IBM

Route 100
Somers, NY 10589

July 22, 2011

Mr. Damian Duda
Remedial Project Manager
US Environmental Protection Agency
290 Broadway, 20th Floor
New York, NY 10007

Re: Shenandoah Road Groundwater Contamination Superfund Site (Site)
7 East Hook Cross Road Facility (Facility)
Transmittal of Final Non-Time Critical Source Removal Action (NTCSRA) Report
Administrative Order on Consent (AOC) for Removal Action
Index #: CERCLA 02-2001-2020

Dear Mr. Duda:

This letter transmits the final draft Non-Time Critical Source Removal Action Report for the 7 East Hook Cross Road Facility which incorporates comments received from the Environmental Protection Agency (EPA), the New Your State Department of Environmental Conservation (NYSDEC) and the United States Geological Survey (USGS). This letter also provides IBM's responses to the Agencies comments on the draft of the above referenced report.

In this regard, IBM has reviewed comments on the Non-Time Critical Source Removal Action (NTCSRA) Draft Report transmitted in your letter dated July 14, 2011 and also those received in a separate correspondence from Ms. Kiera Becker of the NYSDEC on July 15, 2011. Following are responses to those comments.

EPA Comments

1. Page 2, Section 1.2, Previous Response Actions: Please include a fourth bullet sentence which identifies that the Remedial Investigation/Feasibility Study (RI/FS) for the Shenandoah Road site is ongoing. As such, please modify the heading to "Previous and Ongoing Response Actions."

   Response: The text of the report was modified as requested to reflect the above comment.

2. Page 4, Section 1.5.2, Cost: The 15-year project life should be classified as "projected" or "estimated." This reference should also be included in Section 6.2, Cost. Also, please

include some discussion to support the proposed 15-year time frame which should also include discussion on the technical effectiveness of the three alternatives in removing chlorinated volatile organic compounds (CVOCs) from the contaminated groundwater.

Response: The text of section 1.5.2 has been modified in response to this comment. The text of Section 6.2 has not been modified since the rationale for the 15-year duration had already been included in that section.

3. Page 5, Section 2.1, Background Information, 1st ¶: Since this action represents the second removal action conducted at the Site, please include the word "second" before removal action at the beginning and end of the paragraph.

   Response: The text of the report was modified as requested to reflect the above comment.

4. Page 5, continued 1st ¶: Please include the final status of the NYSDEC discharge permit at the end of this paragraph. Also, please include a copy of the final approved discharge permit as part of the Appendices of the report.

   Response: The text of the report was modified as requested to reflect the above comment. In addition, the final approved discharge permit has been included as Appendix A.

5. Page 8, Section 3, Identification of Remedial Action Objectives, 2nd ¶, 1st sentence: Please revise the narrative as follows: Conversely, however, based on the occurrence of declining trends in some long-term residential monitoring wells, there is clear evidence that concentrations are naturally attenuating in some areas of the aquifer. This declining trend is likely in response to the source removal work that was completed in 2002 and the use of the residential point-of-entry treatment systems from 2001 until the completion of the public water supply system connections in 2009.

   Response: The text of the report was modified as requested to reflect the above comment.

6. 3rd ¶: Please identify "Agencies."

   Response: The text of the report was modified as requested to reflect the above comment.

7. 4th Partial ¶ continued to Page 9: In an effort to focus this report on the alternatives presented herein, any discussion regarding remedial alternatives that may be presented in the upcoming FS is premature. As such, please revise the narrative as follows: The second component of this approach is to address the contamination in the plume area beyond the Facility by evaluating remedial alternatives which will be presented in the FS for the Site under the current Administrative Order on Consent for RI/FS [CERCLA-02-2002-2025.

   Response: The text of the report was modified as requested to reflect the above comment.

8. Page 9, last ¶: In order to complete the identified goals and objectives, please revise the narrative as follows and include it as Bullet #3: To reduce concentrations of CVOCs in the source area groundwater by reducing the significance of mass flux from the source area to levels that will permit Federal and state groundwater cleanup standards to be met within the groundwater plume.

   Response: The text of the report was modified as requested to reflect the above comment.

9. Page 9: Please change Bullet "#3" to Bullet "#4."

   Response: The text of the report was modified as requested to reflect the above comment.

10. Page 9, last ¶: Please add the following narrative as the last paragraph: Upon completion of the RI/FS, EPA will ultimately issue a Record of Decision identifying a final selected remedy for the Site. The NTCSRA will be a part of that final selected remedy.

    Response: The text of the report was modified as requested to reflect the above comment.

11. Page 29, Section 5.1.2, Alternative #2: With respect to the need for off-gas treatment, were the NYSDEC air discharge requirements applied? Also, was air modeling performed associated with such discharge requirements?

    Response: The text of the report was modified to respond to the above comment. Since the design of the off-gas treatment system is expected to result in no detectable concentrations of CVOCs in off-gas, air discharge requirements and modeling were not considered in the detailed and comparative analysis of alternatives. In the event that this alternative is selected and the remedial design predicts detectable concentrations of CVOCs in off-gas, then full consideration will be given at that time to air discharge requirements of the NYSDEC's Division of Air Resources (DAR).

12. Plate 7 and Appendix B: The section C-C' (E-W) across the Site gives the lowest water level on 5/17/11 for SRMW-1RC as 442.84 feet; however, the hydrograph plot in Appendix B clearly shows the water level in SRMW-1RC to be about 320.5 feet, with a test-induced drawdown of about 17 feet. This would imply that the capture zone extends across (or under) the groundwater divide postulated at EHC-017 which would make the capture zone larger than is shown. Likewise, the pre-test head in SRMW-1RC was 337 feet on 4/14/11 on the hydrograph while the section on Plate 2 shows it to be 459.9 feet. Note that SRMW-1RC could not be logged. With respect to SRMW-1RC (open hole), is there a packered-off zone in this well, such that the transducer was recording much lower heads than the composite head? Or, perhaps the GWE axis on the hydrograph for SRMW-1RC is mis-labeled. Please confirm.

    Response: The axis on the hydrograph plot in Appendix B for the monitoring well SRMW-1RC was inadvertently mislabeled. The corrected hydrograph has been included in Appendix B. No revisions to the text are required.

NYSDEC Comments

1. Three alternatives are proposed for groundwater extraction and treatment in order to control reduce residual DNAPL source in bedrock beneath the facility and to control groundwater chemical flux from the source area to the plume. Please provide an explanation why other technologies aside from 'pump and treat' were not explored as possible alternatives in the NTCSRA document.

   Response: The NTCSRA is not the equivalent of a feasibility study. It is performed to implement a selected response action at a site prior to completion of the RI/FS. In this case that action is groundwater extraction, treatment and discharge to control flux from the source and reduce CVOC mass in the source area. The evaluation of alternatives therefore examines the various technology options available to implement this response action. This includes determining how many wells to use for groundwater extraction, the treatment technology options and the discharge options. It does not, however, provide a detailed and comparative analysis of alternatives for source control/reduction such as groundwater extraction and treatment and available in situ treatment technologies, which is more appropriately the function of the FS.

2. If alternative #2, treatment of groundwater via air stripping and off-gas treatment with vapor phase GAC, is selected, post-treatment air emission rates must be evaluated using DAR-1 (Division of Air Resources Annual Guideline Concentration and Short-term Guideline Concentration tables, October, 2010). Please revise the NTCSRA to state that this analysis will be provided to the Department upon selection of this alternative. DAR-1 can be found on the Department website at:
   http://www.dec.ny.gov/chemical/30560.html
   If post treatment emission rates exceed a total VOC emission rate of 9.5lb per hour, compliance must be reassessed using modeling procedures for an air quality impact analysis outlined in DAR-10 (NYSDEC Guidelines on Dispersion Modeling Procedures for Air Quality Impact Analysis, May, 2006), found at:
   http://www.dec.ny.gov/chemical/8923.html.

   Response: Please see the response to EPA Comment #11 above.

If you have any questions regarding the above responses to your comments, please contact me at 914-766-2739.

Sincerely yours,
International Business Machines Corporation

Thomas D Morris

Thomas D. Morris
IBM Program Manager

cc: K. Becker, NYSDEC
R. Reynolds, USGS

P.E. Certification
Non-Time Critical Source Removal Action Report
7 East Hook Cross Road Facility
Hopewell Junction, Dutchess County, NY

Pursuant to Paragraph 41(f) of the Administrative Order on Consent
for Removal Action, Index Number CERCLA-02-2001
Site #3-14-104

July 21, 2011

I certify that I have prepared and reviewed the Non-Time Critical Source Action Report for the 7 East Hook Cross Road Facility in Hopewell Junction, Dutchess County, New York pursuant to Paragraph 41(f) of the Administrative Order on Consent for Removal Action, Index Number CERCLA-02-2001, Site #3-14104. This report is dated July 21, 2011 and was prepared by Groundwater Sciences, P.C. and Groundwater Sciences Corporation for IBM Corporation and the United States Environmental Protection Agency (EPA). I certify that to the best of my knowledge, all engineering-related information contained in this report is complete and accurate and has been performed under my direct supervision.

No alterations to the engineering-related information contained in this report may be made unless made in accordance with 145-Subsection 7209 of New York State Education Law.

Signature: ____________ Date: 7/21/2011

Name: Matthew T. Luckman

License No: 076619

State: New York

Corporate Environmental Affairs

SHENANDOAH ROAD GROUNDWATER CONTAMINATION SUPERFUND SITE

NON-TIME CRITICAL SOURCE REMOVAL ACTION REPORT
7 EAST HOOK CROSS ROAD FACILITY
HOPEWELL JUNCTION, DUTCHESS COUNTY, NY

FINAL REPORT

Prepared for:

IBM Corporation
Corporate Environmental Affairs
Somers, New York

July 21, 2011

Prepared by:

Groundwater Sciences, P.C.
Groundwater Sciences Corporation

2601 Market Place Street, Suite 310
Harrisburg, Pennsylvania 17110

560 Route 52, Suite 202
Beacon, New York 12508

1108 Vestal Parkway East, Suite 2
Vestal, New York 13850

Table of Contents

Table of Tables

Table of Figures

Table of Appendices

Table of Plates

Table of Acronyms and Defined Terms

ABS	ABSMaterials (manufacturer of the Osorb VOCEater technology)
Agencies:	United States Environmental Protection Agency Region 2; New York State Department of Environmental Conservation; New York State Department of Health
AOC:	Administrative Order on Consent for Removal Action, Index Number CERCLA-02-2001
bgs:	below ground surface
CVOCs:	chlorinated volatile organic compounds
EPA:	United States Environmental Protection Agency Region 2
Facility:	7 East Hook Cross Road (the building on this property formerly housing J. Manne, Inc. cleaning operations was demolished in 2001).
GAC:	granular activated carbon
gpm:	gallons per minute
GSC:	Groundwater Sciences Corporation
GSPC:	Groundwater Sciences, P.C.
IBM:	International Business Machines
MNA:	Monitored Natural Attenuation
NTCSRA	Non-Time Critical Source Removal Action
NYSDEC:	New York State Department of Environmental Conservation
NYSDOH:	New York State Department of Health
PCE:	tetrachloroethene
RI:	remedial investigation
RI/FS:	Remedial Investigation/Feasibility Study
Site:	Shenandoah Road Groundwater Contamination Superfund Site
TAL:	target analyte list
TCE:	trichloroethene
TCL:	target compound list
ug/L:	micrograms per Liter
USGS :	United States Geological Survey
WBZ:	Water-bearing zone
WP:	Work Plan

1 EXECUTIVE SUMMARY

This Non-Time Critical Source Removal Action Report (NTCSRA Report) has been prepared by Groundwater Sciences, P.C. (GSPC) and Groundwater Sciences Corporation (GSC) pursuant to Paragraph 41(f) of the Administrative Order on Consent for Removal Action, Index Number CERCLA-02-2001 (AOC), entered into by IBM Corporation (IBM) and the United States Environmental Protection Agency (EPA) on May 16, 2001 to facilitate IBM's involvement in continuing response actions at the Shenandoah Road Groundwater Contamination Superfund Site (Site). This NTCSRA Report is being submitted to EPA following acceptance and approval by EPA of a NTCSRA Statement of Work (SOW) and the NTCSRA Work Plan (WP) submitted by IBM to EPA. The location of the 7 East Hook Cross Road Facility ("Facility") and the area of the Site as defined by the extent of contaminant migration in groundwater are shown on Figure 1-1.

1.1 Previous Investigations

Investigations at this Site began in 2000 following the discovery of contamination by chlorinated volatile organic compounds (CVOCs) in residential wells. Since that time the following investigations have been completed:

- Installation of monitoring wells at twenty locations (SRMW-1 to SRMW-20 on Plate 1) and sampling of groundwater from 78 depth intervals at these 20 locations;
- Quarterly groundwater sampling at as many as 146 residential wells from 2000 to 2010;
- Conversion of twenty (20) private supply wells to monitoring wells at the locations identified on Plate 1;
- Performance of geophysical logging and packer tests in twenty (20) new monitoring wells and twenty-three (23) converted residential wells;
- Sampling of surface water and sediments at six locations each;
- Performance of short-term and long-term aquifer tests in four extraction wells.

1.2 Previous and Ongoing Response Actions

Previous response or removal actions implemented at this Site include:

- Installation, operation and maintenance of as many as 105 point-of-entry treatment (POET) systems on residential wells;
- Excavation and off-site disposal of approximately 10,000 tons of soil from the source area at the Facility; and
- Installation of an alternate water supply system to provide public water supply to replace the use of 146 residential wells.
- The Remedial Investigation / Feasibility Study (RI/FS) for the Shenandoah Road Site is ongoing.

1.3 NTCSRA Objectives

The goals and objectives of this NTCSR are:

1. To reduce to the extent practicable the residual DNAPL source in bedrock beneath the Facility;
2. To control groundwater chemical flux from this source area to the plume; and
3. To treat extracted groundwater to within appropriate concentration limits prior to discharge to surface water.

1.4 NTCSRA Testing

The current effort involved three stages of testing to evaluate various groundwater extraction configurations. This testing was also performed to assess the potential effectiveness of groundwater extraction in achieving the NTSCRA objectives. The results of this testing were as follows:

- Groundwater extraction at the Facility is predicted to achieve the NTCSRA objectives of reducing the DNAPL source in bedrock and controlling groundwater chemical flux from the source area to the plume;

- The maximum predicted extraction rate and associated concentration of tetrachloroethene (PCE) are 30 gpm and 1500 ug/L, respectively and the average for these parameters are anticipated to be 20 gpm and 1000 ug/L, respectively;

- Groundwater extracted during this testing was consistently treated to achieve the discharge limits of the SPDES Discharge Equivalent Permit using filtration to remove suspended solids and granular activated carbon (GAC) to remove chlorinated volatile organic compounds (CVOCs);

- Field testing of an emerging groundwater treatment technology (Osorb nanotechnology) failed to demonstrate the ability of this technology to meet limits imposed on CVOC concentrations in the SPDES Discharge Equivalent Permit.

1.5 Analysis of Groundwater Treatment Alternatives

Three alternatives have been evaluated for the removal of CVOCs from groundwater prior to discharge to surface water. They are as follows:

- Alternative No. 1: Removal of CVOCs from groundwater by aqueous phase granular activated carbon (GAC).

- Alternative No. 2: Remove of CVOCs from groundwater by counter-current air stripping with off-gas treatment using vapor phase GAC.

- Alternative No. 3: Removal of CVOCs from groundwater using Osorb nanotechnology.

Consistent with the approved NTCSRA WP, two criteria, implementability and cost, were used to evaluate these three alternatives.

1.5.1 Implementability

Each of the three alternatives is constructable. The complexity of the construction is lowest for Alternative No. 1 and highest for Alternative No. 3. Alternatives No. 1 and No. 2 are highly reliable and effective in removing CVOCs from contaminated groundwater; the reliability and effectiveness of Alternative No. 3 in removing CVOC contamination from groundwater is unproven. The expandability of Alternative No. 1 is the highest of the three. Approvals required for implementation of the alternatives are least complex with Alternative No. 1 given its successful application during testing and problematic for Alternative No. 3, given its consistent failure to meet discharge limits during field testing.

1.5.2 Cost

For this calculation, all of the alternatives have been evaluated based on an estimated fifteen years of operation and maintenance to facilitate comparative analysis. This duration is based on previous remedial experience in comparable geologic conditions with comparable contamination that suggests the objectives of this NTCSRA will be achieved in ten to fifteen years following startup. The actual time period for operation of the system as a CERCLA response action will depend on future decisions to be made with regard to restoration of the groundwater.

Costs were calculated using guidance from USEPA document 540-R-00-002, "A Guide to Developing Cost Estimates During the Feasibility Study." As suggested in the guide, the discount rate used for the present worth calculation comes from the Office of Management and Budget (OMB) Circular A-94 Appendix C last updated December 2010. For a 15 year project life, Circular A-94 suggests a linear interpolation between the 10-year (1.3%) and 20-year (2.1%) real discount rates or 1.7%. As shown in the table below, Alternative No. 1 has the lowest capital and annual operating cost and therefore the lowest calculated present worth while Alternative No. 3 has the highest calculated present worth.

Table 1.1: Comparative Cost of Alternatives

	Alternative No. 1	**Alternative No. 2**	**Alternative No. 3**
Capital Cost	$570,052	$616, 620	$926,200
Annual O&M	$92,395	$146,052	$161,551
Annual Monitoring	$64,930 (Years 1-5)	$64,930 (Years 1-5)	$64,930 (Years 1-5)
	$44,623 (Years 6-15)	$44,623 (Years 6-15)	$44,623 (Years 6-15)
15 Years Present Worth	$1,994,347	$2,799,208	$3,031,693
Total Present Worth	$2,467,348	$3,219,103	$3,372,378

2 SITE CHARACTERIZATION

The Shenandoah Road Groundwater Contamination Superfund Site (Site) is located in southern Dutchess County, New York (Figure 1-1). The Site is comprised of a source area at 7 East Hook Cross Road (the Facility) where releases of the chlorinated volatile organic compound (CVOC), tetrachloroethene (PCE) by the operator, Jack Manne, Inc, resulted in contamination of soil and groundwater and a plume of contaminated groundwater extending north, south and east from the Facility as outlined on Plate 1.

2.1 Background Information

This second source removal action is planned at the Facility to remove residual source material that has been determined to be present in the bedrock underlying and adjacent to the area of a previous soil excavation response action conducted at the Facility. The area within which this excavation was completed is shown on Plate 1. The excavation work was initially performed by EPA from November 2000 to April 2001 and completed by IBM from May 2001 to April 2002. This second removal action will be comprised of a groundwater extraction and treatment system with discharge of treated groundwater to surface water.

Since the previous source removal was completed, various activities have been performed to investigate the physical and chemical condition of groundwater in the area comprising the Site (including on the Facility) and beyond based on the scope of the Remedial Investigation/ Feasibility Study (RI/FS) Work Plan. These activities have principally included the installation and sampling of groundwater monitoring wells at twenty locations (SRMW-1 to SRMW-20 on Plate 1). Through the use of multilevel sampling systems in bedrock wells at most of the twenty (20) monitoring well locations and the installation of single soil wells or soil well clusters at locations with saturated conditions in the soil, the total number of monitoring intervals at these twenty locations is seventy-eight (78).

In addition to work performed at these twenty (20) locations, groundwater sampling has been conducted at approximately 146 residential water supply wells generally on a quarterly frequency since 2000. Since the installation of the alternate water supply system was completed in 2009, nearly all of the properties served by these residential wells have been connected to the public water supply and the use of these wells for water supply purposes has been discontinued.

Concurrent with the transition from the private supply wells to the public system, GSC identified twenty-six (26) private supply wells at which it appeared to be appropriate to continue the long-term groundwater sampling program begun in 2000. The locations of these twenty-six wells are identified on Plate 1.

The SPDES equivalent discharge permit application was submitted to the NYSDEC on March 10, 2011. The SPDES equivalent discharge permit was received on April 11, 2011 and included a memorandum dated April 8, 2011 from the Division of Water detailing the Effluent Limitations and Monitoring Requirements for the Shenandoah Road Site. The maximum daily flow rate as detailed in the Effluent Limitations on Monitoring requirements is 28,800 gallons per day or 20 gpm. In anticipation of future testing during recharge conditions, a request for modification to the SPDES daily discharge limit from 28,800 gpd to the equivalent of 30 gpm or 43,200 gpd was submitted to the NYSDEC on April 26, 2011. A modification to the SPDES equivalent discharge permit for increase in the daily maximum discharge limit and associated loadings was received and dated May 25, 2011. A copy of the SPDES equivalent discharge permit, dated May 25, 2011 is provided in Appendix A.

Once the investigation activities described above had been completed, Section 5.3.1.2 of the RI/FS Work Plan called for aquifer testing to be performed on the basis of an aquifer testing plan to be prepared by GSC and approved by EPA prior to its implementation. This aquifer testing plan was submitted to EPA on April 26, 2010 and approved by EPA on May 5, 2010. Implementation of the aquifer testing work plan is currently ongoing with the analysis of data collected during a long-term constant rate aquifer test completed from June 6, 2011 to June 14, 2011. The results of this long-term constant rate test are being analyzed to determine aquifer characteristics of the granitic gneiss that underlies the Facility and a substantial portion of the Site.

Data collected during this testing will be analyzed to determine the hydraulic response in the aquifer and changes in extracted groundwater quality. The results of this analysis will be used to refine the plan for long-term, temporary operation of groundwater extraction and treatment at the Facility which is the initial step in this NTCSR Action.

2.2 Site Description

A schematic conceptual Site model is presented on Figure 2-1. As shown on this figure, the Facility is located in a small valley within an upland area that is part of the Hudson Highlands and is underlain by fractured granitic gneiss. More than 10,000 tons of contaminated soil within this valley was removed during the excavation work described above. Figure 2-1 shows that some uncontaminated residual soil remained in the area of this excavation, which was then backfilled with clean soil approved by EPA. During the removal of the contaminated soil, shallow groundwater entered the excavation to an elevation higher than the elevation of groundwater in the underlying bedrock, as depicted on Figure 2-1. Concentrations of PCE in this pit water were reported to be as high as 9900 ug/L. Subsequent sampling of groundwater in shallow bedrock beneath the Facility indicated concentrations of PCE as high as 14,000 ug/L. Both of these results suggest the likely presence of residual separate phase liquid PCE in fracture openings within the bedrock which is otherwise referred to as a dense non-aqueous phase liquid (DNAPL) and is labeled on Figure 2-1 as “DNAPL Source Zone in Bedrock”.

As shown on Figure 2-1, a plume of dissolved PCE and related constituents extends downgradient from the Facility eventually crossing the fault contact that separates the granitic gneiss that underlies the uplands from solution-prone carbonate rock (primarily dolostone) that underlies valleys to the north and east of the Facility. Also as shown on Figure 2-1, both the surface topography and structural geology of the area underlying and surrounding the Facility suggest the presence of a similar fault passing beneath the Facility and trending north-northeast, potentially into the dolostone valley north of the Facility.

The dissolved phase plume is also shown on Figure 2-1 to cross from the bedrock into the glacial outwash sediments that constitute the surficial material underlying most of these valley areas. After passing through these unconsolidated materials, the potential exists for the groundwater associated with this plume to discharge into nearby streams and wetlands.

Groundwater monitoring data collected since 2000 from as many as 146 residential wells in all areas of the plume area has been evaluated to identify trends in groundwater concentrations. Examination of data from these wells shows that, while some of them exhibit declining CVOC concentrations with time (primarily to the north of the Facility along Shenandoah Road), more of these wells exhibit either stable or increasing concentrations. These include wells located to the east of the Facility along Burbank Road and Seymour Lane, to the south along Shenandoah Road and in the northernmost well along Townsend Road.

3 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

Given the site description provided above, both the level of PCE dissolved in groundwater in shallow bedrock beneath the Facility and the prevalence of stable and increasing concentration trends in many long-term monitoring wells within the plume indicate the presence of primary and/or secondary sourcing from within the fractured granitic bedrock underlying the Facility. Any primary sourcing would be from residual DNAPL retained by capillary forces within individual fractures. Secondary sourcing from mass diffused into the matrix of the rock or sorbed onto aquifer solids is not believed to be significant. This conclusion is supported by the results of matrix diffusion studies completed at the Facility which have indicated little or no potential for secondary sourcing due to reverse diffusion from pore water within the rock matrix to groundwater being transmitted through fractures. However, the results of these studies, which will be published in the Remedial Investigation Report, may indicate potential secondary sourcing due to diffusion of PCE into micro fractures in the granitic gneiss.

Conversely, however, based on the occurrence of declining trends in some long-term residential monitoring wells, there is clear evidence that concentrations are naturally attenuating in some areas of the aquifer. This declining trend is likely in response to the source removal work that was completed in 2002 and the use of the residential point-of-entry treatment systems from 2001 until the completion of the public water supply system connections in 2009. This is particularly the case in wells located north of the Facility along East Hook Cross Road and Shenandoah Road. From the observations of declining trends where they occur, it can be concluded that in the absence of significant groundwater chemical flux from the source area, concentrations within the plume at this Site will diminish with time.

In discussing these observations with the EPA, NYSDEC, NYSDOH and USGS, agreement has been reached on an approach to the conditions at this Site that entails two components. The first of these is to establish hydraulic control of the remaining source to prevent active chemical flux from the source to the plume, but more importantly to induce cleaner groundwater to flow through the remaining source material to substantially diminish primary and secondary source material. This component of the approach to this Site is being implemented as this non-time critical source removal response action based on the approved NTCSRA WP.

The second component of this approach is to address the contamination in the plume area beyond the Facility by evaluating remedial alternatives which will be presented in the FS for the Site under the current Administrative Order on Consent for RI/FS [CERCLA-02-2002-2025] which will consider monitored natural attenuation (MNA) among other remedial technologies. As such, a potential MNA remedy is one alternative that will be evaluated under the RI/FS work plan and the separate consent order that governs that process.

Based on the preceding discussion of the rationale for the approach to be taken at this Site, the goals and objectives of this NTCSRA are:

1. To reduce to the extent practicable the residual DNAPL source in fractured granitic gneiss bedrock beneath the Facility;

2. To control groundwater chemical flux from this source area to the plume until such time as the suspension of hydraulic source control will not result in increasing trends in groundwater concentrations in downgradient areas where the selected remedial alternative has been successfully applied to meeting plume remediation goals; and

3. To reduce concentrations of CVOCs in the source area groundwater by reducing the significance of mass flux from the source area to levels that will permit Federal and State groundwater cleanup standards to be met within the groundwater plume.

4. To treat extracted groundwater to within appropriate concentration limits prior to discharge of this water to the storm water catch basin on the Facility.

It is important to note that the principal goal of this NTCSRA is to reduce concentrations in the source area to levels that may still exceed applicable groundwater standards but nonetheless reduce the significance of mass flux from the source to levels that will permit such cleanup standards to be met in the plume.

Upon completion of the RI/FS, EPA will ultimately issue a Record of Decision identifying a final selected remedy for the Site. The NTCSRA will be a part of that final selected remedy.

4 DESIGN SUPPORT DATA COLLECTION AND ANALYSIS

GSC prepared and EPA approved a memorandum dated March 28, 2011 with the subject *"Final Proposed Long-term Aquifer Testing Plan, Shenandoah Road Groundwater Contamination Superfund Site"* (Testing Plan, Appendix B). The Testing Plan describes procedures to be followed in performing both a long-term constant rate aquifer test in support of the RI/FS for this Site and six weeks of long-term temporary operations to collect data to support alternatives evaluation for this NTCSRA.

Based on this Testing Plan and the NTCSRA WP, a long-term constant rate test was to be completed as a remedial investigation task prior to beginning testing in support of the NTCSRA evaluation. The constant rate test was begun on April 14, 2011. However, less than three days into that test, a 3-inch rainfall event caused more than 40 feet of recovery in the test well. After monitoring the effects of this recharge event and consulting with EPA, the decision was made to abort the long-term constant rate test and to begin the NTCSRA long-term temporary operations testing. This phase of the testing was then begun on April 19, 2011 as the initial step in implementing the NTCSRA. The first six weeks of these operations were used to collect data to support the evaluation of various alternatives for the final design of this groundwater extraction, treatment and discharge activity. That six-week testing period, divided into three steps with associated data collection, is described further in the following subsection.

4.1 Testing Design and Implementation

As noted above, the Testing Plan describes a stepwise procedure for long-term temporary operations at the Facility. For the most part this plan was followed with limited exceptions. The following paragraphs describe the sequencing that unfolded during the actual testing.

Step 1: April 19-May 2, 2011:

During the first two weeks the temporary long-term operations involved extraction solely from the SRMW-18RE open borehole with a goal of maintaining a constant pumping water level. This configuration was applied to give a better view of the maximum extraction capacity of this well and the associated hydraulic effectiveness throughout the network of water level monitoring points.

Step 2: May 2 - May 16, 2011:

At the beginning of this second step, the plan called for expanding groundwater extraction to add pumping from SRMW-18RA, -18RB, and -18RC to the extent that the water levels in these wells still showed significant remaining available drawdown. As planned, these wells were to be operated together with SRMW-18RE in a mode intended to maintain a constant pumping water level, thus maximizing the overall extraction rate. However, as will be discussed further below, limitations on the permitted discharge rate of 20 gallons per minute (gpm) required that these wells be added to the total extraction effort sequentially. Therefore, SRMW-18RA was added at the beginning of Step 2; SRMW-18RB was added two days into Step 2 and SRMW-18RC was added ten days into Step 2. As a result of this approach to completing Step 2, at no time did the total daily extraction rate exceed the 20 gpm daily discharge limit.

Step 3: May 16 - May 31, 2011:

At the end of Step 2, the plan called for evaluation of data for the first and second steps to determine the relative effectiveness of operating SRMW-18RE alone (Step 1) or this well together with some combination of the other three wells added in Step 2. Based on this analysis, it was determined that the extraction configuration for Step 3 would include operation of all four wells together, which provided the final data necessary to evaluate treatment alternatives for the NTCSRA. Since this configuration had already been initiated near the end of Step 2, the total period of operation in the Step 3 mode was 15 days from May 12, 2011 to May 27, 2011. The final four days of this final step involved the monitoring of recovery for a four-day period from May 27 - May 31, 2011.

During this step, the testing plan also called for two additional tests to be performed. One was an injection test for treated groundwater and the other was a field test of an emerging treatment technology for removal of CVOCs from groundwater (Osorb nanotechnology). Prior to implementing this three-step testing program for the NTCSRA, EPA and IBM agreed that the injection testing to evaluate an option for discharge of treated groundwater to deeper groundwater beneath the Facility would not be necessary or appropriate. It was deemed not to be necessary because the issuance of the SPDES Permit Equivalent by NYSDEC provided the necessary reassurance that discharge to surface water would be feasible. The injection testing was deemed not to be appropriate because short-term aquifer tests had revealed a degree of interconnection between shallow and deep water-bearing zones beneath the Facility that EPA believed made injection in the deepest water-bearing zone a potential negative influence on extraction from shallower water-bearing zones. Therefore, the only additional testing performed during Step 3 was the field test of the Osorb nanotechnology option for removal of CVOCs from extracted groundwater.

Throughout the period of long-term temporary operation, water level monitoring was performed in the extraction well(s) and the observation wells listed in Table 4.1 and shown on Plate 1. Transducers and data loggers were dedicated to monitor water levels in a total of seventy-eight (78) intervals at forty-four (44) well locations. These locations include twenty-one (21) wells installed as part of the remedial investigation and twenty-three (23) residential wells converted to monitoring wells. In addition to these recorded water levels, manual water levels were measured to calibrate the recorded data. Time versus groundwater elevation graphs for the wells listed in Table 4.1 are provided in Appendix C.

Table 4.1. Long-term Temporary Operations Observation Well Locations

RI Monitoring Wells		**Converted Residential Wells**	
SRMW-1RA	SRMW-15S	BRB003	SEY004
SRMW-1RB	SRMW-16R	BRB005	SEY005
SRMW-1RC	SRMW-17R	BRB006	SEY006
SRMW-2R	SRMW-18RA	BRB007	SEY007
SRMW-5R	SRMW-18RB	BRB009	SHN478
SRMW-12RA	SRMW-18RC	BRB011	SHN499
SRMW-12RB	SRMW-18RD	EHC002	SHN589
SRMW-14R	SRMW-18RF	EHC009	STN051
SRMW-14RA	SRMW-19S	EHC017	TWN134
SRMW-14RB		GRF007	
SRMW-14S		JCK117	
SRMW-15R			

Treatment of the effluent from the long-term temporary operations was accomplished by a temporary treatment system mobilized to the Facility in advance of the long-term aquifer test. This system included filtration units to remove suspended solids (two bag filters operated in series with a coarser filter followed by a finer filter) and portable GAC units to remove CVOCs (two 1000 lb canisters also operated in series). Discharge of the treated effluent was to the storm sewer system shown on Plate 1 subject to a SPDES Permit Equivalent obtained from the NYSDEC Division of Water. Discharge limits for this permit are included in Appendix A.

In addition to sampling required for the discharge permit, sampling of the treatment system influent and effluent and each extraction well was performed one day, three days, seven days, ten days and fourteen days following the beginning of each step. These samples were analyzed for CVOCs by method 8260B. The last sample collected on the final day was analyzed for the full target compound list (TCL), the full target analyte list (TAL) and the monitored natural attenuation (MNA) parameters by methods previously approved for this Site. The preliminary results of these analyses are tabulated for the combined influent and individual extraction wells in Table 4.2(a) to Table 4.2(e). Laboratory reports will be provided after the completion of data validation which could not be performed due to the short time period between field work and publishing this report.

4.2 Results of Aquifer Testing

Table 4.2(a) provides a summary of results from the implementation of the Testing Plan, including the unsuccessful long-term constant rate test and the three steps in the NTCSRA constant level testing. Time versus groundwater elevation plots for the extraction and monitoring wells in the SRMW-18R well cluster at the Facility are shown on Figure 4-1 along with timelines noting specific changes in the testing configuration. Figure 4-2 presents graphs of time versus extraction rate for each of the individual wells and the total combined extraction rate for all testing stages. These graphs are semi-log plots to make it possible to display the low extraction rate for SRMW-18RA together with the much higher rates for the other wells and the total.

4.2.1 Constant Rate Test

As shown in Table 4.2(a) and Figure 4-2, the SRMW-18RE extraction rate during the constant rate test was held at a nominal rate of 12 gpm until that test was aborted on April 19, 2011. Figure 4-1 shows that during that segment of testing the water levels in the extraction well and the adjacent monitoring wells all drew down and then recovered substantially in response to the recharge event associated with rainfall on April 16th. Water quality results in Table 4.2(e) show that PCE concentrations at the beginning of the constant rate test were comparable to those observed during the short-term test in this well, i.e., 20-46 ug/L. However, by the time the constant rate test was aborted, the PCE concentrations in this well had increased to between 68 and 94 ug/L.

Table 4.2(a) Summary of Facility Aquifer Tests Analytical Monitoring Results: Combined Influent
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 13-Jun-11

Test Location	Well Configuration	Test Rate (avg gpm)	Sample Collection	Minutes Elapsed	Elapsed Time (hours)	TCL VOC 8260B Results (ug/L)		
						PCE	TCE	c12-DCE
SRMW-18RE	SRMW-18RE only	12 gpm	4/14/2011 11:57	57	1	20	ND@ 1	ND@ 1
(Constant Rate)	*data is from SRMW-18RE*	12.00 gpm	4/15/2011 10:50	1430	24	33	ND@ 1	ND@ 1
Long-term Test	*Combined Influent Not Sampled*	12.01 gpm	4/16/2011 10:34	2854	48	46	ND@ 1	ND@ 1
		11.96 gpm	4/17/2011 10:42	4302	72	78 / 82	0.33 J / 0.33 J	ND@ 1
Start of Test:		11.98 gpm	4/18/2011 10:43	5743	96	68	0.23 J	ND@ 1
4/14/2011 11:00		11.94 gpm	4/19/2011 10:33	7173	120	94 / 85	0.32 J / 0.29 J	ND@ 1
Combined Influent	SRMW-18RE only	17.60 gpm	4/20/2011 10:56	1084	18	150	ND@ 2	ND@ 2
(Constant Level)	SRMW-18RE only	19.26 gpm	4/21/2011 10:46	2514	42	250	0.74 J	ND@ 3.3
Long-term Test	SRMW-18RE only	18.78 gpm	4/22/2011 11:38	4006	67	360	1.1 J	ND@ 4
	SRMW-18RE only	17.70 gpm	4/25/2011 13:22	8430	141	590 / 610	1.8 J / 1.8 J	ND@ 6.3 / ND@ 6.3
Start of Test:	SRMW-18RE only	17.20 gpm	4/28/2011 14:02	12790	213	690 / 770	ND@ 8.8 / ND@ 8.8	ND@8.8 / ND@ 8.8
4/19/2011 16:52	SRMW-18RE only	16.60 gpm	5/2/2011 11:45	18413	307	750	2.6 J	ND@ 8.8
	18RE & 18RA	16.62 gpm	5/3/2011 1:34	19242	321	750	2.6 J	ND@ 8.8
	18RE, 18RA and 18RB	18.62 gpm	5/5/2011 12:49	22797	380	750	2.7 J	ND@ 9.2
	18RE, 18RA, 18RB and 18RC	16.04 gpm	5/12/2011 1:48	32216	537	760	3.2 J	ND@ 10
	18RE, 18RA, 18RB and 18RC	16.63 gpm	5/19/2011 2:20	42328	706	840	4.6 J	ND@ 11
	18RE, 18RA, 18RB and 18RC	18.95 gpm	5/23/2011 3:09	48137	802	650	3.5 J	ND@ 8.0
	18RE, 18RA, 18RB and 18RC	18.94 gpm	5/26/2011 15:31	53199	887	620	3.7 J	ND@ 8.0
	18RE, 18RA, 18RB and 18RC	18.39 gpm	5/27/2011 10:00	54308	905	1300	ND@ 16	ND@ 16

Note: Where the influent to the treatment system was only SRMW-18RE, no combined influent sample was collected and the data presented in the table is from SRMW-18RE.

