliente Subarea

The Agua Caliente subarea is located near the center of Sonoma Valley and has an approximate area of 2,809 acres (about 3% of Sonoma Valley). The subarea is located south of the Glen Ellen subarea and includes a large portion of the VOMWD service area. Primary geologic formations include alluvial, stream and terrace surficial deposits, Glen Ellen Formation and Sonoma Volcanics. The subarea includes areas of thermal groundwater along the Eastside Fault.

El Verano/Fowler Creek Subarea

The El Verano/Fowler Creek subarea is located near the center of Sonoma Valley, west of Sonoma Creek, and has an approximate area of 6,098 acres (about 6% of Sonoma Valley). The subarea is located south of the Agua Caliente subarea and includes a large portion of the VOMWD service area. Primary geologic formations include alluvial, stream and terrace surficial deposits, Glen Ellen Formation and Sonoma Volcanics. The subarea includes the El Verano pumping depression.

Rodgers Creek Subarea

The Rodgers Creek subarea is located in the southern of part of Sonoma Valley, west of Sonoma Creek, and has an approximate area of 3,618 acres (about 3% of Sonoma Valley). The subarea is located south of the El Verano/Fowler Creek subarea and encompasses the drainage area of Rodgers Creek. Primary geologic formations include alluvial, stream and terrace surficial deposits, Glen Ellen Formation and Sonoma Volcanics.

City Subarea

The City subarea is located near the center of Sonoma Valley, east of Sonoma Creek, and has an approximate area of 6,798 acres (about 6% of Sonoma Valley). The subarea is located south of the Calabazas subarea and includes the City of Sonoma and unincorporated areas to the south and southeast. Primary geologic formations include alluvial, stream and terrace surficial deposits, Glen Ellen Formation and Sonoma Volcanics. The subarea includes the southeast Sonoma pumping depression and areas of thermal groundwater along the Eastside Fault.

Huichica Subarea

The Huichica subarea is located in the southeast part of Sonoma Valley and has an approximate area of 4,753 acres (about 4% of Sonoma Valley). The subarea is located southeast of the City subarea and generally bordered to the west by the Eastside Fault and to the southwest by the Baylands subarea. The geologic formations in the subarea are dominated by Huichica Formation and some alluvial fan deposits.

Eastern Upland Subarea

The Eastern Upland subarea extends along the east side of Sonoma Valley and has the largest area at approximately 30,044 acres (about 28% of Sonoma Valley). The subarea encompasses portions of the Mayacamas Mountains in the north and includes the eastern ranges of Sonoma Valley. The subarea is nearly entirely underlain by the Sonoma Volcanics, with the exception of the northeastern portions where rocks of the Franciscan Complex are exposed (within and adjacent to Sugarloaf Ridge State Park).

Western Upland Subarea

The Western Upland subarea extends along the west side of Sonoma Valley and has the second largest area of approximately 27,720 acres (about 26% of Sonoma Valley). The subarea encompasses Sonoma Mountain and other ridges flanking the western portions of Sonoma Valley. The subarea is nearly entirely underlain by the Sonoma Volcanics, with the exception of the southwestern portions where sediments of the Petaluma Formation and rocks of the Franciscan Complex are exposed.

Baylands Subarea

The Baylands subarea is located in the southern part of Sonoma Valley and encompasses a significant area with an approximate acreage of 17,139 (about 16% of Sonoma Valley). The subarea is bounded by San Pablo Bay to the south and dominated by low permeability Bay Mud deposits. This subarea is primarily comprised of tidal marshlands and underlain by historically brackish groundwater and therefore groundwater demands are very limited.

3.3.3 Groundwater Level Conditions

This section presents the results of the groundwater level and water quality monitoring program in the Sonoma Valley performed as part of the GMP (see Section 2.2). To maintain consistency with the approach utilized in the 2006 USGS report, wells were subdivided according to their well-screen depth or total depth into the following three categories: (1) less than 200-feet deep; (2) 200 to 500 feet deep; and (3) greater than 500 feet deep. As indicated on Figure 2-1, 73 wells are less than 200-feet deep, 40 wells are between 200 to 500 feet deep, and 22 wells are greater than 500 feet deep. Due to the limited number of wells that are greater than 500 feet deep, for the purposes of preparing depth-specific groundwater-level hydrographs and groundwater-level contour maps, wells were grouped into two categories: (1) less than 200-feet deep – shallow wells; and (2) greater than 200-feet deep – deep wells.

The USGS study identified two primary areas of declining groundwater levels in Sonoma Valley, which are present in the El Verano area and southeast of the City of Sonoma. Subsequent monitoring and studies performed during implementation of the GMP have better defined these areas and indicate that the declining groundwater levels are primarily associated with deeper aquifer zones in these areas (i.e., greater than 200 feet bgs). These areas exhibiting declining groundwater levels (pumping depressions) have persisted and expanded in some portions based on data collected through 2013.

Groundwater level elevation contour maps for Spring 2012 in both shallow wells (less than 200-feet deep) and deeper wells (greater than 200-feet deep) are shown in Figures 3-10 and 3-11, respectively. Groundwater-level elevation contour maps were not prepared for Fall 2012, as a smaller dataset was available for this time period and review of the data indicates that the general groundwater flow patterns in Spring 2012 are similar to Fall 2012. Spring 2012 groundwater level elevations ranged from approximately:

- 491 feet mean sea level (msl) in the north end of the Sonoma Valley to -16 feet msl in the south end measured in shallow wells; and
- 482 feet msl in the north end of the Sonoma Valley to -90 feet msl in the south end measured in deeper wells.

The Spring 2012 groundwater-level contour maps in both the shallow and deeper zones indicate that groundwater flows from recharge areas in the mountains toward the valley axis, in a generally southern direction towards San Pablo Bay. Comparison of the shallow and deeper groundwater-levels indicates that groundwater elevations in the deeper zone: (1) are approximately equivalent to groundwater elevations in the shallow zone in portions of northern Sonoma Valley; and (2) range up to 120 feet lower than groundwater elevations in the shallow-zone in portions of southern Sonoma Valley. The two groundwater pumping depressions described in the 2006 USGS report are most apparent in the deeper zone groundwater level contour map (Figure 3-11). Southeast of the City of Sonoma, measured groundwater levels ranged up to approximately 90 feet below sea level and southwest of El Verano groundwater levels ranged up to 42 feet below sea level in deeper zone wells.

It is important to note that groundwater elevations measured in nearby wells can be highly variable due to differences in well design (i.e., the depth and length of well screen intervals) and the spatial variations in aquifer materials (which can vary abruptly due to the complex geologic conditions and numerous fault zones present in Sonoma Valley). Therefore, the associated groundwater level contour maps represent generalized groundwater level flow patterns and should not be used to interpret more localized or site-specific conditions.

<u>Groundwater Level Trends</u>

Changes in groundwater levels were evaluated for both long-term trends and short-term (e.g., seasonal) trends using data collected from the monitoring program. In general, longer term trends were evaluated using data collected on a monthly to semiannual bases from wells within the monitoring program and short-term trends were evaluated using data collected on a more frequent basis (e.g., hourly or less) using data from wells instrumented with pressure transducers.

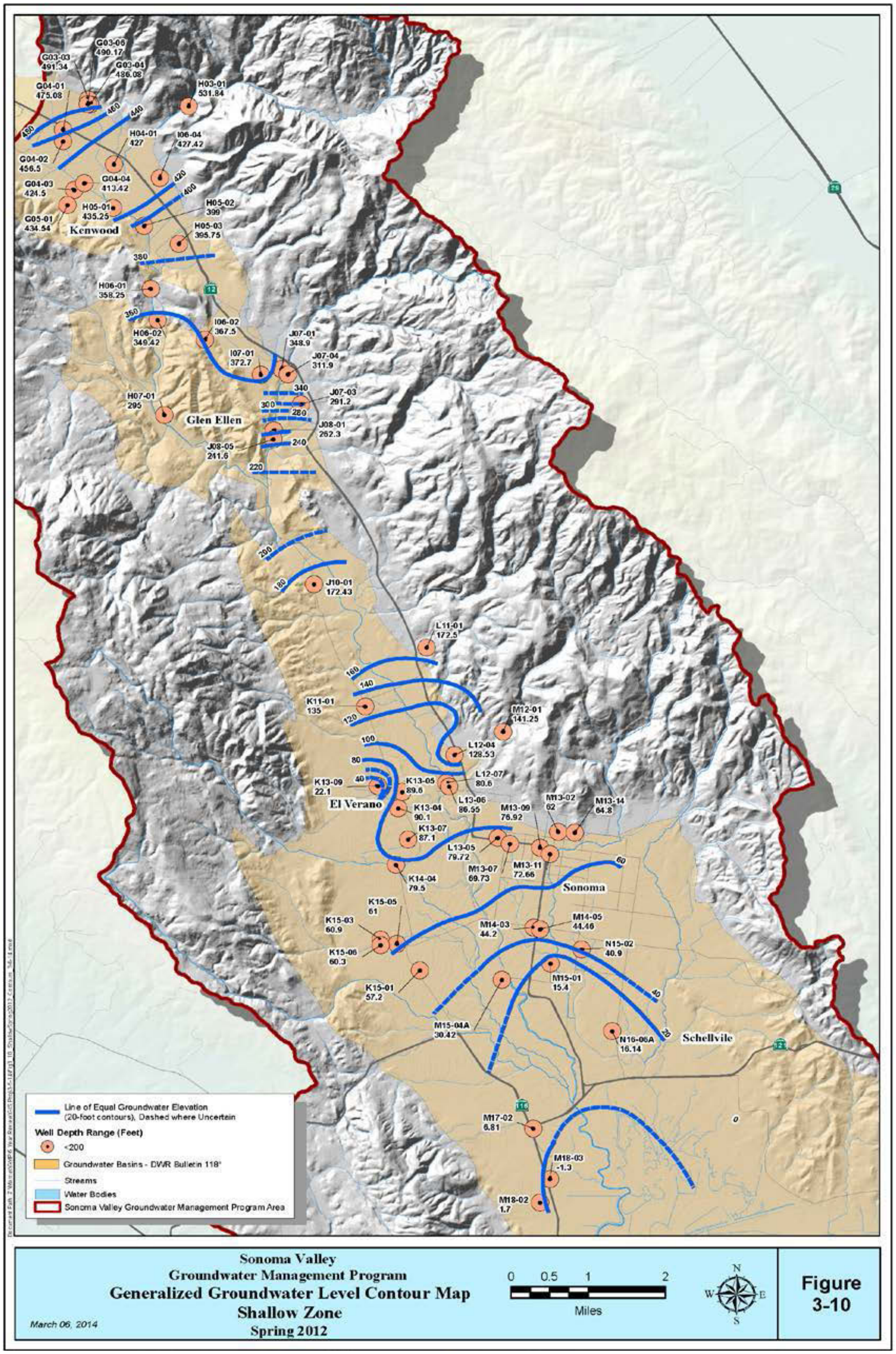


Figure 3-10 Generalized Groundwater Level Contour Map, Shallow Zone, Spring 2012

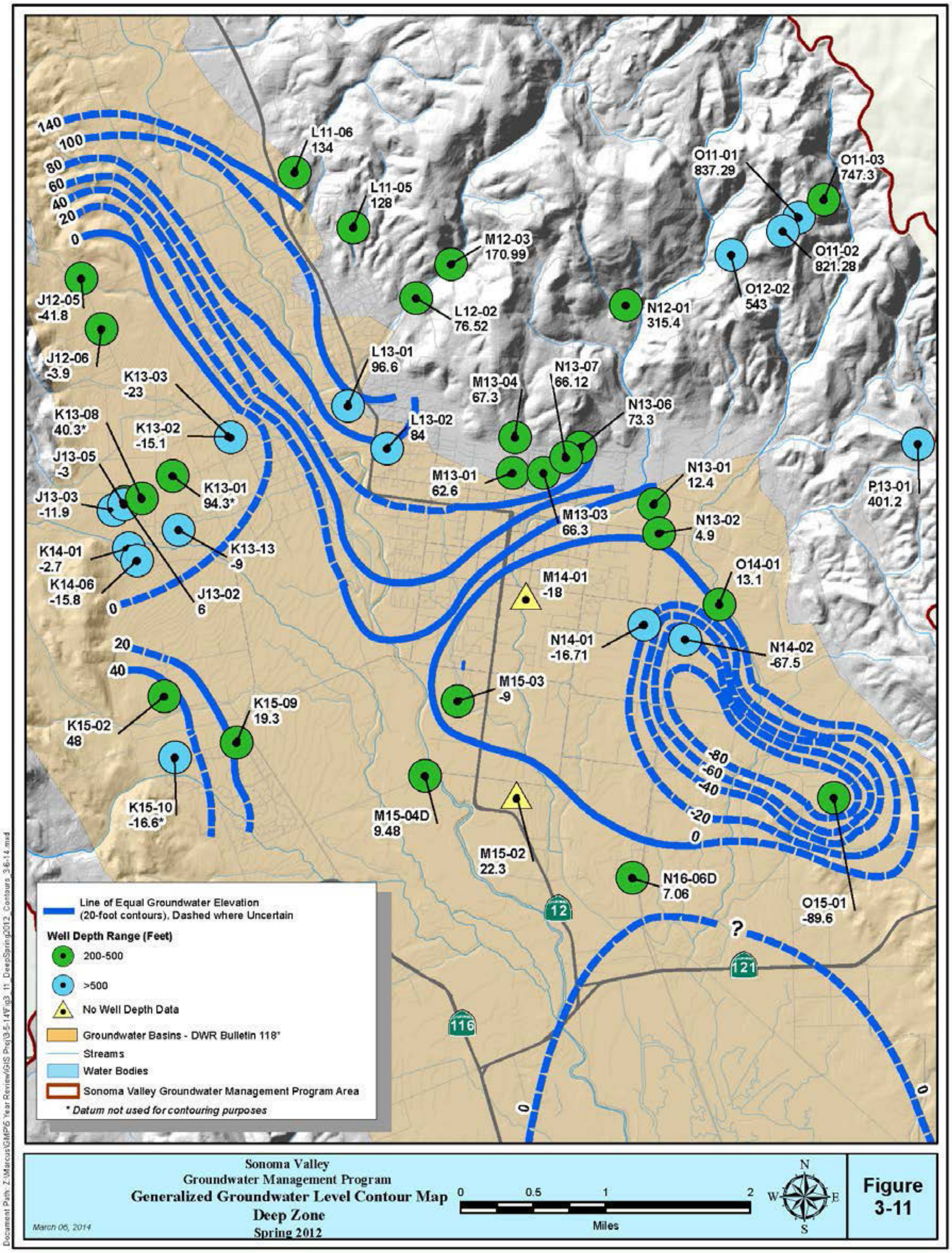


Figure 3-11 Generalized Groundwater Level Contour Map, Deep Zone, Spring 2012

Long-Term Trends

Representative hydrographs are provided in Figures 3-12 and 3-13 for the shallow and deeper-zone wells, respectively, showing a select number of well hydrographs distributed throughout the valley. Additionally, hydrographs for all wells included in the groundwater-level monitoring program are provided in Appendix A. These hydrographs present the change in groundwater elevation (vertical axis in feet) over time (horizontal axis in years). On the hydrographs, spring groundwater-level data are depicted in green and fall groundwater-level data are shown in red.

As indicated on Figure 3-12, groundwater level trends for shallow-zone wells are generally stable and predominantly remain above sea level. Long term groundwater-level declines in shallow-zone wells appear to be limited to a well located in the El Verano area where groundwater levels have declined approximately 60 feet from 1999 to 2010. As indicated in Figure 3-13, declining groundwater level trends are more pervasive in deeper-zone wells, with wells in the El Verano Area and southeast of the City of Sonoma trending below sea level. Numerous well hydrographs shown on Figure 3-13 exhibit groundwater level declines ranging up to 80 feet over the last 30 years.

Many of the hydrographs have less than 10 years of monitoring record, making it unclear whether these are long-term trends, recent accelerated declines, a reflection of the dry years in 2000, 2007 through 2009, and 2012 through 2013 or some combination. To help address this issue, groundwater level changes were further evaluated for a larger subset of wells and displayed in Figures 3-14 and 3-15. For wells that have a minimum of five years of groundwater-level data, five year or ten year trend lines (based on the span of available data) were applied to springtime groundwater levels on the hydrographs to depict overall trends for these time periods. The slope of the trend lines was computed using the method of ordinary least squares linear regression to estimate the change in groundwater level in feet per year. These computed groundwater-level changes are provided in Figures 3-12 and 3-13 for the shallow and deeper-zone wells, respectively, to display the average groundwater level change per year at selected wells over 2003-2013. Wells with at least ten years of data to are displayed as circles and wells with less than ten and at least five years of data are displayed as squares.

As shown on Figure 3-14, groundwater level trends for shallow-zone wells appear generally stable with 27 of the 37 shallow-zone wells exhibiting no significant change (i.e., less than 0.5 feet per year) and three exhibited increasing trends. Nine of the 37 wells exhibited declining trends of 0.5 to 1.5 feet per year with the majority of these occurring in the El Verano/Fowler Creek subarea. One shallow zone well has shown a more significant decrease of 3 to 5 feet per year and is also located within the El Verano/Fowler Creek subarea.

As indicated in Figure 3-15 declining groundwater level trends are more prevalent in deeper-zone wells with 22 of the 31 wells exhibiting declining trends. The nine wells exhibiting the most pronounced declining trends are all located within the El

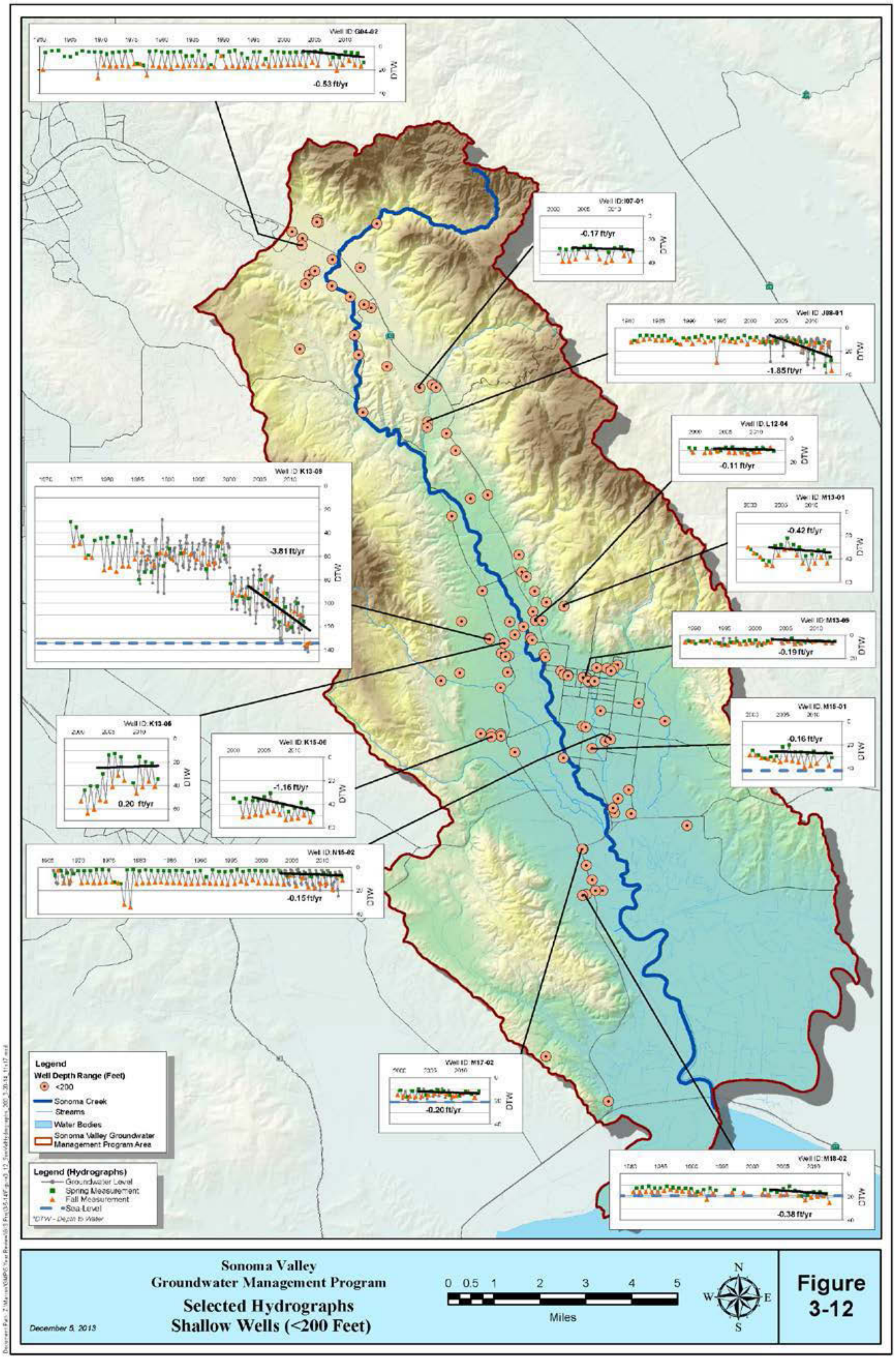


Figure 3-12 Selected Hydrographs, Shallow Wells (<200 feet)

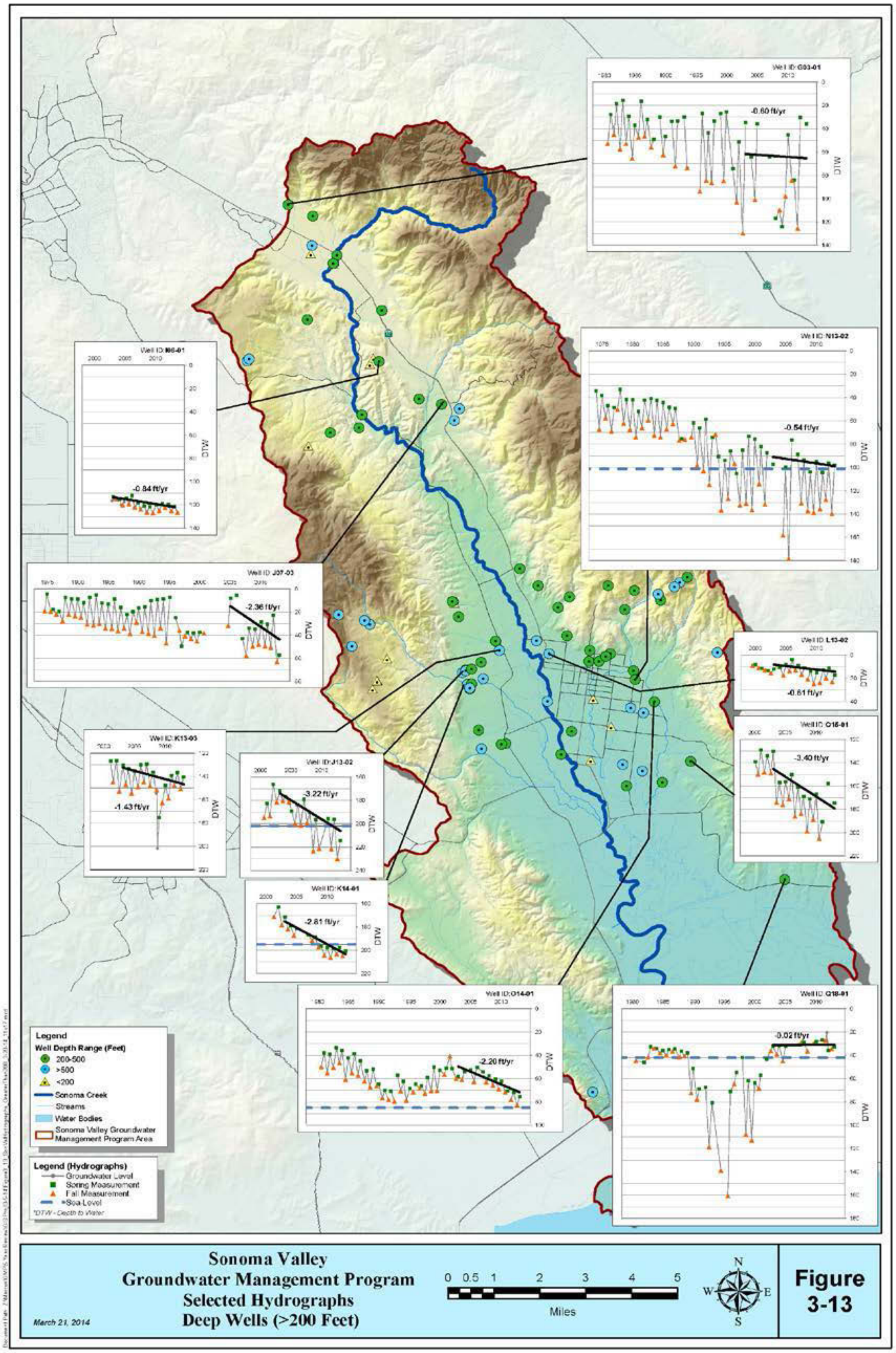


Figure 3-13 Selected Hydrographs, Deep Wells (>200 feet)

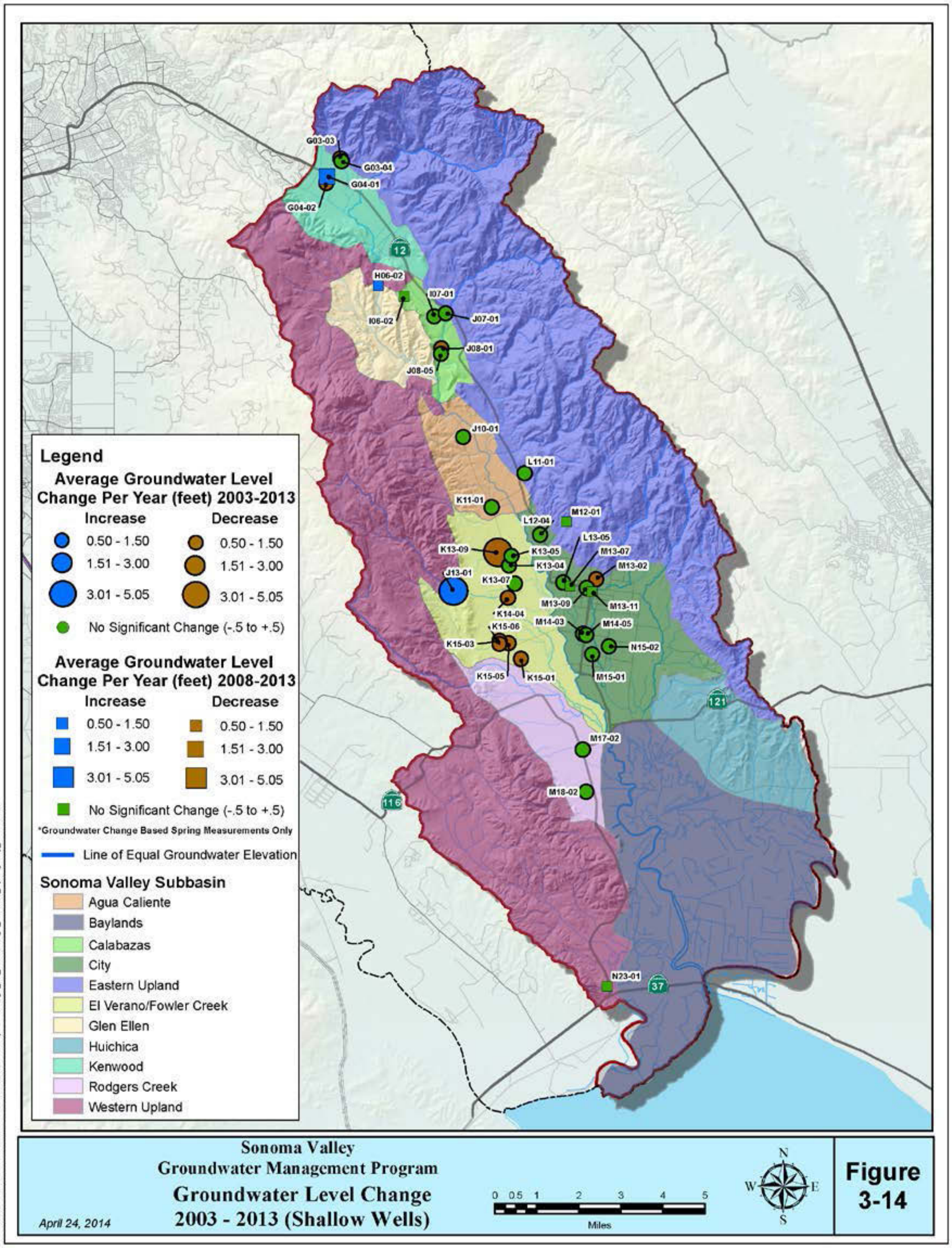


Figure 3-14 Groundwater Level Change 2003-2013 (Shallow Wells)

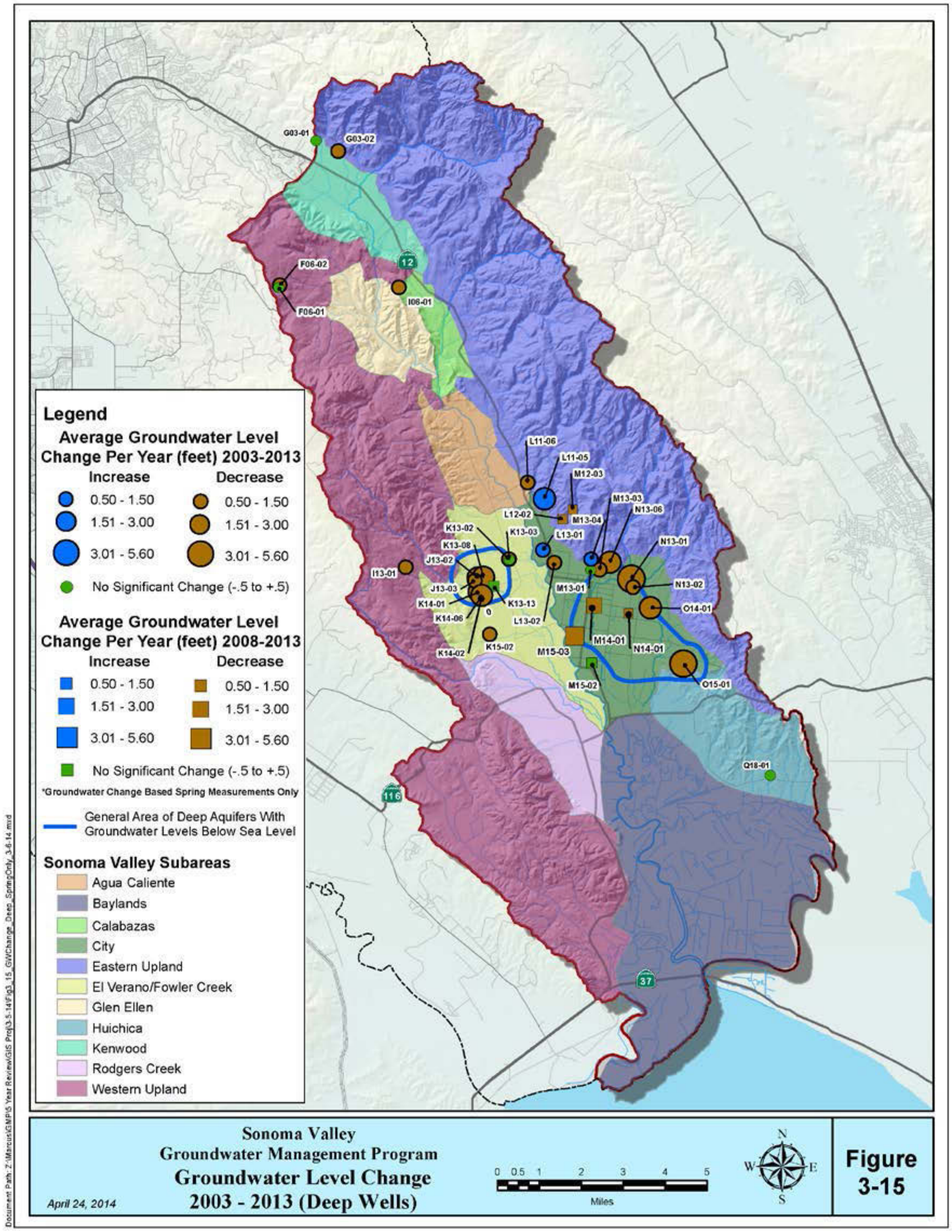


Figure 3-15 Groundwater Level Change 2003-2013 (Deep Zone)

Verano/Fowler Creek (five wells) and City subareas (four wells) and are located within or near areas where groundwater levels have declined below sea level.

Seven of the 31 deep-zone wells throughout Sonoma Valley exhibited no significant change while three exhibited an increasing trend.

Most of the groundwater level declines are considered to likely have resulted from increased groundwater withdrawals in localized areas (USGS 2006). While the magnitude of the declining rate may be influenced, in part, by the lower than average rainfall which has occurred in seven of the last ten years (most notably the last two years), many of the wells with declining groundwater levels exhibit persistent declines, which do not recover during relatively wetter years.

Short-Term Trends

Groundwater-level data has been collected utilizing Water Agency pressure transducers at a number of dedicated monitoring wells, private, mutual water company City of Sonoma and VOMWD wells over the past several years. Figure 3-16 shows the locations of wells that are currently instrumented with electronic pressure transducers and datalogger systems, along with the time period for which they have been instrumented. In addition to these locations, pressure transducers have been utilized for short duration pumping tests at several locations in Sonoma Valley. Pressure transducer data is collected at intervals of minutes or hours, and the data is downloaded periodically and converted to groundwater elevations.

As shown in Figure 3-16, wells currently instrumented with pressure transducers include the following:

- Several shallow dedicated monitoring wells (less than 40 feet in depth) located adjacent to Sonoma Creek and Agua Caliente Creek
- Three nested dedicated monitoring wells located in the El Verano/Fowler Creek subarea (VOMWD nested well) area and City subarea (nested wells SVMW-1 and SVMW-2
- The City of Sonoma's inactive Well No. 7 located at the Sonoma Garden Park on 7th Street East in the City subarea

Additionally, a private well within the El Verano/Fowler Creek subarea was recently instrumented in November 2013, but has not collected enough data to be evaluated for this report. Groundwater-level data collected from the aforementioned wells are presented in Figures 3-17 through 3-21 and discussed below.

<u>Shallow Monitoring Wells Sonoma and Agua Caliente Creeks (City Subarea)</u>

Data collected from these shallow dedicated monitoring wells is representative of the shallow aquifer (wells are less than 40 feet deep) and shown in Figure 3-17. Primary observations from these wells indicate:

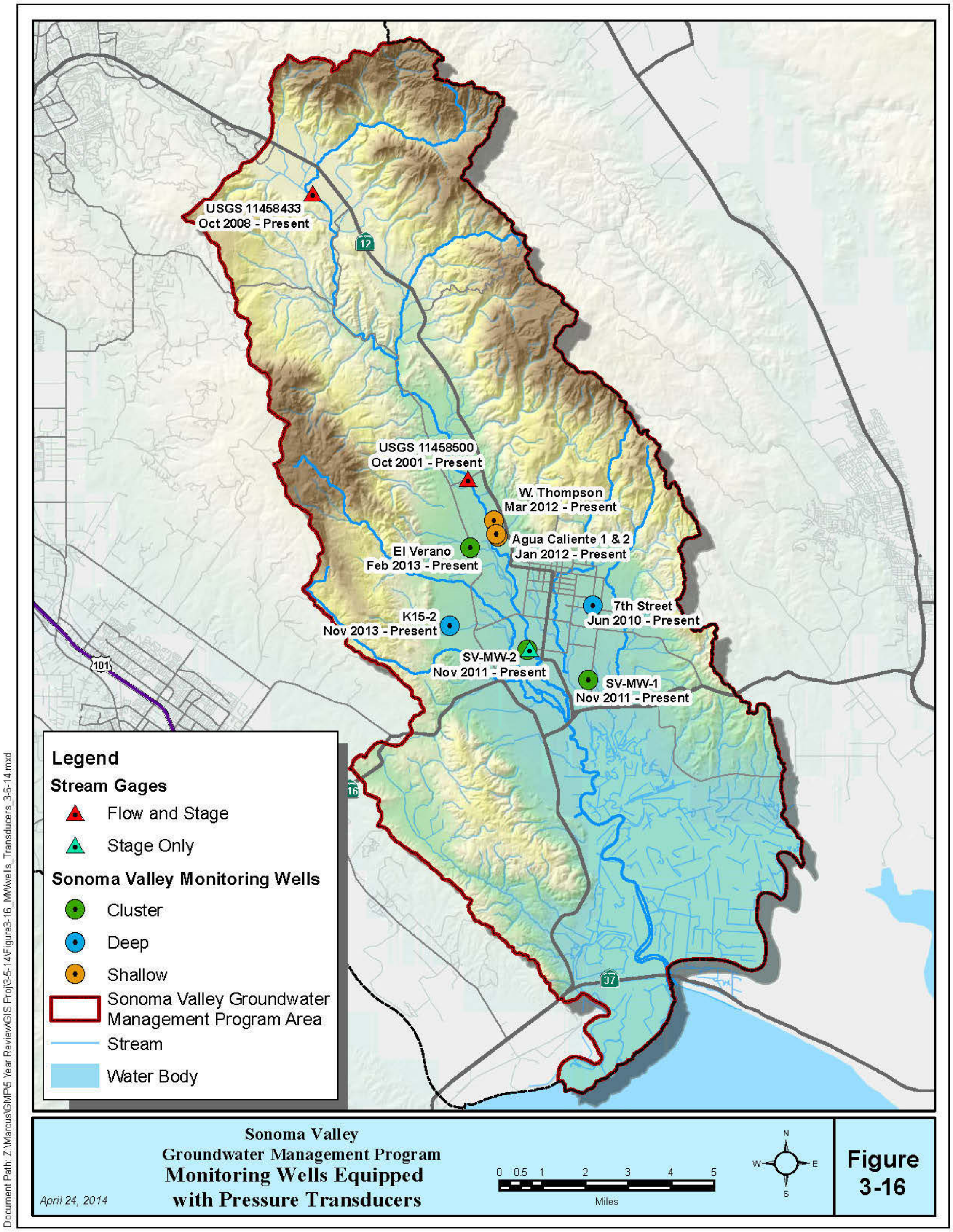
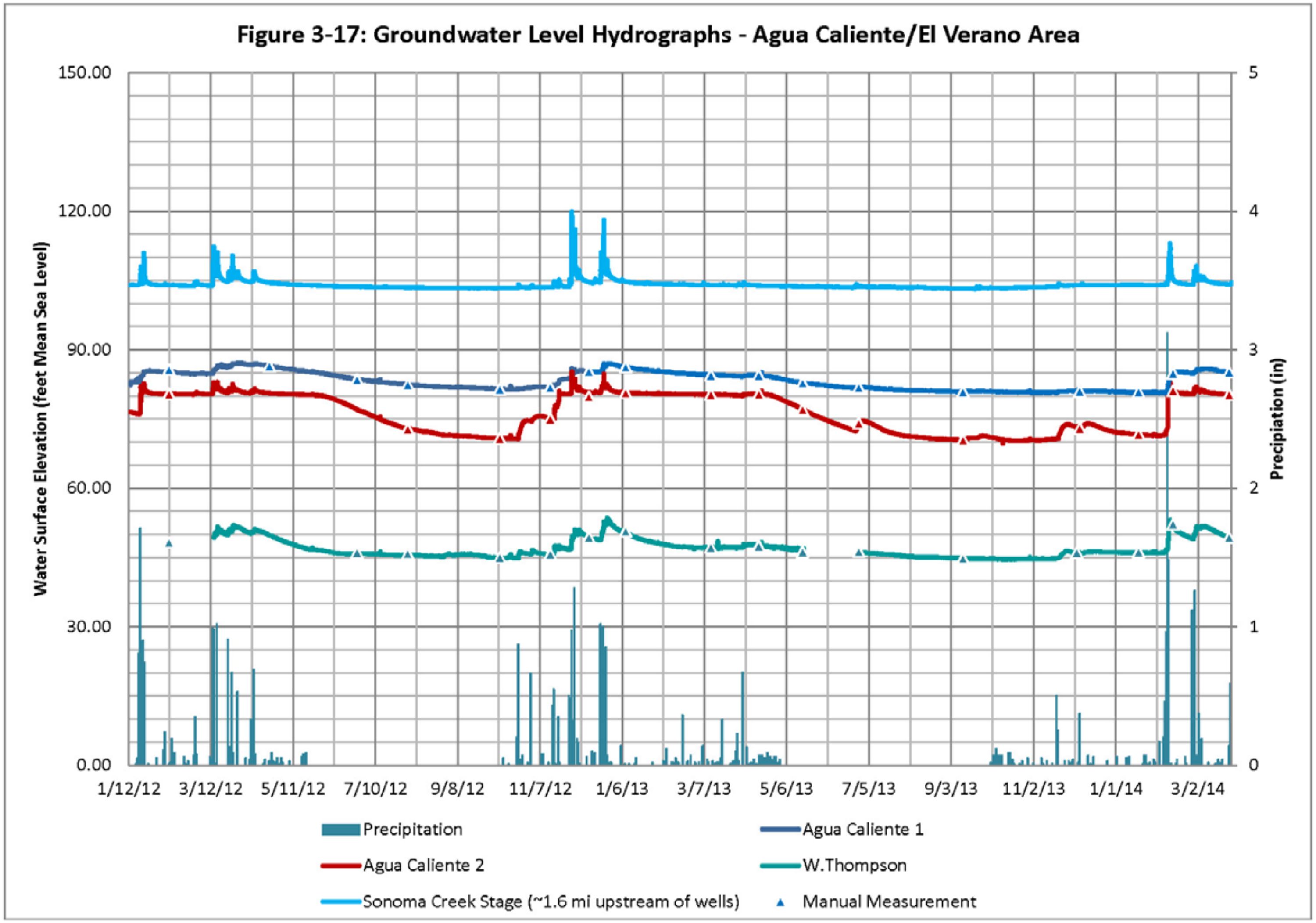
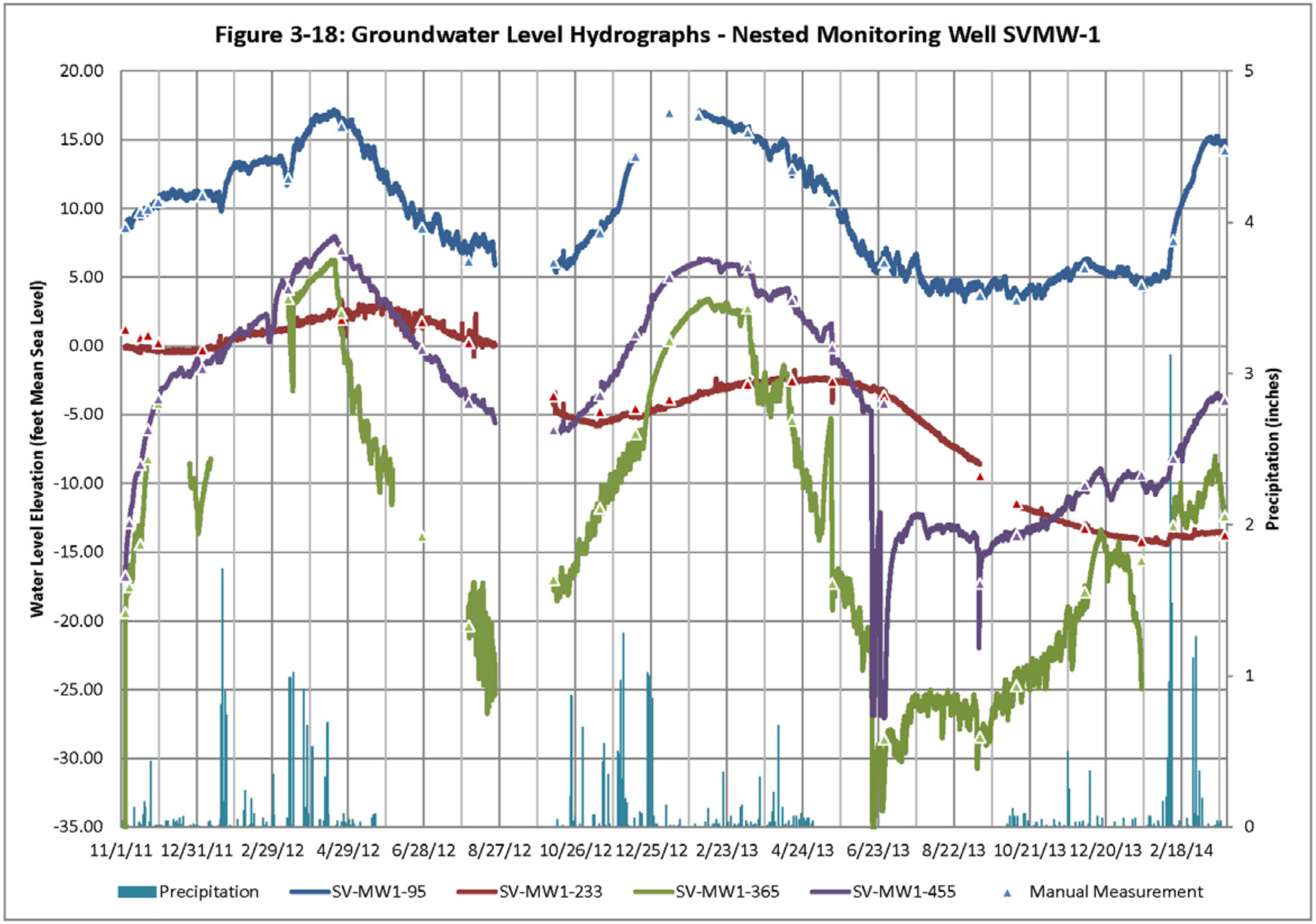


Figure 3-16 Monitoring Wells Equipped with Pressure Transducers



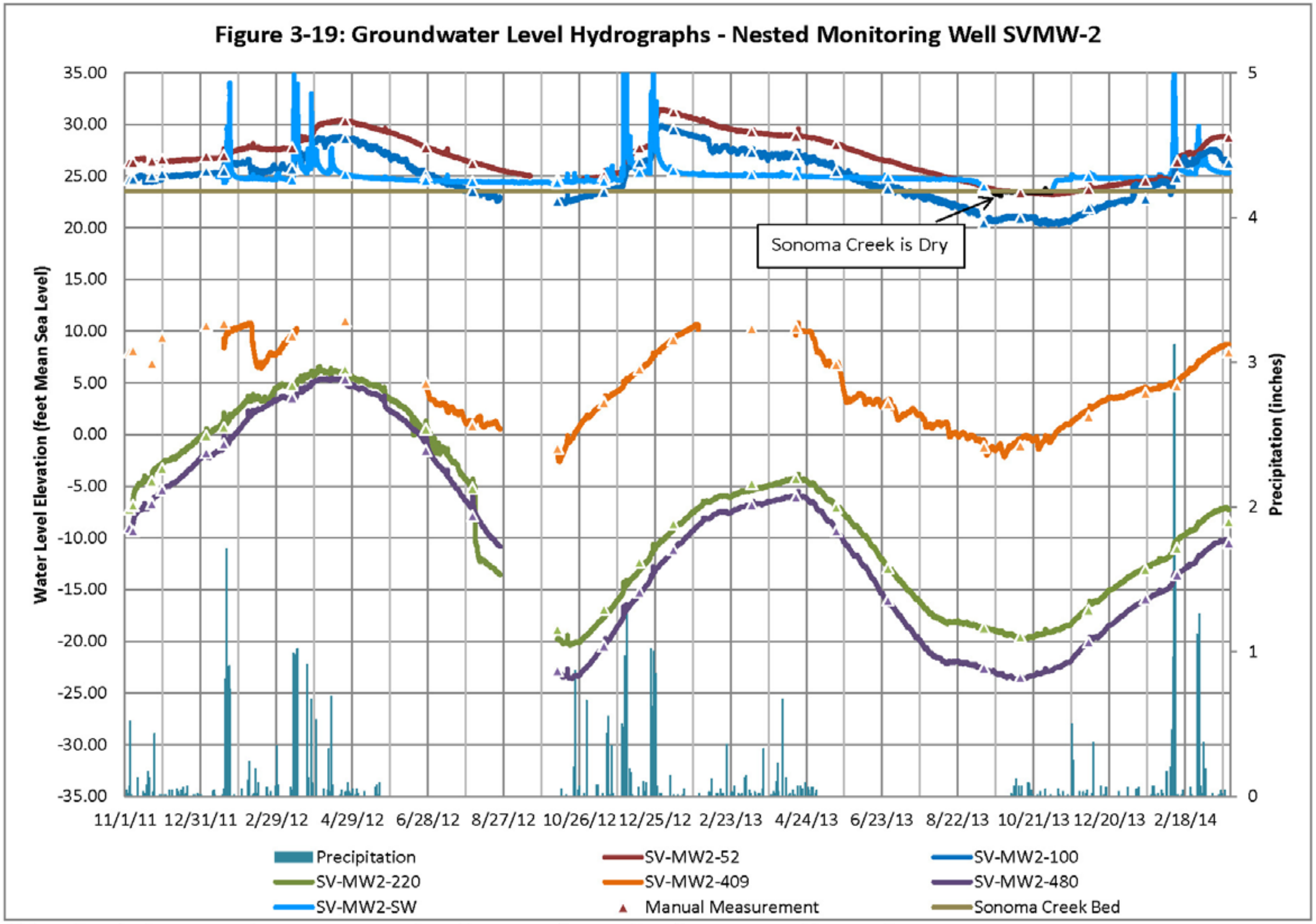
*Note: Gaps in data occur when pressure transducer is temporarily out of service or removed for sampling

Figure 3-17 Groundwater Level Hydrographs – Agua Caliente/El Verano Area



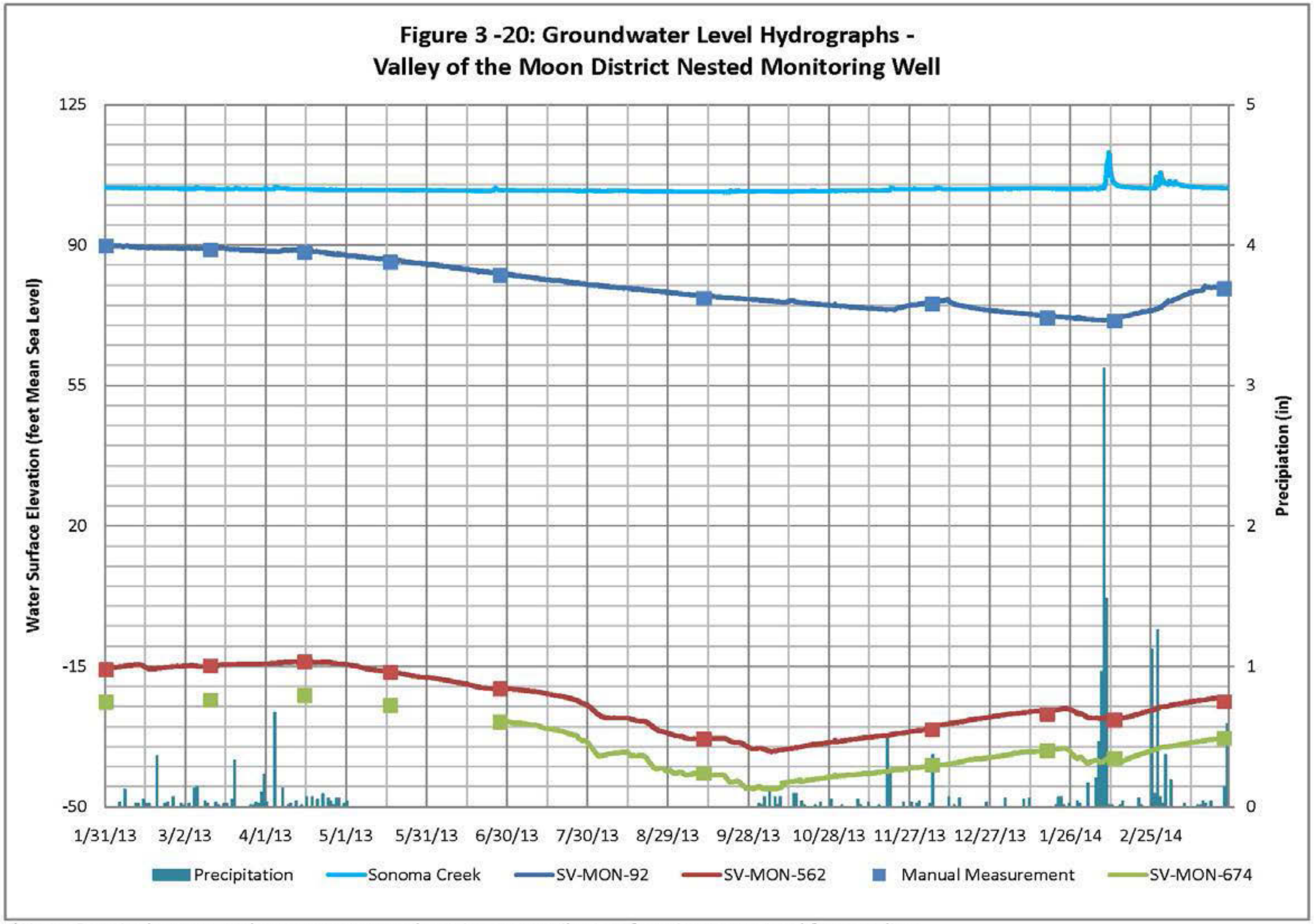
*Note: Gaps in data occur when pressure transducer is temporarily out of service or removed for sampling

Figure 3-18 Groundwater-Level Hydrographs – Nested Monitoring Well SVMW-1



*Note: Gaps in data occur when pressure transducer is temporarily out of service or removed for sampling

Figure 3-19 Groundwater-Level Hydrographs – Nested Monitoring Well SVMW-2



*Note: Gaps in data occur when pressure transducer is temporarily out of service or removed for sampling

Figure 3-20 Groundwater-Level Hydrographs – Valley of the Moon District Nested Monitoring Well

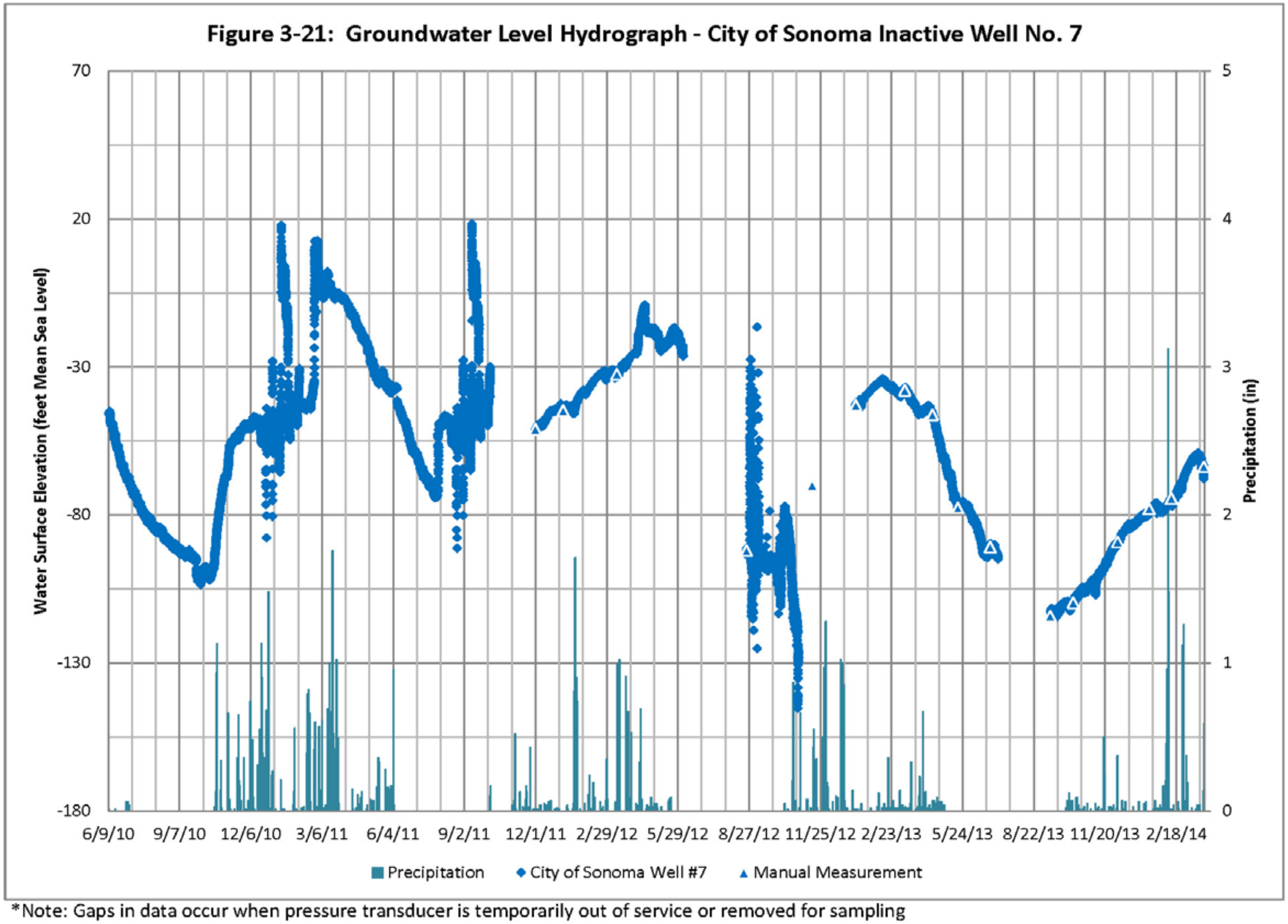


Figure 3-21 Groundwater Level Hydrograph City of Sonoma Inactive Well No. 7

- Groundwater levels in the shallow aquifer respond rapidly to precipitation events and changes in streamflow and are most evident in Agua Caliente 2 and West Thompson.
- Seasonal groundwater level fluctuations range from approximately 5 to 10 feet.
- Seasonal declines are more pronounced in Agua Caliente 2 in comparison with Agua Caliente 1.

Nested Monitoring Wells SVMW-1 and SVMW-2 (City Subarea)

Nested groundwater monitoring wells SVMW-1 and SVMW-2 were constructed in 2011 as part of the Local Groundwater Assistance Grant received from DWR. The wells are completed with multiple discrete screened zones:

- SVMW-1 with discrete well screens located at the following nominal depths: 85 to 95, 223 to 233, 355 to 365, and 440 to 455 ft bgs
- SVMW-2 with discrete well screens located at the following nominal depths: 32 to 52 (separate borehole), 80 to 100, 200 to 220, 374 to 409, and 460 to 480 feet bgs

Groundwater-level data collected from these wells is shown in Figures 3-18 and 3-19. Primary observations from the groundwater-level data collected from the nested groundwater monitoring wells indicate:

- At both locations, groundwater levels (hydraulic heads) are appreciably higher within the shallow aquifer than in the deeper aquifer zones. The degree of separation (between groundwater levels in the shallow and deeper aquifer zones) is greater at nested groundwater monitoring well SVMW-2, which is closer to the central portions of the groundwater pumping depression where groundwater levels in the deeper aquifer are lowest.

- Groundwater levels in the shallow aquifer respond rapidly to precipitation events and changes in streamflow.

- Sonoma Creek is predominantly a gaining stream near Watmaugh Road where groundwater from the shallow aquifer locally discharges to Sonoma Creek, except during precipitation events when the stream level rises above groundwater and recharges groundwater short-term. During late August/September 2013, when groundwater levels in the shallow aquifer at SVMW-2 declined to levels corresponding to the surface water in the nearby Sonoma Creek the stage level within Sonoma Creek also began to decline. This demonstrates the strong connection between groundwater levels within the shallow aquifer and stream baseflow.

- Groundwater levels within the deeper sand and gravel aquifer zones generally present between approximately 360 and 485 feet bgs exhibit fluctuations that appear to be related to localized groundwater pumping, with the possible exception of the aquifer zone between 460 and 480 feet bgs at SVMW-2. Fluctuations that appear to represent responses to pumping events are more prevalent at SVMW-1 in comparison with SVMW-2 and are most evident between 365 and 455 feet bgs.

- Groundwater levels within the thin relatively permeable zones of the thick clay aquitard (generally present between approximately 110 and 360 feet bgs) at both locations do not exhibit short-term fluctuations and exhibit a slower and moderate response to seasonal recharge. This indicates that the thin permeable zones within this thick sequence of clay are likely not laterally continuous and are not directly connected to shallow and deeper aquifer zones.

VOMWD Nested Well (El Verano/Fowler Creek Subarea)
VOMWD's nested monitoring well was instrumented in January 2013 and consists of three discrete screened zones at nominal depths of 92 feet bgs, 562 feet bgs, and 674 feet bgs. Primary observations from the groundwater-level data collected from the nested groundwater monitoring wells, shown in Figure 3-20 indicate:

- Groundwater levels are appreciably higher (approximate 100-foot difference) within the shallow aquifer than in the deeper aquifer zones. The strong degree of separation (between groundwater levels in the shallow and deeper aquifer zones) is likely due to the significant clay layers separating the shallow and deeper aquifers at this location and the location of the well which is within the El Verano/Fowler Creek groundwater pumping depression where groundwater levels in the deeper aquifer are below sea level.
- Groundwater levels and trends between the two deeper zone wells are very similar and likely monitor a single connected aquifer system.

- Groundwater levels within the shallow zone do not appear to respond appreciably to precipitation events.

- Fluctuations associated with nearby groundwater pumping appear to be limited to relatively minor fluctuations beginning in early August 2013.

City of Sonoma Inactive Well No. 7 (City Subarea)
City of Sonoma Well No. 7 is an inactive well constructed by the City, which has never been placed into production due to the low yield from the well and water quality issues. The well is constructed within the deeper aquifer zones, with several well screen intervals ranging from 473 to 666 feet bgs. The well was instrumented in June 2010. Primary observations from the groundwater-level data collected from the well, shown in Figure 3-21, indicate:

- Groundwater levels exhibit large seasonal fluctuations ranging from 20 feet above sea level to 140 feet below sea level.

- The well appears to be strongly influenced by local groundwater pumping which causes substantial short-term fluctuations in groundwater levels.

3.3.4 Groundwater Quality

Groundwater quality has been evaluated over the length of the groundwater management program through additional sample collection and analyses, and through compilation of water quality analyses conducted under public water supply collection under the Department of Public Health required drinking water sampling program. Specific analyses evaluated under the GMP included major ion concentrations, total dissolved solids, specific conductance, arsenic, boron, chloride, and the stable isotopes of oxygen-18 and deuterium. Further, a draft Salt and Nutrient Management Plan for the Sonoma Valley was prepared in 2013 that included additional analyses of total dissolved solids and nitrate, which were used as indicator parameters.

Major Ion Concentrations and Stable Isotopes

Major ion concentrations and stable isotopes were used to help classify and characterize the groundwater in the Sonoma Valley. Major ion concentrations are assessed by looking at relative proportions of common ions and anions, and are used to group and classify by a water type. Water samples that plot within the same group may be indicative of waters that are of similar hydrogeologic origin, or have undergone similar hydrogeochemical processes of transformations. These data may help indicate groundwater flowpaths and interconnection with surface water. In general, results of the major ion concentrations analyses suggests groundwater in the Sonoma Valley is a more mixed-cation bicarbonate moving south to a sodium-bicarbonate type until reaching Highway 121 where chloride becomes a dominant anion associated with brackish water of the Baylands tidal lands at the south end of the valley.

Stable environmental isotopes are measured as the ratio of the two most abundant isotope types of a given element, and in hydrologic studies, oxygen and hydrogen are used commonly. For oxygen it is the ratio of Oxygen-18 (^{18}O) to Oxygen-16 (^{16}O), and for hydrogen, it is the ratio of deuterium (^{2}H or D) to hydrogen (^{1}H), and these data provide information on the potential source, evaporative history, and movement of water in the Sonoma Valley groundwater basin. Results from the oxygen-18 and deuterium analyses suggest that groundwater recharge in the Sonoma Valley is primarily from infiltration of precipitation or the infiltration of seepage from water courses. Groundwater in shallow- and intermediate-depth wells near Sonoma Creek or in the south portion of the valley (Schellville vicinity) suggest the water is at least partly evaporated indicating connection with a surface water source. Groundwater from wells deeper than 200 feet is isotopically lighter, which may indicate older groundwater with a colder, wetter climatic source or water originating from a higher elevation in the watershed. In the El Verano area, results suggest that the main source of overland flow and groundwater recharge is local precipitation, and that there was no evidence to indicate neither a significant component of water from a higher elevation, nor significant component of evaporation before recharge.

Arsenic

Arsenic is a relatively common element that occurs naturally in the environment. Arsenic is considered a carcinogen, and the maximum contaminant level (MCL) for arsenic has been set at 10 micrograms per liter (ug/L). Water sample analyses for arsenic were available from 78 separate public supply collection points in the Sonoma Valley between 1987 and 2009. Eight samples were non-detect, and eight samples exceeded the MCL for arsenic (10 ug/L). The remaining 62 samples ranged between 1.8 and 9.4 ug/L arsenic, all less than the MCL of 10 ug/L. The elevated arsenic concentrations are most likely a result of shallow groundwater mixing with deep thermal waters, which have elevated temperatures and high pH values.

Boron

Boron is a naturally occurring element in rocks and soils, and also may be found in wastewater, fertilizers and pesticides. Boron is a necessary nutrient for human health, but also has been found to be a contaminant to the environment and may cause human health impacts, although it is not considered a carcinogen and not many comprehensive health studies have been completed. California Department of Public Health regulates boron as a drinking water contaminant, and has set a State Notification Level of 1,000 ug/L for public drinking water supplies. Water sample analyses for boron were available from 44 separate public supply collection points in the Sonoma Valley between 1992 and 2008. Seven samples were non-detect, and three samples exceeded the notification level (1,000 ug/L), including one inactive well. Of the remaining 62 analyses, 28 were 100 ug/L or less, five were between 100 and 250 ug/L and one was between 250 and 1,000 ug/L. The distribution of boron may be associated with volcanic rocks, fault zones and geothermal activity in the basin, which commonly lead to higher levels of dissolved minerals in groundwater.

Chloride

Chlorides are widely distributed in nature as salts of sodium (NaCl), potassium (KCl), and calcium (CaCl2). Chlorides are leached from various rocks into soil and water by weathering. Chloride concentrations in excess of about 250 milligrams per liter (mg/L) can give rise to detectable taste in water, but the threshold depends upon the associated cations. No health-based guideline value is proposed for chloride in drinking water. EPA has established National Secondary Drinking Water Regulations that set nonmandatory water quality standards for 15 contaminants that are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color and odor. These contaminants are not considered to present a risk to human health at the SMCL. Chloride has a secondary maximum contaminant level of 250 mg/L. Water sample analyses for chloride were available from 56 separate public supply collection points in the Sonoma Valley between 1987 and 2009. Sample collection points included raw water from active and inactive supply wells, lake intakes, springs and horizontal wells associated with springs. Chloride was measured at 10 mg/L or less in 34 samples, greater than 10 to 100 mg/L in 18 samples, and two samples exceeded 100 mg/L; none were at or exceeded 250 mg/L. In general, chloride values are low, and higher values mostly occur within the alluvial valley areas. There are not many analyses available south of highway 121, which is the area most susceptible to potential subsurface seawater intrusion.

Nitrate

Generally low nitrate concentrations are observed throughout most of the Sonoma Valley. The average nitrate concentrations in the Sonoma Valley 0.06 mg/L and there is no indication of an increasing trend.

Total Dissolved Solids and Specific Conductance

Total dissolved solids refers to the amount of minerals, salts, metals, cations and anions dissolved in water. Specific conductance is the measurement of the ability of the water to conduct electricity, in microseimens per centimeter (us/cm), and it is dependent upon the amount of dissolved solids in the water. Pure water such as distilled water will have a very low specific conductance and sea water has a high specific conductance. The relationship between total dissolved solids in mg/L usually ranges from approximately 0.5 to 1.0 times the specific conductance in us/cm, dependent upon nature of the dissolved solids and the temperature. The factor for sodium chloride is generally near 0.5 times the specific conductance to total dissolved solids.

Total Dissolved Solids

Water sample analyses for total dissolved solids were available from 57 separate public supply collection points in the Sonoma Valley between 1987 and 2009. Generally, relatively low total dissolved solids concentrations (less than 500 mg/L) are observed throughout most of the Sonoma Valley. Total dissolved solids were measured at less than 250 mg/L in 35 samples, from 250 to 500 mg/L in 19 samples, two samples exceeded 500 mg/L, and one sample exceeded 750 mg/L. The higher levels of total dissolved solids (greater than 500 mg/L) are all in the southern most portion of the valley in an area of historic brackish groundwater, as shown in Figure 3-22, and the moderately higher concentrations (250 to 500 mg/L) are nearly all in the basin plain near the Sonoma Creek. Due to the elevated salt in this subarea and land cover that is mostly tidal marshland, groundwater pumping is limited and for the purposes of the Salt and Nutrient Plan, the Baylands subarea of historical brackish groundwater was separated from the rest of the Sonoma Valley. The Baylands subarea has an average total dissolved solids concentration of 1,220 mg/L and the inlands area exclusive of the Baylands subarea has an average total dissolved solids concentration of 372 mg/L.

Specific Conductance

Specific conductance data were collected by USGS in the 2006 study and results were interpreted to suggest that salinity is increasing in a northerly and easterly direction, and this trend may be a result of pumping and lowering of hydraulic heads to the north of highway 121. Additional data have been collected and both the

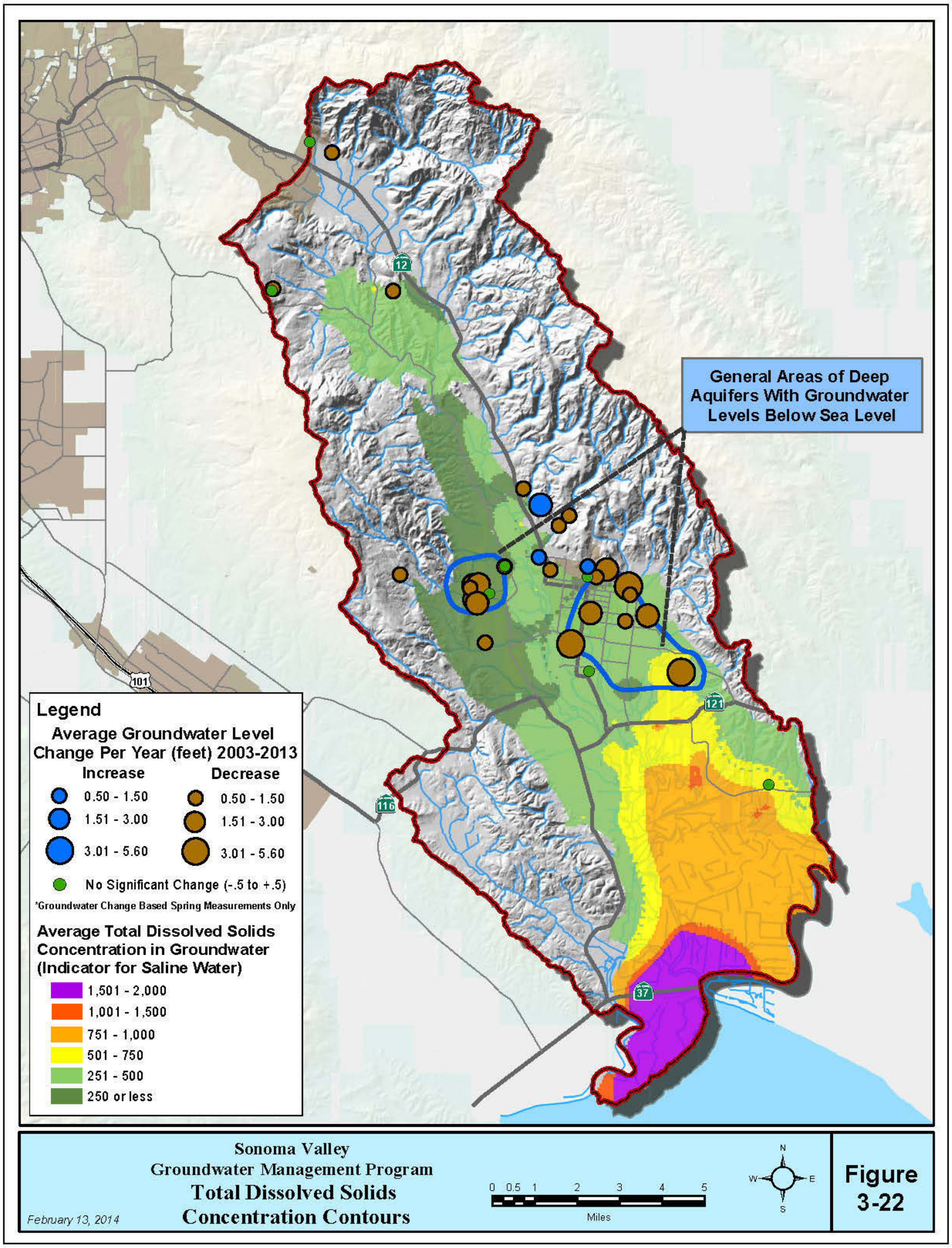


Figure 3-22 Total Dissolved Solids Concentration Contours

USGS 2006 study and post 2006 study data are plotted in Figure 3-22. The results indicate that salinity values along the axis of the valley adjacent to Sonoma Creek are generally low and consistent.

In the southern end of the valley, pervasive levels of salinity are evidenced by the higher conductivity readings, largely 500-1000 us/cm, on the west side with higher concentrations between 1,000 to 2000 us/cm occurring in the southeastern portions of the valley. Time series plots of specific conductance in general suggest variable specific conductance over time, as shown in Figure 3-23. More recent data displays a slight downward trend, which may be related to the 2010 higher than average precipitation, accompanied by possible reduced irrigation and potential recharge in the basin that year.

3.4 Water Demands and Supplies in Sonoma Valley

Water demands in Sonoma Valley are met by four primary sources of supply comprised of local groundwater, imported surface water, local surface water and recycled water. The total estimated water demands from these four sources of supply for Sonoma Valley in Water Year 2012 were approximately 17,900 AF, as shown in Figure 3-24a and summarized below:

- 10,500 AF - Local groundwater pumped from wells located within Sonoma Valley
- 4,700 AF - Imported water from the Russian River Watershed
- 1,500 AF - Local surface water diverted from Sonoma Creek and its' tributaries
- 1,200 AF - Recycled water produced at the Sonoma Valley Wastewater Treatment Plant

The general types of water demands by use type that water supply sources meet in Sonoma Valley are shown below in Figure 3-24b and consist of: agricultural irrigation (an estimated 7,800 AF); rural domestic users, including rural private and mutual water systems (an estimated 3,500 AF); municipal and commercial users including residences and businesses served by the City of Sonoma and Valley of the Moon Water District and private water systems (an estimated 5,900 AF); and irrigated golf courses and parks (an estimated 700 AF).

The following sections provide additional details regarding the characteristics of each of the four primary sources of water supply for Sonoma Valley.

3.4.1 Local Groundwater

As summarized above, local groundwater produced from wells located in Sonoma Valley represents the largest source of supply utilized in Sonoma Valley (approximately 60% of all water demands are met by local groundwater) and provides water for a variety of uses. Figure 3-25 provides the trends in water well construction over the past ten years in Sonoma Valley to provide an indicator of trends in groundwater use over time. As shown in Figure 3-25, the number of

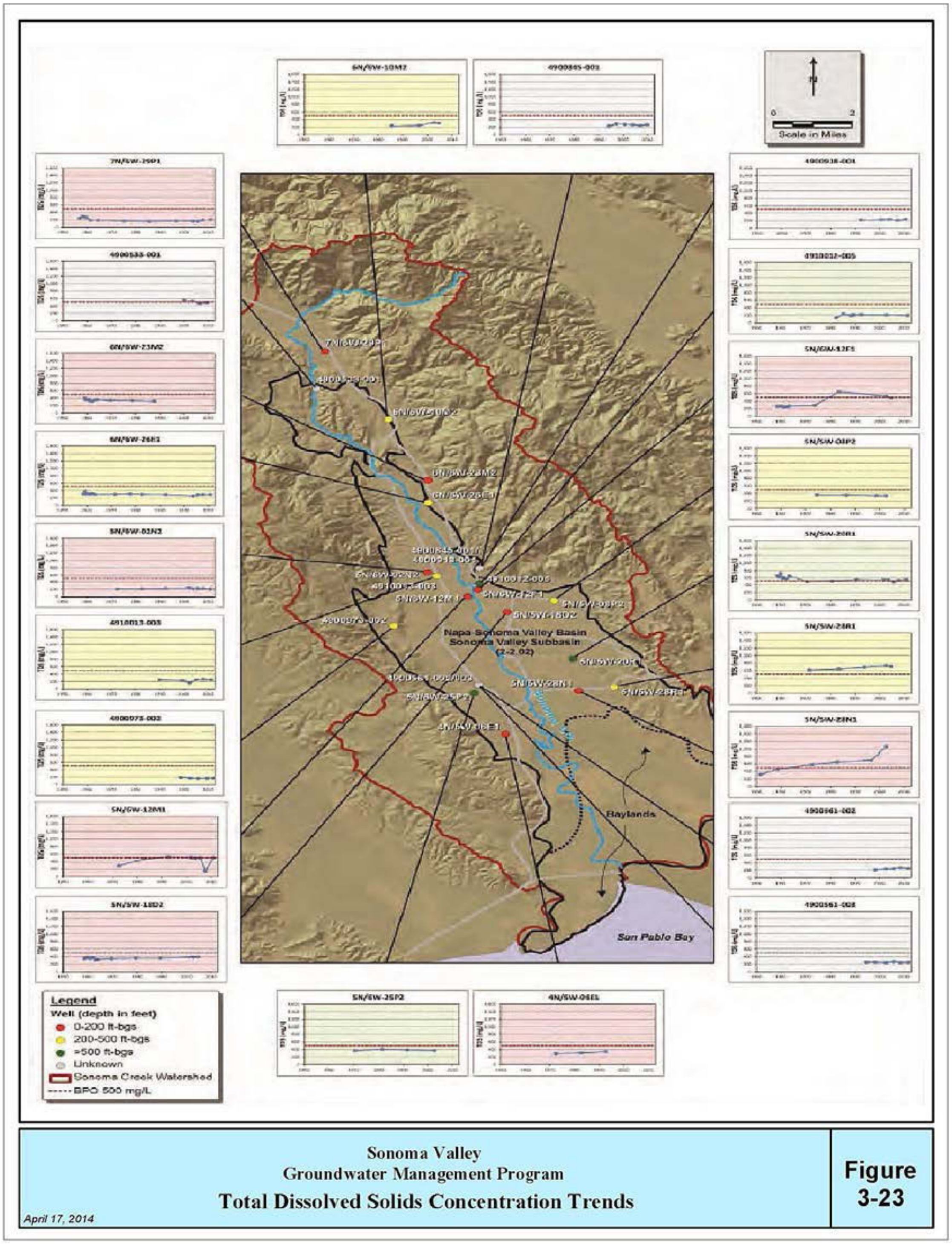
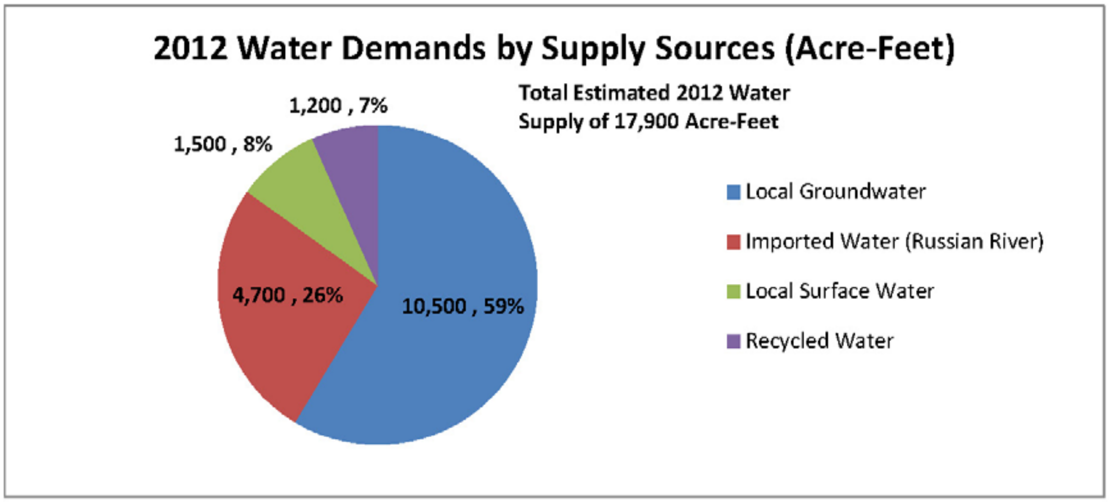


Figure 3-23 Total Dissolved Solids Concentration Trends

Figure 3-24: 2012 Water Supply Sources and Demands



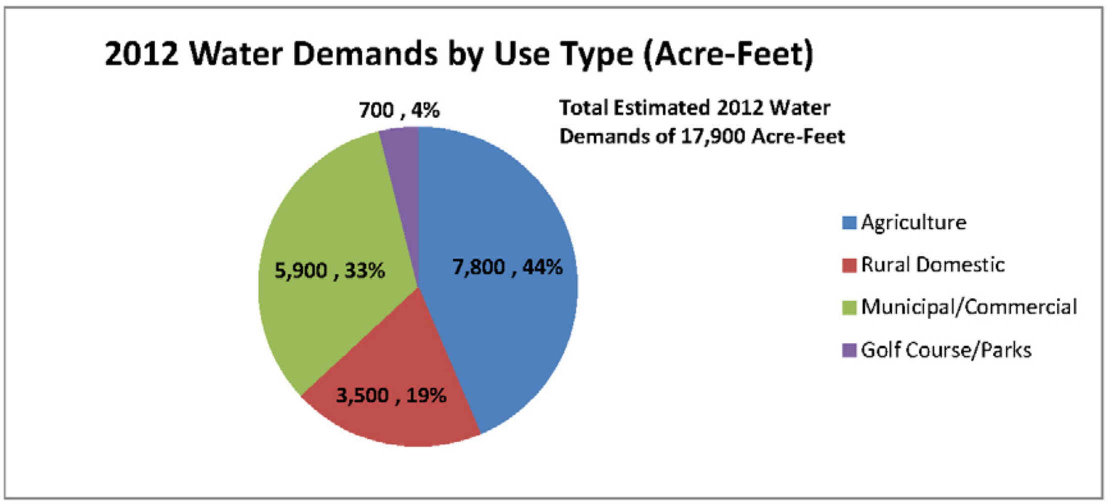


Figure 3-24 2012 Water Supply Sources and Demands

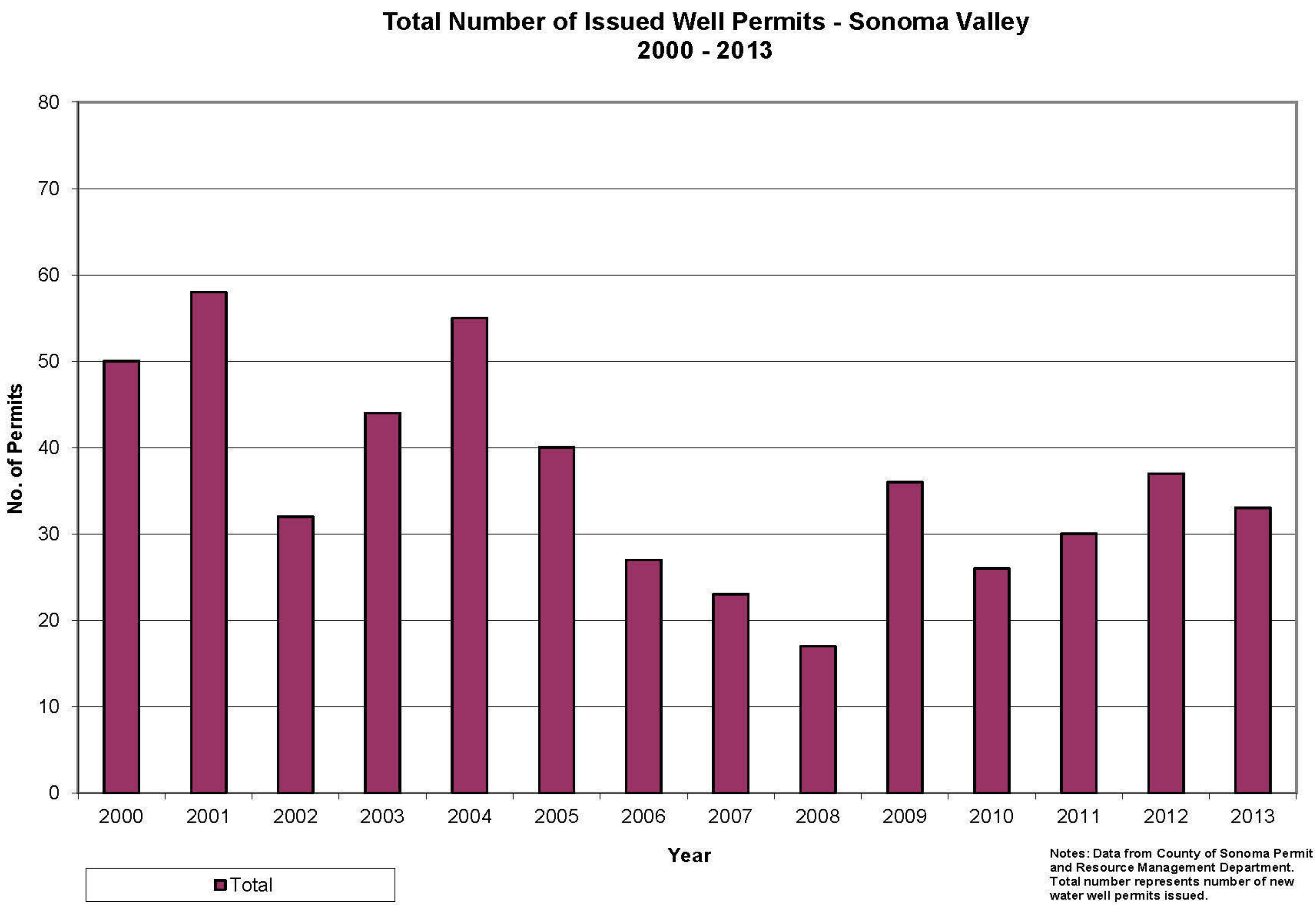


Figure 3-25 Total Number of Issued Well Permits – Sonoma Valley 2000 - 2013

permits issued by PRMD for water supply wells in Sonoma Valley from 2000 to 2009[1] has ranged from 12 in 2008 to 62 in 2004. An overall decreasing trend from 2005 to 2008 is evident, followed by an increase in the relatively dry year of 2009. Private domestic wells represent an average of 75% of the water wells constructed in Sonoma Valley over this time period, followed by agricultural irrigation wells (15%), public supply wells (6%) and industrial wells (4%).

Groundwater demands were estimated for Water Year 2012 in Sonoma Valley utilizing production records for reported groundwater use (municipal and state-regulated mutual, private, and small water systems) and by using land use maps and population estimates for unreported groundwater use (agriculture, rural domestic and golf courses and parks). The methodology for developing these groundwater demand estimates is provided in Appendix B. For the purposes of estimating local groundwater demands, user types were divided into the following six categories:

- **Agriculture** – Irrigation water for vineyards, orchards, and other perennial or non-perennial crops. Groundwater demands are based on estimating crop acreage and crop water demands. Local surface water diversions reported to the California State Water Resources Control Board and local recycled water used for agricultural irrigation were subtracted from the estimated groundwater demands. Groundwater is used to meet an estimated 70% of irrigation water needs for agriculture in Sonoma Valley, with the remaining demands met with local recycled water and surface water.

- **Golf Courses and Parks** – Golf courses, parks, and sports fields that irrigate using private wells. Groundwater demands are based on estimating turf acreage and turf water demands. Local surface water diversions reported to the California State Water Resources Control Board used for turf irrigation were subtracted from the estimated groundwater demands. Groundwater meets nearly 99% of the irrigation water needs for these uses.

