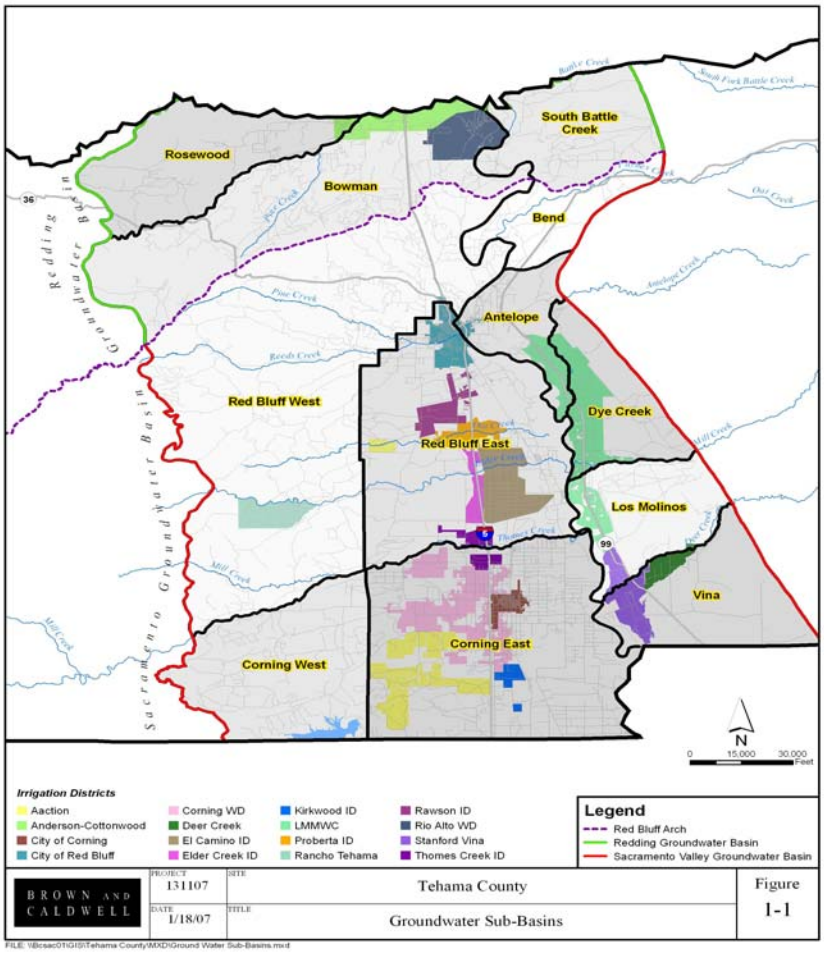
Tehama County AB-3030 Groundwater Management Plan

Background Document

Proposing Groundwater Trigger Levels and Awareness Actions for Tehama County



July 1, 2008

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Technical Memorandum

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

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Subject: Groundwater Trigger Levels and Awareness Actions Background Document

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To: Mr. Ernie Ohlin, Water Resources Manager

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1. INTRODUCTION

1.1 Perspective on Groundwater Management in Tehama County

From the 1970's to the 1990's, reliance on groundwater for agricultural, domestic, environmental, and industrial uses in Tehama County increased from about 30 to 65 percent. Today, groundwater use remains predominant. Concerns with surface water supply reliability, changing land use, local and statewide growth, and increased environmental water use have contributed to greater dependence upon groundwater. This shift to groundwater coupled with concerns about water transfers out of Tehama County in 1992 provided incentive to develop a countywide Groundwater Management Plan (Plan) beginning in about 1995. Landowners, agricultural and domestic water purveyors, environmental interests, and the general public recognized the need to advance with groundwater resource protection by balancing groundwater use with groundwater recharge. In 1998, after considerable public input and review, the Tehama County Groundwater Management Plan was completed and adopted by the Tehama County Flood Control and Water Conservation District.

Tehama County Groundwater:

- Today, groundwater is 65 % of the county's total water supply
- Management Plan adopted 1998
- Plan recognizes complex groundwater issues
- Plan protects groundwater
- Continue Phase 1 of Plan – "construct a basin monitoring program"
- Plan founded on cooperation among local interests

The Plan addresses complex groundwater issues in Tehama County and as a result employs a careful approach that seeks to implement groundwater management as appropriate. The Plan encourages cooperation with cities, special districts, and landowners throughout Tehama County who share in the common objectives of the Plan. The Plan considers water resource and groundwater management interests that are common with neighboring counties and the broader Sacramento Valley area and seeks dialogue and coordination with the appropriate county and regional entities (refer to Section 6 of this document for further discussion of the county and regional setting). The Plan is also consistent with state legislation (AB-3030, 1992 and SB-1938, 2002) that has been incorporated into California Water Code to guide groundwater management.

1.2 Role of the Tehama County Flood Control and Water Conservation District

The Tehama County Flood Control and Water Conservation District (District) works to guide and facilitate implementation of the Plan. The District has a five member elected Board of Directors (who also set as the Tehama County Board of Supervisor's), county staff including a Water Resources Manager with office and field staff to provide oversight and support to implement the Plan. The District's support of the Plan is funded within the existing county budget allocations and supplemented with funds from state competitive grant programs. Since the Plan was first adopted, some important milestones have been accomplished:

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- Beginning in 1998, appointment of a nine member Technical Advisory Committee (TAC). Members of the TAC represent a balanced cross-section of interests including private pumpers, surface diverters, natural resources, water districts and cities in Tehama County's groundwater resources community. Committee members are nominated through a public process and approved by the District's Directors. Committee members serve three-year terms. TAC members provide external review and guidance in implementing the Plan.
- From 1998 to 2007, a groundwater monitoring network to monitor groundwater levels and groundwater quality has expanded. Currently groundwater levels and/or groundwater quality is measured at least semi-annually in about 190 agricultural, domestic, or dedicated monitoring wells distributed throughout Tehama County and contribute to the historic record and current status of groundwater levels and groundwater quality. Since 2003, the District and has received grant funds and installed five dedicated, multi-completion groundwater monitoring wells in areas of Tehama County where groundwater use is most prevalent. In 2008, the District developed a land subsidence monitoring network across the county and completed the first survey of land elevation data.
- In 2003, the District completed a Water Inventory and Analysis to understand past and present trends in surface and groundwater use and to forecast future water needs in the county for various growth and climatic scenarios.
- In 2005, the District developed a website (www.tehamacountywater.ca.gov) which contains many of the documents, agendas, minutes, and data to inform the public of District activities.
- In 2006, the District and the TAC initiated the development of groundwater "trigger levels" in accordance with Section 325 of the Plan and continues to move forward with this charge.

Oversight of Management Plan:

- Implementation facilitated by Tehama County Flood Control and Water Conservation District
- Technical Advisory Committee provides external guidance
- Milestones: active advisory committee, establishment of groundwater monitoring network, completion of countywide water inventory and analysis
- Current charge: develop "trigger levels" and awareness actions

2. TRIGGER LEVEL CONCEPT

2.1 Definition of Trigger Levels

The "trigger level" process creates an awareness of fluctuations in groundwater conditions within Tehama County over time and develops actions to inform local water users of the conditions and potential management needs in the county. Trigger levels are intended to increase the management role of the District and other cooperating, local agencies and water users if groundwater monitoring shows diminishing trends in groundwater levels, groundwater quality, or evidence of land subsidence. The trigger levels and awareness actions will undergo annual review by the District, the TAC, sub-basin advisory committees that may form from this public review

"Trigger levels" create an awareness of fluctuations in groundwater conditions within Tehama County over time and develop actions to inform water users of the conditions and potential management needs in the county.

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process, and the general public to adjust them as more experience is gained from the monitoring of groundwater conditions.

2.2 Types of Trigger Levels

Section 360 in the Plan states "the District shall develop one or more monitoring wells within each sub-basin for the purpose of monitoring groundwater storage. Monitoring groundwater levels will allow the District to gauge the status of the groundwater storage in response to environment and water use practices". It also states "the District shall include one or more monitoring wells within the basin for the purpose of measuring water quality conditions".

This section highlights groundwater storage, which is associated with groundwater levels and groundwater quality as two aspects of the groundwater resource that shall be monitored and protected under this Plan. Land subsidence is also being monitored to prevent it. Land subsidence is the permanent decline in land elevations and results from the de-watering and shrinkage of clay strata in the groundwater aquifer systems. Land subsidence may damage levees, canals, bridges, and other infrastructure.

To achieve protection of groundwater storage, groundwater quality, and prevention of land subsidence, the Plan calls for setting trigger levels for these types of groundwater conditions. Since this is the first effort to set trigger levels in accordance with the Plan and the desire is to achieve approved trigger levels and awareness actions based upon effective public review and feedback, the initial effort will give priority to setting trigger levels for groundwater levels. The task of establishing trigger levels for groundwater quality and land subsidence will be undertaken in a separate process after trigger levels for groundwater levels have been established and approved.

2.3 Approach to Developing Trigger Levels

As required by the adopted AB-3030 Plan, section 325 states that the District and the TAC are to assist in the development of trigger levels. Section 326 of the Plan acknowledges that "water levels may fluctuate considerably in response to pumping, recharge, and climatic cycles" and states that "the District shall develop criteria and actions which will establish the Groundwater Management Involvement Level for each County sub-basin". In accordance with this task in the Plan, this background document has been prepared to explain why, and how the District and the TAC have approached developing trigger levels and corresponding awareness actions. The District and TAC have incorporated three fundamental principles in their approach to developing trigger levels: 1) use of science-based monitoring and data evaluation methods; 2) a commitment to an ongoing local development process that enables public review and input in developing initial trigger levels that are accurate according to current knowledge and acceptable to interested parties ; and 3) acknowledgement that the trigger levels may need adjustments as experience and knowledge is gained from monitoring and data evaluation.

The District and the TAC have also developed complementary Technical Memorandums (TM's) for twelve (12) distinctly different groundwater sub-basins in Tehama County. The TM's describe how detailed groundwater data for the different sub-basins in Tehama County have been evaluated using science-based methods to arrive at an initial draft of recommended trigger levels and awareness actions for each groundwater sub-basin in Tehama County. These draft trigger levels have been recommended to facilitate and catalyze a public process of developing trigger levels and management awareness actions. The draft trigger levels and the methods used to develop them may be modified based upon public review and comment. The District and the TAC recognize landowners retain overlying rights to pump groundwater and it is not the intent to interfere with these rights. The intent of the Plan is to focus on monitoring groundwater conditions, communicating groundwater conditions to water users, and, if appropriate, explore

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creative and collaborative management options to assure reliable groundwater supplies through coordinated groundwater use and recharge.

2.4 Facilitating a Transparent and Local Developmental Process

The District and the TAC, to the extent possible, desire to develop trigger levels and awareness actions that have approval by local landowners, local water purveyors, environmental interests, and the general public. The District and the TAC understand that many local landowners have experience with well drilling and well construction and valuable knowledge of groundwater conditions in their specific sub-basins. The district and the TAC desire to incorporate this breadth of local knowledge into the trigger levels and awareness actions. To facilitate local trigger level development the District and TAC have:

- Developed and duplicated this background document in sufficient quantities so that it can be distributed to interested parties to explain why and how the development of trigger levels are being approached by the District and TAC;
- Developed and duplicated technical memorandums (TM's) in sufficient quantities so that they can be distributed to interested parties for review and comment. The TM's provide technical information, illustrate how it was evaluated, and recommend draft trigger levels for each groundwater sub-basin in Tehama County as a starting point for public review and comment;
- This background document, the TM's that recommend initial trigger levels for each sub-basin, and future documentation of the public review and comment process will be posted on a regular basis at the District's website http://www.tehamacountywater.ca.gov.
- Plans to conduct public workshops in each of the sub-basins to encourage public review and input into the development of trigger levels and awareness actions for each groundwater sub-basin. These workshops will be advertised in local newspapers and various community newsletters.
- The willingness to meet with interested groups or individuals upon their request to discuss the recommended draft trigger levels and awareness actions in their respective groundwater sub-basins.

There is no formal deadline for completing this process of establishing trigger levels in the respective sub-basins to allow adequate time to sufficiently involve parties interested in the Plan. However, the District and the TAC are committed to work diligently and progress with the "trigger level" phase of implementing the Plan. An approximate timeline for the local development of the trigger levels is to distribute this background document and the TM's for the respective sub-basins beginning in the fall of 2008. Shortly thereafter, the District and TAC will begin to initiate outreach in each sub-basin by facilitating public workshops and being available to meet with water users and interested parties upon request. The District and TAC recognize that it will require multiple repeat efforts since the county groundwater resources consist of 12 different sub-basins. It is also understood that water users and interested parties may desire to have time to review this background document and TM's independently of the District and TAC before offering comment. As a result of these considerations, the timeline for incorporating local comment toward the development of trigger levels may extend well into 2009.

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3. METHODS USED TO DEVELOP RECOMMENDED GROUNDWATER LEVEL TRIGGERS

3.1 Identified Groundwater Sub-basins in Tehama County

The first step taken by the District and the TAC in developing this initial draft of recommended trigger levels and awareness actions was to identify unique groundwater sub-basins in Tehama County that reflect variations in land use, groundwater pumping, surface water supplies, and topography. Figure 3-1, located at the end of this document, shows the identified groundwater basins in the county. Twelve sub-basins have been identified and according to the Plan trigger levels and awareness actions need to be developed for each of these sub-basins. These sub-basins are identified in the Water Inventory and Analysis and are for the most part consistent with hydrologic units defined by the California Department of Water Resources, Northern District. Two exceptions are that the Red Bluff and Corning sub-basins have been divided into east and west sections to accurately reflect transitions in the geology and groundwater hydrology.

Further discussion of these groundwater sub-basin delineations is invited during the local development process.

3.2 Five Steps to Develop a Groundwater Level Trigger

A five-step procedure was used by the District and TAC to arrive at recommended groundwater level triggers for nine of the twelve groundwater sub-basins designated in Tehama County. Figure 3-2, located at the end of this document, shows the twelve sub-basins and the locations of monitoring wells in each sub-basin. Of the twelve sub-basins, only nine have adequate existing groundwater level data. A detailed presentation and discussion of specific groundwater level data used to develop and recommend groundwater level triggers is provided in the TM's for each of the groundwater sub-basins. Three sub-basins (Bend, South Battle Creek, and Corning West) had insufficient existing or historic groundwater level monitoring data to recommend trigger levels. For these sub-basins, groundwater monitoring needs were recommended instead of suggesting trigger levels. The five-step process used by the District and the TAC to arrive at recommended draft groundwater level triggers in nine of the sub-basins is outlined and explained below:

Five Steps to Groundwater Level Trigger Development

Step 1: Describe the purpose of the trigger level.

Step 2: Select one or more key wells within the sub-basin to acquire groundwater level data.

Step 3: Designate the time of seasonal groundwater level measurement.

Step 4: Establish triggers levels for the key wells.

Step 5: Define awareness actions associated with each trigger level.

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The purpose of the District's and TAC's recommended draft groundwater level triggers are consistent between sub-basins in the county. Some suggested purposes for developing trigger levels include:

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels and compare changes to aid in identifying conditions that cause declines in groundwater levels.
- Manage groundwater levels in a manner that complement stream and river flows.

Interested parties will review and provide input to the purpose statements within each of the groundwater sub-basins to reflect their local needs during the local development process.

Step 2: Select one or more key wells within the sub-basin to acquire groundwater level data.

Through a coordinated effort, the California Department of Water Resources, Northern District (DWR) and the Tehama County Flood Control and Water Conservation District (District) measures groundwater levels in March and October of each year in approximately 190 wells (a combination of agricultural, domestic, and dedicated monitoring wells). Together, they also monitor groundwater levels in Tehama County in over 80 wells during the summer season. Summer groundwater levels are measured in July and sometimes a second round of summer monitoring is completed in August. In addition, the District has installed a number of multi-completion monitoring wells in areas with more pronounced summer groundwater drawdown. These wells have dataloggers, which enable them to collect data year-round.

The District and the TAC selected key wells from this network of monitoring wells. To make the selections they considered the local setting in each sub-basin, the completeness of the historical record of groundwater level data collection, and the extent of the well drilling and construction records. These key wells were then used to draft recommended groundwater level triggers for each sub-basin.

Interested parties may review and comment on the selection of key wells in a specific sub-basin during the local development process.

The monitoring wells are numbered using the state well numbering system, which identifies each well by its location according to the township, range, section, and tract system. Figure 3-3 illustrates the state well numbering system. In this numbering system, an example well number would be 25N05W17A01M, where the 25N indicates the township, the 05W indicates the range, the 17 indicates the section number, the A indicates the tract portion of the section, the 01 indicates that this is the first well installed in that area. On maps, wells are often represented with just the section, tract portion of section and number; this example well would thus be labeled as 17A01M.

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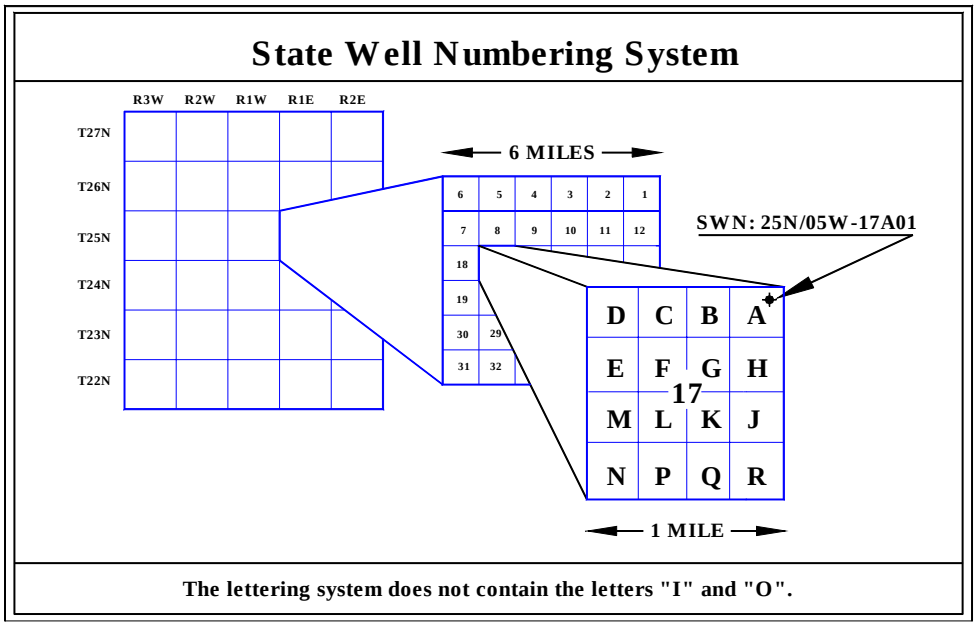

Source: Department of Water Resources, Northern District

Figure 3-3
State Well Numbering System

Factors considered by the District and TAC when selecting key wells included:

Length of monitoring – Wells with longer periods of record were considered better key wells. Longer periods of record reflect fluctuations in water levels under different hydrologic conditions, such as the 1977 drought, the early 1990s drought, and the series of wet years from the mid- to late-1990s. It is recognized that land use patterns have changed to some extent over this period of historical record.

Similarity to the majority of wells in the area – Key wells that were similar in depth and location to the majority of wells in a local area within the sub-basin were selected so that groundwater levels in key wells represent groundwater in the same geologic formation as the majority of extraction wells. For example, if most wells in the management area were 500 feet deep irrigation wells, then deeper wells were selected where possible. In some cases, wells at different depths were selected as key wells to understand the extent that groundwater is being extracted from different aquifer zones and whether there are interactions between them.

Location of surface water bodies – Selection of key wells near a surface water body was avoided, if possible, in this early phase of developing draft groundwater level triggers. Surface water can percolate into the nearby aquifer and elevate the water level in a nearby well and as a result it may not represent other wells in the area that are further away from the water body. As experience is gained, instances may arise where key well selection near a water body is appropriate, if questions occur about the effect of groundwater use on the condition of a water body.

Groundwater flow direction and summer drawdown – Knowledge of the direction of groundwater movement and areas of more intensive summer drawdown were considered when selecting key wells. Monitoring wells in areas of drawdown were considered useful key wells to understand summer groundwater levels, and monitoring wells down gradient of production wells were viewed as important indicators of how pumping practices affect groundwater levels.

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Well construction information – Monitoring wells with construction information were better suited to be key wells. Wells shallower than 100 feet were not selected as key wells if at all possible; these wells may not be representative of the local aquifer conditions, and are more heavily influenced by nearby surface water bodies. Monitoring wells without construction information were only selected if there were no other appropriate monitoring wells in the area.

Step 3: Designate the time of seasonal measurement

The District and TAC considered that groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Late season (summer and fall) water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts within a sub-basin during a season.

The District and TAC have recommended spring and late season trigger levels with associated awareness actions. Spring levels track the extent of groundwater level recovery or recharge following the winter rainfall seasons. The late season trigger levels are sensitive to groundwater levels during the seasons of most intensive groundwater use and provide signals of potential concerns with increased groundwater demand. Late season trigger levels for key wells also help track potential recharge from irrigation with surface water supplies.

Step 4: Establish triggers and define awareness actions for the key wells

In the TM's for each of the nine sub-basins where sufficient key wells and groundwater level data are available, the District and the TAC has recommended spring groundwater level triggers and corresponding awareness actions. The groundwater trigger levels are calculated using past spring groundwater level data from each key well. The groundwater trigger levels are set relative to the average and range in historic spring groundwater levels for each key well.

The District has selected two spring groundwater trigger levels to evaluate recovery of groundwater levels following the winter season and one late season groundwater trigger level to evaluate groundwater conditions when demand is higher. Awareness actions have also been proposed if the groundwater level in a key well falls below a trigger level. If a groundwater level in a key well falls below spring groundwater trigger level 1, the awareness actions focus on informing water users in the sub-basin and the general public of the groundwater condition. If the groundwater level in a key well falls below the groundwater trigger level 1 for two or more consecutive years (possibly indicating a trend), it triggers additional awareness actions that are centered on investigations to understand the causes of the groundwater decline. In the event, spring groundwater levels in a key well fall below the spring groundwater trigger level 2, additional awareness actions are suggested that initiate steps to manage the groundwater condition. If the groundwater level in a key well falls below the late season groundwater trigger level, the proposed awareness action is to notify water users in the sub-basin and the general public of the groundwater condition and initiate investigations to understand the cause. A conceptual diagram of trigger levels and associated awareness actions is presented in Figure 3-4, located at the end of this document.

Review and comment on the recommended groundwater level triggers and corresponding awareness actions for key wells during the local development process. Landowners with experience in well drilling, well construction, and groundwater pumping within the sub-basins may offer important insights to help adjust the recommended groundwater level triggers and awareness actions.

Step 5: Define management actions associated with each trigger level

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Figure 3-4 illustrates the trigger level concept and shows the sequence of awareness actions the District and the TAC have proposed be taken if groundwater level triggers are surpassed. Spring and late season groundwater trigger levels range from notable but non-critical change in groundwater levels to more critical change in groundwater levels. The corresponding awareness actions range from informing water users and the public of noteworthy groundwater conditions, increasing monitoring of groundwater levels in key wells within the management area to understand the cause, to considering management steps to address the lowering of groundwater levels.

The Plan uses trigger levels and awareness actions to focus on monitoring groundwater conditions, communicating groundwater conditions to water users, and, if appropriate, explore creative and collaborative management options to assure reliable groundwater supplies through coordinated groundwater use and recharge.

Public input and review of the process of defining the types of awareness actions deemed appropriate with each trigger level is important and encouraged.

4. STATUS OF DEVELOPING RECOMMENDED TRIGGER LEVELS FOR GROUNDWATER QUALITY

The District and TAC have postponed the development of trigger levels for groundwater quality until after the local process of setting groundwater level triggers has been completed for all of the groundwater sub-basins in the county. The task of setting groundwater quality trigger levels may be undertaken sometime in 2009 or later. This postponement places focus on groundwater supply and the process of setting groundwater level triggers and related awareness actions.

Groundwater quality is generally of high quality in Tehama County and there are several existing and overarching efforts to monitor, understand, and protect groundwater quality in Tehama County. Other groundwater quality monitoring programs in Tehama County include the Department of Health Services monitoring of local domestic sources; the State Water Resources Control Board and U.S. Geological Survey joint effort to perform the Groundwater Ambient Monitoring Assessment (GAMA) program, which performs periodic analyses of a broad suite of constituents; the California Department of Pesticide Regulation, which performs specific investigations of pesticides in groundwater; and the Department of Water Resources, Northern District which monitors groundwater quality to establish baseline conditions and understand groundwater quality trends.

5. STATUS OF DEVELOPING RECOMMENDED TRIGGER LEVELS FOR LAND SUBSIDENCE

The District and the TAC recommend postponing development of trigger levels for land subsidence. There is currently no known evidence of damage to roads, levees, bridges, canals, or other infrastructure that appears associated with land subsidence. Just recently, in April 2008, field monitoring was initiated to track land subsidence, so it is not yet feasible to establish trigger levels. Monitoring land subsidence is being done together with neighboring counties to be more efficient. A coordinated effort with other northern Sacramento Valley counties also ensures consistent methods of monitoring are used throughout the region in the most affordable manner possible.

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Two methods of monitoring subsidence in Tehama County are under consideration: 1) vertical extensometers; and 2) leveling using Global Positioning Systems (GPS). *Vertical extensometers* provide site-specific measurements of subsidence. These instruments consist of a pipe or cable anchored at the bottom of the borehole (Figure 5-1). The pipe or cable extends from the bottom of the borehole, through the geologic layers that are susceptible to compaction, to the ground surface. The pipe or cable is then connected to a recorder that frequently measures the relative distance between the bottom of the borehole and the ground surface. These instruments detect changes in land surface elevation to 1/100th of a foot on a daily basis.

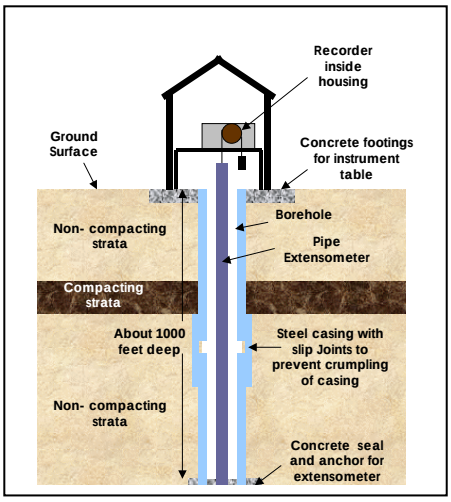

Figure 5-1. Illustration of a pipe extensometer used to monitor land subsidence.

Leveling using Global Positioning Systems (GPS) surveying or conventional leveling are alternatives to vertical extensometers. GPS surveying is used to monitor subsidence over greater distances or at a regional scale. Benchmarks or "geodetic stations" are used along a transect or across a network. Ground elevations at each benchmark can be obtained within plus or minus one inch of accuracy with GPS surveying. For regional scale surveys of this type, conventional leveling is less accurate. In April 2008, land elevations were measured at about 40 geodetic stations on a 3 to 5 mile grid across Tehama County. These measurements provide a baseline for comparison with future surveys. This network of survey monuments will be re-surveyed about every five years to track changes in elevation and look for evidence of land subsidence over time.

6. COUNTY AND REGIONAL GROUNDWATER SETTING

This section of the background document gives context on the countywide and regional groundwater setting that the District and TAC has considered while pursuing the implementation of the Plan. It summarizes some important aspects of the groundwater resources in Tehama County and throughout the larger, northern Sacramento Valley region.

6.1 Countywide Groundwater Setting

Tehama County derives it groundwater supplies from two larger regional groundwater basins, the Redding groundwater basin and Sacramento Valley groundwater basin. A smaller portion of Tehama County overlies the Redding groundwater basin beginning at the Shasta-Tehama County boundary and extending about six miles south to the Red Bluff arch. The majority of Tehama County overlies the Sacramento Valley groundwater basin beginning about six miles north of Red Bluff and extending south to the Tehama-Glenn County and Tehama-Butte County boundaries. Figure 3-1, located at the end of this document, shows the Rosewood, Bowman, and South Battle Creek sub-basins, which are part of the Redding groundwater basin. It also displays the Bend, Red Bluff East, Red Bluff West, Antelope, Corning East, Corning West, Dye Creek, Los Molinos, and Vina sub-basins, which are all part of the Sacramento Valley groundwater basin.

The Redding and Sacramento Valley groundwater basins extend several thousand feet below ground level and include fresh water and marine (saline) formations. The fresh groundwater is only found in the upper geologic formations. The approximate contact between fresh and saline groundwater ranges from 1500 to 3000 feet below ground surface. The principal fresh water bearing units in Tehama County are the Modesto, Riverbank, Tuscan, and Tehama Formations.

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6.1.1 Fresh Water-Bearing Aquifer Systems

Figure 6-1, located at the end of this document, shows the surface exposures of the geologic units within Tehama County. Figure 6-2 shows the vertical relationship between the units. The fresh water-bearing units in Tehama County are described below in order from those nearest the surface to those that are deeper.

Modesto and Riverbank Formations

The Modesto Formation is exposed in the eastern portion of Tehama County, east of the Sacramento River and the Riverbank Formation is exposed west of the Sacramento River. The thickness of these two formations range from 10 to 200 feet depending on location (Helley and Harwood, 1985). The water-bearing capabilities of these formations vary depending on the local thickness of the formations and the concentration of gravels and sands. Lower yields are found in areas with high silt and clay content or where the formation is thin. Groundwater in the Modesto and Riverbank Formations occurs under unconfined conditions.

The Riverbank and Modesto Formations are the primary source of freshwater for many of the shallower wells, such as domestic wells. Fifty percent of the existing domestic wells in Tehama County are less than 100 feet deep (DWR, 2002).

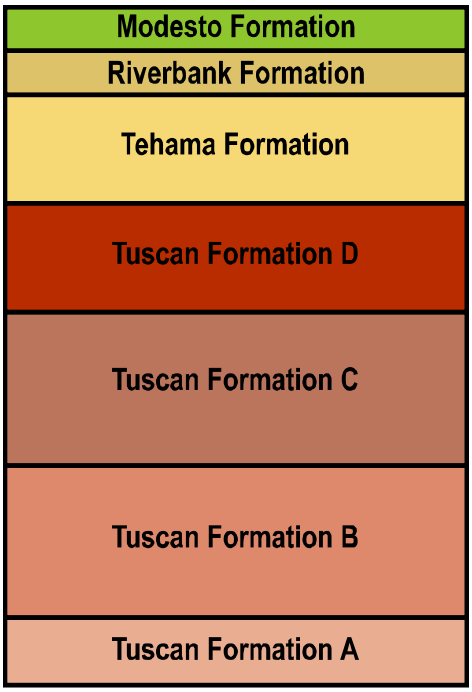

Figure 6-2
Vertical Relationship between Geologic Units

Tehama Formation

The Tehama Formation is exposed throughout the foothills in western Tehama County, and extends under the Riverbank Formation and the Sacramento River. It ranges from 100 to 600 feet thick in Tehama County, increasing in thickness to the east. The quantity of water available from this formation varies depending on the concentration of gravels and sands in the local area.

The Tehama Formation is a principle source of groundwater for deeper wells west of the Sacramento River, such as irrigation and municipal wells. Fifty percent of the agricultural and municipal wells in Tehama County are deeper than 200 feet, some of which extract groundwater from the Tehama Formation.

Upper and Lower Tuscan Formations

The Tuscan Formation has been defined by Helley and Harwood (1985) as four separate but lithologically similar units, Units A, B, C, and D. Recent work by DWR Northern District has combined the units A,B,C, and D into the Upper Tuscan and Lower Tuscan formations. Tuscan Units A and B, in combination, make up the Lower Tuscan Formation which is about 850 feet thick.Tuscan Unit A consists of the oldest and deepest deposits of the Tuscan Formation and underlies Tuscan Unit B in most locations in Tehama County. The Lower Tuscan Formation is considered a water-bearing formation. The Lower Tuscan Formation is confined under pressure by the overlying, impermeable layers of Tuscan Unit C and D, which in combination are the Upper Tuscan Formation. The Upper Tuscan Formation overlies the Lower Tuscan Formation, and ranges from less than 100 feet thick in the eastern portion of Tehama County near the foothills to 600 feet thick under the Sacramento River. The Upper Tuscan Formation is less water-bearing in the east near the foothills, but thickens westward and becomes more water-bearing near of the Sacramento River.

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The Upper and Lower Tuscan Formations are a primary source of groundwater for deeper irrigation and domestic wells, however, the quantity of water available from these Formations varies by unit, location, and thickness. Fifty percent of the agricultural and municipal wells in Tehama County are deeper than 200 feet, some of which extract groundwater from either the Upper or Lower Tuscan Formations.

6.1.2 Surface Water Features and Sources of Groundwater Recharge

The surface waterways are important to groundwater recharge throughout Tehama County. Some of the principal waterways in the county that influence groundwater conditions include the Sacramento River, Antelope Creek, Battle Creek, Cottonwood Creek, Deer Creek, Dye Creek, Elder Creek, Mill Creek, Thomes Creek, Oak Creek, Paynes Creek, Pine Creek, Red Bank Creek, Reeds Creek, Salt Creek, and Thomes Creek . Stony Creek, in northeastern Glenn County, may also influence groundwater conditions in southern portions of Tehama County. A portion of the Sacramento River's flow is diverted in Shasta County for the Anderson Cottonwood Irrigation District's (ACID) canal. The ACID canal supplies surface water to areas in the Redding Groundwater Basin within Tehama County. The Sacramento River is also diverted at the Red Bluff Diversion Dam into the Tehama-Colusa Canal and the Corning Canal for irrigation in some areas of Tehama County as well as other Sacramento Valley counties to the south of Tehama County. Surface water flows in the county are extremely variable, both seasonally and annually. Their dependence on annual snowmelt contributes to this seasonal variability.

6.2 The Broader Sacramento Valley Groundwater Setting

The Tuscan and Tehama formations represent the major groundwater aquifer systems in Tehama County in terms of groundwater storage and capacity to meet current and future water needs of the county. Figures 6-3 and 6-4 show the aerial extent of Tuscan and Tehama aquifer systems, respectively. The figures point out that these groundwater aquifer systems extend well beyond the boundaries of Tehama County and are shared resources with Glenn, Butte, and Colusa Counties. As a result, coordinated planning and management of the resource among the four county area of Tehama, Butte, Glenn, and Colusa counties is important, and already underway as described in the following pages.

Use of contents on this sheet is subject to the limitations specified at the beginning of this document.

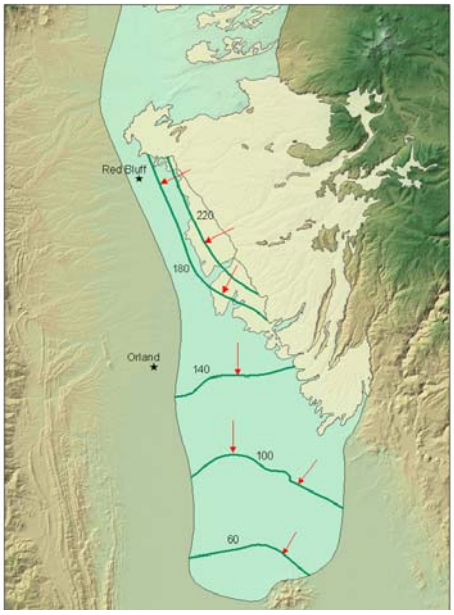

Figure 6-3. Aerial extent of the Upper and Lower Tuscan Formation aquifer systems. Light yellow areas show where they are exposed at the ground surface and the blue areas show where they are buried.

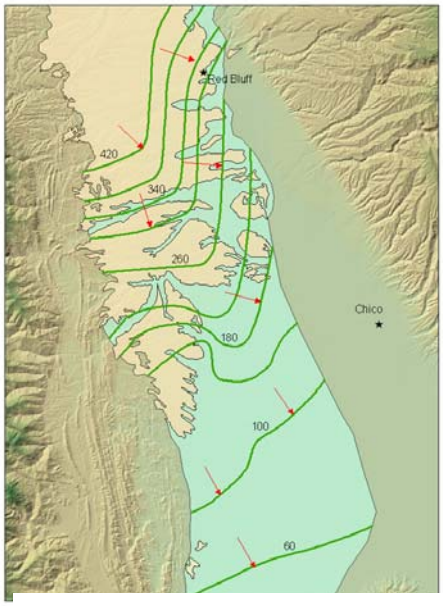

Figure 6-4. Aerial extent of the Tehama Formation aquifer system. Light yellow areas show where it is exposed at the ground surface and the blue areas show where it is buried.

The District is collaborating on a number of regional efforts that reflect areas of common interest as described below, including:

- Four County Memorandum of Understanding (MOU)
- Multi-Party MOU including northern Sacramento Valley counties, various water districts, and other water users
- Sacramento Valley Integrated Regional Water Management Plan (SVIRWMP)
- Butte and Glenn County BMO efforts
- Shasta County Water Agency

Four County MOU/Multi-Party MOU: Tehama County has entered into two MOUs with adjacent counties and agencies. The Four County MOU and the Multi-agency MOU focus on cooperation, collaboration and data sharing amongst participating agencies. The impetus to develop the MOUs was the recognition that the Sacramento Valley groundwater basin encompasses multiple counties and agencies and that local groundwater management decisions should consider both the local and regional setting. MOU participants expect these efforts to improve the current understanding of the regional aquifer and result in groundwater management activities that meet local needs while minimizing the potential for impact to others.

Sacramento Valley Integrated Regional Water Management Plan (SVIRWMP): The SVIRWMP represents a regional approach to integrated water resource management, detailing the current status and priorities for water management strategies, including groundwater management. Tehama County is signatory to the

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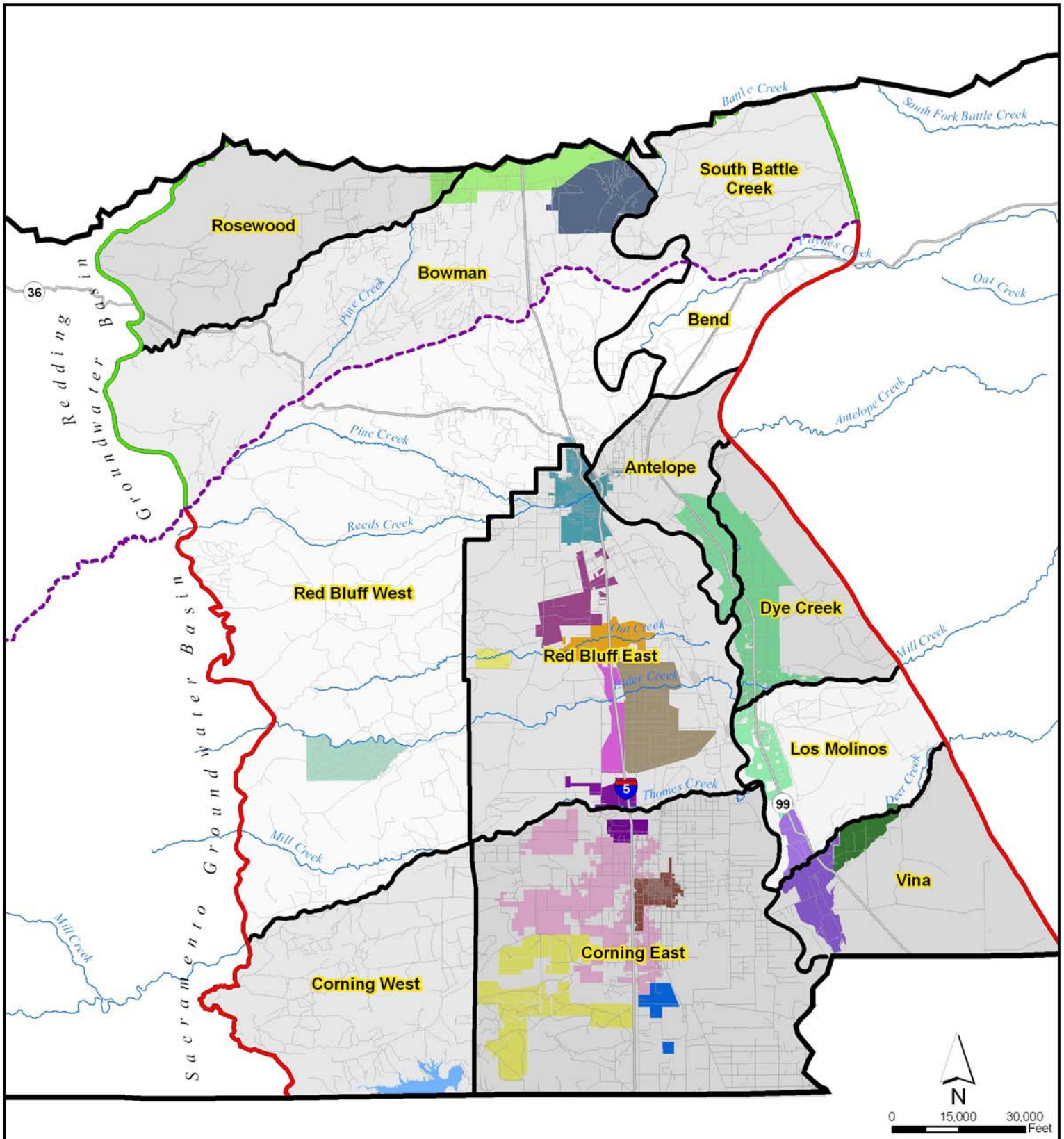
SVIRWMP. Section 6.2 of the SVIRWMP provides detailed information on Tehama County and reflects the County's priority of proactive groundwater management.

Butte, Glenn, Colusa County BMO Efforts: The neighboring counties of Butte and Glenn have already developed Basin Management Objectives (BMO's) and adaptive management actions, which are similar to Tehama County's trigger levels and awareness actions. Tehama County has strived to learn from the efforts to develop BMO's in Glenn and Butte Counties. The trigger level development process is reflective of knowledge gained during those efforts. Tehama County's trigger level development process is unique from the BMO development process of Butte and Glenn County, reflecting the priorities, conditions, and needs of Tehama County residents. Trigger levels strive to meet those needs, while recognizing the activities of adjacent counties and where possible, gaining consistency in management objectives along county borders. Colusa county is presently in the process of developing a coordinated groundwater management plan , which will also include BMO's. Their groundwater management plan is likely to be adopted into county planning code sometime in 2008.

Shasta County Water Agency: The Shasta County Water Agency prepared an AB-3030 Groundwater Management Plan in 1998 and since then has completed the second phase of a Redding Basin Water Management Plan. This plan will serve as the basis for coordinated use and development of water resources through the year 2030. The Tehama County Flood Control and Water Conservation District (District) communicates and works with the Shasta County Water Agency, since the northern portion of Tehama County overlies the Redding Groundwater Basin.

Use of contents on this sheet is subject to the limitations specified at the beginning of this document.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	3-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

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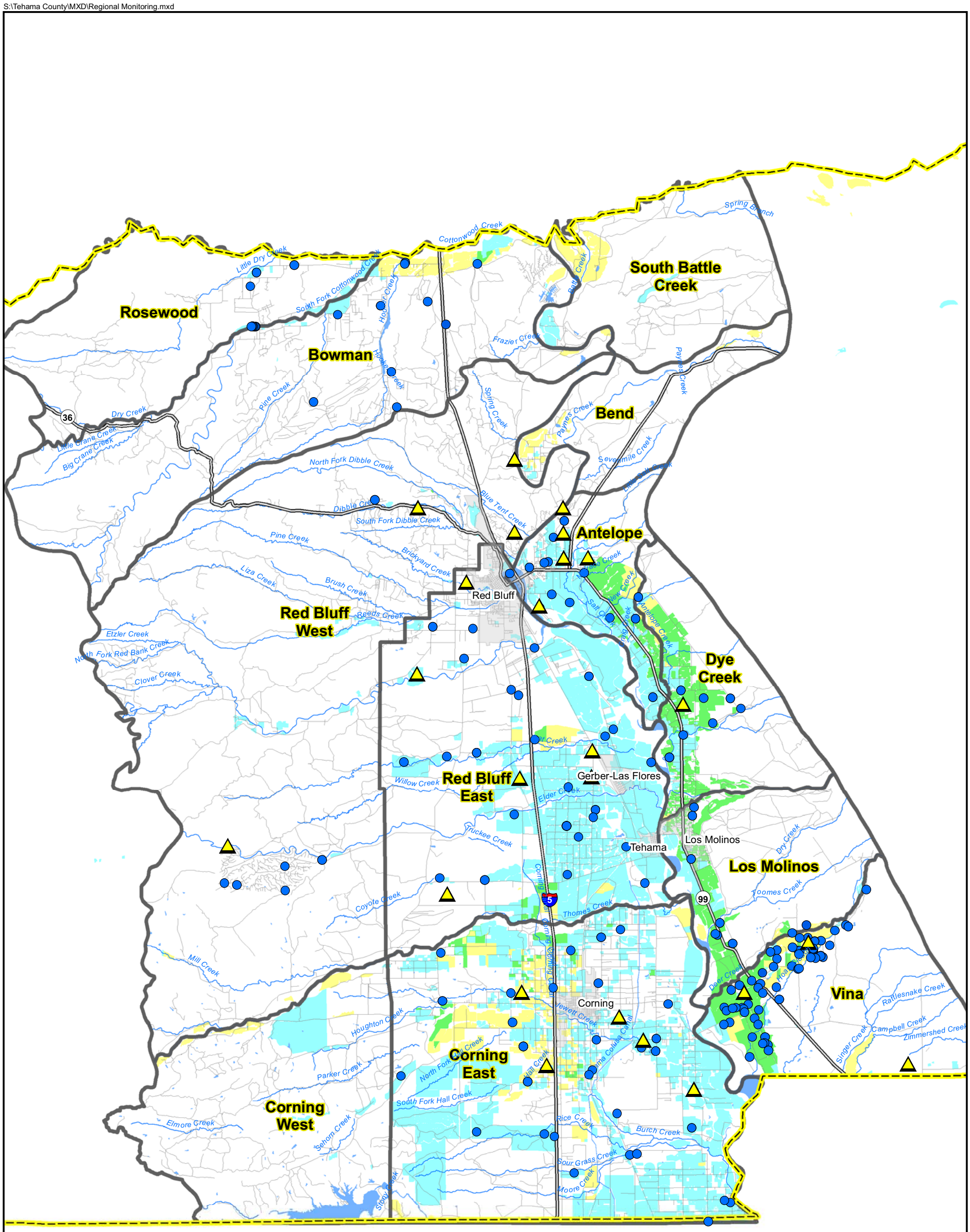


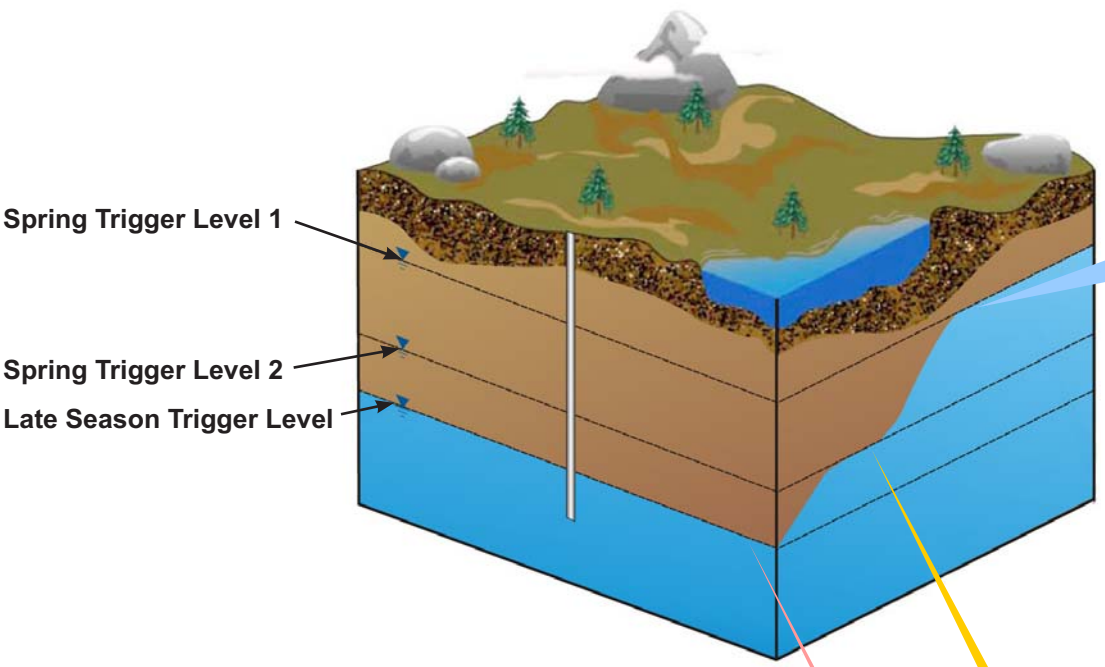
Legend

- Water Quality Monitoring Well
- Water Level Monitoring Well
- County Boundaries
- Inventory Units
- Lakes
- Cities

Water Sources

- Surface Water Source
- Mixed Water Source
- Ground Water Source

SITE	Tehama County, California
TITLE	Monitoring Grid
BROWN AND CALDWELL	
PROJECT	131107
DATE	9/12/07
Figure	3-2



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

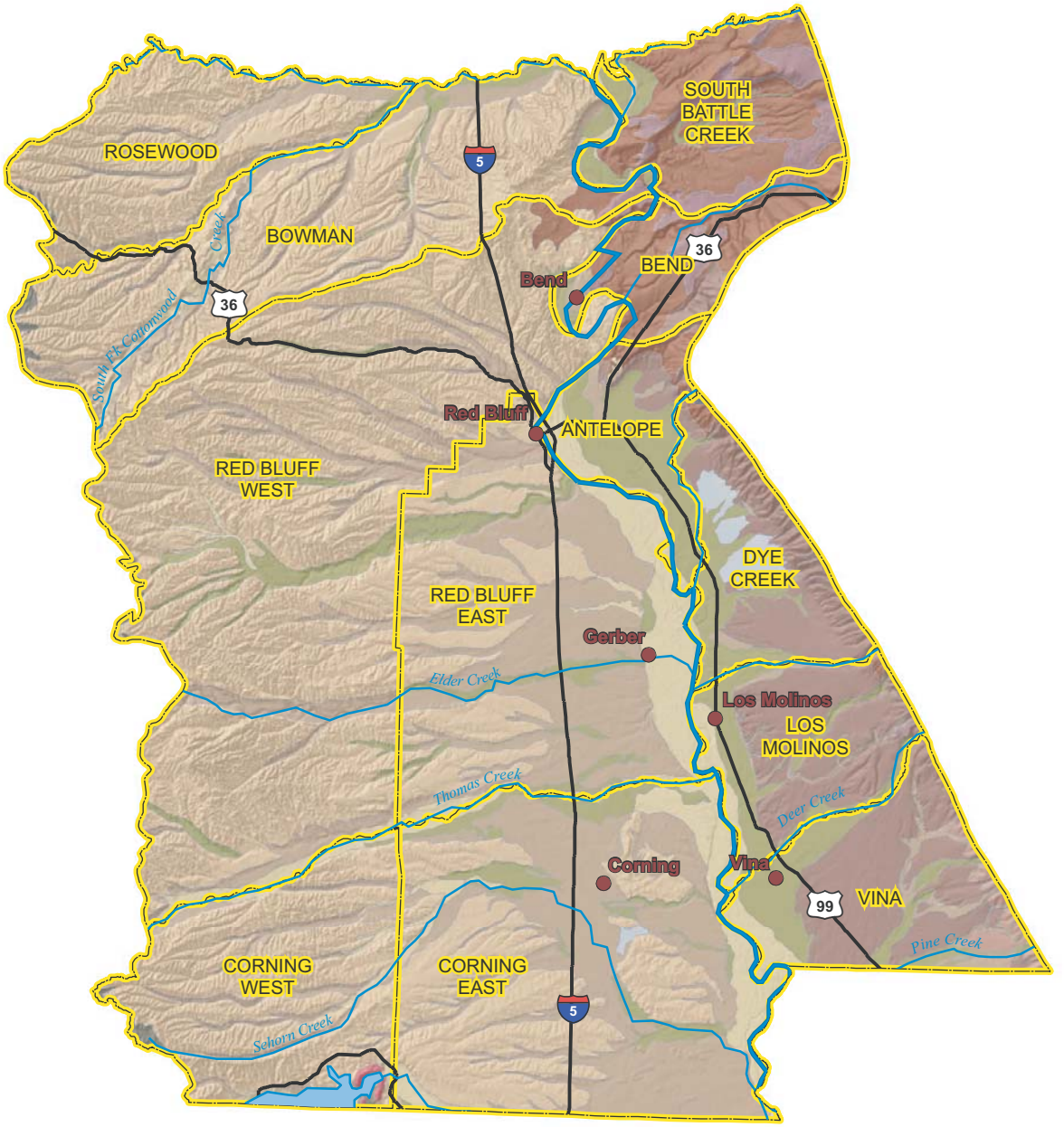
- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 3-4
Trigger Levels and Awareness Actions



Legend

- Great Valley Sequence
- Alluvium
- Basin Deposits
- Modesto Formation
- Riverbank Formation
- Volcanic Basalts
- Lovejoy Basalts
- Tuscan Unit A
- Tuscan Unit B
- Tuscan Unit C
- Tuscan Unit D
- Tehama Formation

NORTH

5 0 5
MILES

Source: CDM, Department of Water Resources, Northern District

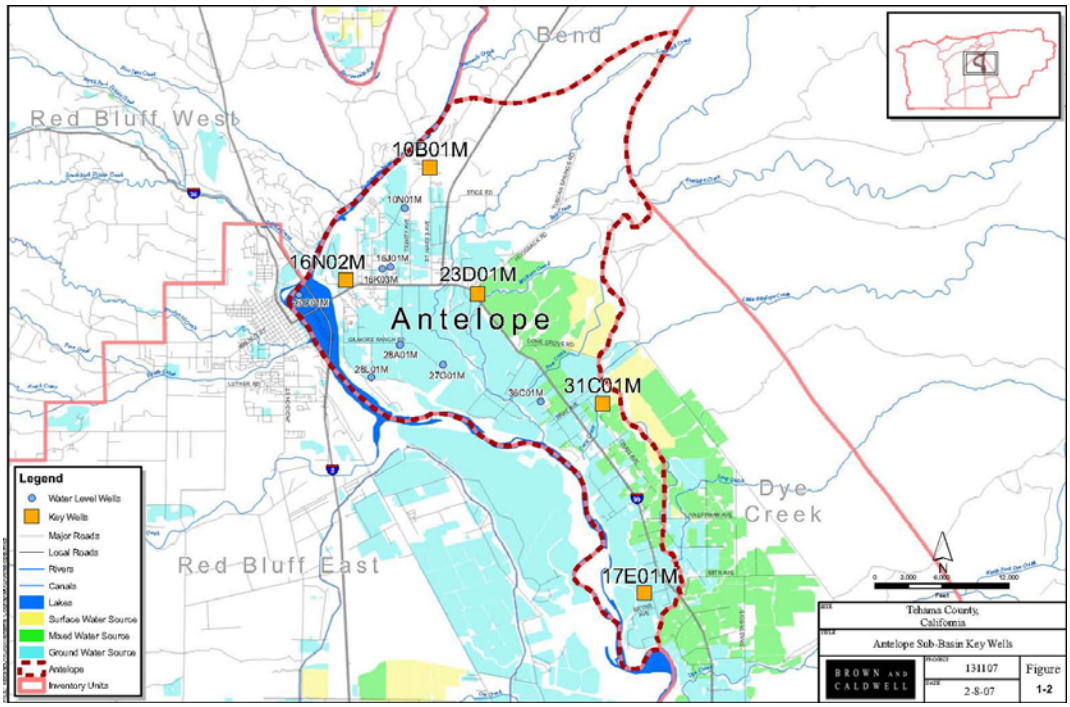
BROWN AND CALDWELL	PROJECT 132214-002	SITE Tehama County	Figure 6-1
	DATE 9-12-07	TITLE Geologic Map	

P:\31000\131107 - CDM-Tehama BMO\!!New Phase\Regional Background Document\Figures

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Antelope Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Antelope Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

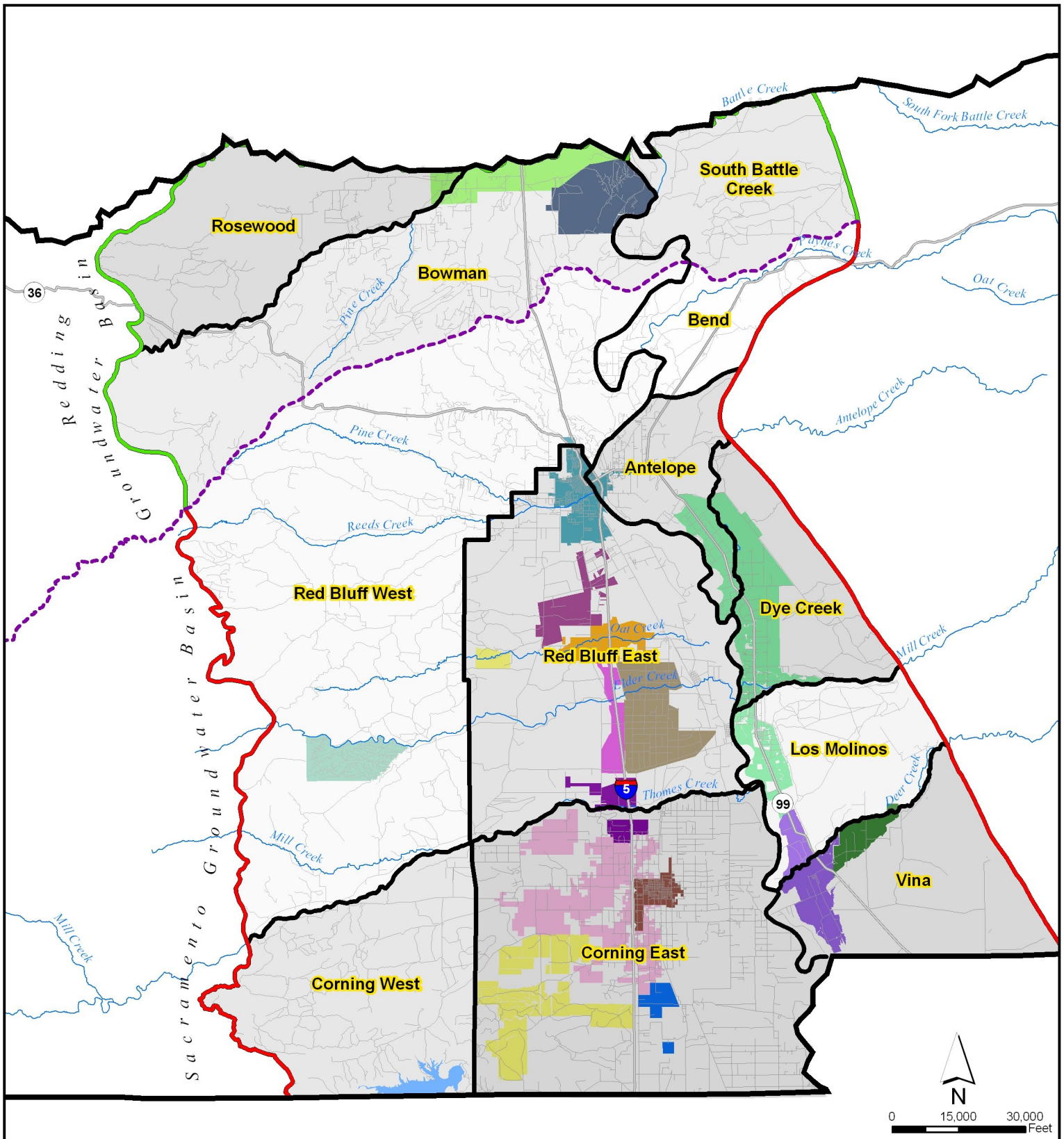
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Antelope sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to three decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Antelope sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
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- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

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1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Antelope sub-basin is primarily a rural area, with agriculture throughout the area and with a portion of Red Bluff in the western portion of the area. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. Groundwater is used for agricultural, municipal, and domestic purposes. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Antelope:	
Irrigation:	88% (15,800 acre-ft)
Municipal, and Industrial:	12% (2,200 acre-ft)
Number of wells by type in Antelope:	
Irrigation:	112 wells
Domestic:	770 wells
Municipal and Industrial:	11 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin

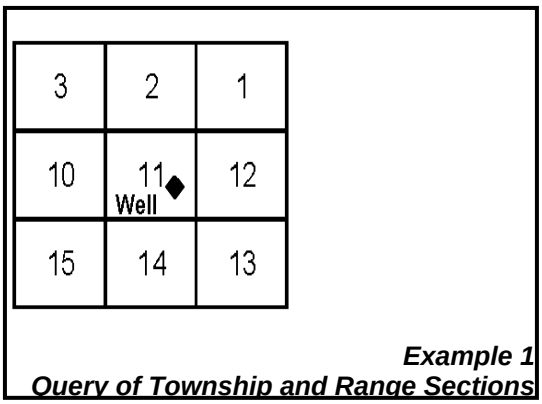
Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods

of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

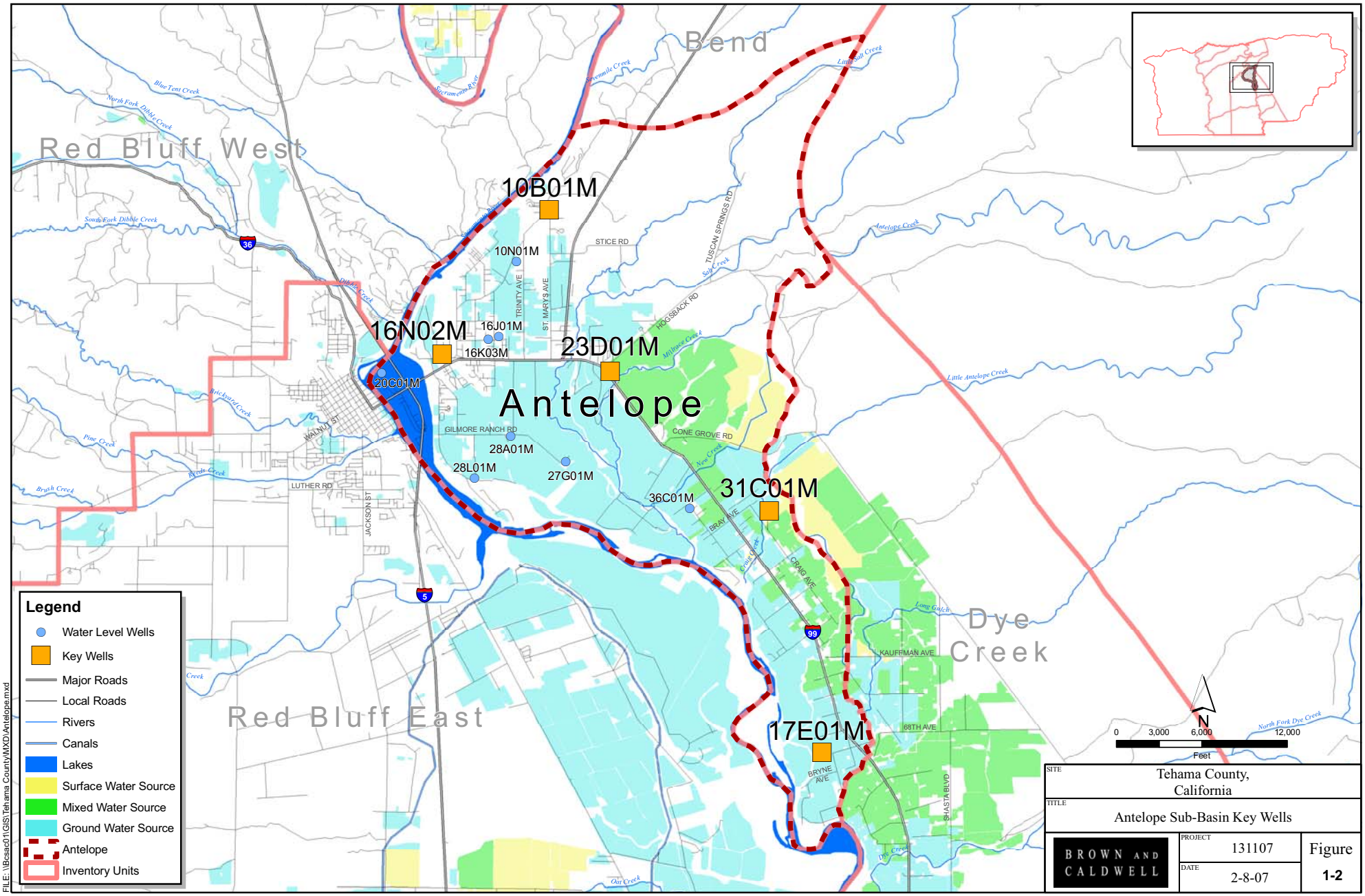
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of five proposed key wells are presented in Figure 1-2. Each of these proposed wells have a period of record of more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **27N03W10B01M (10B01M) –** This monitoring well is in the northern portion of the sub-basin and is 92 feet deep with a screened interval from 80 to 92 feet below ground surface (bgs). This well is situated near urban land use, native vegetation, and orchards and pasture irrigated with groundwater. The nine square miles near this well contain 520 domestic wells with an average depth of 114 feet bgs, and 29 irrigation wells with an average depth of 225 feet bgs.
- **27N03W16N02M (16N02M) –** This monitoring well is in the northwest portion of the sub-basin and is 126 feet deep with a screened interval from 118 to 126 feet bgs. This well is situated near urban land use and hay crops irrigated with groundwater. The nine square miles near this well contain 614 domestic wells with an average depth of 128 feet bgs, and 39 irrigation wells with an average depth of 210 feet bgs.
- **27N03W23D01M (23D01M) –** This monitoring well is in the central portion of the sub-basin and is 250 feet deep with a screened interval from 30 to 250 feet bgs. This well is situated near orchards irrigated with groundwater to the west, and orchards irrigated with both surface and groundwater to the east. The nine square miles near this well contain 212 domestic wells with an average depth of 96 feet bgs, and 30 irrigation wells with an average depth of 215 feet bgs.
- **27N02W31C01M (31C01M) –** This monitoring well is in the east portion of the sub-basin and is 540 feet deep with a screened interval from 289 feet to 500 feet bgs. This well is situated near orchards and pasture irrigated with both surface water and groundwater. The nine square miles near this well contain 151 domestic wells with an average depth of 88 feet bgs, and 38 irrigation wells with an average depth of 167 feet bgs.
- **26N02W17E01M (17E01M) –** This monitoring well is in the southern portion of the sub-basin and is 152 feet deep with a screened interval from 55 to 145 feet bgs. This well is situated near orchards that are irrigated with groundwater. The nine square miles near this well contain 126



SITE	Tehama County, California
TITLE	Antelope Sub-Basin Key Wells
BROWN AND CALDWELL	PROJECT 131107
	DATE 2-8-07
	Figure 1-2

domestic wells with an average depth of 82 feet bgs, and 44 irrigation wells with an average depth of 125 feet bgs.

There are currently no monitoring wells in the northeastern corner of the Antelope sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

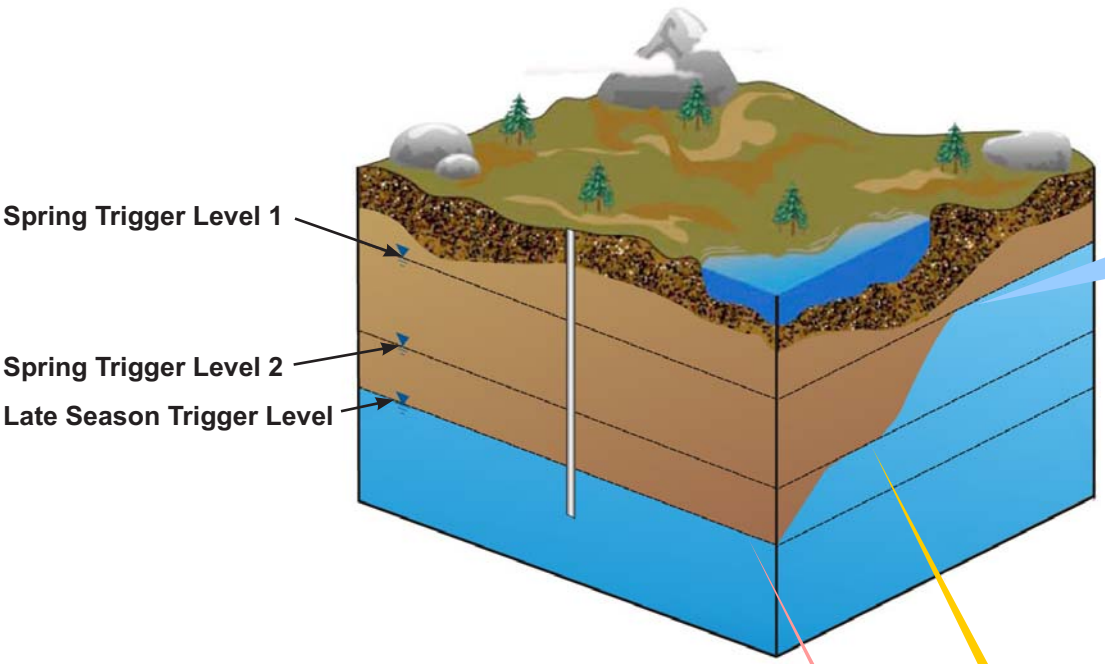
The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows two suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-18 present hydrographs and suggested trigger levels for each of the five Antelope key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water below ground surface in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Antelope sub-basin are provided in Table 1-1.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Antelope Monitoring Well Number				
	10B01M	16N02M	23D01M	31C01M	17E01M
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements				
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements				
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	None	None	None	None	None