Table 4.2(b) Summary of Facility Aquifer Tests Analytical Monitoring Results: SRMW-18RA
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 13-Jun-11

Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Test Rate (avg gpm)	Sample Collection	Minutes Elapsed	Elapsed Time (hours)	TCL VOC 8260B Results (ug/L) PCE	TCE	c12-DCE
SRMW-18RE	WBZ A	75	Single Packer Installation	0.5 gpm			@ 1 hour	90	ND@ 1	ND@ 1
	(Constant Rate)		Top Packer @ 88 ft bgs				@ 12 hours	120	ND@ 1	ND@ 1
	Short Term Test		Bottom of Packer @ 93 ft bgs				@ 24 hours	120	ND@ 1	ND@ 1
	24 hours		*Perf Pipe @ 88 - 83 ft bgs*							
			Pump Intake @ 83 ft bgs							
SRMW-18RA	WBZ A (actual)	75	No Packer Installed	0.5 gpm			@ 1 hour	16000 / 16000	ND@220 / ND@200	ND@220 / ND@200
	Constant Rate		*Pump Intake @ 73.7 ft bgs*				@ 5hrs 20min	15000	ND@ 200	ND@ 200
	Short Term Test						@ 7hrs 30min	16000	ND@ 200	ND@ 200
	~8 hours									
SRMW-18RA	WBZ A (actual)	75	No Packer Installed	0.18 gpm	5/3/2011 13:39	1464	24	10000	ND@ 110	ND@ 110
	(Constant Level)		*Pump Intake @ 74 ft bgs*	0.26 gpm	5/5/2011 12:54	4299	72	12000	ND@ 130	ND@ 130
	Long Term Test			0.17 gpm	5/9/2011 13:23	10088	168	10000 / 11000	ND@ 130	ND@ 130
				0.14 gpm	5/12/2011 13:50	14435	241	12000	ND@ 130	ND@ 130
Start of Test:				0.12 gpm	5/16/2011 15:27	20292	338	9700	ND@ 130	ND@ 130
5/2/2011 13:15				0.13 gpm	5/19/2011 14:35	24560	409	9700	ND@ 130	ND@ 130
				0.15 gpm	5/23/2011 15:17	30362	506	9900	ND@ 120	ND@ 120
				0.15 gpm	5/26/2011 15:37	34702	578	9000	ND@ 130	ND@ 130
				0.13 gpm	5/27/2011 12:00	35925	599	10000	ND@ 130	ND@ 130

Table 4.2(c) Summary of Facility Aquifer Tests Analytical Monitoring Results: SRMW-18RB
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 13-Jun-11

Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Test Rate (avg gpm)	Sample Collection	Minutes Elapsed	Elapsed Time (hours)	TCL VOC 8260B Results (ug/L)		
								PCE	TCE	c12-DCE
SRMW-18RE	WBZ B	127 - 130	Straddle Packer	3 gpm			@ 1 hour	4.8 / 4.7	ND@1 / ND@1	ND@1 / ND@1
			Top Packer @ 118-123 ft bgs				@ 12 hours	11	ND@ 1	ND@ 1
			Open Interval @ 123-133 ft bgs				@ 24 hours	27	ND@ 1	ND@ 1
			bottom 5ft section perf pipe							
			Bottom Packer @ 133-138 ft bgs							
			Pump Intake @ 126 ft bgs							
SRMW-18RB	WBZ B (actual)	127 -130	No Packer Installed	3.70 gpm	5/5/2011 12:52	1417	24	490 / 480	ND@ 5.9 / ND@ 6.3	ND@ 5.9 / ND@ 6.3
	(Constant Level)		*Pump Intake @ 126 ft bgs*	4.72 gpm	5/7/2011 10:47	4172	70	470	ND@ 6.0	ND@ 6.0
	Long Term Test			3.82 gpm	5/11/2011 14:02	10127	169	570	ND@ 8.0	ND@ 8.0
				3.76 gpm	5/12/2011 13:46	11551	193	610	ND@ 8.0	ND@ 8.0
				3.50 gpm	5/14/2011 10:30	14235	237	1900	9.5 J	ND@ 22
				3.40 gpm	5/16/2011 14:50	17375	290	620	ND@ 8.0	ND@ 8.0
				3.19 gpm	5/19/2011 14:25	21670	361	700	ND@ 8.8	ND@ 8.8
				3.67 gpm	5/23/2011 15:15	27480	458	630	ND@ 8.0	ND@ 8.0
Start of Test:				3.74 gpm	5/26/2011 15:35	31820	530	610	ND@ 8.0	ND@ 8.0
5/4/2011 13:15				3.70 gpm	5/27/2011 10:45	32970	550	620	ND@ 8.0	ND@ 8.0

Table 4.2(d) Summary of Facility Aquifer Tests Analytical Monitoring Results: SRMW-18RC
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 13-Jun-11

Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Test Rate (avg gpm)	Sample Collection	Minutes Elapsed	Elapsed Time (hours)	TCL VOC 8260B Results (ug/L)		
								PCE	TCE	c12-DCE
SRMW-18RE	WBZ C	230 - 250	Single Packer Installation	5 gpm			@ 1 hour	58 / 57	0.28 J / 0.31 J	1.1 / 1.1
			Packer Top @ 225 ft bgs				@ 12 hours	74	0.44 J	0.87 J
			Packer Bottom @ 228.5 ft bgs				@ 24 hours	150	0.68 J	ND@1
			Pump Intake @ 228 ft bgs							
SRMW-18RC	WBZ C (actual)		No Packer Installed	4.80 gpm	5/13/2011 10:50	1220	20	1900 / 2000	8.3 J / 8.8 J	ND@ 22 / ND@ 22
	(Constant Level)		*Pump Intake @ 228 ft*	4.90 gpm	5/15/2011 11:08	4118	69	1900	8.7 J	ND@ 22
	Long-term Test			5.07 gpm	5/19/2011 14:22	10072	168	1700 / 1900	9.0 J / 9.2 J	ND@ 20 / ND@20
				5.24 gpm	5/23/2011 15:13	15883	265	1500	8.3 J	ND@ 18
Start of Test:				meter stalled	5/26/2011 15:34	20224	337	1500	8.6 J	ND@ 18
5/12/2011 14:30				meter stalled	5/27/2011 11:30	21420	357	1500	ND@ 16	ND@ 16

Table 4.2(e) Summary of Facility Aquifer Tests Analytical Monitoring Results: SRMW-18RE
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 13-Jun-11

Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Test Rate (avg gpm)	Sample Collection	Minutes Elapsed	Elapsed Time (hours)	TCL VOC 8260B Results (ug/L)		
								PCE	TCE	c12-DCE
SRMW-18RE	open borehole		No Packer Installed	13 gpm			1	30 / 27	ND@ 1	ND@ 1
	(Constant Rate)		*Pump Intake @ 220 ft bgs*				12	35	ND@ 1	ND@ 1
	Short-term Test						20	46	ND@ 1	ND@ 1
SRMW-18RE	open borehole		No Packer Installed	12 gpm	4/14/2011 11:57	57	1	20	ND@ 1	ND@ 1
	(Constant Rate)		*Pump Intake @ 220 ft bgs*		4/15/2011 10:50	1430	24	33	ND@ 1	ND@ 1
	Long-term Test				4/16/2011 10:34	2854	48	46	ND@ 1	ND@ 1
					4/17/2011 10:42	4302	72	78 / 82	0.33 J / 0.33 J	ND@ 1
Start of Test:					4/18/2011 10:43	5743	96	68	0.23 J	ND@ 1
4/14/2011 11:00					4/19/2011 10:33	7173	120	94 / 85	0.32 J / 0.29 J	ND@ 1
SRMW-18RE	open borehole		No Packer Installed	17.5 gpm	4/20/2011 10:56	1084	18	150	ND@ 2	ND@ 2
	(Constant Level)		*Pump Intake @ 220 ft bgs*	19.3 gpm	4/21/2011 10:46	2514	42	250	0.74 J	ND@ 3.3
	Long-term Test			18.8 gpm	4/22/2011 11:38	4006	67	360	1.1 J	ND@ 4
				17.6 gpm	4/25/2011 13:22	8430	141	590 / 610	1.8 J / 1.8 J	ND@ 6.3 / ND@ 6.3
Start of Test:				17.2 gpm	4/28/2011 14:02	12790	213	690 / 770	ND@ 8.8 / ND@ 8.8	ND@8.8 / ND@ 8.8
4/19/2011 16:52				16.1 gpm	5/2/2011 11:45	18413	307	750	2.6 J	ND@ 8.8
				16.3 gpm	5/3/2011 13:36	19964	333	770	2.8 J	ND@ 8.8
				12.0 gpm	5/5/2011 12:51	22799	380	700	2.7 J	ND
				12.0 gpm	5/12/2011 13:45	32933	549	1100	5.4 J	ND@ 13
				8.1 gpm	5/16/2011 14:00	38708	645.2	310	2.3 J	ND@ 4.0
				8.2 gpm	5/19/2011 14:30	43058	717.7	180	1.3 J	ND@ 2.5
				9.9 gpm	5/23/2011 15:11	48859	814.4	150	1.3 J	ND@ 2.0
				meter stalled	5/26/2011 15:31	53199	886.7	160	1.3 J	ND@ 2.2
				meter stalled	5/27/2011 10:00	54308	905.2	320	3.6 J	ND@ 4.0

4.2.2 NTCSRA Step 1 Testing

As noted previously, when the constant rate test was aborted, the decision was made to start the NTCSRA constant level testing. To initiate the first step in this stage of the testing, the extraction rate at SRMW-18RE was increased from 12 gpm to a maximum rate of 19.26 gpm on April 21, 2011 (Table 4.2(a) and Figure 4-2). At the conclusion of Step 1, the extraction rate of SRMW-18RE had declined to 16.6 gpm and the pumping water level was at approximately 210.5 ft bgs with the pump intake set at 220 ft. Samples were collected at the pumping well on five occasions during the test for analysis of CVOCs and just prior to the end of this step, on Monday May 2, for the full TCL/TAL list plus MNA parameters. As shown on Table 4.2(a), the PCE concentrations in extraction well SRMW-18RE increased over the interval of this step from 150ug/L to 750 ug/l. Given the 13 feet of drawdown that had occurred in SRMW-RA from the beginning of the constant rate test to the end of Step 1 (see graph in Appendix C) and the much higher concentrations previously observed in this well, this increase in PCE concentration in SRMW-18RE is attributed to groundwater extraction in this well not only drawing groundwater directly from the shallow water-bearing zone open in both SRMW-18RA and SRMW-18RE, but also to an induced downward vertical gradient between the shallowest water-bearing zone monitored in SRMW-18RA and the deeper water-bearing zones open in SRMW-18RE and discretely monitored in SRMW-18RB and SRMW-18RC. The combined extraction rate and PCE concentration at the end of Step 1 would correspond to an annual mass removal rate of approximately 55 pounds (lbs) of PCE if both were sustained over the long term.

4.2.3 NTCSRA Step 2 Testing

As detailed in the approved Testing Plan, Step 2 of the testing included the pumping of SRMW-18RE together with additional wells within the facility area. Based on previous short-term testing, anticipated rates for this next step included: 12 gpm for the SRMW-18RE open borehole; 0.3gpm for SRMW-18RA; 2.7gpm for SRMW-18RB and; 5 gpm for SRMW-18RC for a total of 20gpm. This total extraction rate constituted the average daily discharge rate specified in the application to the New York State Department of Environmental Conservation (NYSDEC) for a SPDES Discharge Equivalent Permit.

On April 26, due to a substantial increase in available drawdown and associated well yields in all of the wells resulting from the major recharge event on April 16th, a request was submitted to NYSDEC for modification of the SPDES Discharge Equivalent Permit that would include an increase in the daily maximum discharge limit from 28,800 gpd (20 gpm) to 30gpm, or 43,200 gpd. As noted in the request to NYSDEC, the additional capacity was necessary to provide a better understanding of the hydraulic effectiveness of pumping from the multiple well configurations under the altered hydrologic conditions.

As of the start of Step 2 on Monday, May 2nd, the pumping rate at SRMW-18RE was 16.6 gpm, a higher sustained rate than anticipated. As a result of this sustained higher rate and in the absence of approval to discharge at a higher daily maximum, other facility wells were started incrementally until such time as the water levels in the aquifer and associated extraction rates declined to more normal conditions.

As reflected on Figures 4-1 and 4-2, the startup of the additional extraction wells was done sequentially rather than at one time to avoid exceeding the maximum permitted daily discharge rate. Therefore, at 13:15 on Monday May 2nd, SRMW-18RA was started. Over the first 48 hours of pumping at this location, the average pumping rate for SRMW-18RA was approximately 0.3 gpm. The pumping rate for SRMW-18RE was an average of 16.3 gpm for the same period. With anticipated favorable conditions for startup, as of 13:15 on May 4th, SRMW-18RB was started. Within the first hour of operation of SRMW-18RB, the pump at SRMW-18RE began to cycle and the water level in SRMW-18RB drew down almost 25 feet to approximately 100 ft bgs. The pump intake for SRMW-18RB is at 126 ft. bgs. Startup of SRMW-18RC proceeded on Thursday, May 12th when conditions were deemed to be such that the overall extraction rate of the four wells would not exceed the maximum daily flow rate of 28,800 gpd (20 gpm). Each of these startup timelines is shown on Figures 4-1 and 4-2.

By the end of Step 2, Tables 4.2(a) shows that the total influent concentration of PCE had increased only slightly to 760 ug/L. For the individual wells, Tables 4.2(b) to 4.2(e) indicate PCE concentrations had declined slightly in SRMW-18RA to 9700 ug/L; increased in SRMW-18RB to 620 ug/L compared to 27 ug/L at the conclusion of the short-term test; increased to 1900 ug/L in SRMW-18RC compared to 150 ug/L at the conclusion of the short-term test; and decreased to 310 ug/L in SRMW-18RE compared to 750 ug/L at the end of Step 1. The last of these changes appears to be coincident with the substantial concentration increase at SRMW-18RC upon startup of this well in Step 2.

At the conclusion of Step 2, the combination of a 16 gpm total extraction rate and total influent concentration of 760 ug/L would correspond to an annual mass removal rate of approximately 53 pounds (lbs) of PCE if both were sustained over the long term. This calculated mass removal rate is comparable to the rate calculated at the end of Step 1.

4.2.4 NTCSRA Step 3 Testing

As mentioned previously, the extraction configuration for Step 3 was determined on the basis of the results of Steps 1 and 2 to include extraction from all four wells instead of from just SRMW-18RE. This configuration was chosen because it results in a modest increase in the overall extraction rate as shown on Figure 4-2, but also greater reduction in head potential within all three water-bearing zones.

The plots on Figure 4-1 show that following the startup of SRMW-18RC on May 12th, pumps in all four wells were cycling and maintaining pumping water levels within narrow elevation ranges just above the lowest water-bearing zone in each well. Table 4.2(a) shows that the combined extraction rate for Step 3 began at 16 gpm and increased to nearly 19 gpm following a second recharge event on May 17th and 18th. This increase is also apparent on Figure 4-2. At the end of this step, the extraction rate had decreased to 18.4 gpm.

Tables 4.2(b) through 4.2(e) show that over the course of Step 3, the PCE concentration in SRMW-18RA was relatively stable between 9000 and 10,000 ug/L; the PCE concentration in SRMW-18RB was stable at around 620 ug/L; the PCE concentration at SRMW-18RC was stable at 1500 ug/L; and the concentration at SRMW-18RE had decreased from 1100 ug/L at the end of Step 2 to 320 ug/L at the end of Step 3. However, the total combined flow had increased from 16 gpm at the end of Step 2 to 18.4 gpm at the end of Step 3 and the combined influent PCE concentration had increased from 760 ug/L at the end of Step 2 to 1300 ug/L at the end of Step 3 (Table 4.2(a)). The combination of this extraction rate and PCE concentration represents a calculated mass removal rate of 105 lbs per year.

Step 3 concluded on May 27 with the collection of full TCL/TAL plus MNA parameters from each of the four pumping wells. Following sample collection, the system was shut down and recovery was monitored from May 27th through June 1st, when data from all of the observation wells was downloaded.

4.3 Hydraulic Effectiveness of Groundwater Extraction

To achieve the objective of this removal action of controlling groundwater chemical flux from the source area beneath the Facility into the plume area, it is necessary to depress groundwater elevations in the source area and to thereby establish a capture zone that encompasses the entire source of PCE. One purpose of the NTCSRA testing was to provide data on the response of water levels in the bedrock beneath and surrounding the Facility to demonstrate the hydraulic effectiveness of the various groundwater extraction configurations. Based on the preceding discussion of the stepwise testing that was performed and the plots of water level responses in individual wells (Appendix C), it is apparent that the extraction configuration that includes all four wells provided the most robust response in the surrounding aquifer.

To demonstrate the extent of capture afforded by this extraction configuration, six plates have been prepared. Plates 2 and 3 are plan view and cross section views of groundwater elevation contours drawn on the basis of water levels observed just before the beginning of the constant rate test on April 14, 2011. Plates 4 and 5 are postings of maximum drawdown and five-day recovery in all wells monitored during the testing. Finally, Plates 6 and 7 are plan view and cross section views of groundwater elevation contours drawn on the basis of water levels observed at the time of maximum drawdown on May 17, 2011. For both of the plan views that show groundwater elevation contours, the values used for the contouring are highlighted in yellow. In general the values selected from multiple water-bearing zones were the lowest groundwater elevations at each location. For open hole wells with composite water levels, an attempt was made to use the results of logging by the USGS to determine at what depth to assign the groundwater elevation in cross section view, which also affected how that value was used in plan view contouring. An example is BRB009, where the composite water level was assigned to the deepest water-bearing zone based on vertical upward flow in the borehole observed during logging and the fact that the well was flowing artesian at the time of the test.

Plates 2 and 3 depict groundwater elevation contours and associated flow patterns prior to the testing. The combination of these views indicates potential for groundwater flow away from the Facility to the north, east and south. Flow to the west is apparently prohibited by a groundwater divide positioned beneath the ridge to the west of the Facility as reflected in water levels observed in observation well EHC017. The pattern of steeper groundwater gradients along the west side of Burbank Road and the relative response in wells east and west of this road to pumping at the

Facility suggest the potential presence of a normal fault running parallel to Burbank Road with granitic gneiss on both the upthrown and downthrown sides of the fault.

Plates 4 and 5 show both plan view and cross section views of the maximum drawdown and recovery observed during the three steps of the NTCSRA testing. These observations were reviewed together with the time versus water level plots for each observation well (Appendix C) to identify those locations and intervals that exhibited responses to the extraction of groundwater at the Facility. The monitoring intervals that were identified in this manner have been highlighted on both of these plates. Notably they include all of the monitoring intervals at the Facility regardless of depth, three open hole observation wells to the north and northwest of the extraction wells (SRMW-1RC, EHC009 and EHC017), STN051 to the south of the facility and the deeper monitoring interval at EHC-002 north of the Facility. This last interval was identified as having responded to the testing based in part on the observed drawdown of more than four feet, but also because of the pattern of the response seen following shutdown. In this regard, the graph for this well in Appendix C shows that immediately following shutdown the water level in this well continued to draw down when other wells affected by the testing immediately began recovery. However, unlike other wells that showed no drawdown attributable to the testing, the water level in this interval began rising late in the five-day recovery period indicating a likely delayed recovery following the shutdown. Finally, these observations show that all of the intervals monitored in wells along the west side of Burbank Road, with the exception of the shallow interval at BRB011, showed definite responses to the testing. By contrast, none of the wells on the east side of Burbank Road exhibited any response to the testing, including all intervals in SRMW-17 located in the cul-de-sac. These observations support the inference of a fault running parallel to Burbank Road, causing some hydraulic separation within the granitic gneiss aquifer across this fault line. This conclusion is further supported by the fact that the highest concentrations of PCE in the residential well sampling program were located in wells along the west side of Burbank Road and a significant drop in concentrations occurred in wells on the east side of this road.

Finally, Plates 6 and 7 show groundwater elevation contours based on observations made on May 17, 2011 at the time of maximum drawdown in monitoring wells at the Facility and beyond. The combination of the plan view on Plate 6 and the cross sections shown on Plate 7 provide a three dimensional delineation of the capture zone associated with the Step 3 extraction configuration. As shown, this capture zone encompasses all of the wells in the SRMW-18R cluster, virtually all of the converted residential wells along the west side of Burbank Road. Together this group of wells on the Facility and Burbank Road exhibit the highest maximum concentrations of PCE at the Site. In addition to including these wells, the capture zone extends south from the Facility to well STN051.

4.4 Osorb Nanotechnology Field Testing

As detailed in the approved Long-Term Aquifer Testing memo, Step 3 included flow-through testing of an alternate treatment technology, Osorb VOCeater (Osorb) by ABSMaterials (ABS). Osorb is a highly structured nano-scale glass material which instantaneously swells when it comes in contact with organic compounds. The Osorb is arranged in packed, flow-through columns. ABS uses different catalysts (in this case palladium) in conjunction with the Osorb base material to manufacture application specific media. Hydrogen gas is injected into the influent water upstream of the media and the embedded catalyst allows the reduction reactions to take place, ultimately converting CVOCs to ethane and chloride ions. The hydrogen serves as an electron donor to aid dechlorination of the CVOCs. Palladium is present in the packed columns to act as a catalyst. Ethane is a byproduct of the treatment process.

As noted previously, during the last four days of Step 2 and throughout Step 3, the configuration of the pumping system was maintained from May 12th to May 27th, with each well pumped to a constant level (cycling). During this time period, tests were performed of the Osorb system on three separate dates. A short term (approximately 500 gallons) flow-through test was conducted on May 18th. A follow-up step testing of several treatment column configurations and flow rates was conducted on May 25th, followed by a second flow-through test on May 26th.

4.4.1 Initial Flow-Through Test: May 18, 2011

The initial flow-through test of the Osorb technology was performed on May 18, 2011 using a three packed column configuration. As shown in Table 4.3(a), the flow rate was maintained at just over 4 gpm and samples of the influent and effluent water quality were collected during three segments of the overall 500 gallon test. The results in Table 4.3(a) indicate that influent PCE concentrations ranged from 750 - 970 ug/L, and trichloroethene (TCE) levels ranged from 3.8-3.9 ug/L. No other CVOCs were detected in the influent. The effluent results following treatment indicate reduction of PCE concentrations to a range of 10 - 53 ug/L, which did not meet the effluent criteria for the SPDES Equivalent Permit of ND@1ug/L. Furthermore the effluent data in Table 4.3(a) indicate that the concentrations of TCE increased to a range of 9.1 - 12 ug/L.

Table 4.3(a): Summary of Osorb Flow Through Test Analytical Monitoring Results
Shenandoah Road Groundwater Contamination Superfund Site
Date of Testing: 18-May-11

Last Updated: 13-Jun-11

Sample ID	Sample Date	Total Gals Thru System	Flow Thru Rate	Combined Influent PCE ug/l	Combined Influent TCE ug/l	Combined Influent cis-12-DCE ug/l	Combined Influent Chloroethane ug/l	Combined Influent Ethane ug/l	Osorb Effluent PCE ug/l	Osorb Effluent TCE ug/l	Osorb Effluent cis-12-DCE ug/l	Osorb Effluent Chloroethane ug/l	Osorb Effluent Ethane ug/l
A	5/18/2011	100 - 125 gals	4.18 gpm	790	3.8 J	10 U	10 U	4.0 U	10	9.1	5.5 U	5.5 U	5.2
B	5/18/2011	305 - 360 gals	4.3 gpm	970	3.9 J	11 U	11 U	4.0 U	51	12	0.59 J	0.45 J	4.0 U
C	5/18/2011	435 - 478 gals	4.27 gpm	750	3.8 J	10 U	10 U	4.0 U	53	12	0.55 J	0.38 J	4.0 U

Table 4.3(b): Summary of Osorb Configuration / Step Test Analytical Monitoring Results
Shenandoah Road Groundwater Contamination Superfund Site
Date of Testing: 25-May-11

Last Updated: 13-Jun-11

Treatment System Configuration	Sample Date	Flow Thru Rate	Combined Influent PCE ug/l	Combined Influent TCE ug/l	Combined Influent cis-12-DCE ug/l	Combined Influent Chloroethane ug/l	Combined Influent Ethane ug/l	Osorb Effluent PCE ug/l	Osorb Effluent TCE ug/l	Osorb Effluent cis-12-DCE ug/l	Osorb Effluent Chloroethane ug/l	Osorb Effluent Ethane ug/l
3 VOCeater Columns (re-packed)	5/25/2011	4 gpm	660	3.8 J	ND@ 8.0	ND@ 8.0	ND@ 4.0	8.4	9.8	0.59 J	0.53 J	ND@ 4.0
	5/25/2011	3 gpm						7.3	9.3	0.57 J	0.49 J	ND@ 4.0
	5/25/2011	2 gpm						4.5	8.1	ND@ 1.0	0.50 J	ND@ 4.0
4 VOCeater Columns (3 re-packed + 1 new)	5/25/2011	4 gpm	660	3.6 J	ND@ 8.0	ND@ 8.0	ND@ 4.0	3.4	5.9	0.34 J	0.38 J	ND@ 4.0
	5/25/2011	3 gpm						3.1	5.7	0.35 J	0.36 J	ND@ 4.0
	5/25/2011	2 gpm						2.3	5.2	ND@ 2.0	ND@ 2.0	ND@ 4.0
3 VOCeater Columns (re-packed) + 1 enhanced Column	5/25/2011	4 gpm	580	3.3 J	ND@ 8.0	ND@ 8.0	ND@ 4.0	4.1 J	6.6 J	ND@ 8.8	ND@ 8.8	ND@ 4.0
	5/25/2011	3 gpm						4.6 J	6.0 J	ND@ 8.8	ND@ 8.8	ND@ 4.0
	5/25/2011	2 gpm						2.9 J	5.8 J	ND@ 8.8	ND@ 8.8	ND@ 4.0

Table 4.3(c): Summary of Osorb Flow Through Test Analytical Monitoring Results
Shenandoah Road Groundwater Contamination Superfund Site
Date of Testing: 26-May-11

Last Updated: 13-Jun-11

Sample ID	Sample Date	Total Gals Thru System	Flow Thru Rate	Combined Influent PCE ug/l	Combined Influent TCE ug/l	Combined Influent cis-12-DCE ug/l	Combined Influent Chloroethane ug/l	Combined Influent Ethane ug/l	Osorb Effluent PCE ug/l	Osorb Effluent TCE ug/l	Osorb Effluent cis-12-DCE ug/l	Osorb Effluent Chloroethane ug/l	Osorb Effluent Ethane ug/l
B	5/26/2011	24 - 40 gals	4.12 gpm	640	3.5 J	ND@ 8.0	ND@ 8.0	4.0 U	11	9.0	ND@ 1.0	0.36 J	4.0 U
C	5/26/2011	116 - 129 gals	3.99 gpm	940	3.8 J	ND@ 12	ND@ 12	4.0 U	28	10	0.51 J	ND@ 1.0	4.0 U
D	5/26/2011	235 - 250 gals	4.16 gpm	600	3.5 J	ND@ 8.0	ND@ 8.0	4.0 U	35	10	0.49 J	ND@ 1.0	4.0 U

Notes: *TCL VOC analysis by 8260B*
Dissolved Gases by RSK 175

4.4.2 Step Test: May 25, 2011

Following receipt of the results of the initial flow-through testing, ABS prepared a plan to test multiple column configurations including: three repacked VOCeater columns; four VOCeater columns (three repacked and one new); and three repacked VOCeater columns plus one enhanced column. Each of these three configurations was tested at flow rates of 2 gpm, 3 gpm, and 4 gpm.

Table 4.3(b) presents the results of influent and effluent sampling for all nine combinations of flow rate and configuration. From this table it can be seen that none of the configurations was successful in treating the groundwater to less than 1 ug/L and all of them resulted in increased TCE concentrations in the effluent. The best results were achieved by the four-column configuration at 2 gpm, with an effluent PCE concentration of 2.3 ug/L and TCE of 5.2 ug/L. The four-column configuration with one enhanced column did not achieve results as good as those from the four standard column configuration.

4.4.3 Final Flow-Through Test: May 26, 2011

After running samples from the previous day's testing in their in-house lab, ABS decided to run the final flow-through test at 4 gpm using a three-column configuration. They did not have the benefit of the sample results received later by GSC and published in Table 4.3(b). These results indicate that the three-column configuration at 4 gpm gave the poorest performance of the nine combinations tested.

Table 4.3(c) provides the results of the final flow-through test. As in the case of the first flow-through test, sampling was performed at three intervals during the test. The influent data indicates concentrations of PCE ranged from 640 - 940 ug/L. The initial results for PCE and TCE were 11 ug/L and 9 ug/L, respectively. However, the PCE concentration increased in the next two samples to 28 and 35 ug/L, with TCE in both samples at 10 ug/L compared to 3.5 to 3.8 in the influent. Therefore, in all of the fifteen rounds of influent and effluent sampling of the Osorb technology, not a single one produced results that met the discharge limit of 1 ug/L and they all showed an increase in the TCE concentration following treatment. By contrast, all effluent results from the carbon treatment units during all stages of the NTCSRA testing were ND@1ug/L for all CVOCs.

4.5 Determination of Design Influent Flow and Water Quality

The results of the NTCSRA testing described in this section have been used to determine the influent water quality and flow to be used in developing and evaluating treatment alternatives. Based on the data presented in Table 4.2(a) for the four extraction well configuration, the maximum and average influent PCE design concentrations have been determined to be 1500 ug/L (1300 ug/L x a 1.15 safety factor) and 1000 ug/L (roughly the average of the values with all four wells pumping, 850 ug/L x a 1.15 safety factor), respectively.

Since GSC could not test the combined yield of these four wells above the 20 gpm daily discharge limit, it is not possible to take the maximum extraction rate from the test data for this design assumption. Nonetheless, it is apparent from the observations made during this test, including responses to two recharge events, that the maximum rate will be much greater than 20 gpm, and there is good reason to believe it will be on the order of the 30 gpm rate requested as a modification to the SPDES Equivalent Permit. Since this modification was approved on May 26, 2011, it will be possible during upcoming temporary operations to better determine the maximum combined yield of these wells. However, for the purposes of the alternatives discussion in the next section, it is reasonable to assume a maximum extraction rate of 30 gpm. The average extraction rate measured with all four wells pumping was 17.8 gpm. With a safety factor of 1.15, the average design rate is estimated to be 20 gpm.

Therefore, to determine the most extreme conditions for which instantaneous treatment efficiency must achieve ND@1ug/L, it is necessary to combine the maximum anticipated flow with the maximum anticipated concentration, or 30 gpm at 1500 ug/L. Assumptions regarding the total mass of PCE to be removed from groundwater, which will primarily affect carbon consumption rates, would combine the average extraction rate with the average PCE concentration, or 20 gpm at 1000 ug/L. If these averages are achieved, the total PCE mass removal rate would be on the order of 90 lbs per year, which would serve to achieve the NTCSRA objective of source reduction.

5 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

As a result of the selection of groundwater extraction as the technology to be applied to achieving source reduction and source control at the Facility, the only technology options identified in the NTCSRA WP in formulating alternatives for this response action are those that relate to the treatment of the extracted groundwater and the mode and receptor for the discharge of the treated groundwater. In this case, even the extraction wells to be used have been identified (i.e., SRMW18RA, RB, RC, and RE, Plate 1).

With regard to the treatment options, water quality data acquired to date indicates that treatment is likely to be required only to remove CVOCs and to reduce total suspended solids (TSS) which may otherwise contribute to unacceptable levels of total metals. Filtration has been selected as the technology to be applied to removal of suspended solids based on analyses of influent and effluent samples collected across bag filters in place during short-term aquifer tests. There is, therefore, no distinction among alternatives with respect to technology options for removal of TSS.

Two options were identified in the NTCSRA WP for discharge of treated groundwater. These were discharge to storm water/surface water and discharge to groundwater. Following the decision by NYSDEC to issue a SPDES Equivalent Permit for discharge to storm water/ surface water, the option for discharge to groundwater was eliminated.

Therefore, the only technology options that remain to be evaluated are those relating to the removal of CVOCs from contaminated groundwater. Three technologies have been identified to achieve this objective. These are: aqueous phase granular activated carbon (GAC), air stripping with vapor phase GAC and Osorb nanotechnology.

5.1 Identification of Alternatives

With options existing only for the selection of the treatment technology to remove CVOCs, the available alternatives to be evaluated have been condensed to the following:

- Alternative #1: Groundwater extraction from vertical well(s) with treatment to remove suspended solids by filtration and to remove CVOCs by adsorption on granular activated carbon (GAC), with discharge of treated groundwater to surface water and monitoring of groundwater quality at selected monitoring wells.

- Alternative #2: Groundwater extraction from vertical well(s) with treatment to remove suspended solids by filtration and to remove CVOCs by counter-current air stripping with off-gas treatment using vapor phase GAC, with discharge of treated groundwater to surface water and monitoring of groundwater quality at selected monitoring wells.

- Alternative #3: Groundwater extraction from vertical well(s) with treatment to remove suspended solids by filtration and to remove CVOCs using Osorb nanotechnology, with discharge of treated groundwater to surface water and monitoring of groundwater quality at selected monitoring wells.

Since the only difference among these three alternatives is the CVOC treatment technology, the following subsections describe each of these three treatment alternatives. All of these alternatives will involve extraction from four wells, conveyance of the contaminated groundwater through double-walled pipe to the treatment building, which will have a footprint of 12 feet by 20 feet with a ceiling height of 10 feet, discharge of the treated groundwater through a single-walled discharge pipe to the Facility storm sewer and monitoring of groundwater quality at the locations and frequencies identified in Table 5.1 and shown on Figure 5-1.

Table 5.1. Long-term NTCSRA Monitoring Well Program

Extraction Wells[1]	**RI Monitoring Wells**[2]	**Converted Residential Wells**[2]	
SRMW-18RA	SRMW-1RC	BRB003	BRB011 (2 intervals)
SRMW-18RB	SRMW-17R (7 ports)	BRB005 (2 intervals)	EHC002 (2 intervals)
SRMW-18RC	SRMW-18RD	BRB006	EHC009
SRMW-18RE	SRMW-18RF (2 ports)	BRB007 (2 intervals)	EHC017
		BRB009	STN051 (2 intervals)

[1]Extraction wells to be sampled monthly and analyzed for CVOCs throughout the NTCSRA period.

[2]RI Monitoring wells and Converted residential wells to be sampled quarterly in years 1-5 and semiannually in years 6-15 and analyzed for CVOCs.

5.1.1 Alternative #1: Removal of CVOCs from Groundwater by Aqueous Phase GAC

Alternative #1 consists of two (2) GAC adsorption vessels each containing 1000 pounds of Calgon Carbon Corporation (Calgon) DSR-C coal-based aqueous phase GAC and piped in a series, lead-lag arrangement. The Calgon Protect™ Model LM-36 vessels rated for a maximum recommended flow rate of 50 gpm and pressure of 75 psi were selected for this evaluation. Carbon usage estimates provided by Calgon using the maximum expected influent concentrations and treatment system flow rates predict a usage rate of approximately 3 pounds of GAC per day. The GAC units have a recommended minimum empty bed contact time (EBCT) of 6 minutes. At the maximum design flow rate of 30 gpm, the EBCT is 9.6 minutes. The vessels will be installed inside a heated and ventilated concrete enclosure. Exchanges of spent GAC for fresh media are expected to occur on a 12 month interval and the vessels will be stationary.

5.1.2 Alternative #2: Removal of CVOCs from Groundwater by Air Stripping with Vapor Phase GAC Treatment of Off-gas

Alternative #2 consists of a tray-type counter-current air stripper with two (2) GAC adsorption vessels each containing 1000 pounds of Calgon AP4-60 coal-based vapor phase GAC and piped in a series, lead-lag arrangement. For this evaluation, a BISCO Environmental (Formerly NEEP Systems ShallowTray®) Air Stripper model 2341 operating at 300 cfm with a 7.5 HP blower and designed for a maximum flow rate of 45 gpm was selected. The selected GAC adsorption vessels are Calgon Protect™ Model VW-1000 vessels rated for a maximum recommended flow rate of 750 cfm. Carbon usage estimates provided by Calgon using the maximum expected influent concentrations and treatment system flow rates predict a usage rate of approximately 2 pounds of GAC per day. As with Alternative #1, the equipment will be installed within a heated and ventilated concrete enclosure. Exchanges of spent GAC for fresh media are expected to occur on a 16 month interval and the vessels will be stationary.

Dissolved concentrations of inorganic parameters in the extracted groundwater known to be problematic in aeration systems, such as iron, manganese and calcium appear to be at manageable levels. Some calcium carbonate encrustation and/or the formation of oxidized precipitates is expected, but periodic cleaning of the air stripper once per year can be used to maintain system operation.

The design of the vapor phase GAC system provides for removal of CVOCs from the off-gas of the air stripper to non-detectable levels, resulting in no measureable discharge of CVOCs to ambient air. If this treatment option were selected by EPA, evaluation of the air discharge requirements subject to rules and guidelines of the NYSDEC's Division of Air Resources (DAR) would be performed and submitted to DAR to demonstrate compliance of the air discharge with applicable requirements. It is anticipated that the air discharge from the system would comply with the applicable DAR requirements.

5.1.3 Alternative #3: Removal of CVOCs by Osorb Nanotechnology

Alternative #3 is a system designed by ABS that utilizes their proprietary Osorb technology for treatment of CVOCs. Osorb is a highly structured nano-scale glass material which instantaneously swells when it comes in contact with organic compounds. ABS uses different catalysts in conjunction with the Osorb base material to manufacture application specific media. Hydrogen gas is injected into the influent water upstream of the media and the embedded catalyst allows the reduction reactions to take place, ultimately converting CVOCs to ethane and chloride ions. For this application, a palladium catalyst embedded on the base material, Palladium-Osorb (Pd-Osorb), has been proposed. The treatment system consists of a two-stage process which ABS calls VOCEater. The proposed VOCEater system has a foot print of 4 feet wide by 16 feet long by 8 feet high and includes the following:

- One (1) 500 gallon vertical feed collection tank
- One (1) Osorb Chaos Capture (OCC) unit
- One (1) VOCEater unit
- Two (2) hydrogen gas generators to supply 300 mL/min of hydrogen each to the OCC and the VOCEater units
- One (1) deionizer unit to convert treated water to deionized water for use in the hydrogen gas generators
- One (1) 0.5 HP pump and one (1) 2 HP pump
- Automation, control, data collection and alarm panel
- Hydrogen detector, conductivity instrumentation, water flow totalizer

Water from the wells will flow through a 25 micron and then a 5 micron filter before entering the 500 gallon feed tank. The system is designed to operate in a batch mode so that once the water level in the tank has reached a preset level, an inlet valve will close preventing well water from entering the tank until the water level in the tank has reached a predetermined low level. Water pumped from the feed tank passes through another 5 micron filter and is processed by the OCC unit. The OCC unit is a 30 gallon cylindrical tank built to hold Pd-Osorb materials in a fluidized bed system for gross knock-out of high concentrations of VOCs. Water leaving the OCC unit is pumped through another 5 micron filter to the VOCEater unit, which consists of up to 12 columns of Pd-Osorb and is designed to reduce influent concentrations to below 1 ug/L. Conductivity sensors are included to continuously confirm proper system operation. Two hydrogen generators are included to supply hydrogen gas which is injected into the groundwater upstream of the OCC and VOCEater units at a rate of 300 mL/min for each unit. Each hydrogen generator consumes 500 mL of deionized water per day. A deionizer system processes a small stream of treated water to create a supply of deionized water.

Since hydrogen is both an asphyxiant and a flammable gas with a Lower Explosion Limit (LEL) of 4% and an Upper Explosion Limit (UEL) of 74%, several safety precautions are required to protect operators and minimize fire and explosive hazards. The enclosed space will be designed as an NEC Class I, Division 2 space, since explosive gas will not normally be present in the atmosphere and only in the event of a leak. First, an explosion proof fan and fresh air louvers will provide constant ventilation of the equipment enclosure, particularly the area near the ceiling, since hydrogen gas is much lighter than air (SG=0.07). A hydrogen gas detector will be installed in the enclosure and interlocked with the hydrogen gas generators and operator alarm system. The building heater, lights and receptacles will be designed to be explosion proof and intrinsically safe instrumentation will be used.

5.2 Detailed Analysis of Alternatives

The following subsections provide the detailed analysis of the three alternatives described above. As stated in the approved NTCSRA WP, this analysis will examine only the implementability and cost criteria.