- **Rural Domestic** – Privately owned domestic wells located outside of municipal or mutual water company service areas serve an estimated 6,600 people in Sonoma Valley (approximately 15% of the total population). Groundwater demands were estimated by applying water use factor of 0.28 AF per year per person to 2010 Census population data that was extrapolated to 2012. Groundwater meets 100% of the irrigation water needs for these uses.

- **Municipal** – Municipal pumping in Sonoma Valley consists of groundwater use from the City and VOMWD. Groundwater pumping records maintained and reported by the City and VOMWD were used to accurately calculate total municipal pumping. Groundwater is used to meet approximately 10% of municipal demands for these two purveyors, which collectively serve

[1] Note to Reviewer: This will be updated to 2000 to 2012 for the Final Report.

approximately 32,000 people (approximately 72% of the total population in Sonoma Valley). Municipal demands are primarily met with imported water.

- **Mutual/Private Water Systems –** Mutual and private water companies consist of small community systems, including large subdivisions in unincorporated areas and mobile home parks, which collectively serve an estimated 2,300 people (approximately 5% of the total population in Sonoma Valley). Groundwater pumping records maintained and reported by these systems to the California Department of Public Health (CDPH) were used to accurately calculate total pumping from these sources. Groundwater meets nearly 100% of the water needs for these uses.

- **Small Systems –**Small commercial systems such as wineries, warehouses, and regional parks. Groundwater pumping records maintained and reported by these systems to the California Department of Public Health (CDPH) were used to accurately calculate total pumping from these sources. Groundwater meets 100% of the water needs for these uses.

The estimated groundwater demands are apportioned into the eleven subareas within Sonoma Valley, as shown in Table 3-1 and Figures 3-26 and 3-27. In 2012, the agricultural irrigation demand comprised the largest use of groundwater in Sonoma Valley (53% of the total demand), with vineyards making up approximately 97% of the crops. The rural domestic category constitutes the second largest groundwater demand in Sonoma Valley at 27% and is spread out over multiple subareas. The Municipal, Small Systems, and Mutual/Private Systems contributed demands that are very similar (4% to 5%), but are present in less than half the subareas. The Irrigated Turf contributes to 7% of the demand and is concentrated in the El Verano/Fowler Creek subarea, predominantly for golf course irrigation.

The following sections describe the 2012 groundwater demands for each subarea in Sonoma Valley, which are discussed in order of highest to lowest intensity of groundwater use (AF of groundwater per acre of land).

El Verano/Fowler Creek Subarea

This subarea has a very high population with most of the domestic demand (93%) met by imported water served by VOMWD. Agricultural, golf course/parks, and rural domestic demands represent approximately 52%, 24%, and 18% of the total 2,374 AF of groundwater demand from the El Verano/Fowler Creek subarea, respectively. Groundwater demands from the El Verano/Fowler Creek subarea represent approximately 23% of the total Sonoma Valley demand and exhibit a high overall intensity (an estimated 0.39 AF per acre).

Rodgers Creek Subarea

The subarea contains the second highest agricultural demand at 915 AF, which is about 80% of the total subarea demand. Most of domestic supply (about 61%) is

2012 Sonoma Valley Groundwater Basin Groundwater Demand Estimates (AF)

Subarea	Agriculture	Rural	Public Supply			Irrigated Turf*	Totals	
			Municipal	Small Systems	Mutual/Private		AF	AF/ (100 Acres)
Calabazas (1,347 ac)	131	70					202	15
Wetland (17,139 ac)	214						214	1
Glen Ellen (2,778 ac)	138	120			11		269	10
Carneros (4,753 ac)	224	150		9			383	8
Agua Caliente (2,809 ac)	263	222				16	500	18
Western Upland (27,720 ac)	306	351			176		833	3
Rodgers Creek (3,618 ac)	915	155		39		41	1,150	32
Kenwood (5,140)	565	540		51	140		1,296	25
Eastern Upland (30,044 ac)	628	439	277	83	126	47	1,601	5
City (6,798 ac)	814	497	80	112	90	22	1,615	24
El Verano/Fowler Creek (6,098 ac)	1,227	427	145			575	2,374	39
Total Sonoma Valley (108,244 ac)	5,426	2,971	502	294	544	701	10,437	10

*Irrigated golf course, parks, and sports fields

Table 3-1 2012 Groundwater Basin Demand Estimates

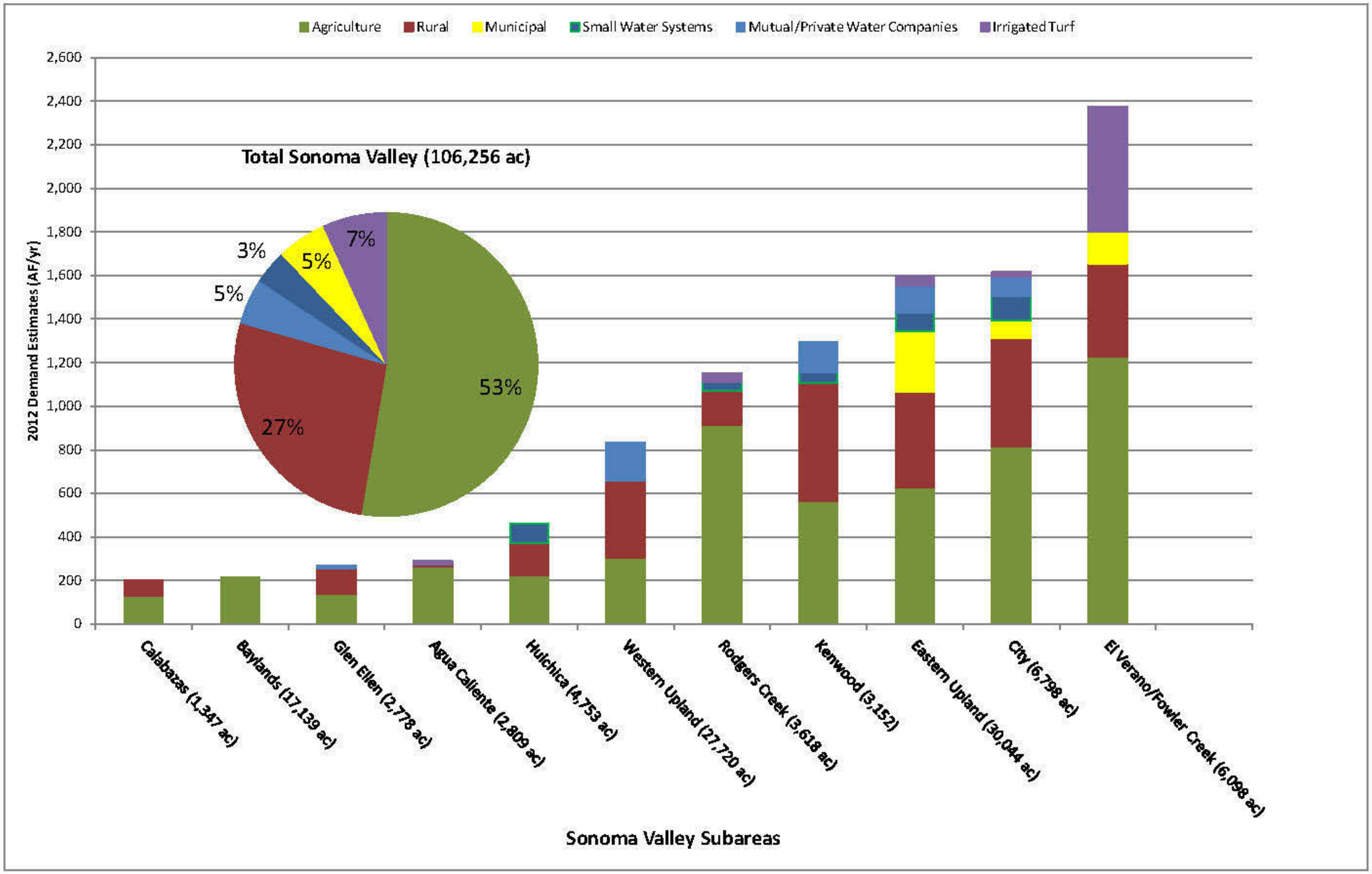


Figure 3-26 2012 Sonoma Valley Groundwater Demand Estimates (AF)

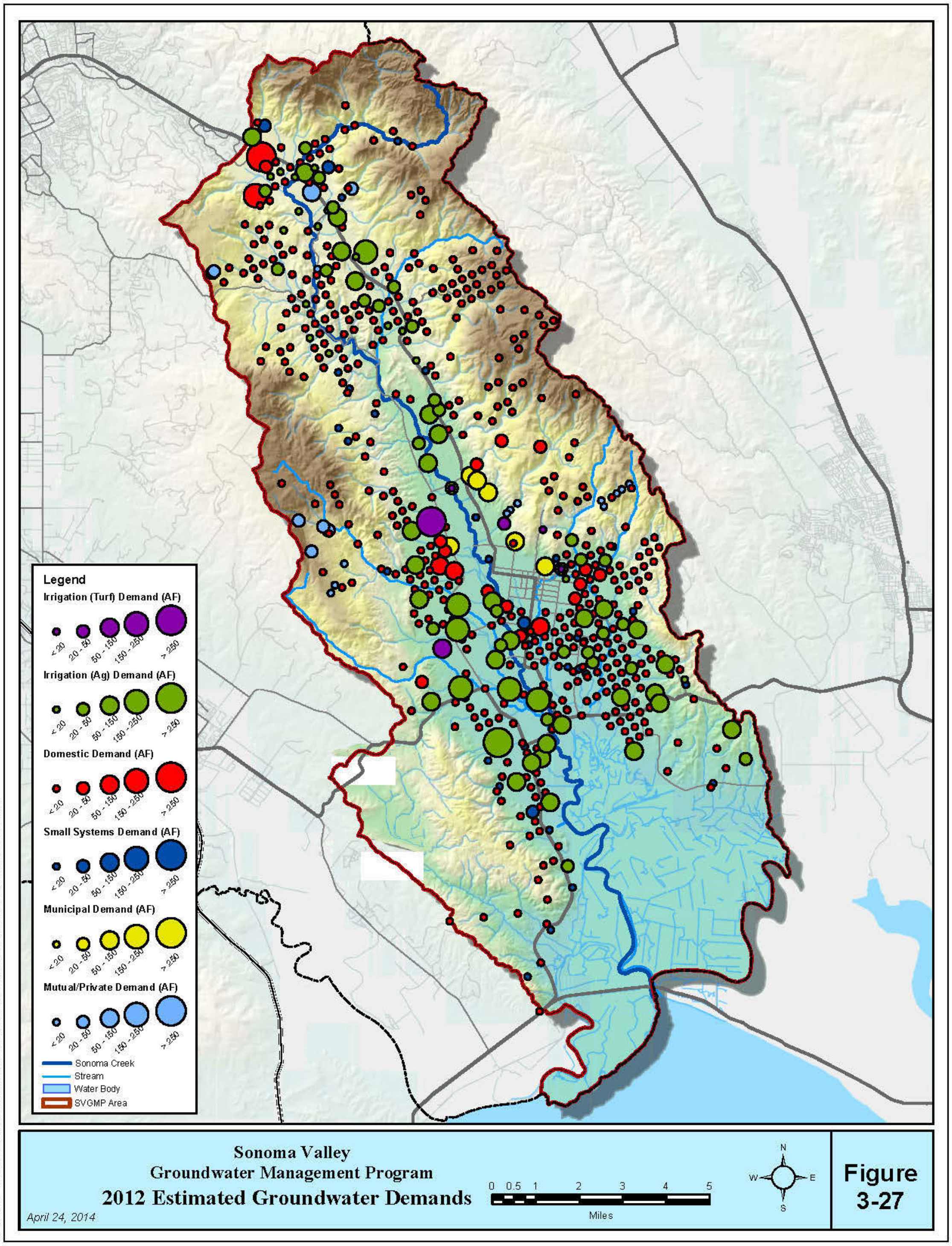


Figure 3-27 2012 Estimated Groundwater Demands

served by VOMWD and sourced from outside the subarea. The majority of the estimated 1,150 AF of groundwater demand for the Rodgers Creek subarea is from agricultural pumping (80%). Groundwater demands from the Rodgers Creek subarea represent approximately 11% of the total Sonoma Valley demand and are relatively intensive (an estimated 0.32 AF per acre).

Kenwood Subarea

The subarea has a relatively high population, much of which is served by the Kenwood Village Water Company (about 31% of domestic population in the subarea). Agricultural and rural domestic demands represent approximately 44% and 42% of the total 1,296 AF of groundwater demand for the Kenwood subarea, respectively. Groundwater demands from the Kenwood subarea represent approximately 13% of the total Sonoma Valley demand and are relatively intensive (an estimated 0.41 AF per acre).

City Subarea

This subarea has the highest population in Sonoma Valley with most of the domestic demand being met by imported water served by the City of Sonoma (56% of domestic demands) and VOMWD (32% of domestic demands). Domestic demands are also met by groundwater pumping from the De Anza Moon Valley Water Company. The subarea also contains a relatively large number of small water systems that serve commercial businesses (primarily along the Eighth Street East corridor). Agricultural, rural domestic and commercial businesses represent approximately 50%, 31% and 7% of the total 1,615 AF of groundwater demand from the City subarea, respectively. Groundwater demands from the City subarea represent approximately 16% of the total Sonoma Valley demand and exhibit a relatively high overall intensity (an estimated 0.24 AF per acre).

Agua Caliente Subarea

This subarea is well populated and has a relatively low amount of agriculture. The majority of the domestic demand is served by VOMWD (about 84%), with another 15% being served by the Sonoma Developmental Center, resulting in a relatively low groundwater demand of 289 AF (3% of the total Sonoma Valley demand) and a relatively low intensity of groundwater use (an estimated 0.06 AF per acre).

Calabazas Subarea

The small area results in relatively limited agricultural demands and domestic demands are mostly met by the VOMWD. The subarea has the lowest groundwater demands in Sonoma Valley (202 AF or 2% of total Sonoma Valley demand) and a moderate intensity of groundwater use (an estimated 0.15 AF per acre of land).

Glen Ellen Subarea

This subarea contains the least amount of agricultural acreage in Sonoma Valley, which results in a very small agricultural demand. The mutual water system Sonoma Springs Water Company pumps and serves a small portion in the northern portions of the subarea, while the Valley of the Moon Water District serves southern portions of the subarea. Additionally, water demands from the Sonoma Developmental Center are met through local surface water supplies. Overall, the estimated groundwater demand in the Glen Ellen subarea is relatively small, 269 AF (3% of the total Sonoma Valley demand) and has a relatively low intensity of groundwater use (an estimated 0.10 AF per acre).

Huichica Subarea

Most of this subarea is covered with agricultural fields (approximately 3,000 acres of vineyards), with about 66% of these being supplied by recycled water. It also has the second smallest population in Sonoma Valley, which contributes to a relatively low groundwater demand of 461 AF (4% of the total Sonoma Valley demand) and a relatively low intensity of groundwater use (an estimated 0.16 AF per acre).

Western Upland Subarea

Domestic demands are focused in a few rural communities where about half the domestic demand is met by mutual water systems and municipalities. The three mutual water systems: Bennett Ridge Mutual Water Company, Diamond A Mutual Water Company, and George Ranch Mutual Water Company, pump groundwater from within the subarea and represent an approximate 21% of the groundwater demand. The large area leads to a large overall amount of agriculture (primarily vineyards), with about half the agricultural demands met with local surface water. Rural domestic, agriculture and mutual water system demands represent approximately 42%, 37%, and 21% of the total 833 AF of groundwater demand from the Western Upland subarea, respectively. Groundwater demands from the Western Upland subarea represent approximately 8% of the total Sonoma Valley demand and exhibit a relatively low overall intensity (an estimated 0.03 AF per acre).

Eastern Upland Subarea

Similar to the Western Upland, this subarea encompasses several small rural communities which are served by a combination of individual domestic wells and several mutual water systems: Kinnybrook Mutual Water Company in the north, Mission Highlands Mutual Water Company in the south, and Sonoma Ranch Mutual Water Company also in the south. Water is also provided to residences from the VOMWD and City of Sonoma in this subarea. Agricultural, rural domestic, and municipal demands represent approximately 39%, 27%, and 17% of the total 1,601 AF of groundwater demand from the Eastern Upland subarea, respectively. Groundwater demands from the Eastern Upland subarea represent approximately 16% of the total Sonoma Valley demand and exhibit a relatively low overall intensity (an estimated 0.05 AF per acre).

Baylands Subarea

The limited agricultural demands in this subarea are met with a combination of recycled water and groundwater, with an estimated groundwater demand of 214 AF (2% of total Sonoma Valley demand) and a very low intensity of groundwater use (an estimated 0.01 AF per acre).

3.4.2 Imported Water

Imported water represents the primary source of potable water supply for urban areas within Sonoma Valley that are served by the City of Sonoma and VOMWD; these two systems collectively serve approximately 73% of the population in Sonoma Valley and delivered approximately 4,575 AF of imported water in Water Year 2012. This includes potable water for landscape irrigation (the largest household use), toilet flushing (second largest household use) showering, washing, for drinking and other uses. A relatively small amount of imported water is also delivered to the Kenwood Village Water Company and the Lawndale Mutual Water Company (approximately 5 AFY and 80 AFY, respectively). Imported water consists of Russian River surface water sourced from the Water Agency's production facilities near Forestville that is delivered via aqueduct to the City of Sonoma and VOMWD.

The 4,660 AF of imported water was used to meet approximately 26% of the total water demand in Sonoma Valley in Water Year 2012. Figure 3-28 provides the annual amounts of imported water delivered within Sonoma Valley over the last ten years. As shown in Figure 3-28, demands for imported water in Sonoma Valley have declined over the past decade from an average of 5,000 to 5,500 AFY between 2002 and 2007 to an average of 4,000 to 4,700 AFY from 2008 to the present.

3.4.3 Local Surface Water Diversions

Estimates of local surface water demands were obtained from reported surface water diversions filed with the California State Water Resources Control Board for Water Year 2012. An estimated 1,500 AF of surface water was diverted from Sonoma Creek and its tributaries in Water Year 2012, representing approximately 8% of the total water use in Sonoma Valley. Figure 3-29, shows the approximate locations and relative amounts for these reported diversions. The majority of reported surface water diversions are for agricultural irrigation (80%). The remaining 20% is for the Sonoma Developmental Center, which reported a diversion of 312 AF in 2012.

3.4.4 Recycled Water

Recycled water is produced at the Sonoma Valley Wastewater Treatment Plant and is used to irrigate vineyards, dairies, and pasturelands in southern Sonoma Valley in lieu of using groundwater. Approximately 1,200 AF of recycled water was delivered and applied as irrigation water in Water Year 2012, fulfilling approximately 7% of the total water demand in Sonoma Valley. Recycled water use primarily occurs in the Huichica and Baylands subareas, as shown in Figure 3-30.

3.4.5 Groundwater Budget

The regional groundwater flow model of Sonoma Valley, CA, developed by the United States Geological Survey (Farrar et al., 2006), was modified, updated, and improved in several ways, including the development of a soil moisture budget model encompassing the entire Sonoma Creek watershed for estimating recharge

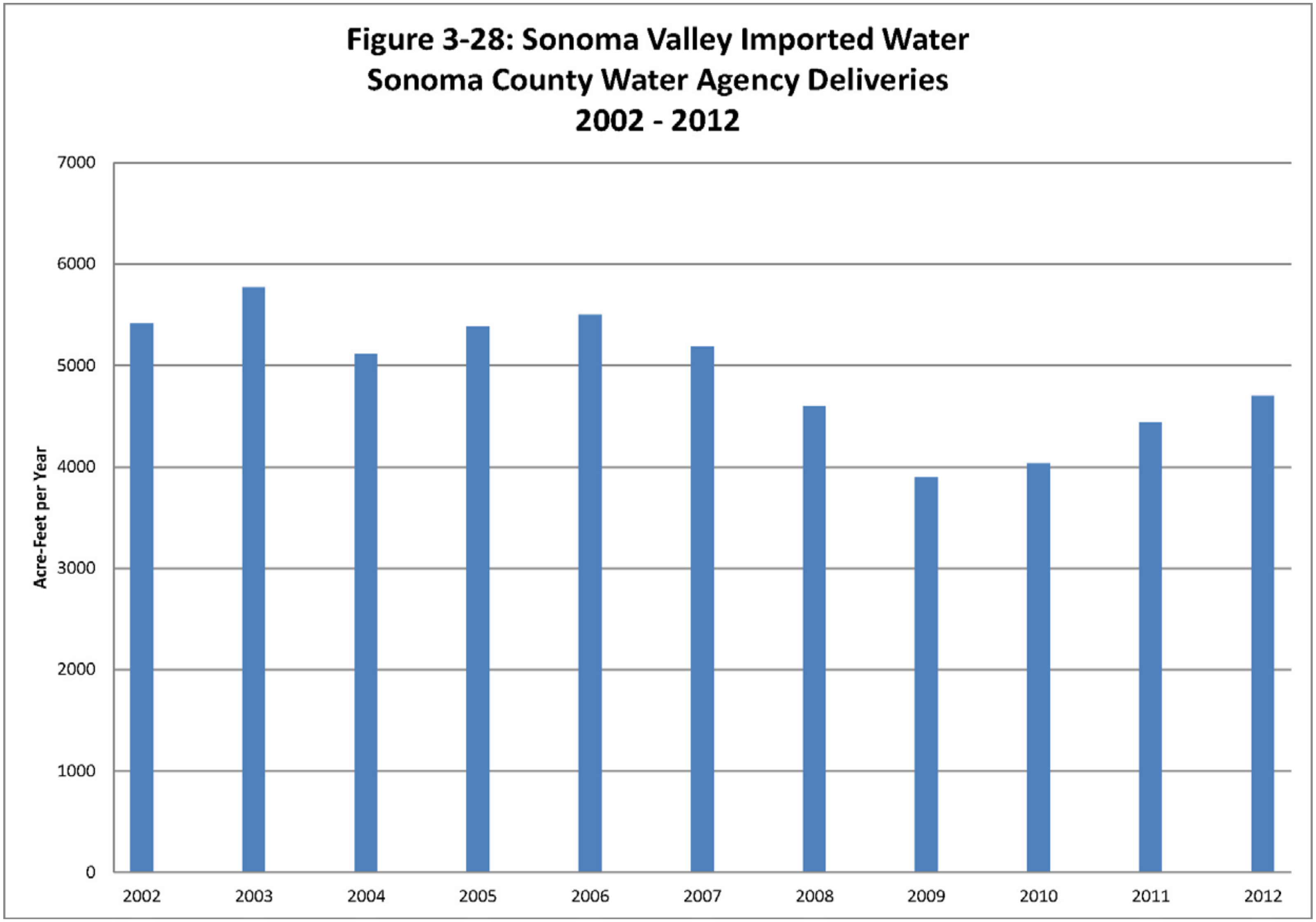


Figure 3-28 Imported Water Deliveries

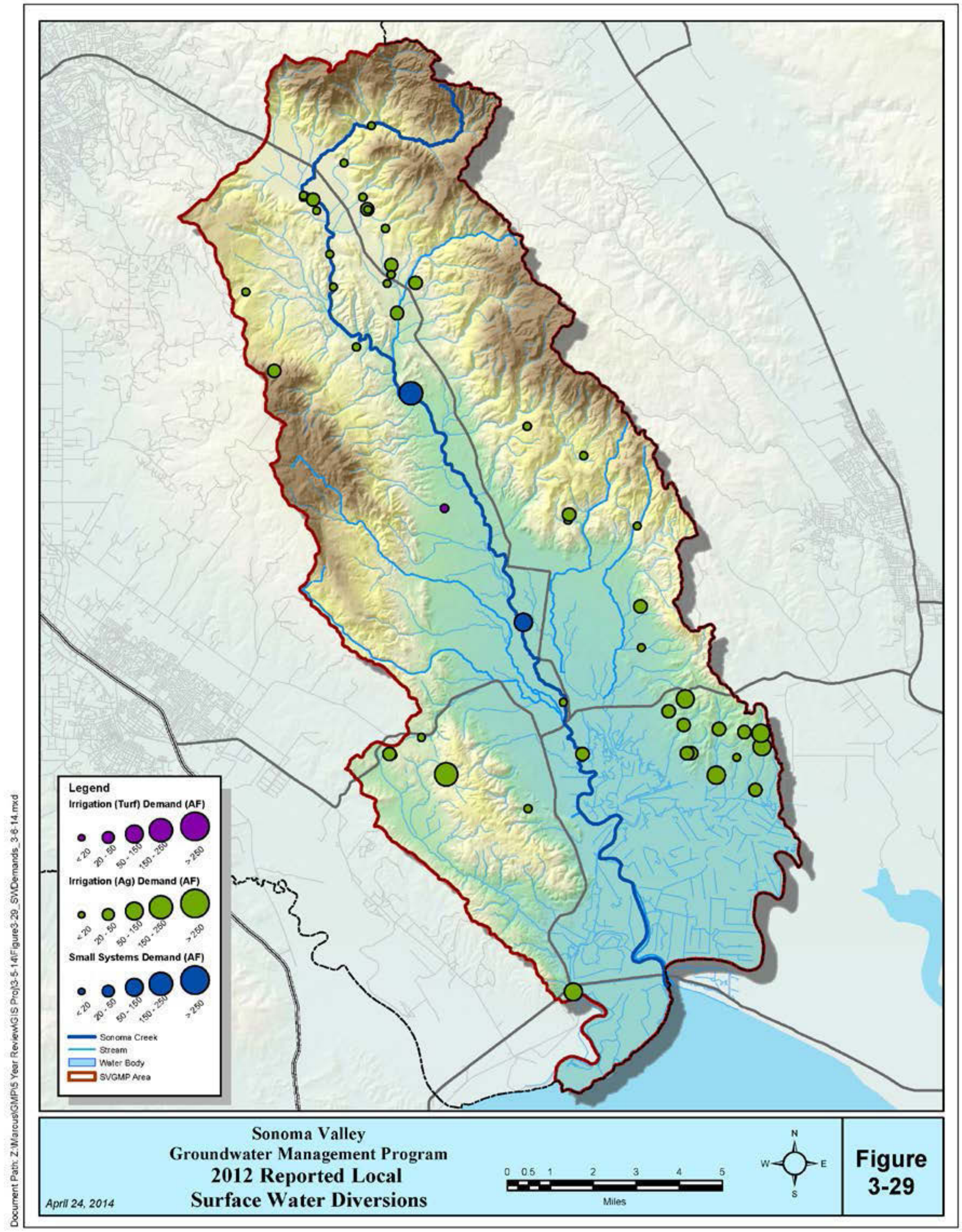


Figure 3-29 2012 Reported Local Surface Water Diversions

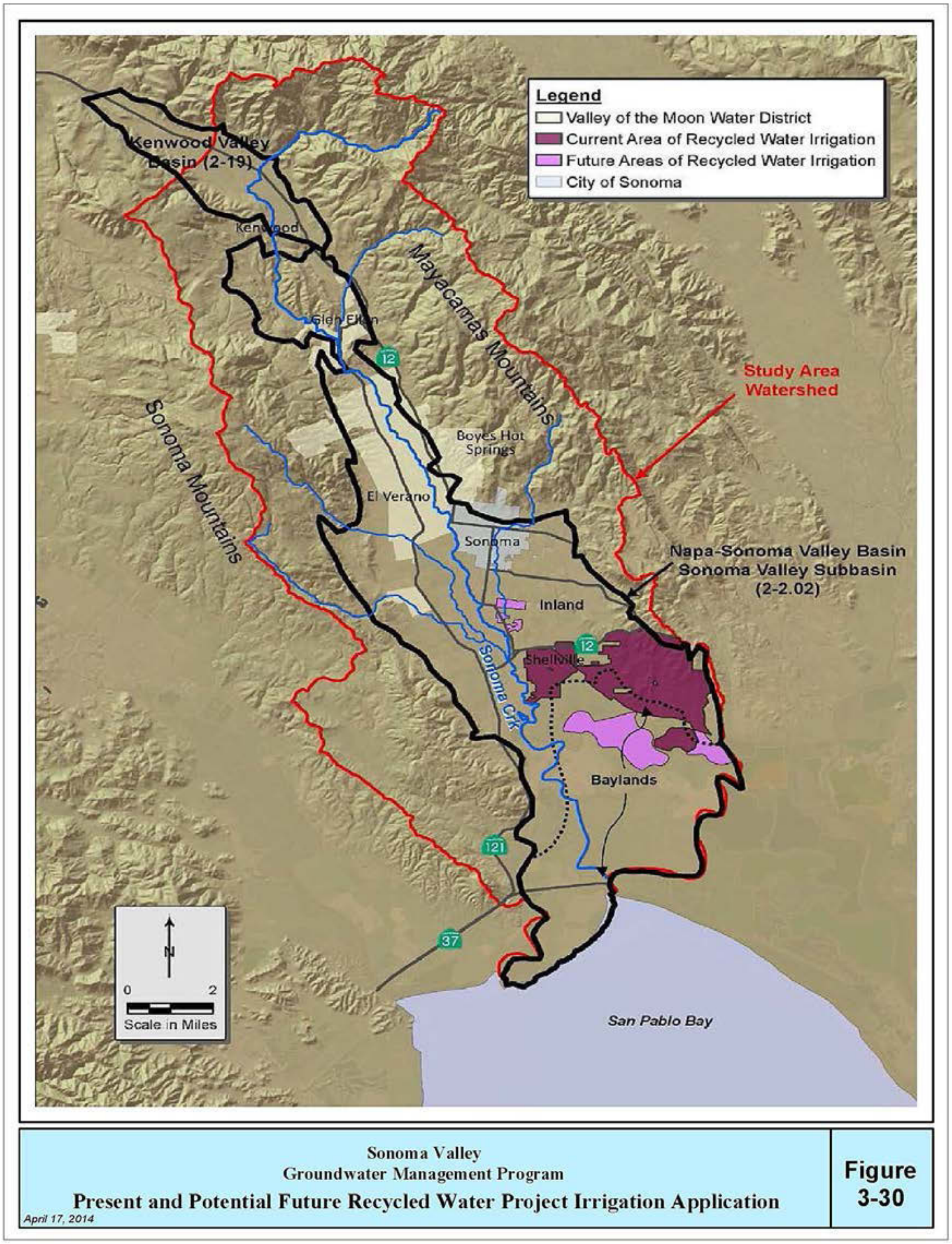


Figure 3-30 Present and Potential Future Recycled Water Project Irrigation Application

and an alternative conceptual model and numerical simulation of the hydrogeologic system in this area (Bauer, J.P., 2008). Several modifications were made to incorporate a more rigorous treatment of surface water-groundwater interactions in Sonoma Valley and to simplify the hydraulic conductivity layering and zonation scheme. The major alterations to the original groundwater flow model were: 1) the upper model layer, which originally represented the geohydrologic unit in the top 125 ft of aquifer material, was replaced by a geohydrologic unit representing the quaternary alluvium and bay mud deposits, 2) remaining portions of the original upper geohydrologic unit not included in the new unit were added to the middle geohydrologic unit, 3) the hydraulic conductivity zonation scheme in the lower two geohydrologic units was simplified, 4) mountain-front recharge in the Sonoma Creek watershed outside the groundwater flow model domain and aerial recharge inside the groundwater flow model domain were separately accounted for and applied to the model, 5) baseflow generated by rejected recharge in the tributaries of Sonoma Creek was represented using simulated subsurface drains.

In the updated model ('SVM2'), the distribution and amount of recharge is based on a soil moisture budget, which factors in precipitation, available water capacity, soil moisture storage, and evapotranspiration. For the period 1974 through 2006, the model simulations estimate an average of 117,000 AFY of excess precipitation, which is the volume of precipitation available for runoff and recharge after soil moisture storage and evapotranspiration are accounted for. Based on hydrograph separation (described in Section 3.2.1), it was determined that approximately half of this water generated surface runoff and the other half went to aquifer recharge on an annual basis. The SVM2 water budget is provided below in Table 3-2.

Table 3-2 Mean Annual Cumulative Groundwater Budget - Water Year 1975-2006 (in acre-feet). From Bauer, J.P., 2008.

Groundwater Budget Elements	Average Annual Values	Cumulative Values
Estimated Inflow		
Recharge[1]	56,756	1,816,196
Streambed infiltration from Sonoma Creek	7,063	226,029
Seepage from San Pablo Bay	104	3,338
Estimated Total Inflow	*63,923*	*2,045,563*
Estimated Outflow		
Discharge[2] to other Streams[3]	34,876	1,116,032
Discharge to Bay-Mud	11,736	375,555
Discharge to Sonoma Creek	10,978	351,310
Well Pumpage	7,799	249,585
Discharge to San Pablo Bay	3	110
Estimated Total Outflow	*65,392*	*2,092,592*
Estimated Storage		
Estimated Change in Storage[4]	-1,400	-44,800

1 - Percolation of precipitation.
2 - Groundwater discharge into streambeds and subsurface soils.

3 - Does not include Sonoma Creek.
4 – Estimated values are rounded to nearest 100 AF.

The water budget calculated by the SVM2 model estimates an average annual loss of storage of 1,400 AFY, and total cumulative storage loss of 44,800 AF for the period 1975 to 2006. The groundwater storage declines estimated by the model are corroborated by groundwater level declines (Section 3.3.1), where two pumping depressions are identified that have existed for several decades and appear to be growing. The water budget for Sonoma Valley will be revised when the model is updated in 2014.

3.5 Summary of Findings

The following primary findings can be drawn from the data described above:

- Precipitation trends indicate that the past decade has been relatively dry, with seven of the last 10 years exhibiting below average annual rainfall.

- Hydrologic models of potential climate change scenarios predict that water supply could be subject to increased variability (and resultant reduced reliability) due to more variable precipitation and that water demands are likely to steadily increase because of increased evapotranspiration rates and climatic water deficit during the extended summers.

- Surface water-groundwater interaction is an important component of the groundwater system in Sonoma Valley, with data from the GMP monitoring program demonstrating the importance of groundwater discharge from the shallow aquifer in providing baseflow to Sonoma Creek and its tributaries.
  - Baseflow (the proportion of streamflow due to groundwater discharge to stream channels) represents an estimated 50% of the total flow in Sonoma Creek upstream of Agua Caliente bridge on an average year. The proportion of baseflow to total streamflow may have been relatively higher during historic dry water years in comparison with more recent dry years.
  - Much of Sonoma Creek and many of its tributaries gain water from groundwater discharge. Reaches of Sonoma Creek that are losing and contribute recharge to the groundwater system during the springtime include portions of the upper reach of Sonoma Creek near Kenwood, much of Carriger Creek and portions of Nathanson and Arroyo Seco Creeks (downstream of upland reaches and upstream of Napa Road).
  - Groundwater levels observed in the shallow aquifer adjacent to Sonoma Creek at Watmaugh Road during Fall 2013 declined below the streambed and locally converted the creek from a gaining reach to a losing reach, which later was observed to be dry in November 2013.

- Hydrostratigraphic information from evaluation of recent lithologic data obtained from the two nested wells constructed in 2011 and other available well logs indicate thick sequences of clay generally present between approximately

100 and 350 feet bgs locally form an effective aquitard which generally limits hydraulic communication between the shallow and deeper aquifer zones. This appears to limit hydraulic communication between shallow and deeper aquifer zones in many areas and results in appreciably higher groundwater levels within the shallow aquifer in comparison with the deeper aquifer zones.

- Groundwater level trends within the shallow zone are generally stable, with the exception of the El Verano/Fowler Creek subarea, where localized declines within the shallow zone are evident.

- Groundwater level declines are present within deep zone aquifers primarily in the City and El Verano/Fowler Creek subarea. The area of declines has persisted for the last decade or more and appears to be expanding. While the magnitude of the declining rate may be influenced, in part, by the lower than average rainfall which has occurred in seven of the last ten years (most notably the last two years), many of the wells with declining groundwater levels exhibit persistent declines, which do not recover during relatively wetter years, indicating that groundwater withdrawals are occurring at a rate exceeding the rate of recharge or replenishment within the deeper zones.

- Brackish groundwater beneath the Baylands subarea of Sonoma Valley, which has historically affected water wells located in southern Sonoma Valley.

- Total water demands in Sonoma Valley for Water Year 2012 were estimated to be 17,900 acre-ft and were sourced from the following supplies:
  - Local groundwater pumped from water wells located within Sonoma Valley – 10,500 AF;
  - Imported water from the Russian River Watershed – 4,700 AF;
  - Local surface water diverted from Sonoma Creek and its' tributaries -1,500 AF; and
  - Recycled water produced at the Sonoma Valley Wastewater Treatment Plant – 1,200 AF.

- Of the total estimated 10,500 AF of groundwater pumped in 2012, the agricultural irrigation demand comprised the largest use of groundwater in Sonoma Valley (52% of the total demand), with vineyards making up approximately 93% of the crops. Rural domestic pumping constituted the second largest groundwater demand in Sonoma Valley at 29%. Municipal, Small Commercial Systems, and Mutual/Private Systems contributed demands that are very similar (3% to 5%). Irrigation of Golf Courses and Parks contributes to 7% of the demand and is concentrated in the El Verano/Fowler Creek subarea, predominantly for golf course irrigation.

- Groundwater demands are most intensive in El Verano/Fowler Creek, Kenwood, Rodgers Creek and City subareas. In the vicinity of groundwater level pumping depressions located within the City and El Verano/Fowler Creek subareas, groundwater demands are primarily a combination of agricultural and rural domestic pumping.

- The water budget estimated using the updated groundwater flow model suggests that more water is going out of the groundwater basin than is coming in, with average annual loss of storage in the basins of 1,400 AF, and total cumulative storage loss in the basin of 44,800 AF for the period 1975 to 2006. Storage loss in the groundwater basin is supported by the measured groundwater level depressions.

In summary, the water budget estimate indicates a net loss to groundwater over the last several decades, which has resulted in declining groundwater levels (primarily observed in the deeper aquifers in the El Verano and area of southeast of the City). The net loss of groundwater is due to a combination of increasing demands and declining levels of precipitation over last few decades. These declining groundwater levels which have fallen below sea level in areas could exacerbate the intrusion of poor quality water (either from brackish water or geothermal fluids) into the deeper aquifer. Reversing the declining trends and recovering groundwater levels in the deeper aquifers is necessary to protect and preserve groundwater uses in these areas.

While the deeper and shallow aquifer systems seem to be separated by clay layers in much of Sonoma Valley, continued groundwater level declines within the deeper aquifers could lead to inducement of water from the shallow aquifer and subsequent groundwater level declines in shallow aquifers. Maintaining groundwater levels in the shallow aquifer is important for maintaining stream habitat and aquatic ecosystems, since shallow groundwater provides baseflow to the streams. The estimated water budget loss to groundwater is not sustainable over the long-term, and will require measures to bring the water budget back into balance so that the net inflow is equivalent to the outflow in the groundwater basin.

3.6 Data Gaps

The following primary data gaps were identified and future efforts planned to address the data gaps are described in Sections 4 and 5:

- Additional groundwater-level data from non-pumping wells and groundwater quality data is needed to more accurately evaluate groundwater conditions in Sonoma Valley, particularly in the vicinity of the two groundwater pumping depressions.

- Additional multi-depth groundwater monitoring wells are needed to further assess the hydrostratigraphy, interconnection of shallow and deep aquifer zones, recharge of deep aquifer zones, and salinity sources and distribution in the Sonoma Valley.

- Additional stream gage and seepage measurements are needed to help quantify surface water-groundwater interaction and further refine the water budget.

- The hydrogeologic conceptual model should be updated to include the additional hydrostratigraphic and hydraulic information, particularly in the areas of groundwater pumping depressions.

- The numerical groundwater flow model should be updated with priority given to the southern Sonoma Valley portions of the model. The model will be updated with new hydrogeologic and hydraulic conductivity data, new well observations, and new stream seepage measurements. Additionally, the grid may be refined in the southern Sonoma Valley. The updated model is needed to better simulate groundwater conditions and assess potential future scenarios and responses to address the areas of declining groundwater levels.

4.0 Progress on Plan Component Actions and BMOs, and Recommendations for Future Actions

Substantial progress toward implementing plan component actions was accomplished by the Sonoma Valley GMP between 2008 and 2013. The accomplishments made and programs planned for 2014-2018 are identified in Table 4-1 and 4-2.

Data collected through the voluntary groundwater-level monitoring program have further refined the distribution and condition of declining groundwater levels within two areas of southern Sonoma Valley. Groundwater-level declines primarily occur within deeper aquifers located in the El Verano area and southeast of the City of Sonoma. These areas were identified in the 2006 USGS study and declining trends have continued ranging up to several feet per year in some wells. This monitoring data suggests that, while progress has been made in many areas of the GMP, additional efforts are needed to meet BMO-1 and BMO-5, which relate to maintaining groundwater elevations and quality. It is recommended that incorporation of quantitative values into BMO-1 and BMO-5 be considered to address these areas of persistent groundwater level declines and associated potential consequences, such as wells going dry, inducement of poor quality water and land subsidence. It is also recommended to refine outreach materials and conduct additional stakeholder outreach efforts focused on these two areas.

Additional stakeholder outreach efforts should be conducted to inform the public of groundwater conditions and obtain their input on future management options. These outreach efforts should include:

- Develop database/mailing list for City and El Verano subareas.
- Refine materials on groundwater level conditions with hydrographs, groundwater level contours, and salinity contours and provide to public.
- Provide Slow It Spread It Sink It guide to land owners in these areas.
- Provide well owners guide to well owners in these areas.
- Brief stakeholder constituencies on GMP draft five-year update report.
- Hold community workshop(s) on GMP draft five-year update report to receive public input prior to finalizing the report for Panel approval.
- Conduct focused neighborhood style meetings in the declining areas with release of five-year update.

Also proposed is a screening of alternatives (alternatives analysis) to consider possible technical, regulatory and institutional approaches to address groundwater depletion in the two aforementioned areas of declining groundwater levels in the southern Sonoma Valley (see Table). The proposed alternatives analysis would be phased and would involve the following steps:

Table 4-1 - Management Components and Actions - Years 1-5 Progress and Years 6-10 Plans

Management Components/Actions	Completed Actions 2008-2012					Future Plans 2013-2018					Relative Cost
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	
4 Stakeholder Involvement											
4.1.1 Involving the Public											
Meetings, coordination, and communication	√	√	√	√	√	❖	❖	❖	❖	❖	----
Public Outreach Plan for implementation- update and imporve	√	√				❖				❖	----
4.1.2 Advisory Groups											
Reform Panel, form TAC, and hold TAC monthly meetings	√	√	√	√	√	❖	❖	❖	❖	❖	----
Hold Quarterly Meetings with the Panel	√	√	√	√	√	❖	❖	❖	❖	❖	----
4.1.3 Informing Public Agencies and Stakeholders											
Meetings, coordination, and communication	√	√	√	√	√	❖	❖	❖	❖	❖	----
4.1.4 Partnerships & Coordination											
Meetings, coordination, and communication	√	√	√	√	√	❖	❖	❖	❖	❖	----
Seek grant funding for Plan actions	√	√	√	√	√	❖	❖	❖	❖	❖	----
4 Monitoring Program											
4.2.2 Groundwater Elevation Monitoring											
Groundwater Elevation Monitoring & Expand Volunteer Wells	√	√	√	√	√	❖	❖	❖	❖	❖	----
Project - Install New Multi-depth Monitoring Wells	1	1	1	1	1	❖					$$
CASGEM Monitoring Plan and Annual Data Submittals						❖					$
4.2.3 Groundwater Quality Monitoring											
Groundwater Quality Monitoring-long-term porgram		√	√	√	√	❖				❖	----
Conduct Depth Specifc Salinity Monitoring - South Valley				√	√	❖				❖	----
4.2.4 Land Subsidence Monitoring											
Establish Long-Term Monitoring Program for Land Subsidence						❖				❖	$
4.2.5 Surface Water-Groundwater Interaction Monitoring											
Study - Tracer Test and Modeling								❖			$$$
Study - Stable Isotope Analysis	√		√	√	√			❖			$$
Project - Install and Maintain New Stream Gauges	√								❖		$$
Project - Conduct Seepage Runs		√	√	√	√	❖	❖	❖	❖	❖	$
4.2.6 Monitoring Protocols											
Adopt and Implement Protocols & Monitoring Program	√	√									----
4.2.7 Central GIS Data Management System											
Update GIS Mapping of Drainage Network								❖			$
Maintain and Update GIS Groundwater Database			√	√	√	❖	❖	❖	❖	❖	$
WEBH2O Web-Based Data Management System	√	√	√	√	√	❖	❖	❖	❖	❖	$
4 Groundwater Quality Protection											
4.3.1 Well Construction, Abandonment, and Destruction											
Study - Obtain Better Information during Well Installations							❖				----
Study - Conduct Well/Abandoned Well Survey								❖			$$
Project - Develop & Distribute Guide for Well Owners		√	√	√	√						----
4.3.2 Wellhead Protection											
Incorporate Information from DWSAP Plans								❖			----
4.3.3 Control Migration and Remediation of Contaminated Groundwater											
Provide Well Owners with County Guide			√	√	√	❖					----
Incorporate & Distribute Information on Sources							❖				----
4.3.4 Control of Saline Water Intrusion											
Study - Salinity Sources and Distribution (Salt & Nutrient Plan)					√	❖			❖		$$
Study - Seawater Intrusion Mitigation Measures (if appropriate)									❖		$$$
4 Groundwater Sustainability											
4.4.1 Stormwater Recharge											
Study - Groundwater Recharge Area Mapping & Analysis		√	√	√	√						$
Study - Recharge Area Alternatives								❖			$$
Project - Public Outreach Program			√	√	√	❖					$
Study/Pilot - Stormwater Capture/Groundwater Recharge Scoping			√	√	√	❖					$$$
4.4.2 Groundwater Banking											
Study - Conduct Groundwater Banking/Conjunctive Use Assessment			√	√	√	❖					$$$
Study/Pilot - Feasibility Analysis/Pilot Groundwater Banking							❖				$$
4.4.3 Recycled Water Supply											
Study - Evaluate Graywater			√	√	√						$$$
Project - Increase Recycled Water for Irrigation			√	√	√	❖					$$$
Study - Evaluate Recycled Water Groundwater Recharge Feasibility										❖	$$
4.4.4 Conservation & Demand Reduction											
Continue Implementing Conservation BMPs & Report Annually	√	√	√	√	√	❖	❖	❖	❖	❖	----
Encourage Water Conservation BMPs for Non-Viticulture Agriculture								❖			$
Encourage Additional Conservation and Best Practices for Viticulture						❖				❖	$
Study - Voluntary Water Conservation BMPs for Uninc. Areas		√	√	√	√						----
Project - Landscape Irrigation Efficiency							❖				$
Pilot/Project - Stormwater Capture and Reuse for Irrigation							❖				$$
4.4.5 Groundwater Modeling											
Study - Update Land Cover Map & Water Use Estimates						❖		❖			$$
Update Hydrogeologic Conceptual Model						❖					$$
Project - Upgrade Groundwater Flow Model to GSFlow							❖	❖	❖		$$$
Feasibility Study to Assess Ways to Address Groundwater Depletion							❖				$
5 Planning Integration											
Project - Develop Multi-Beneficial Projects for Flood Hazards						❖					$$$
5 Implementation Administration											
Implementation Prioritization and Financing	√	√	√	√	√	❖	❖	❖	❖	❖	----
Annual Summary Status Report and Data Transmittal							❖	❖	❖		----
Five-Year Program Review and Implementation Report						❖				❖	----

Notes:

---- - Funded action

$$$ - Unfunded action; indicates relative order magnitude cost

1 - Obtained funding commitment in 2008, funding in late 2010, implementation in 2011.

Table 4-1 Management Components and Actions: Years 1-5 Progress and Years 6-10 Plans

Basin Management Objective	Progress to Date	Plans for 2014-18
BMO-1 Maintain groundwater elevations for the support of beneficial uses of groundwater and to protect against inelastic land subsidence.	Public outreach and stakeholder involvement on groundwater, increased voluntary monitoring, and obtained funding and installed two new multi-depth wells. Distributed and publicized the "Slow It, Spread It, Sink It" guidebook as a resource for property owners to implement stormwater retention and groundwater recharge projects.	Refined and increased public outreach and stakeholder involvement on groundwater, increased voluntary monitoring, and install new multi-depth wells. Propose conducting a feasibility study to update and reassess scenario based planning and consider possible technical, land use and institutional approaches to address groundwater depletion.
BMO-2 Improve water use efficiency and conservation.	Provided annual awards for water conservation. Conducted conservation assessments and prepared report for unincorporated areas with NBWA grant.	Pursue grants for incentive programs. Continue giving awards and publicity for increasing water conservation.
BMO-3 Identify and protect groundwater recharge areas and enhance the recharge of groundwater where appropriate.	Completed recharge-mapping study. Completed stormwater management-groundwater recharge scoping study and groundwater banking feasibility study.	Conduct groundwater banking pilot study and stormwater recharge pilot projects.
BMO-4 Manage groundwater in conjunction with other water sources.	Under the GMP, groundwater is being managed in conjunction with other water resources.	Continue implementation of the GMP with pilot projects on groundwater banking, stormwater and recharge opportunities. Continue to promote the use of recycled water for irrigation to offset groundwater demands.
BMO-5 Protect groundwater quality for beneficial uses including minimizing saline intrusion.	Coordinated monitoring efforts and increased number of wells through voluntary efforts, incorporated selected water quality data from public water systems. Developed and implemented outreach to distribute a Well Owner's Guide "WELLness – A Guide to Your Water Well". Completed a Salt and Nutrient Management Plan.	Continue coordinating monitoring efforts and increase number of wells through voluntary efforts, and install two new multi-depth monitoring wells. Implement the Salt and Nutrient Management Plan monitoring program.
BMO-6 Protect against adverse interactions between groundwater and surface water flows.	Continued stream gage monitoring of the Sonoma Creek watershed and conducted seepage runs along creek beds. Instrumented several shallow monitoring wells adjacent to Sonoma Creek and tributaries with pressure transducer/datalogger systems.	Continue coordinating monitoring efforts and increase number of wells through voluntary efforts, and install two new multi-depth monitoring wells. Implement the Salt and Nutrient Management Plan monitoring program.
BMO-7 Improve the community's awareness of groundwater planning, water resources, and legal issues.	Public outreach and stakeholder involvement through Panel and TAC meetings, newsletters, fact sheets, press releases and GMP website.	Continue public outreach and stakeholder involvement through Panel and TAC meetings, newsletters, fact sheets, press releases and the GMP website. Focus outreach efforts on areas in Southern Sonoma Valley exhibiting groundwater level declines.
BMO-8 Improve the groundwater database and basin understanding through consistent monitoring and additional surveys, and improve basin analytical tools including the groundwater simulation model.	Developed a database for storage and reporting of groundwater data. Coordinated monitoring efforts, conducted volunteer training, increased 86 monitoring wells through voluntary efforts.	Continue coordination and efforts for voluntary monitoring; install two new multi-depth monitoring wells. Update hydrogeologic conceptual model, and upgrade groundwater model. Consider further upgrade to fully-coupled surface water-groundwater flow model.
BMO-9 Manage groundwater with local control.	Implemented the GMP with regular input and direction from local stakeholders through the Panel.	Continue implementation of GMP with regular input and direction from the Panel and TAC.
BMO-10 Explore, identify and maximize non-regulatory approaches to management.	Promoted voluntary groundwater-level monitoring and conservation efforts.	Continue promoting voluntary groundwater-level monitoring and conservation efforts.

Table 4-2 Groundwater Management Program Progress 2008-2013 & 2014-2018 Plans

1) Panel/TAC to identify potential technical, regulatory, land use and institutional response action alternatives to mitigate declining groundwater levels. Response action alternatives could include but are not limited to additional water supply programs, conservation and efficiency programs, increased data collection and reporting, implementation of land use strategies, regulatory responses, and institutional approaches.
2) Panel/TAC will develop screening criteria to evaluate the viability of possible response action alternatives.
3) Panel/TAC will prioritize response action alternatives and develop scenarios consisting of one or more of these alternative actions, and evaluate how effective the alternative actions might be in mitigating declining groundwater levels.
4) Refine conceptual model in the southern Sonoma Valley and refine MODFLOW groundwater flow model to support scenario based planning.
5) TAC to work with Panel and SVGMP staff (Water Agency staff and technical consultant) for input and review on the scenario based planning to include baseline conditions, no action alternative, and a range of climate impacts and land use changes.
6) Panel ultimately to approve response action alternatives screening and make recommendations regarding any technical or policy proposals that come out of the process.
7) Community outreach will be needed throughout this process to educate local stakeholders of basin conditions, inform them of possible response action alternatives, policy recommendations and consider their input.

5.0 Proposed 2014 Program and Funding

This section provides a description of planned and proposed Sonoma Valley GMP activities for 2014-2018 and a discussion of future funding sources.

Activities and actions are recommended for 2014-2018 based on the BMOs identified in the Plan and subsequent stakeholder involvement. These activities and actions are described in the following sections and grouped according to the Plan Component Actions (i.e., Stakeholder Involvement, Monitoring Program, Groundwater Quality Protection, Groundwater Sustainability, and Planning Integration).

5.1 Component 1 – Stakeholder Involvement

Stakeholder involvement will continue to provide the foundation for the collaborative process of decision-making and actions during GMP implementation. Key tasks planned for 2014 are discussed below.

- **Continue To Update And Improve The Public Outreach Plan Under The GMP**
  The public outreach plan will continue to be updated to share information and demonstrate progress in GMP implementation. Such outreach activities identified in the plan, which was developed and initiated in 2008, include briefings, communications, and media activities. This will include developing refined information on groundwater conditions in the southern Sonoma Valley.

- **Advisory Groups** – Conduct quarterly Panel meetings, bi-monthly TAC meetings, several targeted briefings, and focused outreach for water conservation, stormwater capture and recharge, and groundwater banking will continue to be implemented.

- **Informing Public Agencies and Stakeholders** – Communications will be heightened by preparing and disseminating this five year report, sending out meeting announcements and supporting materials in advance to stakeholders, providing periodic informational newsletters and progress reports, developing and distributing fact sheets on the volunteer groundwater monitoring program, maintaining email distribution lists of Sonoma Valley stakeholders, including the Panel and TAC, and maintaining the project website. GMP staff and stakeholders will further develop relationships and work with local media to provide press releases on key events and milestones for the GMP.

5.2 Component 2 – Monitoring Program

The Monitoring Program consists of collection and analyzing a variety of data in a systematic way to provide a foundation of science for GMP decision-making.

- **Groundwater Elevation Monitoring and Expand Volunteer Wells**
  Coordinated groundwater-level monitoring events will be continued through the performance of spring and fall water level measurements 2014-2018, and this will incorporate the two new multi-depth monitoring wells, new shallow monitoring wells, and any additional voluntary monitoring wells added. Priority for adding additional wells into the groundwater-level program should focus on deep-zone wells in the following areas: (1) between Kenwood and Glen Ellen; (2) southeast of El Verano; (3) southeast of the City of Sonoma; and (4) southern Sonoma Valley just north of Highway 121. The addition of wells to the monitoring program in other areas of Sonoma Valley with sparse monitoring coverage (e.g., within the northwestern and northeastern upland areas) should also continue to be pursued and incorporated into the program.

- **Install (two dedicated) New Multi-Depth Monitoring Wells**
  Two multi-depth monitoring wells will be installed in 2014 in the southern Sonoma Valley and several shallow wells installed for assessing recharge potential in several areas in the basins under an AB303 grant awarded to the Agency in 2013. The objectives of the wells are to monitor groundwater levels and further assess the feasibility of enhanced groundwater recharge projects, such as aquifer storage and recovery and stormwater recharge.

- **CASGEM Monitoring Plan and Annual Data Submittals**
  The Water Agency, working with the TAC, will submit annual groundwater elevation monitoring data to DWR for the CASGEM monitoring requirements, as part of the statewide monitoring program requirements mandated under SBX7-6. The CASGEM monitoring network is a subset of the Sonoma Valley monitoring program as outlined in the plan submitted by the Water Agency in 2011 with input from the TAC.

- **Long-Term Groundwater Quality Monitoring Program (funding dependent)**
  The long-term water quality monitoring program developed in 2010 (Section 2.3) will be continued in 2014-2018 to improve long-term monitoring of salinity and other components including boron, manganese, iron and nitrate and to help meet the monitoring requirements for the Sonoma Valley Salt and Nutrient Management Plan.

- **Conduct Depth-Specific Salinity Monitoring - South Valley**
  As discussed in Section 5.2, additional multi-level monitoring wells are planned for installation in 2014, one of which will be used to monitor potential salinity intrusion in southern Sonoma Valley.

- **Establish Long-Term Monitoring Program For Land Subsidence**
  Groundwater extraction related land surface subsidence has not been identified as an issue in Sonoma Valley, based on work completed during development of the plan and benchmark surveying in 2007. However, land subsidence

monitoring is a GMP action that will be conducted periodically to monitor the potential for lowering of the land surface due to groundwater extractions. A long term, monitoring program is in development to assess the potential for land subsidence related to groundwater extractions. This will include coordination with VOMWD and the City to assess if there are additional and/or other suitable benchmarks in the Sonoma Valley to survey periodically to aid in monitoring for potential land subsidence across areas where groundwater level elevations are declining.

- **Maintain Stream Gaging Of Sonoma Creek**
  The two stream gages on Sonoma Creek will continue to be used to collect stream flow data in Sonoma Valley 2014-2018. Stream gage data is extremely useful in measuring flow, flood prediction, water management, and facilitating the estimation of groundwater recharge and discharge in the area. Pending funding availability, additional stream gages will be considered for Sonoma Valley based on technical findings from surface water groundwater interaction studies (described below).

- **Conduct Seepage Runs - Surface Water – Groundwater Interaction Study for Sonoma Creek**
  A program for the routine performance of annual seepage runs was developed with the Sonoma Ecology Center based on results of the seepage runs performed by the USGS in 2010 and will be implemented beginning in 2014. The information obtained from this program will be used to refine gains and losses along reaches of Sonoma Creek and its tributaries, spatially and temporally. The information will improve the understanding of groundwater recharge and discharge characteristics and enhance the groundwater flow model improvement.

5.3 Component 3 – Groundwater Quality Protection

Groundwater quality protection is a key factor to ensuring a sustainable groundwater resource in the Sonoma Valley. The Groundwater Quality Protection component includes recommended actions and activities to protect the quality of groundwater through education and disseminating information to well owners, developing better data on wells and groundwater contamination, and through implementation of the Salt and Nutrient Management Plan.

- **Obtain Better In formation During Well Installations**
  Develop approach to obtain better hydrogeologic information on well completions through a combination of voluntary-no-cost participation by well owners, and funding through soliciting in-kind services from agencies and/or applying for grants.

- **Conduct Abandoned Well Survey**
  Conduct an inventory and survey of active and inactive wells in the Sonoma Valley area to identify potential abandoned wells, and develop an approach for possible grant funding to provide incentives to properly destroy abandoned wells.

- **Incorporate Information from DWSAP Plans**
  Incorporate information on any known high risk potentially contaminating activity (PCA) PCA in the Sonoma Valley from the drinking Water Source Assessment Program (DWSAP) into GIS data management system.

- **Incorporate & Distribute Information on Sources of Contamination**
  GIS layers on Leaking Underground Storage Tank (LUST) sites from the Regional Water Quality Control Board (RWQCB) and Sonoma County Environmental Health Department will be incorporated into the GIS data management system.
  Information on contamination and course will be periodically distributed to Sonoma Valley licensed water system operators on mapped contaminant plumes and LUST sites and made available to all well owners. The RWQCB and Sonoma County Environmental Health Department will be periodically contacted for updates on new occurrences of LUSTs, particularly when contamination is believed to be a threat to groundwater.

- **Implement Salt & Nutrient Management Plan**
  The Salt and Nutrient Management Plan will be implemented, which includes triennial groundwater sampling and analysis, reporting to RWQCB, and implementation of best management practices

5.4 Component 4 – Groundwater Sustainability

The Groundwater Sustainability component includes recommended actions and activities to sustain groundwater through a number of studies and projects, and will include a response actions alternatives screening to address groundwater depletion.

- **Stormwater Capture/Groundwater Recharge Projects**
  The Water Agency received a grant from DWR through the Bay Area IRWMP for implementing a stormwater management/groundwater recharge project within the Nathanson/Fryer Creek watershed, a project that was identified through the Stormwater Management/Groundwater Recharge Scoping Study completed in 2012. Fieldwork to support design of the project began in late 2013. Project progress updates will be presented for input from the TAC and Panel in 2014-2018. Additional sites for multi-benefit stormwater/groundwater projects will be sought and constructed in the future.

- **Groundwater Banking Pilot Project**
  A regional groundwater banking feasibility study, including the Santa Rosa Plain and Sonoma Valley basins, was completed in 2013. Conceptually, the groundwater banking program would involve the diversion and transmission of

surplus Russian River water produced at the Agency's existing production facilities for storage in the Santa Rosa Plain Groundwater Basin and/or Sonoma Valley Groundwater Basin during wet weather conditions (i.e., the winter and spring seasons) for subsequent recovery and use during dry weather conditions (i.e., the summer and fall seasons) or emergency situations. A pilot groundwater banking project will be considered in 2014-2018.

- **Recycled Water**
  Activities planned for 2014-2018 related to the SVRWP include additional expansion of the recycled water trunk main as funding becomes available.

- **Voluntary Water Conservation BMPs for Unincorporated (Rural) Areas**
  Results of the rural area water conservation assessment activities (Section 2.3) reported in 2010, will be used to identify grant-funding opportunities for conservation BMPs , and to summarize the results of the water efficiency and conservation audit assessments and other efforts.

- **Update Hydrogeologic Conceptual Model**
  Lithologic information from well drillers records will be entered into a database, transformed into the common nomenclature, and used to develop cross sections for geologic interpretation. The cross sections will be used to construct a 3D hydrogeologic conceptual model. The 3D hydrogeologic conceptual model will be utilized for the groundwater flow model upgrade.

- **Upgrade Groundwater Flow Model**
  The Water Agency has initiated a project to enhance and improve the groundwater flow model, addressing limitations in recharge, discharge, and the conceptual hydrogeologic model. The focus of this effort will be to further compile and analyze existing lithologic data from water well logs in the valley and update the regional conceptual model and flow model. The work will be conducted by the Water Agency and USGS starting in early 2014, and the final product will be an updated MODFLOW groundwater flow model.

- **Response Actions Alternatives Analysis to Address Groundwater Depletion**
  A response actions alternatives screening is proposed in 2014 to assess scenarios and consider a range of possible approaches to address groundwater depletion in two areas of the southern Sonoma Valley. The proposed alternatives analysis would use the refined MODLFOW model to assess various land use and climate scenarios to evaluate possible future groundwater conditions. A range of technical, regulatory and institutional alternative response action approaches would initially be screened by the TAC, further assessed and provided to the Panel for possible policy recommendations in 2014.

5.5 Component 5 – Planning Integration

Planning integration through efforts and discussions will be continued at the GMP Panel, TAC, outreach meetings and focused briefings to facilitate integrated planning and coordination at the basin and regional scale.

- **Develop Multi-Beneficial Projects for Flood Hazards**
  Multi-beneficial projects addressing stormwater runoff, flood management, habitat enhancement, water quality improvement, and groundwater recharge will continue to explored and developed through follow up to the Stormwater Management/Groundwater Recharge Scoping Study, and seeking partnerships with private and public landowners of appropriate sites for such projects.

- **Land Use Planning**
  Plan activities will be coordinated with local and county agency planning processes and general plans, including Sonoma County General Plan 2020. Future water use and demand projections will be based upon projected growth in local and county agency general plans. This will provide a balance between ensuring enough water is available in the future and not developing excessive water resources to meet growth. The Panel will also coordinate with and exchange information with all land use agencies within the area on a continuing basis to provide the latest information pertaining to activities taking place for the protection and availability of groundwater resources, and to consider making recommendations for potential lands use and well permitting policies to protect Sonoma Valley groundwater resources.

- **Integrated Regional Water Management Program (IRWMP)**
  The Bay Area Integrated Regional Water Management Plan is a nine-county effort to coordinate and improve water supply reliability, protect water quality, manage flood protection, maintain public health standards, protect habitat and watershed resources, and enhance the overall health of the bay. Integration of SVGMPs plans and projects with the Bay Area IRWMP is necessary and provides opportunities for grants and funds beyond what the SVGMP could achieve on its own.

5.6 2014-2018 Annual Summary Data Transmittals and Five Year Plan Implementation Progress Report

The Agency will provide summary data transmittals commencing for 2014 that summarizes the groundwater conditions in the Sonoma Valley, and will provide the next SVGMP Implementation Report for 2018, and every five years thereafter.

The Annual Summary Data Transmittal will include the following:

- Bulleted list of stakeholder meetings and outreach activities
- Groundwater level contour maps and hydrographs illustrating groundwater level and water quality trends in the basin
- Groundwater level tables and water quality data collected during the reporting year

- A written discussion of groundwater conditions
- A one page, two sided fact sheet summarizing all the above for stakeholder outreach communications

The SVGMP Implementation Report will include the following information:

- Activities and progress made in implementing the Plan
- Groundwater data and trends of groundwater levels and quality
- Information on the improved characterization of the Sonoma Valley through continued data collection and analysis
- An update of whether management actions are meeting BMOs
- Any plan component changes, including modification of BMOs during the period covered by the report
- An outline of future Sonoma Valley management actions

5.7 2014 Funding

Currently funded programs include ongoing stakeholder involvement, groundwater elevation monitoring program, stream gage monitoring, and water conservation programs, which are currently funded collectively by Agency, City, VOMWD, Sonoma Valley County Sanitation District, and the County and volunteer services from several BAP and TAC members. The groundwater monitoring program water level data collection is largely completed by local volunteers.

For many proposed actions for 2014, funding mechanisms would need to be identified and pursued. Potential funding mechanisms include state grants, such as AB303 and the Integrated Regional Water Management Program grant.

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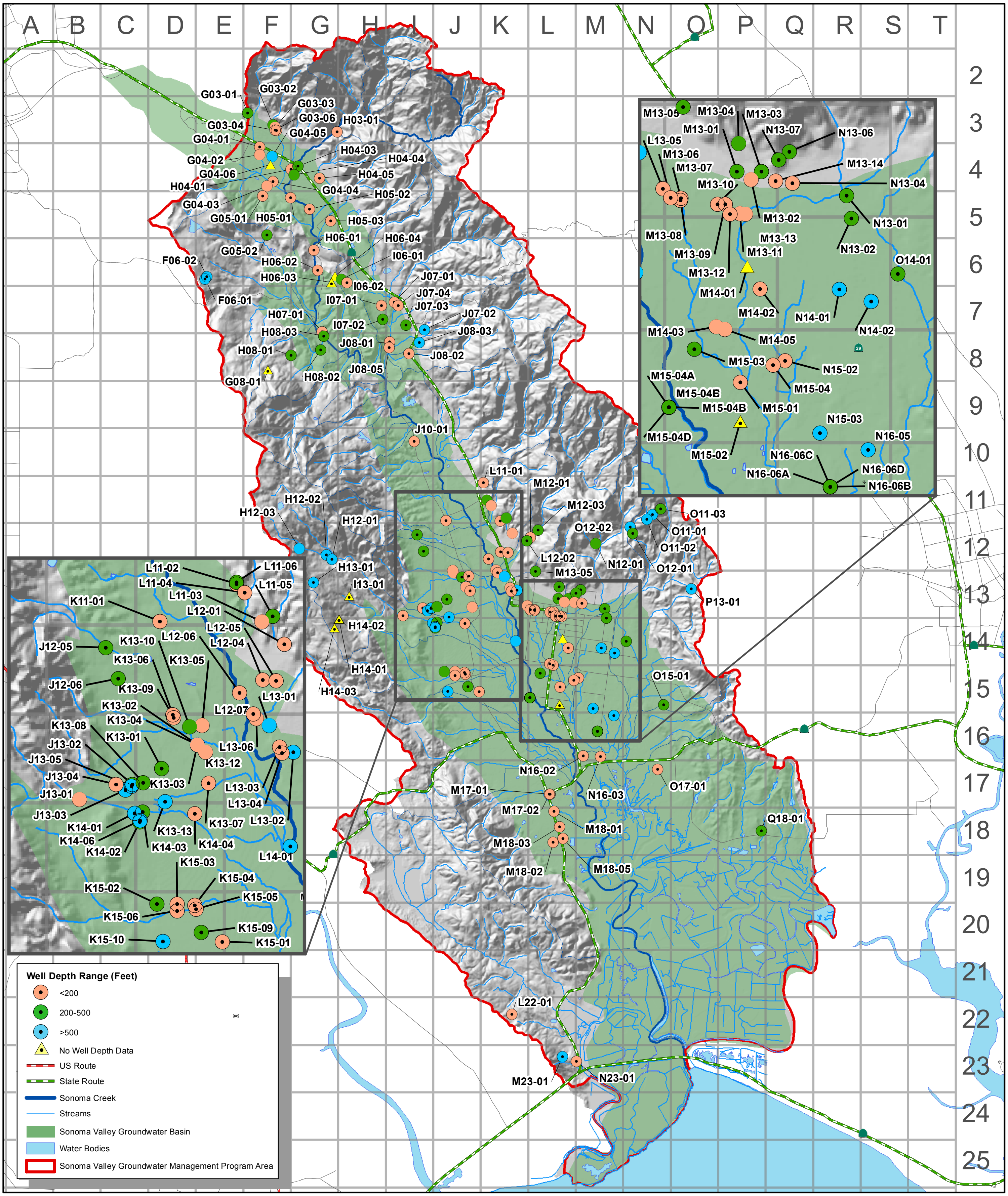
Appendix A
Sonoma Valley Hydrographs



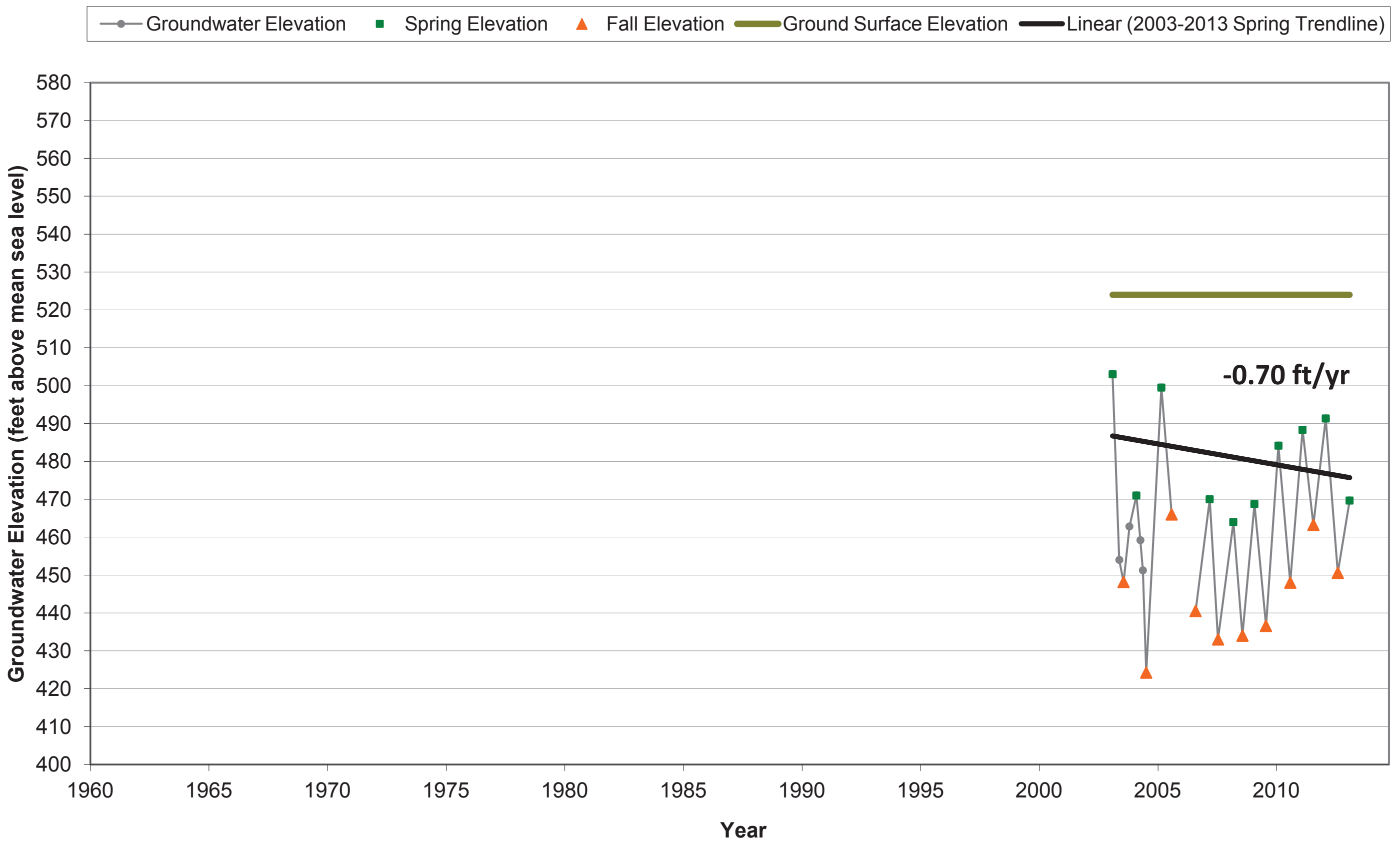
Sonoma Valley
Groundwater Management Program
Groundwater Level Monitoring Network

December 13, 2013

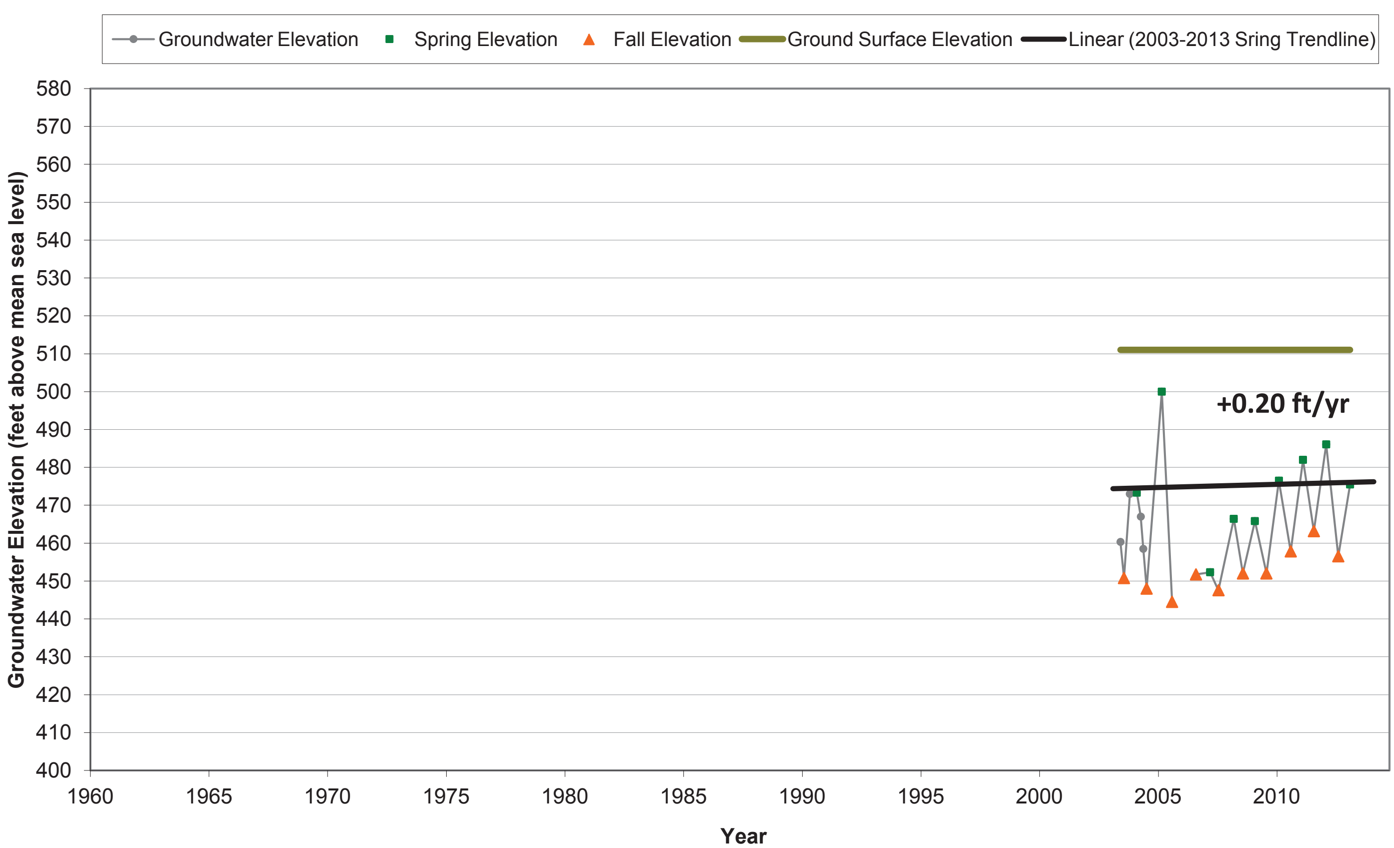
Figure A-1

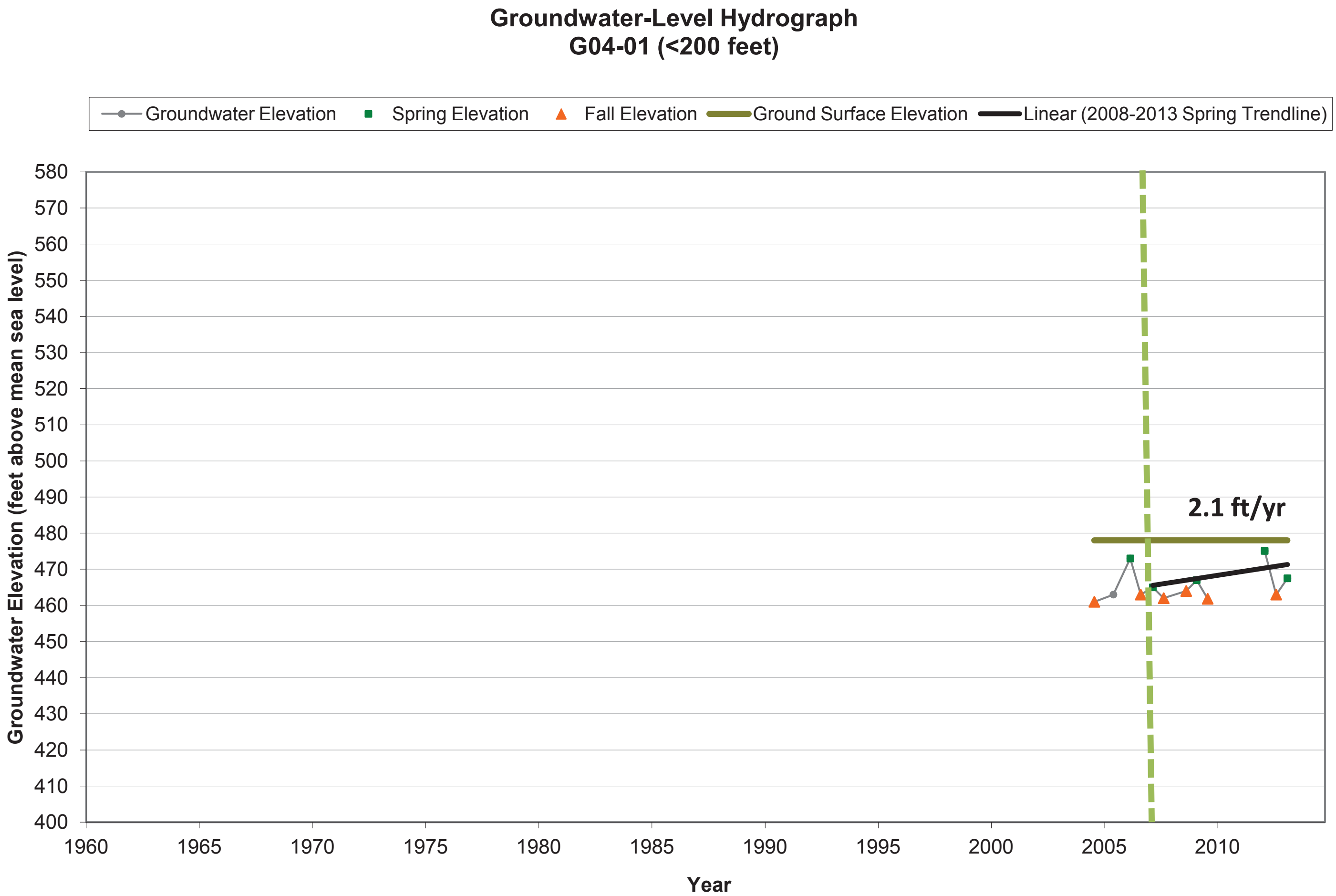
Groundwater Hydrographs
Less Than 200 Feet Deep

Groundwater-Level Hydrograph
G03-03 (<200 feet)

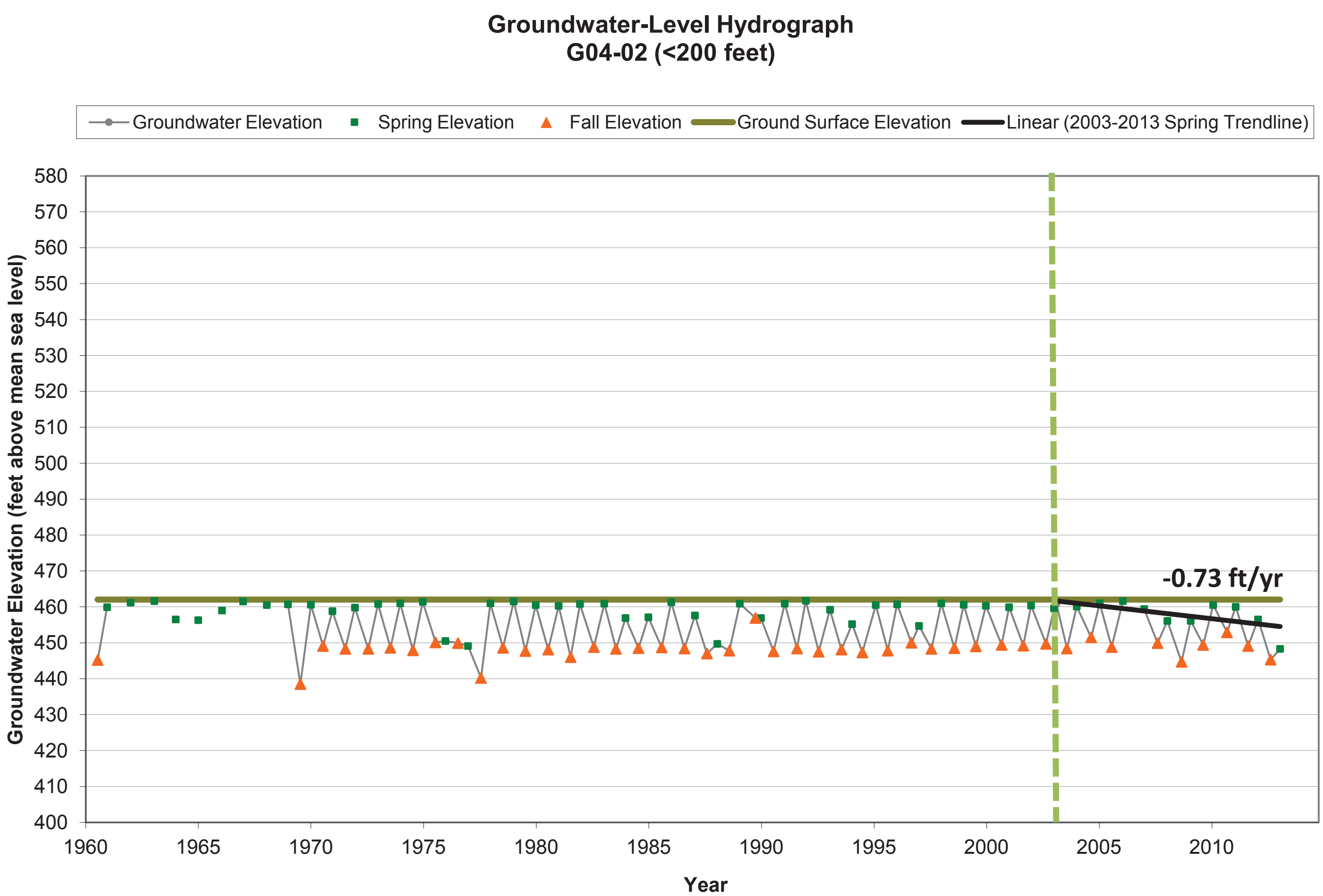


Groundwater-Level Hydrograph
G03-04 (<200 feet)



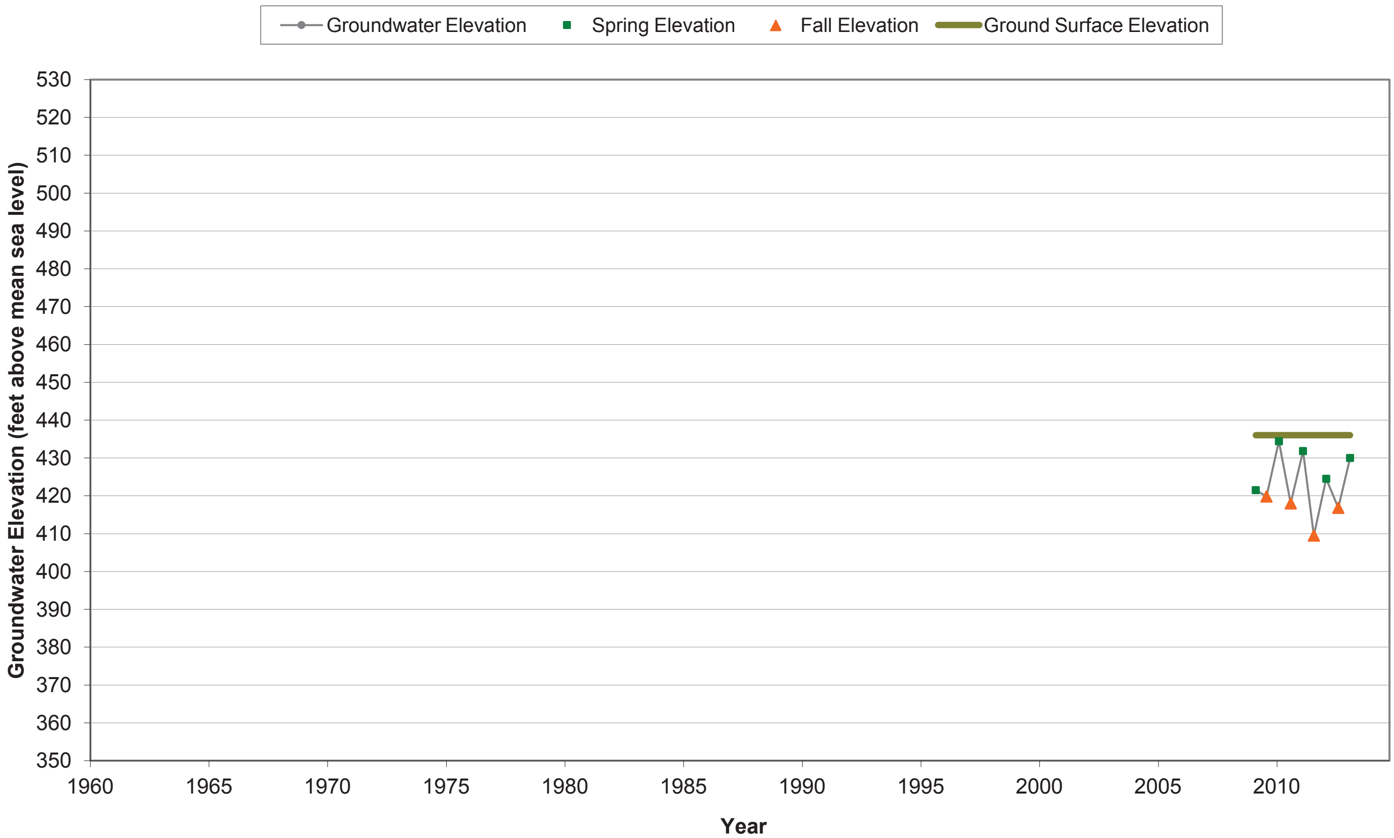


Groundwater-Level Hydrograph
G04-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2008-2013 Spring Trendline)
2.1 ft/yr
Groundwater Elevation (feet above mean sea level)
580
570
560
550
540
530
520
510
500
490
480
470
460
450
440
430
420
410
400
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