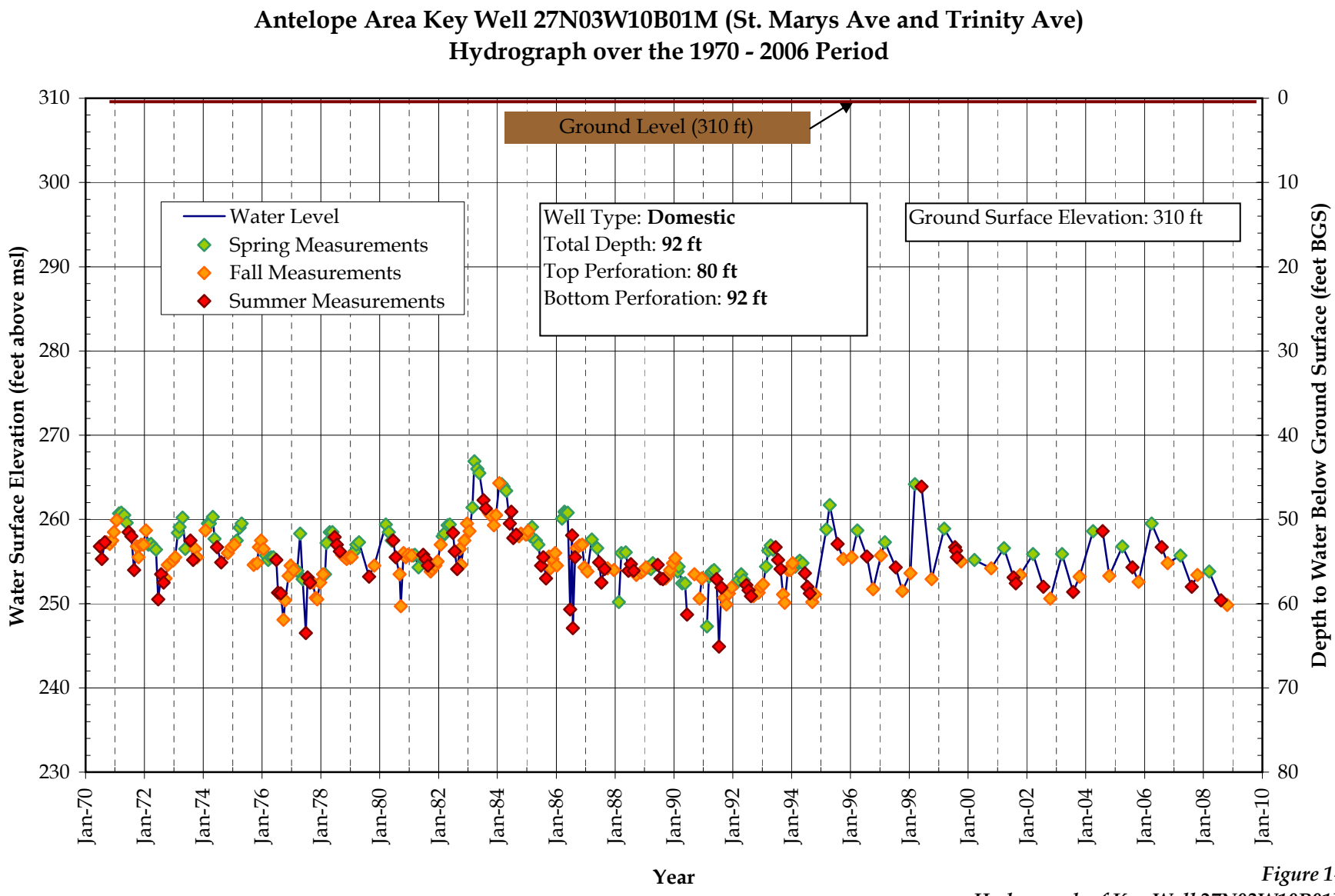


Figure 1-4
Hydrograph of Key Well 27N03W10B01M

Updated 12-01-08

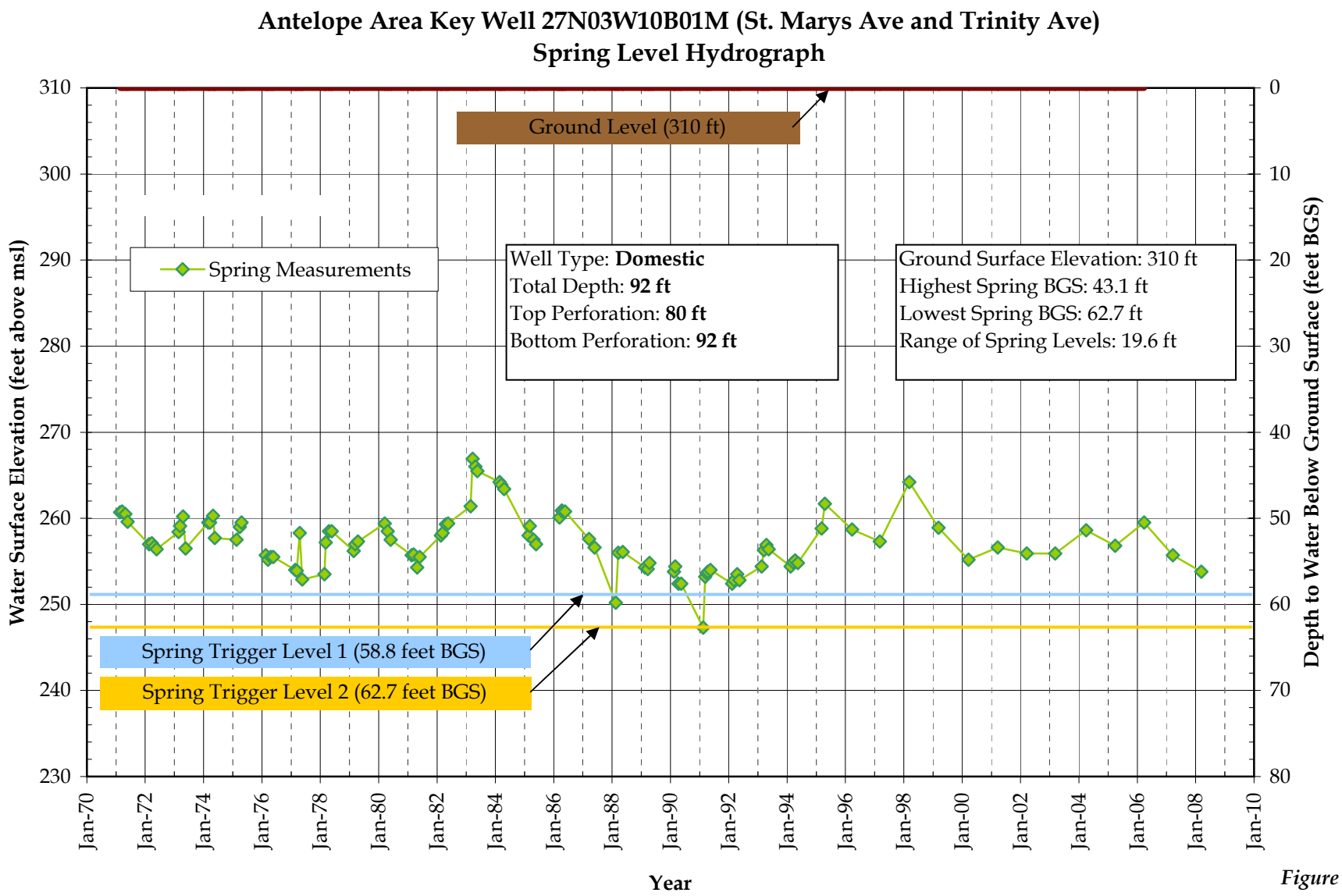


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

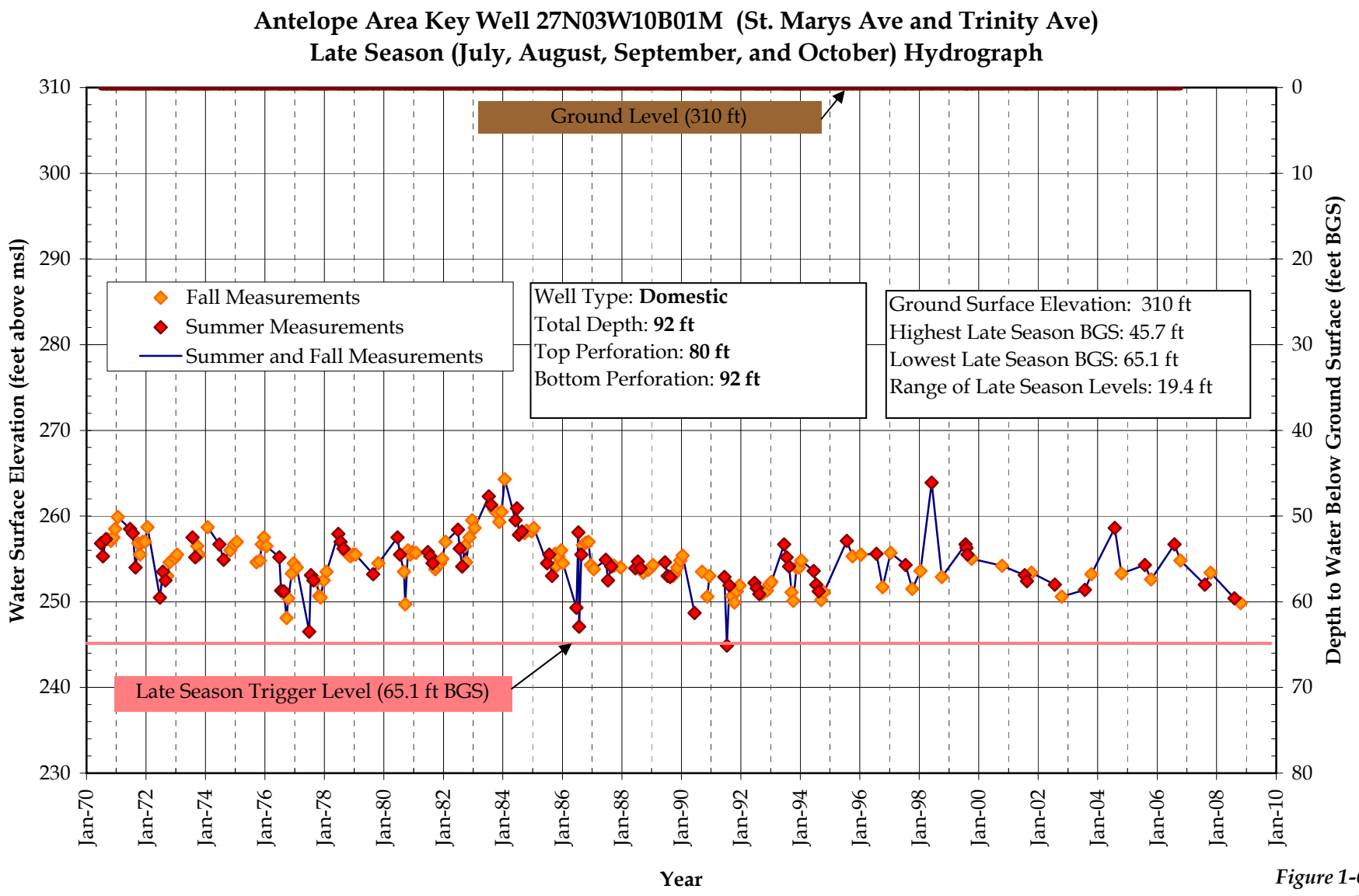


Figure 1-6
Late Season Trigger Levels

Updated 12-01-08

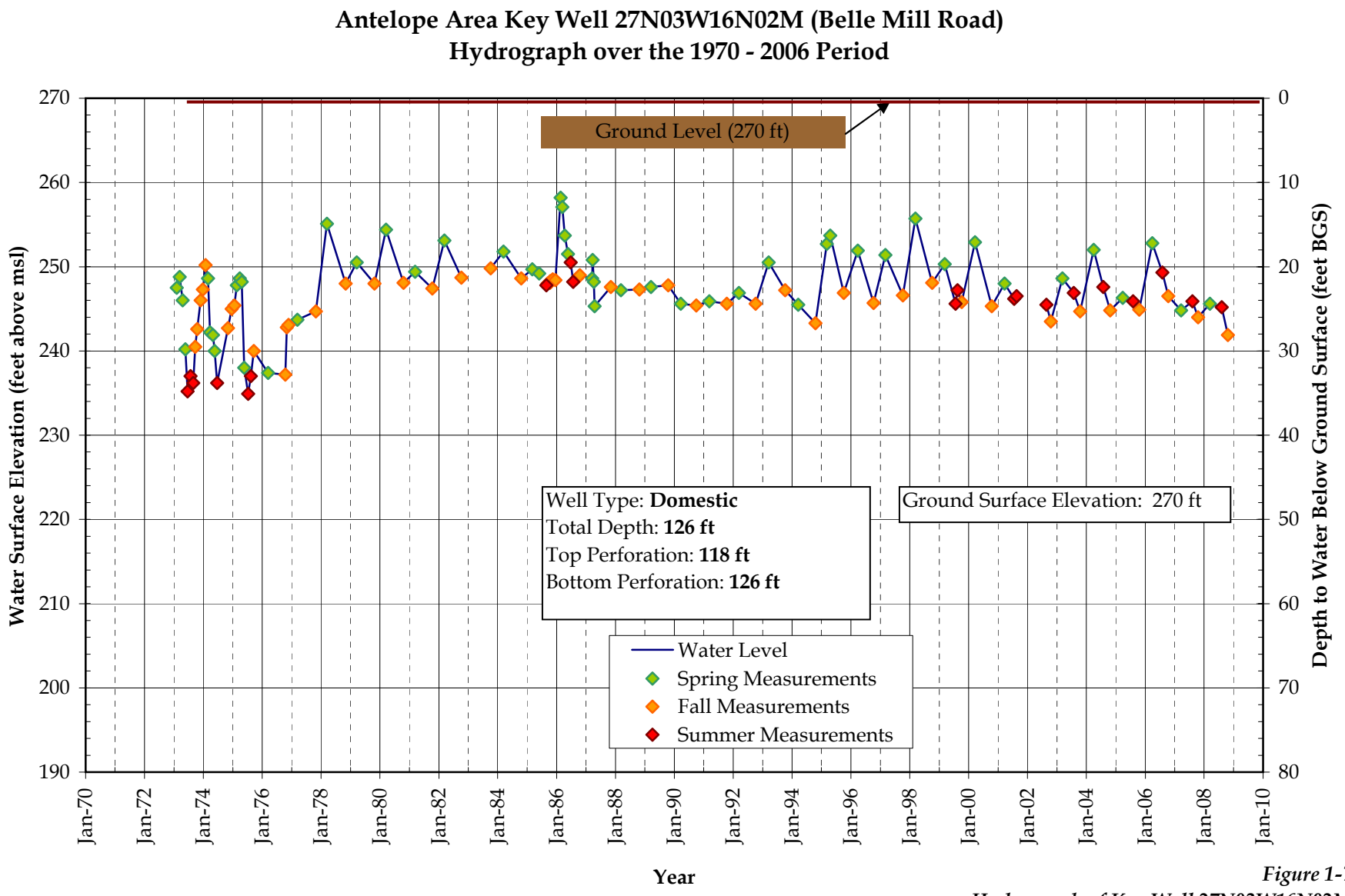


Figure 1-7
Hydrograph of Key Well 27N03W16N02M

Updated 12-01-08

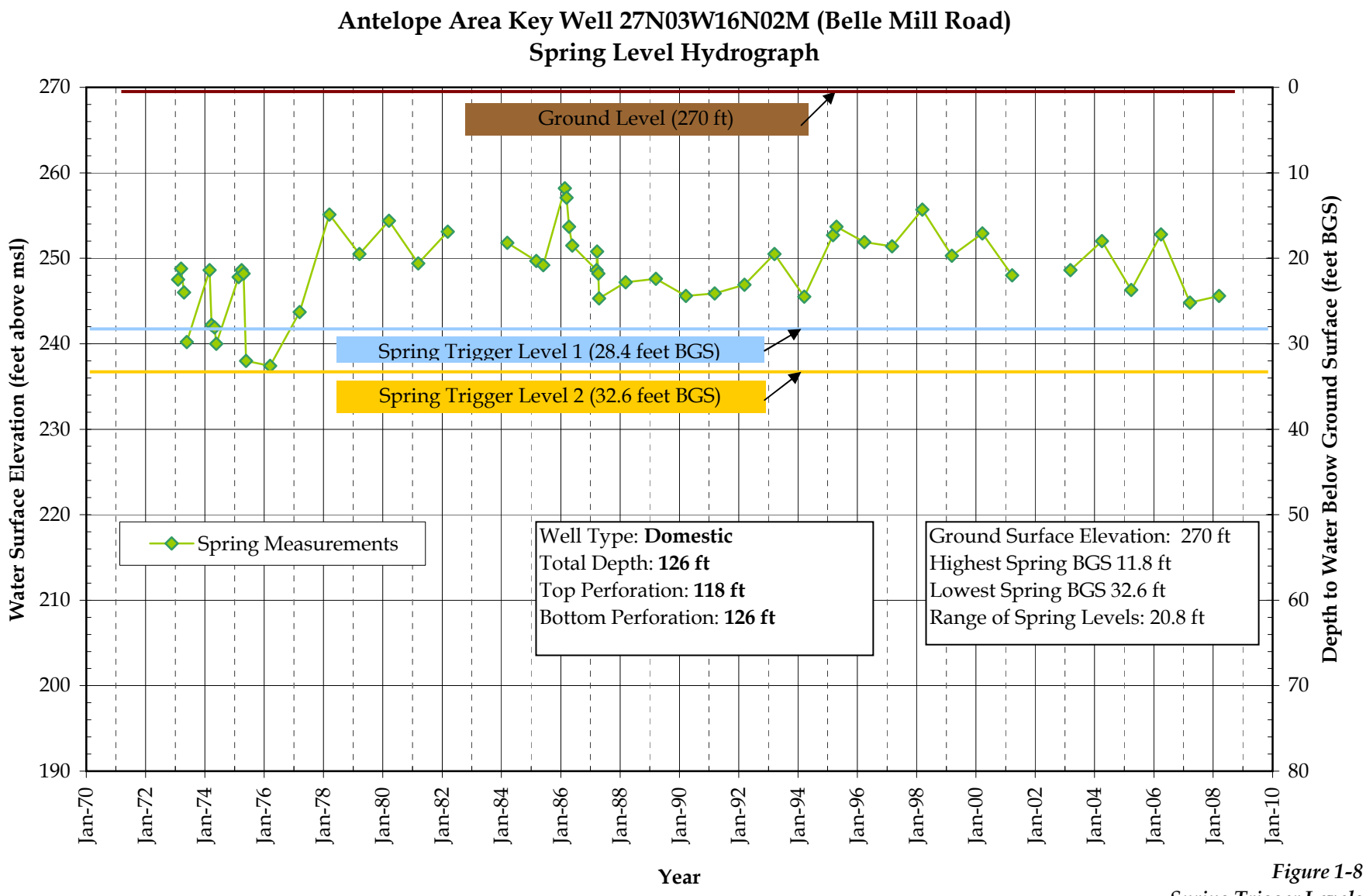


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

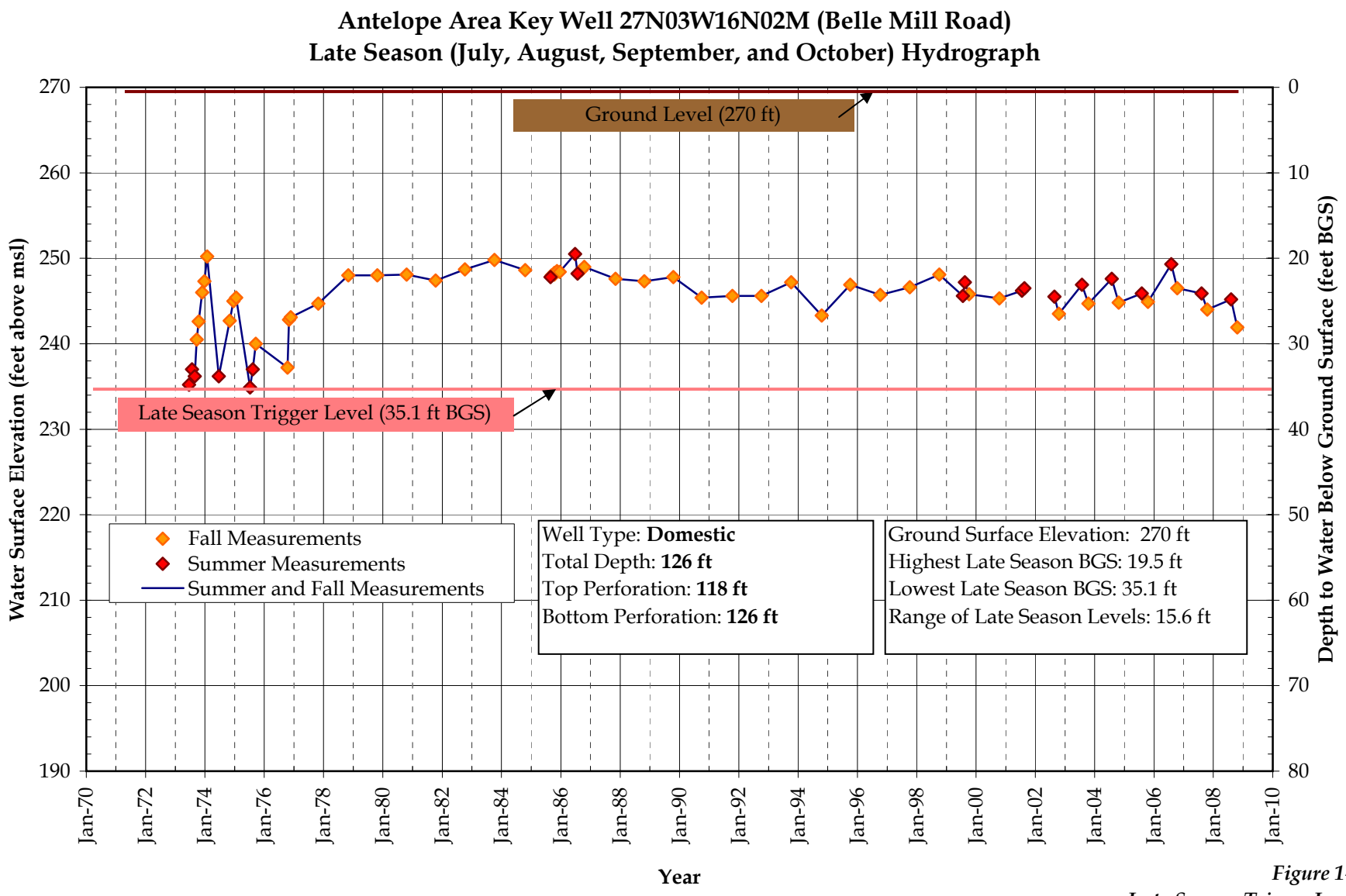


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

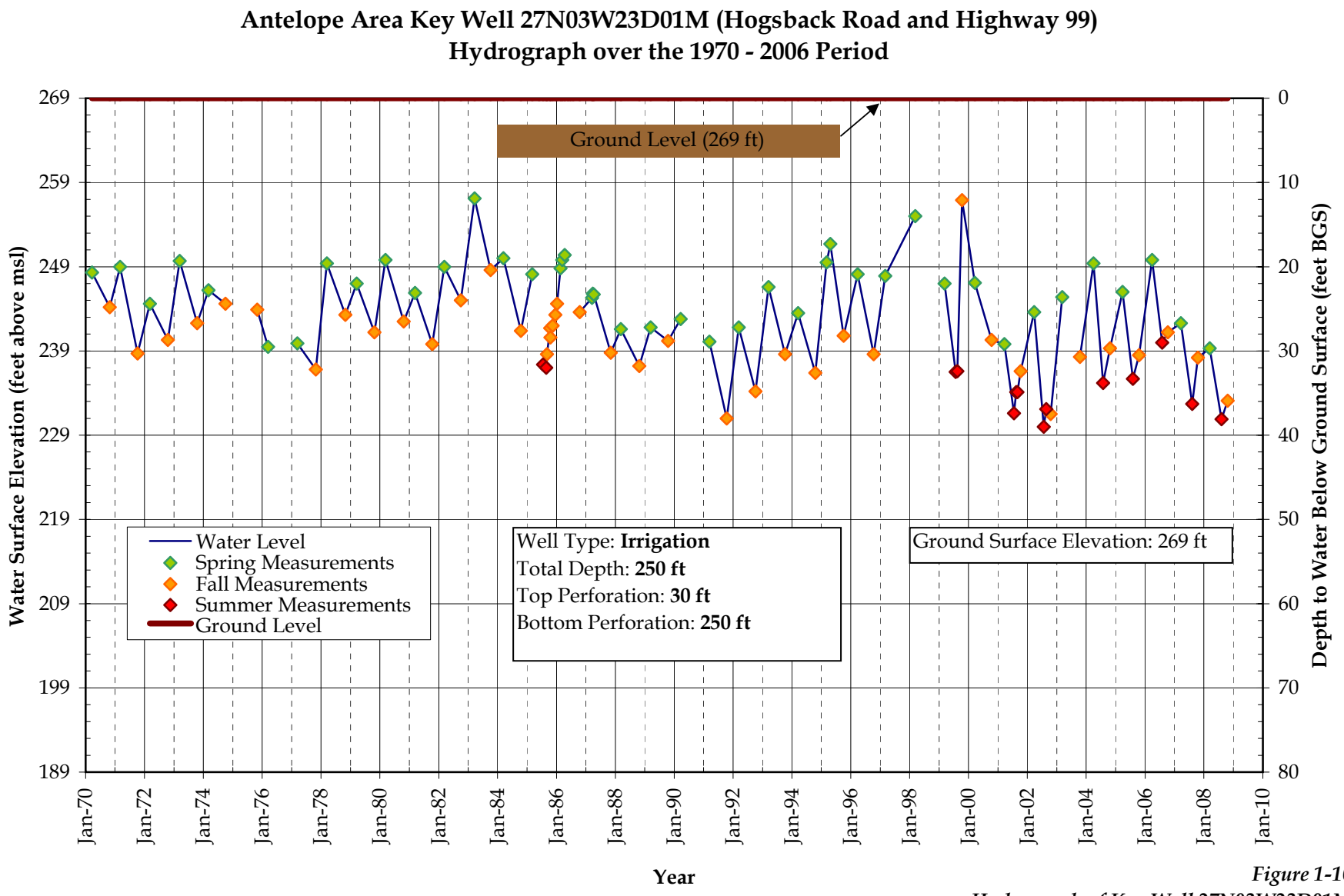


Figure 1-10
Hydrograph of Key Well 27N03W23D01M

Updated 12-01-08

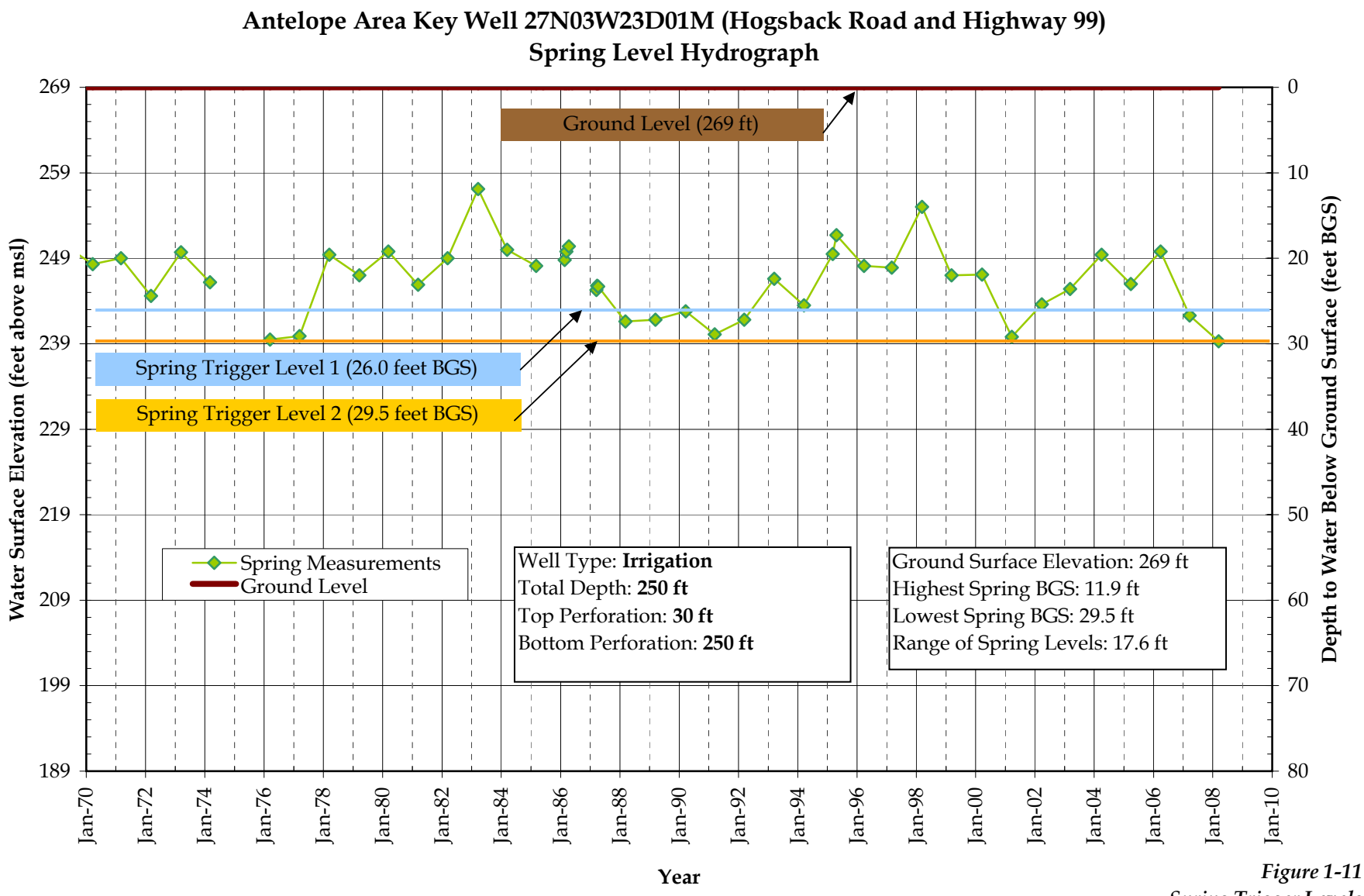


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

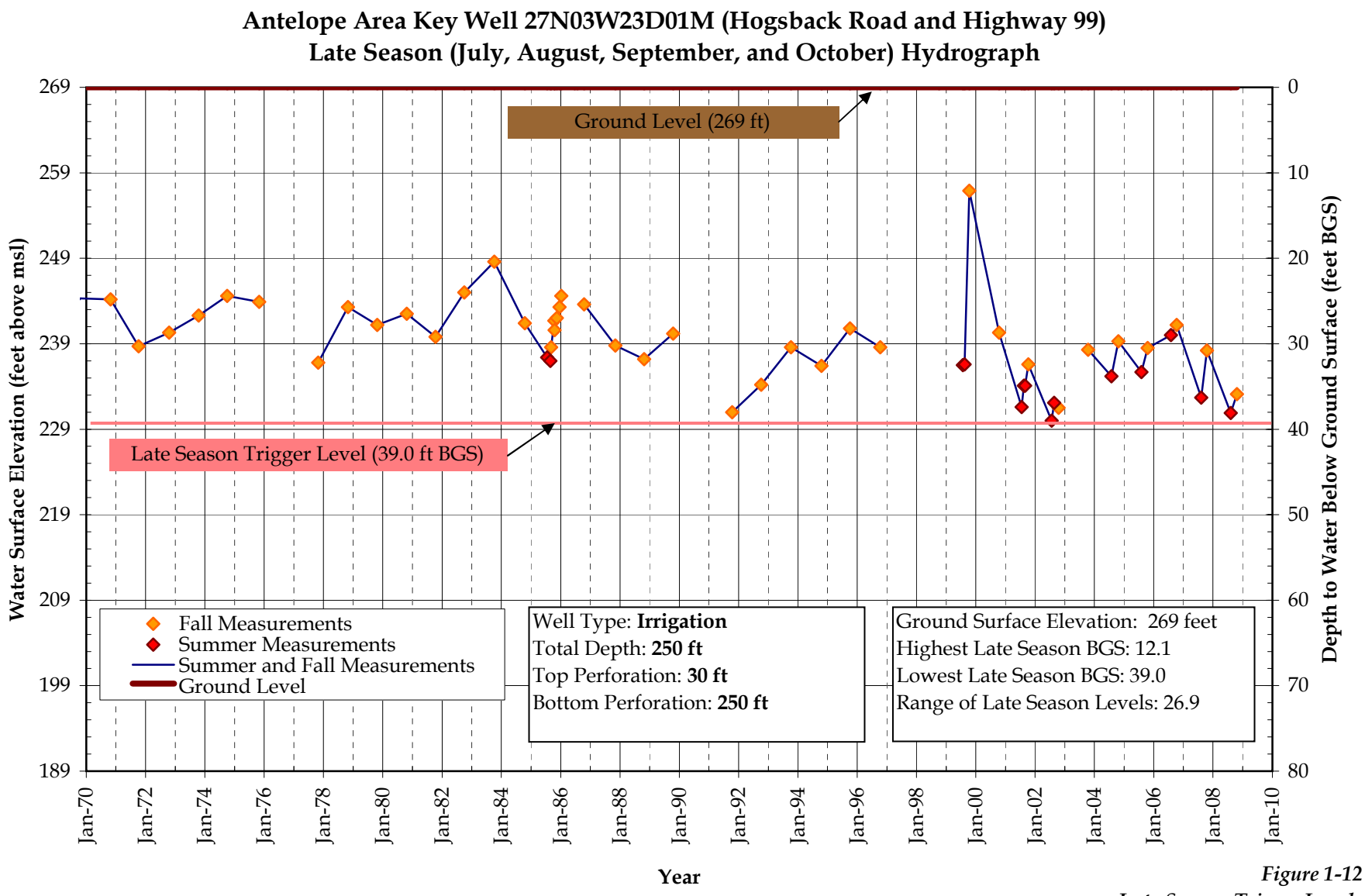


Figure 1-12
Late Season Trigger Levels

Updated 12-01-08

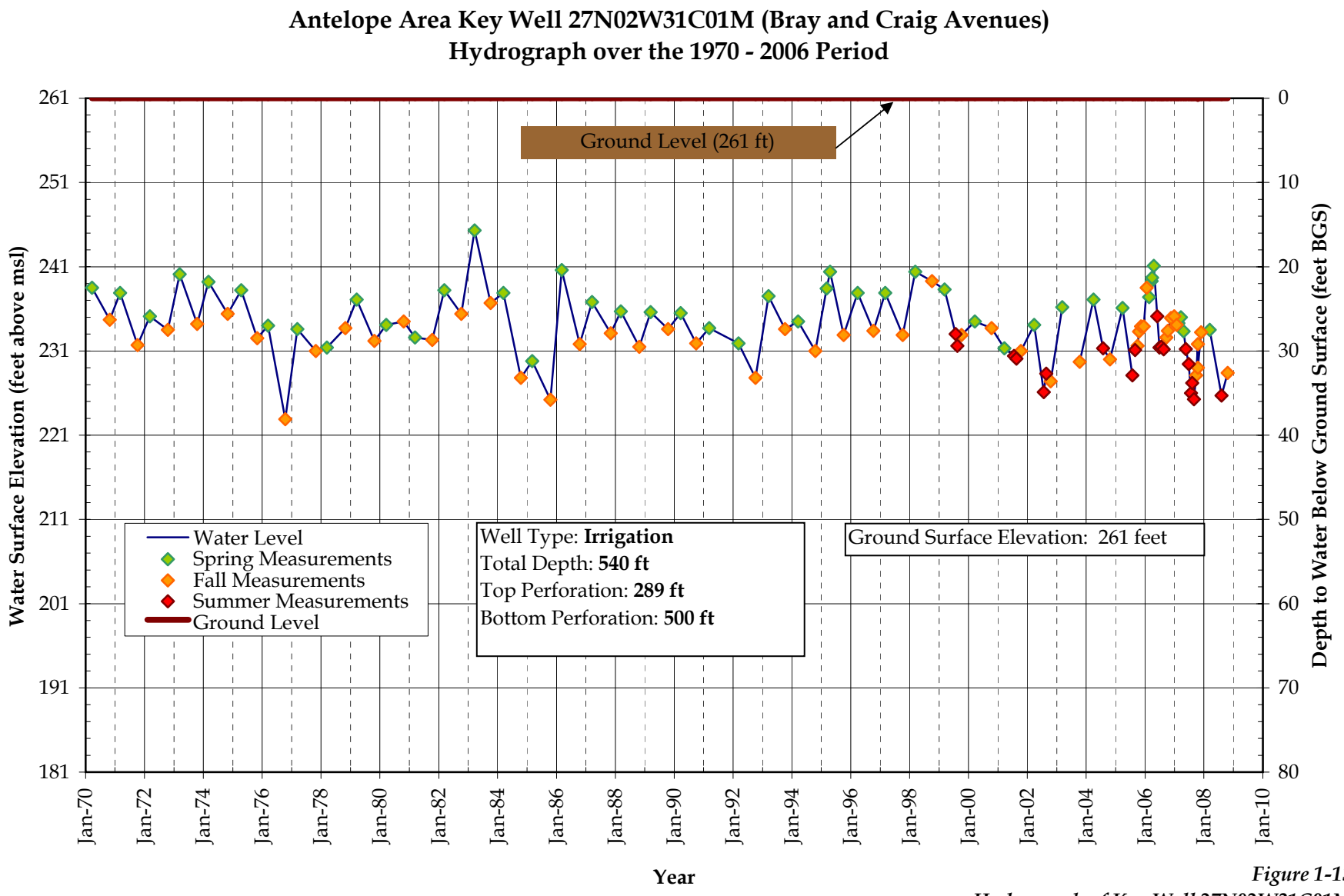


Figure 1-13
Hydrograph of Key Well 27N02W31C01M

Updated 12-01-08

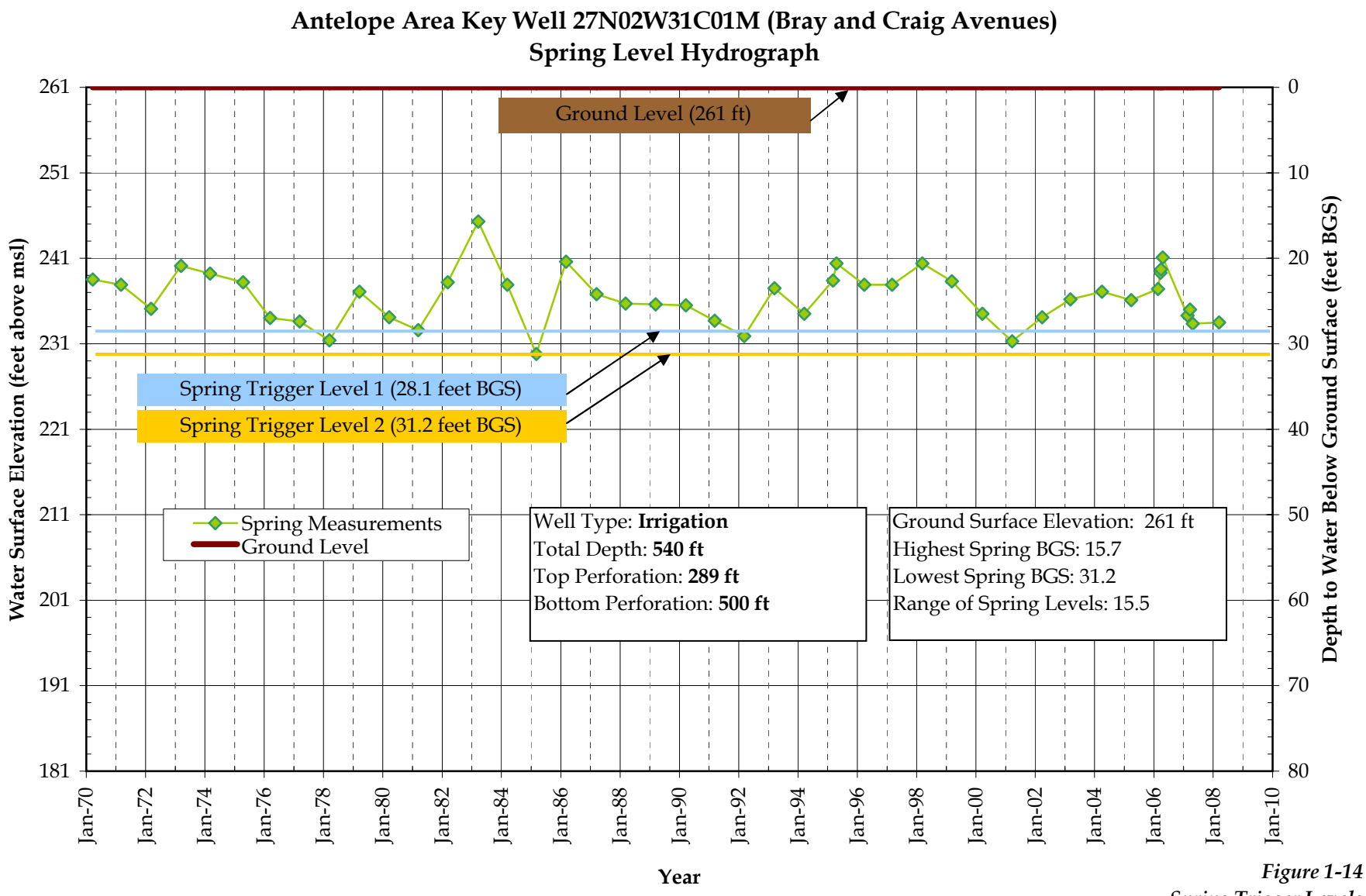


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

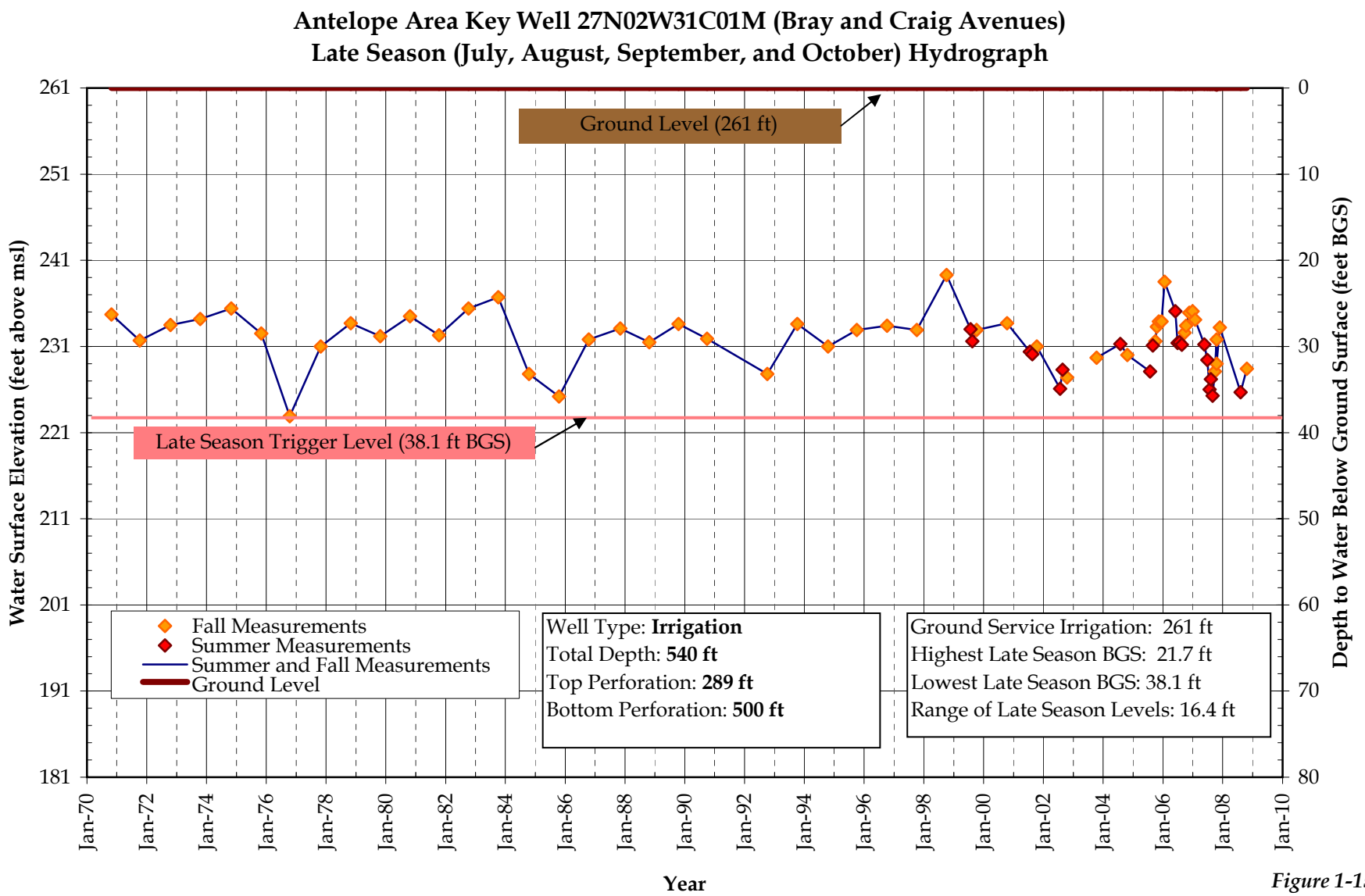


Figure 1-15
Late Season Awareness Stage

Updated 12-01-08

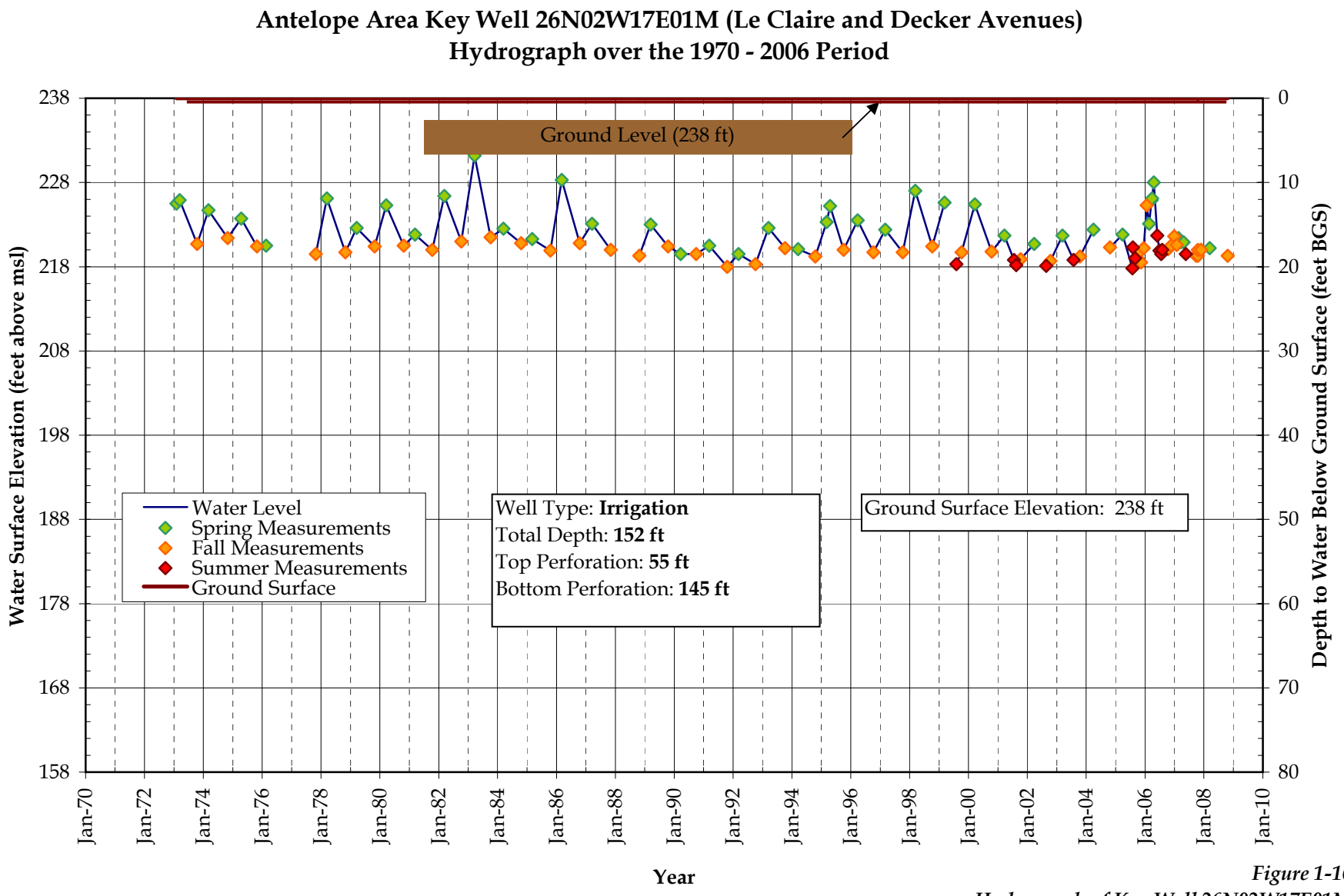


Figure 1-16
Hydrograph of Key Well 26N02W17E01M

Updated 12-01-08

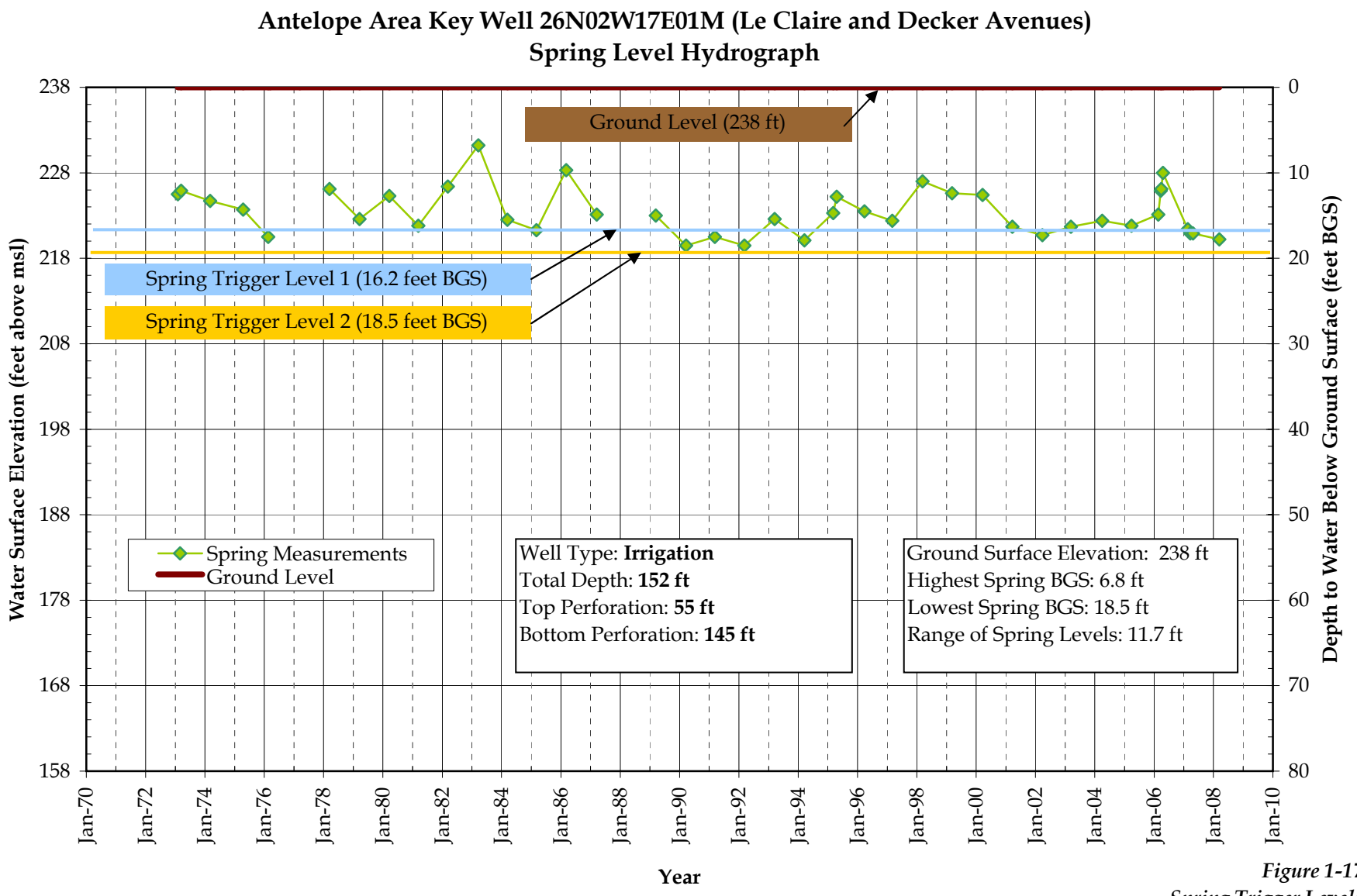


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

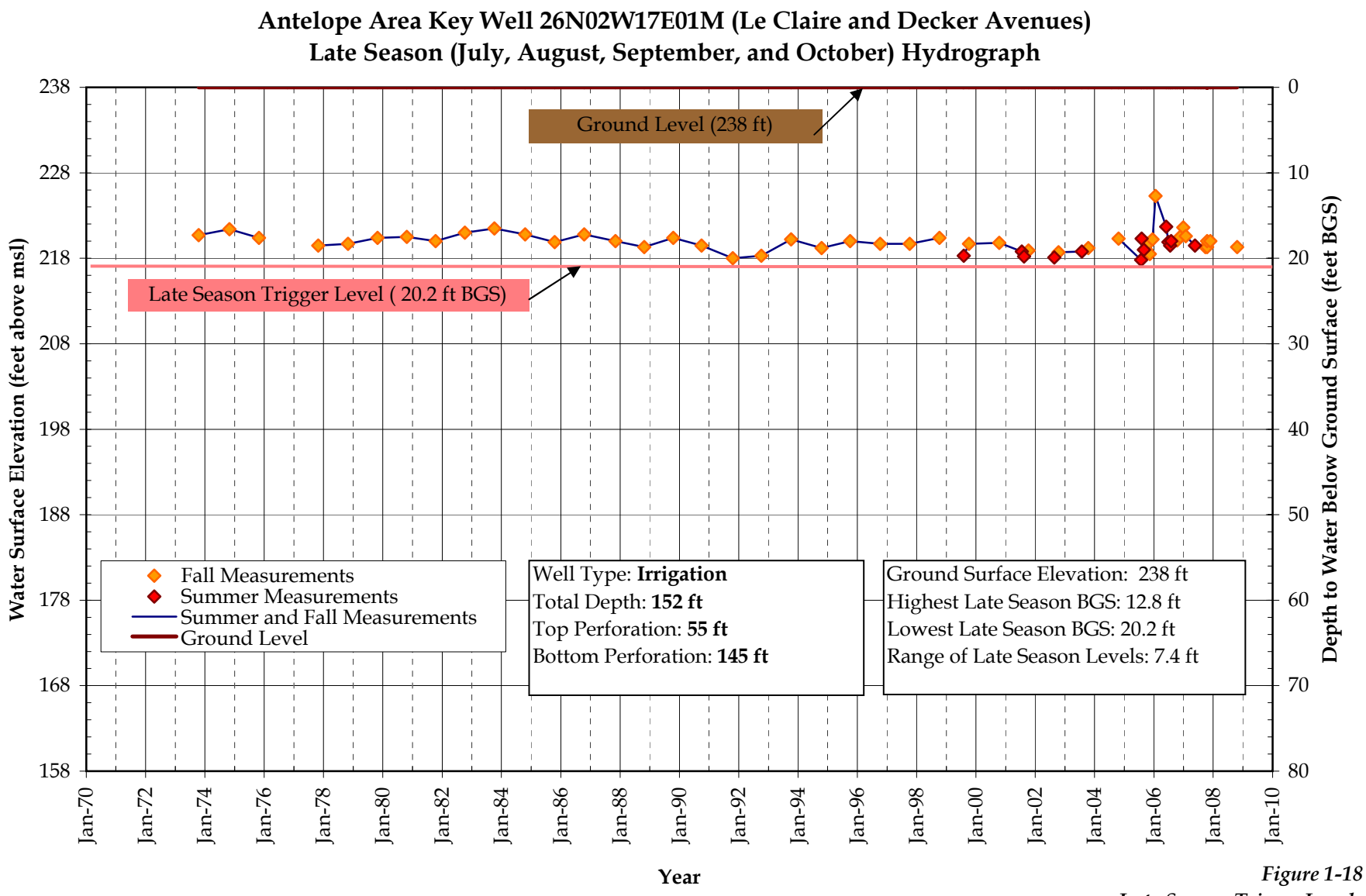


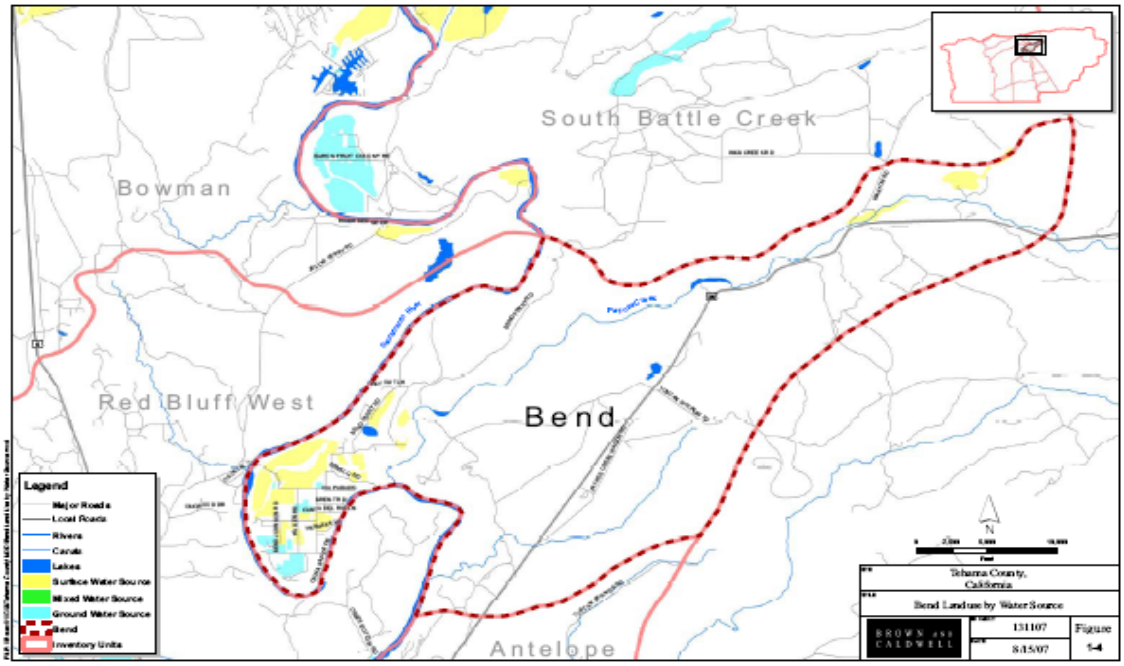
Figure 1-18
Late Season Trigger Levels

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Bend Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

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BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Bend Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

INTRODUCTION

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. Trigger Levels are developed through a five step process as described in Section 1. Bend does not have monitoring wells, and instead of developing trigger levels, will determine priority areas for future monitoring as described in Section 2.

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan incorporated citizen input, review, and approval over a period of three years, Final adoption by the Tehama County FCWCD was achieved in 1998.

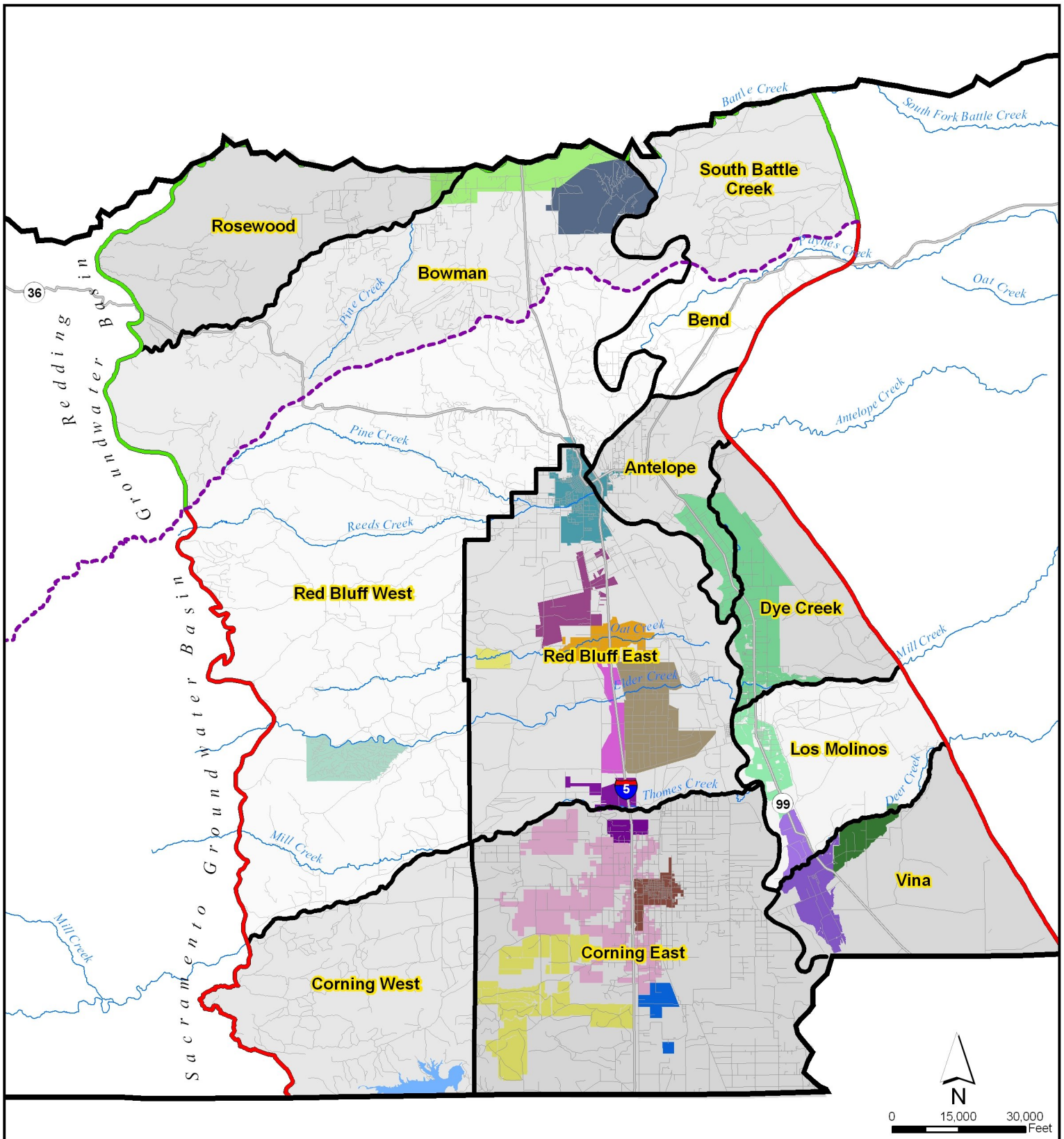
The Plan states that one of the District's functions under the Plan is to provide guidance in the development of groundwater trigger levels. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various trigger levels of increased groundwater discussion, investigation or local management actions.

Sections 325 through 329 of the Plan describe the trigger level concept and detail the District's role in trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Bend sub-basin. Since its inception, the Plan has provided guidance related to groundwater activities. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. Section 1 of this TM describes the methodology used to develop trigger levels.

Because the Bend Sub-Basin does not have formal groundwater monitoring, such as a dedicated monitoring well or wells included in the Department of Water Resources (DWR) monitoring grid, Section 2 of this TM identifies potential areas for new groundwater monitoring within the Bend Sub-Basin.

Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ . Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in each sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1. Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process, listed below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose.

The trigger level's purpose describes the intent of the trigger levels in the area. The purpose may reflect the desire of sub-basin planners to protect historic groundwater uses, minimize long-term drawdown of groundwater levels, maintain springs and habitat, and/or protect groundwater supplies for domestic and irrigation uses.

Step 2: Select one or more key wells within the sub-basin.

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to initiate management activities. If no monitoring wells are available in a sub-basin, such as Bend, then locations for new monitoring wells should be selected.

When selecting new areas for monitoring, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Groundwater levels are more likely to be stressed in areas of active land use. Areas with fixed water demand from crops such as orchards should be higher priority areas for monitoring.

Water Source: Groundwater supplies in areas irrigated with groundwater are more likely to be stressed during drought periods. Locating monitoring wells in areas reliant on groundwater would provide useful information for groundwater management, and should be higher priority areas for monitoring.

Existing Well Infrastructure: Well drilling records should be considered. The screened intervals of monitoring wells should be similar to the average screened interval of production wells in the area.

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well.

Once monitoring wells have been located and developed in an area, the remaining three trigger level steps can take place.

Step 3: Designate the time of seasonal measurement.

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the pumping impacts within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use that can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level.

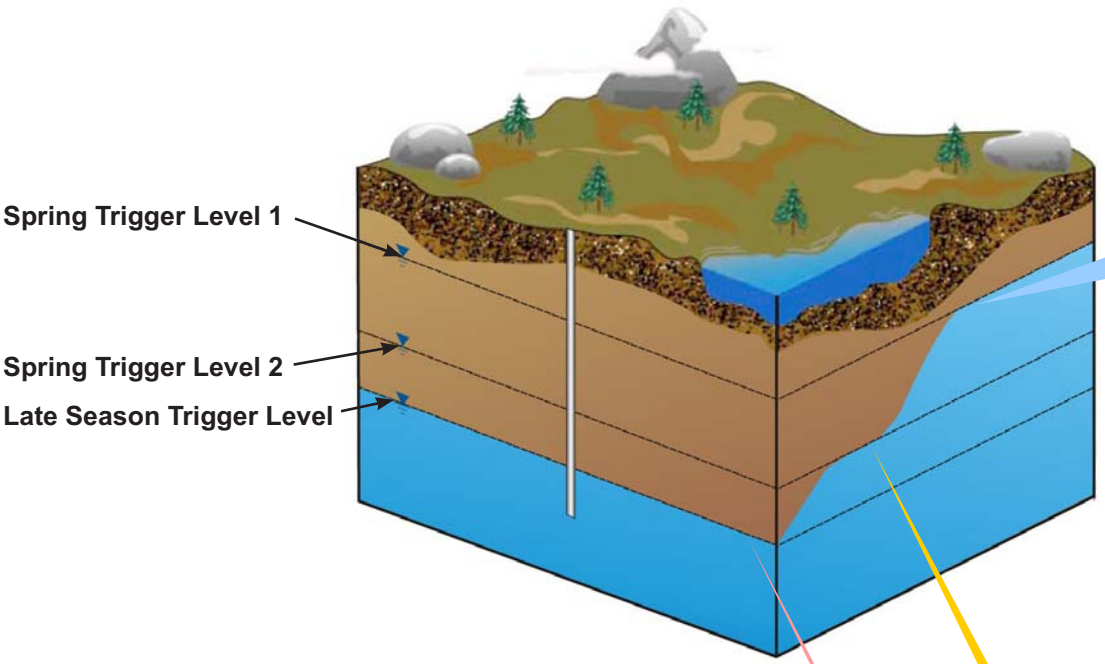
Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-2).

After key wells have been identified, the seasonal measurements have been designated, and a history of groundwater level measurements have begun to develop, sub-basin representatives may review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, (indicating a need to disseminate information or further investigation of groundwater levels), to a larger change in groundwater levels, (indicating a need to take action to stop or reduce the lowering of groundwater levels).

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

A summary of associated awareness actions with each trigger level include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-2
Trigger Levels and Awareness Actions

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

2. Bend Trigger Level Development

Because Bend does not have monitoring wells, this section is focused on the implementation of the first two steps of the five-step methodology:

Step 1: Describe the trigger level's purpose.

The Bend sub-basin is primarily a rural area, with agriculture in the western end of the sub-basin. Groundwater is used for agricultural and domestic purposes. There is one irrigation district, the Bend Water Users Association, in the Bend sub-basin, as indicated in Figure 1-1. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies to protect supplies for current and future uses.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

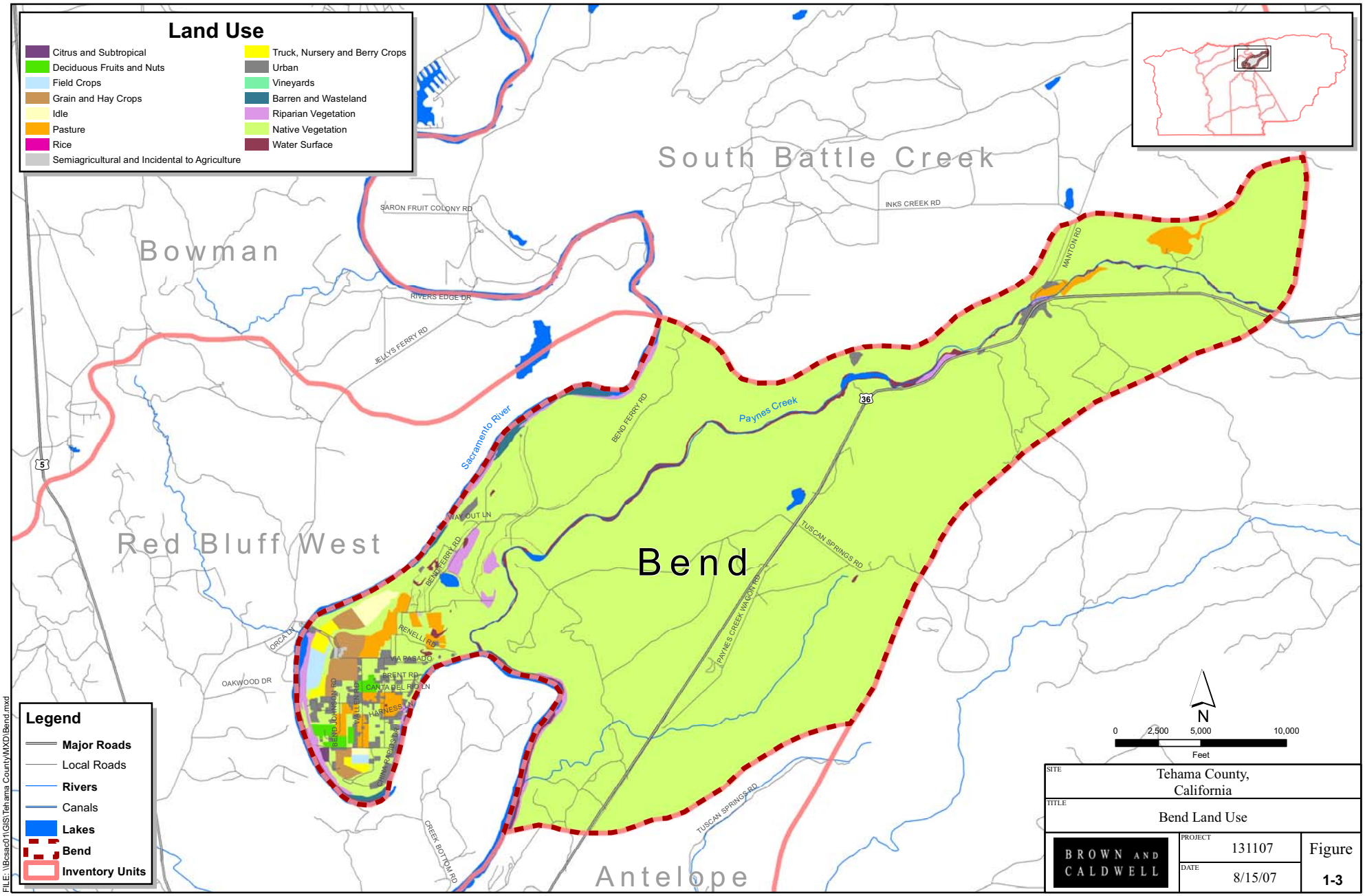
Step 2: Select one or more key wells within the sub-basin.

There are currently no monitoring wells located within the Bend sub-basin. According to the DWR database, there are 163 reported wells in Bend, none of which included in the DWR monitoring grid. Groundwater levels in key wells provide information necessary to initiate management activities. To begin the trigger level process, the District suggests that priority areas for new monitoring be selected in the Bend area.

Groundwater Use in Bend:	
Irrigation:	50% (200 acre-ft)
Municipal, and Industrial:	50% (200 acre-ft)
Number of wells by type in Bend:	
Irrigation:	19 wells
Domestic:	144 wells
Municipal and Industrial:	0 wells

When picking areas for monitoring wells in Bend, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Figure 1-3 presents the land use in the Bend area. Agriculture in Bend is predominantly in the west, with orchards and pasture the predominant crop types. Future land use in Bend is anticipated to be similar to current land use. Additional land use information can be obtained by obtaining the zoning information for the Bend area.



SITE	Tehama County, California
TITLE	Bend Land Use
BROWN AND CALDWELL	PROJECT 131107
	DATE 8/15/07
	Figure 1-3

Water Source: Figure 1-4 presents agricultural land use by water source in the Bend area. Figure 1-4 demonstrates that agriculture in the northwestern corner of Bend is irrigated with surface water, and that agriculture in the southwestern point of Bend is irrigated with groundwater.

Existing Well Infrastructure: Figure 1-5 shows the cumulative frequency curve for domestic wells in Bend. There are 144 domestic wells and 19 irrigation wells in the Bend sub-basin. Fifty percent of the domestic wells are shallower than 50 feet deep, and fifty percent of the irrigation wells are shallower than 165 feet deep. Existing well infrastructure data was developed from DWR's well completion report database. DWR's database contains information on the majority of wells drilled after 1947, while wells drilled prior to 1947 are generally not included. Some wells drilled after 1947 may not have been reported to DWR (potentially up to 30%), and therefore are not included in the database.

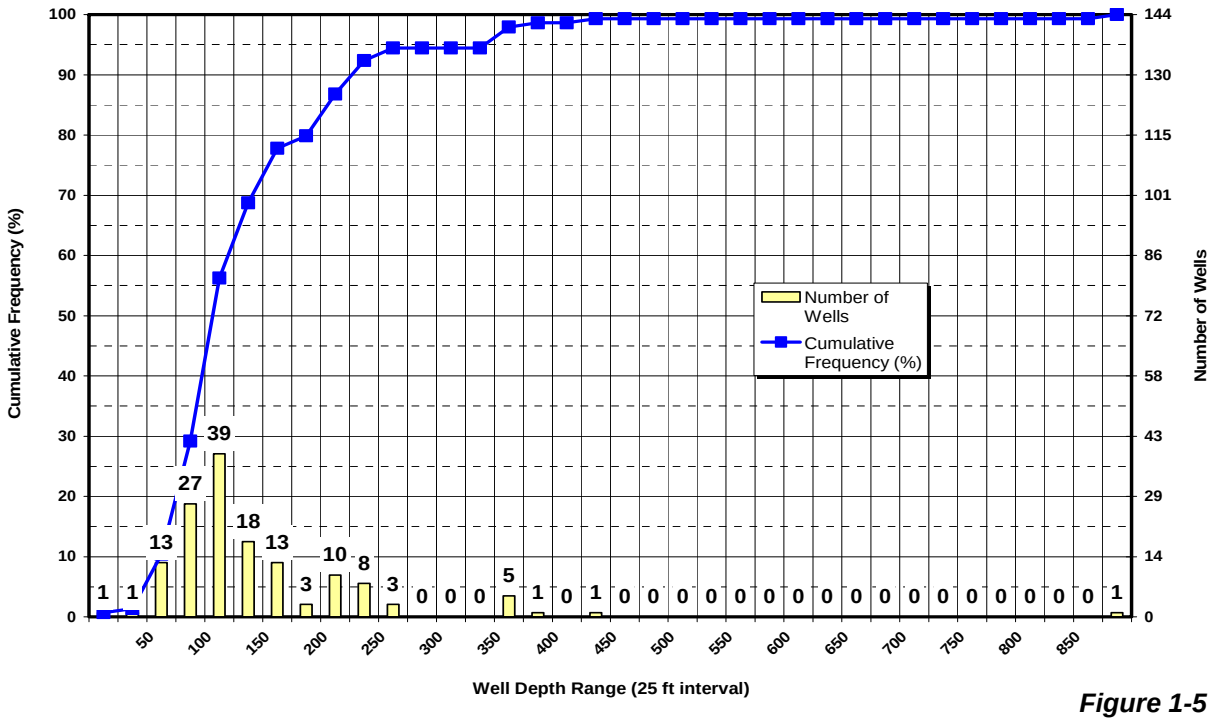


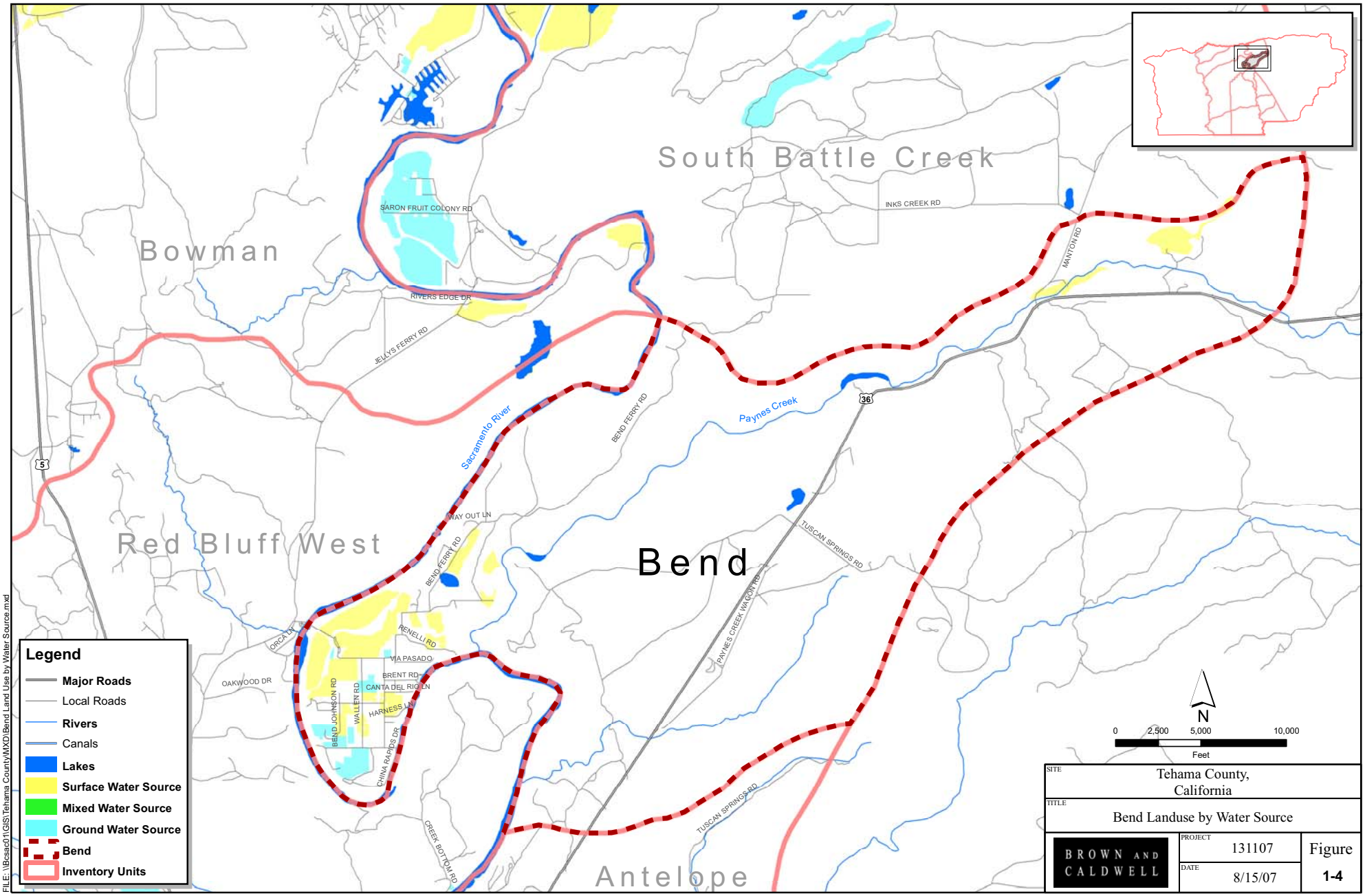
Figure 1-5
Cumulative Frequency Curve of Domestic Wells in the Bend Sub-Basin

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well. Figure 1-4 shows the locations of any monitoring wells adjacent to Bend. As indicated by Figure 1-4, there are no monitoring wells near the boundary of Bend, and new monitoring wells can be sited near the boundary of the sub-basin.

Suggested Monitoring Well Areas:

There are two suggested areas for new monitoring wells in the Bend area which are indicated in Figure 1-6. Monitoring wells installed in the Bend area should be screened to monitor groundwater


South Battle Creek
Bowman
Red Bluff West
Bend
Antelope
SARON FRUIT COLONY RD
INKS CREEK RD
MANTON RD
RIVERS EDGE DR
JELLYS FERRY RD
Sacramento River
BEND FERRY RD
Paynes Creek
36
5
WAY OUT LN
TUSCAN SPRINGS RD
PAYNES CREEK WAGON RD
RENELLI RD
VIA PASADO
BRENT RD
CANTA DEL RIO LN
HARNESS LN
WALLEN RD
BEND JOHNSON RD
CHIVIA RAPIDS DR
ORCA LN
OAKWOOD DR
CREEK BOTTOM RD
Legend
Major Roads
Local Roads
Rivers
Canals
Lakes
Surface Water Source
Mixed Water Source
Ground Water Source
Bend
Inventory Units
N
0
2,500
5,000
10,000
Feet
SITE
Tehama County, California
TITLE
Bend Landuse by Water Source
BROWN AND CALDWELL
PROJECT
131107
DATE
8/15/07
Figure
1-4
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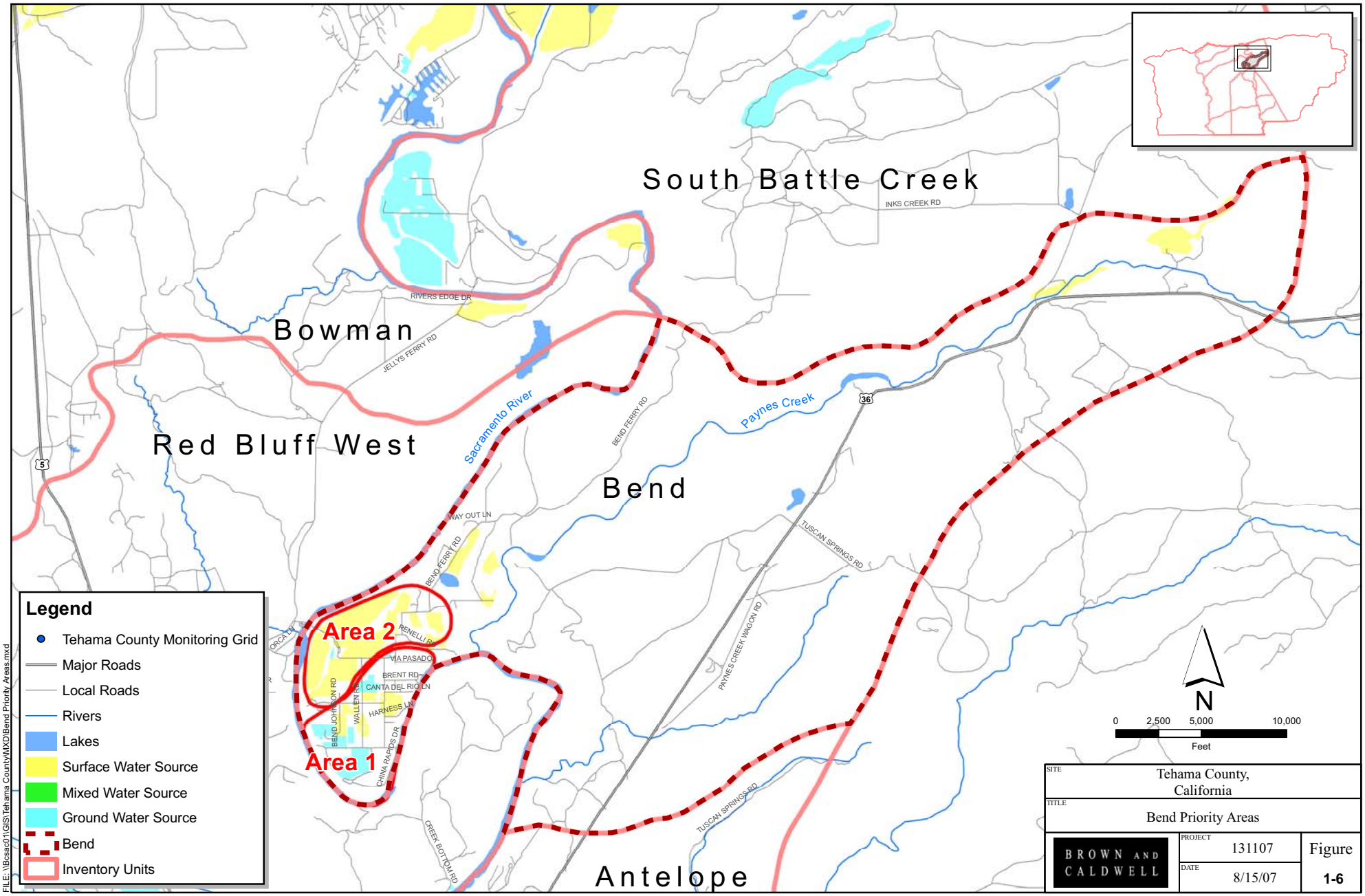


SITE	Tehama County, California
TITLE	Bend Priority Areas
BROWN AND CALDWELL	PROJECT 131107
	DATE 8/15/07
	Figure 1-6

at depths similar to those used for production by domestic and irrigation wells. The majority of domestic and irrigation wells in Bend are screened between 40 and 200 feet below ground surface. The two suggested areas are in the more developed, western end of the sub-basin as listed below:

- The first suggested area (Area 1) is in the southwestern point of the sub-basin, and is a priority area of orchards and pasture irrigated with groundwater, with mixed urban uses. Area 1 is not near other monitoring wells.
- The second suggested area (Area 2) is in the northwestern portion of the sub-basin, north of Area 1. Area 2 is a priority area of grain, hay, and pasture that is irrigated by surface water. Area 2 is not near other monitoring wells.

3. Next Steps

Steps 1 and 2: With the proposed priority areas selected, the next step will be confirmation of priority areas with stakeholders. Once stakeholders have provided local information and input to priority area selection, the availability of existing wells for monitoring and the need for new monitoring wells can be assessed. As monitoring locations are selected and developed, the monitoring program for the Bend sub-basin can be implemented.

Steps 3, 4 and 5: Once the monitoring program is in place, steps 3 through 5 of the trigger level development process can be completed as described in the methodology section. Example trigger levels from the Antelope sub-basin are provided below.

Figures 1-7 through 1-9 present hydrographs and suggested trigger levels for an example key well located in the Antelope sub-basin. The figures are groundwater level hydrographs, demonstrating water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. The methodologies used to determine the suggested trigger levels for the example key well is provided in Table 1-1.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Antelope Monitoring Well Number				
	10B01M	**16N02M**	**23D01M**	**31C01M**	**17E01M**
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements				
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements				
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	None	None	None	None	None

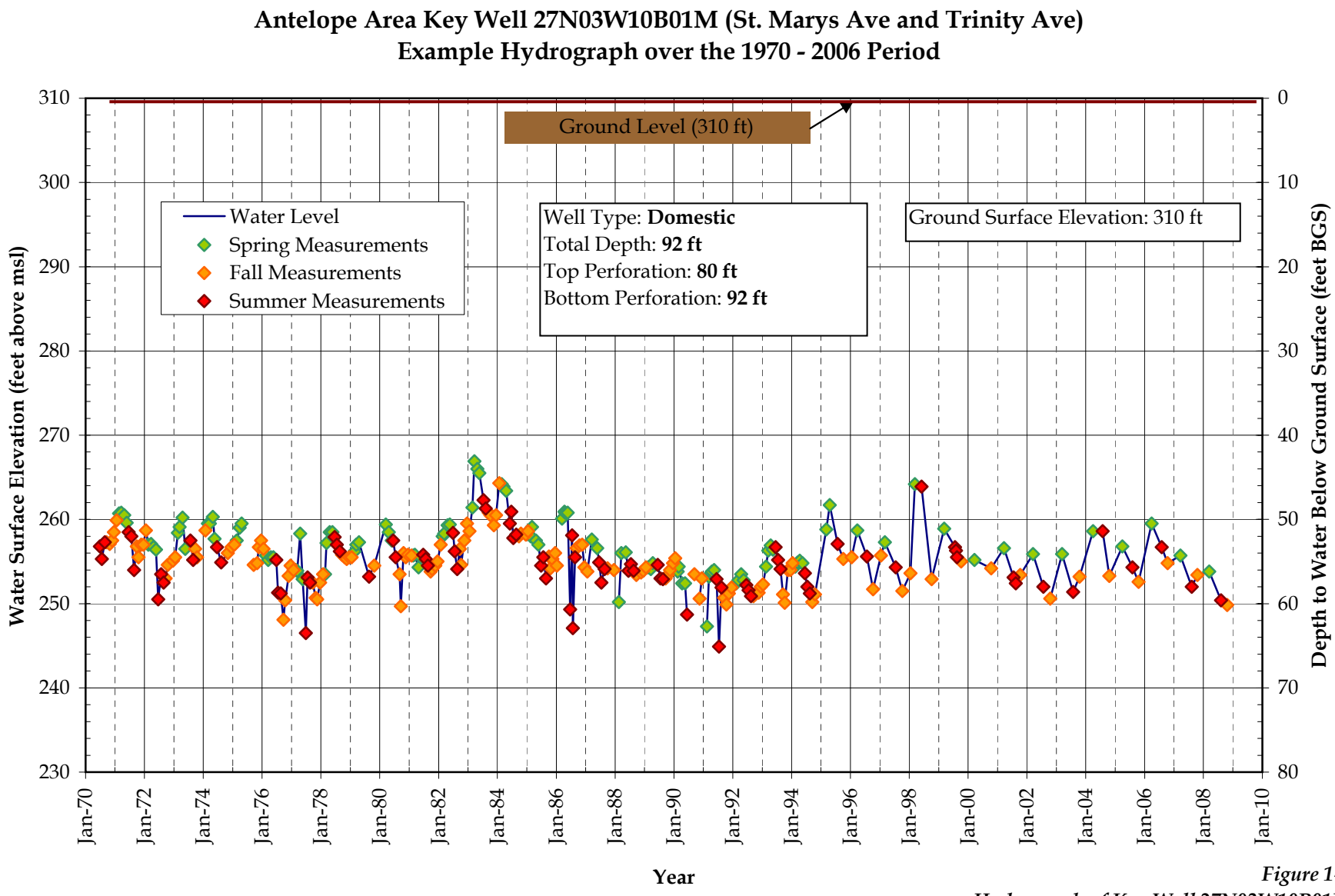


Figure 1-7
Hydrograph of Key Well 27N03W10B01M

Updated 12-01-08

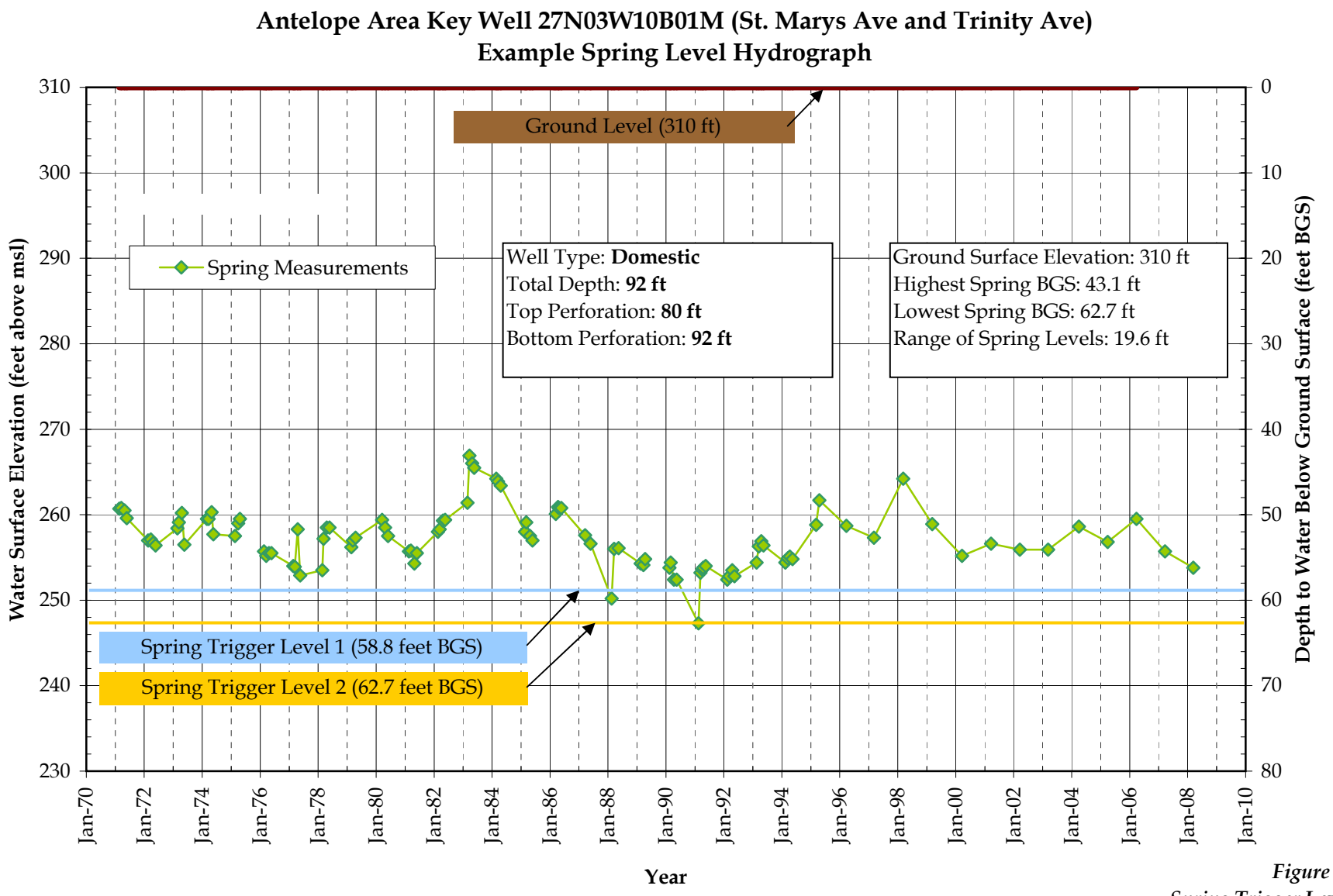


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

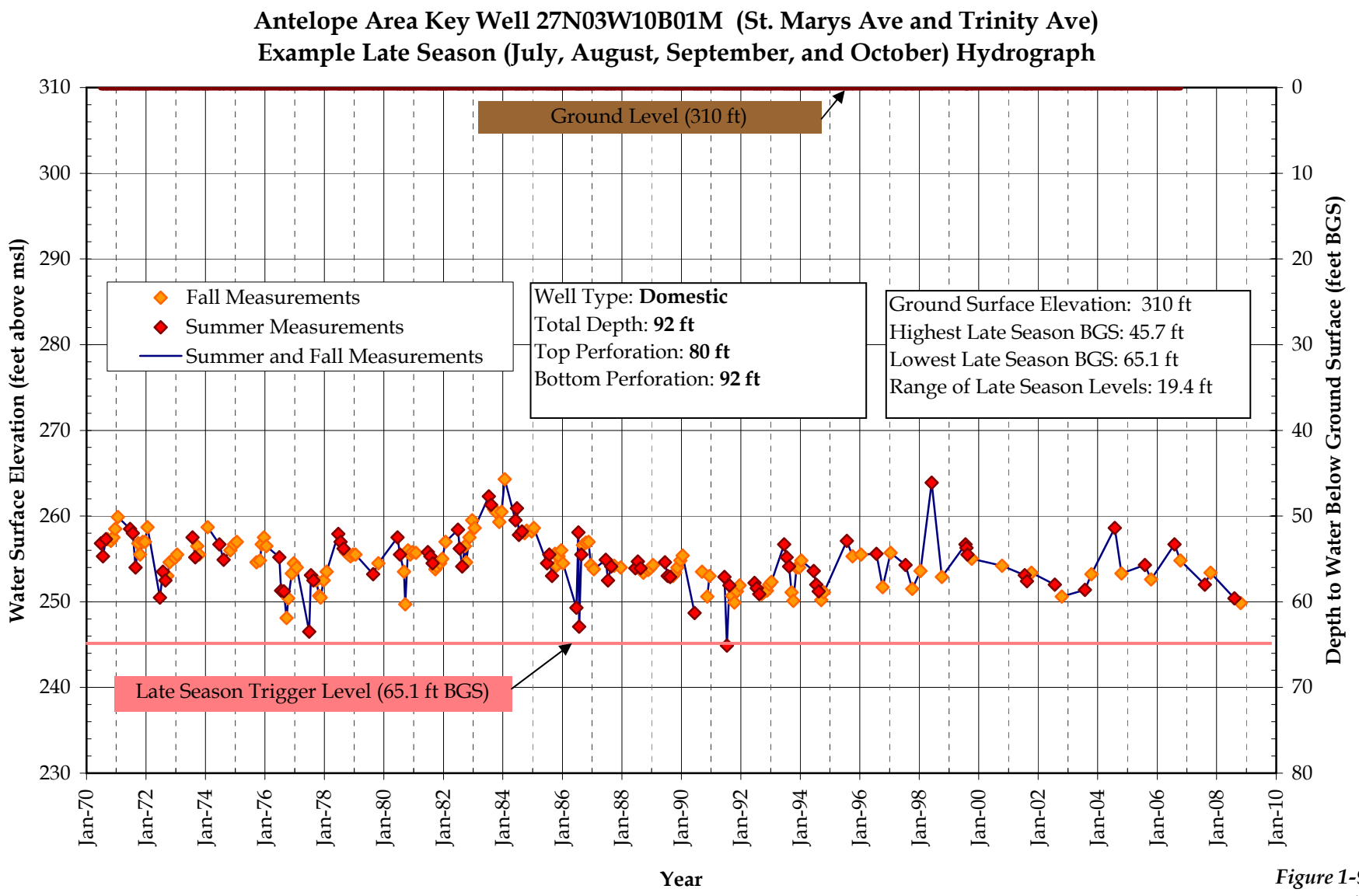


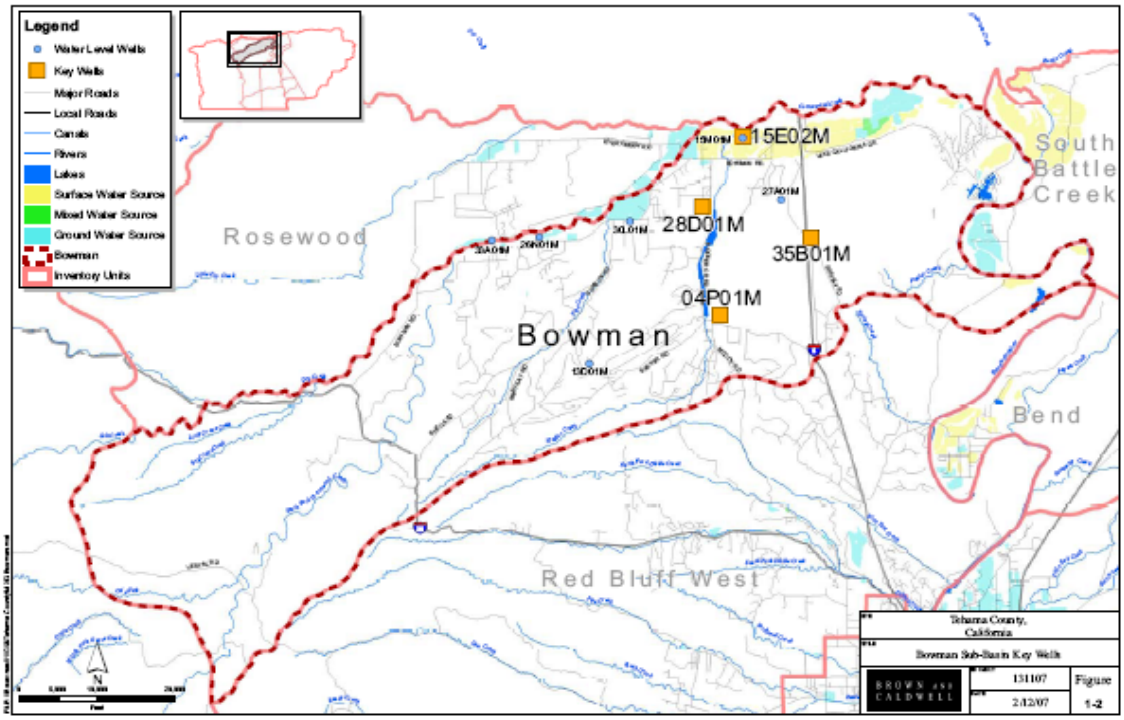
Figure 1-9
Late Season Trigger Levels

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Bowman Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
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BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Bowman Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

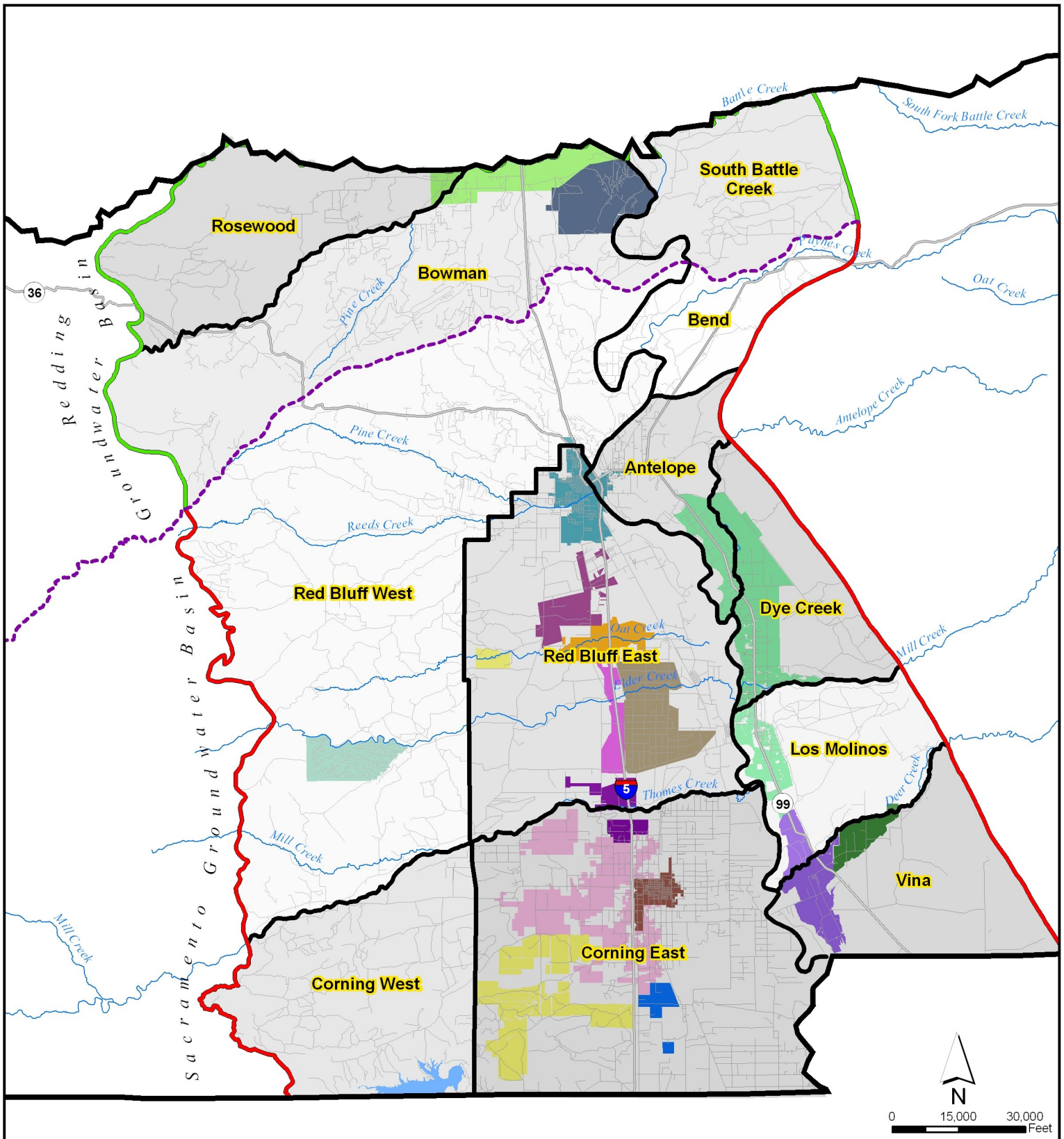
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Bowman sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to three decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Bowman sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
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- Rio Alto WD
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Legend

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- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Bowman sub-basin is primarily a rural area, with agriculture throughout the area and new development occurring near I-5. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. Groundwater is used for agricultural, municipal, and domestic purposes. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Bowman:	
Irrigation:	42% (1,500 acre-ft)
Municipal, and Industrial:	58% (2,100 acre-ft)
Number of wells by type in Bowman:	
Irrigation:	37 wells
Domestic:	1051 wells
Municipal and Industrial:	14 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

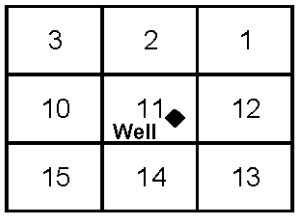
Step 2: Select one or more key wells within the sub-basin

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

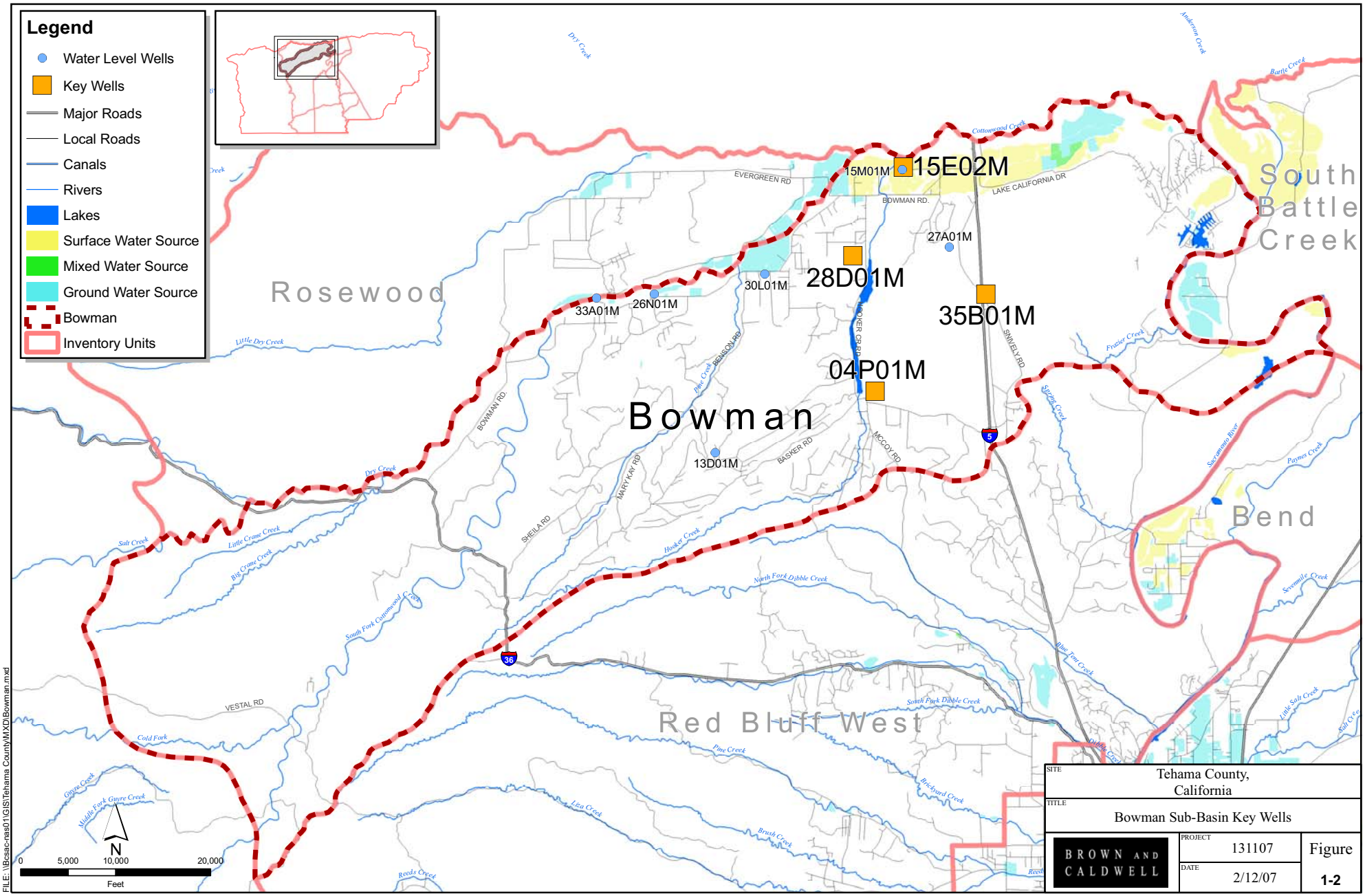
The locations of four proposed key wells are presented in Figure 1-2. Three of the proposed wells have a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **29N04W28D01M (28D01M) –** This monitoring well is in the northern portion of the sub-basin, is 134 feet deep with a screened interval from 130 to 134 feet below ground surface (bgs), and is 134 feet deep. This well is situated in an area of homesteads and native vegetation. This well has a period of record longer than 30 years. The nine square miles near this well contain 357 domestic wells with an average depth of 173 feet bgs, and 4 irrigation wells with an average depth of 283 feet bgs.
- **29N04W35B01M (35B01M) –** This monitoring well is in the eastern portion of the sub-basin, is 759 feet deep,and has a screened interval from 130 to 200 feet bgs. This well is situated near Interstate 5, away from irrigated areas. This well has a period of record longer than 30 years. The nine square miles near this well contain 43 domestic wells with an average depth of 264 feet bgs, and 1 irrigation well with a depth of 324 feet bgs.
- **29N04W15E02M (15E02M) –** This monitoring well is in the northern portion of the sub-basin and is 234 feet deep and has an unknown screened interval. This well is situated near areas of pasture that is irrigated with surface water. This well has a period of record longer than 30 years. The nine square miles near this well contain 223 domestic wells with an average depth of 154 feet bgs, and 7 irrigation wells with an average depth of 292 feet bgs.
- **28N04W04P01M (04P01M)–** This monitoring well is in the southeast portion of the sub-basin, is 270 feet deep, and has a screened interval from 200 feet to 270 feet bgs. This well is situated away from irrigated lands. This well has a period of record of 13 years. The nine square miles near this well contain 98 domestic wells with an average depth of 271 feet bgs, and 3 irrigation wells with an average depth of 429 feet bgs.

There are currently no monitoring wells in the southwestern corner of the Bowman sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.



SITE	Tehama County, California
TITLE	Bowman Sub-Basin Key Wells
BROWN AND CALDWELL	PROJECT 131107
	DATE 2/12/07
	Figure 1-2

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

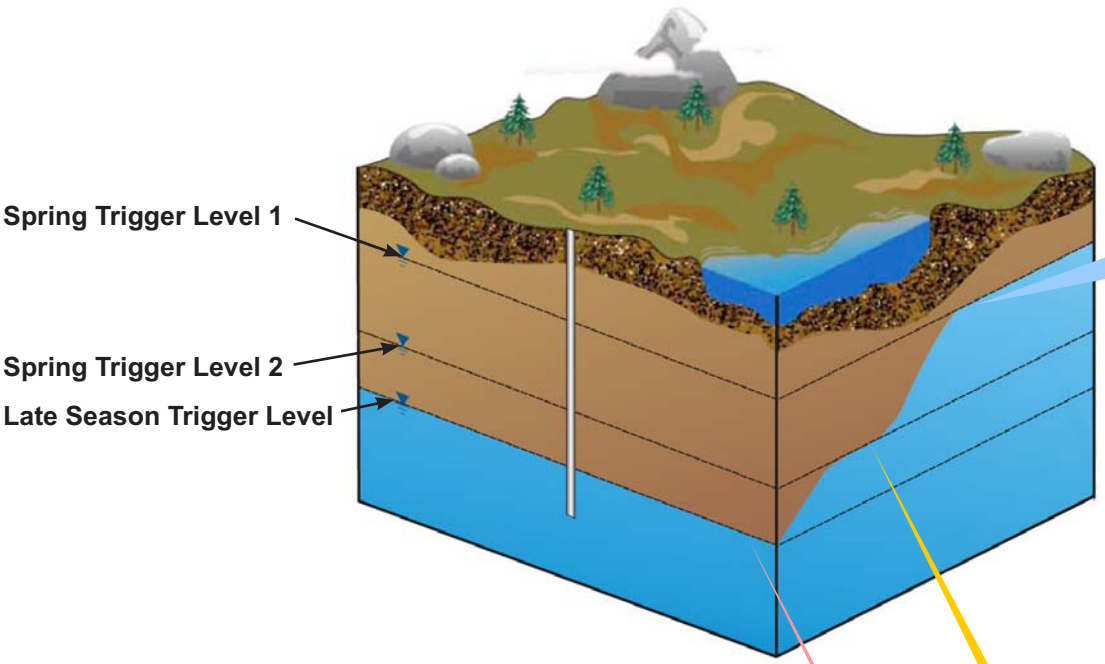
Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows two suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-15 present hydrographs and suggested trigger levels for each of the four Bowman key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water below ground surface in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Bowman sub-basin are provided in Table 1-1. One key well (04P01M) had a limited historic record of groundwater level measurements that did not include a significant drought cycle, so the method of proposing spring and late season trigger levels was modified and is subject to change in annual reviews as more experience is gained.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Bowman Monitoring Well Number			
	28D01M	35B01M	15E02M	04P01M
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements			Historical low of spring measurements
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1			
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements			Historical low of spring measurements minus the range of spring measurements
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements			
Data Anomalies	None	None	None	None