The alternatives analysis for implementability focuses on constructability, reliability, approvals and expandability. The evaluation for constructability and expandability evaluates the space and layout constraints of the Facility property and adjoining properties on which the treatment system may be installed, in addition to considering the expandability of a given treatment unit used to apply one of the treatment technology options that may be required due to an increase in the groundwater extraction rate or the influent concentrations. The reliability of the alternative approaches to treatment are also weighed in the analysis. This includes both the reliability of the individual treatment options in achieving acceptable effluent limits and the operational reliability of the technology under a long-term operation and maintenance mode. Finally, the evaluation based on implementability examines the approvals that are required to construct and operate the technology and to manage waste from each of the technologies being considered.

The cost analysis examines both the capital costs and the operation and maintenance costs for each of the alternatives. In general, this evaluation of costs has been performed in accordance with the EPA guidance document "A Guide to Developing and Documenting Cost Estimates during the Feasibility Study" (July 2000). This cost analysis, therefore, includes a calculation of present value or present worth of each of the alternatives. For this calculation, all of the alternatives have been evaluated based on an estimated fifteen years of operation and maintenance to facilitate comparative analysis. This duration is based on previous remedial experience in comparable geologic conditions with comparable contamination that suggests the objectives of this NTCSRA will be achieved in ten to fifteen years following startup. The actual time period for operation of the system as a CERCLA response action will depend on future decisions to be made with regard to restoration of the groundwater.

5.2.1 Alternative No. 1: Removal of CVOCs from Groundwater by Aqueous Phase GAC

The implementability and cost associated with Alternative No. 1 are presented below.

5.2.1.1 Implementability

This alternative is constructable. Aqueous phase GAC units of the size and type in this alternative are readily available within 4-6 weeks and require basic plumbing, electrical and instrumentation work to install. This alternative is deemed highly reliable as the adsorptive capacity of aqueous phase GAC for PCE, TCE and cis-1,2-DCE are well documented. This alternative is expandable. The proposed GAC units have a hydraulic capacity that is 67% greater than the maximum design flow rate. If influent concentrations prove to be significantly higher than the design concentrations, the GAC usage rate will increase, but with a current change-out frequency of once per year, there is considerable expandability built into the current proposed sizing. The approvals required to construct this alternative include local building and electrical construction permits and their associated inspections and the SPDES Discharge Equivalent Permit. The aqueous phase GAC units used during the testing have demonstrated the ability of this technology to consistently meet the SPDES Discharge Equivalent Permit limits for CVOCs.

5.2.1.2 Cost

A detailed breakdown of the costs associated with this alternative is presented in Appendix D. The following table summarizes those costs:

Total Capital Cost	$ 570,052
15 Years Present Worth O&M	$ 1,994,347
Total Present Worth	$ 2,467,348
Cost of Treatment per 1000 Gallons	$ 10.43
Total Annual O&M	$ 92,395

5.2.2 Alternative No. 2: Removal of CVOCs from Groundwater by Air Stripping with Vapor Phase GAC Treatment of Off-gas

The implementability and cost associated with Alternative No. 2 are presented below.

5.2.2.1 Implementability

This alternative is constructable. Air stripping units and vapor phase GAC units of the size and type proposed in this alternative are readily available within 6-8 weeks and require basic plumbing, electrical and instrumentation work to install. This alternative is deemed highly reliable as air stripper performance modeling and the adsorptive capacity of vapor phase GAC for PCE, TCE and cis-1,2-DCE are well documented. This alternative is expandable. The proposed air stripper and GAC units have a hydraulic capacity that is 50% greater than the maximum design flow rate. The air stripper is a tray-type model which will allow for the installation of an additional tray if influent concentrations prove to be significantly higher than the design concentrations. Also, the GAC usage rate will increase with higher concentrations, but with a current change-out frequency less than once per year, there is considerable expandability built into the current proposed sizing. The approvals required to construct this alternative include local building and electrical construction permits and their associated inspections, an air discharge permit and the SPDES Discharge Equivalent Permit. As in the case of Alternative #1, Alternative #2 has a well-documented record of consistently achieving CVOC concentrations that will meet the related discharge limits.

5.2.2.2 Cost

A detailed breakdown of the costs associated with this alternative is presented in Appendix D. The following table summarizes those costs:

Total Capital Cost	$ 616,620
15 Years Present Worth O&M	$ 2,799,208
Total Present Worth	$ 3,219,103
Cost of Treatment per 1000 Gallons	$ 13.61
Total Annual O&M	$ 146,052

5.2.3 Alternative No. 3: Removal of CVOCs from Groundwater by Osorb Nanotechnology

The implementability and cost associated with Alternative No. 3 are presented below.

5.2.3.1 Implementability

This alternative is constructable. The Osorb VOCEater system proposed by ABS is a vendor packaged system that can be fabricated, delivered and installed in 8-10 weeks. The system will require basic plumbing and somewhat more complex electrical and instrumentation work to install due to the Class I, Division 2 rating of the building. The reliability of the system is unproven based on tests conducted with a pilot scale unit. The system is more complex than the other alternatives and will require greater operator skill and training and more frequent monitoring. The expandability of this alternative is unknown based on pilot testing. Although the system is modular in that additional columns of Pd-Osorb can be installed to improve removal efficiency, the high cost of the Palladium catalyst adds large cost to the system for small improvements in efficiency at low concentrations. The approvals required to construct this alternative include local building and electrical construction permits and their associated inspections and the SPDES Discharge Equivalent Permit. Due to the consistent failure of this technology to meet the SPDES Discharge Equivalent Permit limits for CVOCs, there is no current basis for NYSDEC to approve this alternative for this application.

5.2.3.2 Cost

A detailed breakdown of the costs associated with this alternative is presented in Appendix D. The following table summarizes those costs:

Total Capital Cost	$ 926,200
15 Years Present Worth O&M	$ 3,031,693
Total Present Worth	$ 3,732,378
Cost of Treatment per 1000 Gallons	$ 15.78
Total Annual O&M	$ 161,551

6 COMPARATIVE ANALYSIS OF ALTERNATIVES

This comparative analysis of the three alternatives evaluated in the previous section has been prepared to provide a basis for EPA to select an alternative. This analysis examines the same criteria used in the detailed analysis.

In some cases, this analysis will present objective comparisons, such as the comparative analysis for cost. In some cases, however, the comparative analysis may involve some subjective professional judgment regarding the relative merits of one alternative versus another, and positive or negative comments regarding their relative feasibility.

6.1 Implementability

Each of the three alternatives is constructable. The complexity of the construction is lowest for Alternative No. 1 and highest for Alternative No. 3. Alternatives No. 1 and No. 2 are highly reliable; the reliability of Alternative No. 3 is unproven. The expandability of Alternative No. 1 is the highest of the three. Approvals required for implementation of the alternatives are least complex with Alternative No. 1 given its successful application during testing and problematic for Alternative No. 3, given its consistent failure to meet discharge limits during field testing.

6.2 Cost

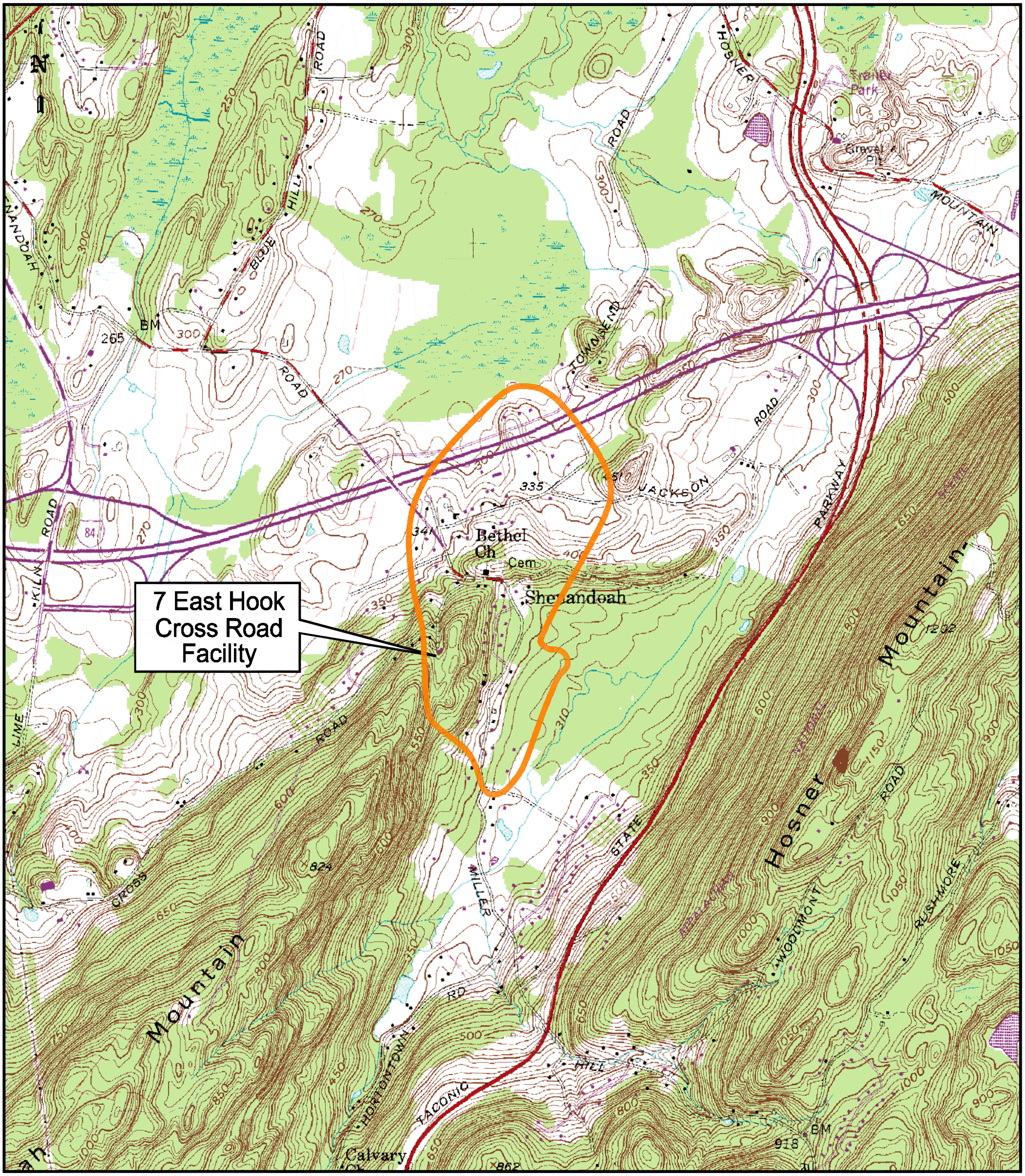
Costs were calculated using guidance from USEPA document 540-R-00-002, "A Guide to Developing Cost Estimates During the Feasibility Study." As suggested in the guide, the discount rate used for the present worth calculation comes from the Office of Management and Budget (OMB) Circular A-94 Appendix C last updated December 2010. For a 15 year project life, Circular A-94 suggests a linear interpolation between the 10-year (1.3%) and 20-year (2.1%) real discount rates or 1.7%.

A summary of the comparative costs for the three alternatives is included in Table 6.1. This table shows that Alternative No. 1 has the lowest capital and annual operating cost and therefore the lowest calculated present worth, while Alternative No. 3 has the highest calculated present worth.

Table 6.1
Shenandoah Road - Groundwater Treatment System Costs
Treatment Alternative Cost Summary

Alternative	Capital	15-year Total O&M	Present Worth
1	$570,052	$1,994,347	$2,467,348
2	$616,620	$2,799,208	$3,219,103
3	$926,200	$3,031,693	$3,732,378

Assumes Concentrations Decline to 1/10 of Initial Values over Course of 15 Year Project Life
Assume 15 Year Project Life with 1.7% Discount Rate



- Limit of Site Constituents Detected

Portion of the Hopewell Junction, NY
7.5-Minute NYSDOT Quadrangle

Scale
0 1000' 2000'

Figure 1-1

Site Location Map
Shenandoah Road Groundwater Contamination Superfund Site

GROUNDWATER SCIENCES CORPORATION

21003-002-I7 / 05-24-10

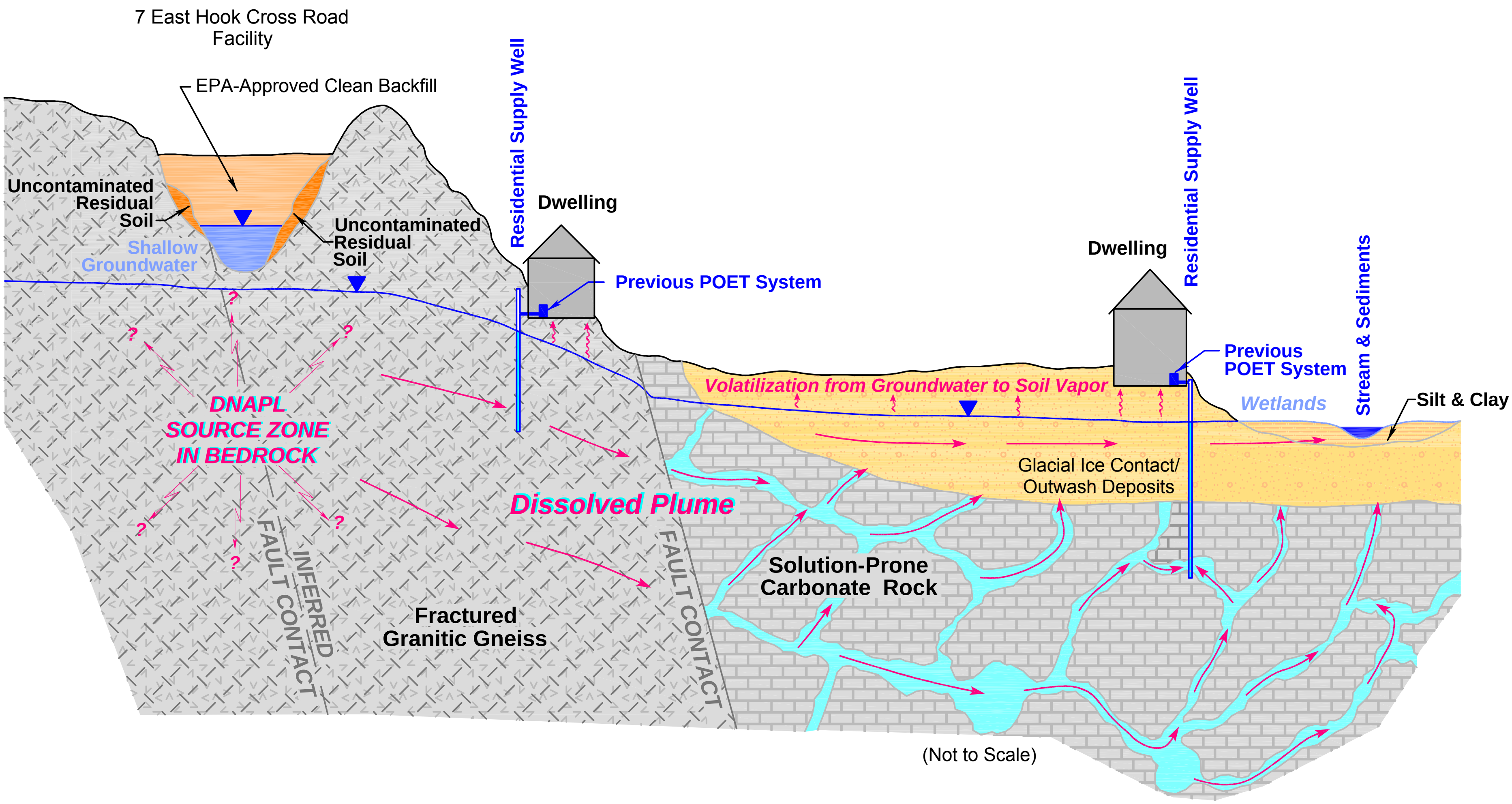


Figure 2-1

Schematic Conceptual Site Model

Shenandoah Road Groundwater Contamination Superfund Site

GROUNDWATER SCIENCES CORPORATION

21003-070-D1 / 10-06-10

Figure 4-1. Facility Observation Wells Water Levels

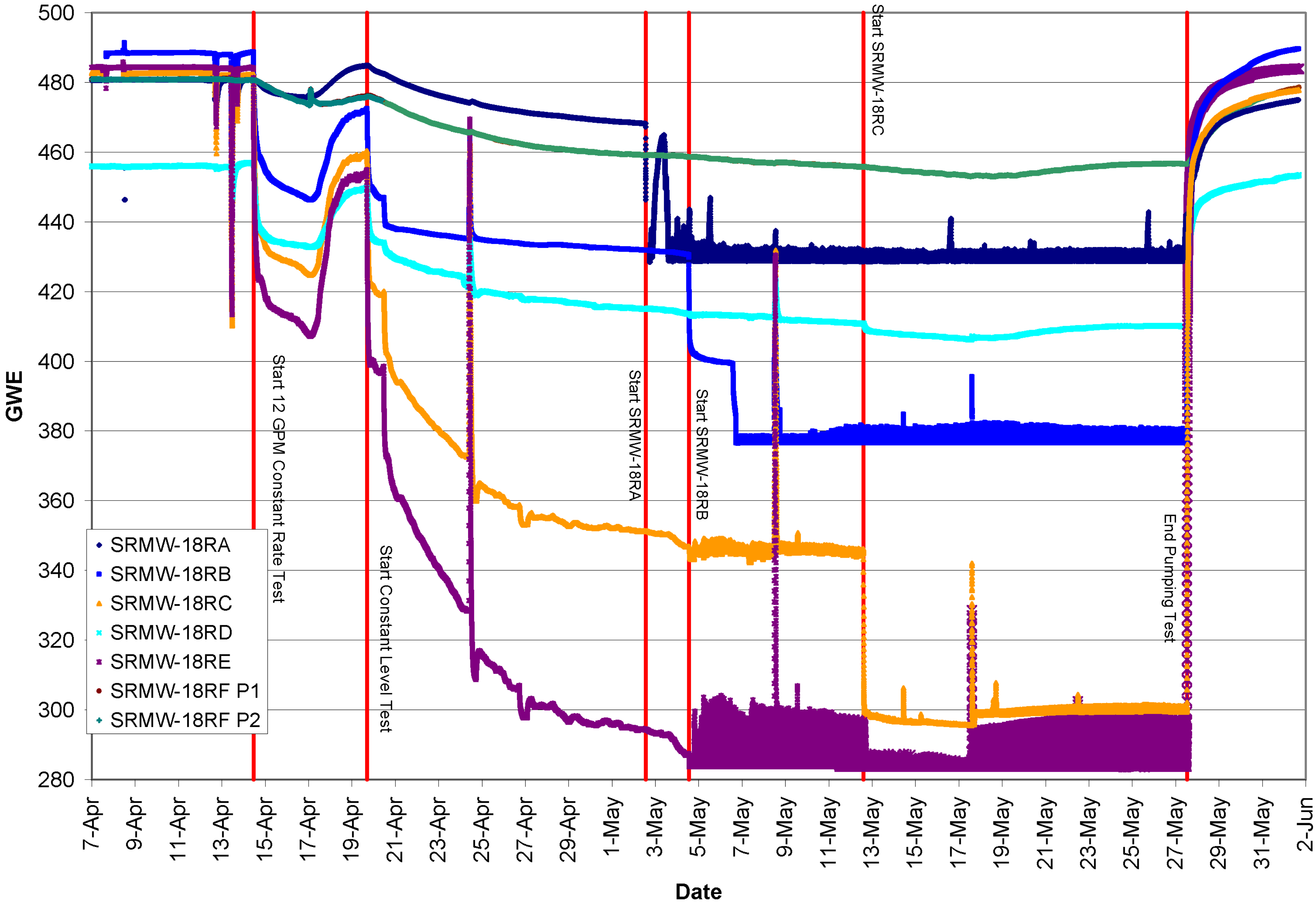
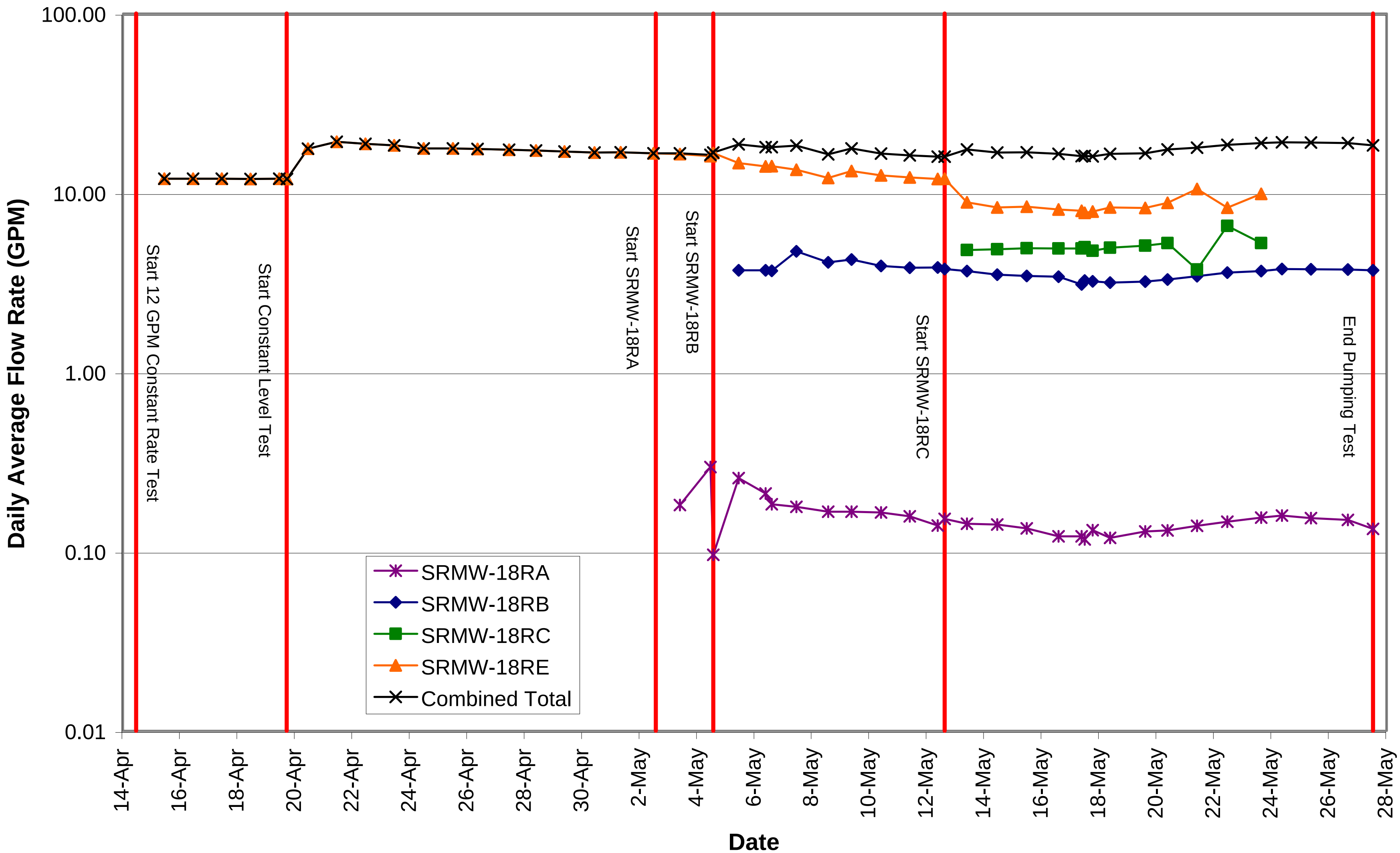


Figure 4-2. Long Term Test Pumping Rates



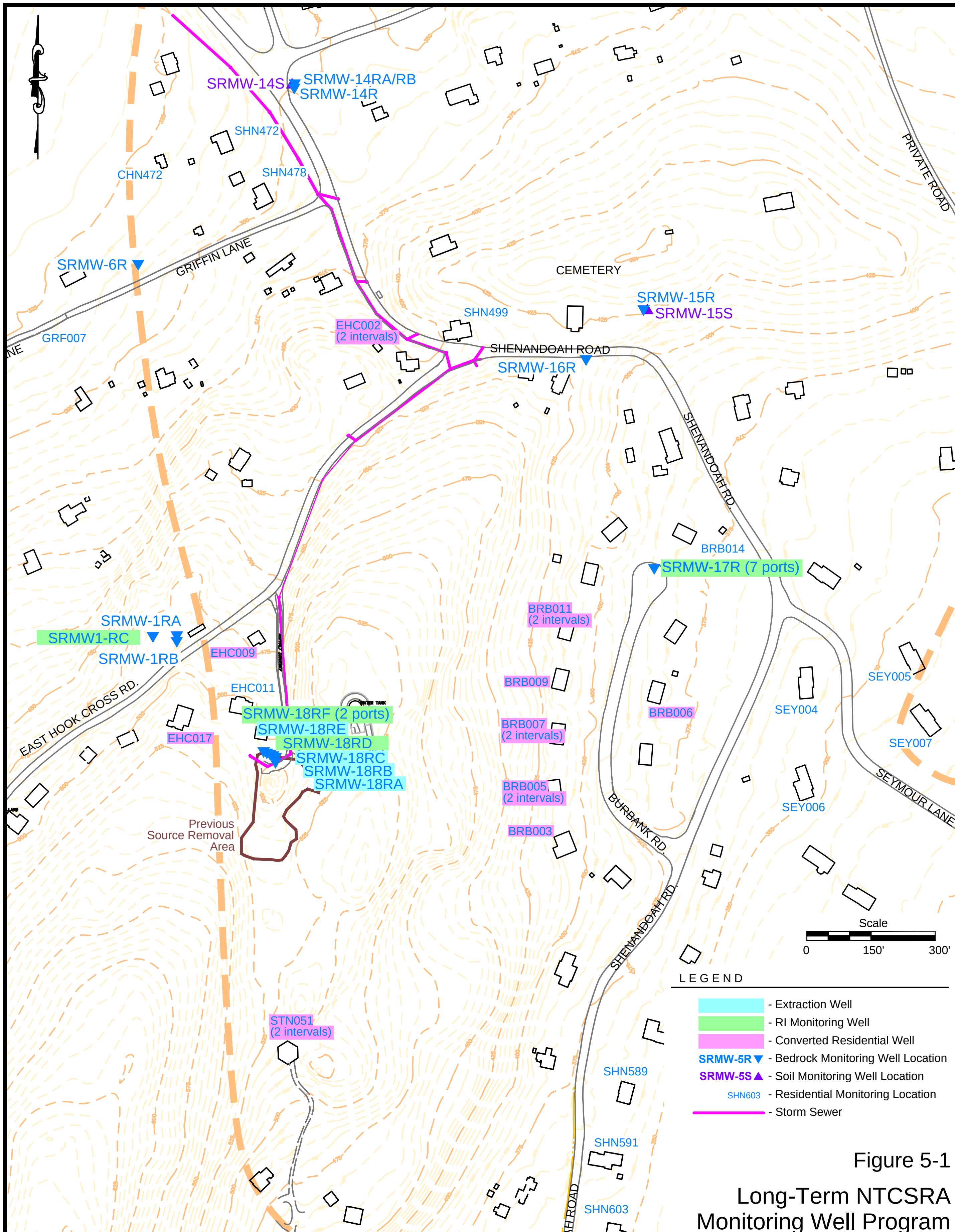


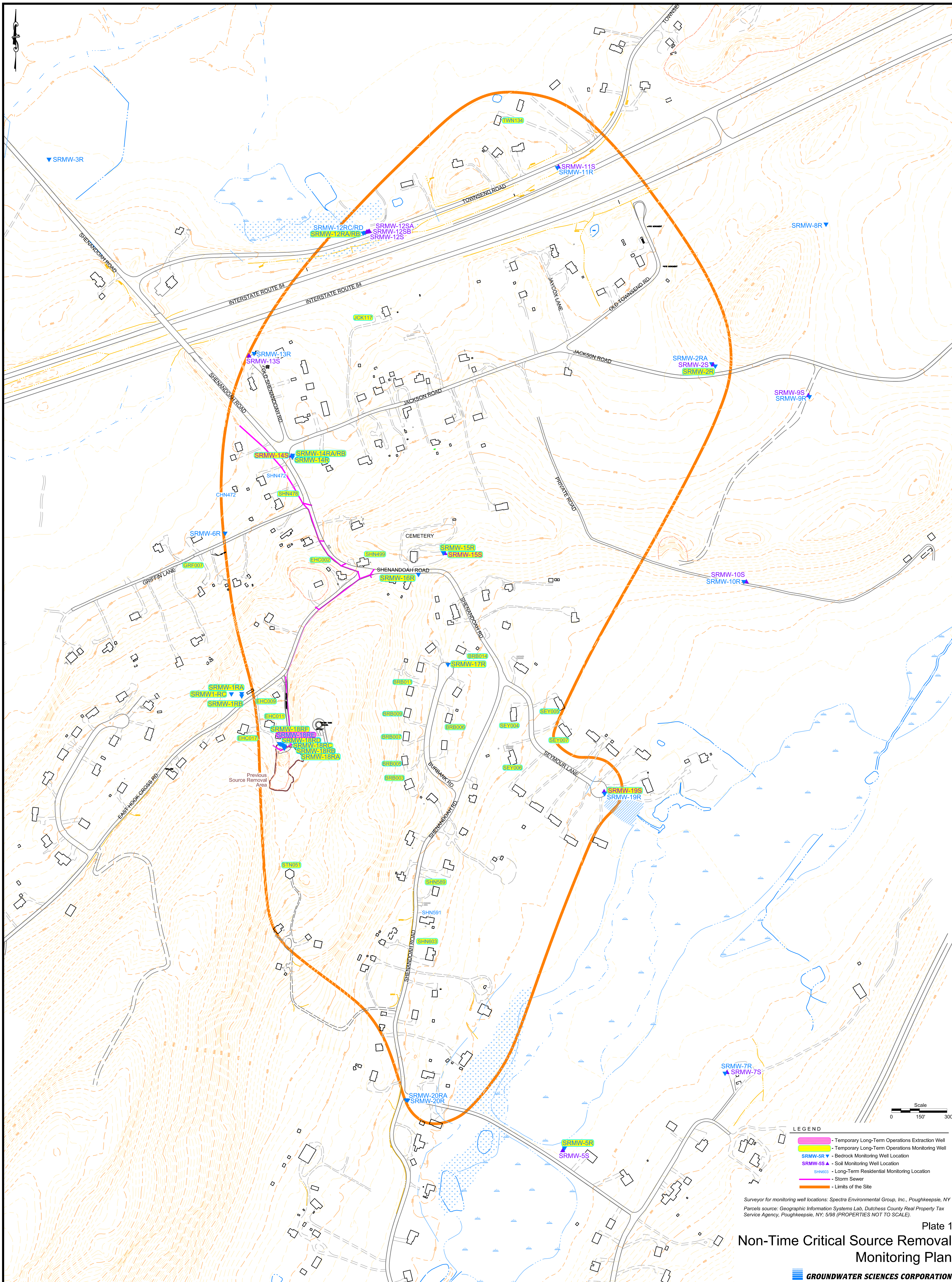
Figure 5-1

Long-Term NTCSRA Monitoring Well Program

Surveyor for monitoring well locations: Spectra Environmental Group, Inc., Poughkeepsie, NY

GROUNDWATER SCIENCES CORPORATION

21003-081-B3 / 02-17-10


SRMW-3R
SRMW-8R
SRMW-11S
SRMW-11R
SRMW-12RC/RD
SRMW-12RA/RB
SRMW-12SA
SRMW-12SB
SRMW-12S
SRMW-13R
SRMW-13S
SRMW-2RA
SRMW-2S
SRMW-2R
SRMW-9S
SRMW-9R
SRMW-14S
SRMW-14RA/RB
SRMW-14R
SRMW-6R
SRMW-15R
SRMW-15S
SRMW-16R
SRMW-10S
SRMW-10R
SRMW-17R
SRMW-1RA
SRMW1-RC
SRMW-1RB
SRMW-18RF
SRMW-18RE
SRMW-18RD
SRMW-18RC
SRMW-18RB
SRMW-18RA
Previous Source Removal Area
SRMW-19S
SRMW-19R
SRMW-20RA
SRMW-20R
SRMW-5R
SRMW-5S
SRMW-7R
SRMW-7S
TWN134
JCK117
SHN472
SHN478
CHN472
SHN499
EHC002
GRF007
EHC009
EHC011
EHC017
BRB014
BRB011
BRB009
BRB007
BRB006
BRB005
BRB003
SEY005
SEY004
SEY007
SEY006
STN051
SHN589
SHN591
SHN603
CEMETERY
TOWNSEND ROAD
INTERSTATE ROUTE 84
SHENANDOAH ROAD
OLD SHENANDOAH RD
JACKSON ROAD
JAYCOX LANE
OLD TOWNSEND RD
PRIVATE ROAD
GRIFFIN LANE
SHENANDOAH RD
BURBANK RD
SEYMOUR LANE
EAST HOOK CROSS RD
Scale
0
150'
300'
LEGEND
- Temporary Long-Term Operations Extraction Well
- Temporary Long-Term Operations Monitoring Well
SRMW-5R - Bedrock Monitoring Well Location
SRMW-5S - Soil Monitoring Well Location
SHN603 - Long-Term Residential Monitoring Location
- Storm Sewer
- Limits of the Site
Surveyor for monitoring well locations: Spectra Environmental Group, Inc., Poughkeepsie, NY
Parcels source: Geographic Information Systems Lab, Dutchess County Real Property Tax Service Agency, Poughkeepsie, NY; 5/98 (PROPERTIES NOT TO SCALE).
Plate 1
Non-Time Critical Source Removal Monitoring Plan
GROUNDWATER SCIENCES CORPORATION
21003-081-F2 / 10-05-10

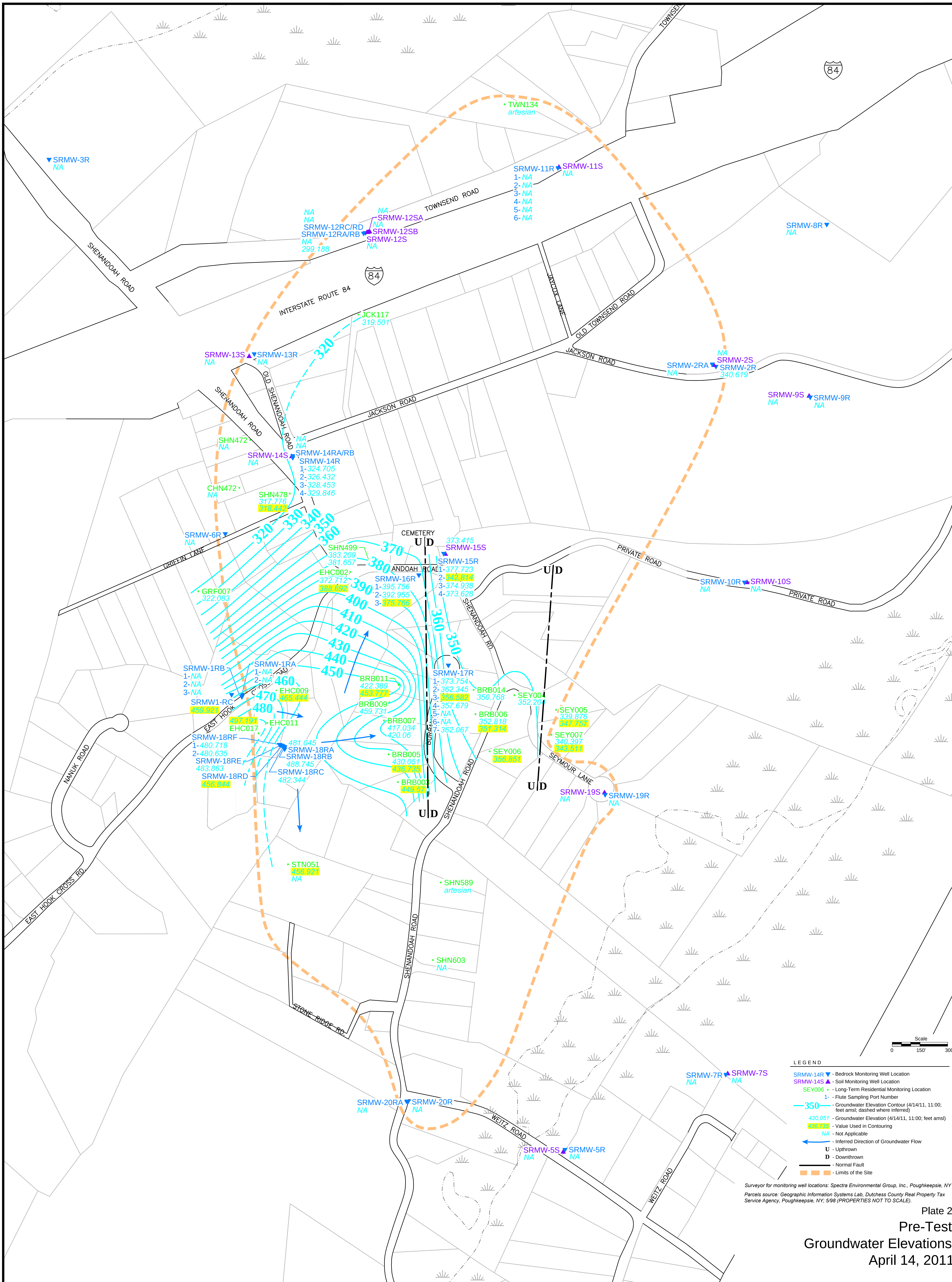
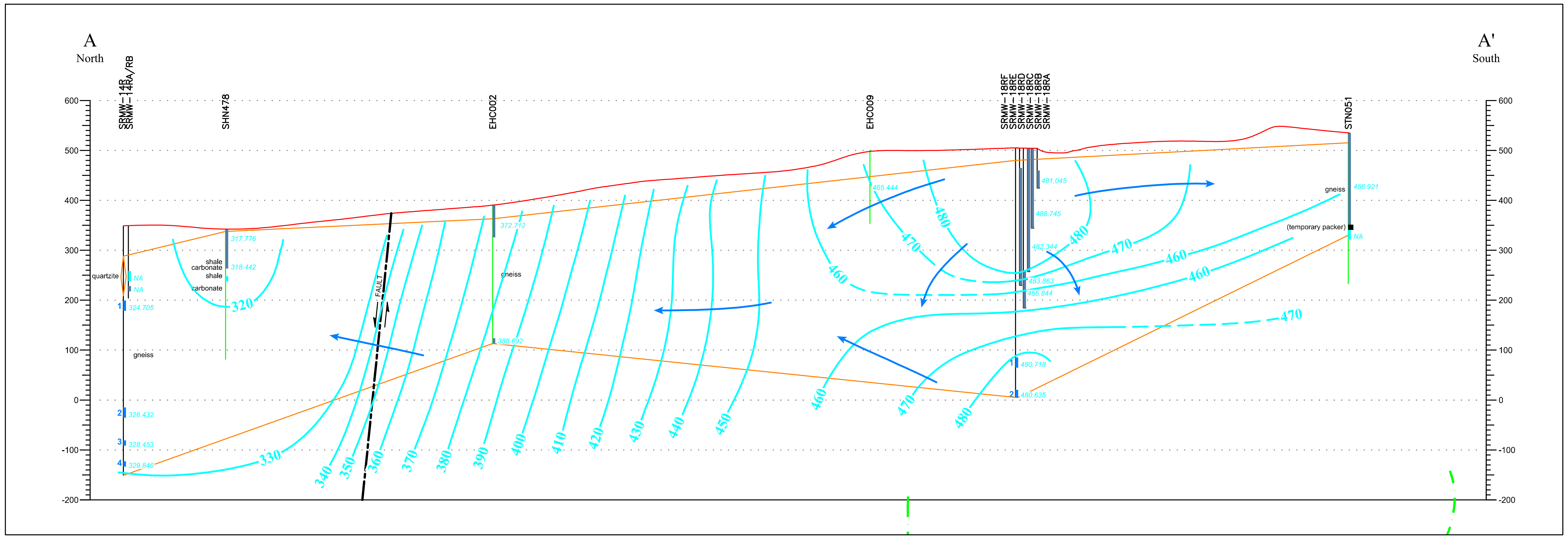
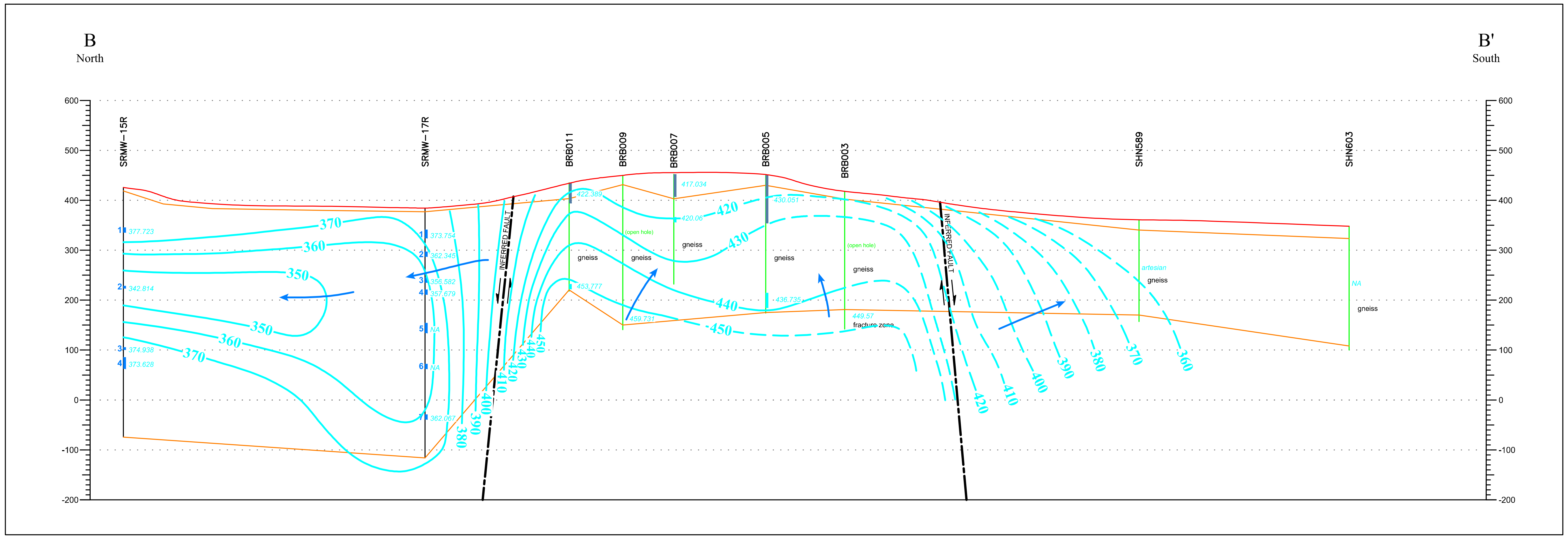