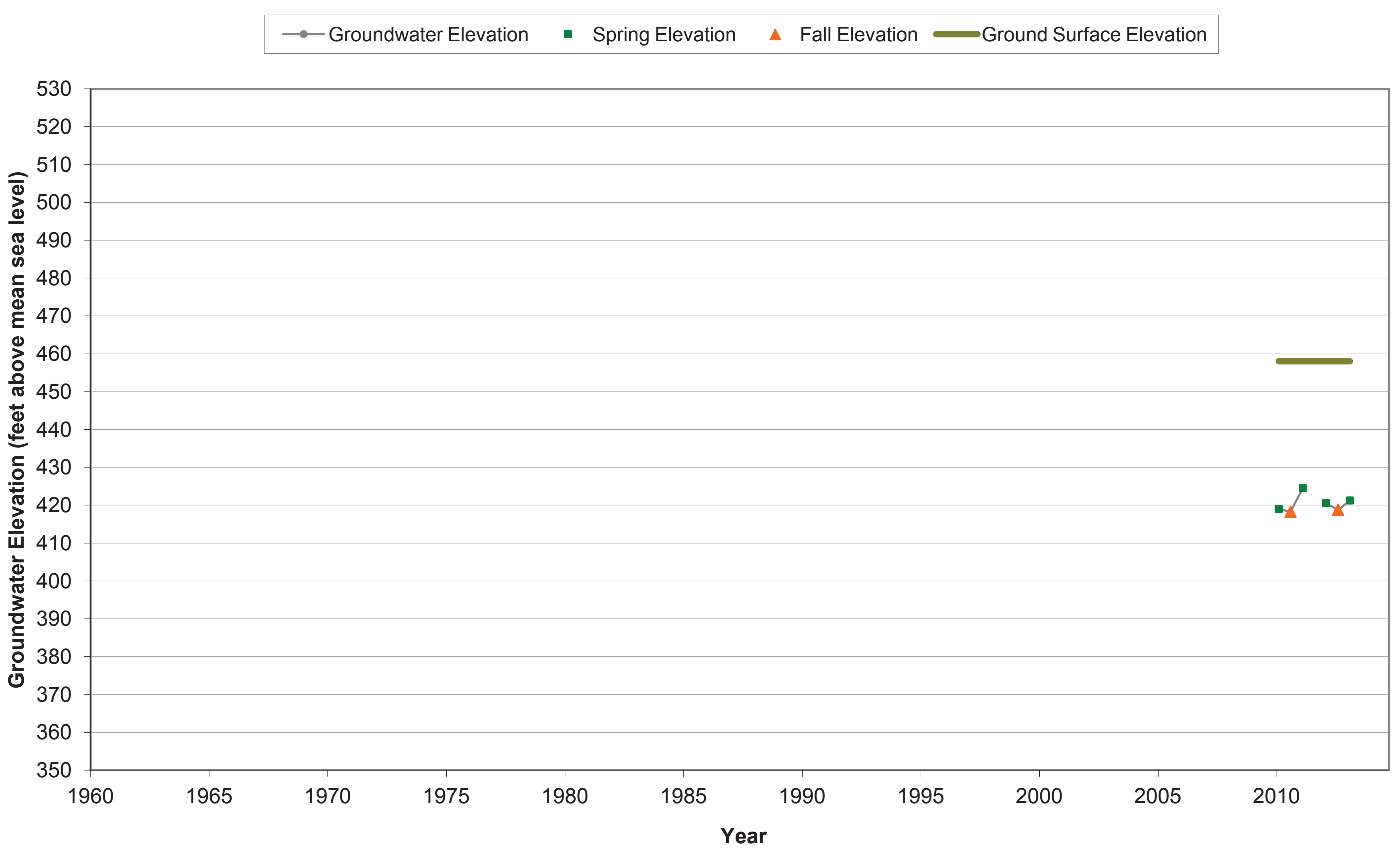


Groundwater-Level Hydrograph
G04-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-0.73 ft/yr
Groundwater Elevation (feet above mean sea level)
580
570
560
550
540
530
520
510
500
490
480
470
460
450
440
430
420
410
400
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

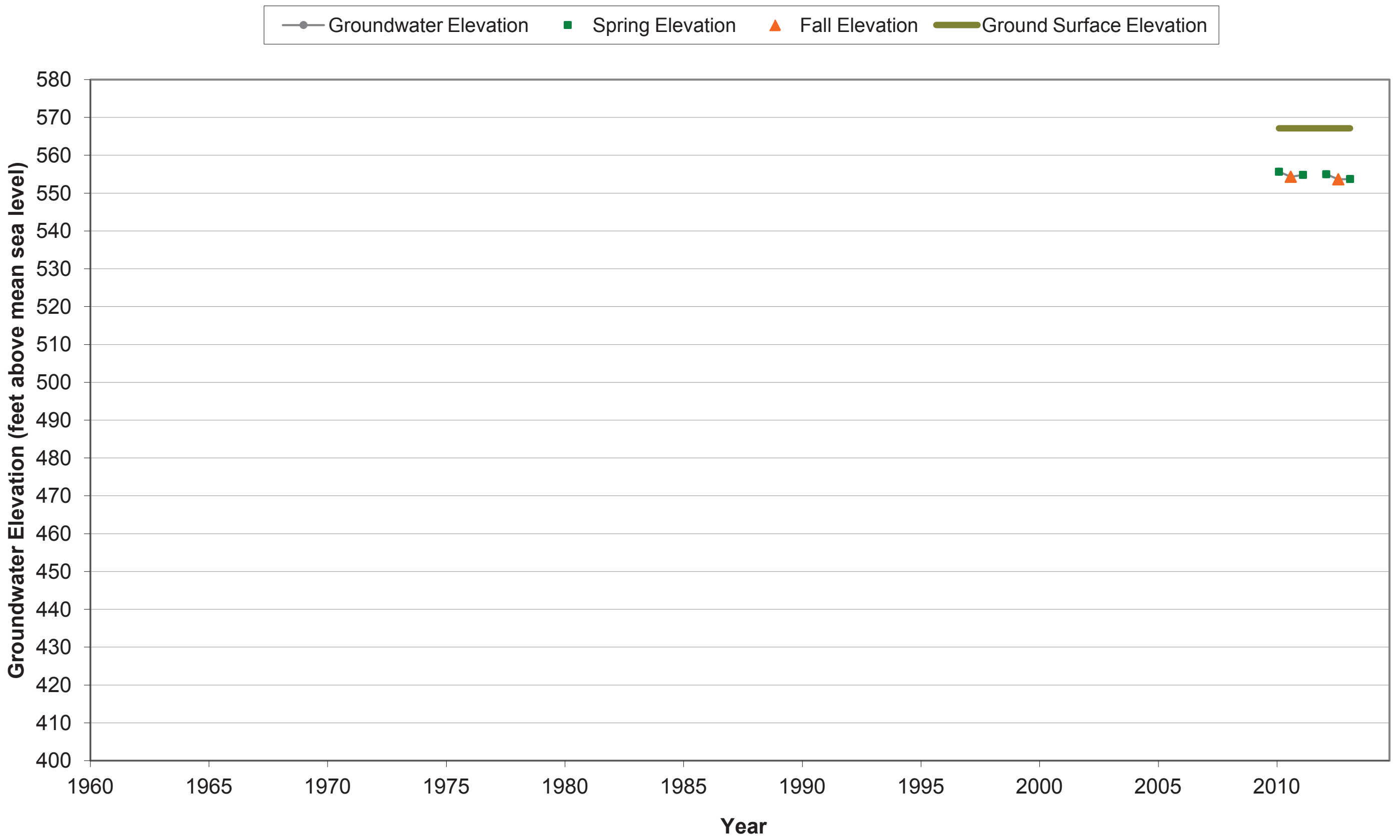
Groundwater-Level Hydrograph
G04-03 (<200 feet)



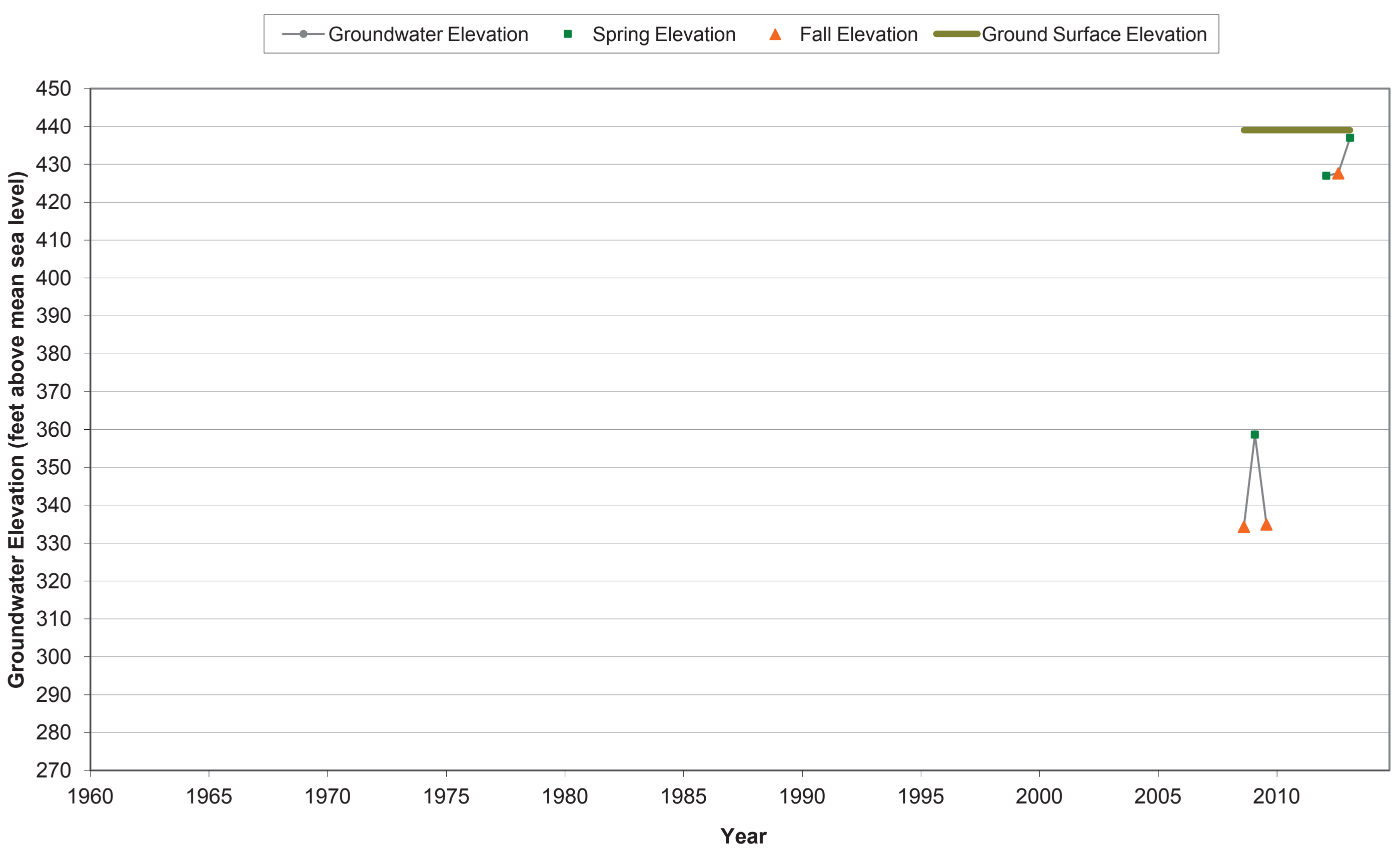
Groundwater-Level Hydrograph
G05-01 (<200 feet)



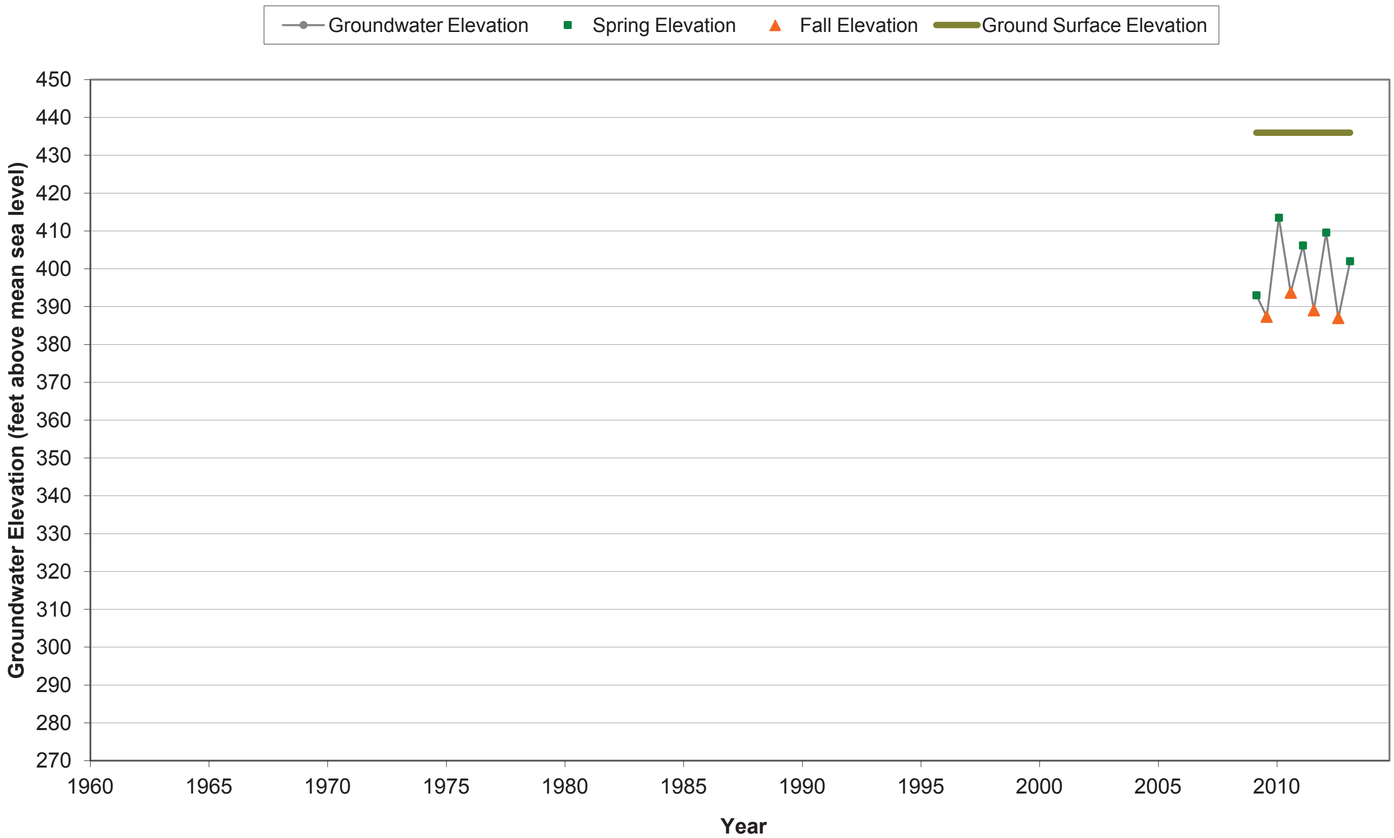
Groundwater-Level Hydrograph
H03-01 (<200 feet)



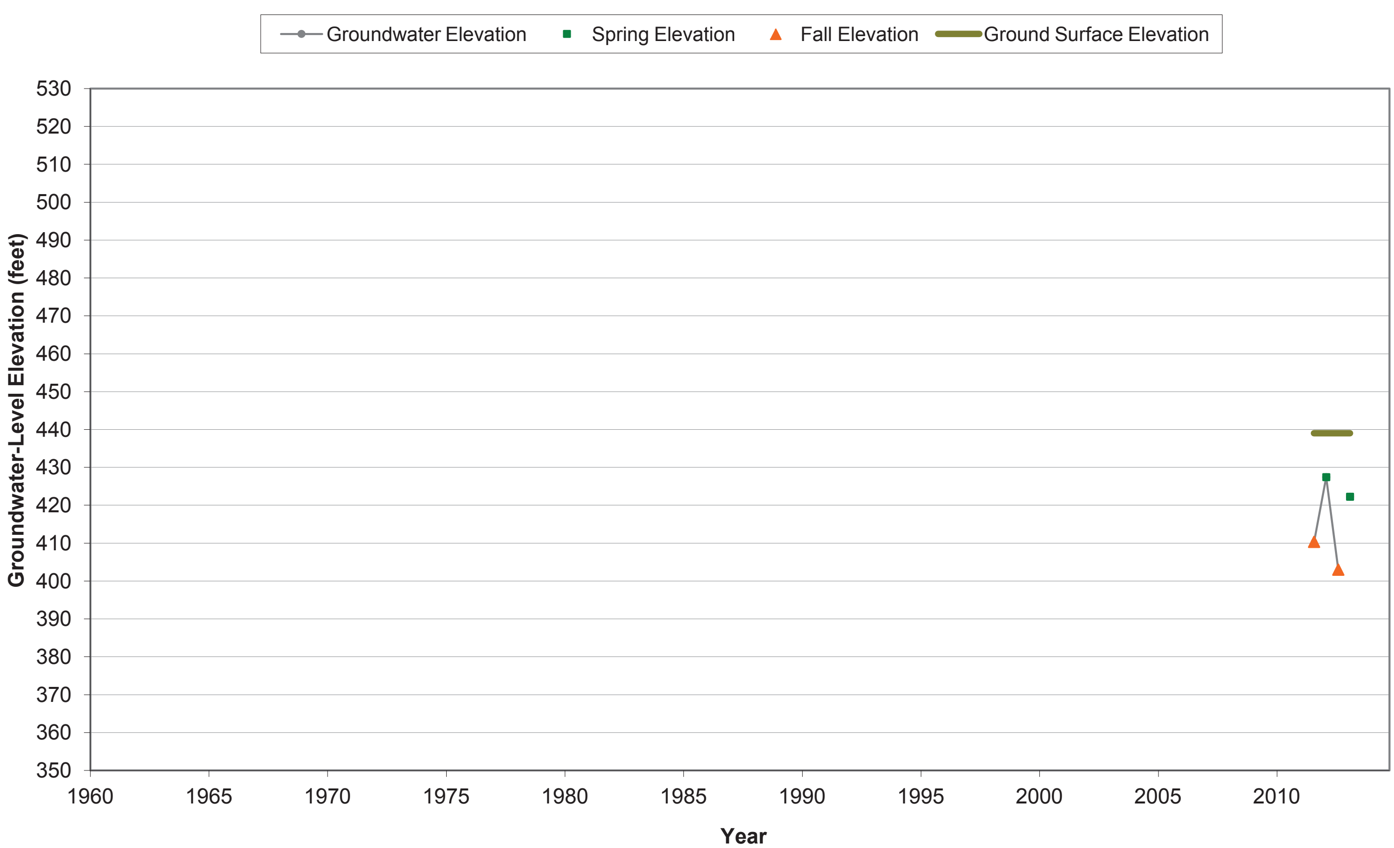
Groundwater-Level Hydrograph
H04-01 (<200 feet)



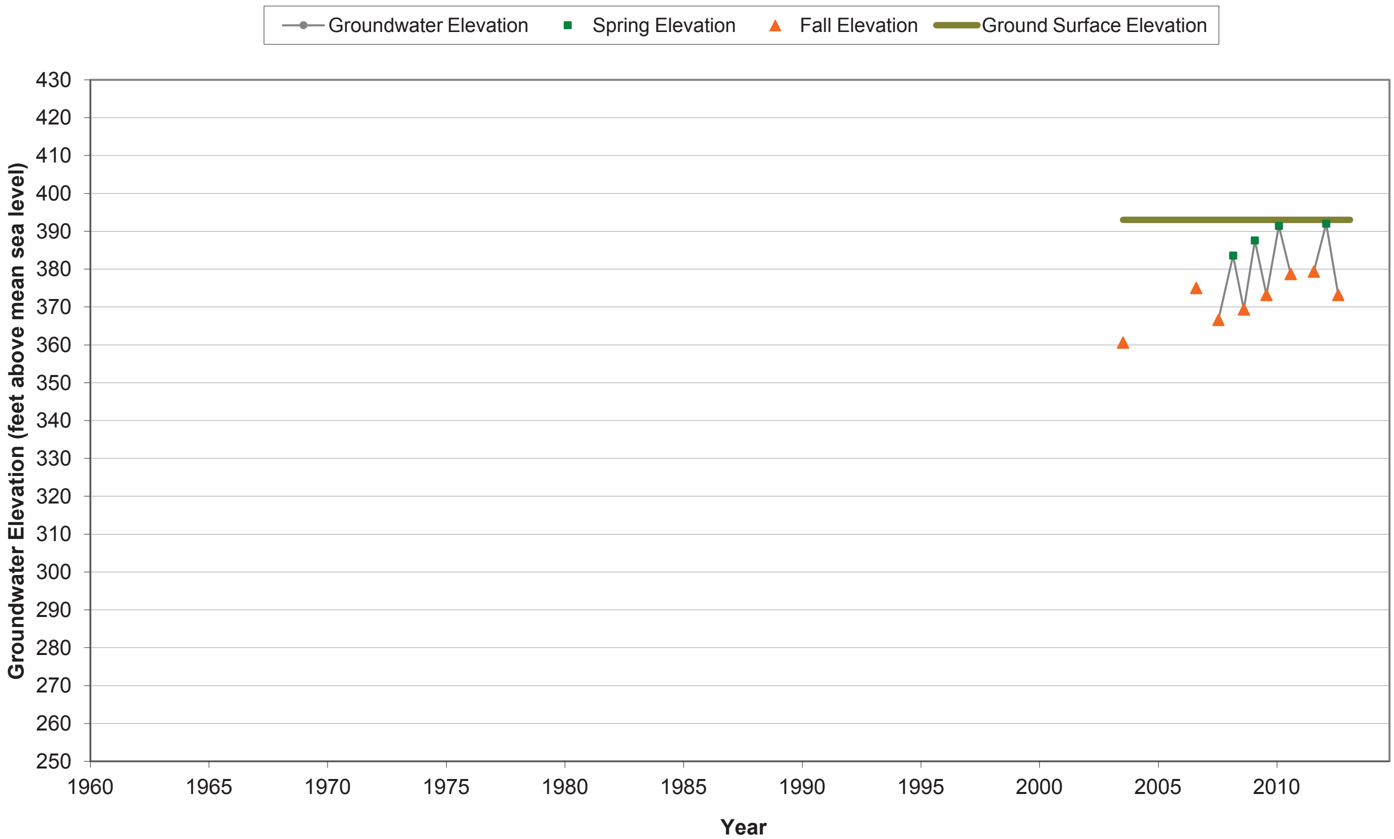
Groundwater-Level Hydrograph
H04-03 (<200 feet)



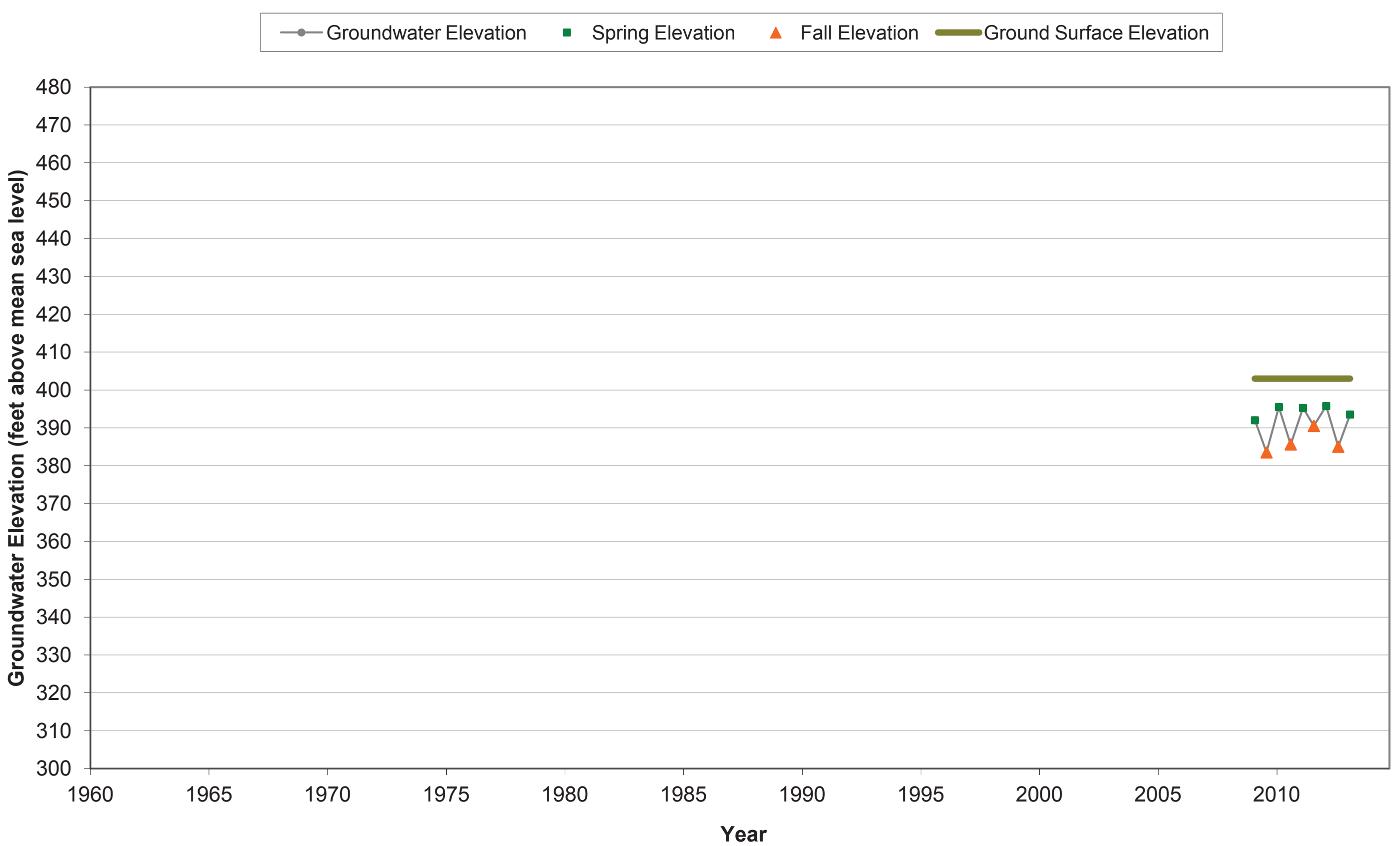
Depth to Groundwater-Level Hydrograph
H04-05 (<200 feet)



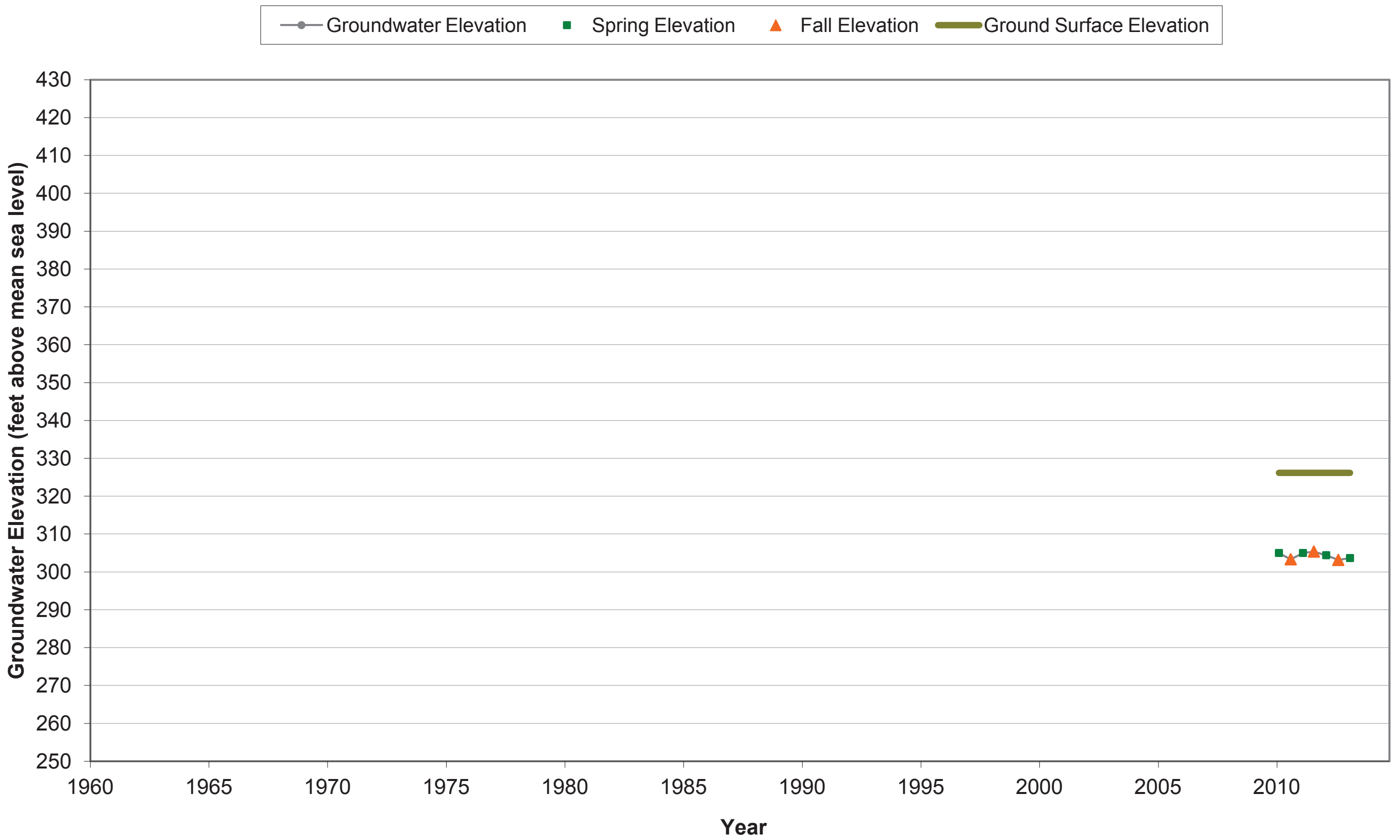
Groundwater-Level Hydrograph
H05-02 (<200 feet)



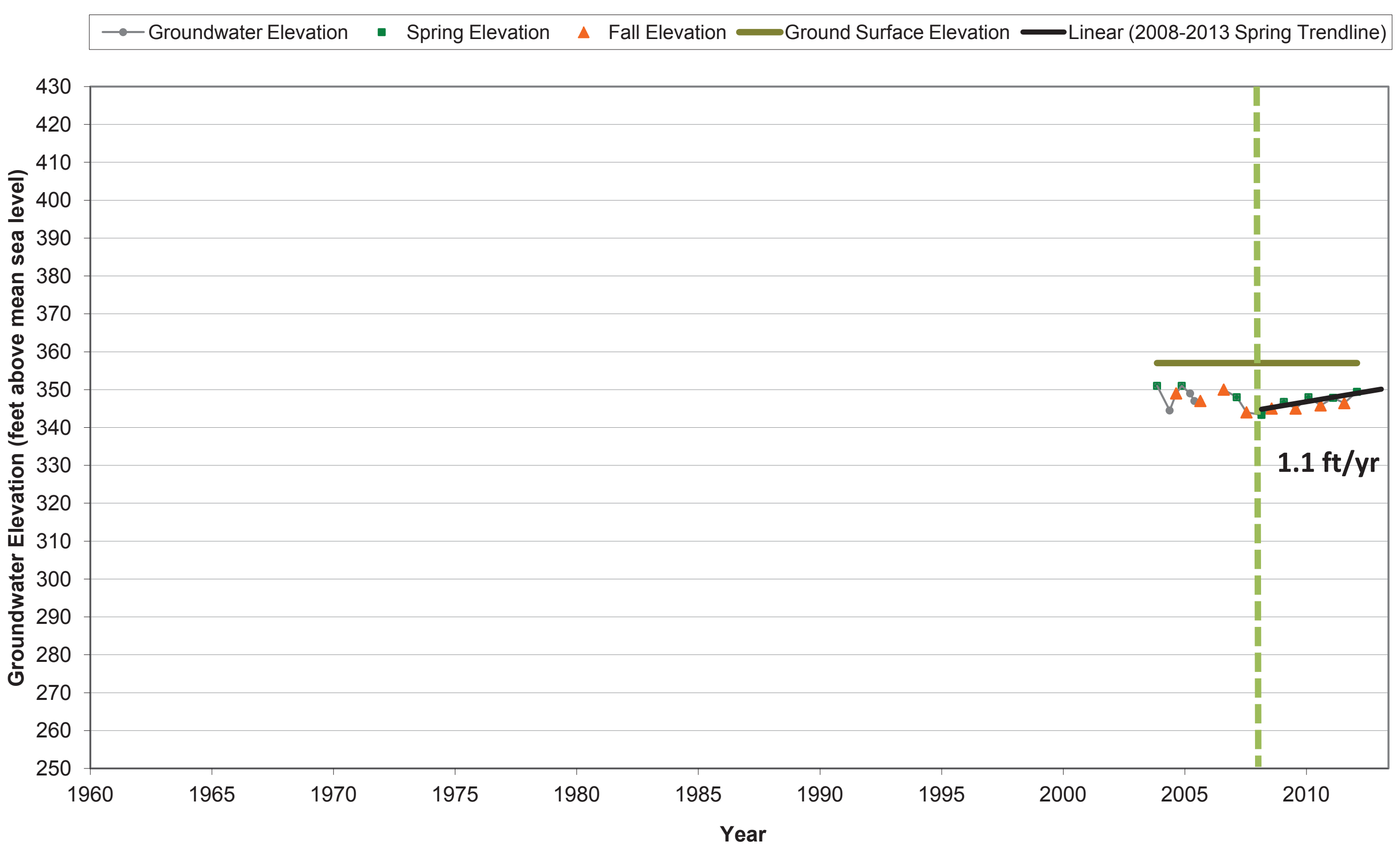
Groundwater-Level Hydrograph
H05-03 (<200 feet)



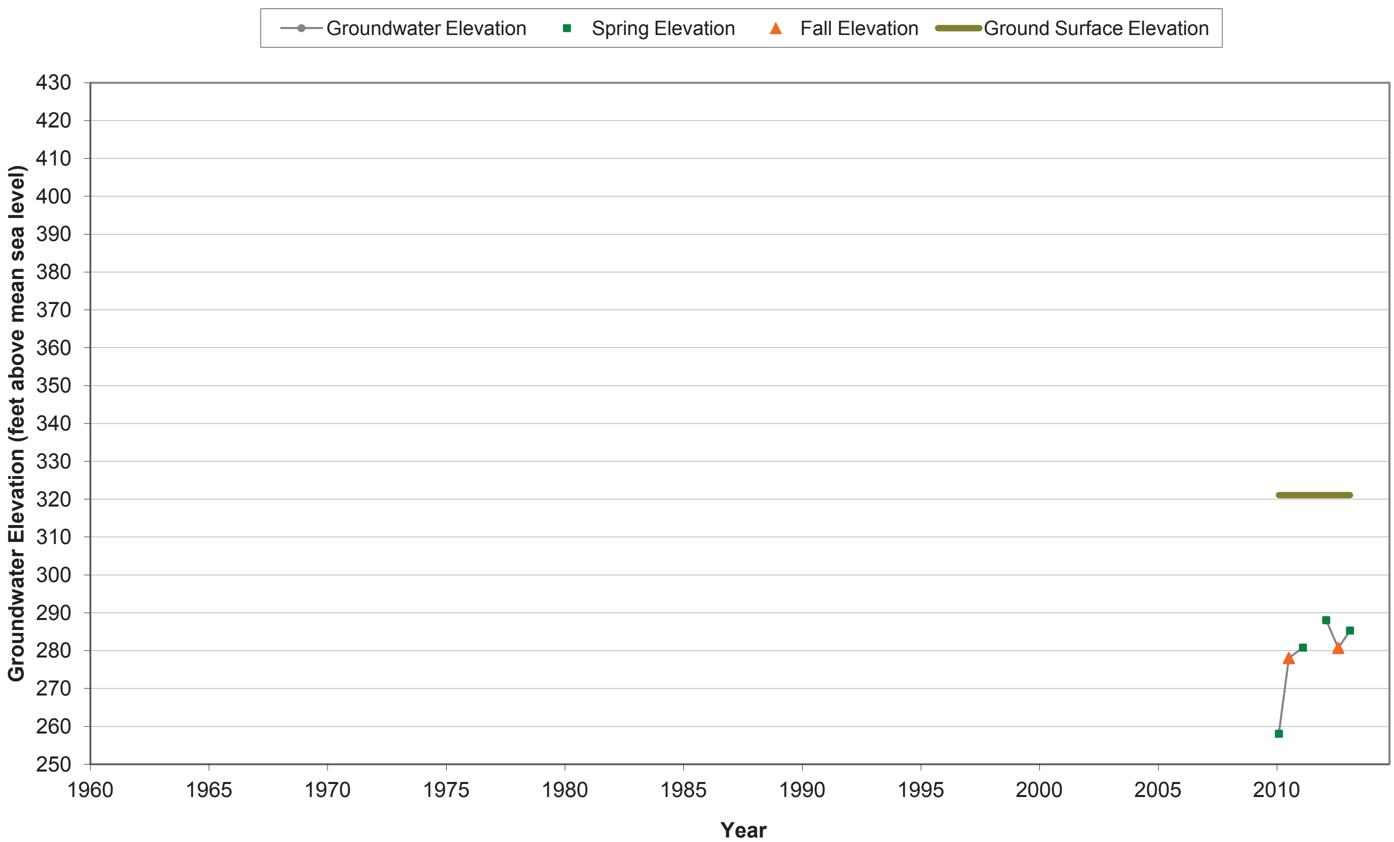
Groundwater-Level Hydrograph
H06-01 (<200 feet)



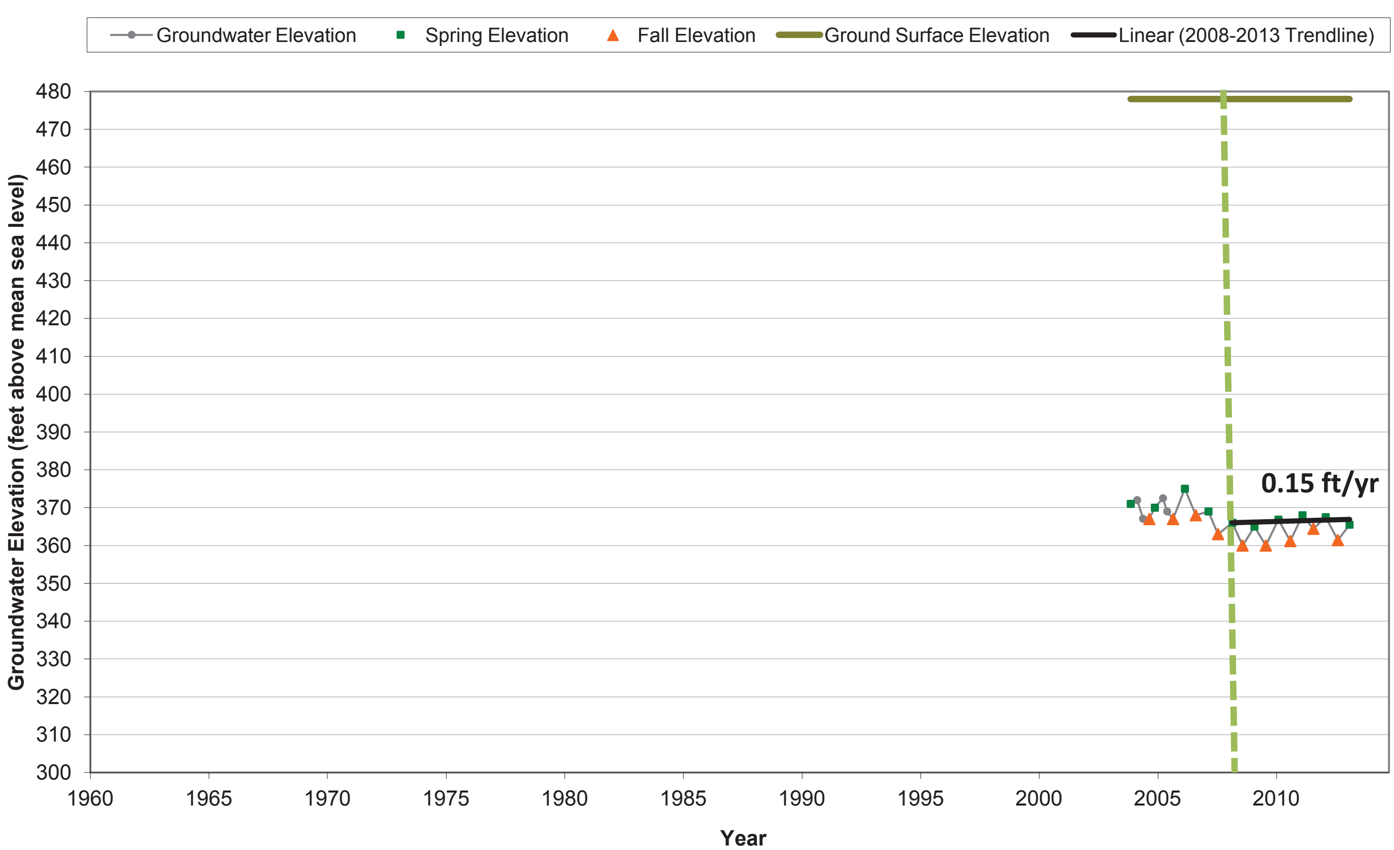
Groundwater-Level Hydrograph
H06-02 (<200 feet)



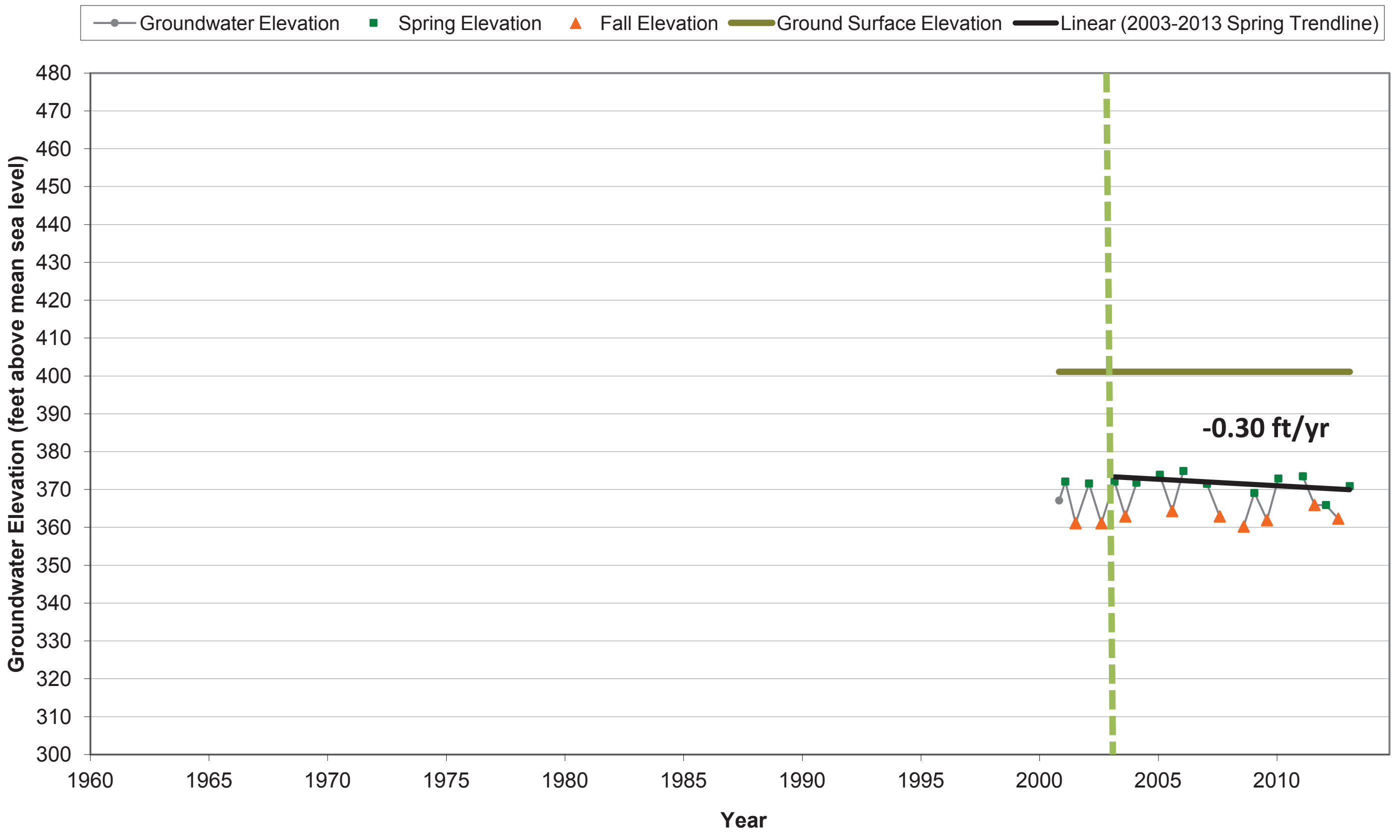
Groundwater-Level Hydrograph
H07-01 (<200 feet)



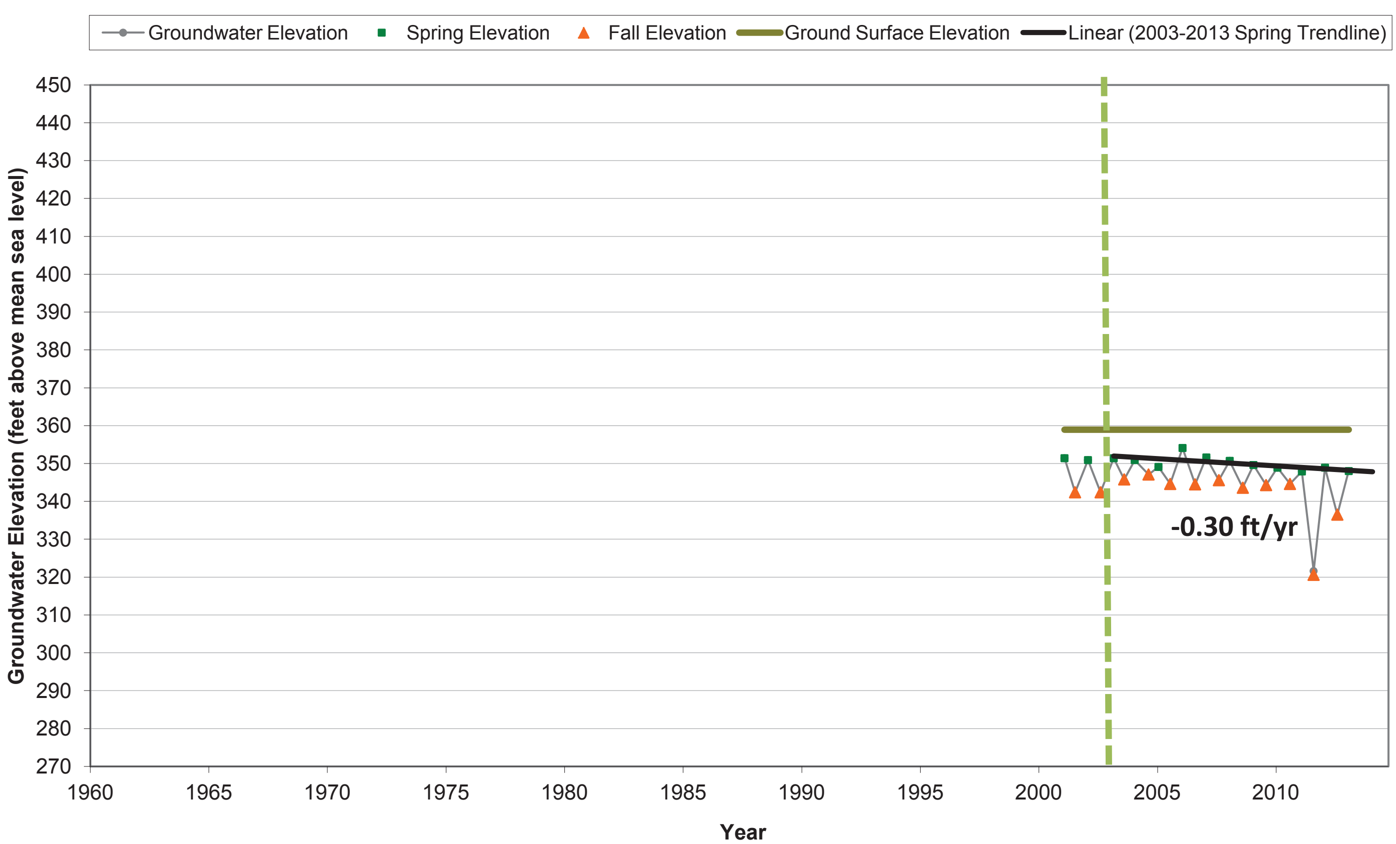
Groundwater-Level Hydrograph
I06-02 (<200 feet)

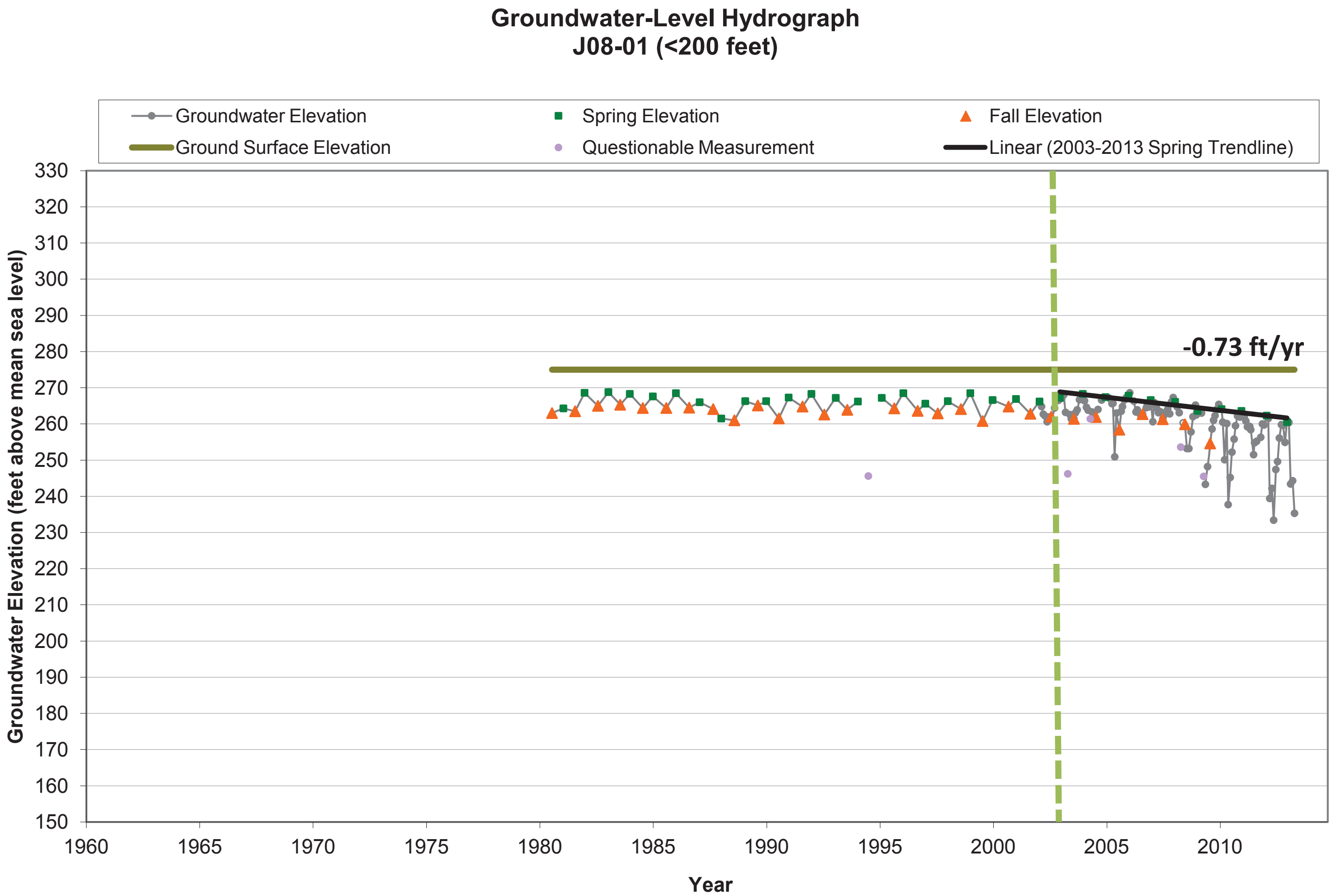


Groundwater-Level Hydrograph
I07-01 (<200 feet)

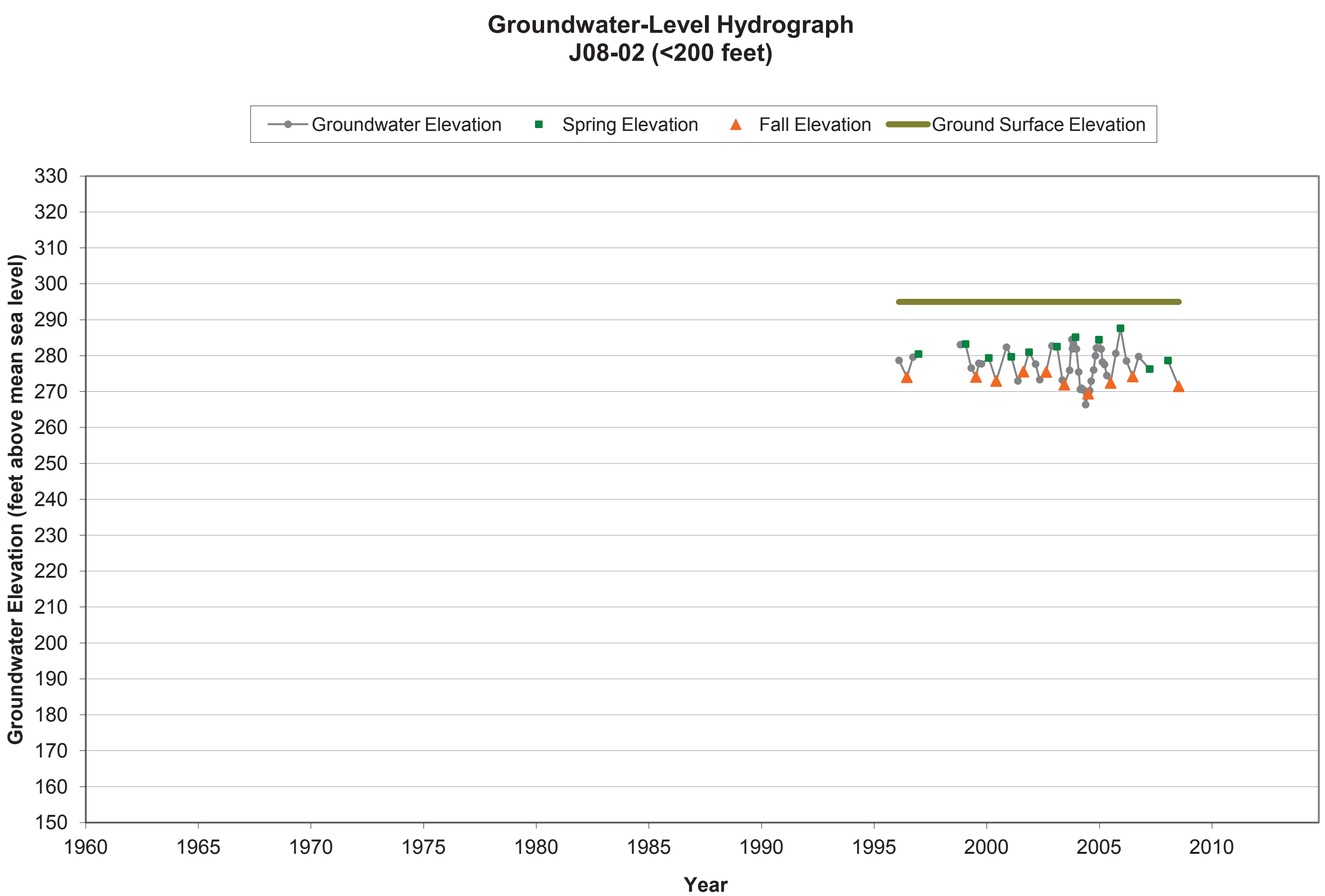


Groundwater-Level Hydrograph
J07-01 (<200 feet)



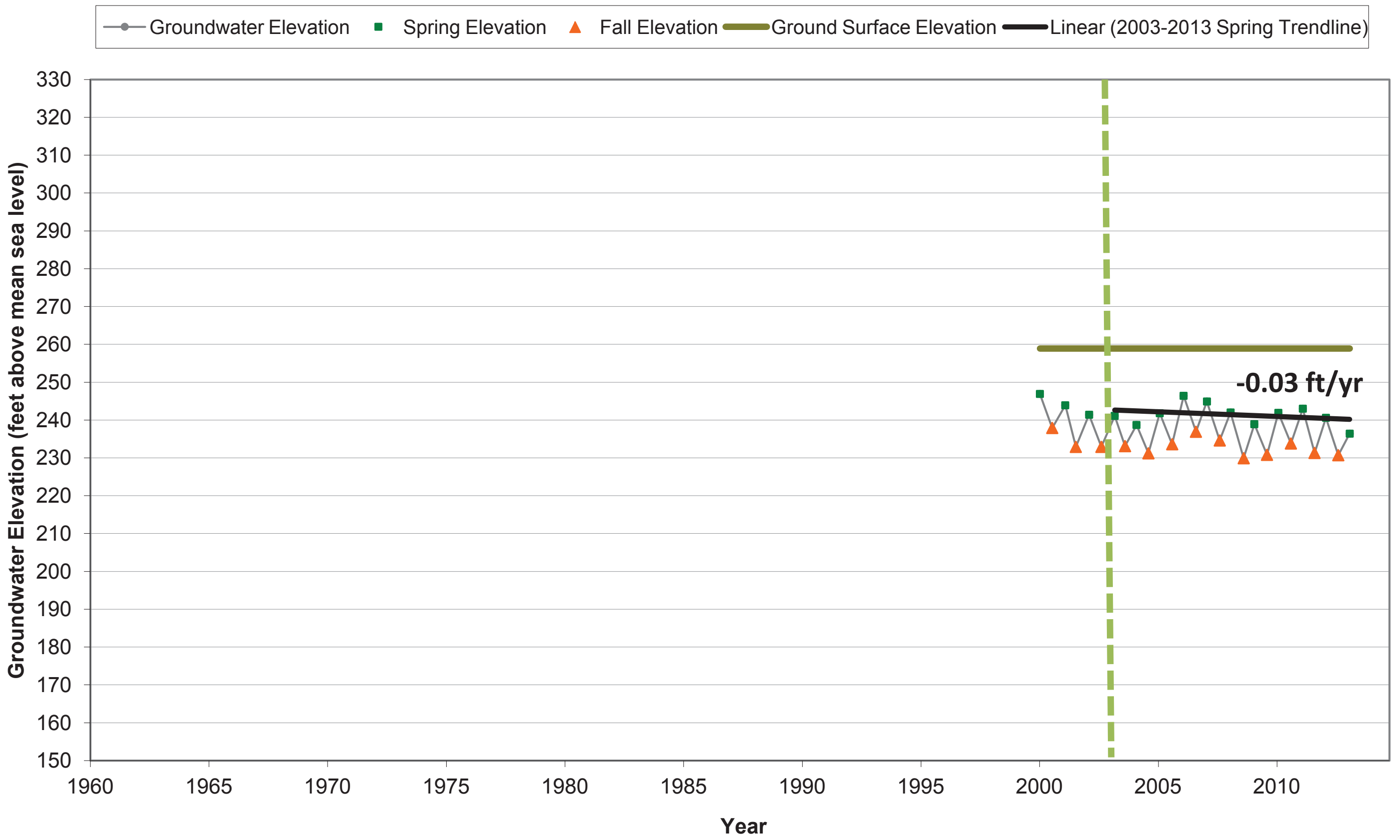


Groundwater-Level Hydrograph
J08-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Questionable Measurement
Linear (2003-2013 Spring Trendline)
-0.73 ft/yr
Groundwater Elevation (feet above mean sea level)
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

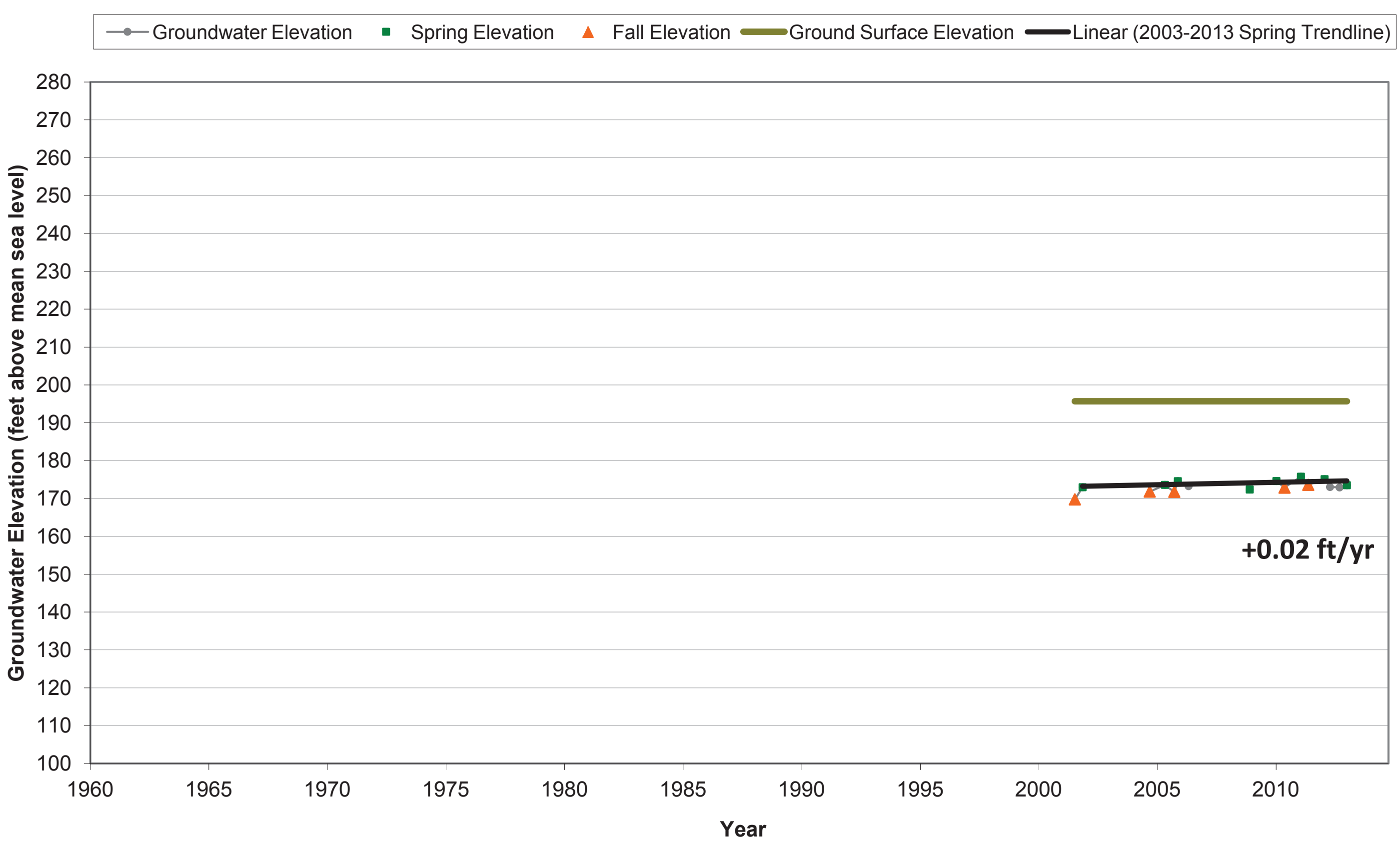


Groundwater-Level Hydrograph
J08-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

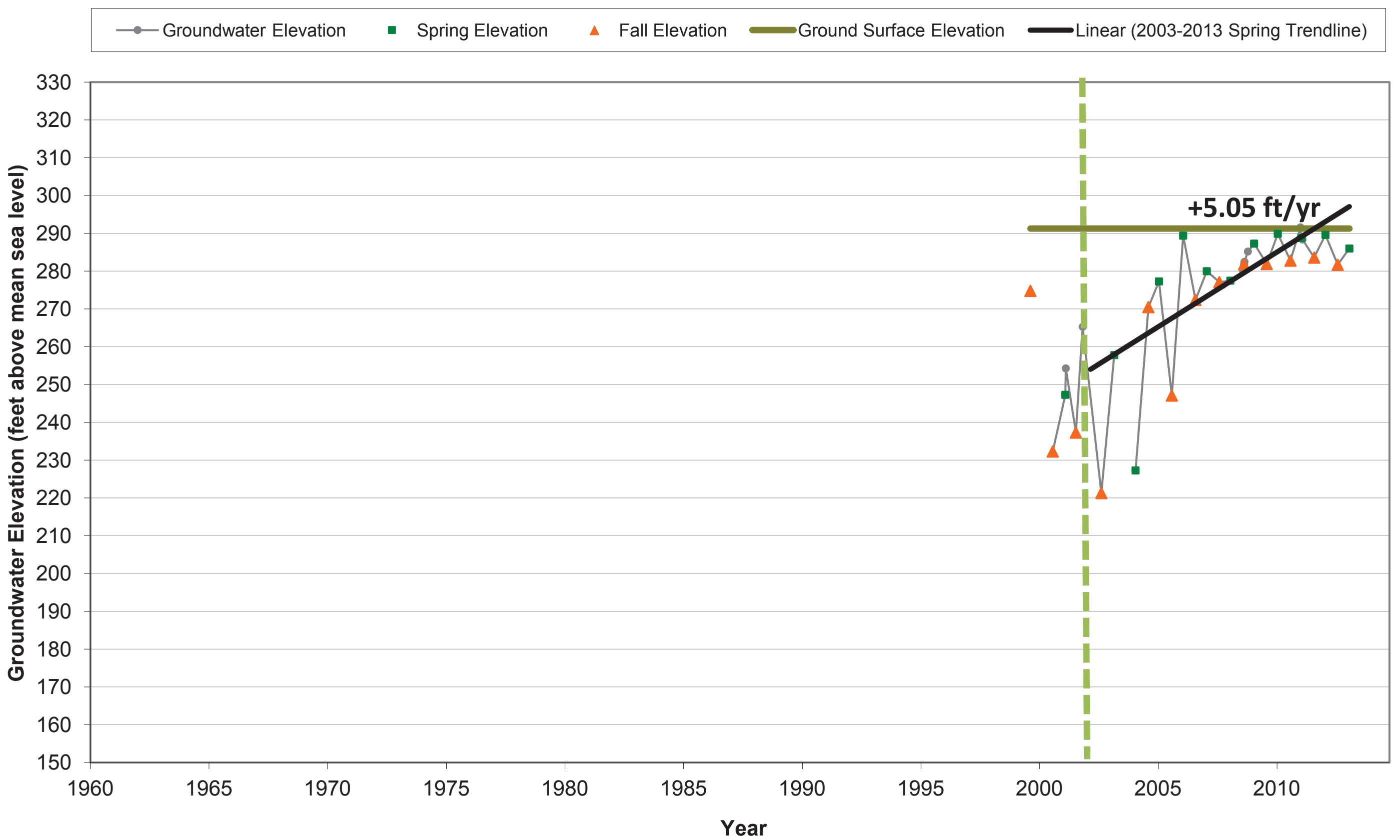
Groundwater-Level Hydrograph
J08-05 (<200 feet)



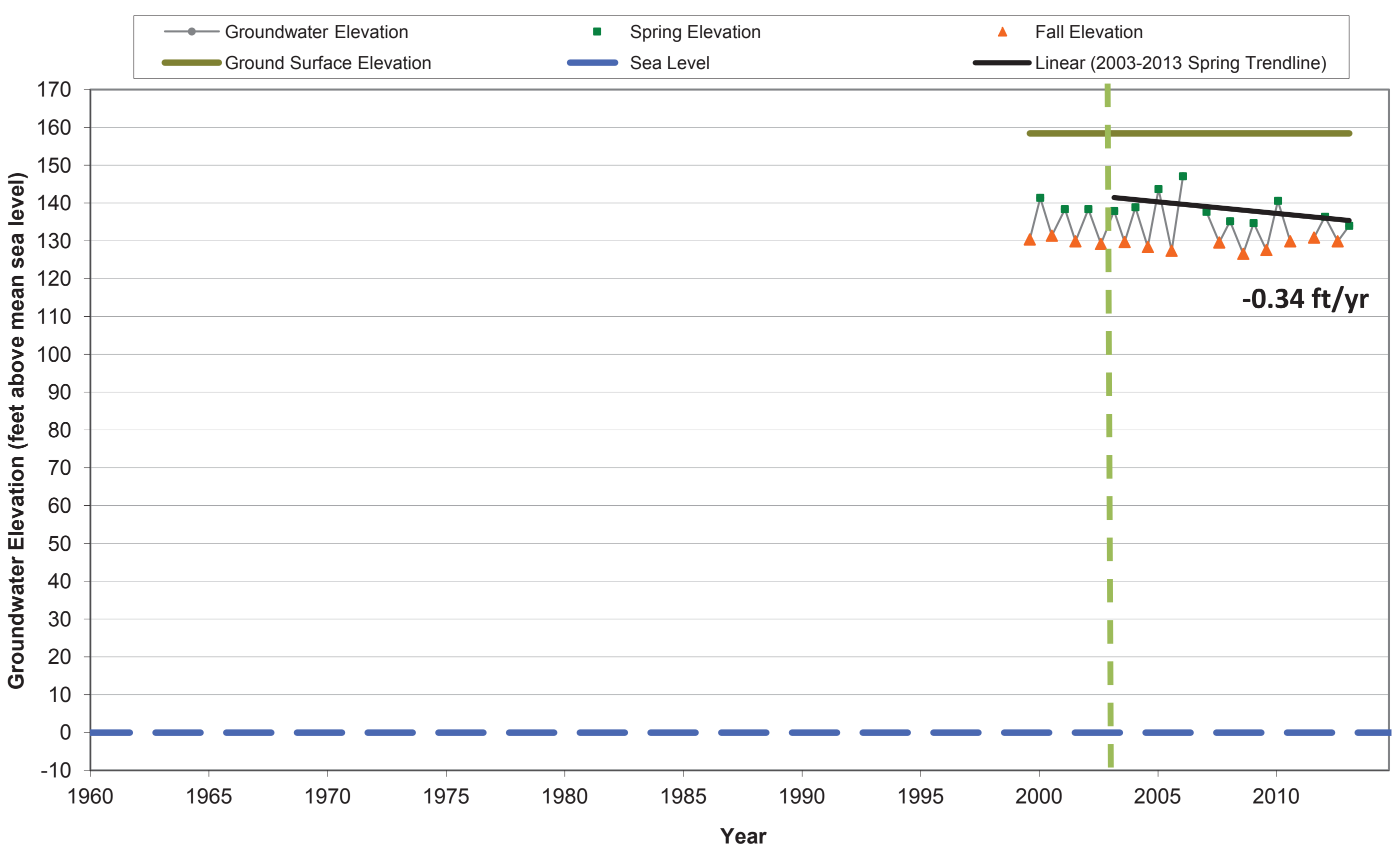
Groundwater-Level Hydrograph
J10-01 (<200 feet)

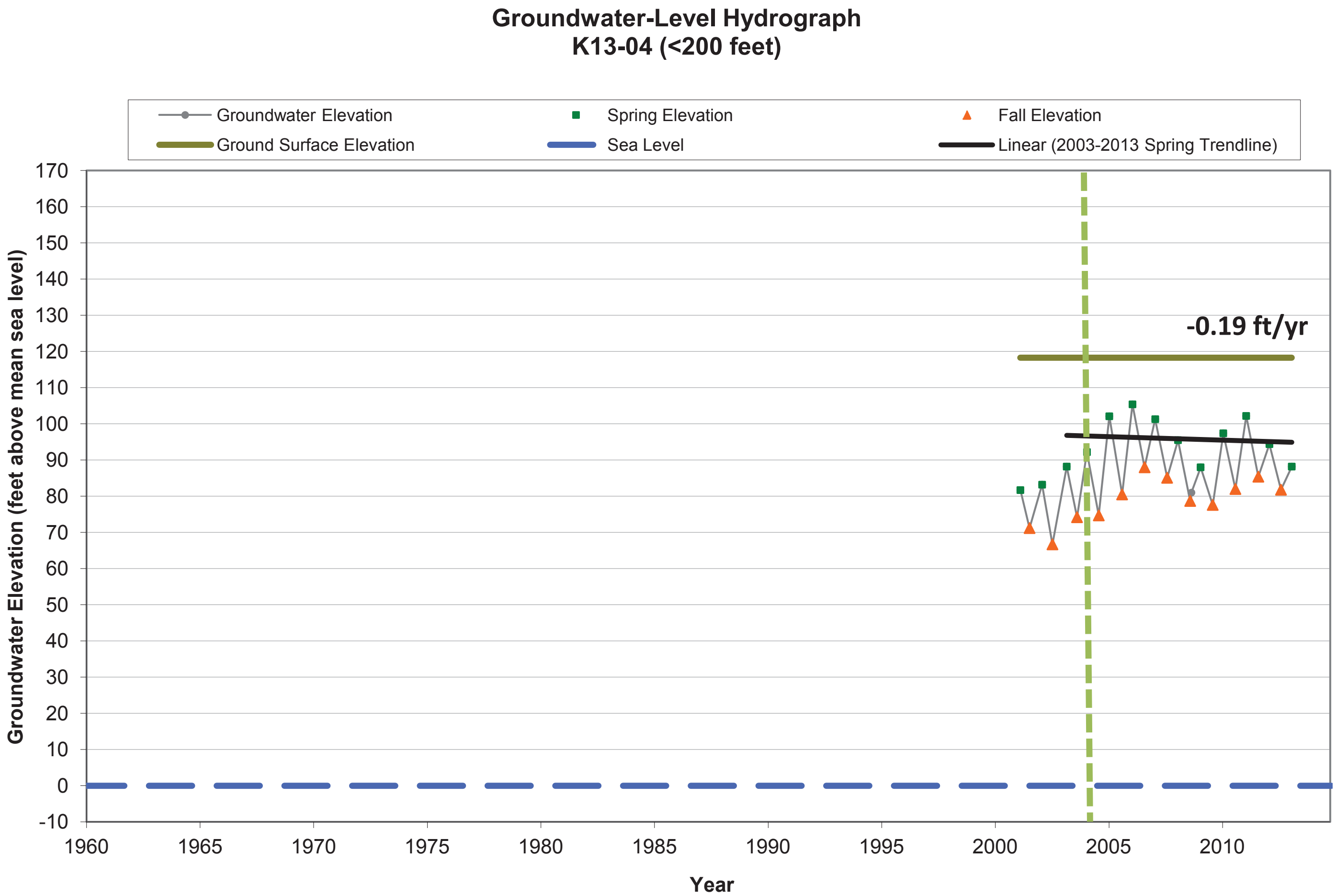


Groundwater-Level Elevation
J13-01 (<200 feet)

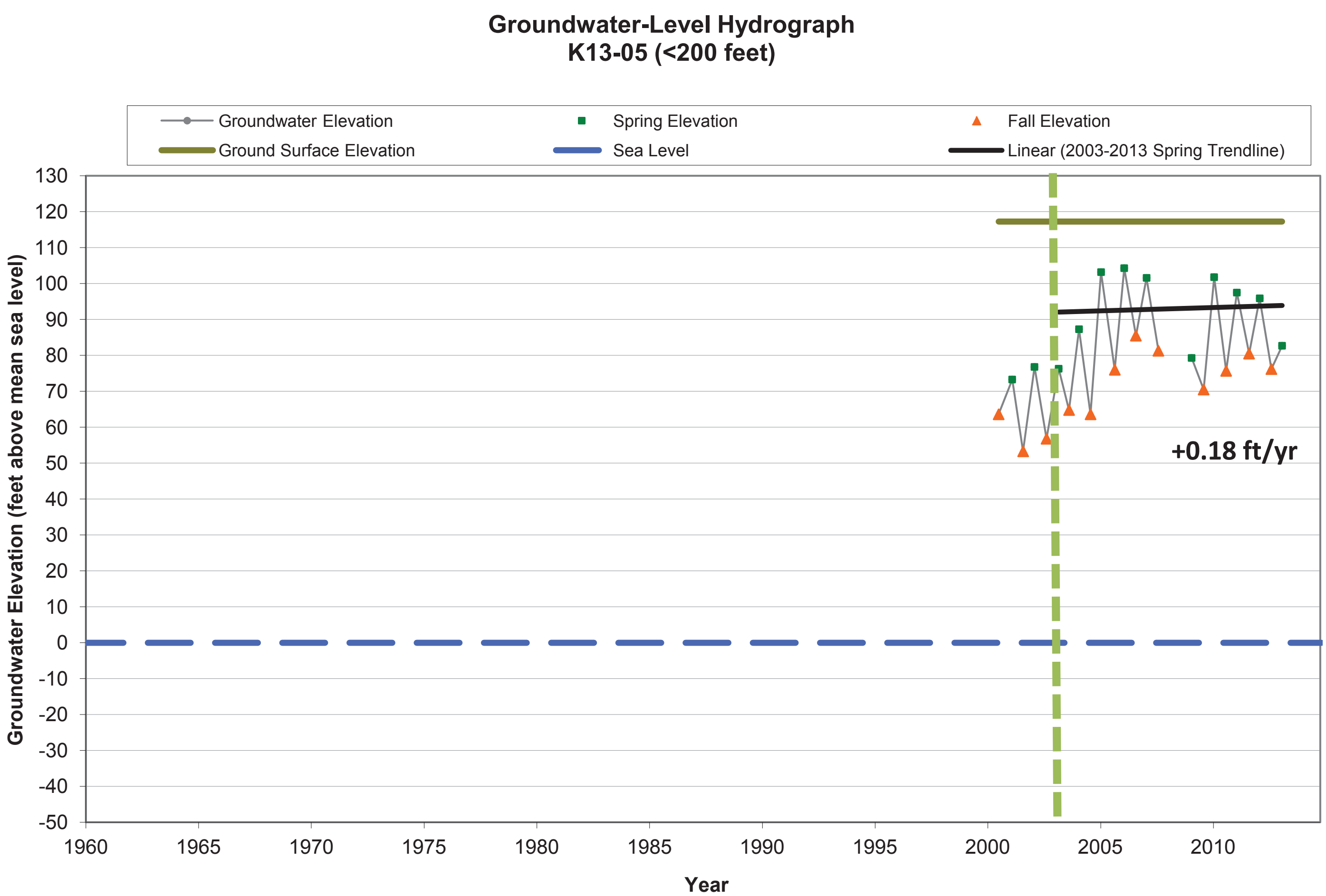


Groundwater-Level Hydrograph
K11-01 (<200 feet)



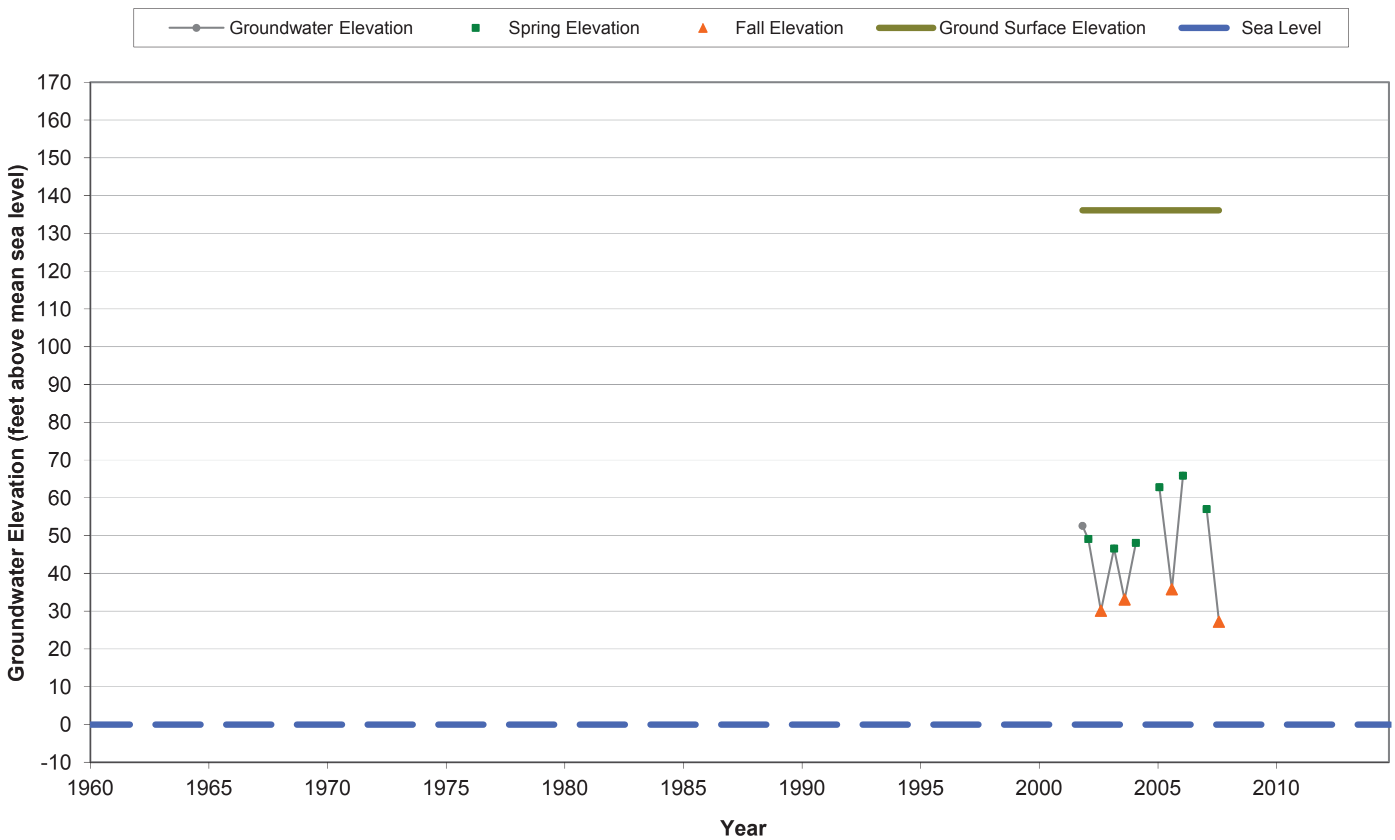


Groundwater-Level Hydrograph
K13-04 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-0.19 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

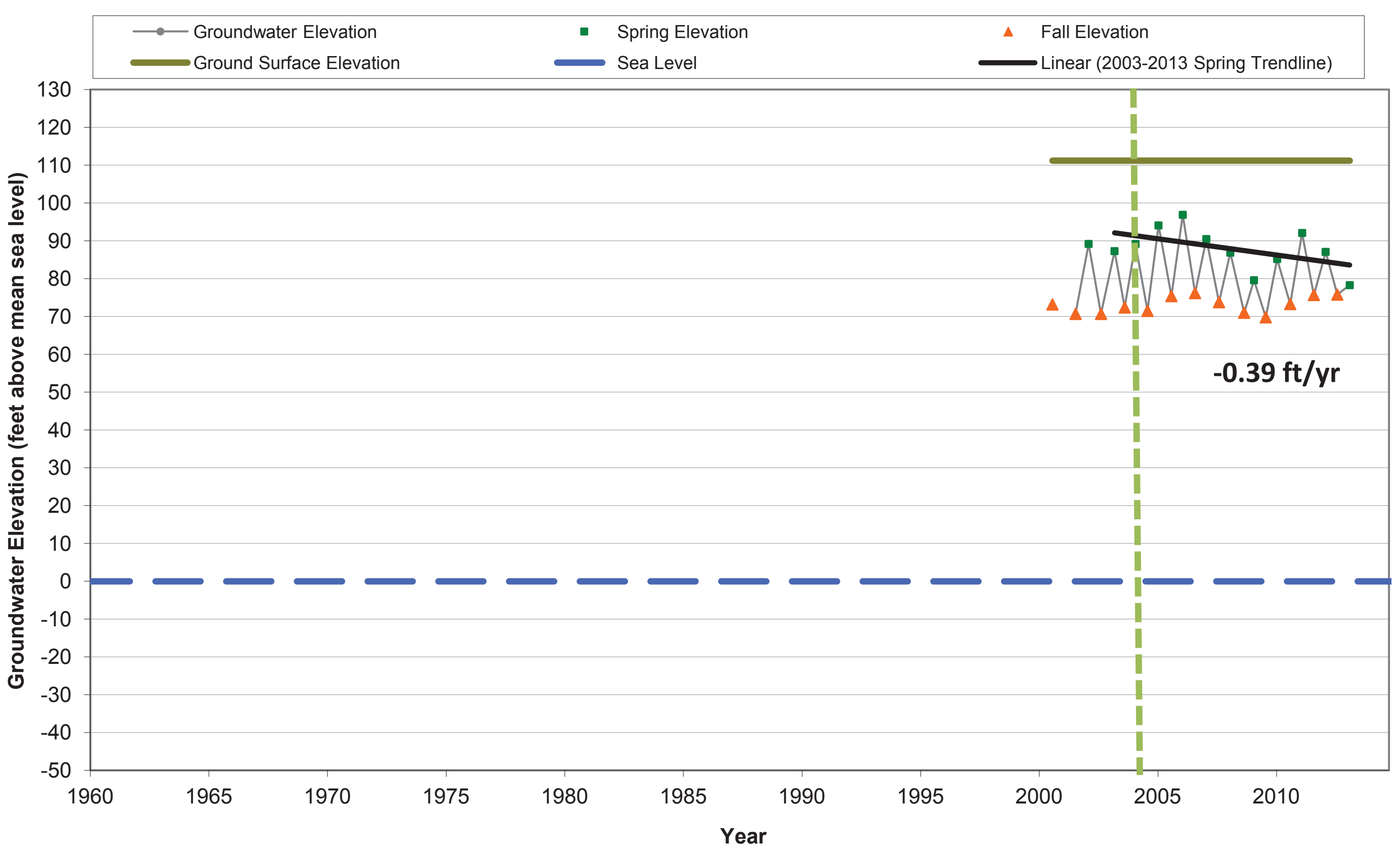


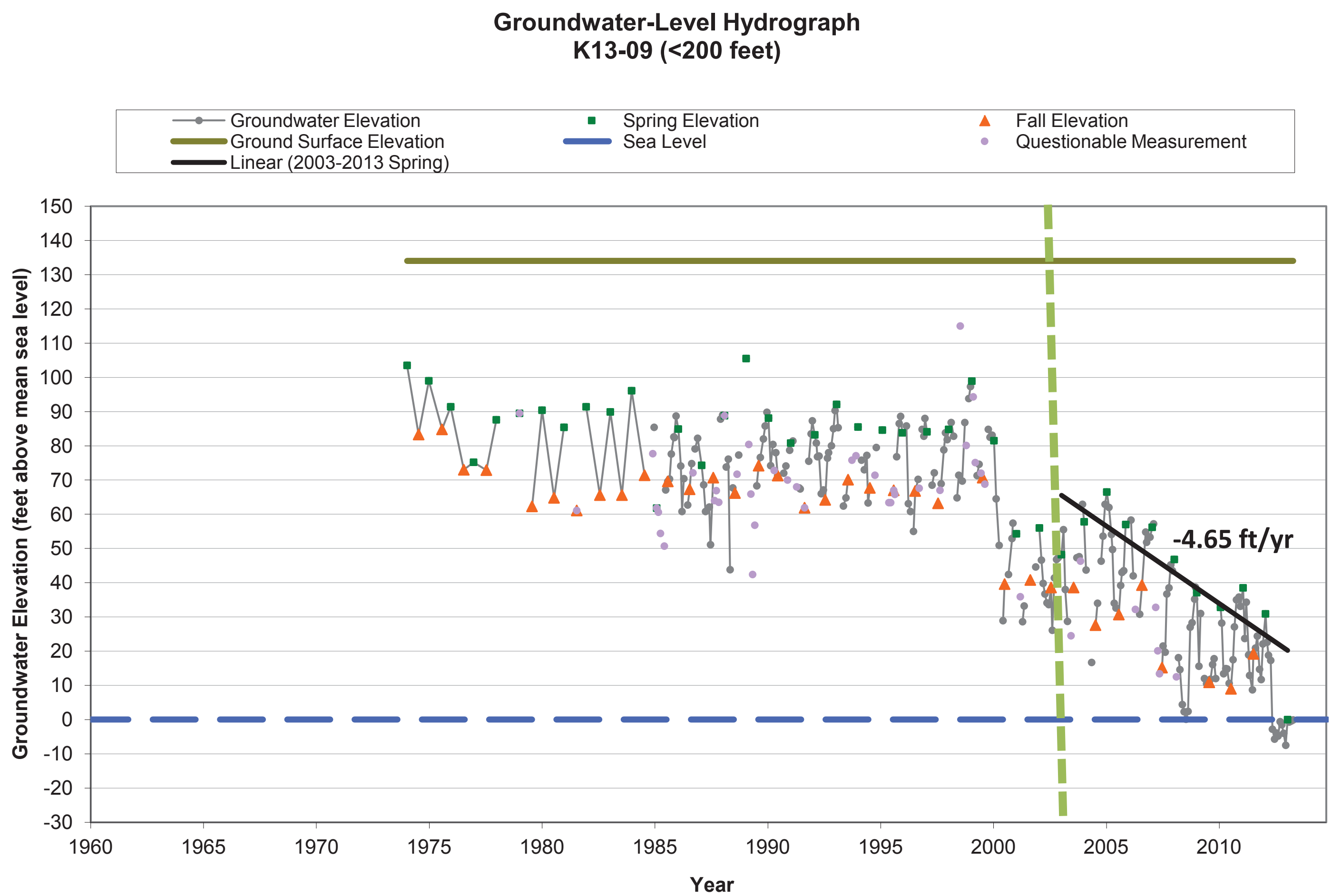
Groundwater-Level Hydrograph
K13-05 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
+0.18 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