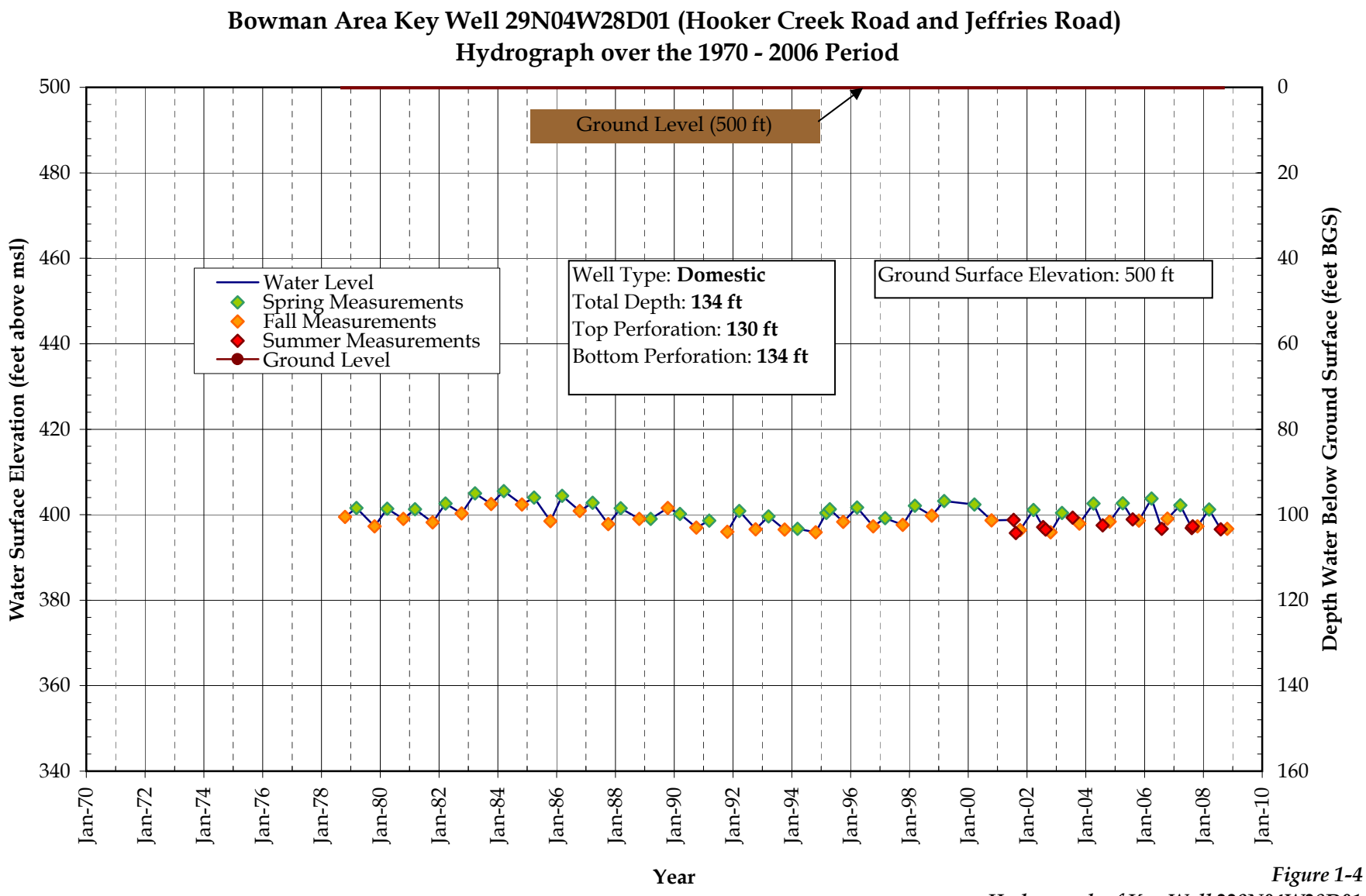


Figure 1-4
Hydrograph of Key Well 229N04W28D01

Updated 12-01-08

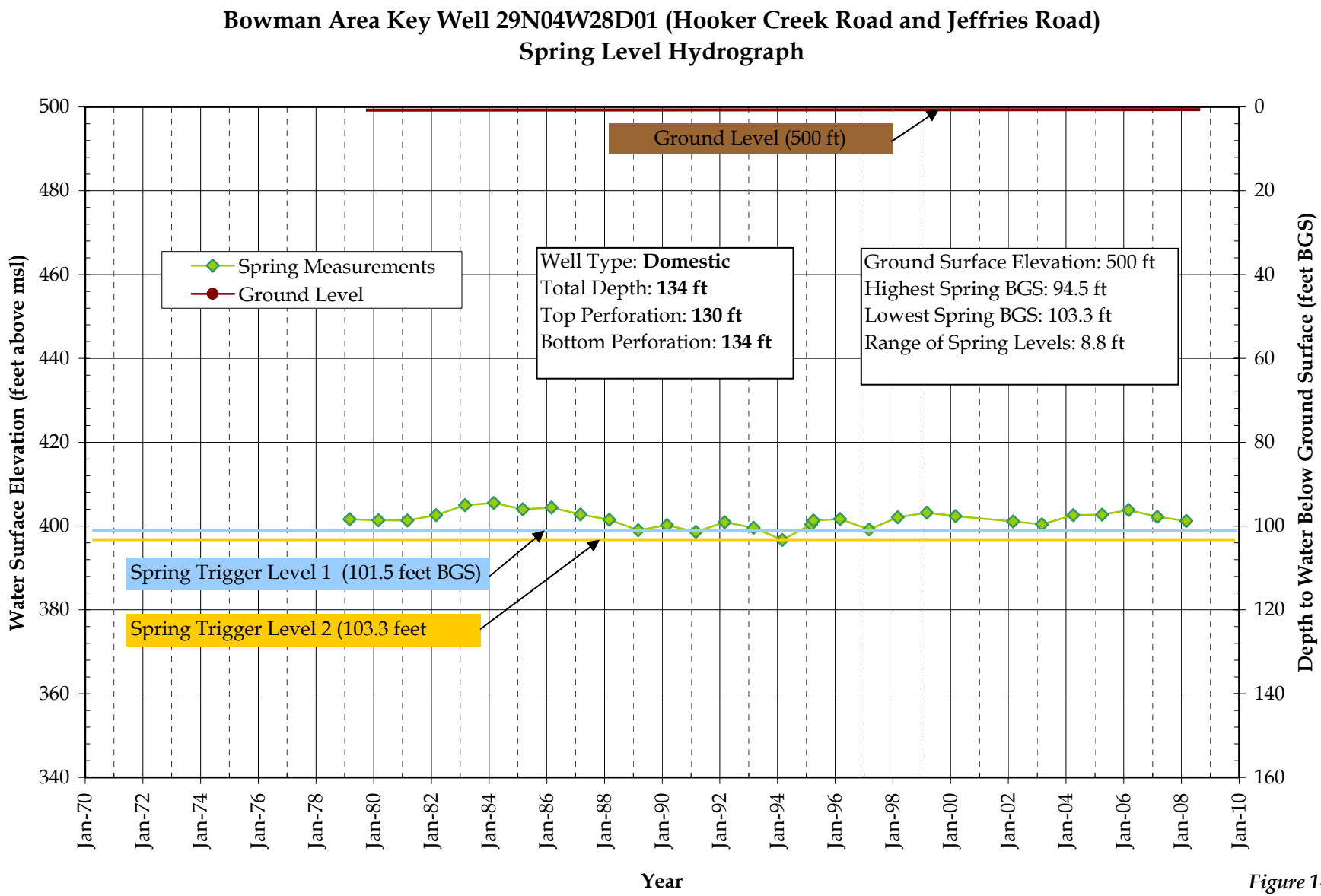


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

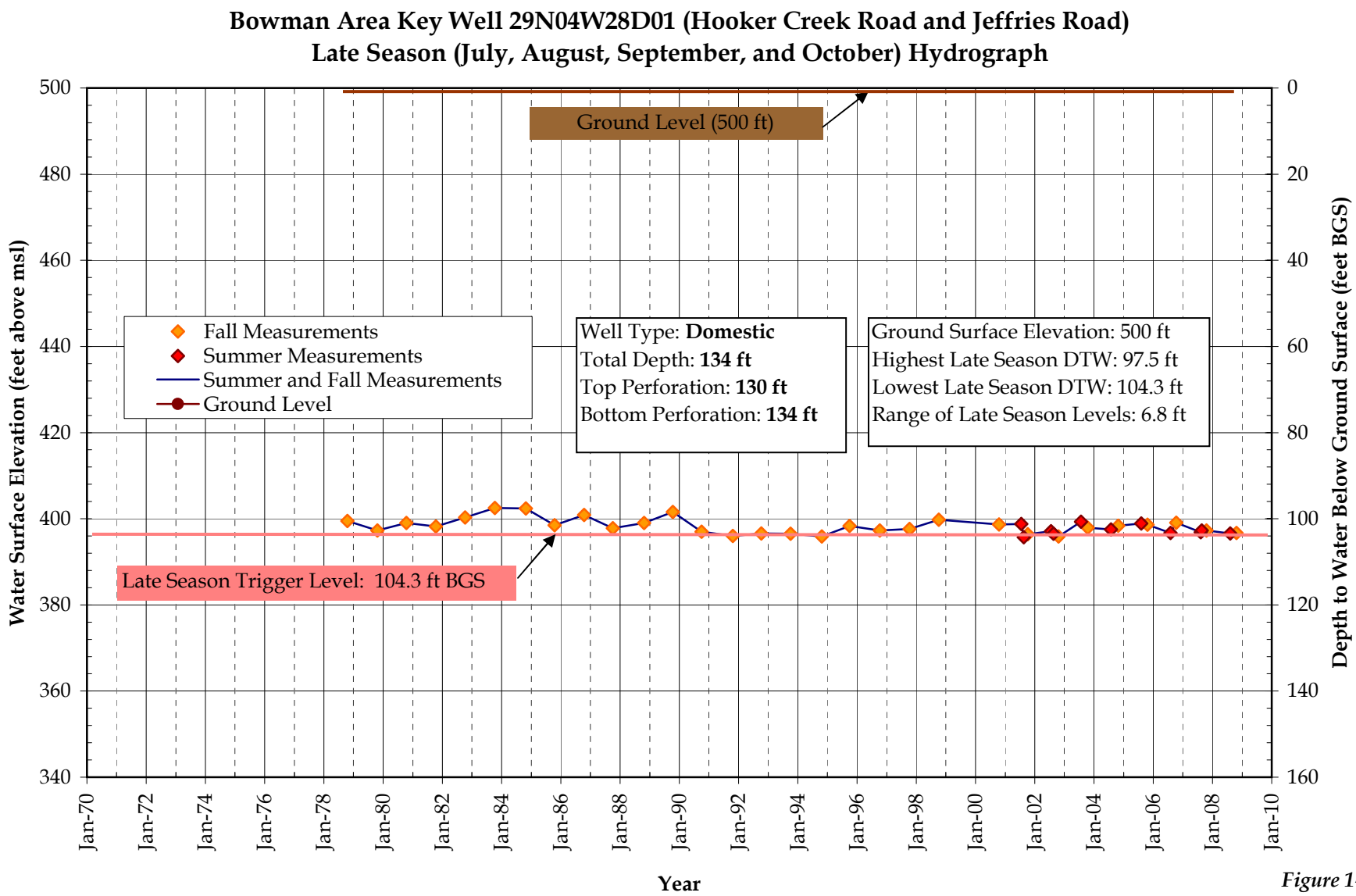


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

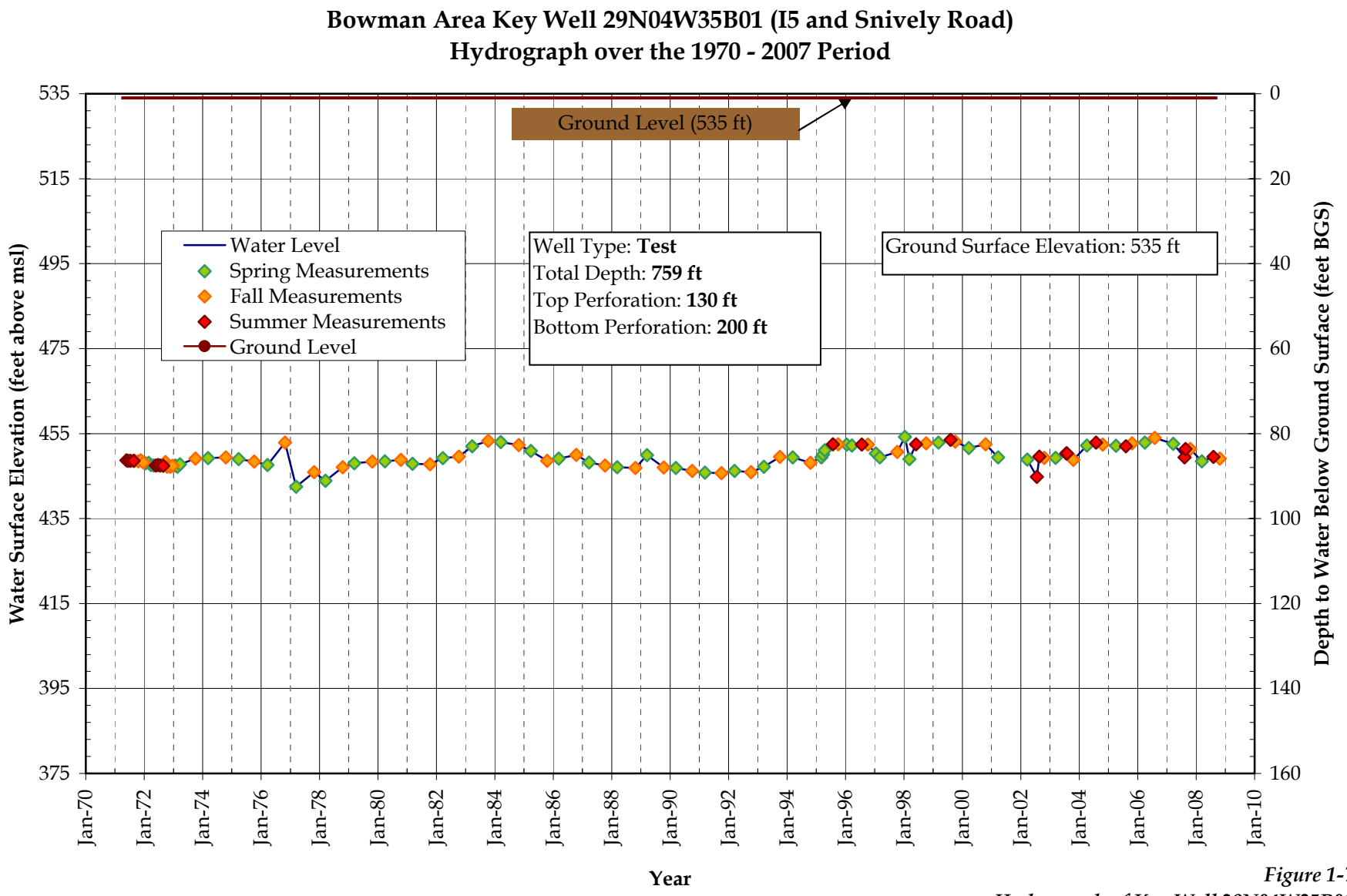


Figure 1-7
Hydrograph of Key Well 29N04W35B01

Updated 12-01-08

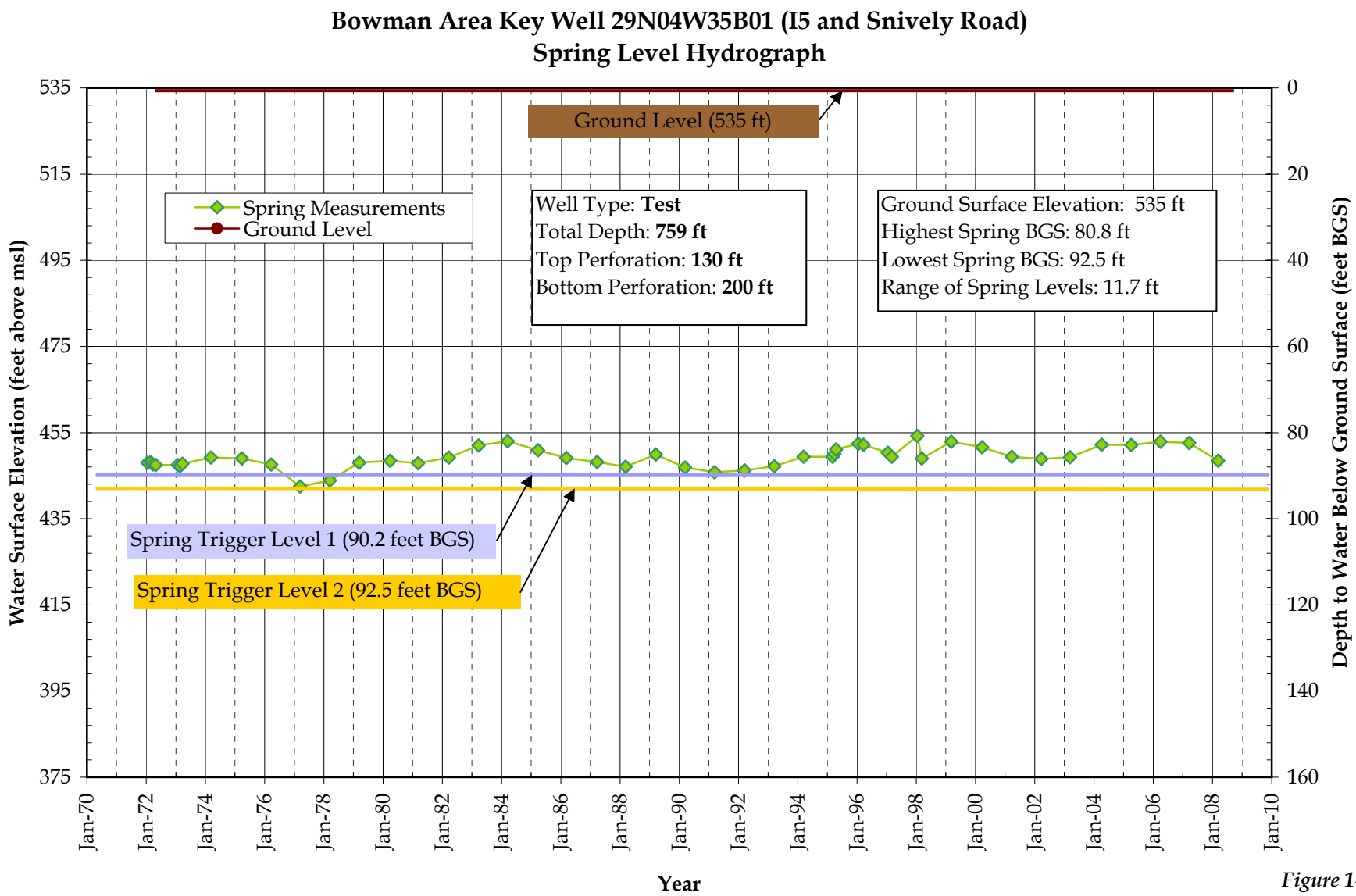


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

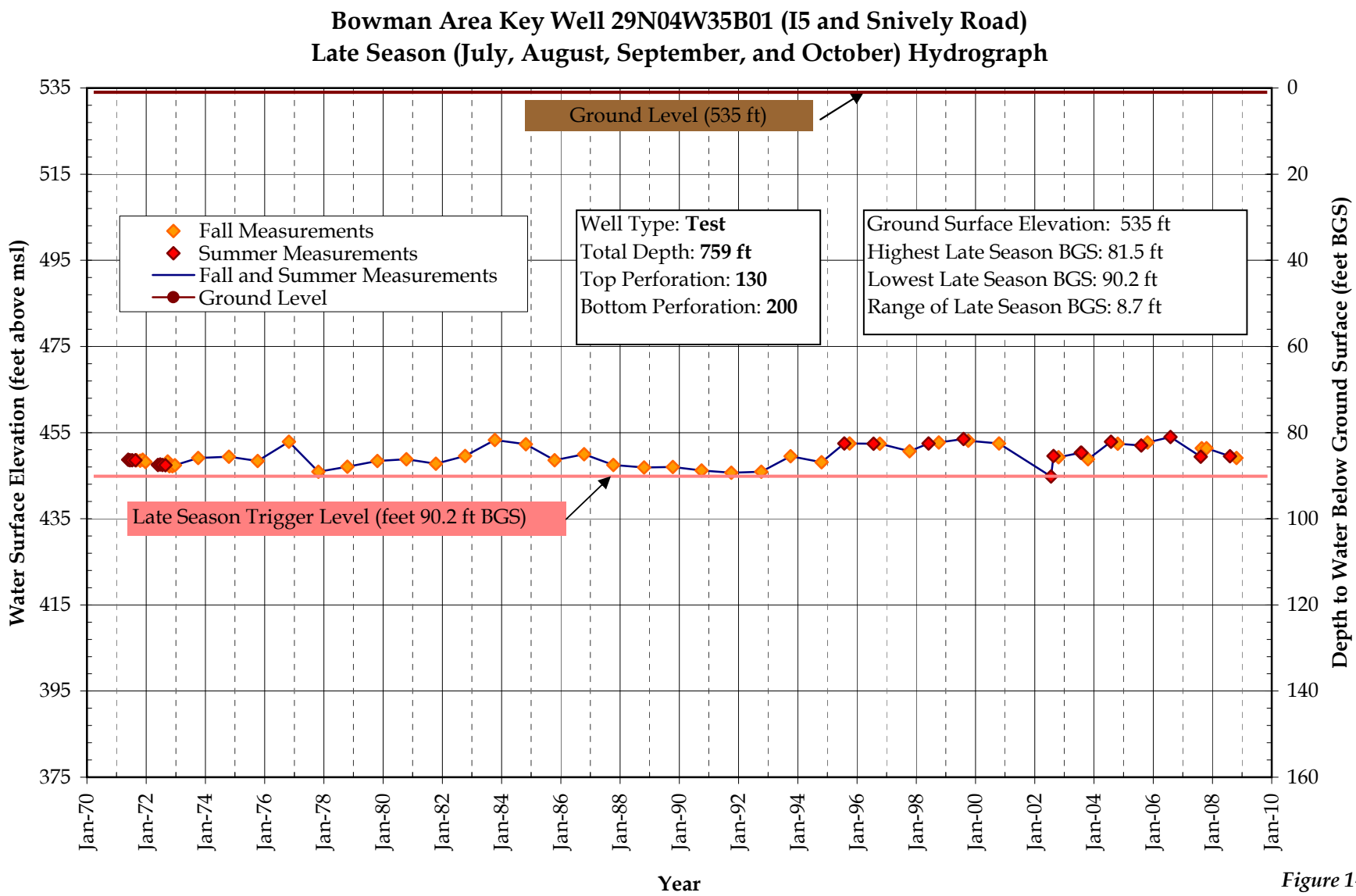


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

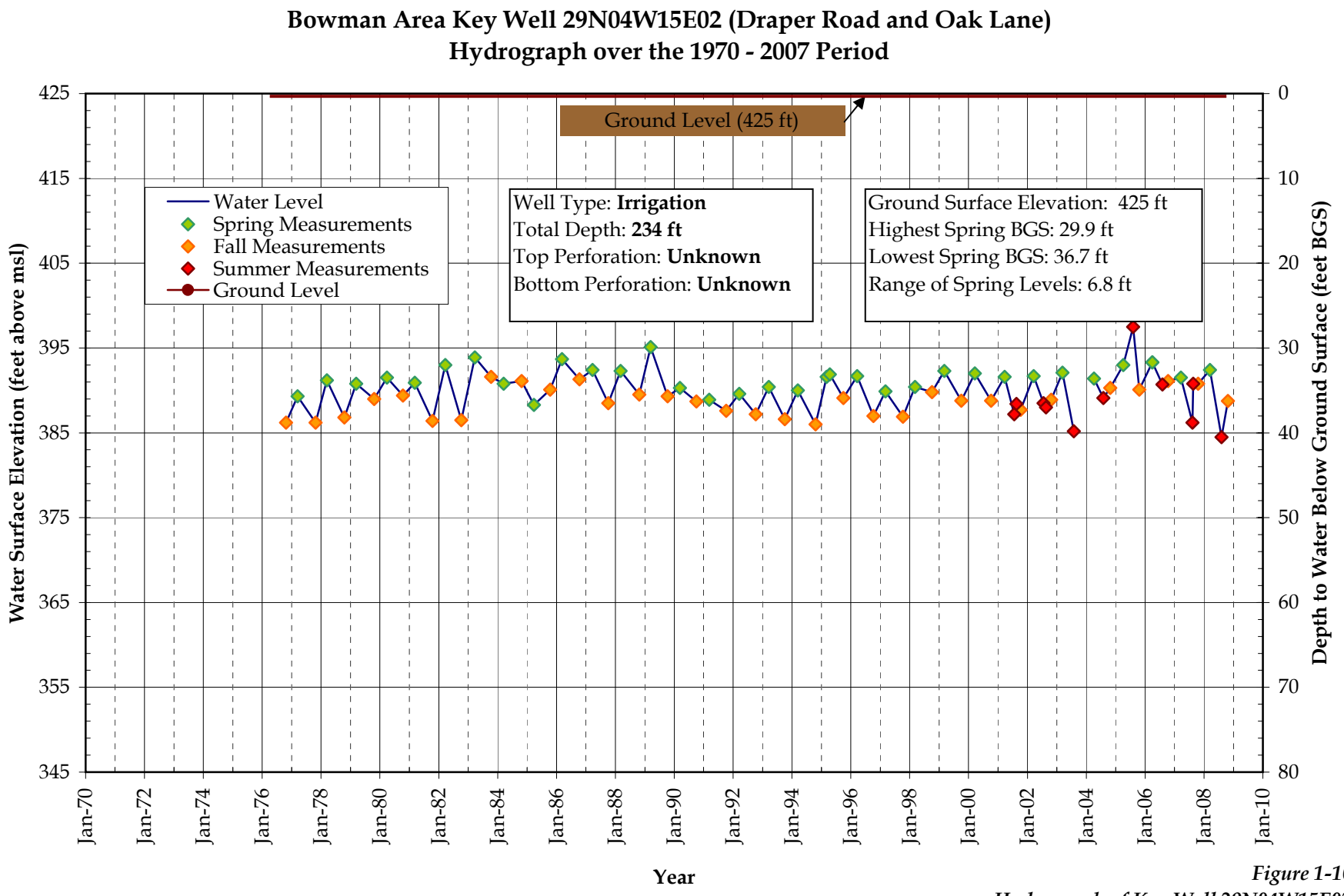


Figure 1-10
Hydrograph of Key Well 29N04W15E02

Updated 12-01-08

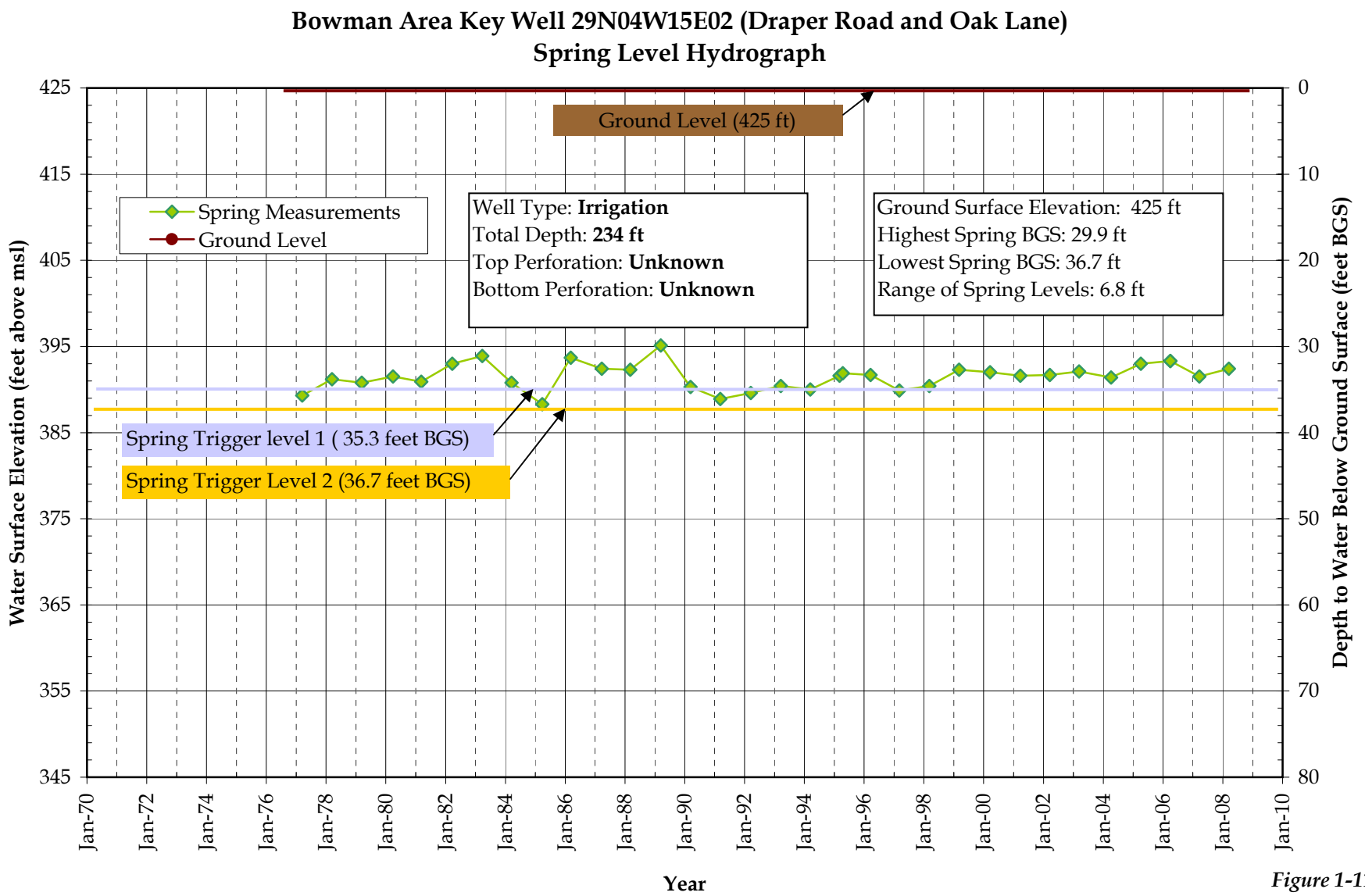


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

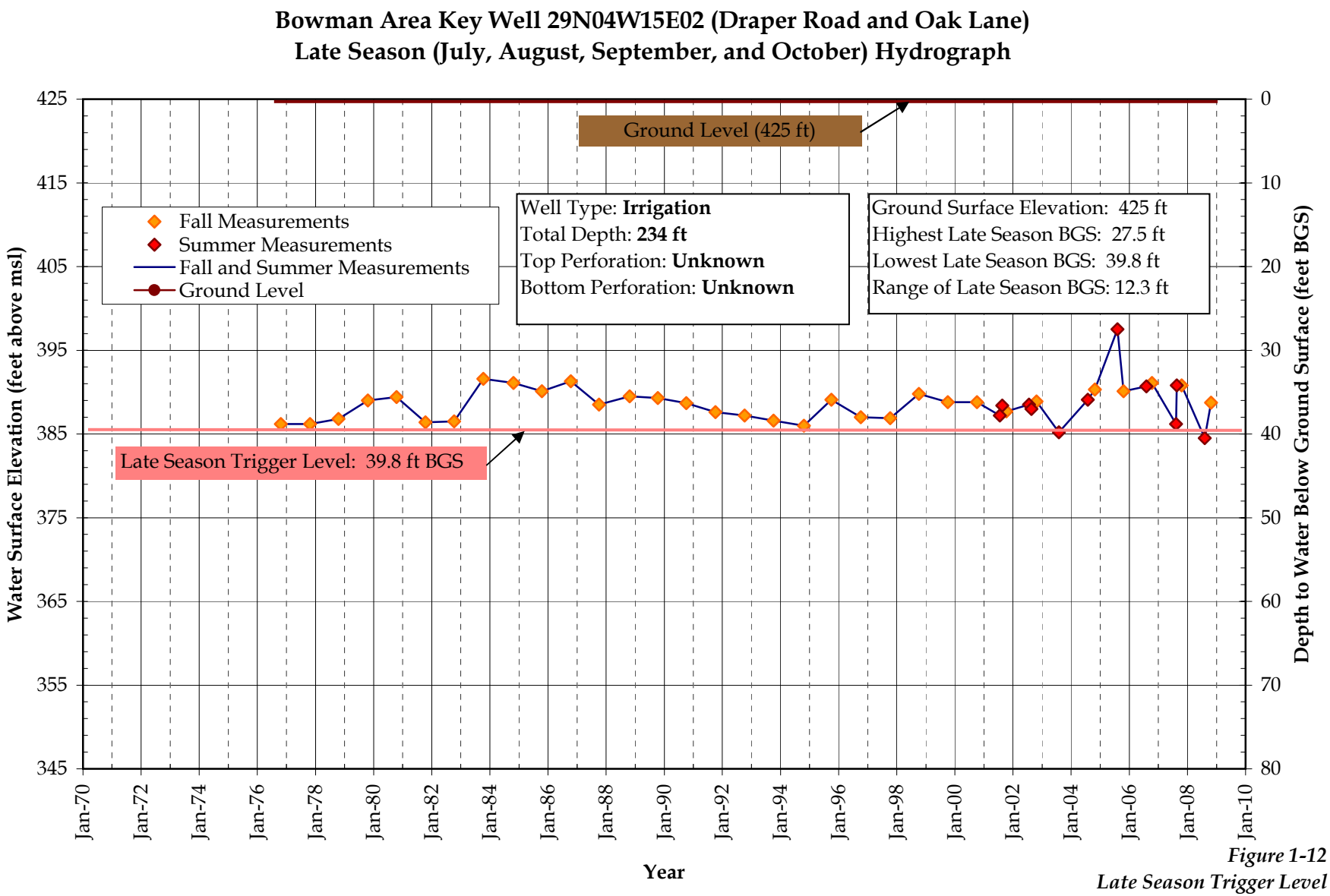


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

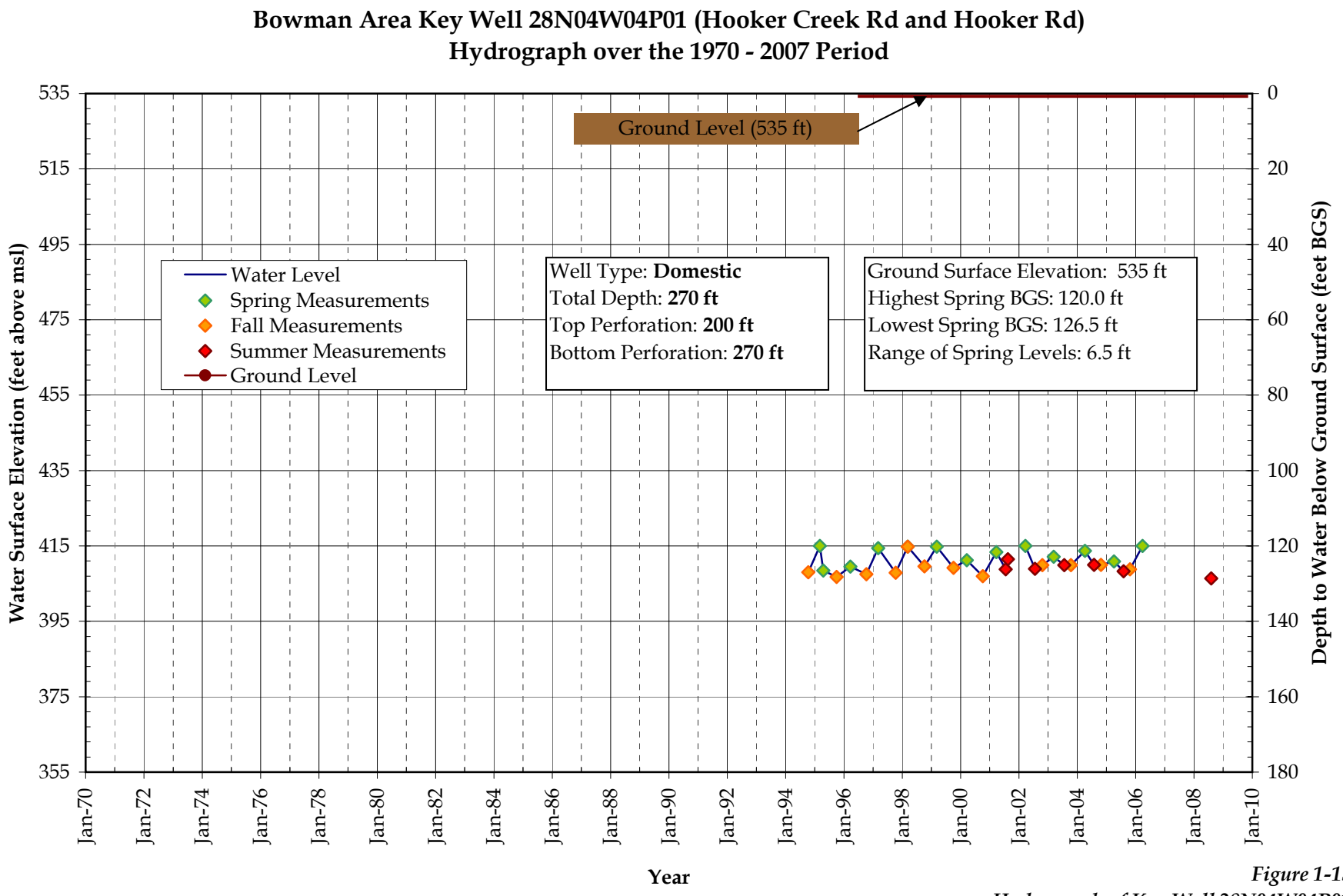


Figure 1-13
Hydrograph of Key Well 28N04W04P01

Updated 12-01-08

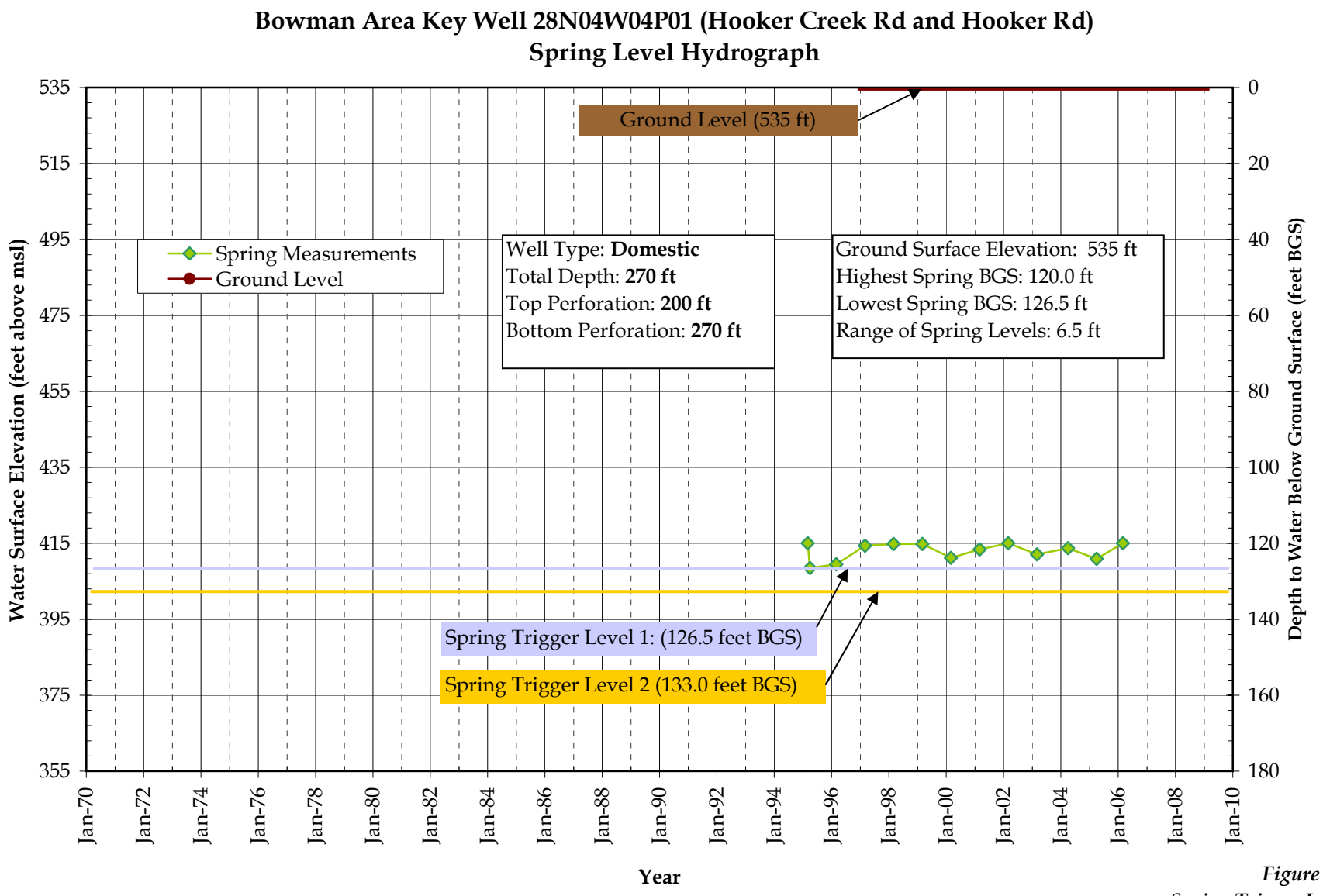


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

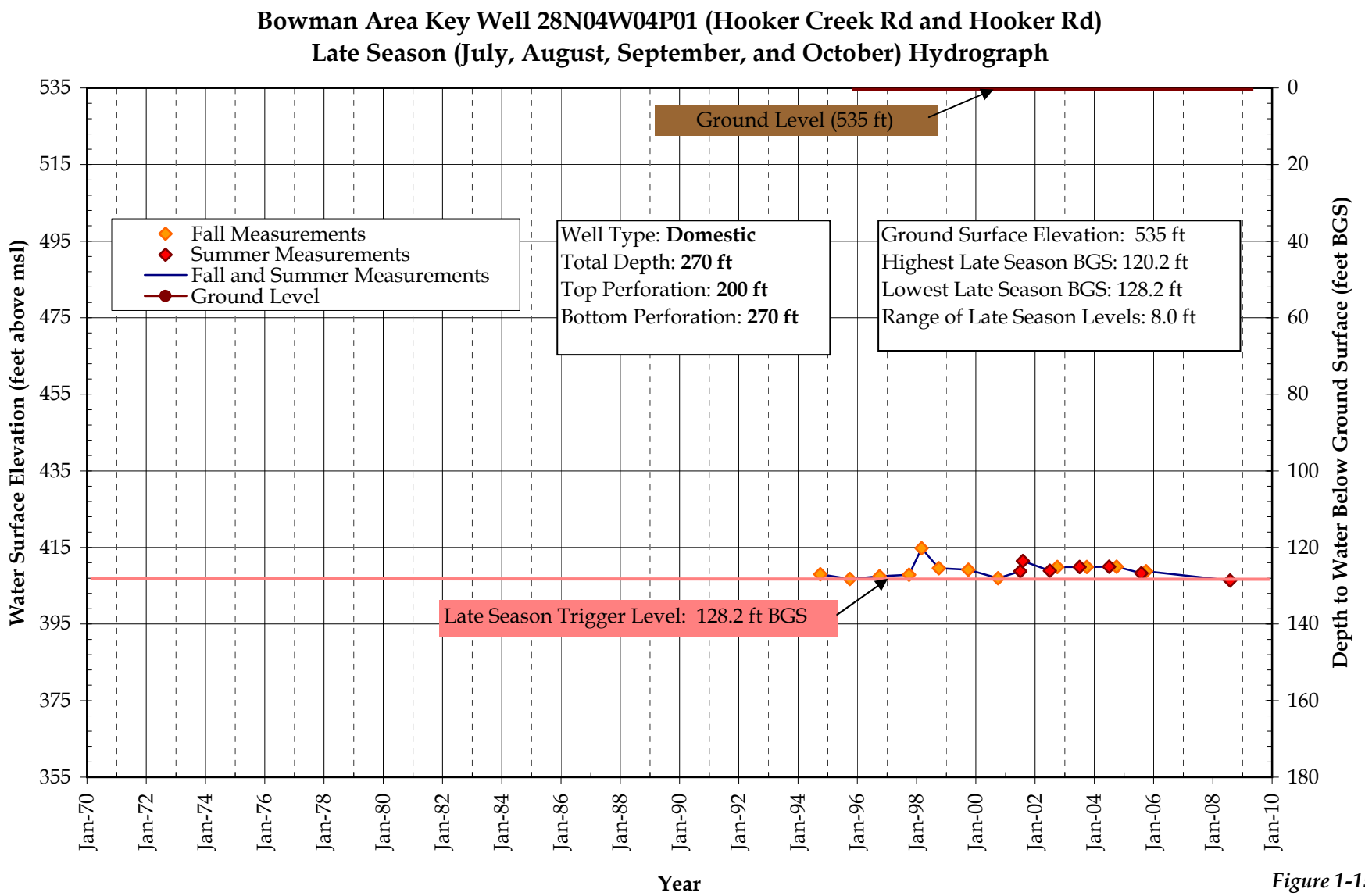


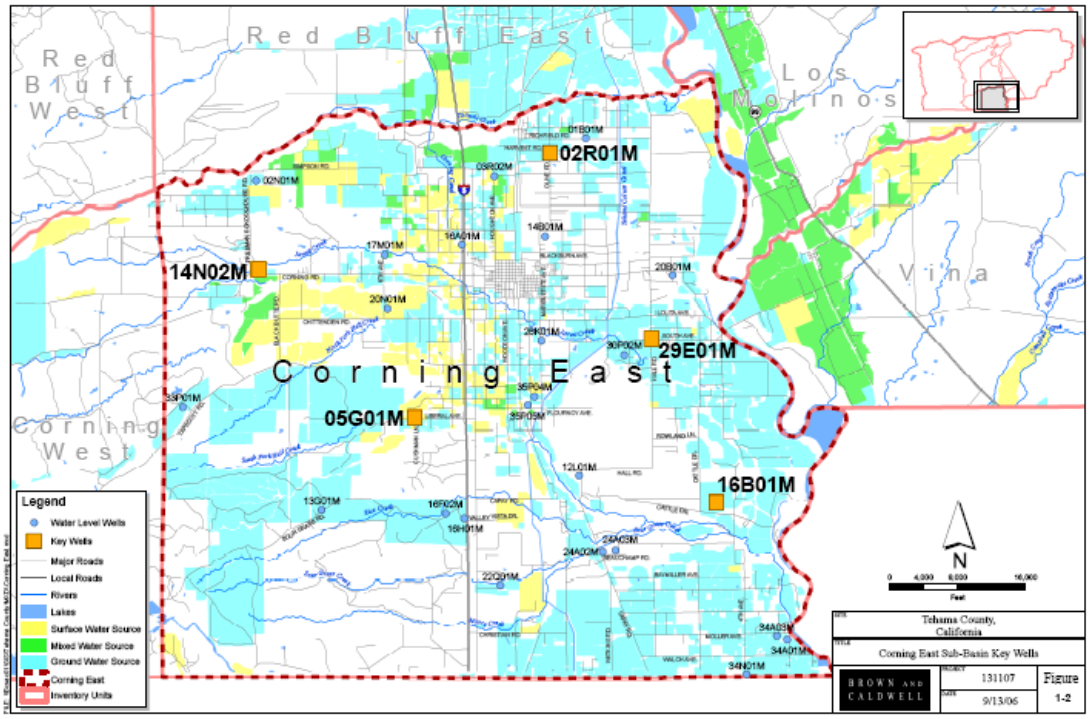
Figure 1-15
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Corning East Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Corning East Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

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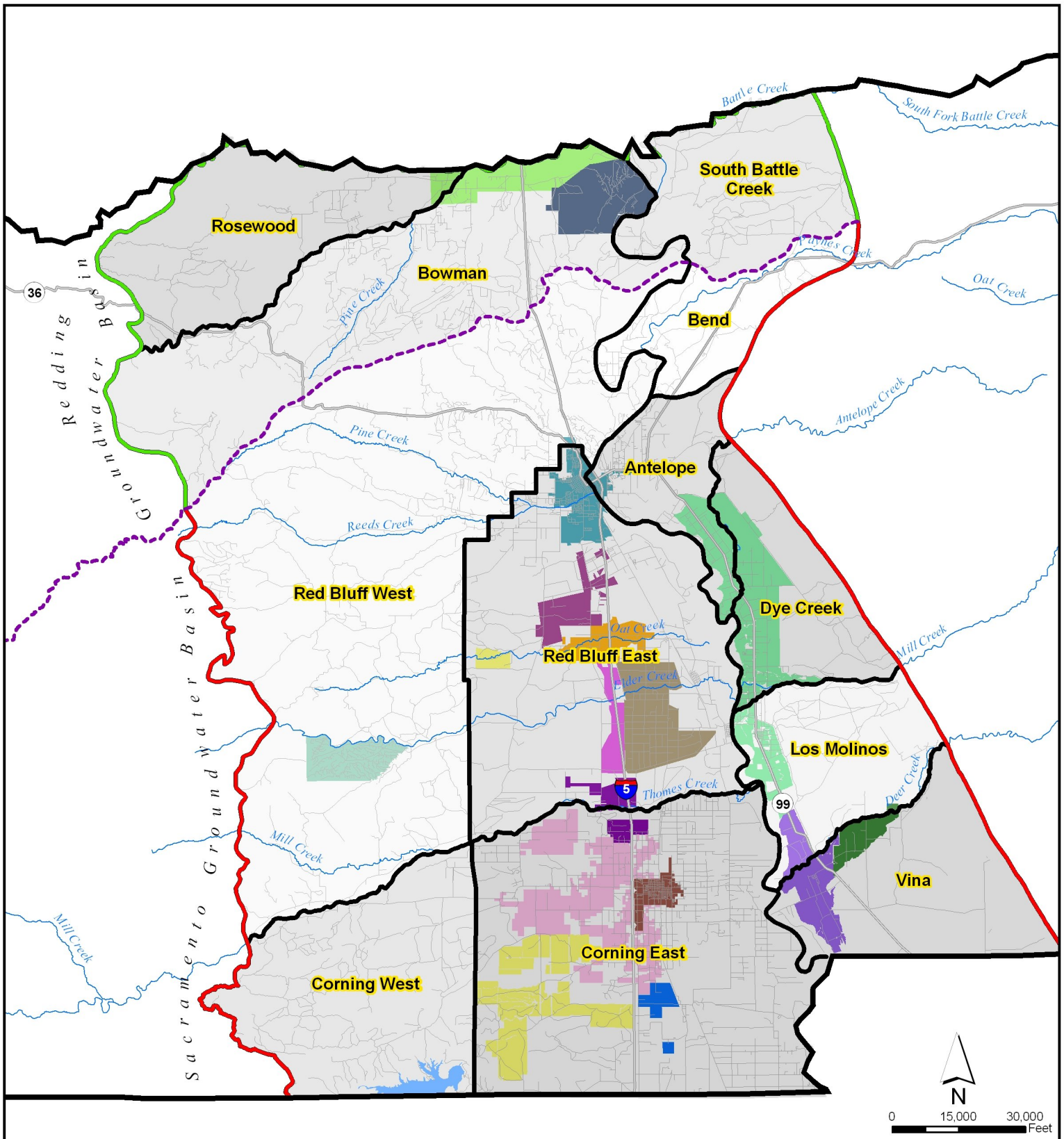

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BROWN AND CALDWELL

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FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

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Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Corning East sub-basin is primarily a rural area, with agriculture throughout the area and new development occurring near Corning. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm.Groundwater is used for agricultural, municipal, and domestic purposes. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Corning East:	
Irrigation:	96% (98,900 acre-ft)
Municipal, and Industrial:	04% (4,600 acre-ft)
Number of wells by type in Corning East:	
Irrigation:	630 wells
Domestic:	1377 wells
Municipal and Industrial:	26 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin

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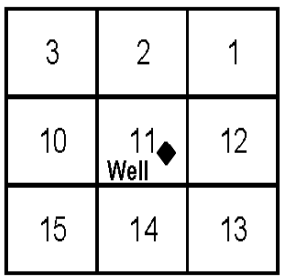
of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

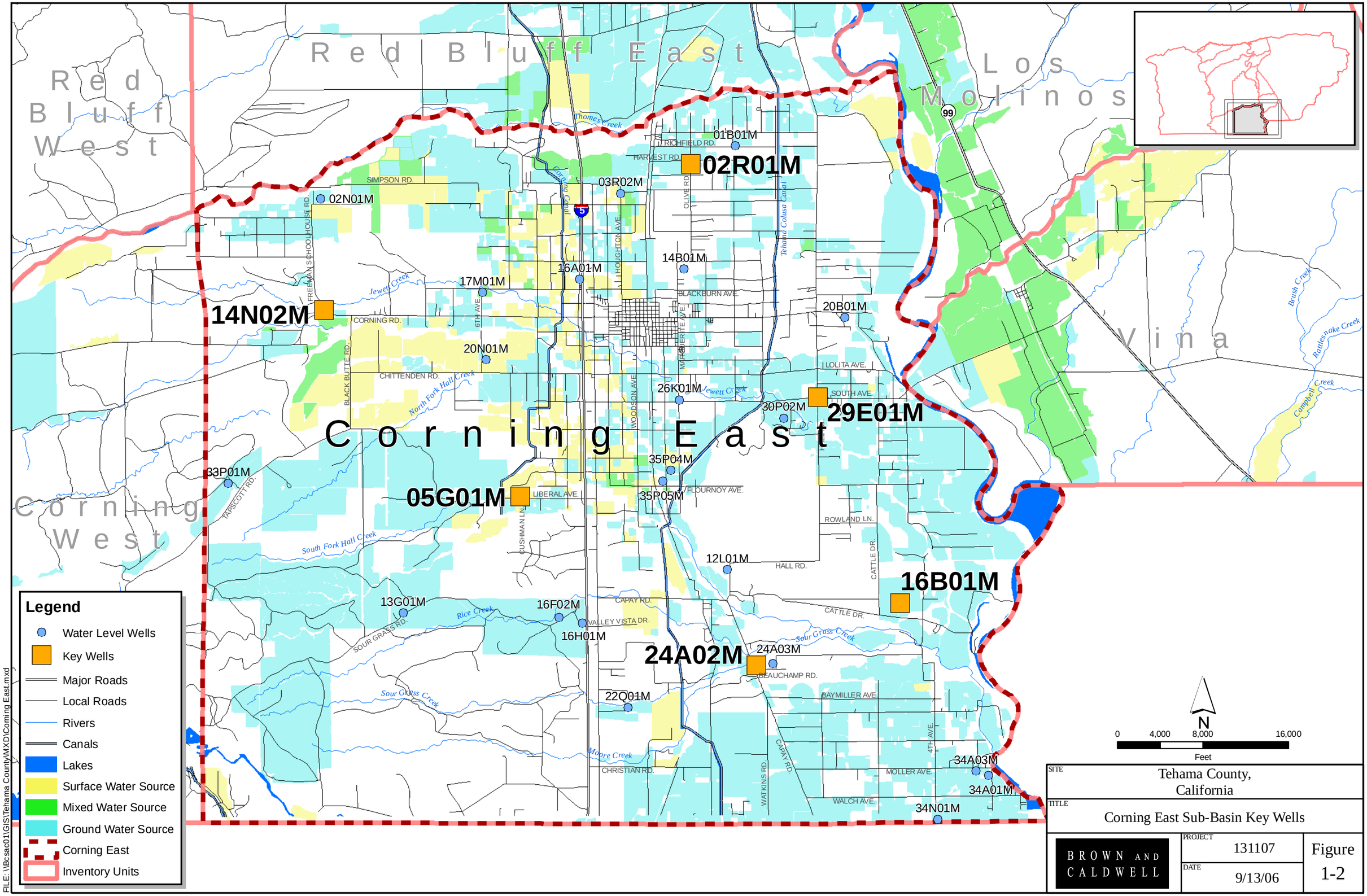
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of six proposed key wells are presented in Figure 1-2. Each of these proposed wells have a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **24N04W14N02M (14N02M) –** This monitoring well is in the northwest portion of the sub-basin and is 180 feet deep and has an unknown screened interval. This well is situated near orchards irrigated with both surface and groundwater. The nine square miles near this well contain 37 domestic wells with an average depth of 238 feet bgs, and 18 irrigation wells with an average depth of 470 feet bgs.
- **24N03W02R01M (02R01M) –** This monitoring well is in the northeast portion of the sub-basin and is 270 feet deep and has an unknown screened interval. This well is situated near orchards irrigated with groundwater and some urban land use. The nine square miles near this well contain 210 domestic wells with an average depth of 129 feet bgs, and 89 irrigation wells with an average depth of 214 feet bgs.
- **23N03W05G01M (15G01M) –** This monitoring well is in the west central portion of the sub-basin and is 70 feet deep and has an unknown screened interval.. This well is situated near pasture irrigated with surface water and orchards irrigated with groundwater. The nine square miles near this well contain 55 domestic wells with an average depth of 142 feet bgs, and 23 irrigation wells with an average depth of 307 feet bgs.
- **24N02W29E01M (29E01M)–** This monitoring well is in the east portion of the sub-basin, is 295 feet deep, and has a screened interval from 42 feet to 295 feet bgs. This well is situated near orchards irrigated with groundwater. The nine square miles near this well contain 164 domestic wells with an average depth of 129 feet bgs, and 87 irrigation wells with an average depth of 190 feet bgs.
- **23N02W16B01M (16B01M)–** This monitoring well is in the southeast portion of the sub-basin, is 120 feet deep, and has a screened interval from 100 feet to 120 feet bgs. This well is situated near pasture irrigated with groundwater. The nine square miles near this well contain 107 domestic wells with an average depth of 124 feet bgs, and 26 irrigation wells with an average depth of 307 feet bgs.



SITE	Tehama County, California
TITLE	Corning East Sub-Basin Key Wells
BROWN AND CALDWELL	PROJECT 131107
	DATE 9/13/06
	Figure 1-2

- **23N03W24A02 (24A02M)–** This monitoring well is in the southeastern portion of the sub-basin, is 200 feet deep, and the screened interval is unknown. This well is situated near pasture irrigated with groundwater. The nine square miles near this well contain 49 domestic wells with an average depth of 125 feet bgs, and 20 irrigation wells with an average depth of 310 feet bgs.

There are currently no monitoring wells in the southwestern corner of the Corning East sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

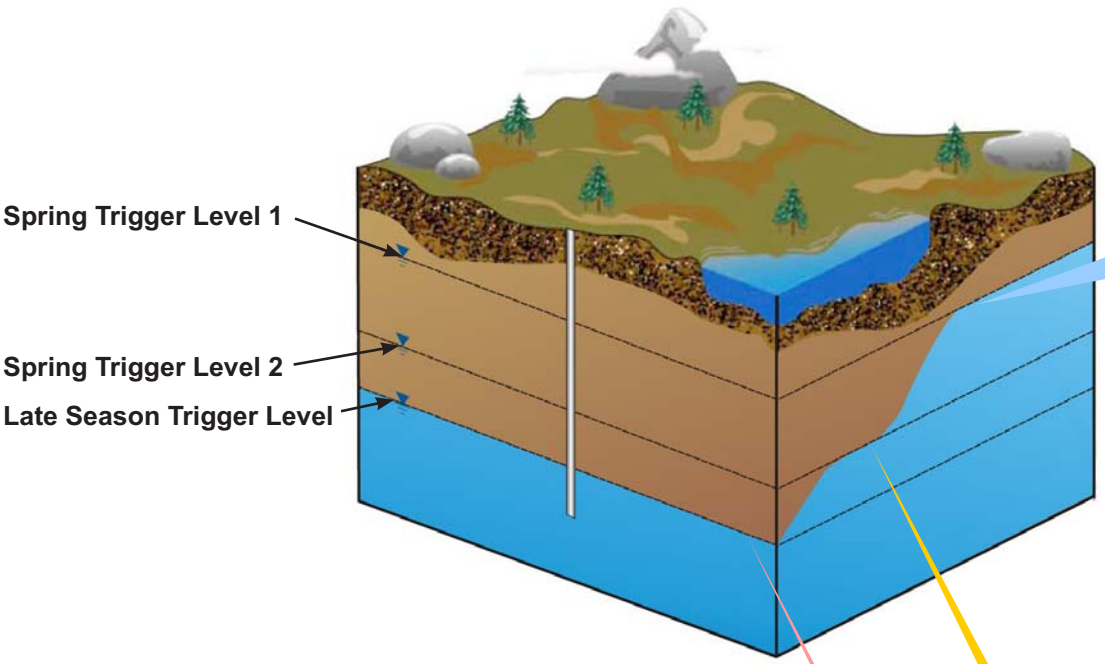
The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows two suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-21 present hydrographs and suggested trigger levels for each of the Corning East key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water below ground surface in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Corning East sub-basin are provided in Table 1-1. Some trigger levels were set using exceptions from the methodologies to account for measurements that are outside the range of normal spring and summer measurements.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Corning East Monitoring Well Number					
	14N02M	02R01M	05G01M	29E01M	16B01M	24AO2M
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements					
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1					
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements					
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements					
Data Anomalies	A	None	B	None	None	C

Footnotes:

A: Late Season Trigger Level set above single outlier water level elevation. The reported low level may be an inaccurate measurement.

B: Spring Trigger Level 2 set above single outlier water level elevation. Low point in 1997 is inconsistent with other spring water level trends in this area.

C: Depth to groundwater was very shallow in the spring of 1983 and not typical of the other years. This measurement was omitted when calculating the range in spring measurements and to propose Spring Trigger Levels.

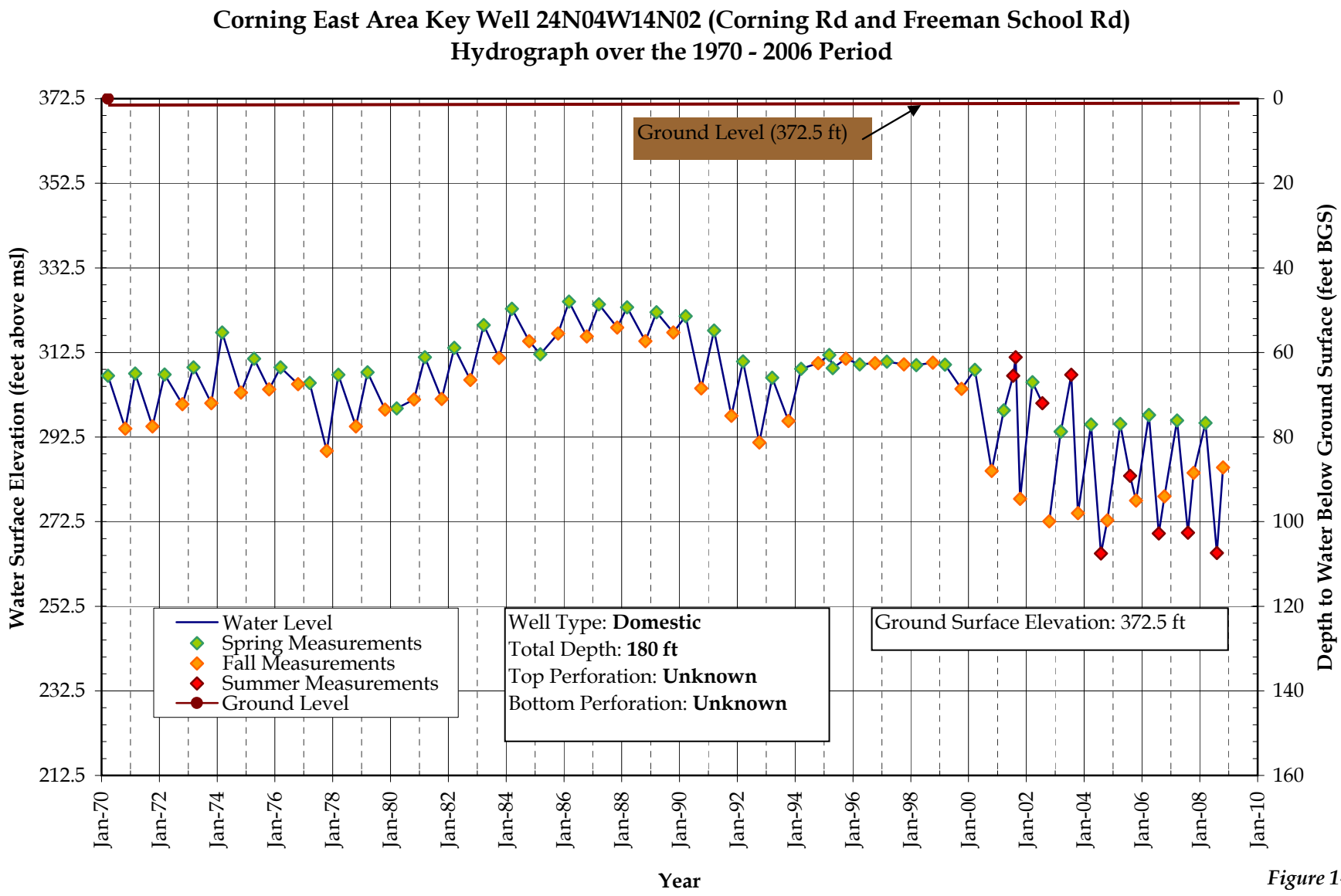


Figure 1-4
Hydrograph of Key Well 24N04W14N02

Updated 12-01-08

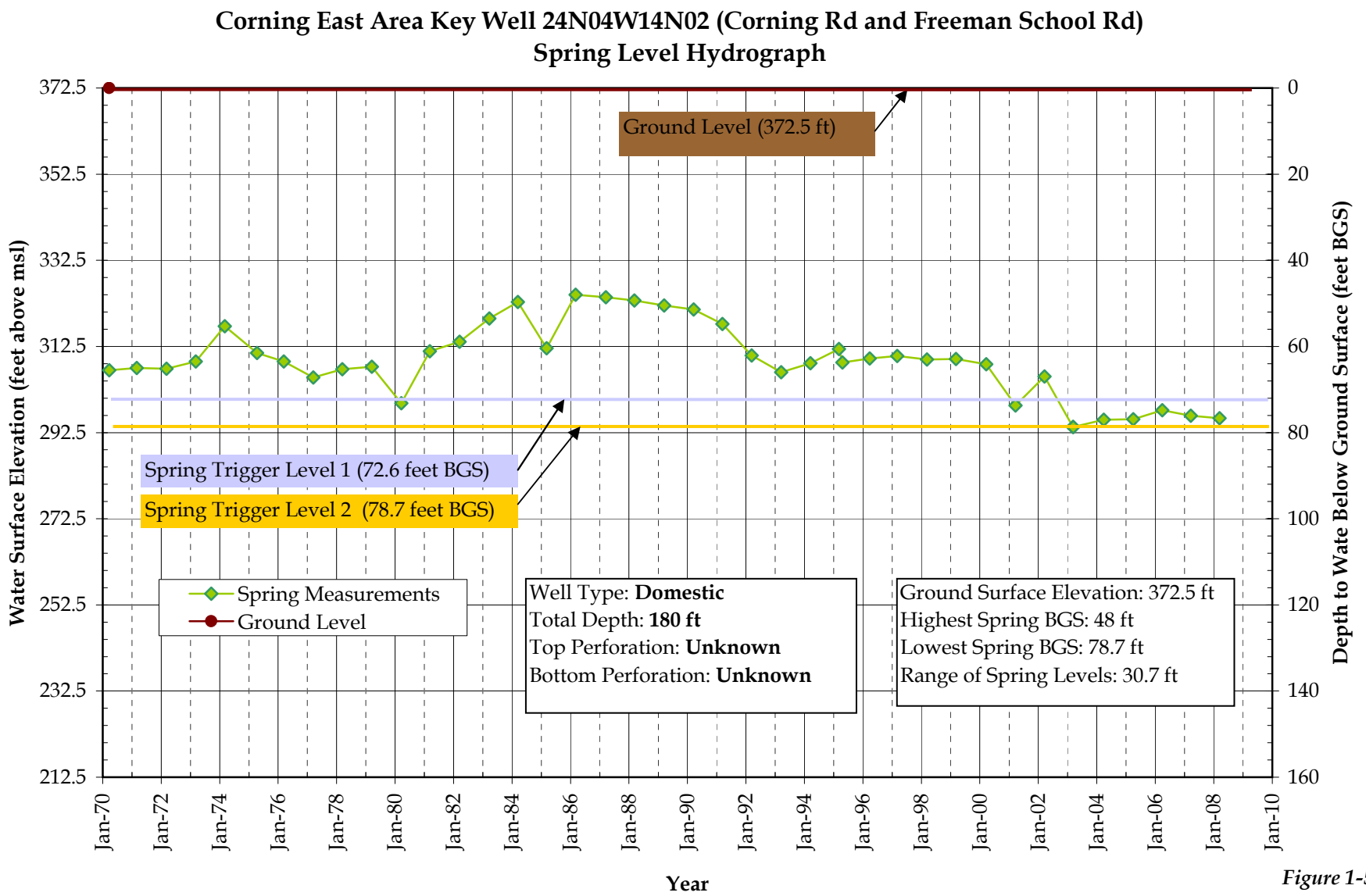


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

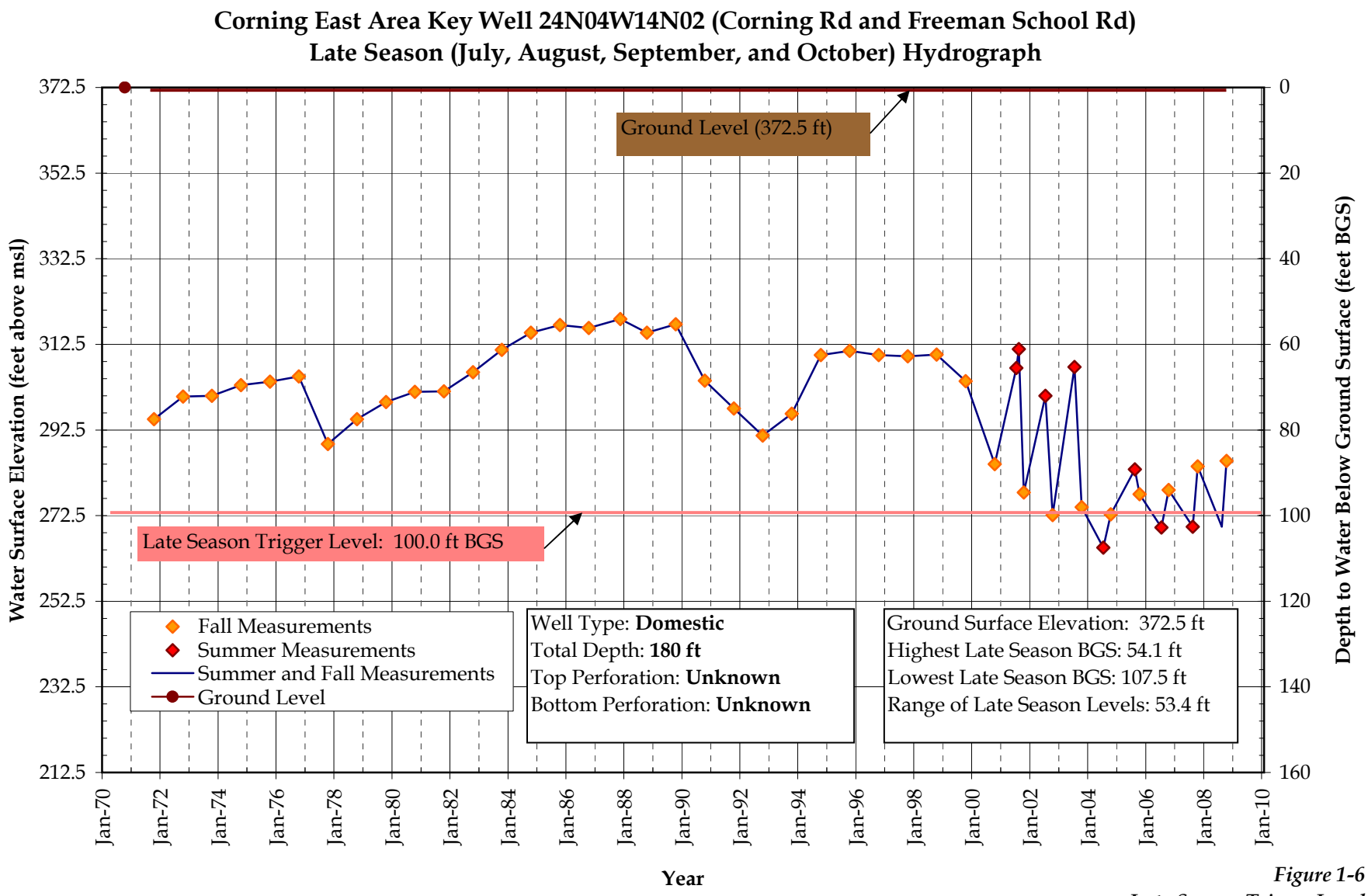


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

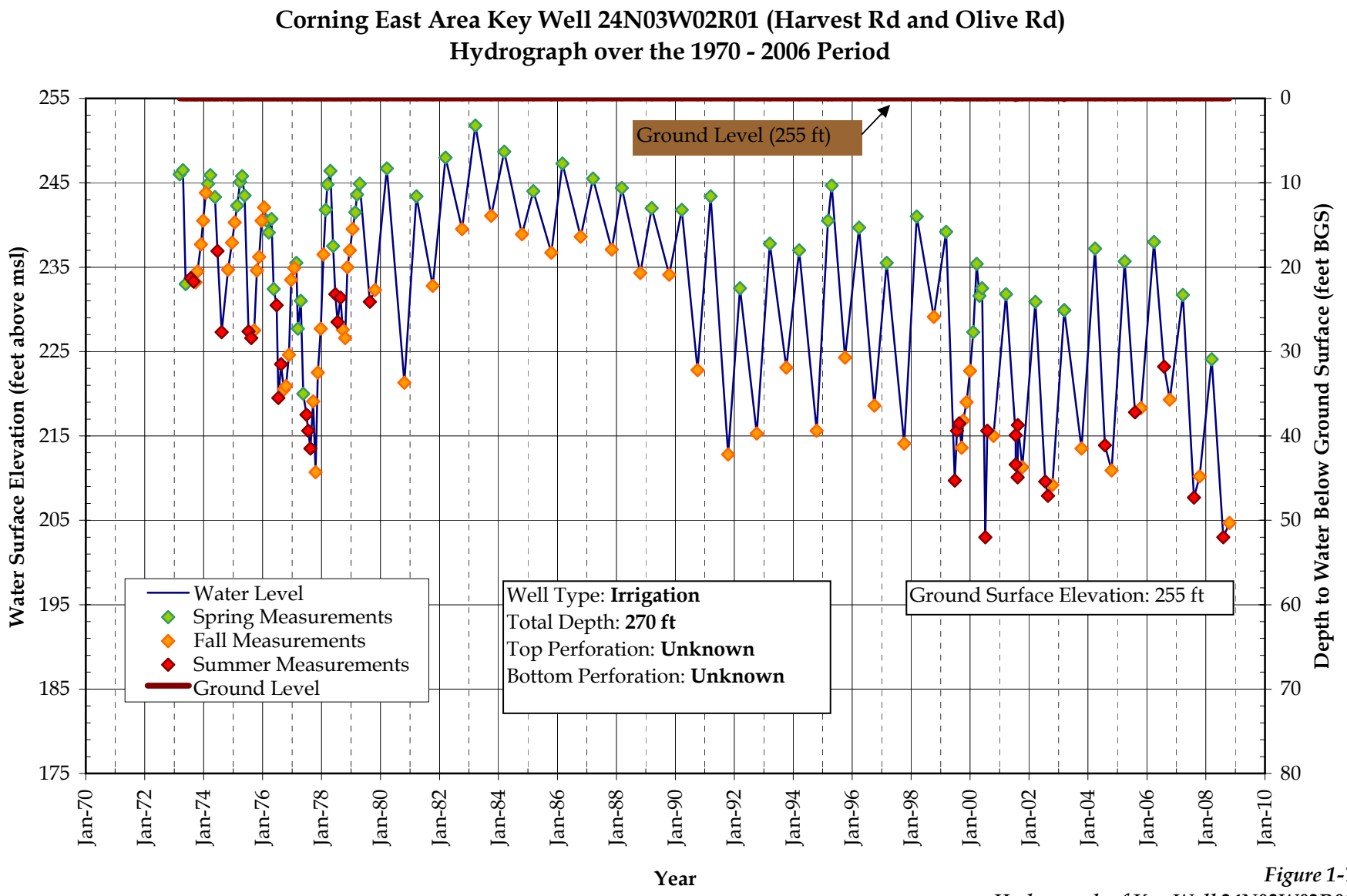


Figure 1-7
Hydrograph of Key Well 24N03W02R01

Updated 12-01-08

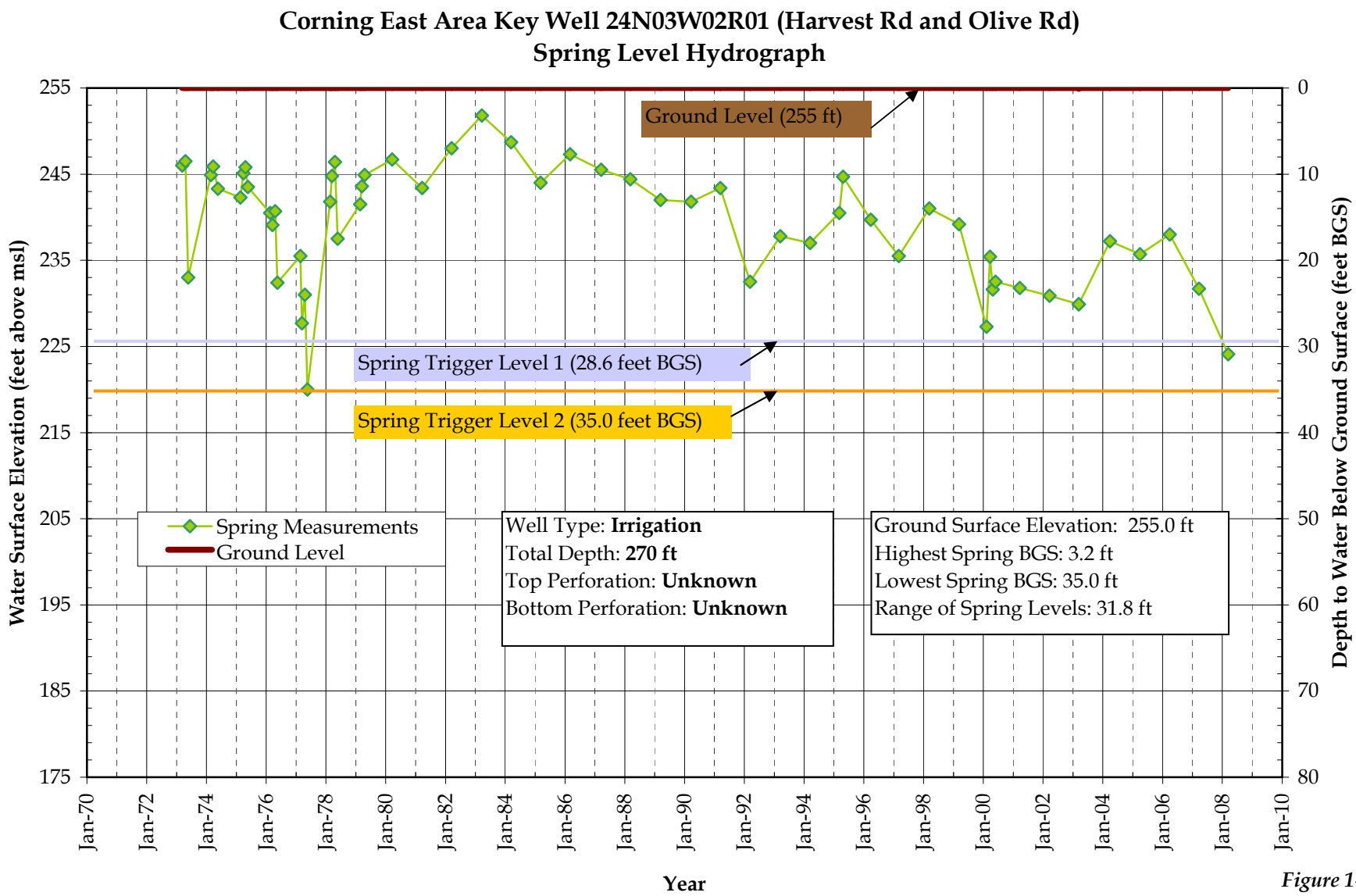


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

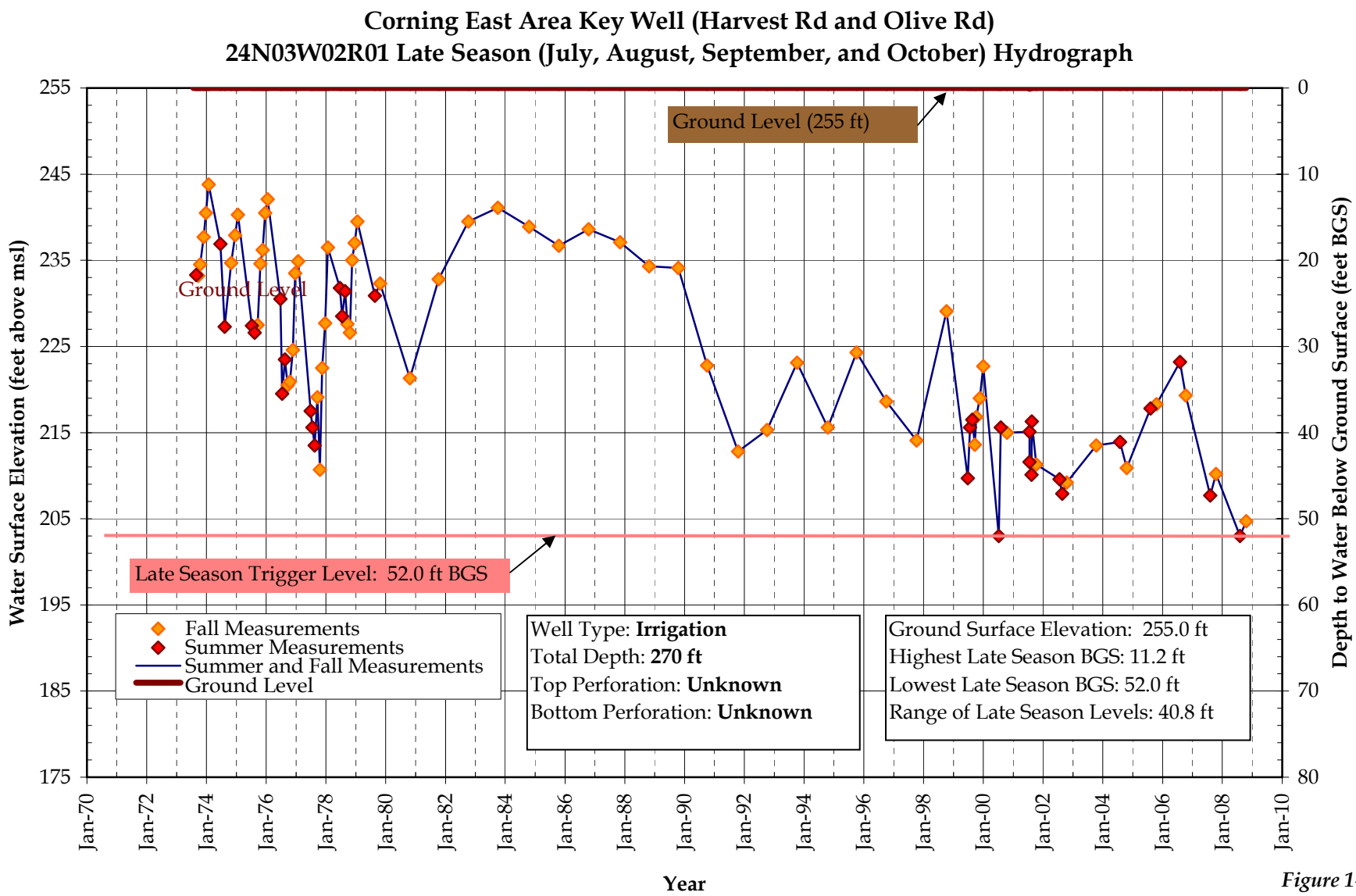


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

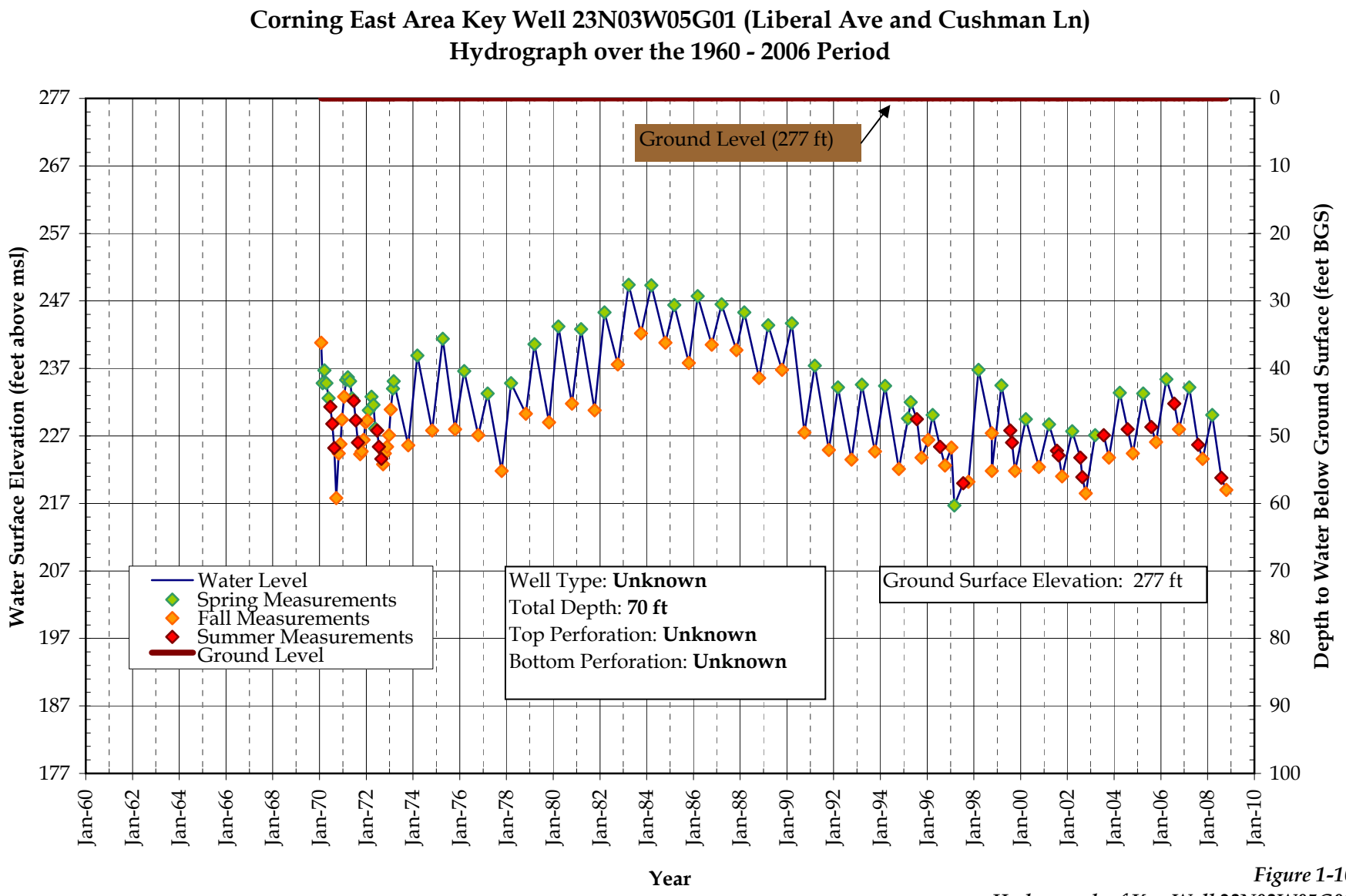


Figure 1-10
Hydrograph of Key Well 23N03W05G01

Updated 12-01-08

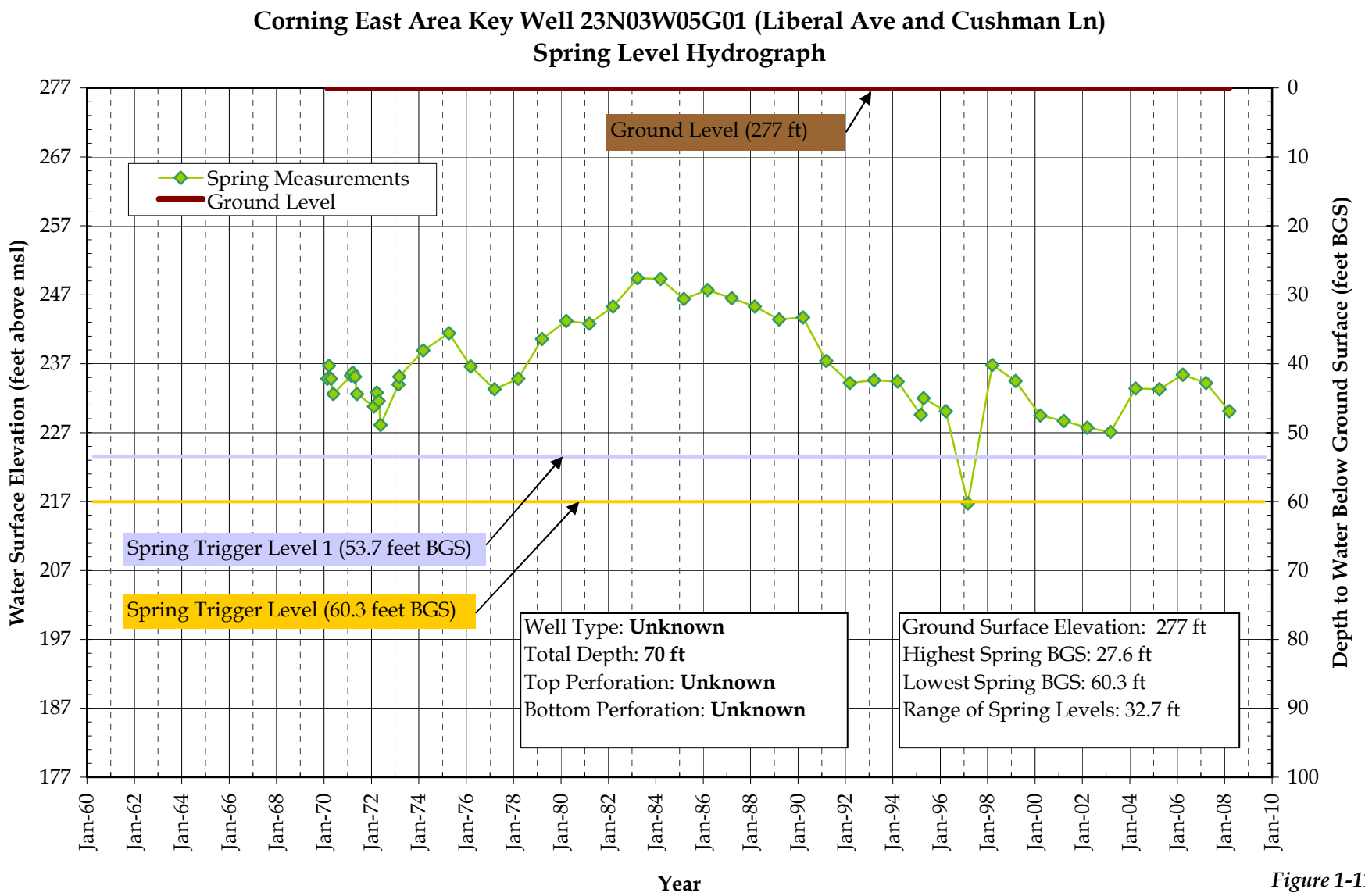


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

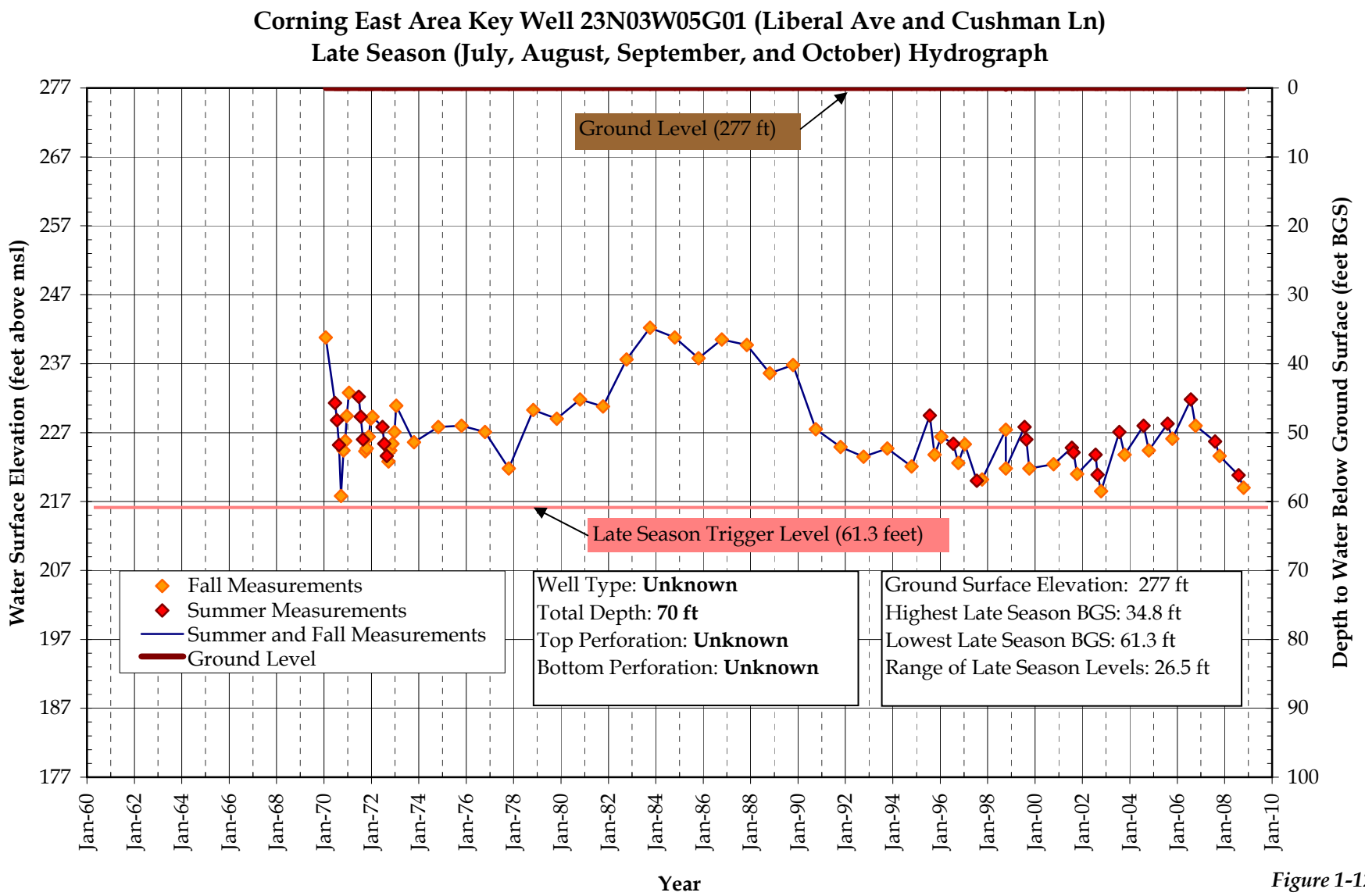


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

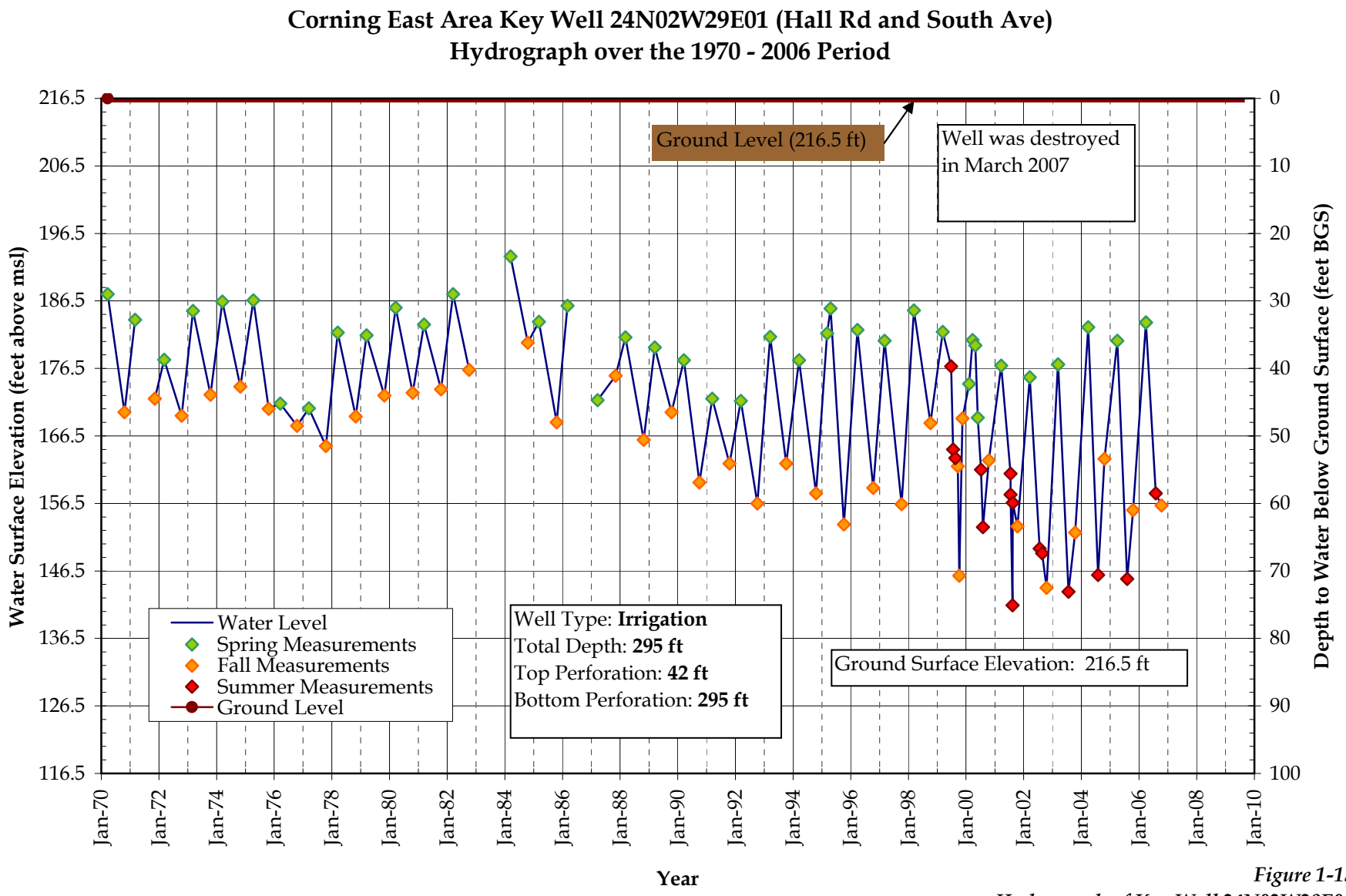


Figure 1-13
Hydrograph of Key Well 24N02W29E01

Updated 12-01-08

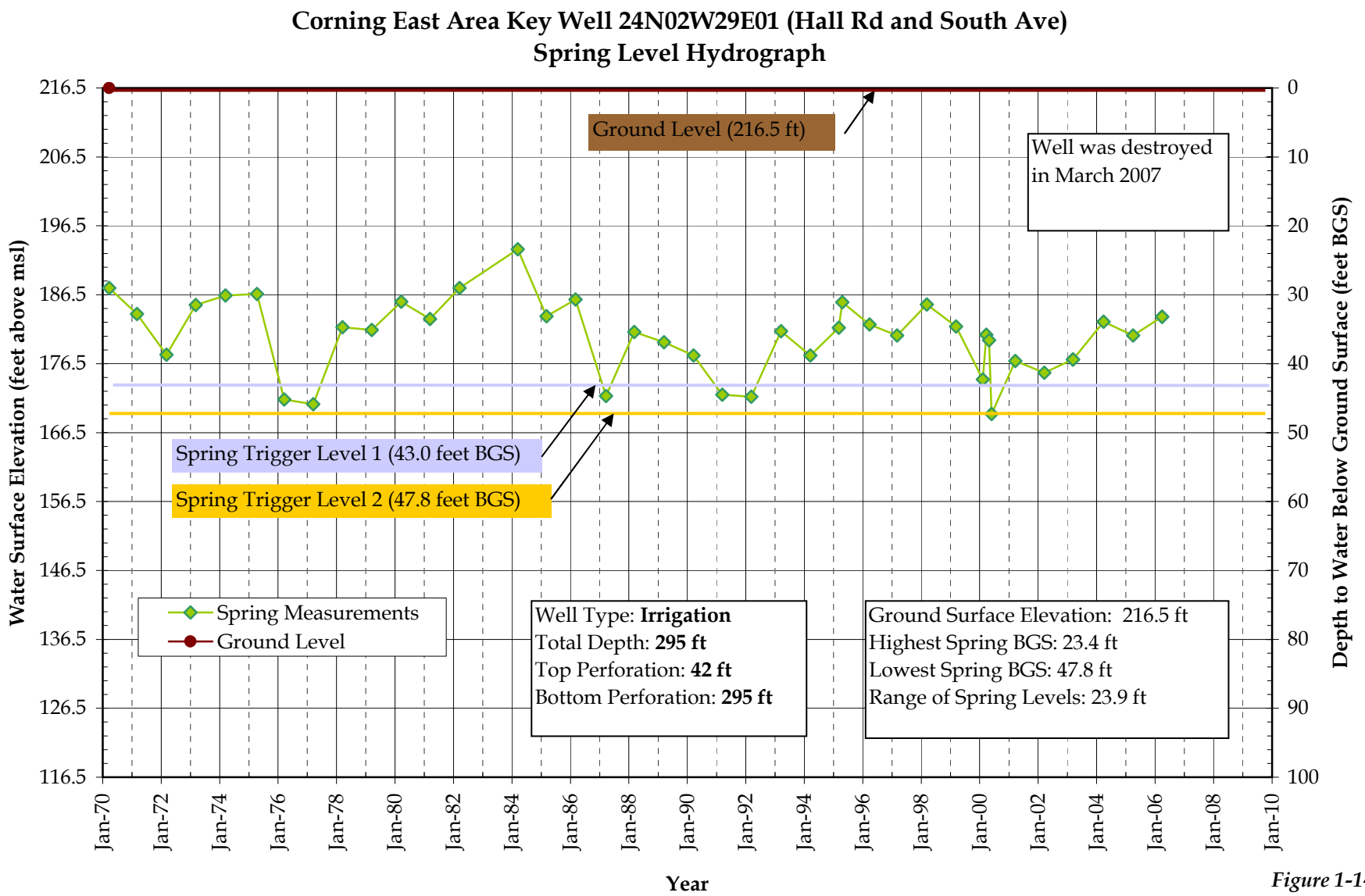


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

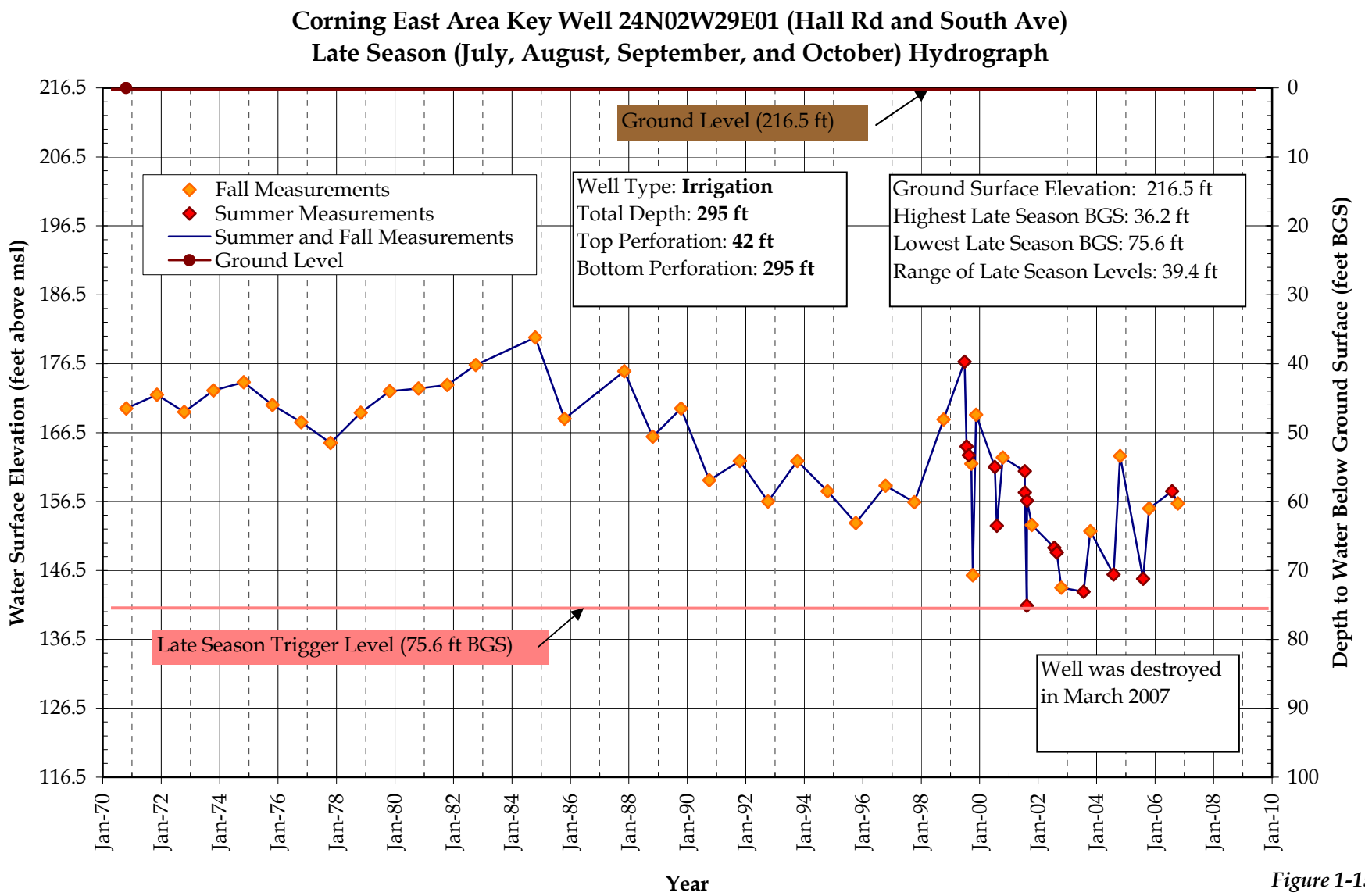


Figure 1-15
Late Season Trigger Level

Updated 12-01-08

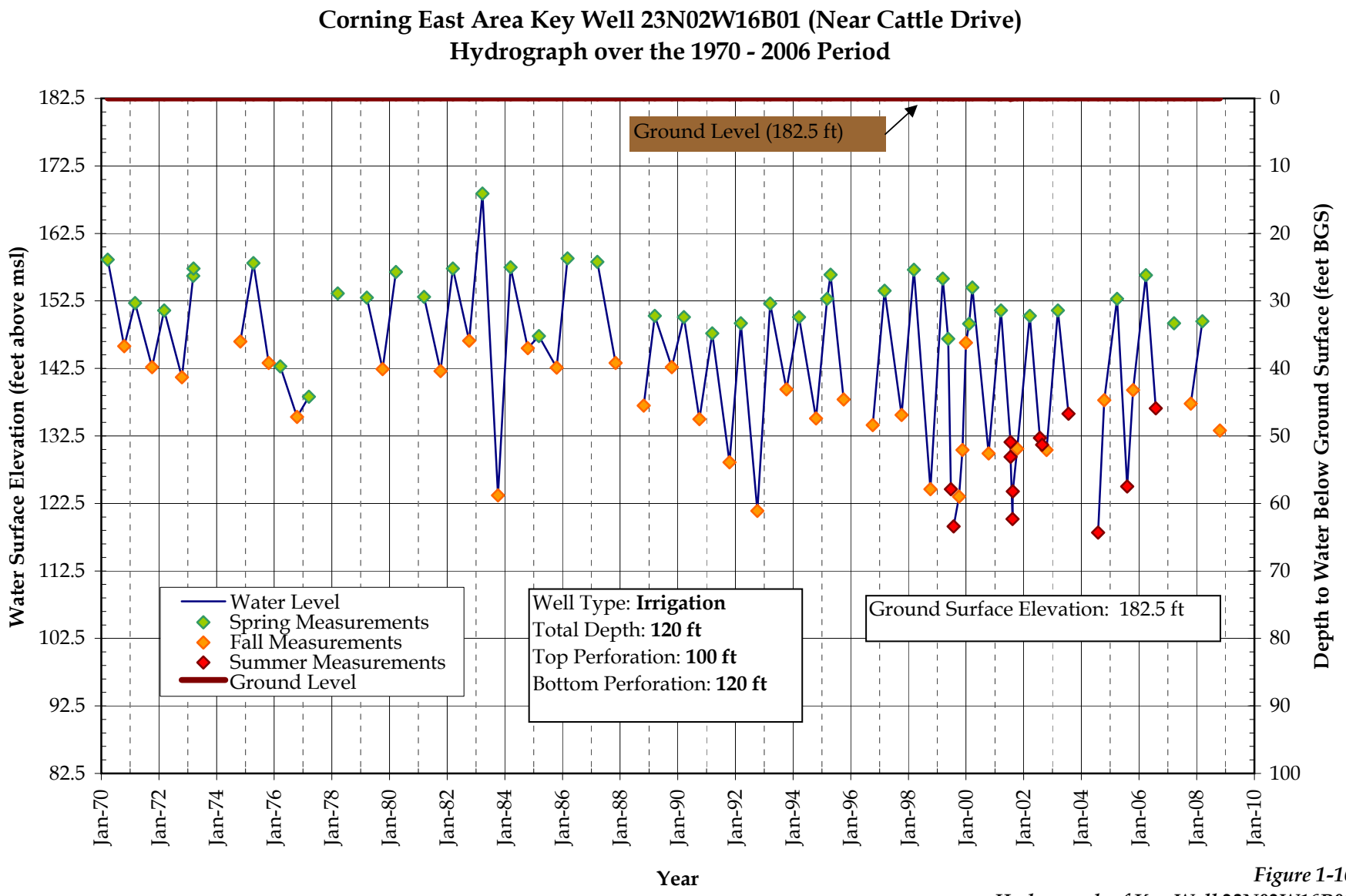


Figure 1-16
Hydrograph of Key Well 23N02W16B01

Updated 12-01-08

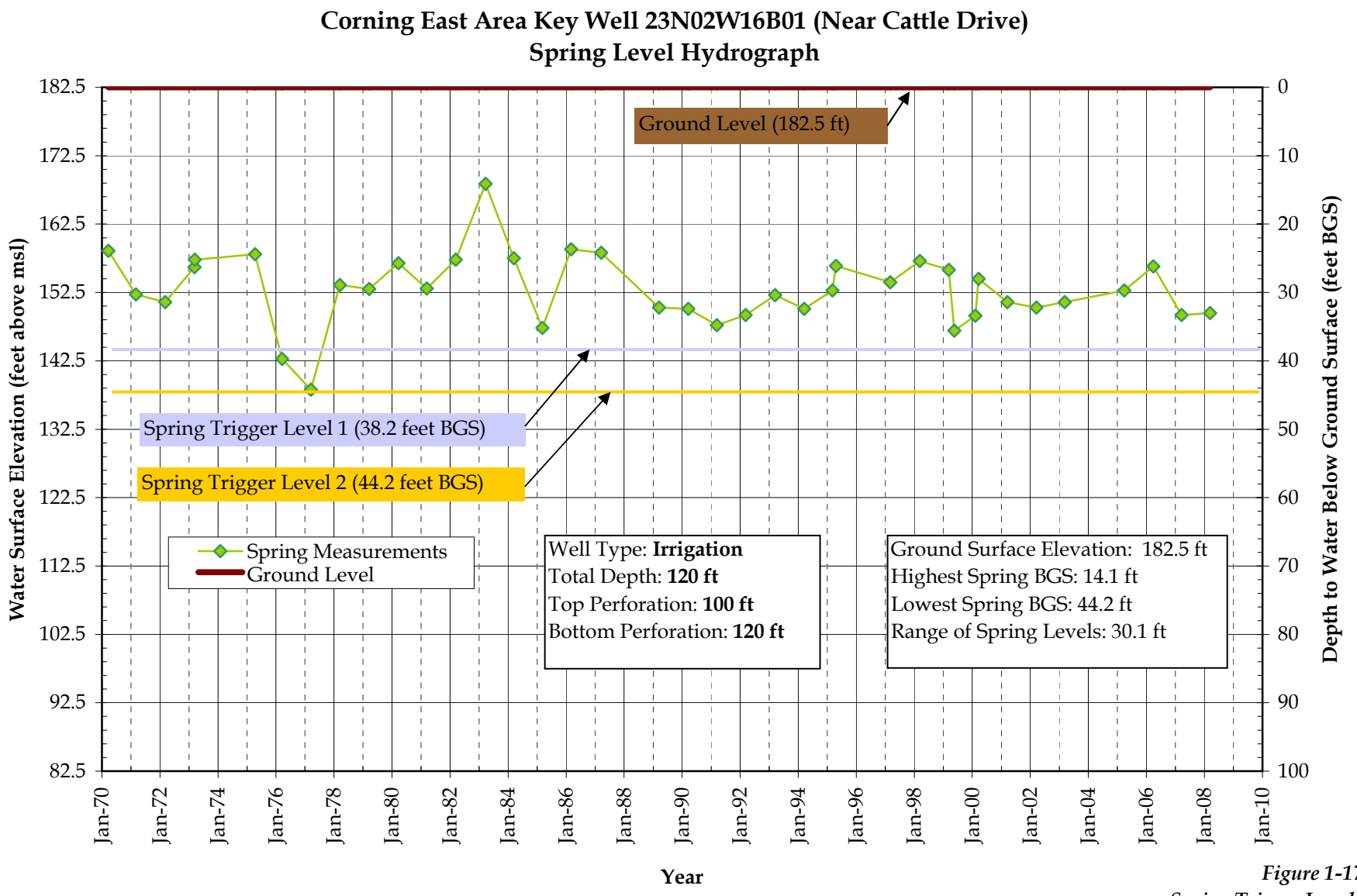


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

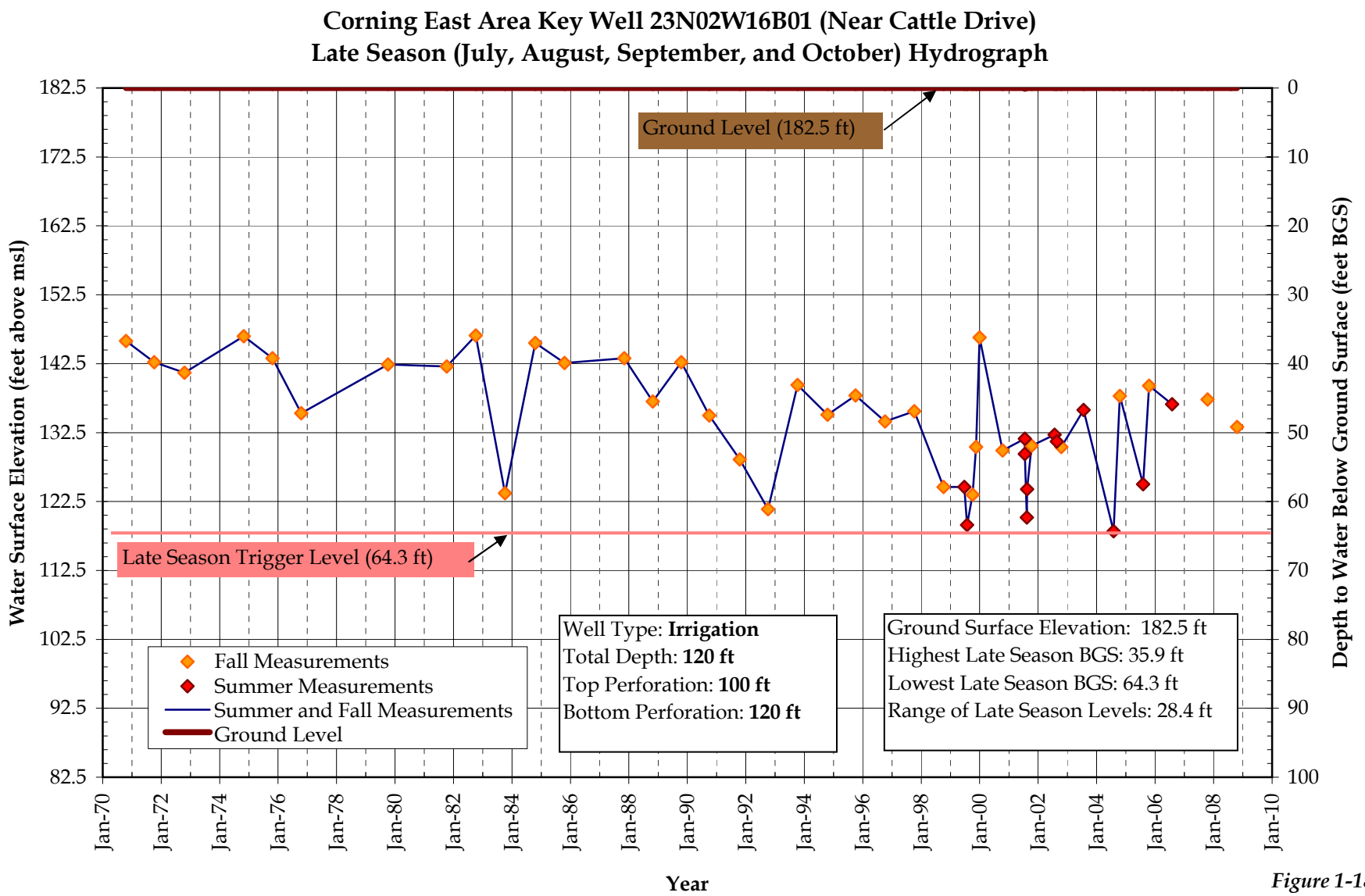


Figure 1-18
Late Season Trigger Level

Updated 12-01-08

Corning East Area Key Well 23N03W24A02 (Capay Rd and Sour Grass Creek Vicinity)
Hydrograph over the 1965 - 2008 Period

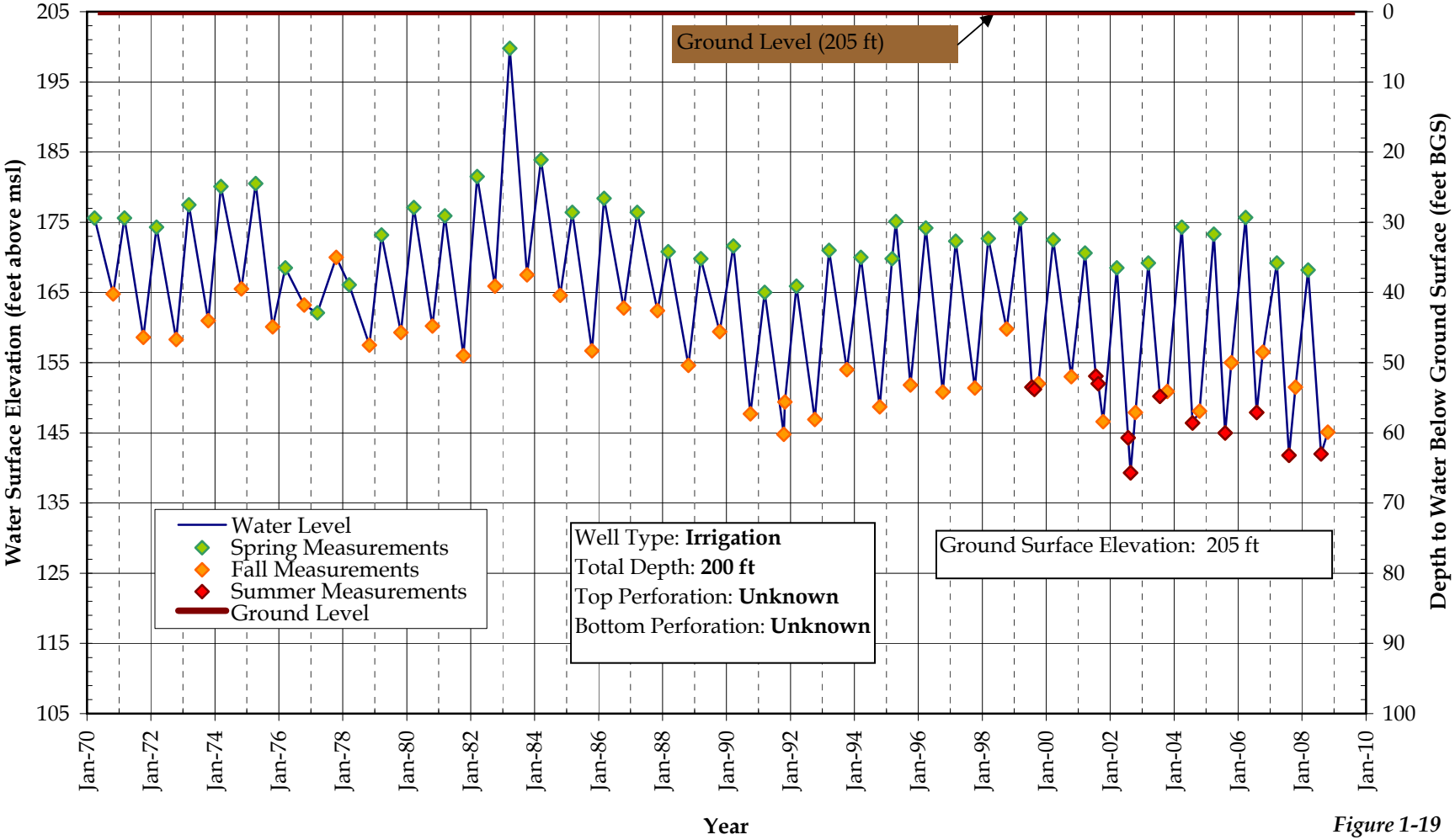


Figure 1-19
Hydrograph of Key Well 23N03W24A02

Updated 12-01-08

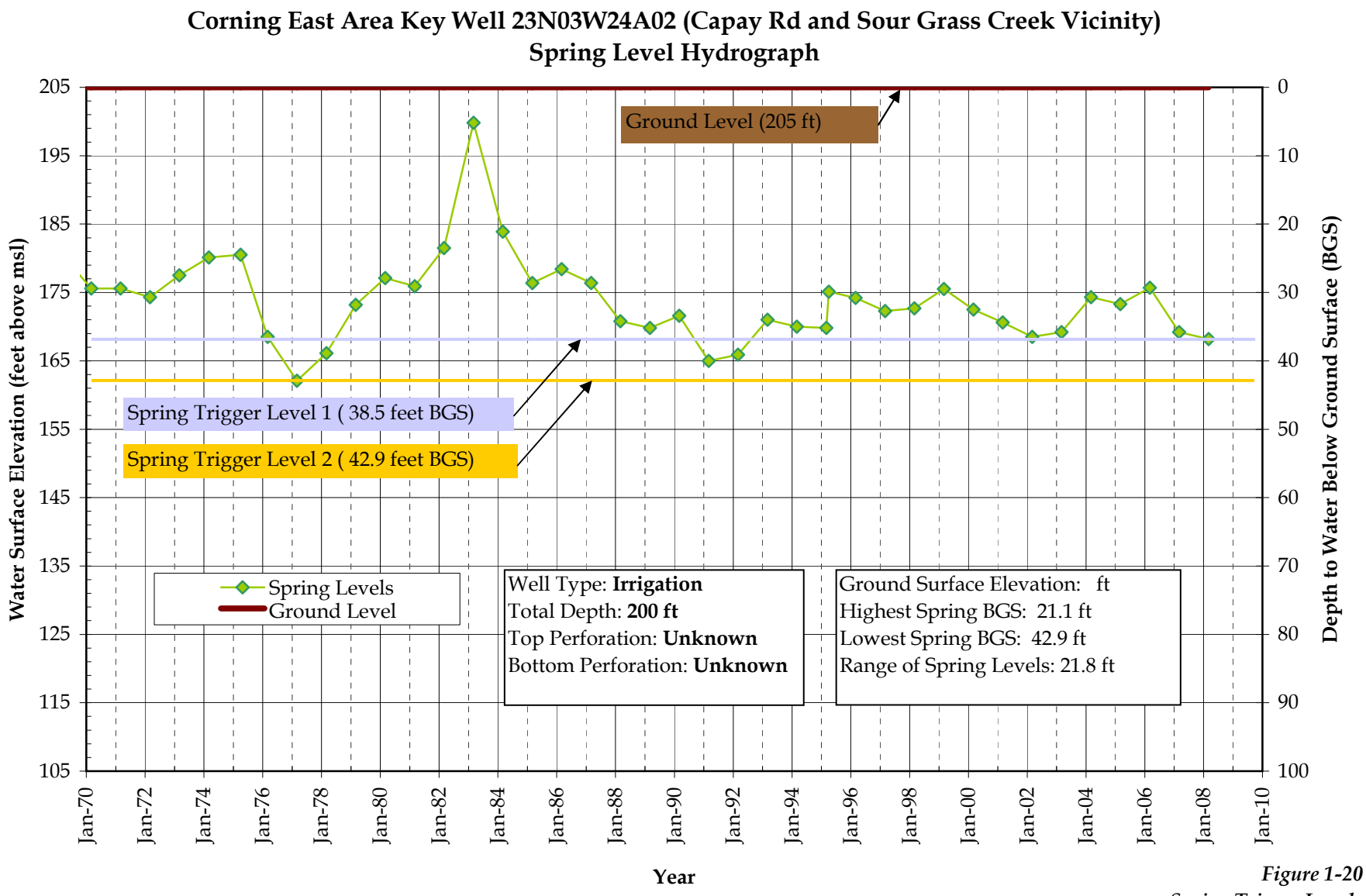


Figure 1-20
Spring Trigger Levels

Updated 12-01-08

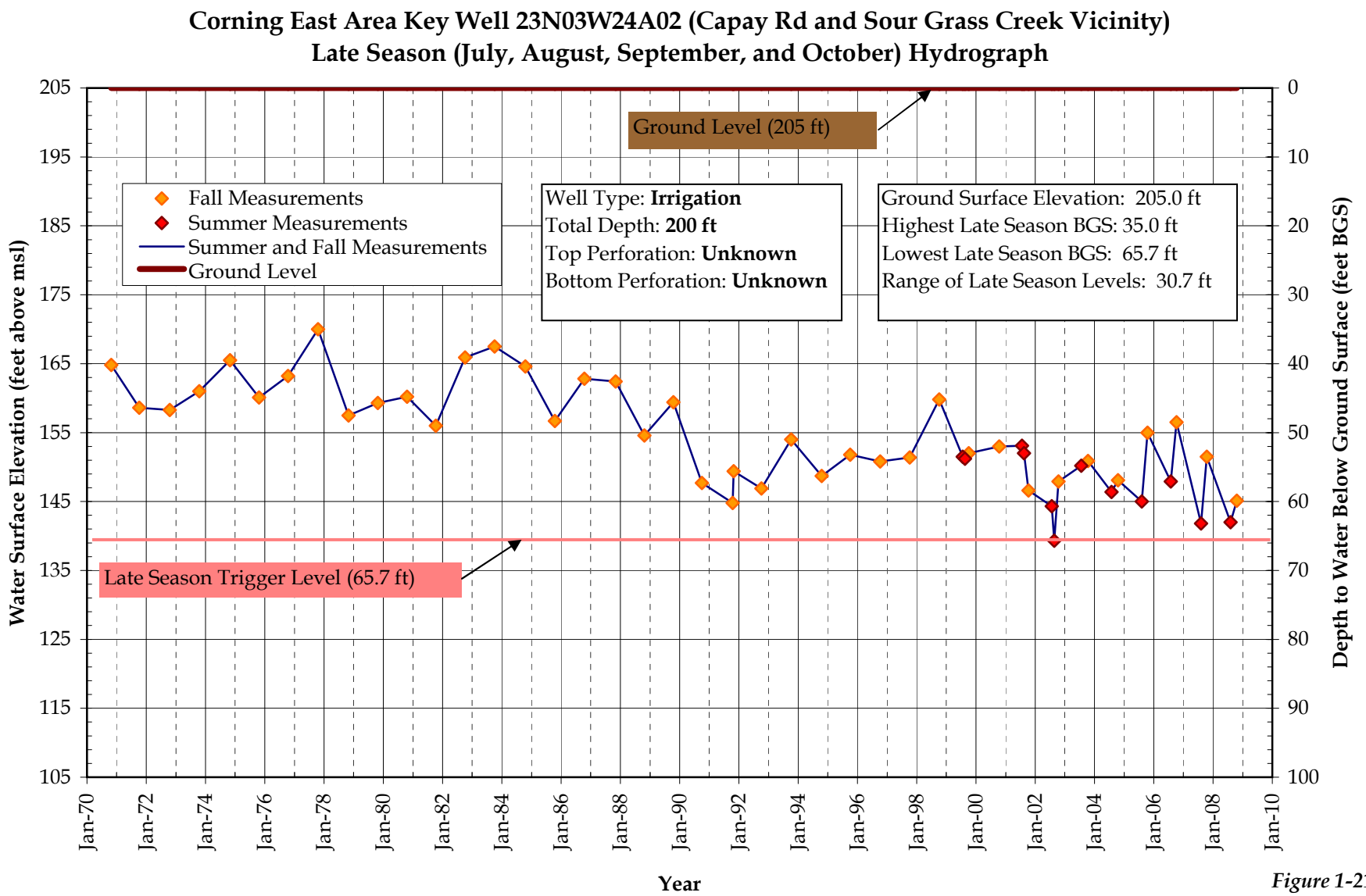


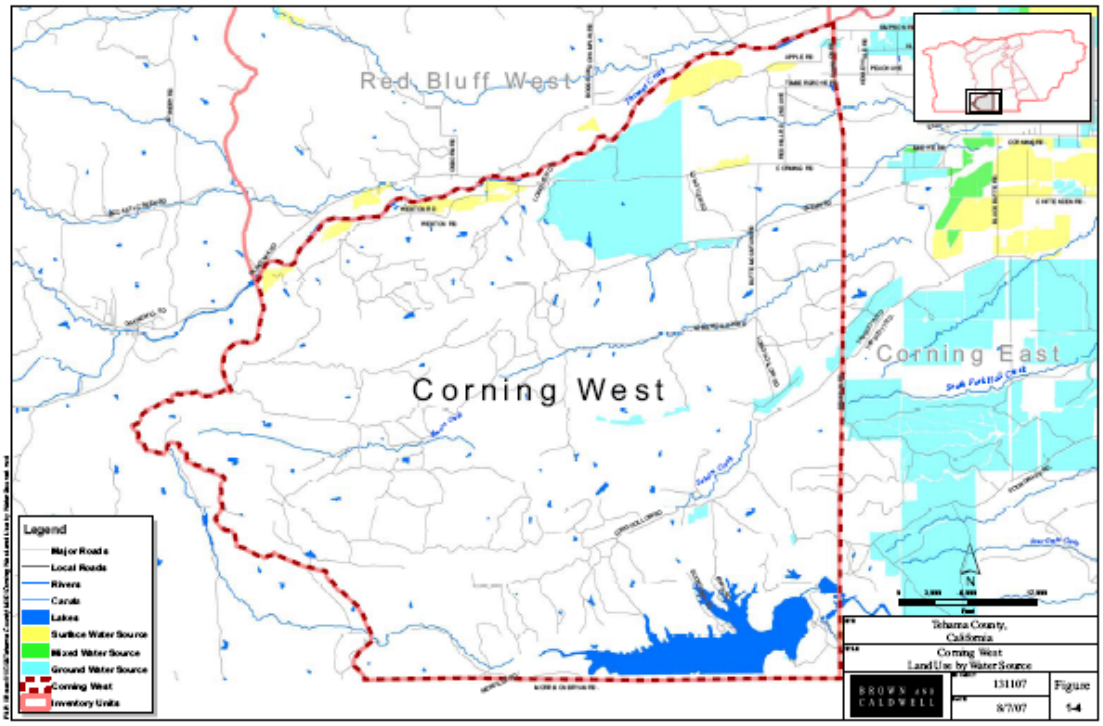
Figure 1-21
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Corning West Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Corning West Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

INTRODUCTION

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. Trigger Levels are developed through a five step process as described in Section 1. Corning West does not have monitoring wells, and instead of developing trigger levels, will determine priority areas for future monitoring as described in Section 2.