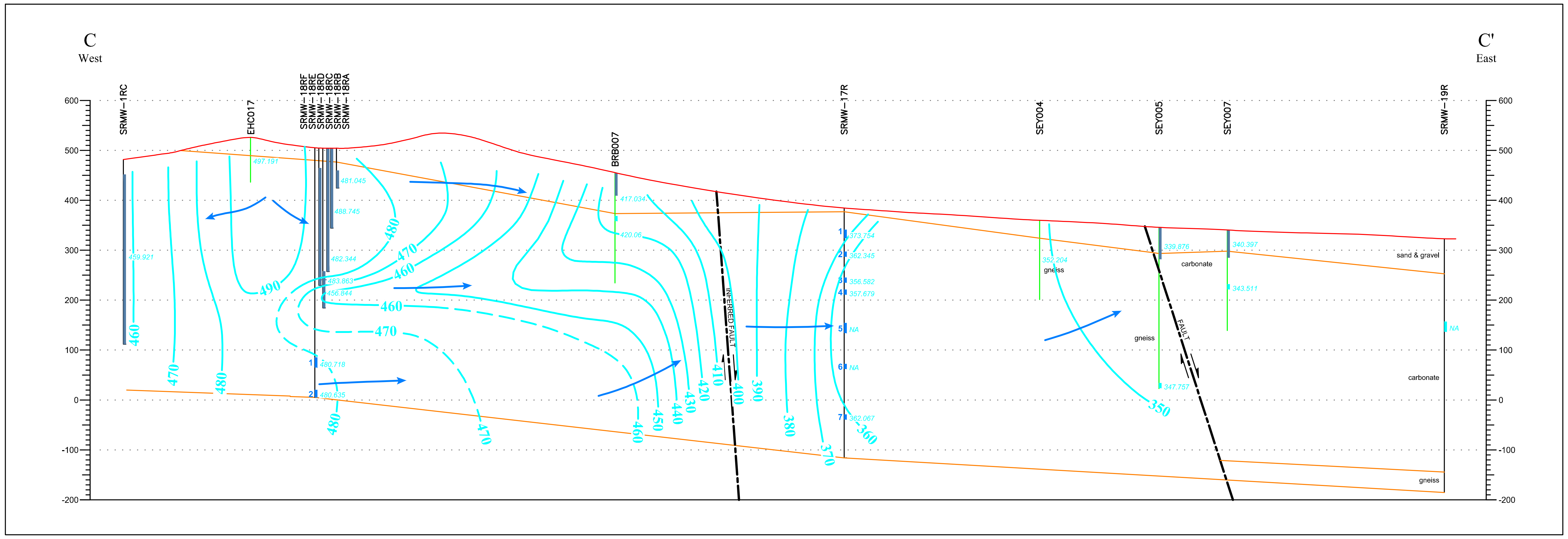
Plate 2

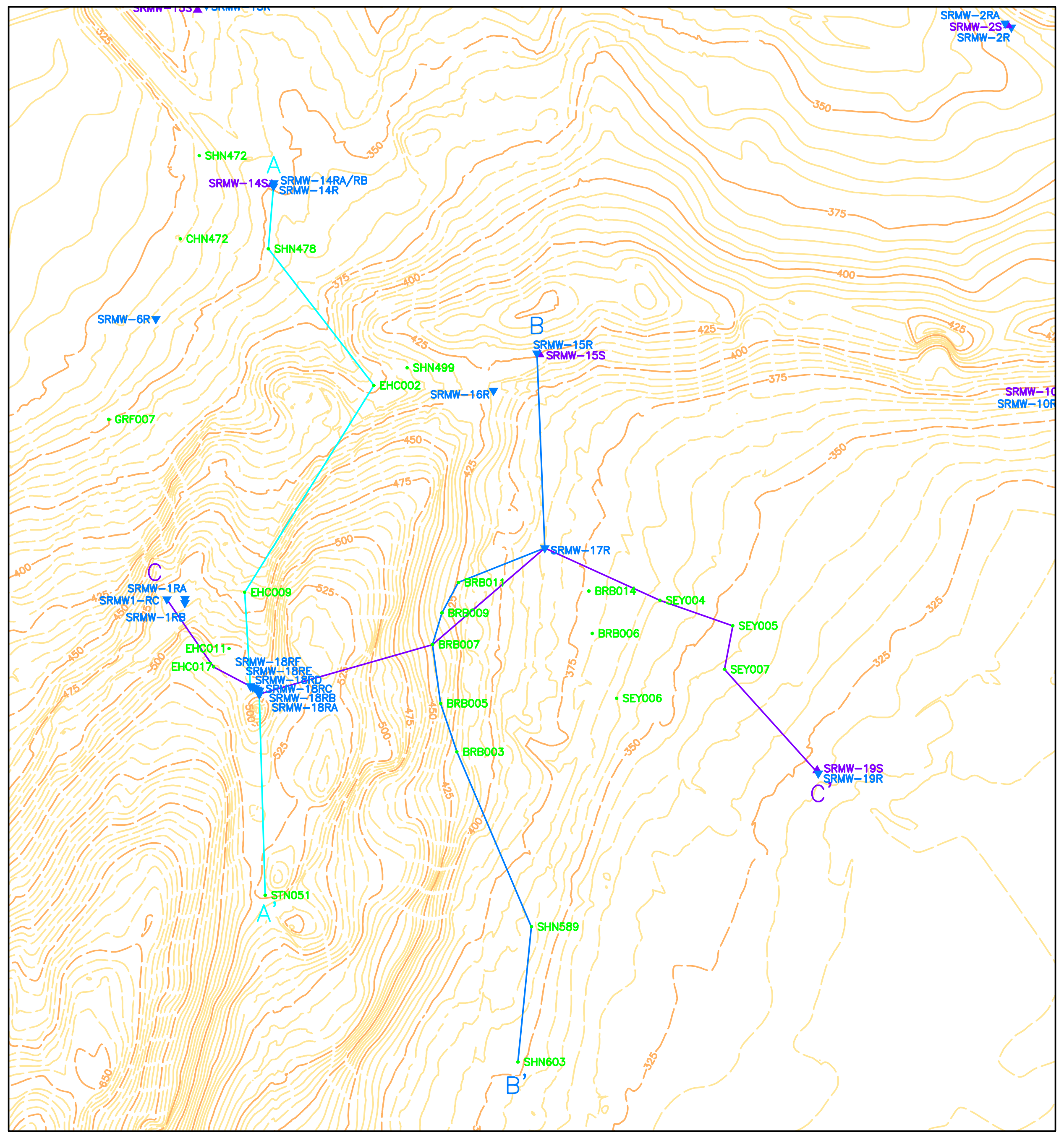
Pre-Test Groundwater Elevations April 14, 2011

PLAN_GWE_2011-04-14 / 06-14-11









LOCATION MAP LEGEND

Scale
0 250' 500'

- Bedrock onitoring Well
- Soil Monitoring Well
- Long-Term Residential Monitoring Well
- Cross Section Trace

CROSS SECTION LEGEND

- Ground Surface
- Monitoring Well
- Lithologic Contact
420.06 - Groundwater Elevation (4/14/11, 11:00; feet amsl; dashed where inferred)
NA - Not Applicable
350 - Groundwater Elevation Contour
- Inferred Direction of Groundwater Flow (schematic)
- Screened Interval
- Open Hole Interval
- Flute Interval

Horizontal Scale: 1"=200'
Vertical Scale: 1"=200'

No Vertical Exaggeration

Scale
0 100' 200'

Plate 3

Pre-Test Groundwater Elevations Cross Sections

GROUNDWATER SCIENCES CORPORATION

21003-CS_GWE_201-2011-04-14 / 06-14-11

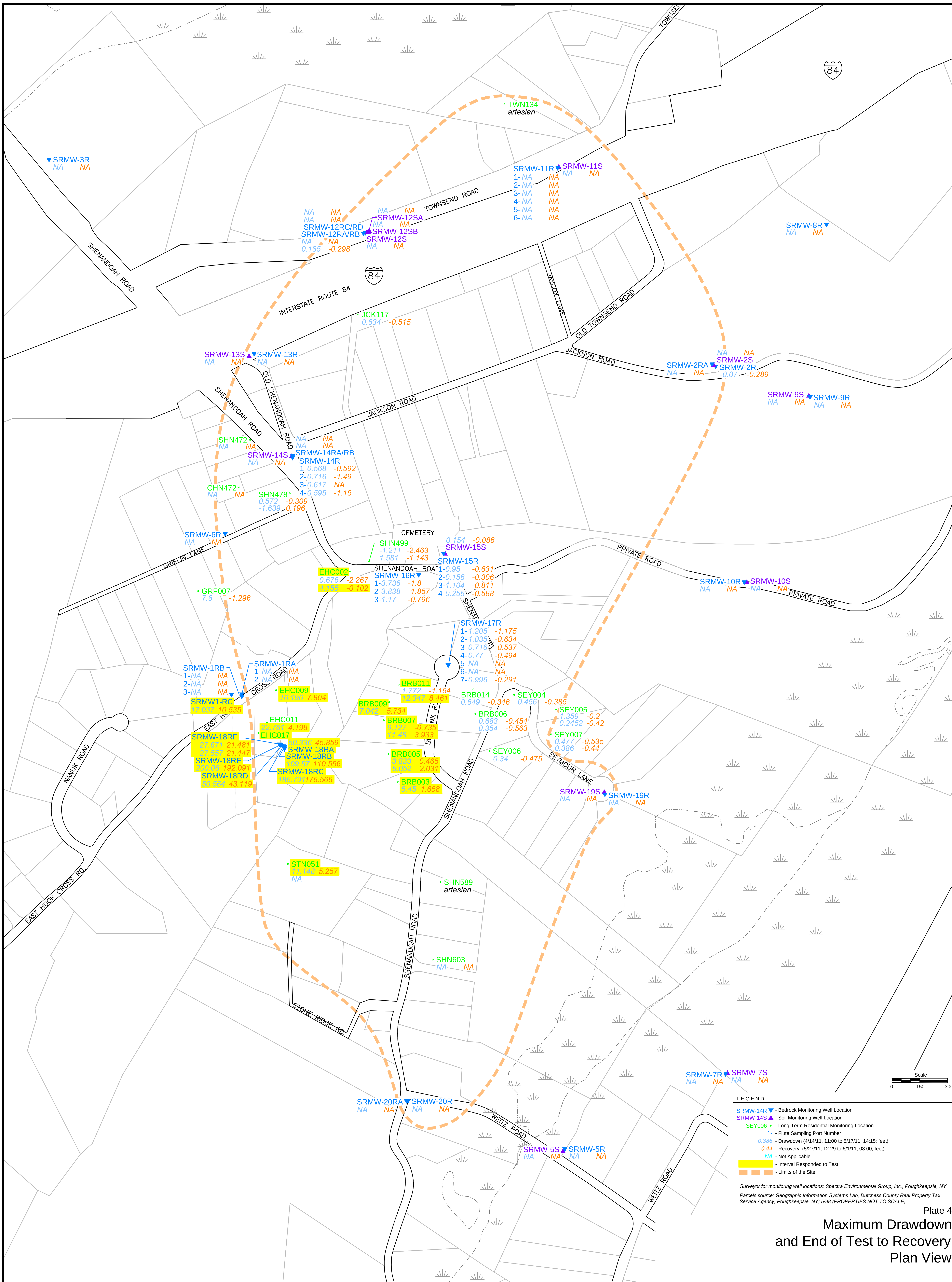
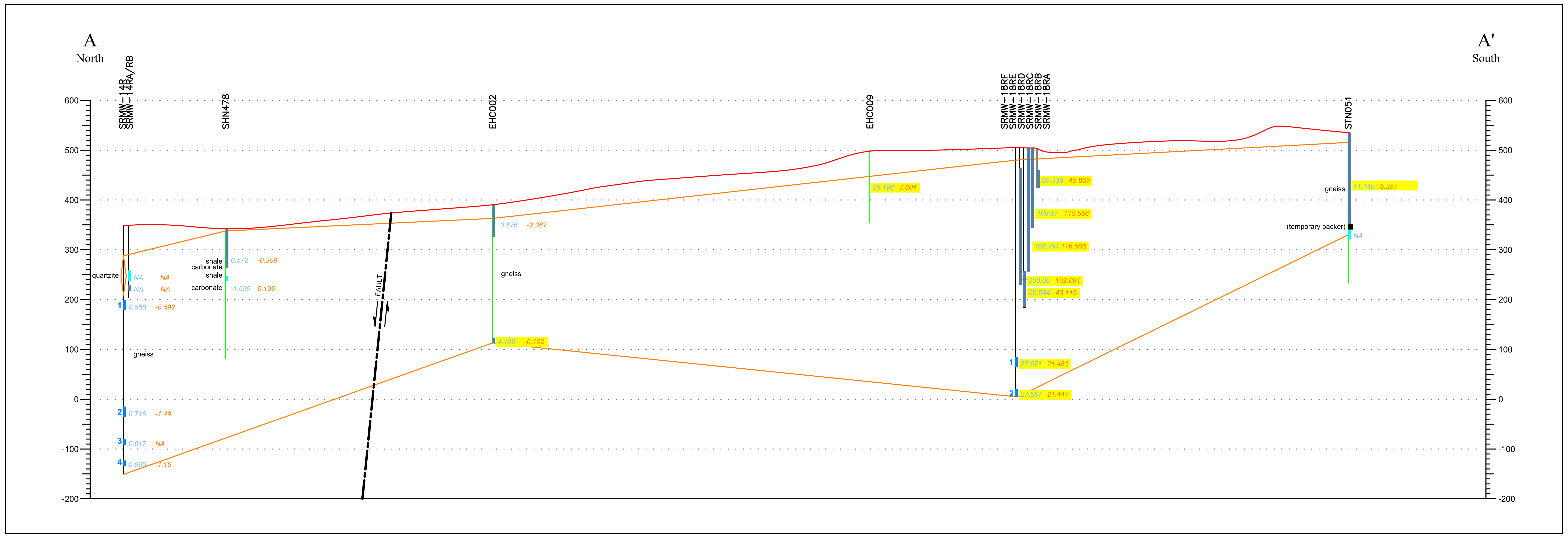
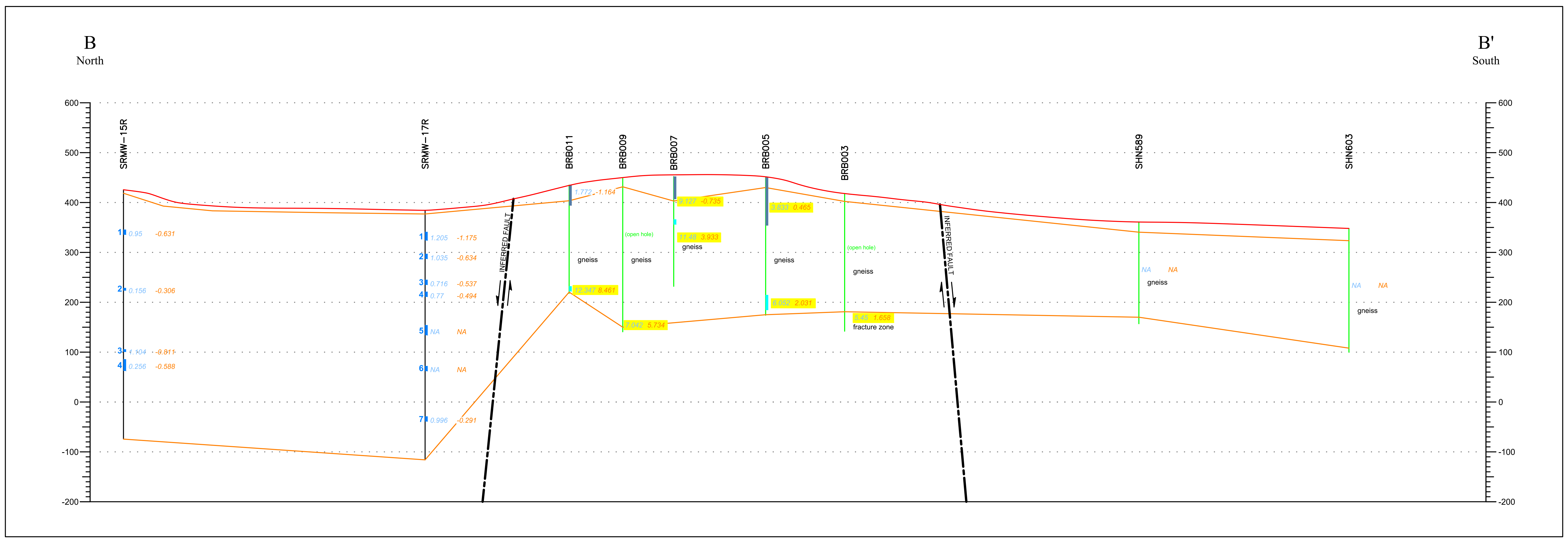
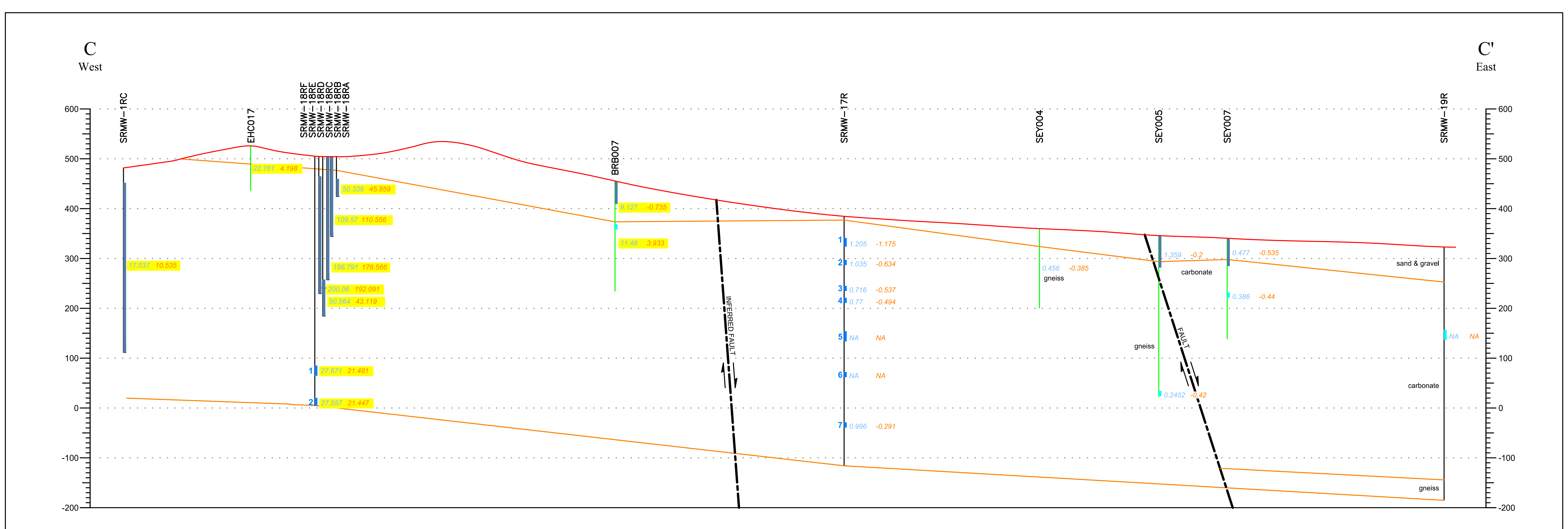
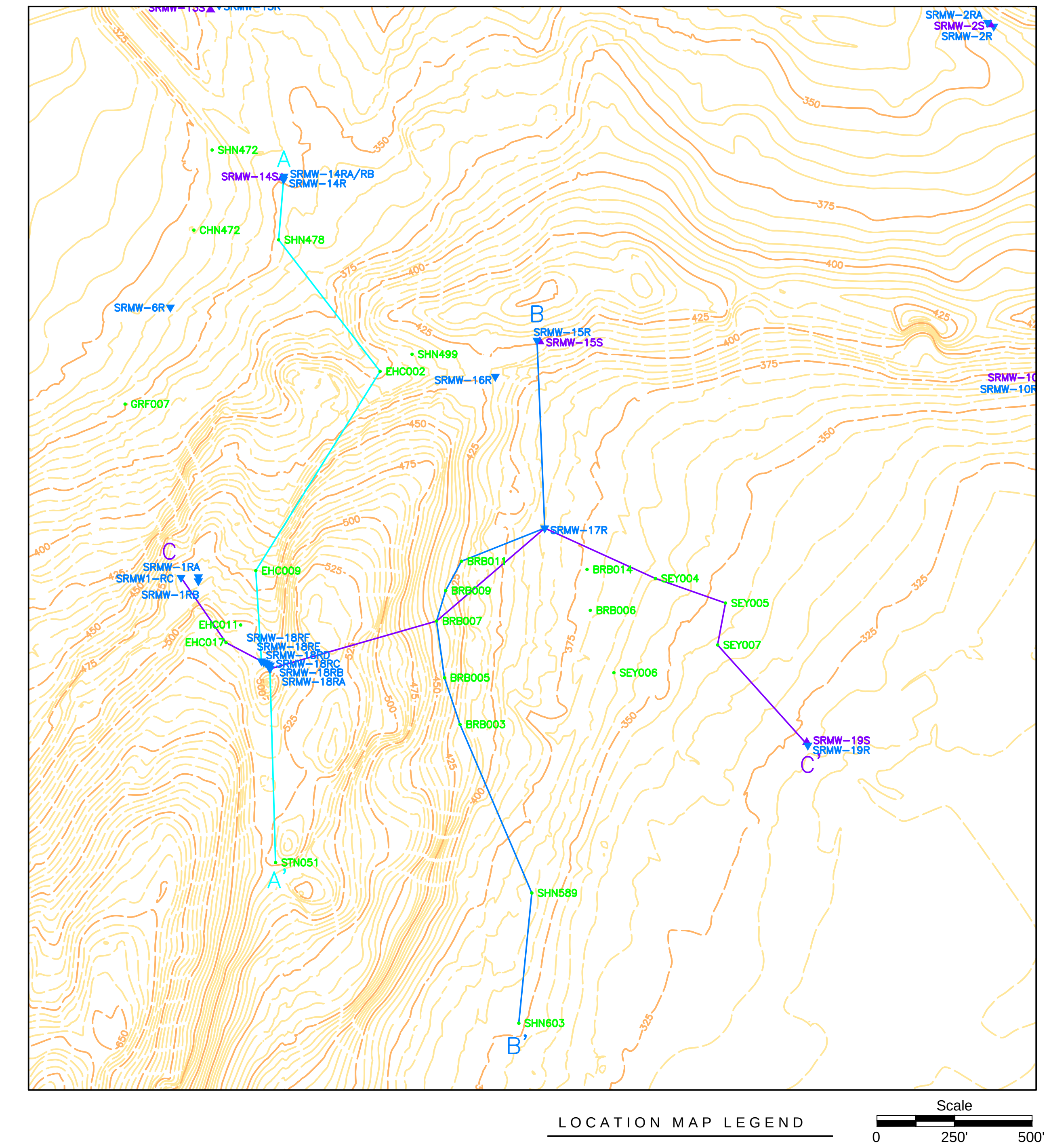


Plate 4
Maximum Drawdown
and End of Test to Recovery
Plan View









LOCATION MAP LEGEND

- Bedrock onitoring Well
- Soil Monitoring Well
- Long-Term Residential Monitoring Well
- Cross Section Trace

CROSS SECTION LEGEND

- Ground Surface
- Monitoring Well
- Lithologic Contact
- 1.359 - Drawdown (4/14/11, 11:00 to 5/17/11, 14:15; feet)
- -0.2 - Recovery (5/27/11, 12:29 to 6/1/11, 08:00; feet)
- NA - Not Applicable
- Screened Interval
- Open Hole Interval
- Flute Interval
- Interval Responded to Test

Horizontal Scale: 1"=200'
Vertical Scale: 1"=200'

No Vertical Exaggeration

Scale
0 100' 200'

Plate 5

Maximum Drawdown and End of Test Recovery Cross Sections

GROUNDWATER SCIENCES CORPORATION

21003-CS_DELTA_04-14_05-17_05-27_06-01 / 06-14-11

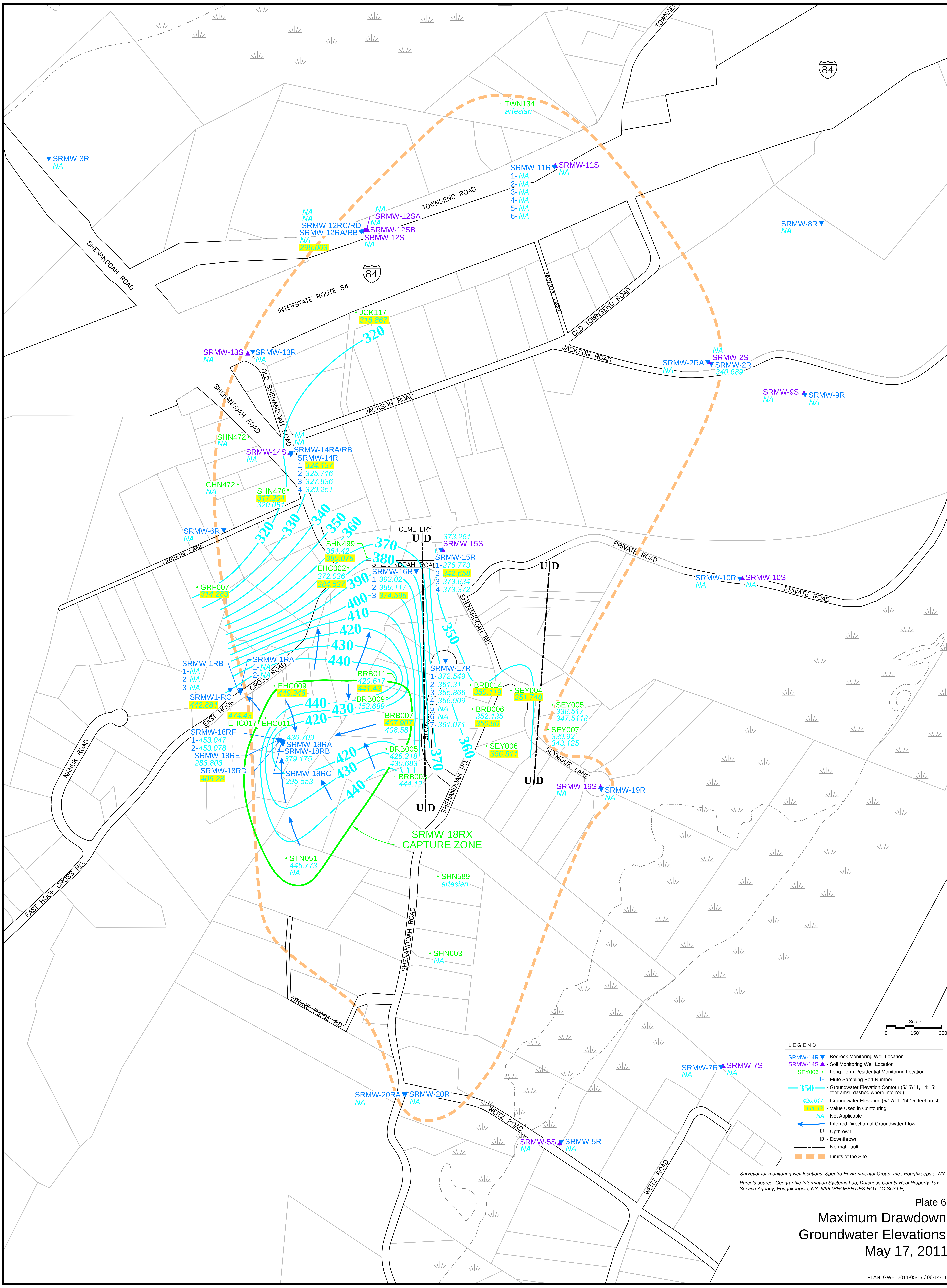
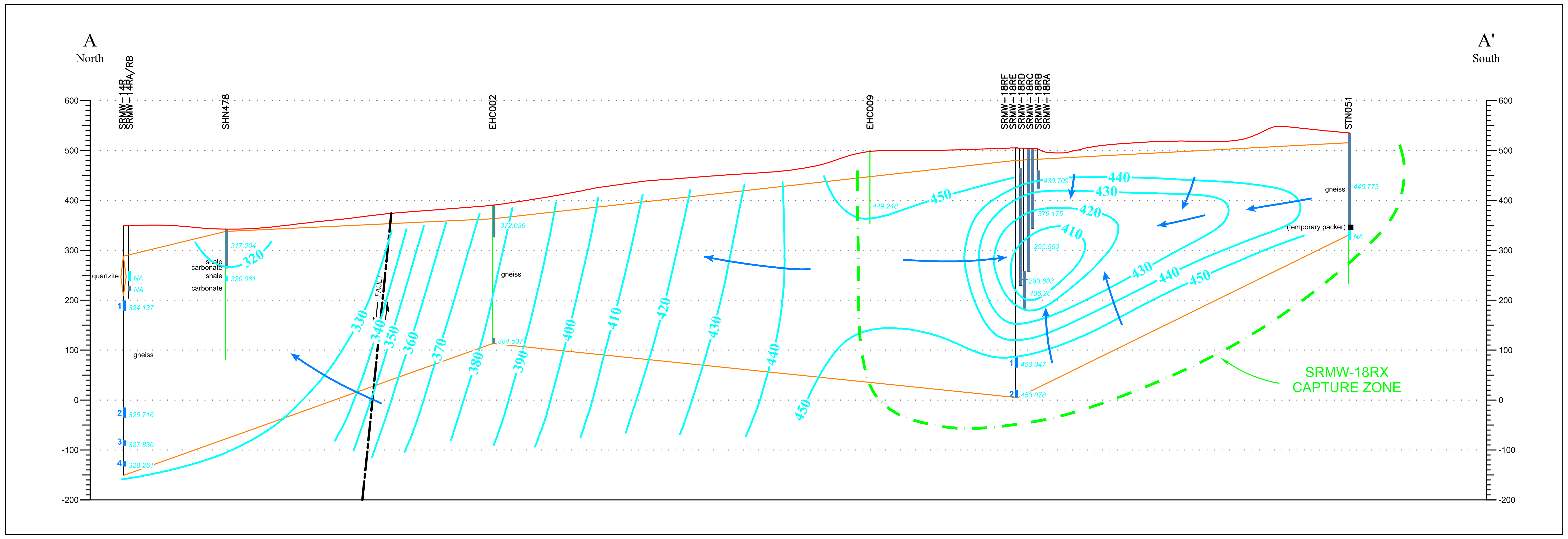
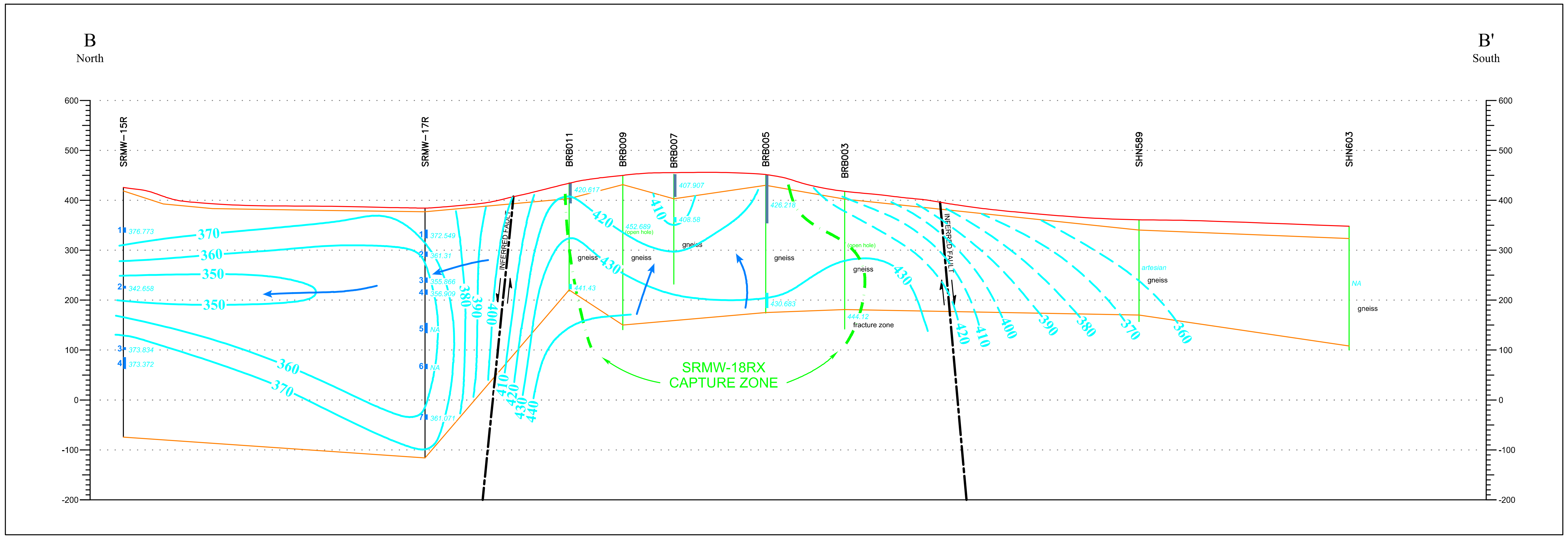
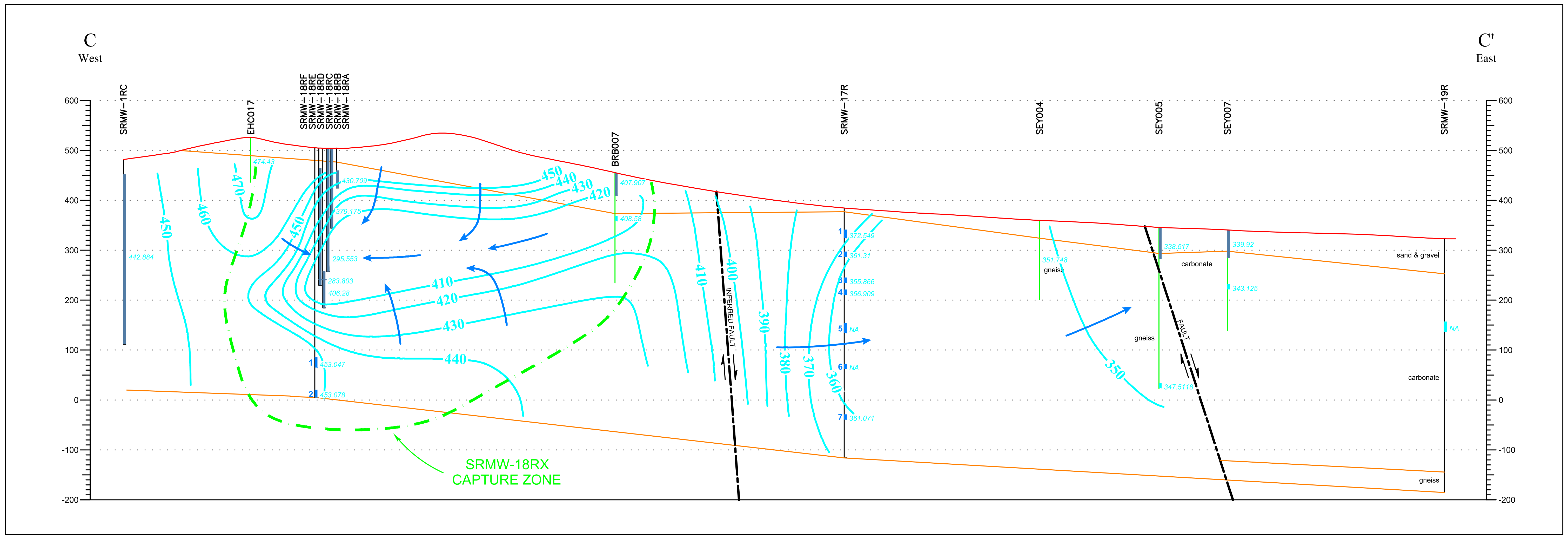
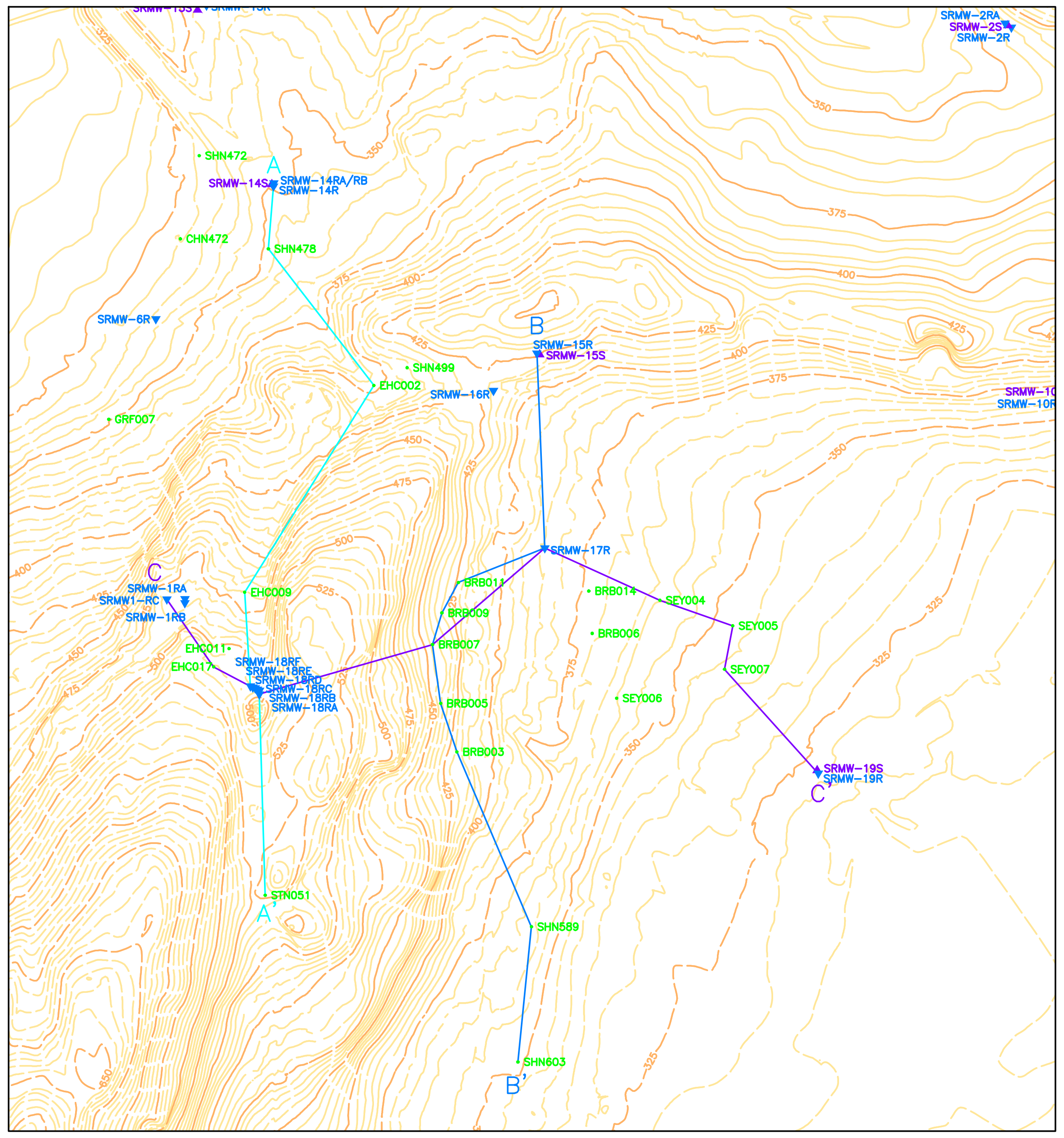


Plate 6
Maximum Drawdown
Groundwater Elevations
May 17, 2011









LOCATION MAP LEGEND

- Bedrock onitoring Well
- Soil Monitoring Well
- Long-Term Residential Monitoring Well
- Cross Section Trace

Scale
0 250' 500'

CROSS SECTION LEGEND

- Ground Surface
- Monitoring Well
- Lithologic Contact
420.06 - Groundwater Elevation (5/17/11, 14:15; feet amsl)
NA - Not Applicable
350 - Groundwater Elevation Contour
- Inferred Direction of Groundwater Flow (schematic)
- Screened Interval
- Open Hole Interval
- Flute Interval

Horizontal Scale: 1"=200'
Vertical Scale: 1"=200'

No Vertical Exaggeration

Scale
0 100' 200'

Plate 7

Groundwater Elevations Maximum Drawdown Cross Sections

GROUNDWATER SCIENCES CORPORATION

21003-CS_GWE_2011-05-17 / 06-14-11

Appendix A

New York State Department of Environmental Conservation

SPDES equivalent discharge permit, dated May 25, 2011

New York State Department of Environmental Conservation
Division of Water
Bureau of Water Permits, 4th Floor
625 Broadway, Albany, New York 12233-3505
Phone: (518) 402-8111 • **FAX:** (518) 402-9029
Website: www.dec.state.ny.us

Joe Martens
Commissioner

MEMORANDUM

TO:	Dave Crosby, Remedial Bureau C and Kiera Becker
FROM:	Sudhir Mahatma, BWP SM
SUBJECT:	**Shenandoah Road Site # 3-14-104**
DRAINAGE BASIN:	13-04
DATE:	May 25,2011

In response to your request dated March 14,2011 and April 27,2011, attached please find effluent limitations and monitoring requirements for the above noted remediation discharge.