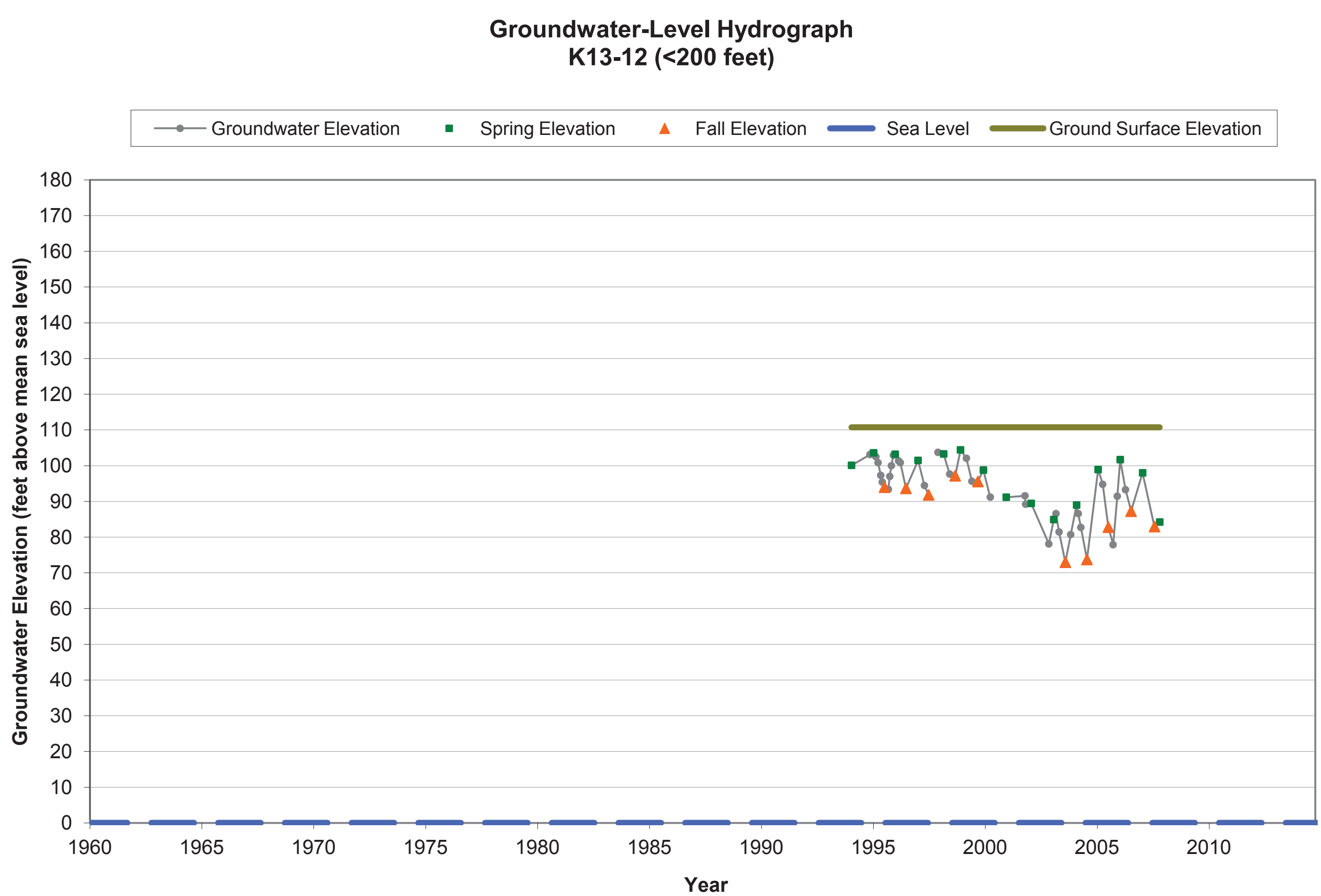
Groundwater-Level Hydrograph
K13-06 (<200 feet)



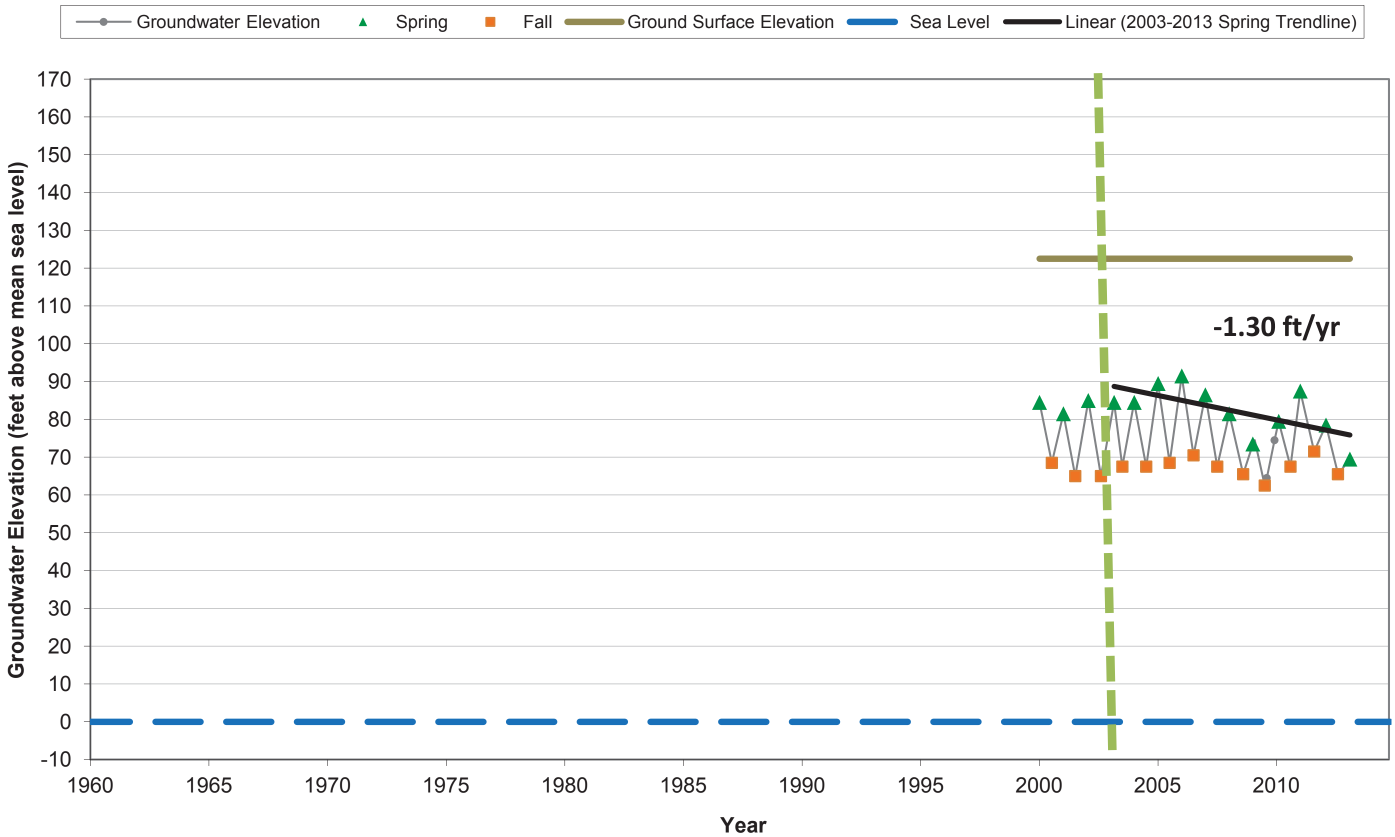
Groundwater-Level Hydrograph
K13-07 (<200 feet)



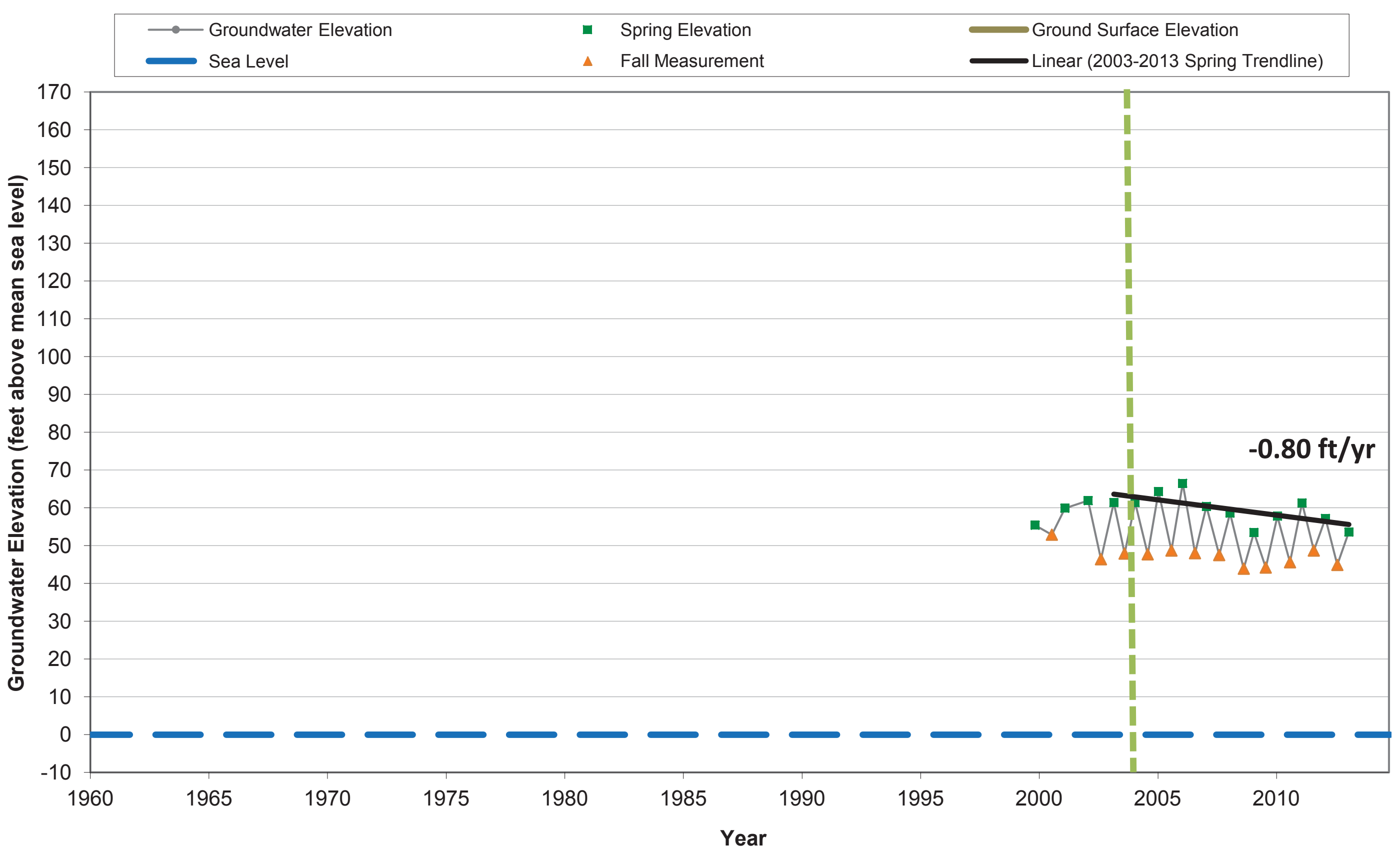

Groundwater-Level Hydrograph
K13-09 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Questionable Measurement
Linear (2003-2013 Spring)
-4.65 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

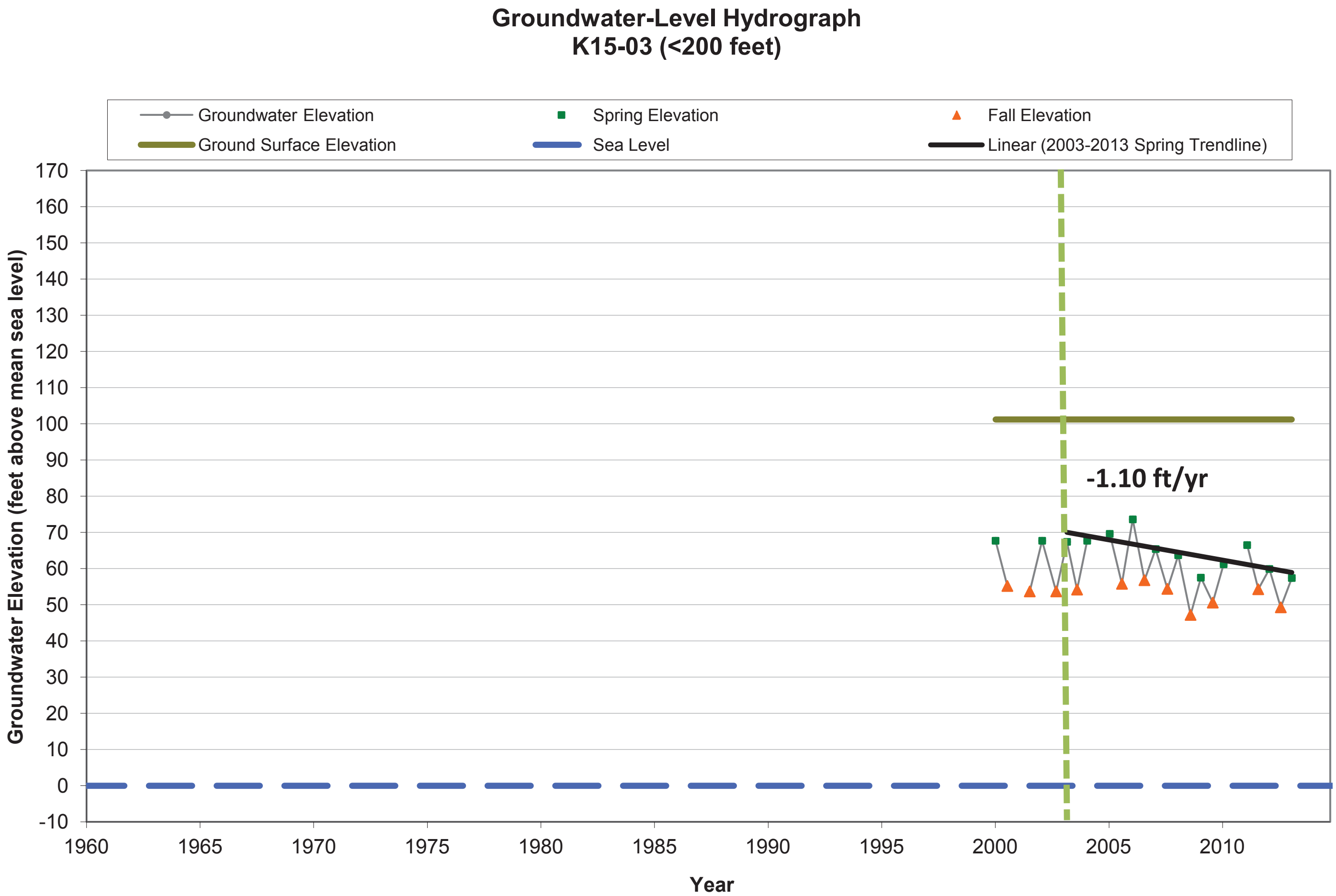

Groundwater-Level Hydrograph
K13-12 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
Year
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Groundwater-Level Hydrograph
K14-04 (<200 feet)

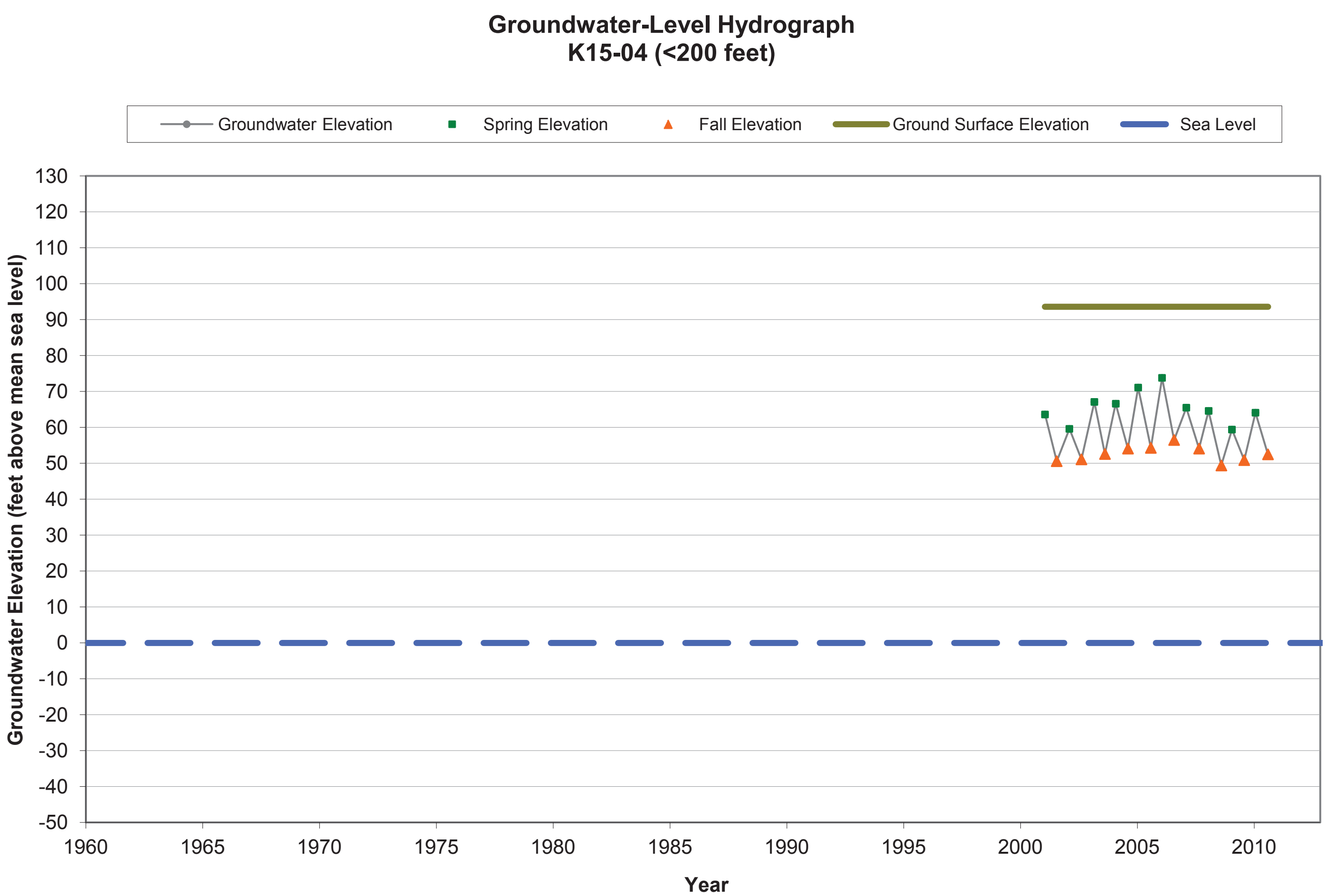


Groundwater-Level Hydrograph
K15-01 (<200 feet)



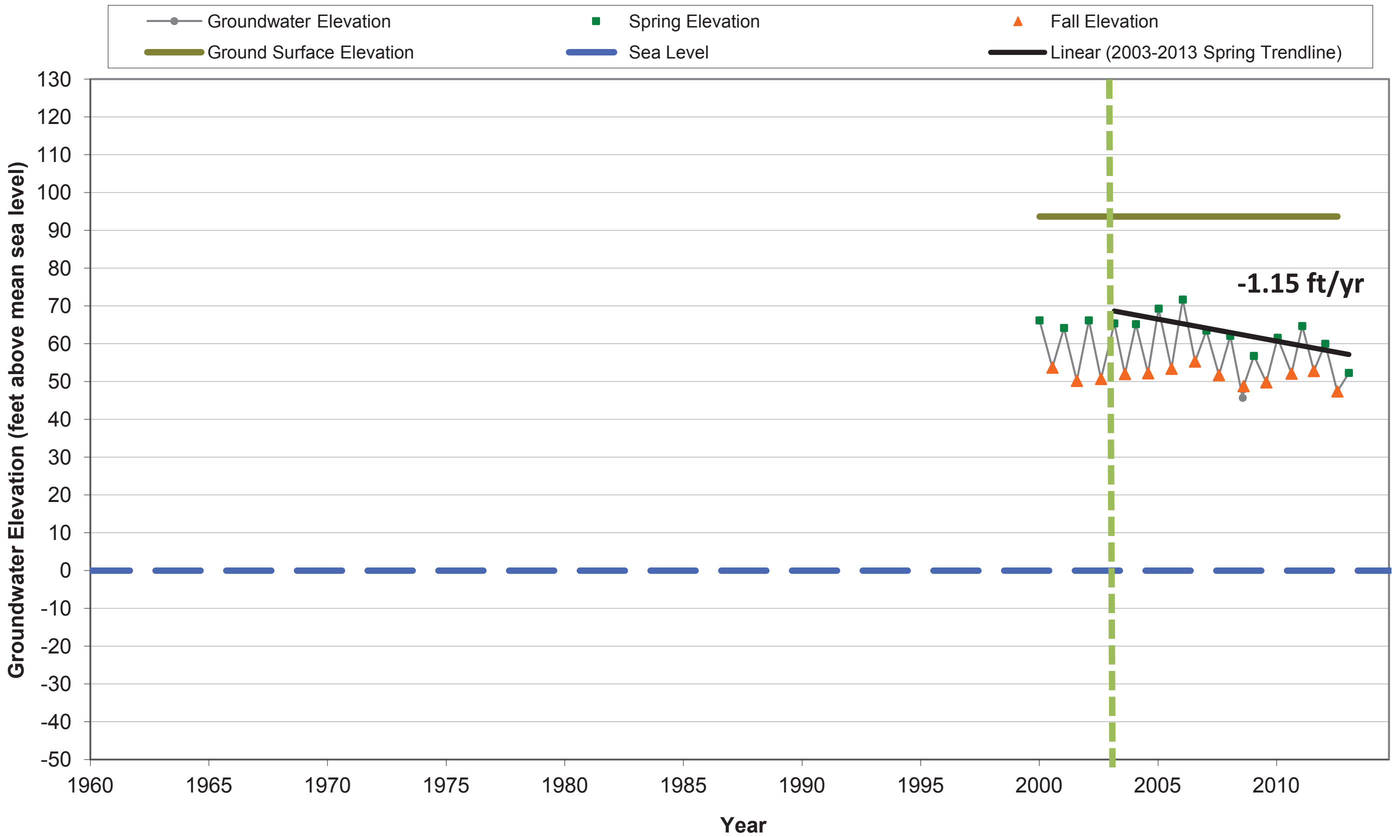


Groundwater-Level Hydrograph
K15-03 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-1.10 ft/yr
Groundwater Elevation (feet above mean sea level)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

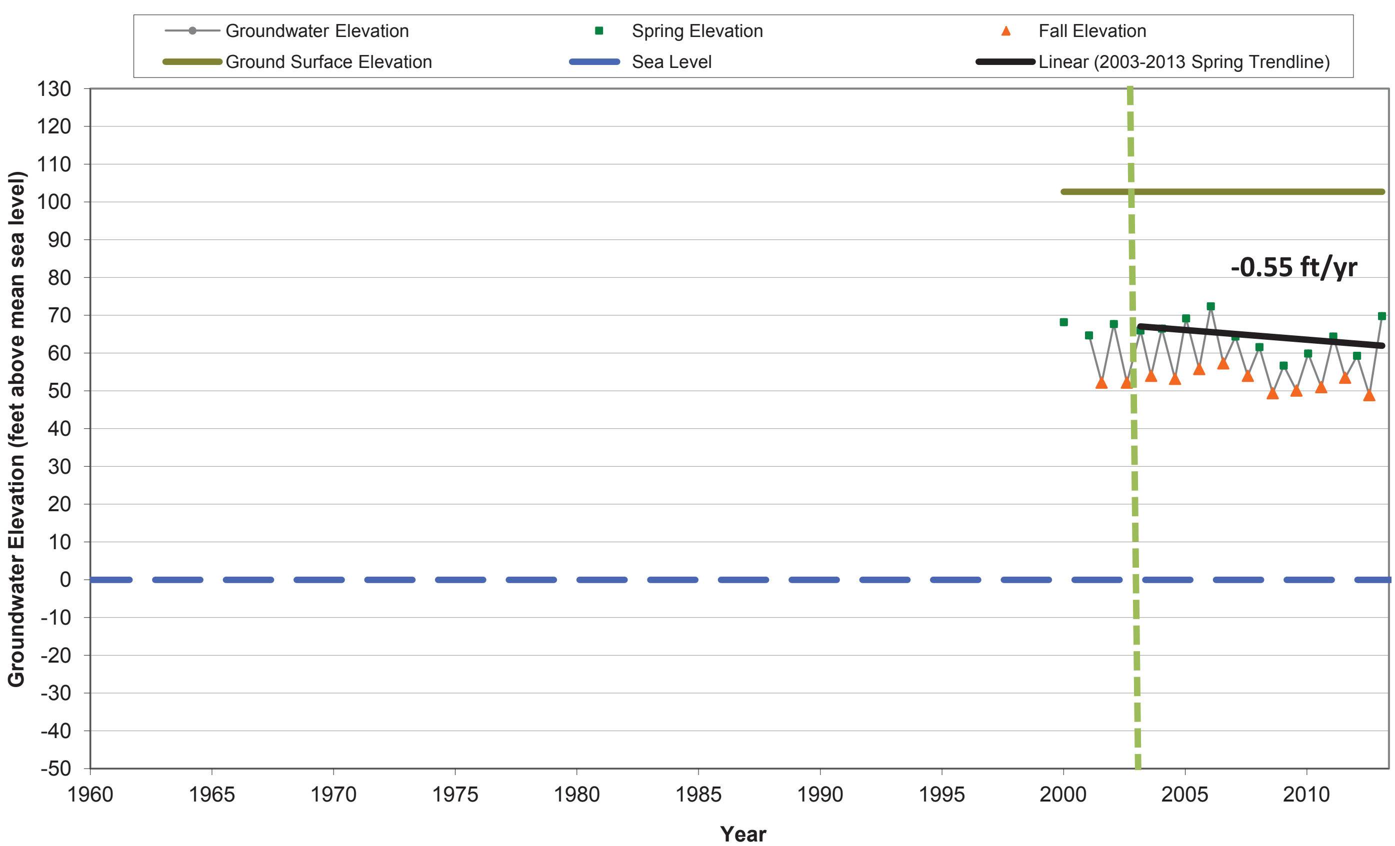


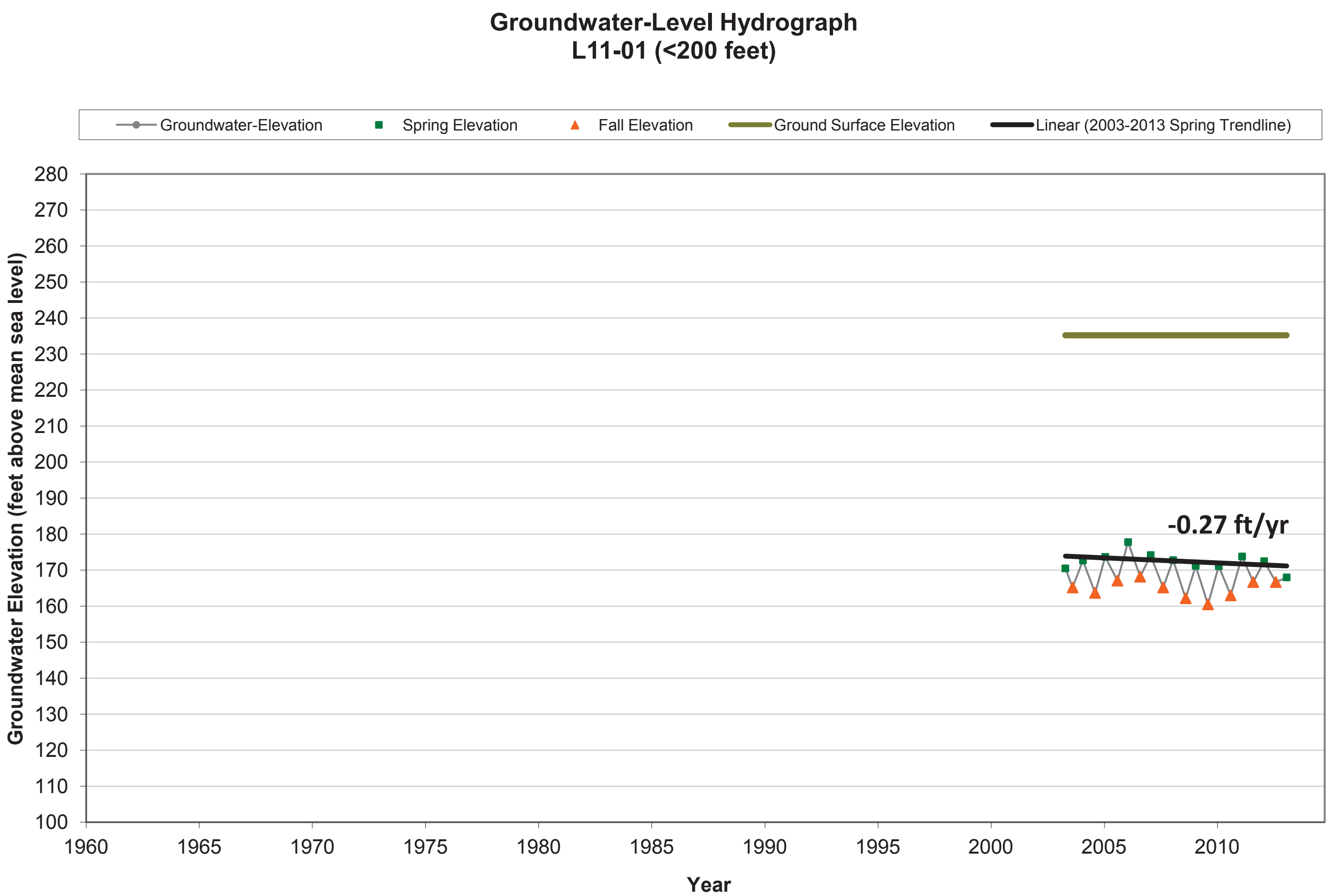
Groundwater-Level Hydrograph
K15-04 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

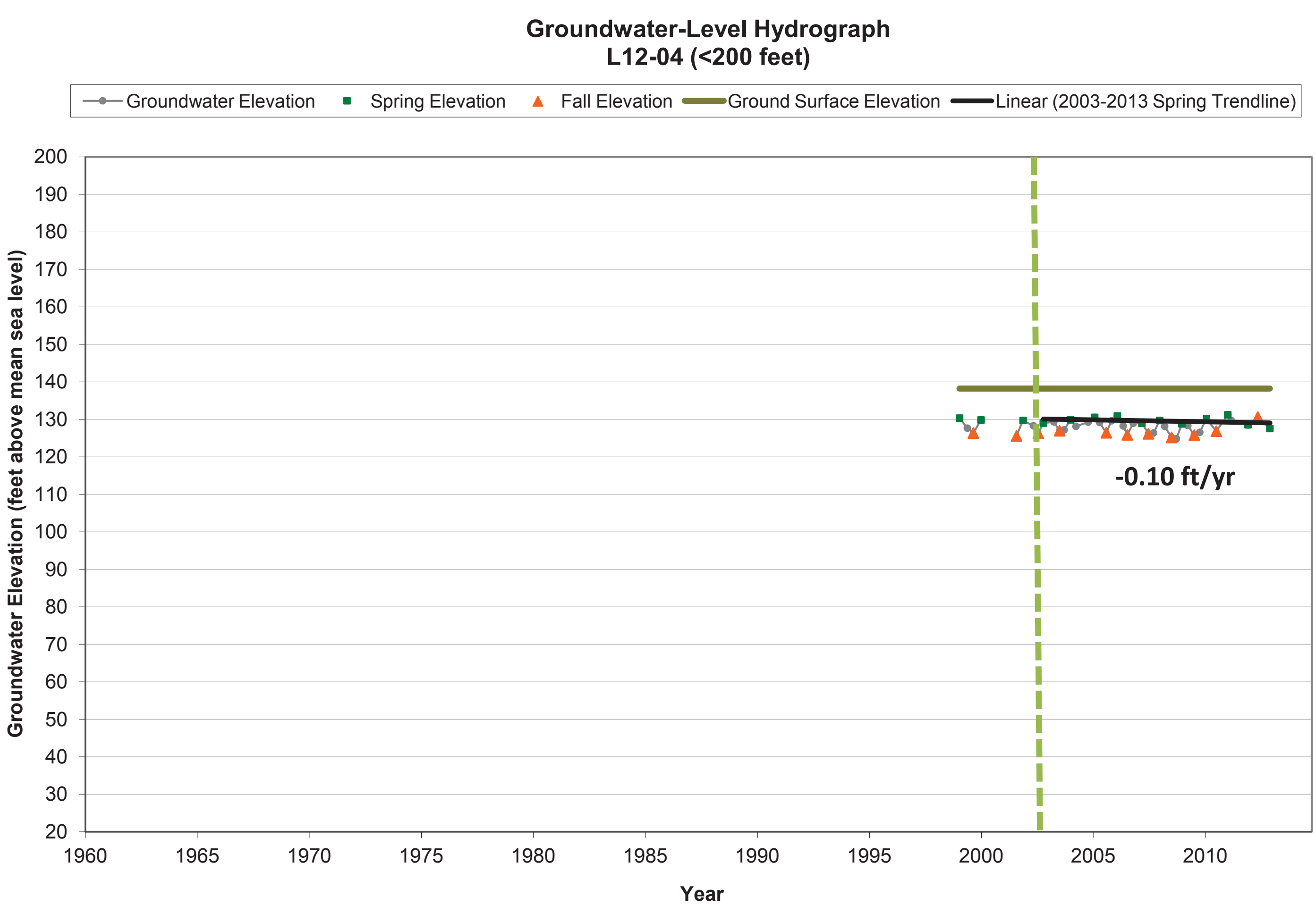
Groundwater-Level Hydrograph
K15-05 (<200 feet)



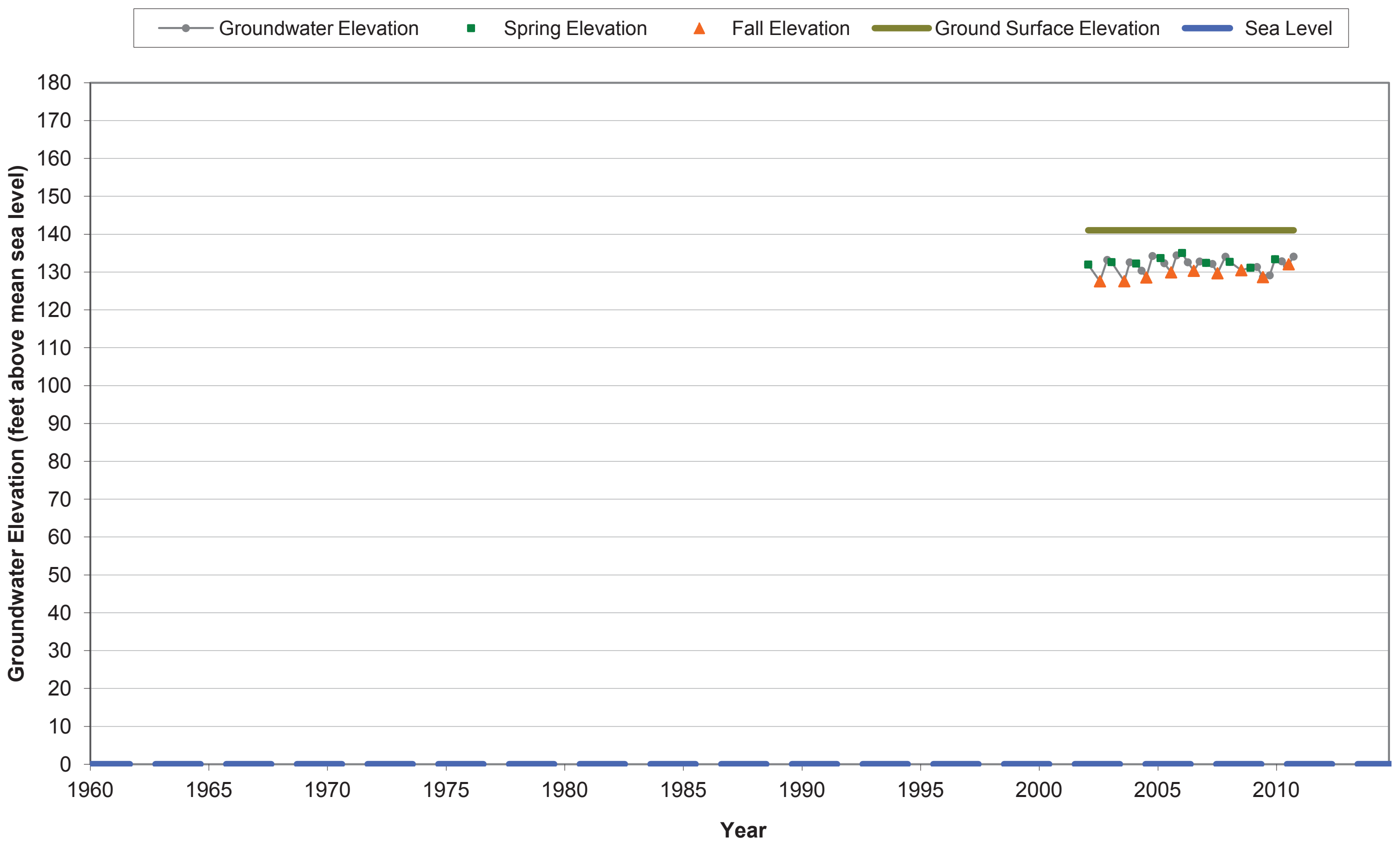
Groundwater-Level Hydrograph
K15-06 (<200 feet)



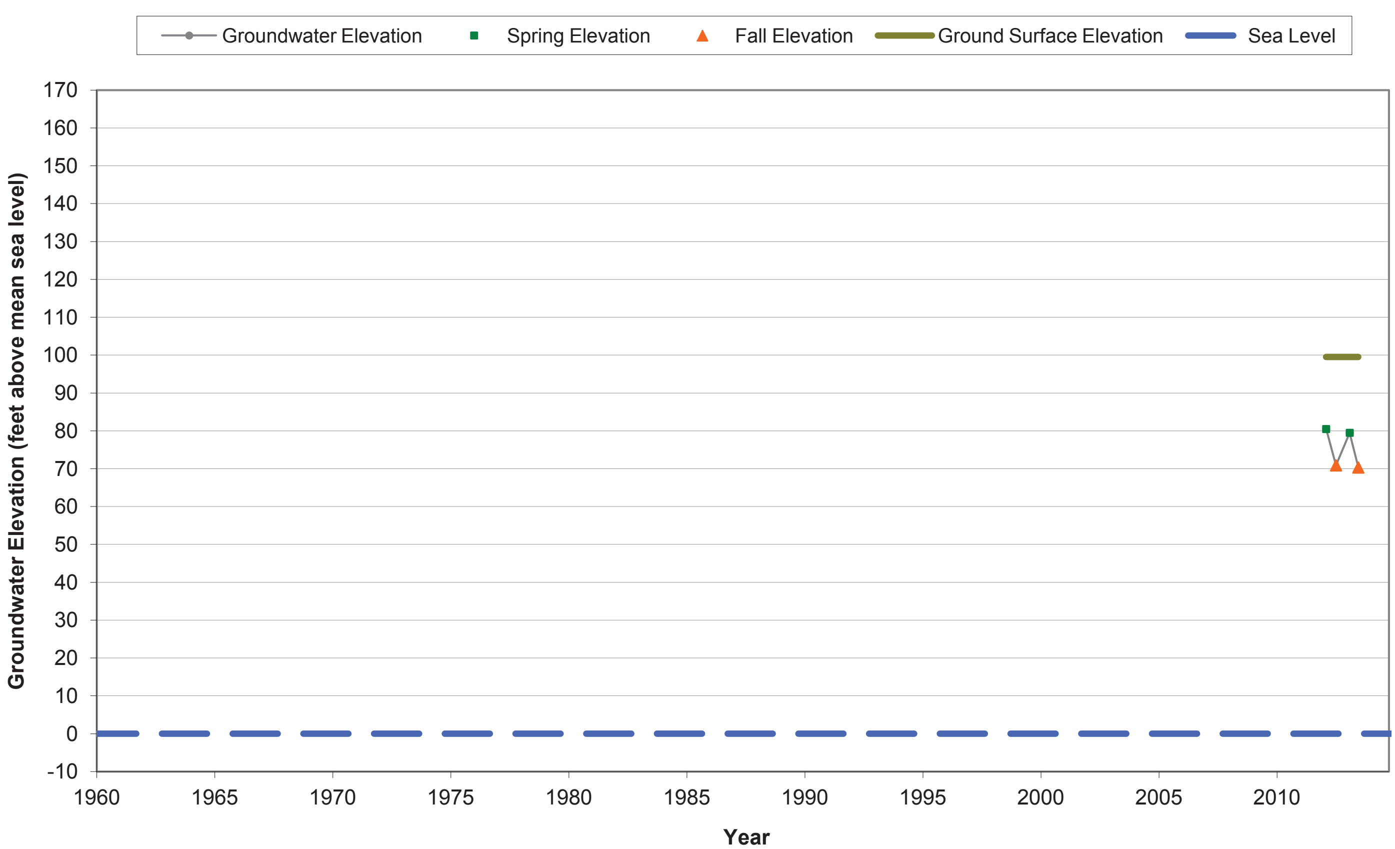

Groundwater-Level Hydrograph
L11-01 (<200 feet)
Groundwater-Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-0.27 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

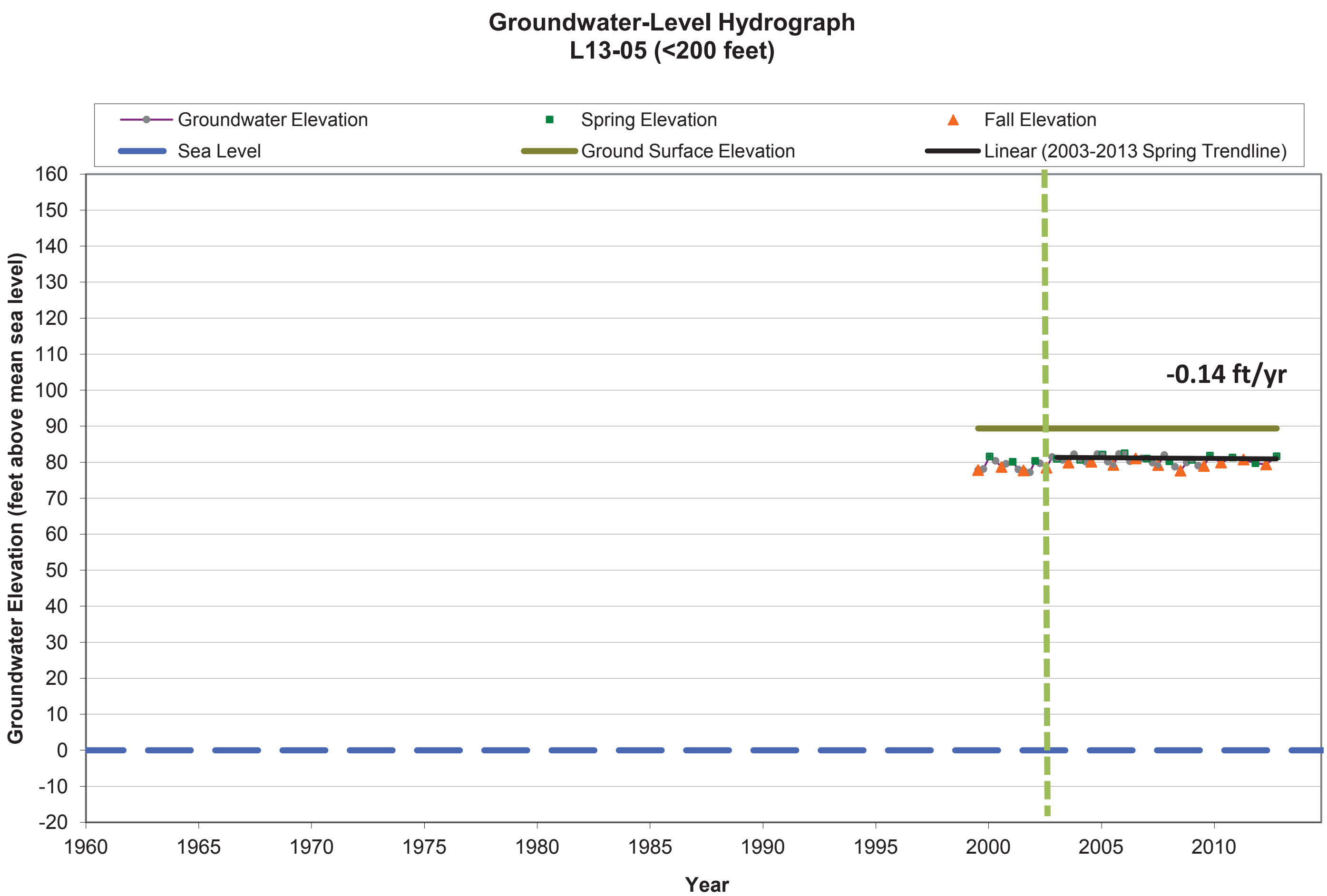

Groundwater-Level Hydrograph
L12-04 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-0.10 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

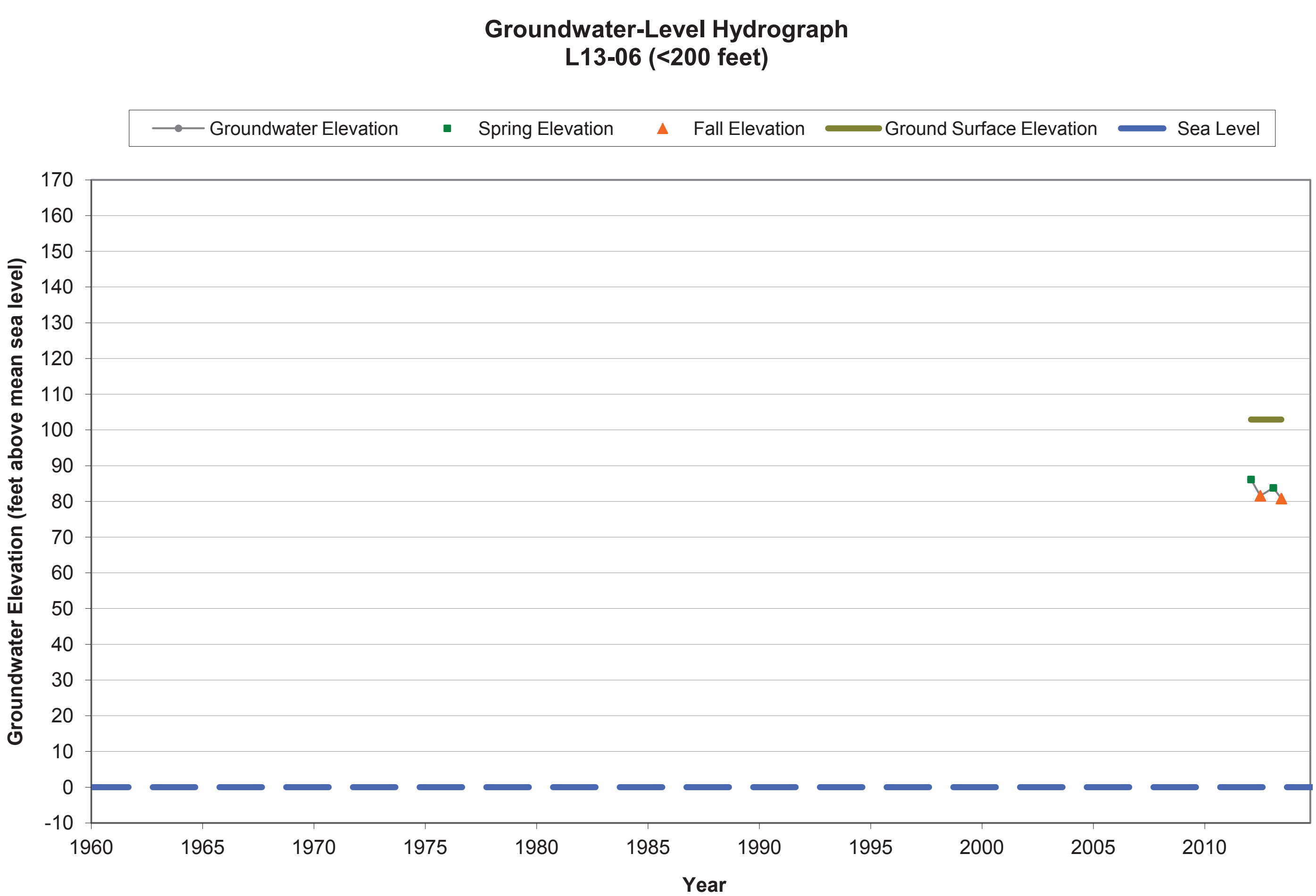
Groundwater-Level Hydrograph
L12-05 (<200 feet)

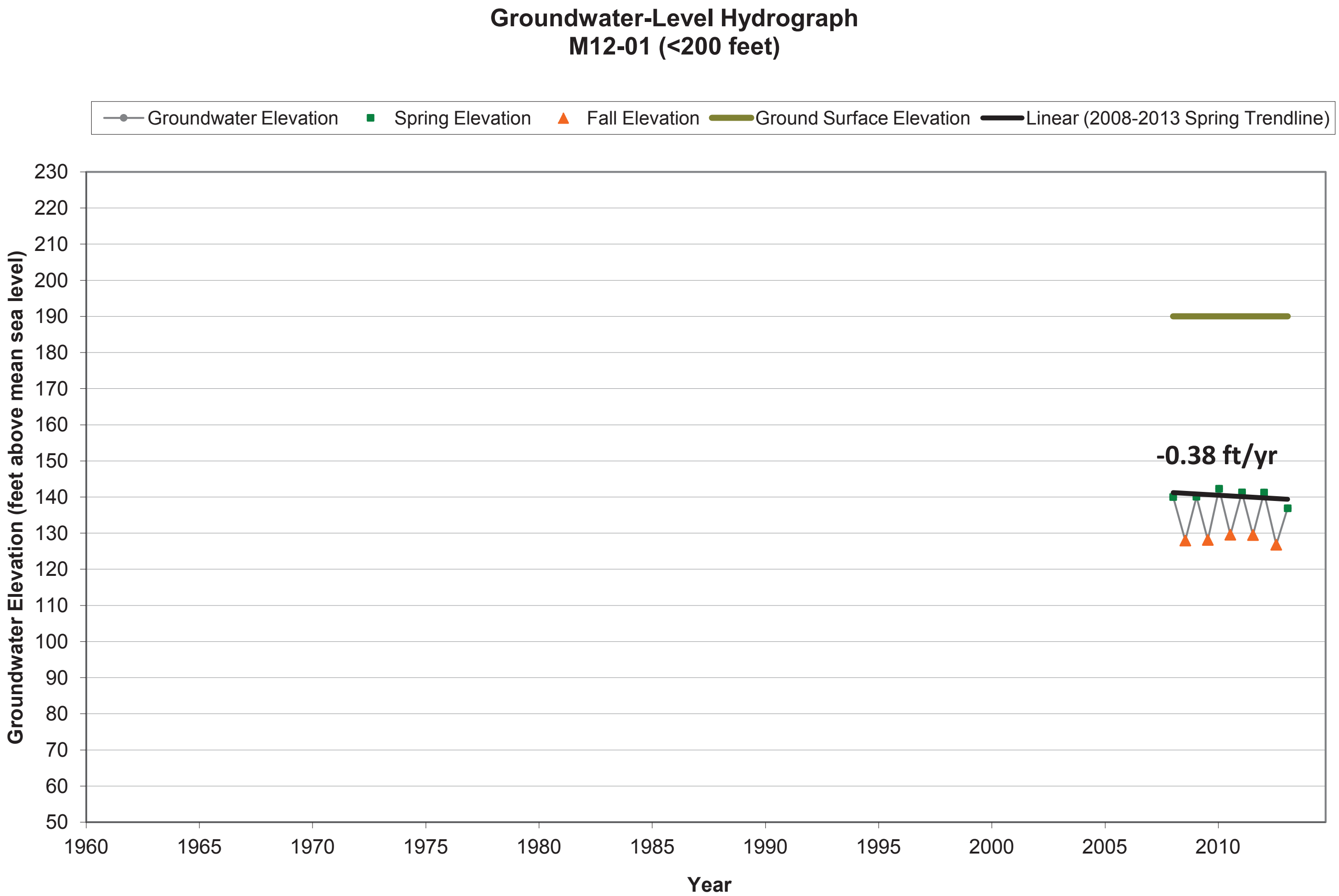


Groundwater-Level Hydrograph
L12-07 (<200 feet)

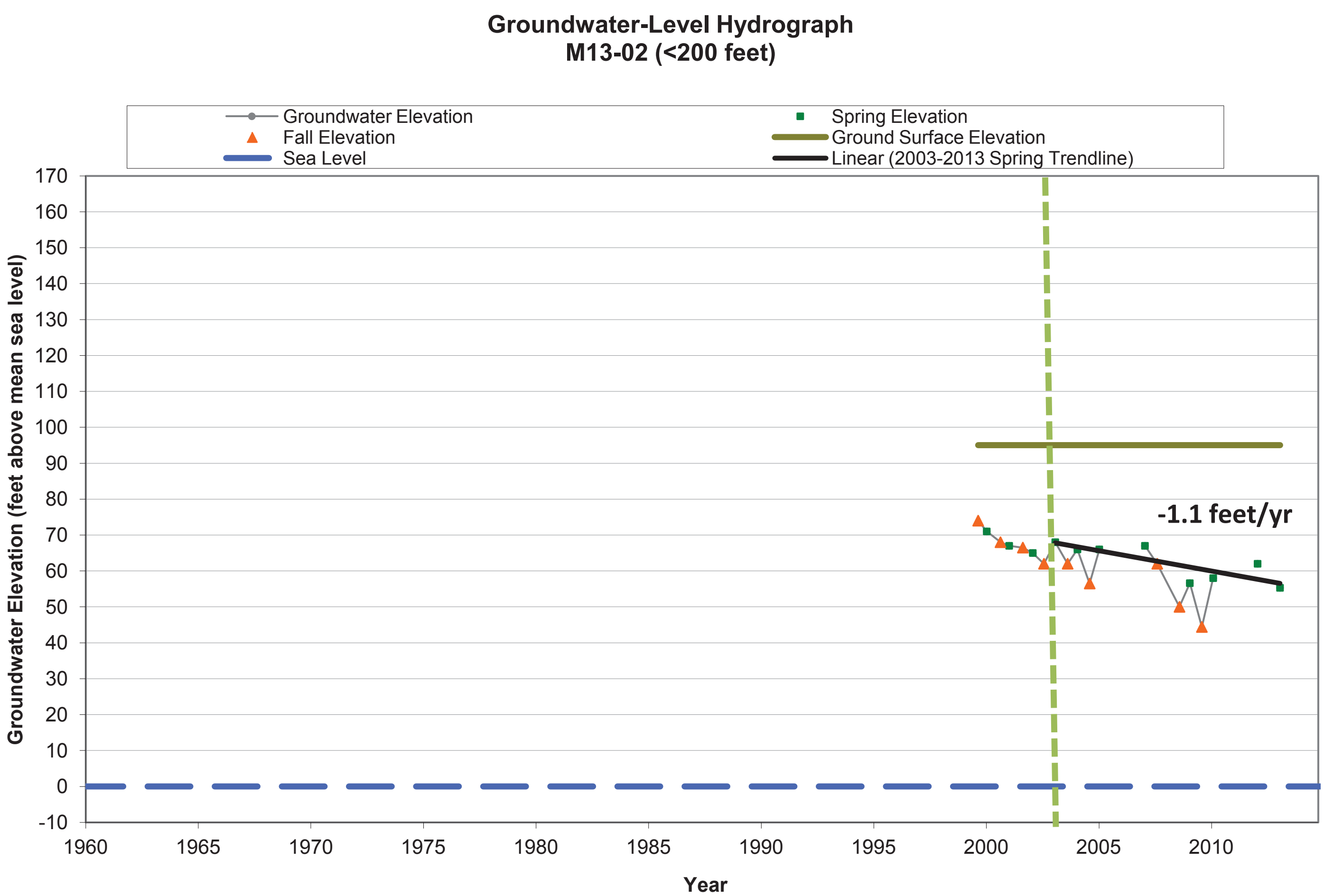



Groundwater-Level Hydrograph
L13-05 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-0.14 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

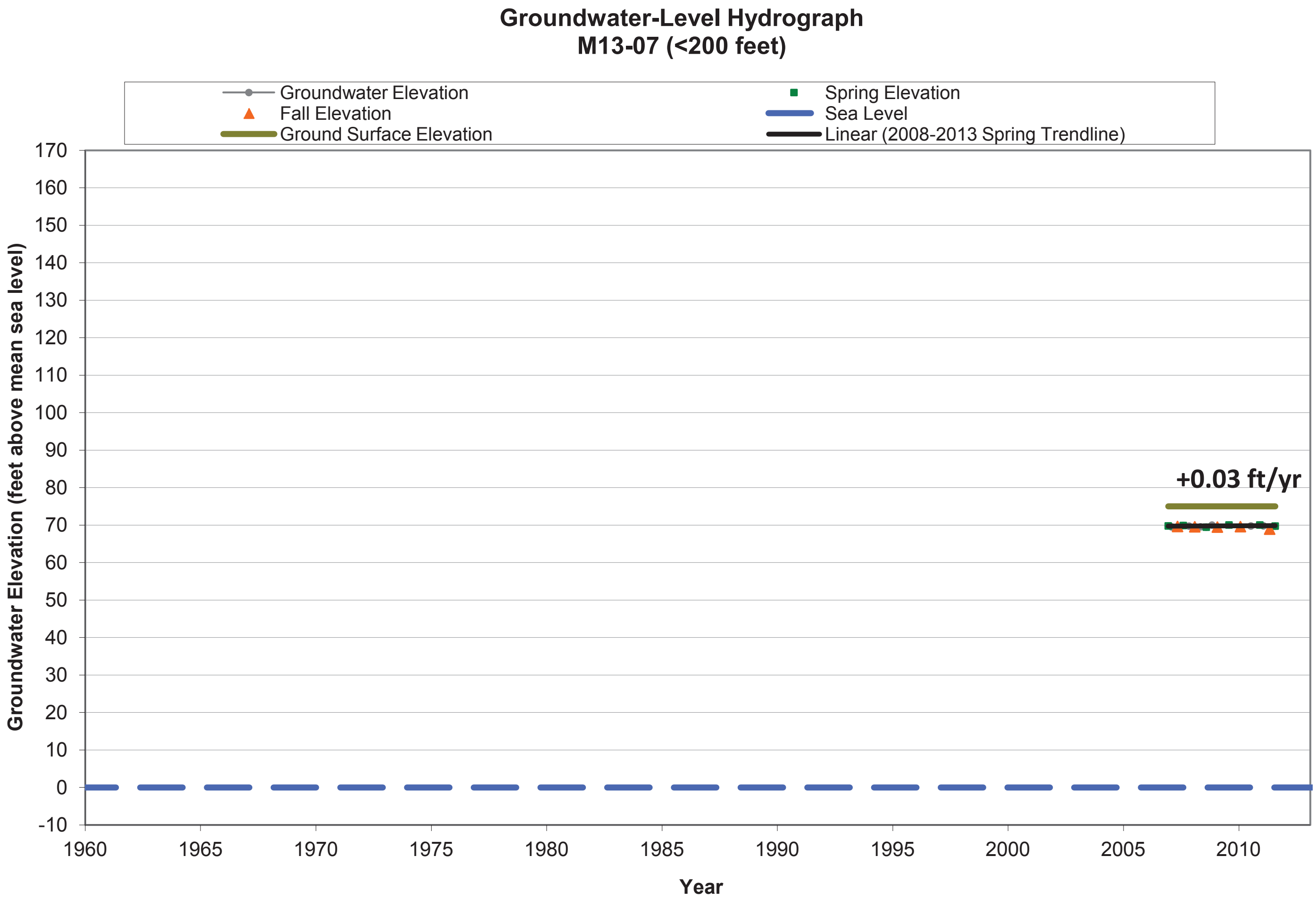

Groundwater-Level Hydrograph
L13-06 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

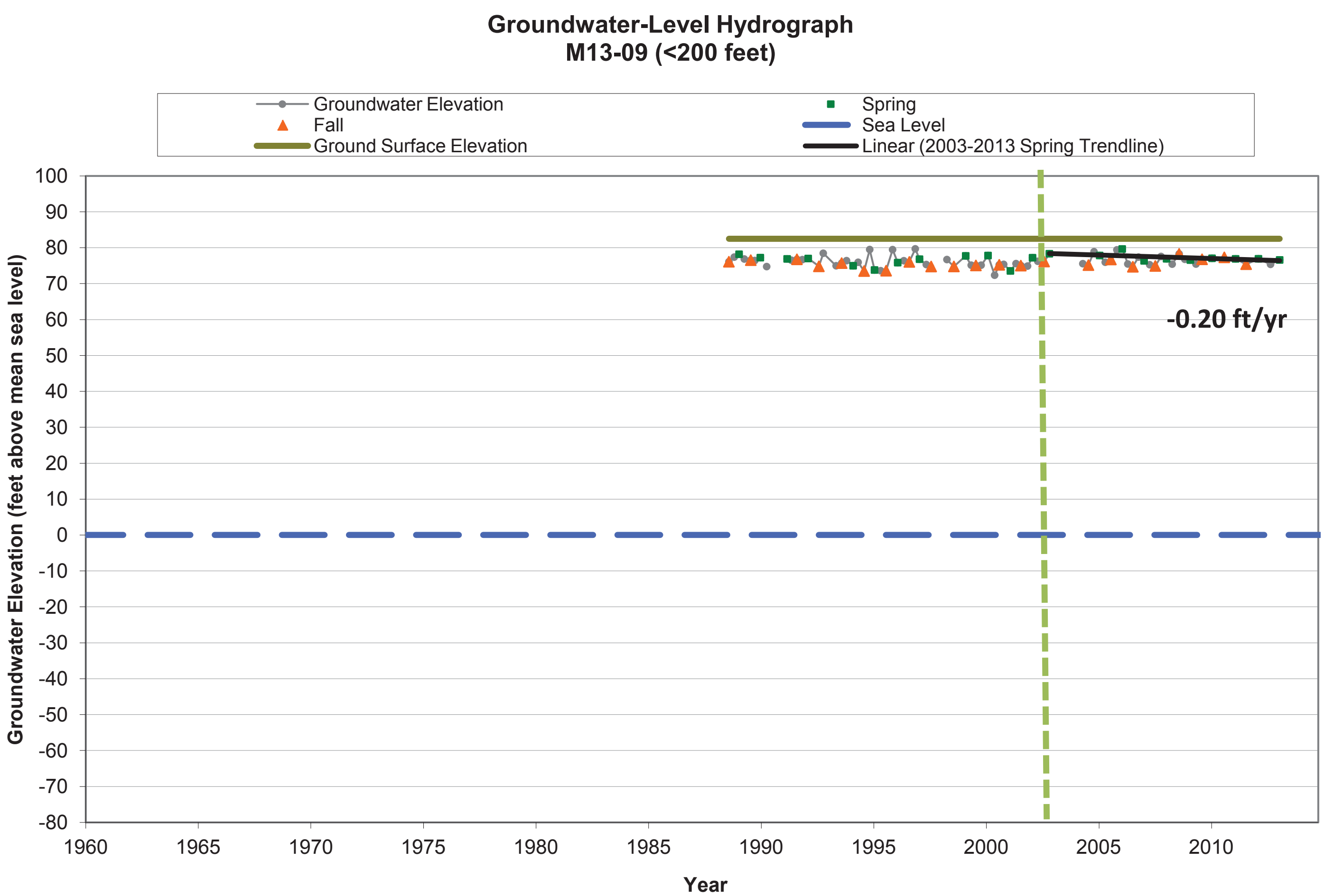


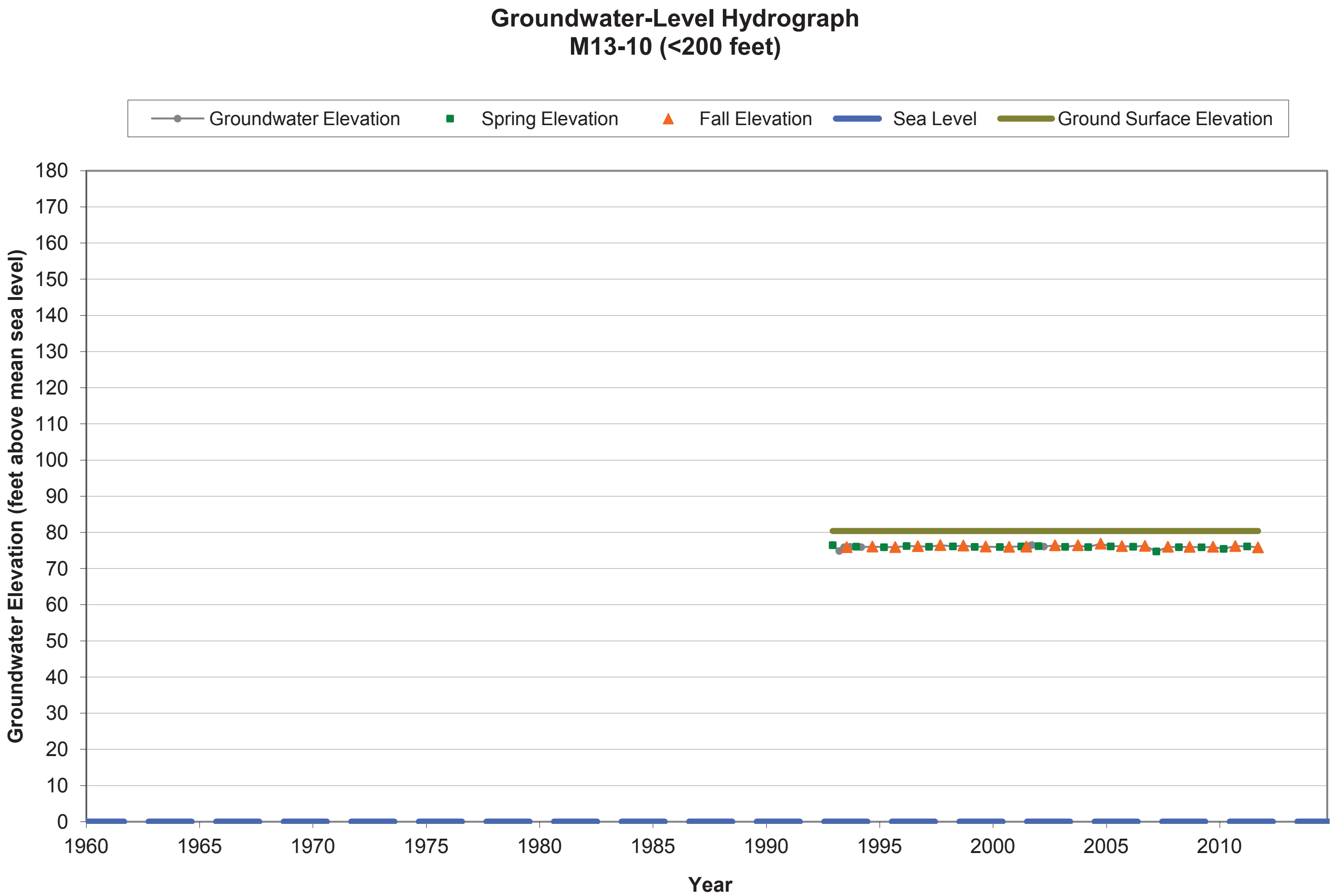
Groundwater-Level Hydrograph
M12-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2008-2013 Spring Trendline)
-0.38 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

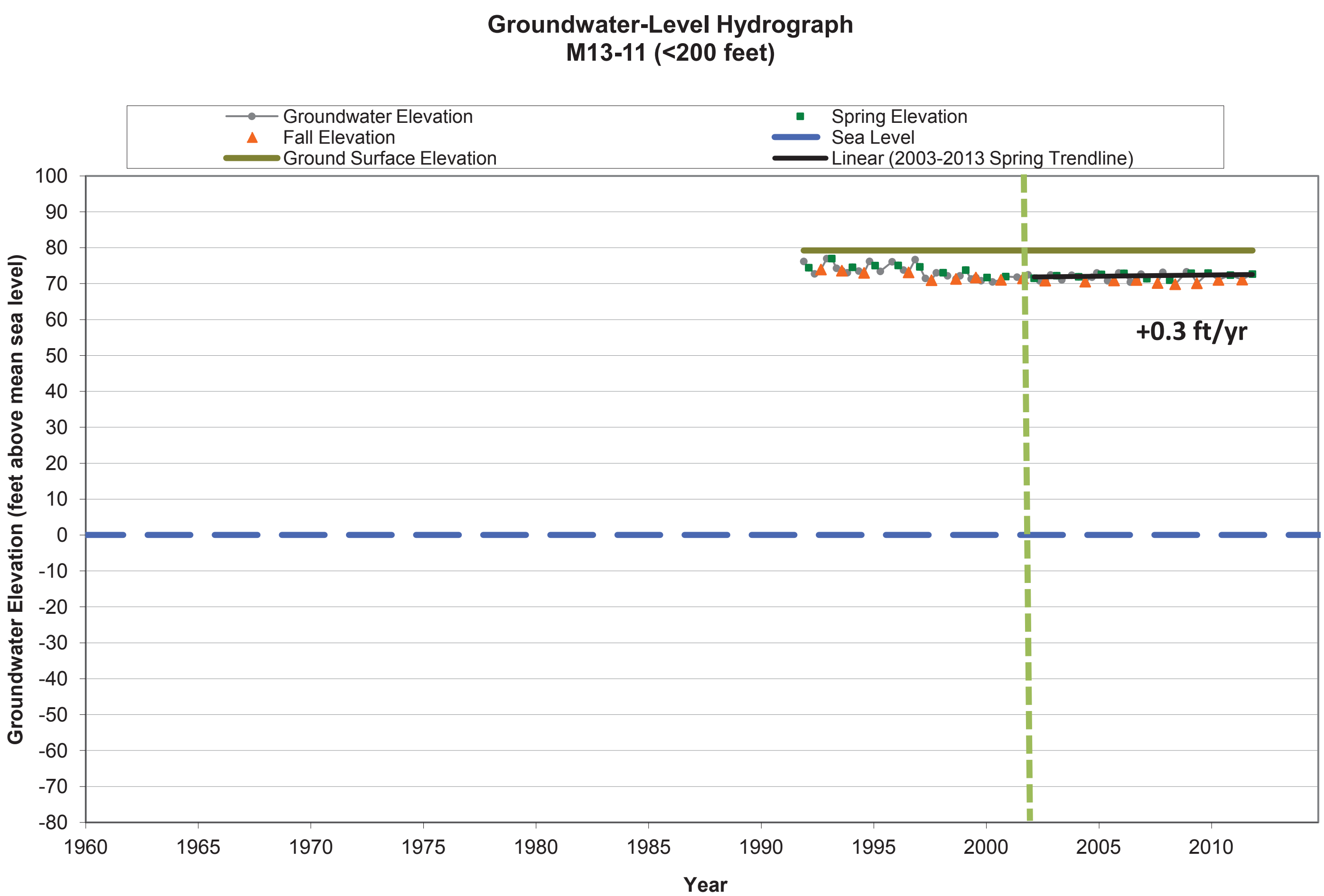


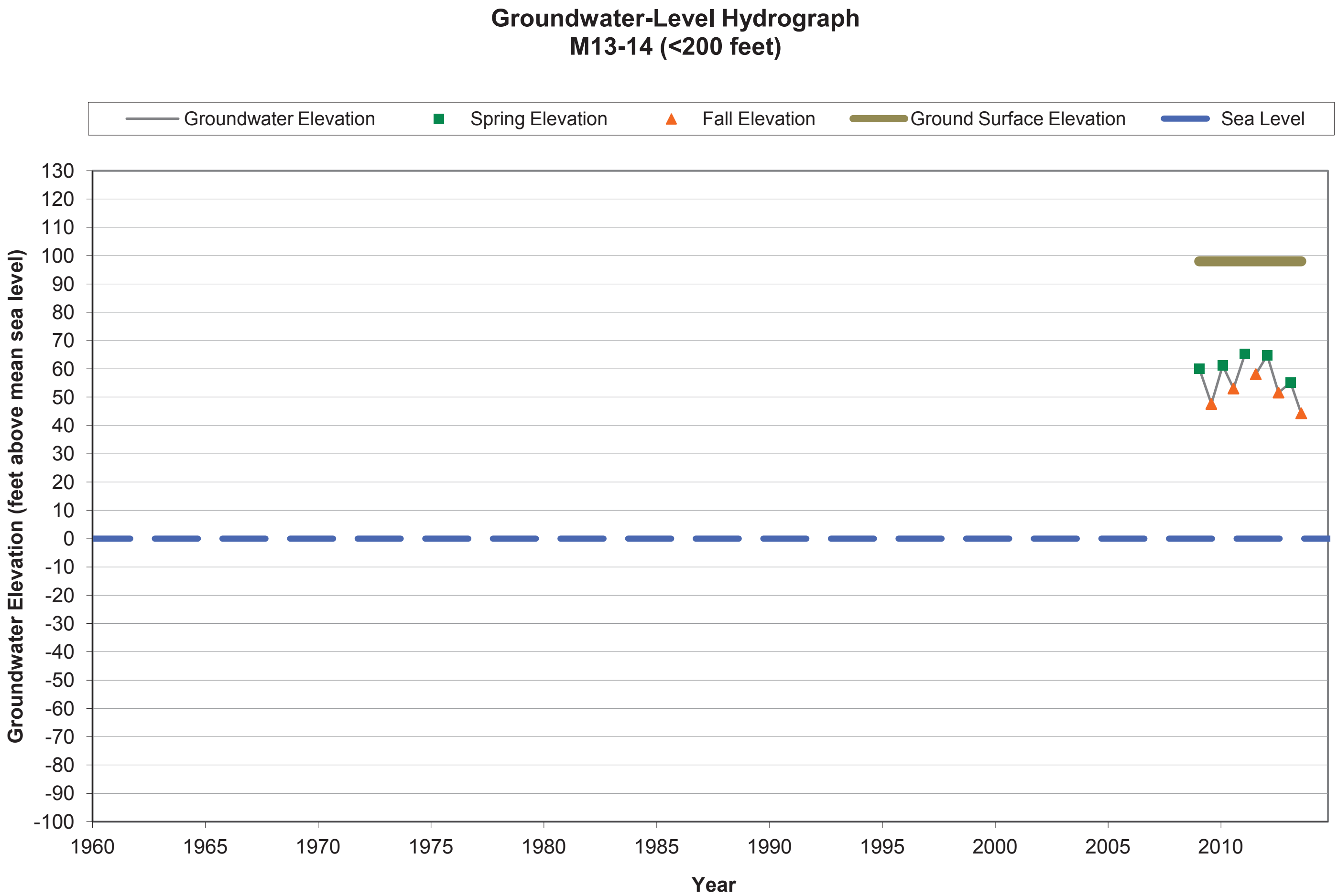
Groundwater-Level Hydrograph
M13-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-1.1 feet/yr
Groundwater Elevation (feet above mean sea level)
Year
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

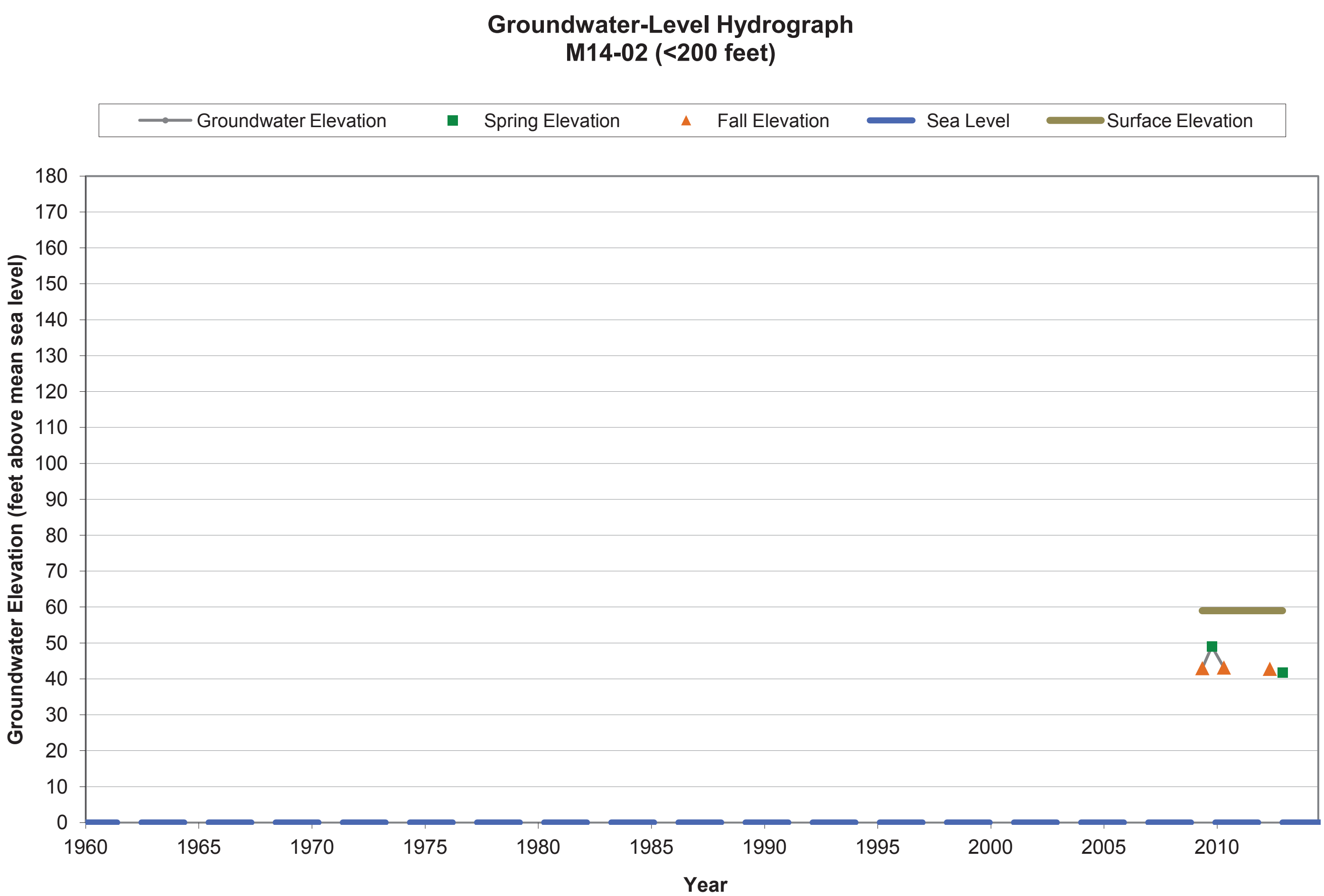

Groundwater-Level Hydrograph
M13-07 (<200 feet)
Groundwater Elevation
Fall Elevation
Ground Surface Elevation
Spring Elevation
Sea Level
Linear (2008-2013 Spring Trendline)
+0.03 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


Groundwater-Level Hydrograph
M13-09 (<200 feet)
Groundwater Elevation
Fall
Ground Surface Elevation
Spring
Sea Level
Linear (2003-2013 Spring Trendline)
-0.20 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

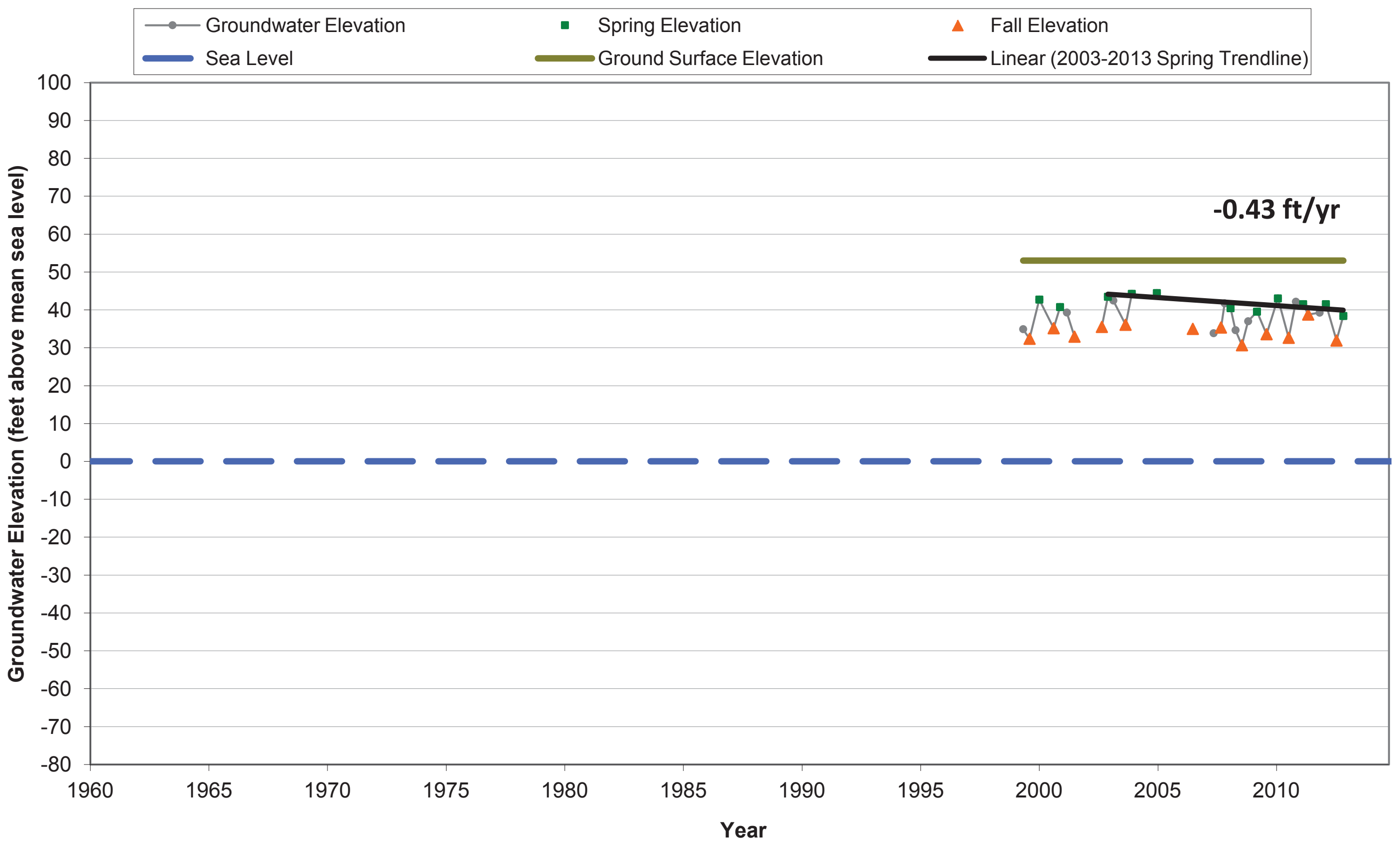

Groundwater-Level Hydrograph
M13-10 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
Year


Groundwater-Level Hydrograph
M13-11 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
+0.3 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

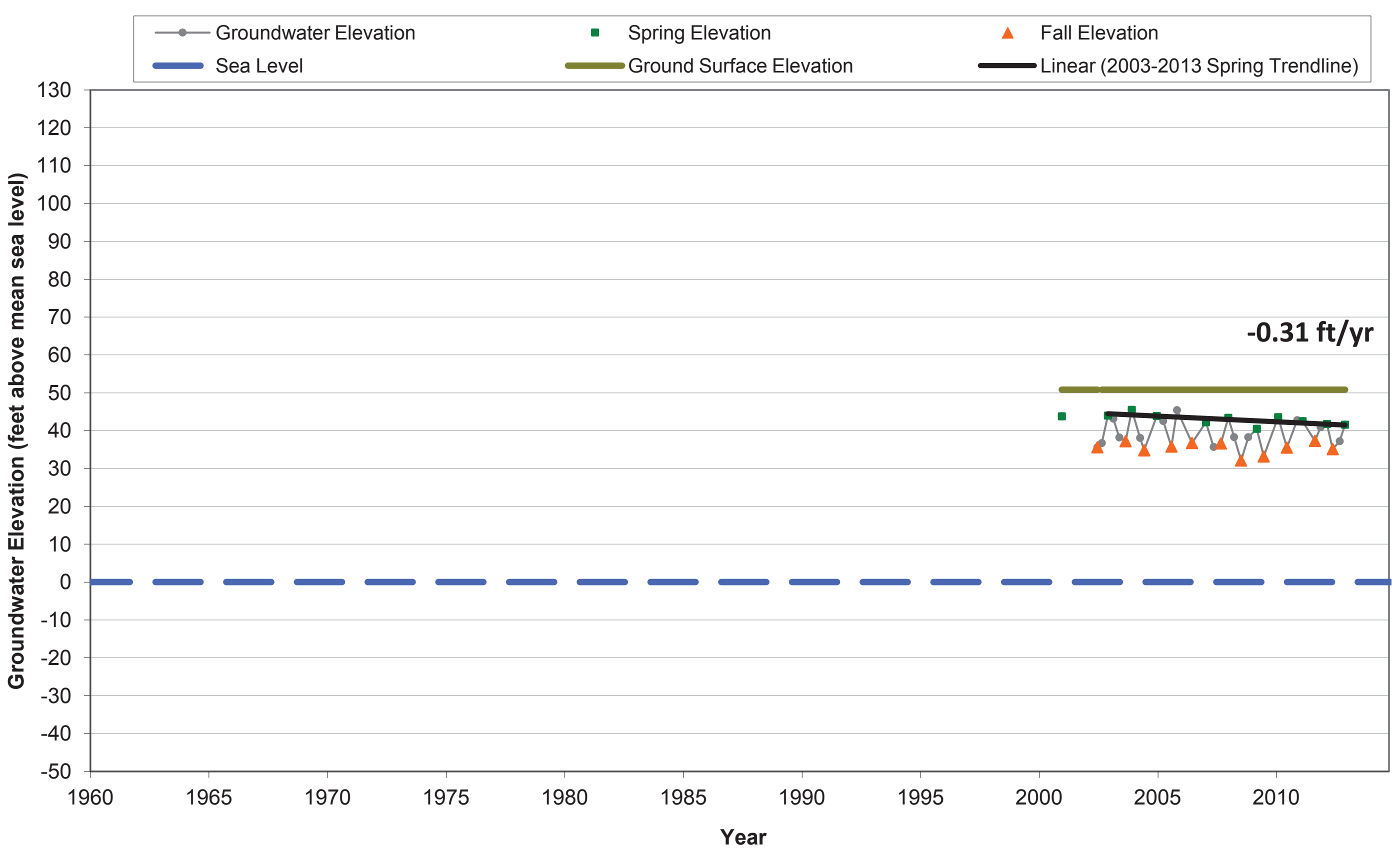

Groundwater-Level Hydrograph
M13-14 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
M14-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Surface Elevation
Groundwater Elevation (feet above mean sea level)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