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan incorporated citizen input, review, and approval over a period of three years, Final adoption by the Tehama County FCWCD was achieved in 1998.

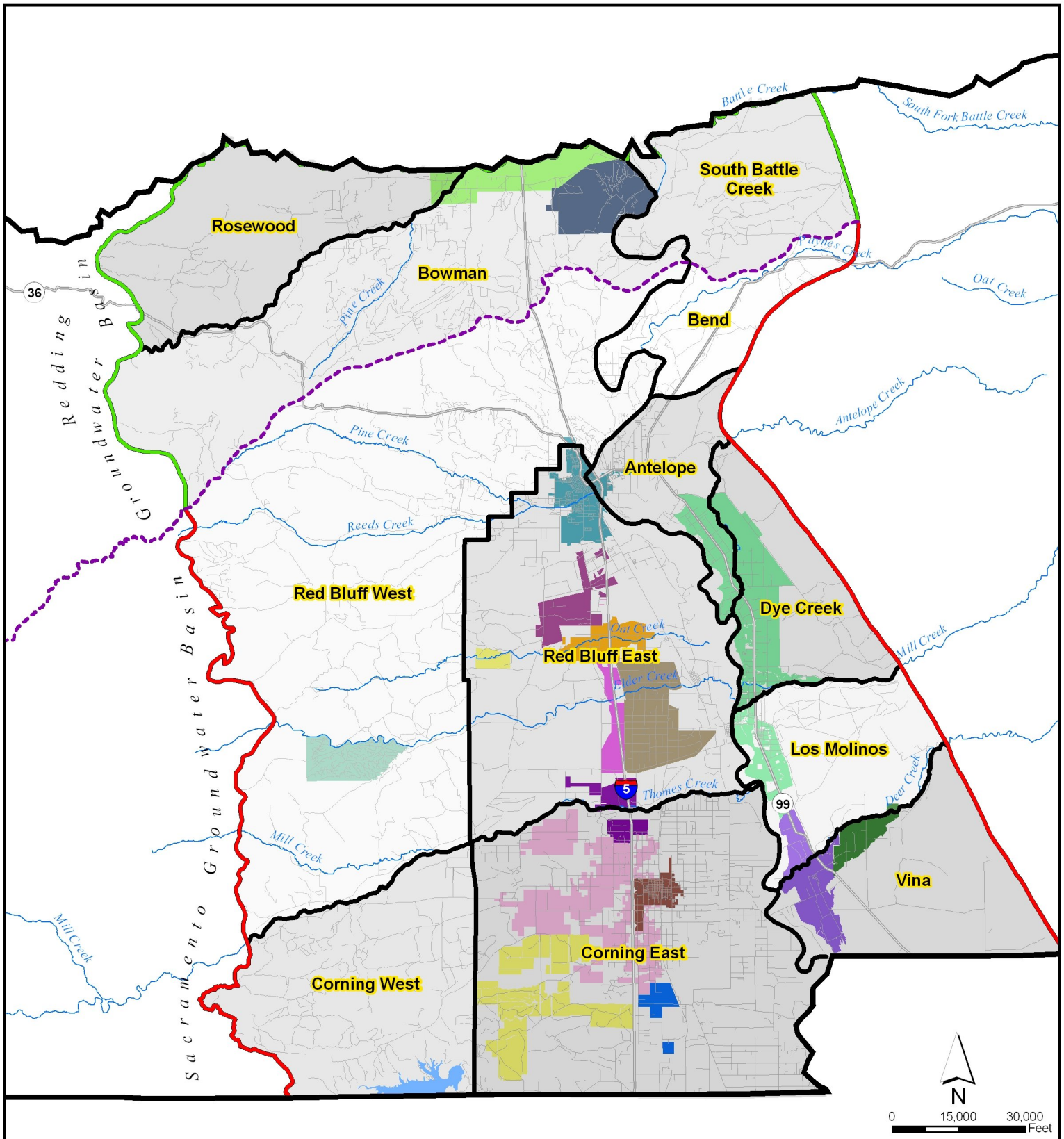
The Plan states that one of the District's functions under the Plan is to provide guidance in the development of groundwater trigger levels. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various trigger levels of increased groundwater discussion, investigation or local management actions.

Sections 325 through 329 of the Plan describe the trigger level concept and detail the District's role in trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Corning West sub-basin. Since its inception, the Plan has provided guidance related to groundwater activities. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. Section 1 of this TM describes the methodology used to develop trigger levels.

Because the Corning West Sub-Basin does not have formal groundwater monitoring, such as a dedicated monitoring well or wells included in the Department of Water Resources (DWR) monitoring grid, Section 2 of this TM identifies potential areas for new groundwater monitoring within the Corning West Sub-Basin.

Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ . Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in each sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1. Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process, listed below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose.

The trigger level's purpose describes the intent of the trigger levels in the area. The purpose may reflect the desire of sub-basin planners to protect historic groundwater uses, minimize long-term drawdown of groundwater levels, maintain springs and habitat, and/or protect groundwater supplies for domestic and irrigation uses.

Step 2: Select one or more key wells within the sub-basin.

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to initiate management activities. If no monitoring wells are available in a sub-basin, such as Corning West, then locations for new monitoring wells should be selected.

When selecting new areas for monitoring, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Groundwater levels are more likely to be stressed in areas of active land use. Areas with fixed water demand crops such as orchards should be higher priority areas for monitoring.

Water Source: Groundwater supplies in areas irrigated with groundwater are more likely to be stressed during drought periods. Locating monitoring wells in areas reliant on groundwater would provide useful information for groundwater management, and should be higher priority areas for monitoring.

Existing Well Infrastructure: Well drilling records should be considered. The screened intervals of monitoring wells should be similar to the average screened interval of production wells in the area.

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well.

Once monitoring wells have been located and developed in an area, the remaining three trigger level steps can take place.

Step 3: Designate the time of seasonal measurement.

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the pumping impacts within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use that can provide a warning of potential issues such as increased groundwater demand.

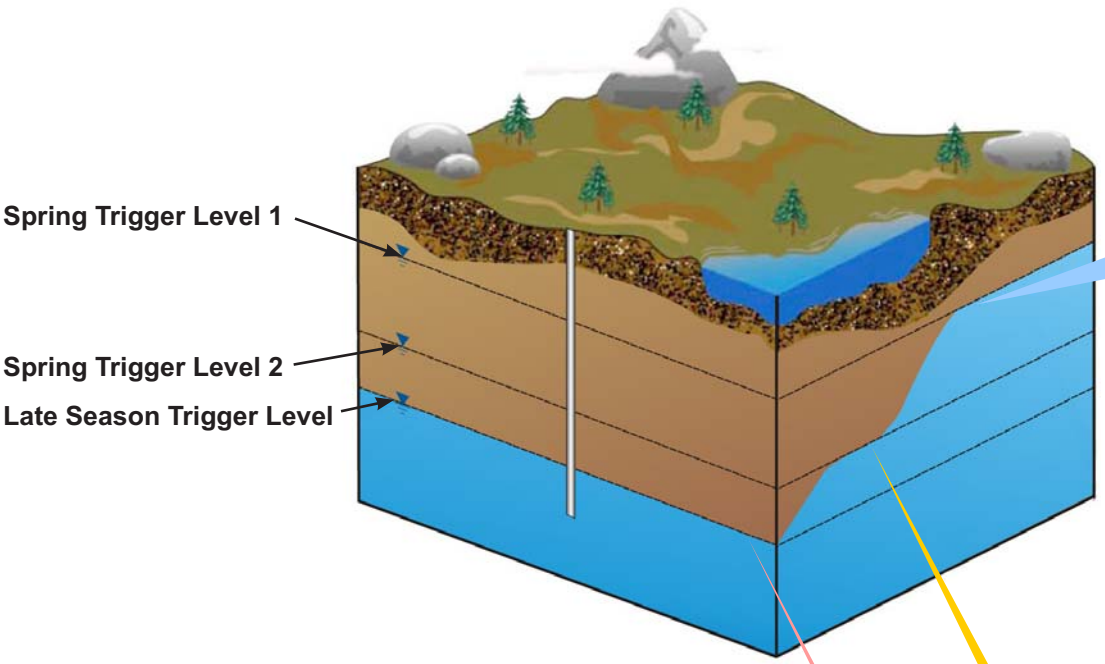
Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level.

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-2).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, (indicating a need to disseminate information or further investigation of groundwater levels), to a larger change in groundwater levels, (indicating a need to take action to stop or reduce the lowering of groundwater levels).

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. As an example, Figure 1-2 shows a diagram that details two suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-2
Trigger Levels and Awareness Actions

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

2. Corning West Trigger Level Development

Because Corning West does not have monitoring wells, this section is focused on the implementation of the first two steps of the five step methodology:

Step 1: Describe the trigger level's purpose.

The Corning West sub-basin is primarily a rural area, with agriculture in the eastern portion of the sub-basin. Groundwater is used for agricultural and domestic purposes. There are no organized irrigation districts in the Corning West sub-basin, as indicated in Figure 1-1. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Corning West:	
Irrigation:	90% (900 acre-ft)
Municipal, and Industrial:	10% (100 acre-ft)
Number of wells by type in Corning West:	
Irrigation:	14 wells
Domestic:	60 wells
Municipal and Industrial:	1 wells

- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies to protect supplies for current and future uses.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin.

There are currently no monitoring wells located within the Corning West sub-basin. According to the DWR database, there are 74 reported wells in Corning West, none of which are included in the DWR monitoring grid. Groundwater levels in key wells provide information necessary to initiate management activities. To begin the trigger level process, the District suggests that priority areas for new monitoring be selected in the Corning West area.

When picking areas for monitoring wells in Corning West, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Figure 1-3 presents the land use in the Corning West area. Agriculture in Corning West is predominantly in the northeast, with grain and hay the predominant crop types. Future land use in Corning West is anticipated to be similar to current land use. Additional land use information can be obtained by obtaining the zoning information for the Corning West area.

Water Source: Figure 1-4 presents agricultural land use by water source in the Corning West area. Figure 1-4 demonstrates that agriculture in the northeastern portion of Corning West is irrigated with groundwater.

Existing Well Infrastructure: Figure 1-5 shows the cumulative frequency curve for domestic wells in Corning West. There are 60 domestic wells and 14 irrigation wells in the Corning West sub-basin. Fifty percent of the domestic wells are shallower than 200 feet deep, and fifty percent of the irrigation wells are shallower than 175 feet deep. Existing well infrastructure data was developed from DWR's well completion report database. DWR's database contains information on the majority of wells drilled after 1947, while wells drilled prior to 1947 are generally not included. Some wells drilled after 1947 may not have been reported to DWR (potentially up to 30%), and therefore are not included in the database.

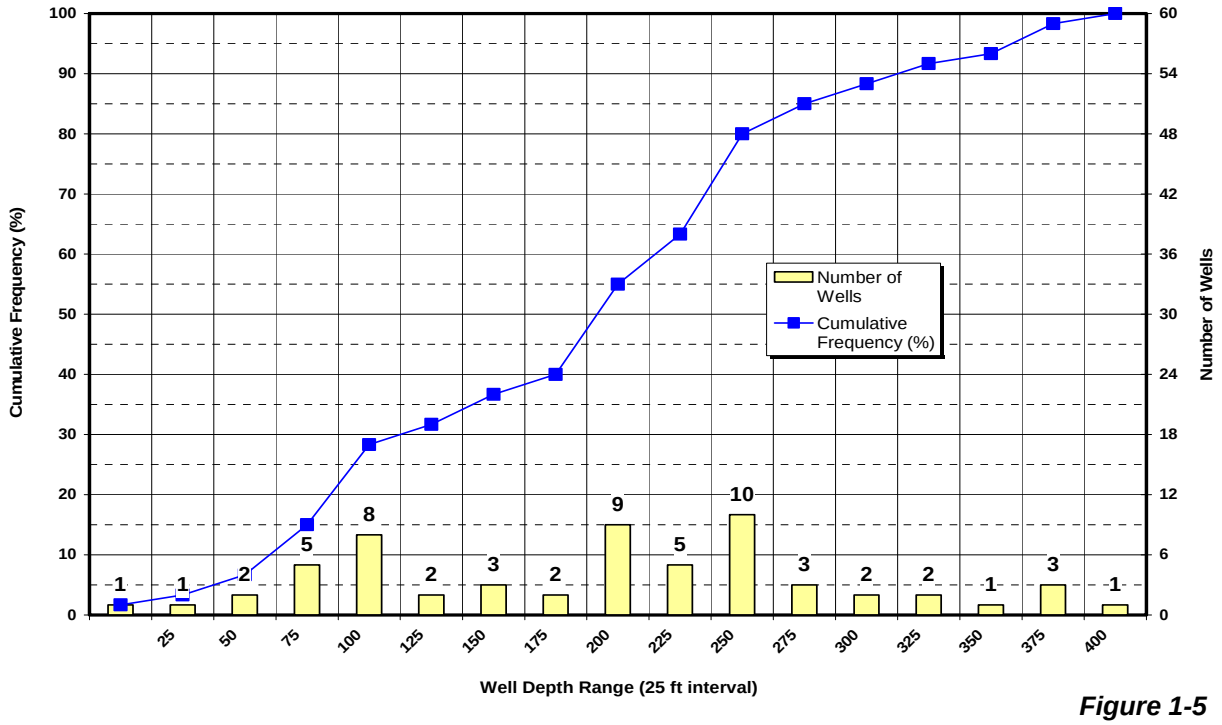
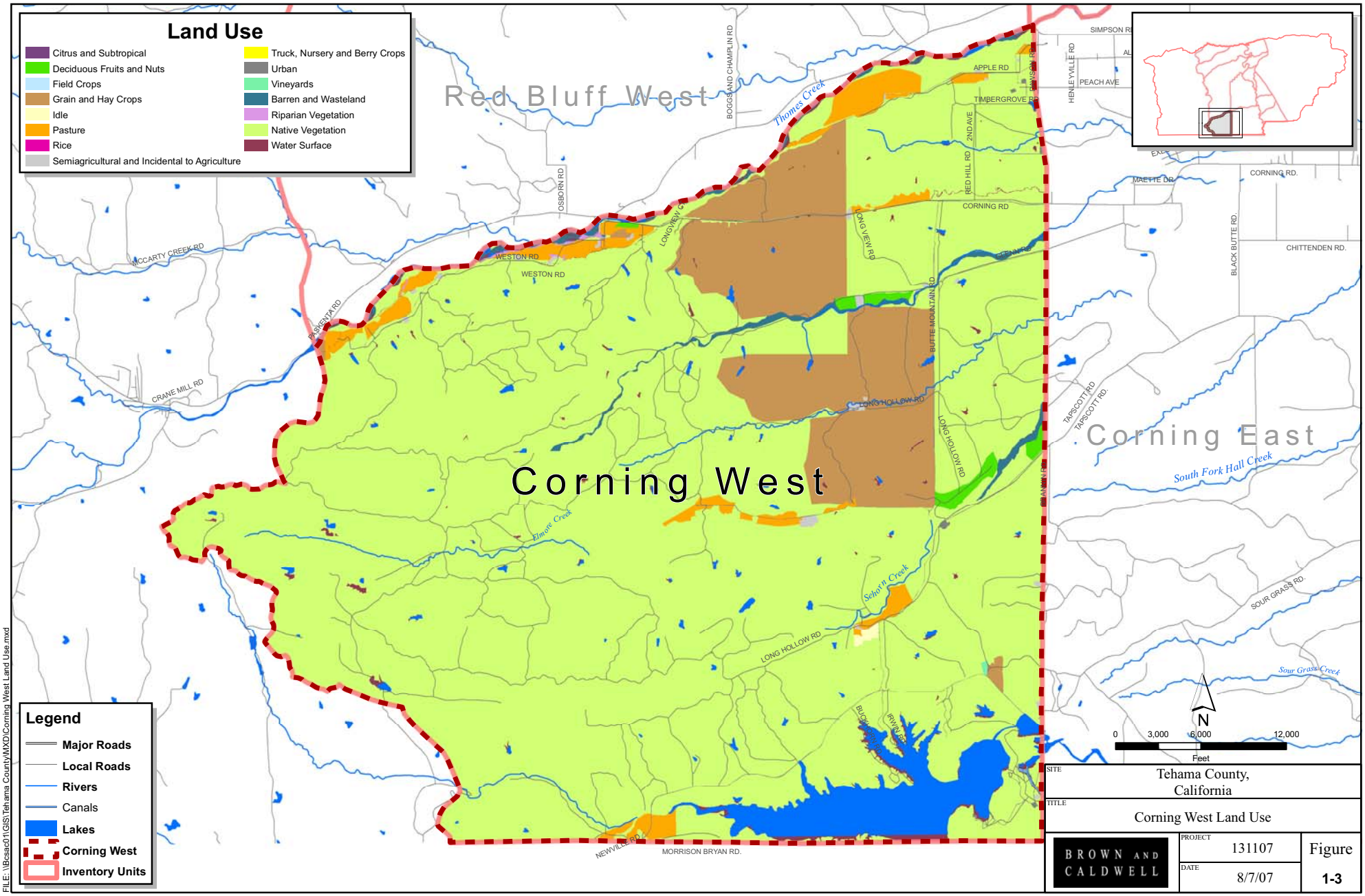


Figure 1-5
Cumulative Frequency Curve of Domestic Wells in the Corning West Sub-Basin

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well. Figure 1-4 shows the locations of any monitoring wells adjacent to Corning West. As indicated by Figure 1-4, there are no monitoring wells near the boundary of Corning West, and new monitoring wells can be sited near the boundary of the sub-basin.



SITE: Tehama County, California

TITLE: Corning West Land Use

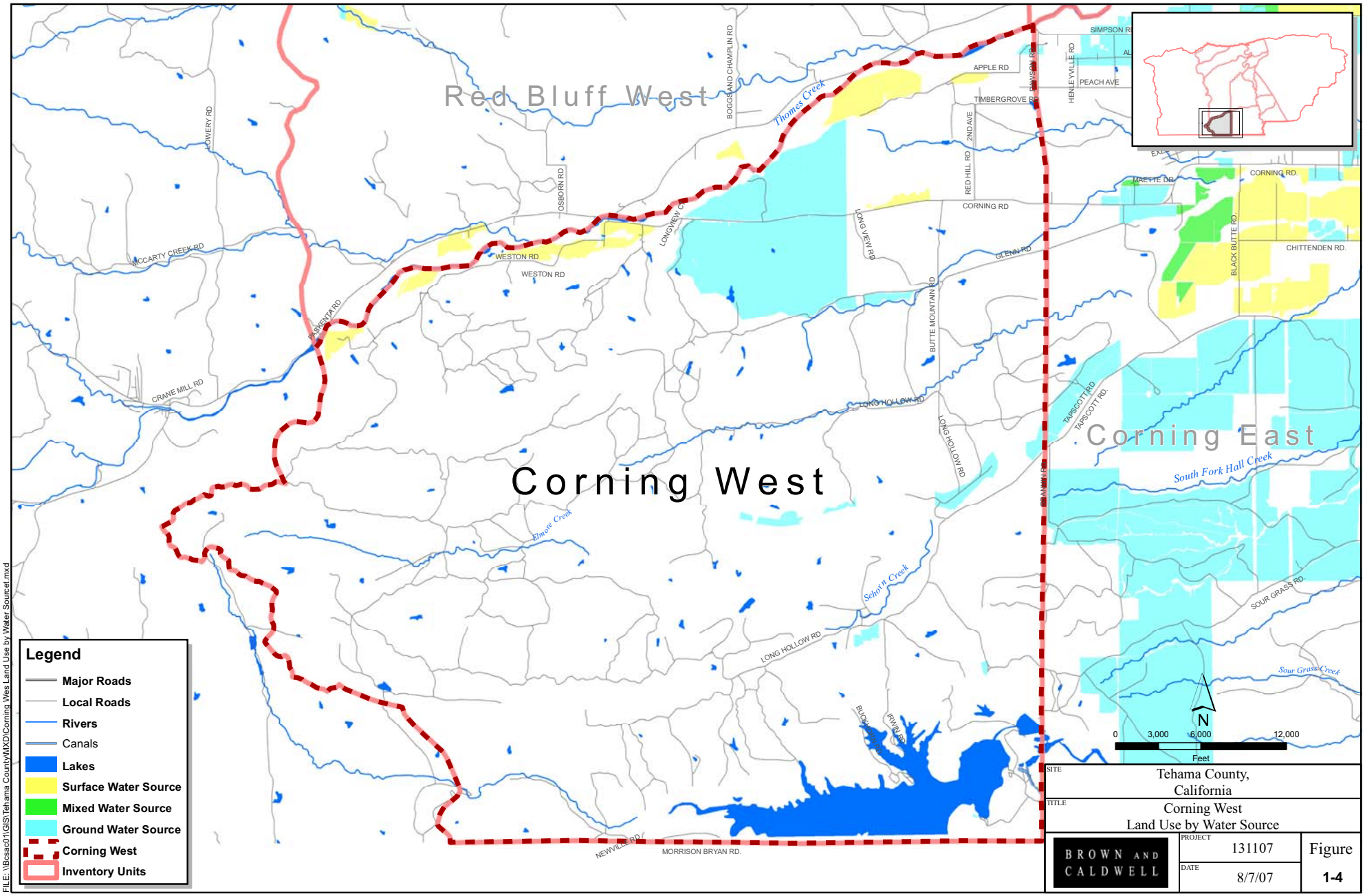
BROWN AND CALDWELL

PROJECT: 131107

DATE: 8/7/07

Figure 1-3

FILE: \\Bcsac01\GIS\Tehama County\MXD\Corning West Land Use.mxd



FILE: \\Bcsac01\GIS\Tehama County\MXD\Corning Wes Land Use by Water Source.mxd

SITE	Tehama County, California
TITLE	Corning West Land Use by Water Source
BROWN AND CALDWELL	PROJECT 131107
	DATE 8/7/07
	Figure 1-4

Suggested Monitoring Well Areas:

There are four suggested areas for new monitoring wells in the Corning West area which are indicated in Figure 1-6. Monitoring wells installed in the Corning West area should be screened to monitor groundwater at depths similar to those used for production by domestic and irrigation wells. The majority of domestic and irrigation wells in Corning West are screened between 150 and 250 feet below ground surface. The two suggested areas are in the more developed, western end of the sub-basin as listed below:

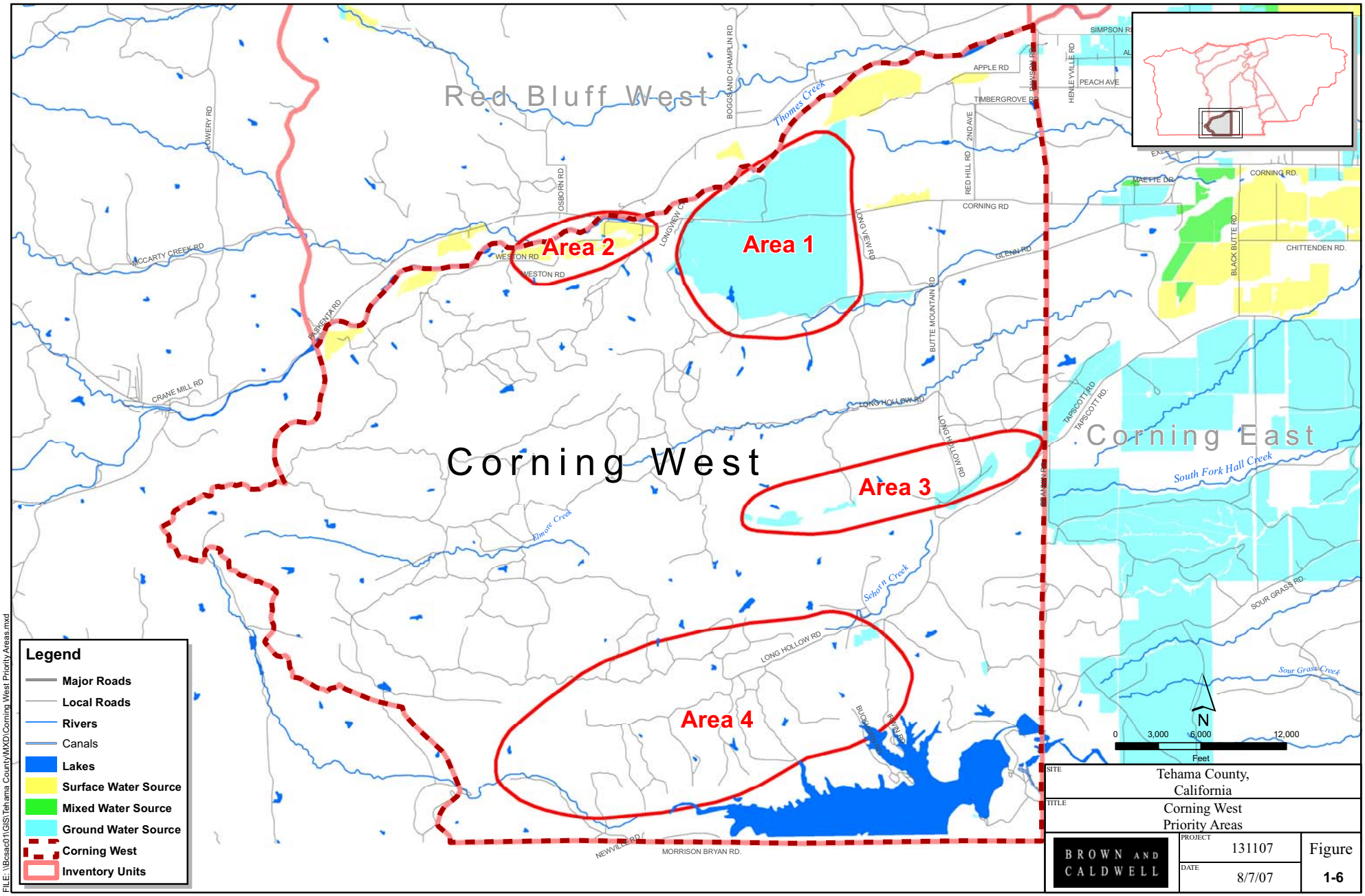
- The first suggested area (Area 1) is in the northern portion of the sub-basin, and is a priority area of grain and hay crops irrigated with groundwater, with mixed urban uses. Area 1 is not near other monitoring wells.
- The second suggested area (Area 2) is in the northwestern portion of the sub-basin, west of Area 1. Area 2 is a priority area of pasture irrigated with surface water. Area 2 is also near a site of a potential gravel pit and recharge facility. Area 2 is not near other monitoring wells.
- The third suggested area (Area 3) is in the eastern portion of the sub-basin, and is a priority area of orchards and pasture irrigated with groundwater. Area 3 is not near other monitoring wells.
- The fourth suggested area (Area 4) is in the southwestern portion of the sub-basin, and is a priority area to establish baseline groundwater levels near out of county areas with changing supply sources. Area 4 is not near other monitoring wells.

3. Next Steps

Steps 1 and 2: With the proposed priority areas selected, the next step will be confirmation of priority areas with stakeholders. Once stakeholders have provided local information and input to priority area selection, the availability of existing wells for monitoring and the need for new monitoring wells can be assessed. As monitoring locations are selected and developed, the monitoring program for the Corning West sub-basin can be implemented.

Steps 3, 4 and 5: Once the monitoring program is in place, steps 3 through 5 of the trigger level development process can be completed as described in the methodology section. Example trigger levels from the Corning East sub-basin are provided below.

Figures 1-7 through 1-9 present hydrographs and suggested trigger levels for an example key well located in the Corning East sub-basin. The figures are groundwater level hydrographs, demonstrating water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. The methodologies used to determine the suggested trigger levels for the example key well is provided in Table 1-1. Some trigger levels were set using exceptions from the methodologies to account for measurements that are outside the range of normal spring and summer measurements.



SITE	Tehama County, California	
TITLE	Corning West Priority Areas	
BROWN AND CALDWELL	PROJECT 131107	Figure
	DATE 8/7/07	1-6

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Corning East Monitoring Well Number				
	14N02M	**02R01M**	**05G01M**	**29E01M**	**16B01M**
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements				
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements				
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	A	None	B	None	None

Footnotes:

A: Late Season Trigger Level set above single outlier water level elevation. The reported low level may be an inaccurate measurement.

B: Spring Trigger Level 2 set above single outlier water level elevation. Low point in 1997 is inconsistent with other spring water level trends in this area.

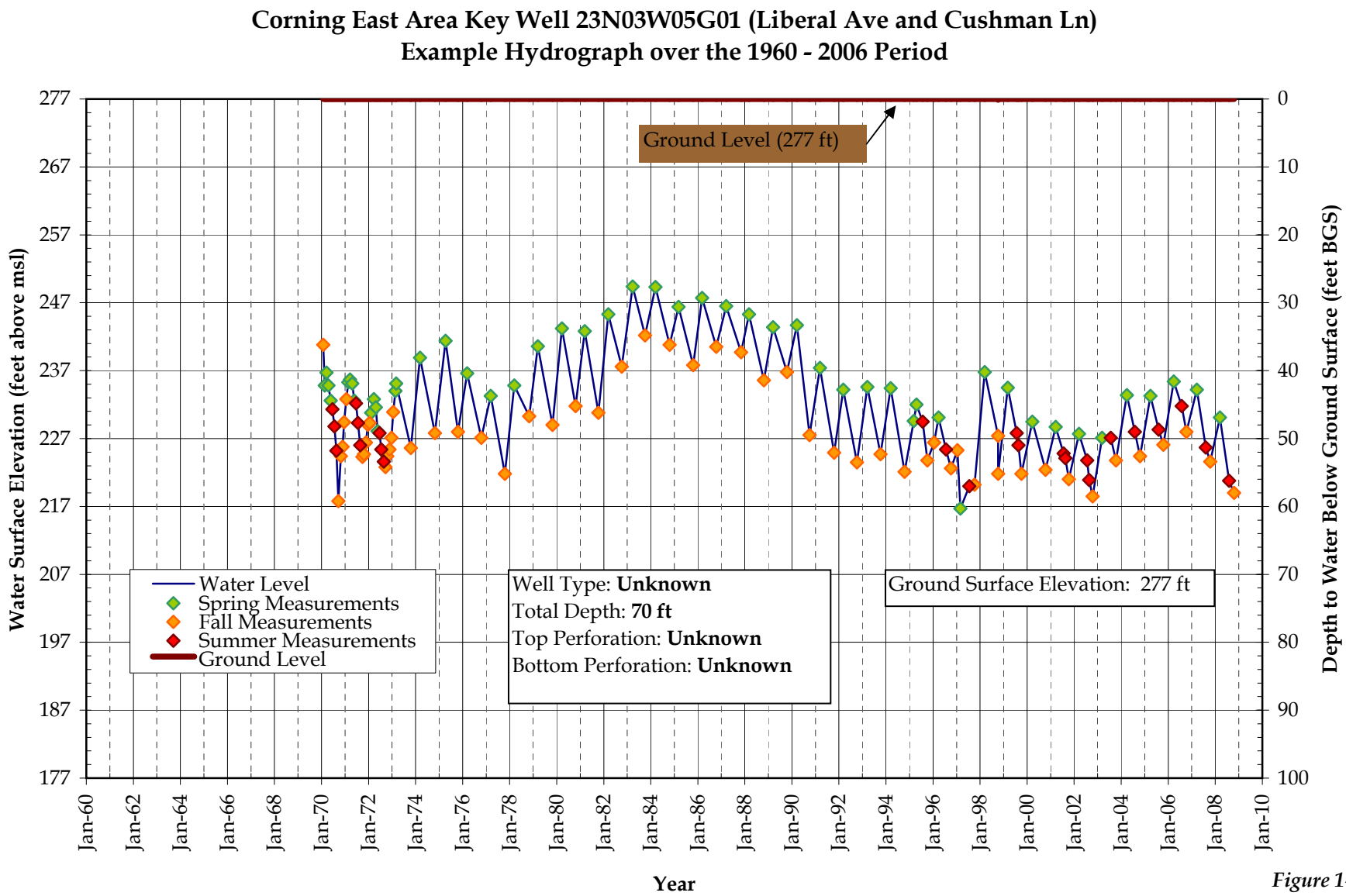


Figure 1-7
Example Hydrograph of Key Well 23N03W05G01

Updated 12-01-08

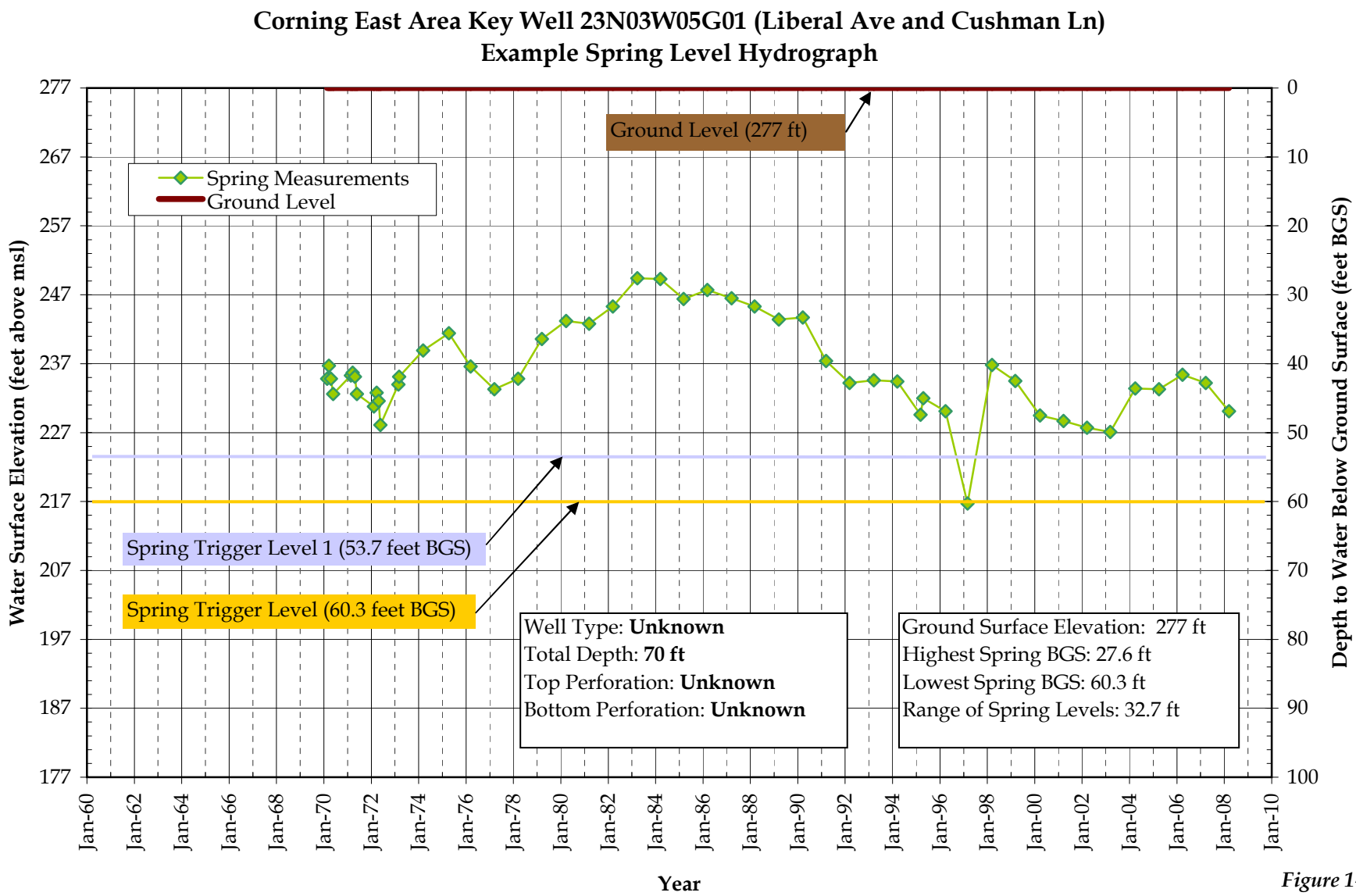


Figure 1-8
Example Spring Trigger Levels

Updated 12-01-08

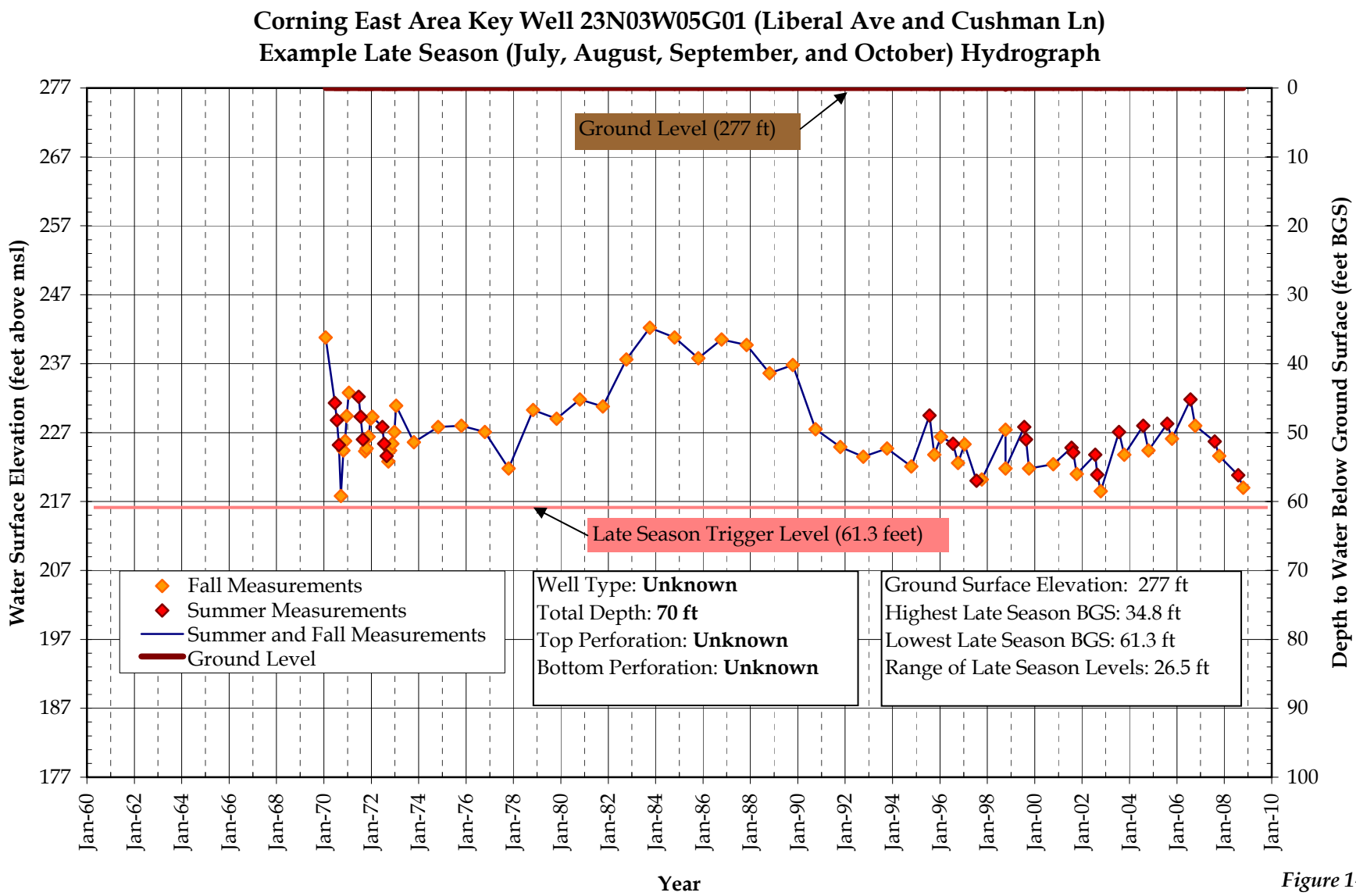


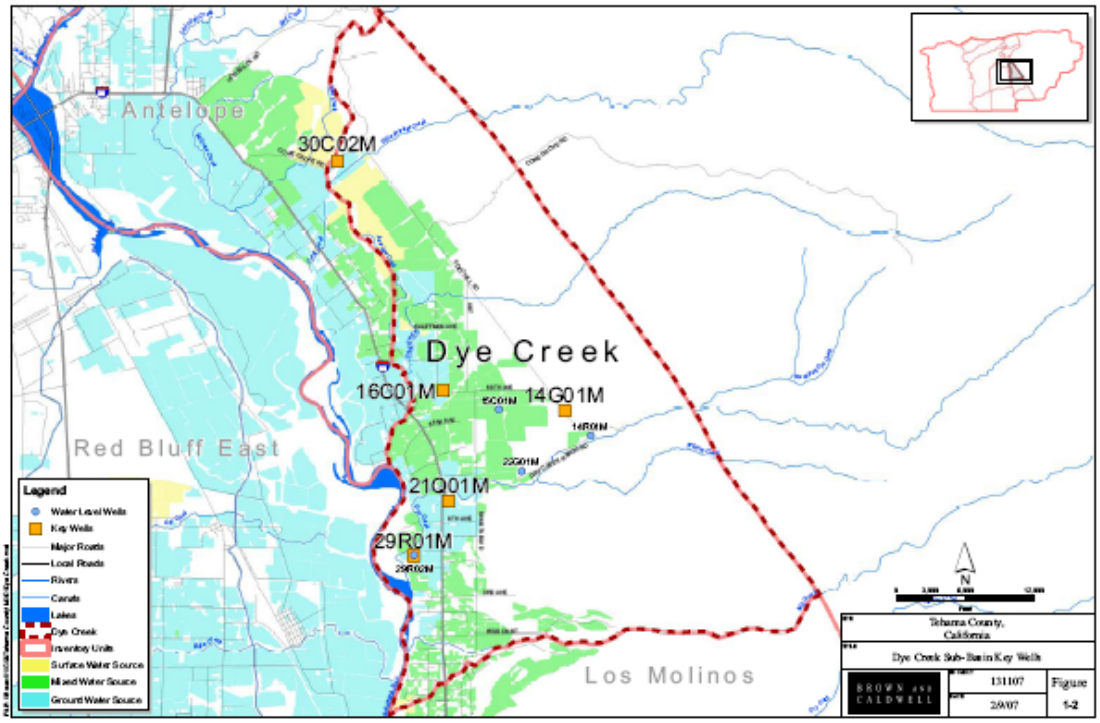
Figure 1-9
Example Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Dye Creek Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Dye Creek Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

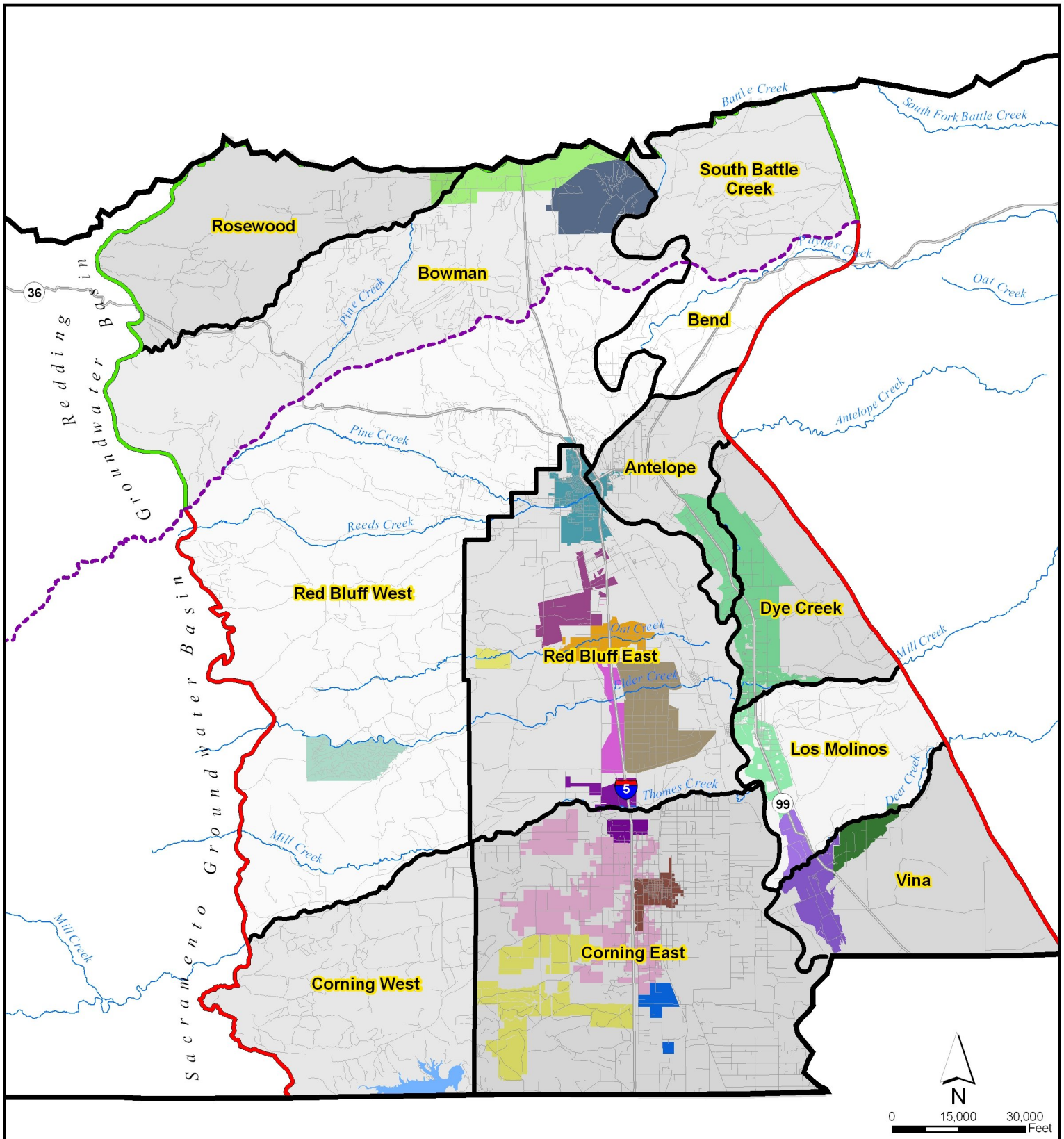
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Dye Creek sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to two decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Dye Creek sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

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1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Dye Creek sub-basin is primarily a rural area, with agriculture throughout the area. Groundwater is used for agricultural, and domestic purposes. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Dye Creek:	
Irrigation:	78% (4,500 acre-ft)
Municipal, and Industrial:	22% (1,300 acre-ft)
Number of wells by type in Dye Creek:	
Irrigation:	50 wells
Domestic:	314 wells
Municipal and Industrial:	2 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

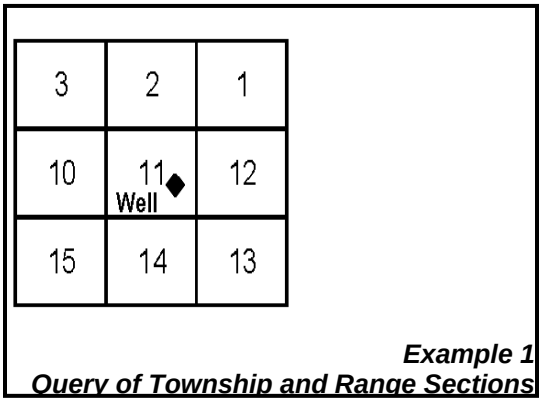
Step 2: Select one or more key wells within the sub-basin

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

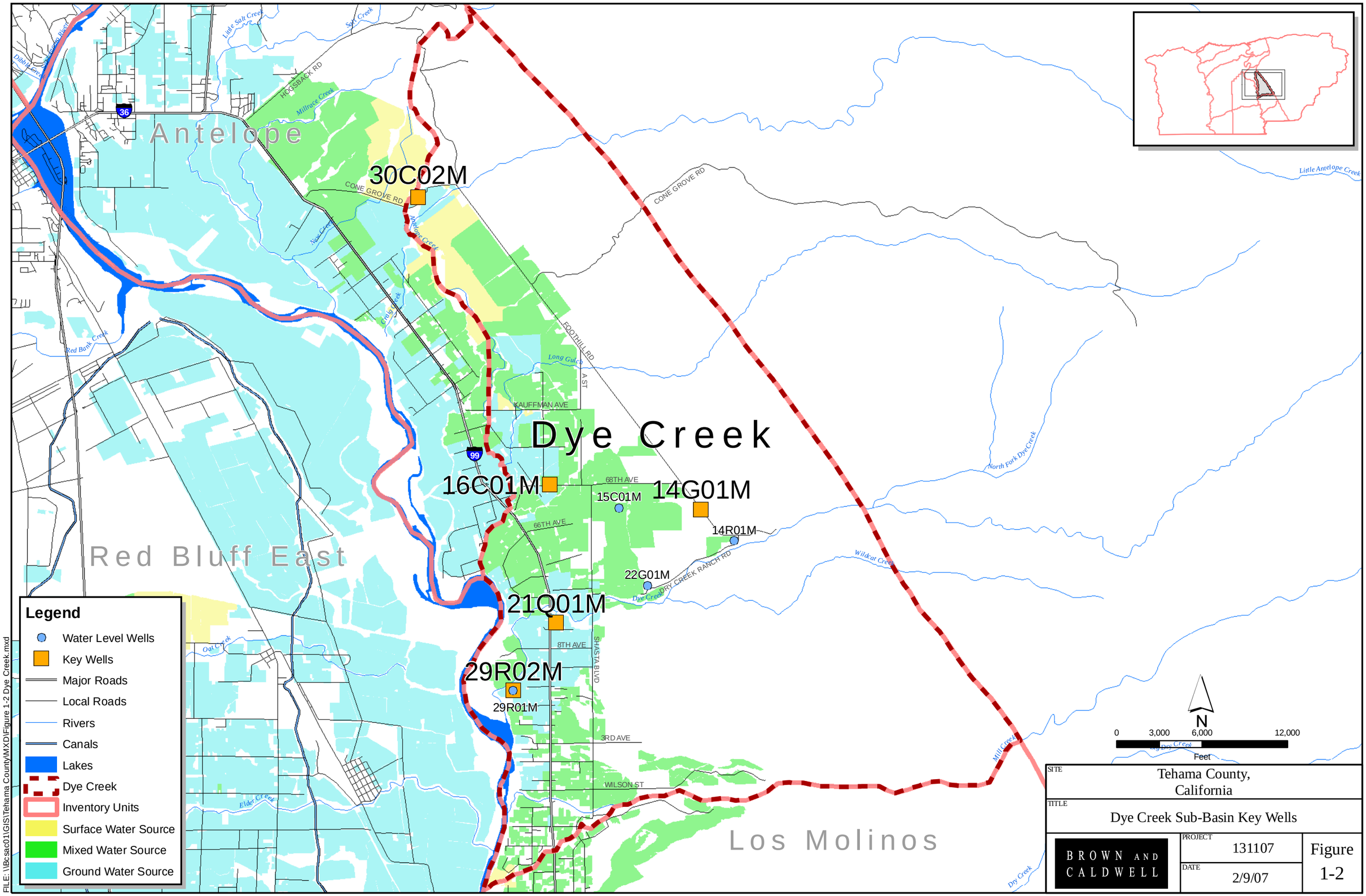
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of five proposed key wells are presented in Figure 1-2. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **26N02W14G01M (14G01M) –** This monitoring well is in the eastern portion of the sub-basin and is 152 feet deep and has an unknown screened interval. This well is situated uphill from pasture irrigated with both surface and groundwater. This well has a period of record of more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 13 domestic wells with an average depth of 115 feet below ground surface (bgs), and 3 irrigation wells with an average depth of 343 feet bgs.
- **27N02W30C02M (30C02M) –** This monitoring well is in the northern portion of the sub-basin and is 296 feet deep with a screened interval from 133 to 296 feet bgs. This well is situated near orchards irrigated with groundwater and areas irrigated with surface water. This well has a period of record of more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 105 domestic wells with an average depth of 87 feet bgs, and 26 irrigation wells with an average depth of 217 feet bgs.
- **26N02W16C01M (16C01M) –** This monitoring well is in the west central portion of the sub-basin and is 50 feet deep and has an unknown screened interval.. This well is situated near pasture irrigated with both surface water and groundwater, and orchards irrigated with groundwater. This well has a period of record of more than 26 years, which provides information on water levels during the drought of the late 1980s and early 1990s. The nine square miles near this well contain 119 domestic wells with an average depth of 87 feet bgs, and 46 irrigation wells with an average depth of 139 feet bgs.
- **26N02W21Q01M (21Q01M)–** This monitoring well is in the southeast portion of the sub-basin and is 55 feet deep with a screened interval from 48 to 55 feet bgs. This well is situated near orchards irrigated with groundwater. This well has a period of record of more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 95 domestic wells with an average depth of 92 feet bgs, and 42 irrigation wells with an average depth of 125 feet bgs.
- **26N02W29R02M (29R02M)–** This monitoring well is in the southeast portion of the sub-basin and is 840 feet deep with an unknown screened interval. This well is situated near orchards


Antelope
Red Bluff East
Dye Creek
Los Molinos
30C02M
16C01M
15C01M
14G01M
14R01M
22G01M
21O01M
29R02M
29R01M
CONE GROVE RD
HOGSBACK RD
FOOTHILL RD
A ST
KAUFFMAN AVE
68TH AVE
66TH AVE
DRY CREEK RANCH RD
8TH AVE
SHASTA BLVD
3RD AVE
WILSON ST
Little Salt Creek
Salt Creek
Millrace Creek
Antelope Creek
Craig Creek
Red Bank Creek
Long Gulch
North Fork Dye Creek
Wildcat Creek
Dye Creek
Oat Creek
Elder Creek
Mill Creek
Dry Creek
Little Antelope Creek
Legend
Water Level Wells
Key Wells
Major Roads
Local Roads
Rivers
Canals
Lakes
Dye Creek
Inventory Units
Surface Water Source
Mixed Water Source
Ground Water Source
N
0
3,000
6,000
12,000
Feet
SITE
Tehama County, California
TITLE
Dye Creek Sub-Basin Key Wells
BROWN AND CALDWELL
PROJECT
131107
DATE
2/9/07
Figure 1-2
FILE: \\Bcsac01\GIS\Tehama County\MXD\Figure 1-2 Dye Creek.mxd

irrigated with groundwater. This well has a period of record of more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 171 domestic wells with an average depth of 94 feet bgs, and 33 irrigation wells with an average depth of 143 feet bgs.

There are currently no monitoring wells in the southeastern corner of the Dye Creek sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

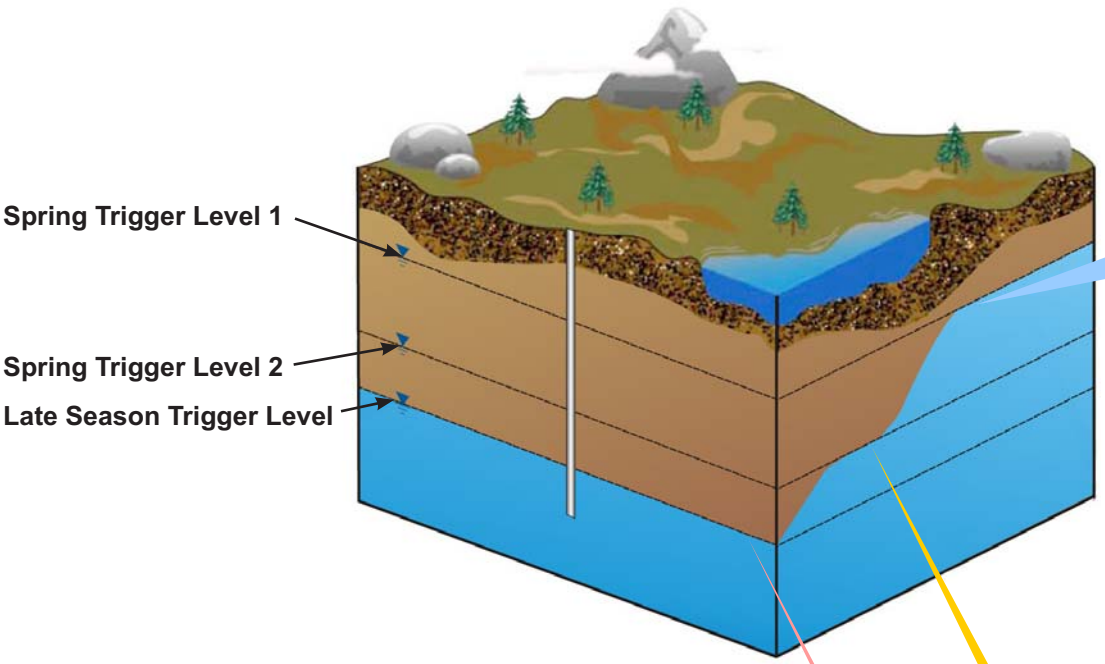
The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows three suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-18 present hydrographs and suggested trigger levels for each of the five Dye Creek key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Dye Creek sub-basin are provided in Table 1-1.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Dye Creek Monitoring Well Number				
	14G01M	30C02M	16C01M	21Q01M	29R02M
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements				
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements				
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	None	None	None	None	None