The DOW does not have any regulatory authority over a discharge from a State, PRP, or Federal Superfund Site. DER will be responsible for ensuring compliance with the attached effluent limitations and monitoring requirements, and approval of all engineering submissions. Footnote 1 identifies the appropriate DER Section Chief as the place to send all effluent results, engineering submissions, and modification requests. The Regional Water Engineer should be kept appraised of the status of this discharge and, in accordance with the attached criteria, receive a copy of the effluent results for informational purposes.

If you have any questions, please call me at 2-8126 .

Attachment (Effluent Limitations and Monitoring Requirements)

cc: Regional Water Engineer, R-3(w/attach)
Shayne Mitchell, Section Chief, DOW (w/attach)
Ron Entringer,
Ed Reilly

EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

During the period beginning June 2011 and lasting until March 2012, the discharges from the treatment facility to trib. of Wickopee Creek , water index number H-95-13-3-1 , Class C, shall be limited and monitored by the operator as specified below:

Outfall Number and Parameter	Discharge Limitations		Units	Minimum Monitoring Requirements	
	Monthly Avg.	Daily Max		Measurement Frequency	Sample Type
Outfall 001 - Treated Groundwater Remediation Discharge:					
Flow	Monitor	43,200	GPD	Continuous	Meter
pH (range)	6.5 to 8.5		SU	Monthly	Grab
TDS mg/l	Monitor	Monitor	mg/l	Monthly	Grab
Acetone mg/l	Monitor	Monitor	mg/l	Monthly	Grab
Aluminum, Total	Monitor	0.03	lb/d	Monthly	24 hr. comp.
Antimony , Total	Monitor	Monitor	lb/d	Monthly	24 hr. comp
Arsenic, Total	Monitor	0.06	lb/d	Monthly	24 hr. comp
Barium, Total	Monitor	Monitor	lb/d	Monthly	24 hr. comp
Cadmium, Total	Monitor	0.0003	lb/d	Monthly	24 hr. comp
Chromium, Total	Monitor	0.02	lb/d	Monthly	24 hr. comp
Cobalt, Total	Monitor	0.02	lb/d	Monthly	24 hr. comp
Copper, Total	Monitor	0.001	lb/d	Monthly	24 hr. comp
Iron, Total	Monitor	0.300	lb/d	Monthly	24 hr. comp
Lead, Total	Monitor	0.0007	lb/d	Monthly	24 hr. comp
Nickel, Total	Monitor	0.006	lb/d	Monthly	24 hr. comp
Thallium, Total	Monitor	0.002	lb/d	Monthly	24 hr. comp
Zinc, Total	Monitor	0.008	lb/d	Monthly	24 hr. comp
Tetrachloroethene	Monitor	1.0	ug/l	Monthly	Grab
Toluene	Monitor	5.0	ug/l	Monthly	Grab

Additional Conditions:

(1) Discharge is not authorized until such time as an engineering submission showing the method of treatment is approved by the Department. The discharge rate may not exceed the effective or design treatment system capacity. All monitoring data, engineering submissions and modification requests must be submitted to:

Dave Crosby, Remedial Bureau C
NYSDEC, 625 Broadway,
Albany, New York 12233- 7014
518-402-9662

With a copy sent to:

Regional Water Engineer, Region – 3
21 South Putt Corners Rd.
New Paltz, NY 12561
914-428-2505

(2) Only site generated wastewater is authorized for treatment and discharge.

(3) Authorization to discharge is valid only for the period noted above but may be renewed if appropriate. A request for renewal must be received 6 months prior to the expiration date to allow for a review of monitoring data and reassessment of monitoring requirements.

(4) Both concentration (mg/l or µg/l) and mass loadings (lbs/day) must be reported to the Department for all parameters except flow and pH.

(5) Any use of corrosion/scale inhibitors, biocidal-type compounds, or other water treatment chemicals used in the treatment process must be approved by the department prior to use.

(6) This discharge and administration of this discharge must comply with the substantive requirements of 6NYCRR Part 750.

Appendix B

Final Proposed Long-term Aquifer Testing Plan, Shenandoah Road Groundwater Contamination Superfund Site, March 28, 2011

MEMORANDUM

To: ***Thomas D. Morris, P.E., IBM Project Manager***

From: ***Craig G. Robertson, P.G., and Dorothy A. Bergmann, P.G.; Groundwater Sciences Corporation***

Subject: ***Final Proposed Long-term Aquifer Testing Plan***
Shenandoah Road Groundwater Contamination Superfund Site

Date: ***March 28, 2011***

Introduction

The purpose of this memorandum is to describe the approach to long-term aquifer testing that GSC is proposing to perform at the Facility located at 7 East Hook Cross Road. This testing will include the final step in aquifer testing for the remedial investigation (RI) at this Site and the initial steps in the implementation of the Non-Time Critical Source Removal Action (NTCSRA). As such it will include an initial constant-rate, long-term aquifer test lasting for one week followed by a six-week period of temporary long-term operation that will include additional testing.

Summary of Short-term Testing Results

In all, four short-term tests have been performed at the Facility with durations ranging from 8 to 24 hours. The locations of the test wells and observation wells are shown on Figure 1 (attached). Each test was preceded by a step drawdown test to select an extraction rate for the short-term test. The results of these tests have been reviewed with the Agencies in detail as they were completed. The purpose of these short-term tests was threefold:

- to observe hydraulic responses in the test well and selected observation wells close to the test well;
- to determine the water quality of the extracted groundwater at the conclusion of each test; and
- to select a well location, extraction rate and treatment system design for a seven-day, long-term, constant-rate aquifer test to be followed by long-term temporary operations.

Tables 1 and 2 (attached) summarize the results of these four short-term tests. Table 1 displays the physical data for each test and Table 2 presents the results of chemical analyses of extracted groundwater. The focus of this testing was on three discrete water-bearing zones (WBZs) exposed in well SRMW-18RE. This well exhibits an open, uncased borehole from the bottom of the casing at 40 feet below ground surface (bgs) to the total depth of 275 ft. bgs. Three distinct WBZs occur within this open borehole interval, the shallowest at 75 ft. bgs (WBZ-A); an intermediate zone from 127 to 130 ft. bgs (WBZ-B); and a deep zone from 230 to 250 ft. bgs (WBZ-C). Each of these WBZs corresponds to the sole WBZ exposed in an adjacent monitoring well with the same letter suffix (i.e., SRMW-18RA discretely monitors WBZ-A; SRMW-18RB discretely monitors WBZ-B and SRMW-18RC discretely monitors WBZ-C).

The plan for these tests called for extracting groundwater from each discrete WBZ in SRMW-18RE by isolating each WBZ using packers for each of three successive tests. A final test was then to be performed in the open borehole with no packers present so the combined yield of all three WBZs would contribute to the extraction rate and chemistry of the pumped effluent. During each of these tests, water level responses were to be monitored in each of the adjacent wells open to discrete WBZs, including the three zones mentioned above and two other WBZs in wells SRMW-18RD and SRMW-18RF, and in selected monitoring wells beyond the Facility boundaries.

As shown in Table 1, only three of the four tests were completed in SRMW-18RE. These are the tests in WBZ-B, WBZ-C and the open borehole. Testing was attempted in WBZ-A in SRMW-18RE, but it was not possible to achieve a satisfactory packer seal to separate this WBZ from the remainder of the borehole. Therefore, the short-term test in this WBZ was performed in SRMW-18RA.

The results presented in Tables 1 and 2 show a wide range of extraction rates and end-of-test PCE concentrations. The results for SRMW-18RA produced the highest chemical concentrations by far (PCE = 16,000 ug/L) with the lowest extraction rate (0.5 gallons per minute (gpm) sustainable for only 8 hours). By contrast, the highest extraction rate was associated with the test in the open borehole (13 gpm, sustainable for 20 hours), but with an end-of-test PCE concentration equal to only 46 ug/L. However, this was not the lowest end-of-test concentration; the result for WBZ-B, after pumping for 24 hours at 3 gpm, was 27 ug/L for PCE. The result for WBZ-C after pumping at 5 gpm for 24 hours showed a much higher end-of-test PCE concentration of 150 ug/L.

Table 1 also lists the available drawdown for each test, the maximum observed drawdown at the end of the test and the maximum drawdown produced by each test in each of the observation wells monitored during these tests. As seen from these tabulated values, with the exception of the test performed in SRMW-18RA, the available drawdown in the pumping well was not exhausted during any of the other three tests. Also excluding the test in WBZ-A, of the three other tests, the open borehole test produced more drawdown in SRMW-18RA (5.36 ft.) than did the tests in WBZ-B and WBZ-C (1.33 ft. And 2.25 ft., respectively), which is consistent with the fact that WBZ-A contributed to the well yield during the open borehole test. However, given the available drawdown in SRMW-18RA (approximately 50 ft.) drawdown on the order of only five feet is not expected to exert much influence on groundwater flow in the shallowest WBZ, which also exhibits by far the highest PCE concentrations. Finally, the test performed in the open borehole produced greater drawdown in each of the adjacent wells in the SRMW-18R well cluster than was observed during any of the other tests.

Table 1 also lists the response to each of these tests in five monitoring wells beyond the Facility boundaries. These data show a distinction between the off-site connectivity of WBZ-B versus WBZ-C. In this regard, more than two feet of drawdown were observed in monitoring well SRMW-1RC northwest of the Facility in response to the test in WBZ-C versus only 0.26 feet of drawdown in this well during the WBZ-B test. The same is true for responses in two wells on Burbank Road; drawdown in response to pumping from WBZ-C was 1.24 ft. and 1.44 ft. versus only 0.23 ft. in each of these wells in response to pumping from WBZ-B. This pattern of response suggests there is a stronger hydraulic connection between WBZ-C on the Facility and the WBZs monitored in these off-site wells than exists between these WBZs and WBZ-B. Since WBZ-C is open and contributing a portion of the yield to the open borehole test, the response in these off-site wells should be similar during the open borehole test. Table 1 does show a similar response in SRMW-1RC to the northwest; however, the wells on Burbank were under artesian pressure and the response in these wells could not be recorded. It should be expected, however, that future pumping from the open borehole would include a response in these wells similar to that seen during the WBZ-C test. Table 1 also shows that a water level response of approximately 1.4 ft. was observed in one additional off-site monitoring well located south of the Facility (STN-51).

Attachment A contains time versus water level graphs that show the response in each of the observation wells monitored during the open borehole short-term test. From these graphs it is possible to see that roughly 43 ft. of available drawdown remained in SRMW-18RA, 55 ft. in SRMW-18RB and 133 ft. in SRMW-18RC at the conclusion of that short-term test in the SRMW-18RE open borehole.

Aquifer Testing Plan

The primary purpose of the aquifer testing completed to date is to select a groundwater extraction configuration for a constant-rate, long-term aquifer test (seven-day duration). Based on the results of the short-term tests as discussed above and in monthly progress meetings over the past several months, GSC is proposing to perform that test using a single extraction point – the SRMW-18RE open borehole. This configuration has been selected for the following reasons:

- It provides the highest extraction rate that can be sustained for the entire duration of the long-term test;
- It requires flow adjustments on a single well to maintain a constant rate; and
- It stresses all of the water-bearing zones that exhibit PCE concentrations that must be addressed by the NTCSRA.

Therefore, the long-term test will be performed by operating this well alone at an extraction rate of 12 gpm (based on a projection of the short-term test data) and monitoring the list of wells included in the original aquifer test plan (GSC, April, 2010). Otherwise this test will be performed in a manner consistent with that work plan.

Data collected during this long-term test will be analyzed to determine aquifer characteristics for the granitic gneiss bedrock. The aquifer test data from the pumping well and the observation wells will be analyzed using AquiferTest Pro® software and applying appropriate analytical methods for the type of aquifer tested. The applicable analytical methods may include but will not be limited to: Theis, Boulton, Moench fracture flow, Warren-Root double porosity, and Cooper-Jacob. These methods are curve fitting methods where the test data is fitted to method type curves using either automated or manual fits. Diagnostic plots using drawdown derivative data (time versus change in drawdown) will also be used to help select an appropriate method for analysis. Diagnostic plots will determine if the data represents a confined, leaky-confined, or unconfined aquifer, whether a barrier boundary is encountered, if a double porosity condition exists, or if well effects (i.e. borehole storage in the pumping well) are present. If well effects are found to be present in the data, the Papadopulos-Cooper method would be applied. Data will be analyzed using both log and semi-log plots as needed and both time-drawdown and distance-drawdown data will be used for the analysis where appropriate. In addition to the pumping data, recovery data will be analyzed by the Theis Recovery or Agarwal methods.

NTCSRA Temporary Long-term Extraction Operations

Following the completion of the long-term aquifer test, including at least a two-day shutdown to observe recovery, long-term temporary operations will begin as the initial step in implementing the NTCSRA. As discussed in the recently submitted revision to the NTCSRA Work Plan (GSC, March 4, 2011), the first six weeks of these operations will be used to collect data to support the evaluation of various alternatives for the final design of this groundwater extraction, treatment and discharge activity. The following subsections discuss the anticipated testing configurations that will be used during that time period to collect the necessary data.

Step 1: First Two-Week Period:

During the first two weeks the temporary long-term operations will continue to use only the SRMW-18RE open borehole for extraction, but with a goal of maintaining a constant pumping water level rather than a constant rate. This configuration will give a better view of the maximum extraction capacity of this well and the associated hydraulic effectiveness throughout the network of water level monitoring points.

Step 2: Second Two-Week Period:

At the beginning of this second step, groundwater extraction will be expanded to include pumping from SRMW-18RA, -18RB, and -18RC to the extent that the water levels in these wells still show significant remaining available drawdown. These wells will be operated together with SRMW-18RE in a mode intended to maintain a constant pumping water level, thus maximizing the overall extraction rate.

Step 3: Third Two-Week Period:

At the end of Step 2, data for the first and second two-week periods will be compared to determine the relative effectiveness of operating SRMW-18RE alone (Step 1) and this well together with some combination of the other three wells added in Step 2. Based on this analysis, a configuration will be selected for Step 3 which is anticipated to be the most likely extraction alternative for the permanent system. This configuration will then form the basis for operations during Step 3, which will provide the final data necessary to evaluate extraction alternatives for the NTCSRA.

NTCSRA Temporary Long-term Treatment Operations

Beginning with the long-term aquifer test, treatment of the extracted groundwater will be provided to meet NYSDEC surface water discharge limitations. The results of effluent sampling from the short-term tests have been used to calculate the influent water quality to the temporary treatment system. The extraction rates listed in Table 3 have been used together with these analytical results to estimate the concentrations of each parameter for which NYSDEC applies an effluent limit.

Table 3: Anticipated Step 2 Extraction Rates	
Well No.	Flow
18RE (open borehole)	12 gpm
18RA	0.3 gpm
18RB	2.7 gpm
18RC	5.0 gpm
Total	20.0 gpm

Given the well interference effects that are certain to occur in Step 2, these extraction rates are anticipated to be the maximum rates achievable at each of these wells when they are operated together. On the basis of these rates, Table 4 lists the calculated concentrations of each parameter in the treatment system influent. Based on a comparison of these levels to the effluent criteria required by NYSDEC to be met for discharge to surface water, treatment is required only to meet the limit applied to PCE. Therefore, as previously stated in the aquifer testing plan, the primary treatment technology will be aqueous phase granular activated carbon (GAC), which is a well-proven technology for removing levels of PCE anticipated to be present in the influent to this treatment system.. GSC has also indicated previously that the influent to the treatment system will first be passed through filtration units to remove suspended solids. This treatment step is also expected to reduce the total iron content of the influent such that it will be closer to the much lower dissolved iron concentration listed in Table 4.

Table 4: Long-Term Aquifer Test, Step 2 - Design Influent Parameter Concentrations

ORGANIC PARAMETERS	**Influent Treatment Stream Concentrations (ug/L)**			**Effluent Limit (ug/L)**
	(Minimum)	(Maximum)	(Average)	
Acetone	1	20	11	100
Cis-1,2-Dichloroethene	0	0	0	5
Tetrachloroethene	248	309	275	0.7
Toluene	0	1	0	5
Trichloroethene	0	0	0	3

INORGANIC PARAMETERS	**Influent Treatment Stream Concentrations (ug/L)**			**Effluent Limit (ug/L)**
	(Minimum)	(Maximum)	(Average)	
Total Alkalinity	80860	80860	80860	Not listed

INORGANIC PARAMETERS	Influent Treatment Stream Concentrations (ug/L)			Effluent Limit (ug/L)
Solids, Total Suspended	0	0	0	Not listed
Solids, Total Dissolved	141080	141080	141080	Not listed
Chloride	2799	2799	2799	250000
Nitrate as Nitrogen	402	402	402	10000
Sulfate	28325	28325	28325	250000
Aluminum (total)	9	9	9	100
Arsenic (dissolved)	1.60	1.60	1.60	36*
Arsenic (total)	2.58	2.58	2.58	36
Barium (dissolved)	0.62	0.62	0.62	1000*
Barium (total)	0.72	0.72	0.72	1000
Calcium (dissolved)	28491	28491	28491	Not listed
Calcium (total)	26555	27490	26555	Not listed
Cadmium (dissolved)	0.02	0.02	0.02	1.2*
Cadmium (total)	0.02	0.02	0.02	1.2
Cobalt (dissolved)	0.00	0.00	0.00	5*
Cobalt (total)	0.02	0.02	0.02	5
Chromium (dissolved)	0.02	0.02	0.02	207*
Chromium (total)	0.31	0.31	0.31	207
Copper (dissolved)	3.16	3.16	3.16	Monitor
Copper (total)	1.87	1.87	1.87	24
	(Minimum)	(Maximum)	(Average)	
Iron (dissolved)	77.08	77.08	77.08	300*
Iron, ferrous	46.50	46.50	46.50	300*
Iron (total)	176.1	264.4	176.1	300
Potassium (dissolved)	2120	2120	2120	Not listed
Potassium (total)	2131	2131	2131	Not listed
Magnesium (dissolved	8747	8747	8747	35000*
Magnesium (total)	7515	8112	7515	35000
Manganese (dissolved	4.096	7.080	4.096	300*
Manganese (total)	9.255	10.570	9.255	300
Sodium (dissolved)	4646	4646	4646	Not listed
Sodium (total)	3801	4125	3801	Not listed
Nickel (dissolved)	0.73	0.73	0.73	96*
Nickel (total)	0.06	0.06	0.06	96
Lead (total)	2.16	2.16	2.16	4.0
Antimony (total)	5.52	5.52	5.52	10.0
Thallium (dissolved)	0.04	0.04	0.04	4.0*
Zinc (dissolved)	27.47	27.47	27.47	166*
Zinc (total)	19.01	19.01	19.01	166
Mercury (dissolved)	0	0	0	0.8*
Mercury (total)	0	0	0	0.8
Hardness, Total as CaCO3	102615	102615	102615	Not listed
TOC	31.50	31.50	31.50	Not listed
Methane	1.80	1.80	1.80	Not listed
Carbon dioxide	6800	6800	6800	Not listed
Dissolved Oxygen	3019	3019	3019	Not listed

INORGANIC PARAMETERS	Influent Treatment Stream Concentrations (ug/L)			Effluent Limit (ug/L)
Sulfide (total)	0	0	0	50
* Total Metal Effluent Limit Where Dissolved Metal Result Greater than Non-Detect				

Preliminary work has been completed to design this temporary treatment system. Figure 2 shows the anticipated location and layout of this system at the Facility. The location as shown is consistent with the property owner's preference. As shown, the treatment system will include bag filters, an equalization tank, a transfer pump and two 1000-lb GAC canisters operating in series. The extracted groundwater will be collected into a common header for conveyance to the treatment area. Treated groundwater will then be conveyed to the point of discharge at a storm water catch basin in the driveway adjacent to the extraction well area. Metering and flow control for the extraction wells will be provided at each well head and the final effluent will be metered separately following treatment. With the concurrence of the property owner and expecting that this temporary system will not operate into the next winter, none of the conveyance piping will be buried. All conveyance piping for contaminated groundwater and the treatment units will be provided with secondary containment and leak detection with automatic shutdown and a callout feature to notify GSC personnel of any alarms.

In addition to any sampling required for the discharge permit, sampling of the treatment system influent and effluent and each extraction well will be performed one day, three days, seven days, ten days and fourteen days following the beginning of each step. Analysis will be for volatile organic compounds by method 8260B. The last sample collected on the fourteenth day will be analyzed for the full target compound list (TCL), the full target analyte list (TAL) and the monitored natural attenuation (MNA) parameters by methods previously approved for this Site.

In order to accommodate the pilot testing of the Osorb treatment technology, the piping upstream of the first GAC unit will be plumbed in a manner to allow the bypass of a portion of the influent groundwater. At the beginning of Step 3, a pilot scale Osorb unit will be installed on this bypass so that a portion of the groundwater passes through the Osorb material before entering the GAC treatment units. Sampling will be performed of the Osorb influent and effluent to allow separate evaluation of its treatment effectiveness.

NTCSRA Temporary Long-term Discharge

As noted previously, the calculated influent water quality presented in Table 4 indicates that treatment to remove PCE is necessary to meet water quality criteria for discharge of the treated effluent to the on-site storm sewer. This same information has been provided to NYSDEC on March 10, 2011 as the final submission necessary to permit IBM to receive a SPDES Discharge Equivalent Permit. As stated in the schedule section presented in the recent revision to the NTCSRA Work Plan, receipt of that permit by March 31, 2011 is necessary to allow that schedule to be maintained. Based on discussions with NYSDEC, it is reasonable to expect that milestone will be met.

The NTCSRA Work Plan provides for the evaluation of two discharge options. The first is to the storm sewer as will be the case for this testing. The second is by injection to deep groundwater via existing well SRMW-18RF. Therefore, by the end of Step 2, operating data and water level data for observation wells will be evaluated to determine the viability of performing an injection test during Step 3 of extraction operations. If it is determined that such a test can and should be performed, it will be completed during the second week of Step3.

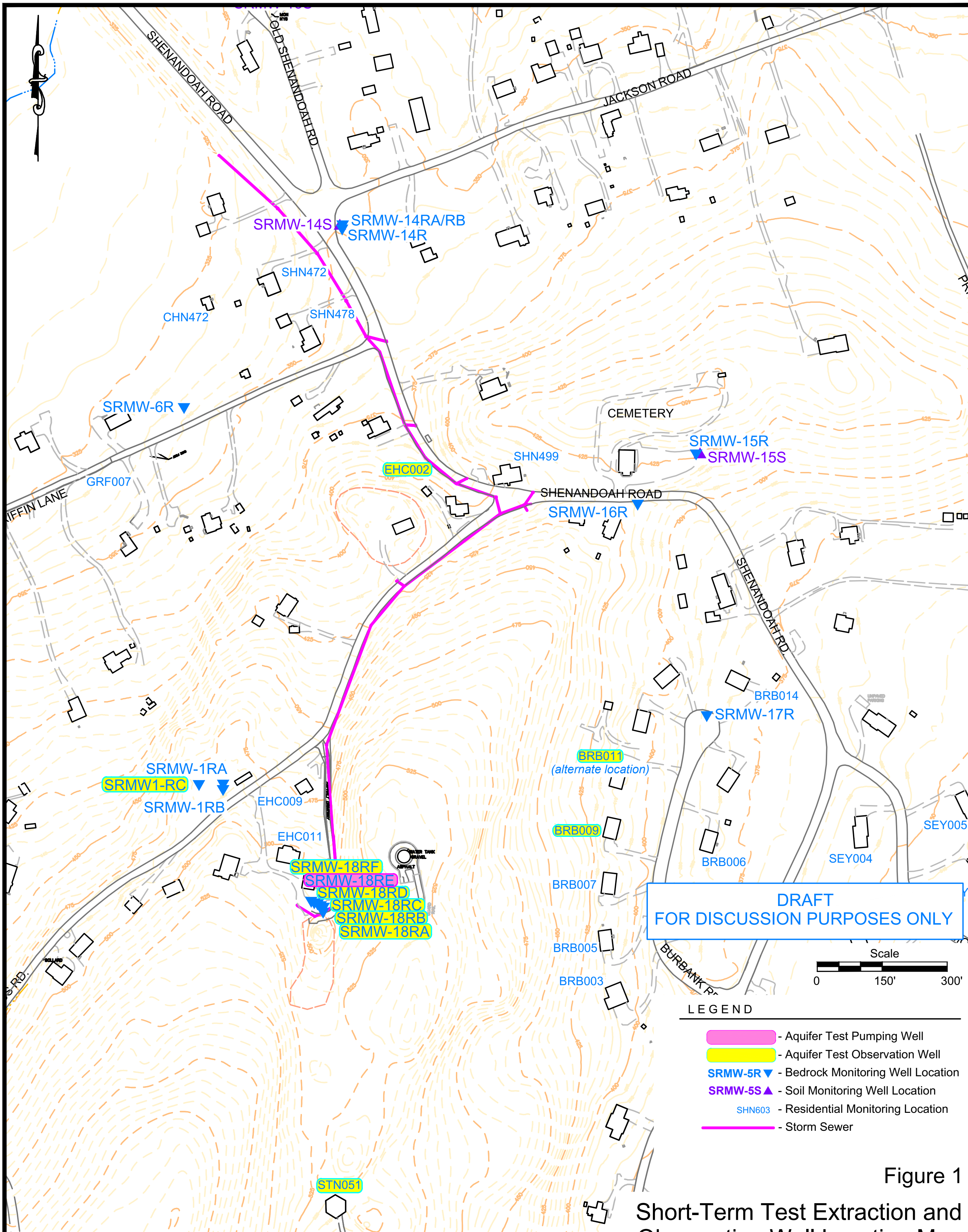


Figure 1

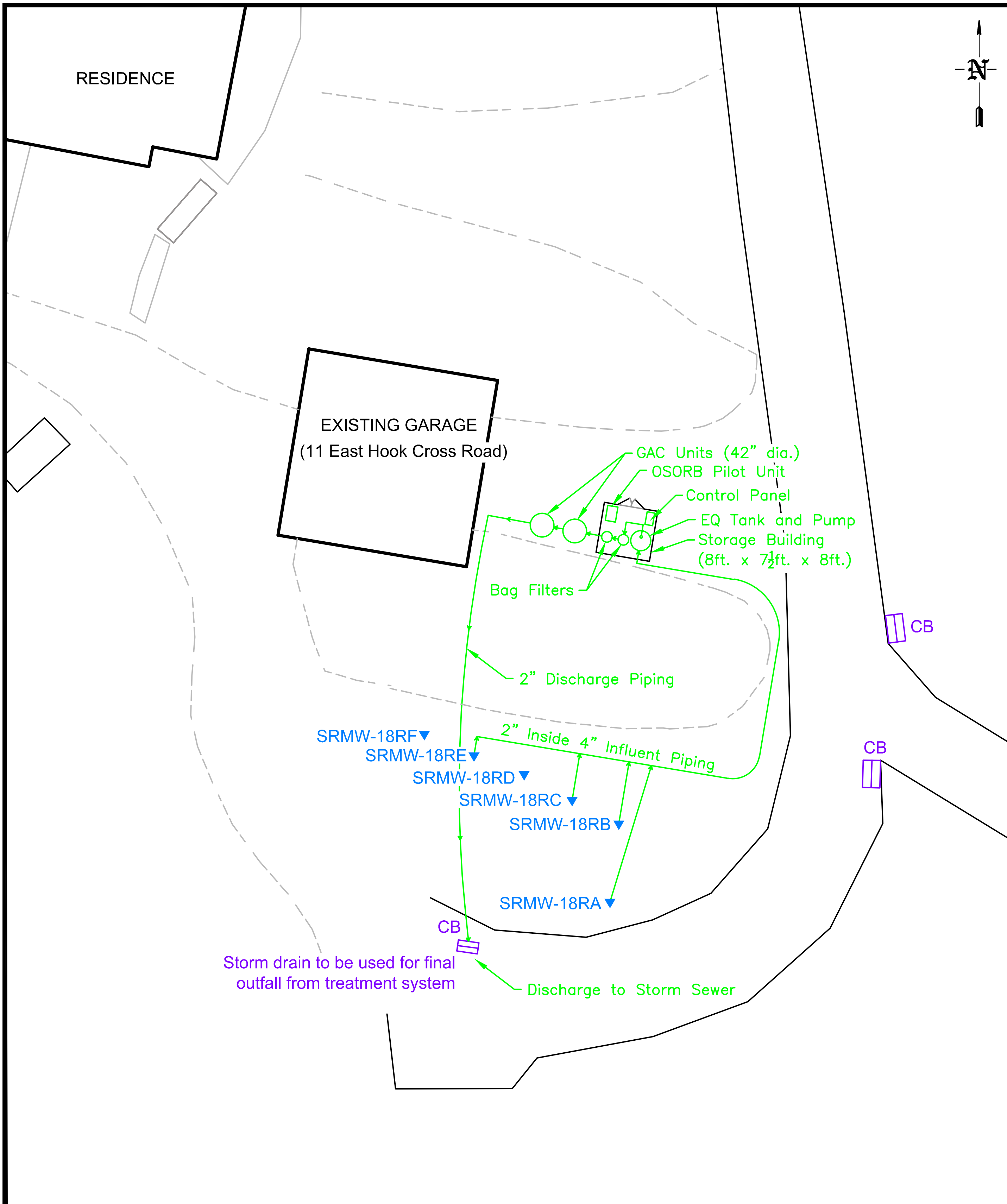
Short-Term Test Extraction and Observation Well Location Map

Surveyor for monitoring well locations: Spectra Environmental Group, Inc., Poughkeepsie, NY

Parcels source: Geographic Information Systems Lab, Dutchess County Real Property Tax Service Agency, Poughkeepsie, NY; 5/98 (PROPERTIES NOT TO SCALE).