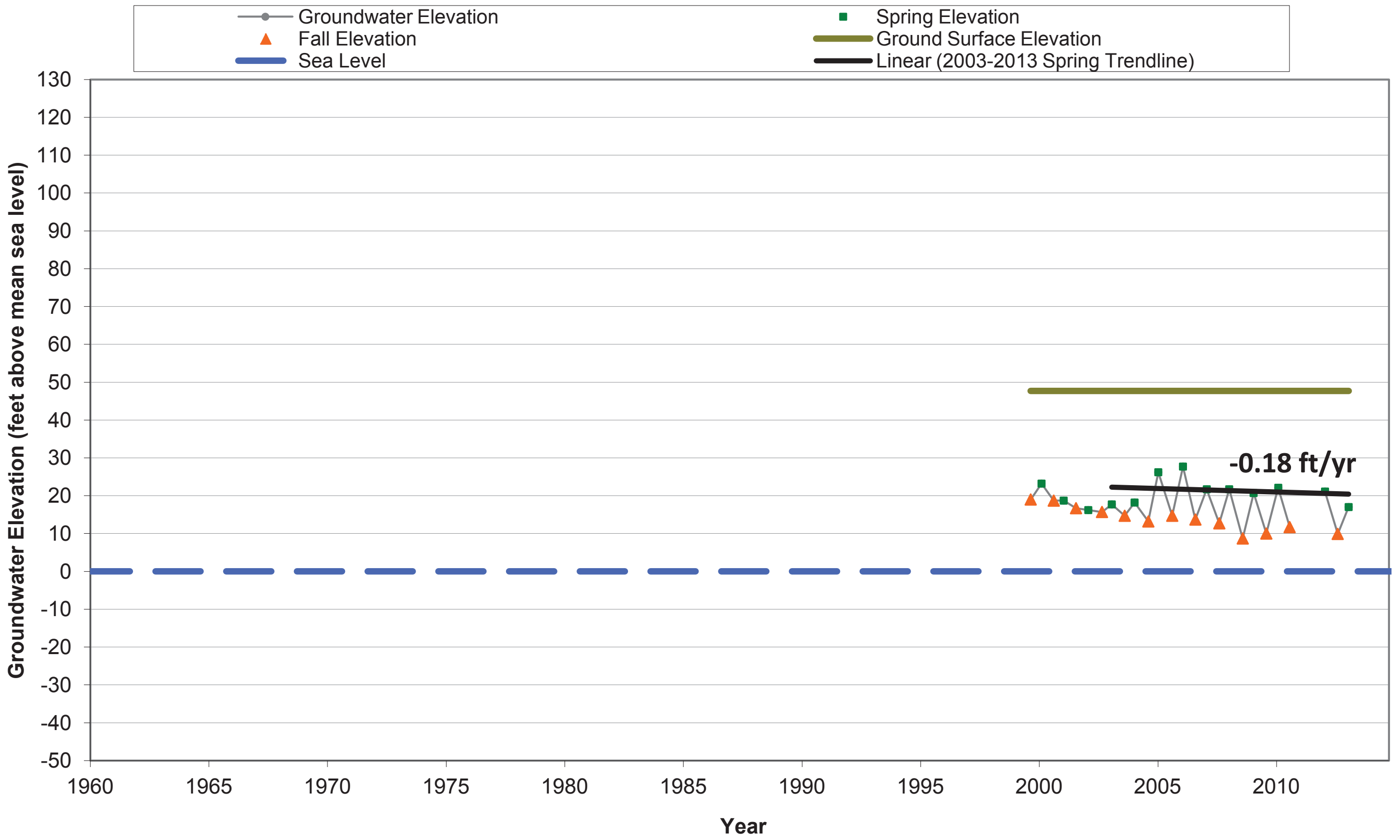
Groundwater-Level Hydrograph
M14-03 (<200 feet)



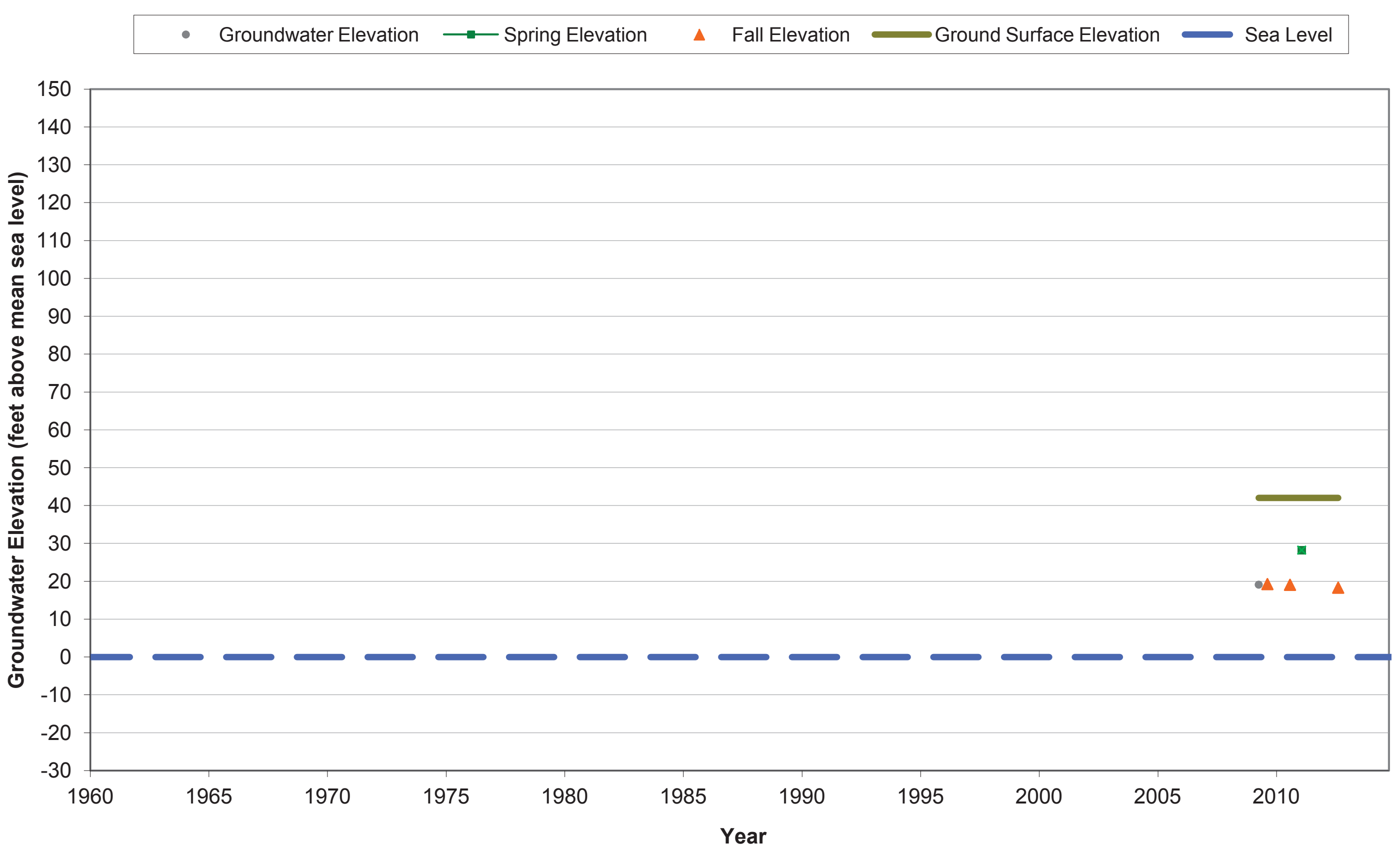
Groundwater-Level Hydrograph
M14-05 (<200 feet)



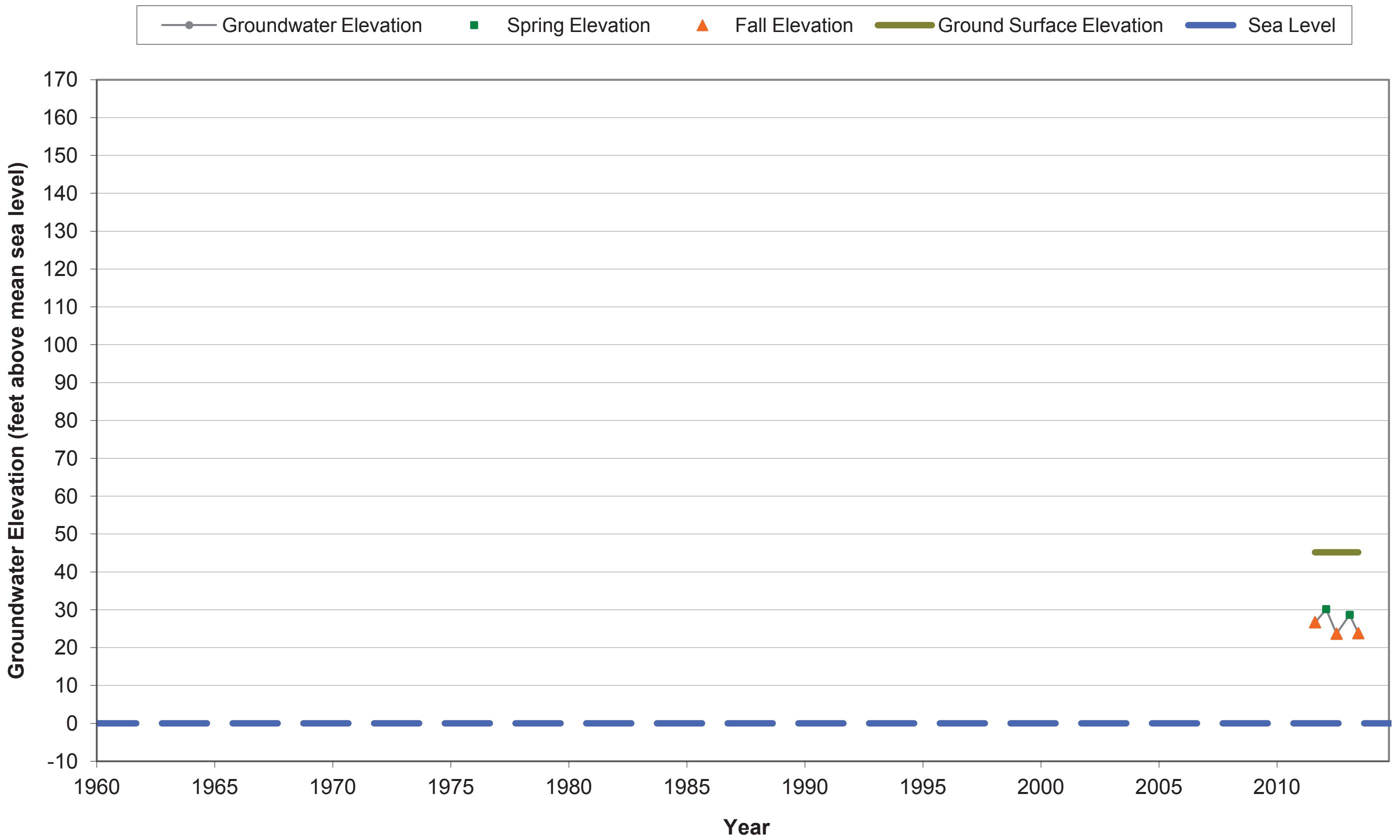
Groundwater-Level Hydrograph
M15-01 (<200 feet)



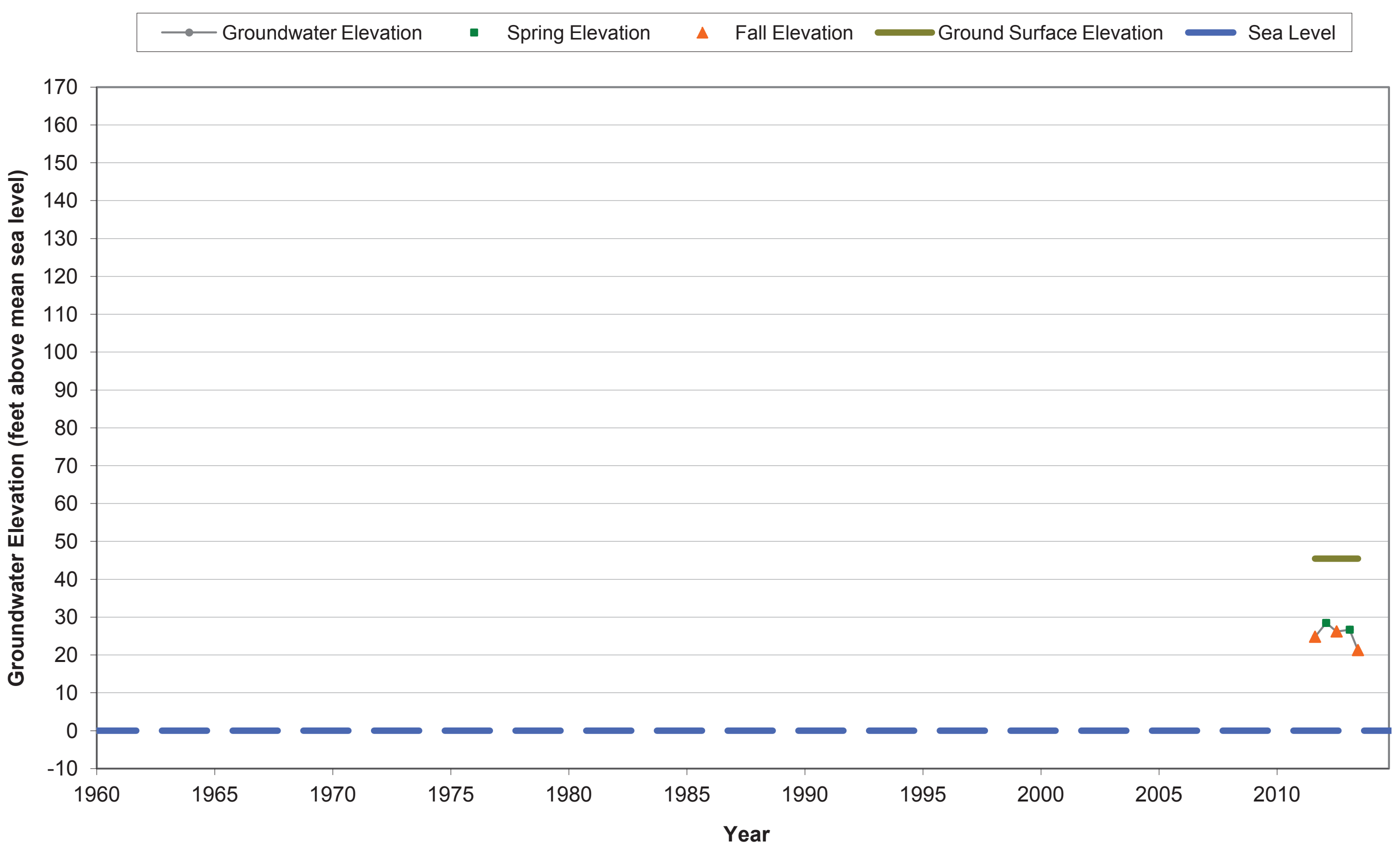
Groundwater-Level Hydrograph
M15-04 (<200 feet)

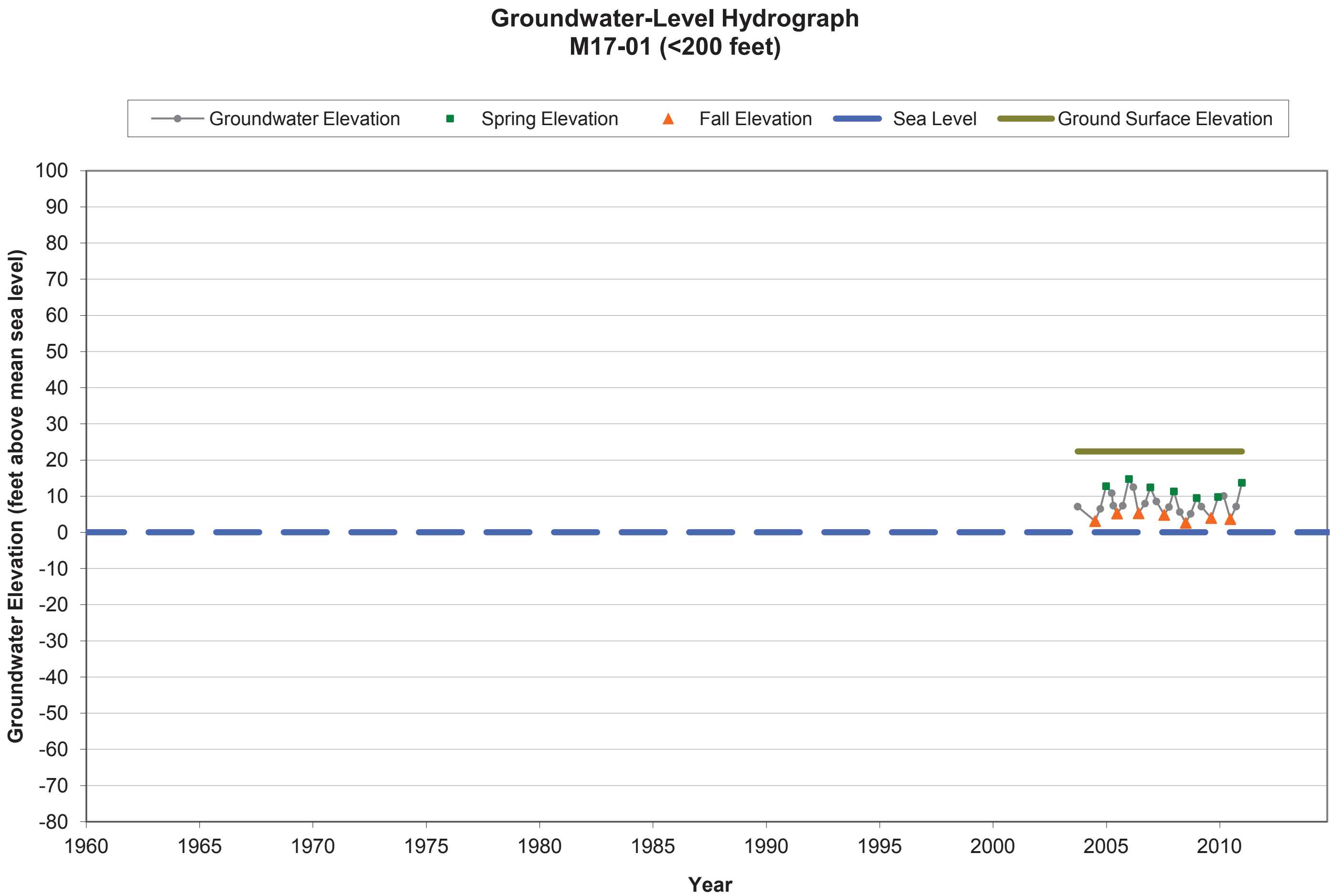


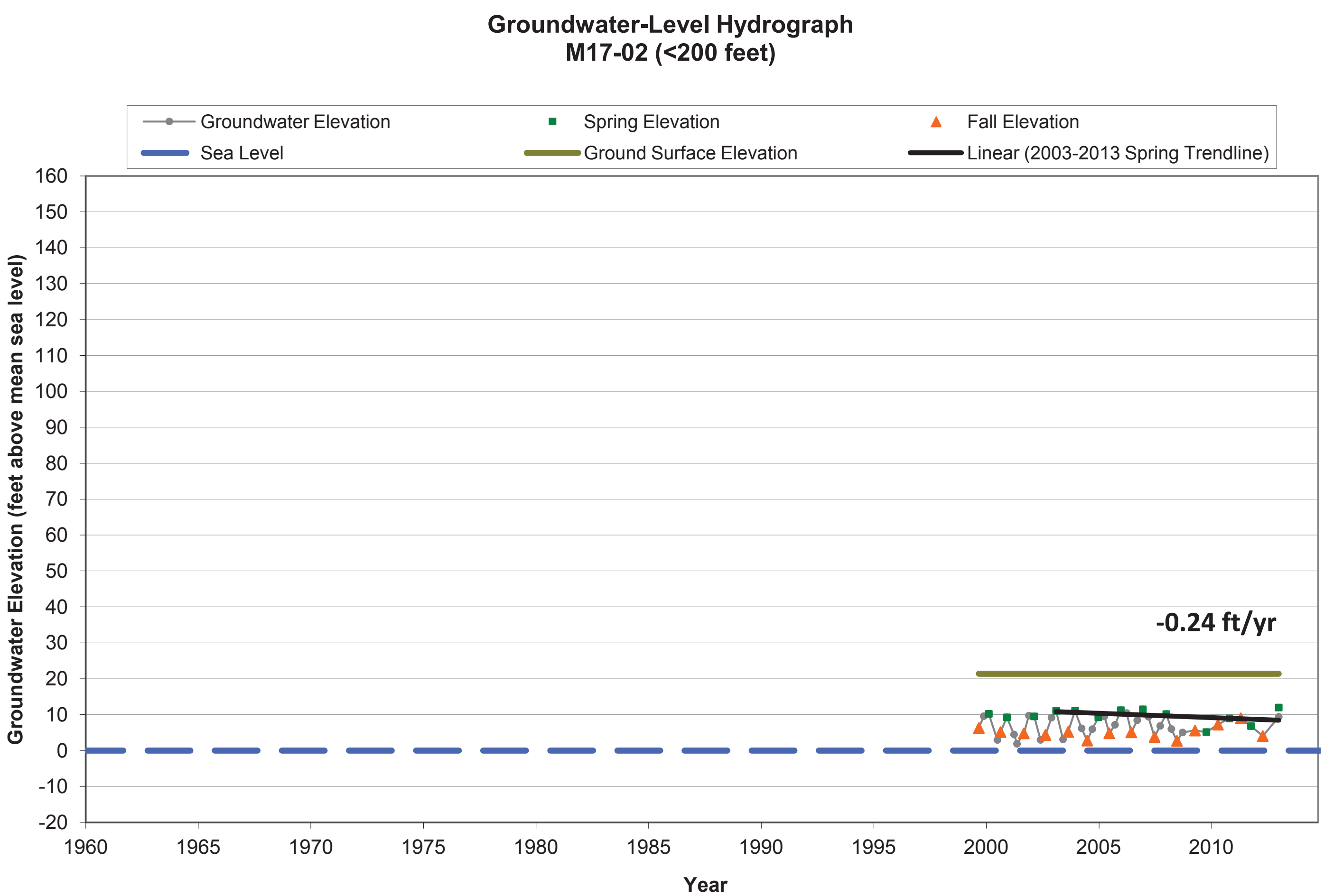
Groundwater-Level Hydrograph
M15-04A (<200 feet)

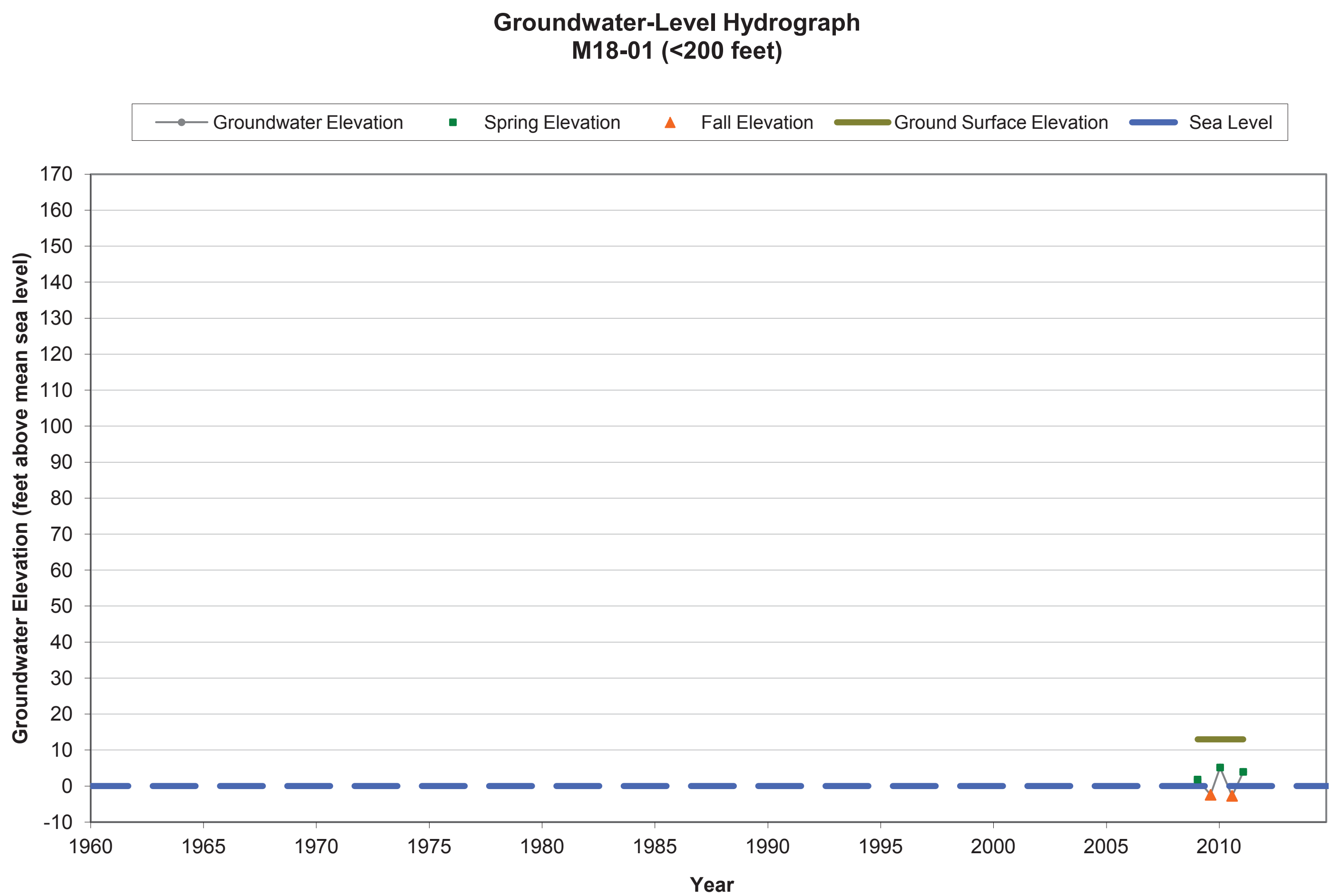


Groundwater-Level Hydrograph
M15-04B (<200 feet)

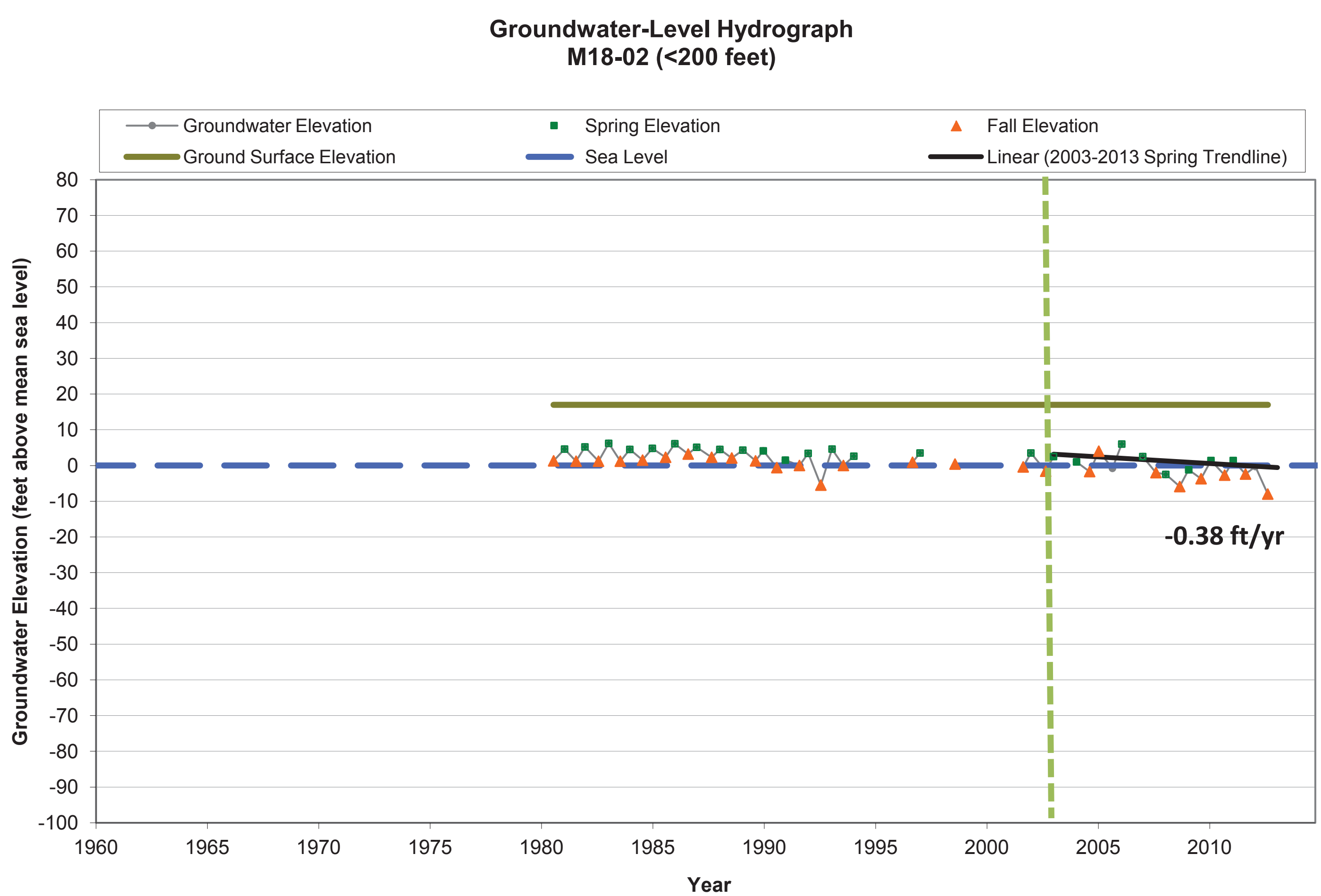



Groundwater-Level Hydrograph
M17-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
M17-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-0.24 ft/yr
Groundwater Elevation (feet above mean sea level)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

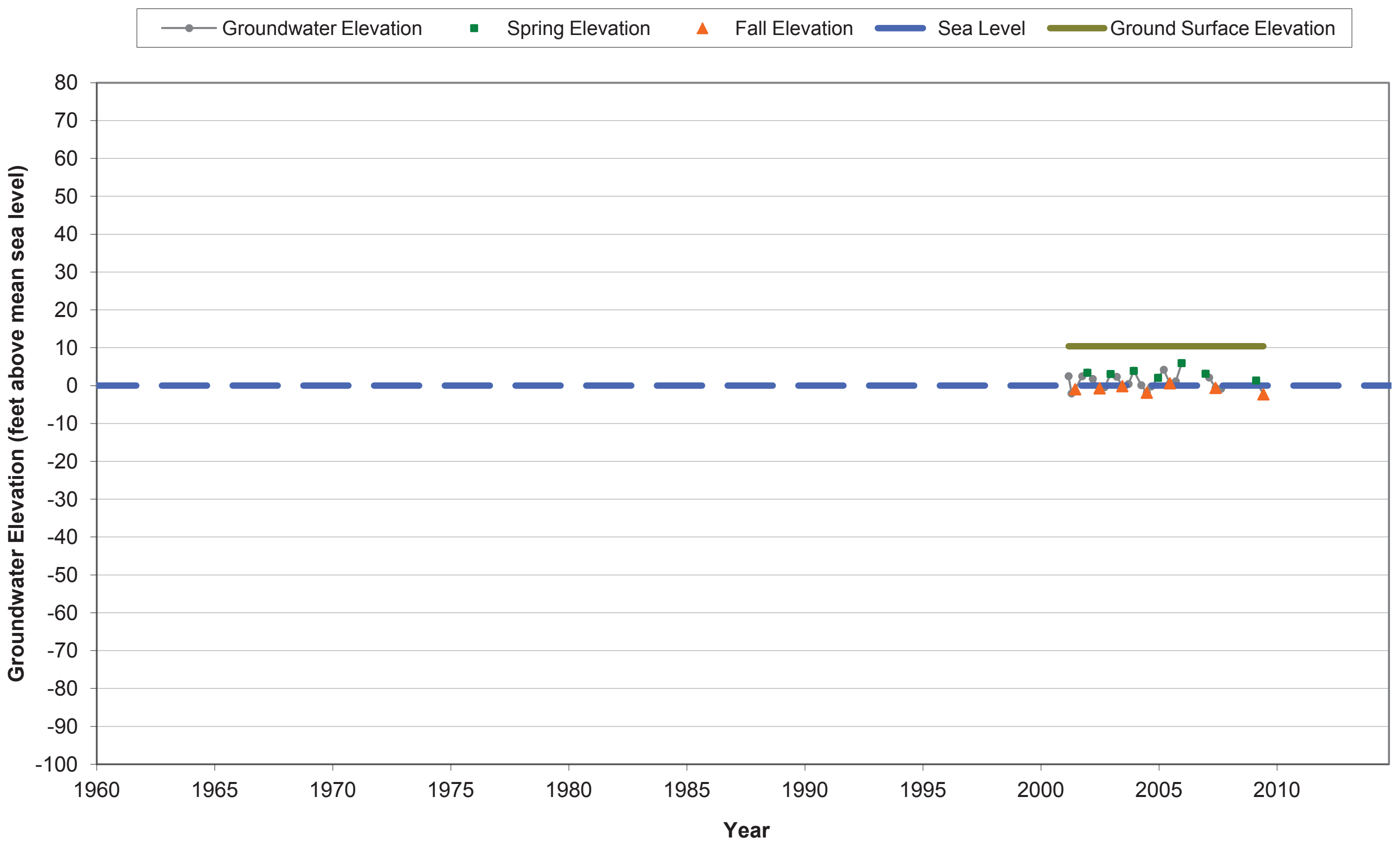


Groundwater-Level Hydrograph
M18-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year

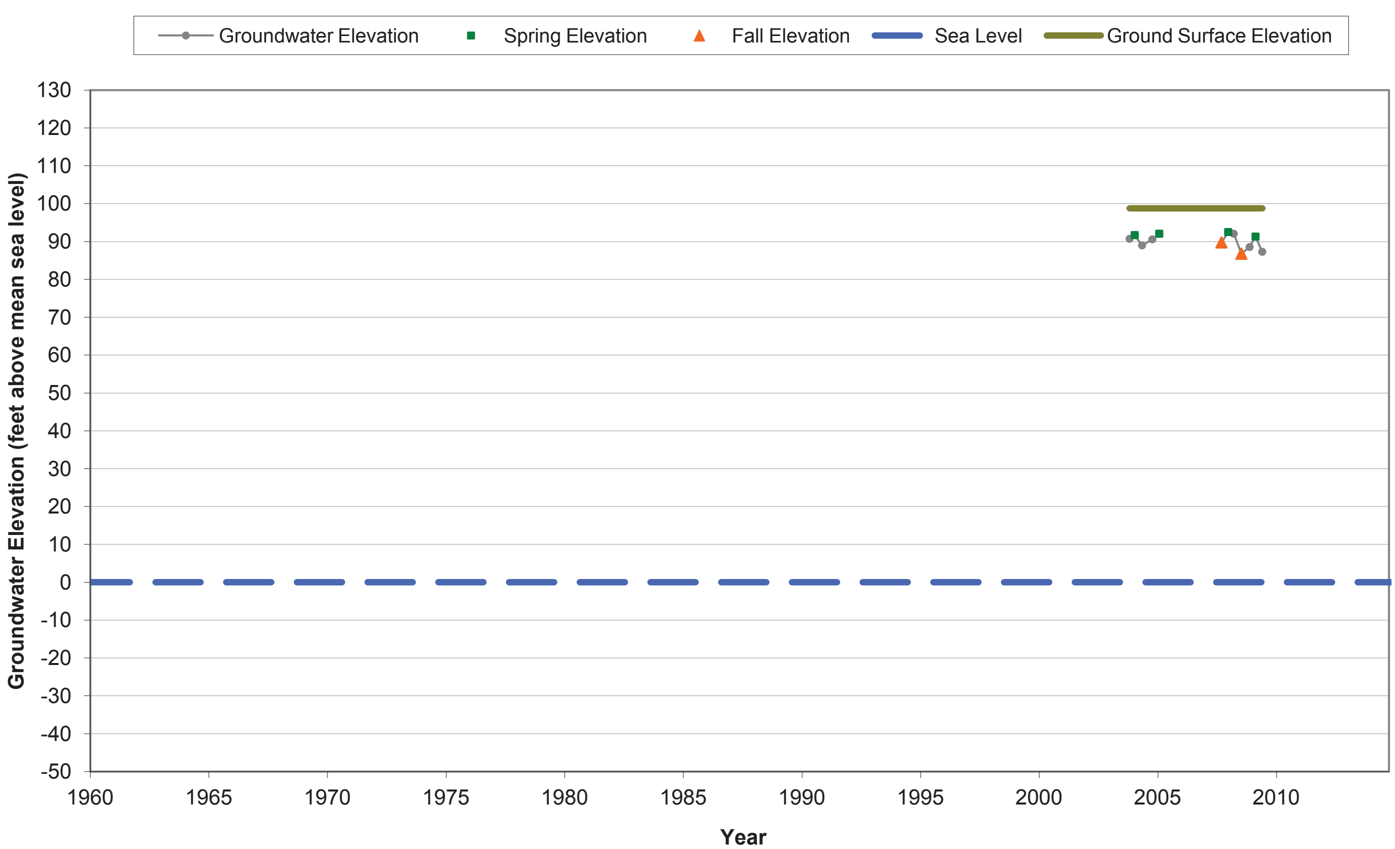


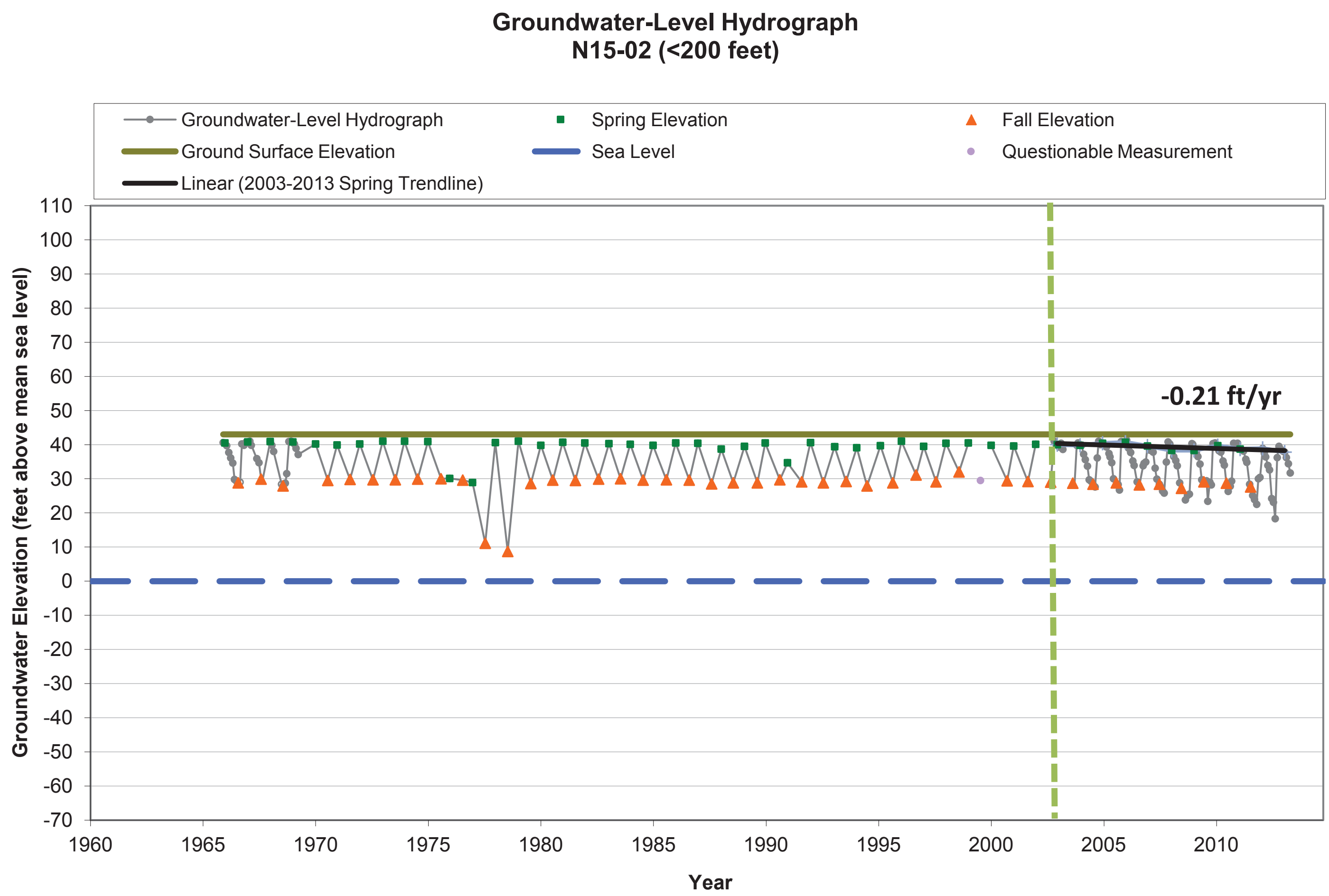
Groundwater-Level Hydrograph
M18-02 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-0.38 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

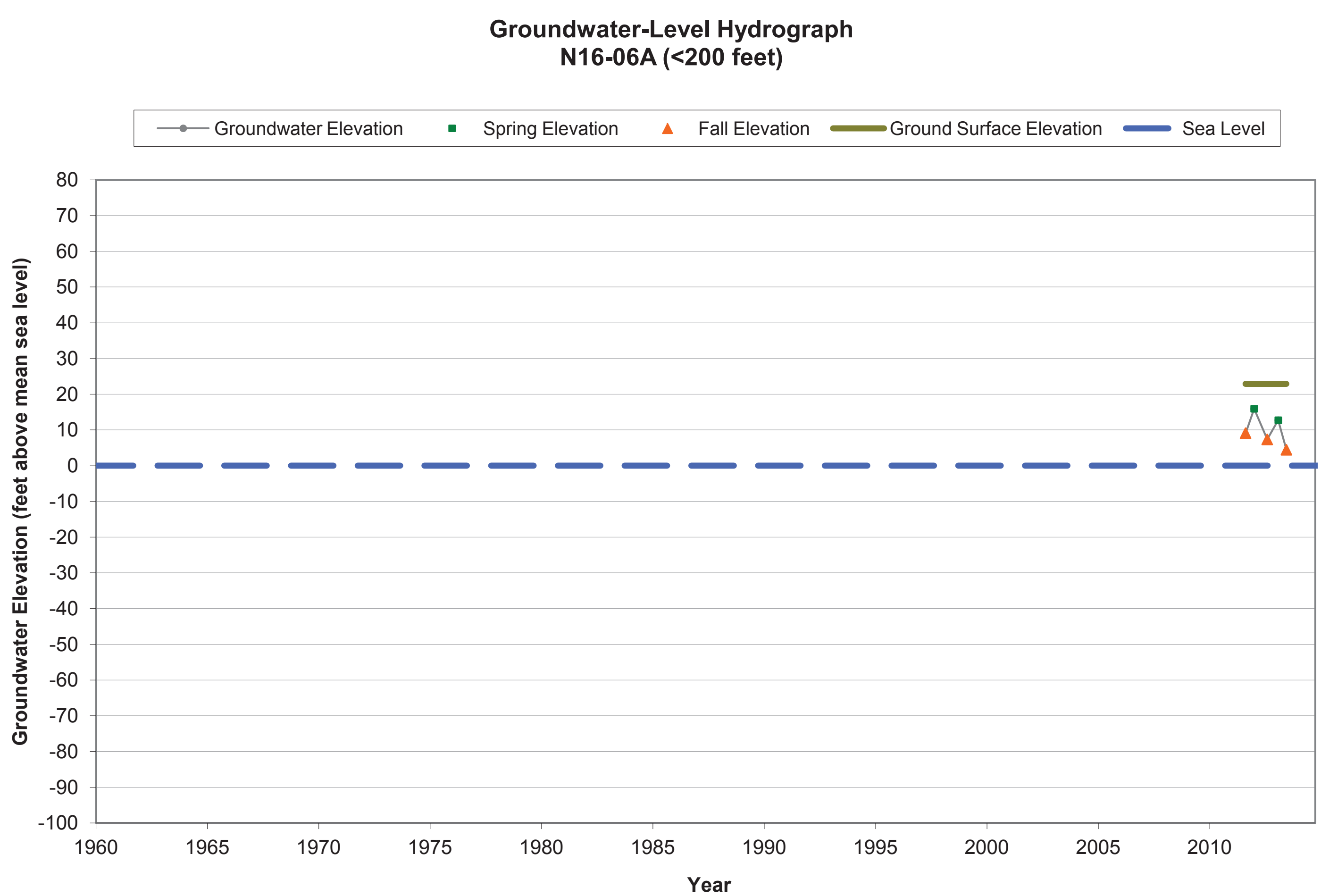
Groundwater-Level Hydrograph
M18-05 (<200 feet)



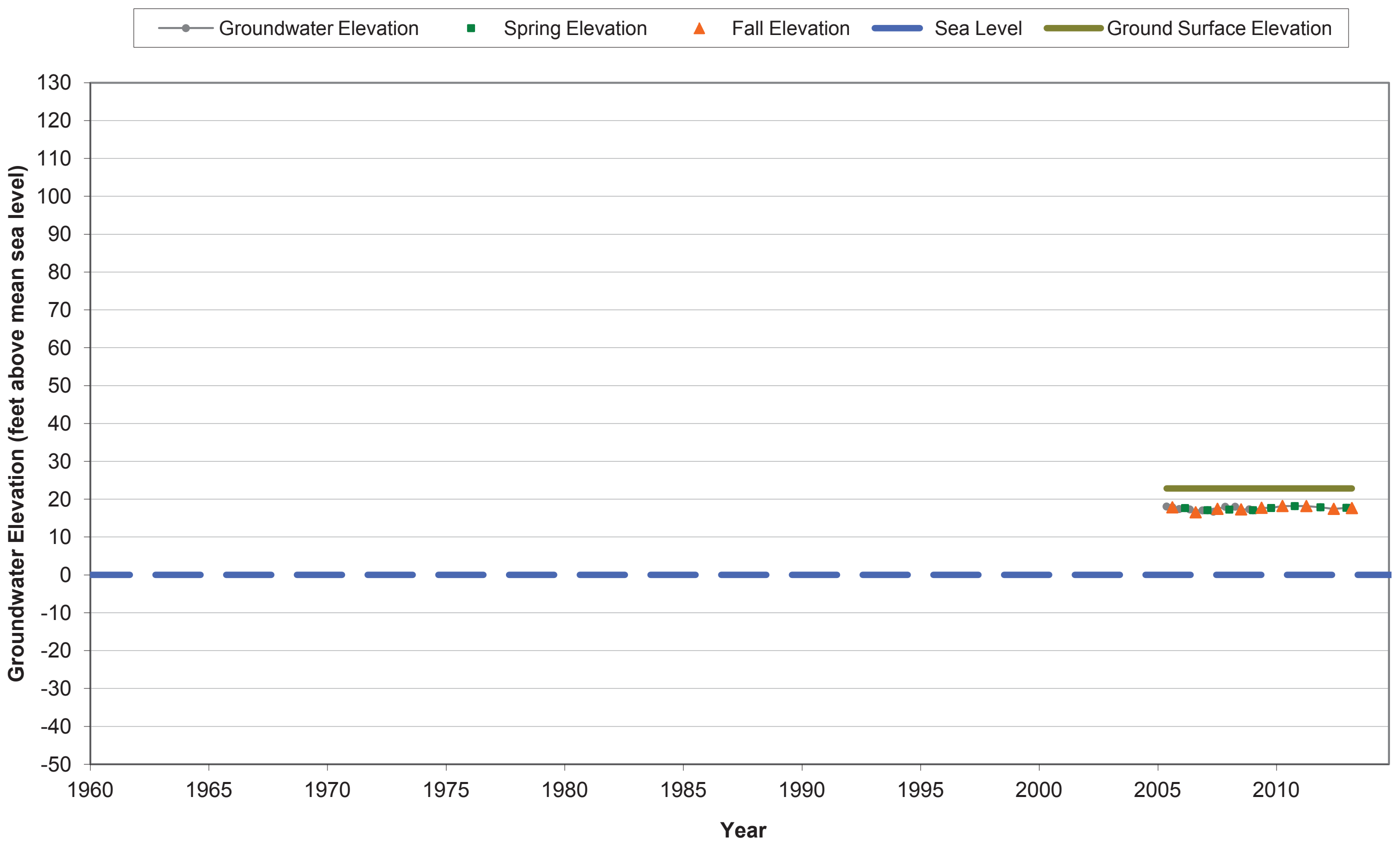
Groundwater-Level Hydrograph
N13-04 (<200 feet)



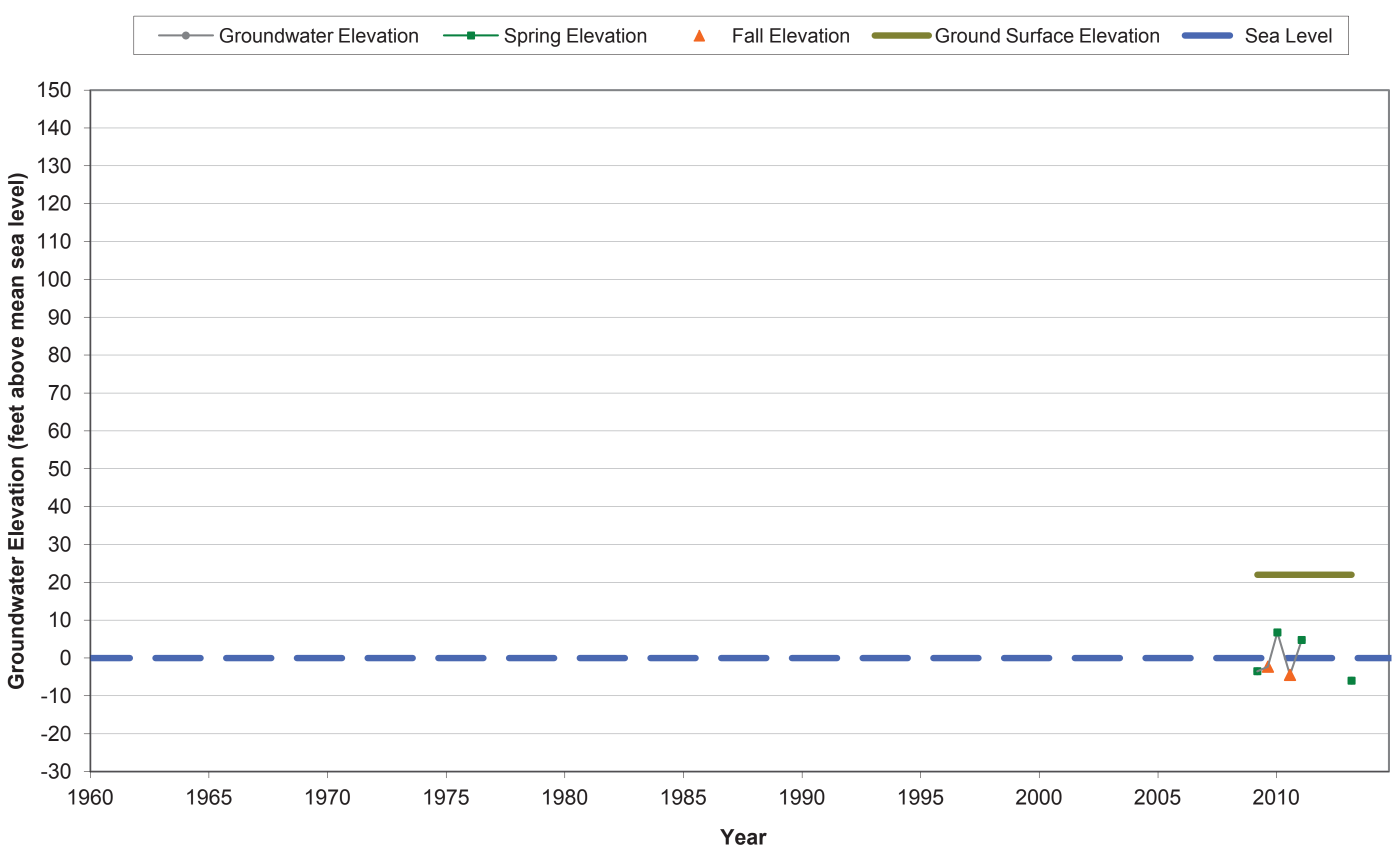

Groundwater-Level Hydrograph
N15-02 (<200 feet)
Groundwater-Level Hydrograph
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Questionable Measurement
Linear (2003-2013 Spring Trendline)
-0.21 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


Groundwater-Level Hydrograph
N16-06A (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

Groundwater-Level Hydrograph
N23-01 (<200 feet)

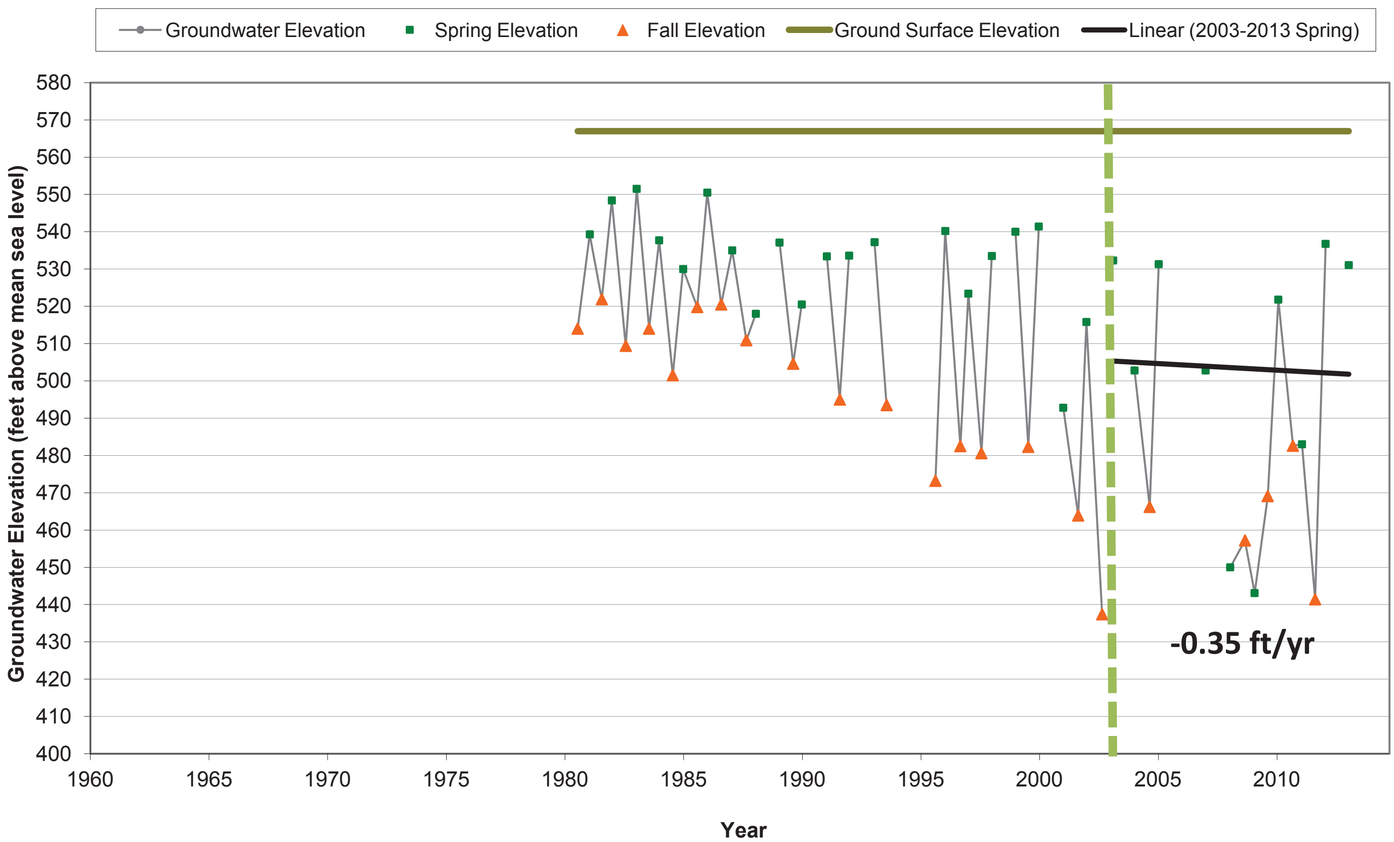


Groundwater-Level Hydrograph
O17-01 (<200 feet)

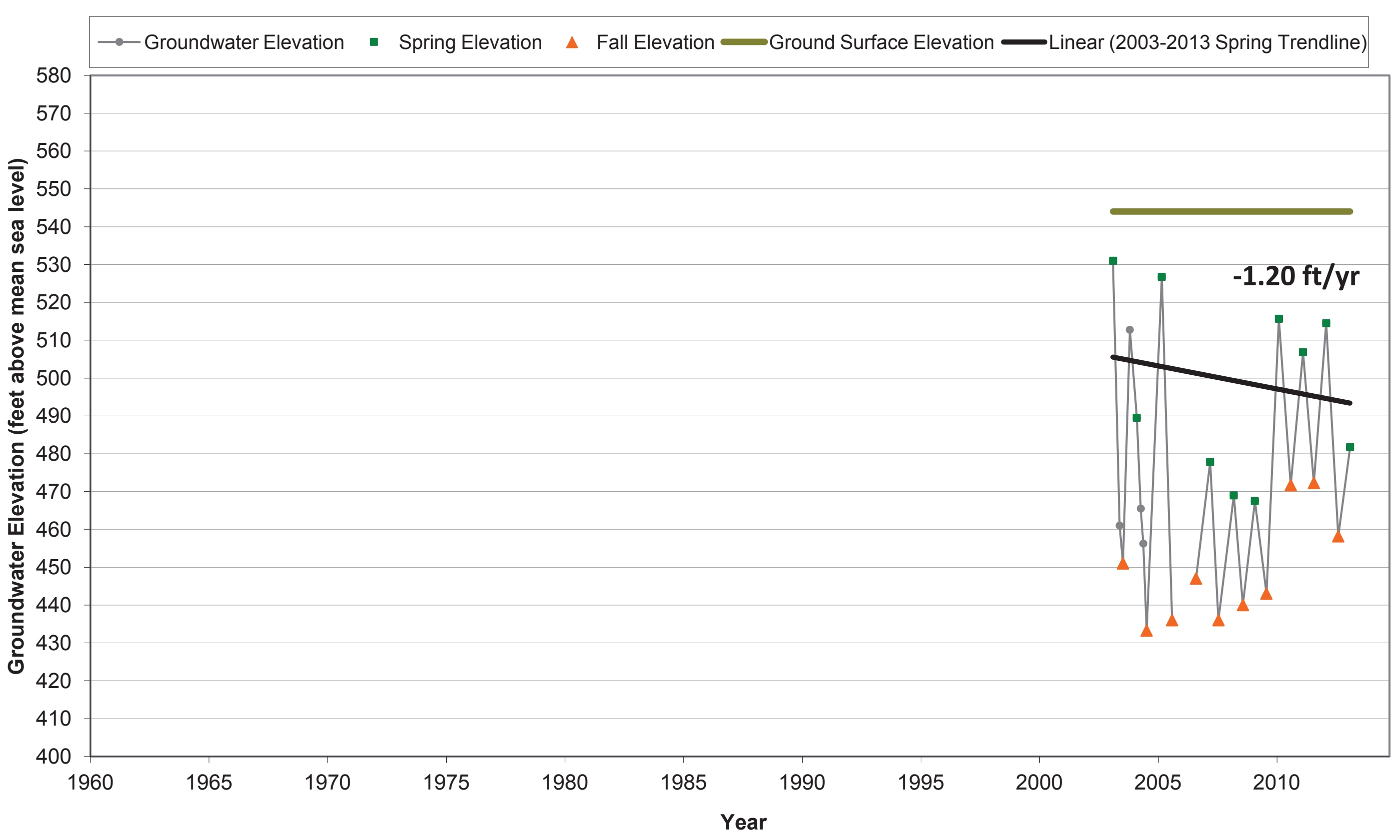


Groundwater Hydrographs
200 – 500 Feet Deep

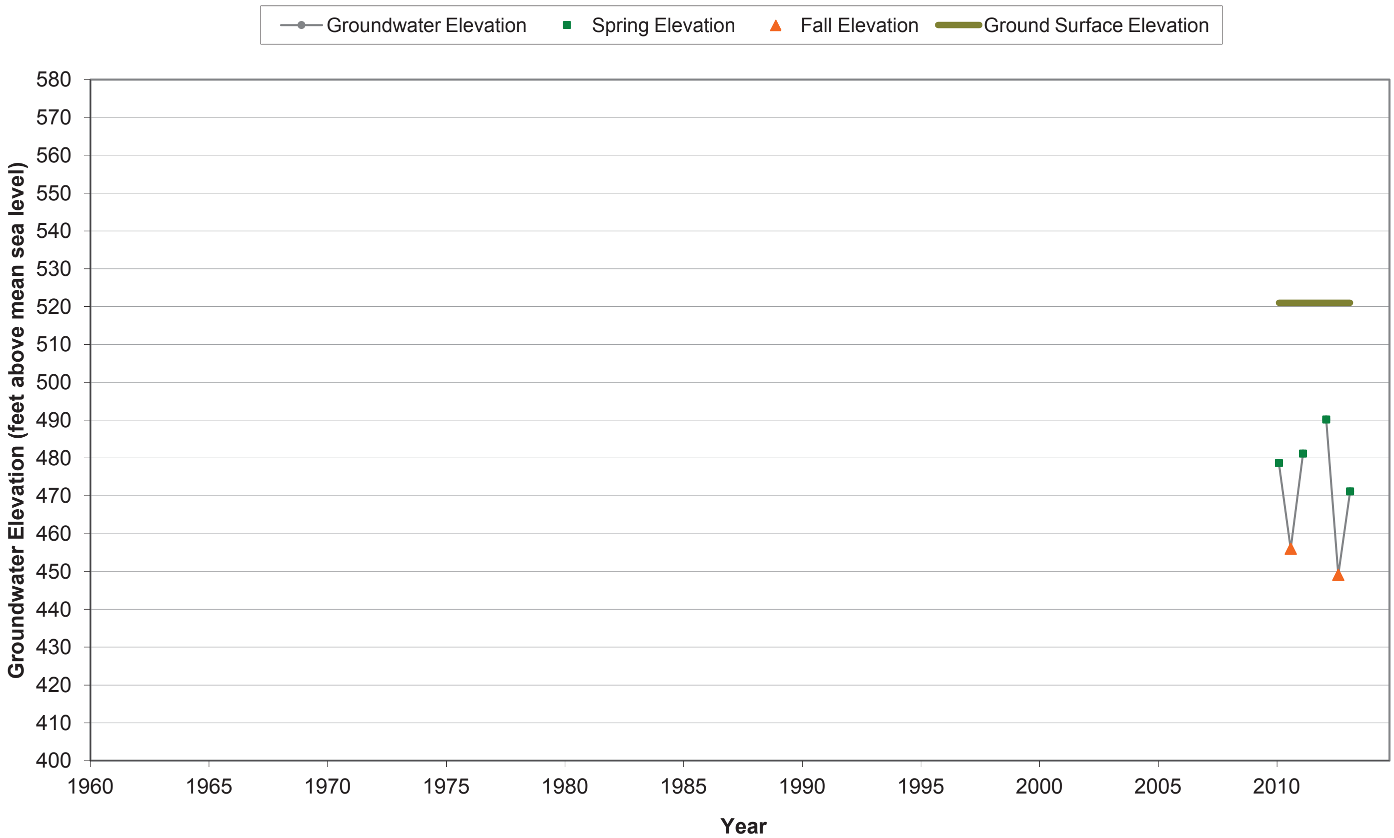
Groundwater- Level Hydrograph
G03-01 (200-500 feet)



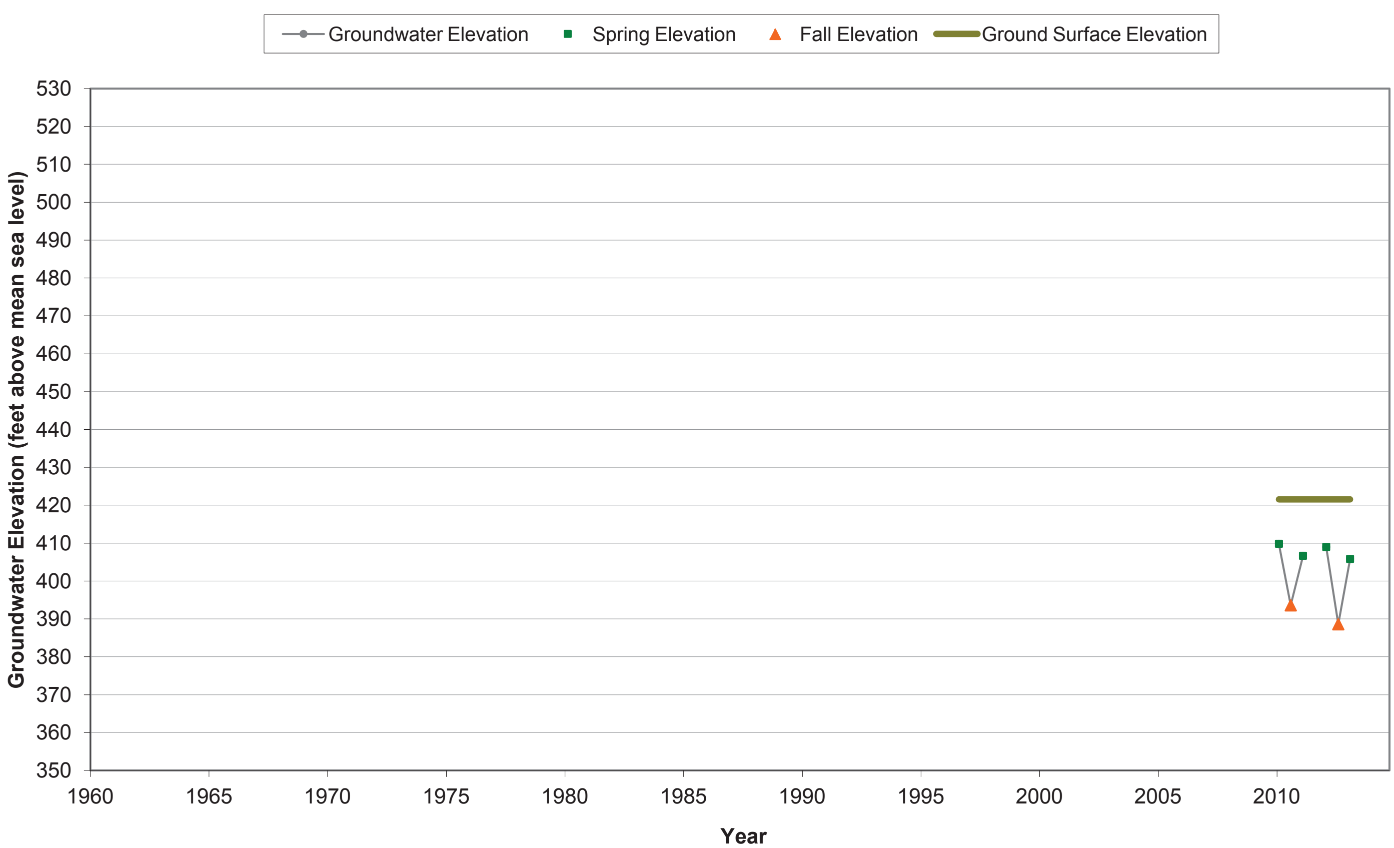
Groundwater-Level Hydrograph
G03-02 (200-500 feet)

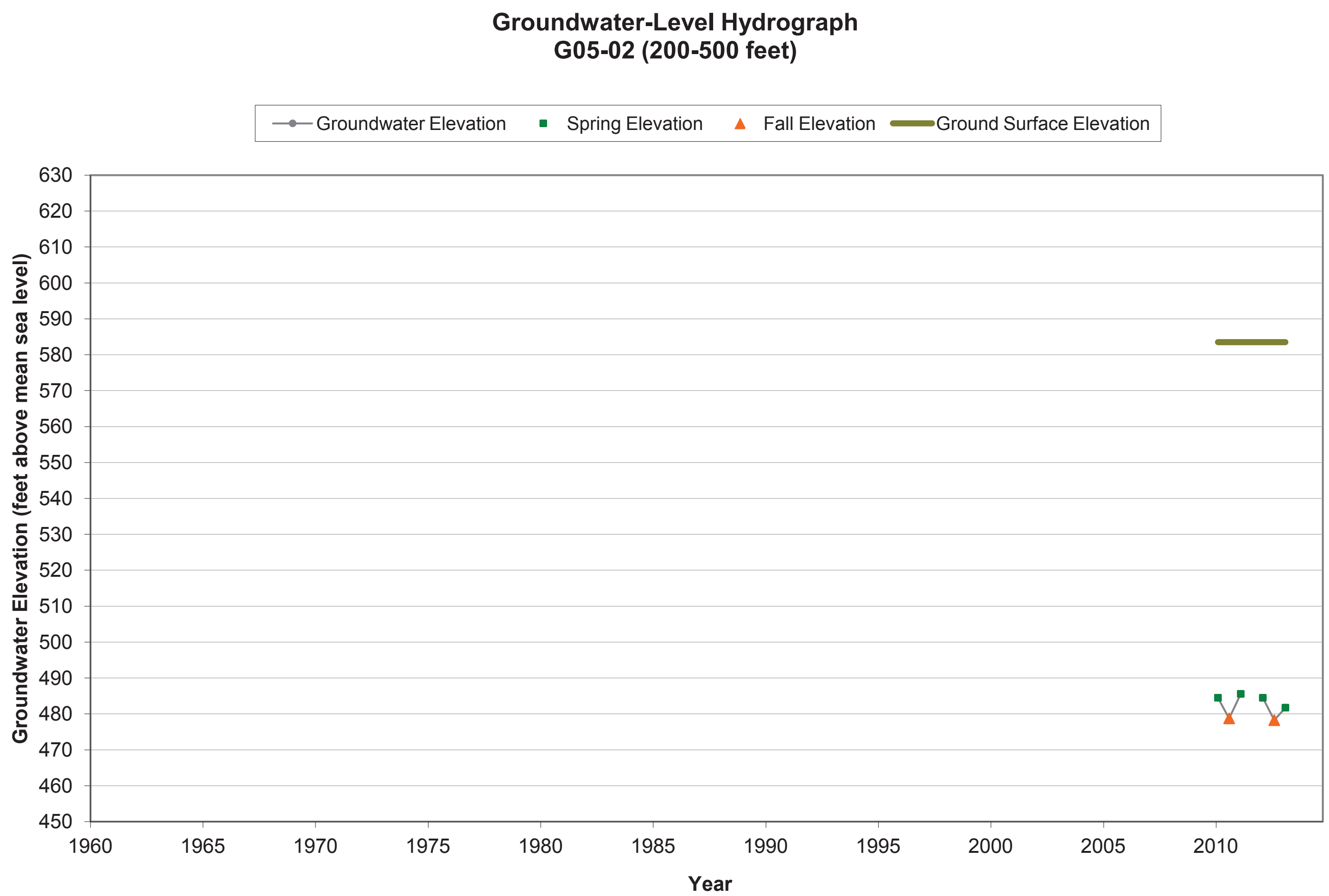


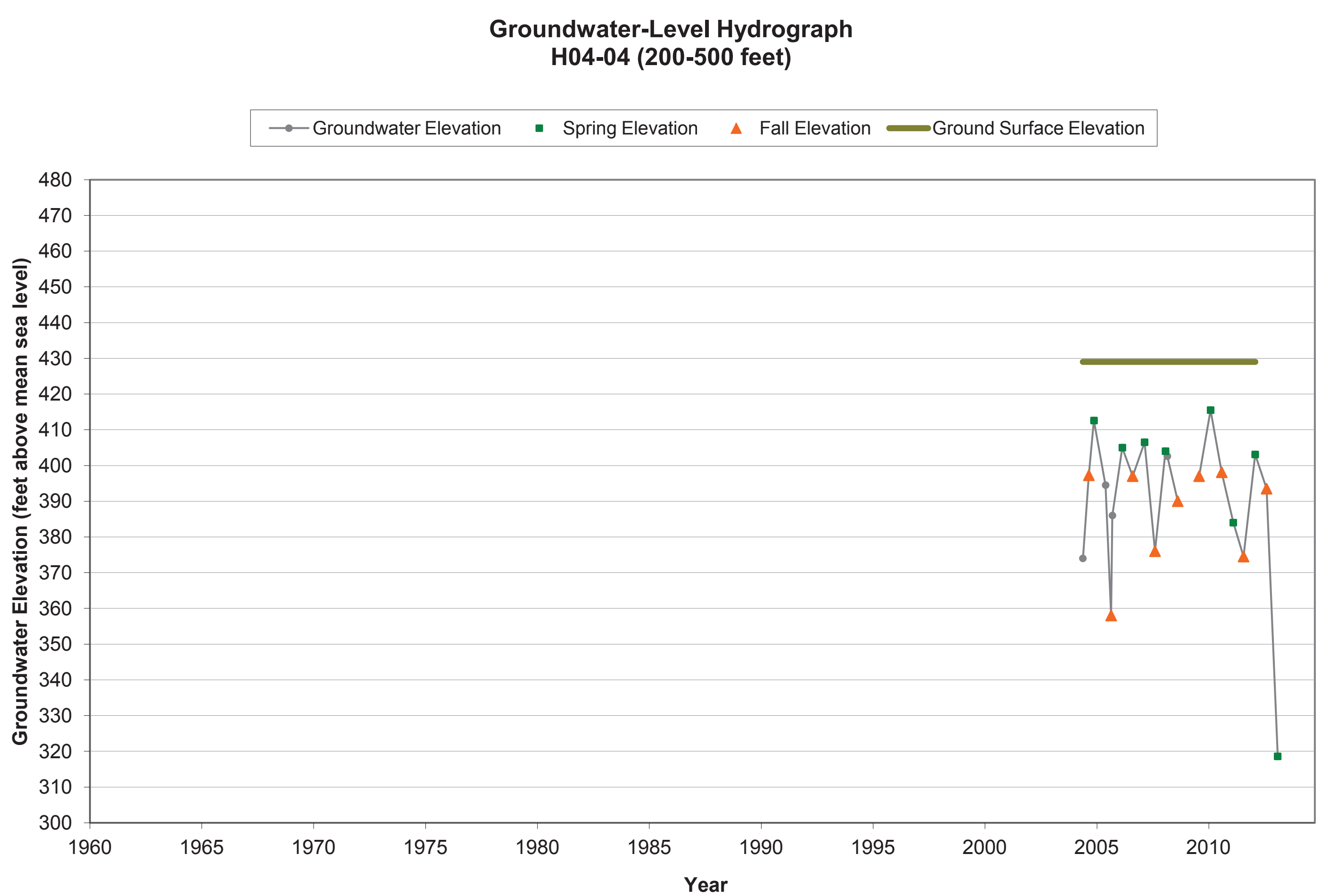
Groundwater-Level Hydrograph
G03-06 (200-500 feet)



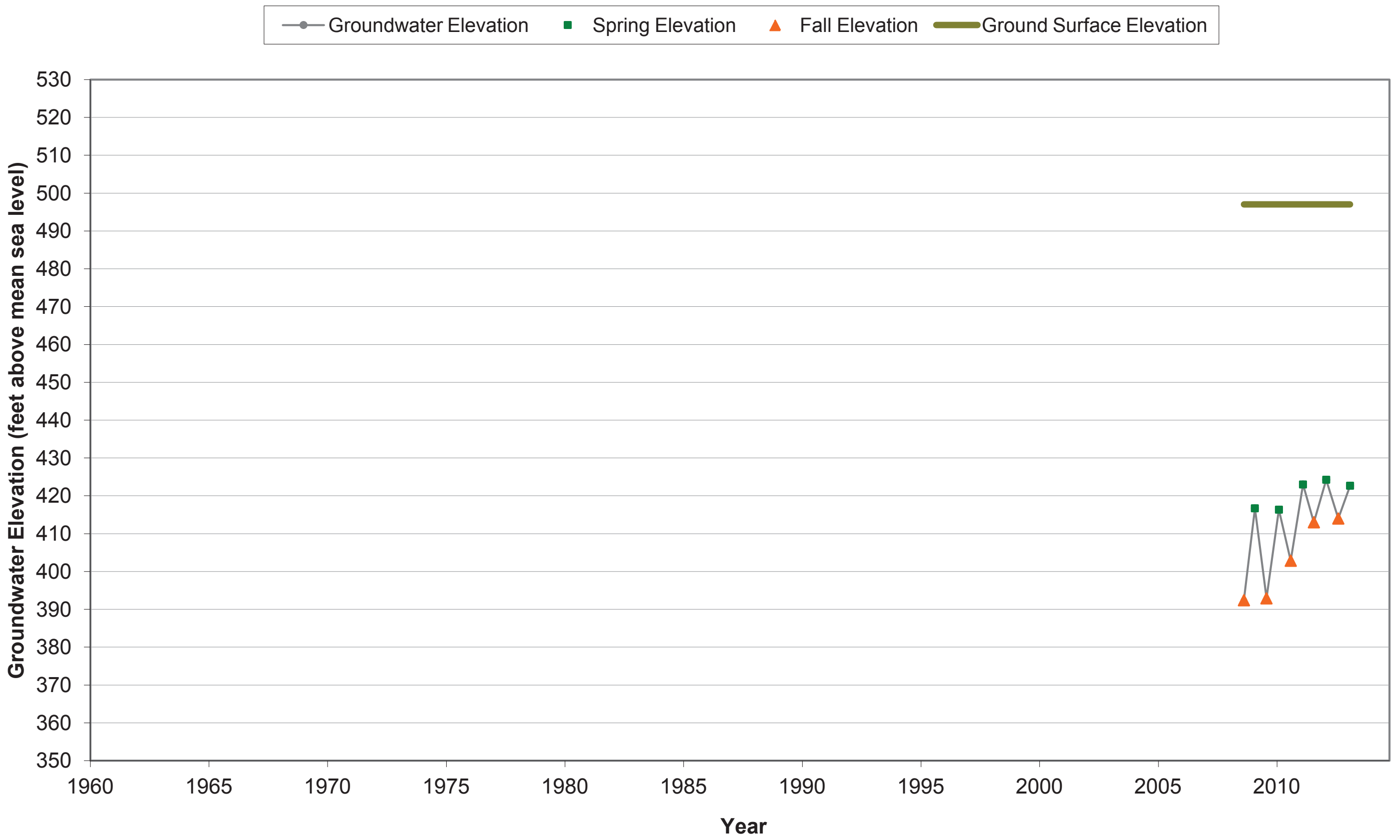
Groundwater-Level Hydrograph
G04-04 (200-500 feet)



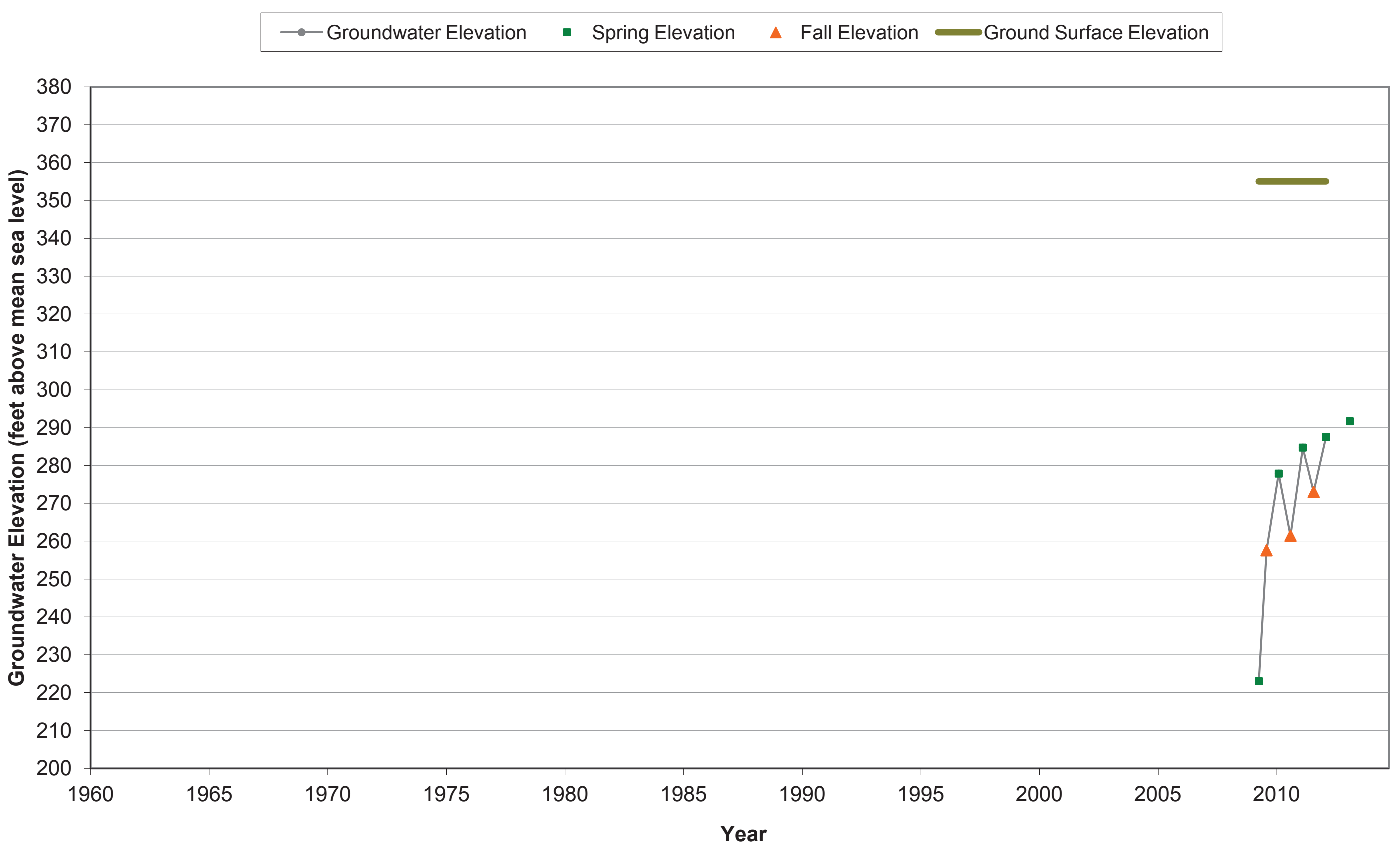

Groundwater-Level Hydrograph
G05-02 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
630
620
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
450
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
H04-04 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
480
470
460
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

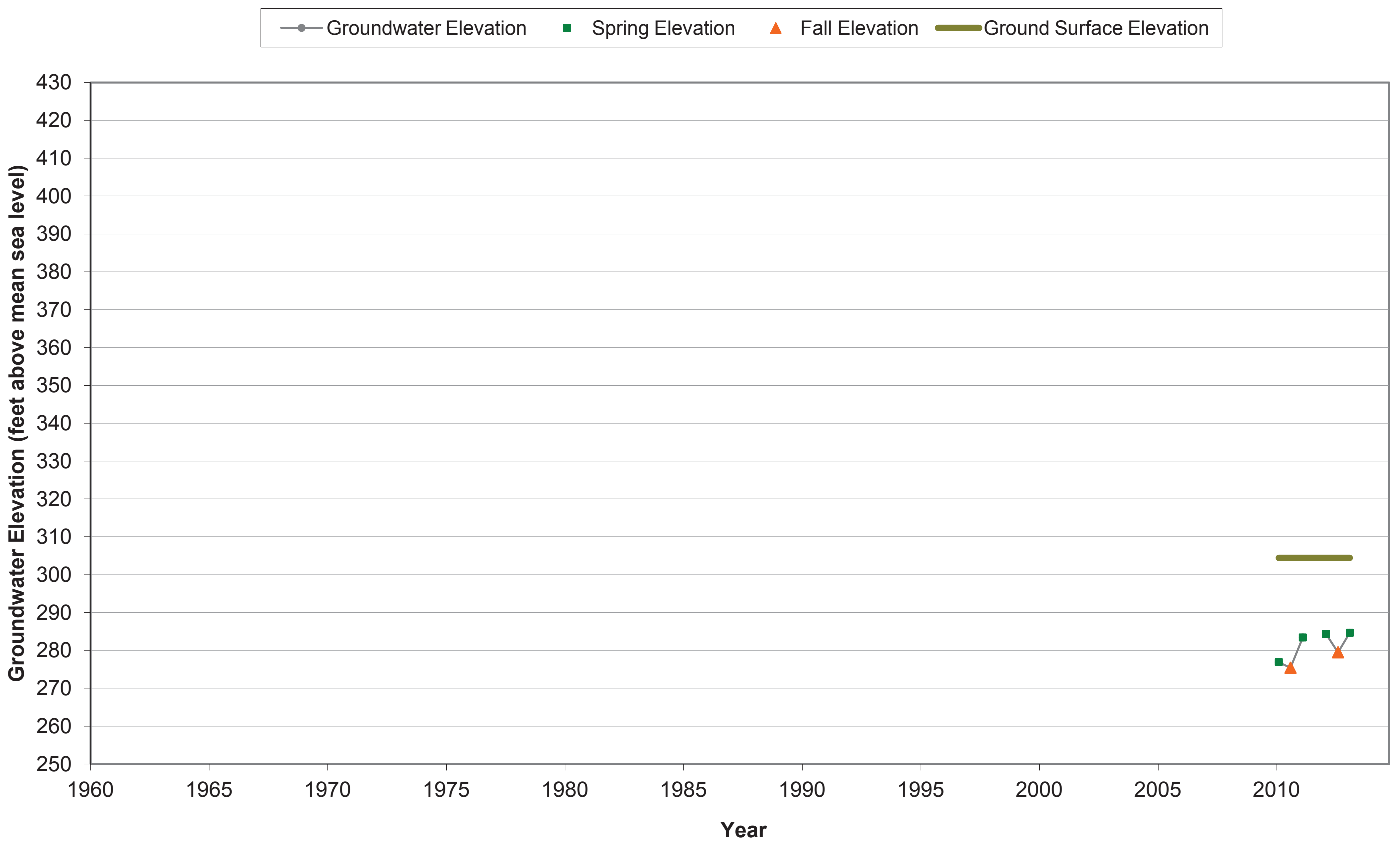
Groundwater-Level Hydrograph
H05-01 (200-500 feet)