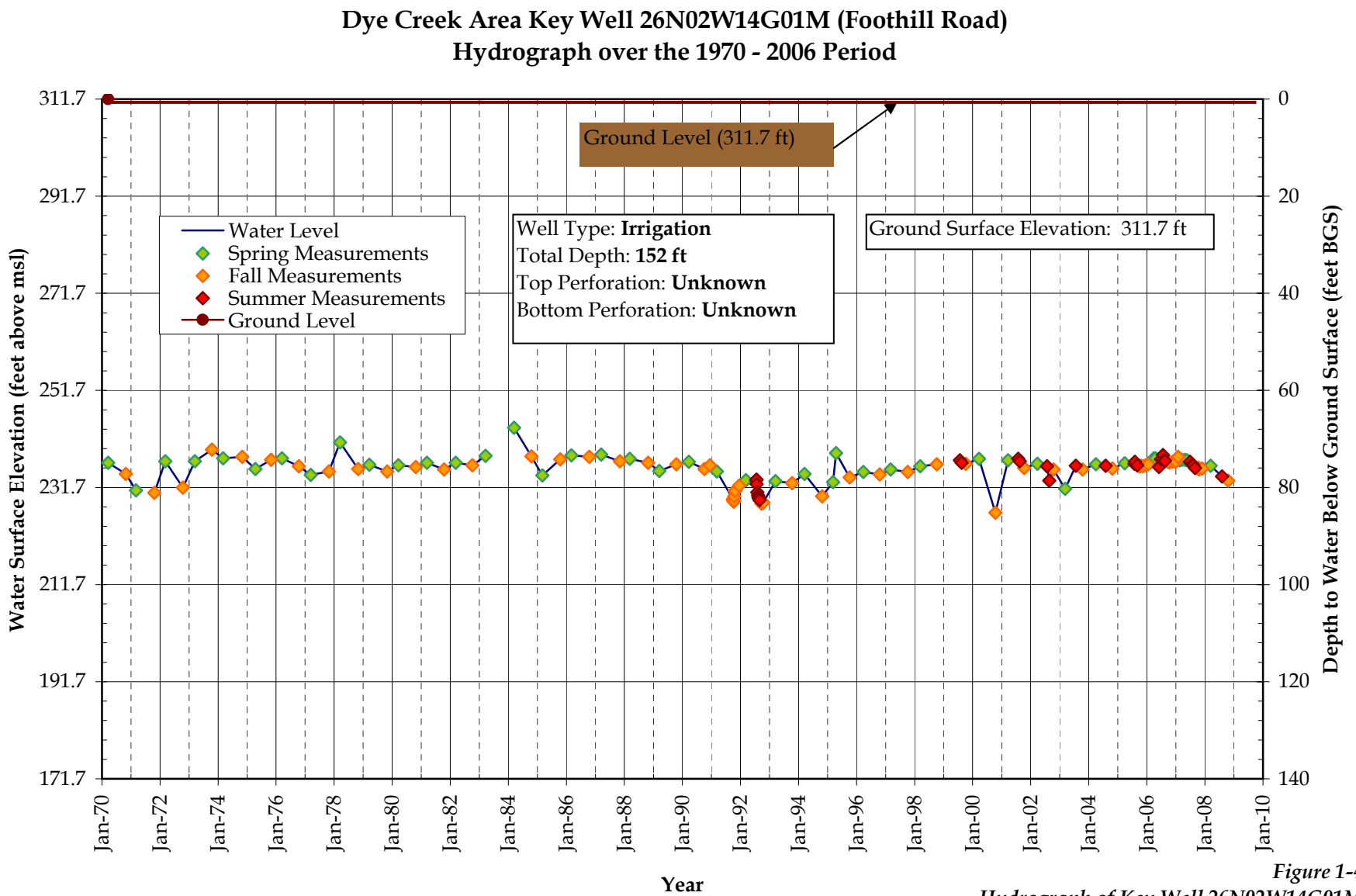


Figure 1-4
Hydrograph of Key Well 26N02W14G01M

Updated 12-01-08

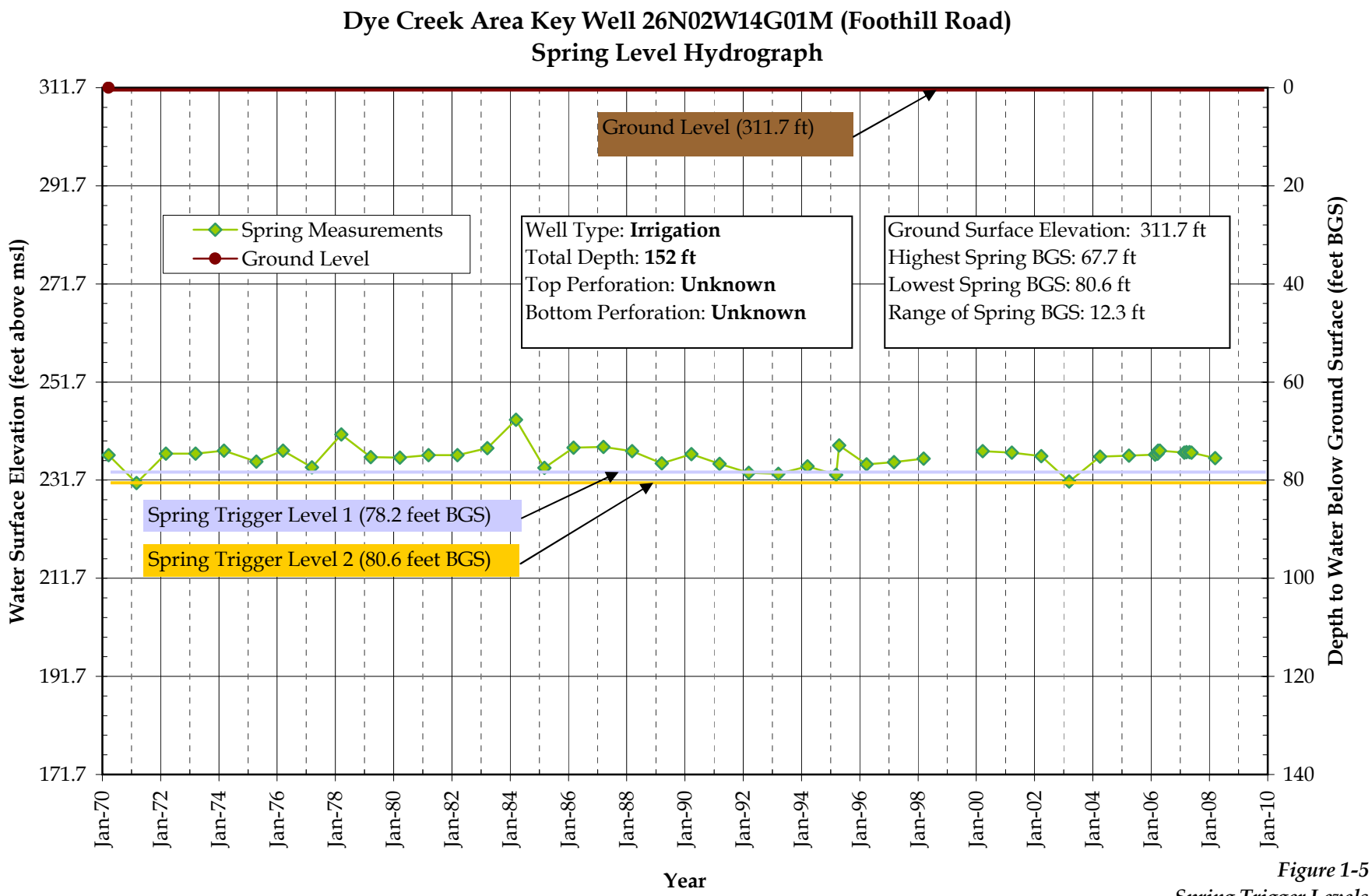


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

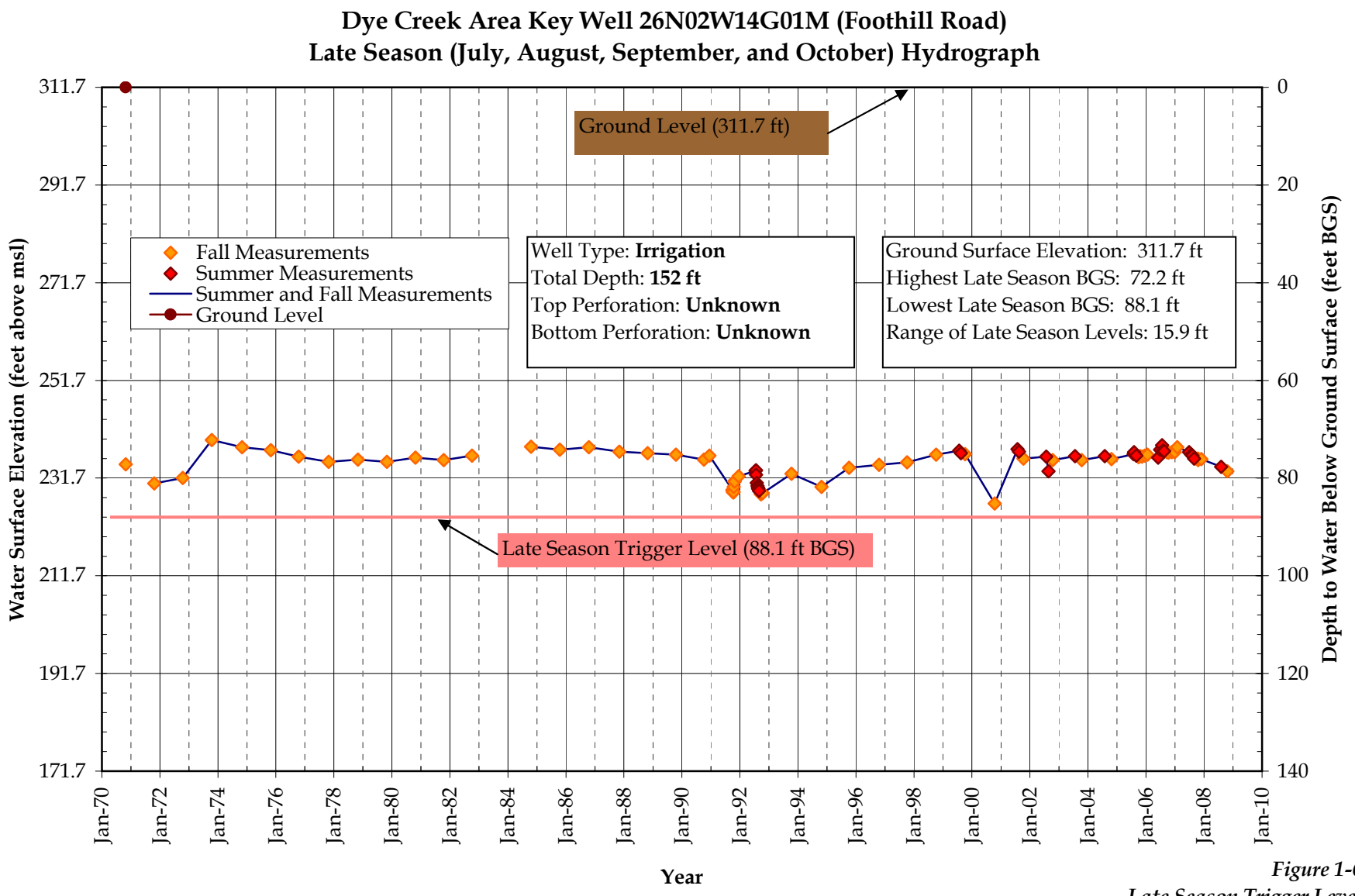


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

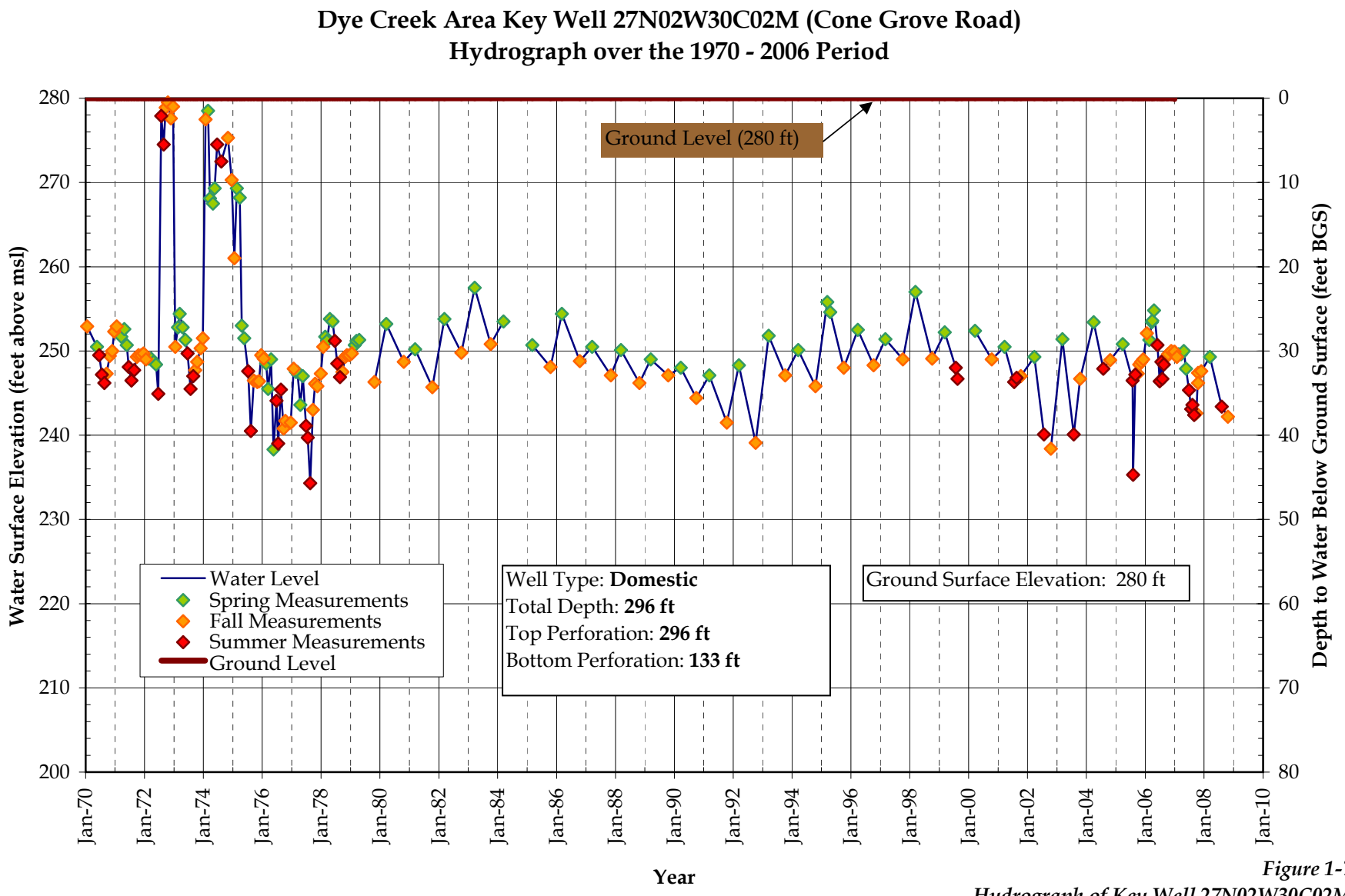


Figure 1-7
Hydrograph of Key Well 27N02W30C02M

Updated 12-01-08

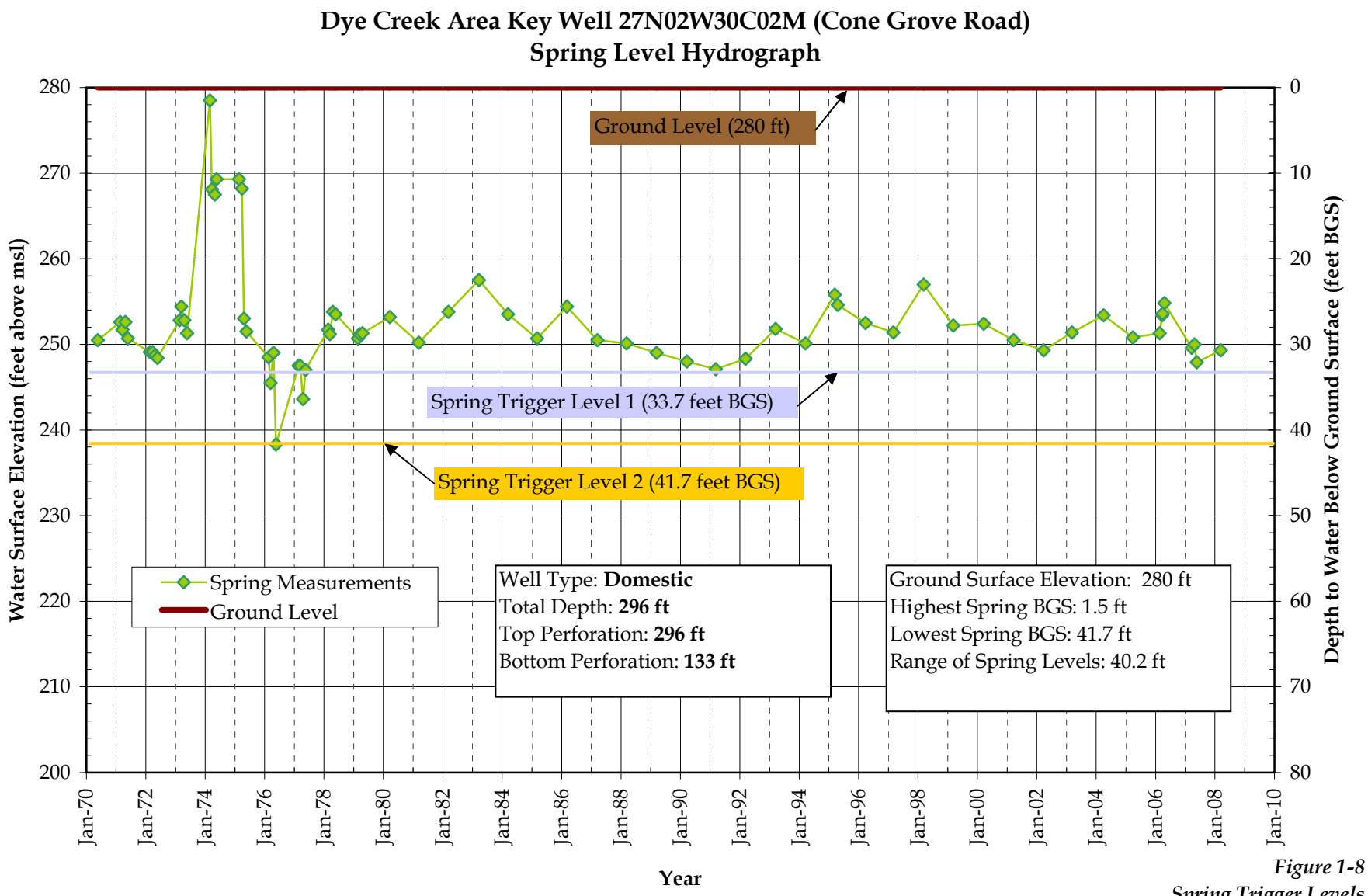


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

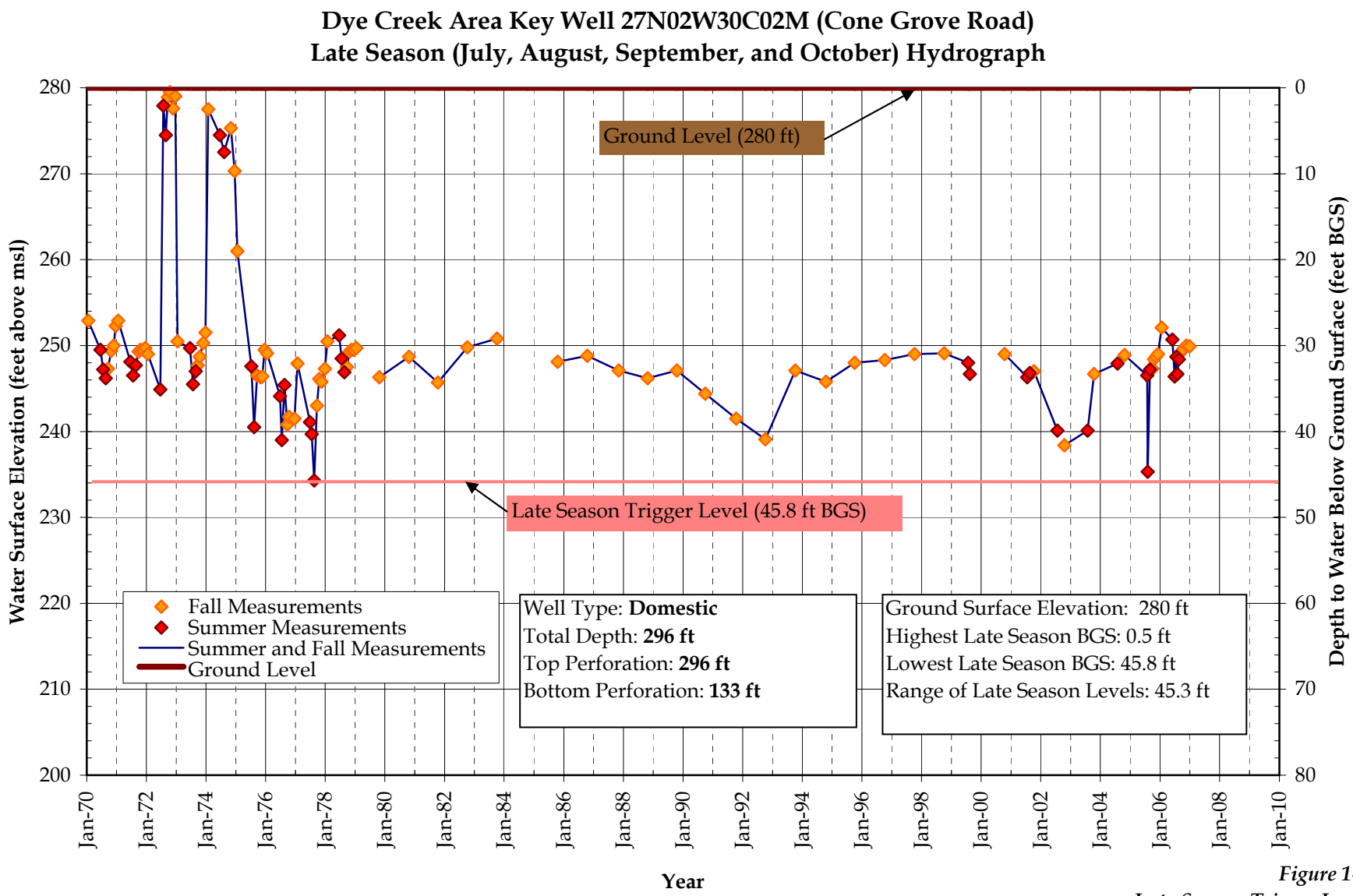


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

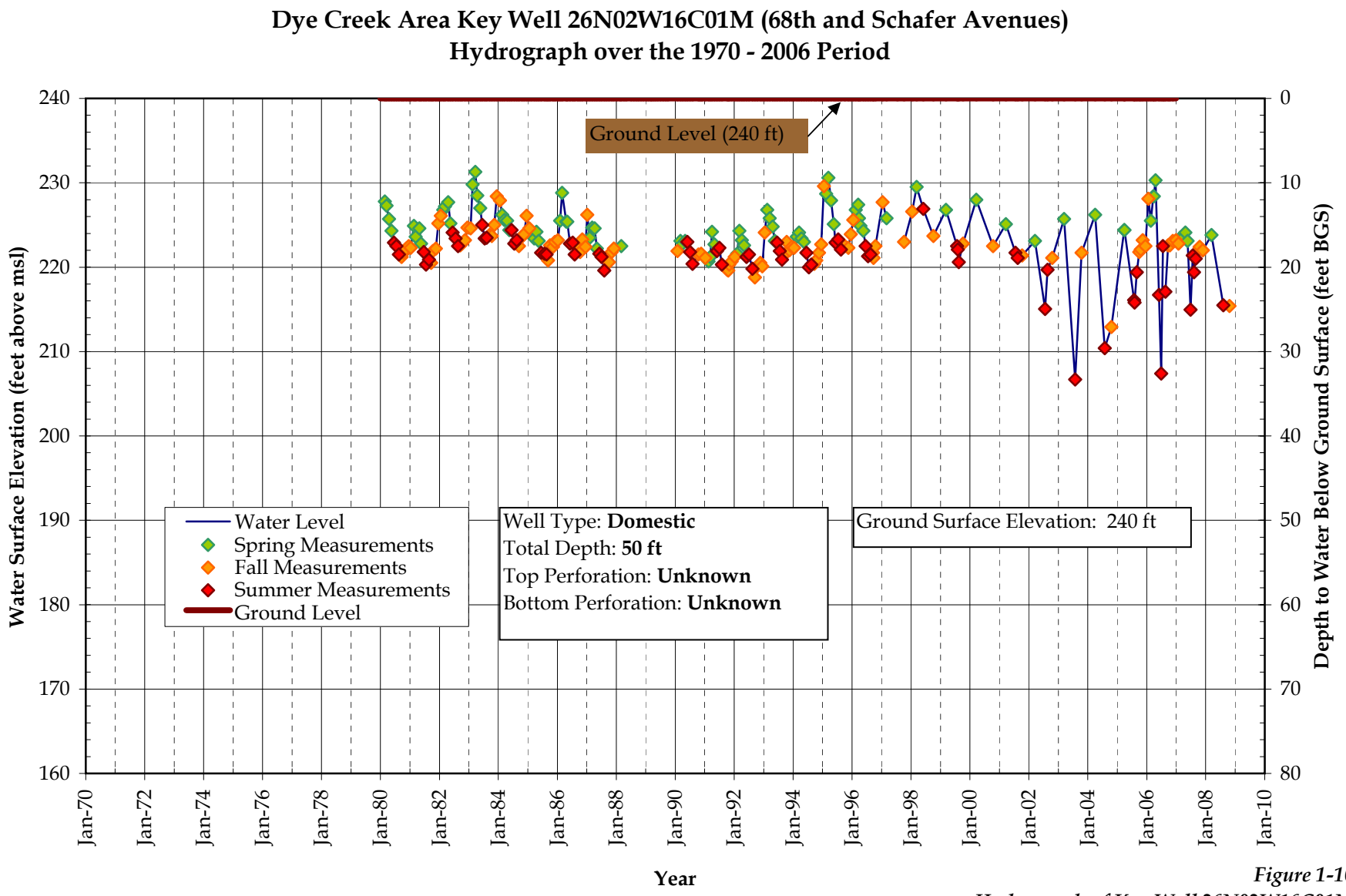


Figure 1-10
Hydrograph of Key Well 26N02W16C01M

Updated 12-01-08

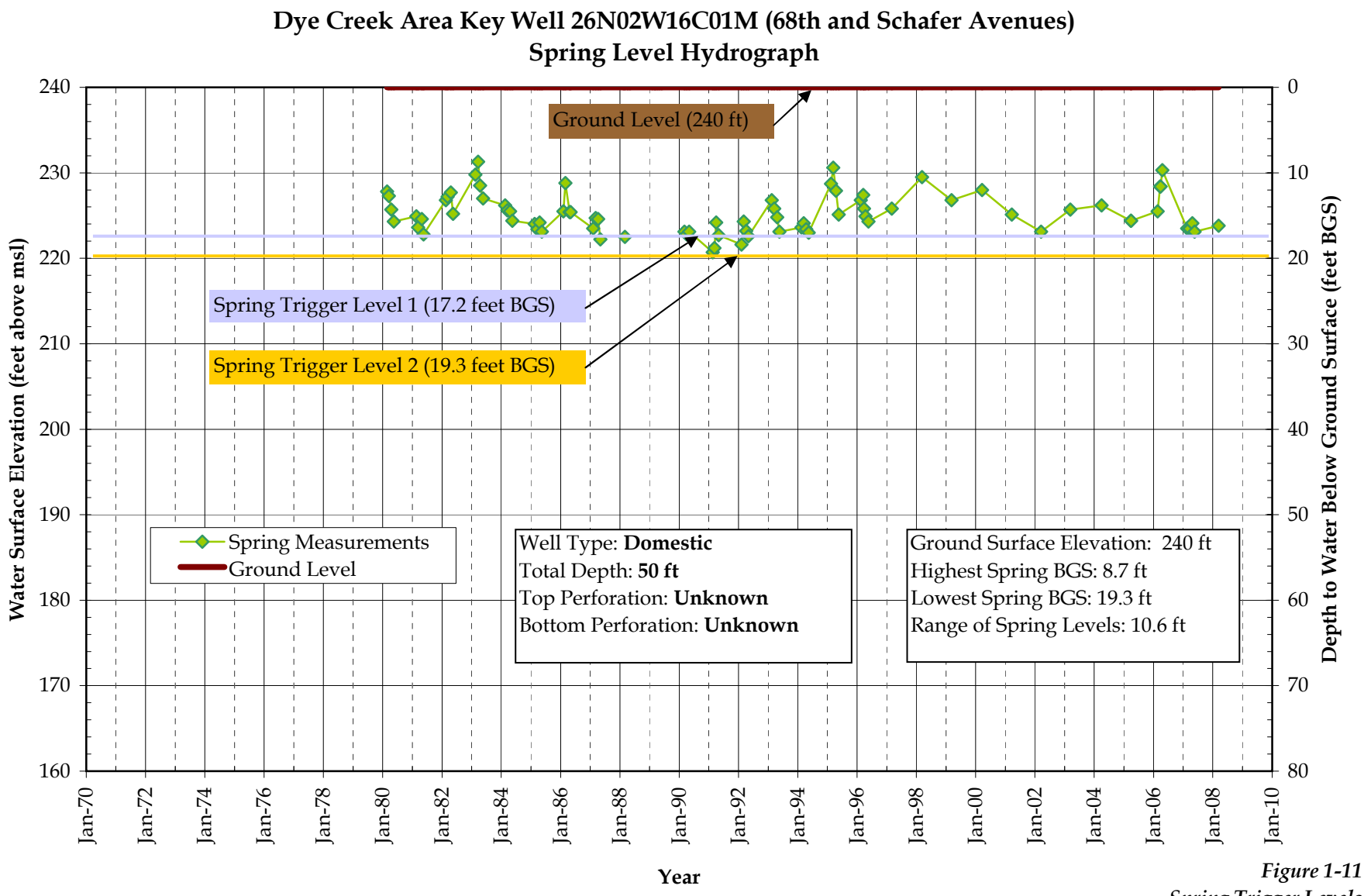


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

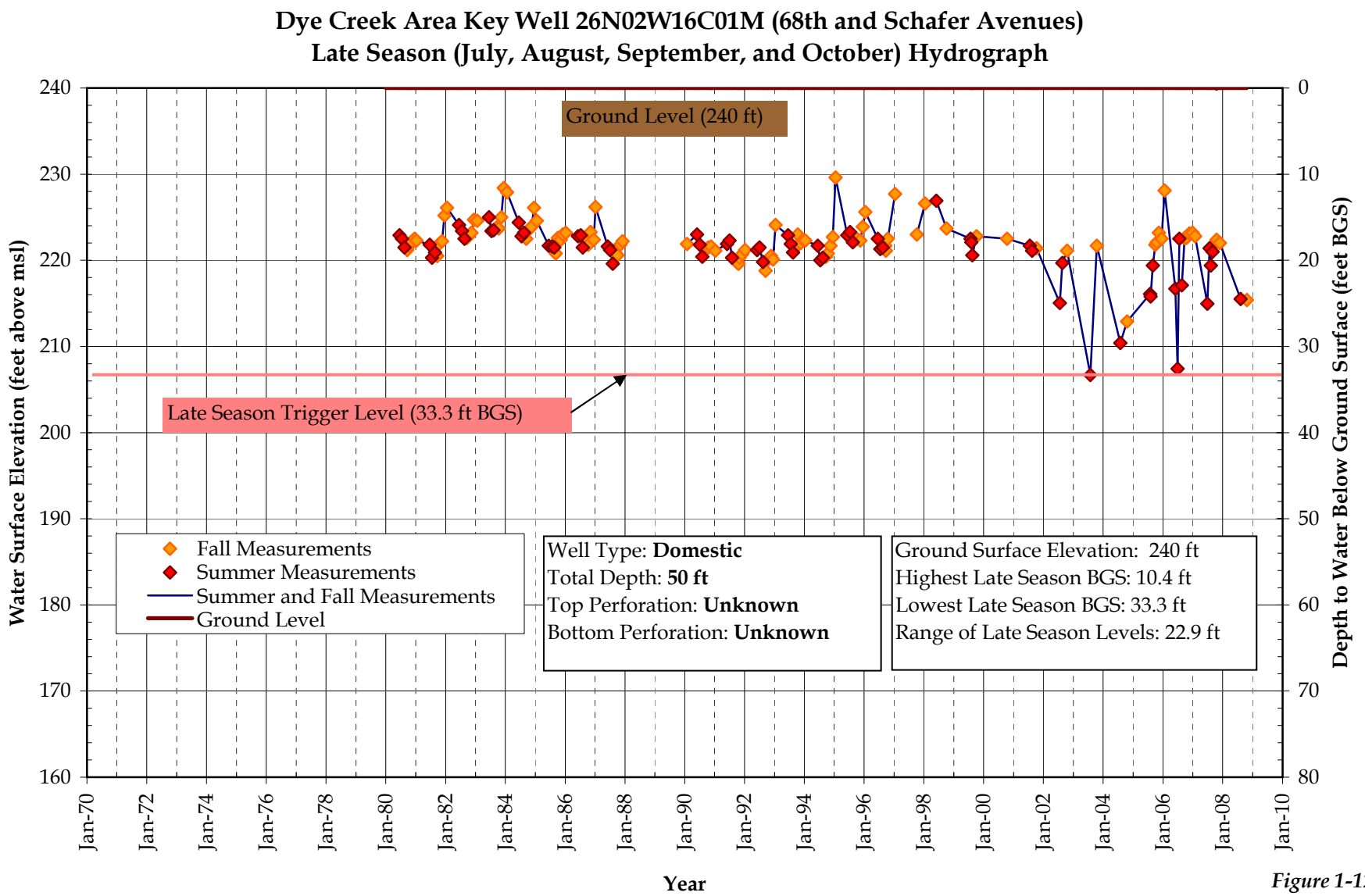


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

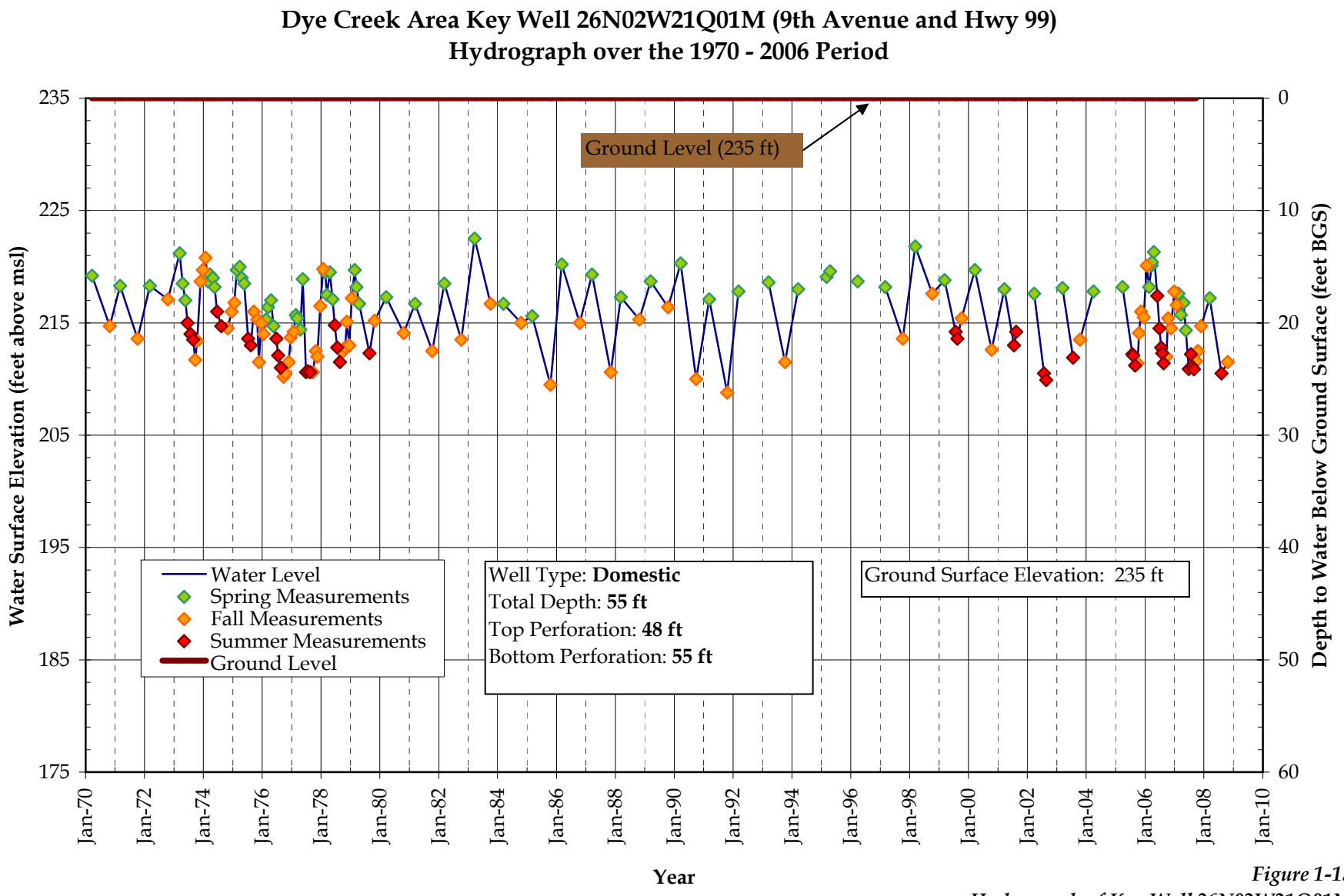


Figure 1-13
Hydrograph of Key Well 26N02W21Q01M

Updated 12-01-08

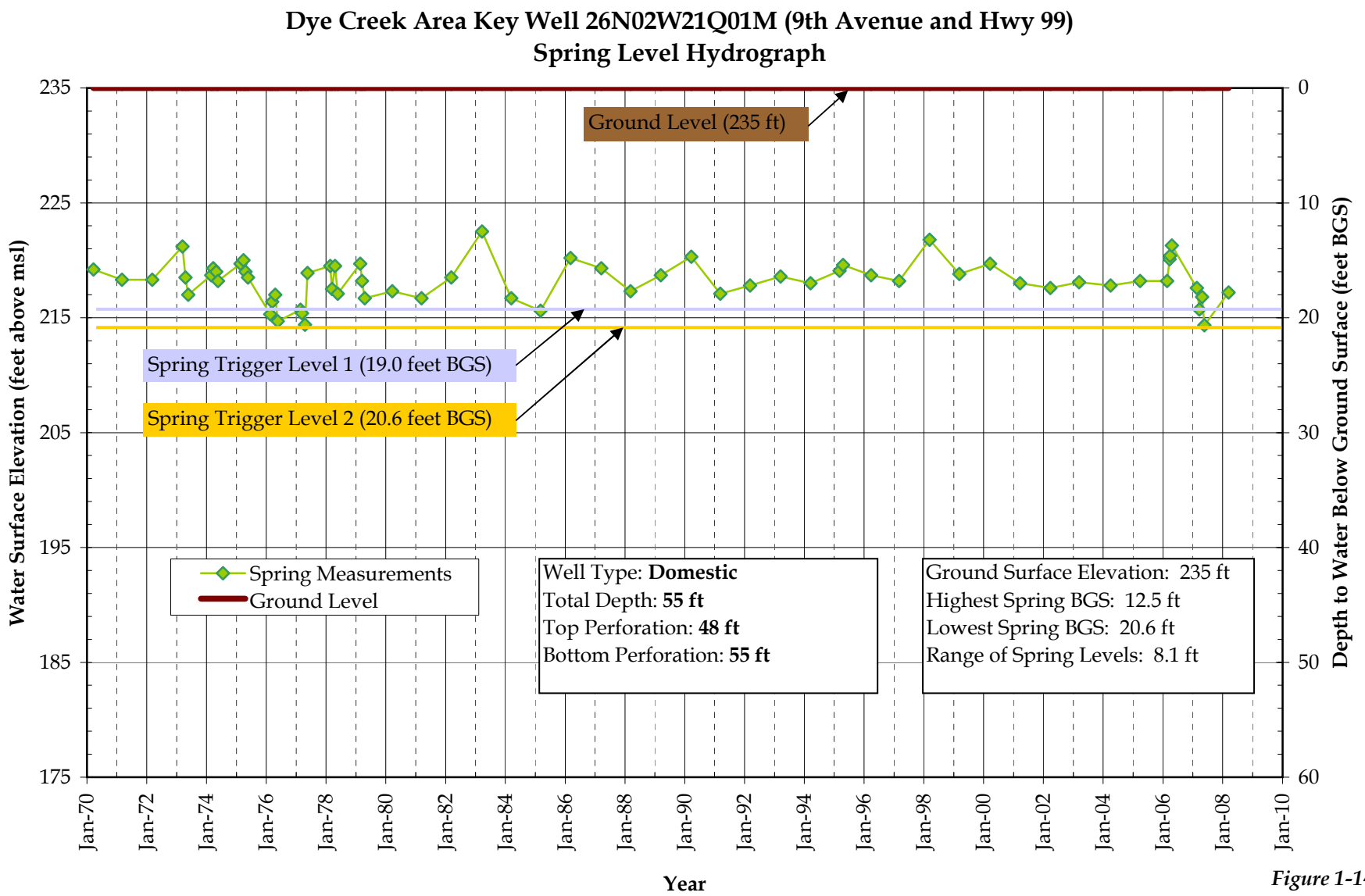


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

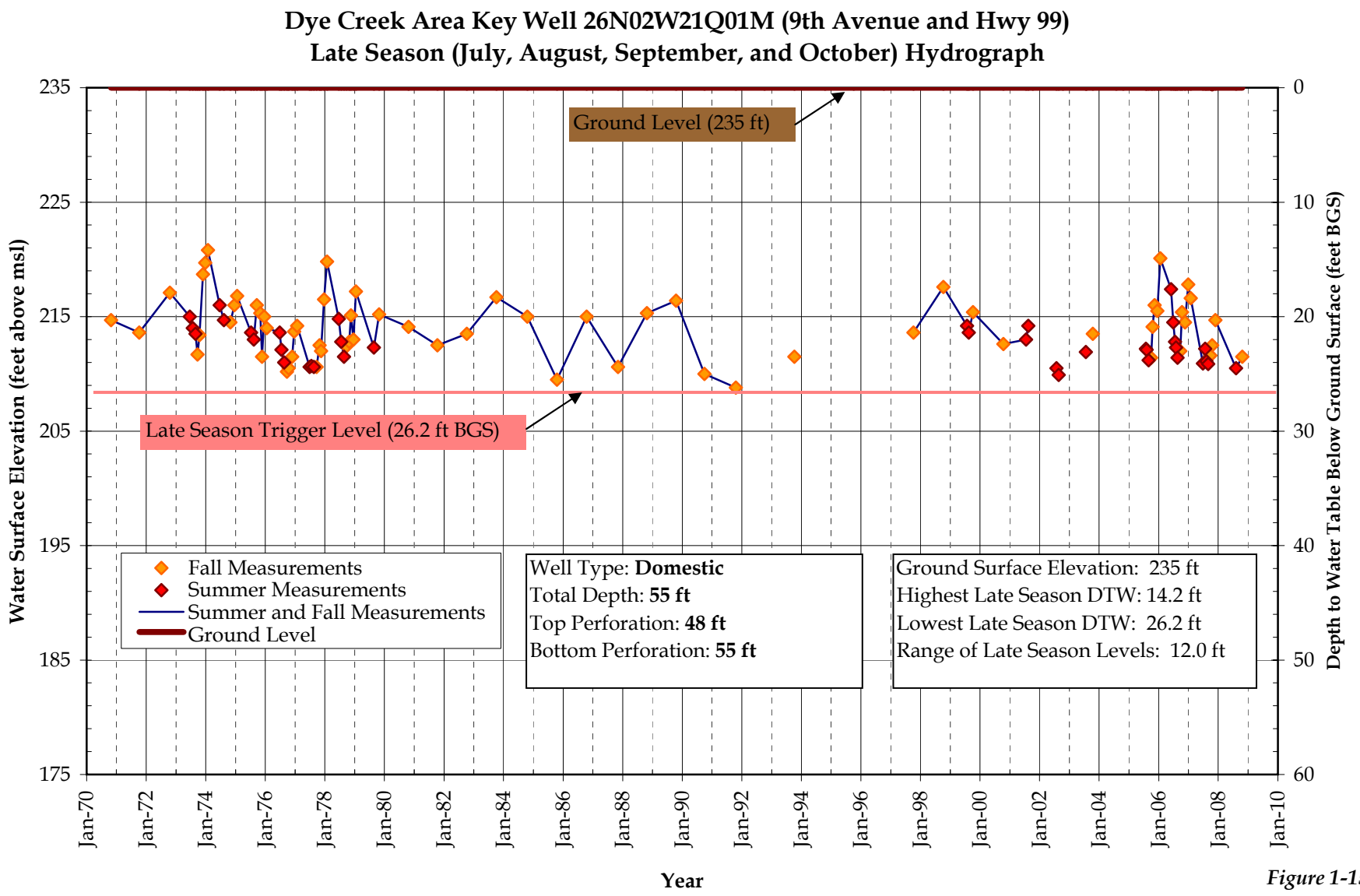


Figure 1-15
Late Season Trigger Levels

Updated 12-01-08

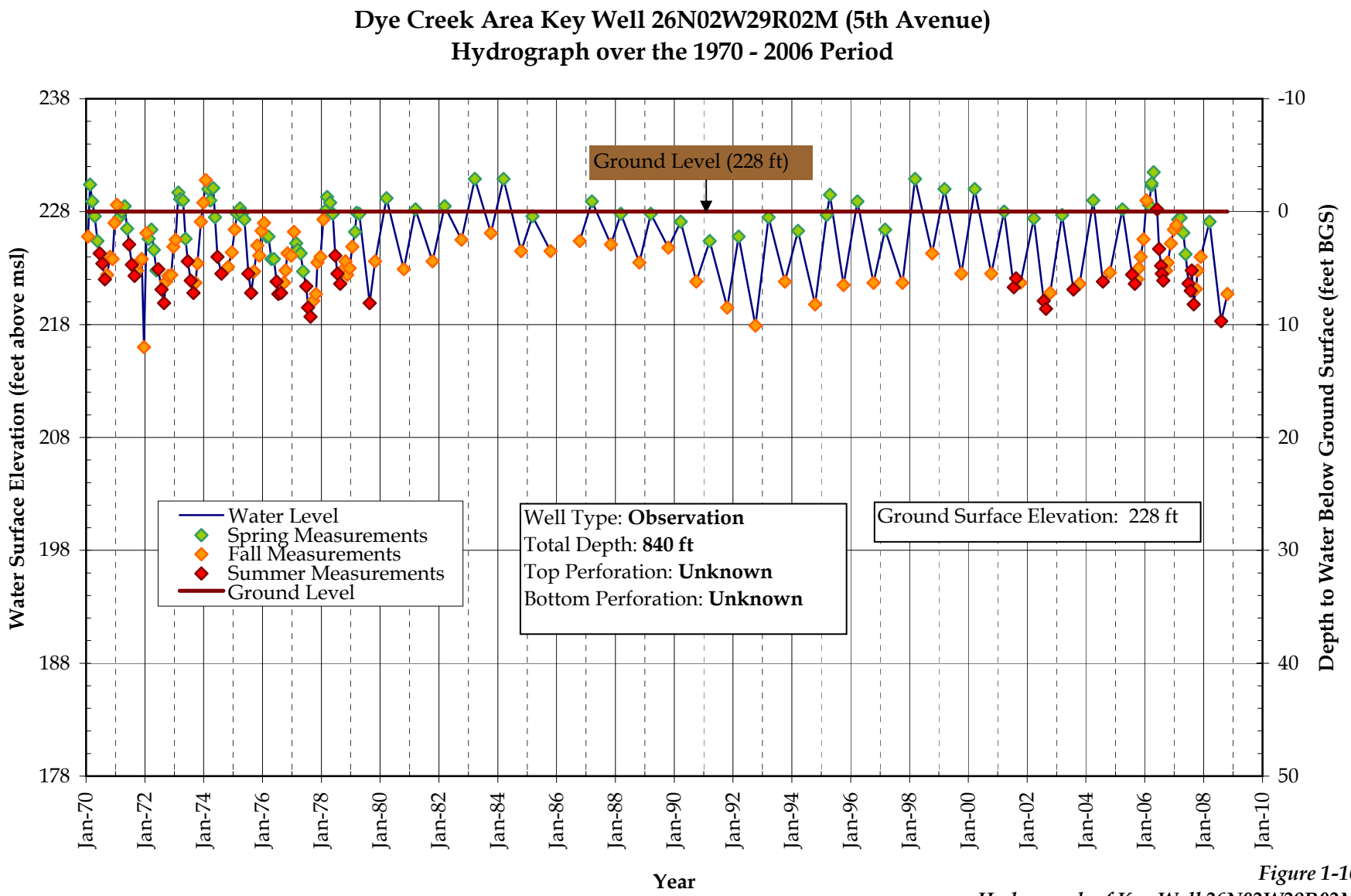


Figure 1-16
Hydrograph of Key Well 26N02W29R02M

Updated 12-01-08

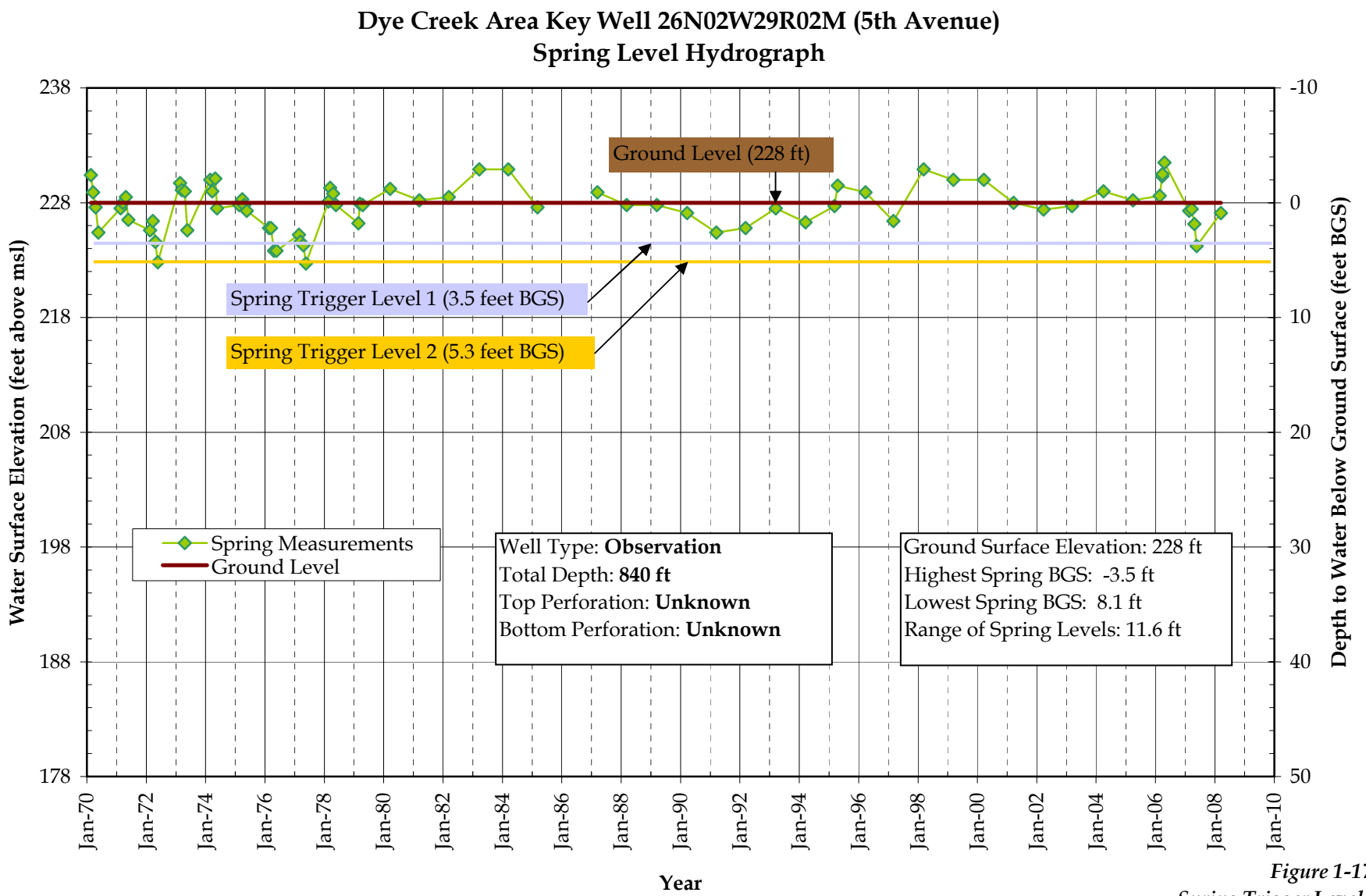


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

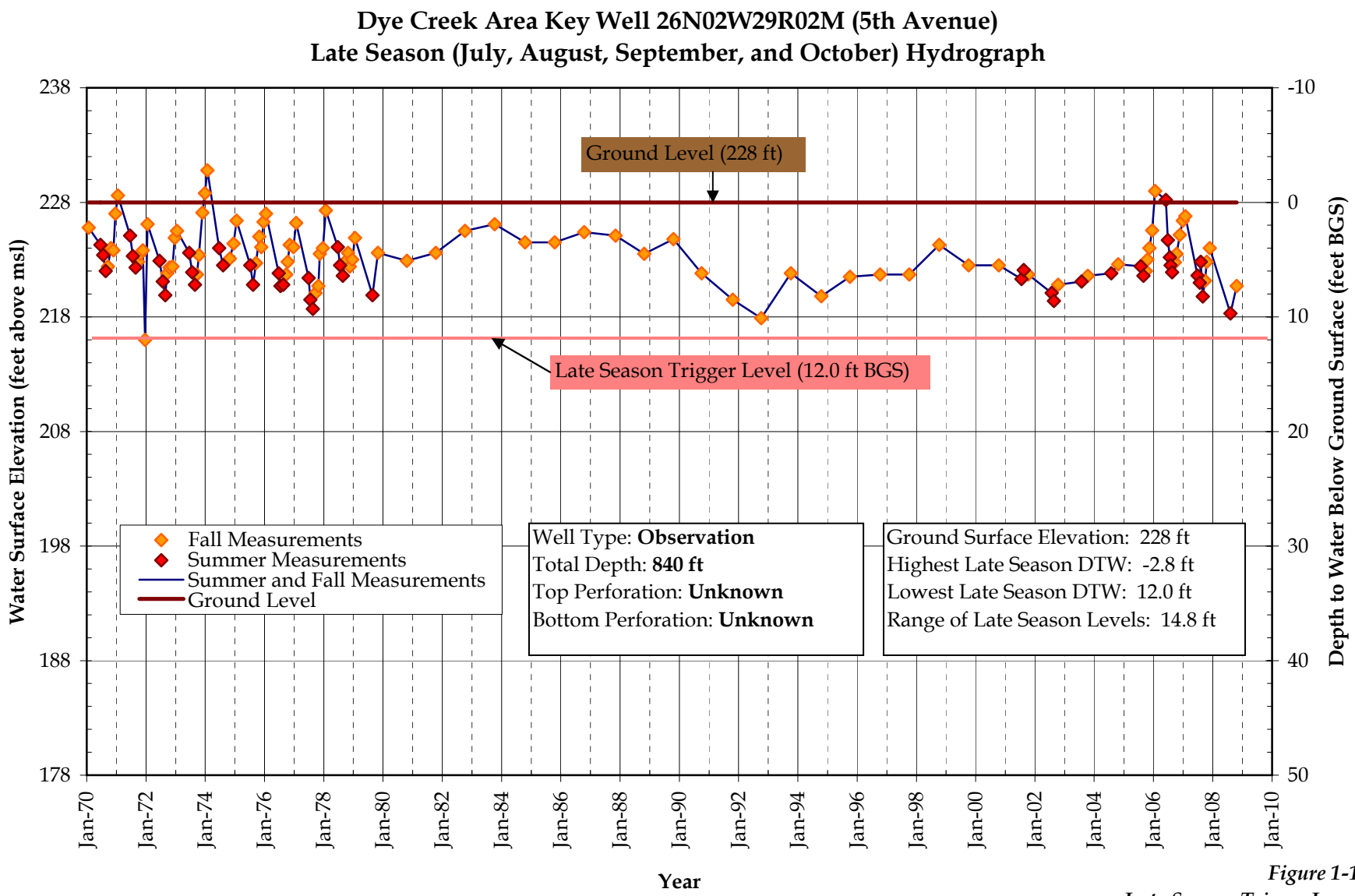


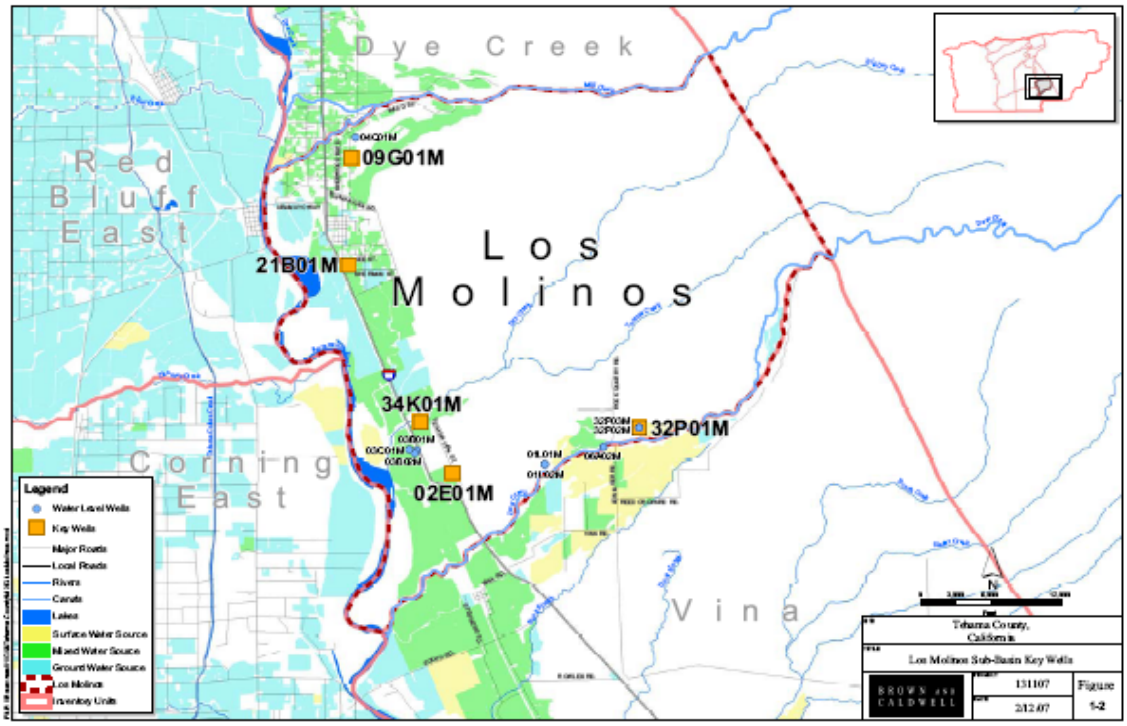
Figure 1-18
Late Season Trigger Levels

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Los Molinos Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Los Molinos Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

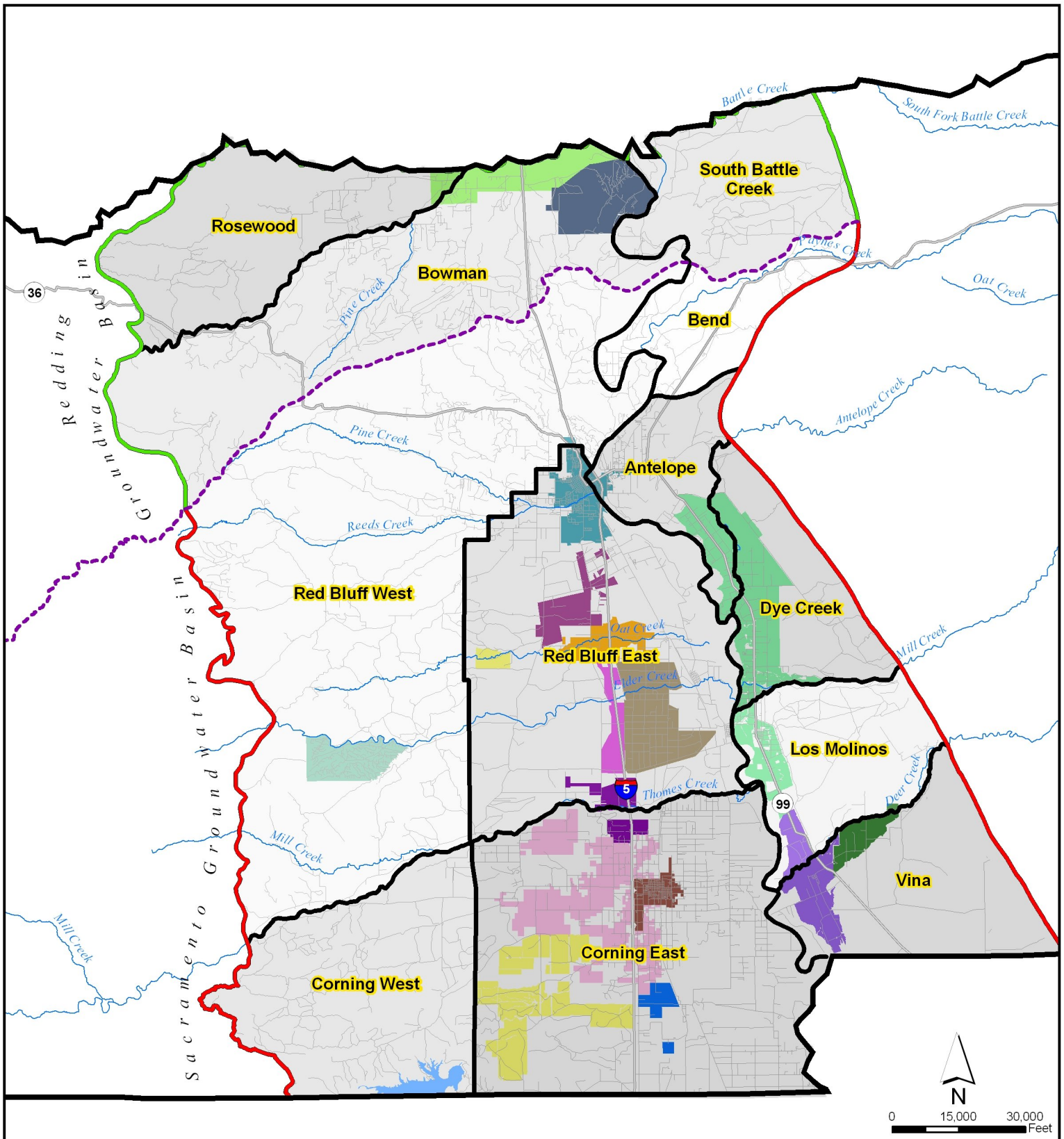
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Los Molinos sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to two decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Los Molinos sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Los Molinos sub-basin is primarily a rural area, with agriculture in the western portion and uplands in the western portion of the area. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. Groundwater is used for agricultural, municipal, and domestic purposes. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Los Molinos:	
Irrigation:	68% (4,500 acre-ft)
Municipal, and Industrial:	32% (2,100 acre-ft)
Number of wells by type in Los Molinos:	
Irrigation:	38 wells
Domestic:	303 wells
Municipal and Industrial:	6 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin

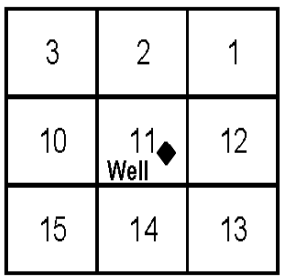
Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods

of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

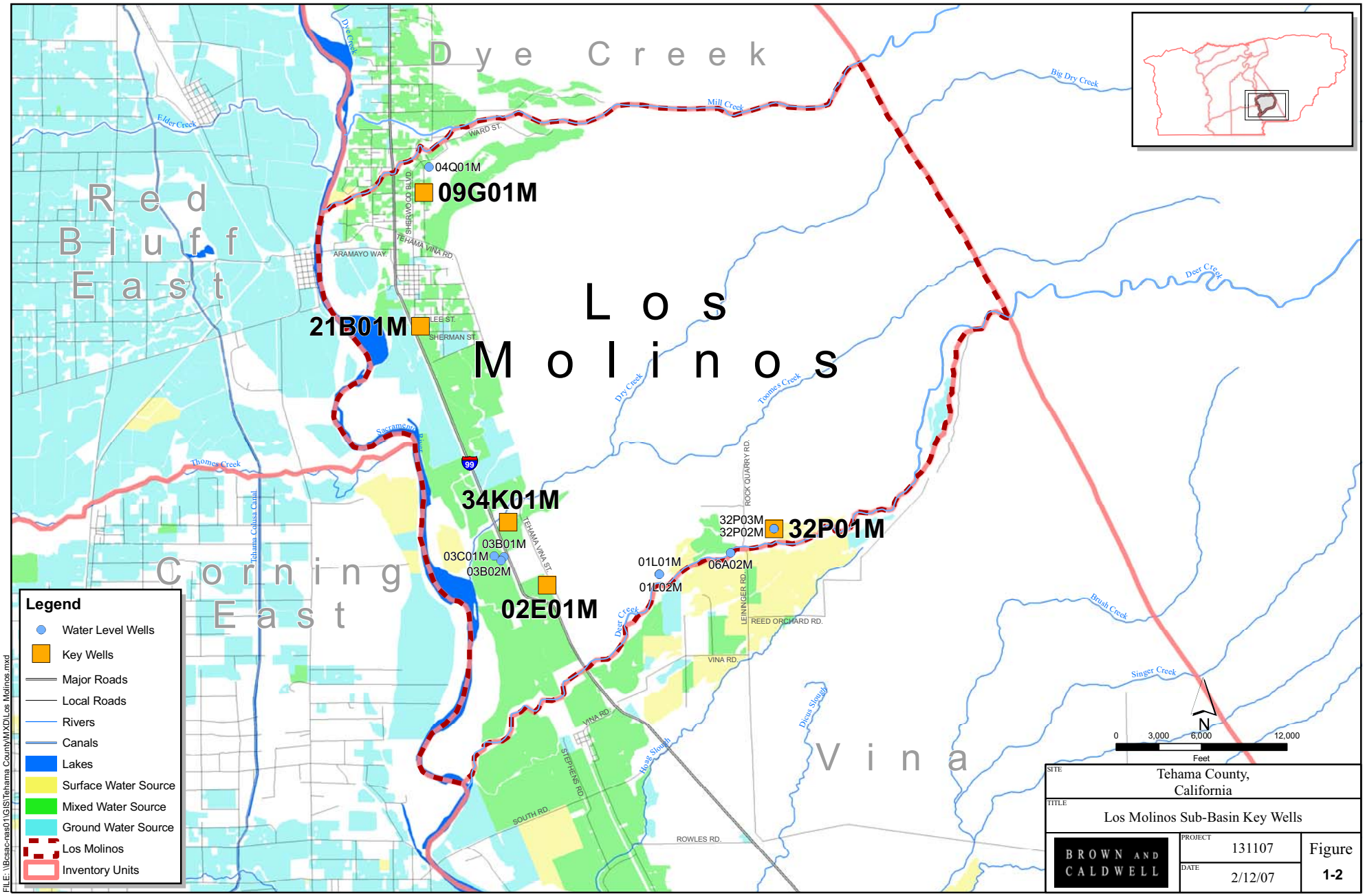
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of five proposed key wells are presented in Figure 1-2. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **25N02W09G01M (09G01M) –** This monitoring well is in the northern portion of the sub-basin and is 60 feet deep with a screened interval from 40 to 60 feet below ground surface (bgs).. This well is situated near pasture irrigated with both surface and groundwater. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 398 domestic wells with an average depth of 86 feet bgs, and 9 irrigation wells with an average depth of 112 feet bgs.
- **25N02W21B01M (21B01M) –** This monitoring well is in the northwest portion of the sub-basin and is 110 feet deep with a screened interval from 52 to 110 feet bgs. This well is situated near pasture and orchards irrigated with both surface water and groundwater. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 118 domestic wells with an average depth of 83 feet bgs, and 16 irrigation wells with an average depth of 196 feet bgs.
- **25N012W34K01M (34K01M) –** This monitoring well is in the west central portion of the sub-basin and is 213 feet deep with a screened interval from 46 to 213 feet bgs. This well is situated near orchards with groundwater and surface water. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 13 domestic wells with an average depth of 103 feet bgs, and 12 irrigation wells with an average depth of 283 feet bgs.
- **24N02W02E01M (02E01M)–** This monitoring well is in the southwest portion of the sub-basin is 328 feet deep with a screened interval from 90 feet to 310 feet bgs. This well is situated near pasture irrigated with groundwater and surface water. This well has a period of record is more


Dye Creek
Red Bluff East
Los Molinos
Corning East
Vina
04Q01M
09G01M
21B01M
34K01M
03B01M
03C01M
03B02M
02E01M
32P03M
32P02M
32P01M
06A02M
01L01M
01L02M
Legend
Water Level Wells
Key Wells
Major Roads
Local Roads
Rivers
Canals
Lakes
Surface Water Source
Mixed Water Source
Ground Water Source
Los Molinos
Inventory Units
0 3,000 6,000 12,000
Feet
N
SITE
Tehama County, California
TITLE
Los Molinos Sub-Basin Key Wells
BROWN AND CALDWELL
PROJECT
131107
DATE
2/12/07
Figure
1-2
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than 8 years. The nine square miles near this well contain 16 domestic wells with an average depth of 122 feet bgs, and 11 irrigation wells with an average depth of 353 feet bgs.

- **25N01W32P01M (32P01M)–** This monitoring well is in the southeast portion of the sub-basin and is 330 feet deep with a screened interval from 209 to 256 feet bgs. This well is situated near pasture irrigated with surface water. This well has a period of record is more than 7 years. The nine square miles near this well contain 13 domestic wells with an average depth of 103 feet bgs, and 12 irrigation wells with an average depth of 283 feet bgs.

There are currently no monitoring wells in the northeastern corner of the Los Molinos sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the area.

Step 3: Designate the time of seasonal measurement

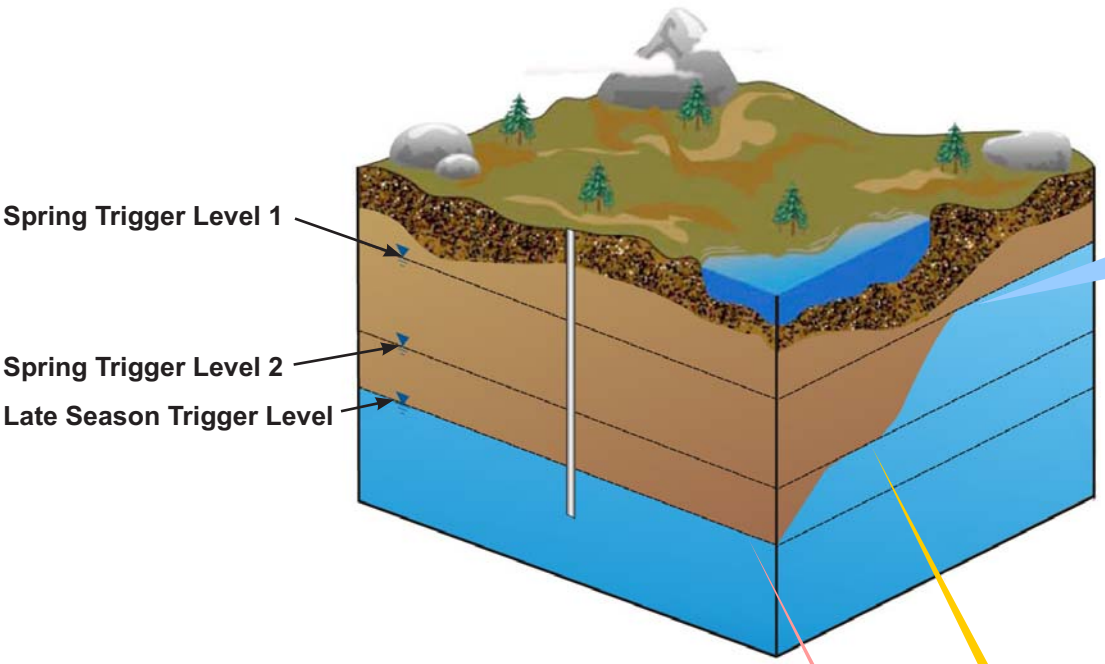
Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows three suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-18 present hydrographs and suggested trigger levels for each of the five Los Molinos key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Los Molinos sub-basin are provided in Table 1-1. Some trigger levels were set using exceptions from the methodologies to account for measurements that are outside the range of normal spring and summer measurements. Two key wells (02E01M, 32P01M) had limited historic records of groundwater level measurements that did not include a significant drought cycle, so the method of proposing spring and late season trigger levels was modified and is subject to change in annual reviews as more experience is gained.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Los Molinos Monitoring Well Number				
	09G01M	**21B01M**	**34K01M**	**02E01M**	**32P01M**
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements			Historical low of spring measurements	
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements			Historical low of spring measurements minus the range of spring measurements	
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	None	A	None	None	None

Footnotes:

A: Late Season Trigger Level set above single outlier water level elevation. The reported low level may be an inaccurate measurement and occurred during a non-drought period..

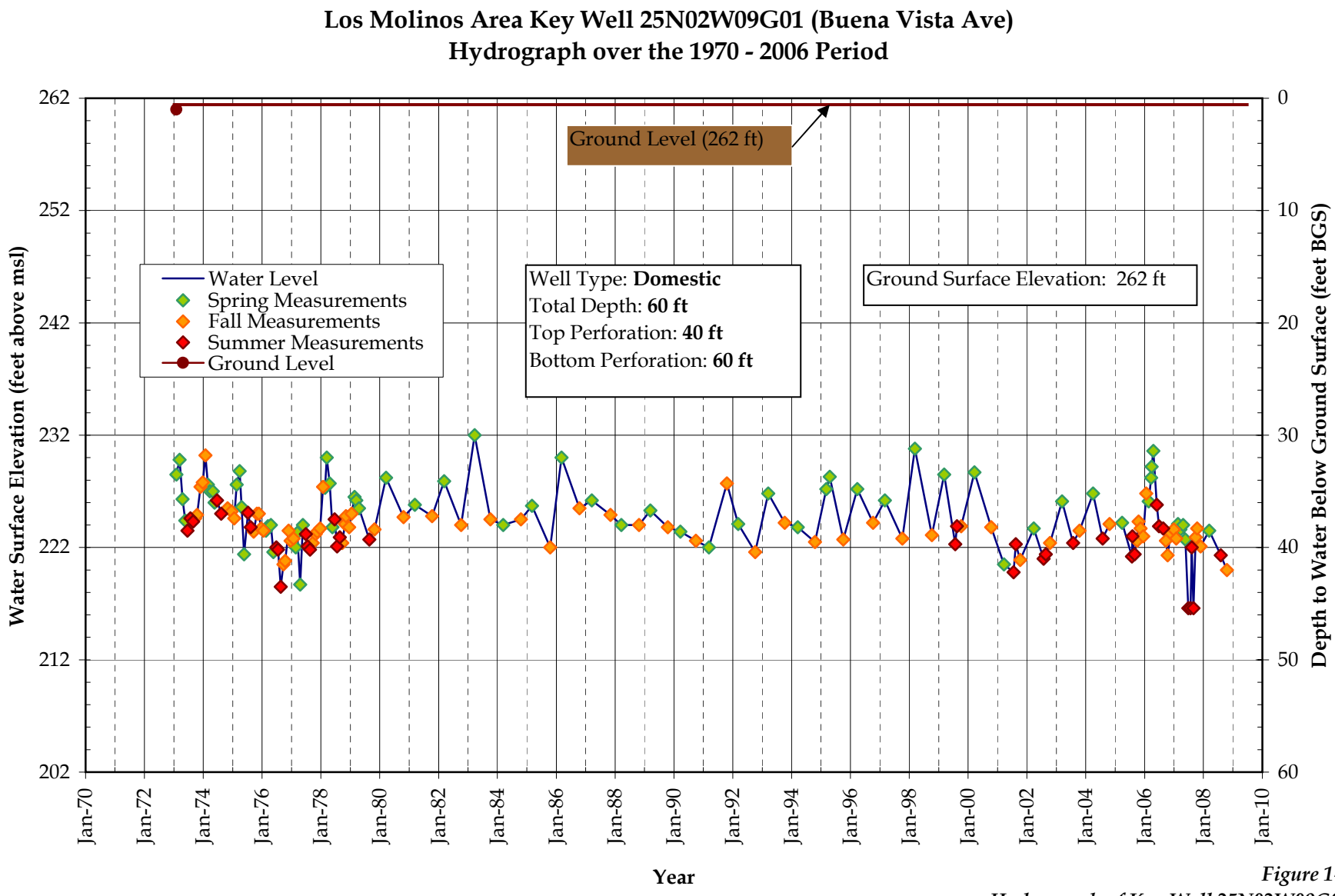


Figure 1-4
Hydrograph of Key Well 25N02W09G01

Updated 12-01-08

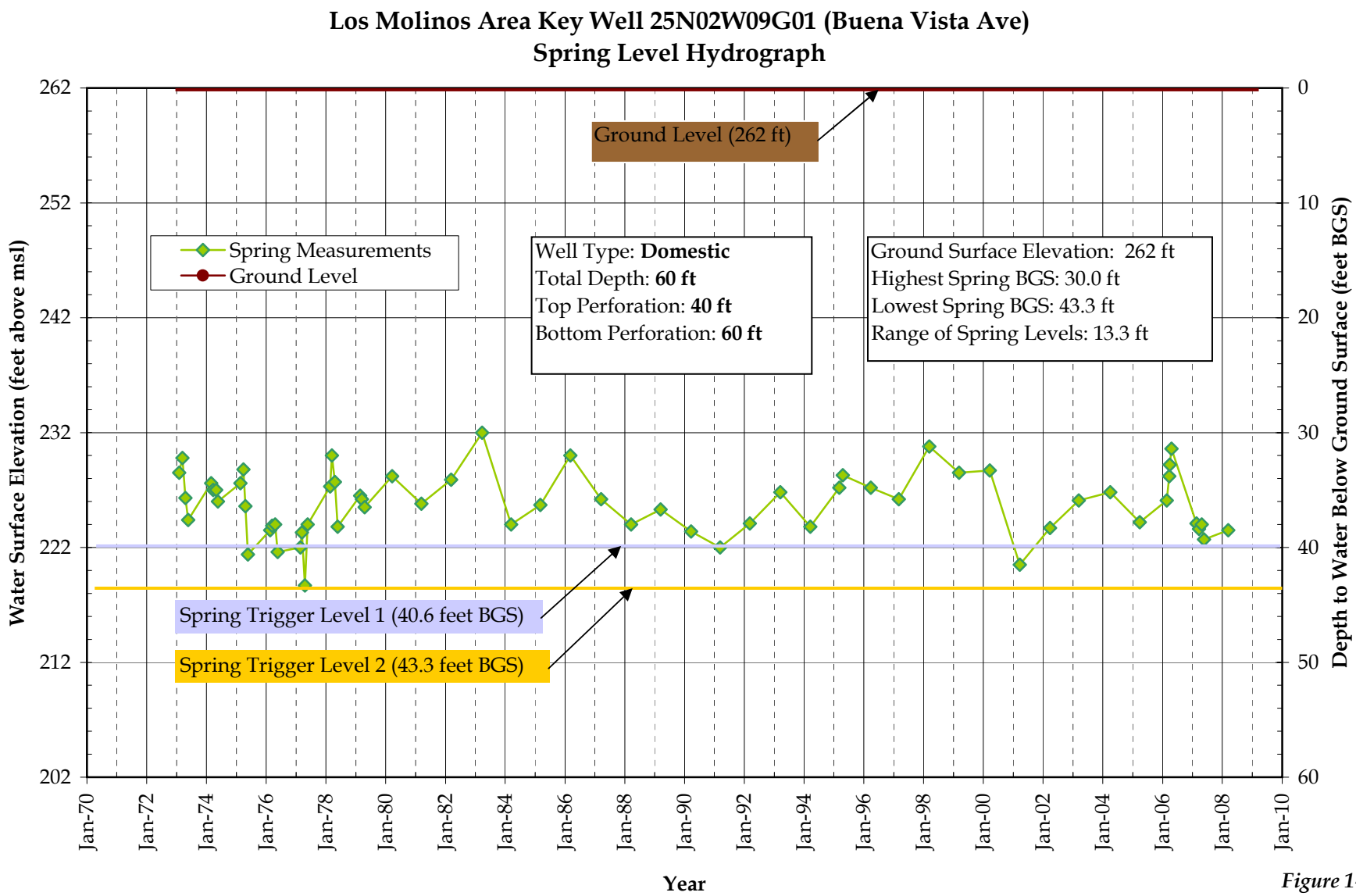


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

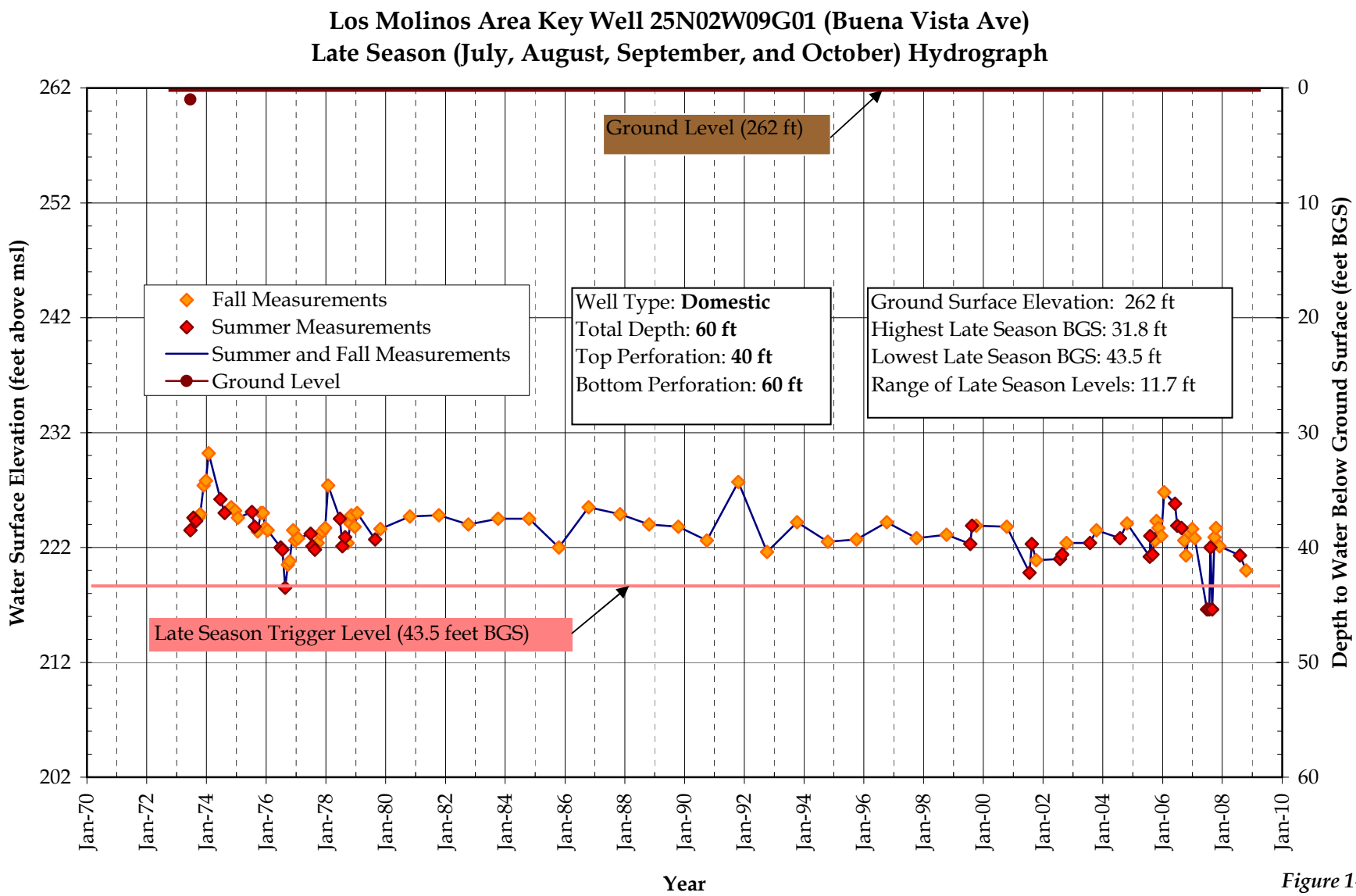


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

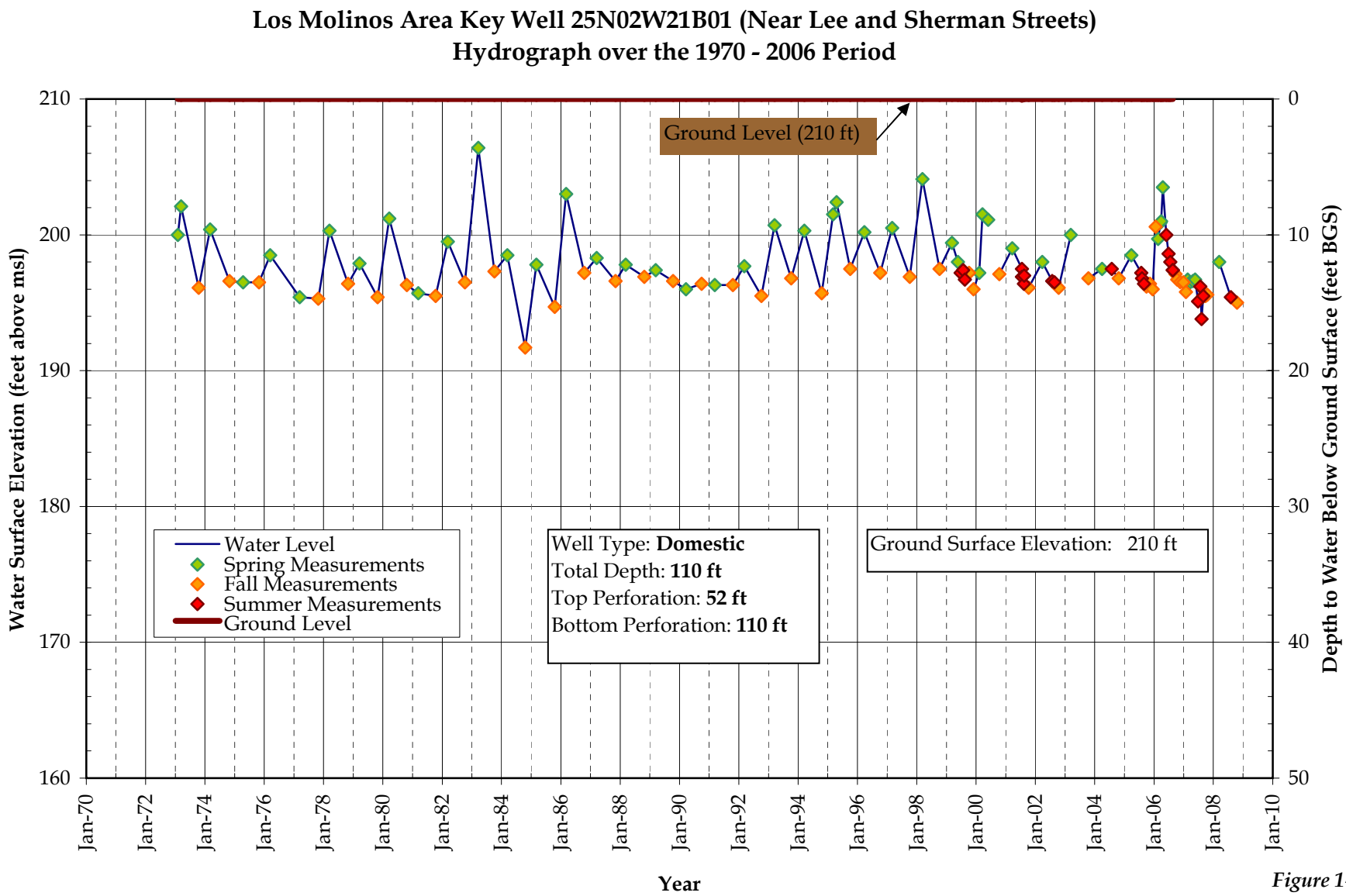


Figure 1-7
Hydrograph of Key Well 25N02W21B01

Updated 12-01-08

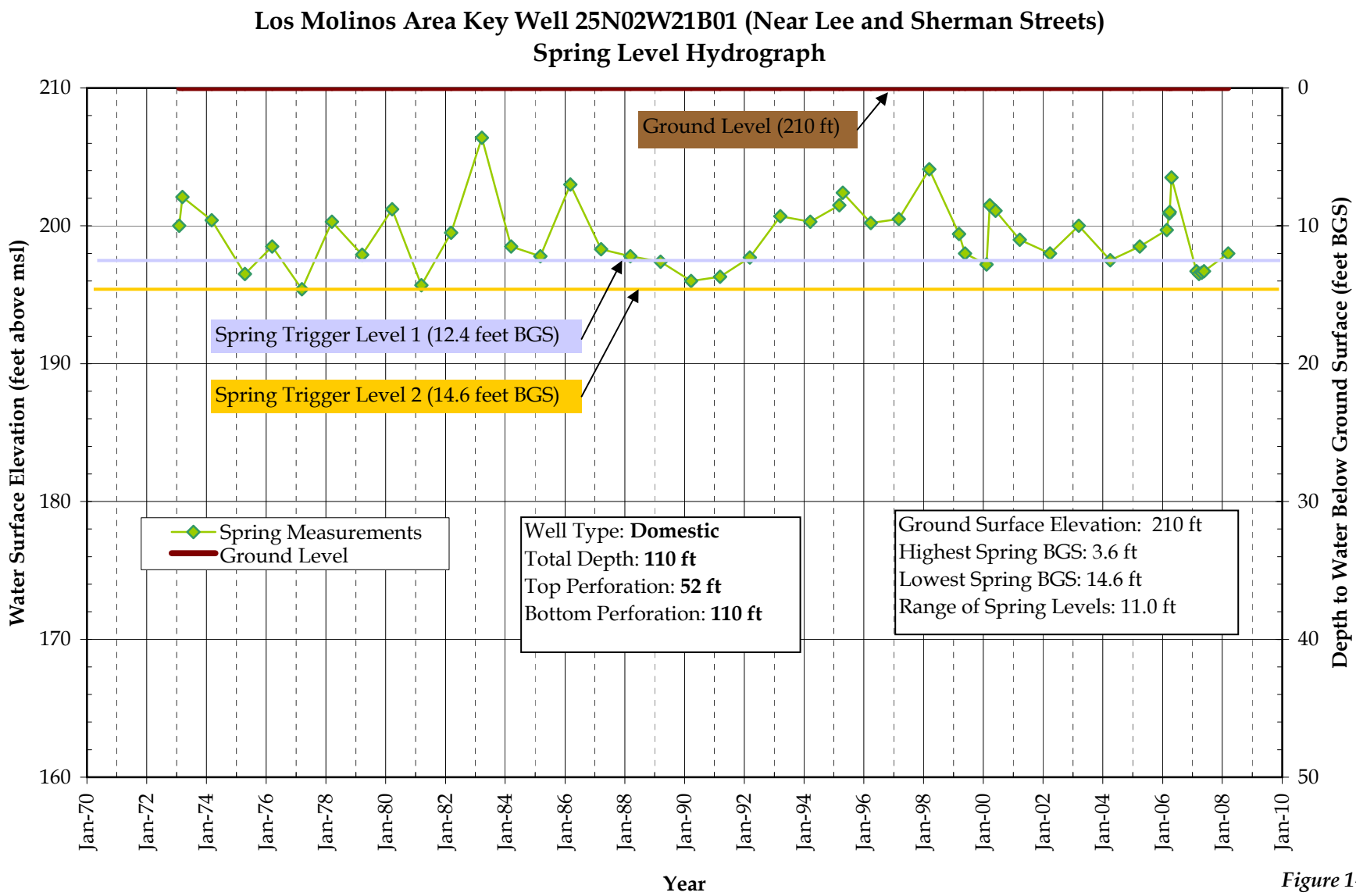


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

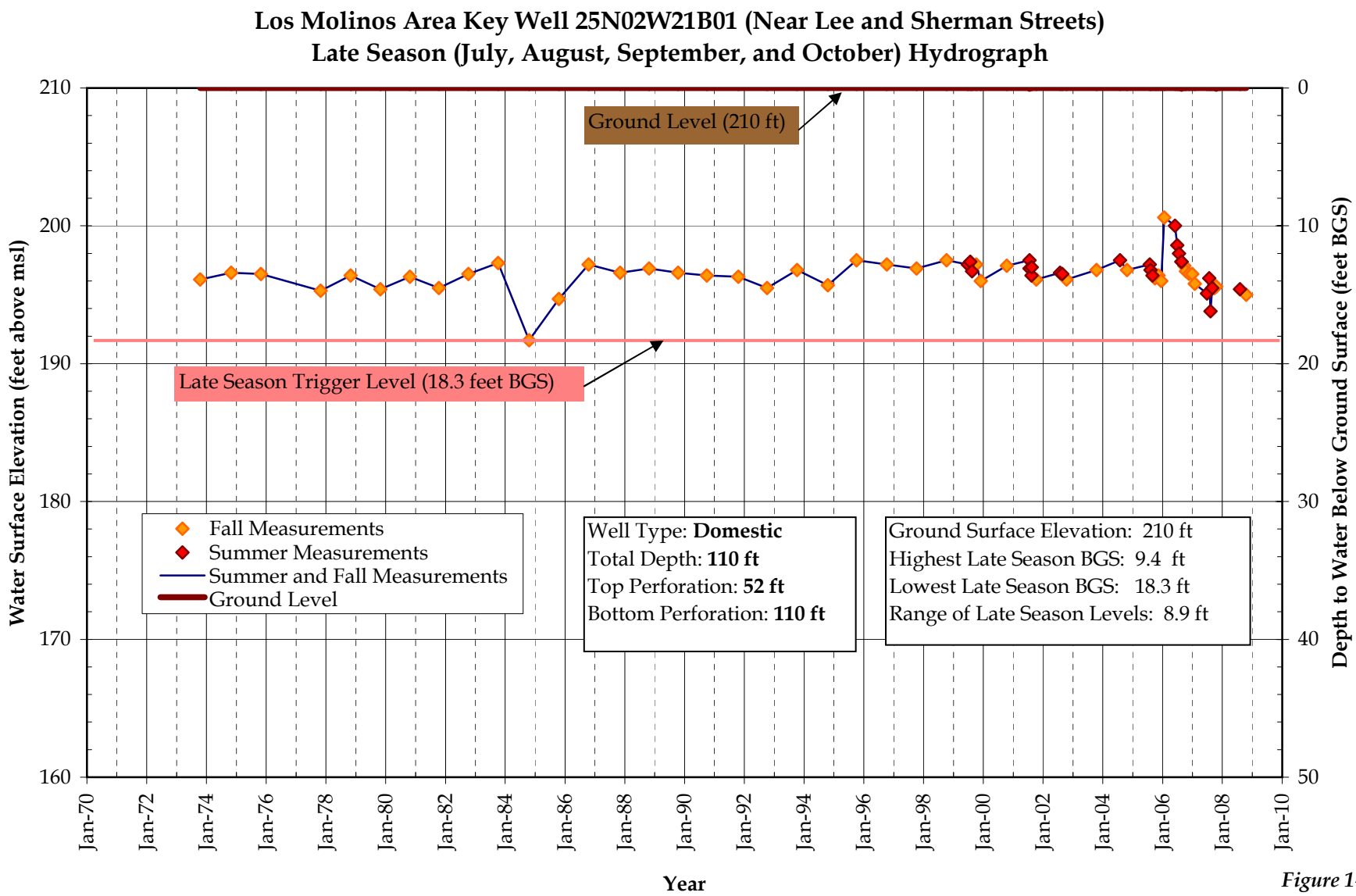


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

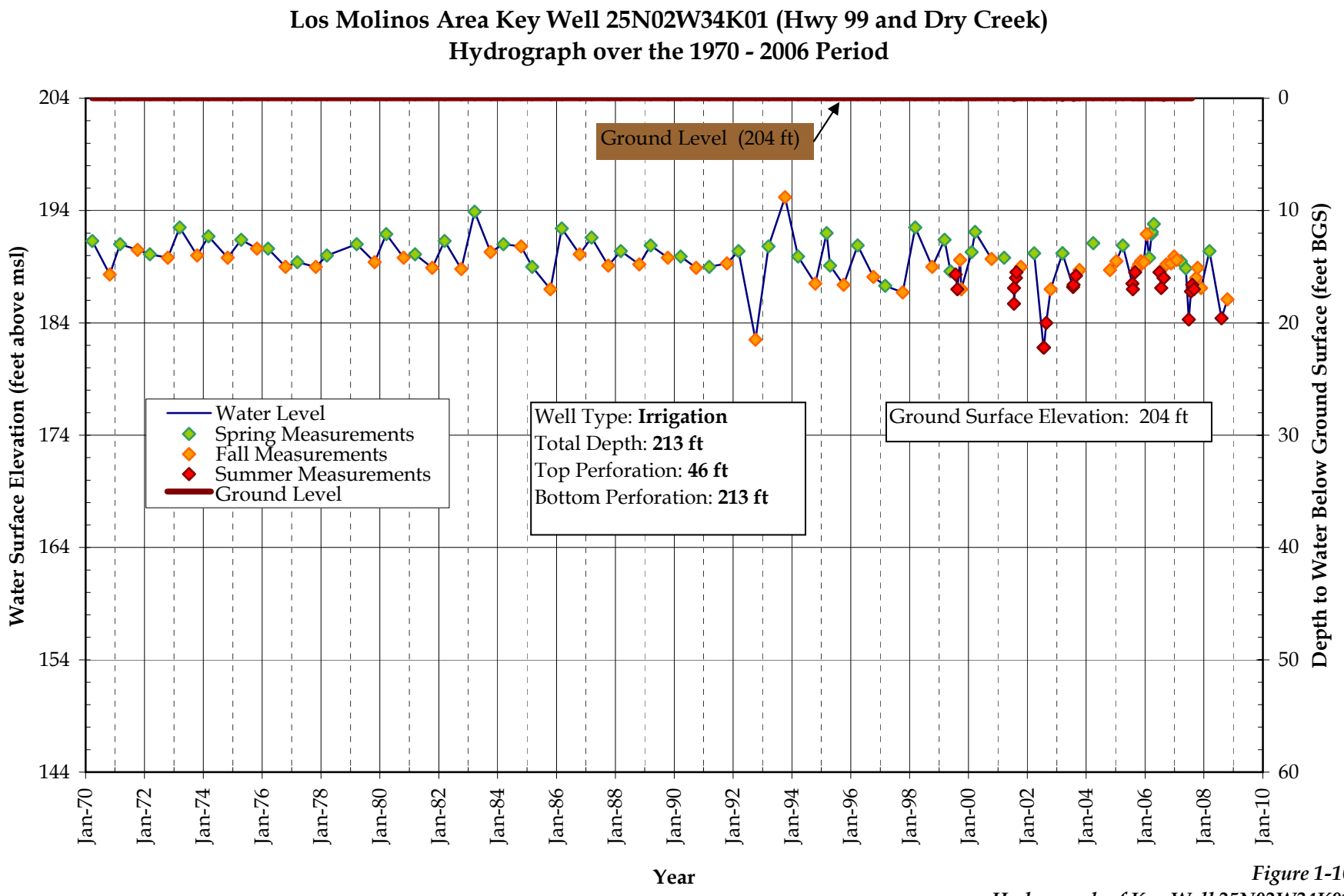


Figure 1-10
Hydrograph of Key Well 25N02W34K01

Updated 12-01-08

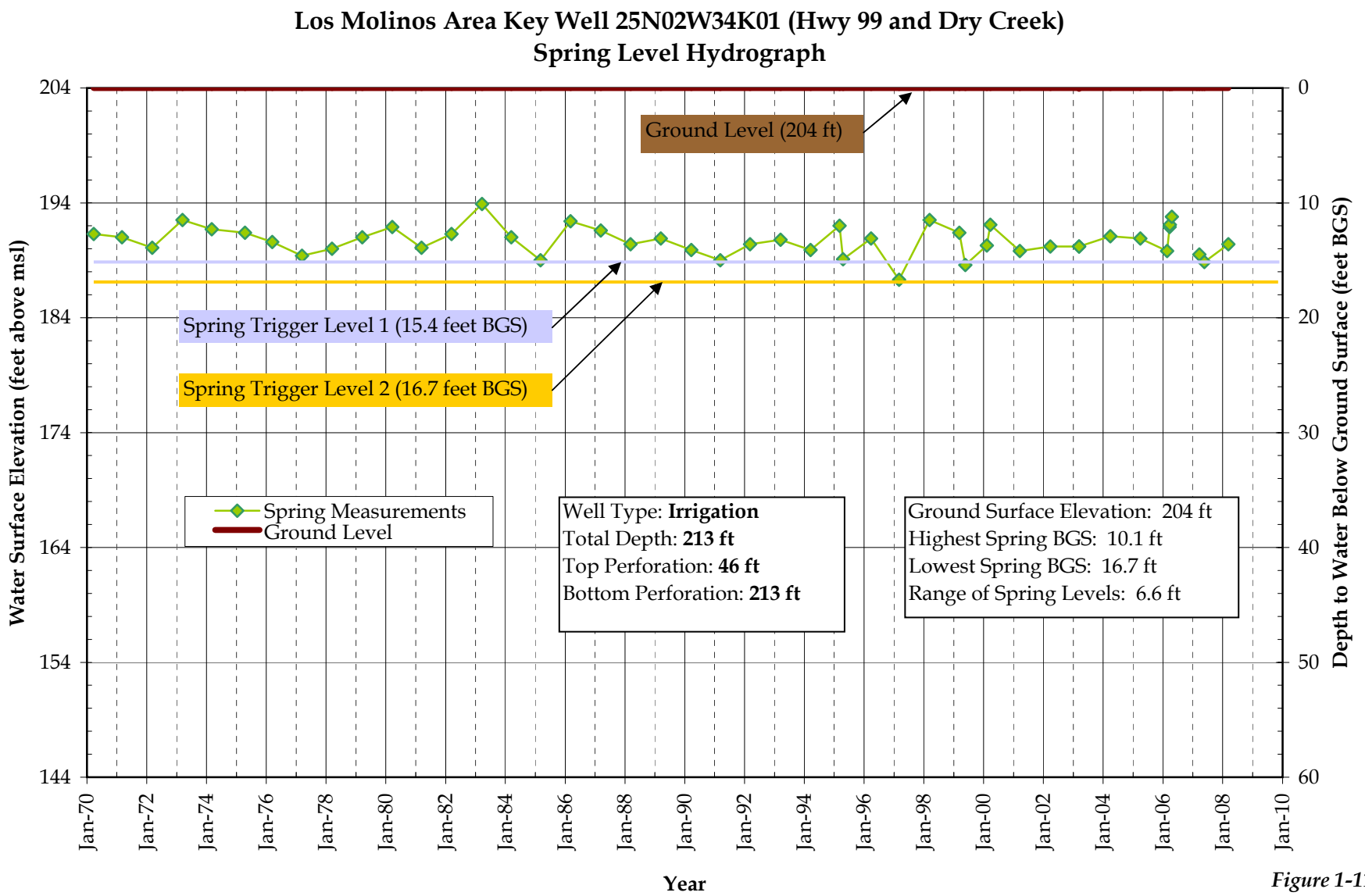


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

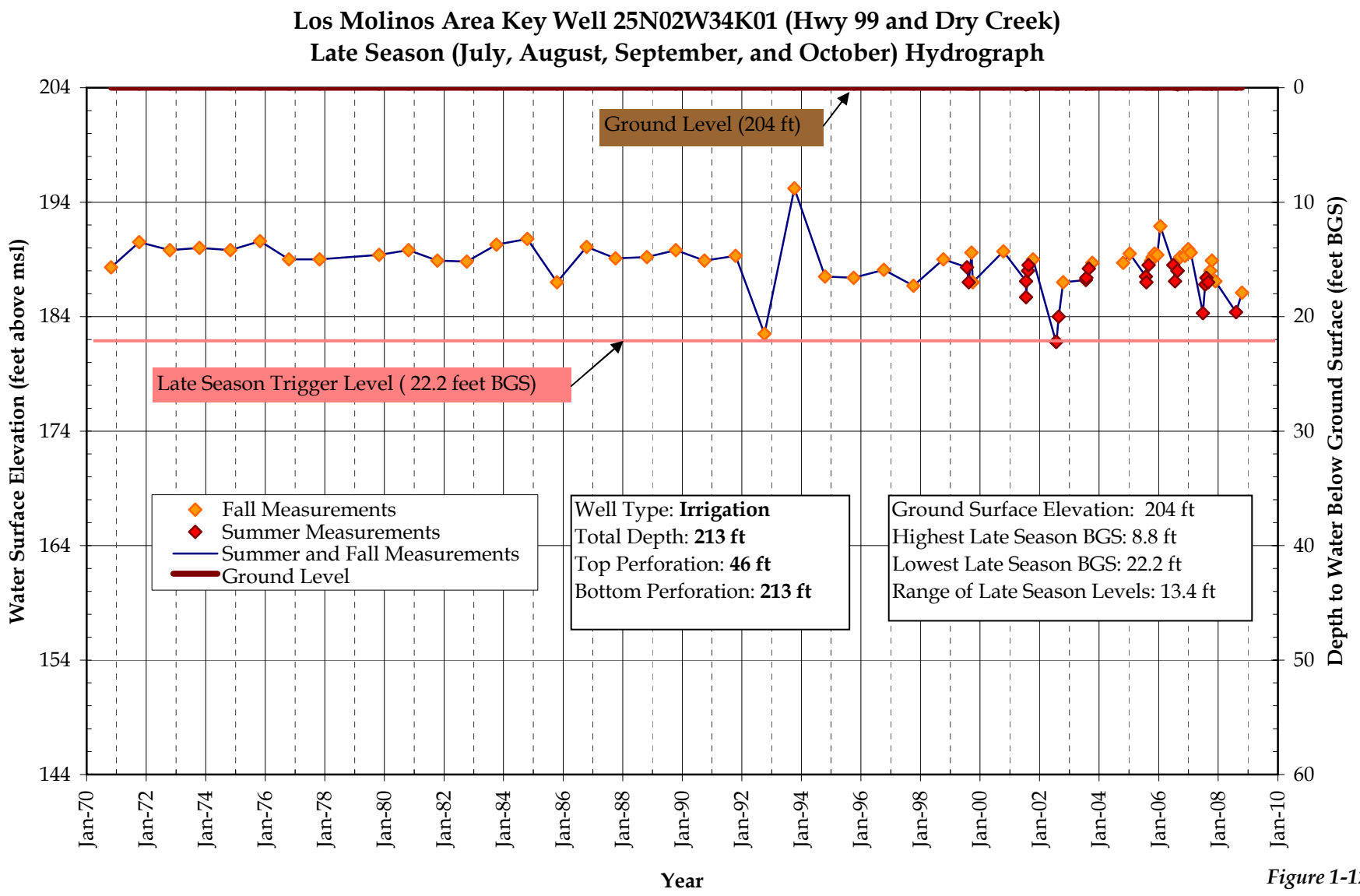


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

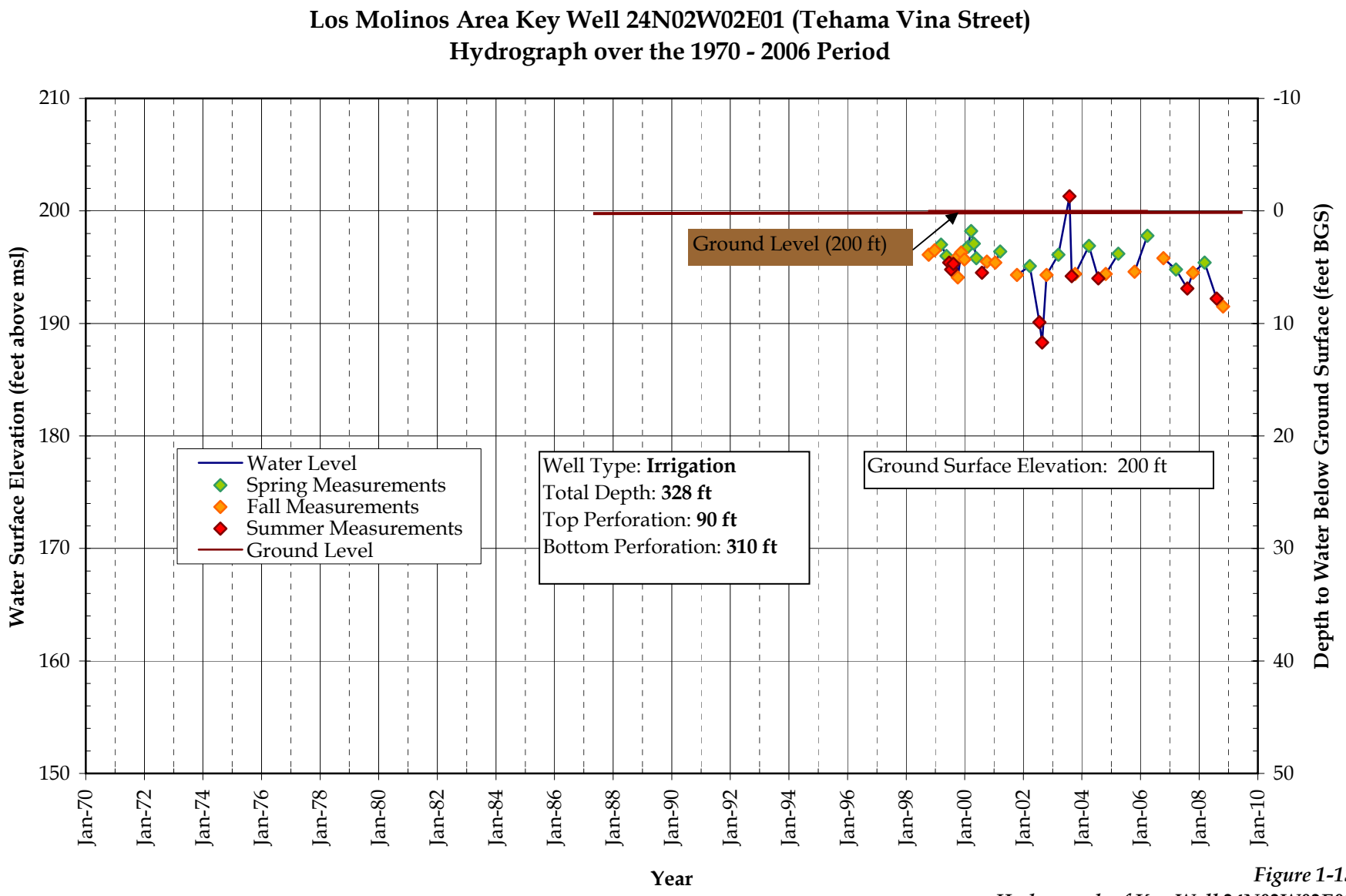


Figure 1-13
Hydrograph of Key Well 24N02W02E01

Updated 12-01-08

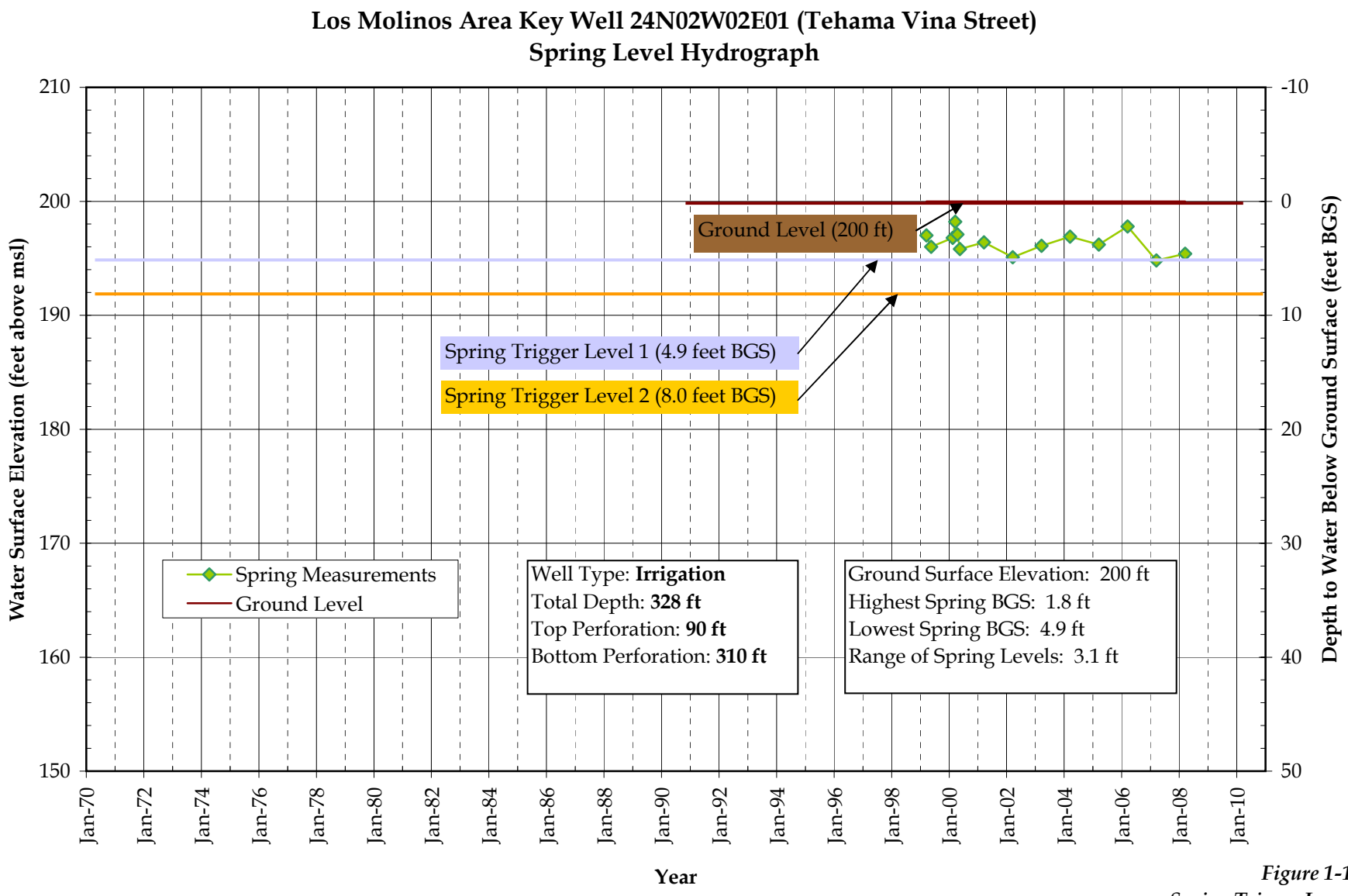


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

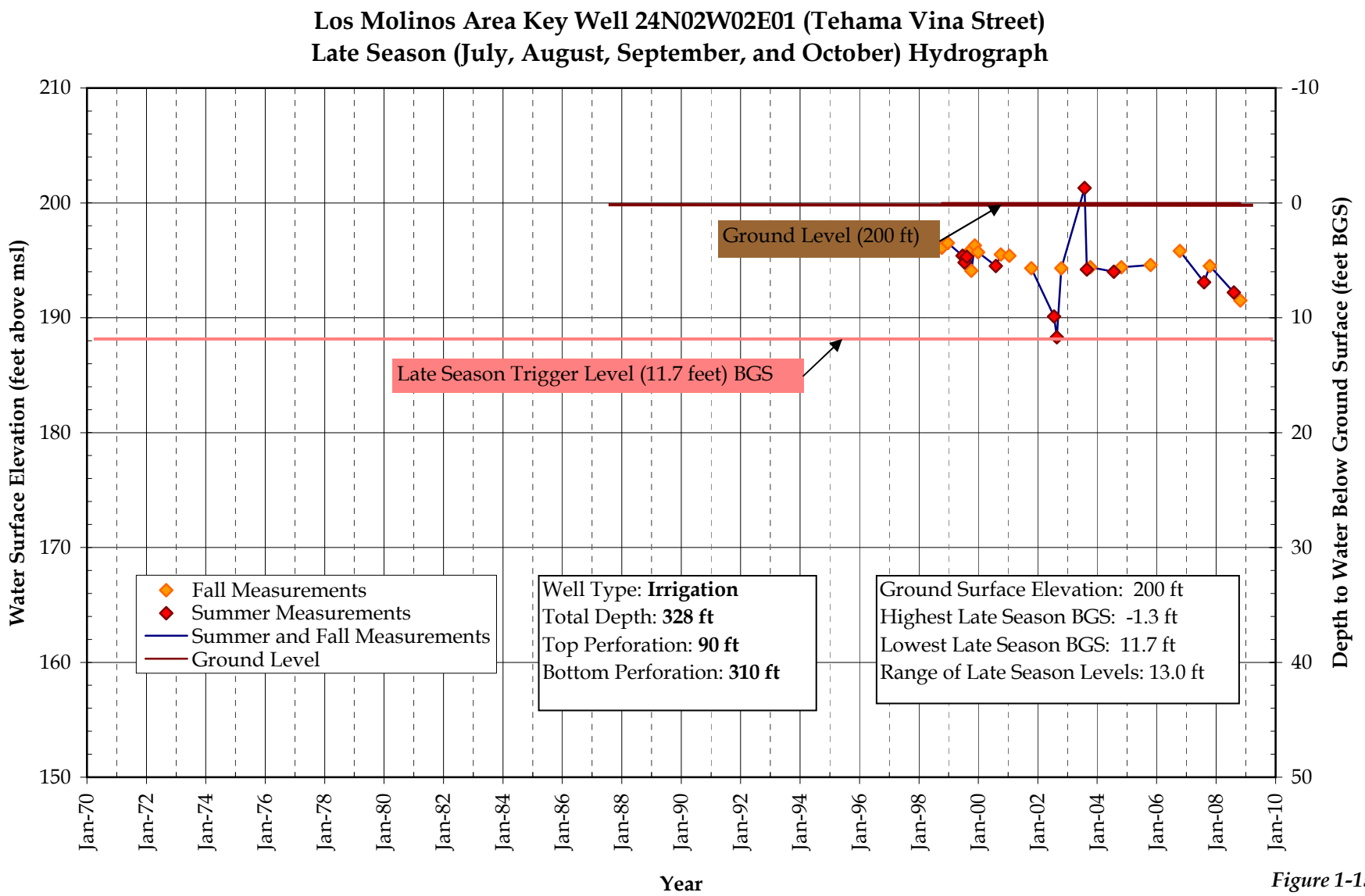


Figure 1-15
Late Season Trigger Level

Updated 12-01-08

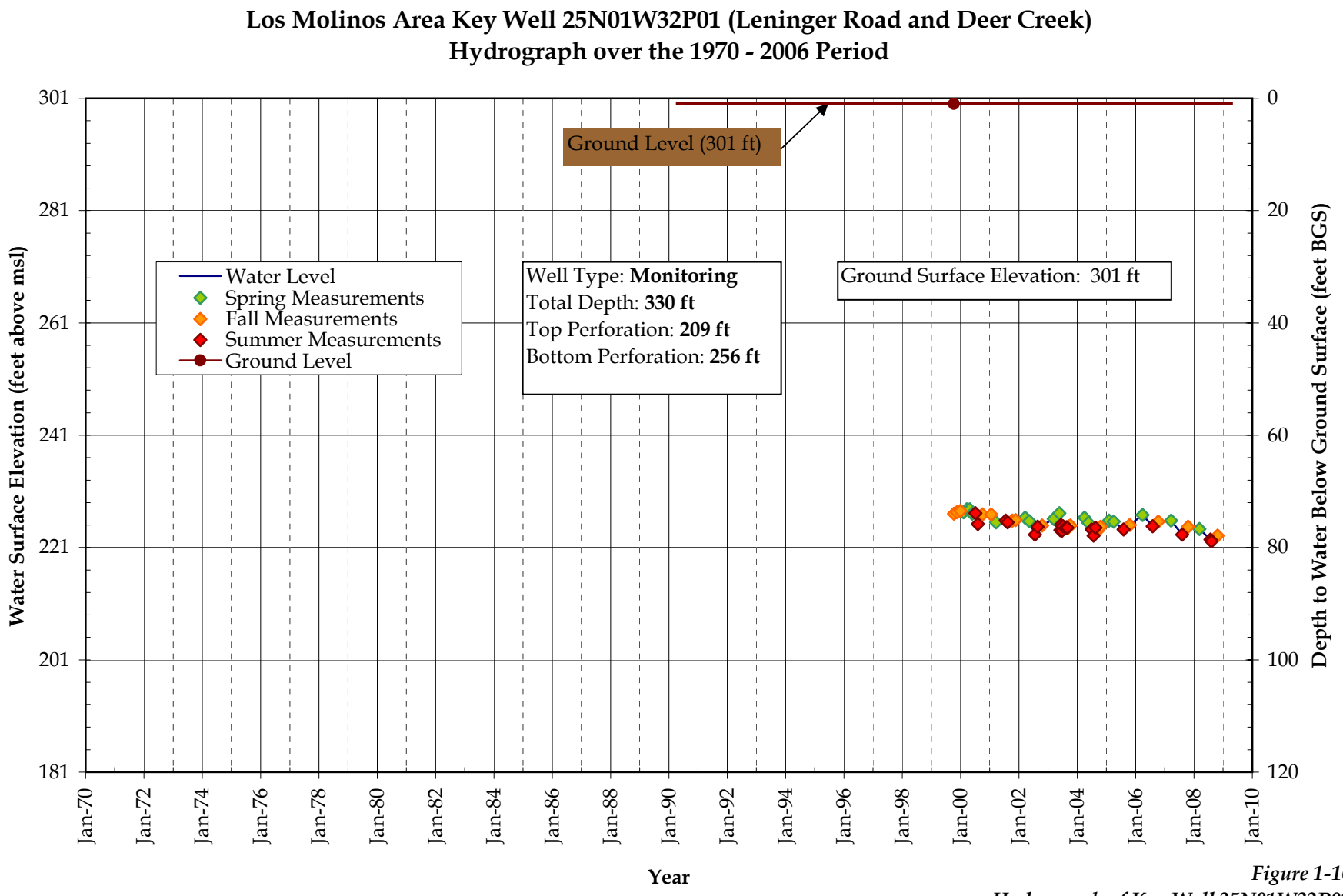


Figure 1-16
Hydrograph of Key Well 25N01W32P01

Updated 12-01-08

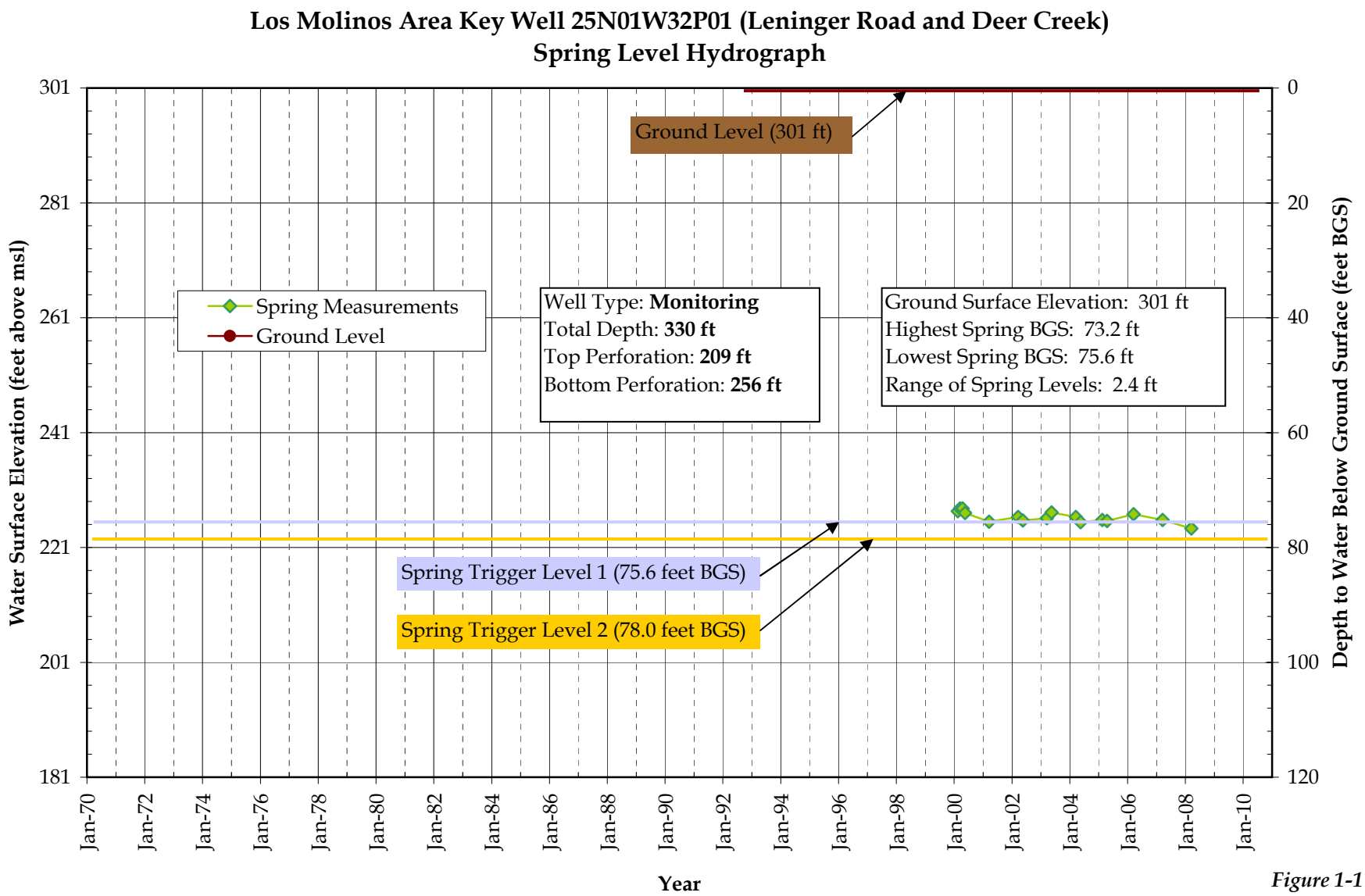


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

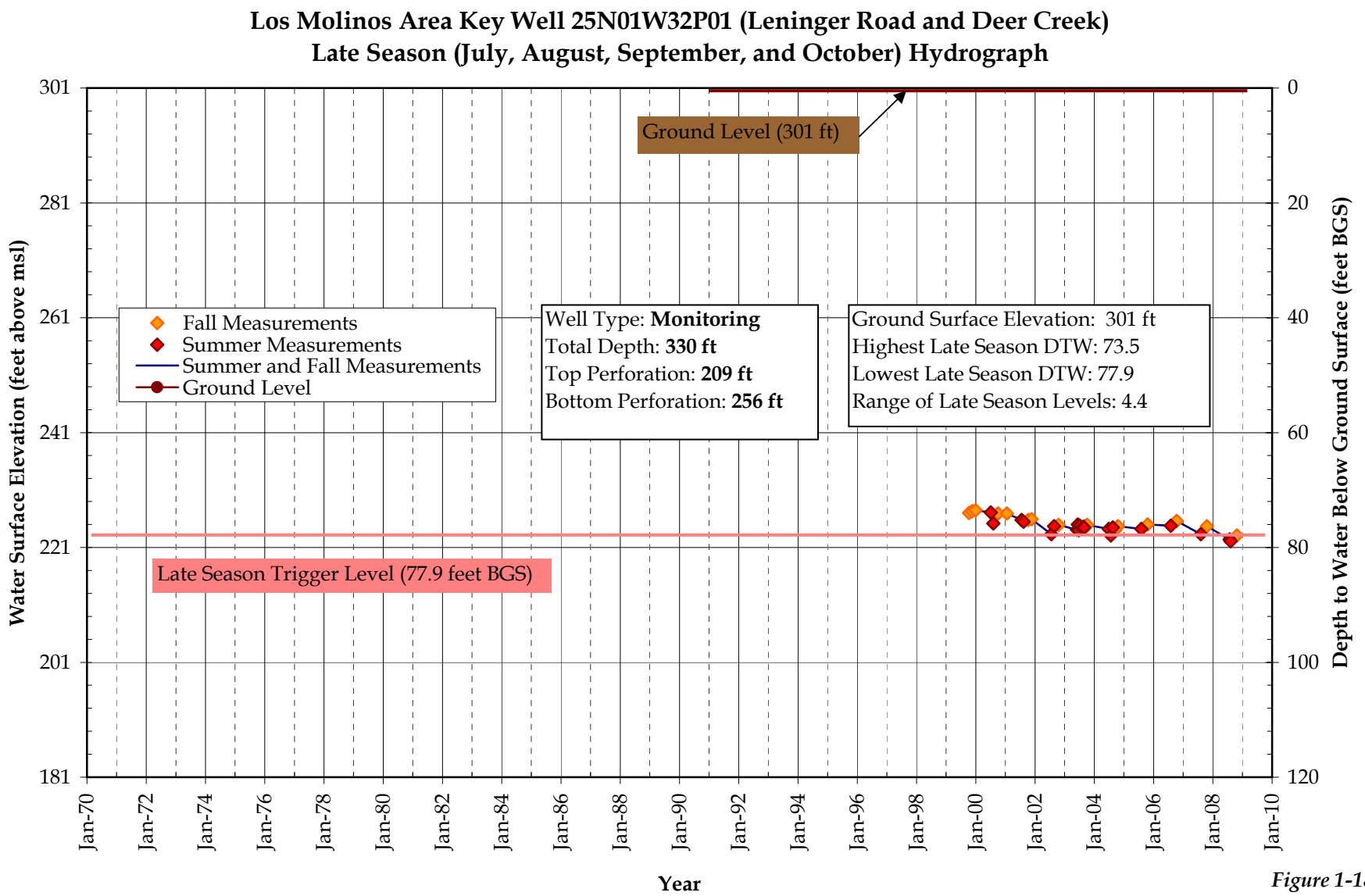


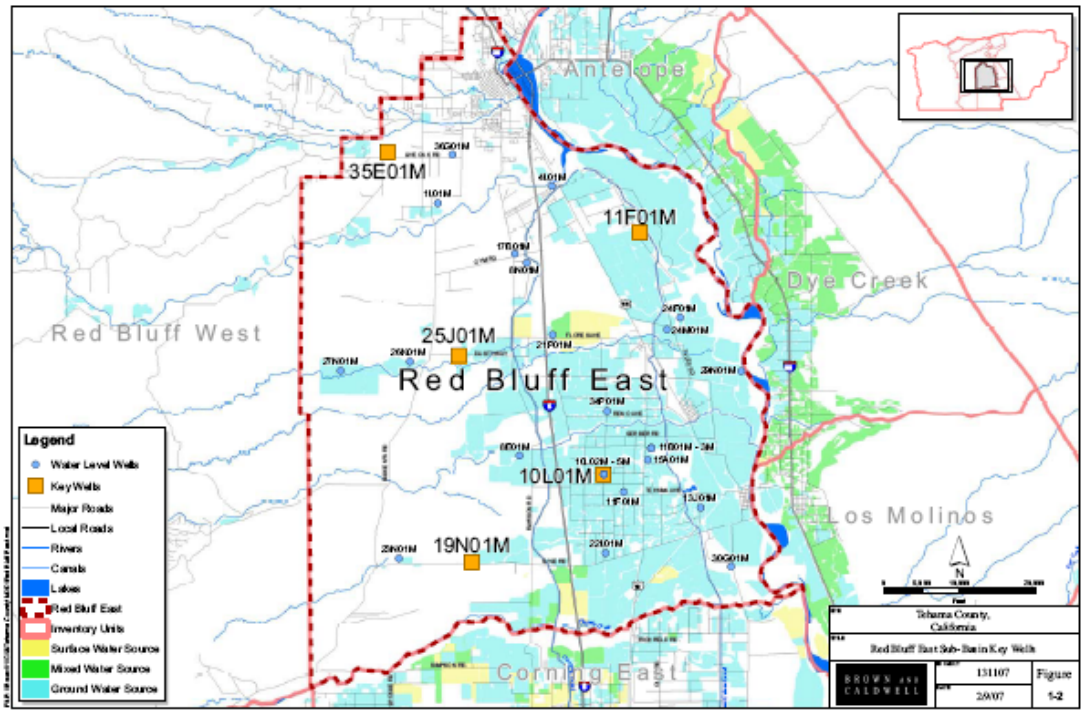
Figure 1-18
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Red Bluff East Sub-basin of Tehama County



Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Red Bluff East Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

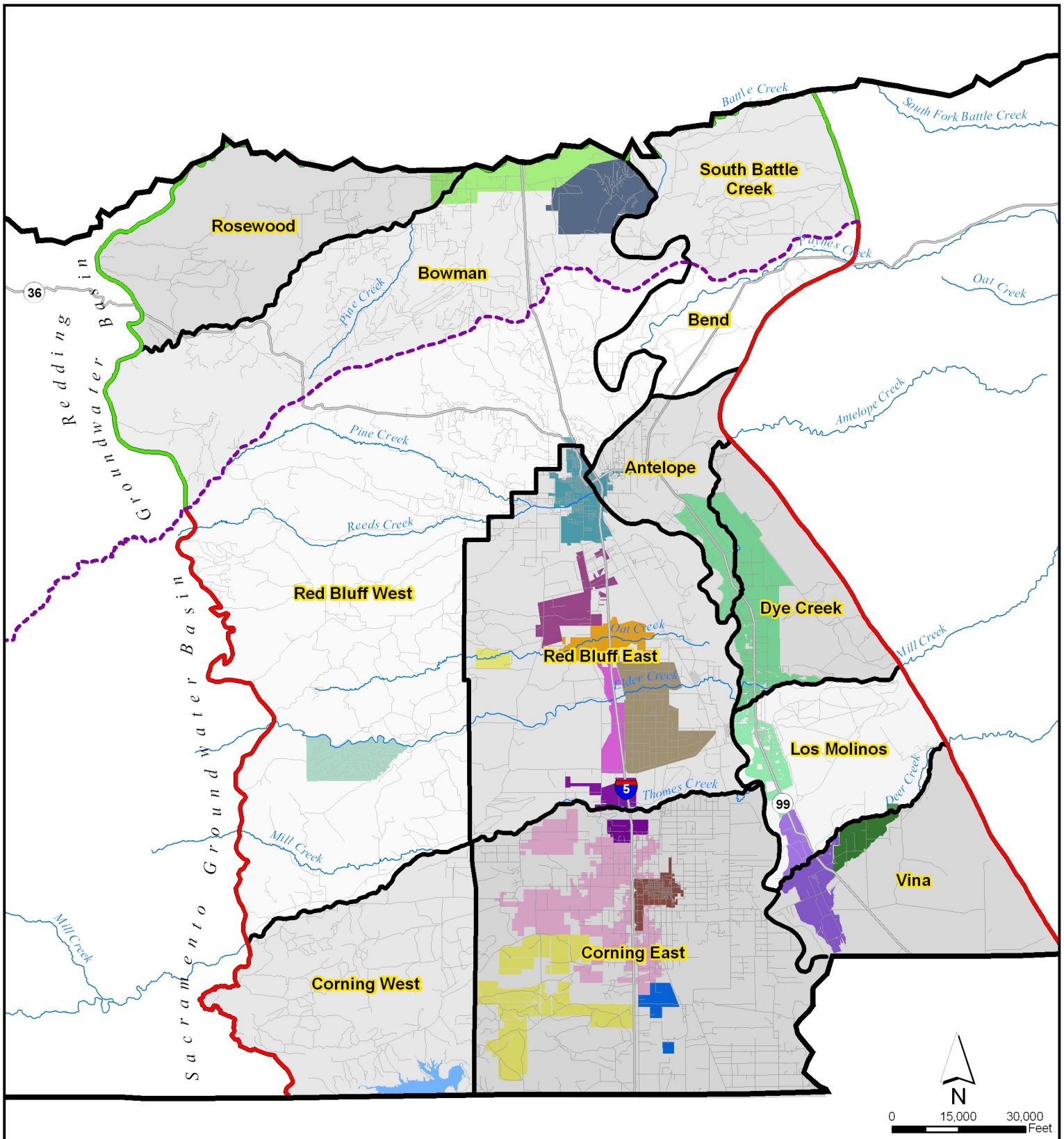
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Red Bluff East sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to two decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Red Bluff East sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated in the following table:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Red Bluff East sub-basin is primarily a rural area, with agriculture throughout the area and the City of Red Bluff in the north. . Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. Groundwater is used for agricultural, municipal, and domestic purposes. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Red Bluff East:	
Irrigation:	89% (66,900 acre-ft)
Municipal, and Industrial:	11% (8,100 acre-ft)
Number of wells by type in Red Bluff East:	
Irrigation:	254 wells
Domestic:	1137 wells
Municipal and Industrial:	37 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin

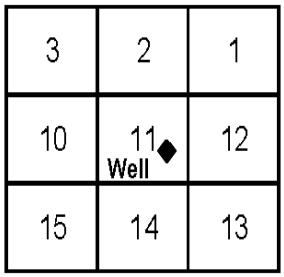
Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods

of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

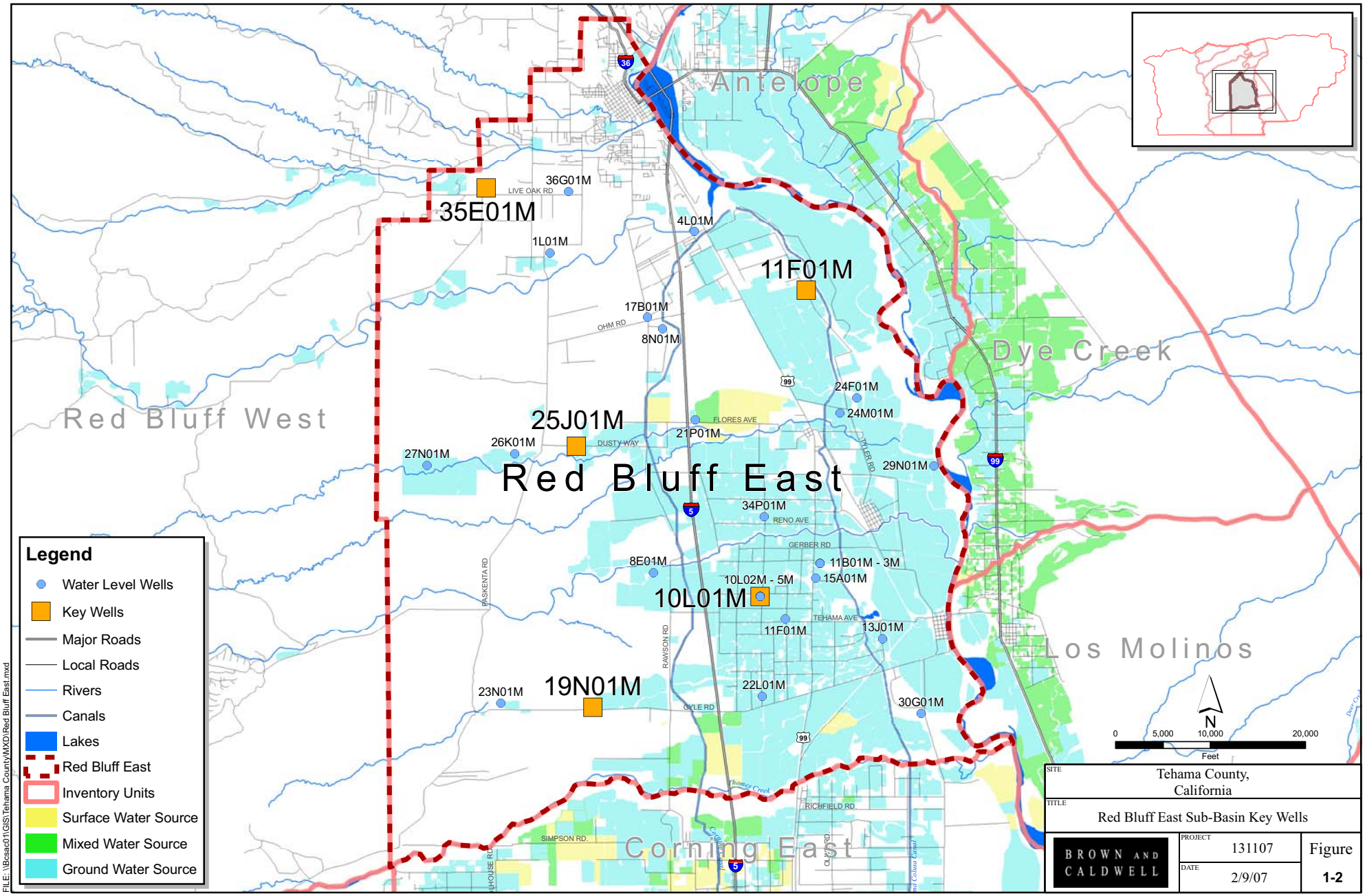
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of five proposed key wells are presented in Figure 1-2. Each of these proposed wells have a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **25N03W10L01M (10L01M) –** This monitoring well is in the southeast portion of the sub-basin and is 400 feet deep with a screened interval from 190 to 400 feet below ground surface (bgs). This well is situated near pasture irrigated with groundwater and idle lands. The nine square miles near this well contain 137 domestic wells with an average depth of 126 feet bgs, and 35 irrigation wells with an average depth of 415 feet bgs.
- **26N04W25J01M (25J01M) –** This monitoring well is in the western portion of the sub-basin and is 128 feet deep with a screened interval from 116 to 124 feet bgs. This well is situated near native vegetation and pasture irrigated with groundwater. The nine square miles near this well contain 520 domestic wells with an average depth of 114 feet bgs, and 29 irrigation wells with an average depth of 225 feet bgs.
- **25N03W19N01M (19N01M) –** This monitoring well is in the southwest portion of the sub-basin and is 370 feet deep with a screened interval from 135 feet to 358 feet bgs. This well is situated near pasture and grain crops irrigated with groundwater. The nine square miles near this well contain 30 domestic wells with an average depth of 166 feet bgs, and 9 irrigation wells with an average depth of 318 feet bgs.
- **26N03W11F01M (11F01M)–** This monitoring well is in the northeast portion of the sub-basin and is 190 feet deep with a screened interval from 70 to 80 feet bgs. This well is situated near areas irrigated with groundwater. The nine square miles near this well contain 31 domestic wells with an average depth of 127 feet bgs, and 24 irrigation wells with an average depth of 218 feet bgs.
- **27N04W35E01M (35E01M)–** This monitoring well is in the northwest central portion of the sub-basin and is 280 feet deep with a screened interval from 266 to 272 feet bgs. This well is


Antelope
Red Bluff West
Red Bluff East
Dye Creek
Los Molinos
Corning East
35E01M
36G01M
LIVE OAK RD
1L01M
4L01M
11F01M
17B01M
OHM RD
8N01M
24F01M
24M01M
25J01M
26K01M
27N01M
DUSTY WAY
FLORES AVE
21P01M
TYLER RD
29N01M
34P01M
RENO AVE
GERBER RD
8E01M
11B01M - 3M
15A01M
10L02M - 5M
10L01M
TEHAMA AVE
11F01M
13J01M
RAWSON RD
PASKENTA RD
23N01M
19N01M
22L01M
30G01M
GYLE RD
Thomes Creek
RICHFIELD RD.
SIMPSON RD.
HOUSE RD.
OLD ARBUCKLE RD.
Legend
Water Level Wells
Key Wells
Major Roads
Local Roads
Rivers
Canals
Lakes
Red Bluff East
Inventory Units
Surface Water Source
Mixed Water Source
Ground Water Source
N
0
5,000
10,000
20,000
Feet
SITE
Tehama County, California
TITLE
Red Bluff East Sub-Basin Key Wells
BROWN AND CALDWELL
PROJECT
131107
DATE
2/9/07
Figure
1-2
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situated near urban land use. The nine square miles near this well contain 307 domestic wells with an average depth of 243 feet bgs, and 20 irrigation wells with an average depth of 289 feet bgs.