GROUNDWATER SCIENCES CORPORATION

21003-081-B3 / 02-17-10



LEGEND

- Bedrock Monitoring Well Location
- Storm Sewer Catch Basin

Approximate Scale
0 10' 20'

DRAFT
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Figure 2

Temporary Treatment System Location and Layout

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21003-079-B1 / 03-11-11

Table 1. Summary of Short-term Facility Aquifer Tests
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 28-Mar-11
DRAFT for Discussion Purposes Only

Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Short Term Test Rate	Short Term Test Duration	Max Obs Drawdown (ft)	Max Avail Drawdown (ft)	Max Drawdown in Observation Wells (ft) 18RA	18RB-P1	18RB-P2	18RC	18RD	18RF-P1	1RC	EHC-002	BRB-009	BRB-011	STN051
SRMW-18RE	WBZ C	230 - 250	Single Packer Installation *Packer Top @ 225 ft bgs* *Packer Bottom @ 228.5 ft bgs* *Pump Intake @ 228 ft bgs*	5 gpm	24 hours	132.22	172.72	2.25	5.38	10.68	41.23	25.96	5.22	2.26	0.21	1.44	1.24	inaccess
SRMW-18RE	WBZ B	127 - 130	Straddle Packer *Top Packer @ 118-123 ft bgs* *Open Interval @ 123-133 ft bgs* *bottom 5ft section perf pipe* *Bottom Packer @ 133-138 ft bgs* *Pump Intake @ 126 ft bgs*	3 gpm	24 hours	61.37	92.67	1.33	32.74	32.65	3.00	1.23	0.52	0.26	0.18	0.23	0.23	inaccess
SRMW-18RA	WBZ A (actual)	75	No Packer Installed *Pump Intake @ 73.7 ft bgs*	0.5 gpm	~8 hours	46.87	49.79	46.815 *(pumping well)*										
SRMW-18RE	open borehole (Constant Rate)		No Packer Installed *Pump Intake @ 220 ft bgs*	13 gpm	~20 hours	170.44	196.37	5.42	58.18	FLUTe intentionally depressurized use 18RB-P1	66.78	33.70	5.75	2.11	0.07	artesian	artesian	1.40

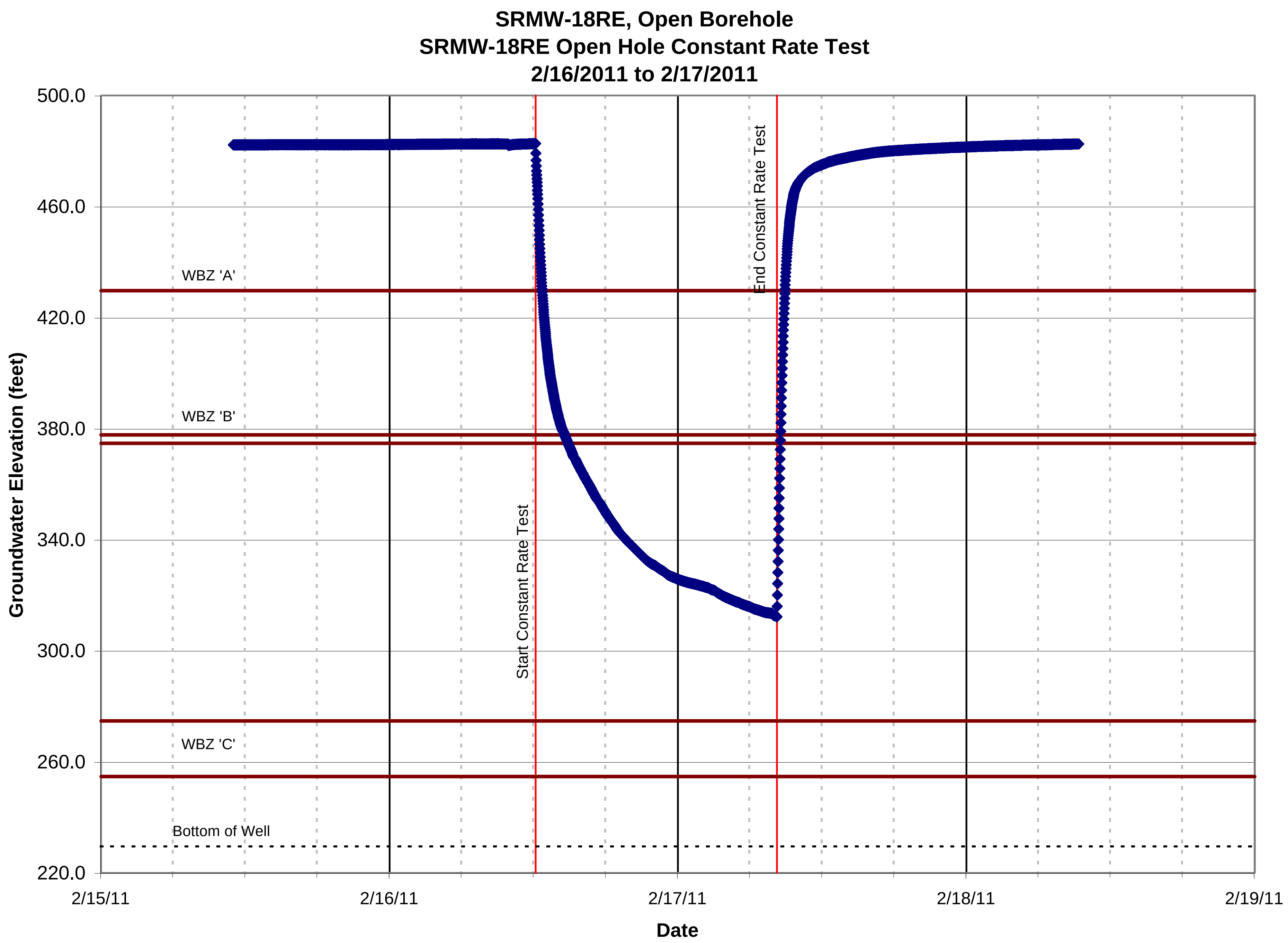
Table 2: Summary of Short-term Facility Aquifer Tests Analytical Monitoring Results
Shenandoah Road Groundwater Contamination Superfund Site

Last Updated: 10-Mar-11
DRAFT for Discussion Purposes Only

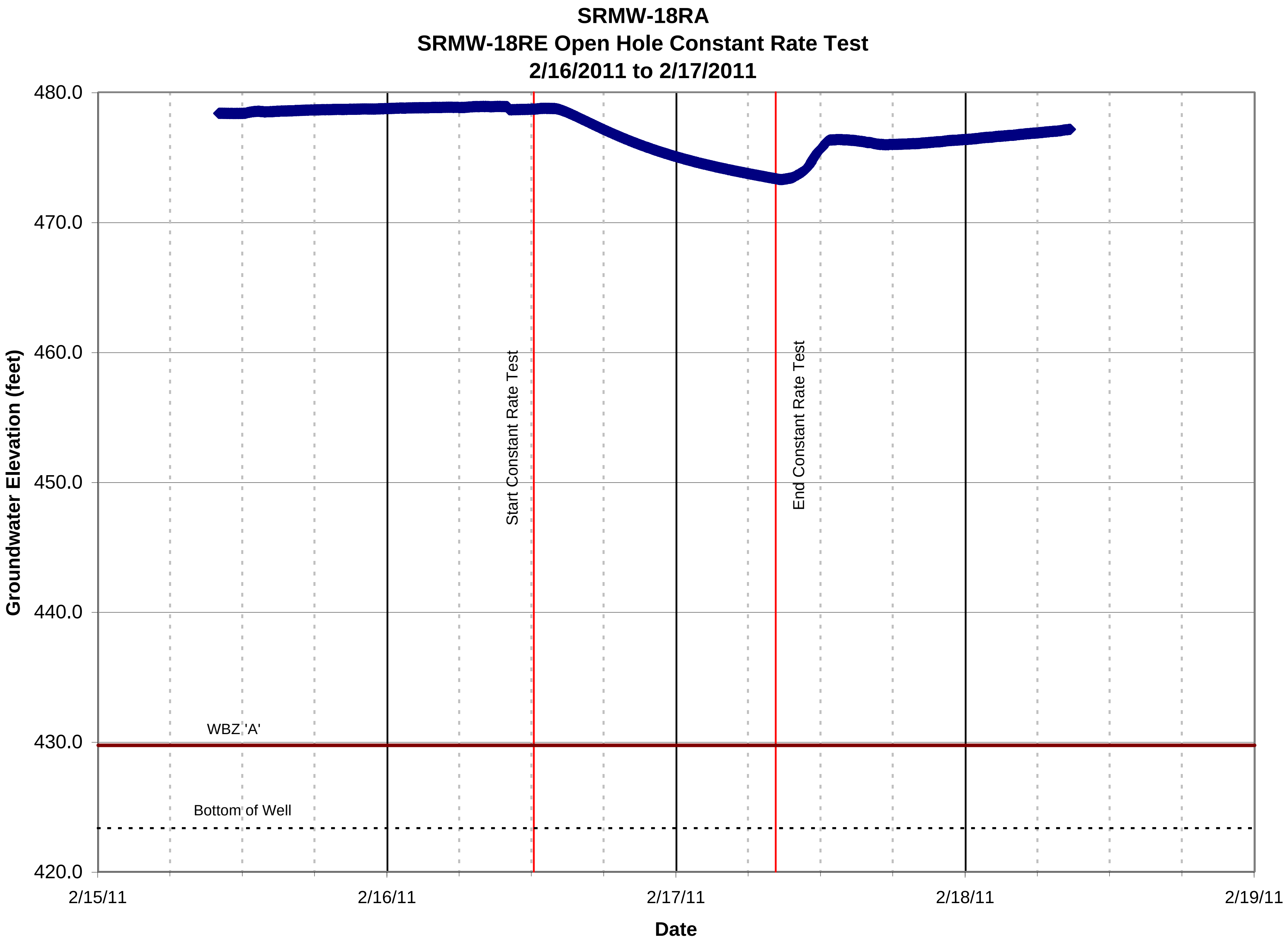
Test Location	WBZ ID	Interval ft bgs	Borehole Configuration	Short Term Test Rate	Sample Time	TCL VOC 8260B Results (ug/L)		
						PCE	TCE	c12-DCE
SRMW-18RE	WBZ C	230 - 250	Single Packer Installation	5 gpm	@ 1 hour	58 / 57	0.28 J / 0.31 J	1.1 / 1.1
			Packer Top @ 225 ft bgs		@ 12 hours	74	0.44 J	0.87 J
			Packer Bottom @ 228.5 ft bgs		@ 24 hours	150	0.68 J	ND@1
			Pump Intake @ 228 ft bgs					
SRMW-18RE	WBZ B	127 - 130	Straddle Packer	3 gpm	@ 1 hour	4.8 / 4.7	ND@1 / ND@1	ND@1 / ND@1
			Top Packer @ 118-123 ft bgs		@ 12 hours	11	ND@1	ND@1
			Open Interval @ 123-133 ft bgs		@ 24 hours	27	ND@1	ND@1
			bottom 5ft section perf pipe					
			Bottom Packer @ 133-138 ft bgs					
			Pump Intake @ 126 ft bgs					
SRMW-18RA	WBZ A (actual)	75	No Packer Installed	0.5 gpm	@ 1 hour	16000 / 16000	ND@220 / ND@200	ND@220 / ND@200
			Pump Intake @ 73.7 ft bgs		@ 5hrs 20min	15000	ND@200	ND@200
					@ 7hrs 30min	16000	ND@200	ND@200
SRMW-18RE	open borehole (Constant Rate)		No Packer Installed	13 gpm	@ 1 hour	30 / 27	ND@1	ND@1
			Pump Intake @ 220 ft bgs		@ 12 hours	35	ND@1	ND@1
					@ 20 hours	46	ND@1	ND@1

Attachment A

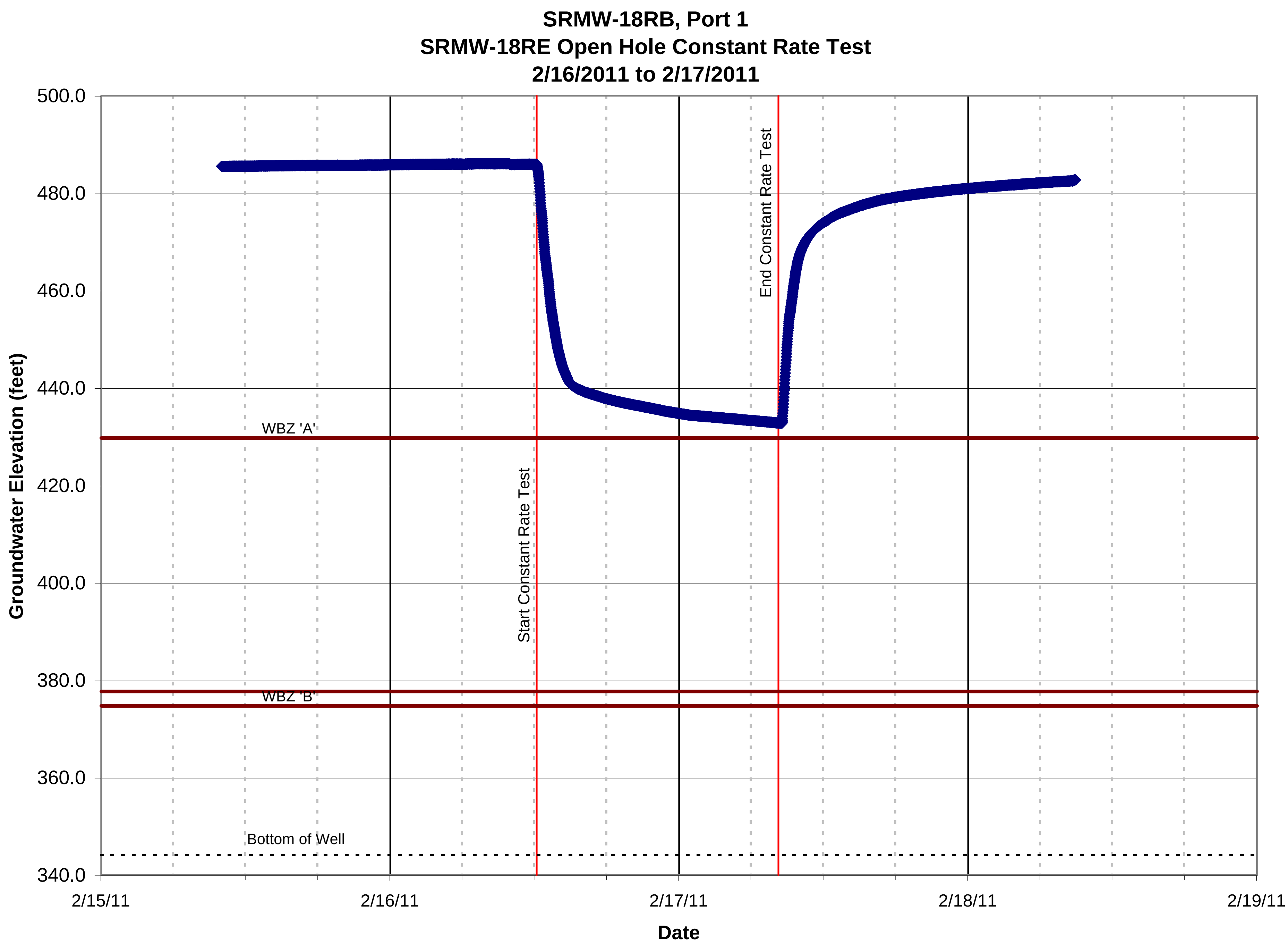
Time versus Water Level Graphs
SRMW-18RE Open Hole Short Term Test

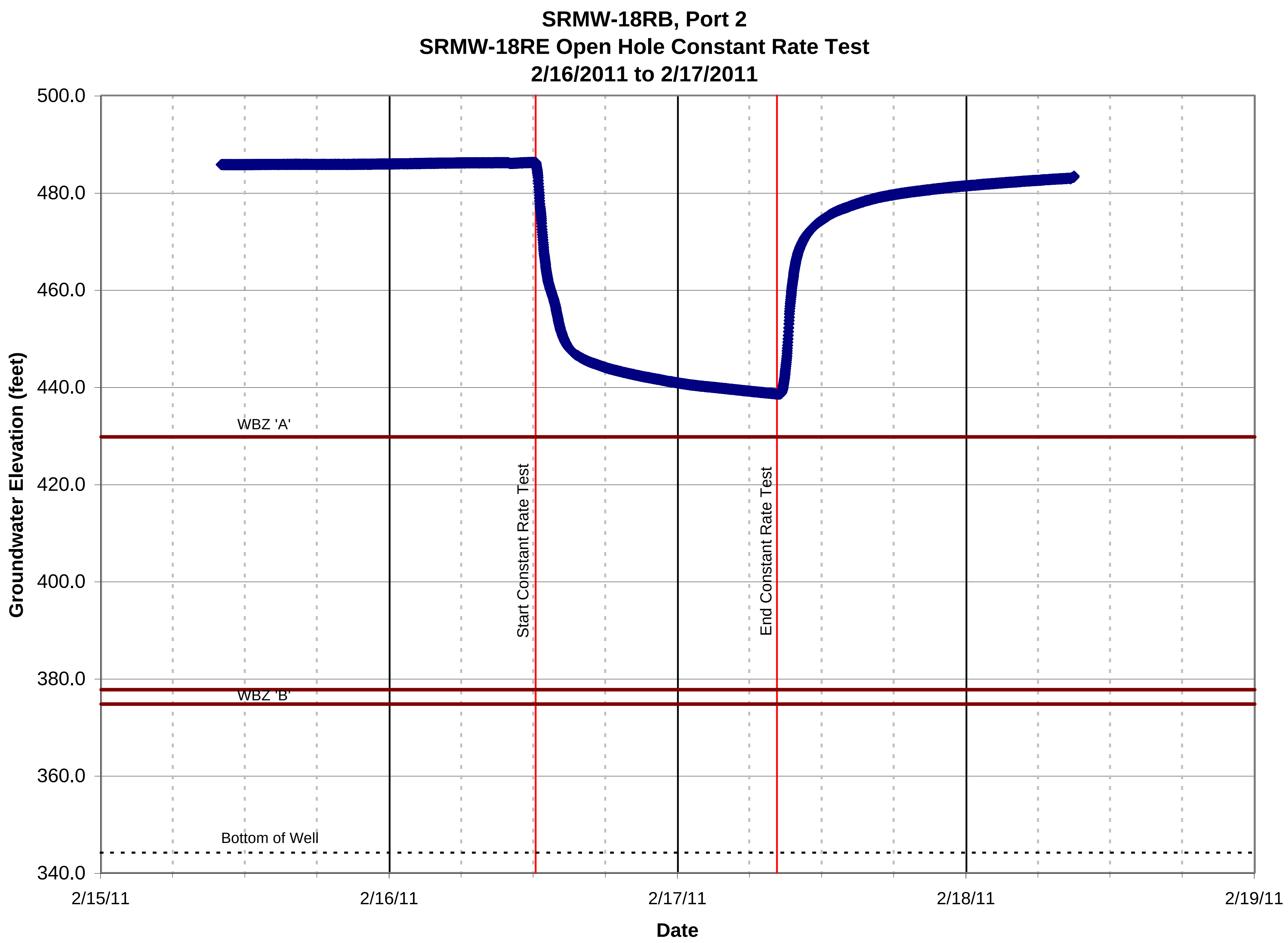


SRMW-18RE, Open Borehole
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
500.0
460.0
420.0
380.0
340.0
300.0
260.0
220.0
WBZ 'A'
WBZ 'B'
WBZ 'C'
Bottom of Well
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

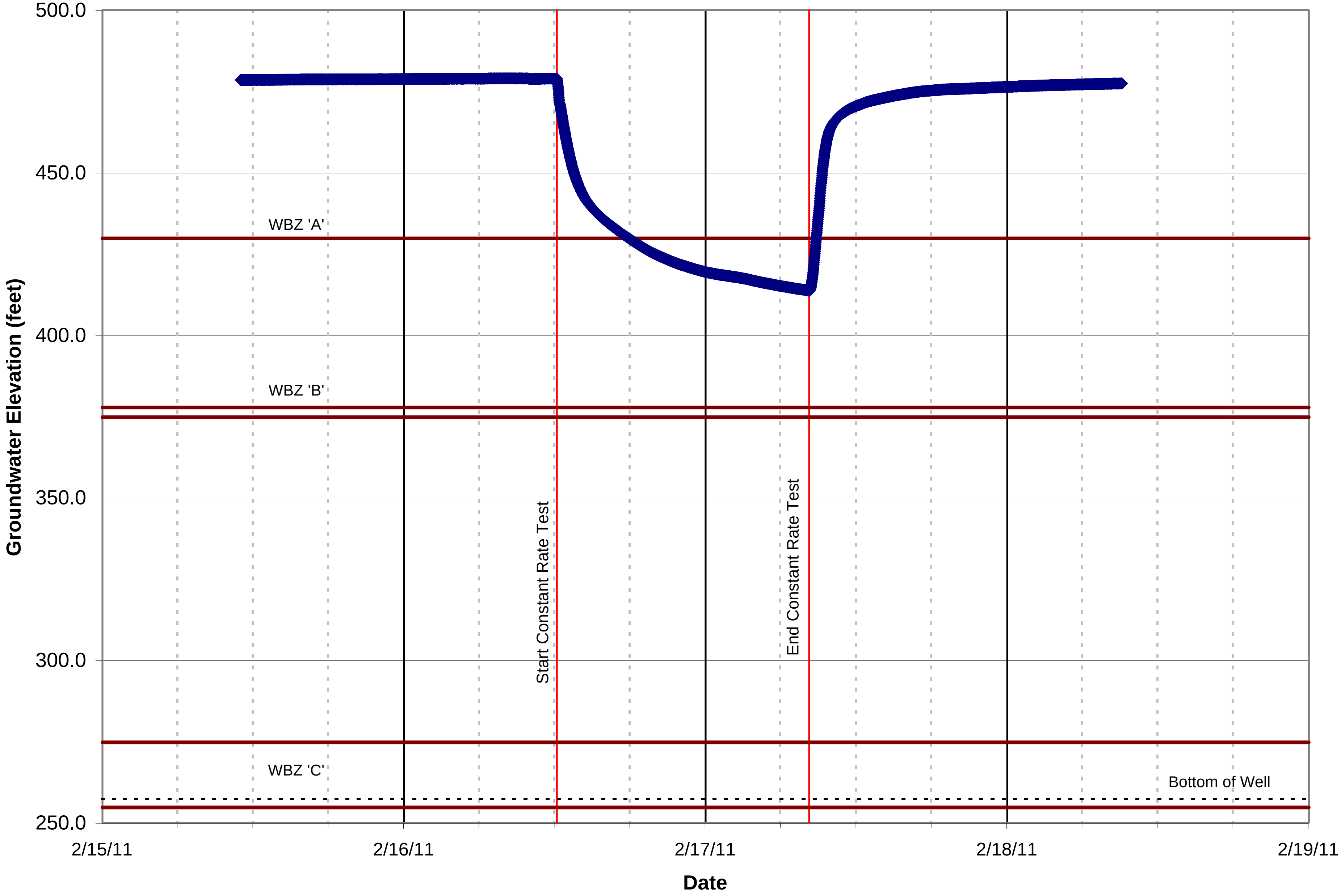


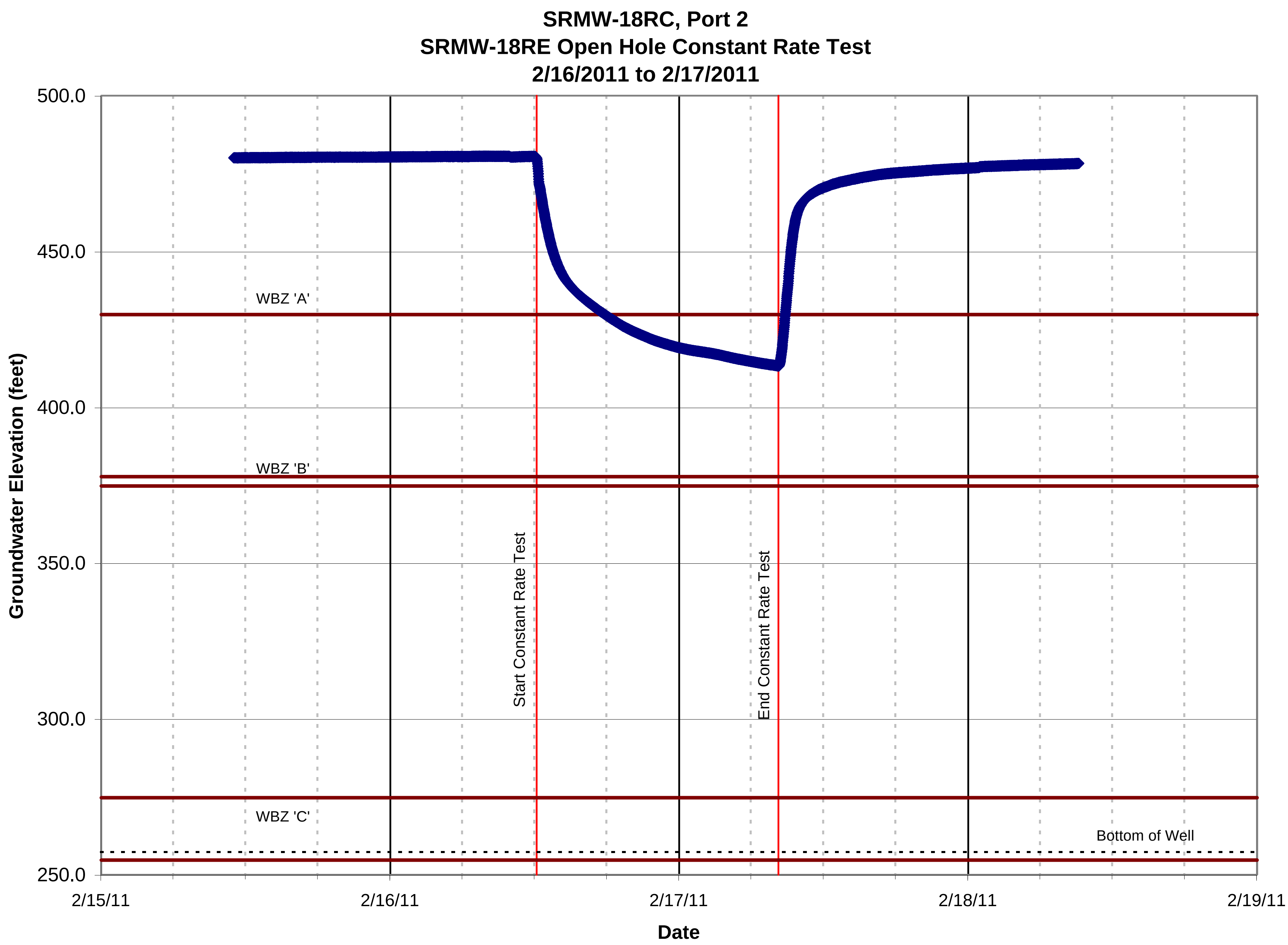
SRMW-18RA
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
480.0
470.0
460.0
450.0
440.0
430.0
420.0
Start Constant Rate Test
End Constant Rate Test
WBZ 'A'
Bottom of Well
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date


SRMW-18RB, Port 1
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
WBZ 'A'
WBZ 'B'
Bottom of Well
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

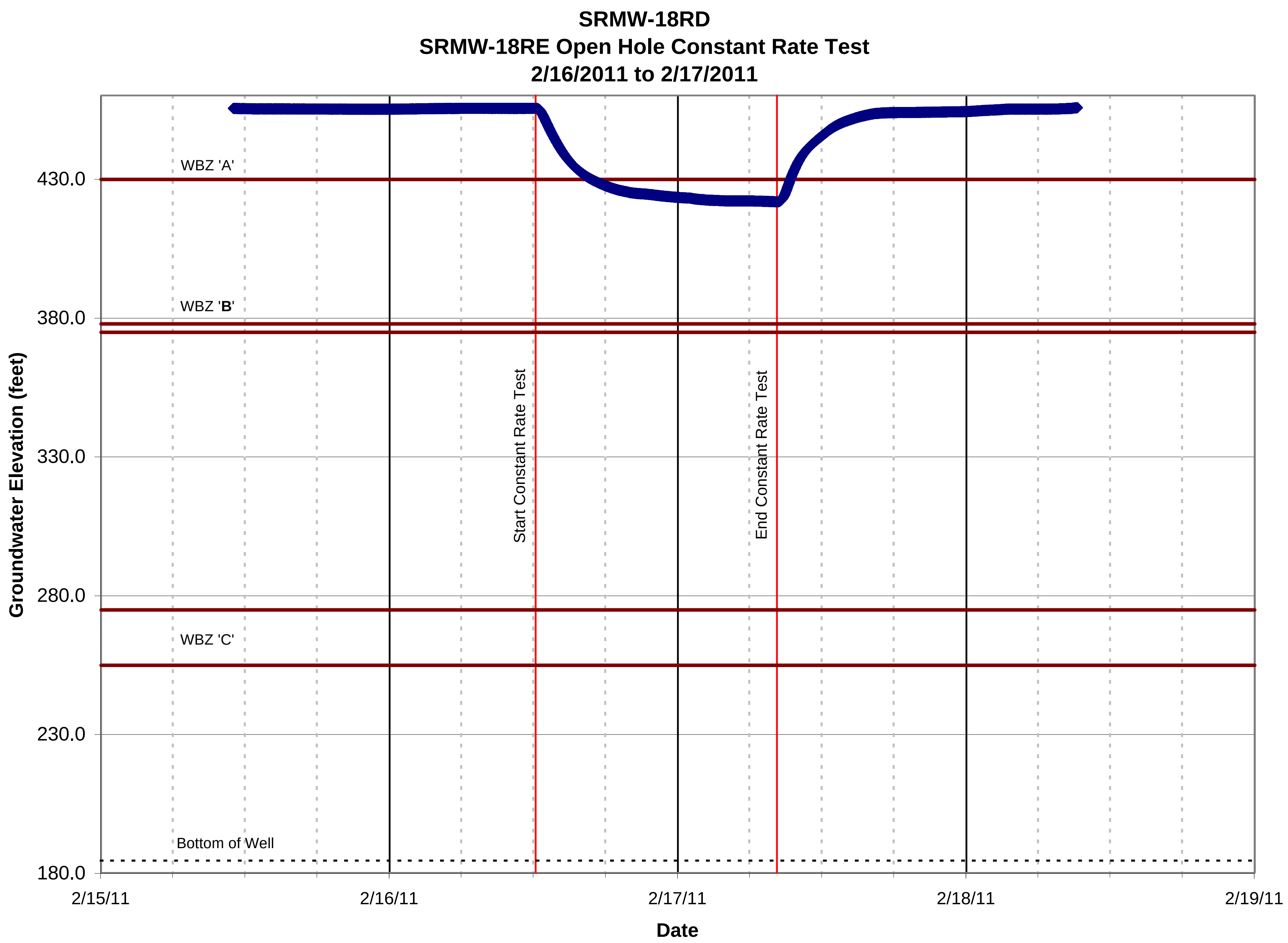

SRMW-18RB, Port 2
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
WBZ 'A'
WBZ 'B'
Bottom of Well
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

SRMW-18RC, Port 1
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011

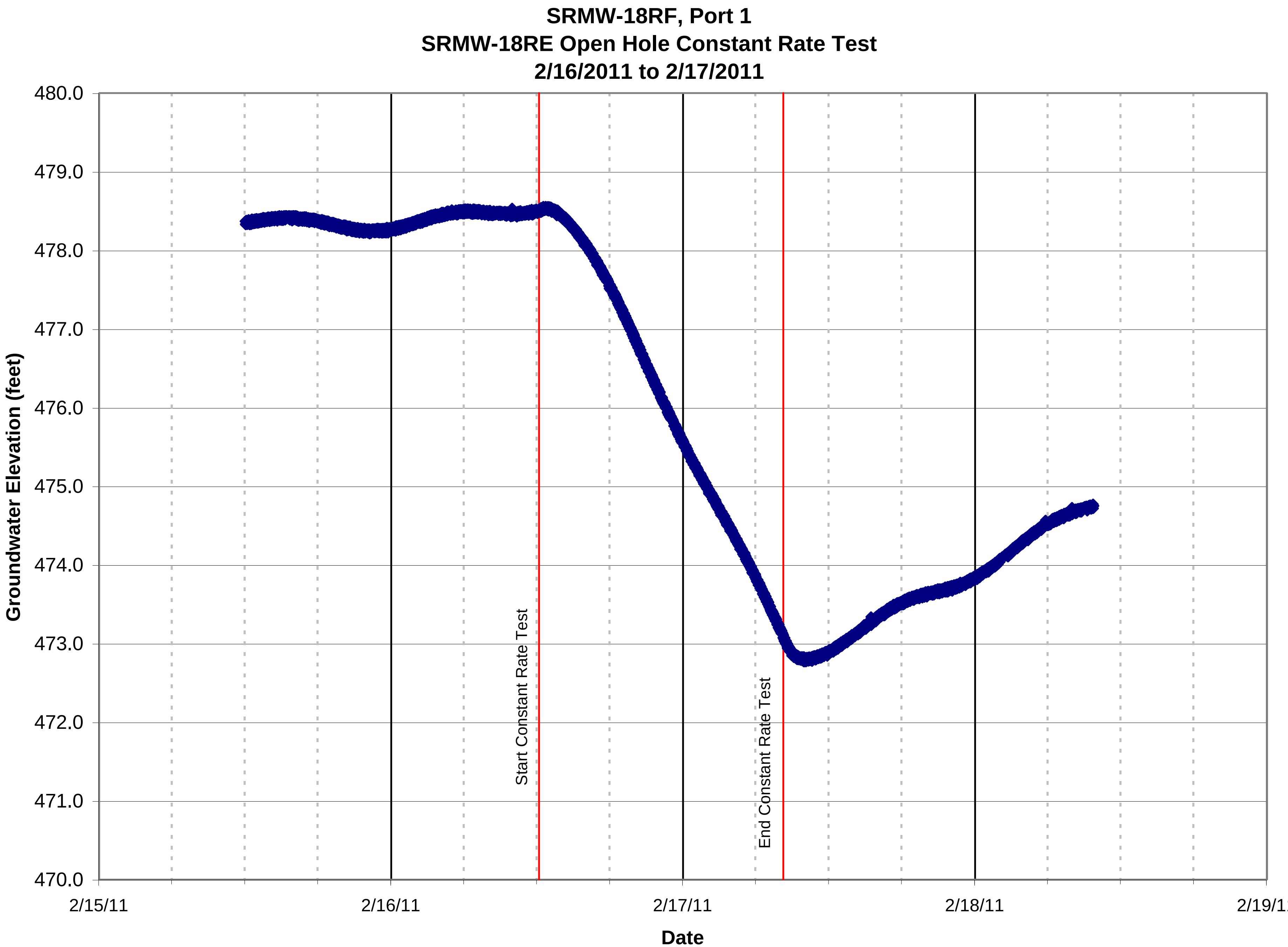


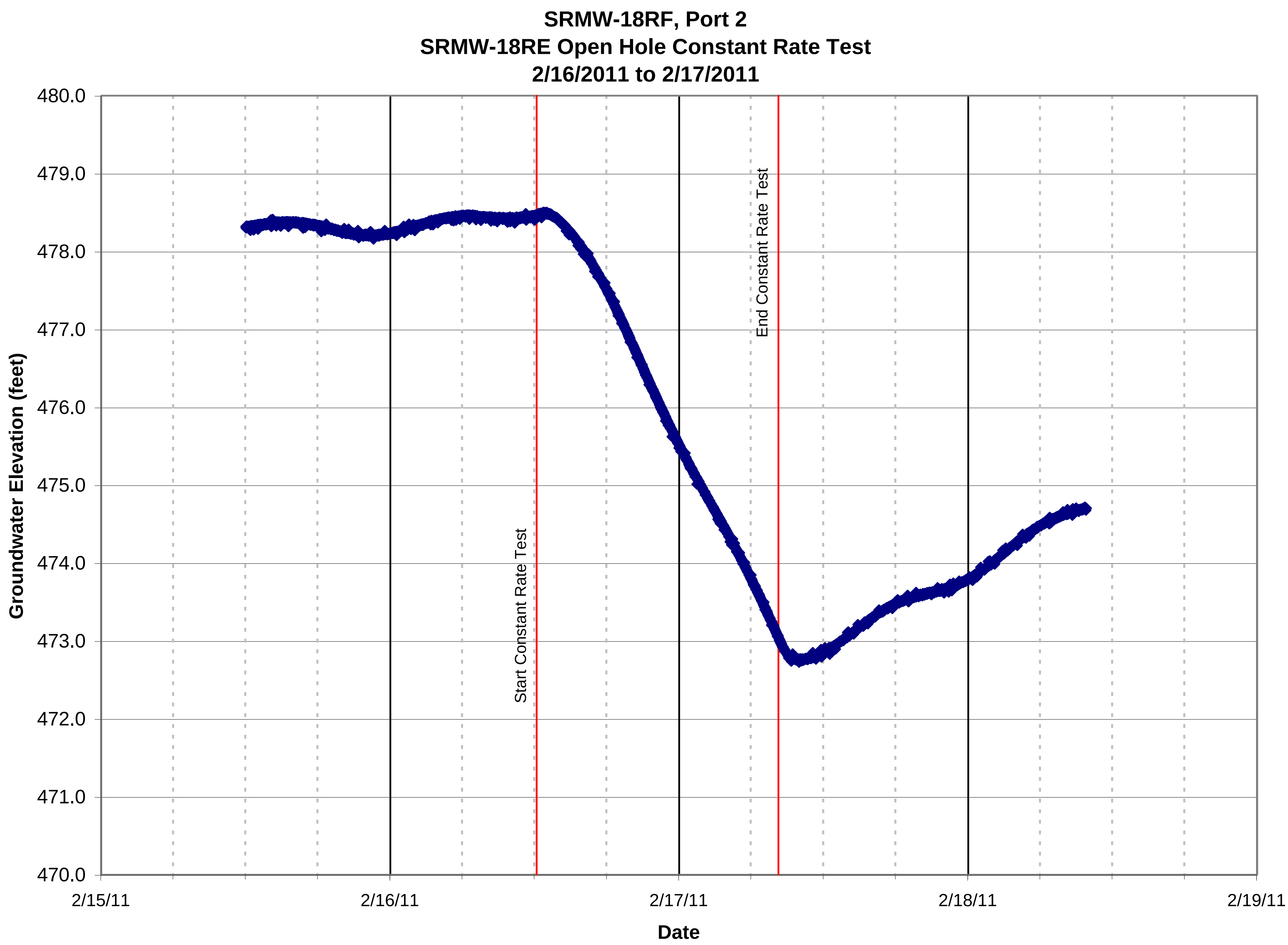


SRMW-18RC, Port 2
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
500.0
450.0
400.0
350.0
300.0
250.0
WBZ 'A'
WBZ 'B'
WBZ 'C'
Start Constant Rate Test
End Constant Rate Test
Bottom of Well
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

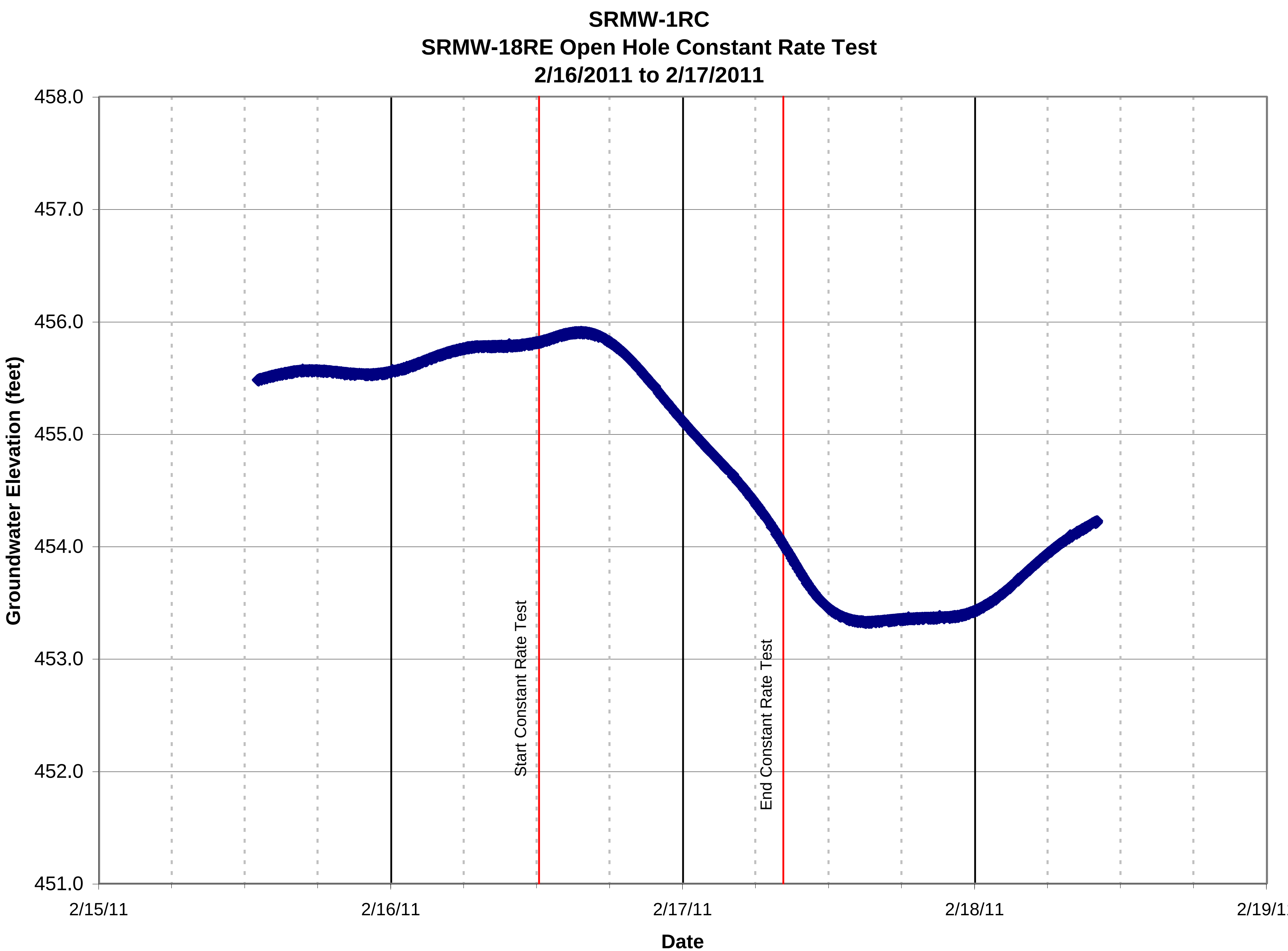


SRMW-18RD
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
430.0
380.0
330.0
280.0
230.0
180.0
WBZ 'A'
WBZ 'B'
WBZ 'C'
Bottom of Well
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