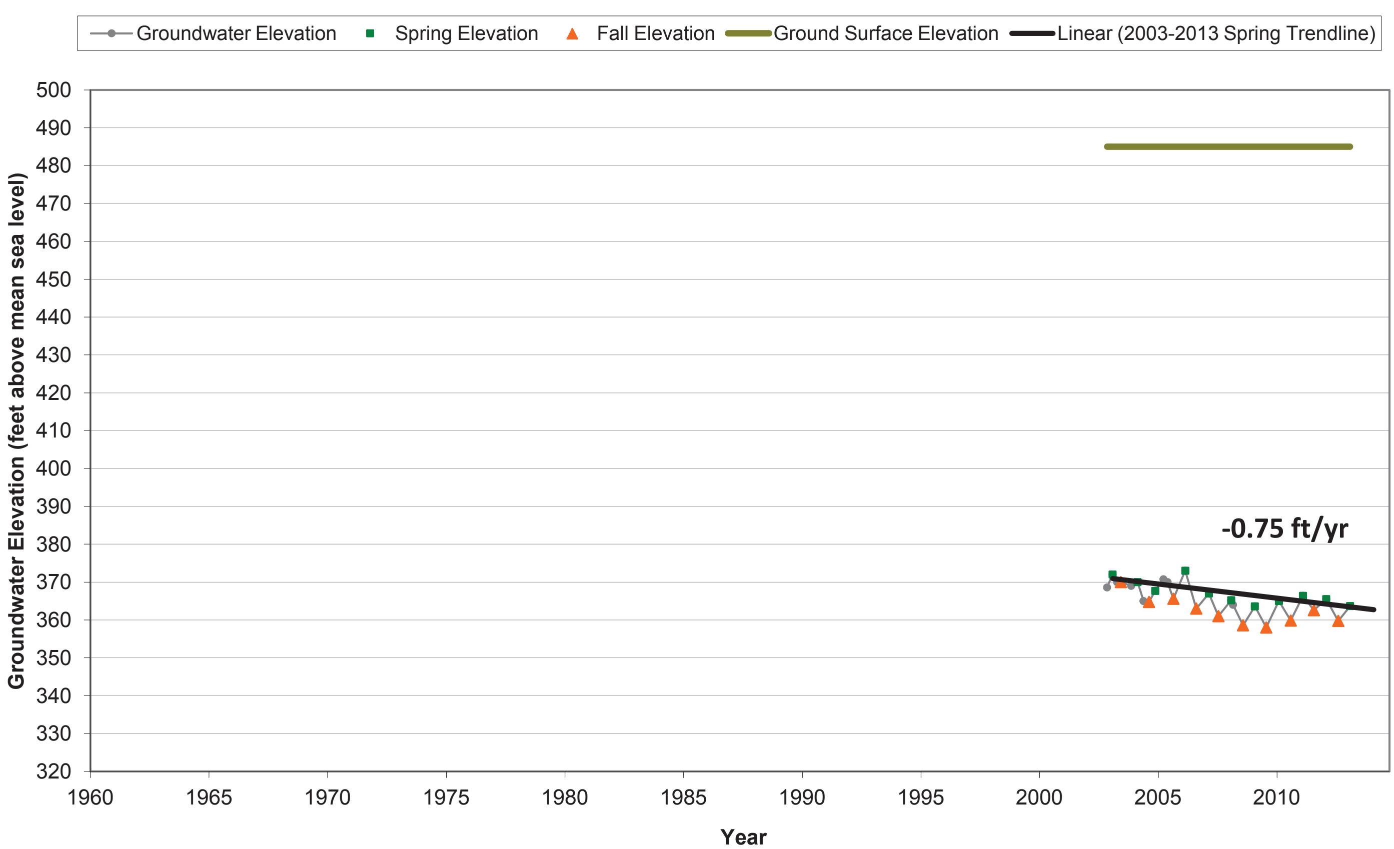
Groundwater-Level Hydrograph
H08-02 (200-500 feet)



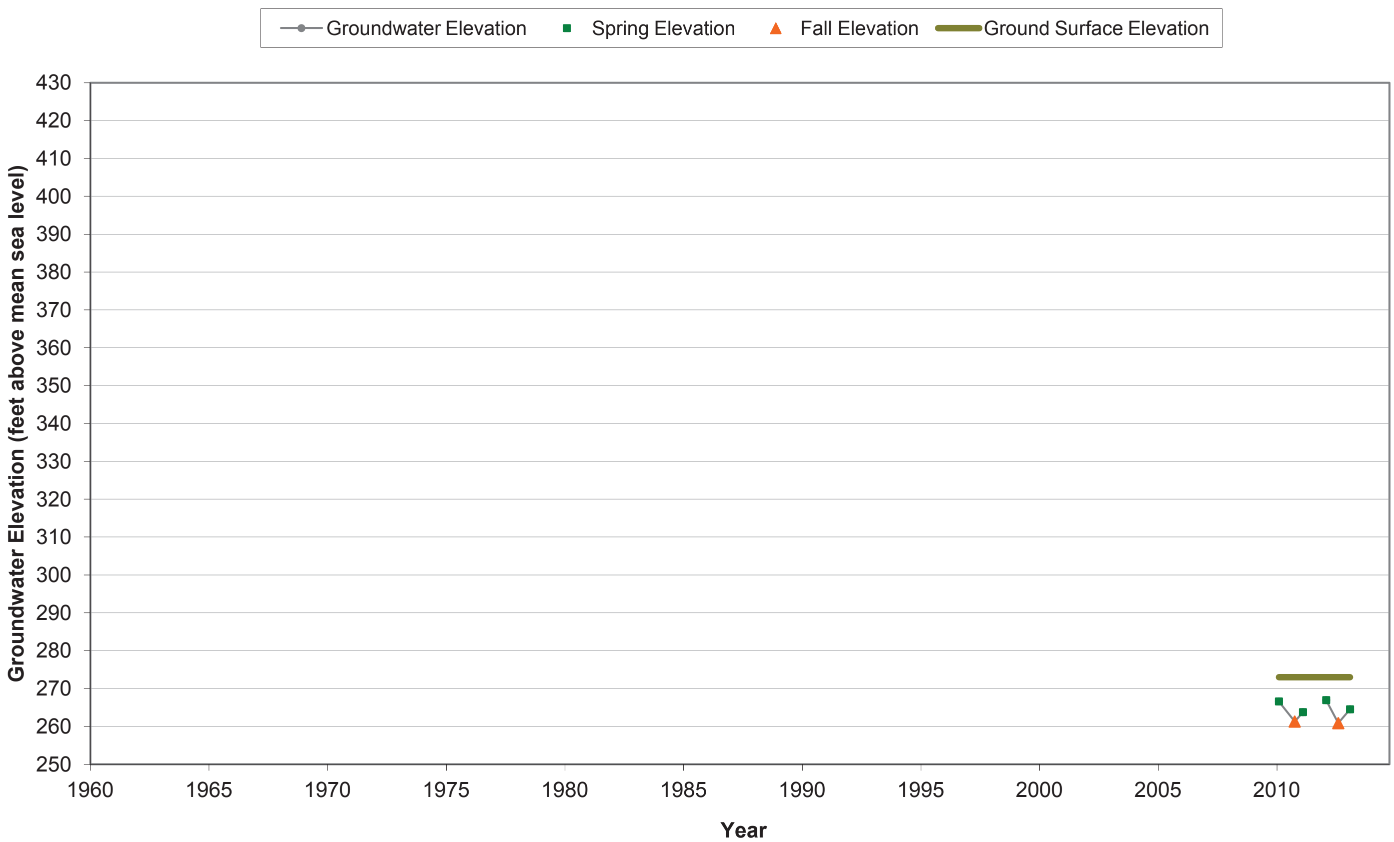
Groundwater-Level Hydrograph
H08-03 (200-500 feet)



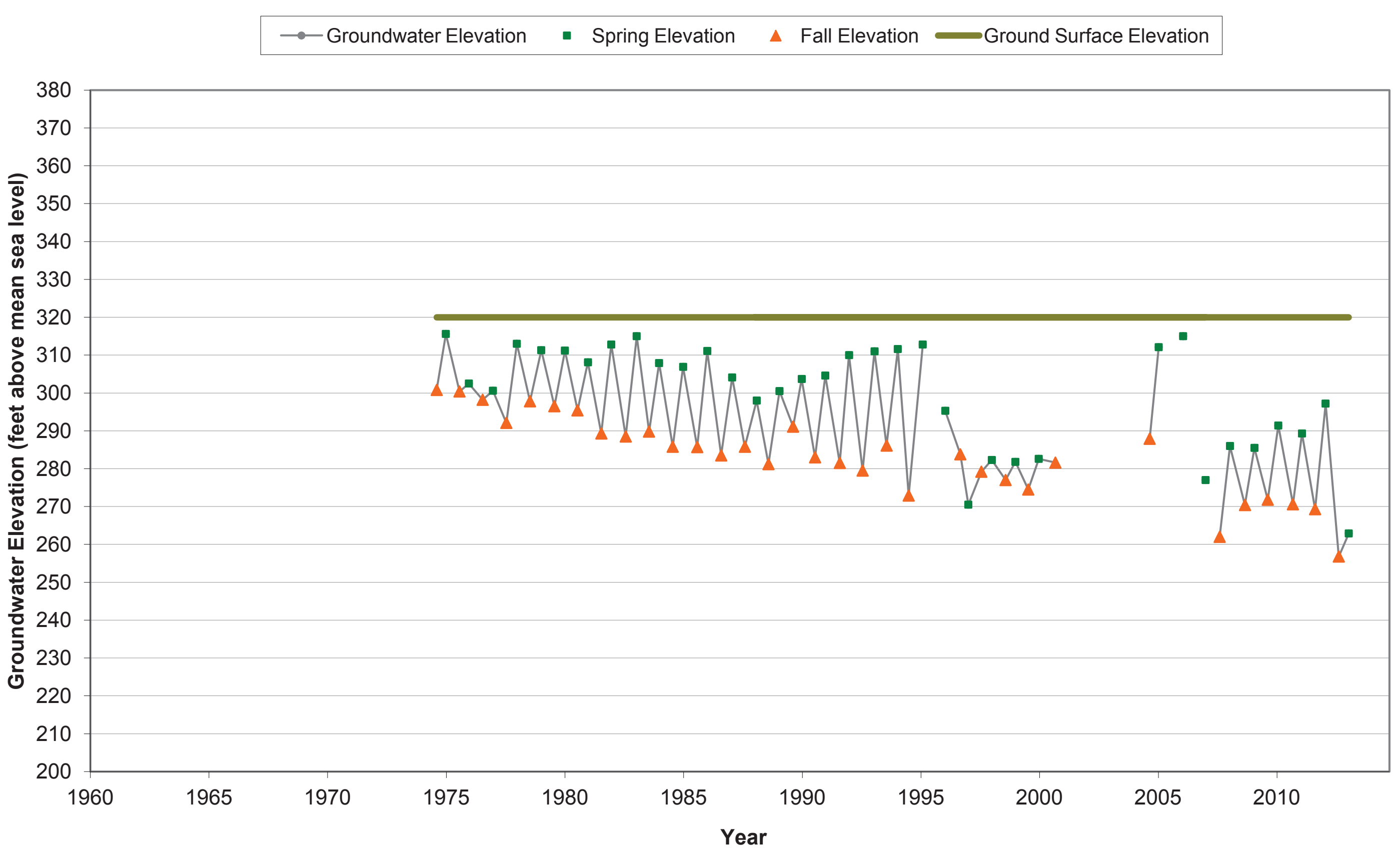
Groundwater-Level Hydrograph
I06-01 (200-500 feet)

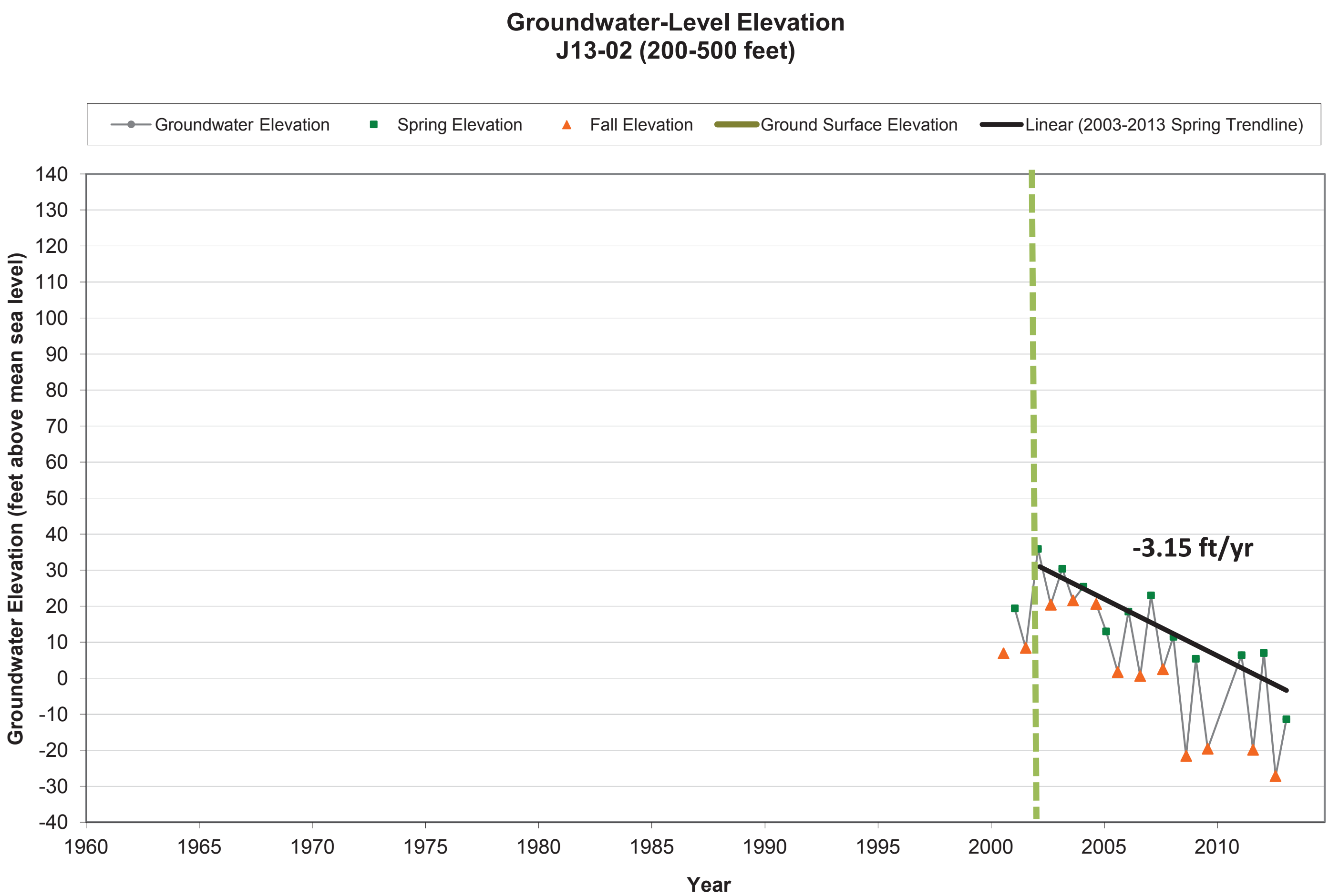


Groundwater-Level Hydrograph
I07-02 (200-500 feet)

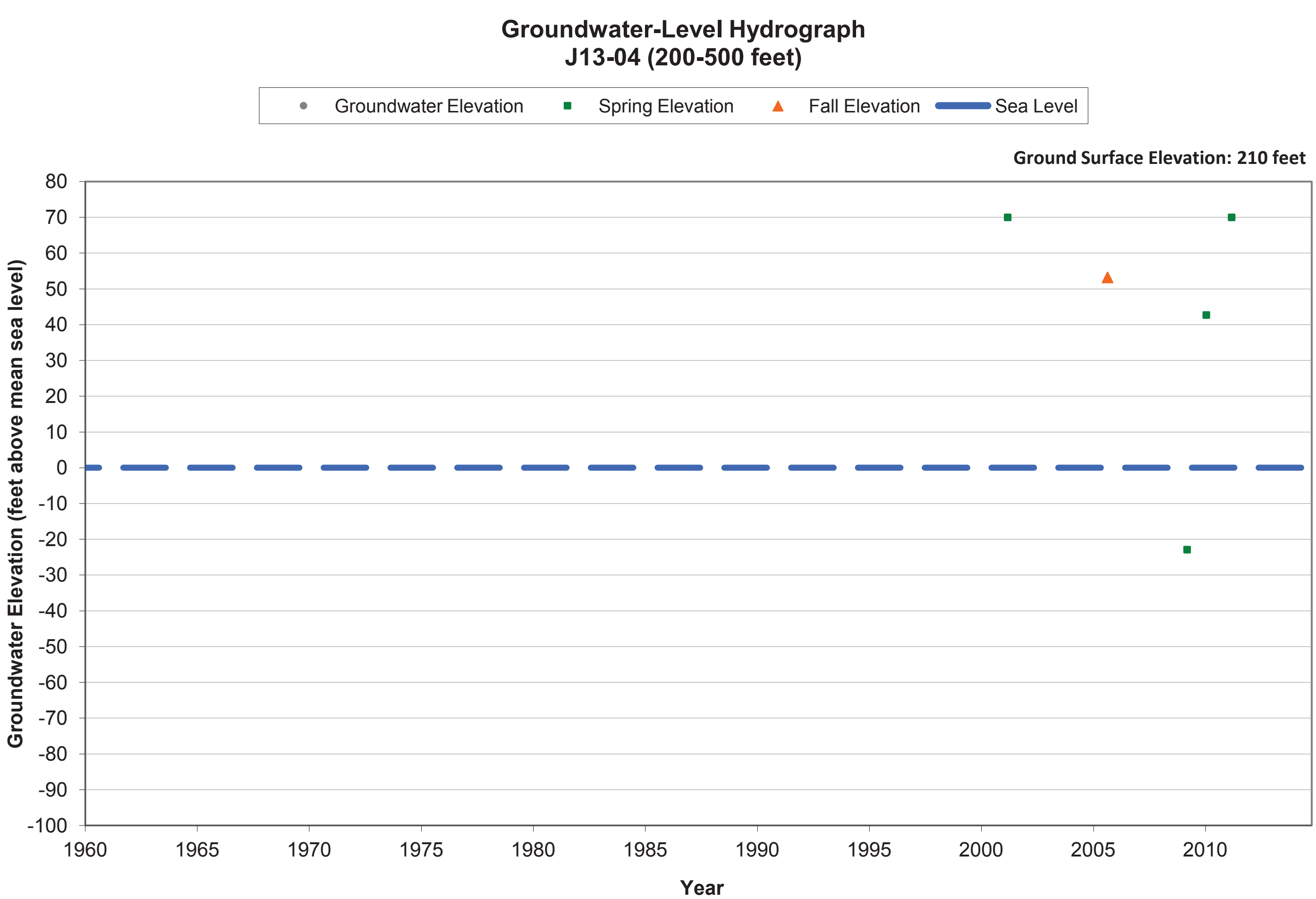


Groundwater-Level Hydrograph
J07-03 (200-500 feet)



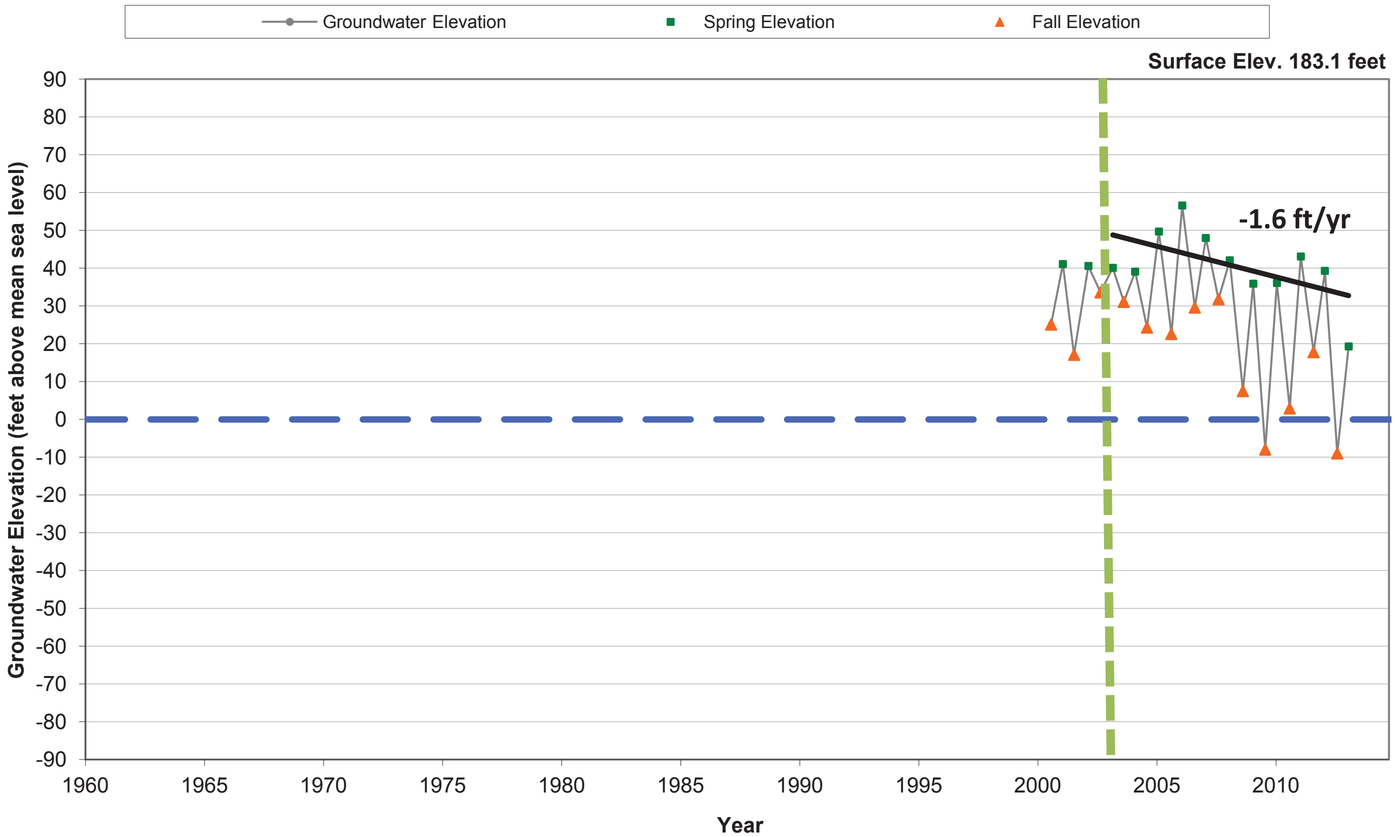


Groundwater-Level Elevation
J13-02 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Linear (2003-2013 Spring Trendline)
-3.15 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

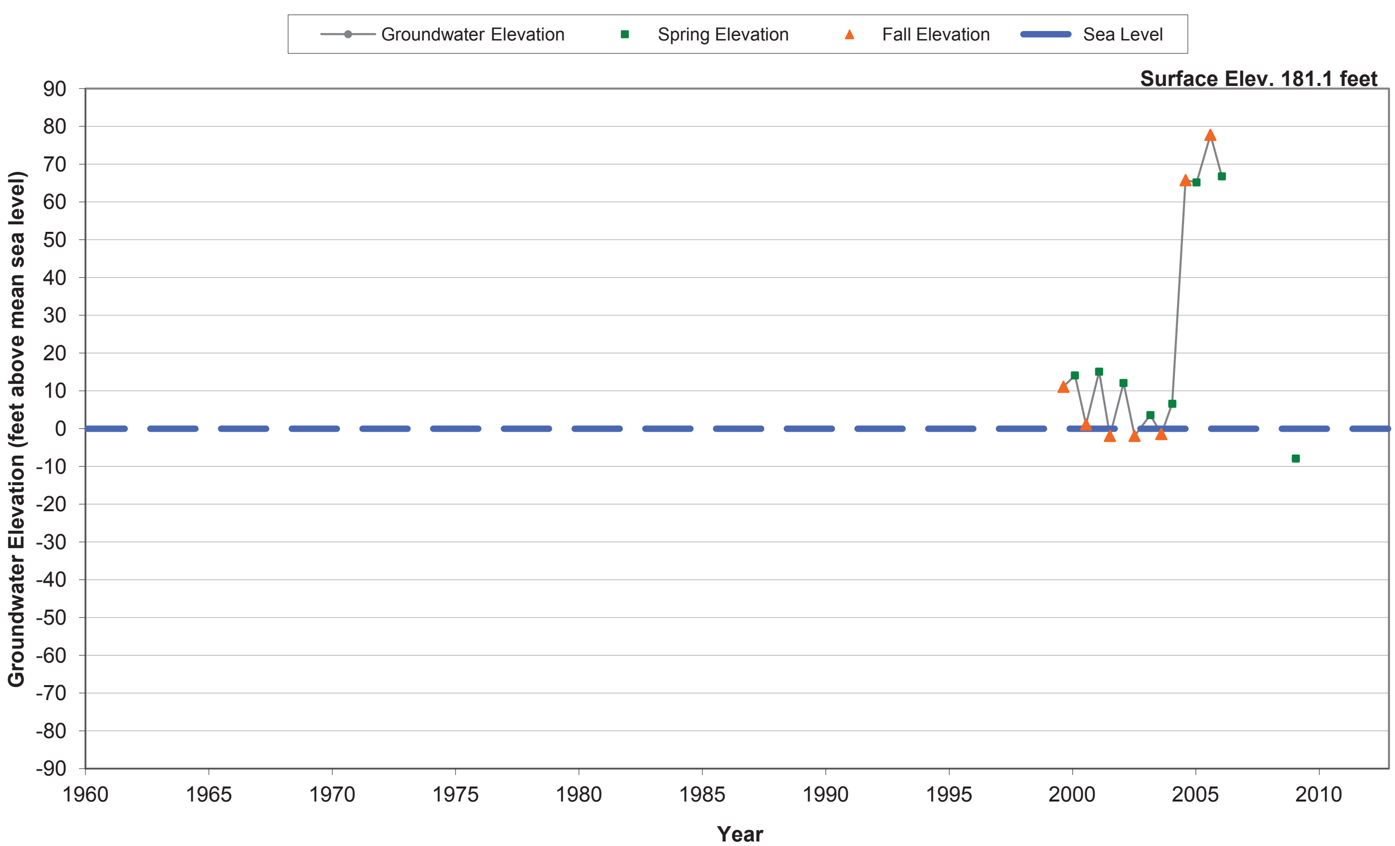


Groundwater-Level Hydrograph
J13-04 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Ground Surface Elevation: 210 feet
Groundwater Elevation (feet above mean sea level)
Year
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

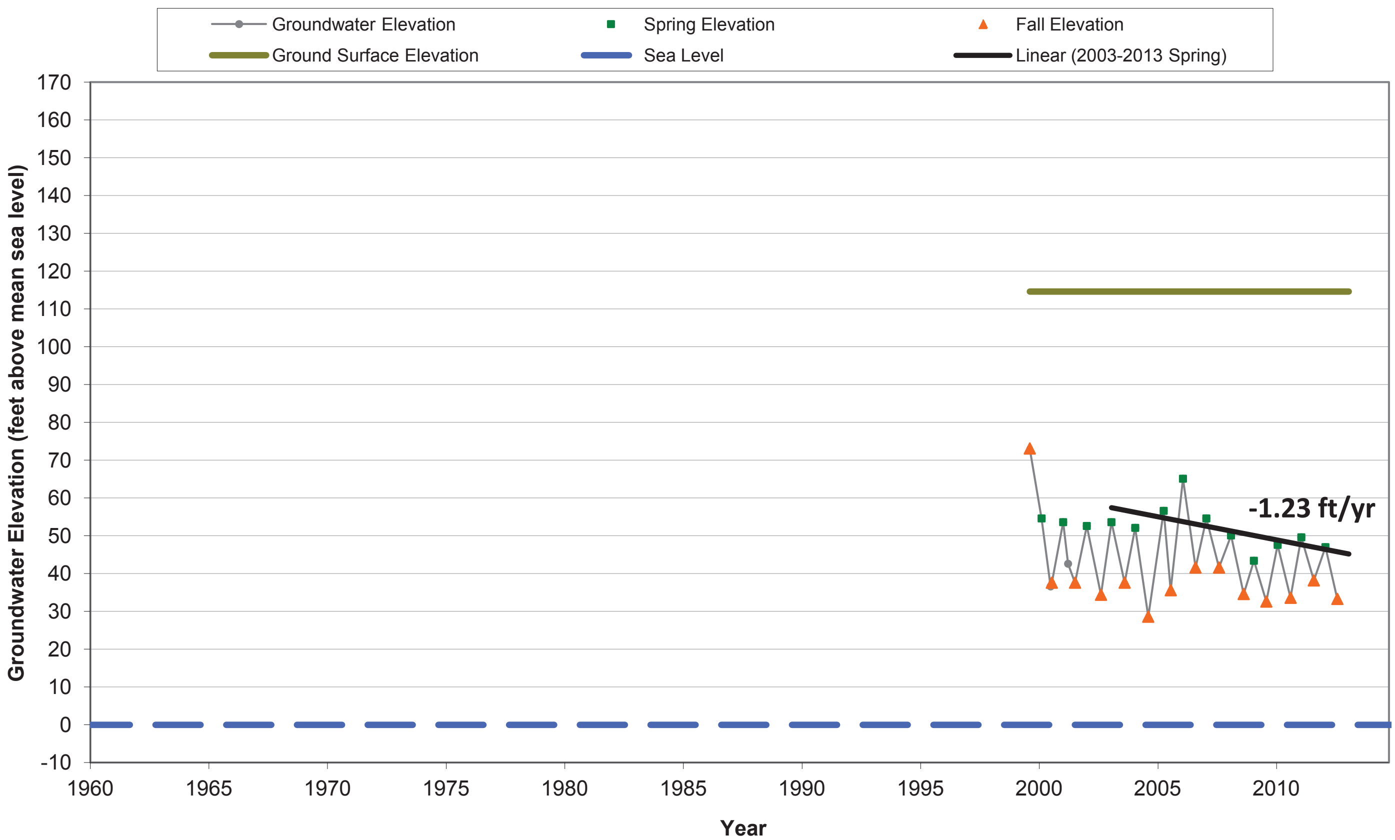
Groundwater-Level Hydrograph
K13-08 (200-500 feet)



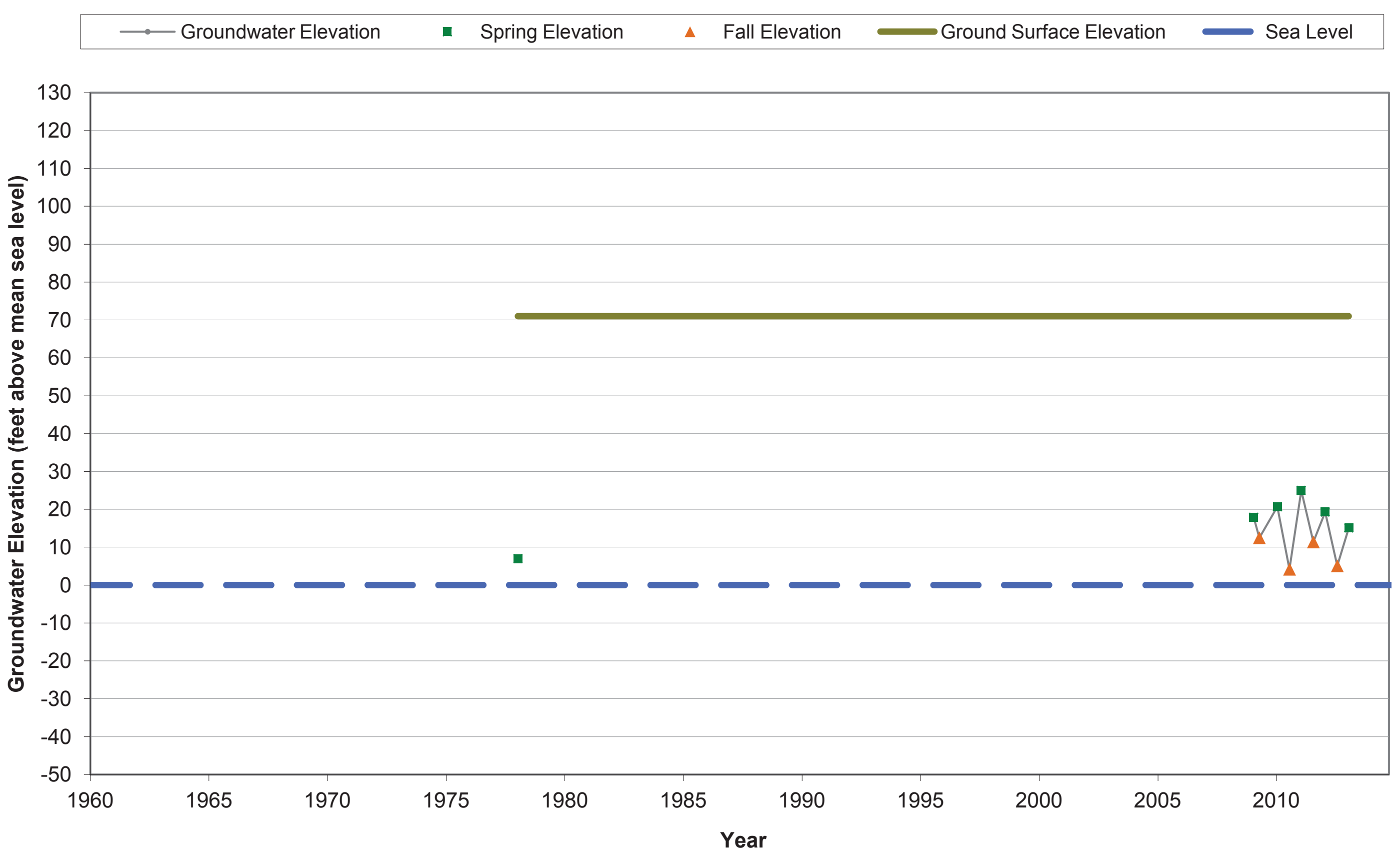
Groundwater-Level Hydrograph
K14-03 (200-500 feet)

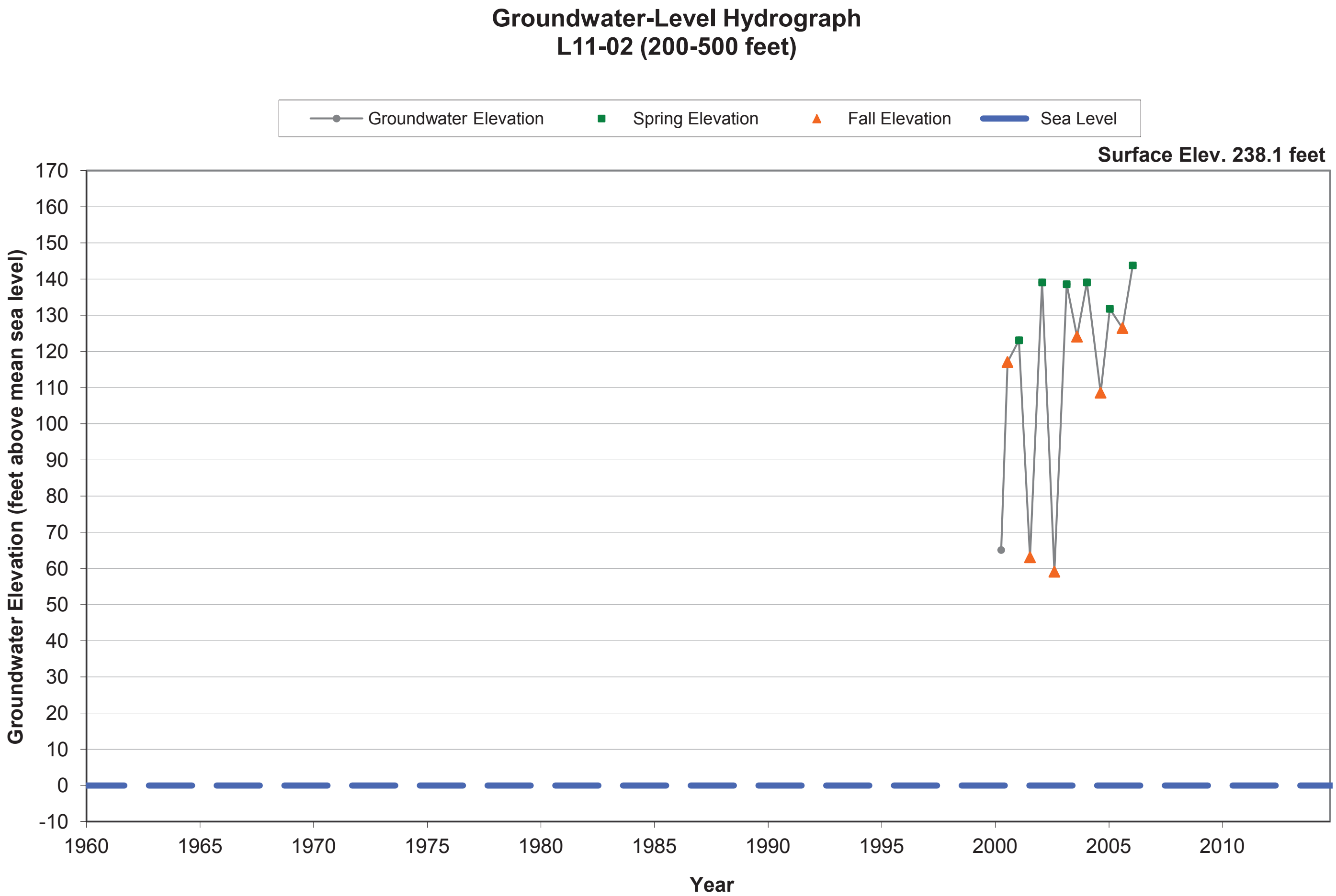


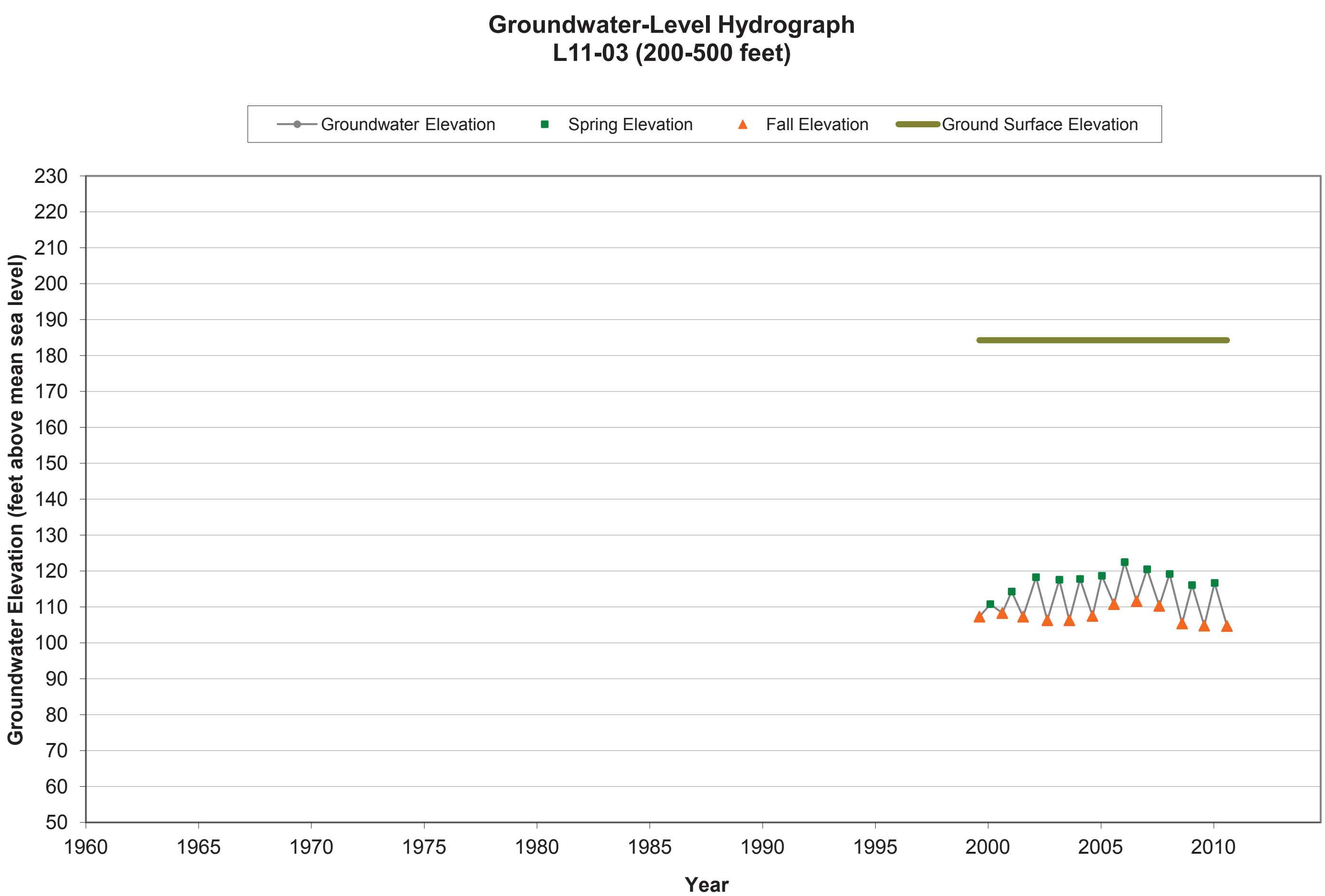
Groundwater-Level Hydrograph
K15-02 (200-500 feet)



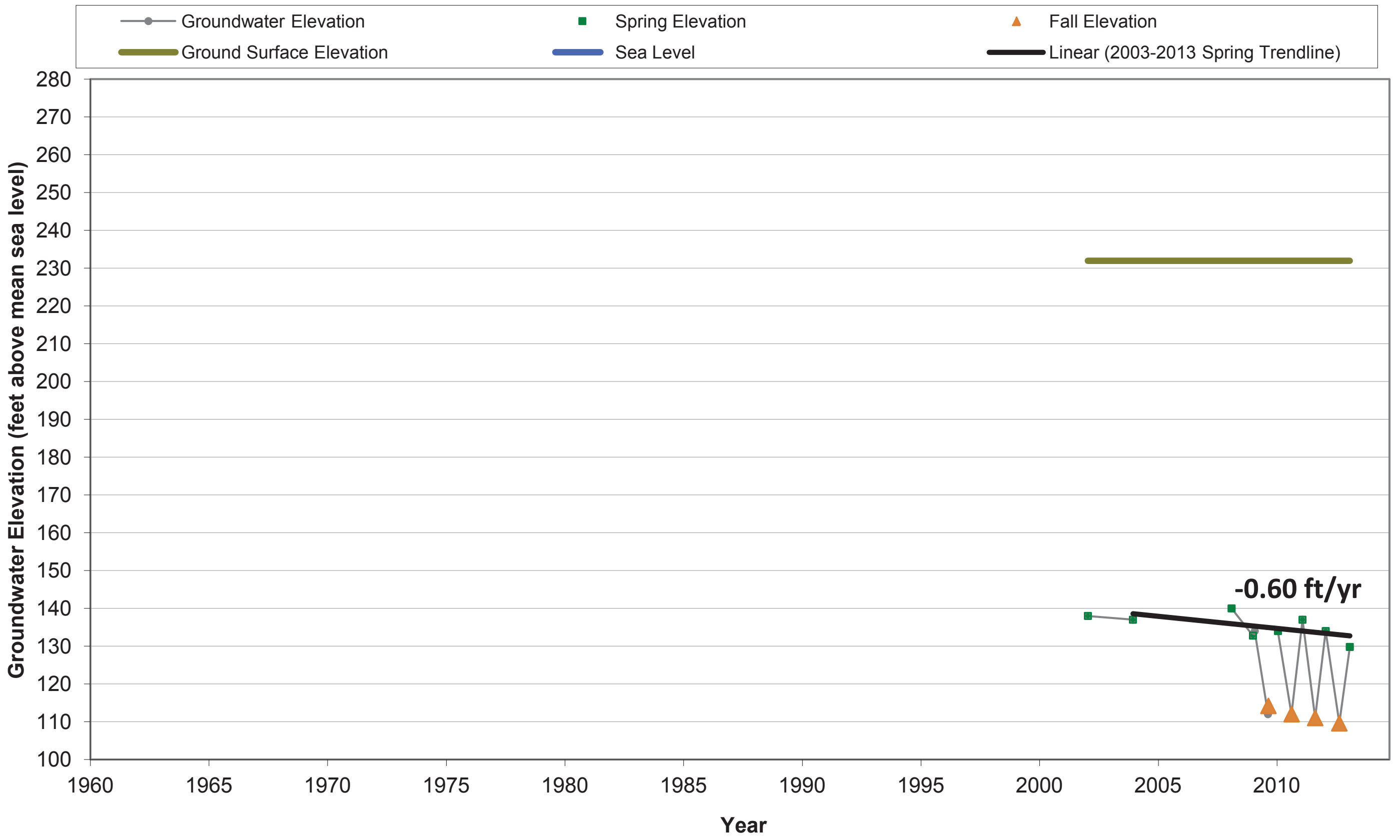
Groundwater-Level Hydrograph
K15-09 (200-500 feet)



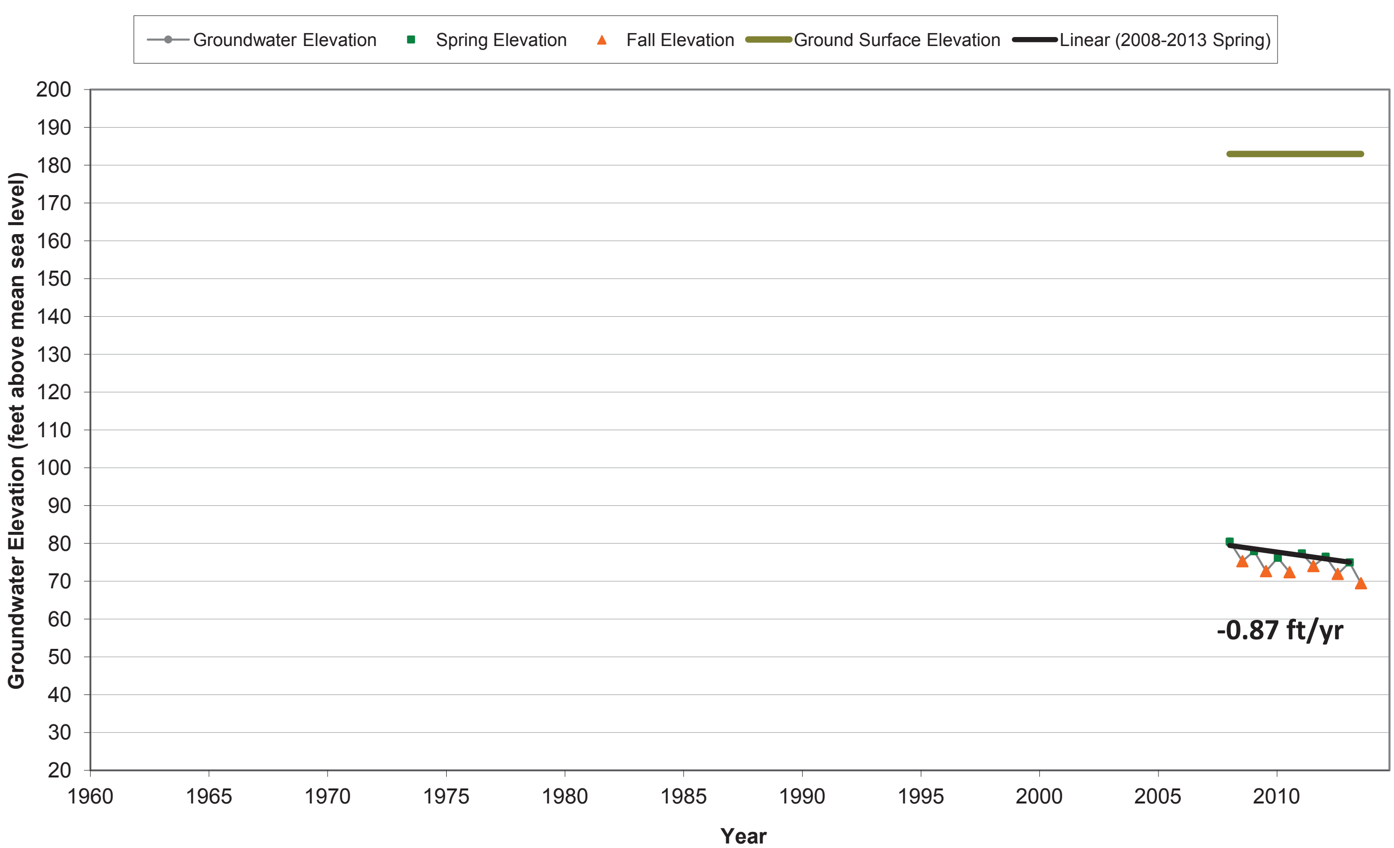

Groundwater-Level Hydrograph
L11-02 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Surface Elev. 238.1 feet
Groundwater Elevation (feet above mean sea level)
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

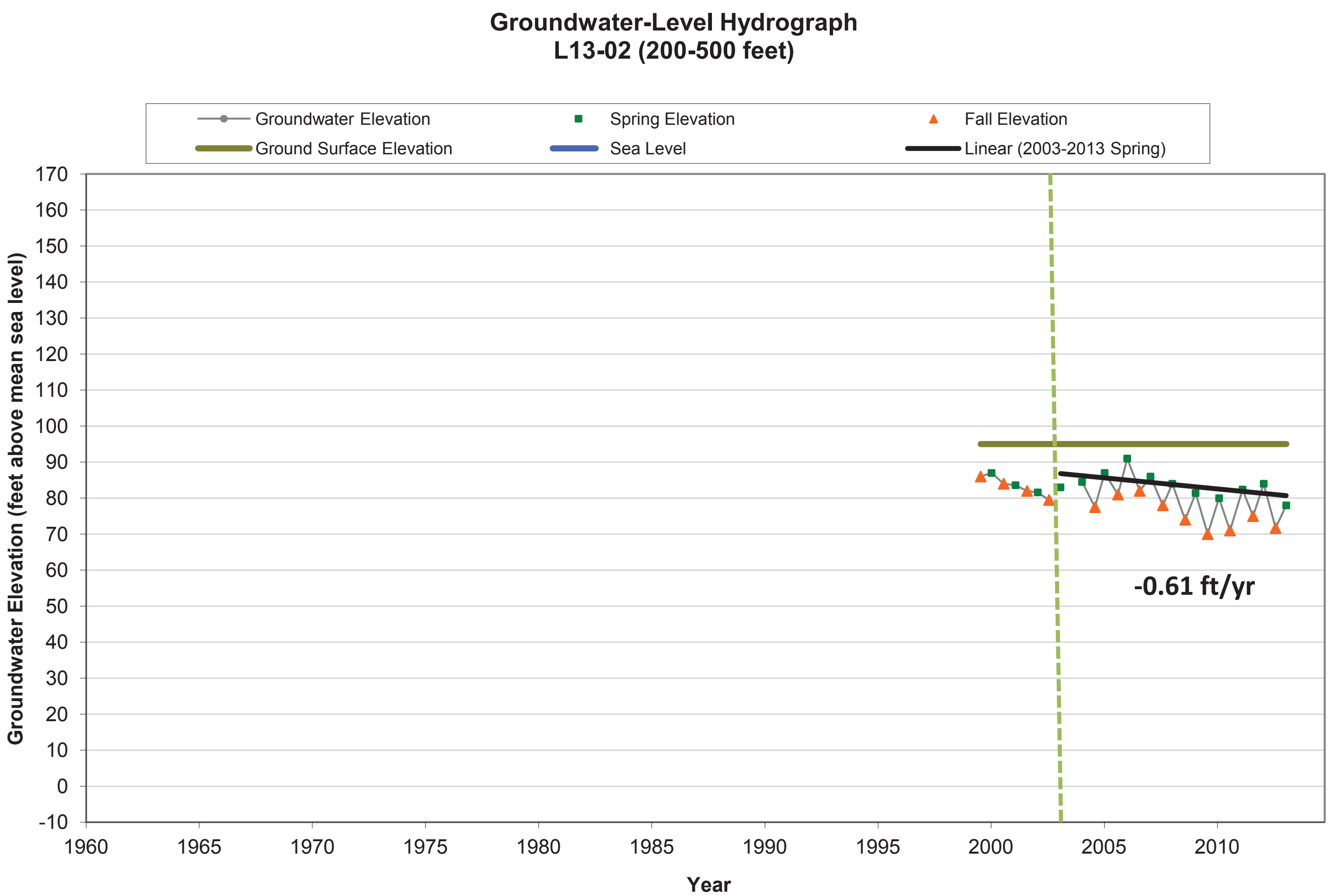

Groundwater-Level Hydrograph
L11-03 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

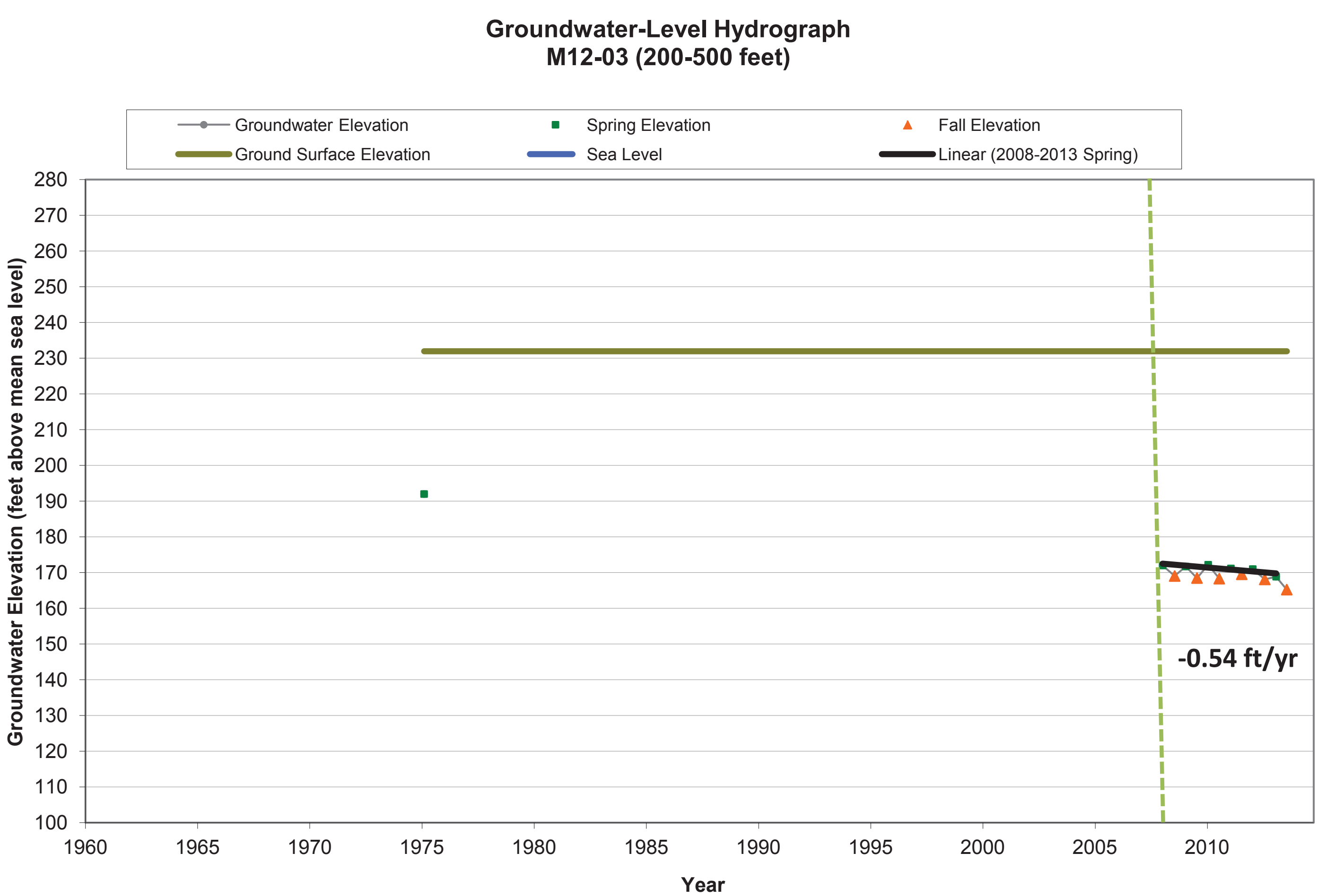
Groundwater-Level Hydrograph
L11-06 (200-500 feet)

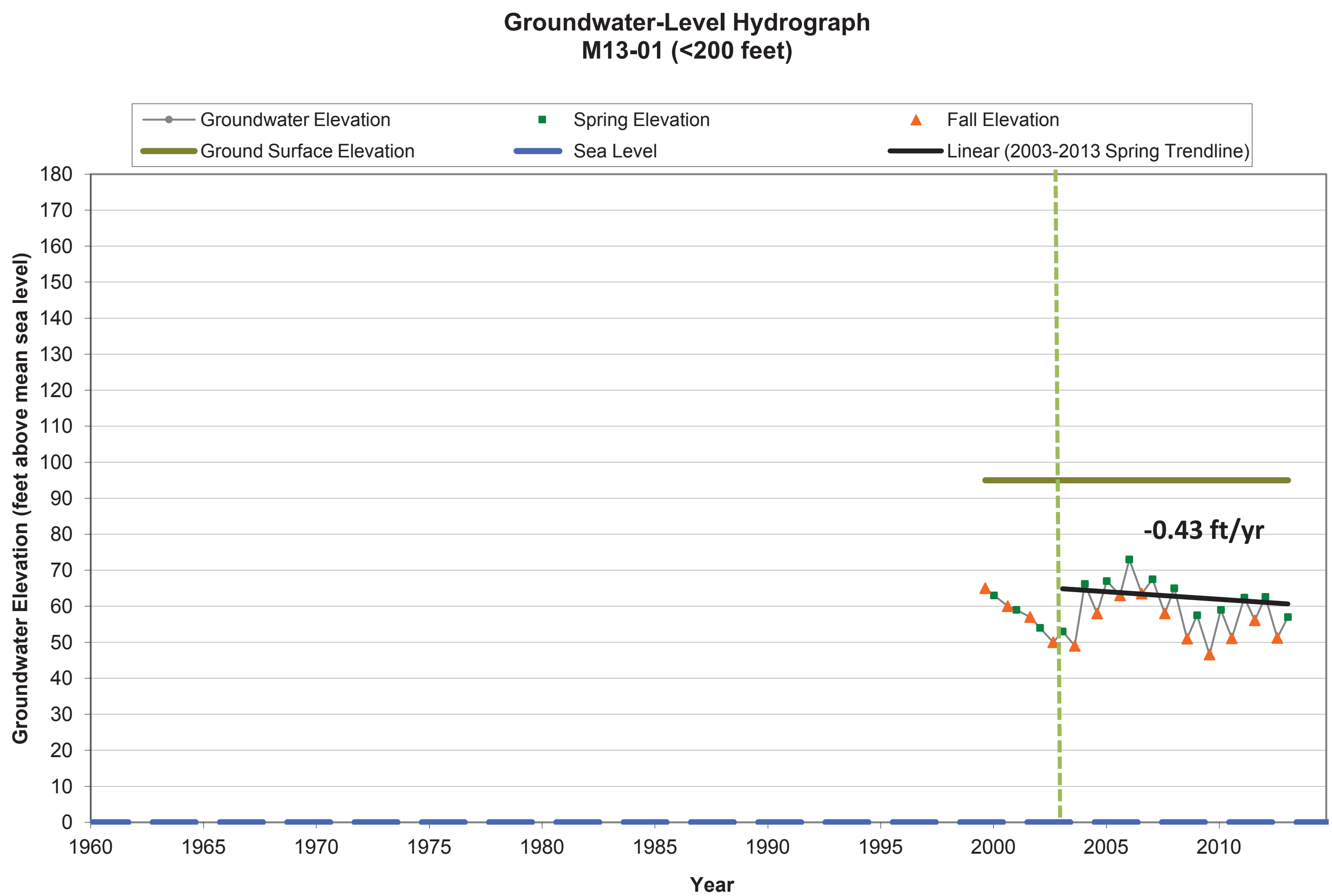


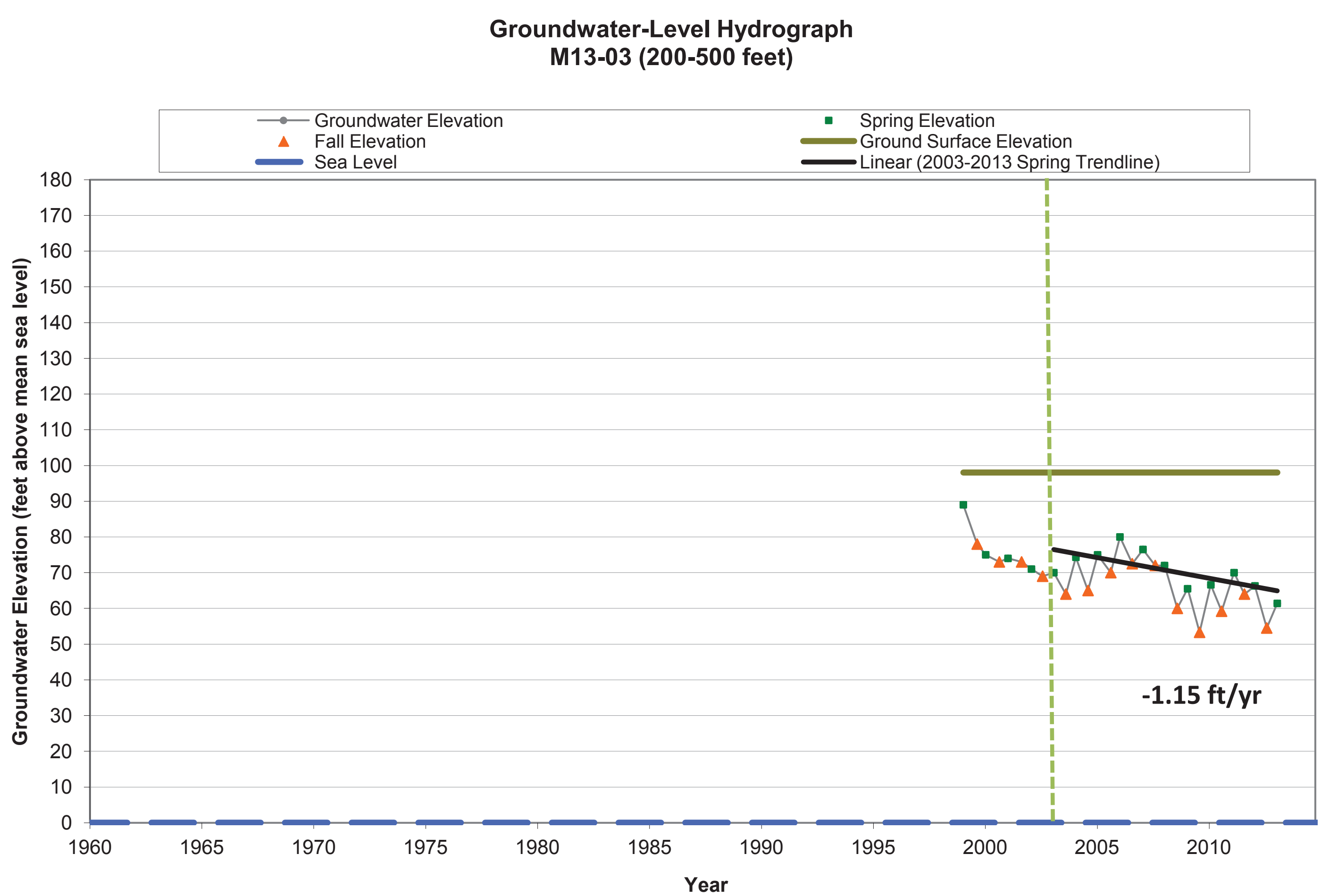
Groundwater-Level Hydrograph
L12-02 (200-500 feet)



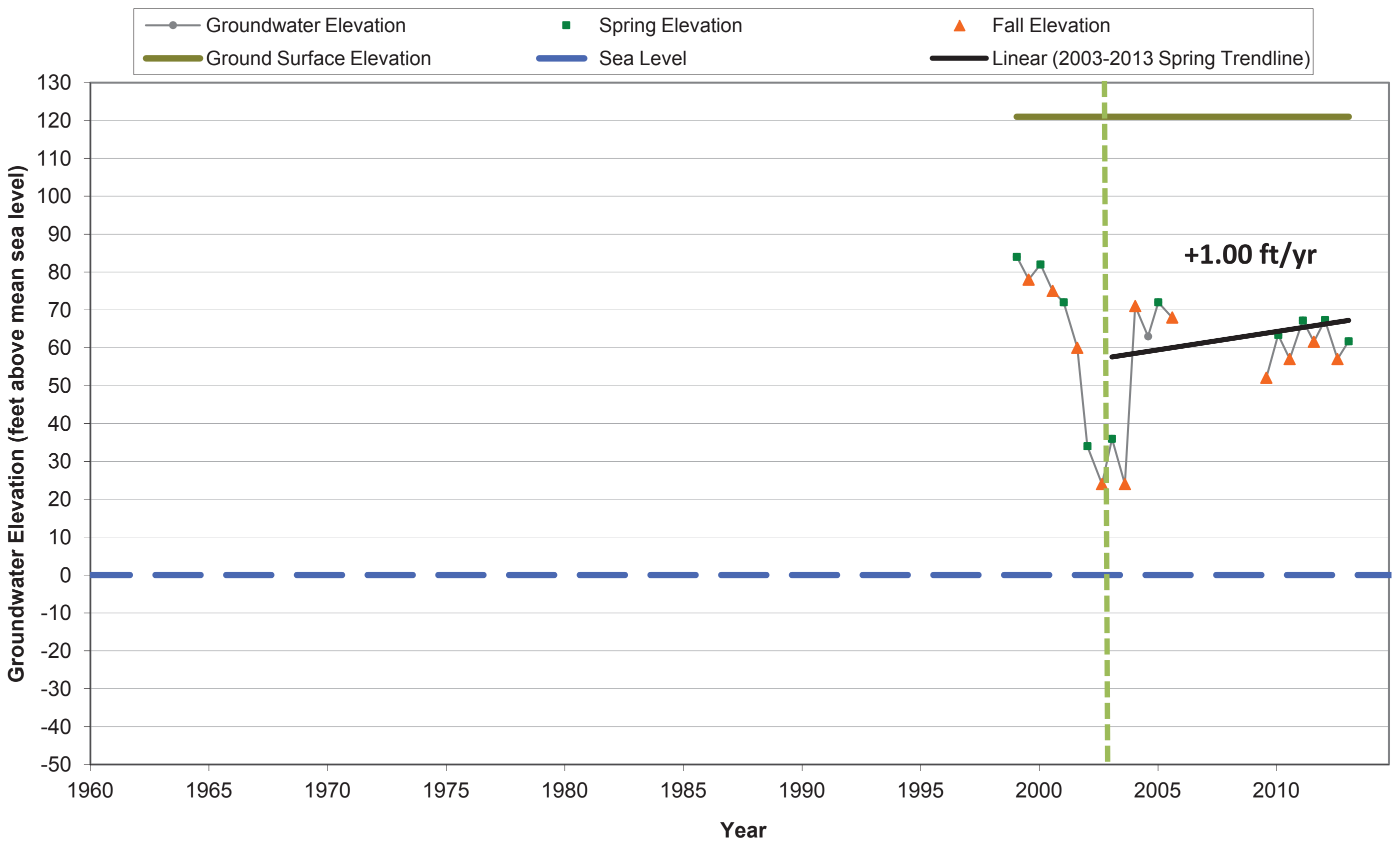

Groundwater-Level Hydrograph
L13-02 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring)
Groundwater Elevation (feet above mean sea level)
Year
-0.61 ft/yr


Groundwater-Level Hydrograph
M12-03 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2008-2013 Spring)
Groundwater Elevation (feet above mean sea level)
Year
-0.54 ft/yr

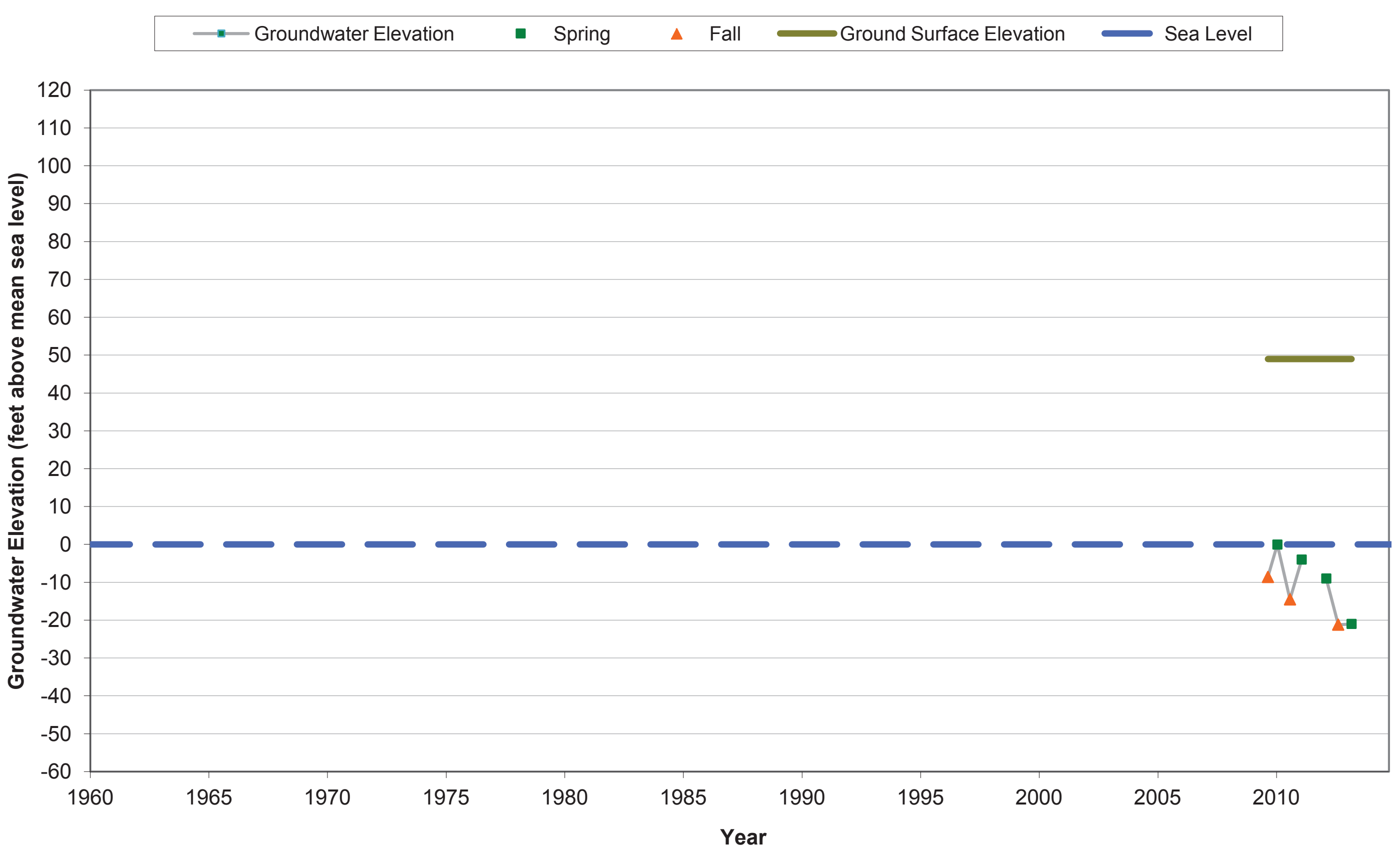

Groundwater-Level Hydrograph
M13-01 (<200 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-0.43 ft/yr
Groundwater Elevation (feet above mean sea level)
Year


Groundwater-Level Hydrograph
M13-03 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-1.15 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

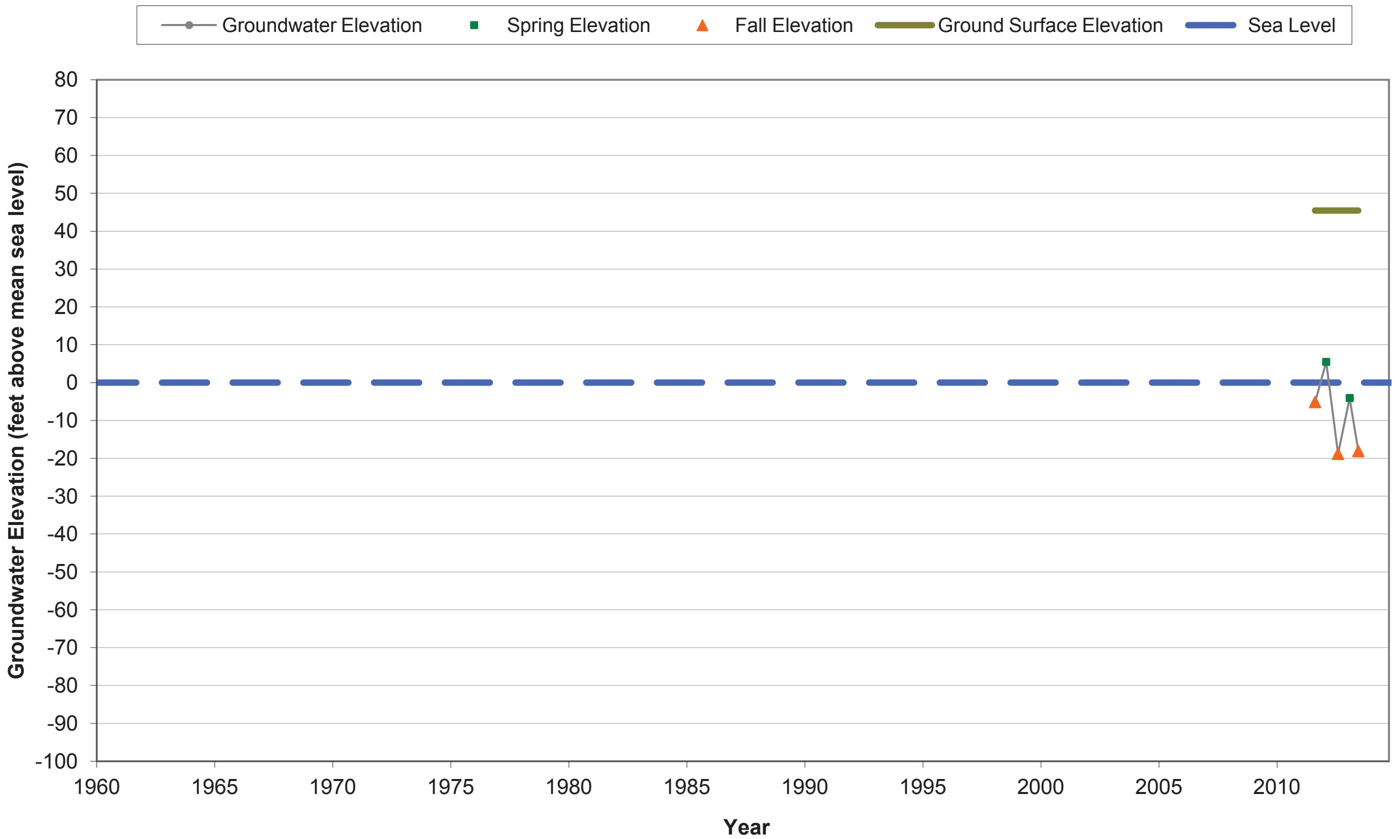
Groundwater-Level Hydrograph
M13-04 (200-500 feet)



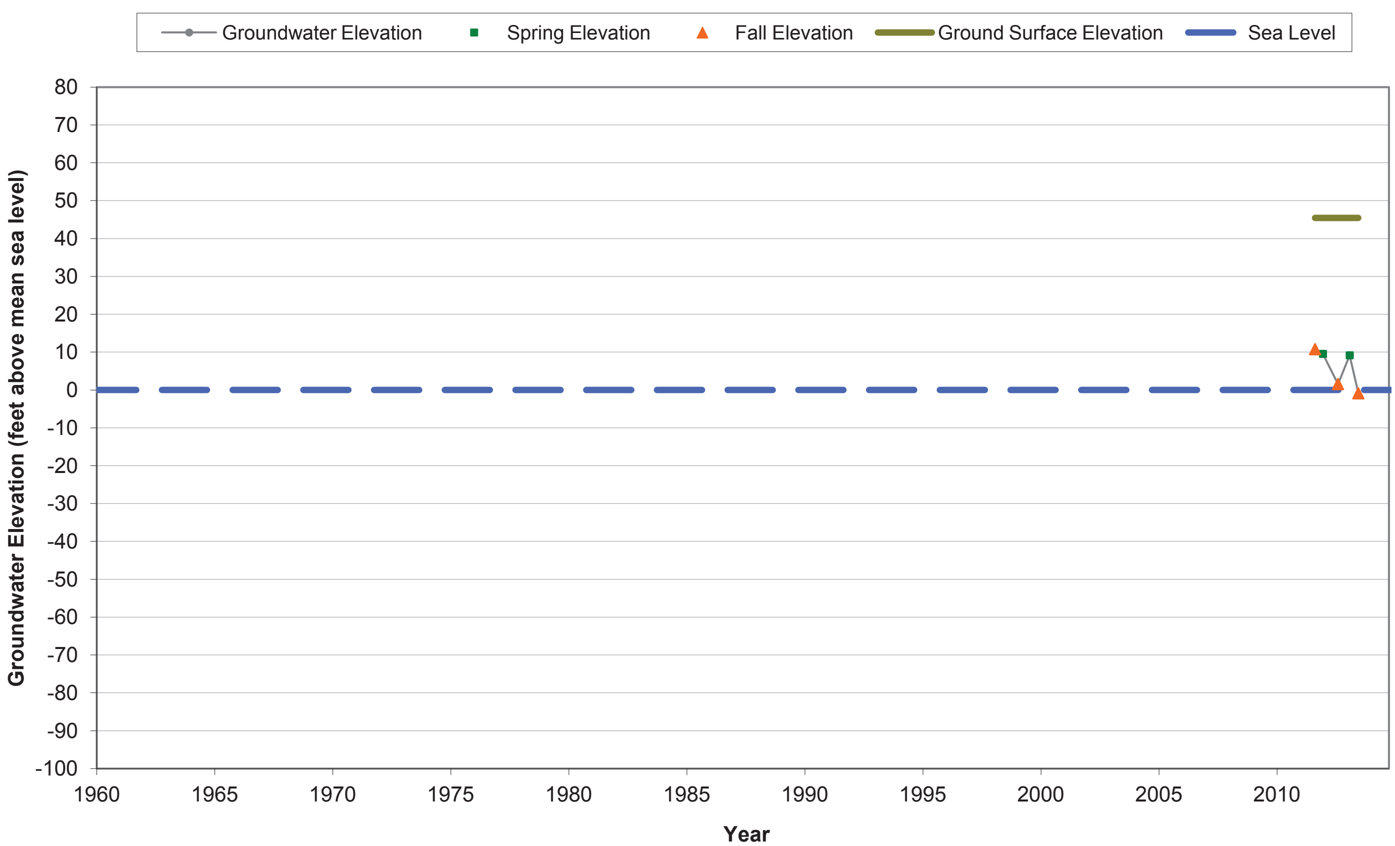
Groundwater-Level Hydrograph
M15-03 (200-500 feet)

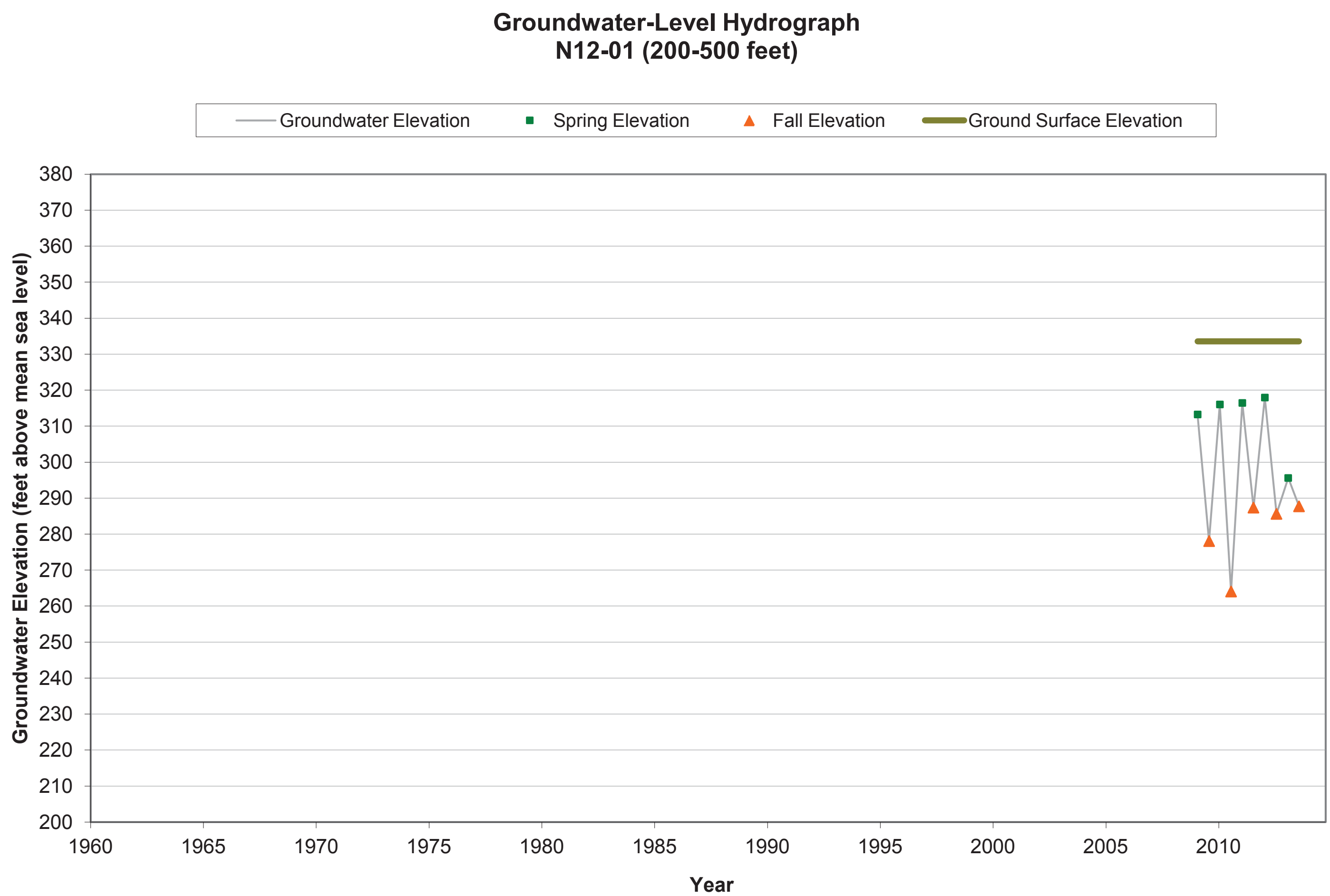


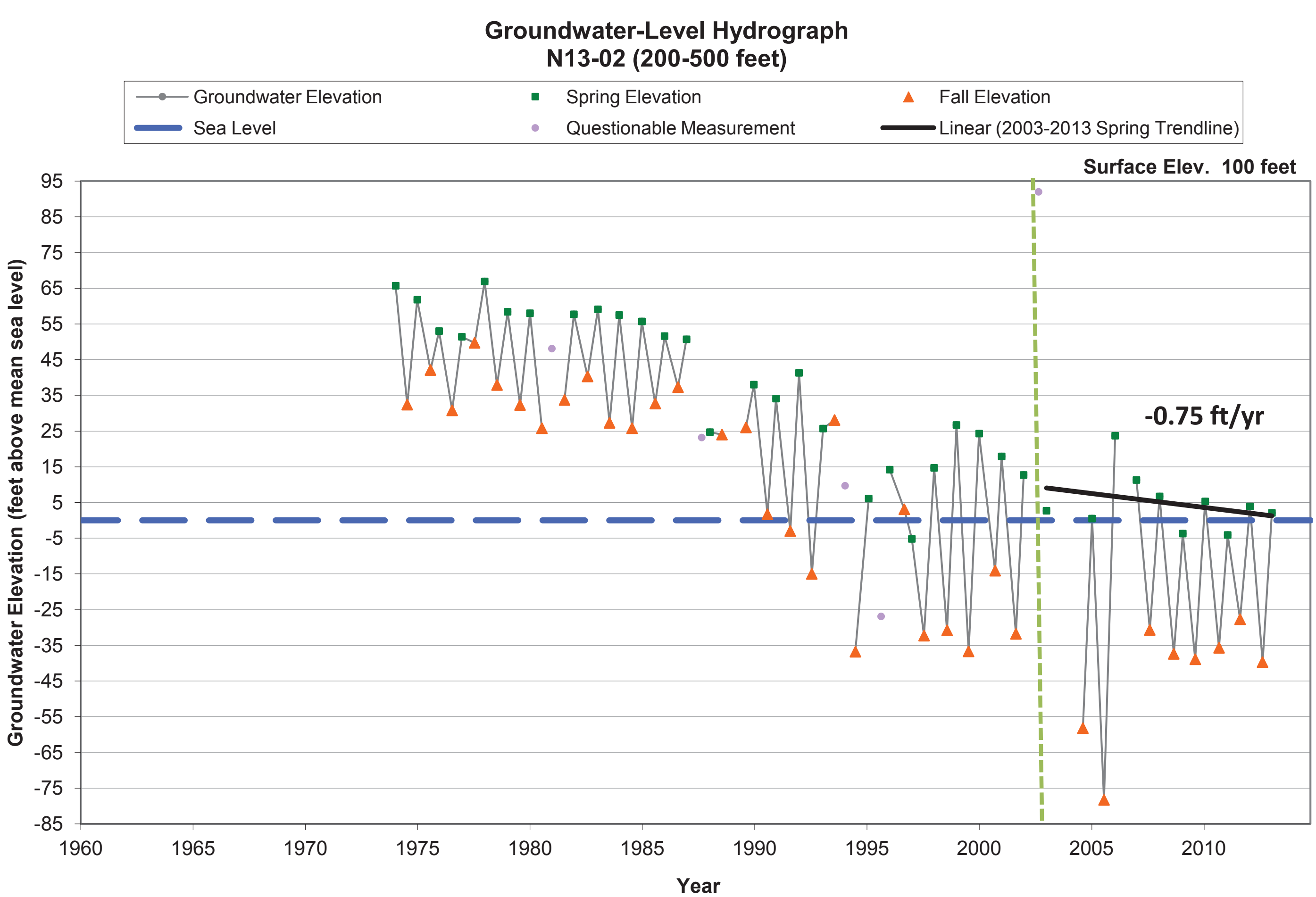
Groundwater-Level Hydrograph
M15-04C (200-500 feet)