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

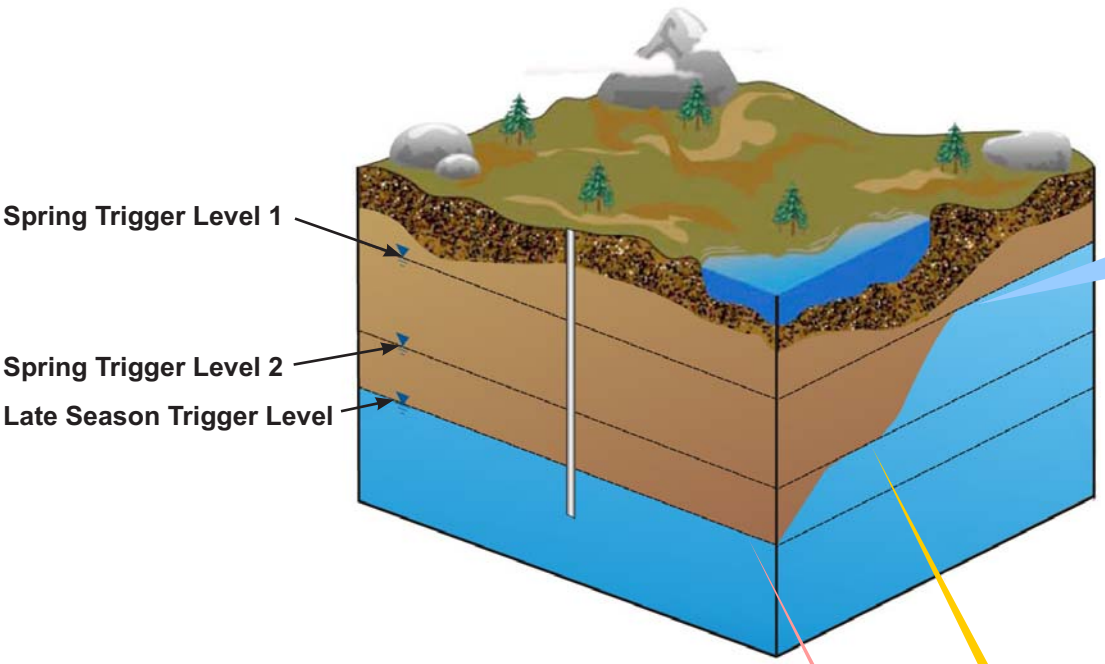
Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows three suggested spring trigger levels and one



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-18 present hydrographs and suggested trigger levels for each of the five Red Bluff East key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Red Bluff East sub-basin are provided in Table 1-1.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Red Bluff East Monitoring Well Number				
	10L01M	**25J01M**	**19N01M**	**11F01M**	**35E01M**
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements				
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1				
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements				
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements				
Data Anomalies	None	None	None	None	None

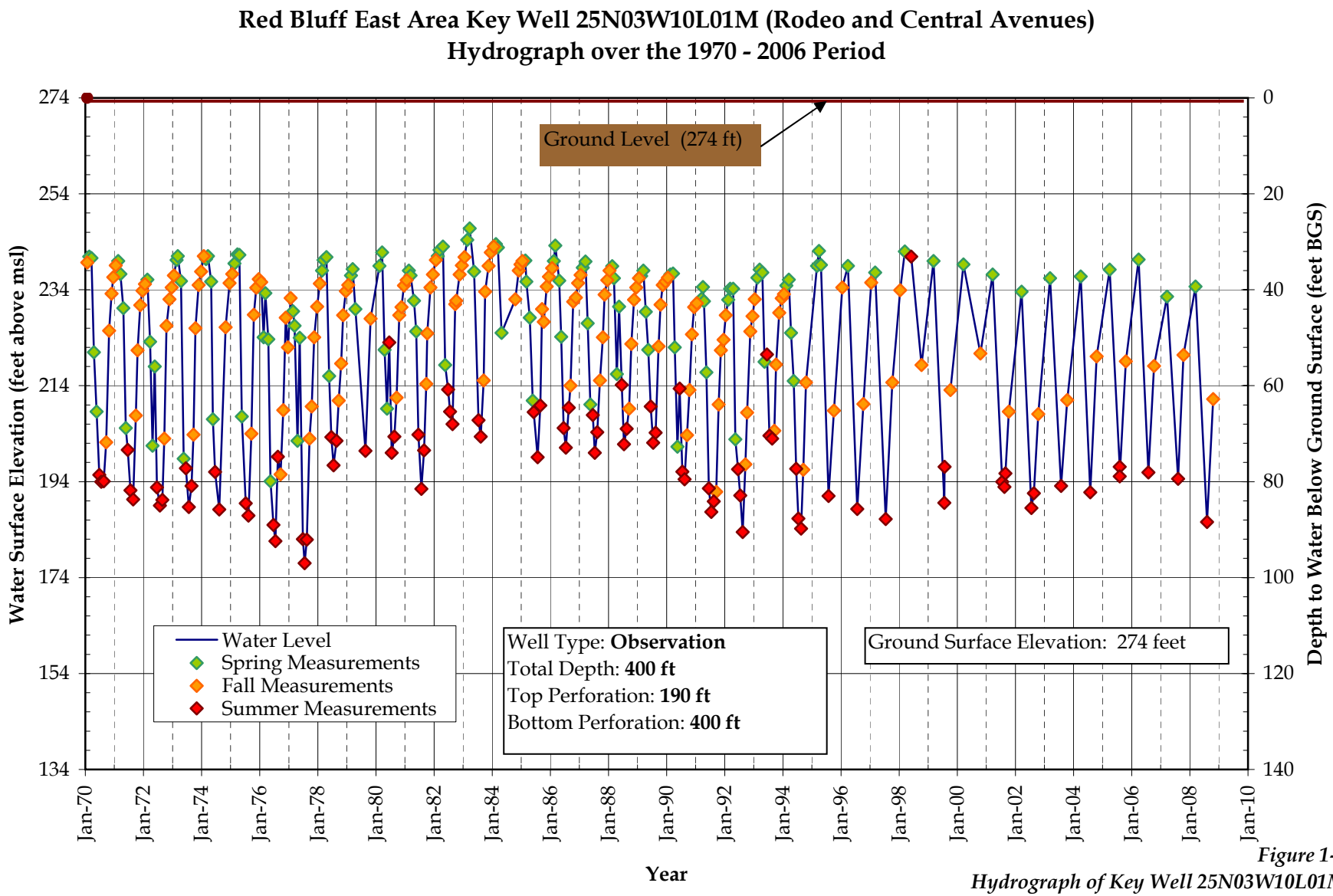


Figure 1-4
Hydrograph of Key Well 25N03W10L01M

Updated 12-01-08

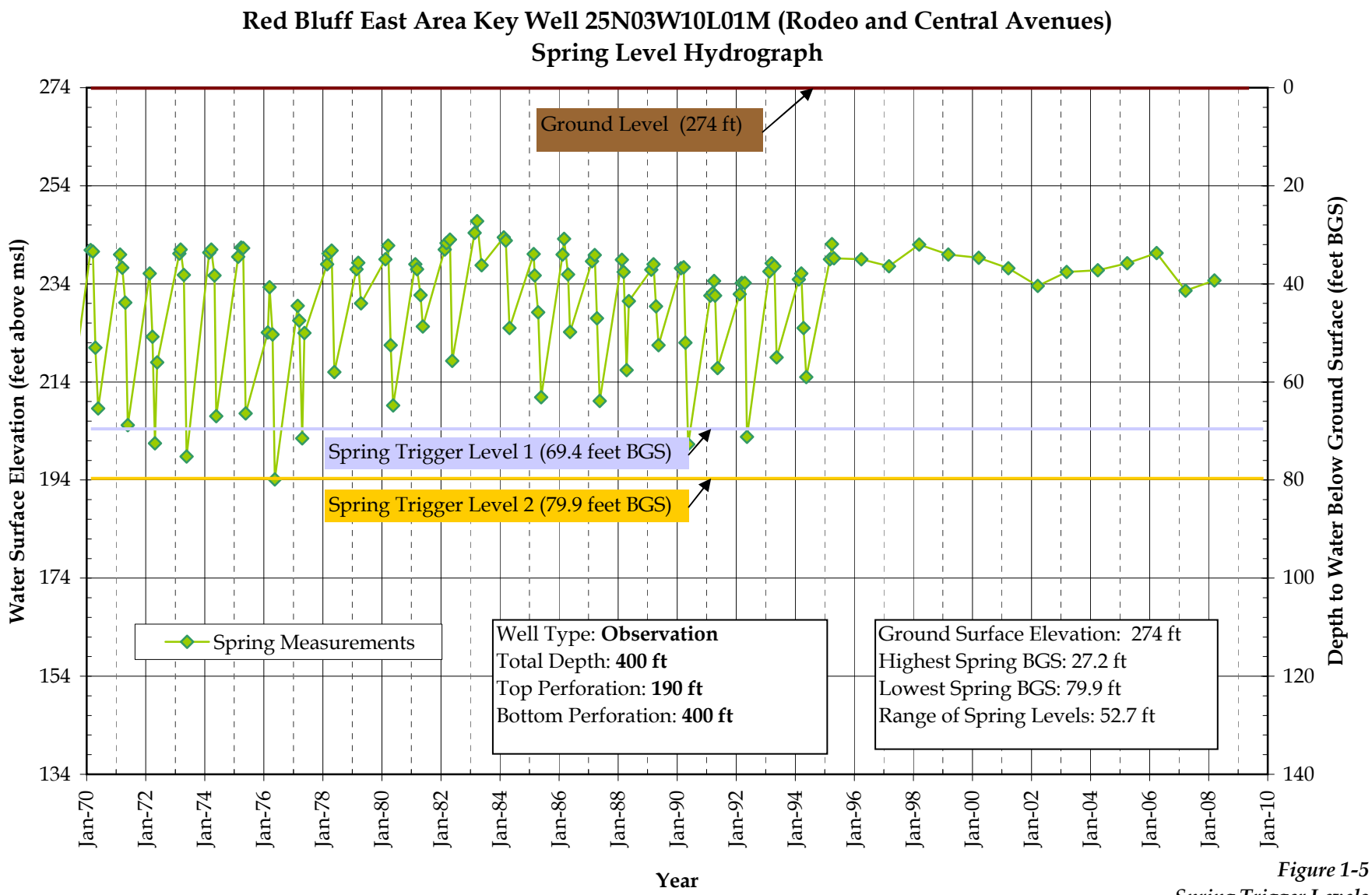


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

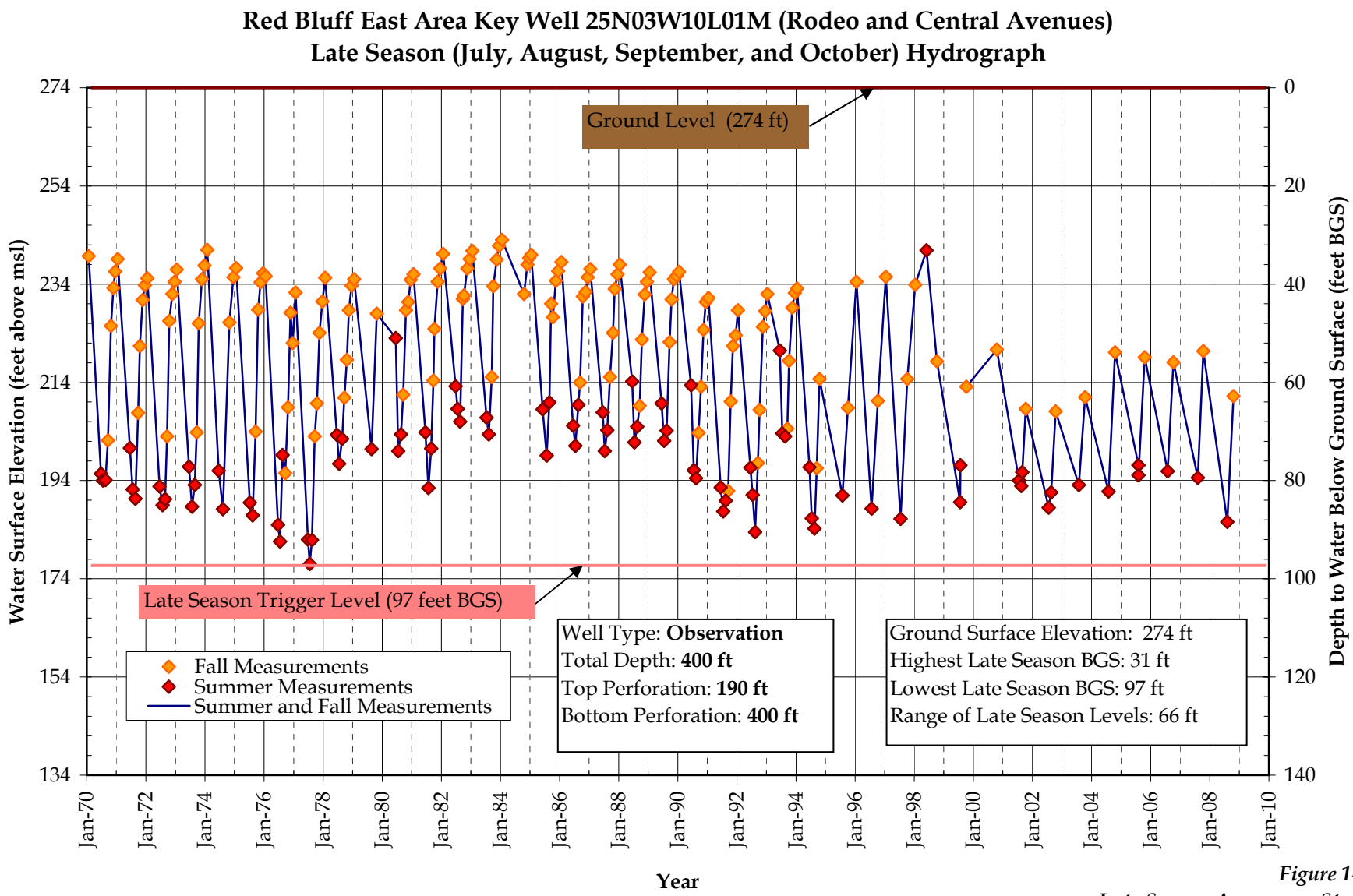


Figure 1-6
Late Season Awareness Stage

Updated 12-01-08

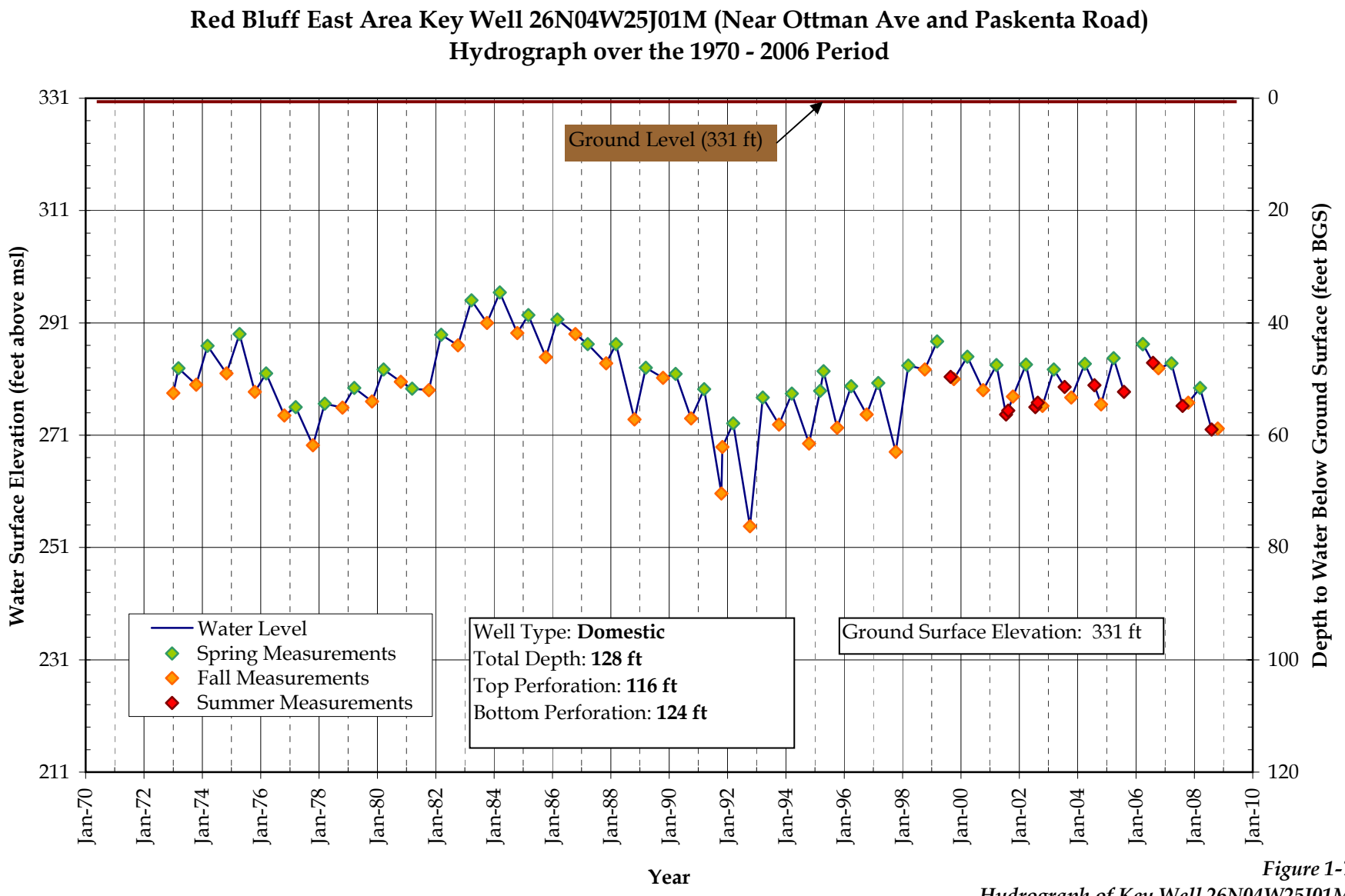


Figure 1-7
Hydrograph of Key Well 26N04W25J01M

Updated 12-01-08

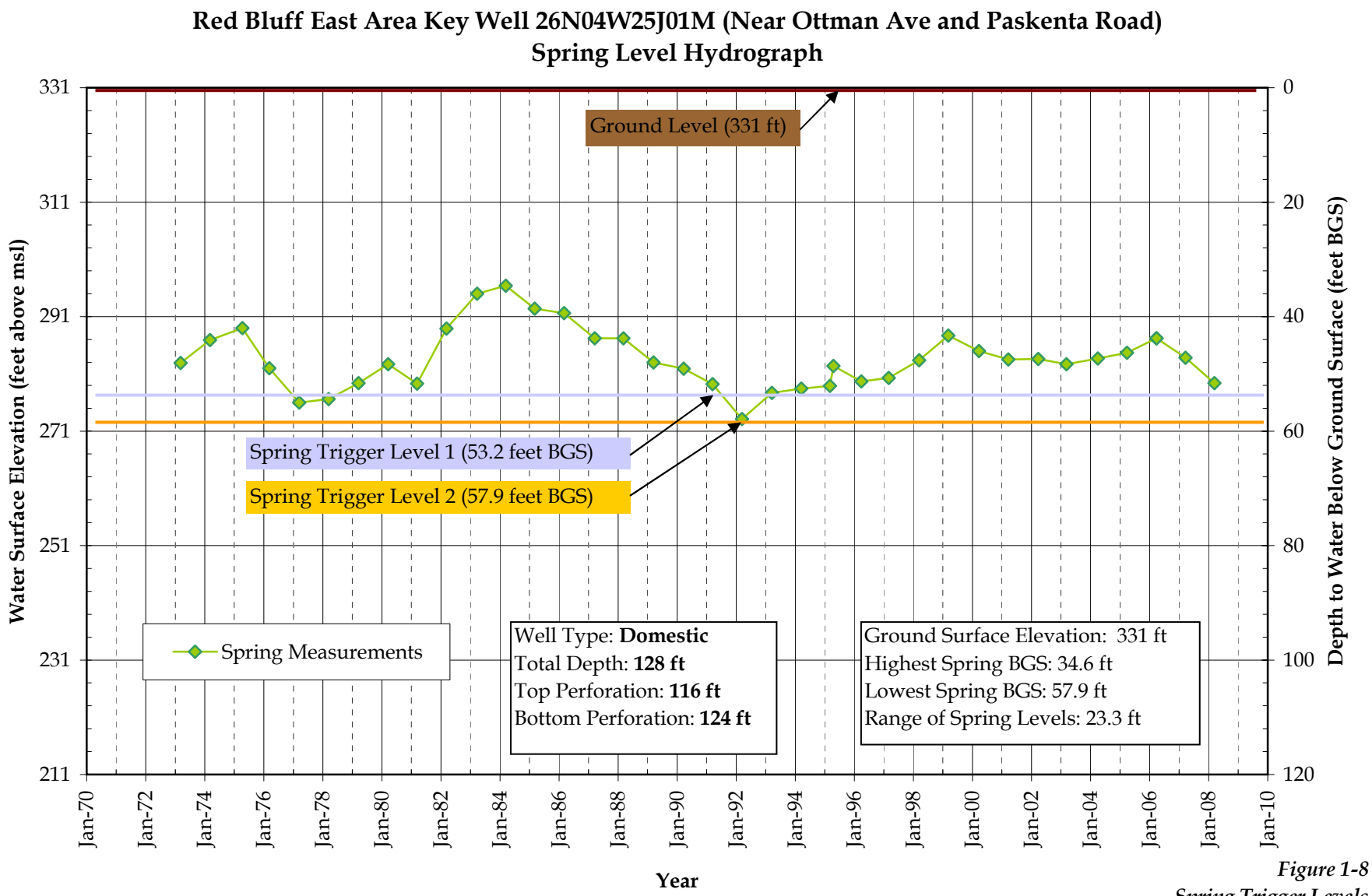


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

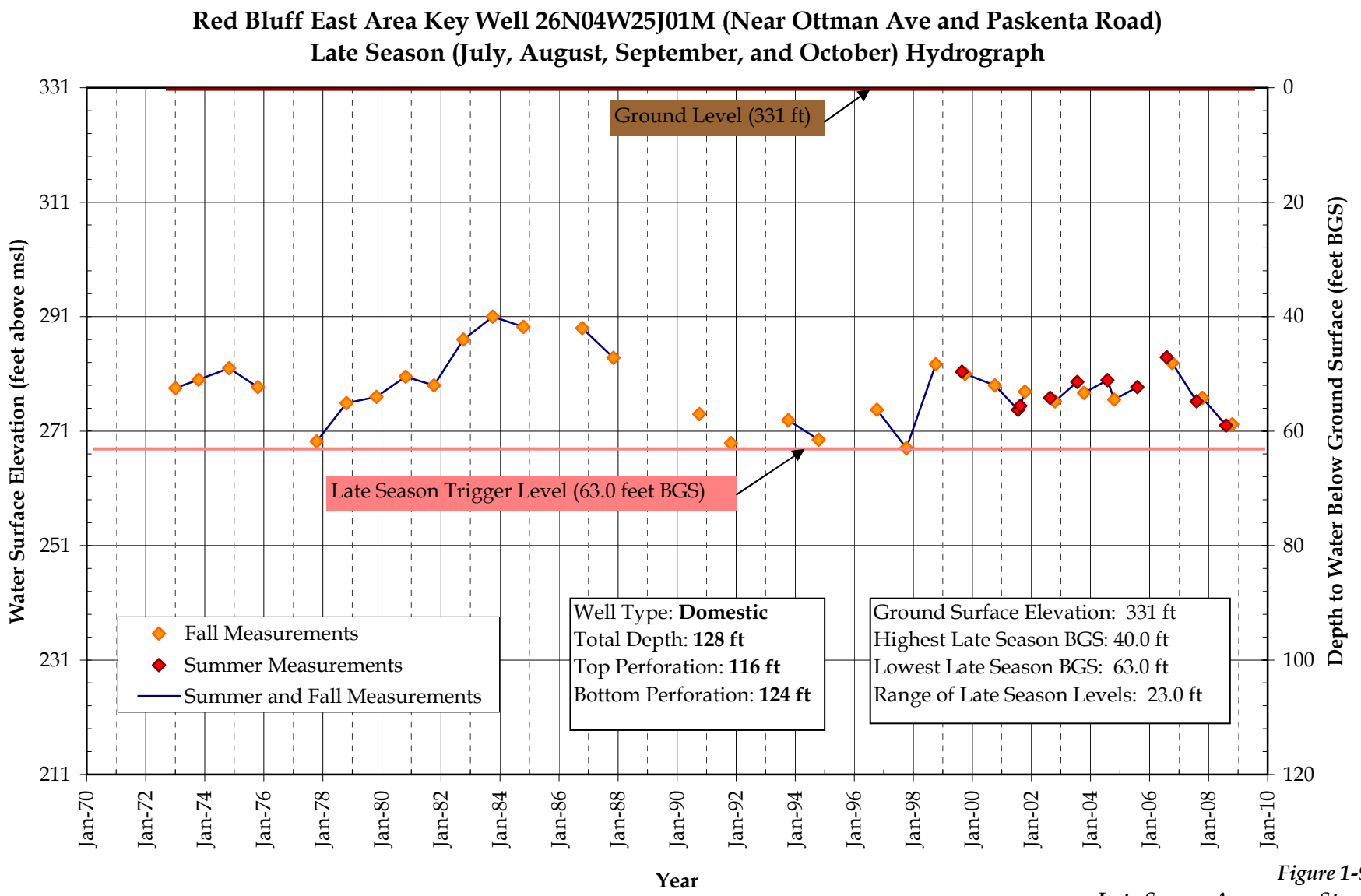


Figure 1-9
Late Season Awareness Stage

Updated 12-01-08

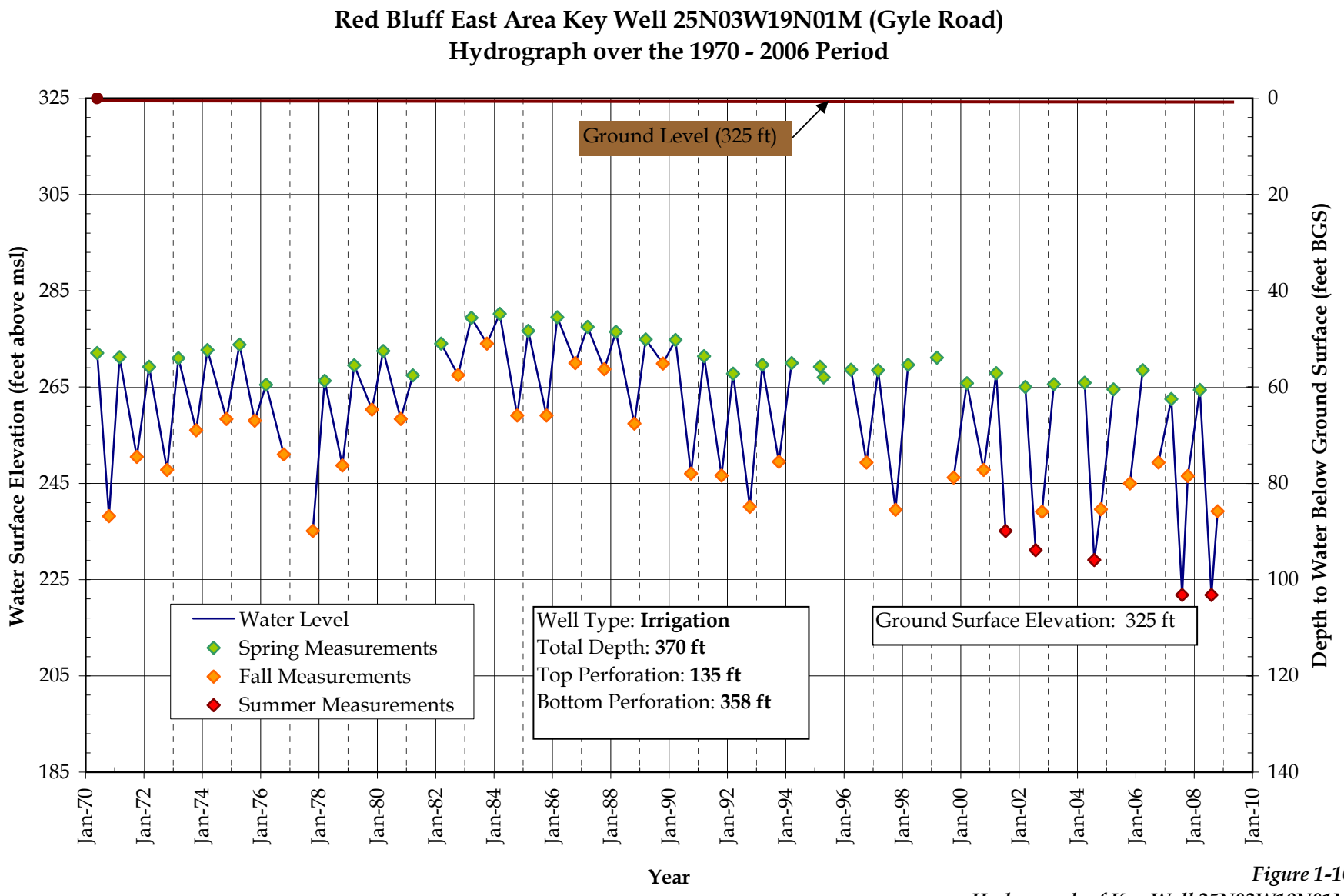


Figure 1-10
Hydrograph of Key Well 25N03W19N01M

Updated 12-01-08

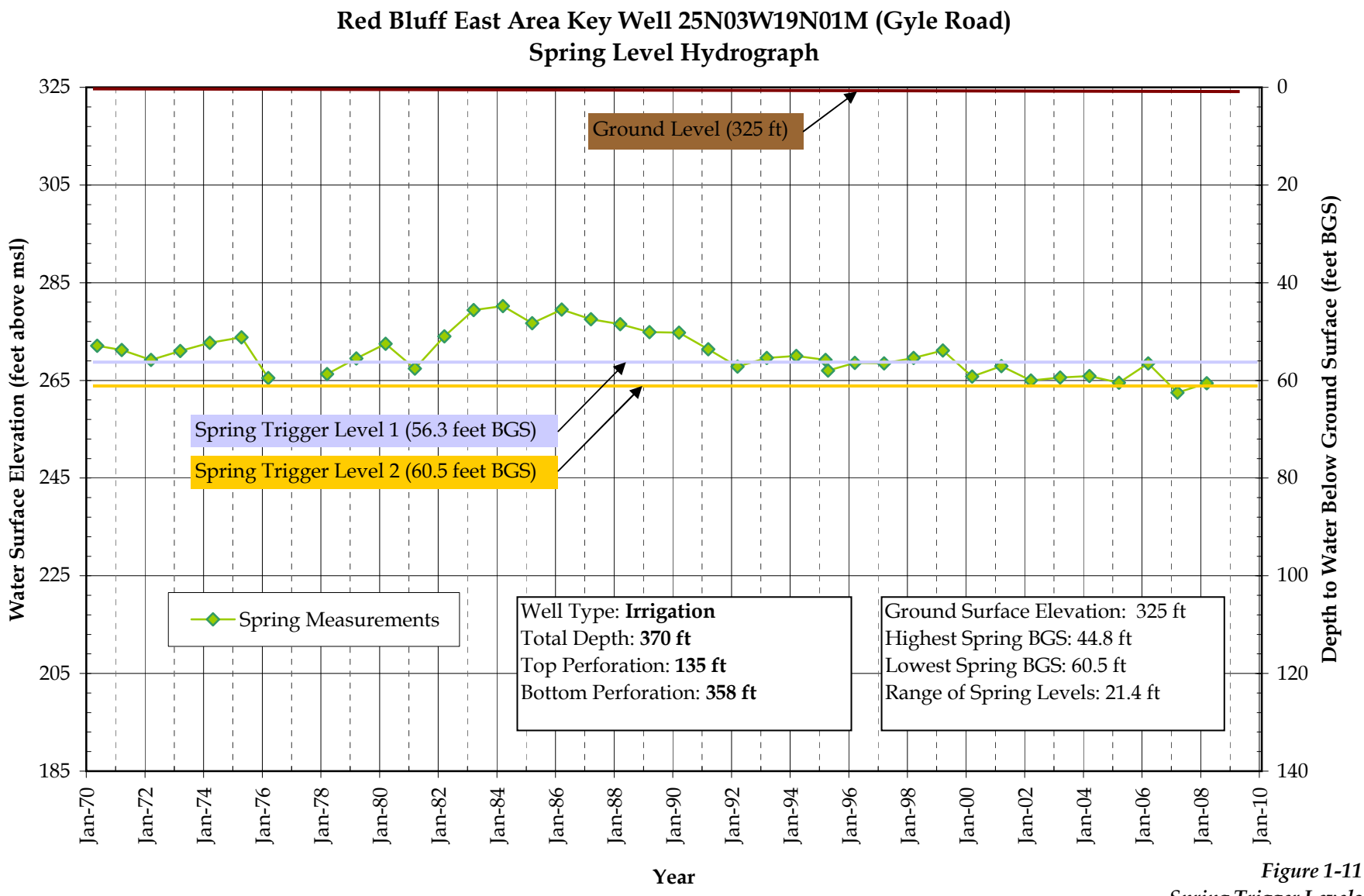


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

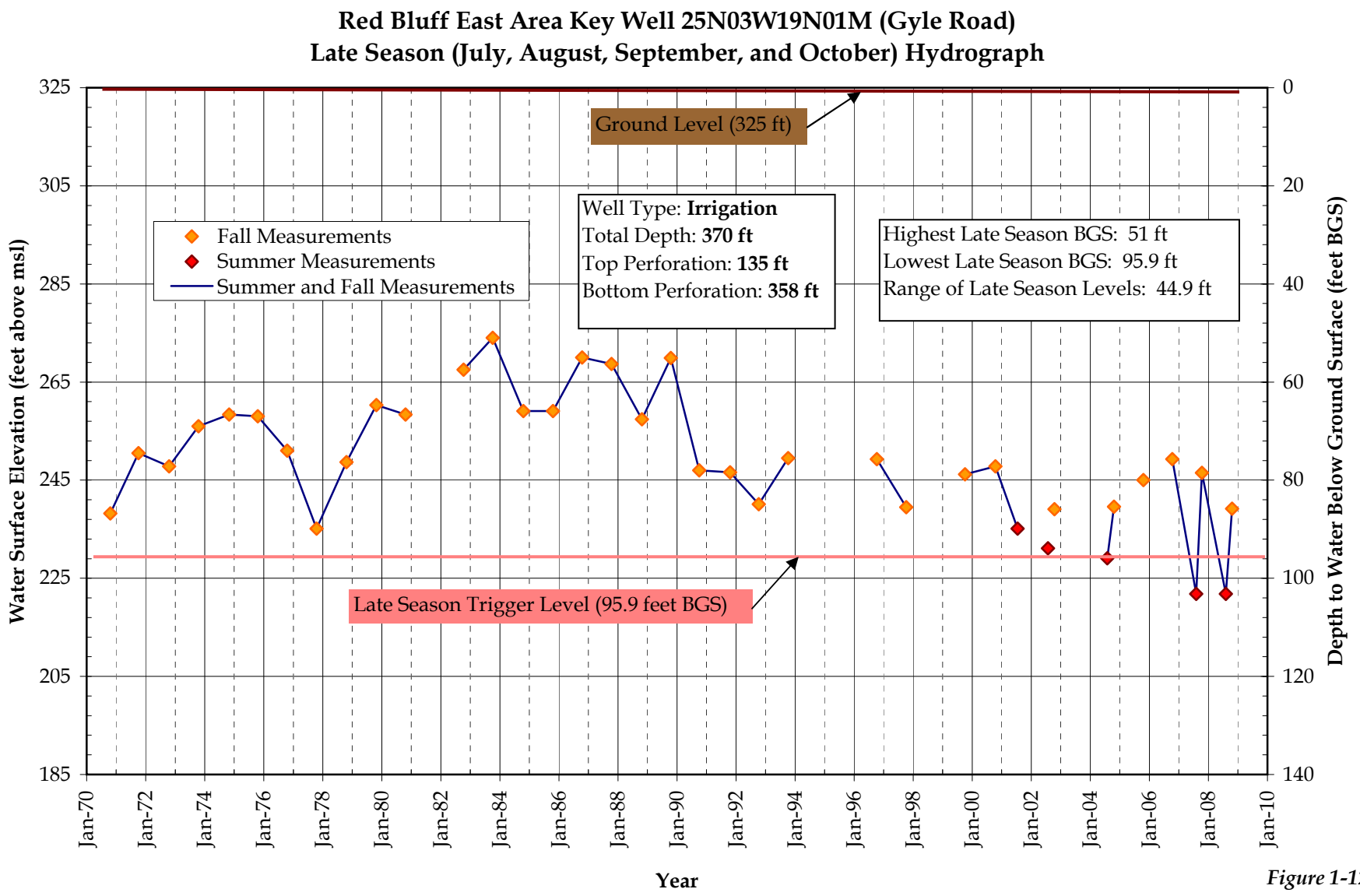


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

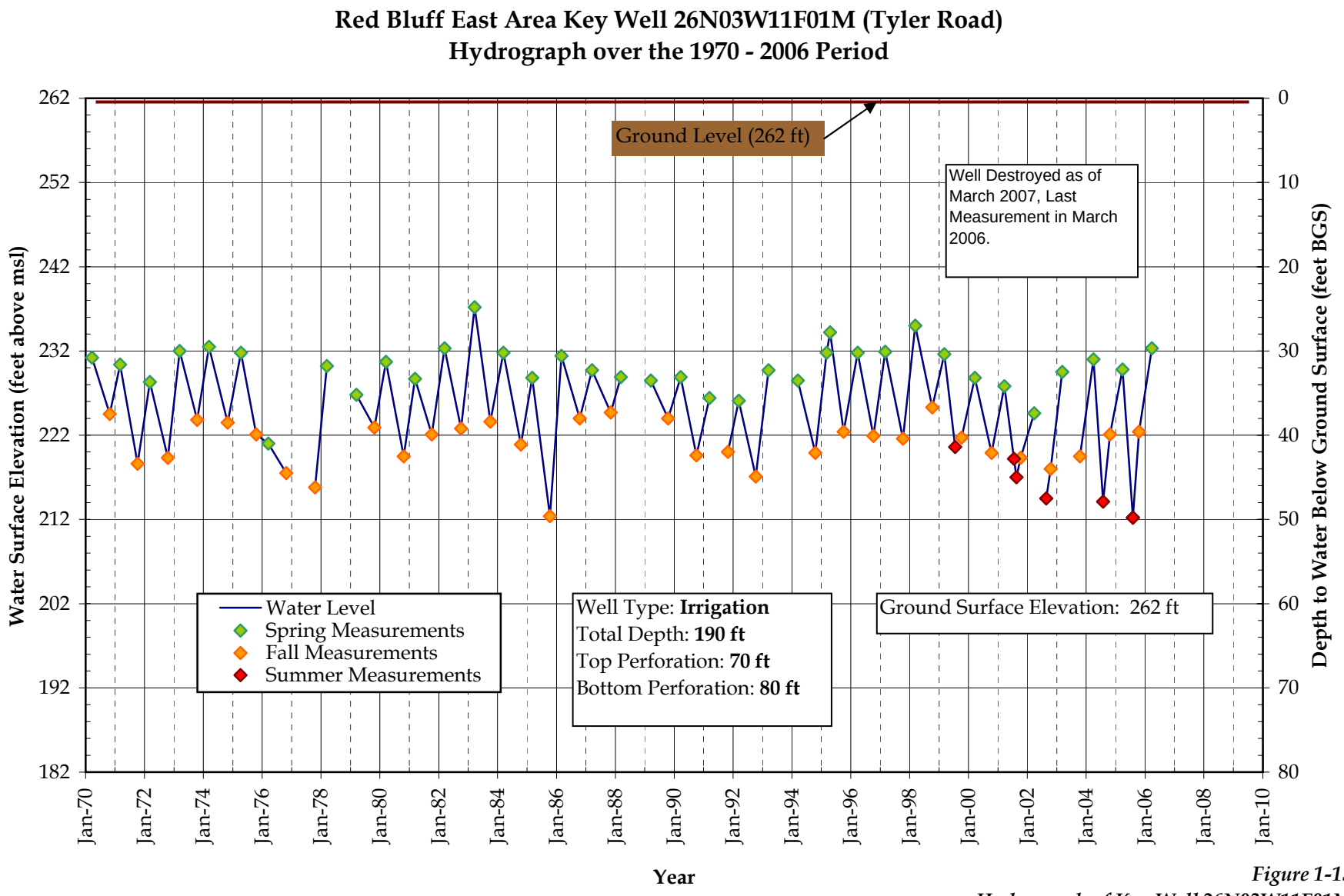


Figure 1-13
Hydrograph of Key Well 26N03W11F01M

Updated 12-01-08

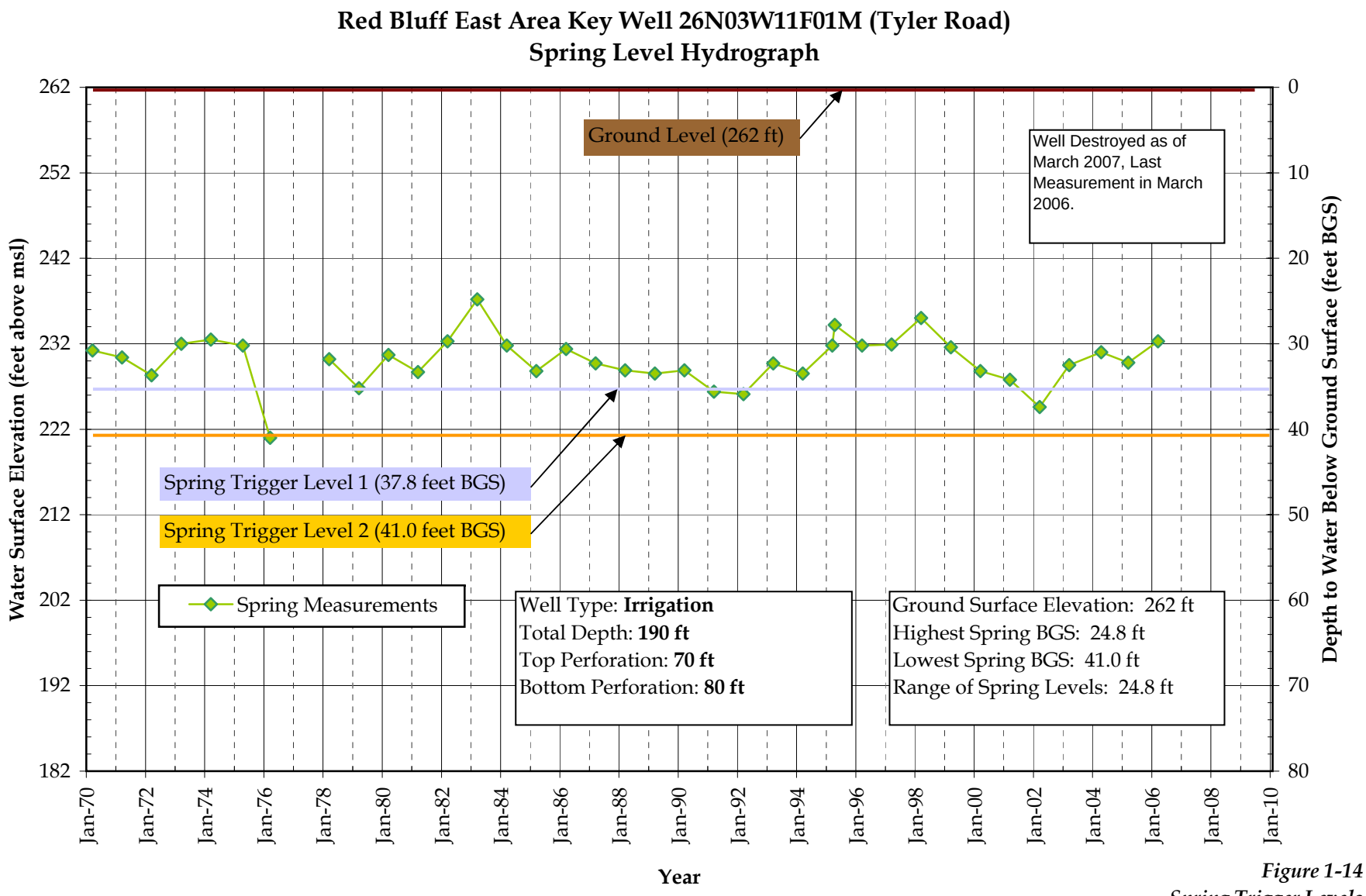


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

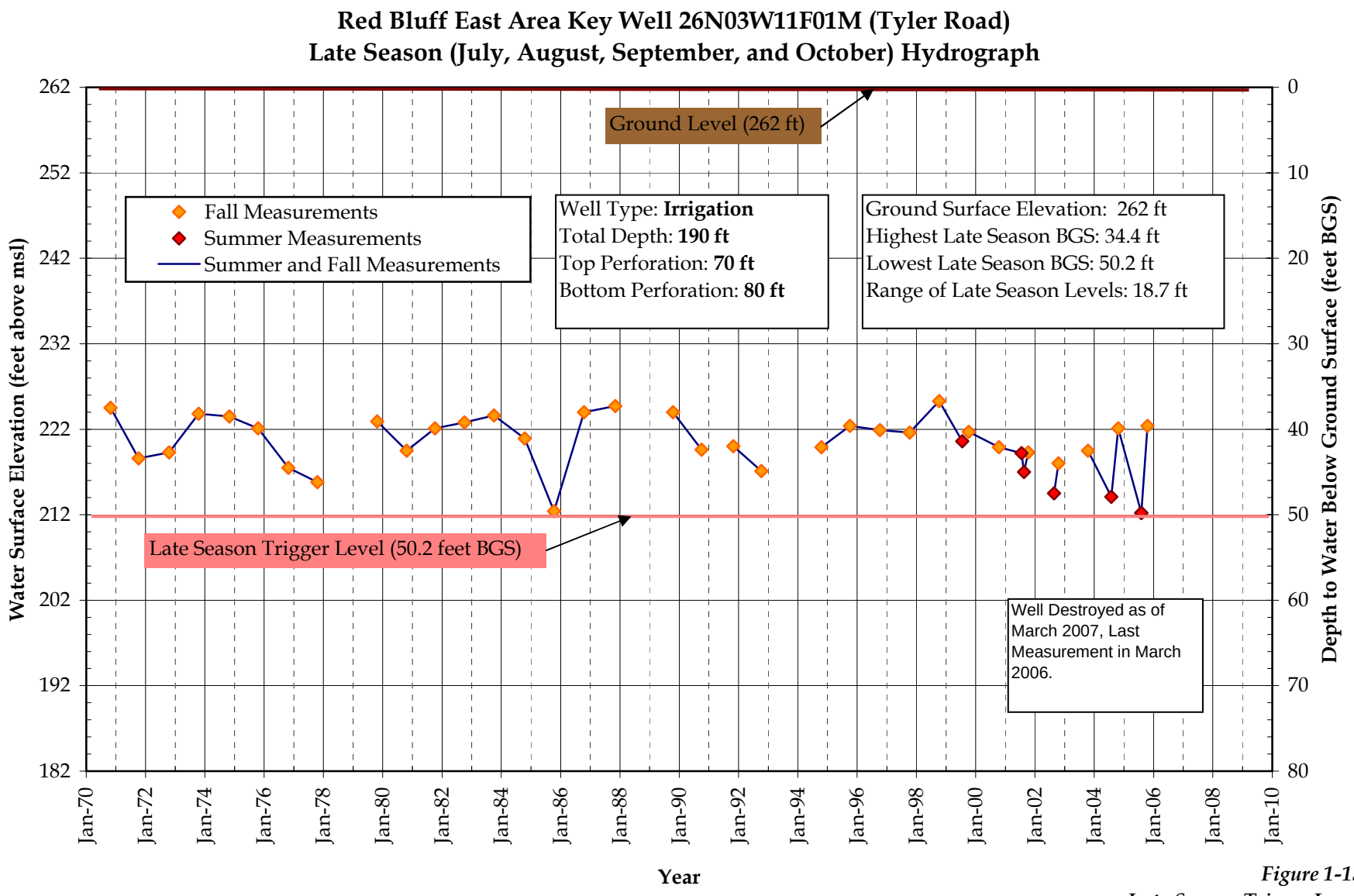


Figure 1-15
Late Season Trigger Level

Updated 12-01-08

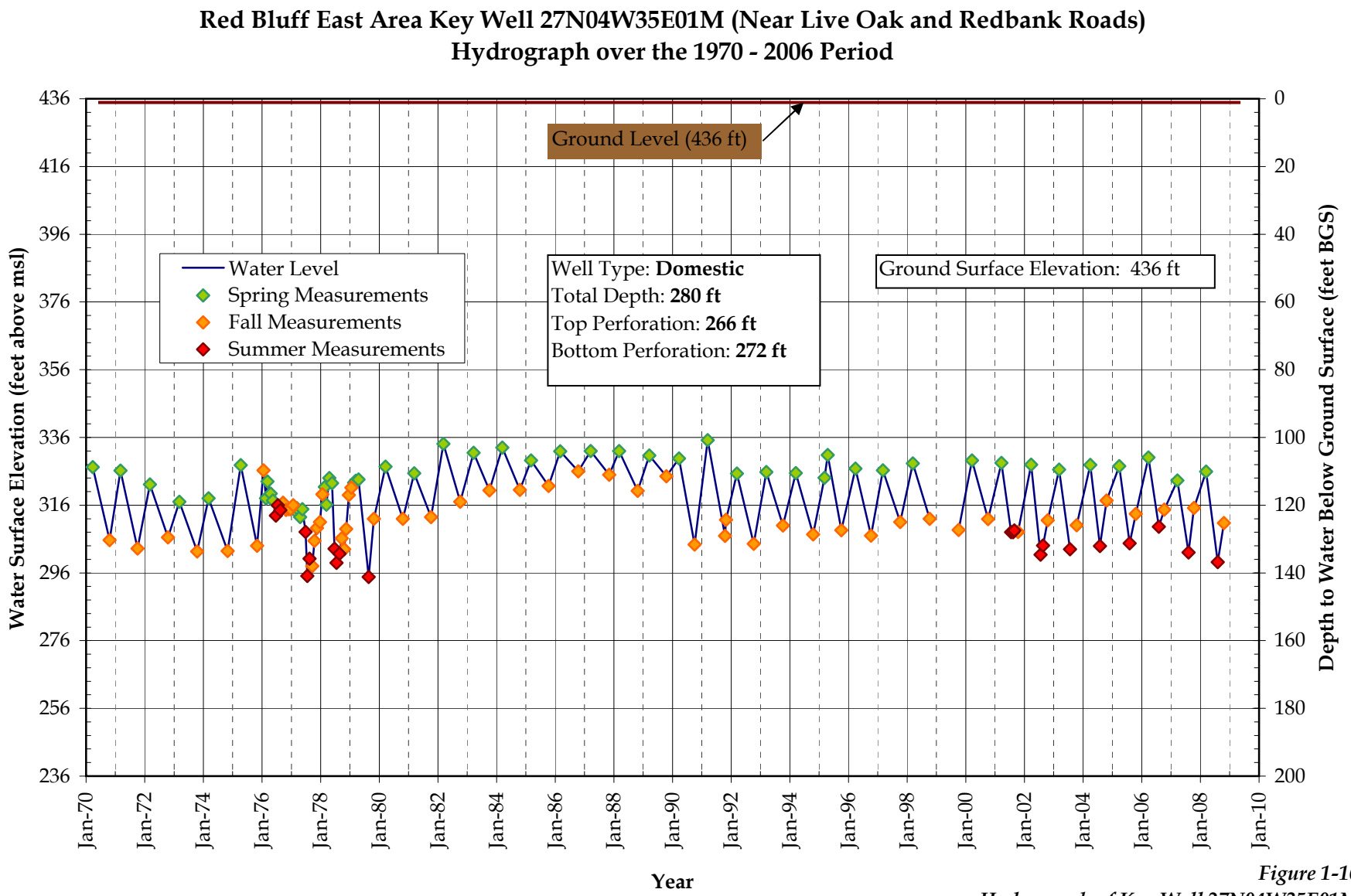


Figure 1-16
Hydrograph of Key Well 27N04W35E01M

Updated 12-01-08

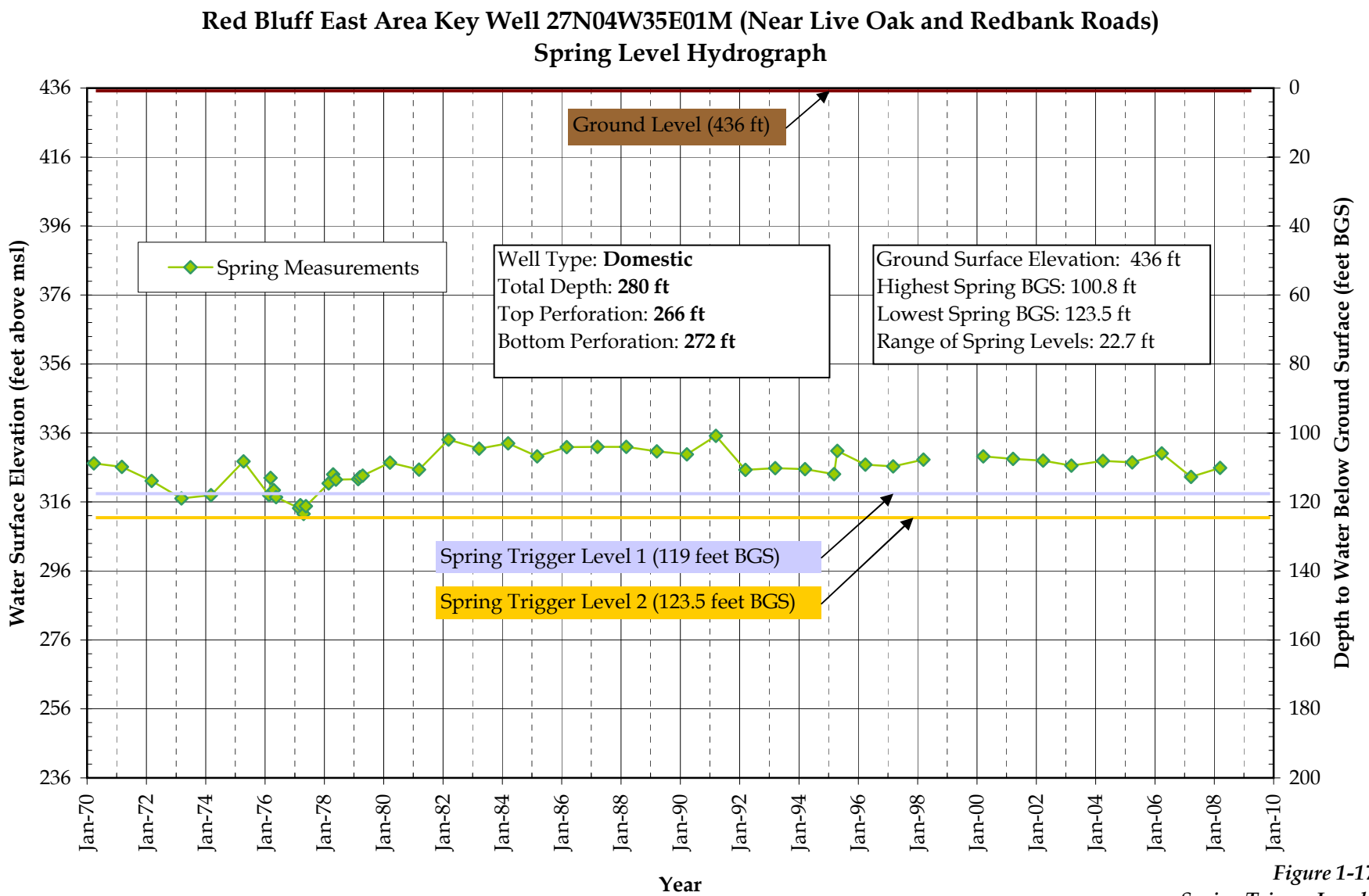


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

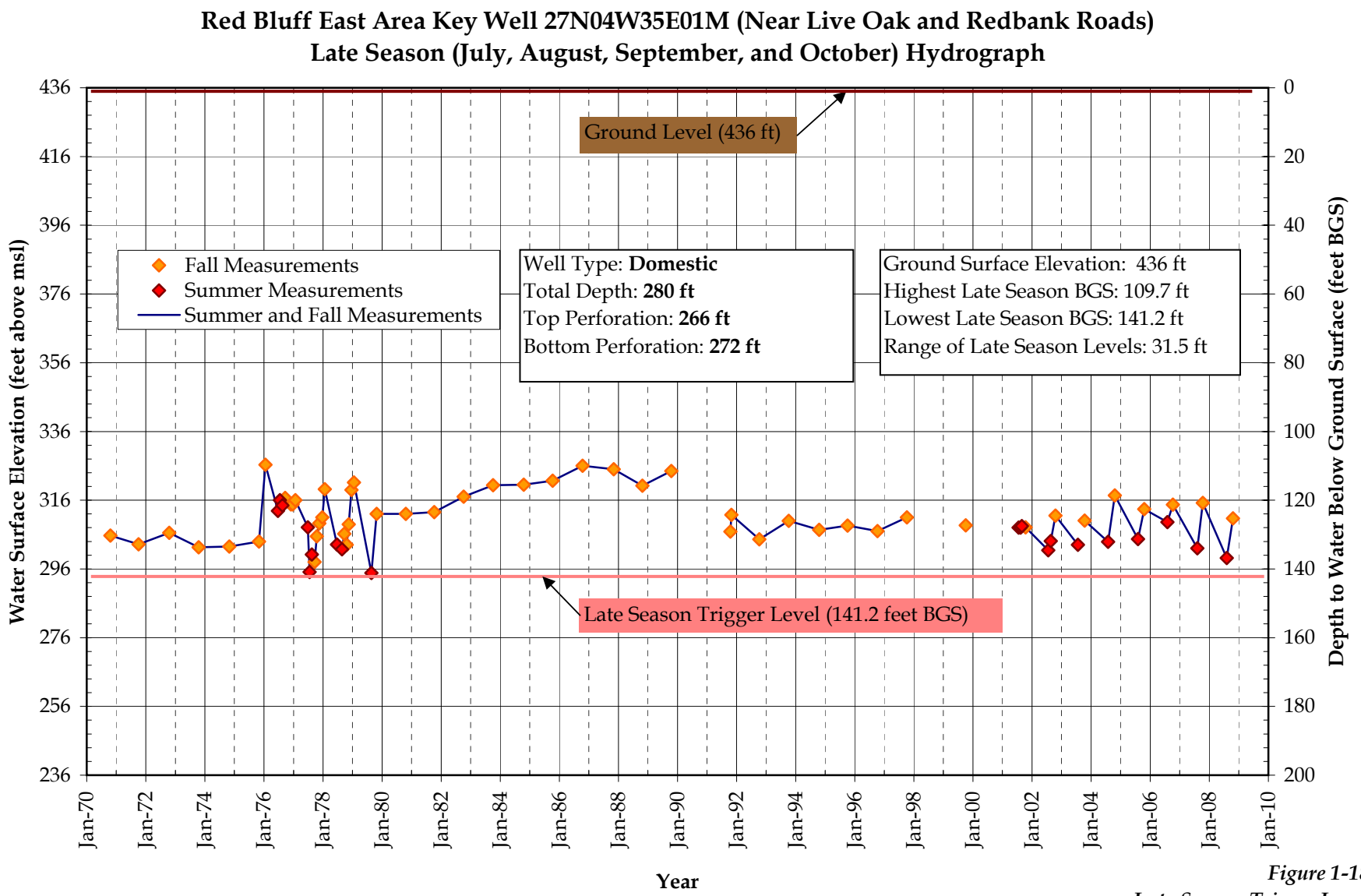


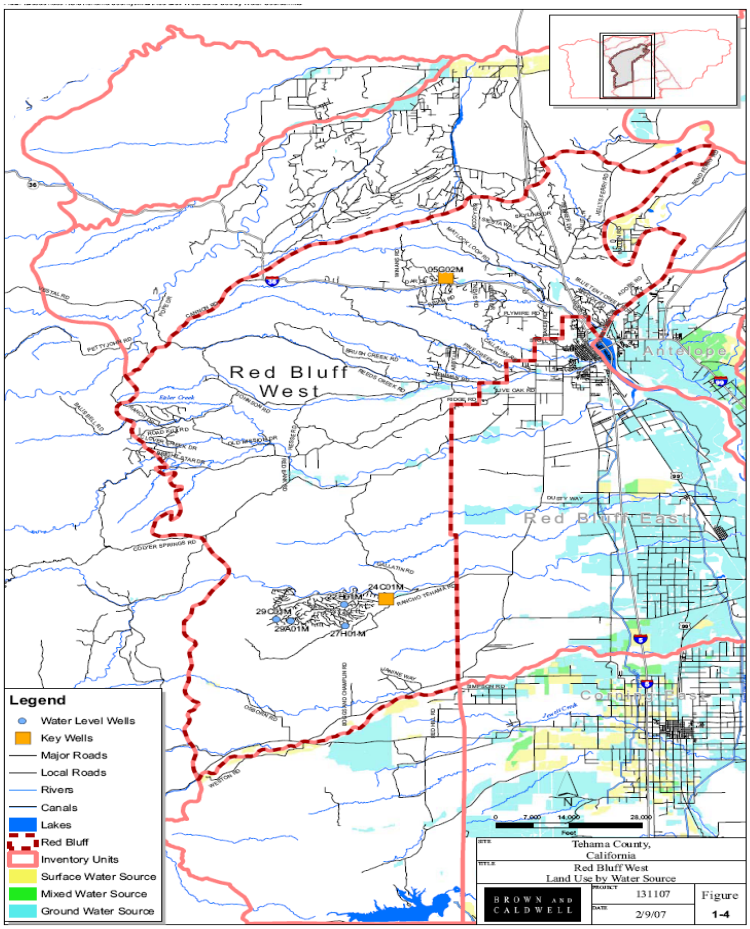
Figure 1-18
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Red Bluff West Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Red Bluff West Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

INTRODUCTION

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. Trigger Levels are developed through a five step process as described in Section 1. Red Bluff West does not have an adequate amount of coverage in existing monitoring wells, and in addition to developing trigger levels, this area will need to determine priority areas for future monitoring as described in Section 2.

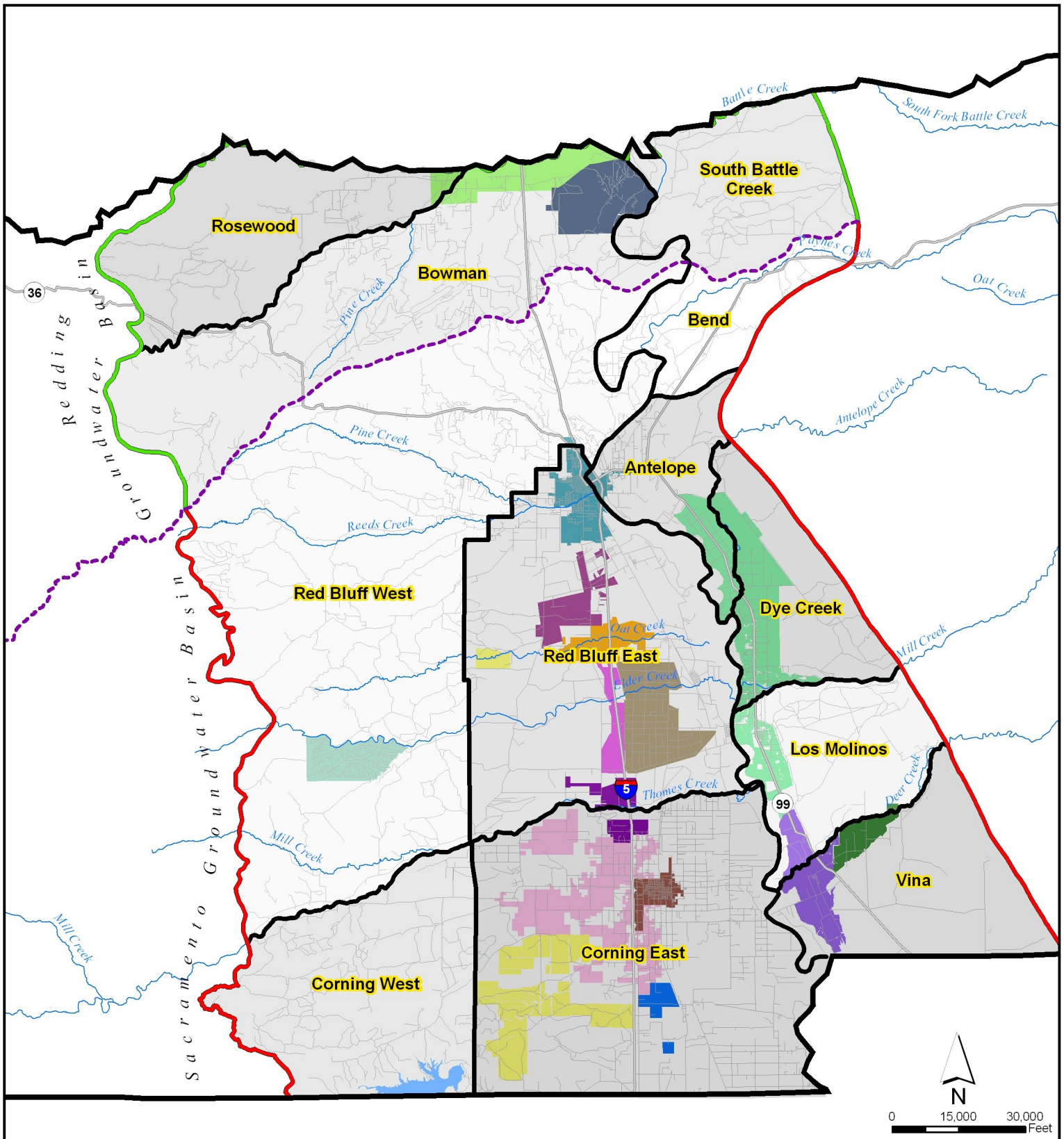
The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan incorporated citizen input, review, and approval over a period of three years, Final adoption by the Tehama County FCWCD was achieved in 1998.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of groundwater trigger levels. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various trigger levels of increased groundwater discussion, investigation or local management actions.

Sections 325 through 329 of the Plan describe the trigger level concept and detail the District's role in trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Red Bluff West sub-basin. Since its inception, the Plan has provided guidance related to groundwater activities. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. Section 1 of this TM describes the methodology used to develop trigger levels.

Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ . Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in each sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1. Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process, listed below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose.

The trigger level's purpose describes the intent of the trigger levels in the area. The purpose may reflect the desire of sub-basin planners to protect historic groundwater uses, minimize long-term drawdown of groundwater levels, maintain springs and habitat, and/or protect groundwater supplies for domestic and irrigation uses.

Step 2: Select one or more key wells within the sub-basin.

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to initiate management activities. Locations for new monitoring wells should be selected for the portions of Red Bluff West without adequate monitoring.

When selecting new areas for monitoring, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Groundwater levels are more likely to be stressed in areas of active land use. Areas with fixed water demand crops such as orchards should be higher priority areas for monitoring.

Water Source: Groundwater supplies in areas irrigated with groundwater are more likely to be stressed during drought periods. Locating monitoring wells in areas reliant on groundwater would provide useful information for groundwater management, and should be higher priority areas for monitoring.

Existing Well Infrastructure: Well drilling records should be considered. The screened intervals of monitoring wells should be similar to the average screened interval of production wells in the area.

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well.

Step 3: Designate the time of seasonal measurement.

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the pumping impacts within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use that can provide a warning of potential issues such as increased groundwater demand.

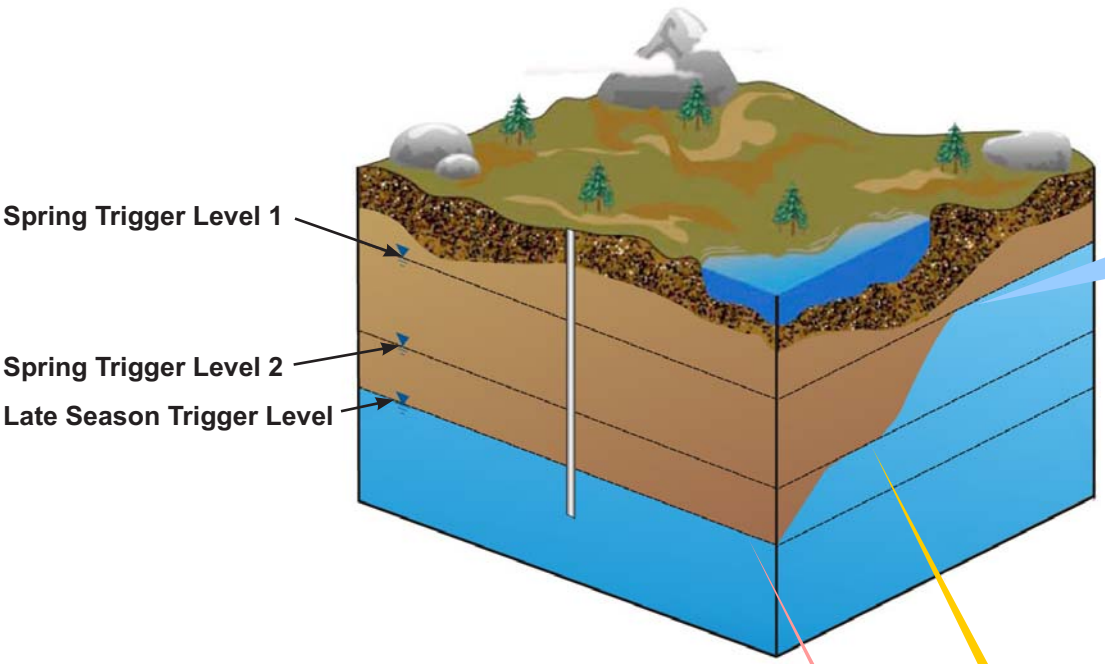
Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level.

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-2).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, (indicating a need to disseminate information or further investigation of groundwater levels), to a larger change in groundwater levels, (indicating a need to take action to stop or reduce the lowering of groundwater levels).

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. As an example, Figure 1-2 shows a diagram that details two suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-2
Trigger Levels and Awareness Actions

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

2. Red Bluff West Trigger Level Development

Because Red Bluff West does not have adequate coverage in monitoring wells, this section describes key well selection for the Red Bluff West sub-basin and describes the process for selecting priority areas for monitoring.

Step 1: Describe the trigger level's purpose.

The Red Bluff West sub-basin is primarily a rural area, with limited agriculture in the sub-basin. Groundwater is used for agricultural and domestic purposes. There are no organized irrigation districts in the Red Bluff West sub-basin, as indicated in Figure 1-1. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Red Bluff West:	
Irrigation:	51% (1,900 acre-ft)
Municipal, and Industrial:	49% (1,800 acre-ft)
Number of wells by type in Red Bluff West:	
Irrigation:	63 wells
Domestic:	2119 wells
Municipal and Industrial:	7 wells

- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies to protect supplies for current and future uses.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin.

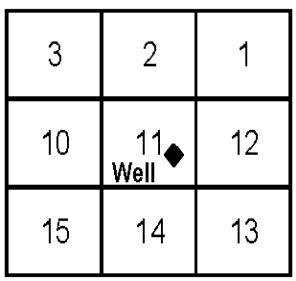
Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods

of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of two proposed key wells are presented in Figure 1-3 and Figure 1-7. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **25N05W24C01M (24C01M) –** This monitoring well is in the southern portion of the sub-basin and is of unknown depth with an unknown screened interval. This well is situated on the eastern end of the Rancho Tehama area of urban use. The nine square miles near this well contain 242 domestic wells with an average depth of 216 feet below ground surface (bgs), and 7 irrigation wells with an average depth of 307 feet bgs. This well's period of record is near 20 years, which provides information on water levels during the drought of the late 1980s and early 1990s.
- **27N04W05G02M (05G02M) –** This monitoring well is in the northeast portion of the sub-basin and is 260 feet deep with a screened interval between 48 and 251 feet bgs. This well is situated away from irrigated areas. The nine square miles near this well contain 220 domestic wells with an average depth of 204 feet bgs, and 3 irrigation wells with an average depth of 263 feet bgs. This well's period of record is near 20 years, which provides information on water levels during the drought of the late 1980s and early 1990s.

There are currently no monitoring wells in the central and northeastern portions of the Red Bluff West sub-basin reflecting that no wells are monitored in that area. To begin the trigger level process in these unmonitored areas of Red Bluff West, the District suggests that priority areas for new monitoring be selected in the Red Bluff West area.

When picking locations for monitoring wells in Red Bluff West, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use:. Figure 1-3 presents the land use in the Red Bluff West area. Agricultural land use is not predominate in Red Bluff West. Future land use in Red Bluff West is anticipated to be similar to current land use. Additional land use information can be obtained by obtaining the zoning information for the Red Bluff West area.

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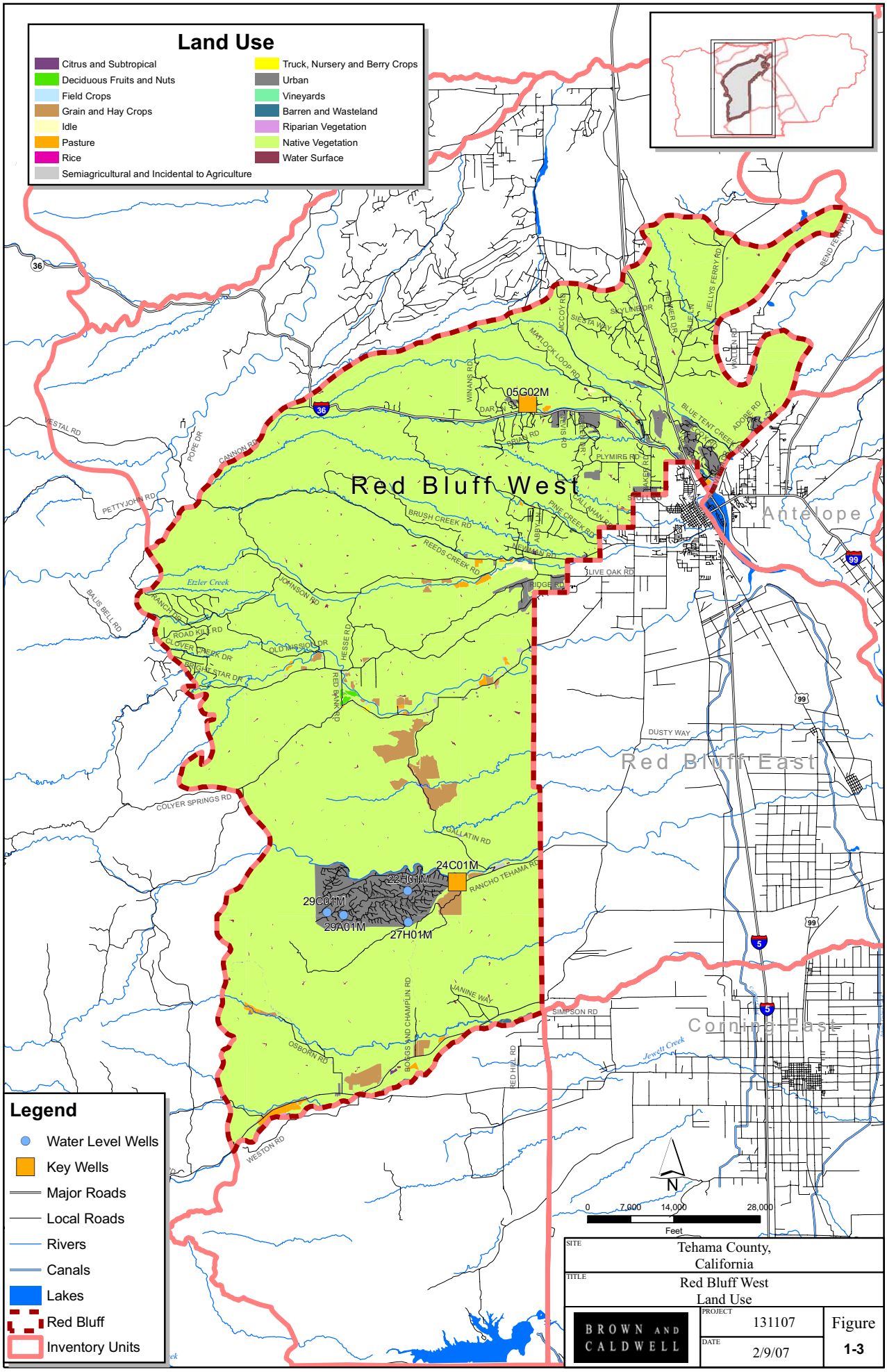

Water Source: Figure 1-4 presents agricultural land use by water source in the Red Bluff West area. Figure 1-4 demonstrates that irrigated agriculture is not common in Red Bluff West.

Existing Well Infrastructure: According to the DWR database, there are 2,119 domestic wells and 63 irrigation wells in the Red Bluff West sub-basin. Figures 1-5 and 1-6 show cumulative frequency curves for domestic and irrigation wells, respectively. Fifty percent of the domestic wells are shallower than 225 feet deep, and fifty percent of the irrigation wells are shallower than 250 feet deep. Existing well infrastructure data was developed from DWR's well completion report database. DWR's database contains information on the majority of wells drilled after 1947, while wells drilled prior to 1947 are generally not included. Some wells drilled after 1947 may not have been reported to DWR (potentially up to 30%), and therefore are not included in the database.

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well. Figure 1-4 shows the locations of any monitoring wells adjacent to Red Bluff West. As indicated by Figure 1-4, there are no monitoring wells near the boundary of Red Bluff West, and new monitoring wells can be sited near the boundary of the sub-basin.

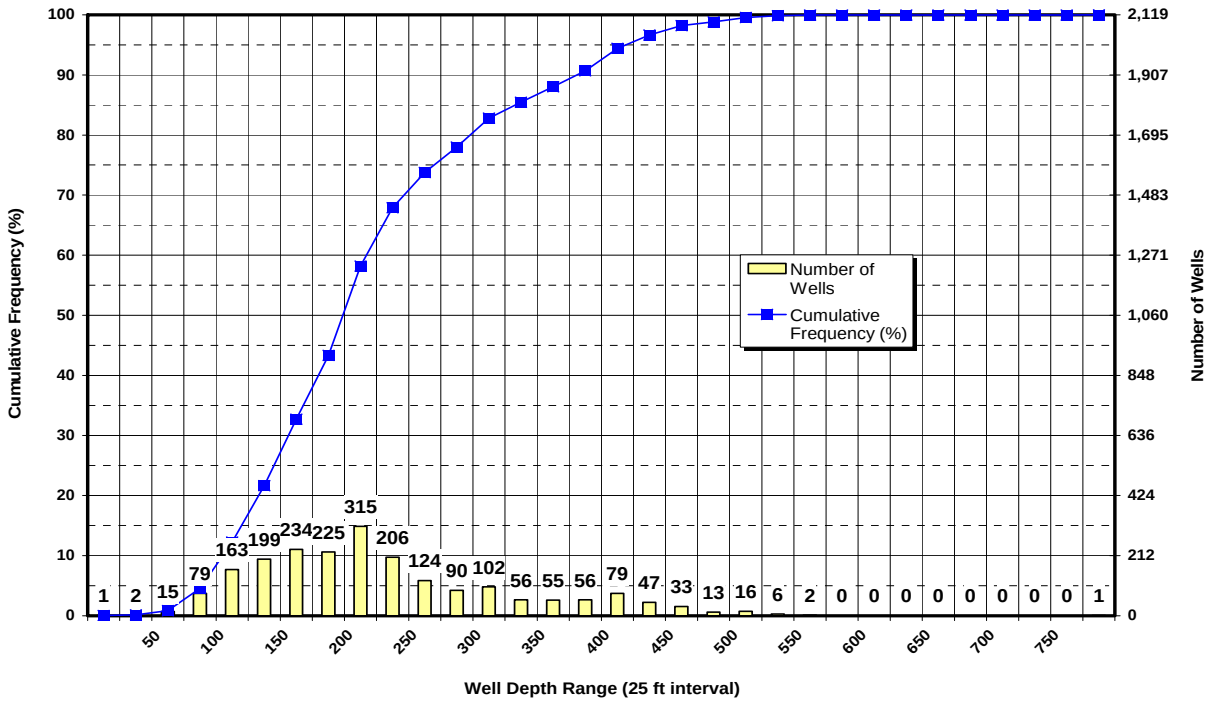

Figure 1-5

Cumulative Frequency Curve of Domestic Wells in the Red Bluff West Sub-Basin

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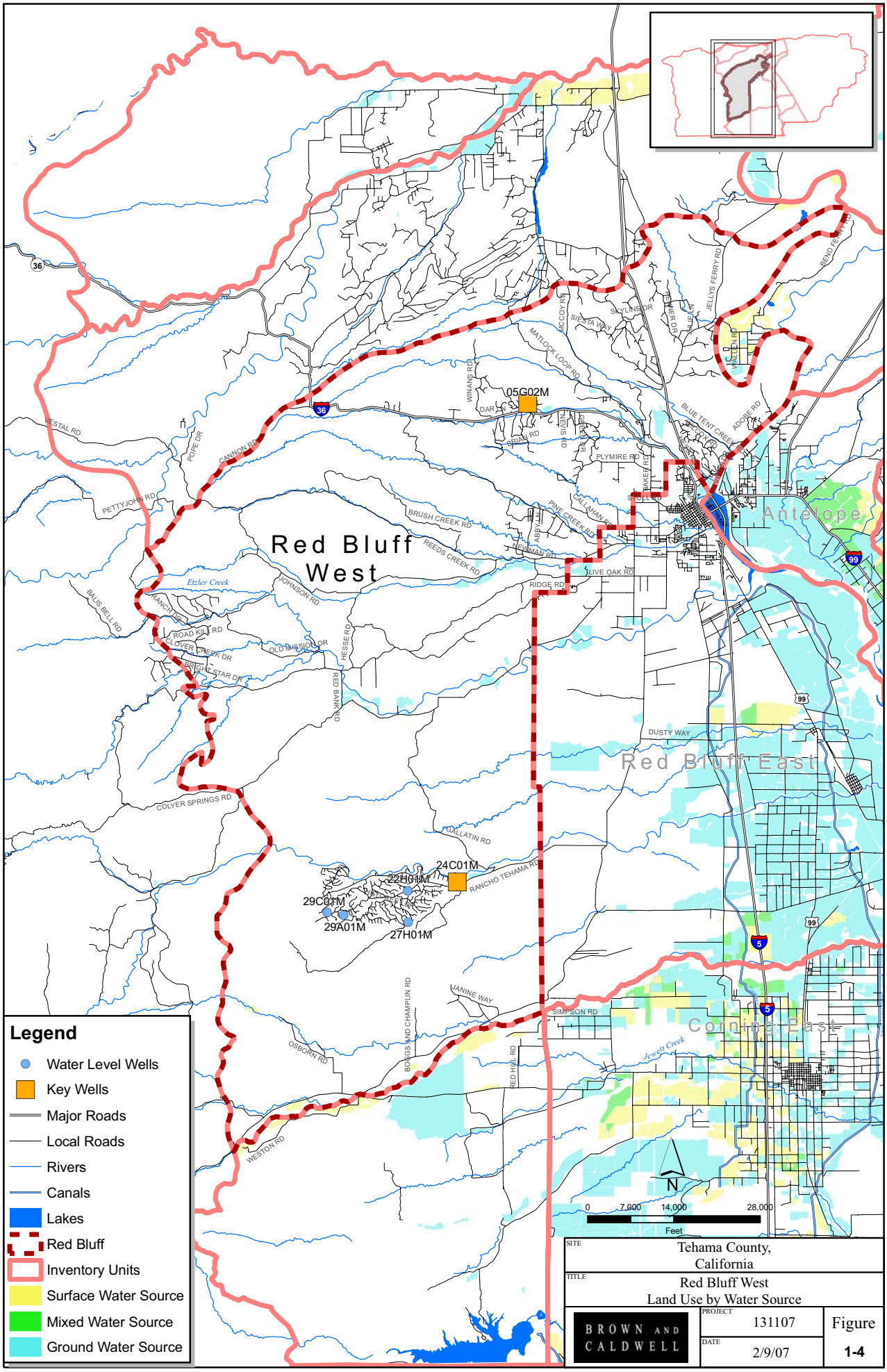

SITE	Tehama County, California
TITLE	Red Bluff West Land Use by Water Source
BROWN AND CALDWELL	PROJECT 131107
	DATE 2/9/07
	Figure 1-4

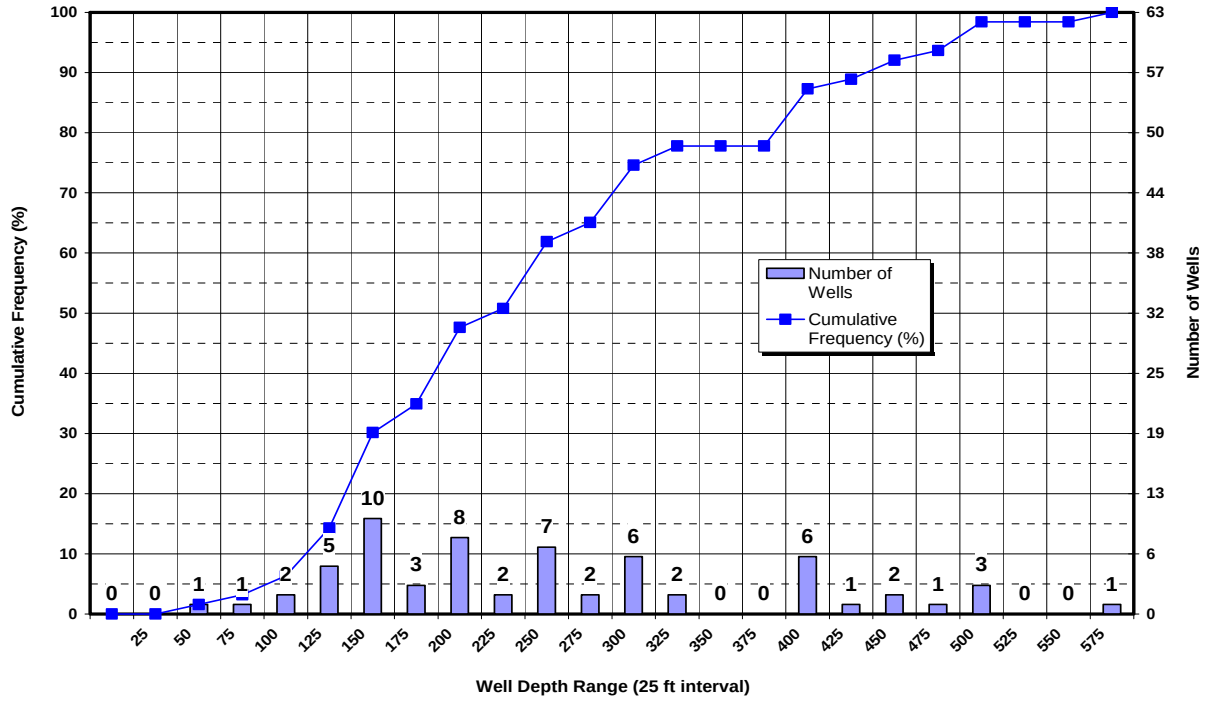

Figure 1-6

Cumulative Frequency Curve of Irrigation Wells in the Red Bluff West Sub-Basin

Suggested Monitoring Well Areas:

There are two suggested areas for new monitoring wells in the Red Bluff West area which are indicated in Figure 1-7. Monitoring wells installed in the Red Bluff West area should be screened to monitor groundwater at depths similar to those used for production by domestic and irrigation wells. The majority of domestic and irrigation wells in Red Bluff West are screened between 200 and 300 feet below ground surface. The two suggested areas are listed below:

- The first suggested area (Area 1) is in the northeastern portion of the sub-basin, and is a priority area near the I-5 freeway. Area 1 lies in an area of potential future development, and is not near other monitoring wells.
- The second suggested area (Area 2) is in the central portion of the sub-basin, and is a priority area because of its large area and lack of monitoring. Area 2 lies away from the center of the valley, and is not near other monitoring wells.

3. Next Steps

Steps 1 and 2: With the proposed key wells priority areas selected, the next step will be confirmation of priority areas with stakeholders. Once stakeholders have provided local information and input to priority area selection, the availability of existing wells for monitoring and the need for new monitoring wells can be assessed. As monitoring locations are selected and developed, the expanded monitoring program for the Red Bluff West sub-basin can be implemented.

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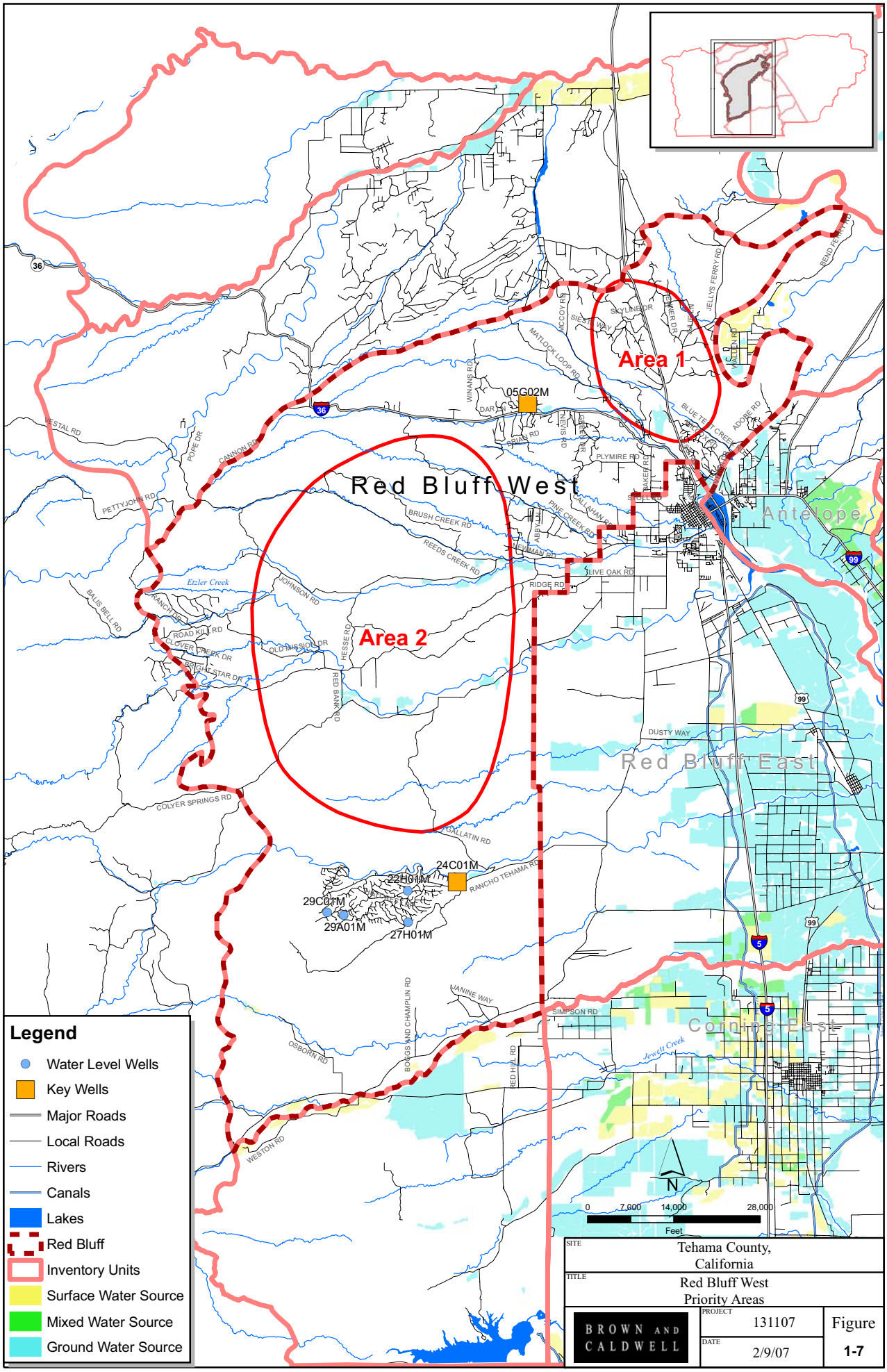


SITE	Tehama County, California
TITLE	Red Bluff West Priority Areas
BROWN AND CALDWELL	PROJECT 131107
	DATE 2/9/07
	Figure 1-7

Steps 3, 4 and 5: Trigger levels for key wells can be developed immediately, and once the expanded monitoring program is in place, steps 3 through 5 of the trigger level development process can be completed for new monitoring wells.