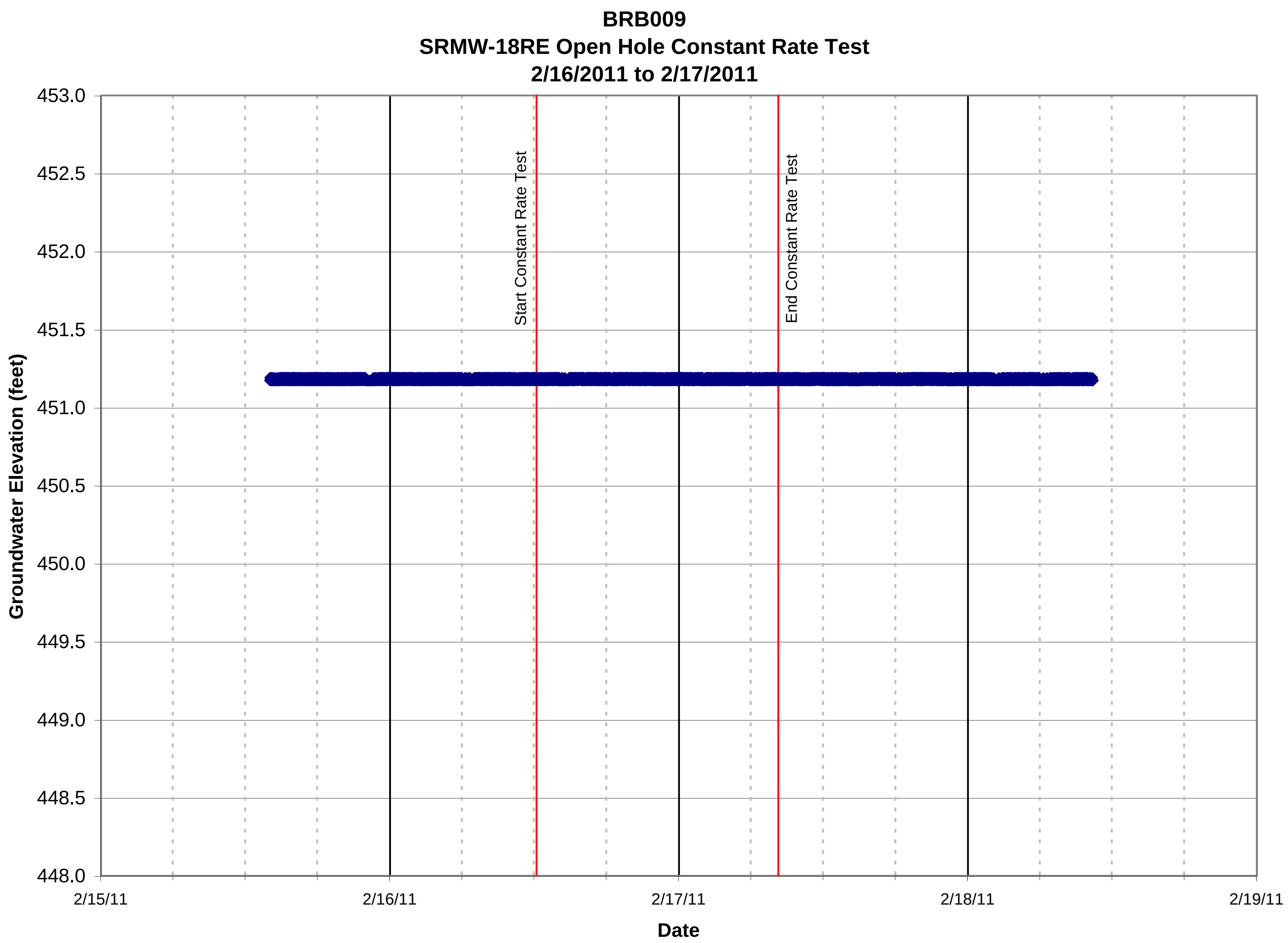

SRMW-18RF, Port 1
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
480.0
479.0
478.0
477.0
476.0
475.0
474.0
473.0
472.0
471.0
470.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

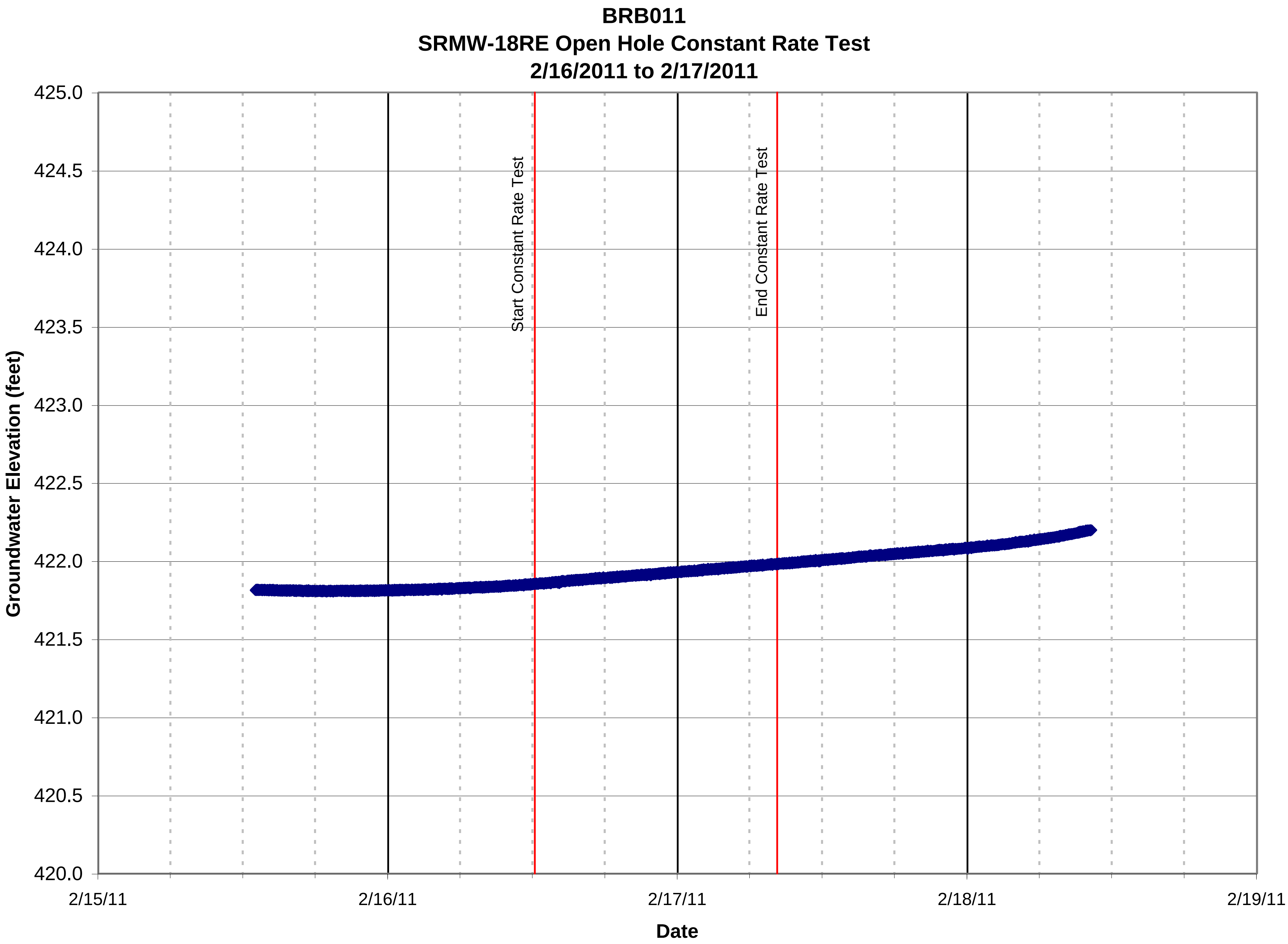


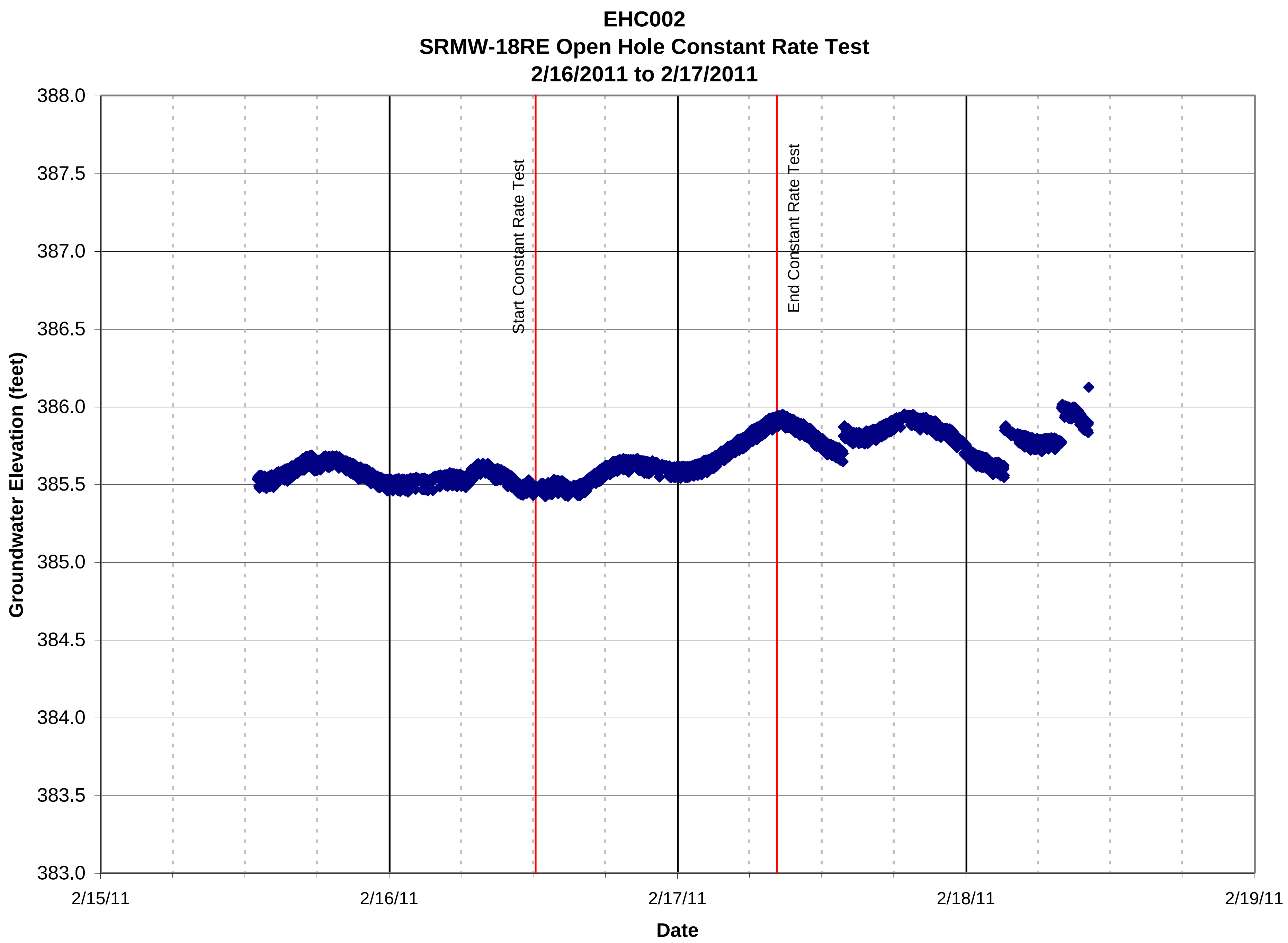
SRMW-18RF, Port 2
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
480.0
479.0
478.0
477.0
476.0
475.0
474.0
473.0
472.0
471.0
470.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date



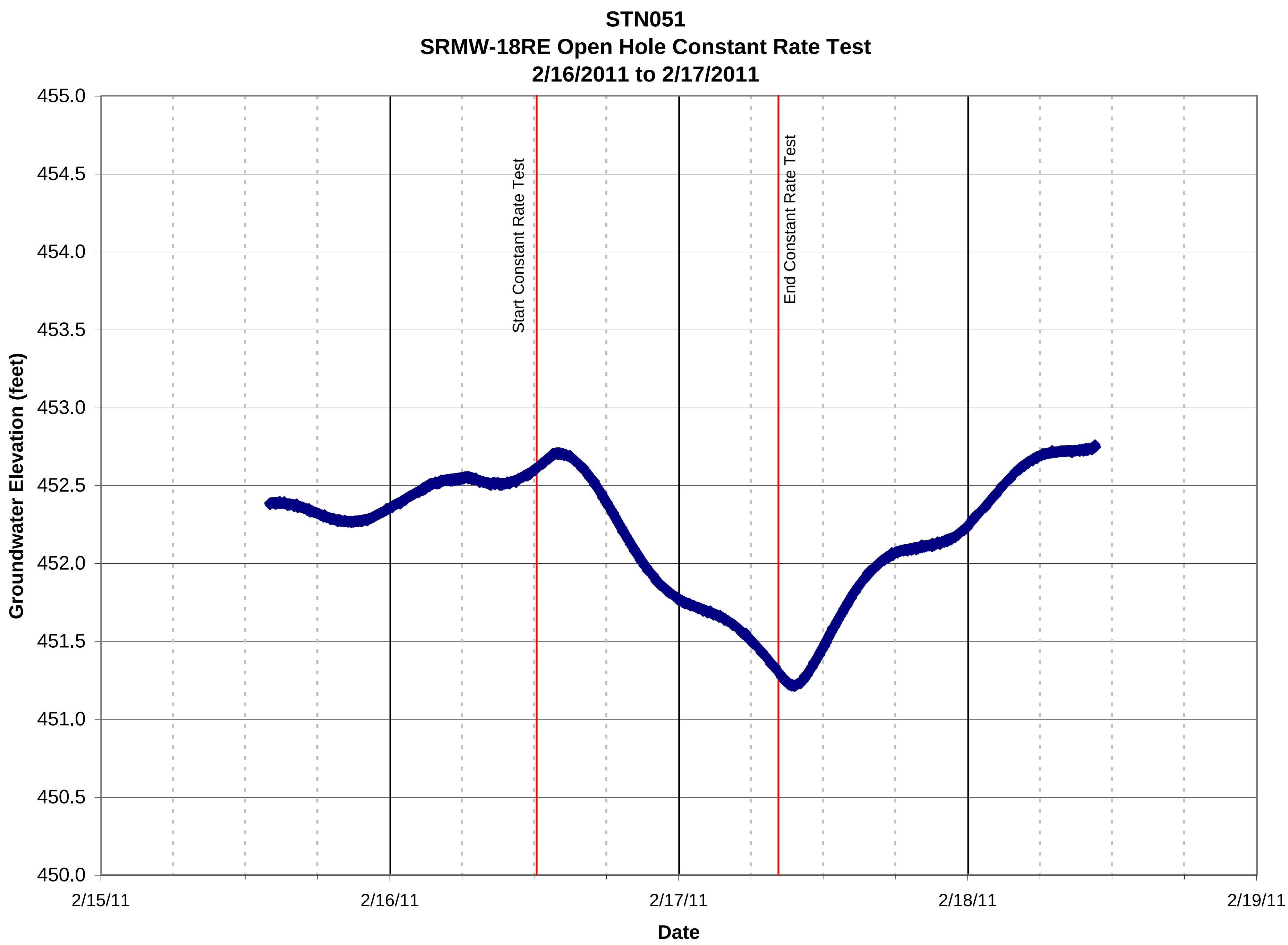
SRMW-1RC
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
458.0
457.0
456.0
455.0
454.0
453.0
452.0
451.0
Groundwater Elevation (feet)
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date


BRB009
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
453.0
452.5
452.0
451.5
451.0
450.5
450.0
449.5
449.0
448.5
448.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date


BRB011
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
425.0
424.5
424.0
423.5
423.0
422.5
422.0
421.5
421.0
420.5
420.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

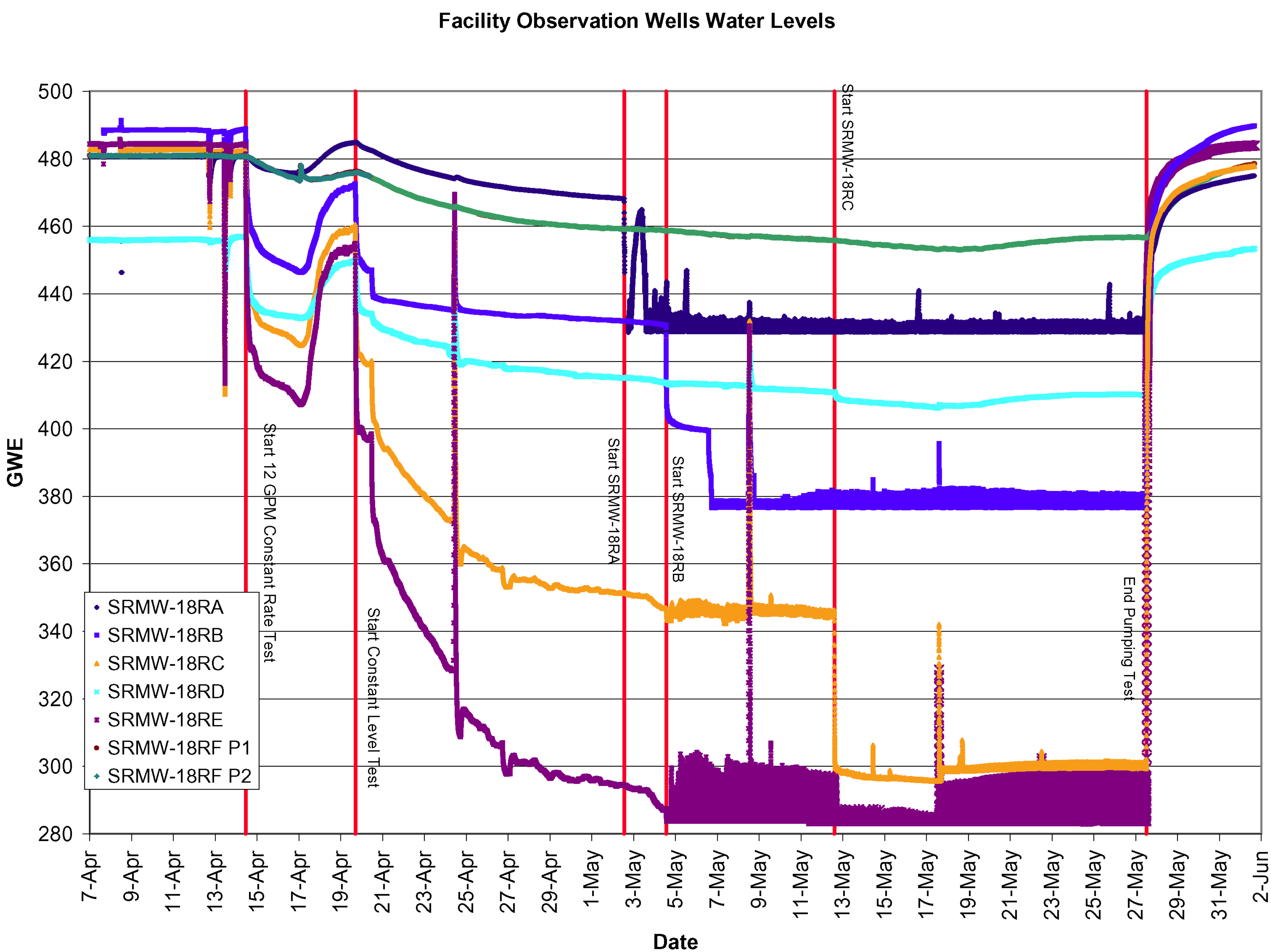


EHC002
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
388.0
387.5
387.0
386.5
386.0
385.5
385.0
384.5
384.0
383.5
383.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

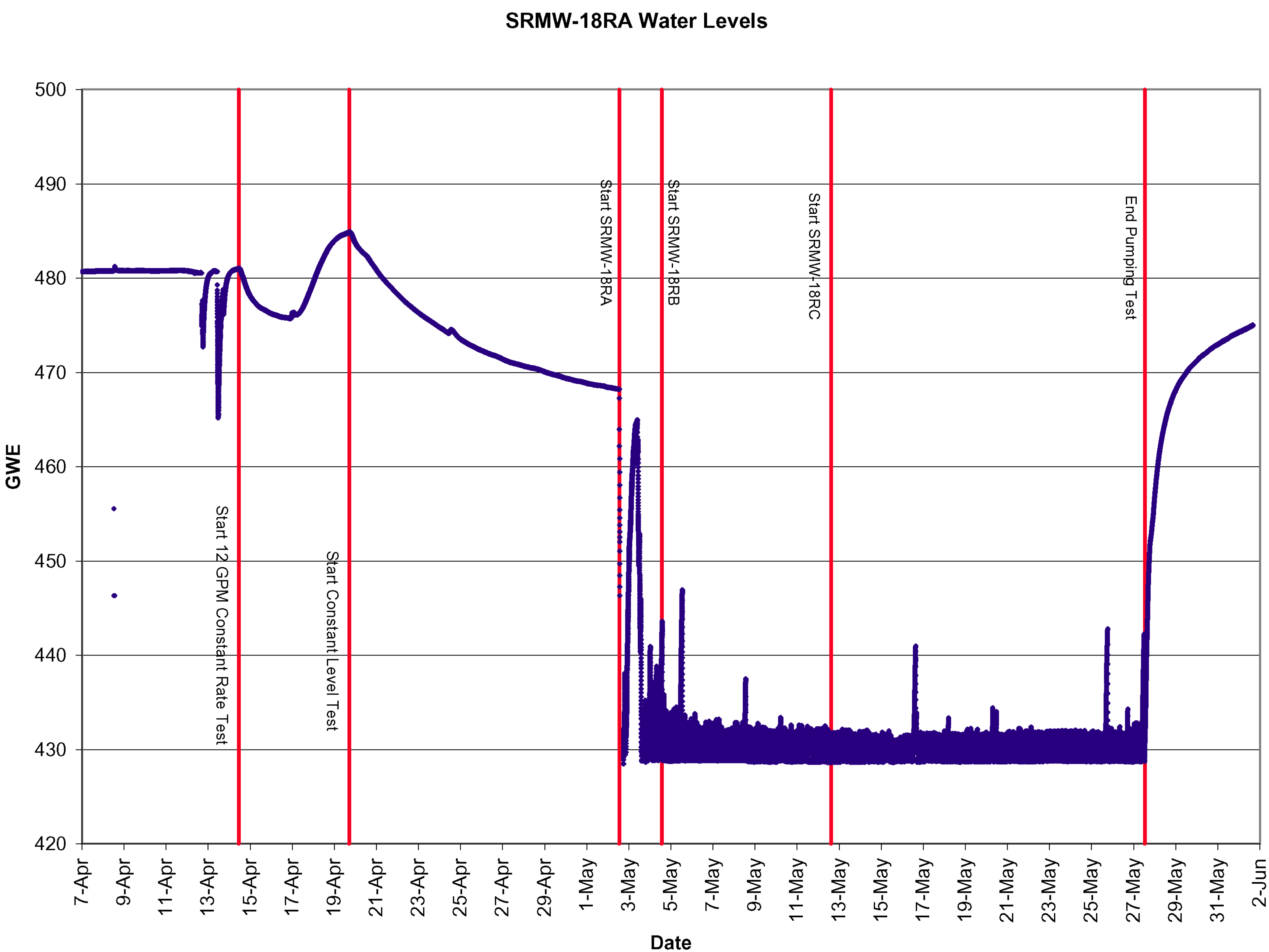

STN051
SRMW-18RE Open Hole Constant Rate Test
2/16/2011 to 2/17/2011
Groundwater Elevation (feet)
455.0
454.5
454.0
453.5
453.0
452.5
452.0
451.5
451.0
450.5
450.0
Start Constant Rate Test
End Constant Rate Test
2/15/11
2/16/11
2/17/11
2/18/11
2/19/11
Date

Appendix C

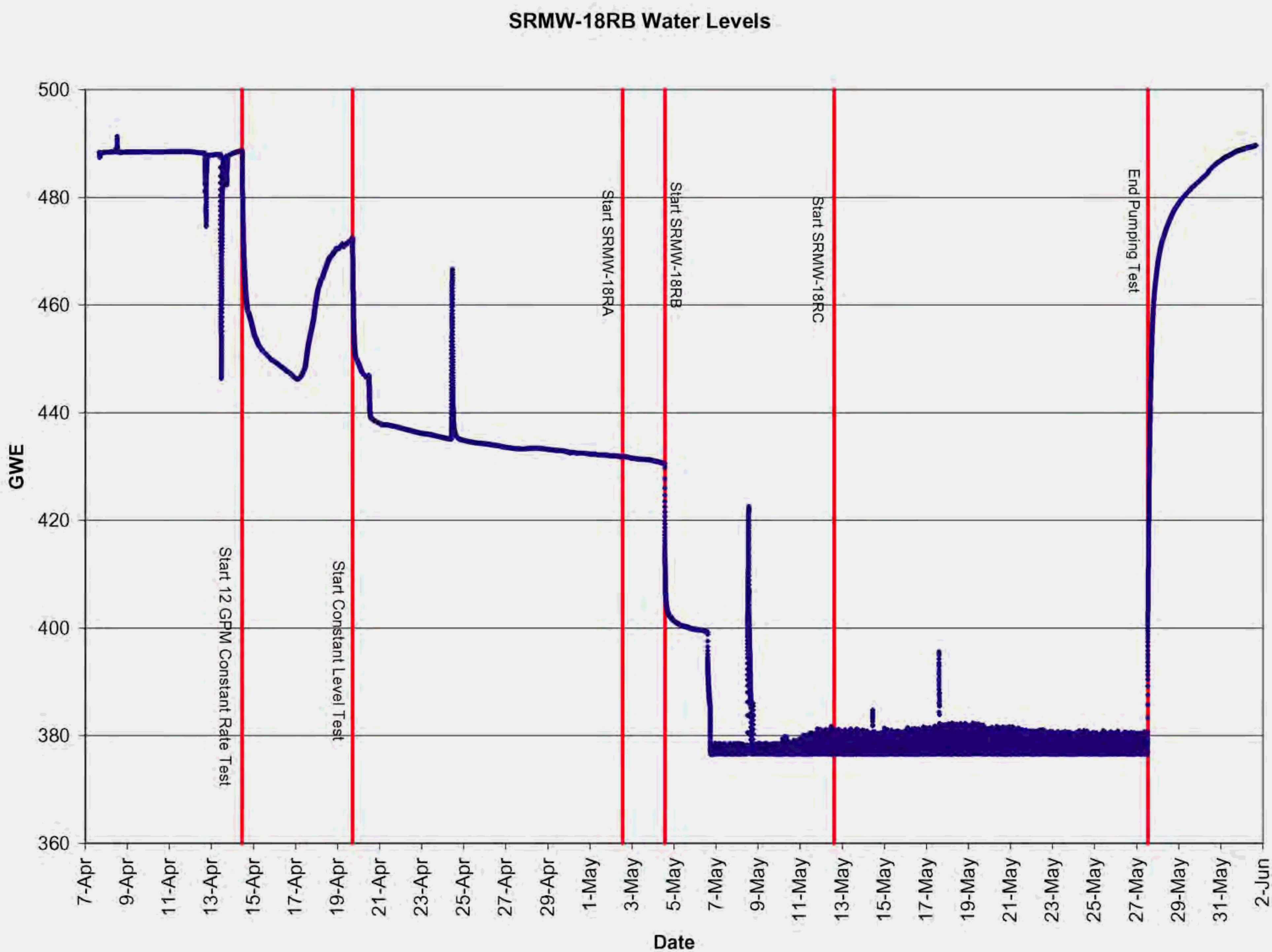
Extraction and Observation Well Time versus Groundwater Elevation Graphs



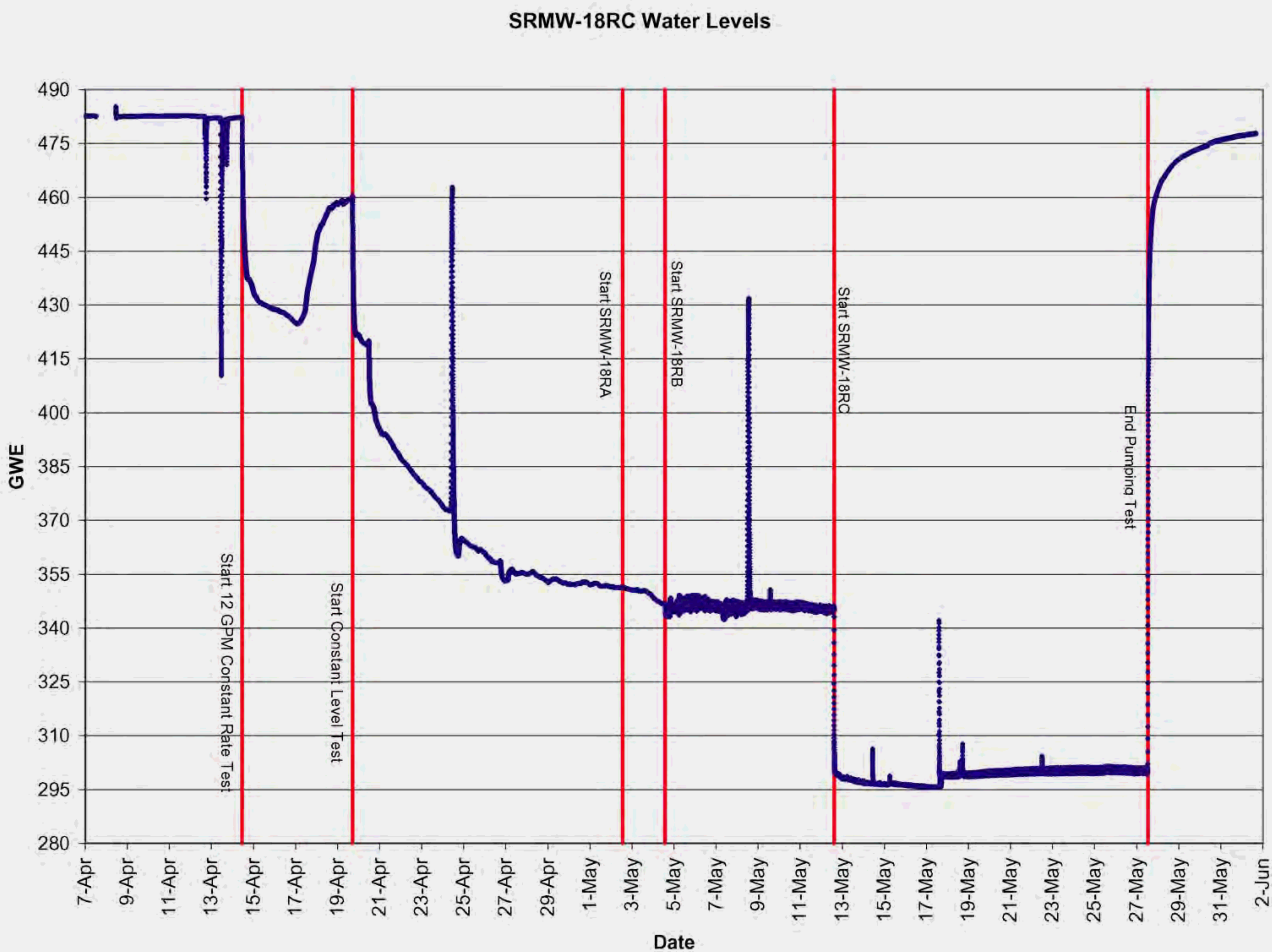
Facility Observation Wells Water Levels
GWE
Date
500
480
460
440
420
400
380
360
340
320
300
280
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
SRMW-18RA
SRMW-18RB
SRMW-18RC
SRMW-18RD
SRMW-18RE
SRMW-18RF P1
SRMW-18RF P2



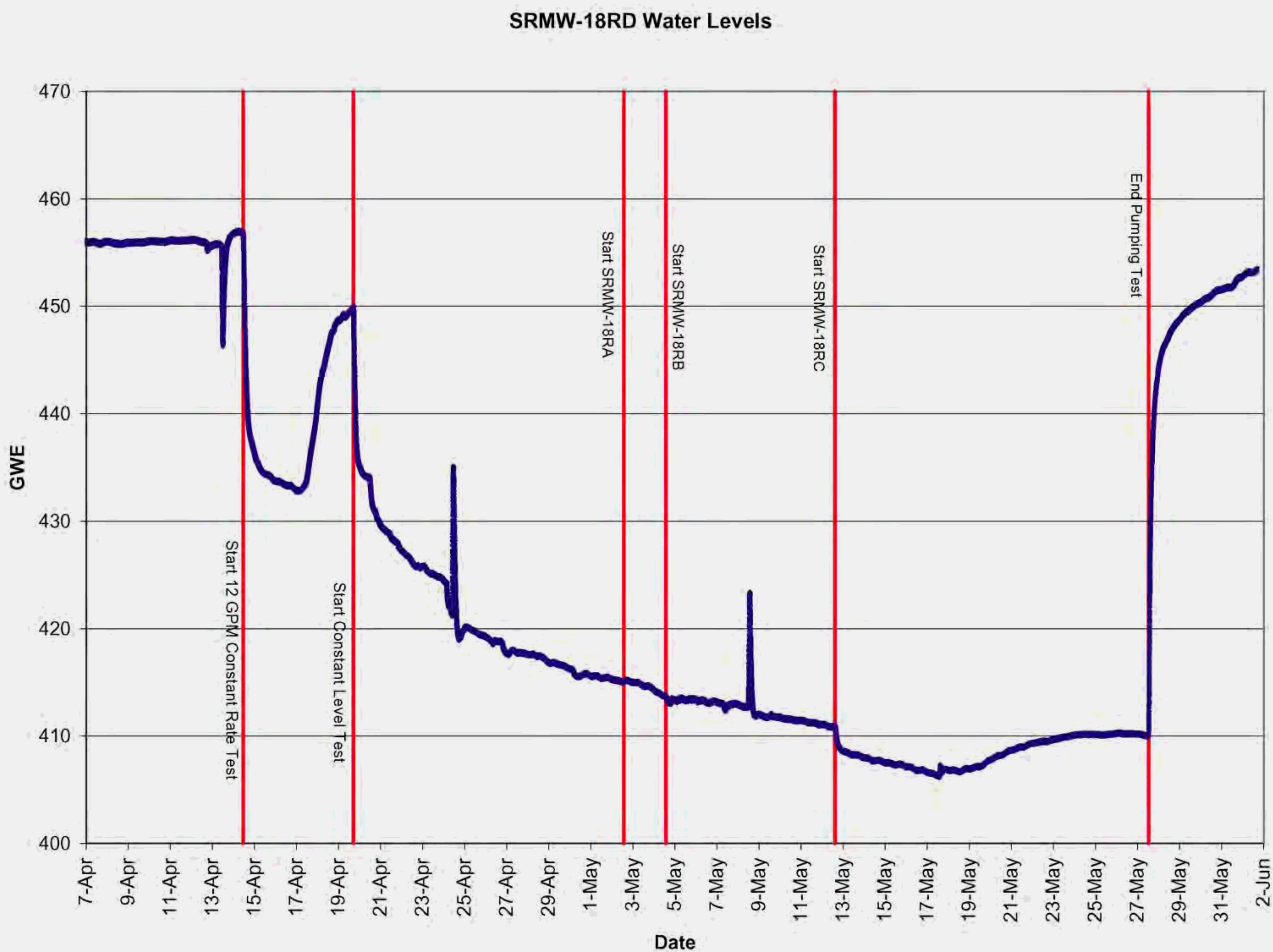
SRMW-18RA Water Levels
GWE
Date
500
490
480
470
460
450
440
430
420
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