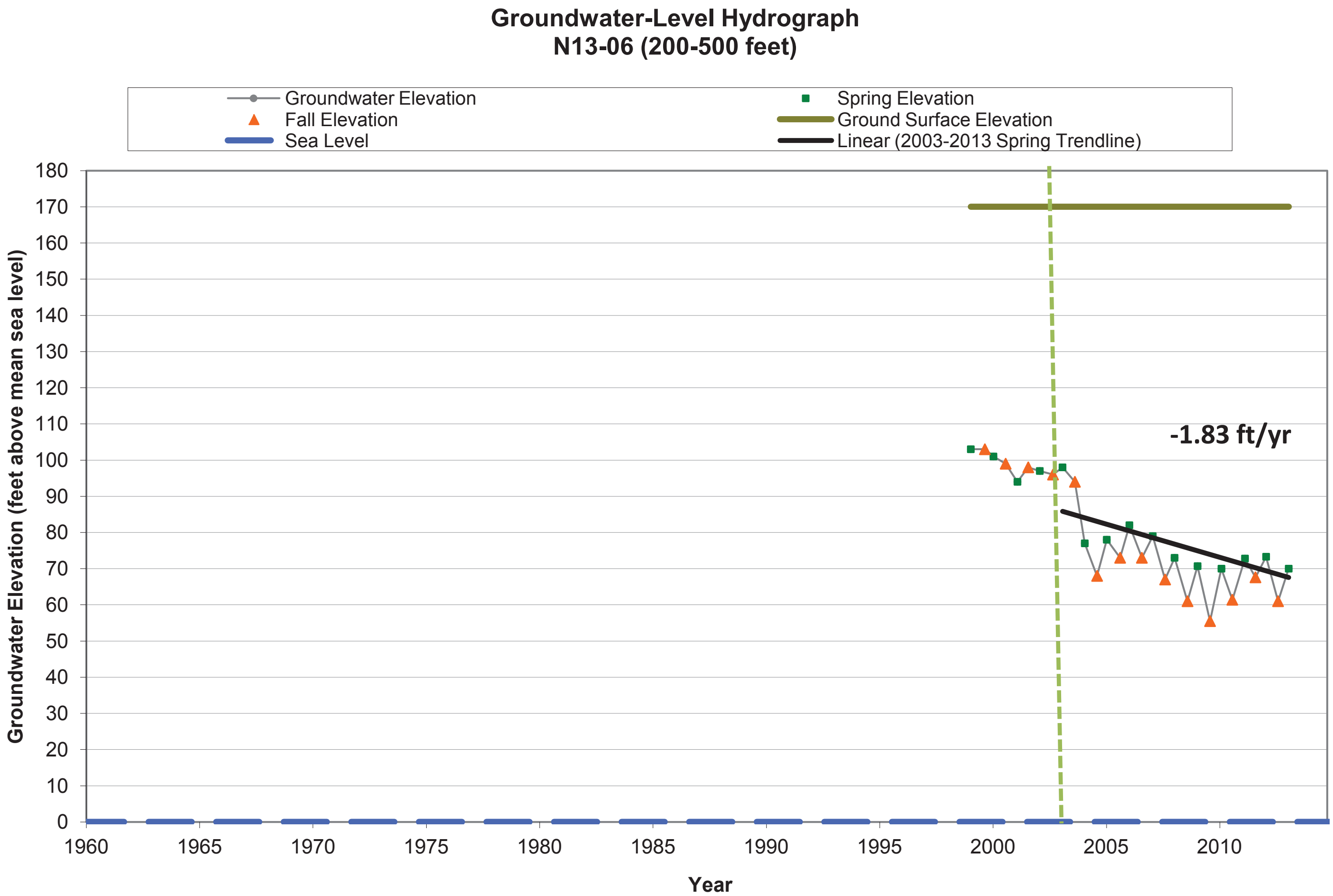


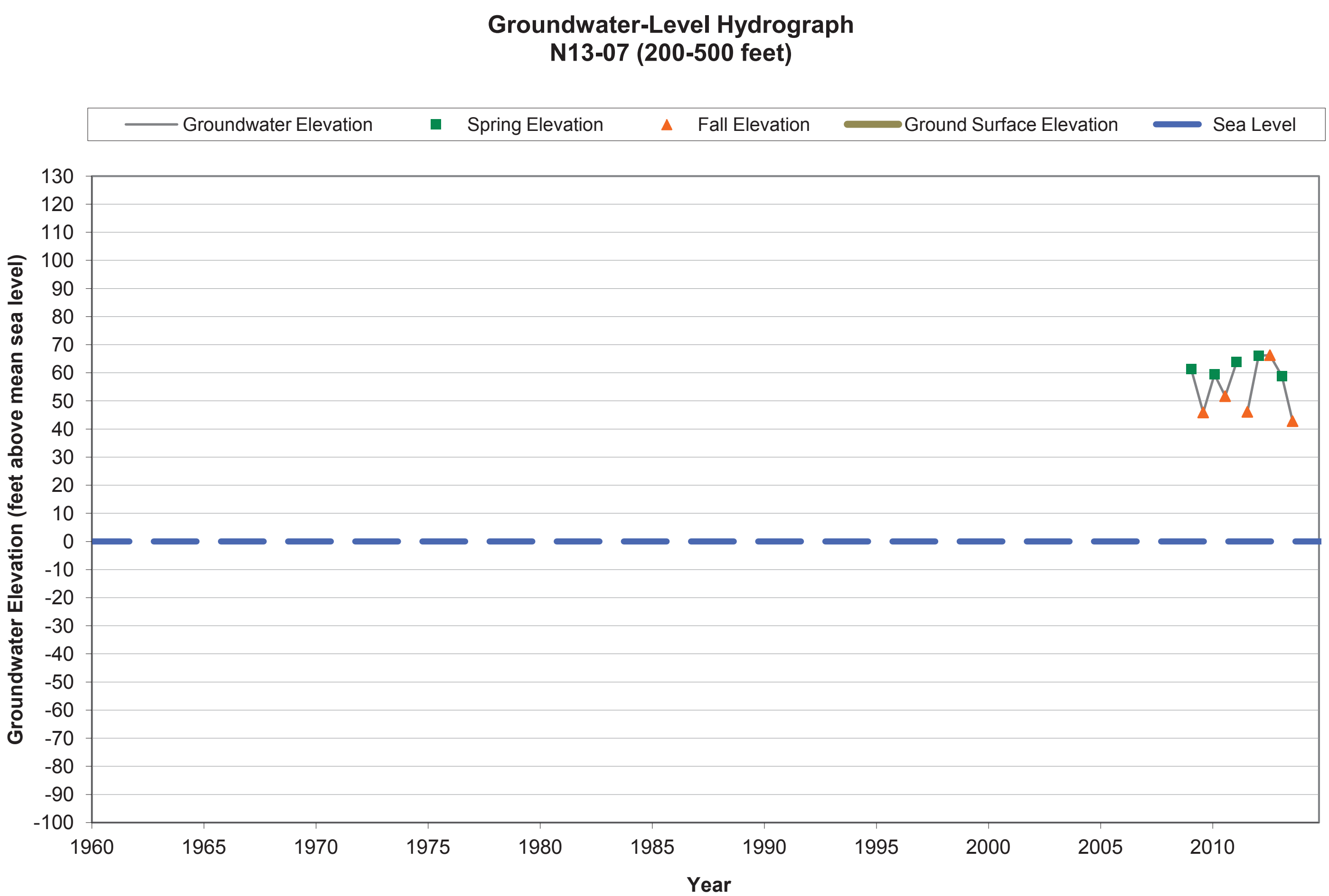
Groundwater-Level Hydrograph
M15-04D (200-500 feet)



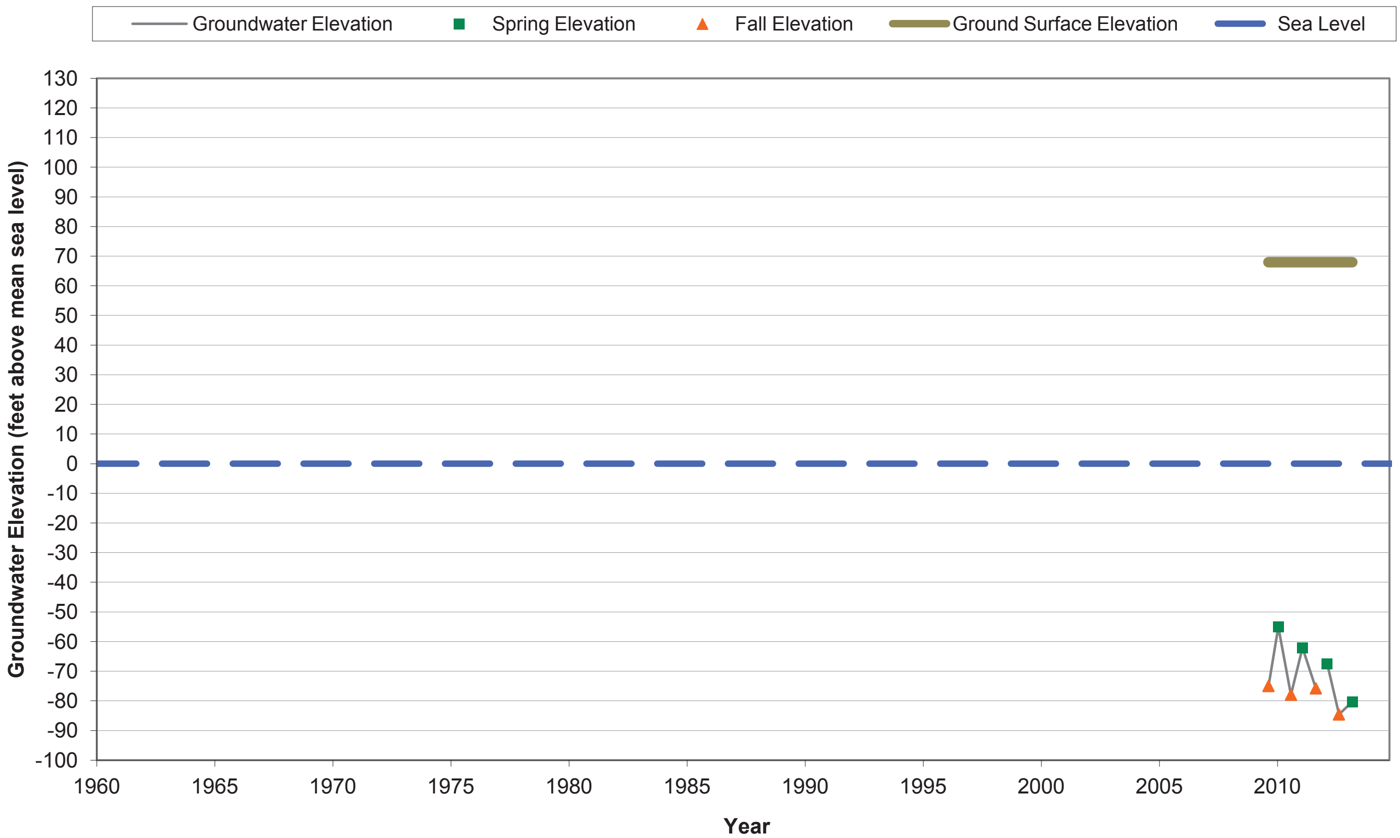

Groundwater-Level Hydrograph
N12-01 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
Year


Groundwater-Level Hydrograph
N13-02 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Questionable Measurement
Linear (2003-2013 Spring Trendline)
Surface Elev. 100 feet
-0.75 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

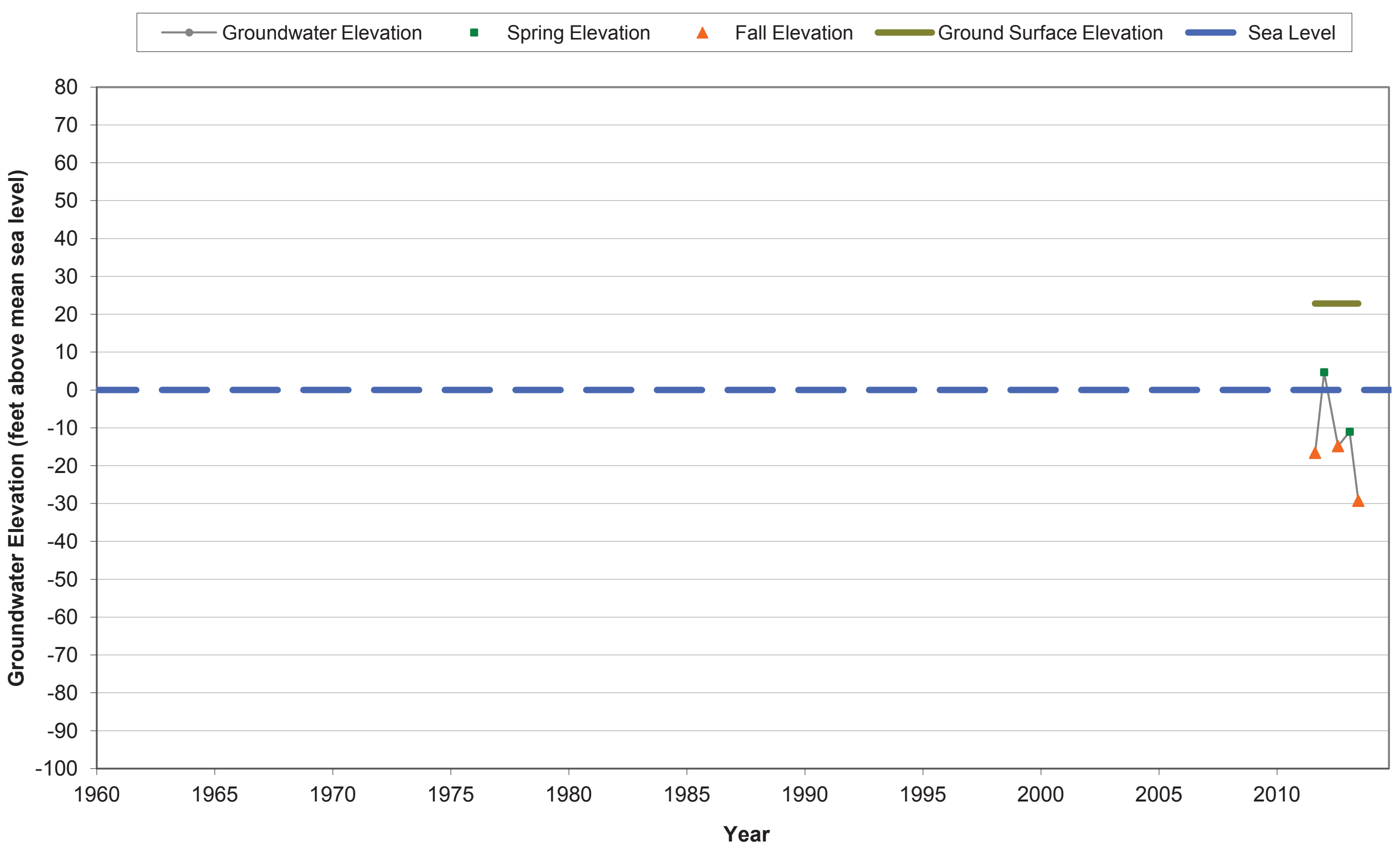

Groundwater-Level Hydrograph
N13-06 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-1.83 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

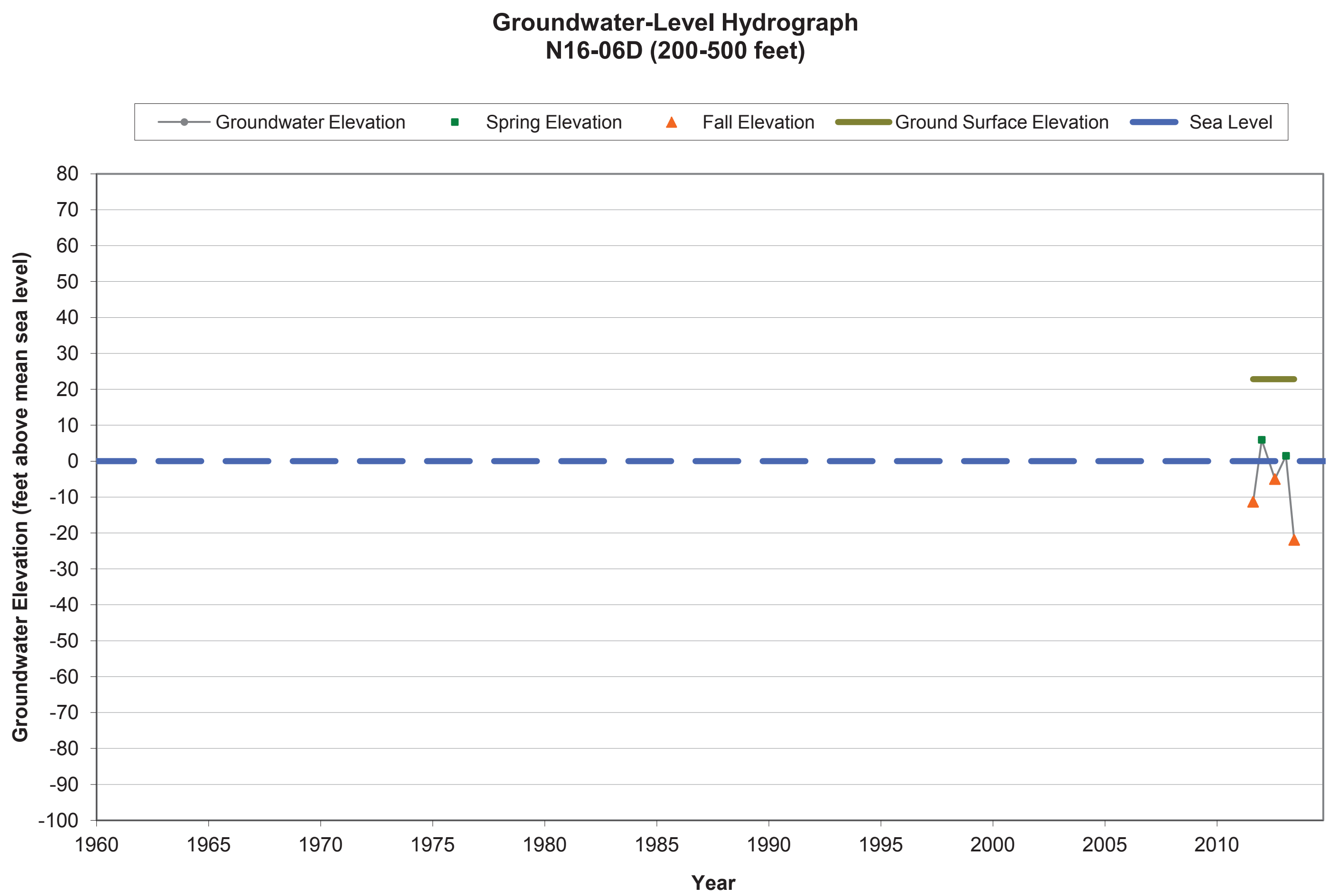

Groundwater-Level Hydrograph
N13-07 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year

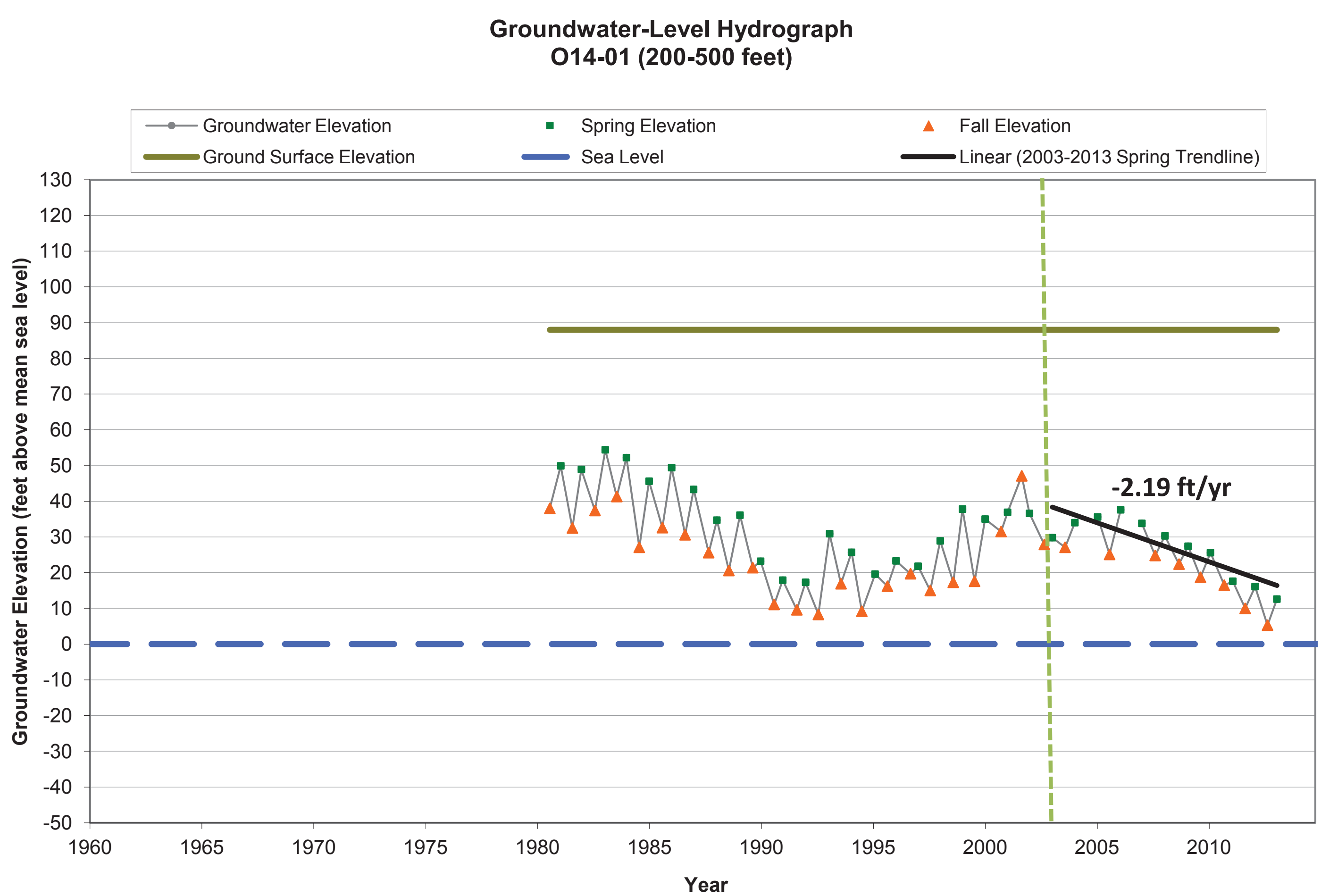
Groundwater-Level Hydrograph
N14-02 (200-500 feet)

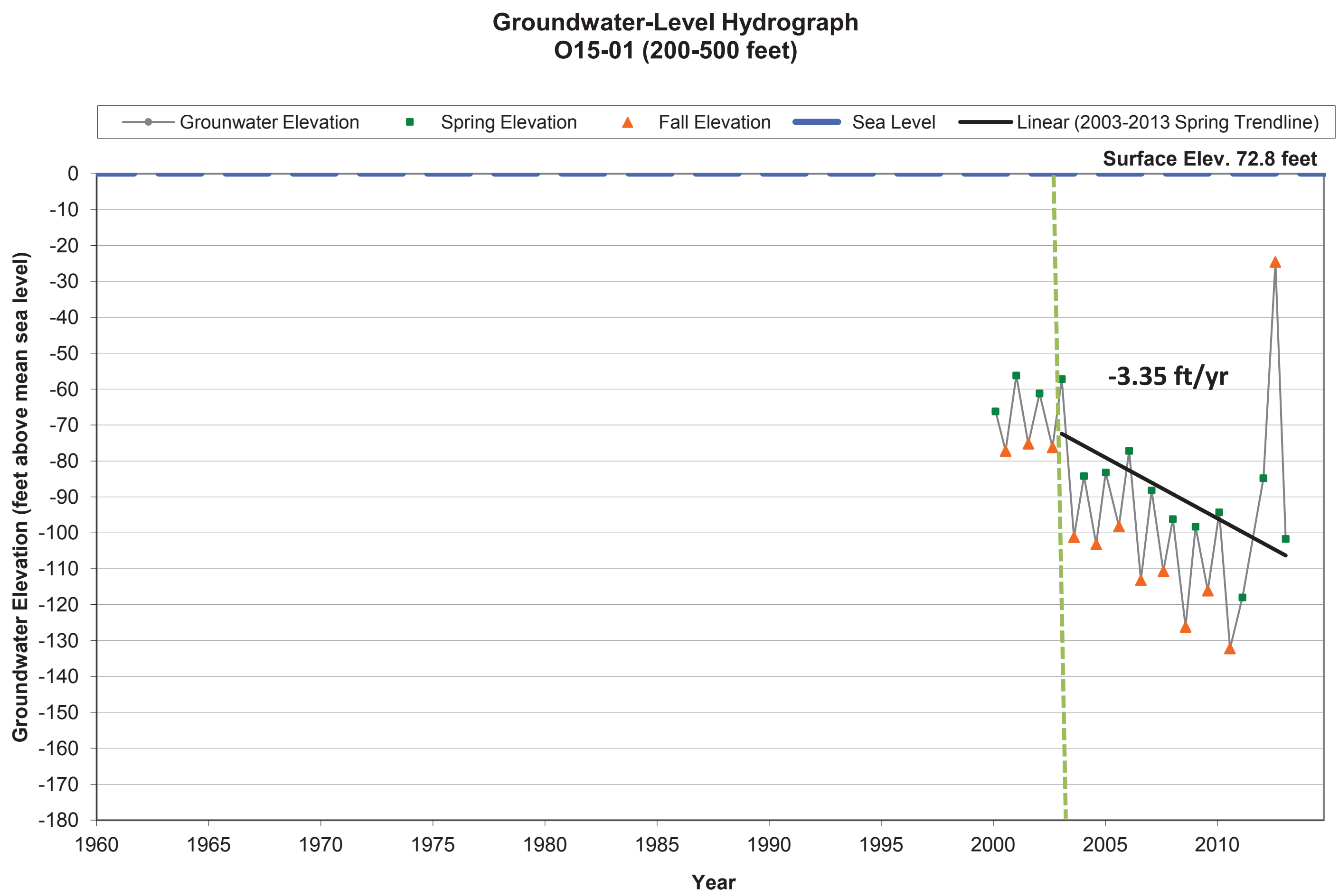


Groundwater-Level Hydrograph
N16-06C (200-500 feet)

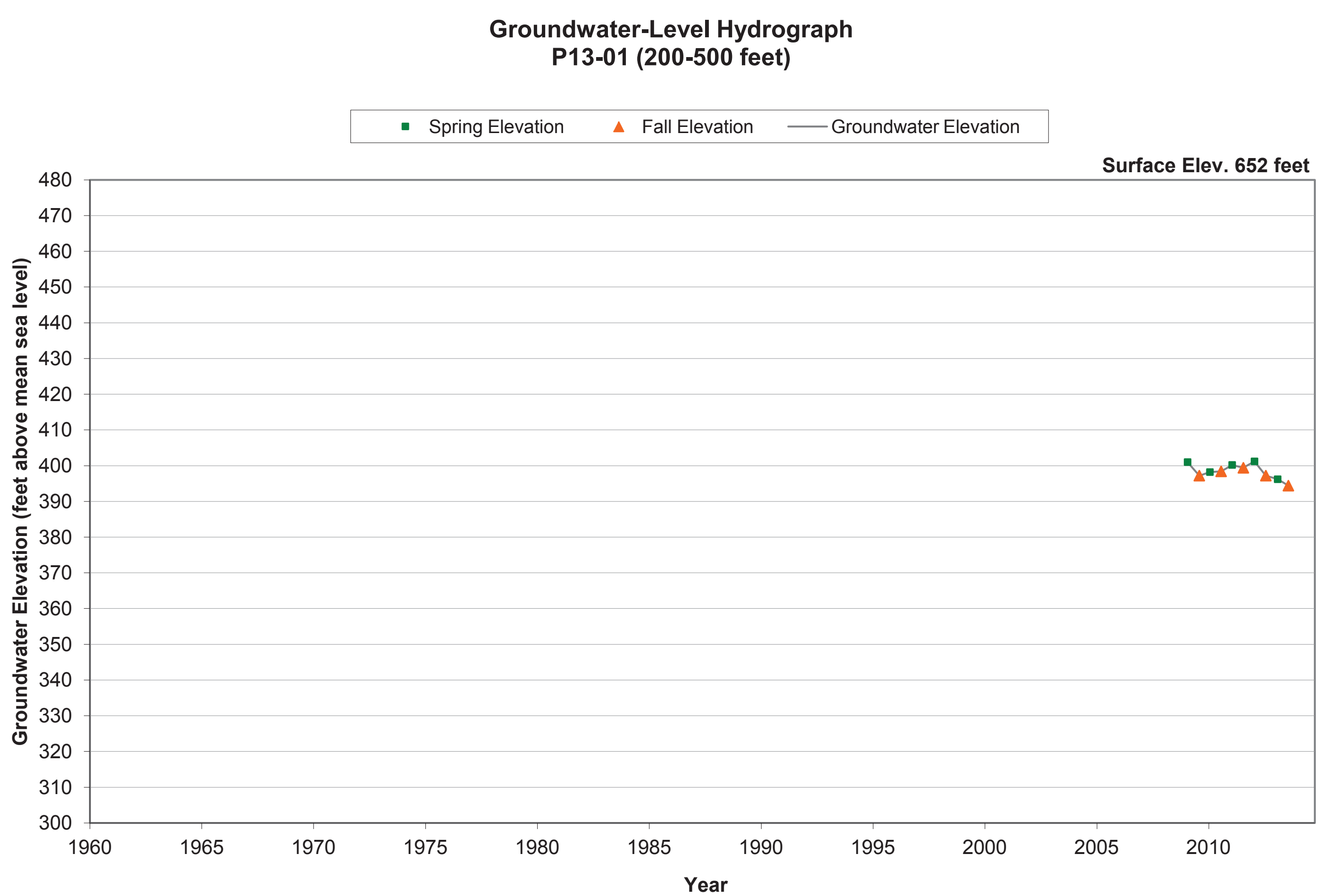



Groundwater-Level Hydrograph
N16-06D (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


Groundwater-Level Hydrograph
O14-01 (200-500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
-2.19 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

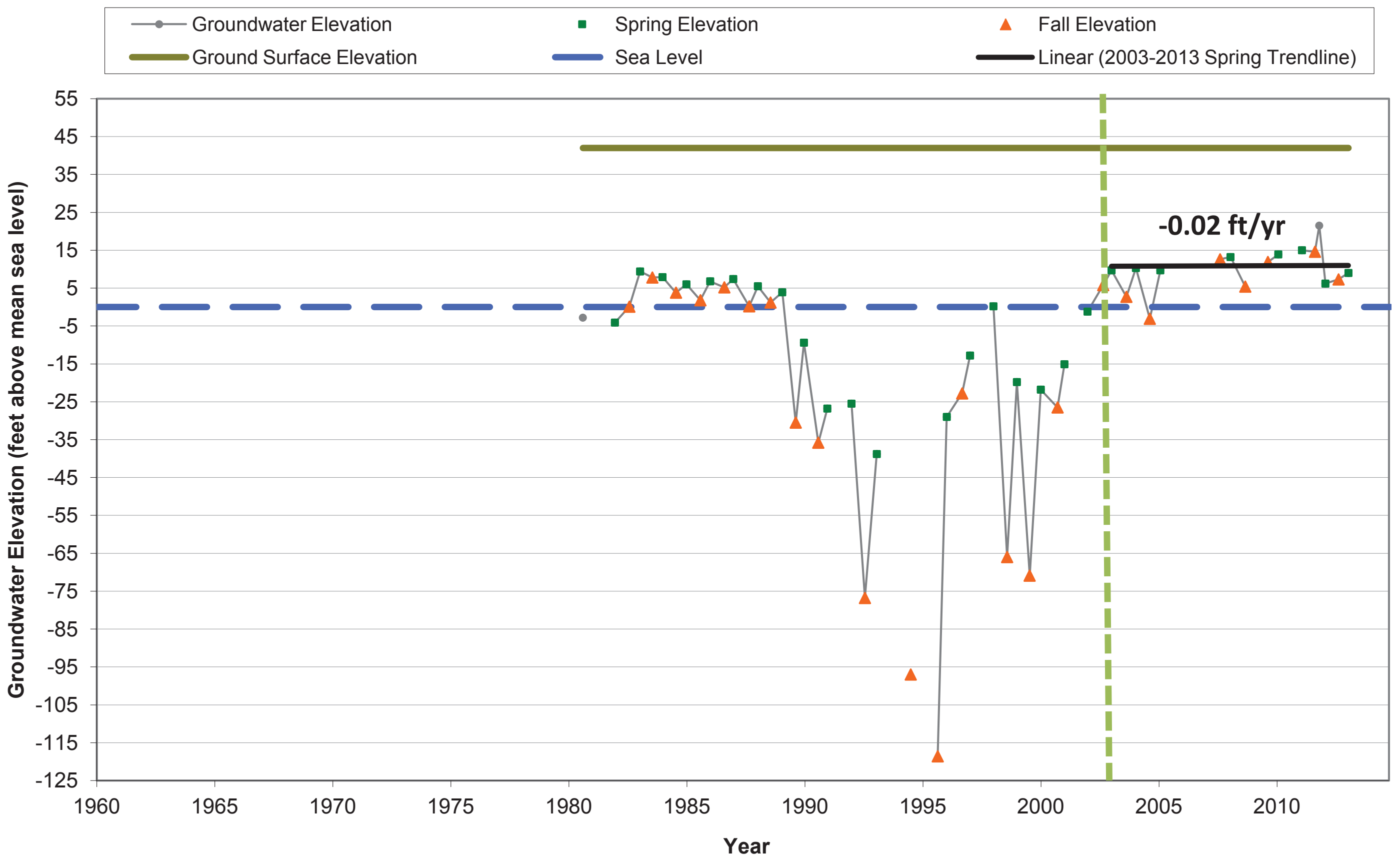


Groundwater-Level Hydrograph
O15-01 (200-500 feet)
Grounwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
Surface Elev. 72.8 feet
-3.35 ft/yr
Groundwater Elevation (feet above mean sea level)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

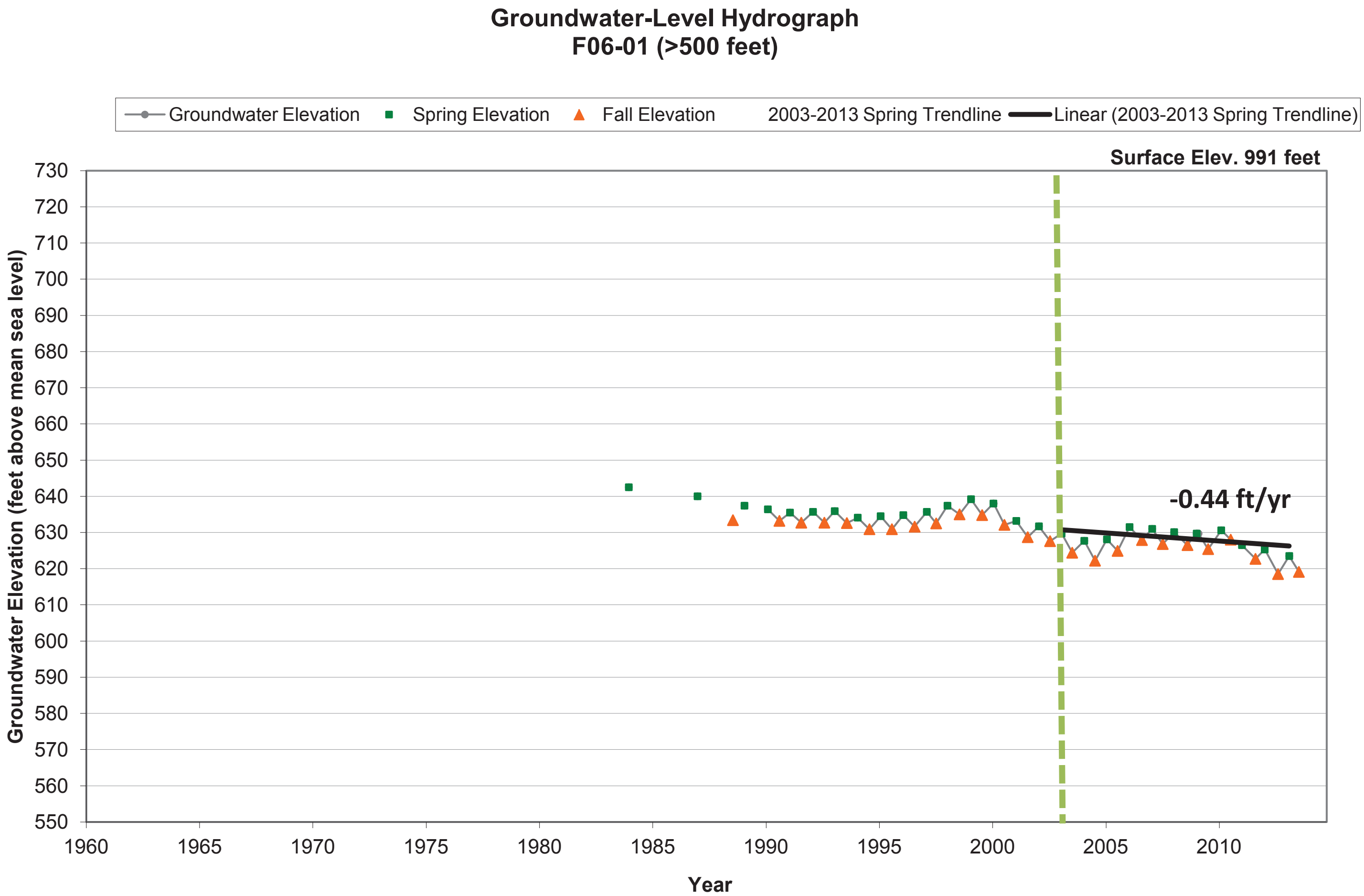


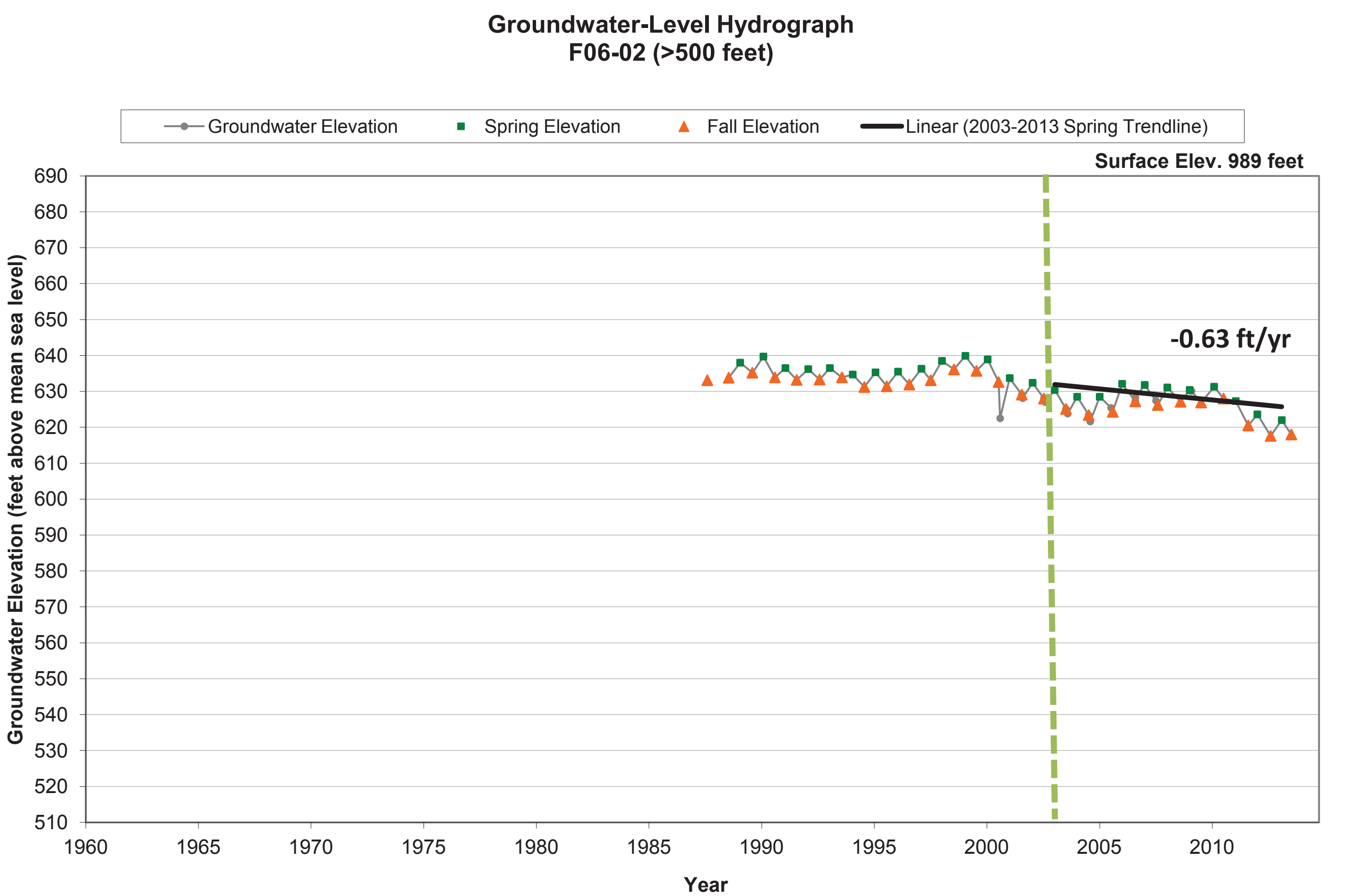
Groundwater-Level Hydrograph
P13-01 (200-500 feet)
Spring Elevation
Fall Elevation
Groundwater Elevation
Surface Elev. 652 feet
Groundwater Elevation (feet above mean sea level)
480
470
460
450
440
430
420
410
400
390
380
370
360
350
340
330
320
310
300
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Groundwater-Level Hydrograph
Q18-01 (200-500 feet)

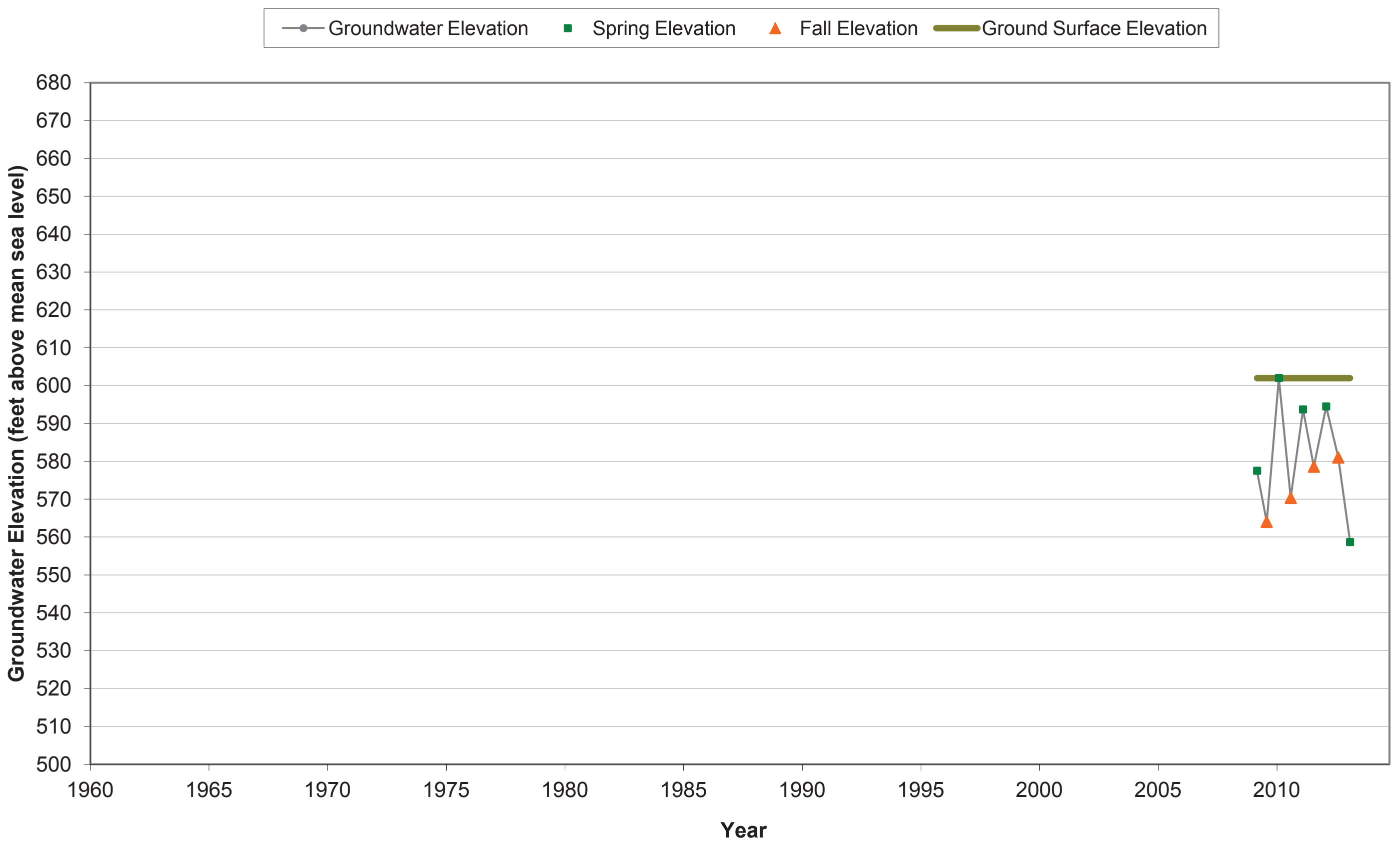


Groundwater Hydrographs
Greater Than 500 Feet Deep

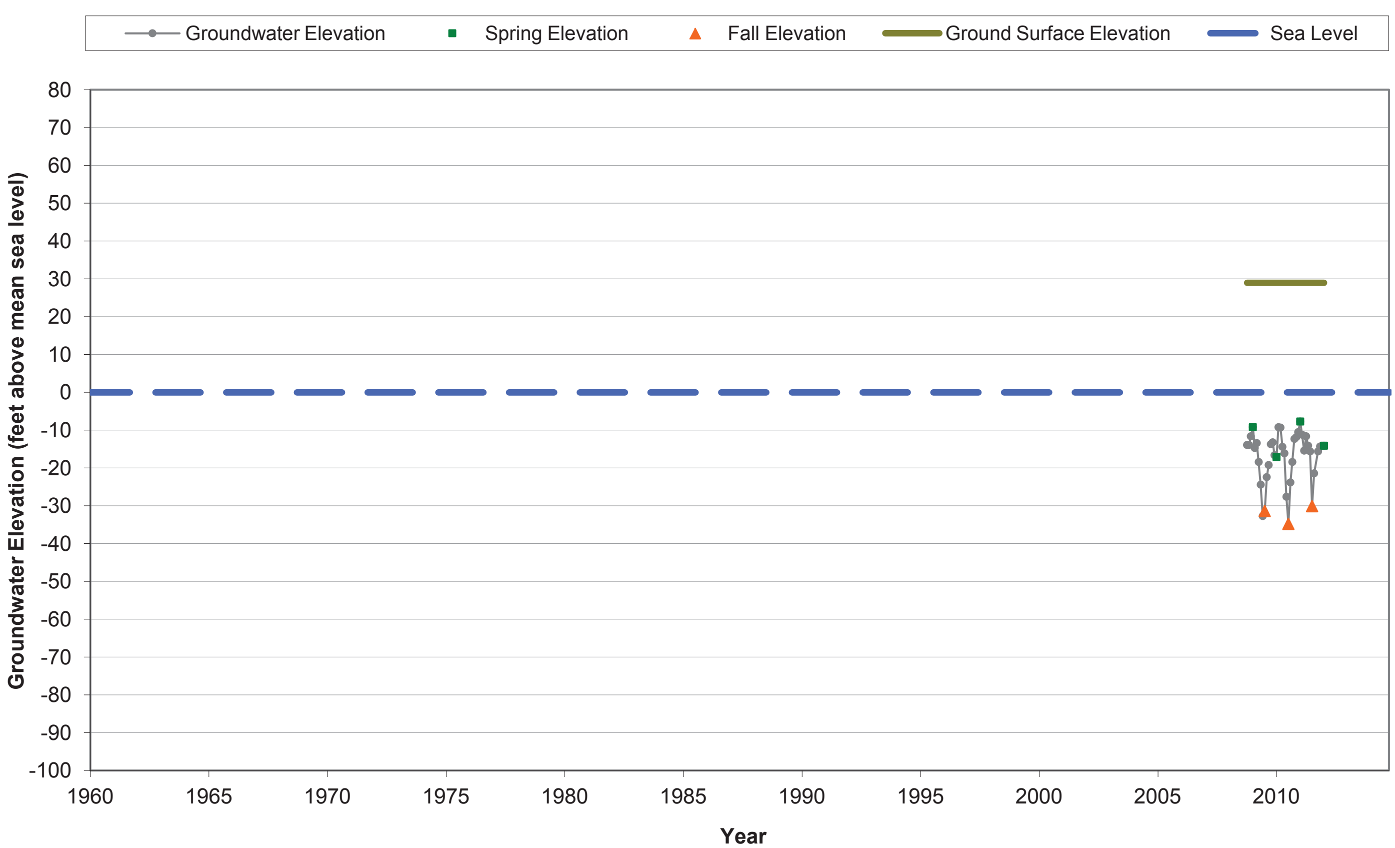

Groundwater-Level Hydrograph
F06-01 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
2003-2013 Spring Trendline
Linear (2003-2013 Spring Trendline)
Surface Elev. 991 feet
-0.44 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
730
720
710
700
690
680
670
660
650
640
630
620
610
600
590
580
570
560
550
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010


Groundwater-Level Hydrograph
F06-02 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Linear (2003-2013 Spring Trendline)
Surface Elev. 989 feet
-0.63 ft/yr
Groundwater Elevation (feet above mean sea level)
Year
690
680
670
660
650
640
630
620
610
600
590
580
570
560
550
540
530
520
510
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

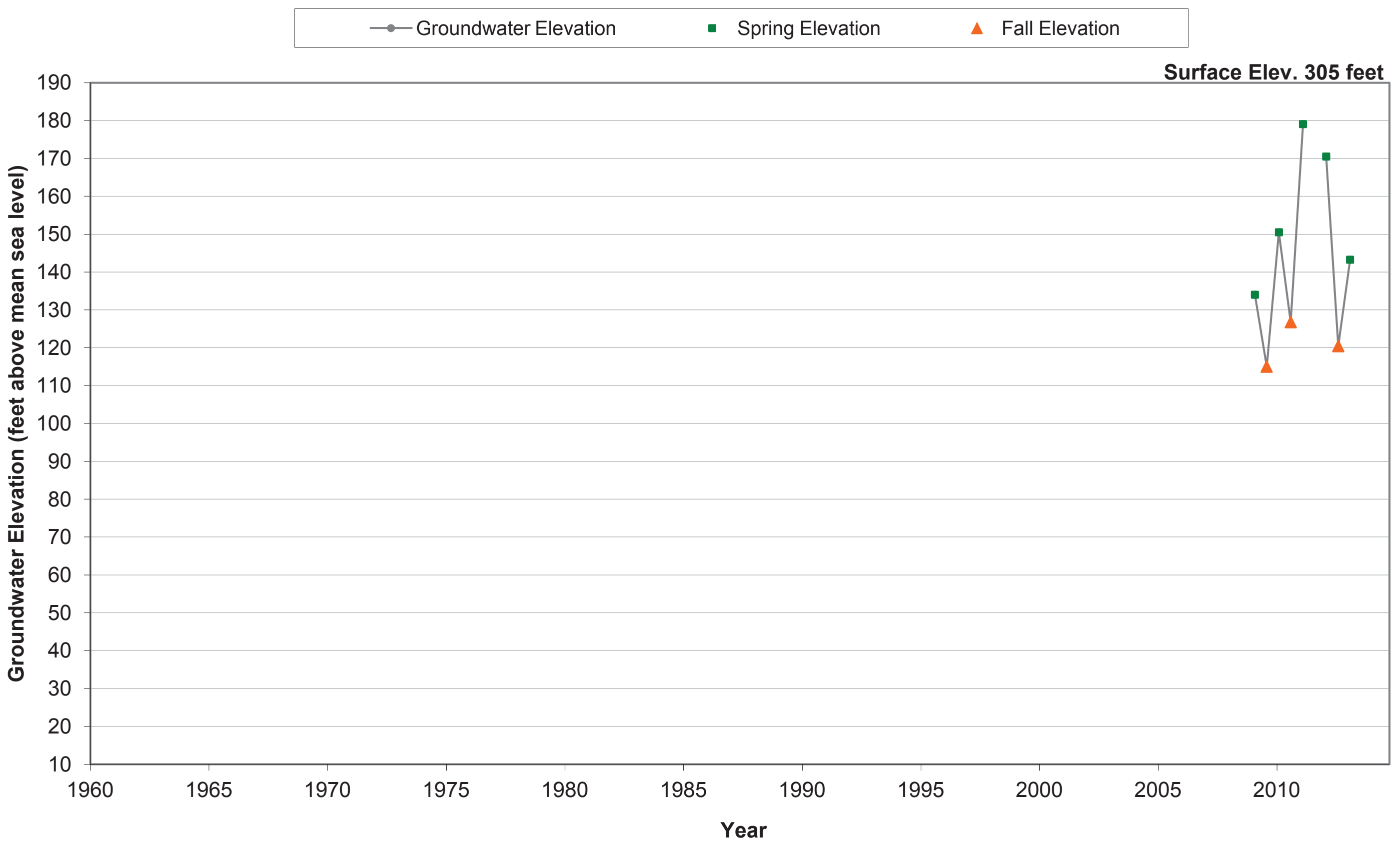
Groundwater-Level Hydrograph
H08-01 (>500 feet)



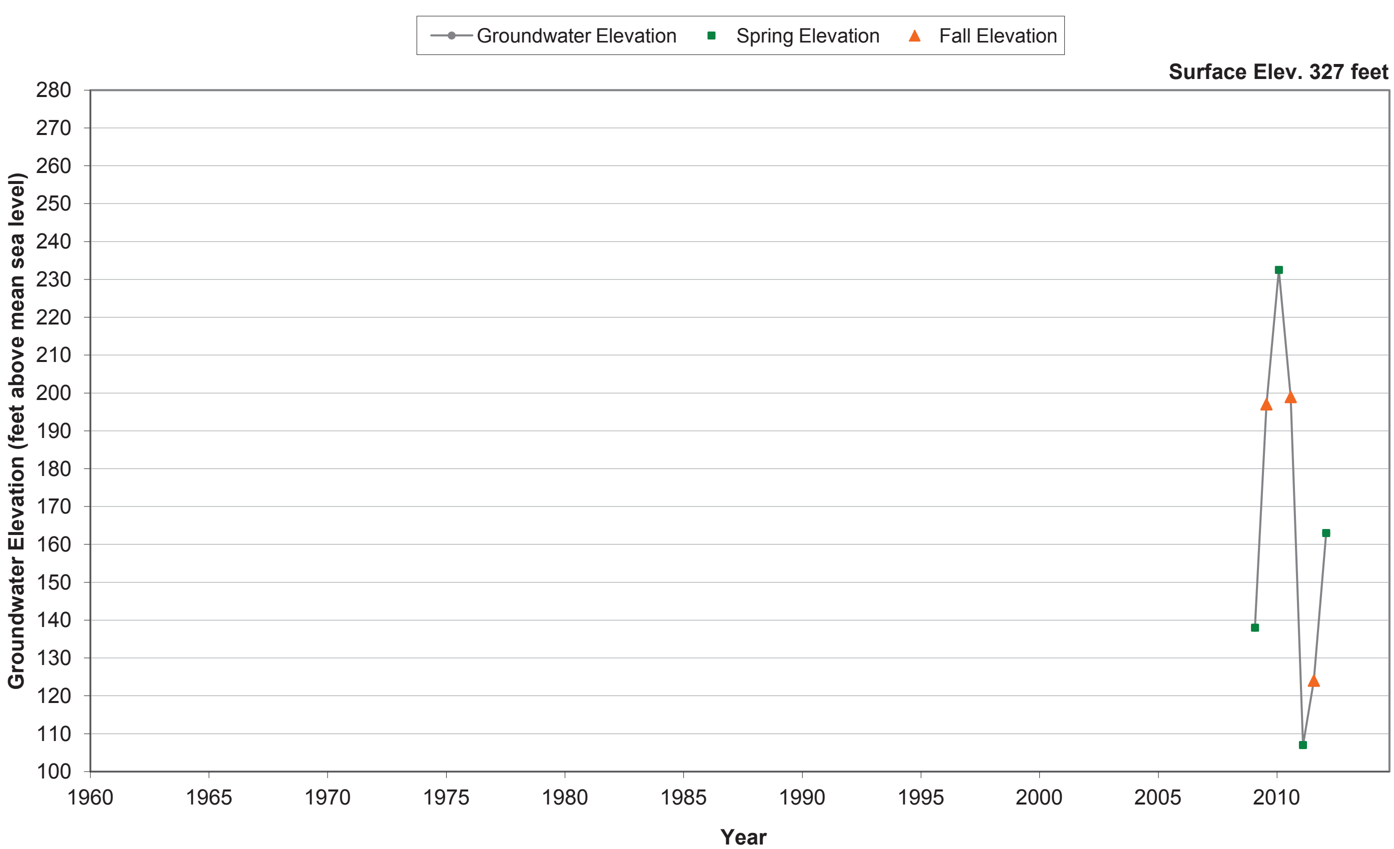
Groundwater-Level Hydrograph
N16-05 (>500 feet)



Groundwater-Level Hydrograph
J07-02 (>500 feet)

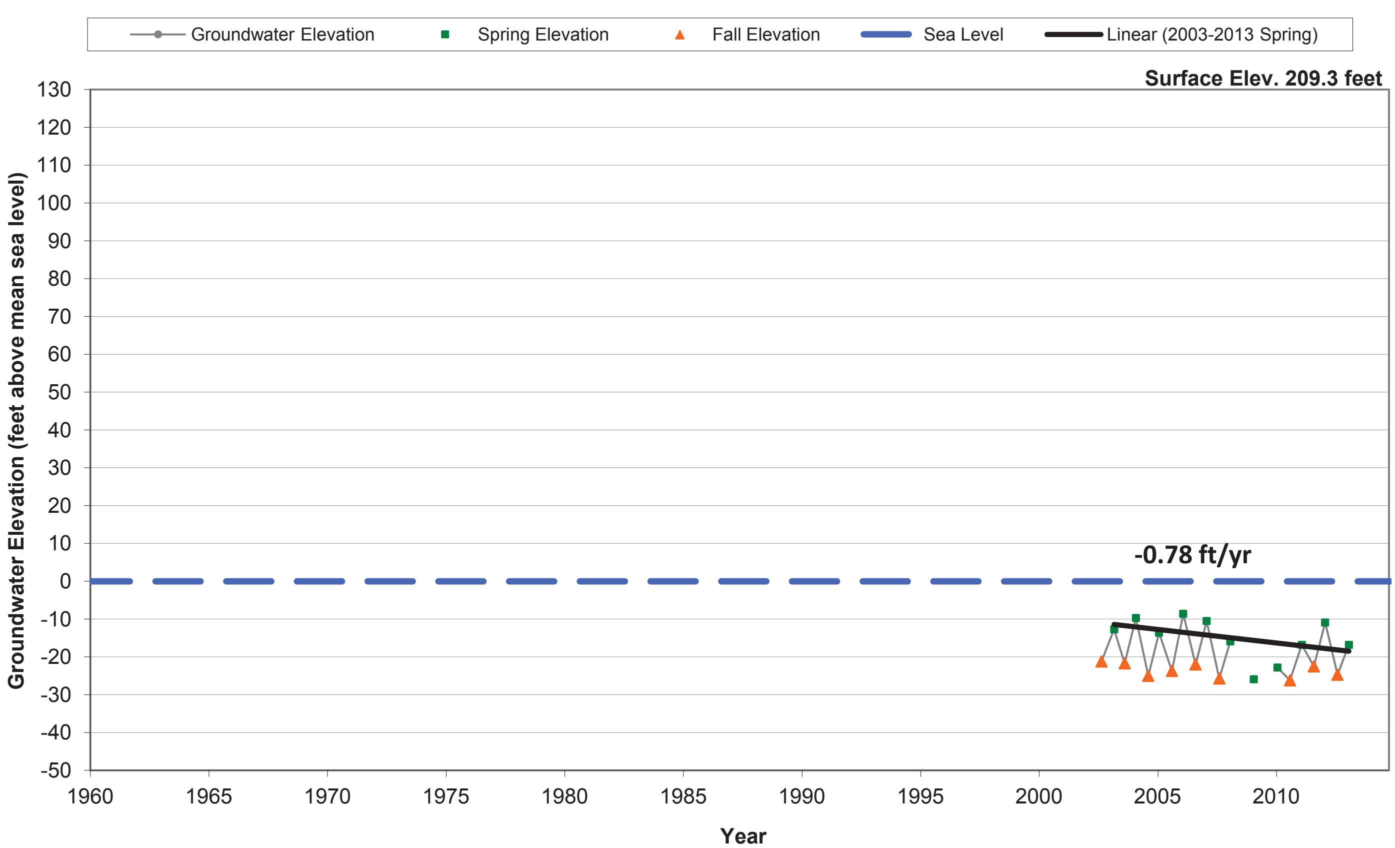


Groundwater-Level Hydrograph
J08-03 (>500 feet)

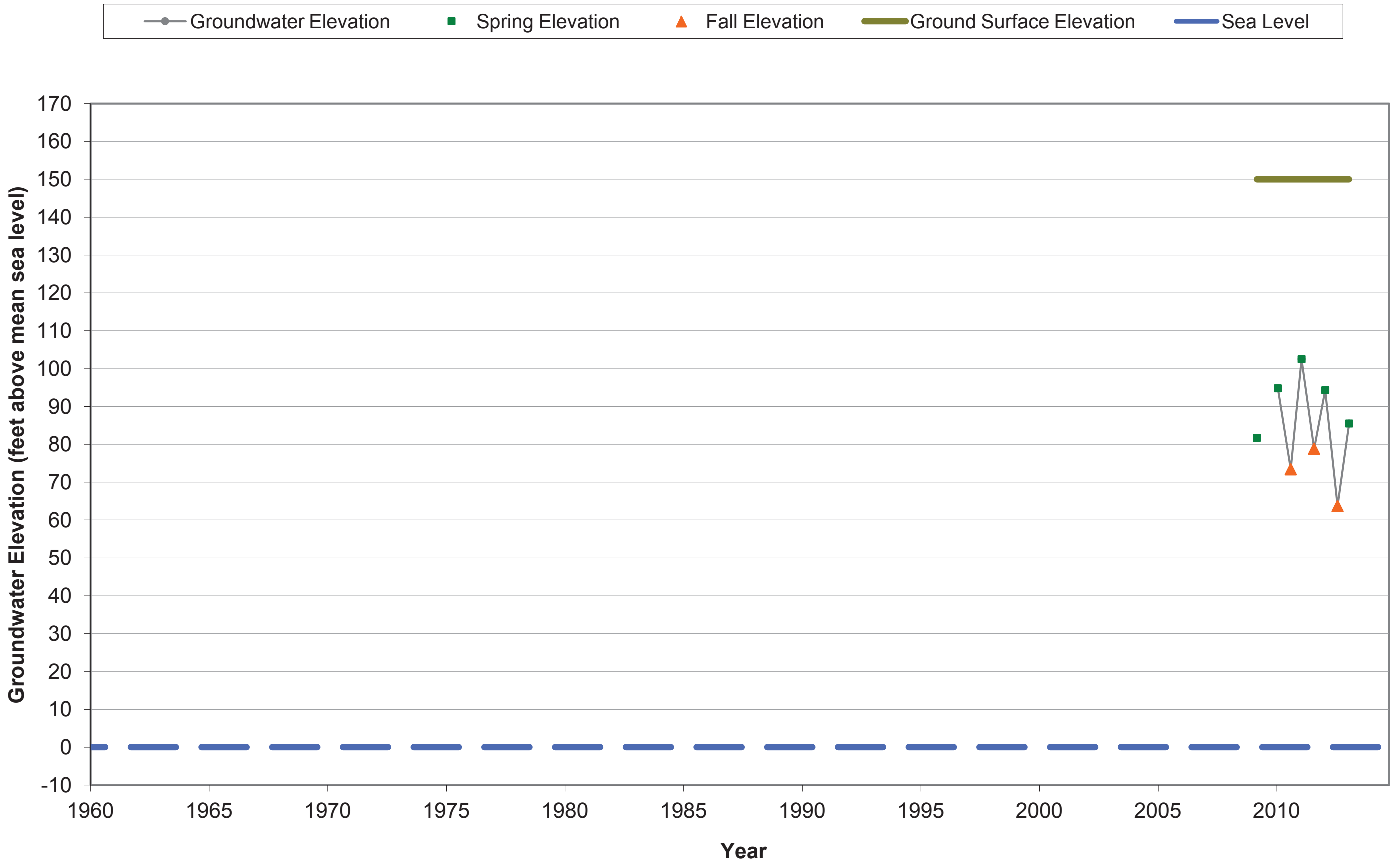


Groundwater-Level Hydrograph
J12-05 (>500 feet)

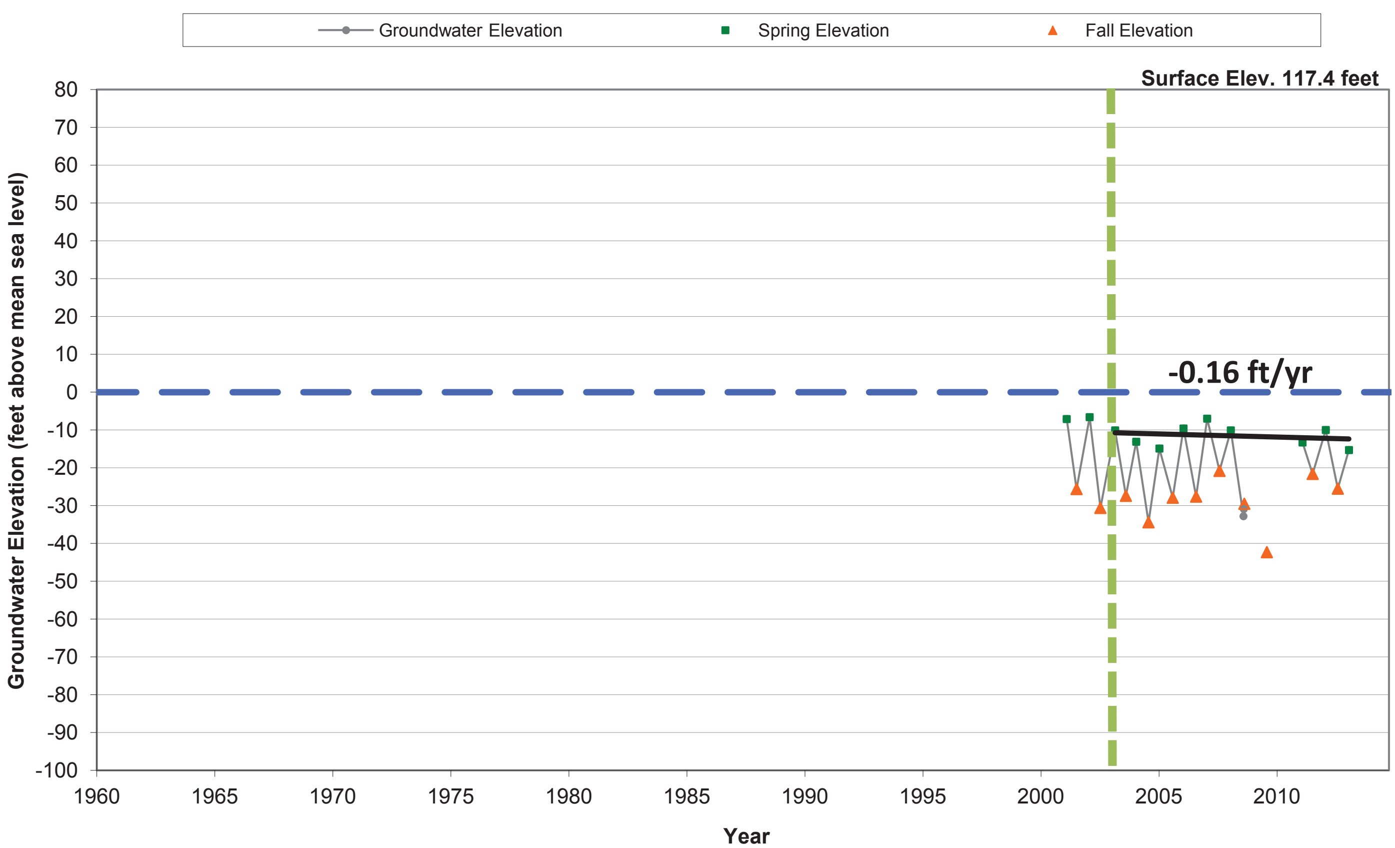
Groundwater-Level Hydrograph
J13-03 (>500 feet)

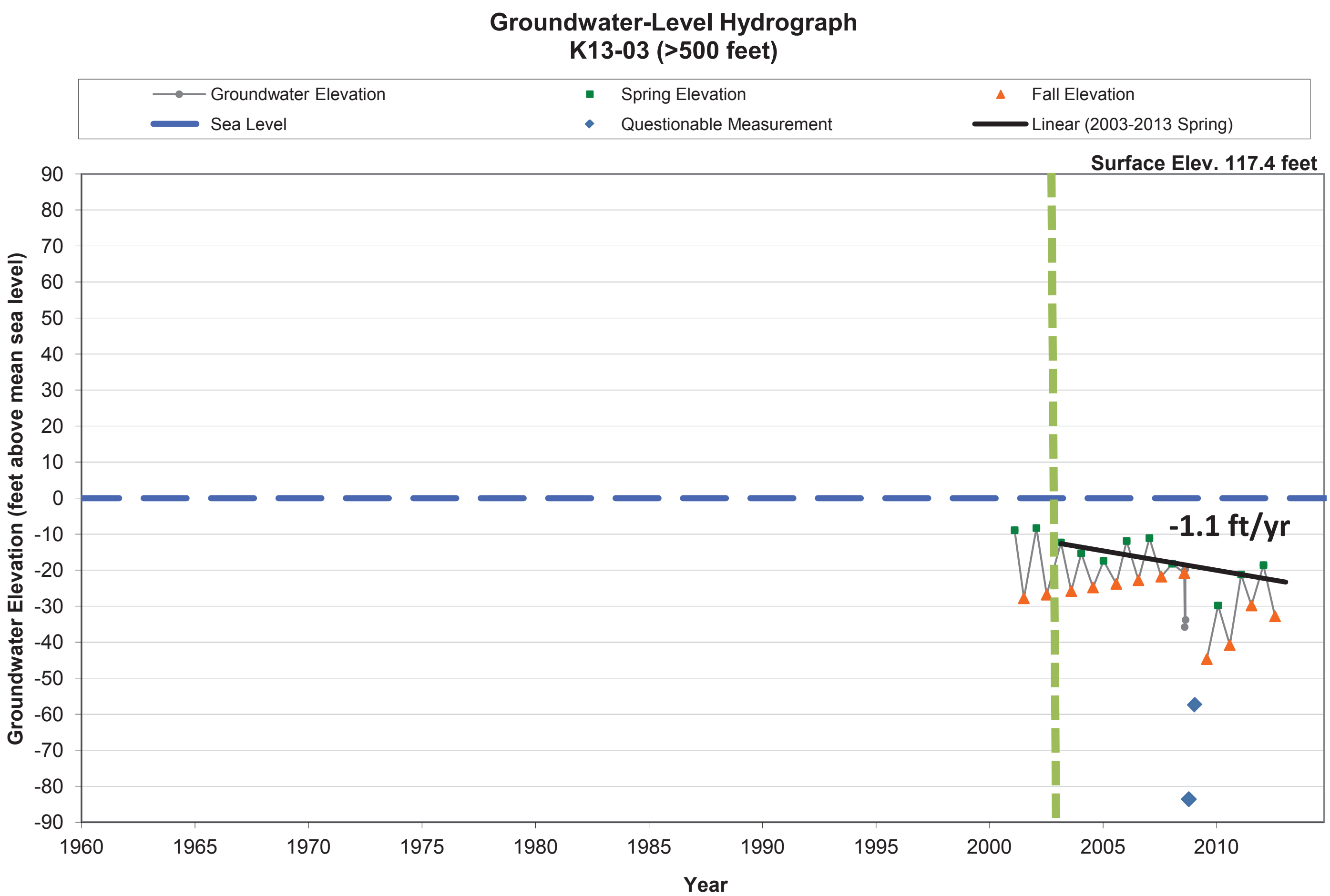


Groundwater-Level Hydrograph
K13-01 (>500 feet)

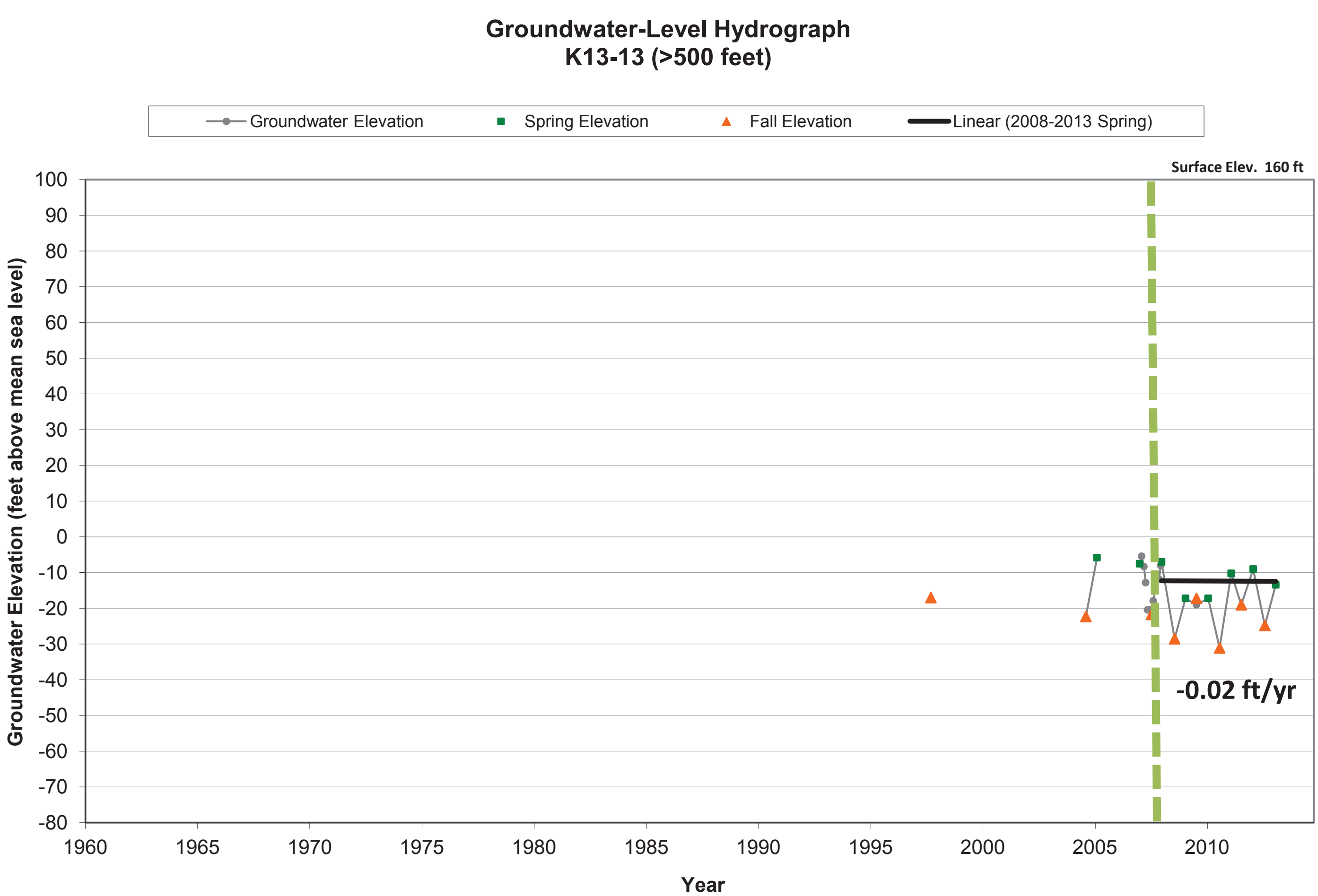


Groundwater-Level Hydrograph
K13-02 (>500 feet)



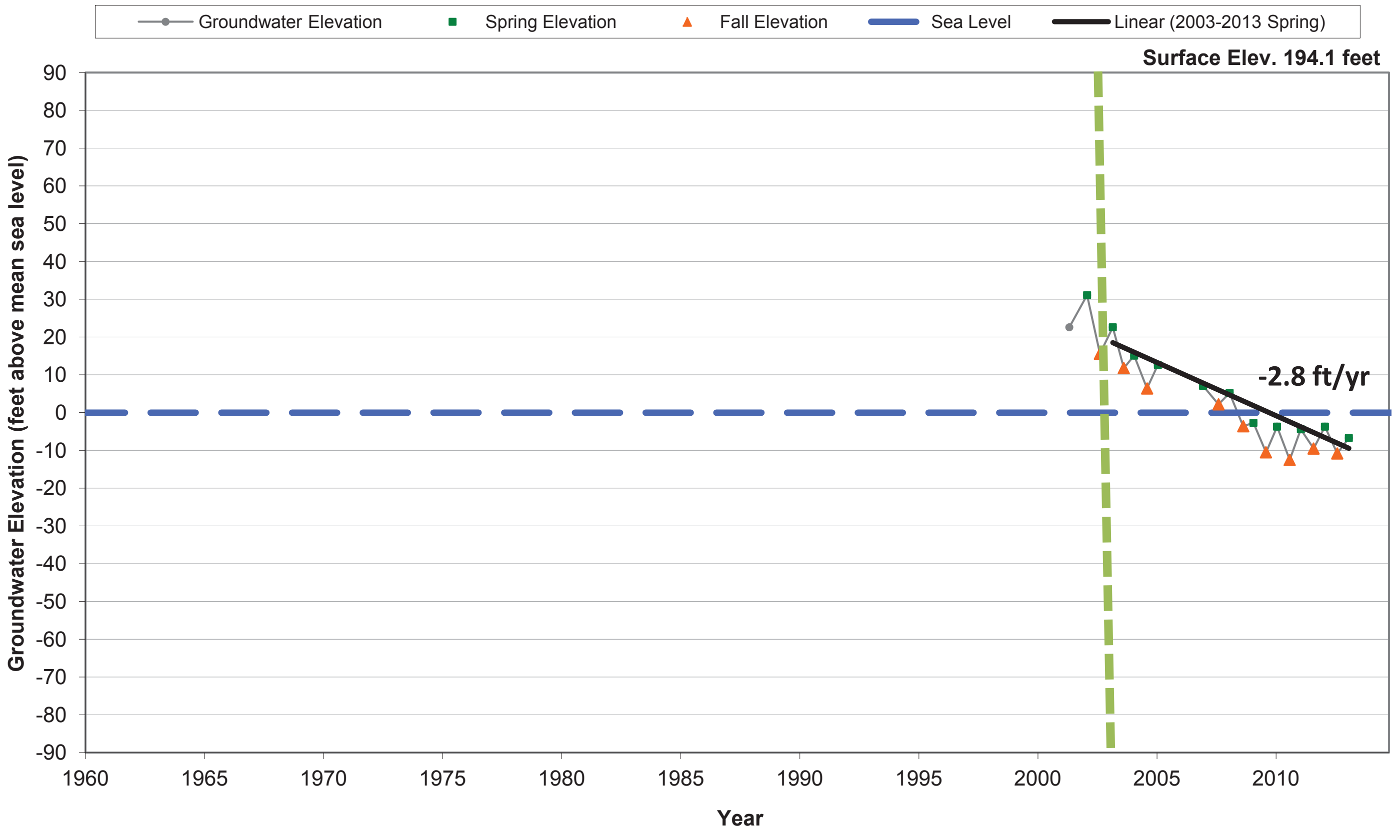


Groundwater-Level Hydrograph
K13-03 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Sea Level
Questionable Measurement
Linear (2003-2013 Spring)
Surface Elev. 117.4 feet
-1.1 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

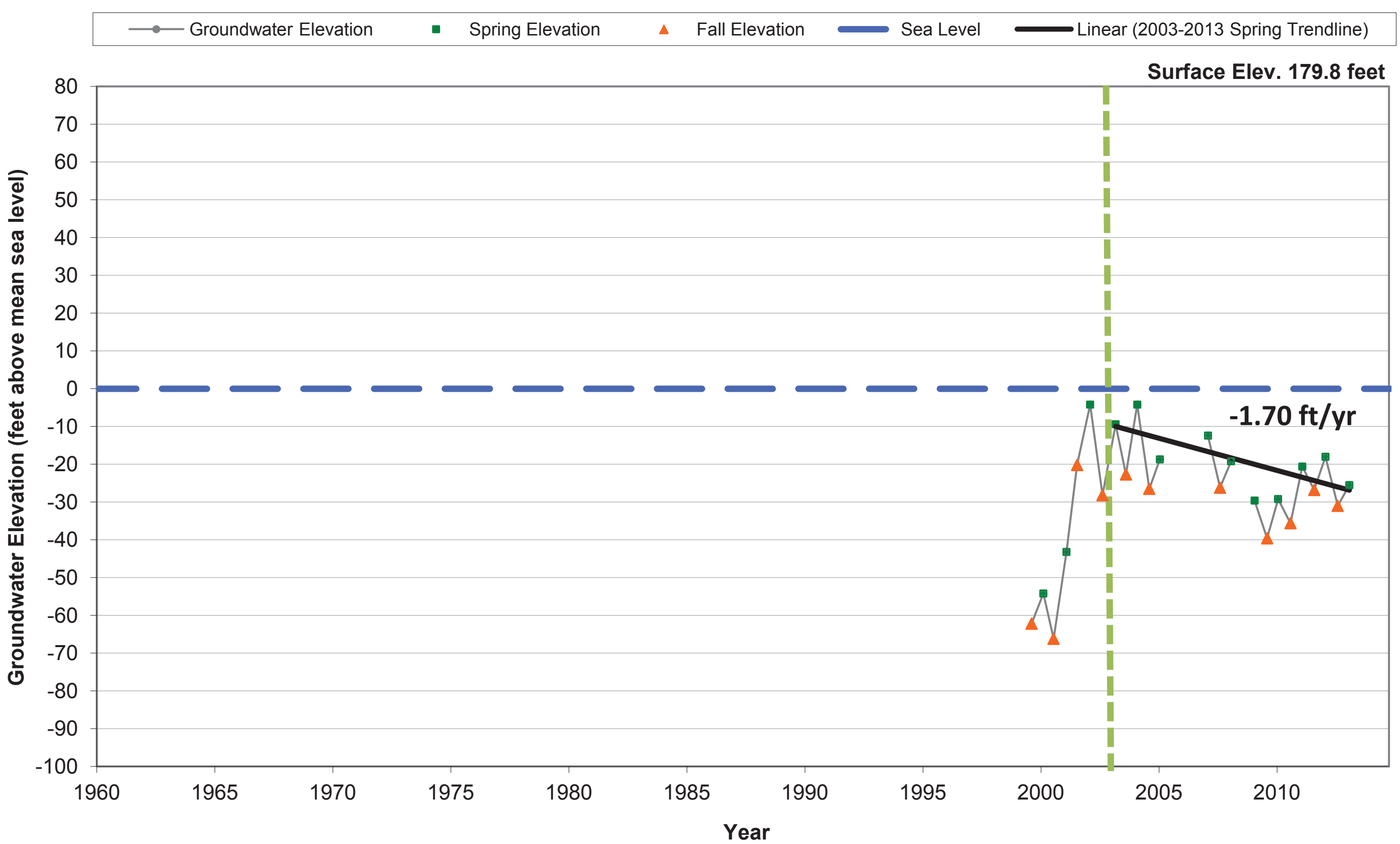


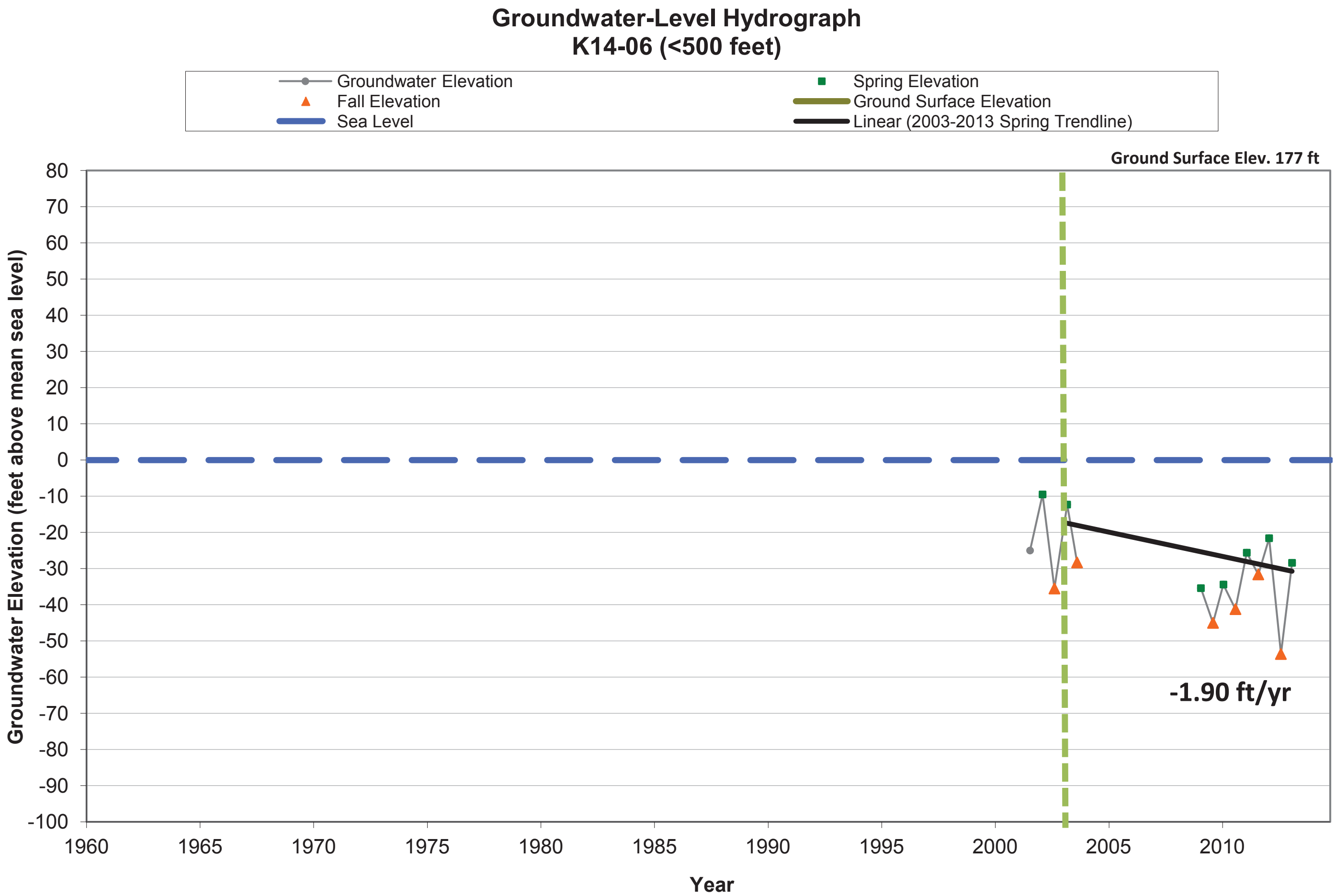
Groundwater-Level Hydrograph
K13-13 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Linear (2008-2013 Spring)
Surface Elev. 160 ft
-0.02 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