Figures 1-8 through 1-13 present hydrographs and suggested trigger levels for the existing Red Bluff West key wells. The figures are groundwater level hydrographs, demonstrating water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. The methodologies used to determine the suggested trigger levels for the example key well is provided in Table 1-1.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Red Bluff West Monitoring Well Number	
	25N0524C01M	27N0405G02M
Spring Trigger Level 1 – Notify and Inform Public	20% of the range of spring measurements above the historical low	
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Stage 1	
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements	
Late Season Trigger Level – Notify public and begin investigations	Historical low of summer and fall measurements	
Data Anomalies	None	None

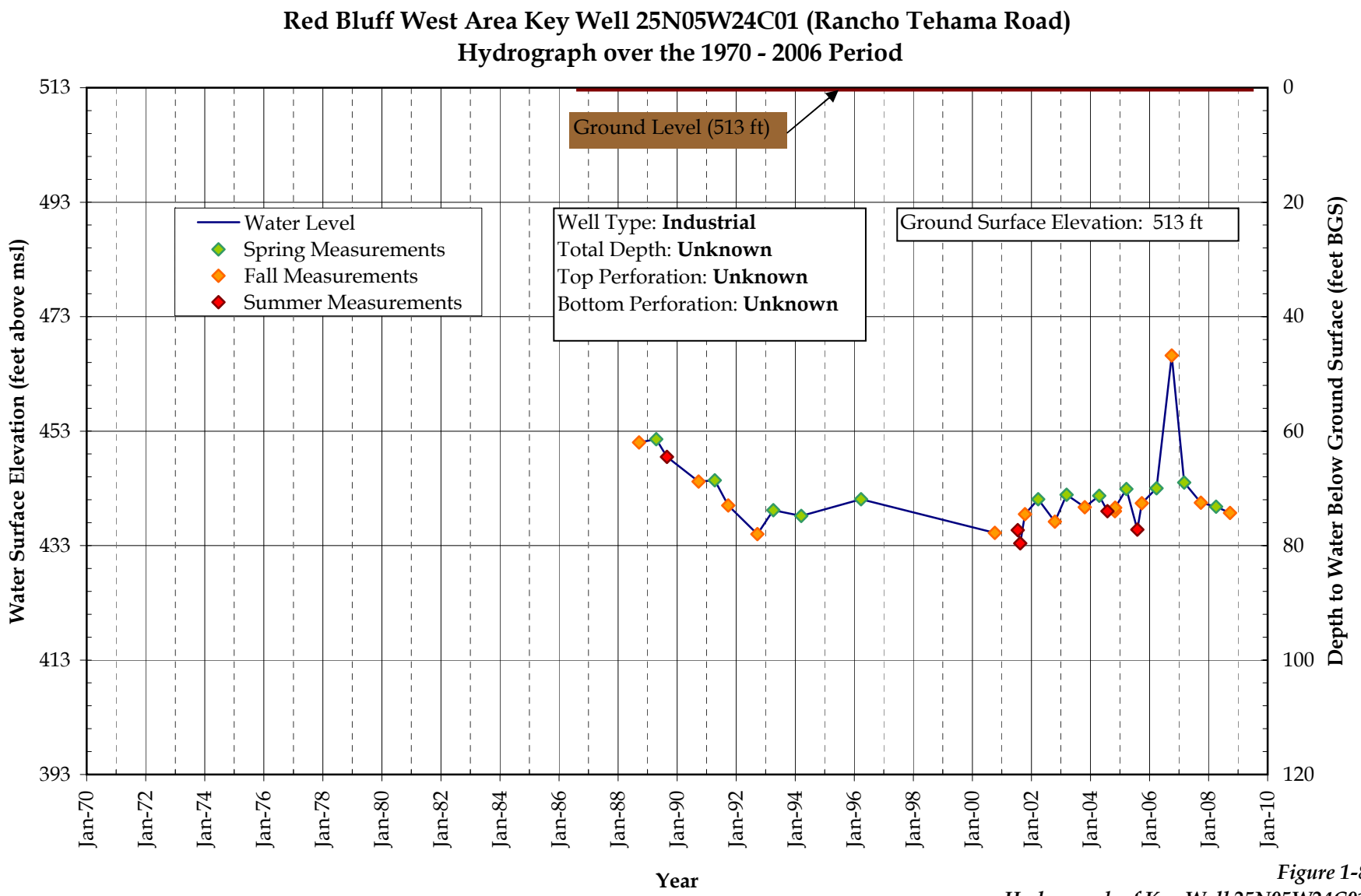


Figure 1-8
Hydrograph of Key Well 25N05W24C01

Updated 12-01-08

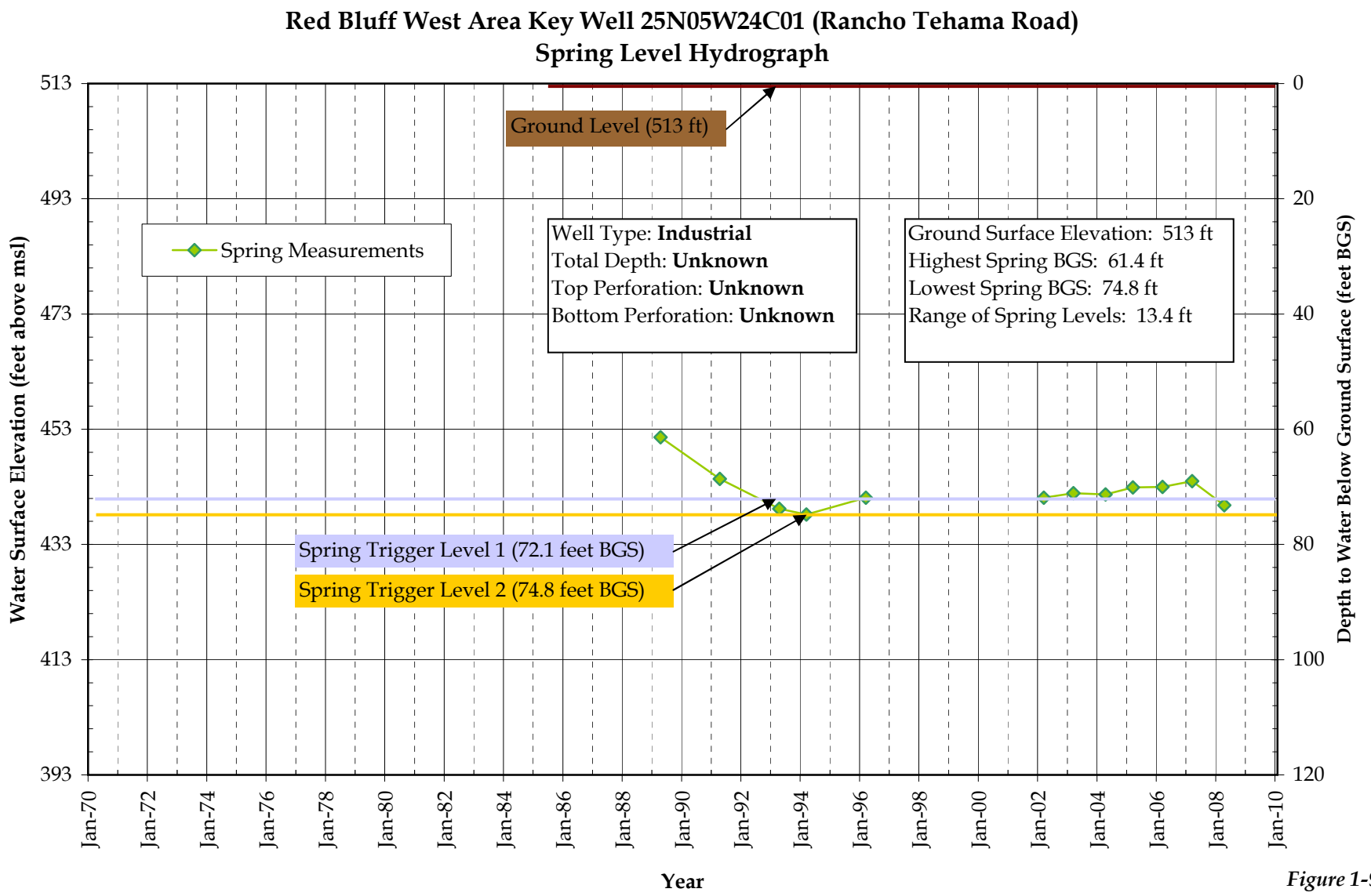


Figure 1-9
Spring Trigger Levels

Updated 12-01-08

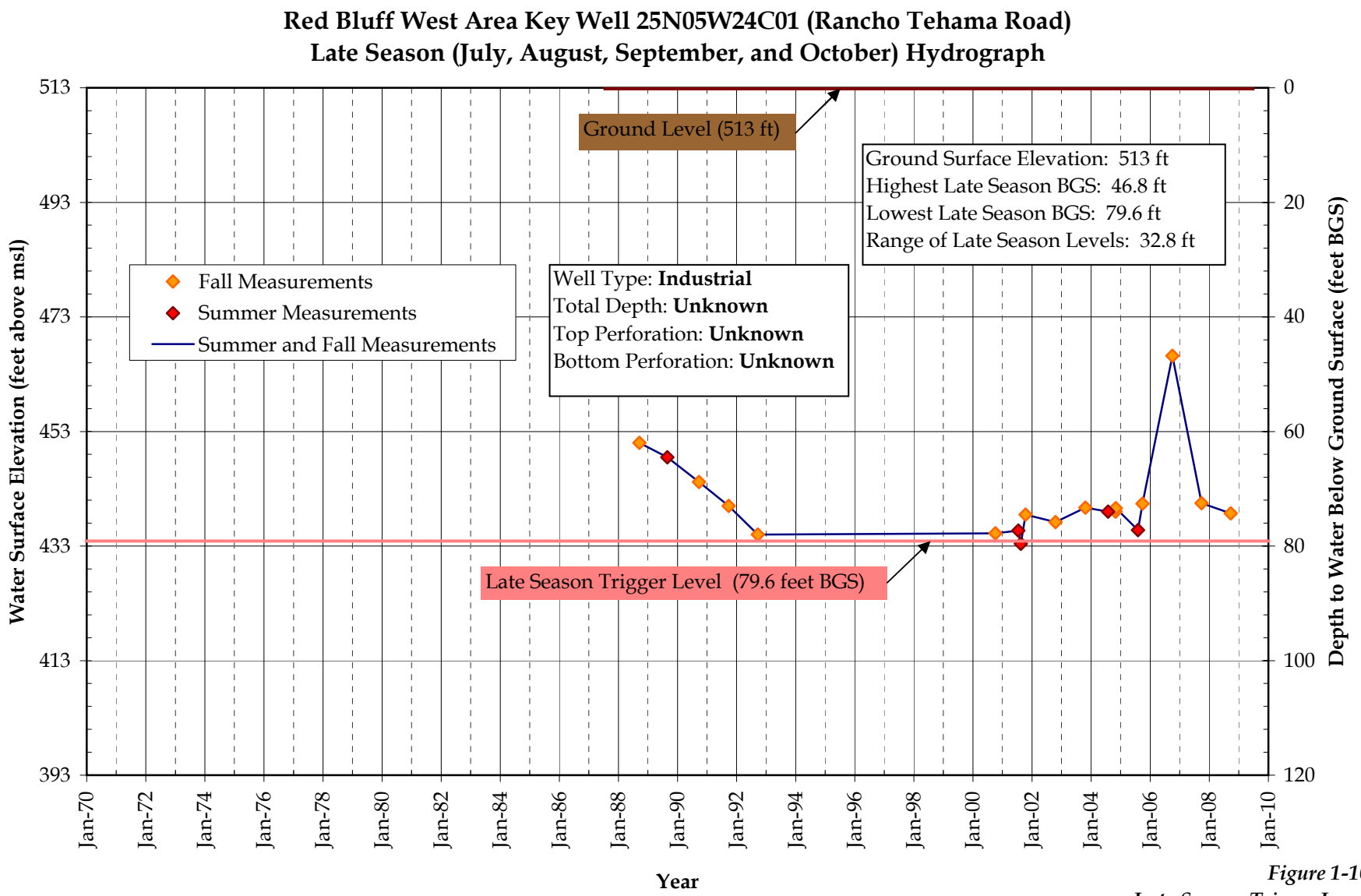


Figure 1-10
Late Season Trigger Level

Updated 12-01-08

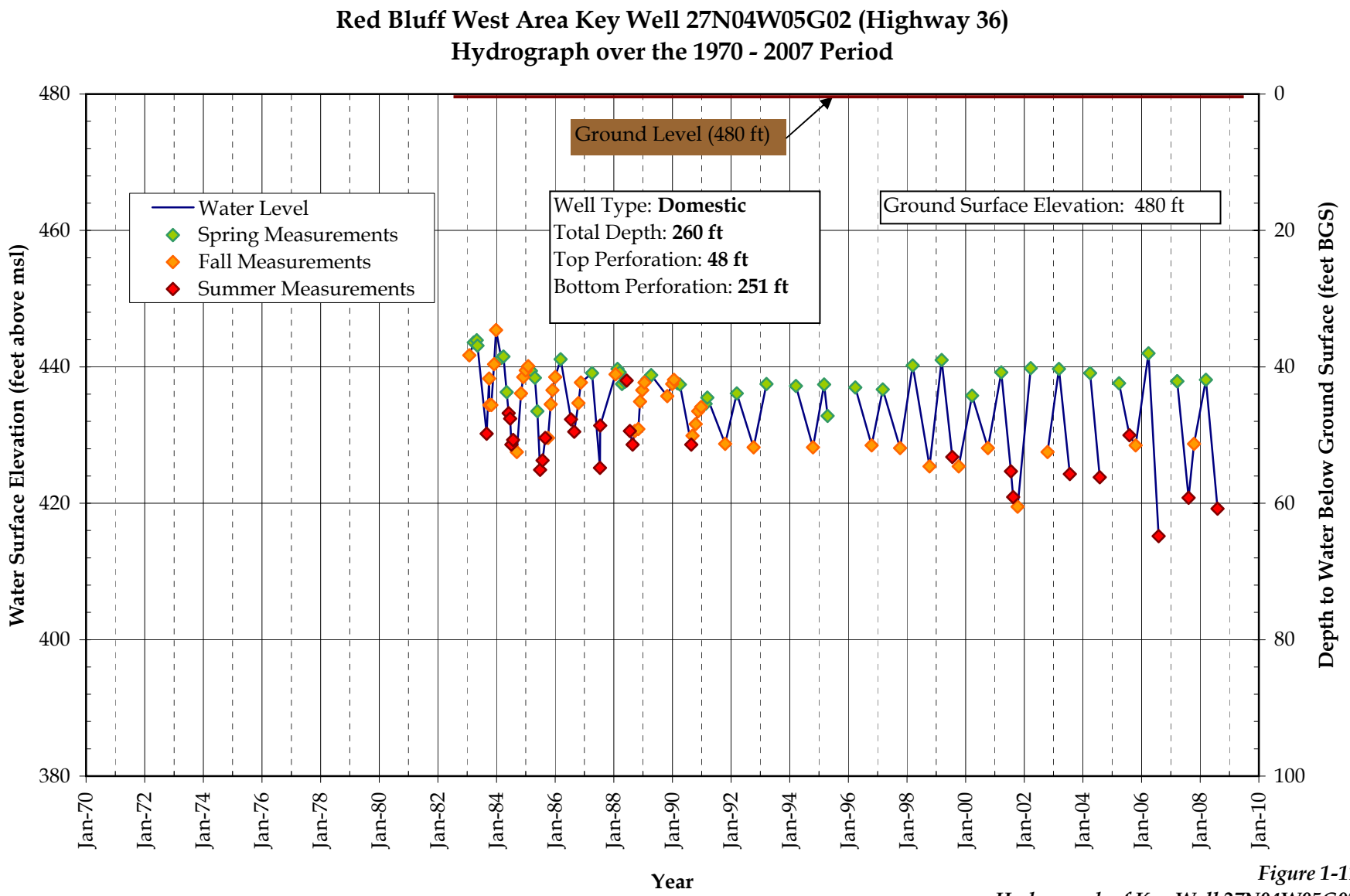


Figure 1-11
Hydrograph of Key Well 27N04W05G02

Updated 12-01-08

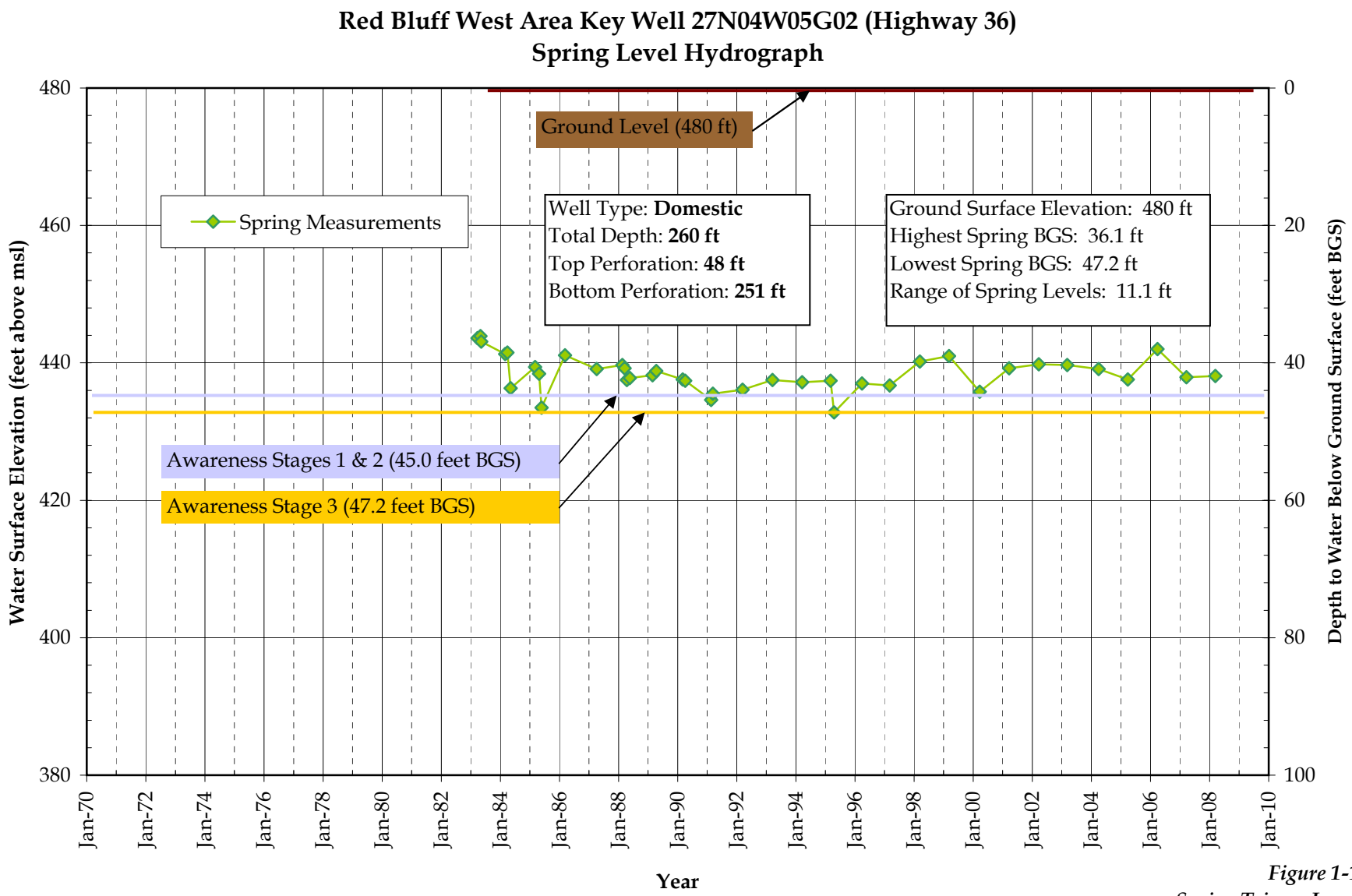


Figure 1-12
Spring Trigger Levels

Updated 12-01-08

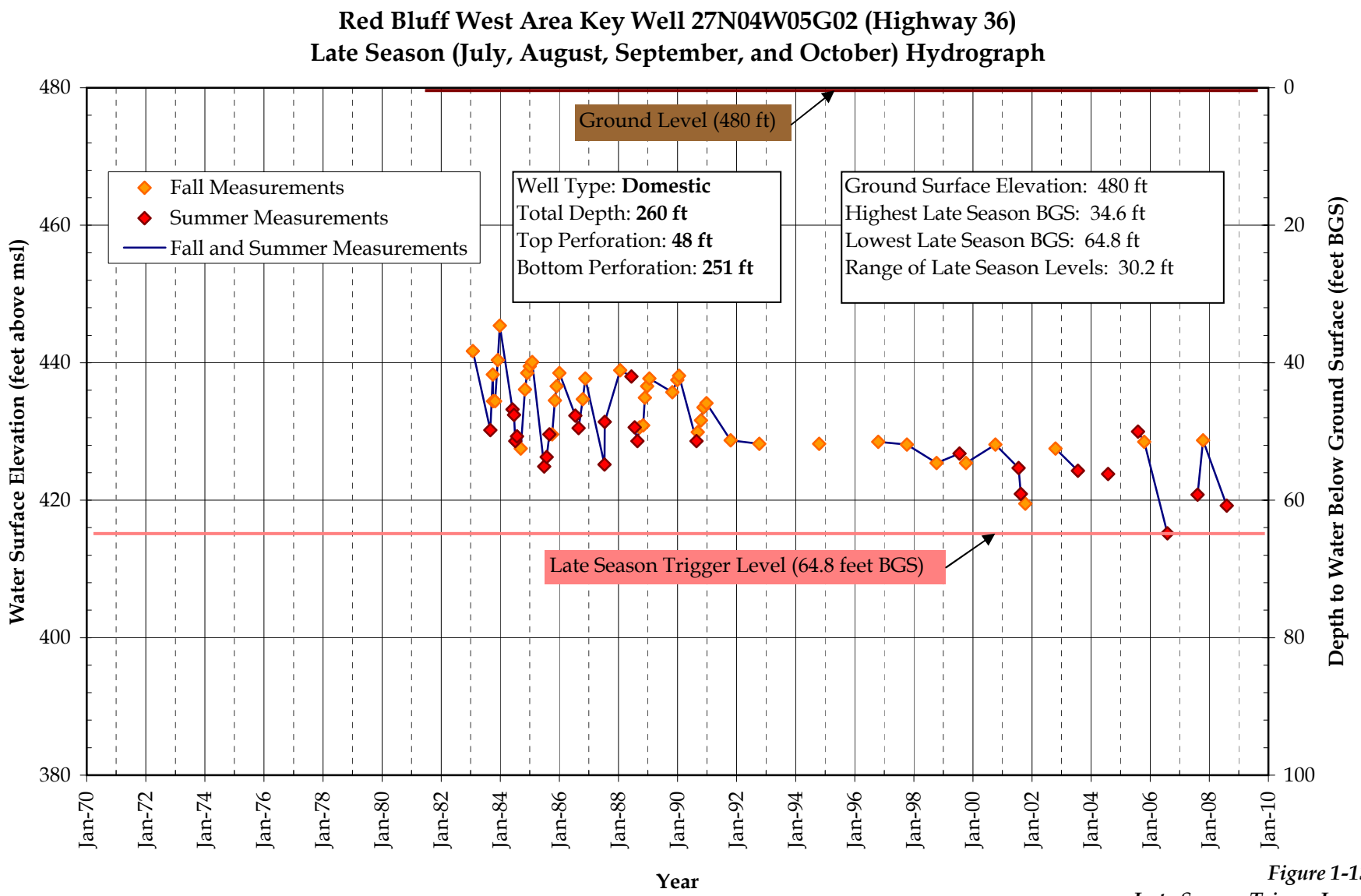


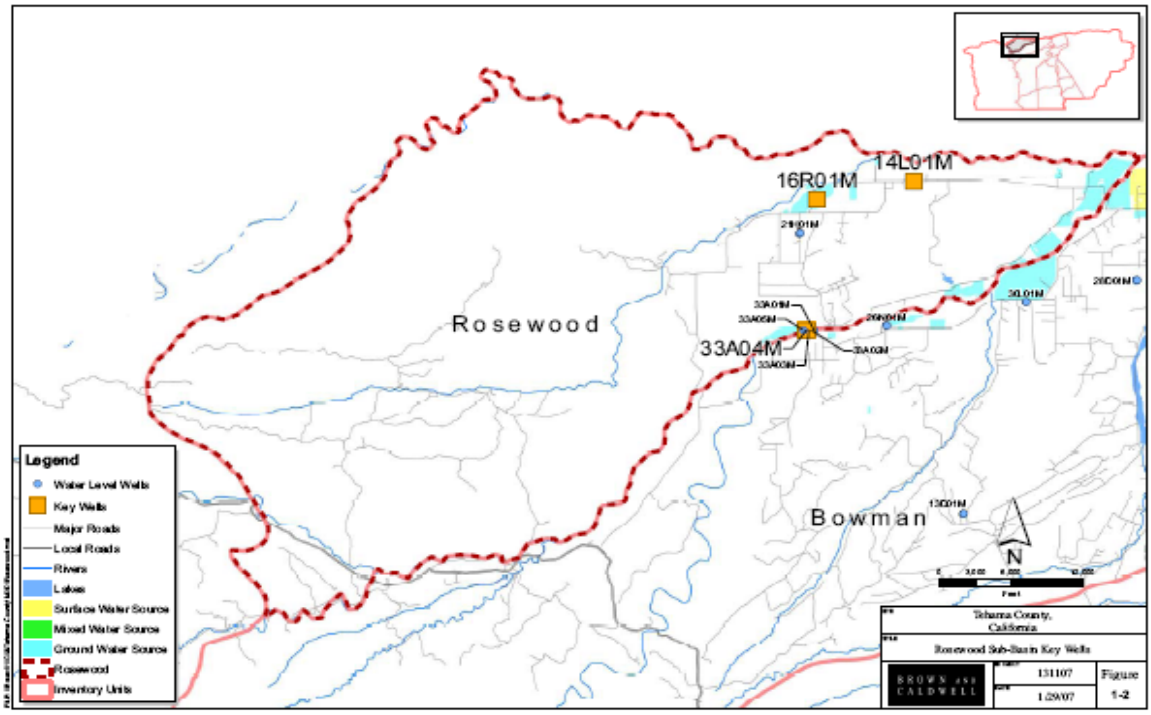
Figure 1-13
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Rosewood Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Rosewood Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

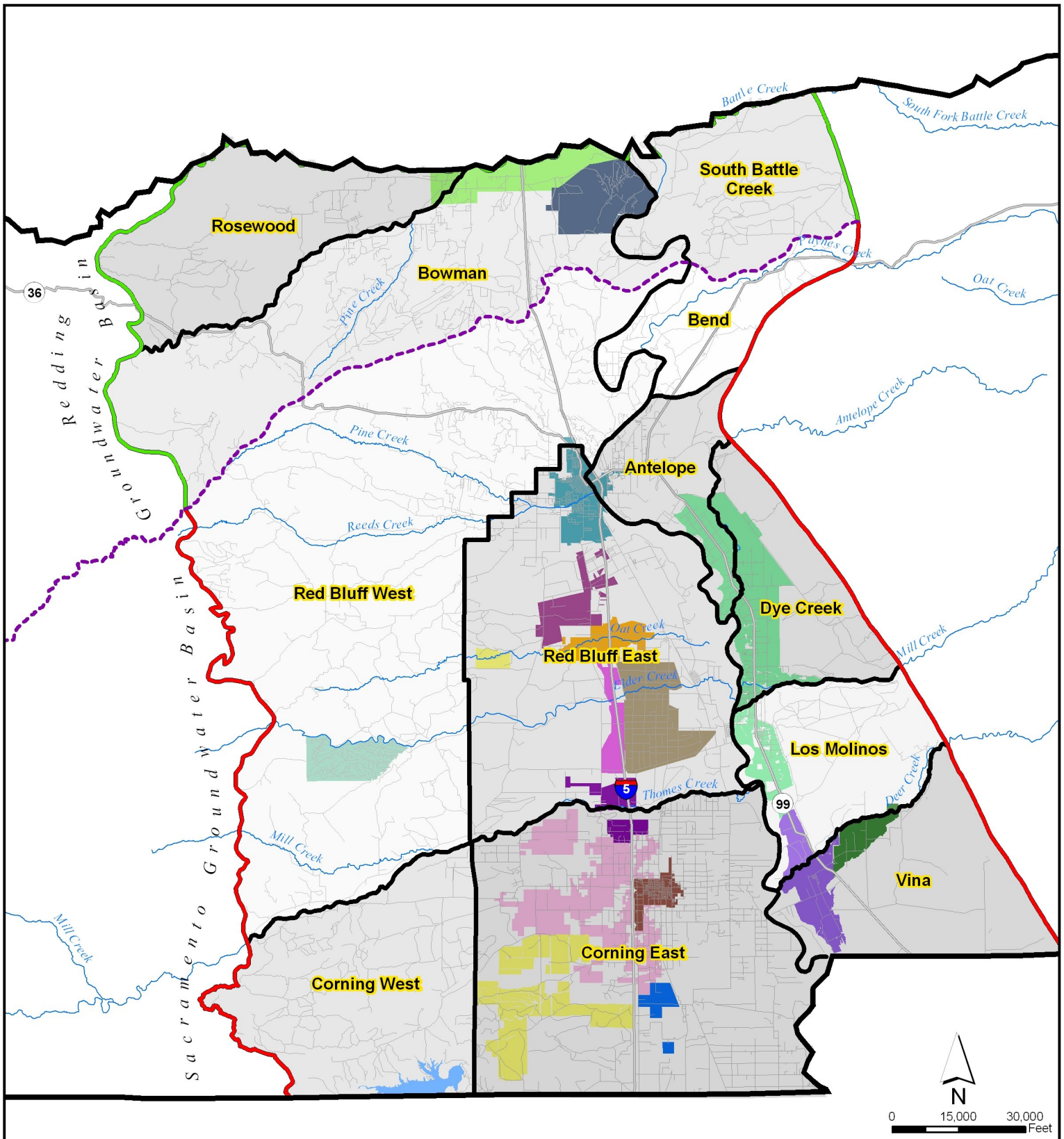
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Rosewood sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to two decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Rosewood sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
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- City of Red Bluff
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- Deer Creek
- El Camino ID
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- LMMWC
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- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

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- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Rosewood sub-basin is a rural area, with agriculture in the western edge of the sub-basin. Groundwater is used for agricultural and domestic purposes. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Rosewood:	
Irrigation:	85% (1,100 acre-ft)
Municipal, and Industrial:	15% (200 acre-ft)
Number of wells by type in Rosewood:	
Irrigation:	13 wells
Domestic:	196 wells
Municipal and Industrial:	1 well

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

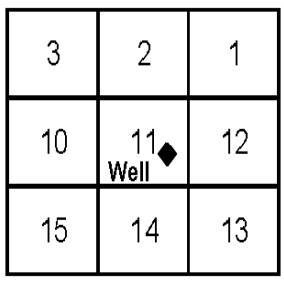
Step 2: Select one or more key wells within the sub-basin

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of three proposed key wells are presented in Figure 1-2. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



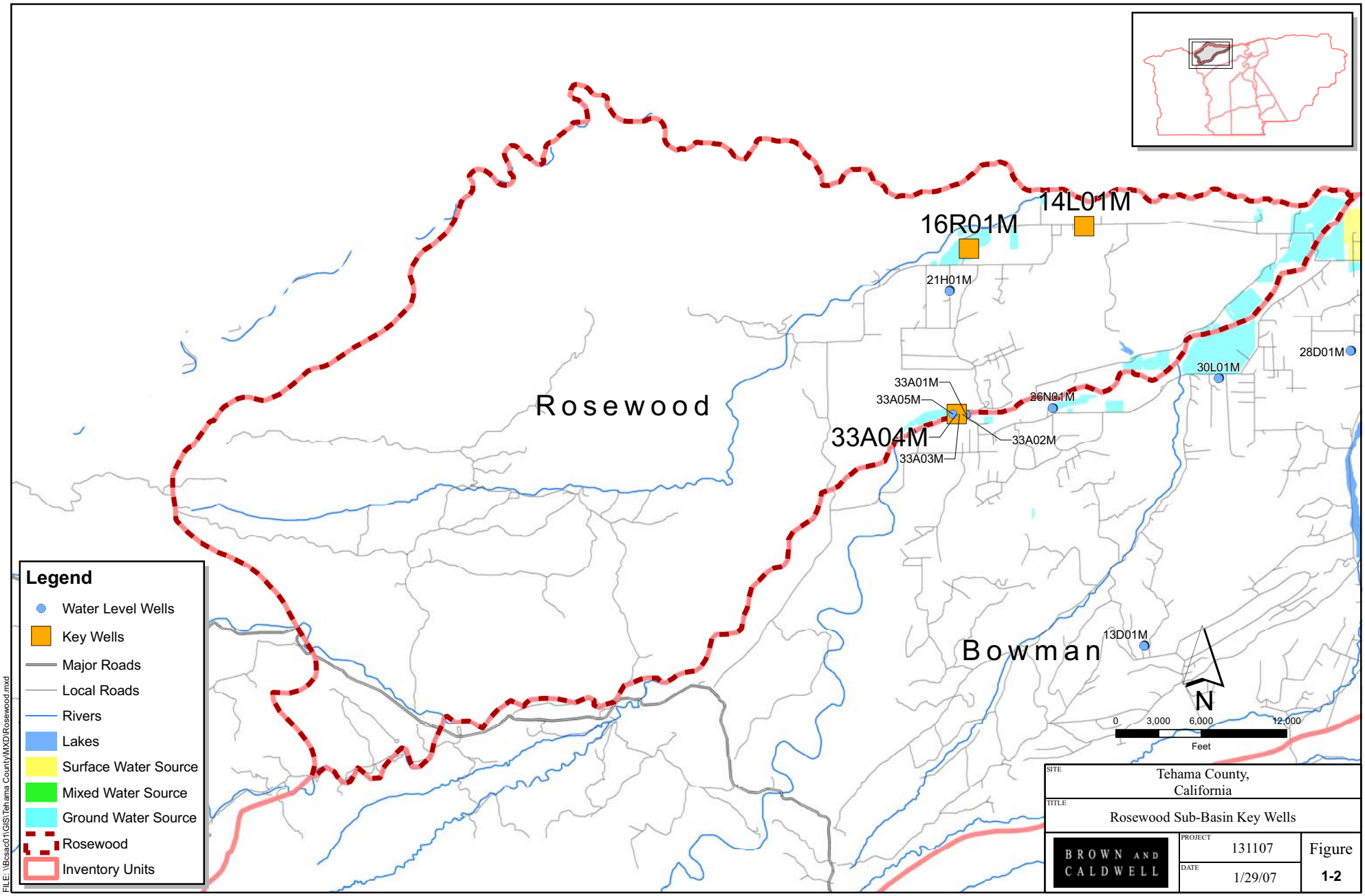
Example 1
Query of Township and Range Sections

- **29N05W16R01M (16R01M) –** This monitoring well is in the north central portion of the sub-basin and is 225 feet deep and has an unknown screened interval. This well is situated near pasture irrigated with groundwater. The nine square miles near this well contain 85 domestic wells with an average depth of 238 feet below ground surface (bgs), and 1 irrigation wells with a depth of 370 feet bgs. This well's period of record is near 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s.
- **29N05W14L01M (14L01M) –** This monitoring well is in the northeast portion of the sub-basin and is 130 feet deep with a screened interval between 125 and 130 feet bgs. This well is situated away from irrigated areas. The nine square miles near this well contain 69 domestic wells with an average depth of 203 feet bgs, and 1 irrigation well with a depth of 400 feet bgs. This well's period of record is near 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s.
- **29N05W33A04M (33A04M)–** This monitoring well is in the southeast portion of the sub-basin, is 295 feet deep, and has a screened interval from 42 feet to 295 feet bgs. This well is situated near orchards irrigated with groundwater. The nine square miles near this well contain 159 domestic wells with an average depth of 237 feet bgs, and 3 irrigation wells with an average depth of 341 feet bgs. This well's period of record is 10 years, which provides information on water levels during the drought during the late 1980s and early 1990s.

There are currently no monitoring wells in the southwestern portion of the Rosewood sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.

Step 3: Designate the time of seasonal measurement

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall


14L01M
16R01M
21H01M
28D01M
30L01M
33A01M
33A05M
26N01M
33A04M
33A02M
33A03M
Rosewood
Bowman
13D01M
N
0
3,000
6,000
12,000
Feet
Legend
Water Level Wells
Key Wells
Major Roads
Local Roads
Rivers
Lakes
Surface Water Source
Mixed Water Source
Ground Water Source
Rosewood
Inventory Units
FILE: \\Bcsac01\GIS\Tehama County\MXD\Rosewood.mxd
SITE
Tehama County, California
TITLE
Rosewood Sub-Basin Key Wells
BROWN AND CALDWELL
PROJECT
131107
DATE
1/29/07
Figure
1-2

water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

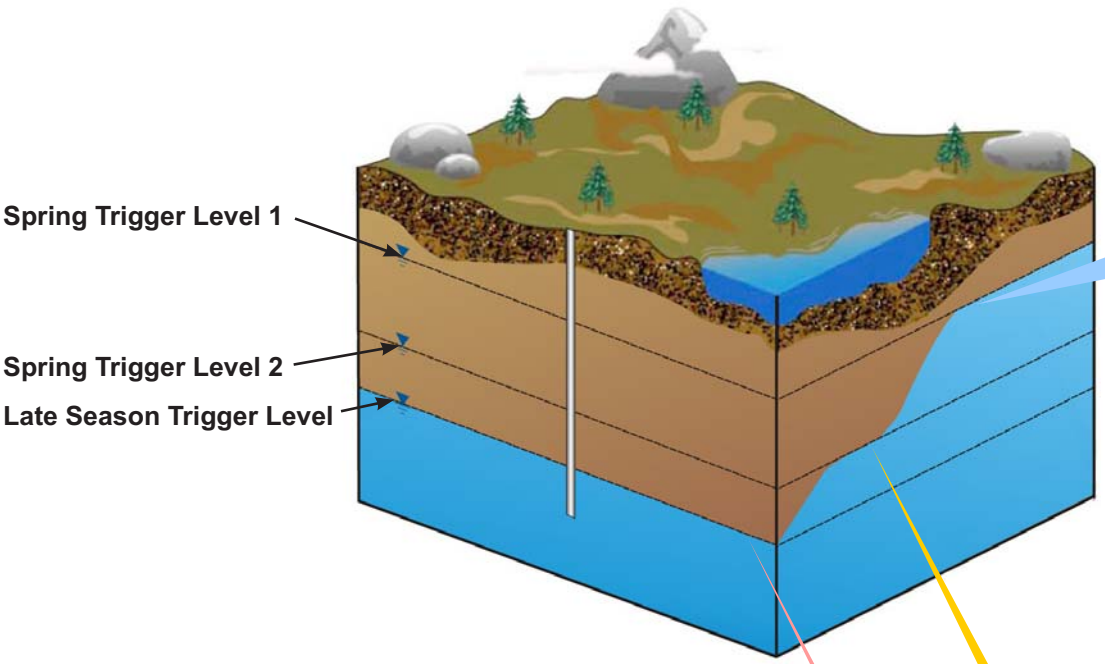
Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows three suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-12 present hydrographs and suggested trigger levels for each of the three Rosewood key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Rosewood sub-basin are provided in Table 1-1. One key well (33A04M) had a limited historic record of groundwater level measurements that did not include a significant drought cycle, so the method of proposing spring and late season trigger levels was modified and is subject to change in annual reviews as more experience is gained.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Rosewood Monitoring Well Number		
	16R01M	**14L01M**	**33A04M**
Spring Trigger Level - 1 Notify and Inform Public	Set at lowest spring measurement during the 1988 to 1994 period	20% of the range of spring measurements above the historical low	Historical low of spring measurements
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Stage 1		
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements		Historical low of spring measurements minus the range of spring measurements
Late Season Trigger Level – Notify public and begin investigations	Historical low of summer and fall measurements		
Data Anomalies	None	None	None

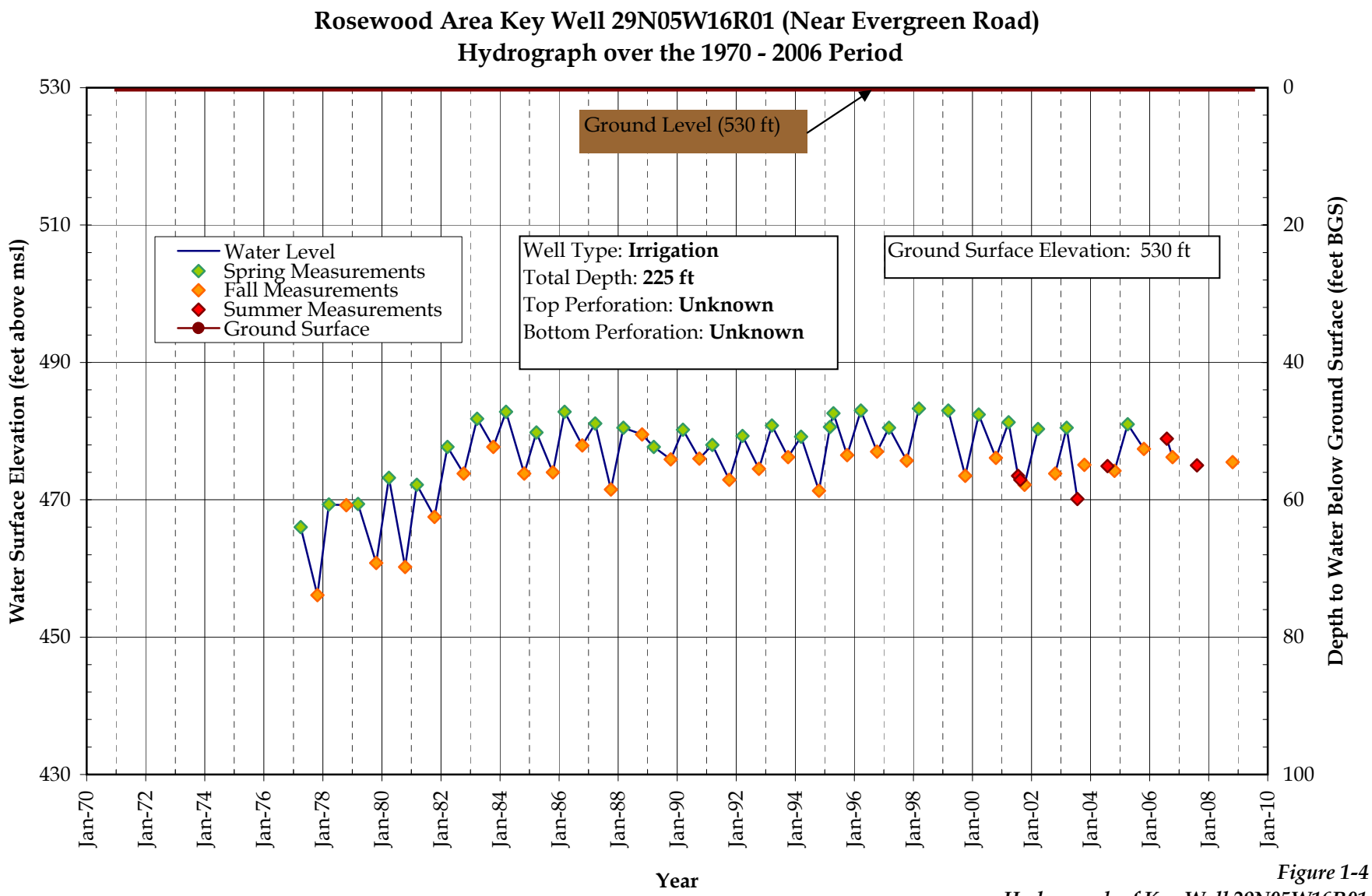


Figure 1-4
Hydrograph of Key Well 29N05W16R01

Updated 12-01-08

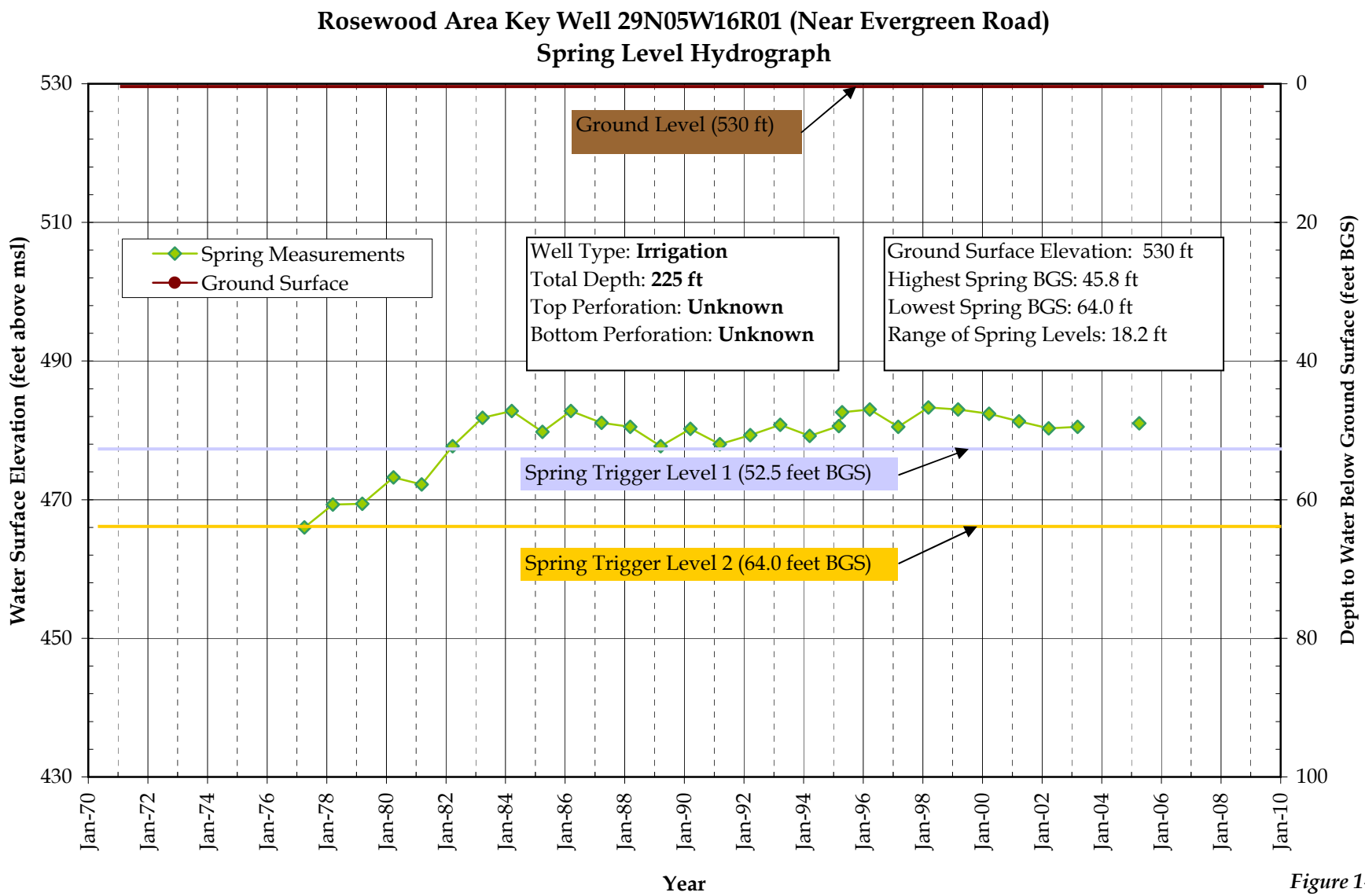


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

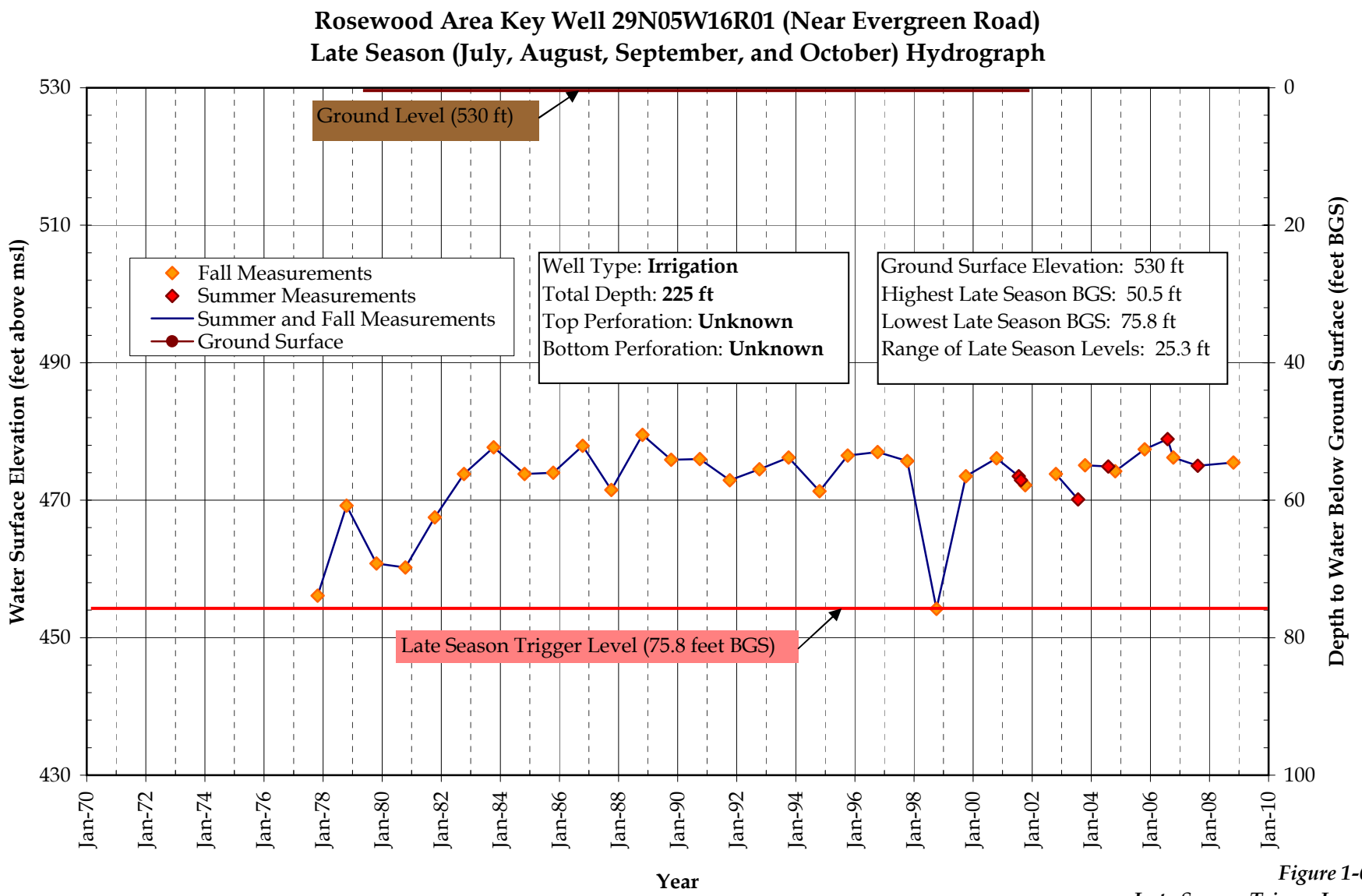


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

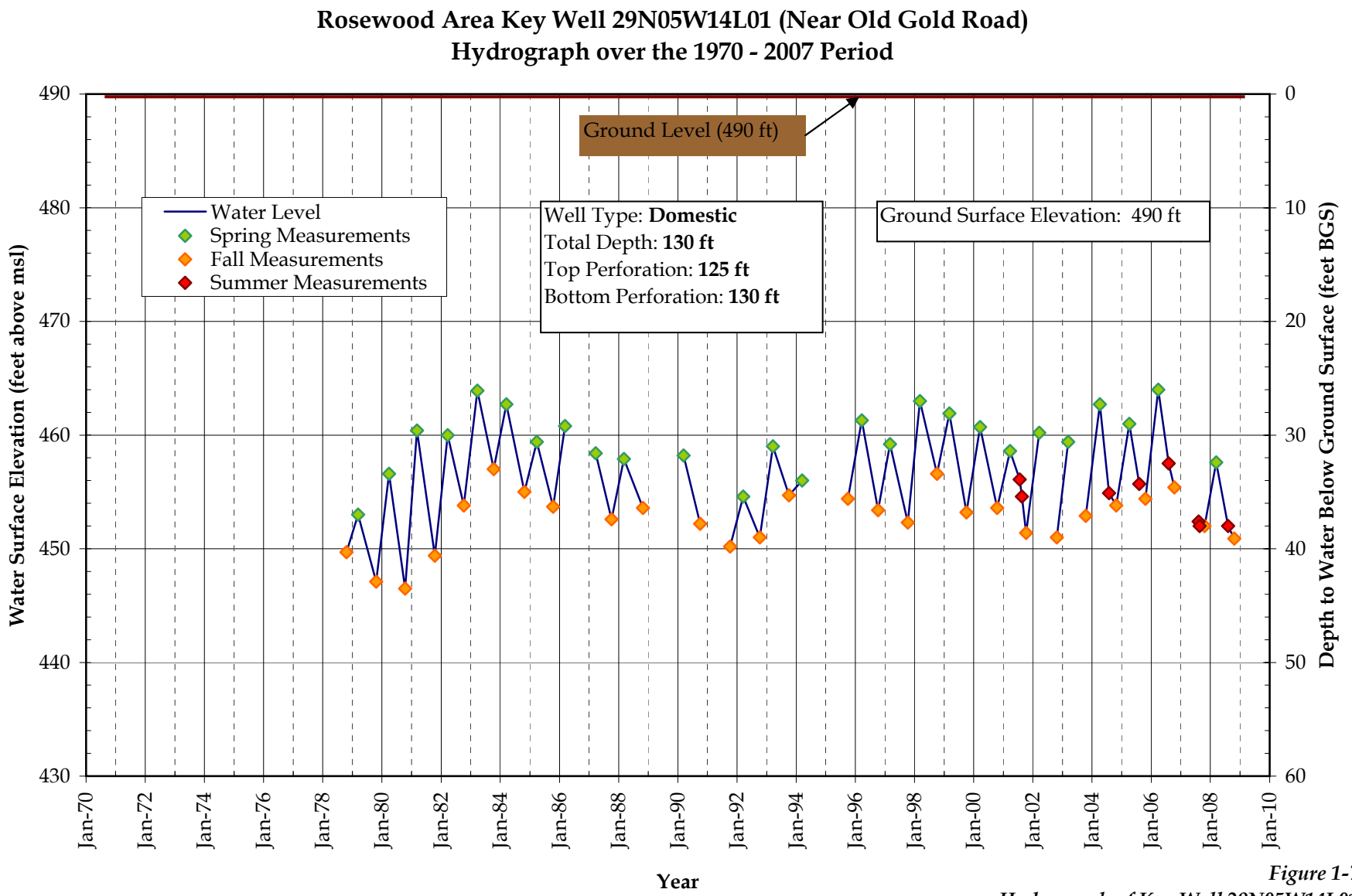


Figure 1-7
Hydrograph of Key Well 29N05W14L01

Updated 12-01-08

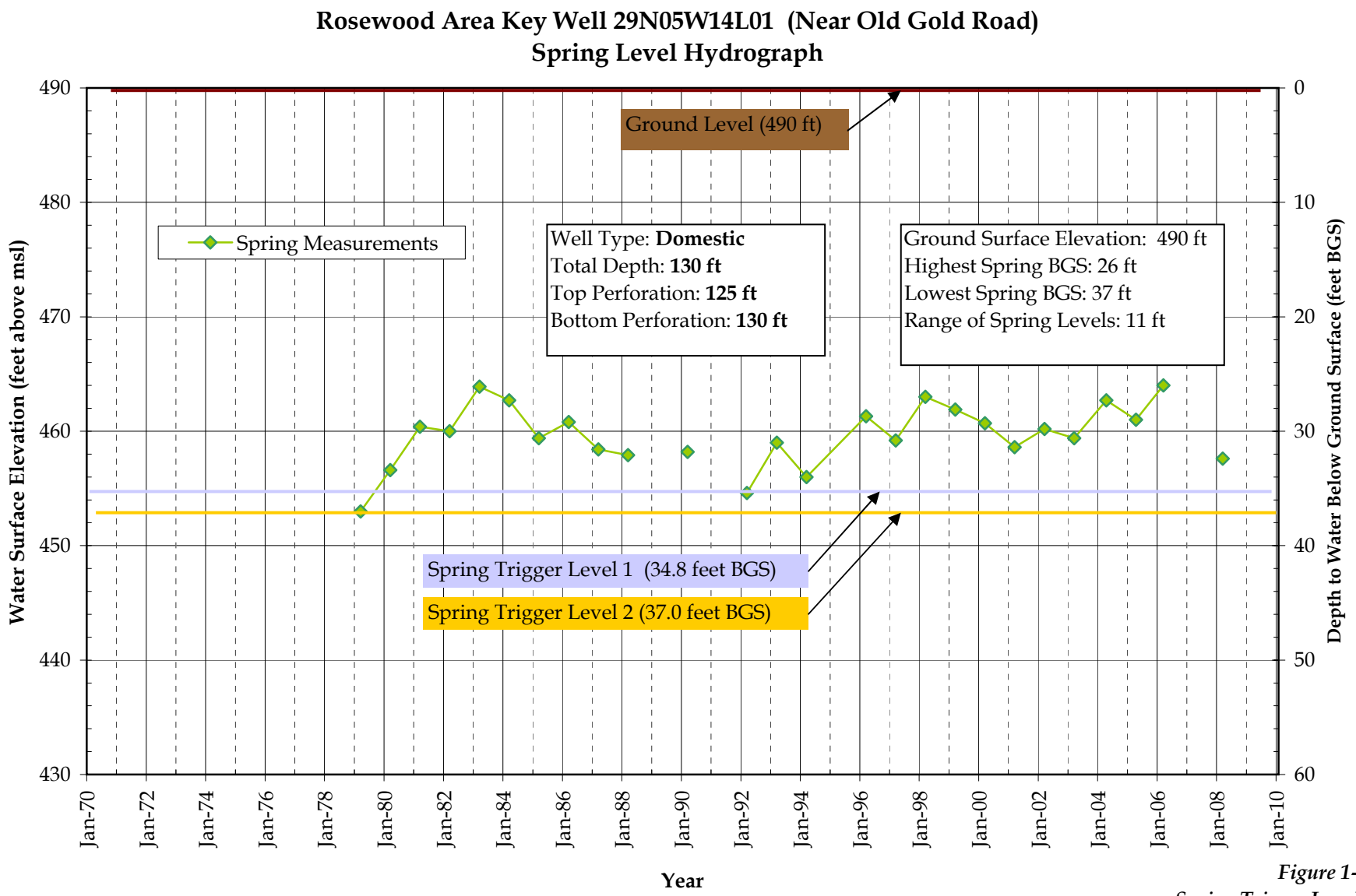


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

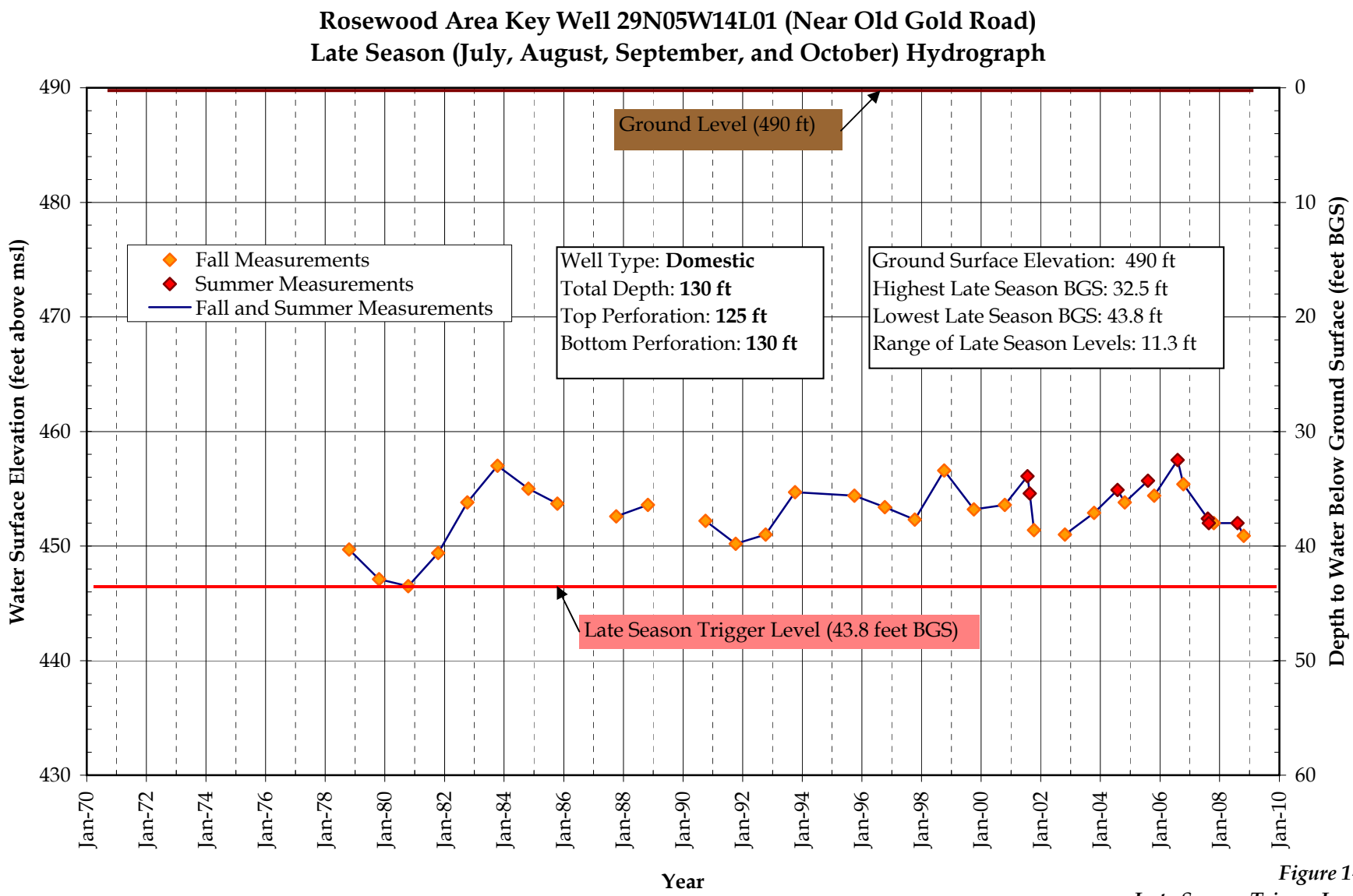


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

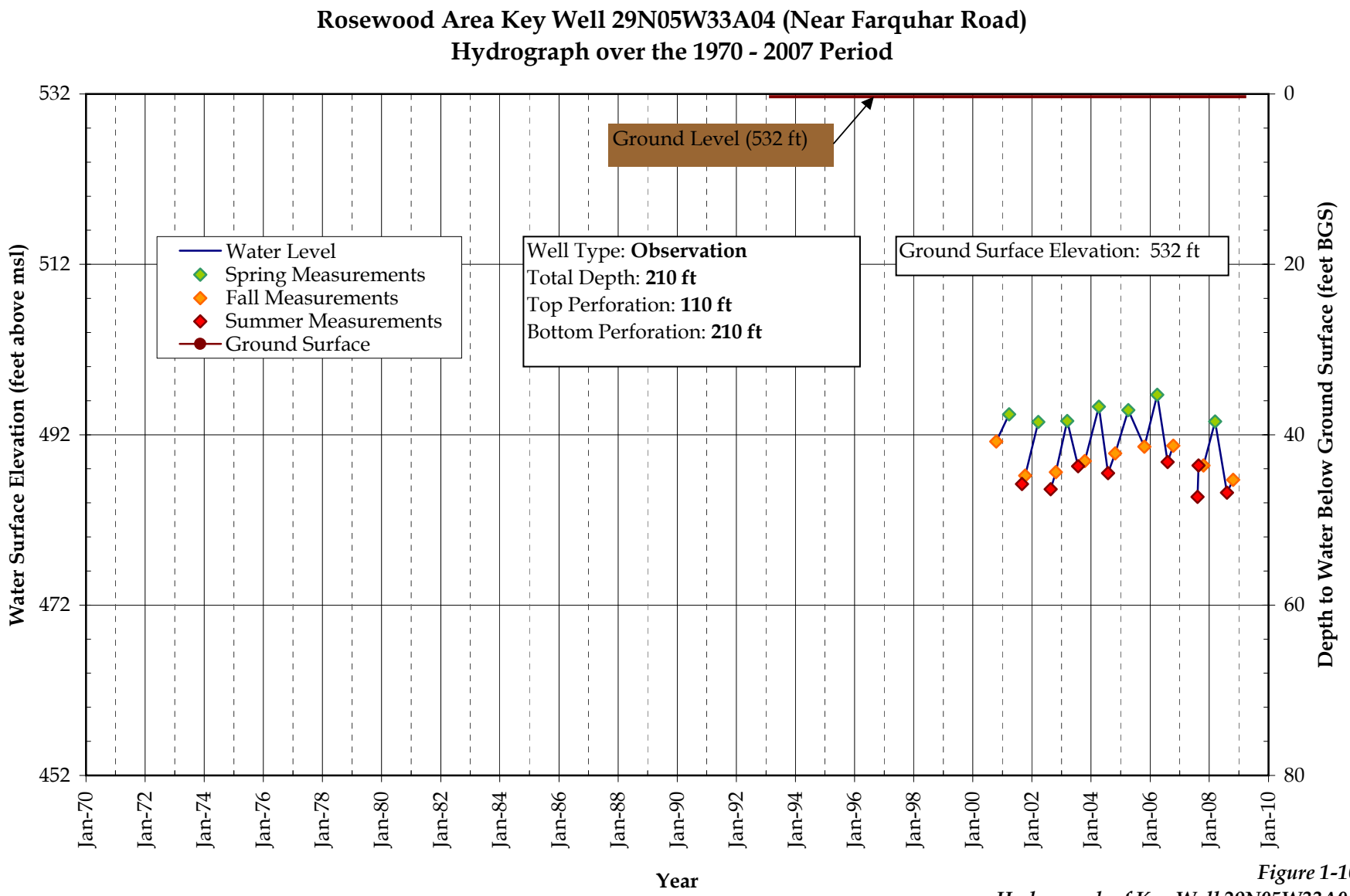


Figure 1-10
Hydrograph of Key Well 29N05W33A04

Updated 12-01-08

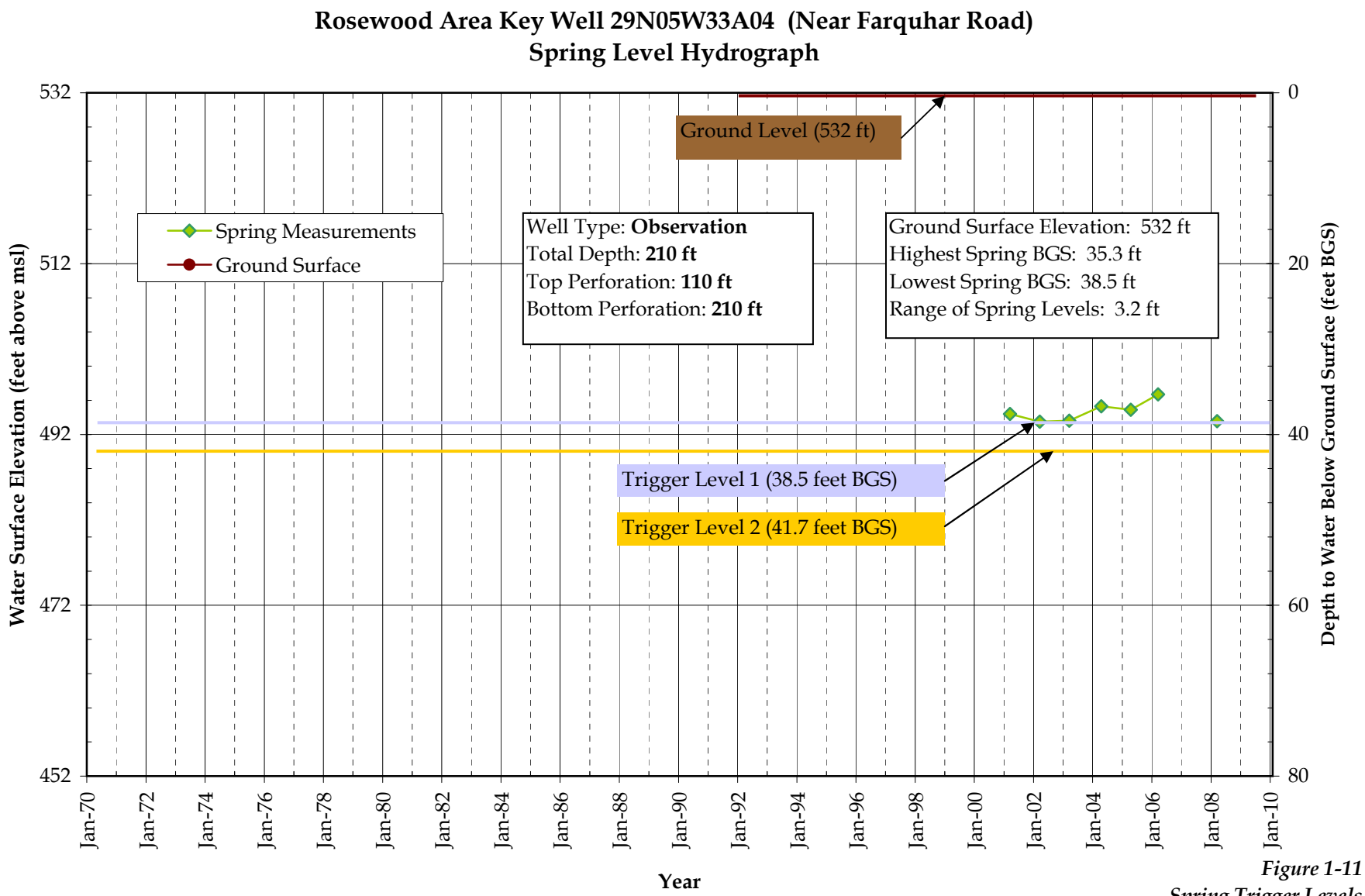


Figure 1-11
Spring Trigger Levels

Updated 12-01-08

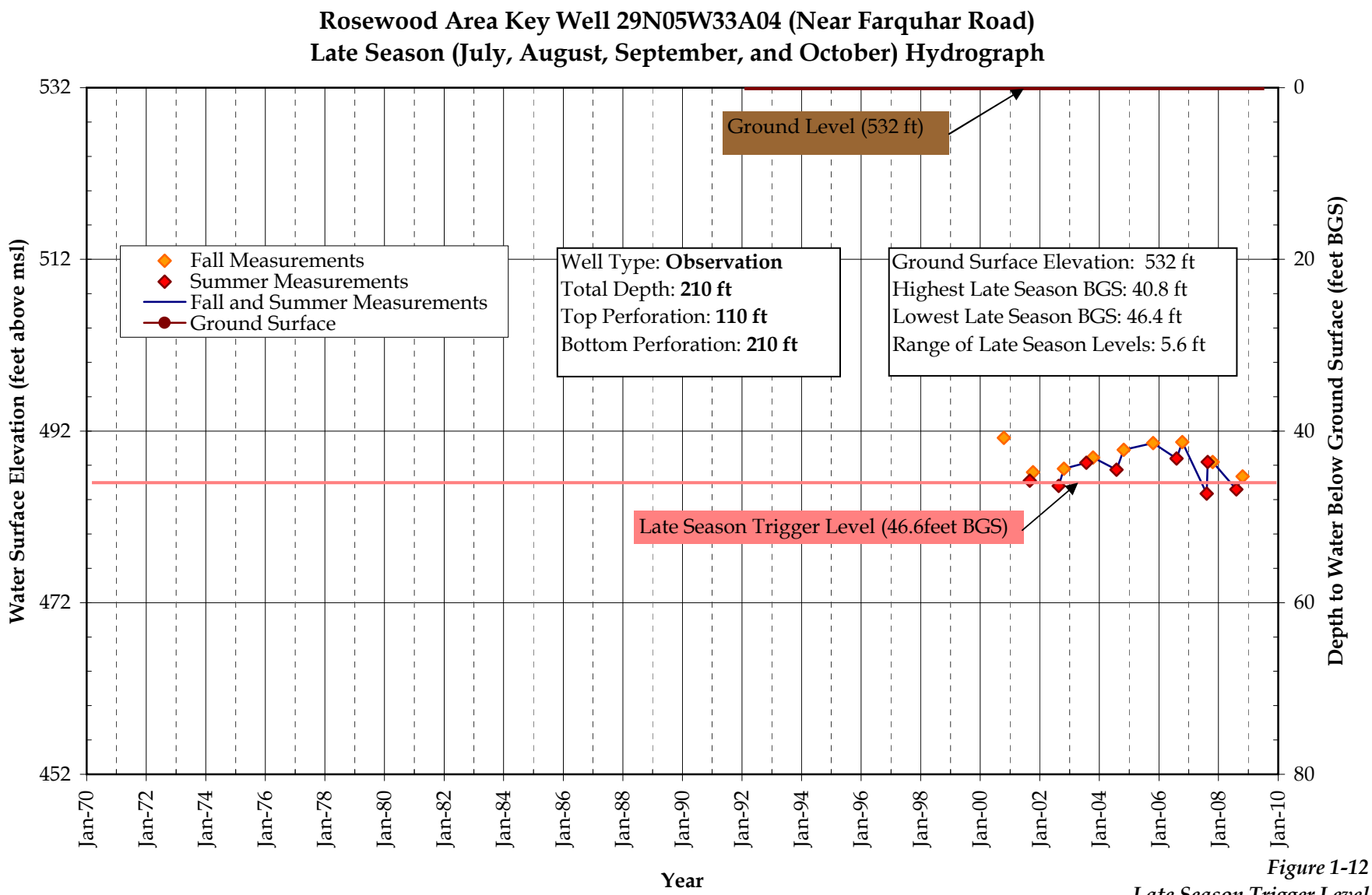


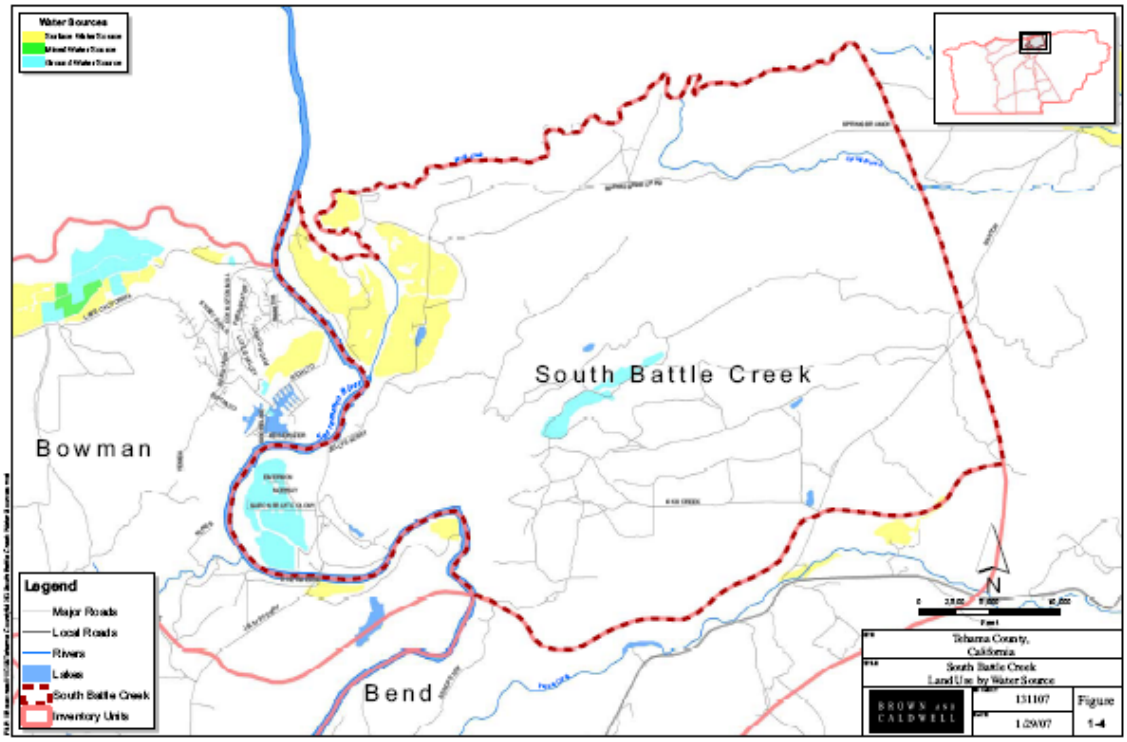
Figure 1-12
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the South Battle Creek Sub-basin of Tehama County



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To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

INTRODUCTION

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. Trigger Levels are developed through a five step process as described in Section 1. South Battle Creek does not have monitoring wells, and instead of developing trigger levels, will determine priority areas for future monitoring as described in Section 2.

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan incorporated citizen input, review, and approval over a period of three years, Final adoption by the Tehama County FCWCD was achieved in 1998.

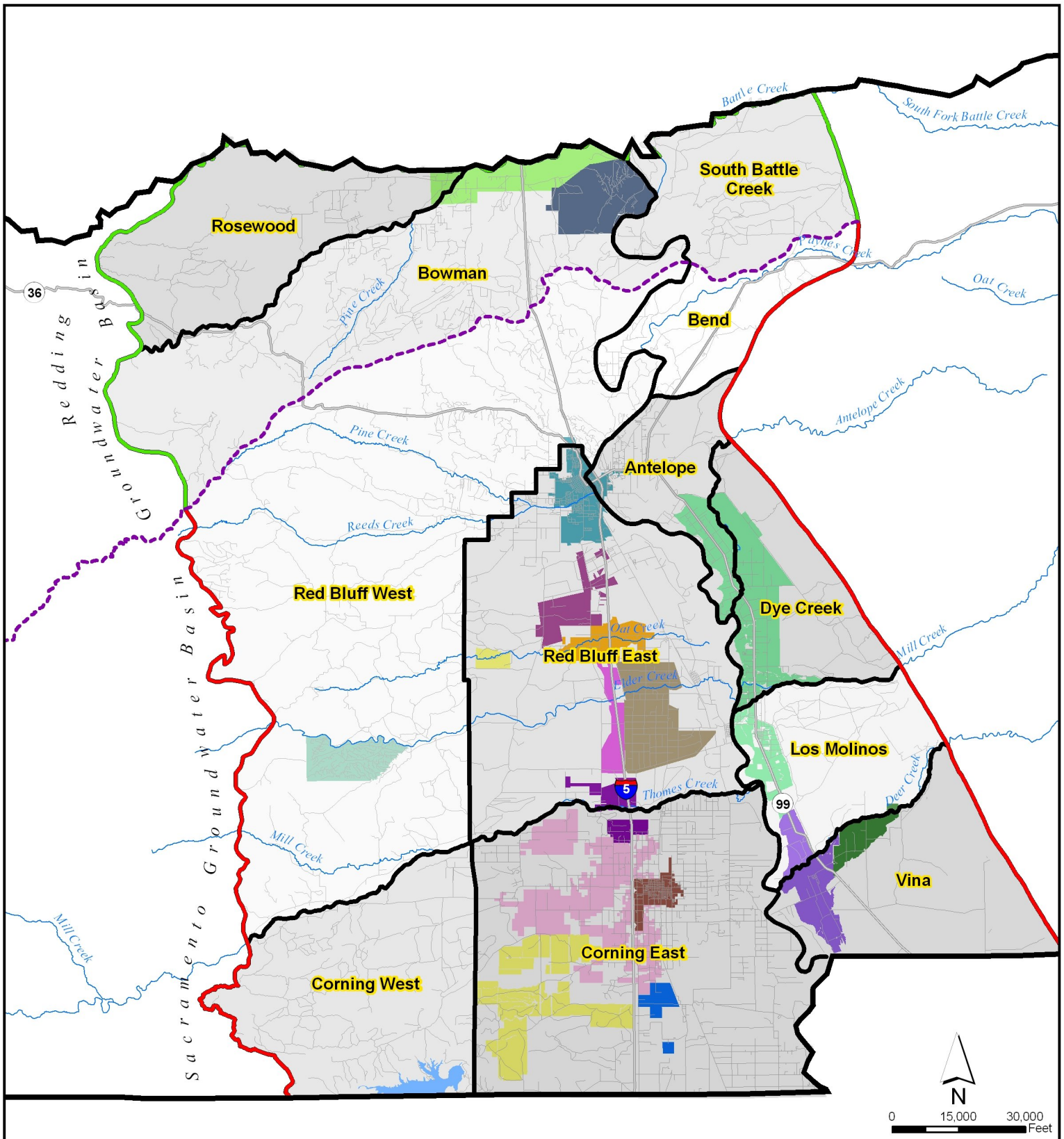
The Plan states that one of the District's functions under the Plan is to provide guidance in the development of groundwater trigger levels. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various trigger levels of increased groundwater discussion, investigation or local management actions.

Sections 325 through 329 of the Plan describe the trigger level concept and detail the District's role in trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This Technical Memorandum (TM) focuses on groundwater level trigger level development for the South Battle Creek sub-basin. Since its inception, the Plan has provided guidance related to groundwater activities. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. Section 1 of this TM describes the methodology used to develop trigger levels.

Because the South Battle Creek Sub-Basin does not have formal groundwater monitoring, such as a dedicated monitoring well or wells included in the Department of Water Resources (DWR) monitoring grid, Section 2 of this TM identifies potential areas for new groundwater monitoring within the South Battle Creek Sub-Basin.

Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ . Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in each sub-basin.



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BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

FILE: \\Bcsac01\GIS\Tehama County\MXD\Ground Water Sub-Basins.mxd

1. Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process, listed below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose.

The trigger level's purpose describes the intent of the trigger levels in the area. The purpose may reflect the desire of sub-basin planners to protect historic groundwater uses, minimize long-term drawdown of groundwater levels, maintain springs and habitat, and/or protect groundwater supplies for domestic and irrigation uses.

Step 2: Select one or more key wells within the sub-basin.

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to initiate management activities. If no monitoring wells are available in a sub-basin, such as South Battle Creek, then locations for new monitoring wells should be selected.

When selecting new areas for monitoring, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use: Groundwater levels are more likely to be stressed in areas of active land use. Areas with fixed water demand crops such as orchards should be higher priority areas for monitoring.

Water Source: Groundwater supplies in areas irrigated with groundwater are more likely to be stressed during drought periods. Locating monitoring wells in areas reliant on groundwater would provide useful information for groundwater management, and should be higher priority areas for monitoring.

Existing Well Infrastructure: Well drilling records should be considered. The screened intervals of monitoring wells should be similar to the average screened interval of production wells in the area.

Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well.

Once monitoring wells have been located and developed in an area, the remaining three trigger level steps can take place.

Step 3: Designate the time of seasonal measurement.

Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the pumping impacts within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use that can provide a warning of potential issues such as increased groundwater demand.

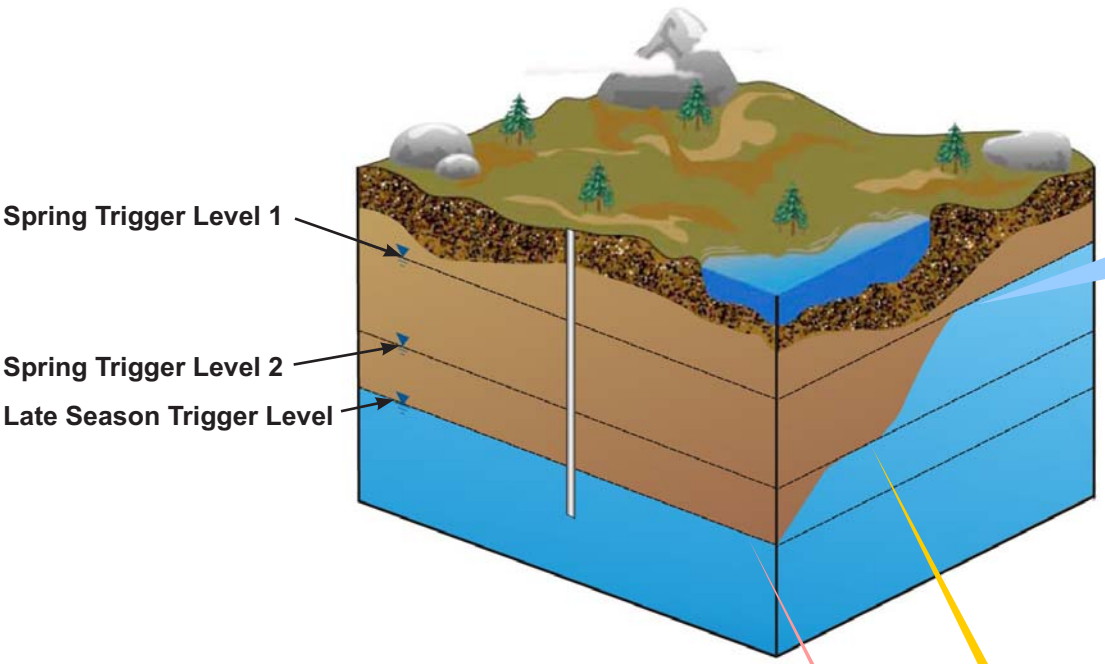
Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level.

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-2).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, (indicating a need to disseminate information or further investigation of groundwater levels), to a larger change in groundwater levels, (indicating a need to take action to stop or reduce the lowering of groundwater levels).

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. As an example, Figure 1-2 shows a diagram that details three suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-2
Trigger Levels and Awareness Actions

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

2. South Battle Creek Trigger Level Development

Because South Battle Creek does not have monitoring wells, this section is focused on the implementation of the first two steps of the five step methodology:

Step 1: Describe the trigger level's purpose.

The South Battle Creek sub-basin is primarily a rural area, with agriculture in the western end of the sub-basin. Groundwater is used for agricultural and domestic purposes. There are no organized irrigation districts in the South Battle Creek sub-basin, as indicated in Figure 1-1. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in South Battle Creek:	
Irrigation:	100% (2,100 acre-ft)
Municipal, and Industrial:	0% (0 acre-ft)
Number of wells by type in South Battle Creek:	
Irrigation:	5 wells
Domestic:	12 wells
Municipal and Industrial:	0 wells

- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies to protect supplies for current and future uses.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

Step 2: Select one or more key wells within the sub-basin.

There are currently no monitoring wells located within the South Battle Creek sub-basin. According to the DWR database, there are 17 reported wells in South Battle Creek, none of which included in the DWR monitoring grid. Groundwater levels in key wells provide information necessary to initiate management activities. To begin the trigger level process, the District suggests that priority areas for new monitoring be selected in the South Battle Creek area.

When picking areas for monitoring wells in South Battle Creek, the choice should be guided by a number of criteria including land use, agricultural water source, existing well infrastructure, accessibility, and monitoring in adjacent sub-basins.

Land Use:. Figure 1-3 presents the land use in the South Battle Creek area. Agriculture in South Battle Creek is predominantly in the west, with orchards and pasture the predominant crop types. Future land use in South Battle Creek is anticipated to be similar to current land use. Additional land use information can be obtained by obtaining the zoning information for the South Battle Creek area.

Water Source: Figure 1-4 presents agricultural land use by water source in the South Battle Creek area. Figure 1-4 demonstrates that agriculture in the northwestern corner of South Battle Creek is irrigated with surface water, and that agriculture in the southwestern point of South Battle Creek is irrigated with groundwater.

Existing Well Infrastructure: There are 12 domestic wells and 5 irrigation wells in the South Battle Creek sub-basin. Fifty percent of the domestic wells are shallower than 113 feet deep, and fifty percent of the irrigation wells are shallower than 230 feet deep. Existing well infrastructure data was developed from DWR's well completion report database. DWR's database contains information on the majority of wells drilled after 1947, while wells drilled prior to 1947 are generally not included. Some wells drilled after 1947 may not have been reported to DWR (potentially up to 30%), and therefore are not included in the database.

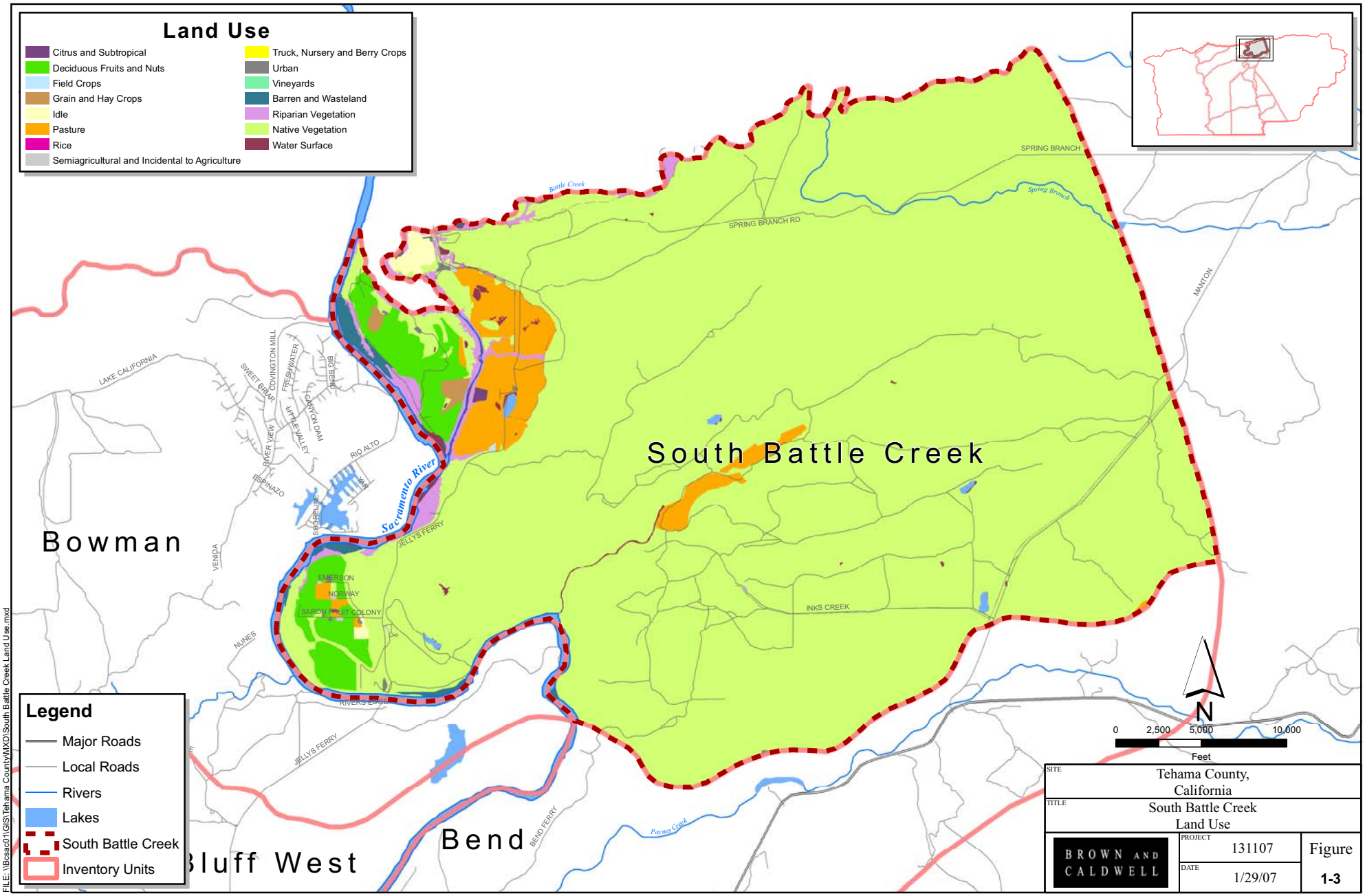
Accessibility: The monitoring well should be located in an accessible area to allow for monitoring activities. New monitoring should occur in areas with cooperative landowners that provide a right of entry to monitoring activities.

Monitoring in Adjacent Sub-Basins: A new monitoring well should not be sited near an existing monitoring well. Figure 1-4 shows the locations of any monitoring wells adjacent to South Battle Creek. As indicated by Figure 1-4, there are no monitoring wells near the boundary of South Battle Creek, and new monitoring wells can be sited near the boundary of the sub-basin.

Suggested Monitoring Well Areas:

There are four suggested areas for new monitoring wells in the South Battle Creek area which are indicated in Figure 1-5. Monitoring wells installed in the South Battle Creek area should be screened to monitor groundwater at depths similar to those used for production by domestic and irrigation wells. The majority of domestic and irrigation wells in South Battle Creek are screened between 100 and 250 feet below ground surface. The four suggested areas are listed below:

- The first suggested area (Area 1) is in the southwestern point of the sub-basin, and is a priority area of orchards that are irrigated with groundwater. Area 1 lies toward the center of the valley, and is not near other monitoring wells.
- The second suggested area (Area 2) is in the central portion of the sub-basin, and is a priority area of pasture that is irrigated by groundwater. Area 2 lies away from the center of the valley, and is not near other monitoring wells.
- The third suggested area (Area 3) is in the northwestern portion of the sub-basin, and is a priority area of orchards that are irrigated with surface water. Area 3 is close to the river, and separated from the rest of the sub-basin by a slough. Area 3 lies toward the center of the valley, and is not near other monitoring wells.


Land Use
Citrus and Subtropical
Deciduous Fruits and Nuts
Field Crops
Grain and Hay Crops
Idle
Pasture
Rice
Semiagricultural and Incidental to Agriculture
Truck, Nursery and Berry Crops
Urban
Vineyards
Barren and Wasteland
Riparian Vegetation
Native Vegetation
Water Surface
South Battle Creek
Bowman
Bluff West
Bend
Sacramento River
Battle Creek
Spring Branch
SPRING BRANCH
SPRING BRANCH RD
MAYTON
INKS CREEK
JELLYS FERRY
BEND FERRY
Payne Creek
LAKE CALIFORNIA
SWEET BRIAR
COVINGTON MILL
FRESHWATER
BIG BEND
CANYON DAM
LITTLE VALLEY
RIVER VIEW
ESPINAZO
RIO ALTO
SHORELINE
VENIDA
NUNES
EMERSON
NORWAY
SAROW FRUIT COLONY
RIVERS EDGE
Legend
Major Roads
Local Roads
Rivers
Lakes
South Battle Creek
Inventory Units
N
0 2,500 5,000 10,000
Feet
SITE
Tehama County, California
TITLE
South Battle Creek Land Use
BROWN AND CALDWELL
PROJECT
131107
DATE
1/29/07
Figure
1-3
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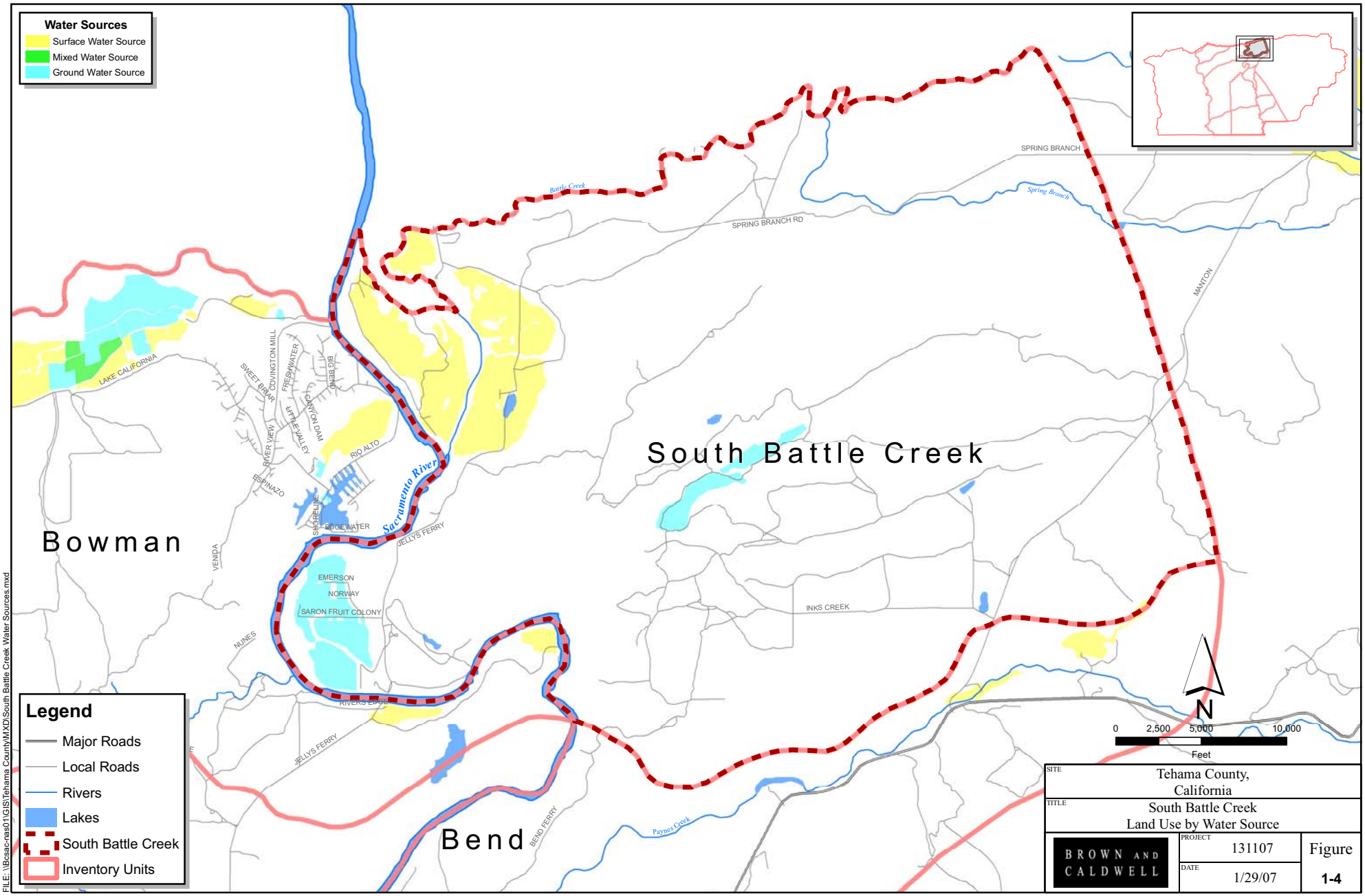
Water Sources
Surface Water Source
Mixed Water Source
Ground Water Source
Legend
Major Roads
Local Roads
Rivers
Lakes
South Battle Creek
Inventory Units
South Battle Creek
Bowman
Bend
Sacramento River
Battle Creek
Spring Branch
Paynes Creek
SPRING BRANCH
SPRING BRANCH RD
MAYTON
INKS CREEK
LAKE CALIFORNIA
SWEET BRIAR
COVINGTON MILL
FRESHWATER
BIG BEND
CANYON DAM
LITTLE VALLEY
RIVER VIEW
ESPINAZO
RIO ALTO
SHORELINE
EDGEWATER
JELLYS FERRY
VENIDA
EMERSON
NORWAY
SARON FRUIT COLONY
NUNES
RIVERS EDGE
BEND FERRY
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Feet
SITE
Tehama County, California
TITLE
South Battle Creek Land Use by Water Source
BROWN AND CALDWELL
PROJECT
131107
DATE
1/29/07
Figure
1-4
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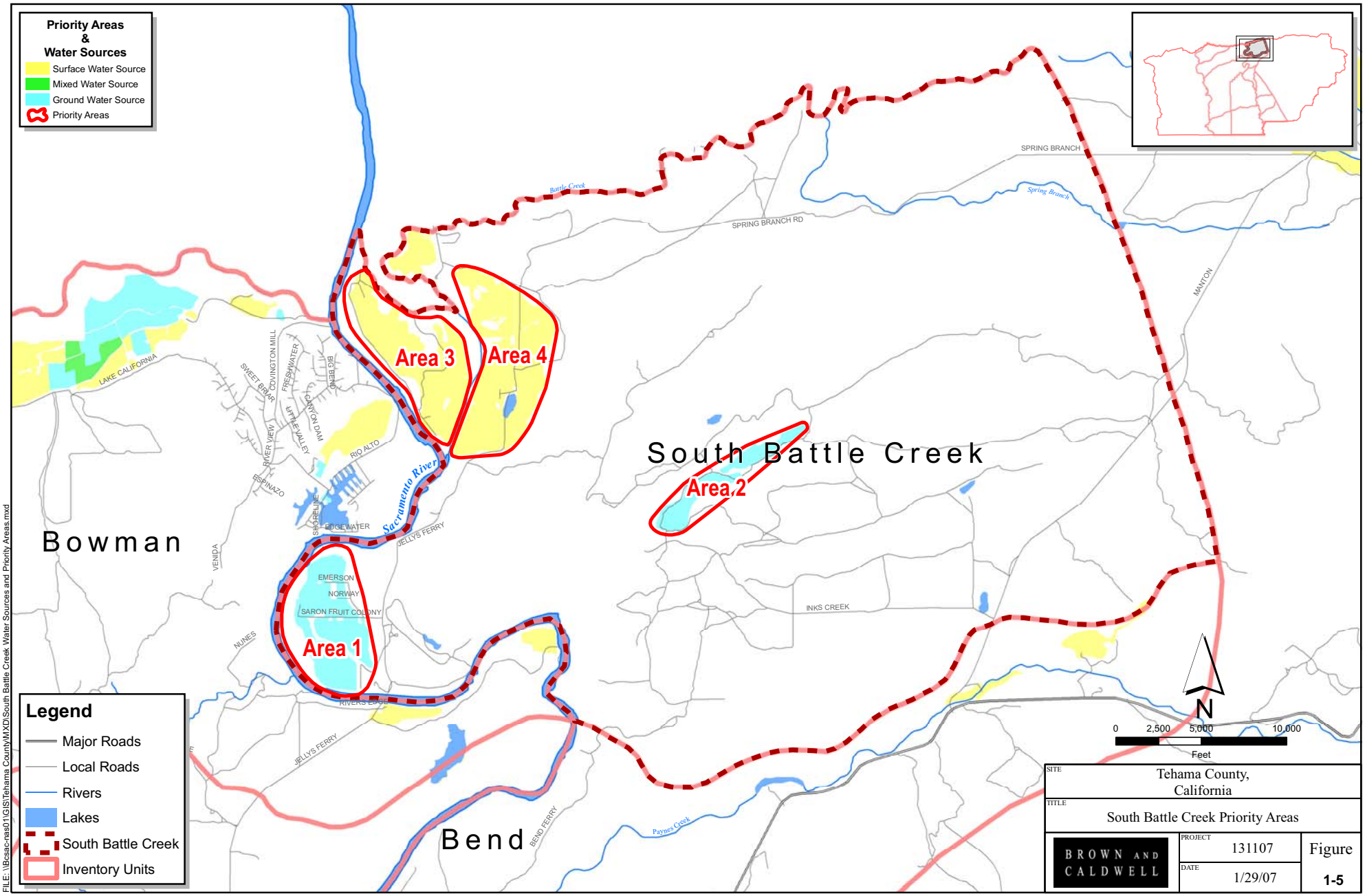
Priority Areas
&
Water Sources
Surface Water Source
Mixed Water Source
Ground Water Source
Priority Areas
Area 1
Area 2
Area 3
Area 4
South Battle Creek
Bowman
Bend
Sacramento River
Battle Creek
Spring Branch
Paynes Creek
SPRING BRANCH
SPRING BRANCH RD
MANTON
INKS CREEK
JELLYS FERRY
BEND FERRY
LAKE CALIFORNIA
SWEET BRIAR
COVINGTON MILL
FRESHWATER
BIG BEND
CANYON DAM
LITTLE VALLEY
RIVER VIEW
ESPINAZO
RIO ALTO
SHORELINE
EDGEWATER
VENIDA
EMERSON
NORWAY
SARON FRUIT COLONY
NUNES
RIVERS EDGE
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5,000
10,000
Feet
Legend
Major Roads
Local Roads
Rivers
Lakes
South Battle Creek
Inventory Units
SITE
Tehama County,
California
TITLE
South Battle Creek Priority Areas
BROWN AND CALDWELL
PROJECT
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DATE
1/29/07
Figure
1-5
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- The fourth suggested area (Area 4) is in the northwestern portion of the sub-basin, and is a priority area of pasture that is irrigated with surface water from. Future land use trends include the possibility of this area being irrigated with groundwater. Area 4 lies toward the center of the valley, and is not near other monitoring wells.

3. Next Steps

Steps 1 and 2: With the proposed priority areas selected, the next step will be confirmation of priority areas with stakeholders. Once stakeholders have provided local information and input to priority area selection, the availability of existing wells for monitoring and the need for new monitoring wells can be assessed. As monitoring locations are selected and developed, the monitoring program for the South Battle Creek sub-basin can be implemented.

Steps 3, 4 and 5: Once the monitoring program is in place, steps 3 through 5 of the trigger level development process can be completed as described in the methodology section. Example trigger levels from the Bowman sub-basin are provided below.

Figures 1-6 through 1-8 present hydrographs and suggested trigger levels for an example key well located in the Bowman sub-basin. The figures are groundwater level hydrographs, demonstrating water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. The methodologies used to determine the suggested trigger levels for the example key well is provided in Table 1-1.

Table 1-1. Example Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Bowman Monitoring Well Number			
	28D01M	35B01M	15E02M	04P01M
Spring Trigger Level 1 – Notify and Inform Public	Historical low of spring measurements plus 20 % of the range of spring measurements			Historical low of spring measurements
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Trigger Level 1			
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements			Historical low of spring measurements minus the range of spring measurements
Late Season Trigger Level – Notify public and begin investigations	Historical low of late season groundwater measurements			
Data Anomalies	None	None	None	None

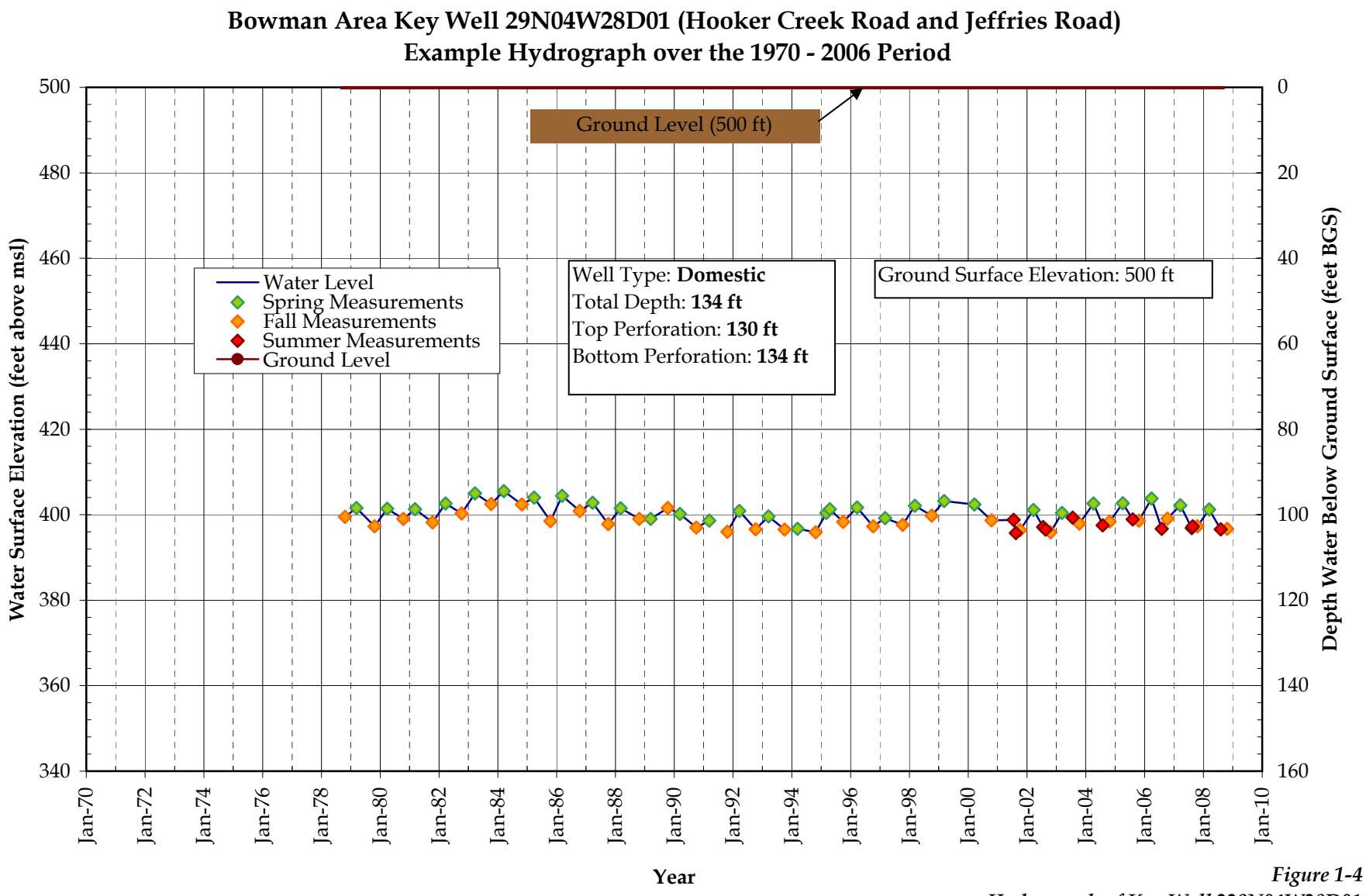


Figure 1-4
Hydrograph of Key Well 229N04W28D01

Updated 12-01-08

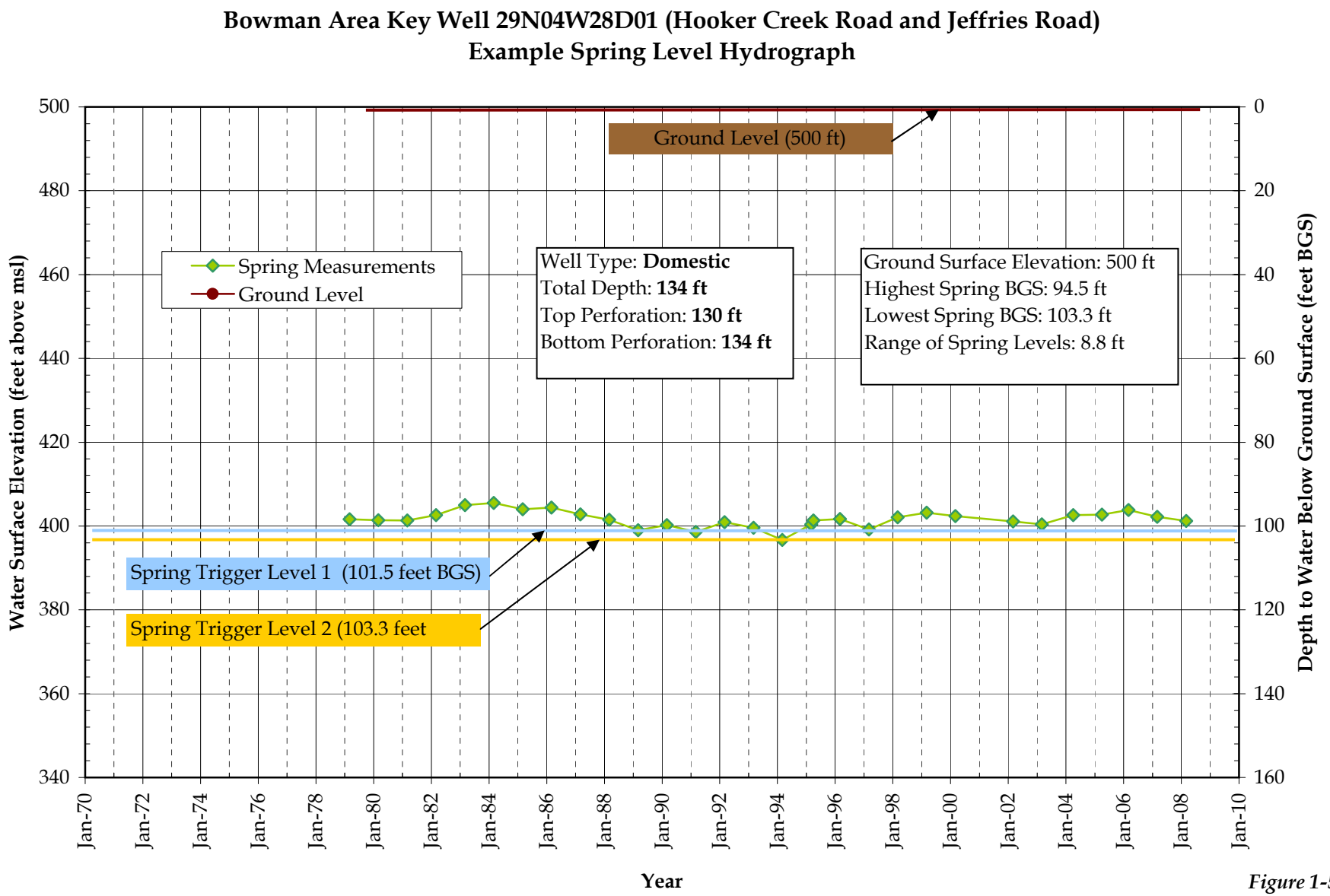


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

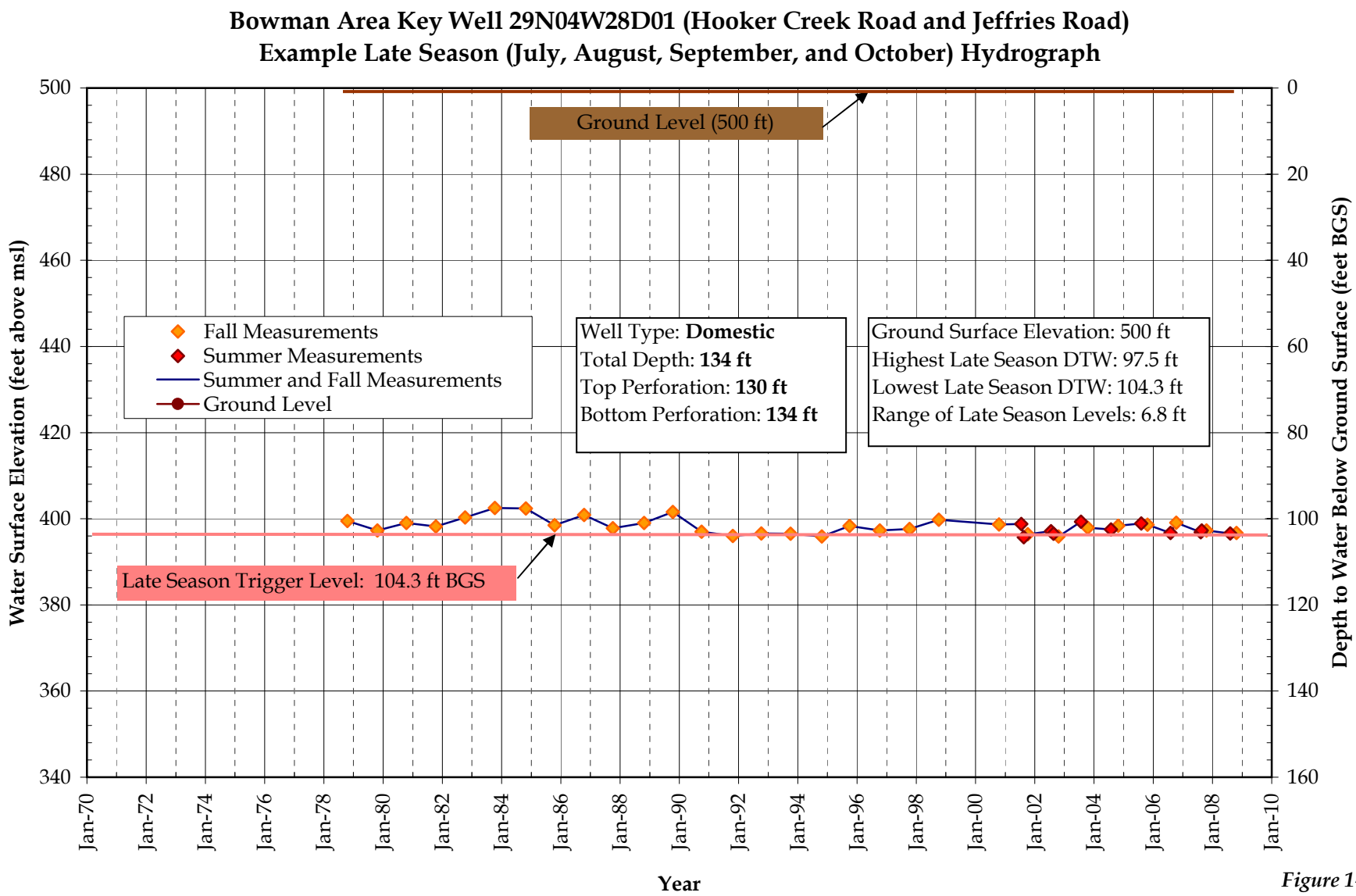


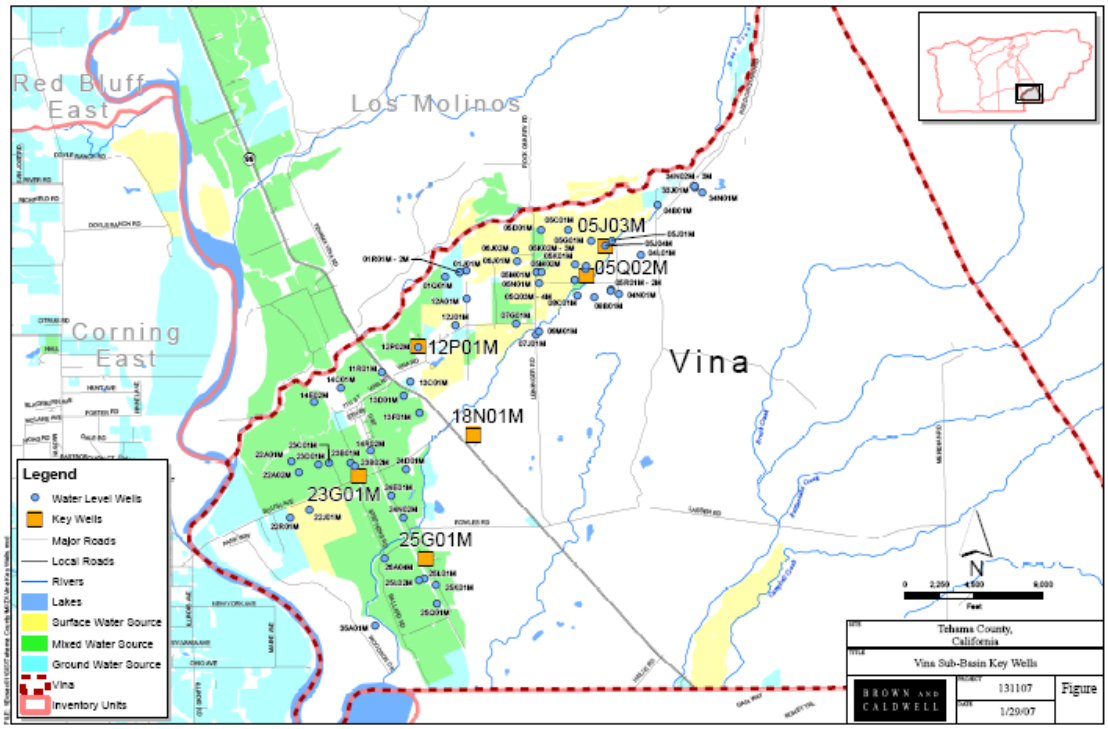
Figure 1-6
Late Season Trigger Level

Updated 12-01-08

Tehama County AB-3030 Groundwater Management Plan

Technical Memorandum

For the Vina Sub-basin of Tehama County



Draft for Public Review and Comment

Proposed Groundwater Trigger Levels and Awareness Actions

July 1, 2008

Tehama County Flood Control and Water Conservation District
9380 San Benito Avenue
Gerber, CA 96035-9701

(530)-385-1462

BROWN AND CALDWELL

10540 White Rock Road, Suite 180
Rancho Cordova, CA 95670

Technical Memorandum

DRAFT

Prepared for: Tehama County Flood Control and Water Conservation District

Project Title: BMO Trigger Level Development

Project No: 131107

Technical Memorandum

Subject: Proposed Groundwater Trigger Levels and Awareness Actions for the Vina Sub-basin

Date: July 1, 2008

To: Mr. Ernie Ohlin, Water Resources Manager

From: John Ayres, PG

Prepared by: John Ayres, PG

Reviewed by: Robert Vince, PG, CHG

1. INTRODUCTION

The Tehama County Flood Control and Water Conservation District (District) cooperated with private landowners, County groups, and local agencies overlying the groundwater basin to develop a Groundwater Management Plan (Plan) focusing on groundwater resources protection and management. The Plan took three years to develop with citizen input, review, approval, and achieving final adoption by the Tehama County FCWCD in 1998.

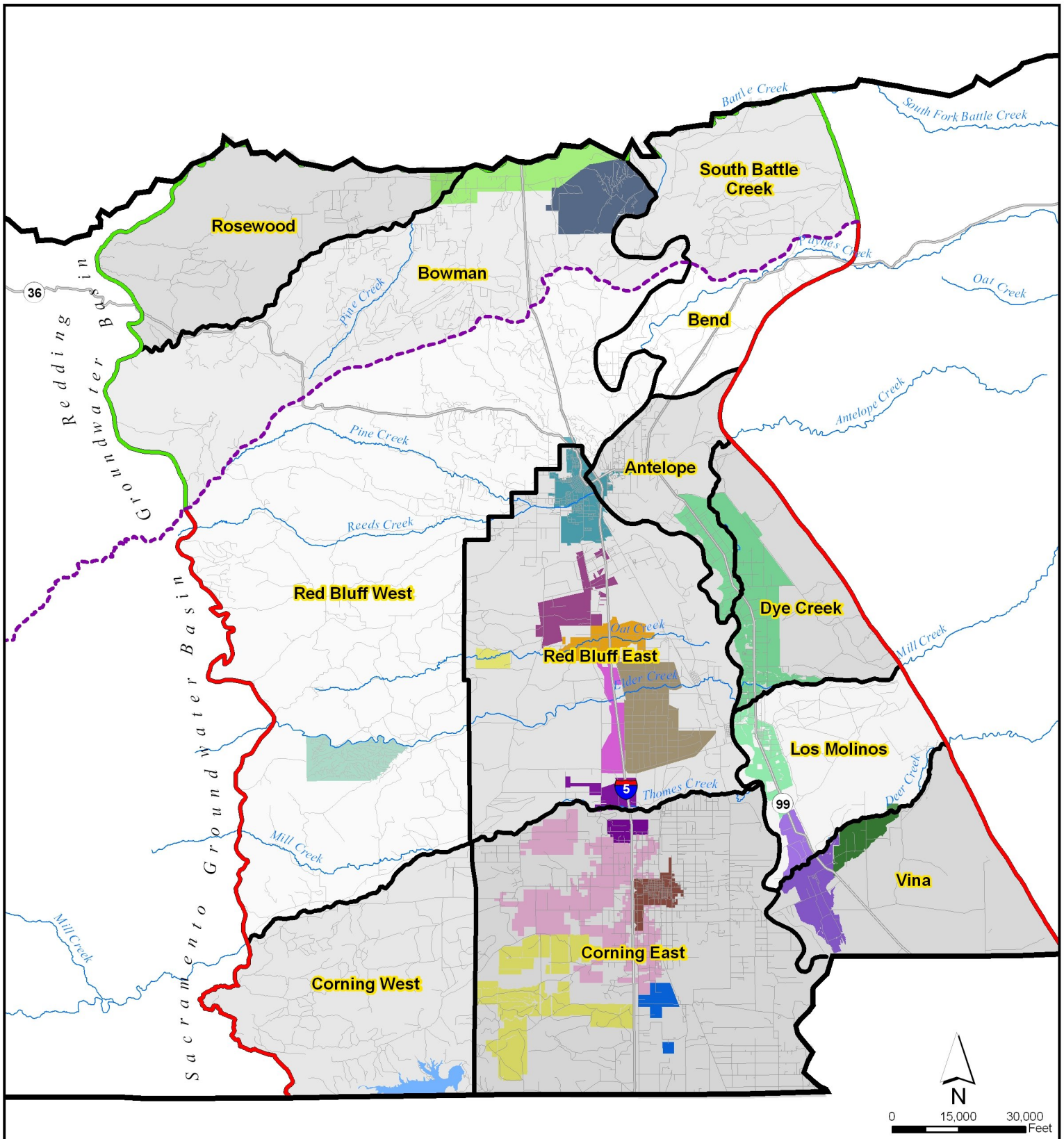
This Plan has provided guidance related to groundwater activities since adoption. Landowners and water purveyors alike recognize the need to move forward with groundwater resource protection by developing measures (trigger levels) that determine the level of active management needed within each sub-basin. Trigger levels can be established for groundwater levels, groundwater quality, or inelastic land subsidence due to groundwater extraction. This Technical Memorandum (TM) focuses on groundwater level trigger level development for the Vina sub-basin.

Groundwater trigger levels represent declines in groundwater levels that, when reached or exceeded, may cause some type of action such as public outreach, increased monitoring, or consideration of modifying the groundwater trigger level. The Plan defines trigger levels as increasing stages of groundwater decline that correspond with various levels of increased groundwater discussion, investigation or local management actions. This TM identifies trigger levels that correspond to two decreasing levels of groundwater in the spring, and one trigger level that corresponds with decreasing levels of groundwater in the summer and fall.

The Plan states that one of the District's functions under the Plan is to provide guidance in the development of trigger levels. Sections 325 through 329 of the Plan describe the trigger level concept and the District's role in Trigger level development. The District, working with a Technical Advisory Committee (TAC) composed of local representatives, identified twelve groundwater sub-basins where trigger levels may be established (Figure 1-1).

This TM presents the process for developing groundwater elevation trigger levels and provides specific suggestions for the Vina sub-basin. Additional information on the trigger level development process and regional hydrogeology is available in the *Trigger Level Background Technical Memorandum,* available on the District's website at: http://www.tehamacountywater.ca.gov/ .

The District understands that final trigger levels should reflect stakeholders' in-depth knowledge and management objectives for their sub-basin. Representatives from each sub-basin will review and provide input on the proposed trigger levels and suggested management actions contained herein for use in their sub-basin. The District is open to revisions that reflect stakeholder knowledge of groundwater conditions in their sub-basin. Ultimately, it is the District's desire to have management objectives that are understood and supported by groundwater users in the respective sub-basin.



Irrigation Districts

- Aaction
- Anderson-Cottonwood
- City of Corning
- City of Red Bluff
- Corning WD
- Deer Creek
- El Camino ID
- Elder Creek ID
- Kirkwood ID
- LMMWC
- Proberta ID
- Rancho Tehama
- Rawson ID
- Rio Alto WD
- Stanford Vina
- Thomes Creek ID

Legend

- Red Bluff Arch
- Redding Groundwater Basin
- Sacramento Valley Groundwater Basin

BROWN AND CALDWELL

PROJECT	SITE	Figure
131107	Tehama County	1-1
DATE 1/18/07	TITLE Groundwater Sub-Basins	

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1.1 Groundwater Level Trigger Level Development Methodology

Groundwater trigger levels are derived through interpretation of historic groundwater levels. A series of awareness actions are proposed for each trigger level stage. Development of groundwater level triggers is a five-step process as illustrated below:

Step 1: Describe the trigger level's purpose.

Step 2: Select one or more key wells within the sub-basin.

Step 3: Designate the time of seasonal measurement.

Step 4: Establish trigger levels in the selected key wells.

Step 5: Define awareness actions associated with each trigger level.

Step 1: Describe the trigger level's purpose

The Vina sub-basin is primarily a rural area, with agriculture in northern and western portions of the area. Groundwater is used for agricultural and domestic purposes. Additional water use information is available in the Tehama County Water Inventory and Analysis, available in PDF format at: http://www.tehamacountywater.ca.gov/grndwtr_inv_ana.htm. The trigger level's purpose in this sub-basin should reflect the needs of local water users. Some suggested trigger level purposes are:

Groundwater Use in Vina:	
Irrigation:	98% (8,400 acre-ft)
Municipal, and Industrial:	2% (200 acre-ft)
Number of wells by type in Vina:	
Irrigation:	66 wells
Domestic:	115 wells
Municipal and Industrial:	4 wells

- Maintain groundwater at an elevation that promotes the continued economical use of groundwater for irrigation, domestic, and municipal needs.
- Protect groundwater supplies for current and future domestic and irrigation use.
- Maintain a stable trend of groundwater in storage to ensure adequate drinking water and agricultural supplies during future drought periods.
- Monitor groundwater levels to record and compare changes to aid in identifying conditions that cause declines in groundwater levels.

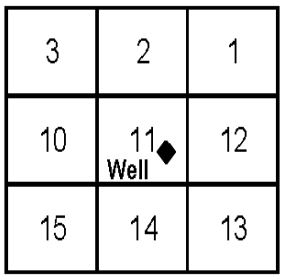
Step 2: Select one or more key wells within the sub-basin

Key wells are monitoring wells that are representative of groundwater conditions within a particular aquifer interval, or range of aquifer intervals underlying the sub-basin. Groundwater levels in key wells provide information necessary to begin management activities.

Key wells should be selected from the County groundwater level monitoring well network with consideration of duration of monitoring. The monitoring period of record in some wells is more than 30 years; the long period of record helps identify seasonal and long-term aquifer response over a wide range of climatic conditions (wet, normal or drought), changes in agricultural and domestic development, and changes in available water supply. Some monitoring wells may have short periods of record, but are located in a key area and have preferable depth and screened intervals. These wells may be useful as key wells also.

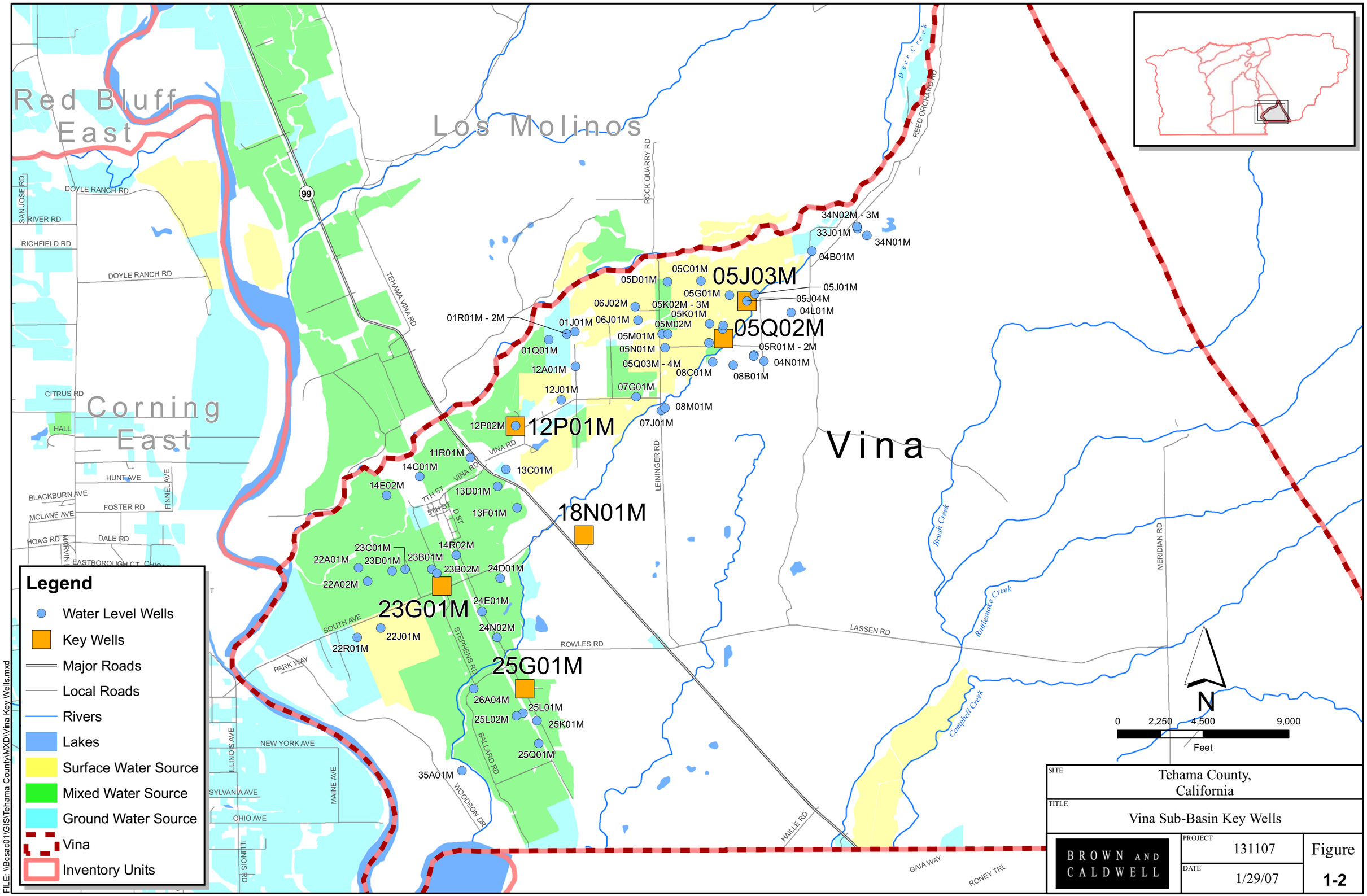
Key wells should be selected from the County groundwater level monitoring well network with consideration of location, total well depth, perforated interval from which the well produces water, and other well drilling records. Key wells should be distributed as evenly as possible throughout the sub-basin. Monitoring wells with screened intervals or depths near 100 to 250 feet below ground surface correspond to the average depth of domestic wells in the sub-basin and are good candidates for monitoring aquifer conditions associated with domestic use.

The locations of five proposed key wells are presented in Figure 1-2. A query was conducted to find nearby wells, their uses, and average depths. The query located wells in the section the well was in, and the eight sections surrounding that section (Example 1). Each section is one square mile in size. Each well is described in detail below:



Example 1
Query of Township and Range Sections

- **24N01W05J03M (05J03M) –** This monitoring well is in the northeast portion of the sub-basin and is 1005 feet deep and has a screened interval from 295 to 305 feet below ground surface. This well is situated near grain crops, pasture, and orchards irrigated with surface water. This well has a period of record of more than 8 years. The nine square miles near this well contain 26 domestic wells with an average depth of 149 feet bgs, and 11 irrigation wells with an average depth of 460 feet bgs.
- **24N01W05Q02M (05Q02M) –** This monitoring well is in the northeast portion of the sub-basin and is 150 feet deep with a screened interval from 60 to 150 feet below ground surface. This well is situated near pasture and orchards irrigated with surface water. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 26 domestic wells with an average depth of 149 feet bgs, and 11 irrigation wells with an average depth of 460 feet bgs.
- **24N01W18N01M (18N01M) –** This monitoring well is in the west central portion of the sub-basin and is 102 feet deep with a screened interval from 64 to 102 feet below ground surface. This well is situated away from irrigated areas. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 44 domestic wells with an average depth of 146 feet bgs, and 9 irrigation wells with an average depth of 373 feet bgs.
- **24N02W12P01M (12P01M)–** This monitoring well is in the north central portion of the sub-basin and is 370 feet deep with a screened interval from 164 to 359 feet below ground surface. This well is situated near pasture irrigated with groundwater and surface water. This well has a period of record of more than 8 years. The nine square miles near this well contain 64 domestic wells with an average depth of 115 feet bgs, and 10 irrigation wells with an average depth of 367 feet bgs.
- **24N02W23G01M (23G01M)–** This monitoring well is in the south western portion of the sub-basin and is 362 feet deep with a screened interval from 83 to 362 feet below ground surface.. This well is situated near orchards irrigated with both groundwater and surface water. This well



SITE: Tehama County, California

TITLE: Vina Sub-Basin Key Wells

BROWN AND CALDWELL

PROJECT: 131107

DATE: 1/29/07

Figure 1-2

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has a period of record of more than 8 years. The nine square miles near this well contain 65 domestic wells with an average depth of 100 feet bgs, and 34 irrigation wells with an average depth of 360 feet bgs.

- **24N02W25G01M (25G01M)–** This monitoring well is in the western portion of the sub-basin and is 256 feet deep with a screened interval from 108 to 256 feet below ground surface.. This well is situated near orchards irrigated with both groundwater and surface water. This well has a period of record is more than 30 years, which provides information on water levels during the drought of 1976-1977 and the drought during the late 1980s and early 1990s. The nine square miles near this well contain 29 domestic wells with an average depth of 118 feet bgs, and 39 irrigation wells with an average depth of 385 feet bgs.

There are currently no monitoring wells in the south and southeastern portions of the Vina sub-basin reflecting that no wells are monitored in that area. This may represent an area within the sub-basin where an additional monitoring well may eventually need to be established to begin to develop a groundwater level history in the southwestern area.

Step 3: Designate the time of seasonal measurement

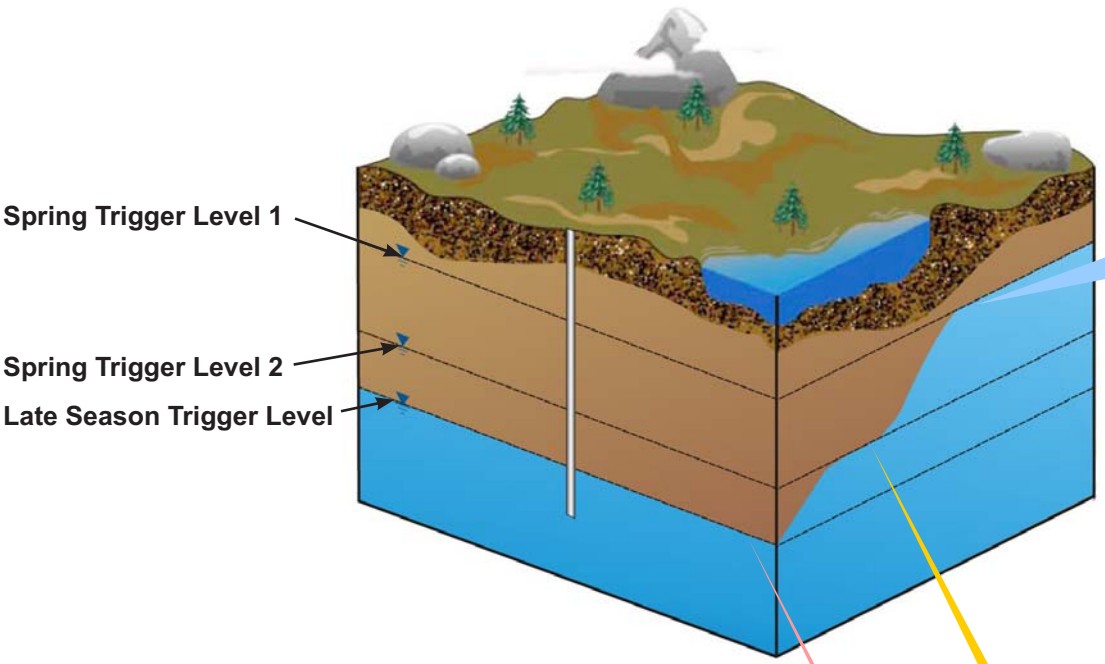
Groundwater levels fluctuate seasonally, and measurements from the different seasons provide different snapshots of groundwater conditions. Spring measurements provide information on whether the basin has recharged during the wet season to elevations observed in previous years. Typically, spring water levels are the highest water levels observed during the year. Summer and fall water level elevation measurements provide information about decreased water levels during groundwater pumping and illustrate the cumulative pumping impacts from a sub-basin within a season.

The District suggests that spring measurements be used to set trigger levels with associated awareness actions, and late season measurements (summer and fall) be used to set an additional trigger level with associated awareness actions that is sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Steps 4 and 5: Establish trigger levels in selected key wells and define awareness actions associated with each trigger level

Trigger levels act as an early warning system for identifying potential problems. A trigger level corresponds to a predetermined target groundwater level during a season of measurement. For example, if a trigger level is set at a water surface elevation of 50 feet below ground surface (bgs) in the spring, then only spring measurements should be compared to the trigger level. A spring measurement of 40 feet bgs would not require an awareness action in this case. A spring measurement of 60 feet bgs, on the other hand, would be below the trigger level, and should prompt awareness actions (Figure 1-3).

Sub-basin representatives review and provide input on the proposed trigger levels within their sub-basin and the awareness actions associated with each level. Potential trigger levels, and the accompanying awareness actions, may range from a small decrease in groundwater levels compared to historical levels, indicating a need to disseminate information or further investigation of



AWARENESS ACTIONS

Spring Trigger Level 1 Awareness Actions

ONE YEAR BELOW TRIGGER LEVEL 1

- TAC meetings to address issues in the area
- Water user/stakeholder meeting for the subbasin
- Send mail to known water users in subbasin, notifying them about a overall decrease in water levels or quality in the subbasin
- Notify public of groundwater issue
  - County to make a press release
  - Updates to the District website
  - District to attend agriculturally related and city meetings
  - Site visits
- Review recent precipitation trends to look for drought trends

CONSECUTIVE YEARS BELOW TRIGGER LEVEL 1

- Continue to inform water users and general public
- Verify data
- Increase monitoring frequency in subbasin
- Add new monitoring location in subbasin
- Begin monitoring land subsidence
- Install data loggers
- Investigate cause of low groundwater levels

AWARENESS ACTIONS

Spring Trigger Level 2 Awareness Actions

- Continue Spring Trigger Level 1 Awareness Actions
- Solicit voluntary public involvement in resolving issues in the area
- Consider groundwater recharge efforts
- Review condition of approval for new development reliant on groundwater by the County
- Review of the County's approval process regarding water supply for development or additional groundwater pumping projects
- Increase land subsidence monitoring

AWARENESS ACTIONS

Late Summer Trigger Level Awareness Actions

- Perform Spring Trigger Level 1 and 2 Awareness Actions
- Investigate potential higher groundwater demand or other causes

Figure 1-3
Trigger Levels and Awareness Actions

groundwater levels to a larger change in groundwater levels, indicating a need to take action to stop or reduce the lowering of groundwater levels.

For each trigger level, sub-basin representatives should work with local groundwater users and the District to implement the awareness actions associated with the trigger level. Management actions may include providing information on trigger level exceedance to the public, investigating the trigger level exceedance, and taking action to remedy the issue.

Suggested trigger levels and corresponding awareness actions were selected by the TAC and the District to provide the appropriate level of management in response to exceedance of trigger levels. The trigger levels and corresponding awareness actions should coincide with the severity of groundwater issues in the sub-basin. Figure 1-3 shows three suggested spring trigger levels and one suggested late season trigger level with corresponding actions. The methodology for the suggested trigger levels is provided in Table 1-1. A summary of associated awareness actions include:

Spring Trigger Level 1: The first trigger level would cause the dissemination of information to the public about the potential groundwater issue. Additional awareness actions are triggered by a second consecutive year of groundwater levels at or below Spring Groundwater Trigger Level 1.

Spring Trigger Level 2: The second and deeper spring groundwater trigger level would lead to increased monitoring activities and continued public information on the groundwater condition plus investigations and the development of actions to remedy the groundwater issue.

Late Season Trigger Level: The late season trigger level would cause the dissemination of information to the public and the beginning of investigations to understand the cause. Late season measurements are sensitive to groundwater levels during the seasons of heavy groundwater use and can provide a warning of potential issues such as increased groundwater demand.

Figures 1-4 through 1-21 present hydrographs and suggested trigger levels for each of the five Vina key wells. The figures are groundwater level hydrographs, showing water level elevation measurements over the monitoring period of record and the suggested trigger levels during a particular season. On each figure, the date of measurement is indicated on the bottom axis, the depth to water in feet is on the right vertical axis, and the water surface elevation is indicated on the left vertical axis. The methodologies used to determine the suggested trigger levels for the key wells in the Vina sub-basin are provided in Table 1-1. Some trigger levels were set using exceptions from the methodologies to account for measurements that are outside the range of normal spring and summer measurements. Three key wells (05J03M, 12P01M, and 25G01M) had limited historic records of groundwater level measurements that did not include a significant drought cycle, so the method of proposing spring and late season trigger levels was modified and is subject to change in annual reviews as more experience is gained.

Table 1-1. Trigger Level Methodology

Groundwater Trigger Level and Awareness Action	Vina Monitoring Well Number					
	05Q02M	18N01M	23G01M	05J03M	12P01M	25G01M
Spring Trigger Level - 1 Notify and Inform Public	20% of the range of spring measurements above the historical low			Historical low of spring measurements		
Monitor and investigate Cause	Second consecutive year of groundwater levels at or below Spring Stage 1					
Spring Trigger Level 2 – Consider Management Options	Historical low of spring measurements			Historical low of spring measurements minus the range of spring measurements		
Late Season Trigger Level – Notify public and begin investigations	Historical low of summer and fall measurements					
Data Anomalies	None	None	None	None	None	None

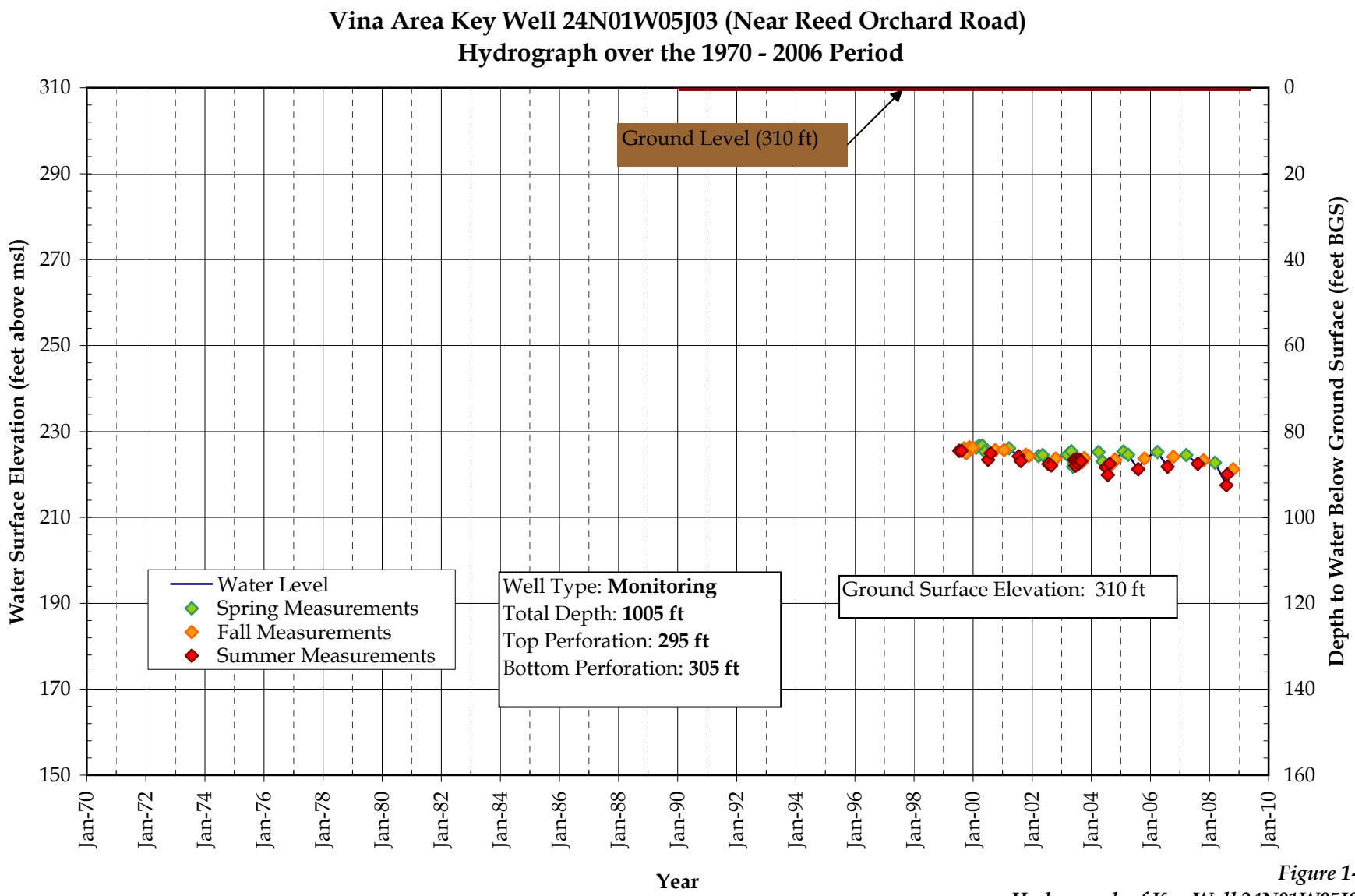


Figure 1-4
Hydrograph of Key Well 24N01W05J03

Updated 12-01-08

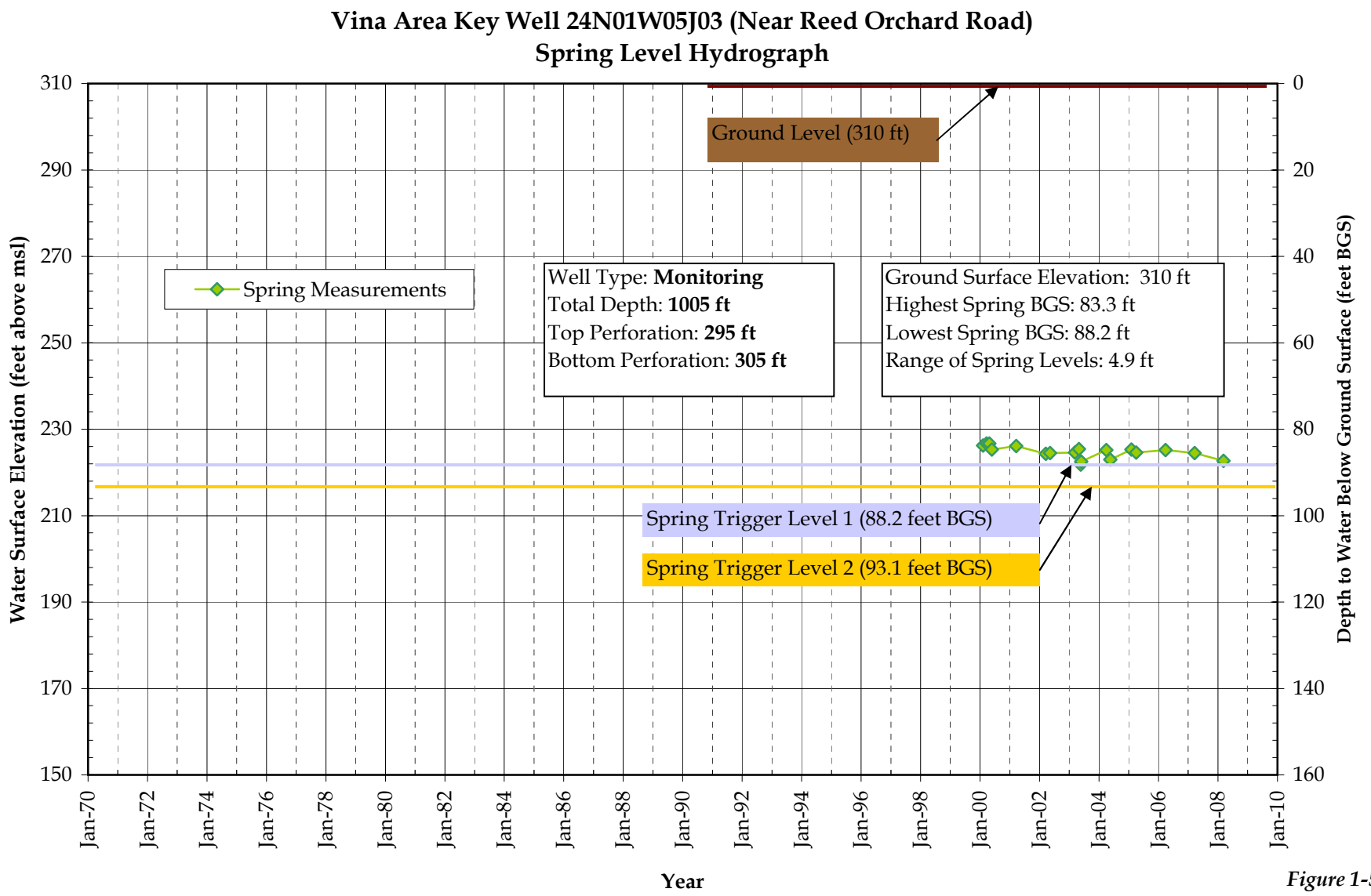


Figure 1-5
Spring Trigger Levels

Updated 12-01-08

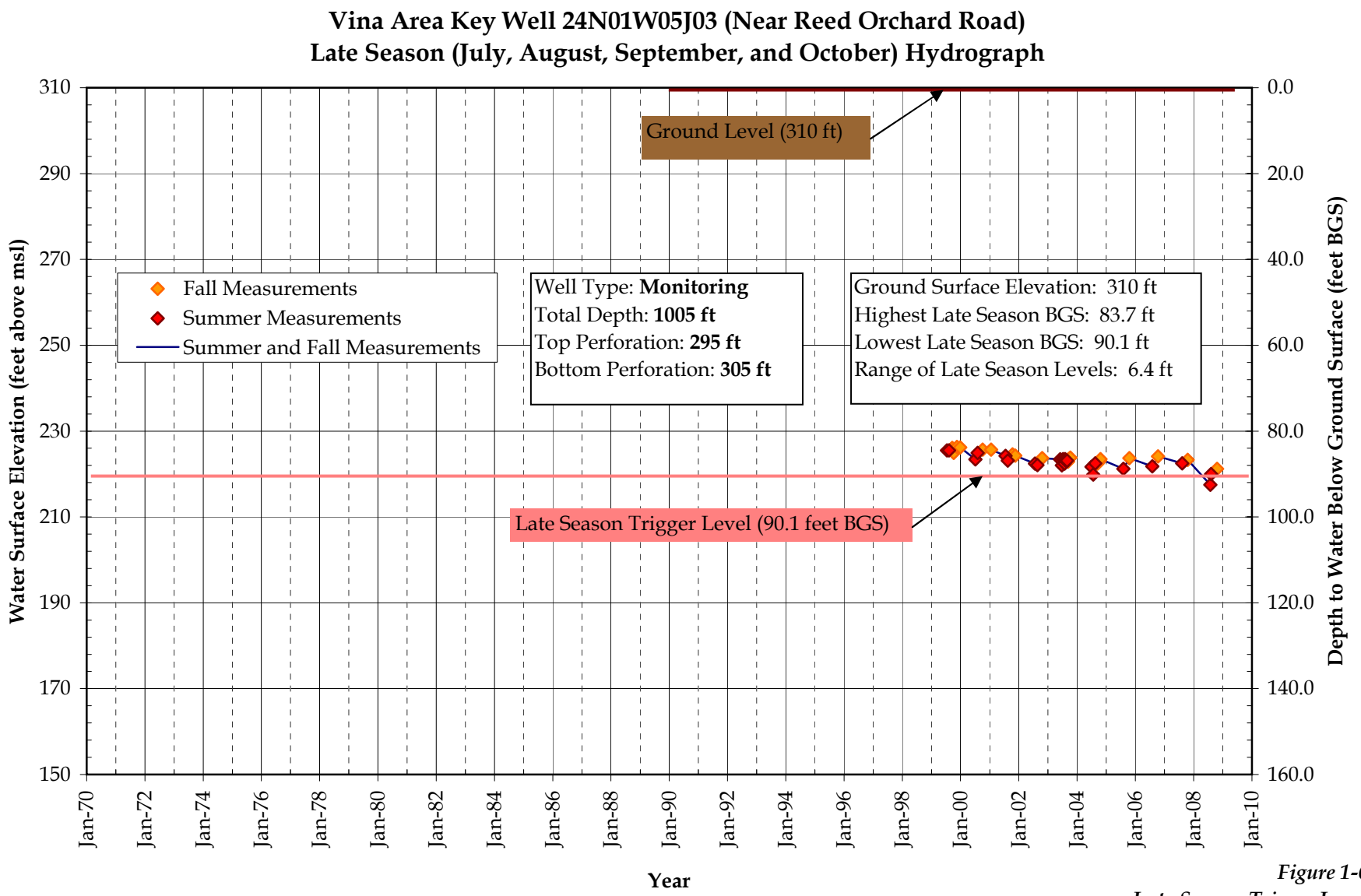


Figure 1-6
Late Season Trigger Level

Updated 12-01-08

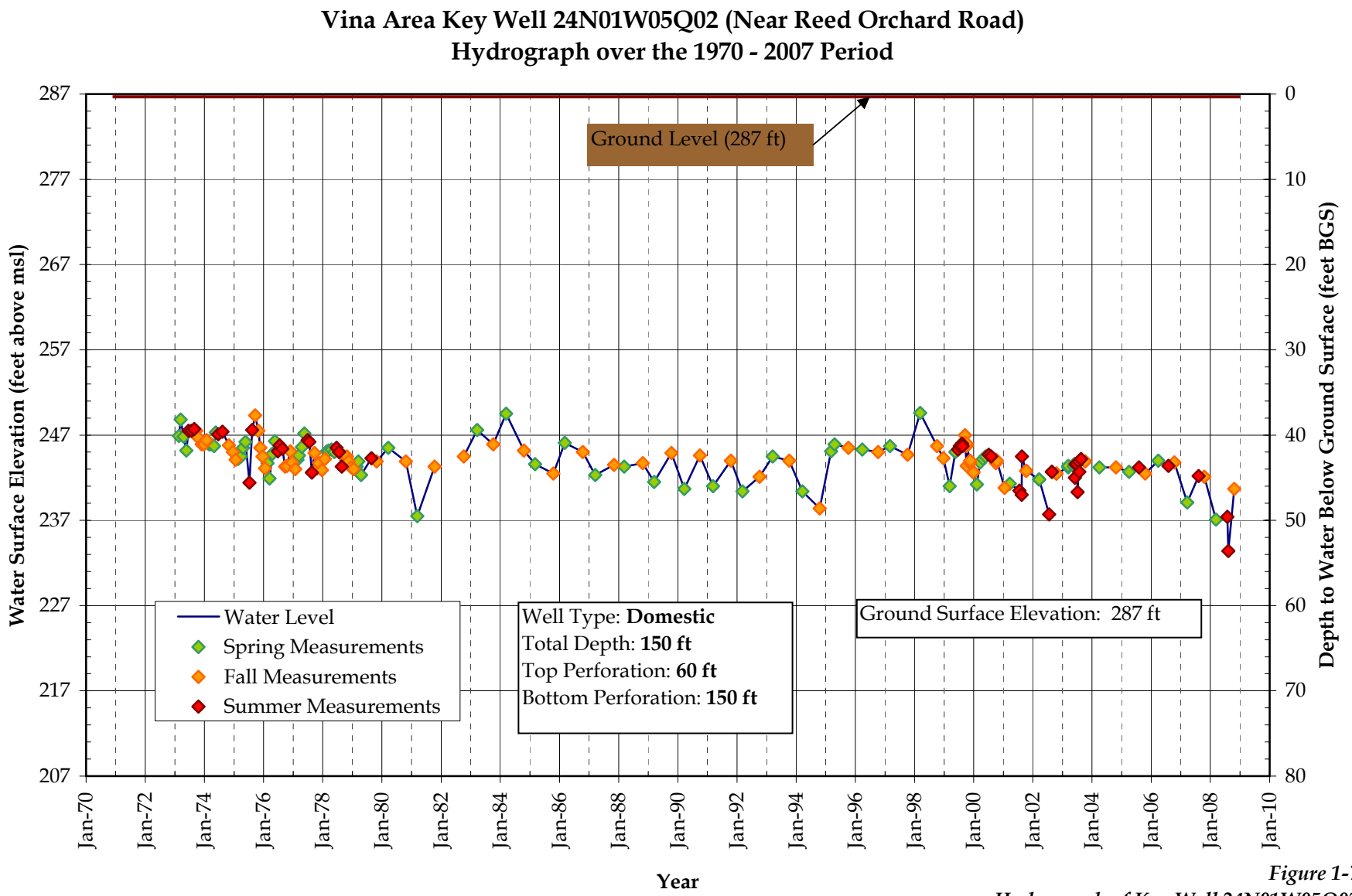


Figure 1-7
Hydrograph of Key Well 24N01W05Q02

Updated 12-01-08

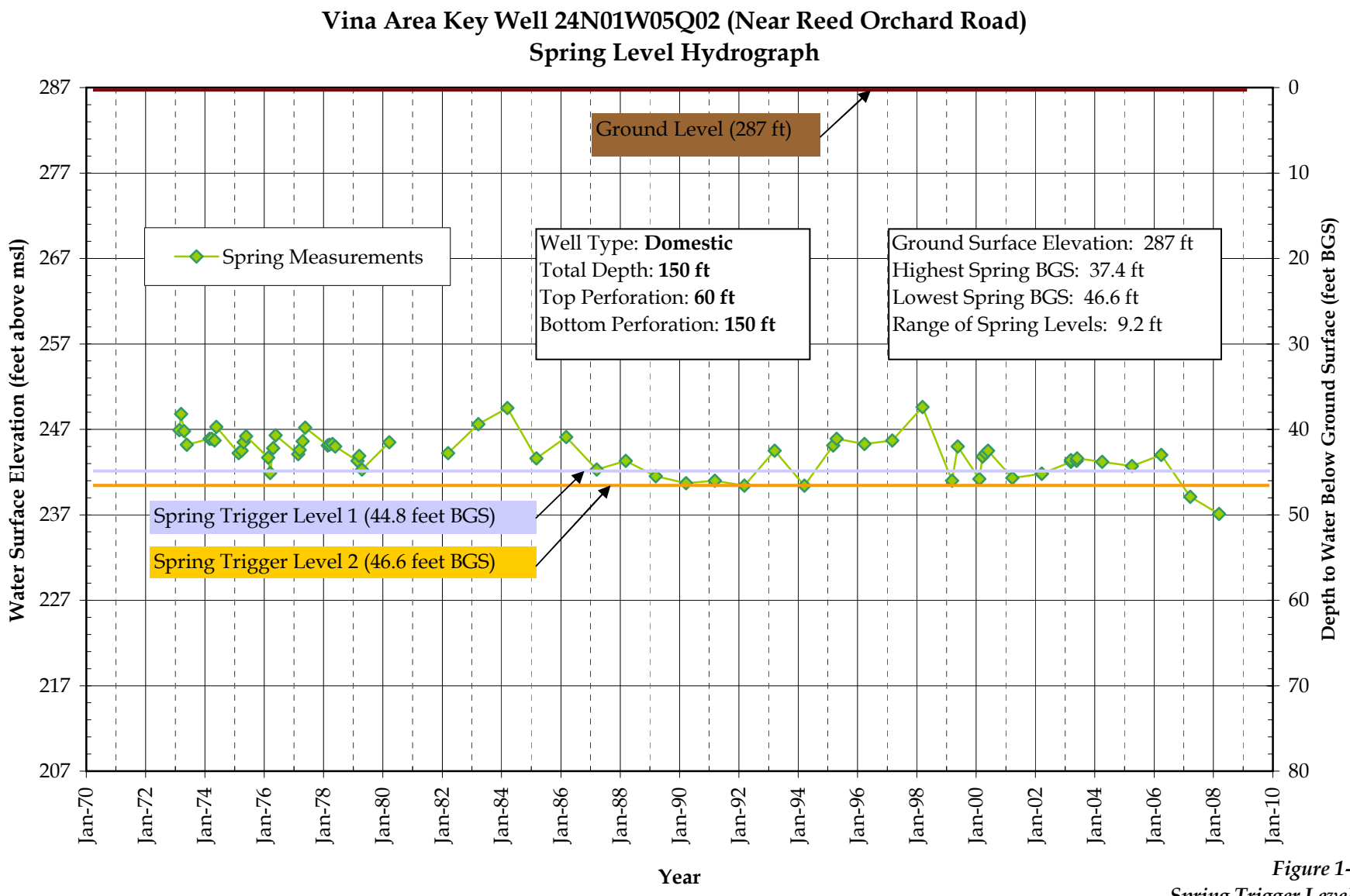


Figure 1-8
Spring Trigger Levels

Updated 12-01-08

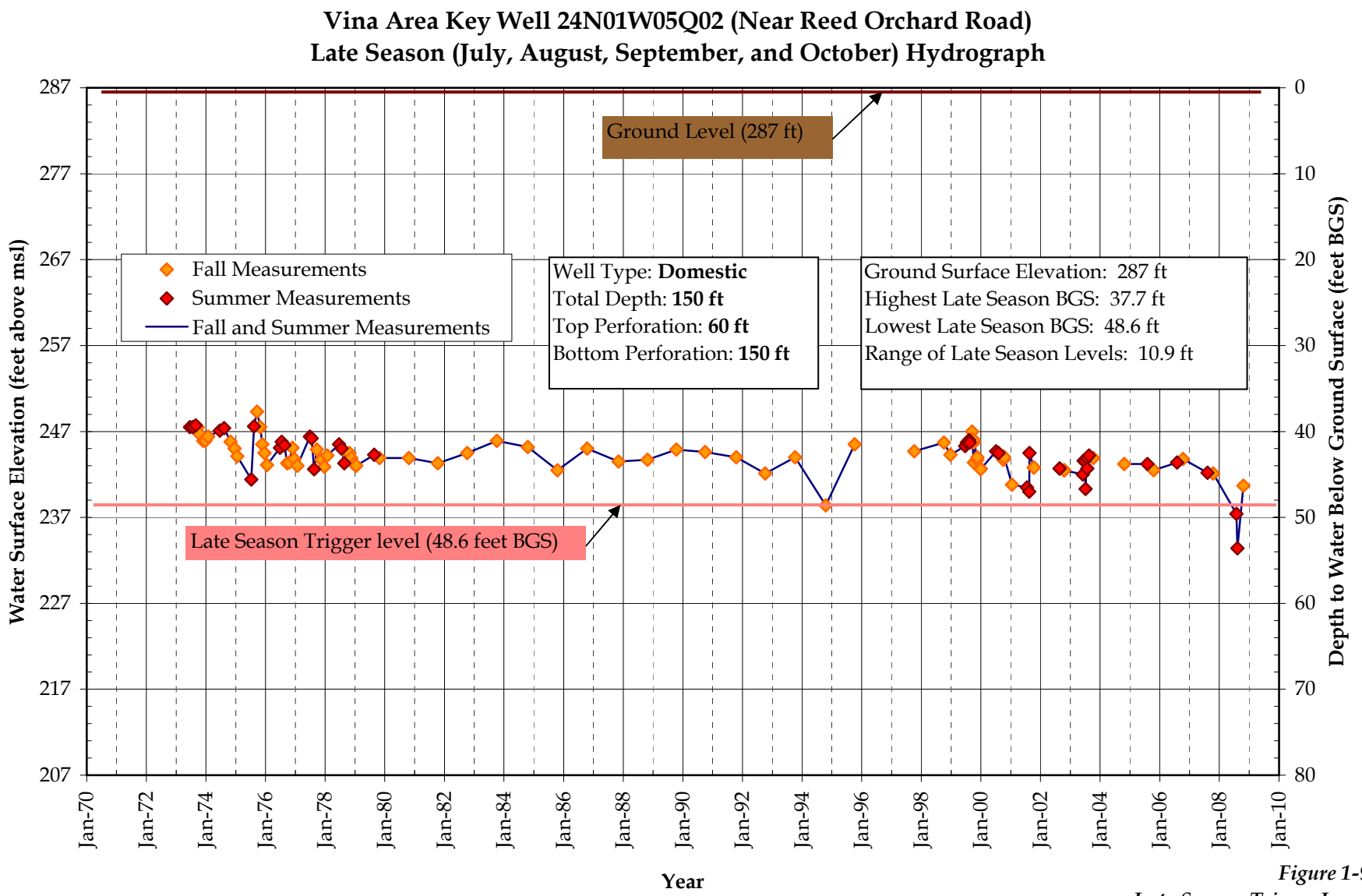


Figure 1-9
Late Season Trigger Level

Updated 12-01-08

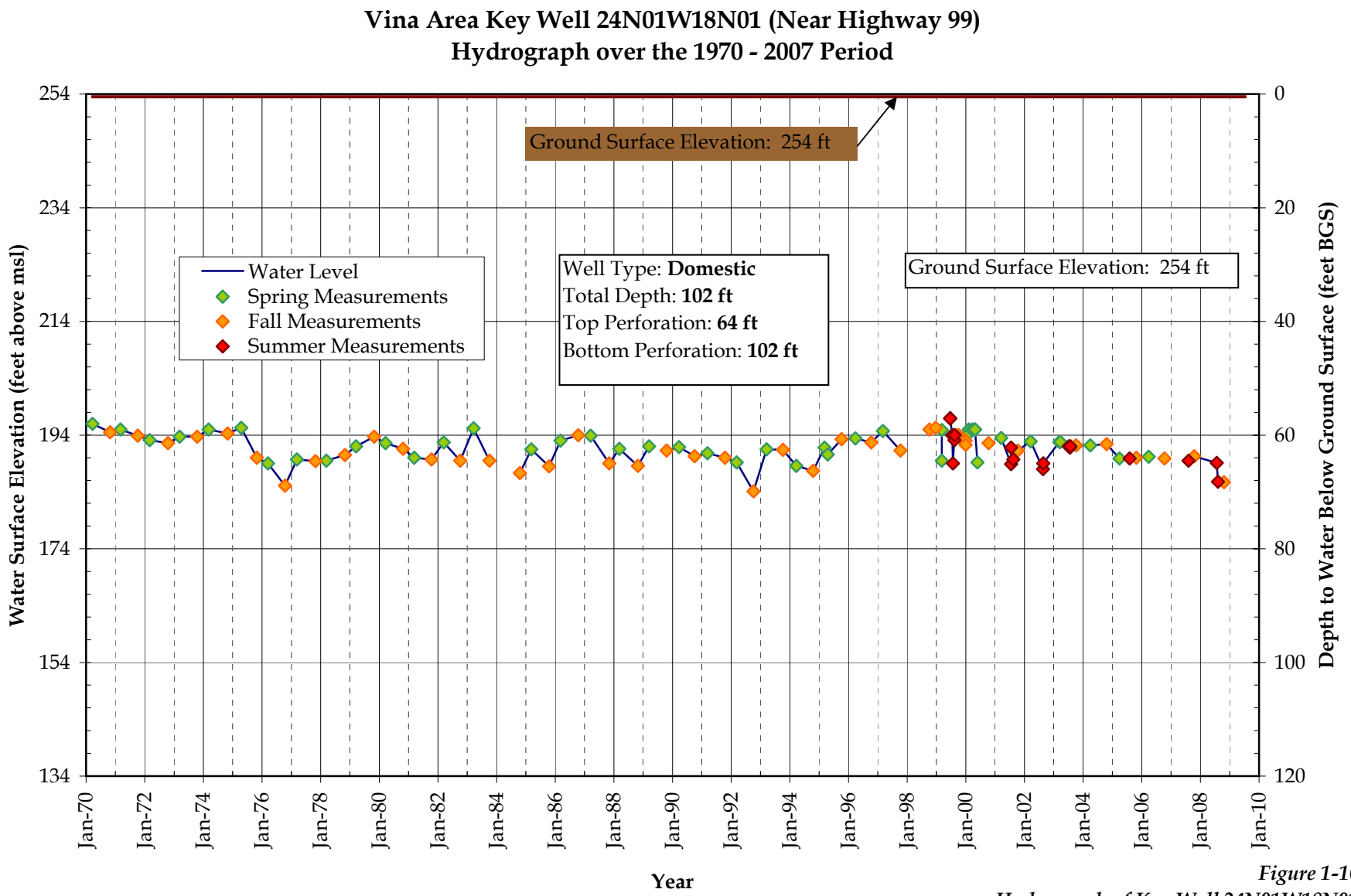


Figure 1-10
Hydrograph of Key Well 24N01W18N01

Updated 12-01-08

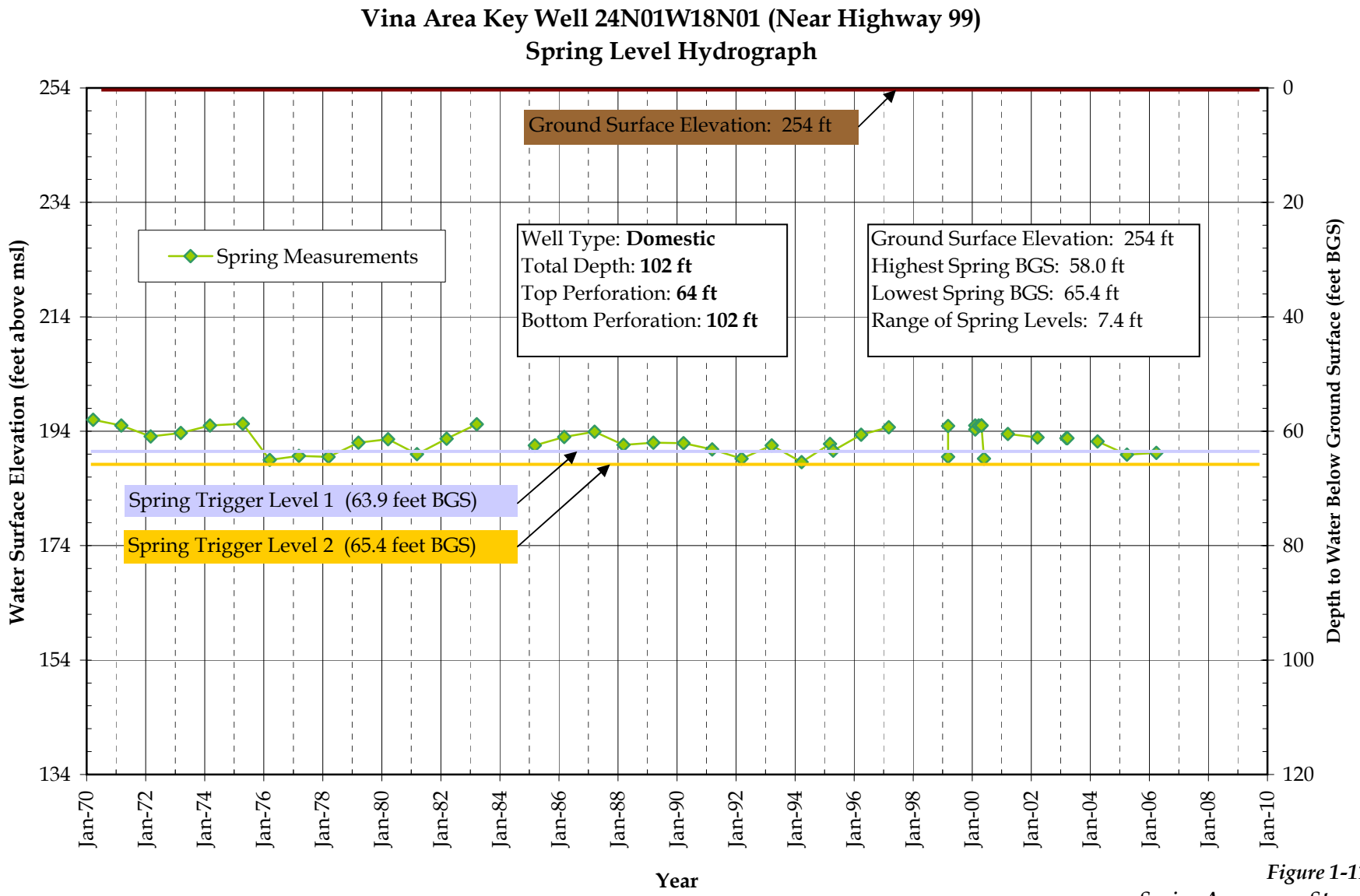


Figure 1-11
Spring Awareness Stages

Updated 12-01-08

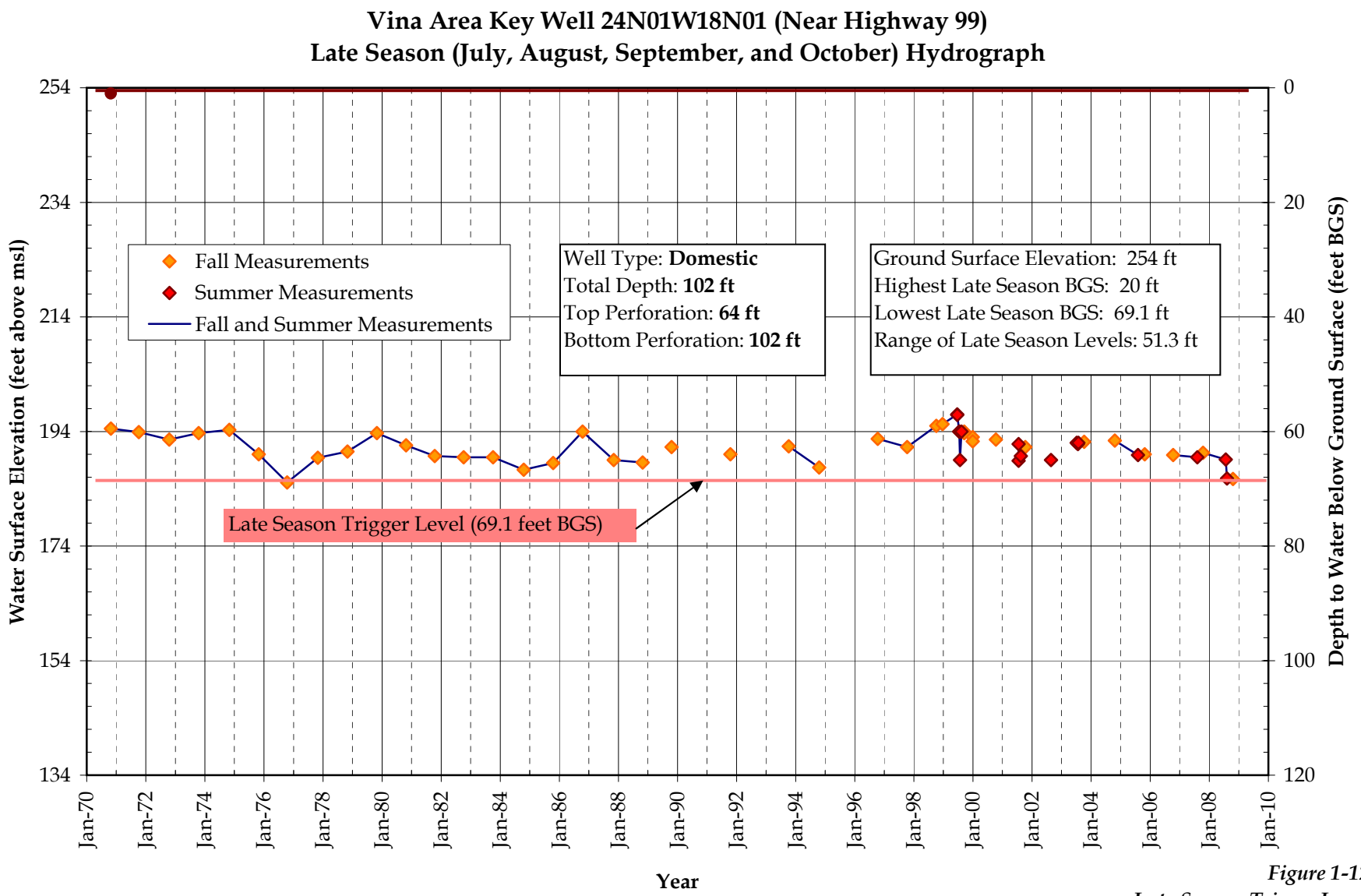


Figure 1-12
Late Season Trigger Level

Updated 12-01-08

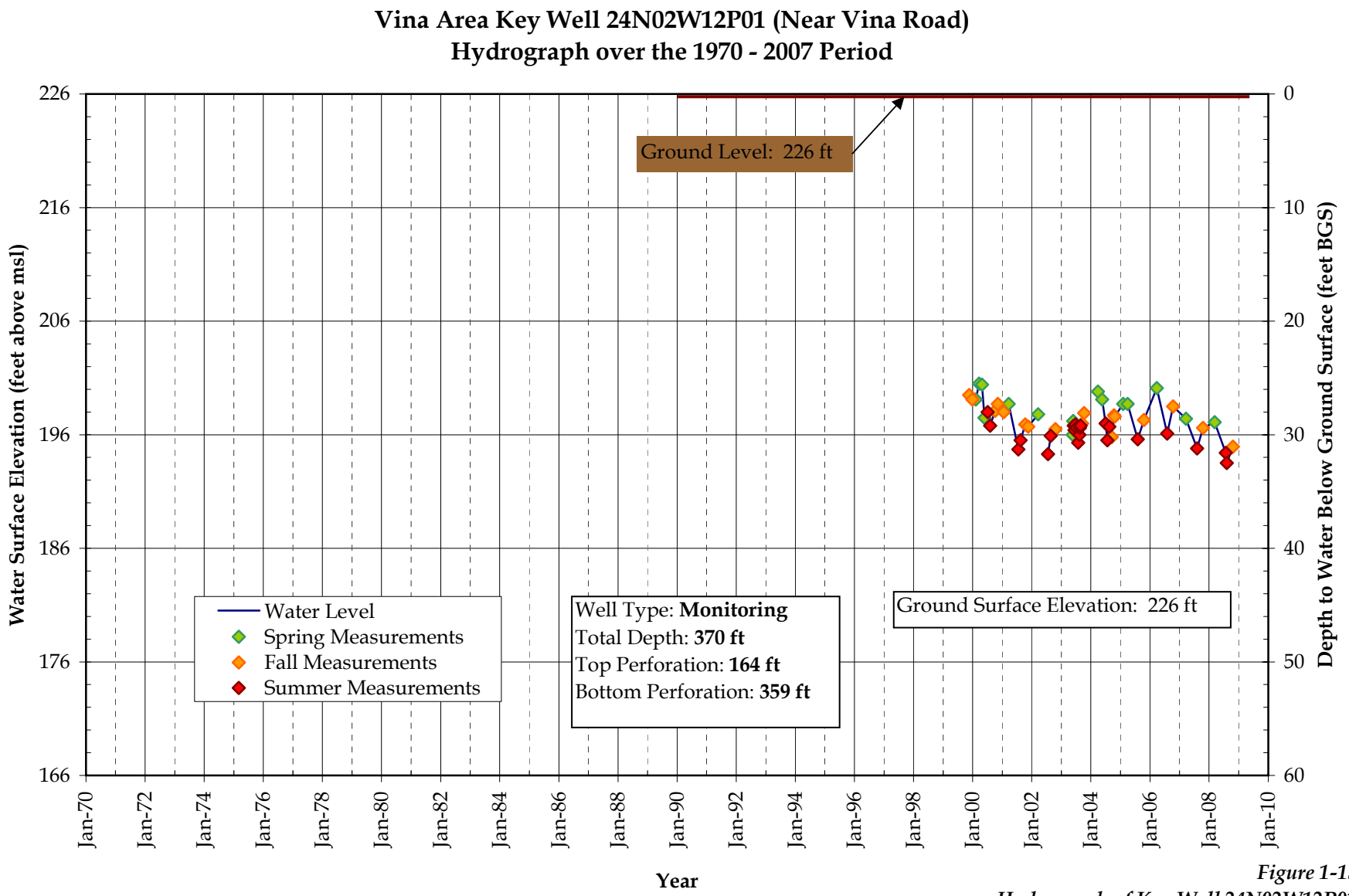


Figure 1-13
Hydrograph of Key Well 24N02W12P01

Updated 12-01-08

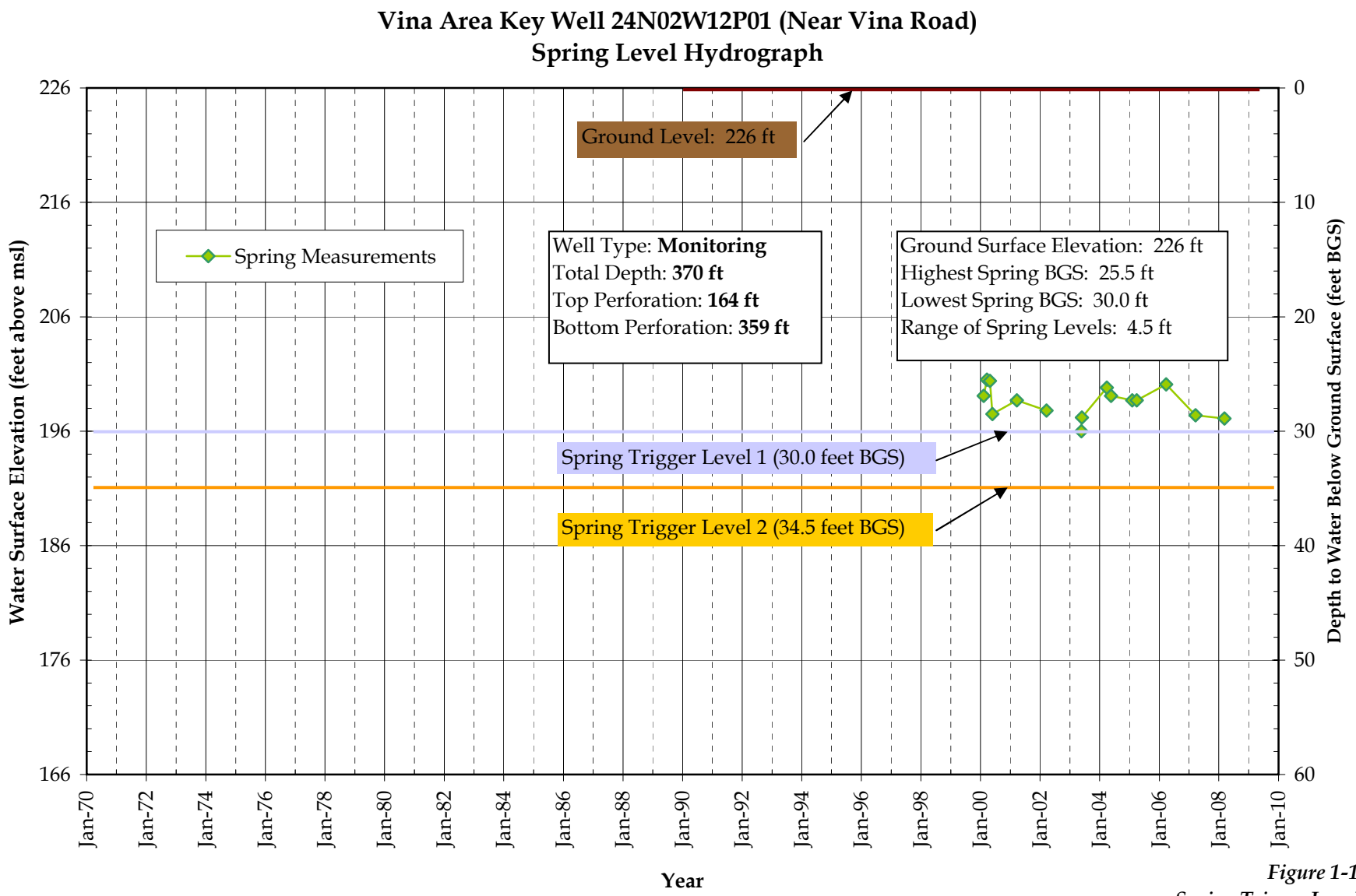


Figure 1-14
Spring Trigger Levels

Updated 12-01-08

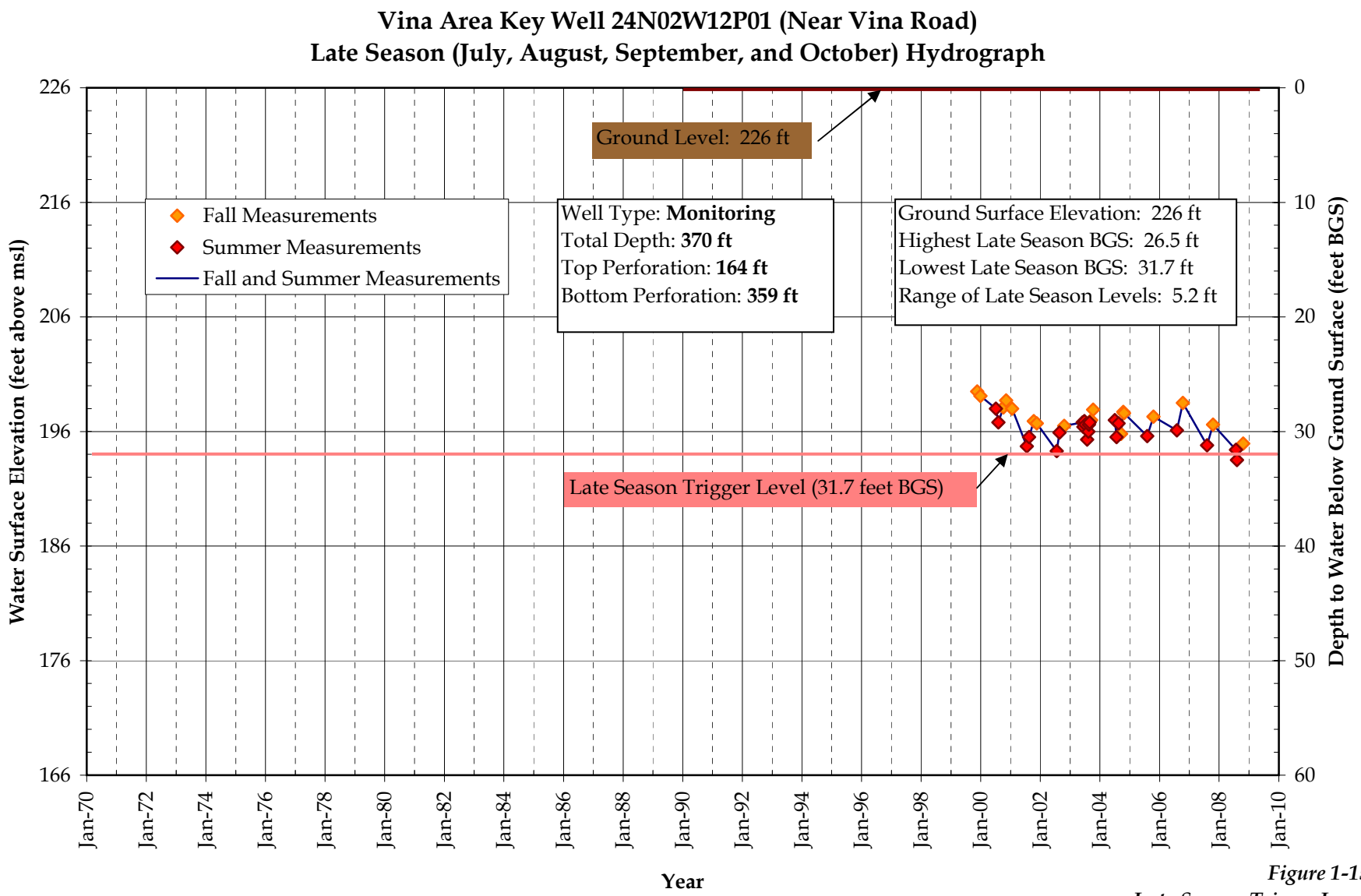


Figure 1-15
Late Season Trigger Level

Updated 12-01-08

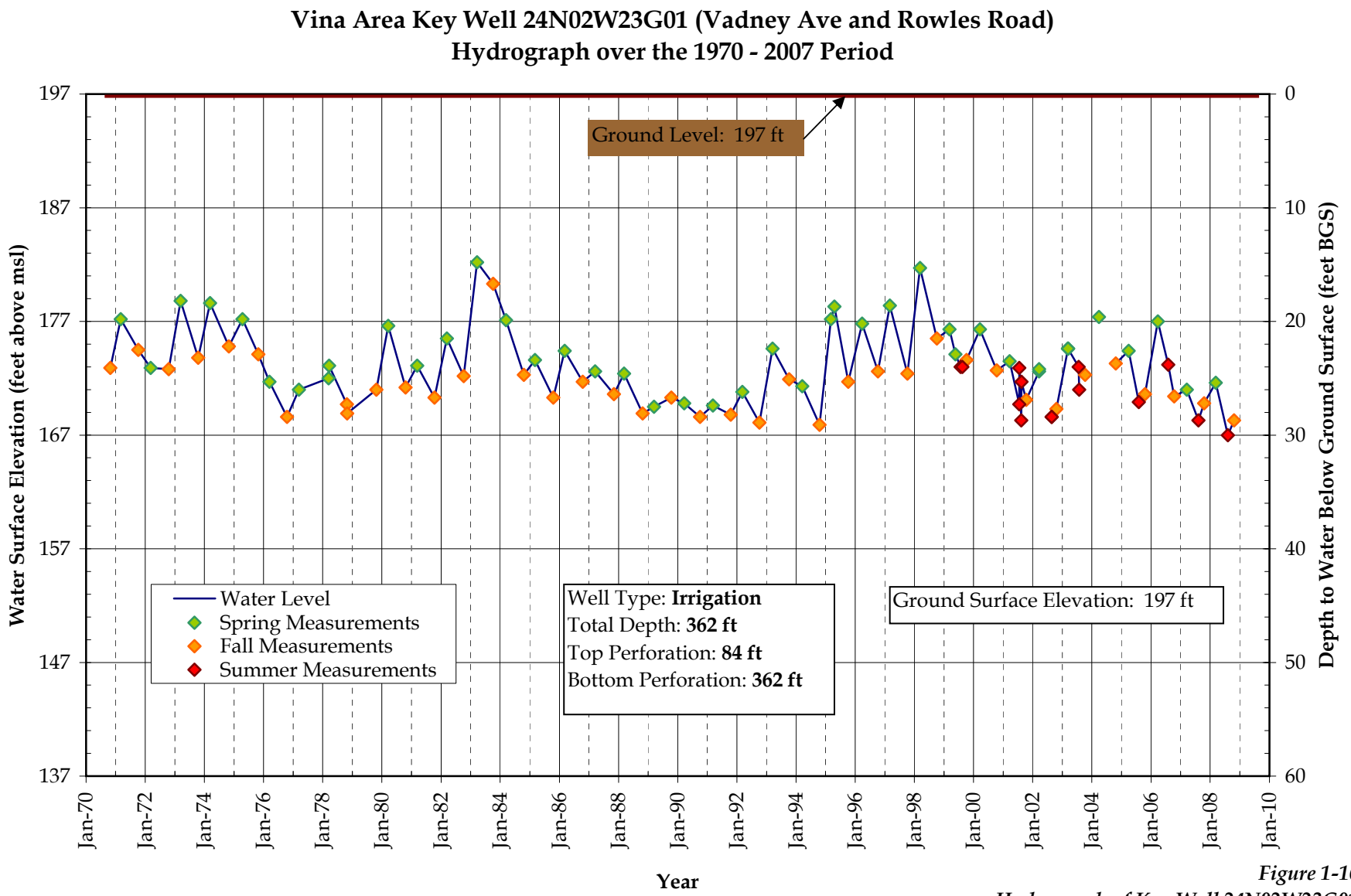


Figure 1-16
Hydrograph of Key Well 24N02W23G01

Updated 12-01-08

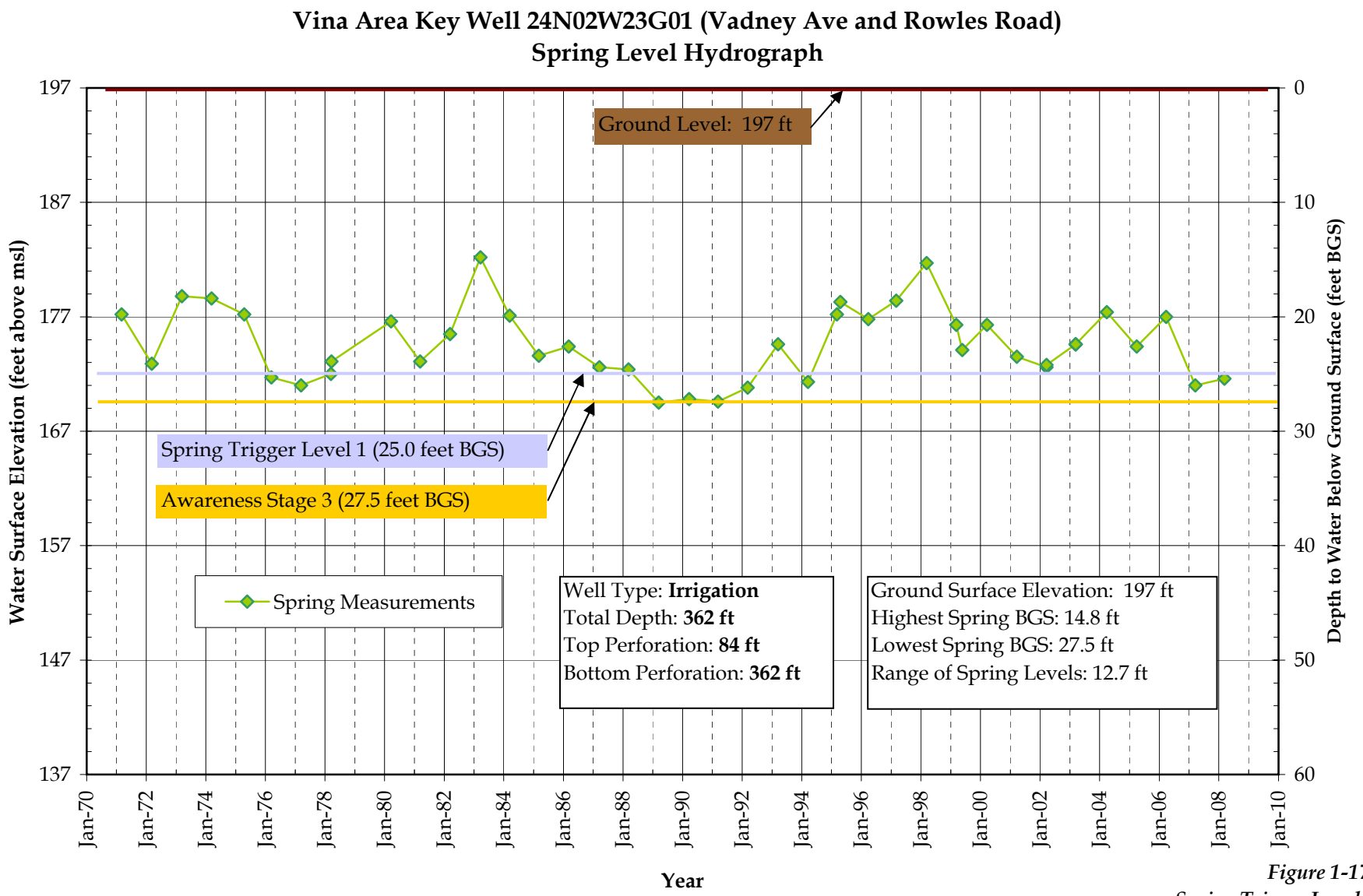


Figure 1-17
Spring Trigger Levels

Updated 12-01-08

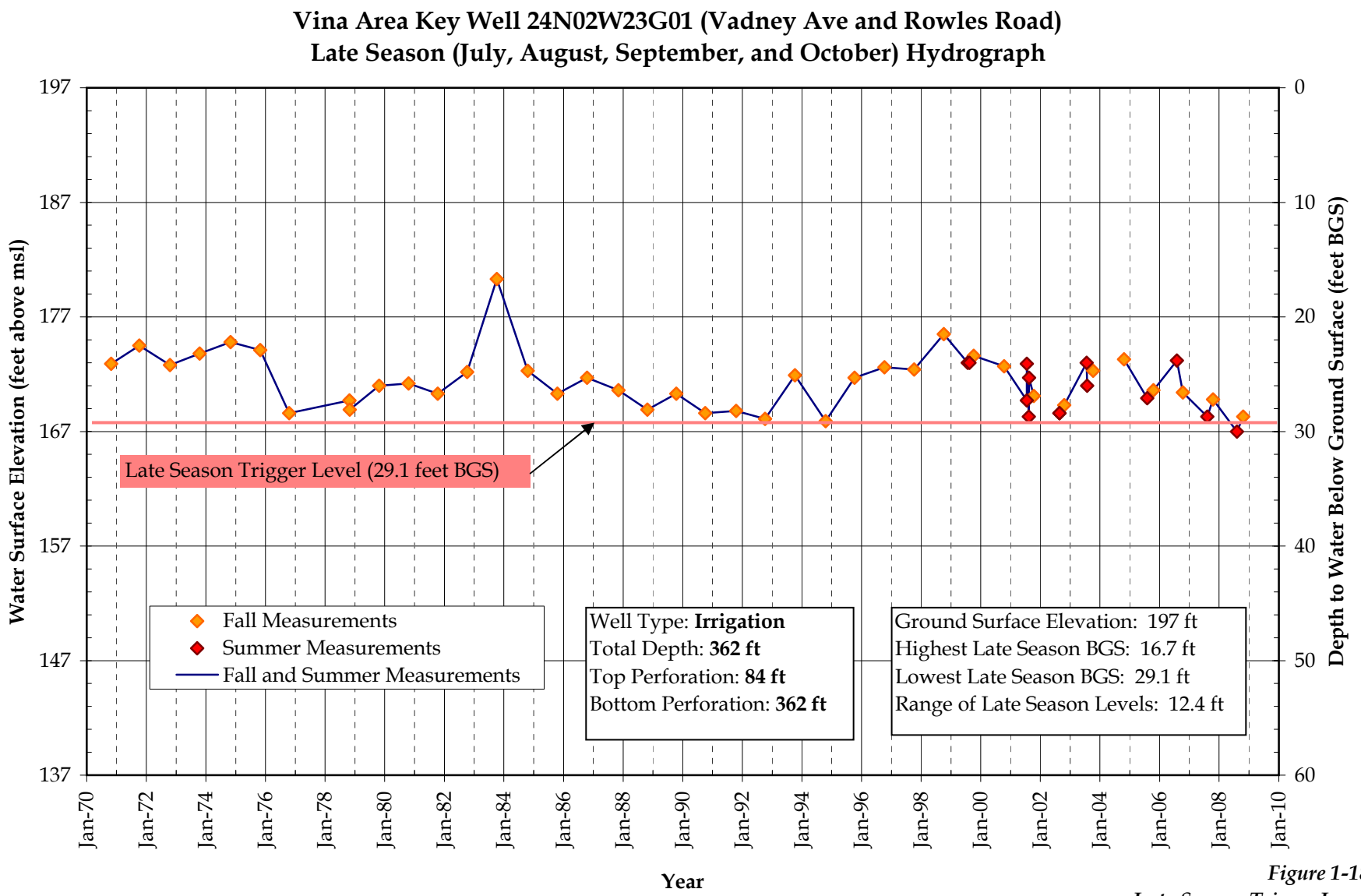


Figure 1-18
Late Season Trigger Level

Updated 12-01-08

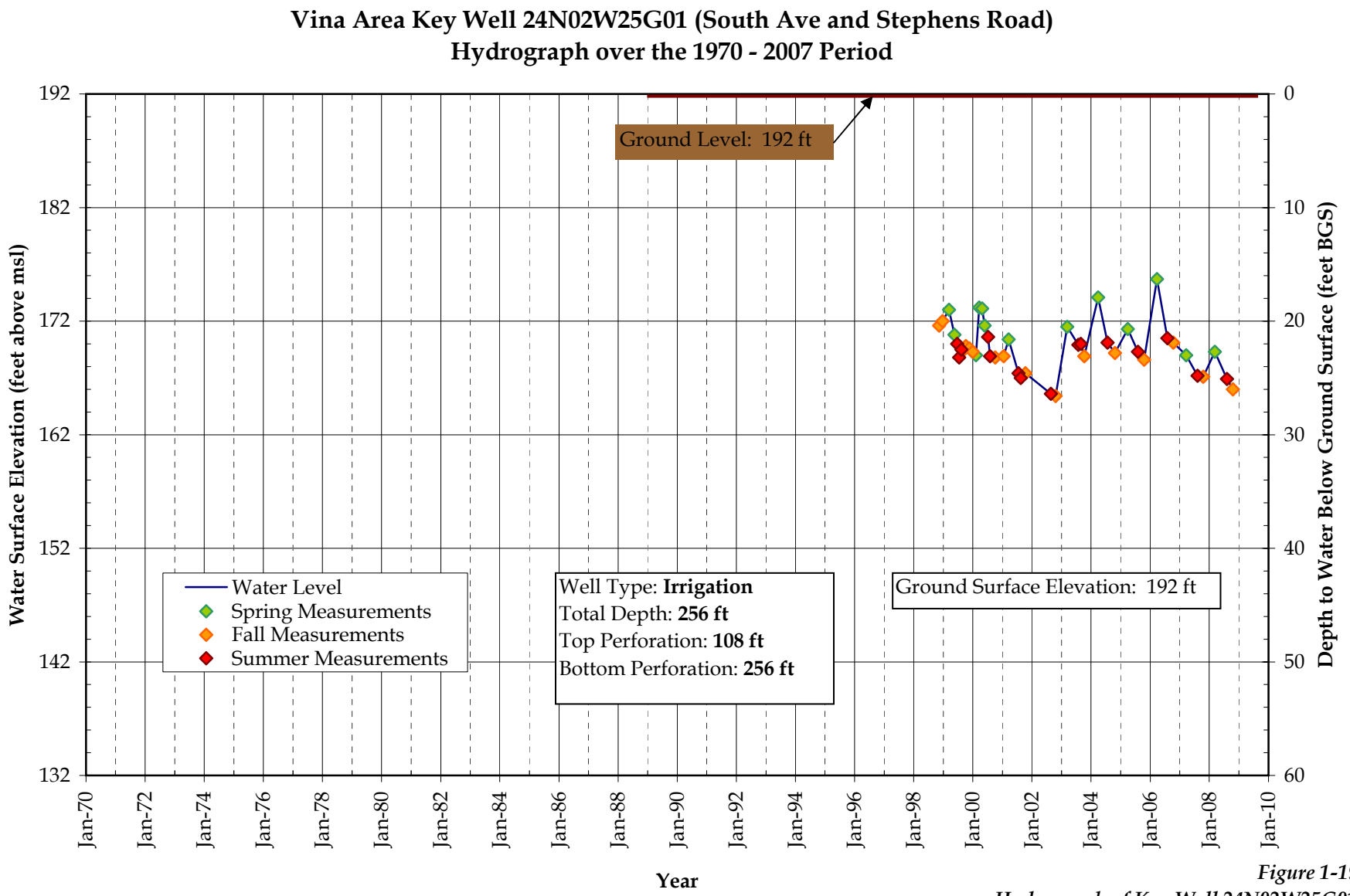


Figure 1-19
Hydrograph of Key Well 24N02W25G01

Updated 12-01-08

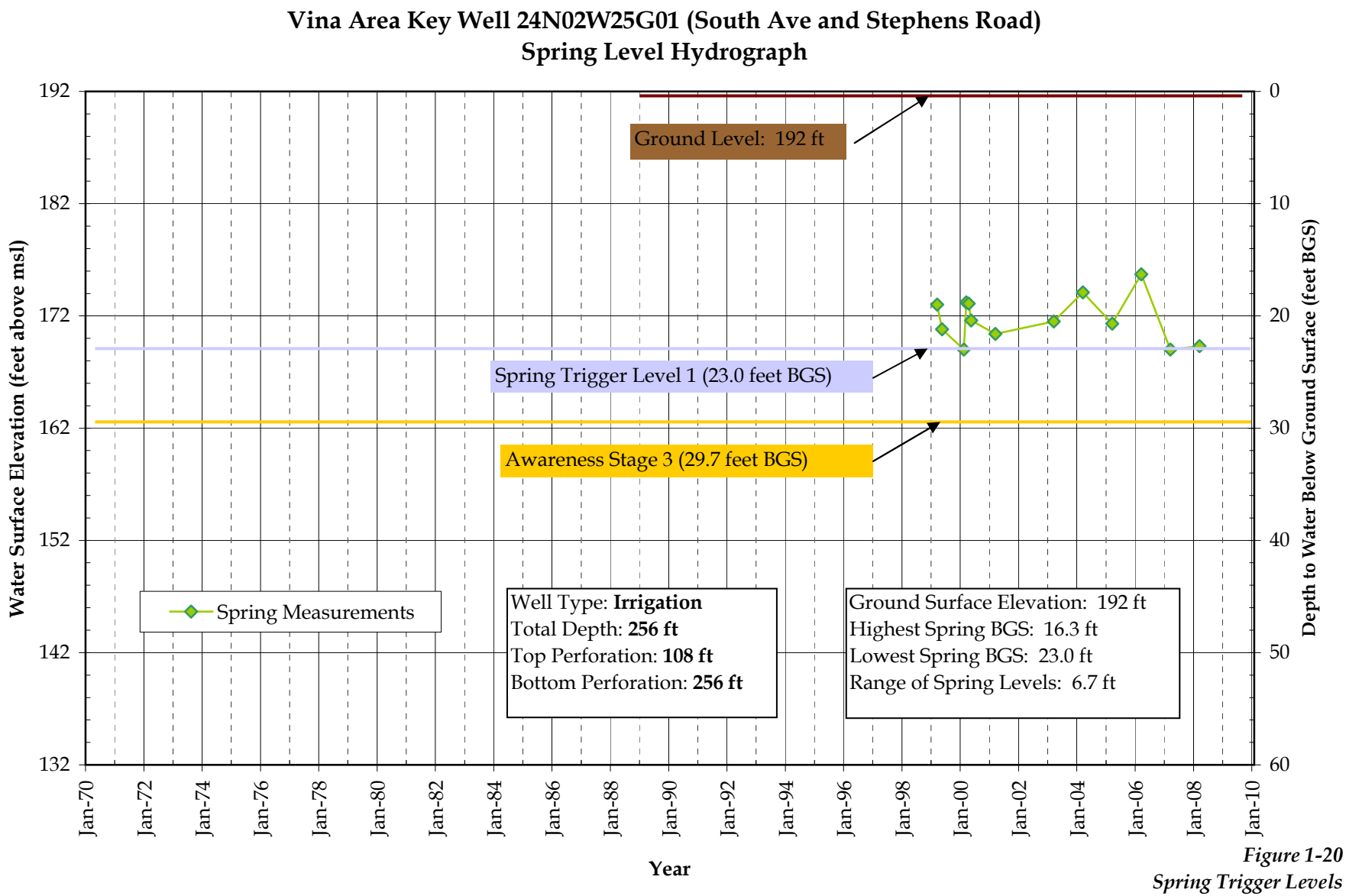


Figure 1-20
Spring Trigger Levels

Updated 12-01-08

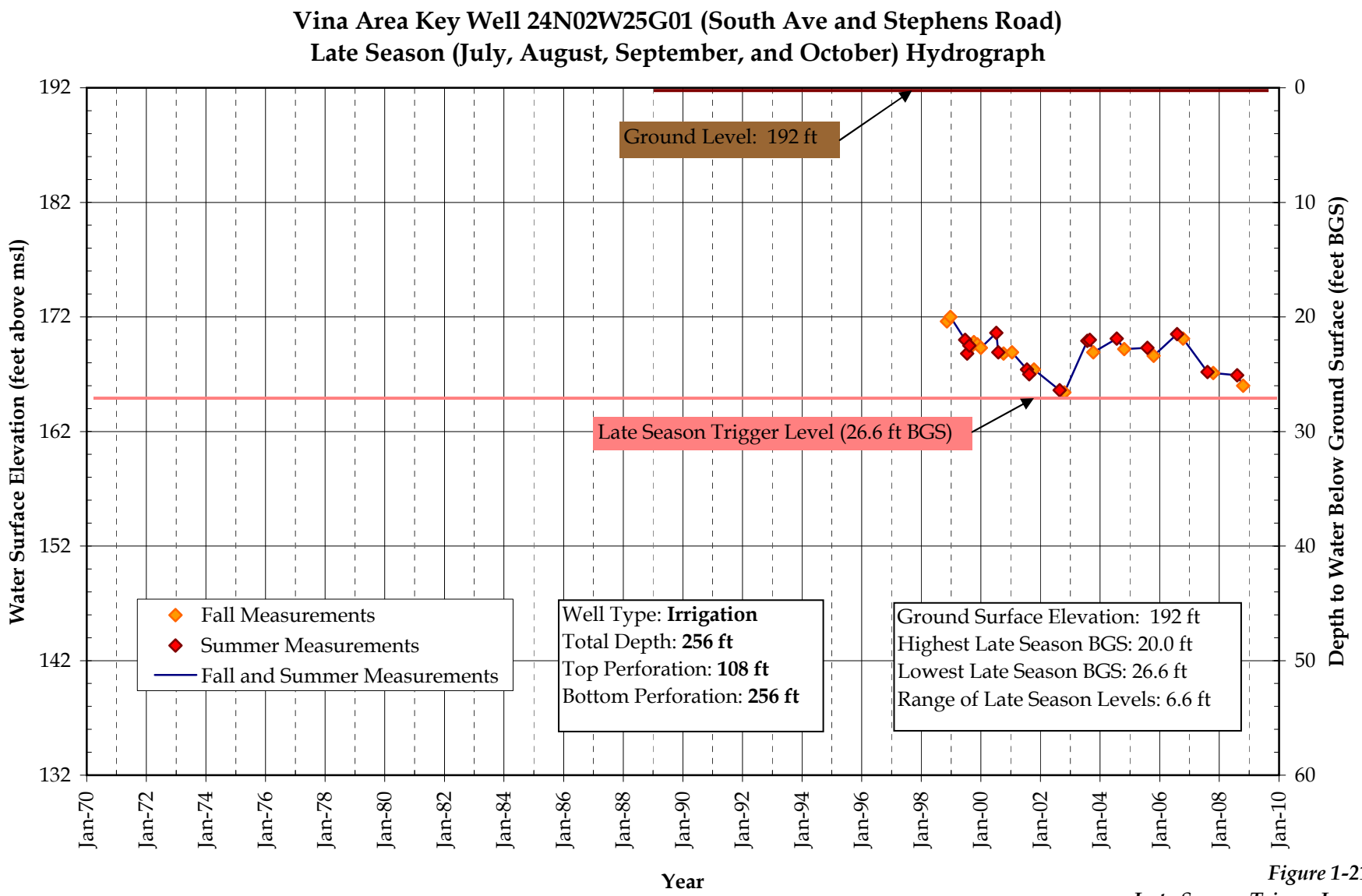


Figure 1-21
Late Season Trigger Level

Updated 12-01-08