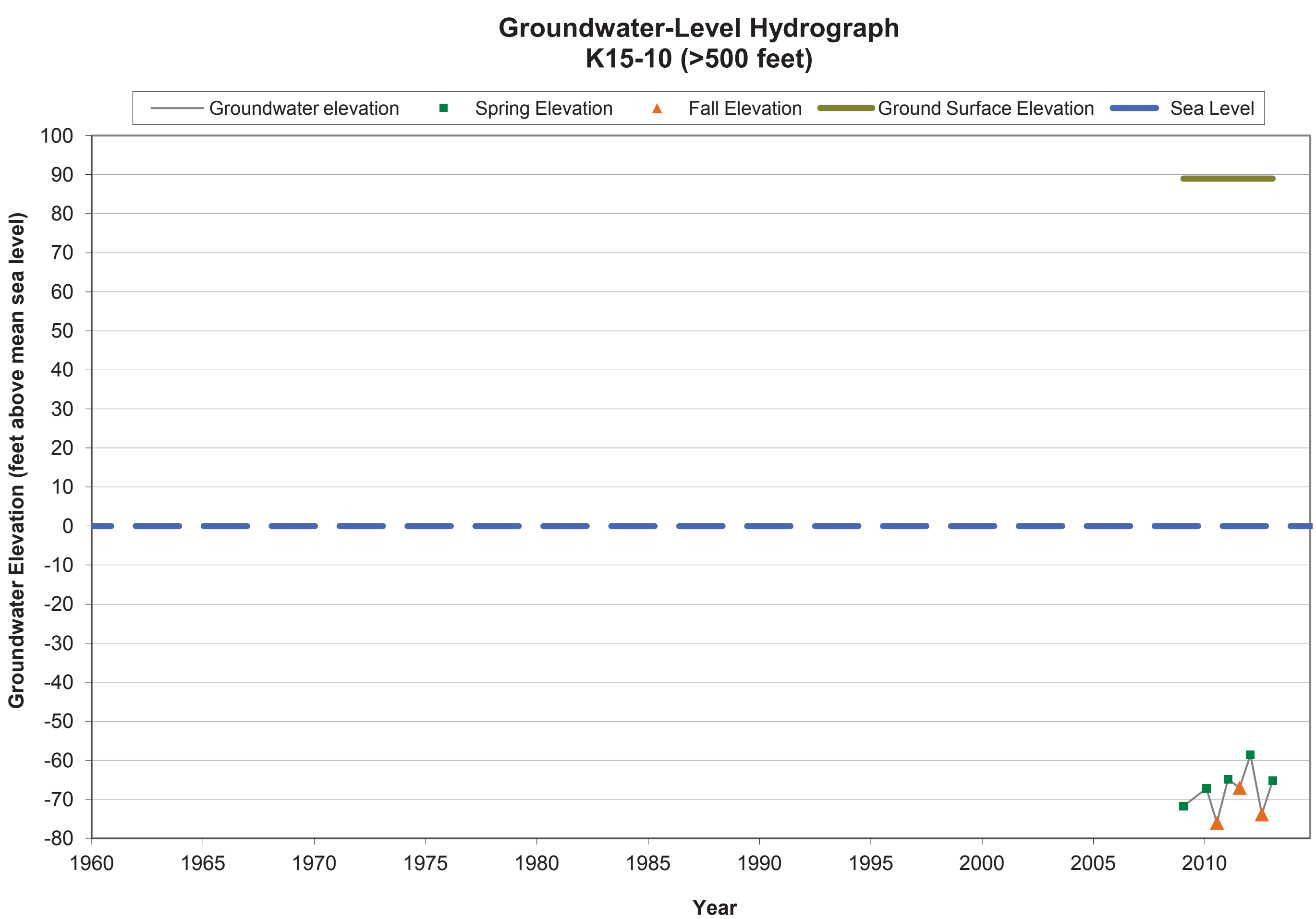
Groundwater-Level Hydrograph
K14-01 (>500 feet)

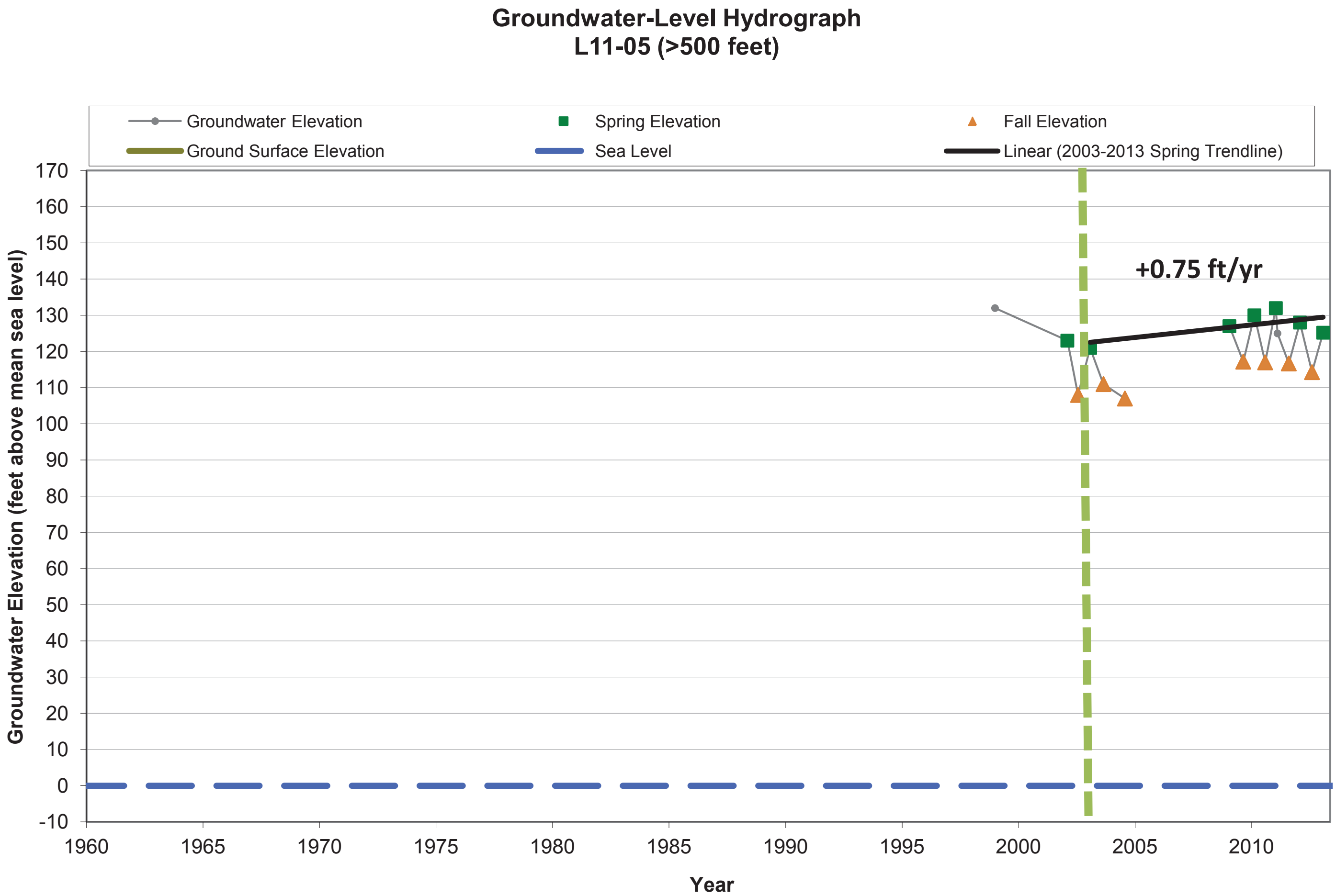


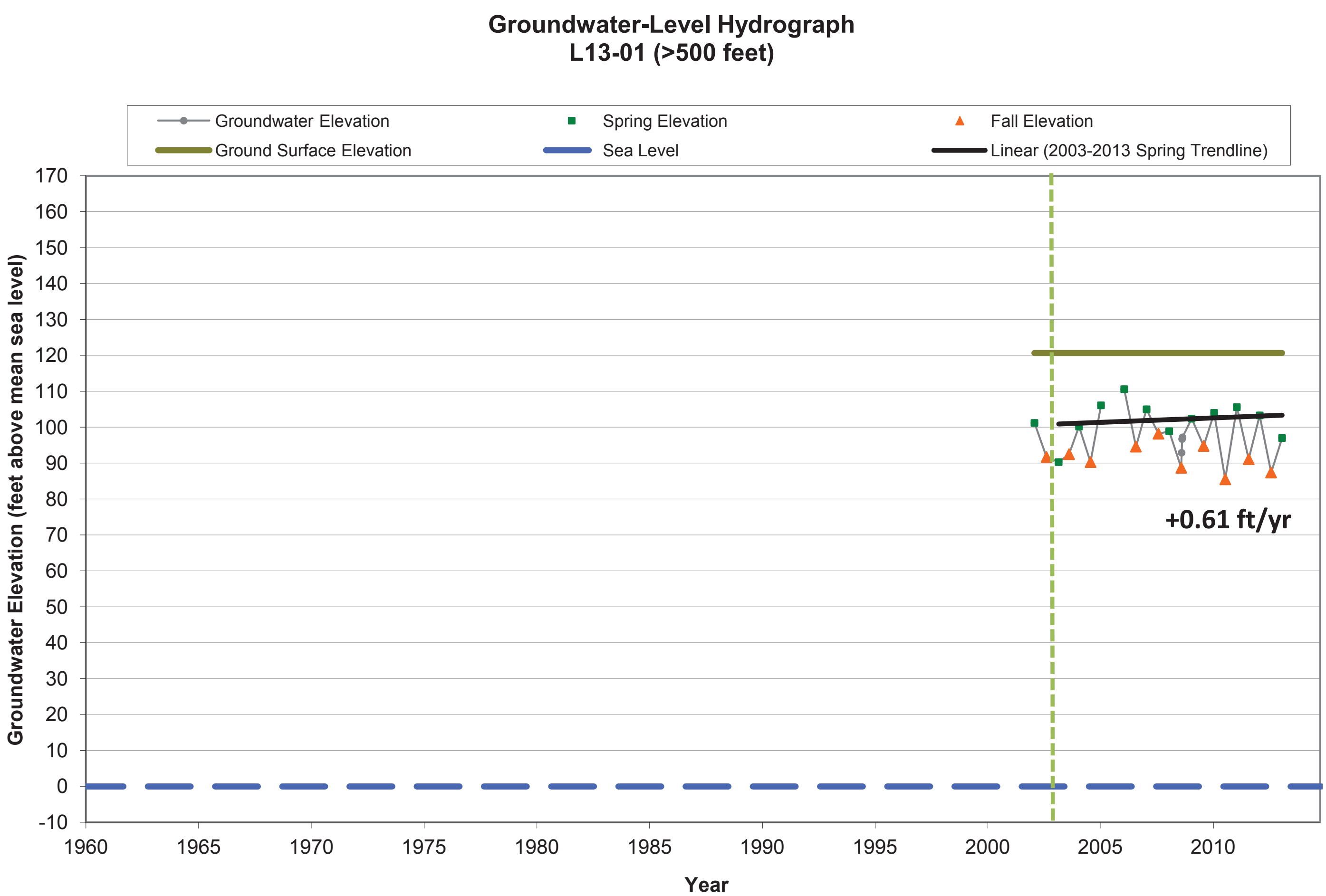
Groundwater-Level Hydrograph
K14-02 (>500 feet)

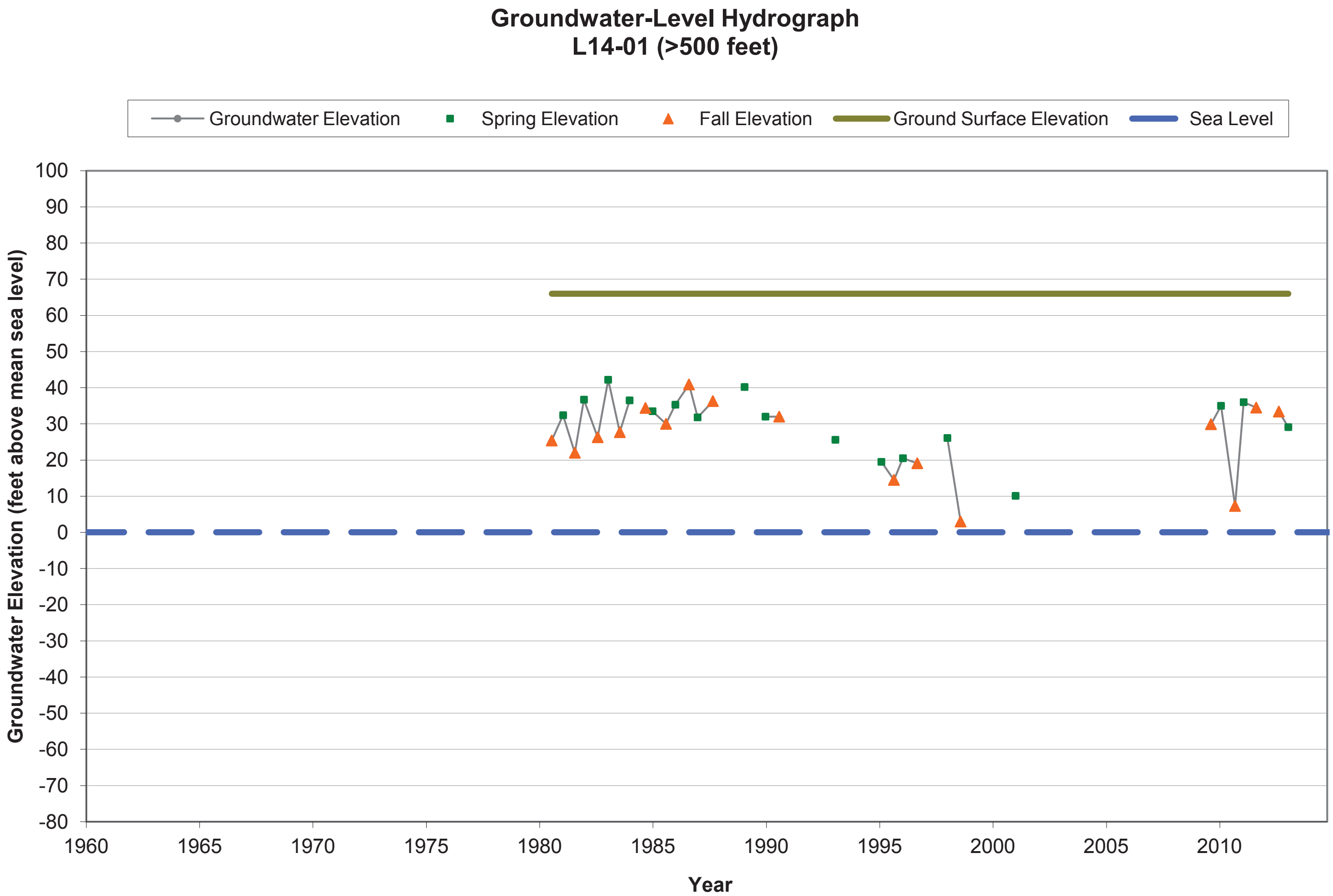


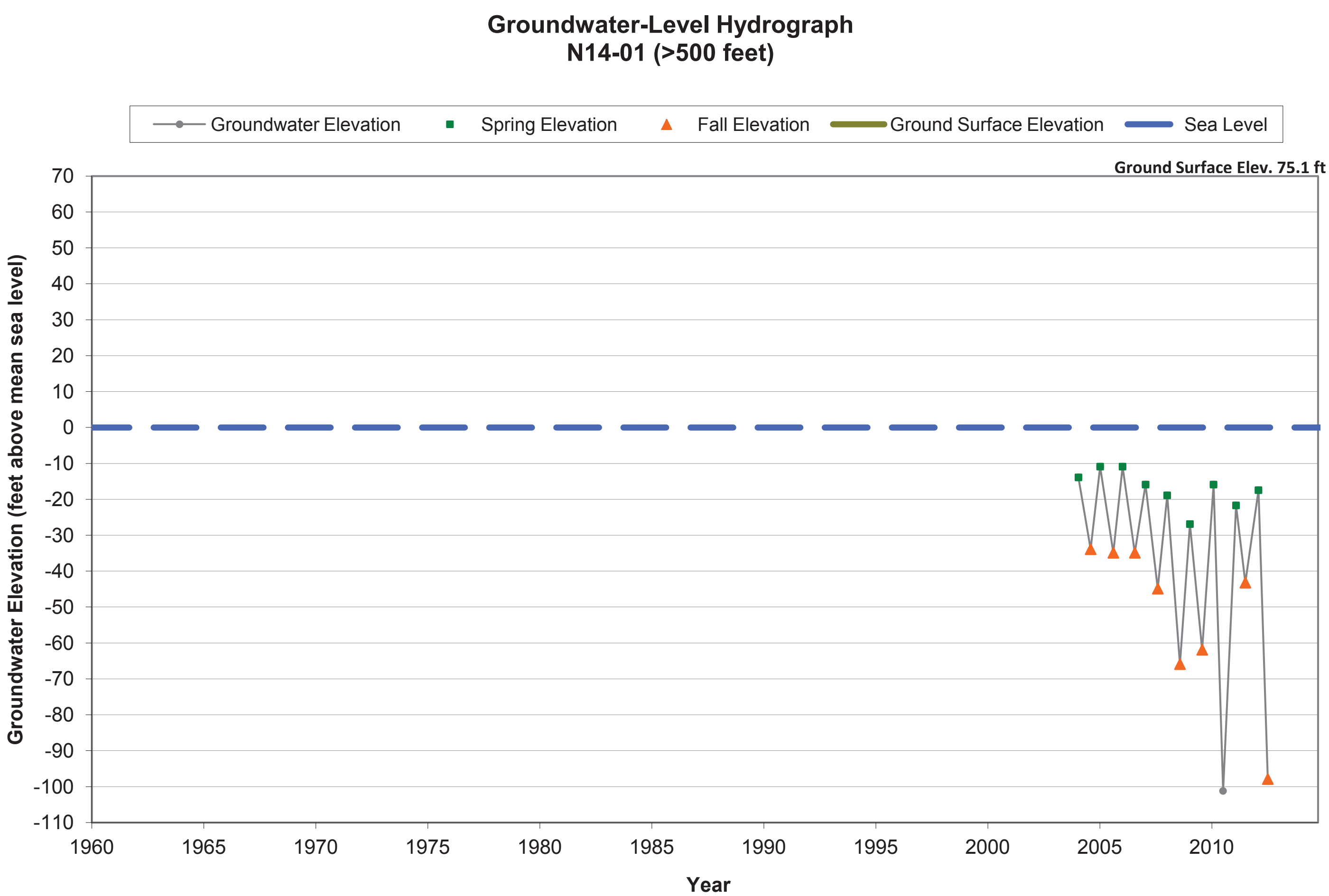

Groundwater-Level Hydrograph
K14-06 (<500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
Ground Surface Elev. 177 ft
-1.90 ft/yr
Groundwater Elevation (feet above mean sea level)
Year


Groundwater-Level Hydrograph
K15-10 (>500 feet)
Groundwater elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
Year

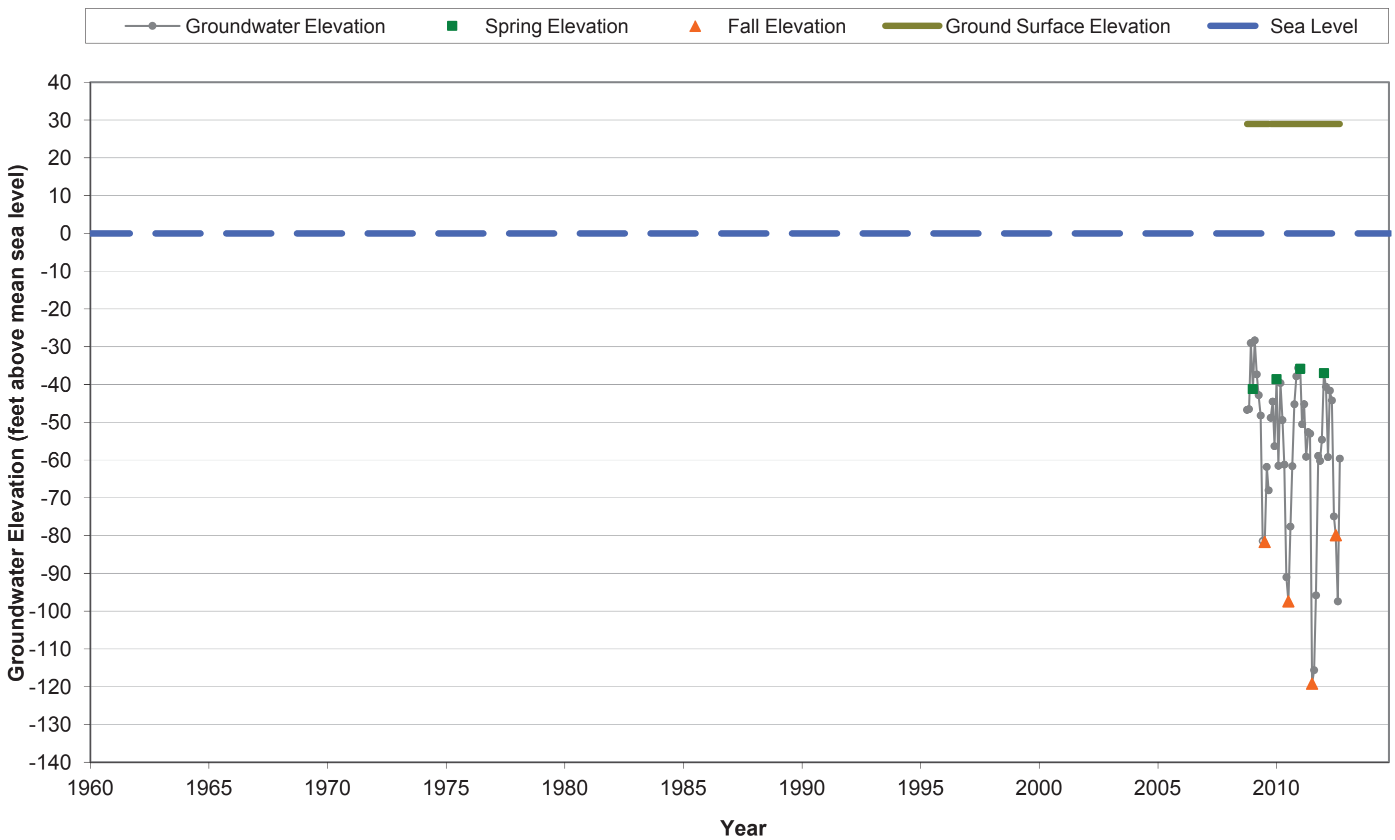

Groundwater-Level Hydrograph
L11-05 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
+0.75 ft/yr
Groundwater Elevation (feet above mean sea level)
Year


Groundwater-Level Hydrograph
L13-01 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2003-2013 Spring Trendline)
+0.61 ft/yr
Groundwater Elevation (feet above mean sea level)
Year

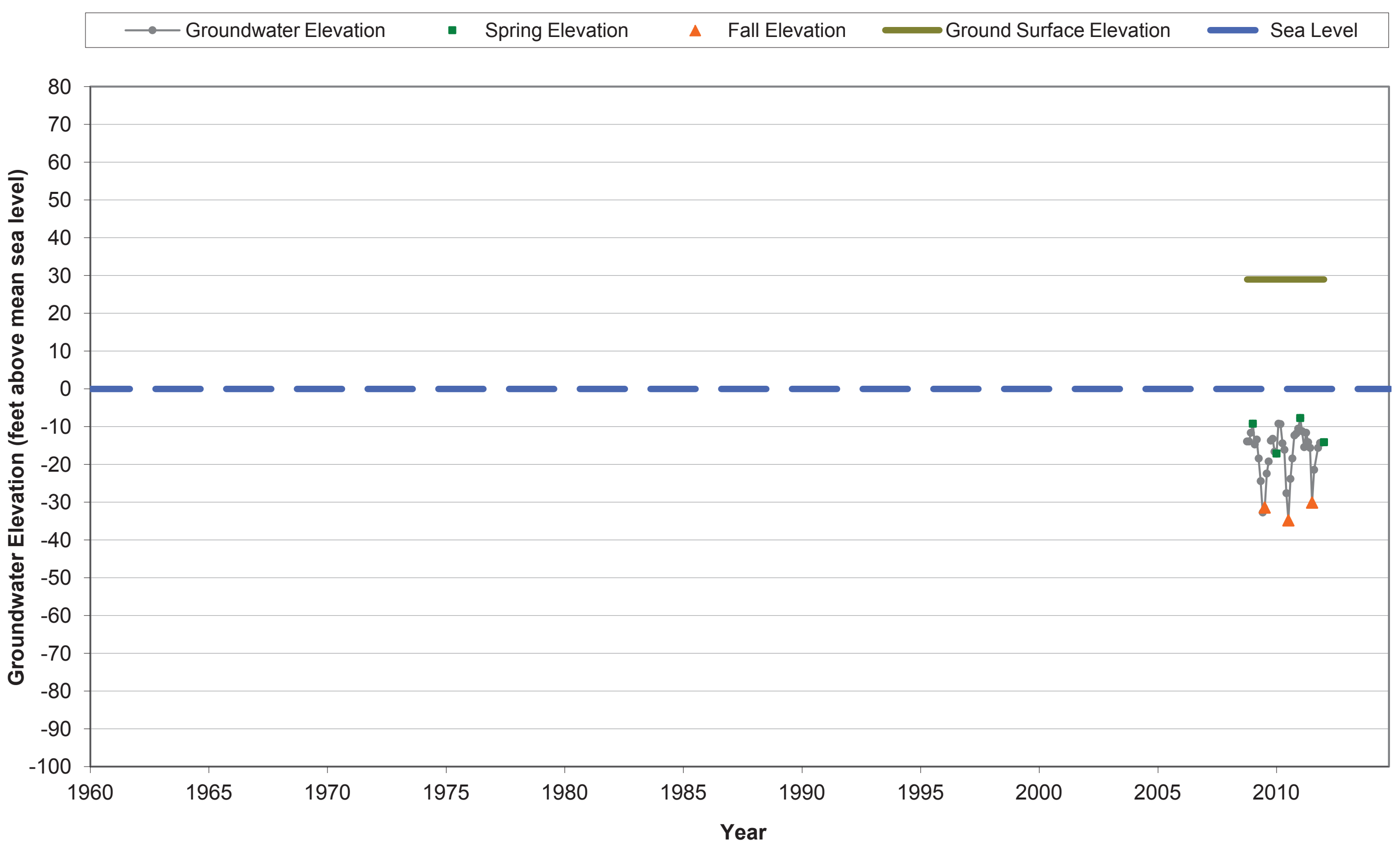

Groundwater-Level Hydrograph
L14-01 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Groundwater Elevation (feet above mean sea level)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
N14-01 (>500 feet)
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Ground Surface Elev. 75.1 ft
Groundwater Elevation (feet above mean sea level)
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

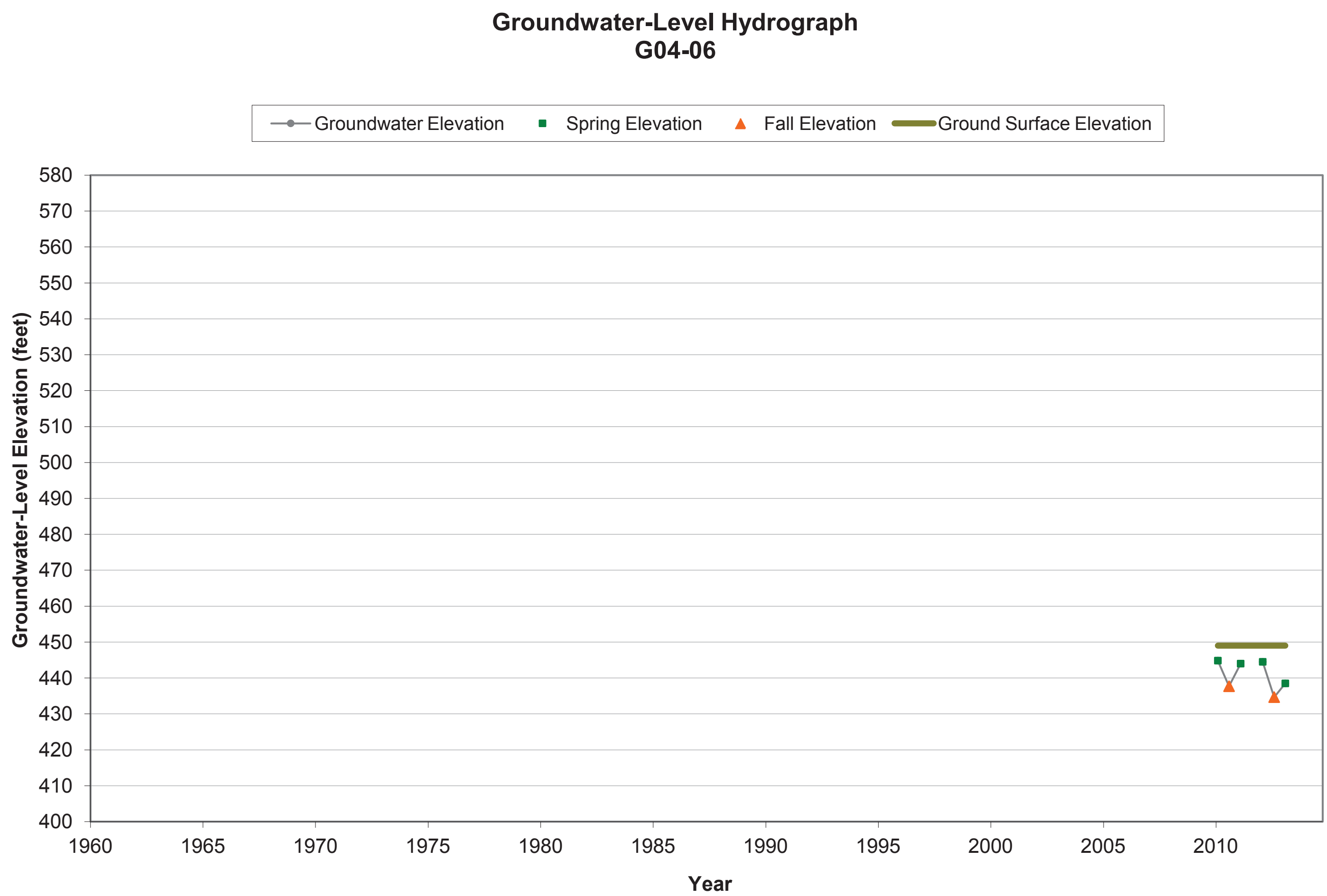
Groundwater-Level Hydrograph
N15-03 (>500 feet)



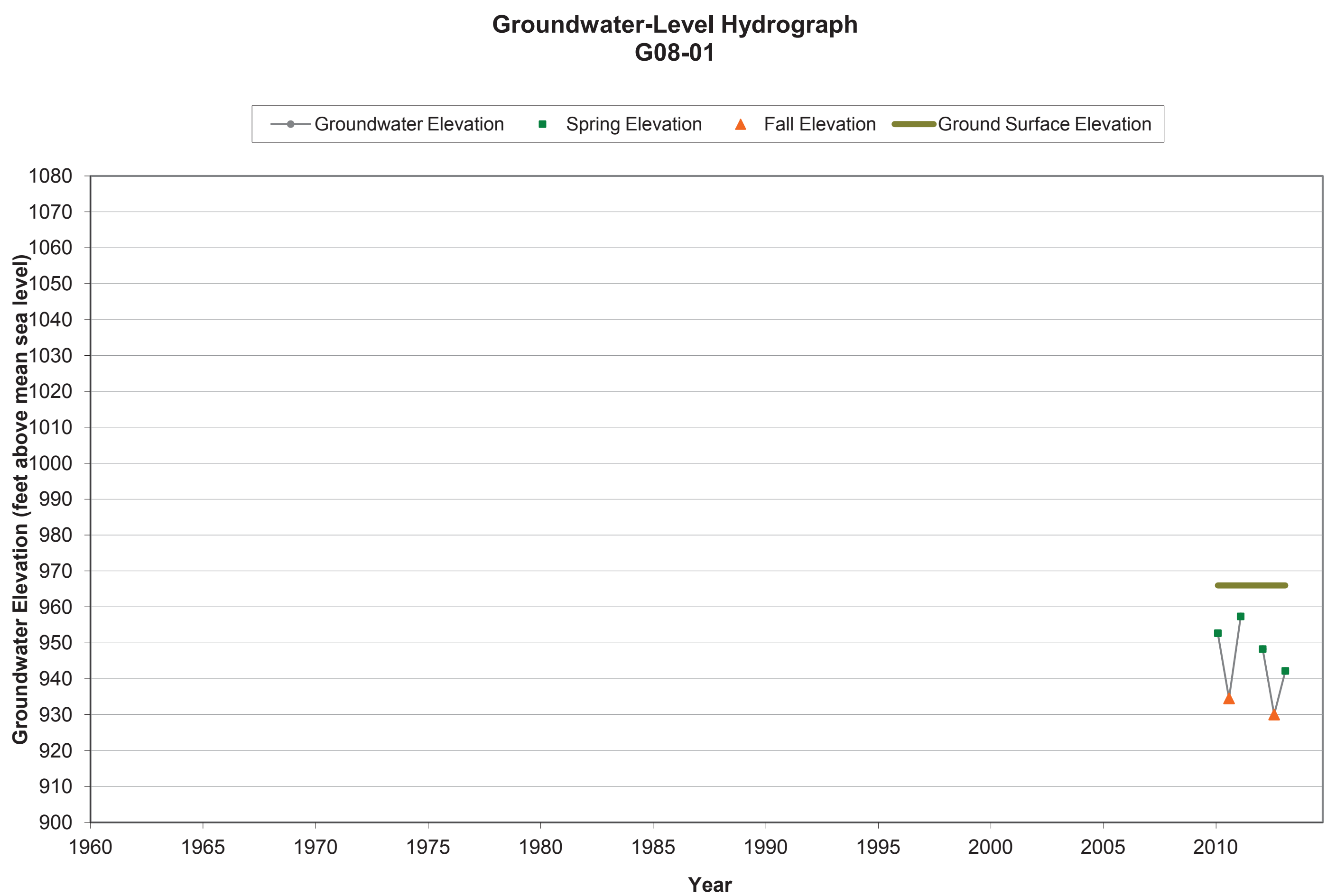
Groundwater-Level Hydrograph
N16-05 (>500 feet)



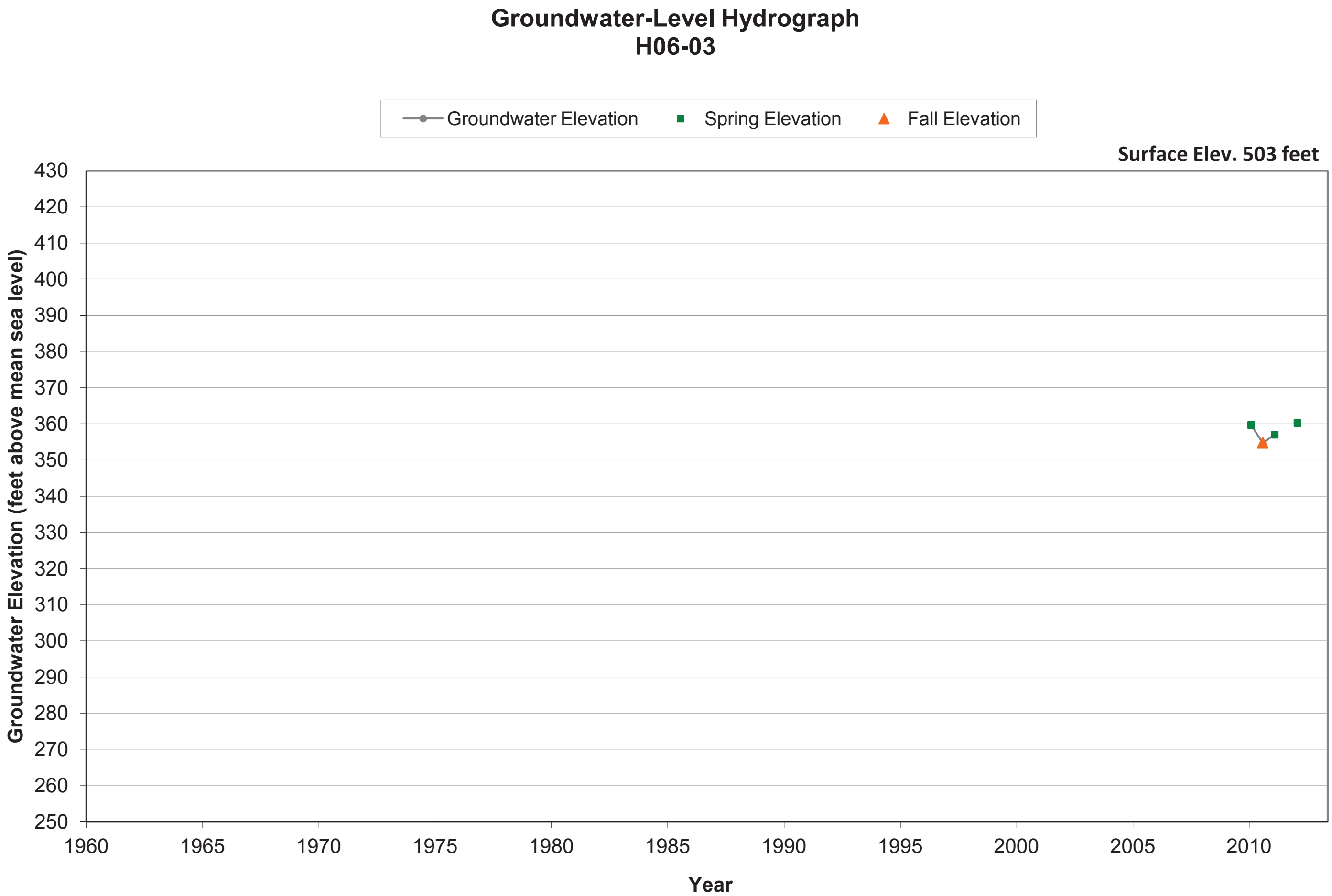
Groundwater Hydrographs
Unknown Depth

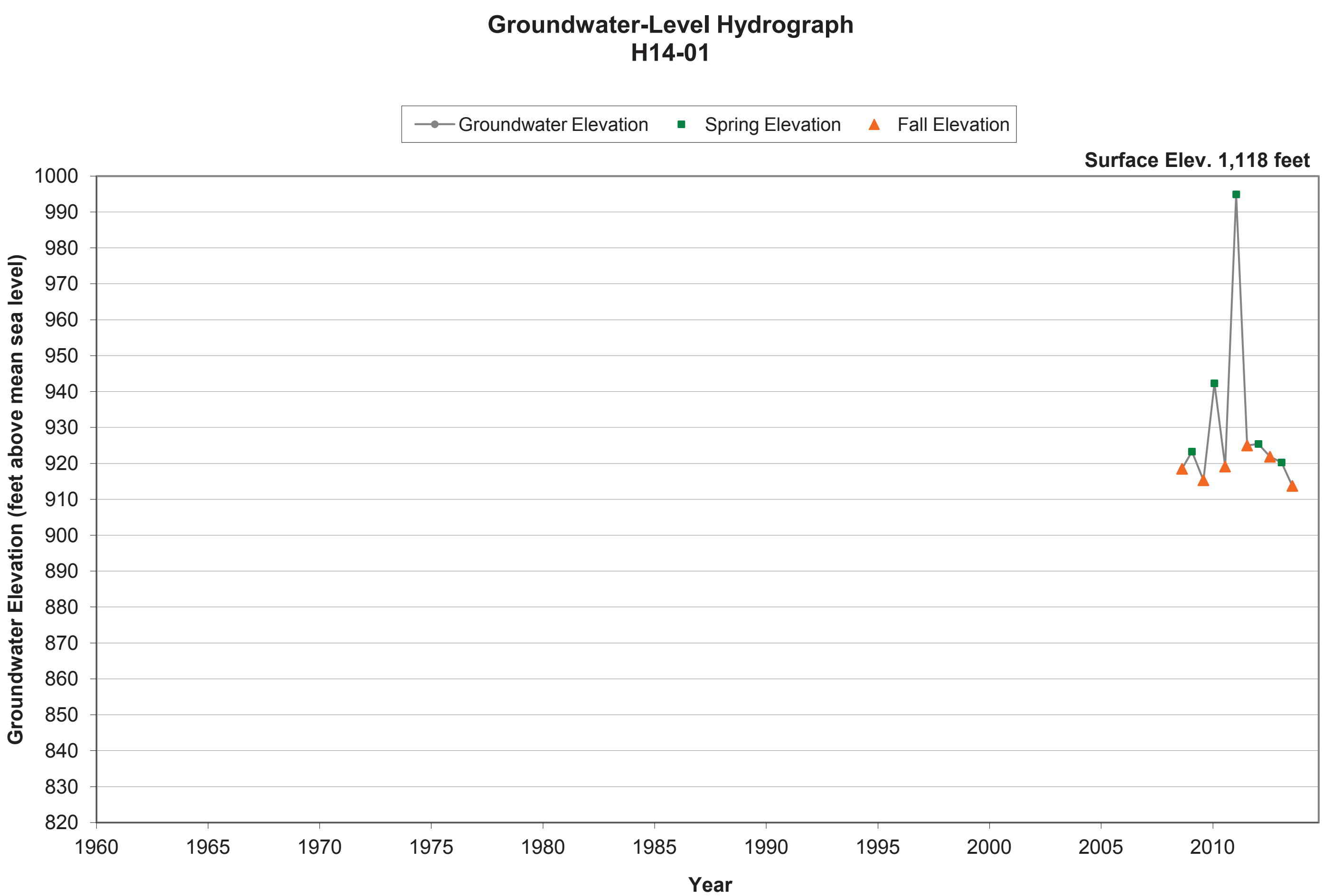


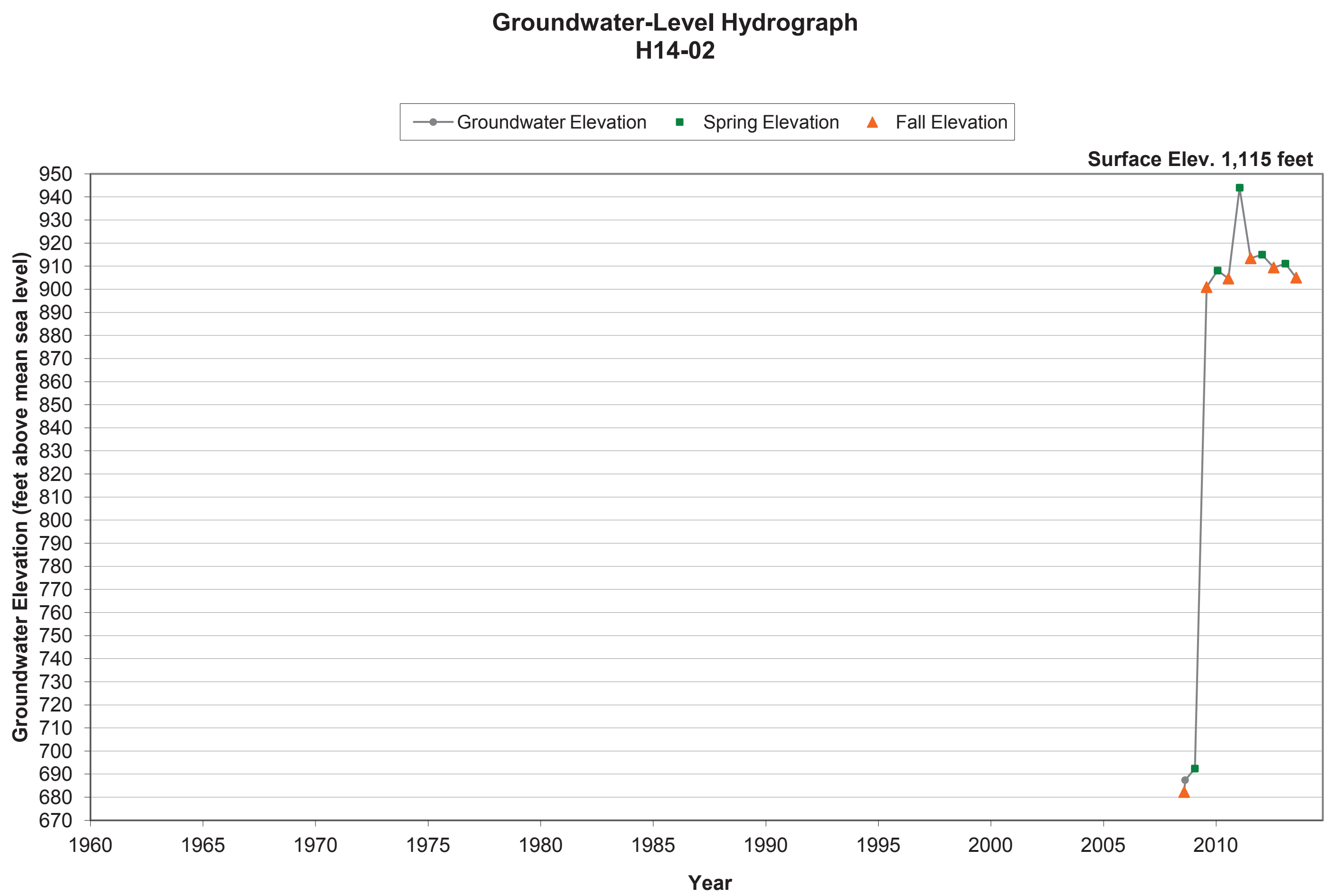
Groundwater-Level Hydrograph
G04-06
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
580
570
560
550
540
530
520
510
500
490
480
470
460
450
440
430
420
410
400
Groundwater-Level Elevation (feet)
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year



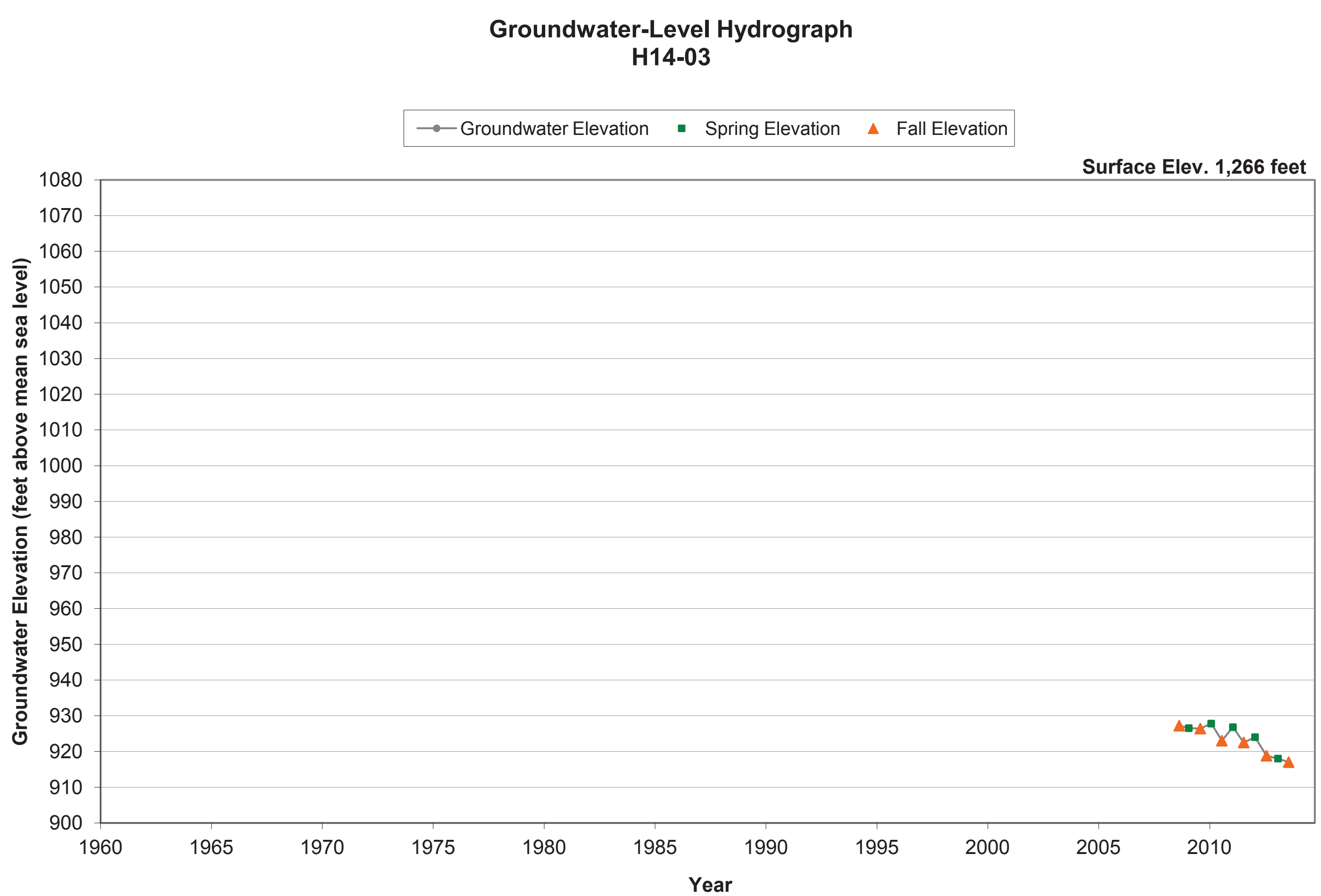
Groundwater-Level Hydrograph
G08-01
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
910
900
Groundwater Elevation (feet above mean sea level)
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
H06-03
Groundwater Elevation
Spring Elevation
Fall Elevation
Surface Elev. 503 feet
Groundwater Elevation (feet above mean sea level)
430
420
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
H14-01
Groundwater Elevation
Spring Elevation
Fall Elevation
Surface Elev. 1,118 feet
Groundwater Elevation (feet above mean sea level)
1000
990
980
970
960
950
940
930
920
910
900
890
880
870
860
850
840
830
820
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

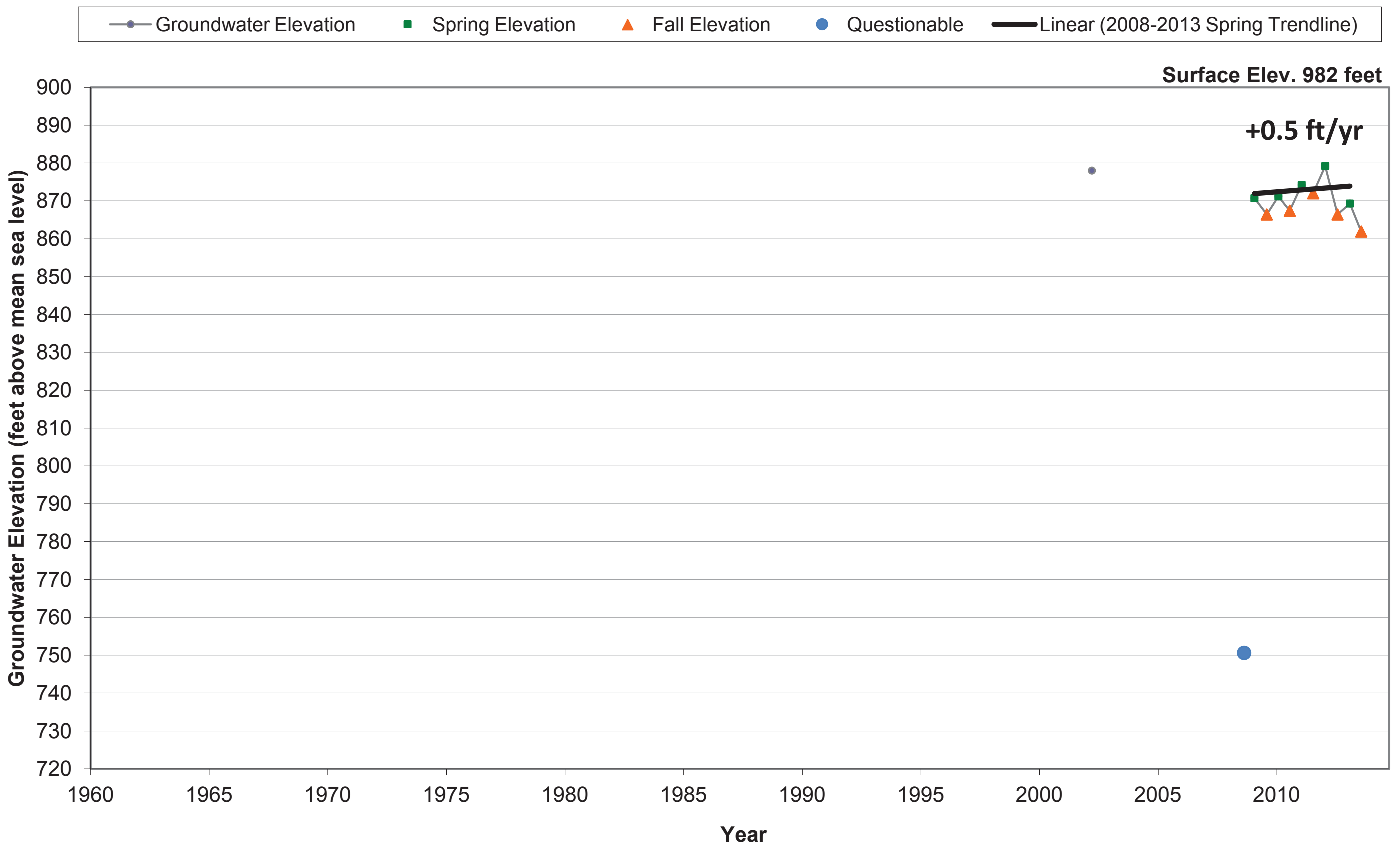


Groundwater-Level Hydrograph
H14-02
Groundwater Elevation
Spring Elevation
Fall Elevation
Surface Elev. 1,115 feet
Groundwater Elevation (feet above mean sea level)
950
940
930
920
910
900
890
880
870
860
850
840
830
820
810
800
790
780
770
760
750
740
730
720
710
700
690
680
670
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

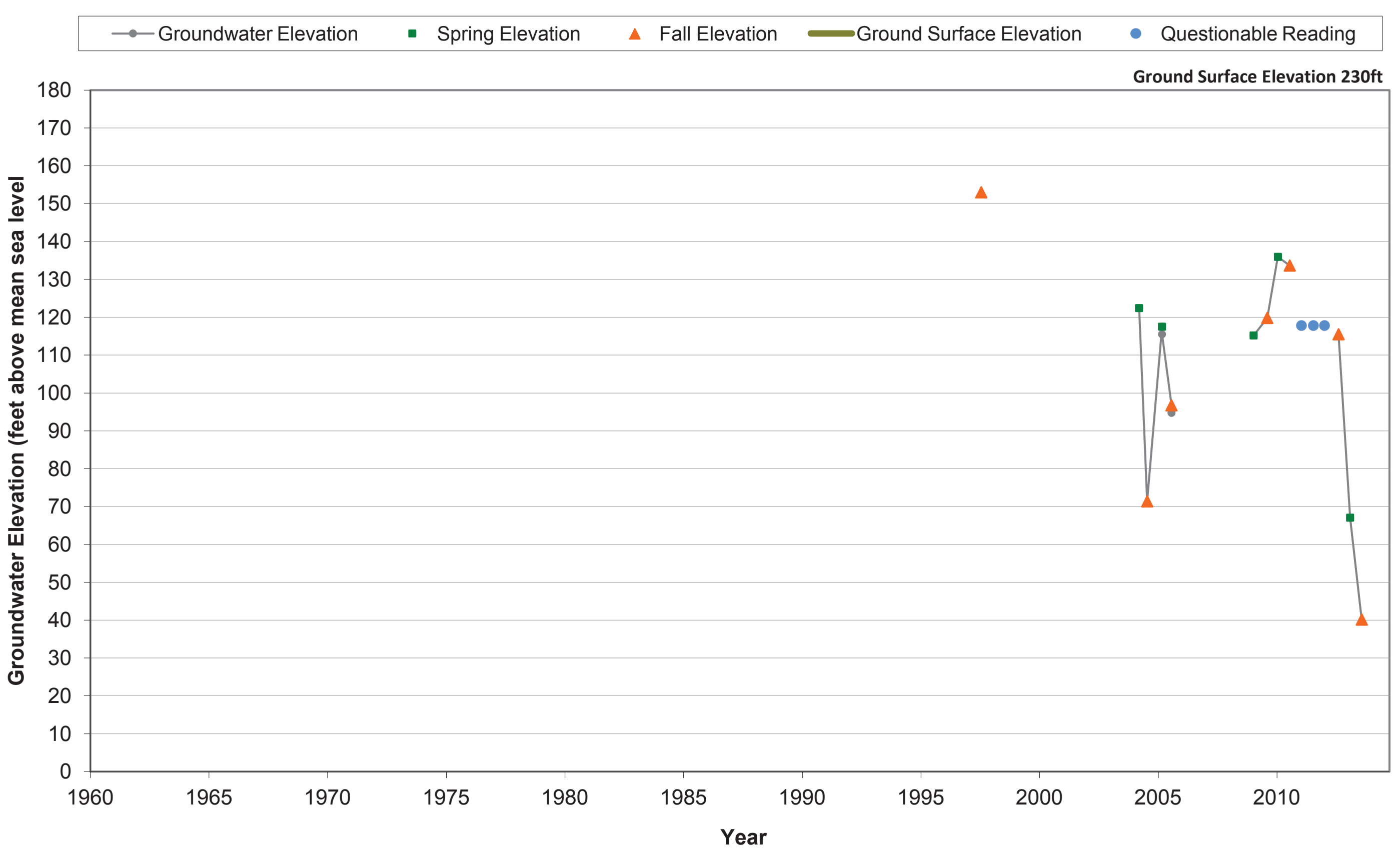


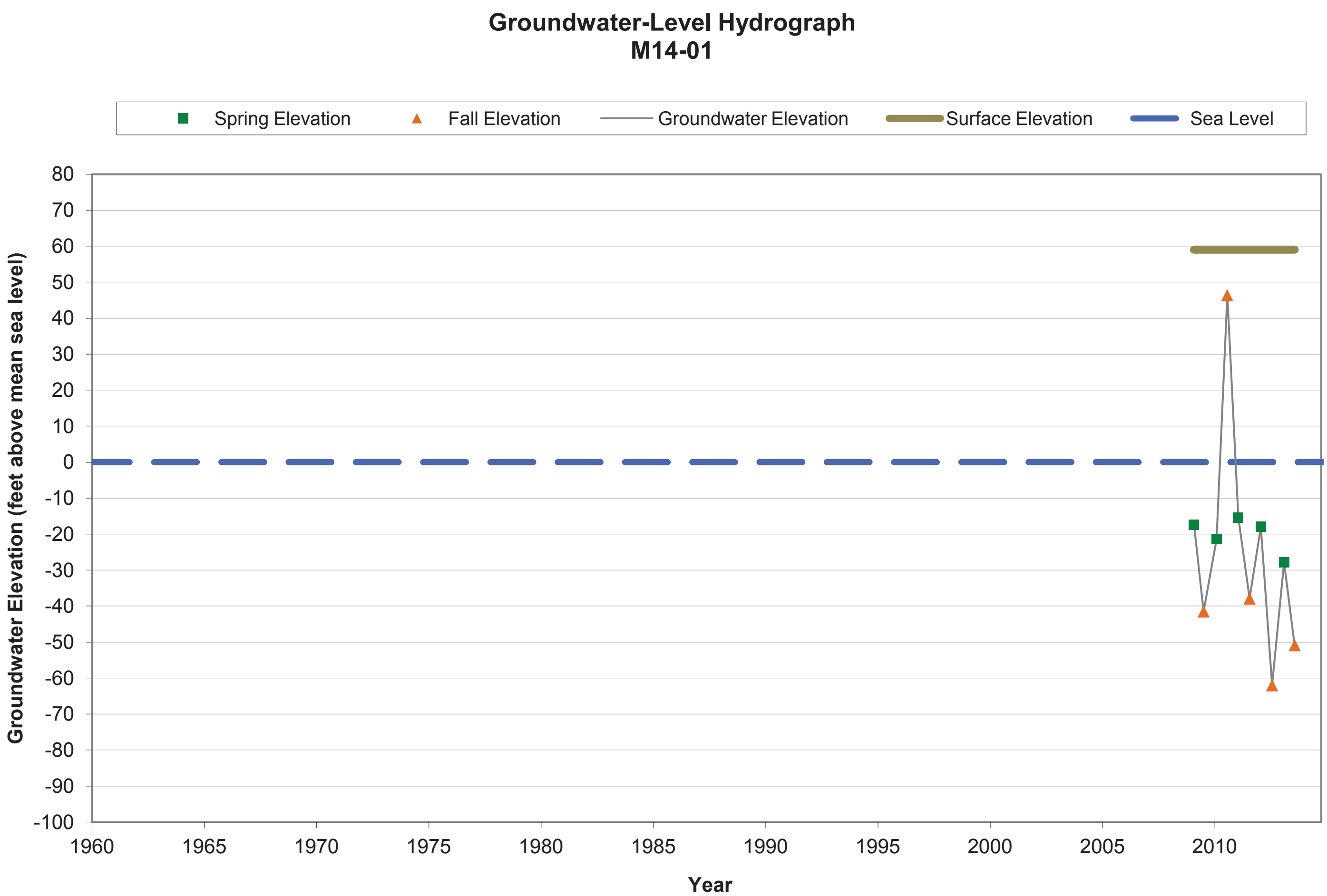
Groundwater-Level Hydrograph
H14-03
Groundwater Elevation
Spring Elevation
Fall Elevation
Surface Elev. 1,266 feet
Groundwater Elevation (feet above mean sea level)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
950
940
930
920
910
900
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

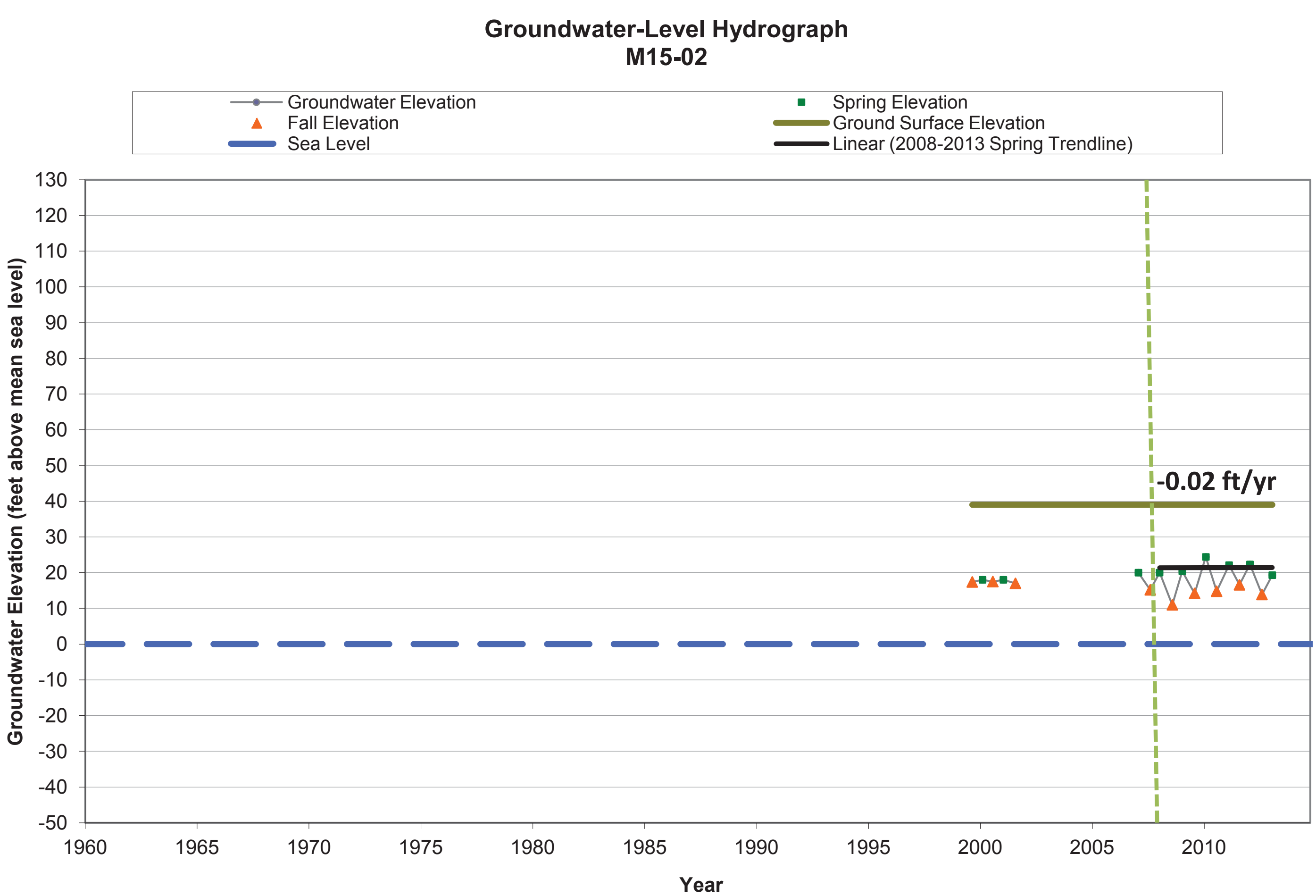
Groundwater-Level Hydrograph
I13-01

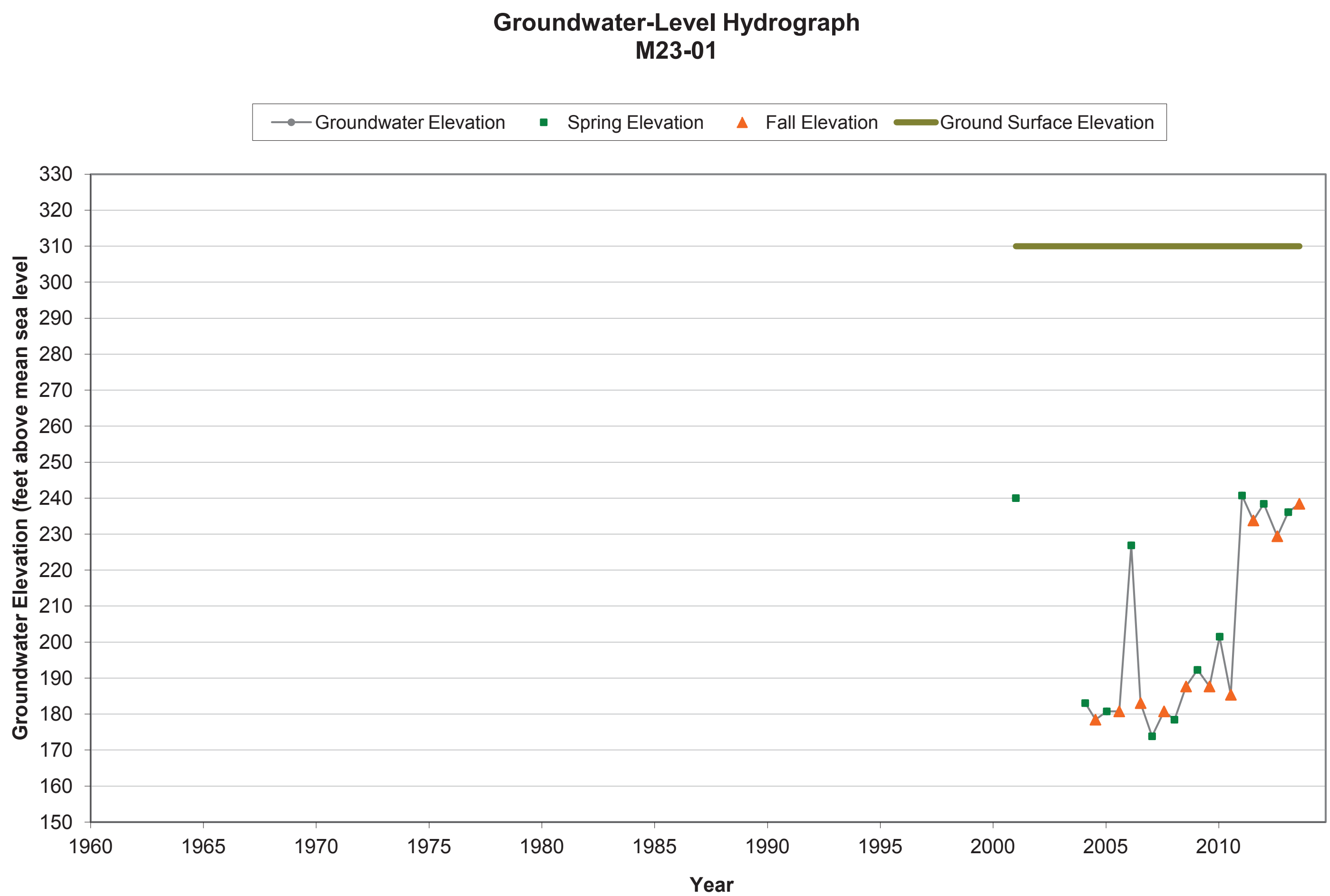


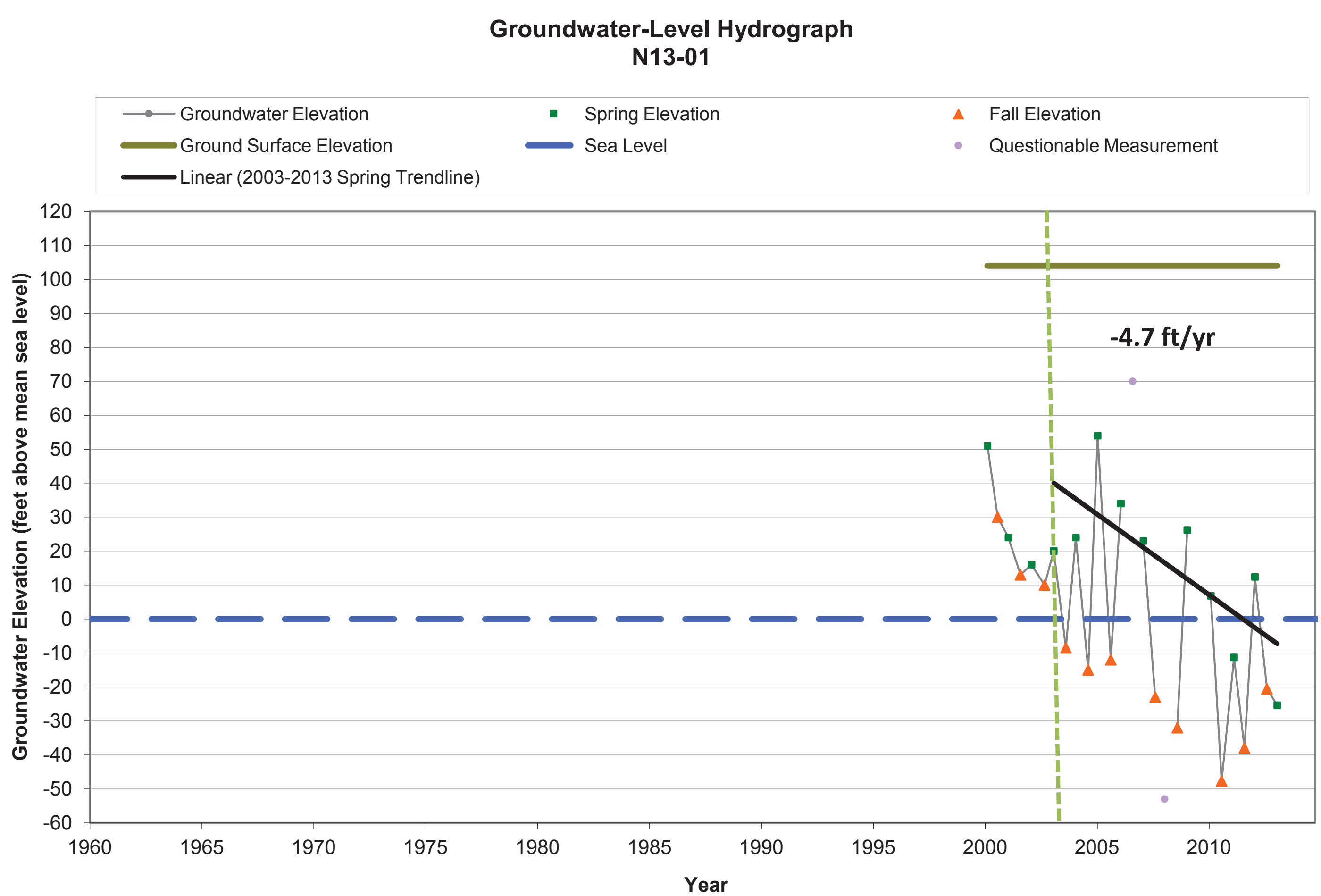
Groundwater-Level Hydrograph
L22-01




Groundwater-Level Hydrograph
M14-01
Spring Elevation
Fall Elevation
Groundwater Elevation
Surface Elevation
Sea Level
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Groundwater Elevation (feet above mean sea level)
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
M15-02
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Linear (2008-2013 Spring Trendline)
-0.02 ft/yr
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
Groundwater Elevation (feet above mean sea level)
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
M23-01
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Groundwater Elevation (feet above mean sea level)
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year


Groundwater-Level Hydrograph
N13-01
Groundwater Elevation
Spring Elevation
Fall Elevation
Ground Surface Elevation
Sea Level
Questionable Measurement
Linear (2003-2013 Spring Trendline)
-4.7 ft/yr
Groundwater Elevation (feet above mean sea level)
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Appendix B
Methods for Determining Groundwater Demands in Sonoma Valley

Methods for Determining Groundwater Demands in Sonoma Valley

Irrigation

Agricultural and Irrigated Turf pumping were estimated from spatial information on land use and specific crop water demands.

Land use data for the Sonoma Valley in 2012 was updated from a geodatabase created by Emily Heaton for a 2006 research project at the University of California, Berkeley, which covered all of Sonoma County and the Russian River watershed. This original geodatabase was created using 2004 satellite imagery to digitally identify field boundaries and associated crop type using ArcGIS. Selected fields were then field checked to confirm crop type. This original dataset was then updated by Sonoma County Water Agency (SCWA) in 2013 using 2012 National Agriculture Imagery Program (NAIP) imagery. The resulting geodatabase contains the final crop land parcels used for the 2012 analysis. The parcels were then divided into the eleven subareas defined for Sonoma Valley and the total acreages were calculated (Table 1).

The original geodatabase divided the land use into eleven categories listed in Table 2. However, for the 2012 Sonoma Valley analysis the crops types were consolidated into four categories based on identification in the basin and crop water demand (Table 3). Pasture land use was excluded from the analysis because it was difficult to determine if it was irrigated. Annual crop water demand for vineyards, orchards, and other agriculture are based on methodology from the most recent update to the MODFLOW model for Sonoma Valley (Bauer, 2008), while the values for irrigated turf are from a previous analysis of potential recycled water use (Raines, Melton & Carella, Inc., 2005). The overall demand was then estimated by multiplying the acreage by the crop water demand (Table 4).

While most of the agricultural and turf demands are assumed to be met with groundwater, some is met with surface water and reclaimed water. The reclaimed water service area boundary was obtained from the SCWA GIS department and the irrigated acreage it serves is tabulated in Table 5. The applicable surface water diversions in Sonoma Valley reported in the State Water Resources Control Board eWRIMs database for 2012 were identified, input into a geodatabase, and summarized for each subarea (Table 6). The general locations of diversions are shown in Figure 1. The surface water diversions and reclaimed water were then subtracted from the overall demand, resulting in the estimated 2012 groundwater pumping for irrigation (Table 7).

The location and magnitude of pumping for irrigation was estimated by consolidating irrigation wells into a gridded system and relating the demand to each well. First a geodatabase was acquired from the USGS that includes well with reported use type. The USGS also supplied a shapefile of a grid (~¼ x ¼ mile squares) that was developed for a MODFLOW model of Sonoma Valley (USGS 2006). The irrigation wells were then selected from the geodatabase and matched to the grid. Each grid cell that contained at least one irrigation well was identified as an approximate location of irrigation pumping. Then each irrigated parcel from the land use geodatabase was matched to the closest irrigation pumping location.

The total demand for each pumping location was then calculated by summing the matched parcel demands, while separating out agricultural and turf parcels. These consolidated irrigation pumping demands were then mapped to visualize the distribution of pumping (Figure 2).

Small Public Supply Systems

The small systems category in this analysis is made up of small commercial systems such as wineries, warehouses, and regional parks. Reported pumping amounts for 2012 and estimated location of service area are supplied by the California Department of Public Health (CDPH) (Table 8). Some of the CDPH reported pumping values were supplemented with reported values from Sonoma County Permit and Resource Management Division (PRMD). All the data was then entered into a geodatabase, divided into the subareas, and the pumping was calculated (Table 9). The generalized locations of the small systems, along with estimated demands are shown on Figure 2.

Mutual/Private Water Systems

Mutual and Private Water Systems consist of small community systems, including large subdivisions in unincorporated areas and mobile home parks. Reported pumping amounts for 2012 and estimated location of service area are supplied by the California Department of Public Health (CDPH) (Table 10). The service area data was enhanced with information acquired from the Sonoma County Local Agency Formation Commission (LAFCO), which provided shapefiles for the service areas of six out the ten systems. All the data was then entered into a geodatabase, divided into subareas, and the total pumping was calculated (Table 9). The generalized locations of the mutual and private water systems, along with estimated demands are shown on Figure 2.

Public Supply

Municipal pumping in Sonoma Valley consists of groundwater use from the City of Sonoma and the Valley of Moon Water District (VOMWD). Reported pumping amounts for 2012 and service area geographic information were provided by each municipality (Table 11). All the data was then entered into a geodatabase, divided into subareas, and the total pumping was calculated (Table 9). The generalized locations of the municipal water systems, along with estimated demands are shown on Figure 2.

Rural Domestic

Rural Domestic demands consist of privately owned domestic wells located outside of municipal or mutual water company service areas.

Pumping estimates were derived from estimating population outside mutual/private water companies' and municipalities' service areas and applying a per capita water use. The population was estimated using 2010 census geographical data acquired from US Census Bureau TIGER Products. The census

geodatabase contained population estimations in each census blocks, which can vary in area, within Sonoma County. The population density was then calculated for each census block by dividing the population by the block area (this method assumes an even distribution of population within the block, which is not always the case for the larger blocks). The area of Sonoma Valley was then extracted from larger census geodatabase, with blocks that cross the border being cut, reducing their effective area. The new areas were then calculated and multiplied by the population density to get the new total populations for Sonoma Valley (Table 12). The service areas for the City of Sonoma and VOMWD were then subtracted from the new population dataset, resulting in new sized blocks near the boundaries. The area of new census blocks were then calculated and multiplied by the corresponding population density to get the adjusted population dataset. The populations served by mutual and private water systems for 2012 were reported by CDPH (Table 10). These populations were subtracted from census blocks that intersected the service areas, resulting in the 2010 rural domestic population dataset.
In order to estimate the 2012 populations, the 2010 census populations were extrapolated using a 0.7% per year population growth (Bauer 2006, County of Sonoma). A per capita water demand of 0.28 acre-feet was then applied to the resulting 2012 population. The 0.28 acre-feet was estimated by taking the average of the per capita demand of the mutual and private water companies. The final result is the net rural domestic pumping demand for 2012, which were divided into the subareas, and summarized in Table 9.

The method used for estimating the locations and magnitude of the rural domestic pumping is similar to that used for irrigation demands. First the 2010 census blocks were overlaid onto the USGS model cells, resulting in the largest census parcel being the size of a model cell. Then the areas of the new parcels were calculated and the corresponding population density was applied to get the population estimate. Next, the USGS well geodatabase was filtered for domestic use wells, which were then matched to cells on the USGS model grid. The model cells which contained domestic wells were assumed to be the approximate location of domestic pumping. Each census parcel was then matched to its nearest domestic pumping location. The total 2010 population for individual pumping locations was then calculated. The populations were then extrapolated to 2012 and applied the per capita water demand, resulting in the final estimated distribution of rural domestic demands (Figure 2).

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Table 1 - Irrigated Field Acreage (2012)

Subarea	Vineyard	Orchard	Other Irrigated	Irrigated Turf
Calabazas	238	5	0	0
Baylands	603	0	0	0
Glen Ellen	202	8	0	0
Agua Caliente	429	3	0	10
Huichica	2,967	0	0	0
Western Upland	2,067	60	0	0
Rodgers Creek	1,494	1	8	14
Kenwood	843	50	1	0
Eastern Upland	2,516	21	23	0
City	1,349	10	0	18
El Verano/Fowler Creek	2,010	6	13	167

Table 2 - Original Land Use Identifiers

Land Use	Description
Vineyard	Grape vines
Previous Vineyard	Was identified as vineyard previously, but now not irrigated
Converted from Vineyard	Was identified as vineyard previously, but now another irrigated land type
Possible Vineyard	Poor imagery quality makes it difficult to confirm vineyard presence
Orchard	Olive trees, fruit trees, nut trees, tree nursery
Perennial Agriculture	Ornamental shrubs
Non-Perennial Agriculture	Row crops
Pasture	Grazing land for livestock
Other Irrigated Land	Golf courses, parks, sports fields
Prepared Vineyard	Field cleared, distinctive rows, vines may have just been planted
Possible Irrigated Land	Area appears to be irrigated

Table 3 - Consolidated Land Use Indentifiers

Land Use	Description
Vineyard	Grape vines
Orchard	Olive trees, fruit trees, nut trees, tree nursery
Other Agriculture	Ornamental shrubs, row crops
Irrigated Turf	Golf courses, parks, sports fields

Table 4 - Water Demand by Crop Types (feet per year)

Subarea	Vineyard	Orchard	Other Irrigated	Irrigated Turf	
				Golf Course	Parks/Sports Fields
Calabazas	0.6	2	2	3.5	3
Baylands	0.6	2	2	3.5	3
Glen Ellen	0.6	2	2	3.5	3
Agua Caliente	0.6	2	2	3.5	3
Huichica	0.6	2	2	3.5	3
Western Upland	0.3	2	2	3.5	3
Rodgers Creek	0.6	2	2	3.5	3
Kenwood	0.6	2	2	3.5	3
Eastern Upland	0.3	2	2	3.5	3
City	0.6	2	2	3.5	3
El Verano/Fowler Creek	0.6	2	2	3.5	3

Table 5 - Reclaimed Water Service Area Irrigated Field Acreages (acre-feet in 2012)

Subarea	Vineyard	Orchard	Other Irrigated	Irrigated Turf
Calabazas	0	0	0	0
Baylands	211	0	0	0
Glen Ellen	0	0	0	0
Agua Caliente	0	0	0	0
Huichica	1,971	0	0	0
Western Upland	0	0	0	0
Rodgers Creek	0	0	0	0
Kenwood	0	0	0	0
Eastern Upland	54	0	0	0
City	0	0	0	0
El Verano/Fowler Creek	0	0	0	0

Table 6 - Surface Water Diversion Acreages (2012)

Subarea	Agriculture	Turf
Calabazas	22	0
Baylands	21	0
Glen Ellen	0	0
Agua Caliente	0	0
Huichica	373	0
Western Upland	434	0
Rodgers Creek	0	0
Kenwood	43	0
Eastern Upland	236	0
City	15	0
El Verano/Fowler Creek	17	10

Table 7 - Net 2012 Irrigation Groundwater Pumping (acre-feet)

Subarea	Vineyard	Orchard	Other Irrigated	Irrigated Turf
Calabazas	143	11	0	0
Baylands	362	0	0	0
Glen Ellen	121	17	0	0
Agua Caliente	257	5	0	16
Huichica	1,780	0	0	0
Western Upland	620	120	0	0
Rodgers Creek	896	3	16	41
Kenwood	506	99	2	0
Eastern Upland	755	42	84	47
City	809	20	0	22
El Verano/Fowler Creek	1,206	12	27	575

Table 8 - Summary of Small Systems Demands

Small System CDPH Number	Subarea	Year Reported	Reported Groundwater Pumping (acre-feet)
4901254	Carneros	2012	9
4901247	City	2012	10
4901218	City	2012	6
4900945	City	2012	7
4900845	City	2011	13
4901273	City	2011	1
4901193	City	2012	0
4901258	City	2008	40
4900918	City	2009	17
4901234	City	2012	0
4901069	City	2011	1
4901061	City	2012	0
4901225	City	2012	0
4901083	City	2012	1
4901294	City	2012	16
4900986	Eastern Upland	2012	1
4900957	Eastern Upland	2012	26
4901144	Eastern Upland	2011	8
4910302	Eastern Upland	2012	2
4901018	Eastern Upland	2012	6
4901233	Eastern Upland	2012	4
4900875	Eastern Upland	2011	6
4901274	Eastern Upland	2012	3
4901255	Eastern Upland	2012	26
4900925	Eastern Upland	2012	0
4900909	El Verano/Fowler Creek	2012	1
4901278	El Verano/Fowler Creek	2012	37
4901275	El Verano/Fowler Creek	2012	1
4901227	Kenwood	2012	4
4901133	Kenwood	2012	11
4900841	Kenwood	2011	0
4901204	Western Upland	2012	5
4910305	Western Upland	2012	2
4901028	Western Upland	2012	5
4901120	Western Upland	2012	2
4901262	Western Upland	2012	15
4901151	Western Upland	2012	2
4901198	Western Upland	2012	0
4901080	Western Upland	2012	6
4900967	Western Upland	2011	2
4901129	Western Upland	2012	6
4901096	Western Upland	2011	8

Table 9 - Summary of 2012 Sonoma Valley Groundwater Basin Demands (acre-feet)

Subarea	Agriculture				Irrigated Turf*		Rural	Public Supply			Small	Mutual/
	Total Demand	Surface Water	Reclaimed	Groundwater	SW	GW	GW	City	VOM	Total	Systems	Private
Calabazas	153	22		131			70					
Baylands	362	21	127	214								
Glen Ellen	138	0		138			120					11
Agua Caliente	263			263		16	11					
Huichica	1,780	373	1,183	224			150				87	
Western Upland	740	434		306			351					176
Rodgers Creek	915			915		41	155				39	
Kenwood	607	43		565			540				51	140
Eastern Upland	880	236	16	628		47	439		277	277	83	126
City	829	15		814		22	497	80		80	112	90
El Verano/Fowler Creek	1,244	17		1,227	10	575	427		145	145		
Totals	7,913	1,161	1,326	5,426	10	701	2,760	80	422	502	372	544

*Irrigated golf course, parks, and sports fields

Table 10 - Summary of Reported Mutual/Private Water Company Demands

Mutual/Private Ware Company	Subarea	2012 Reported Groundwater Pumping (acre-feet)	2012 Served Population
Bennett Ridge Mutual Water Company	Western Upland	47	200
Diamond A Mutual Water Company	Western Upland	100	250
George Ranch Mutual Water Company	Western Upland	28	75
Kinnybrook Mutual Water Company	Eastern Upland	44	21
Mission Highlands Mutual Water Co.	Eastern Upland	56	200
Sonoma Ranch Mutual Water Company	Eastern Upland	26	100
De Anza Moon Valley Water Company	City	90	495
Sonoma Springs Water Company (PUC)	Glen Ellen	11	55
Kenwood Village Water Company (PUC)	Kenwood	140	850

Table 11 - Summary of Municipality Groundwater Demands

Municipality	Well Name	Subarea	2012 Reported Groundwater Pumping (acre-feet)
Valley of Moon	Agua Caliente Well	Eastern Upland	91
Valley of Moon	Donal Ave Well	Eastern Upland	61
Valley of Moon	Larbre Well	El Verano/Fowler Creek	145
Valley of Moon	Mountain Ave Well	Eastern Upland	68
Valley of Moon	Park Ave Well	Eastern Upland	57
City of Sonoma	COS Well	City	80

Table 12 - Summary of Estimated Rural Domestic Demands (2012)

Subarea	Total 2012 Population	Valley of Moon 2012 Population	City of Sonoma 2012 Population	Mutual/Small Systems 2012 Population	Net Rural 2012 Population	Net Rural 2012 Groundwater Pumping (acre-feet)
Western Upland	1,906	129	0	525	1,252	351
Eastern Upland	3,737	1,747	99	321	1,569	439
Agua Caliente	4,929	4,136	0	753	40	11
Calabazas	773	522	0	0	251	70
Huichica	536	0	0	0	536	150
City	18,575	5,965	10,340	495	1,775	497
El Verano/Fowler Creek	8,094	7,513	56	0	525	147
Rogers Creek	1,454	902	0	0	553	155
Glen Ellen	689	207	0	55	427	120
Kenwood	2,824	0	0	895	1,929	540
Baylands	0	0	0	0	0	0