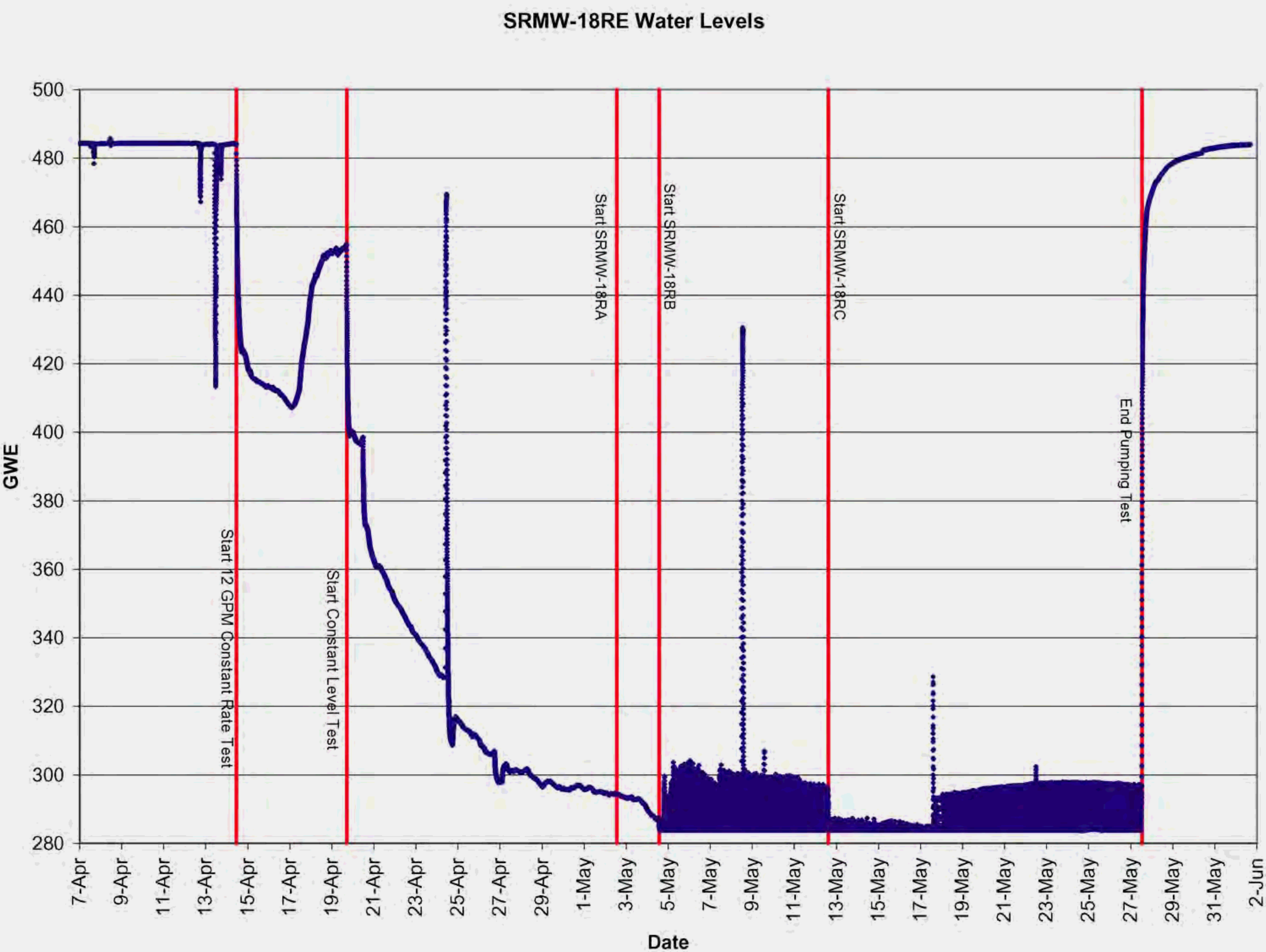


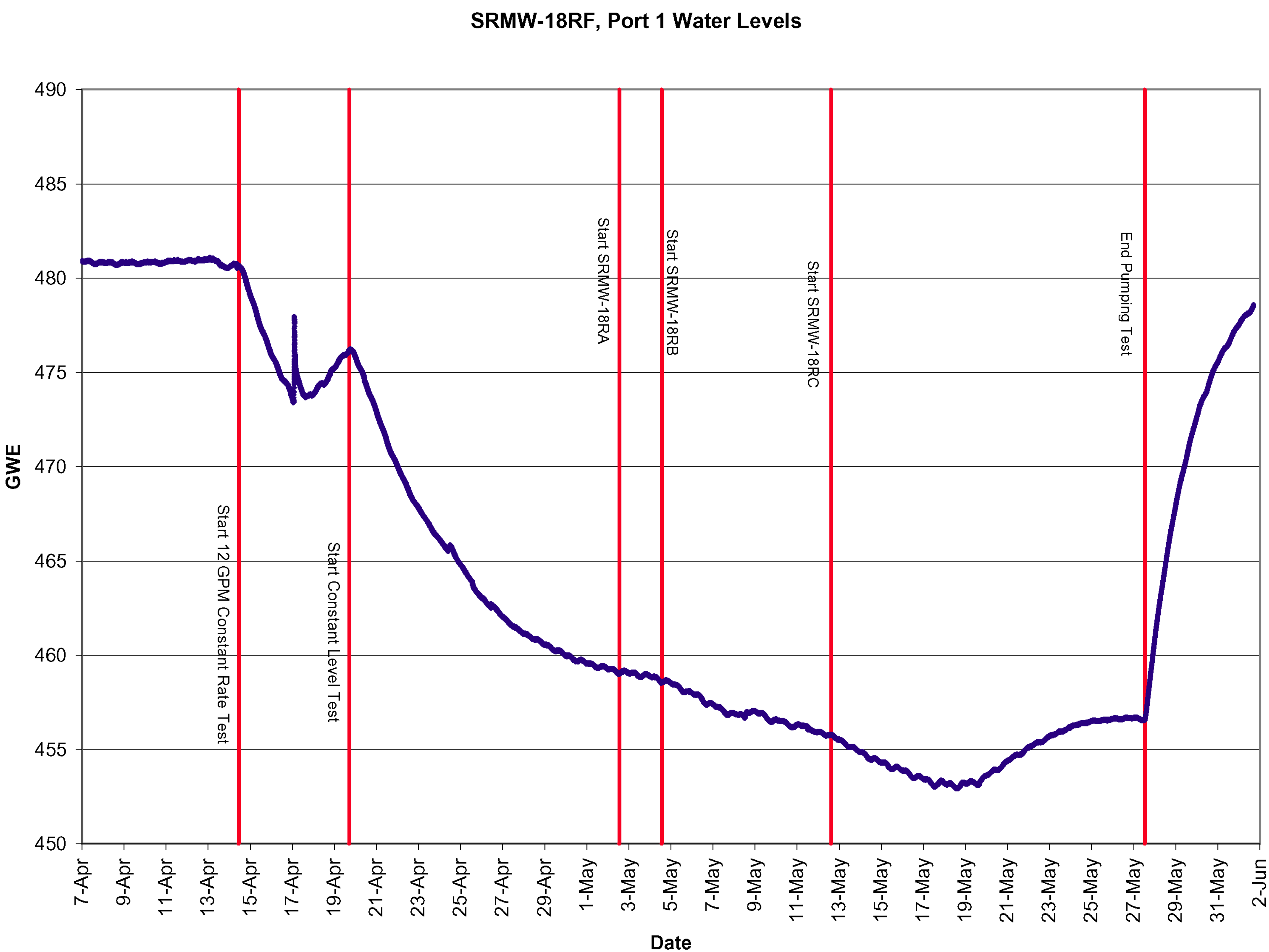
SRMW-18RB Water Levels
GWE
Date
500
480
460
440
420
400
380
360
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



SRMW-18RC Water Levels
GWE
490
475
460
445
430
415
400
385
370
355
340
325
310
295
280
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-18RD Water Levels
GWE
470
460
450
440
430
420
410
400
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-18RE Water Levels
GWE
Date
500
480
460
440
420
400
380
360
340
320
300
280
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-18RF, Port 1 Water Levels
GWE
490
485
480
475
470
465
460
455
450
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
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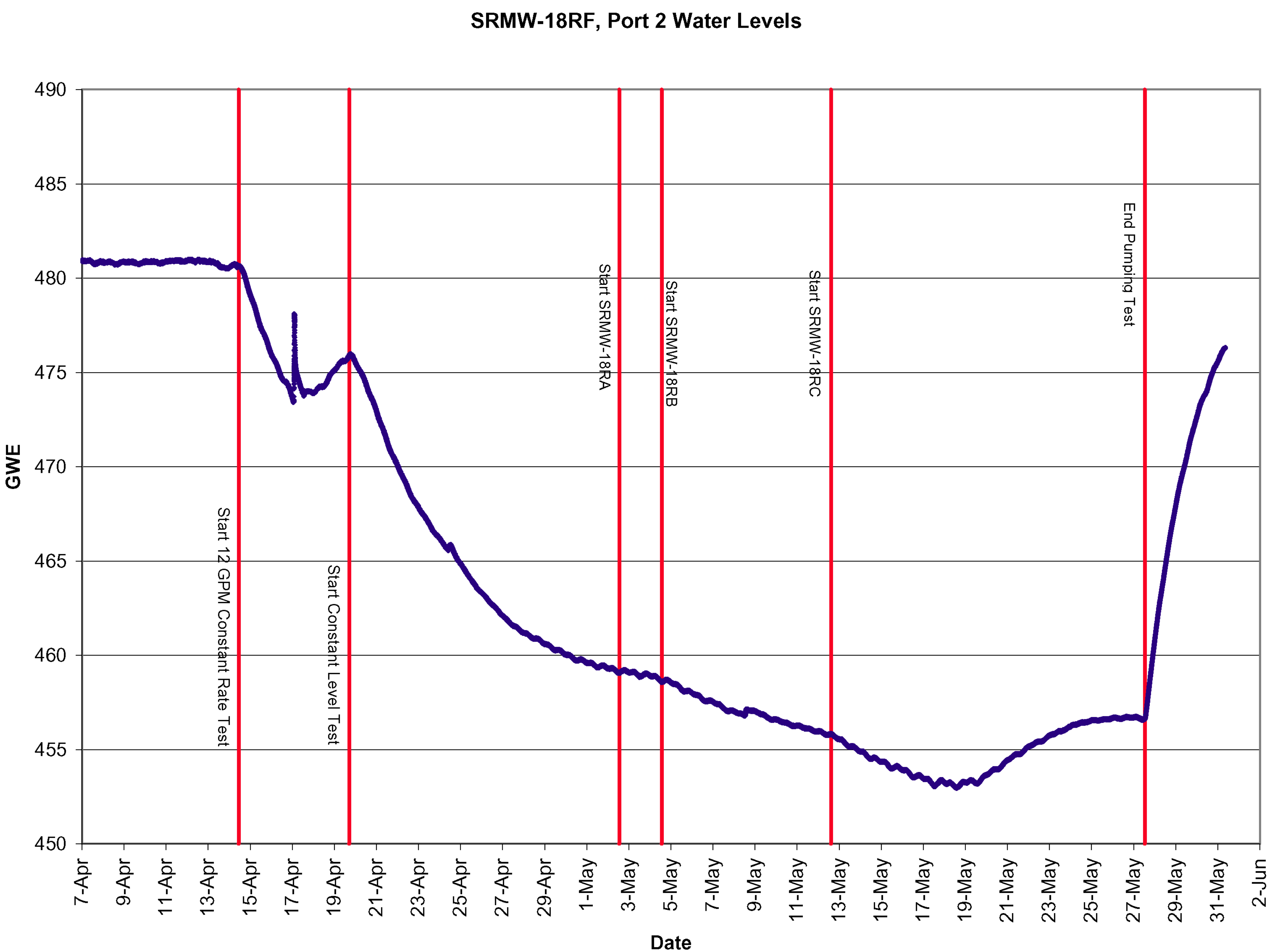
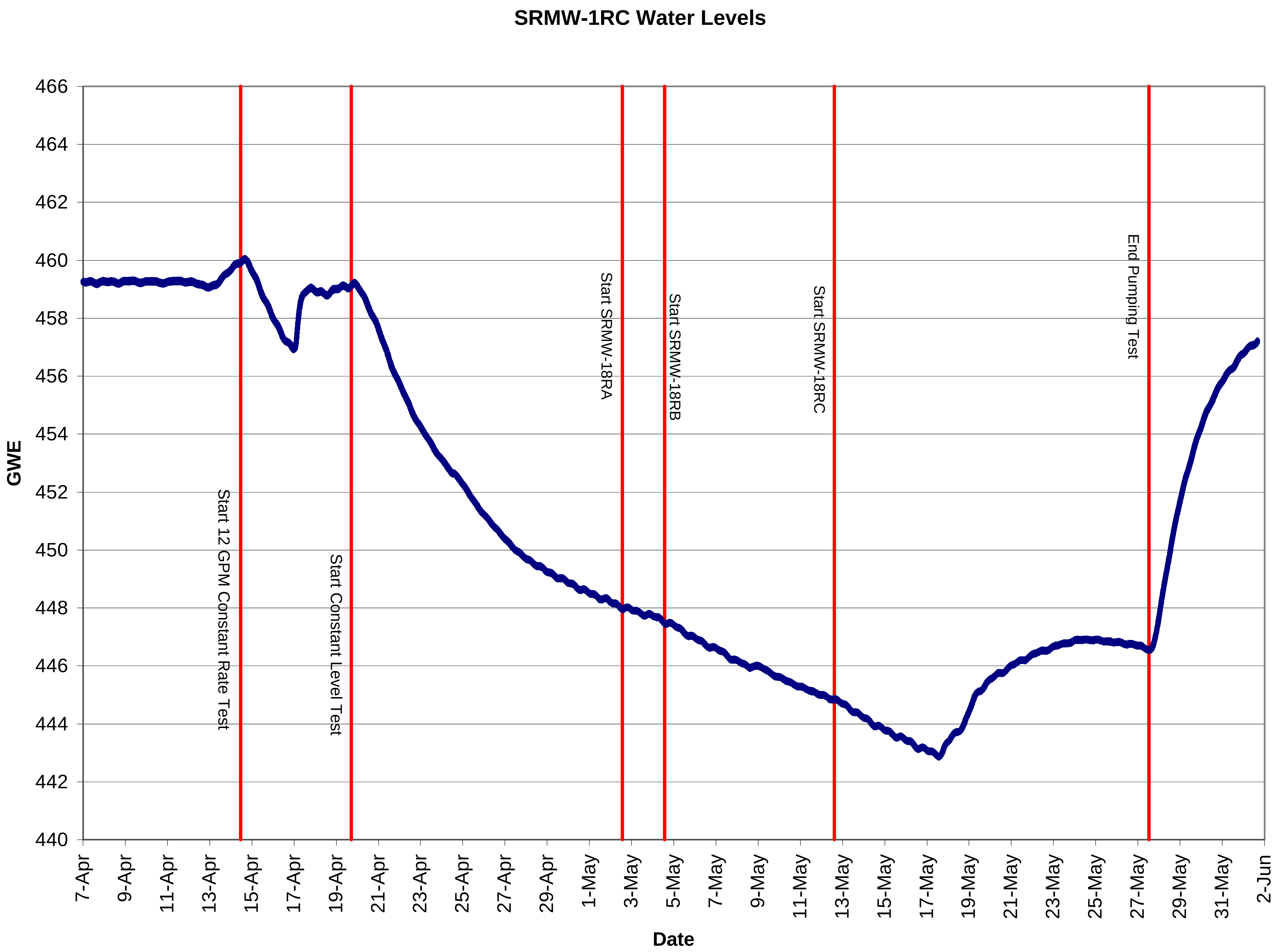
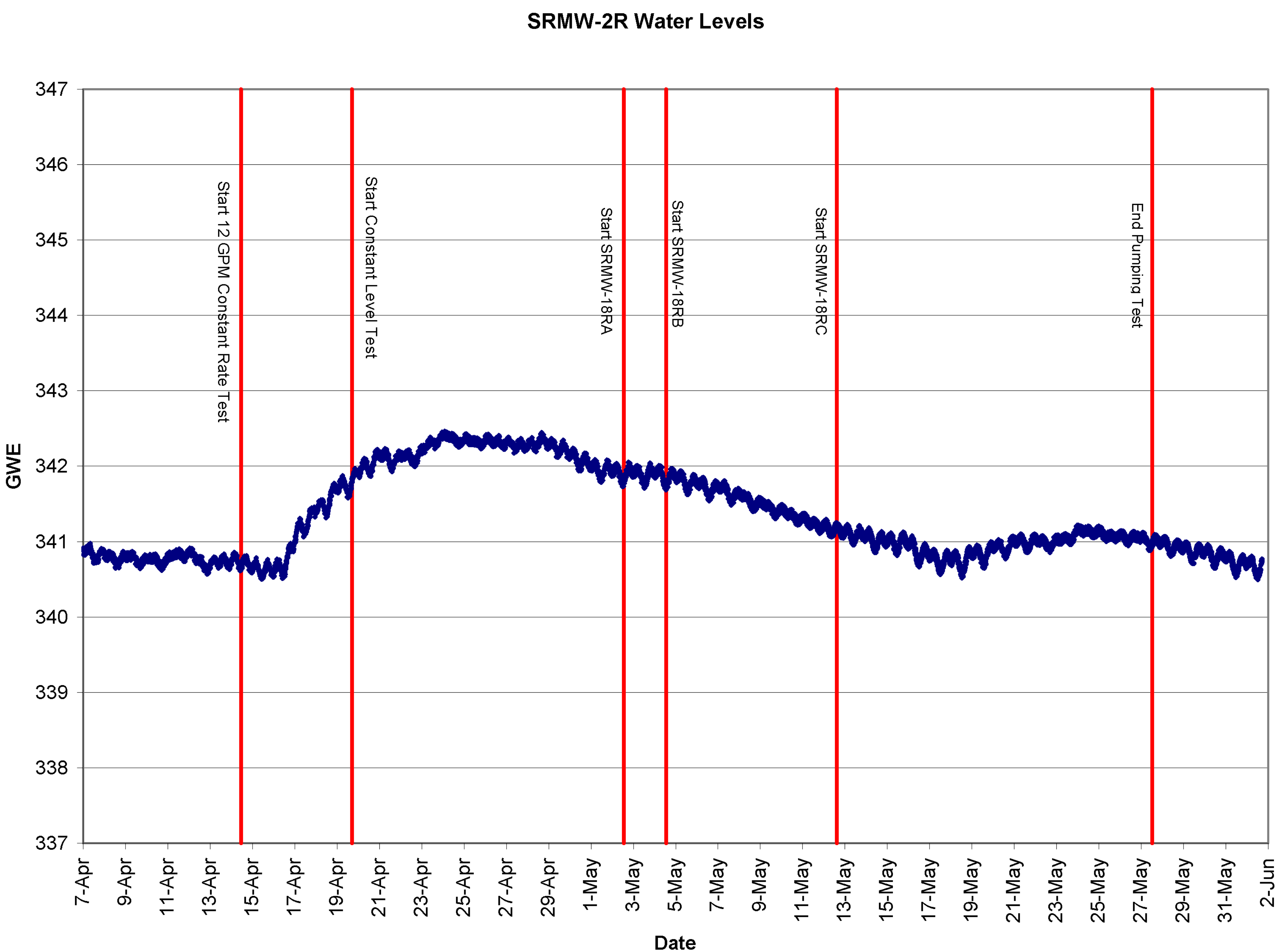
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

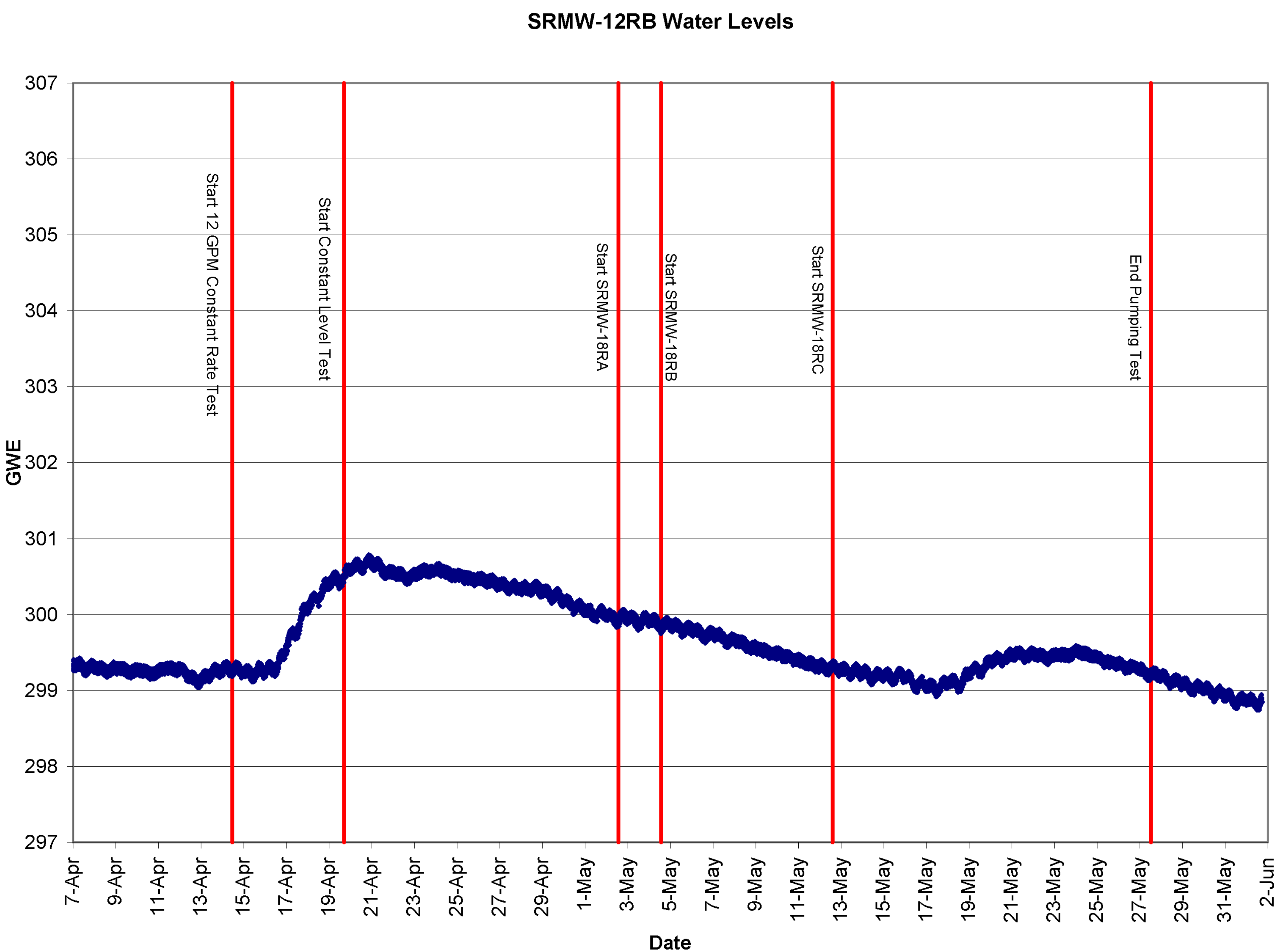

SRMW-18RF, Port 2 Water Levels
GWE
Date
490
485
480
475
470
465
460
455
450
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

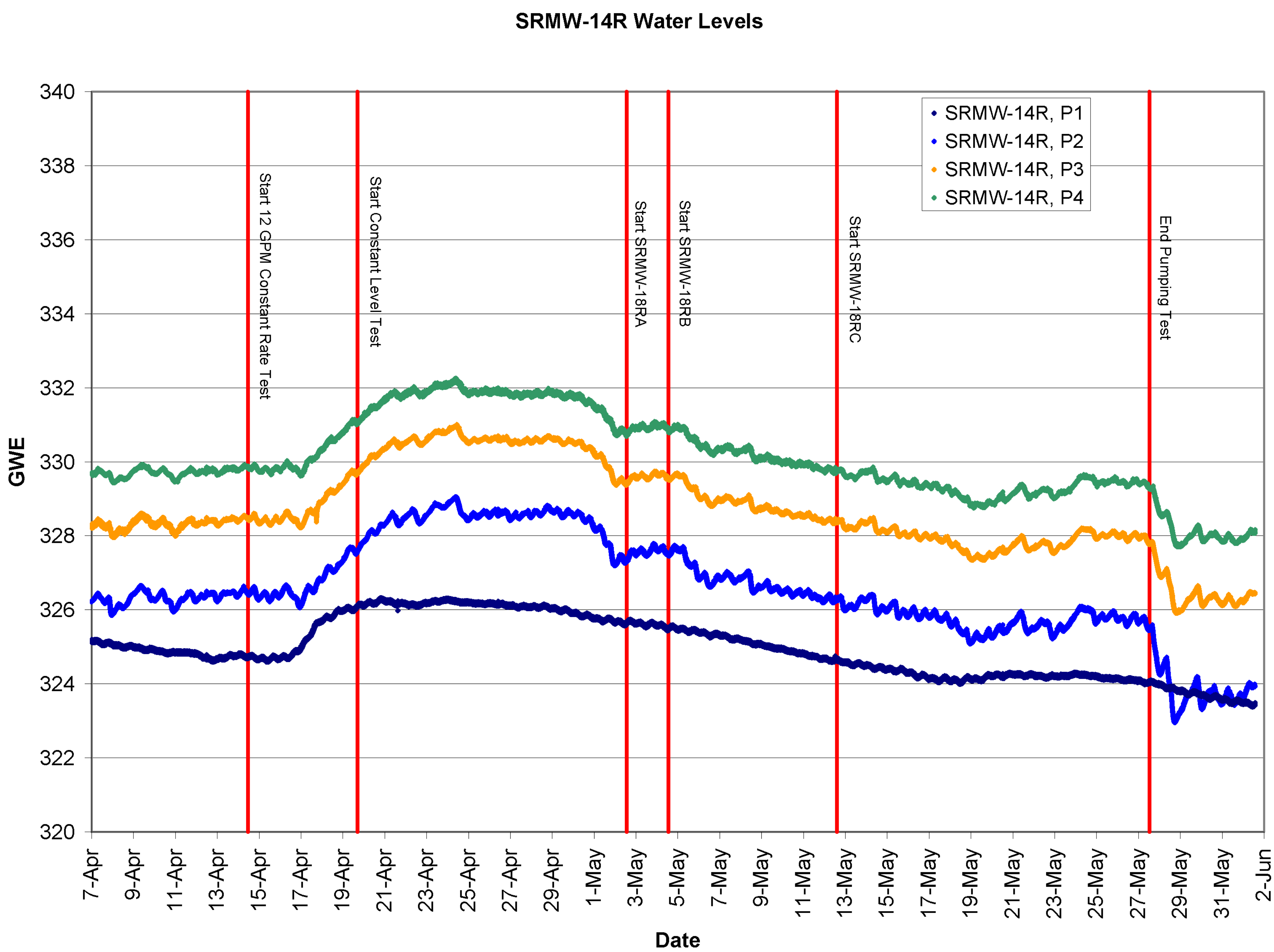


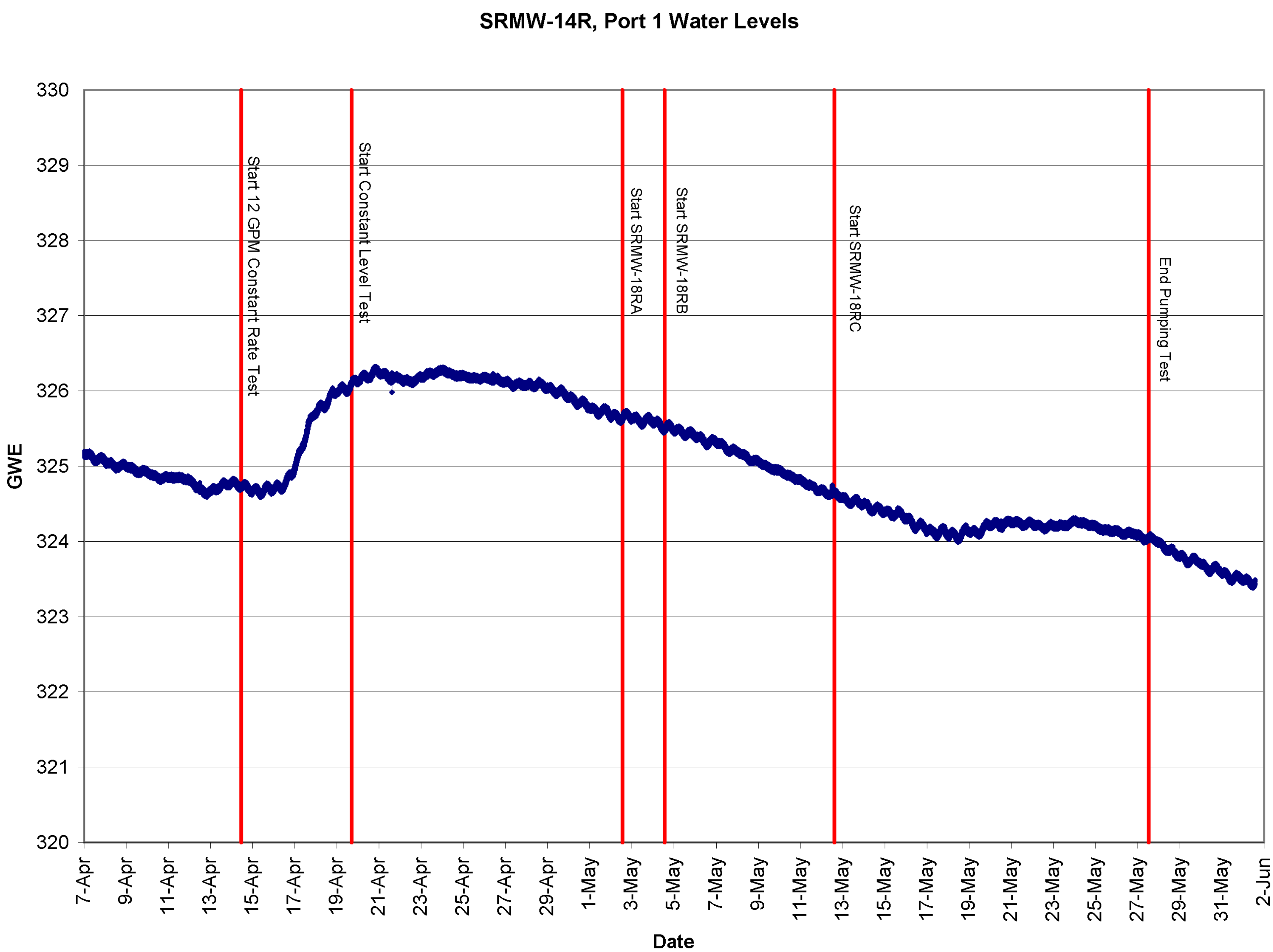
SRMW-1RC Water Levels
GWE
466
464
462
460
458
456
454
452
450
448
446
444
442
440
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



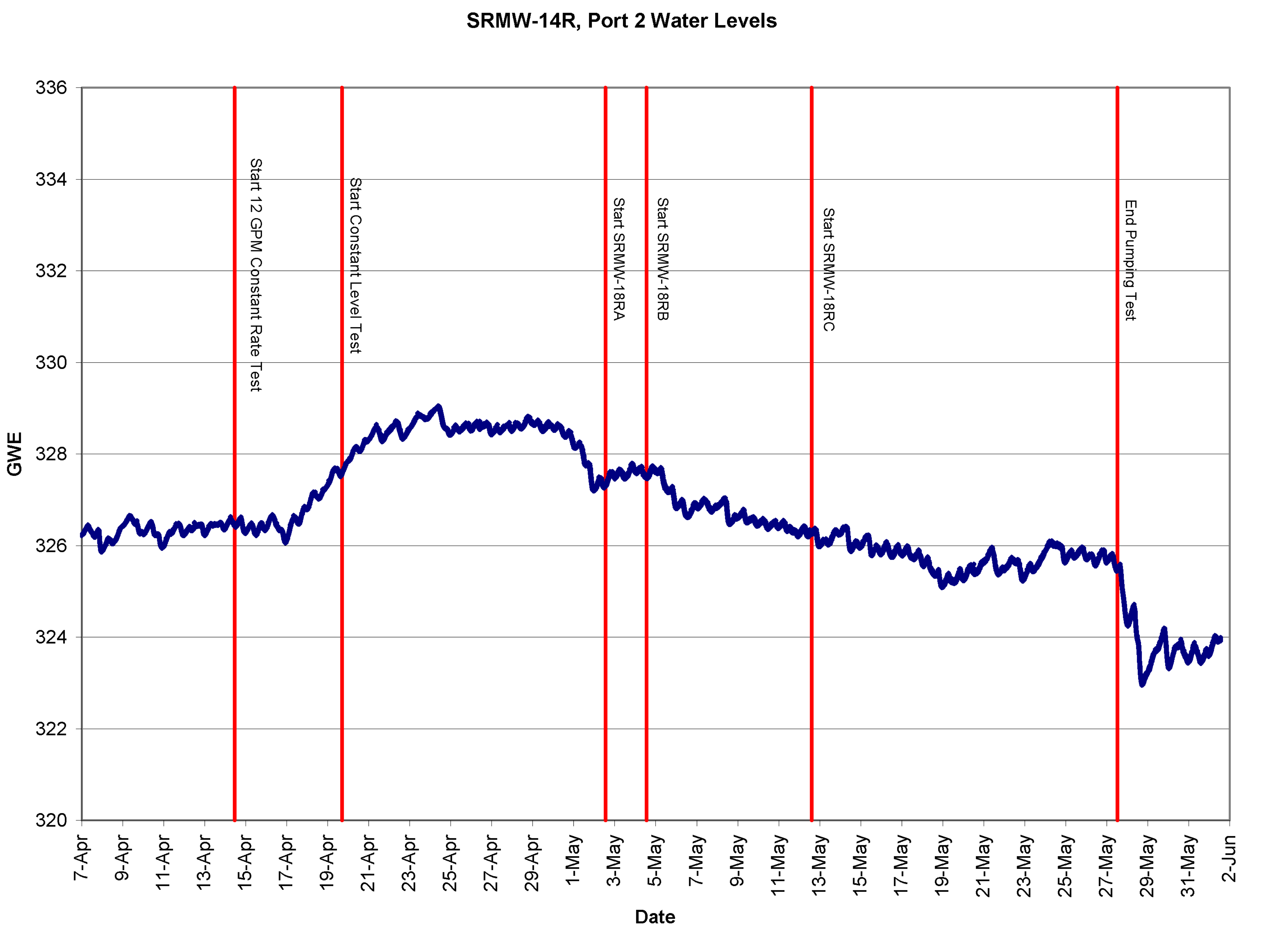
SRMW-2R Water Levels
GWE
Date
347
346
345
344
343
342
341
340
339
338
337
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

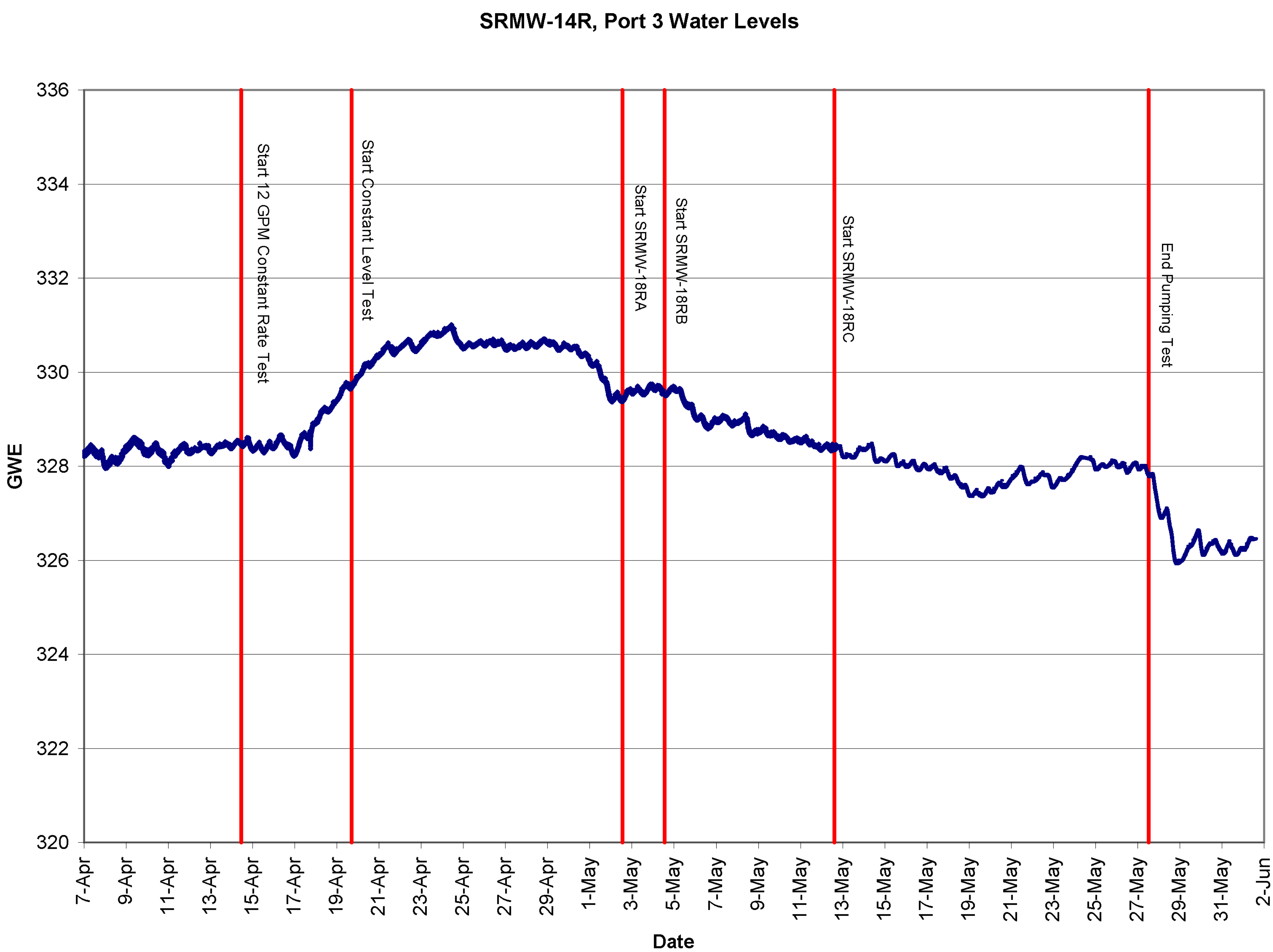

SRMW-12RB Water Levels
GWE
Date
307
306
305
304
303
302
301
300
299
298
297
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-14R Water Levels
340
338
336
334
332
330
328
326
324
322
320
GWE
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
SRMW-14R, P1
SRMW-14R, P2
SRMW-14R, P3
SRMW-14R, P4

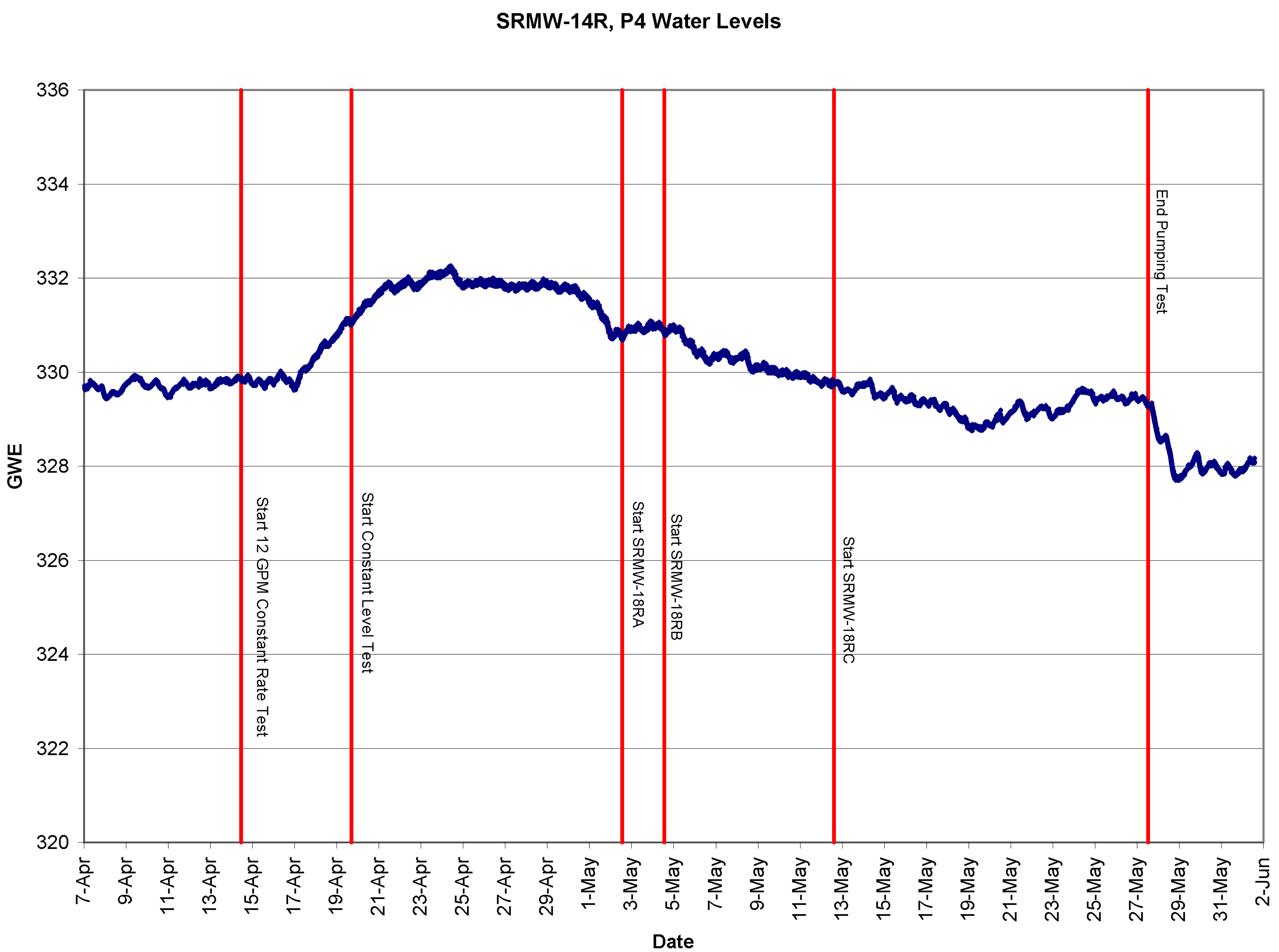


SRMW-14R, Port 1 Water Levels
GWE
Date
330
329
328
327
326
325
324
323
322
321
320
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

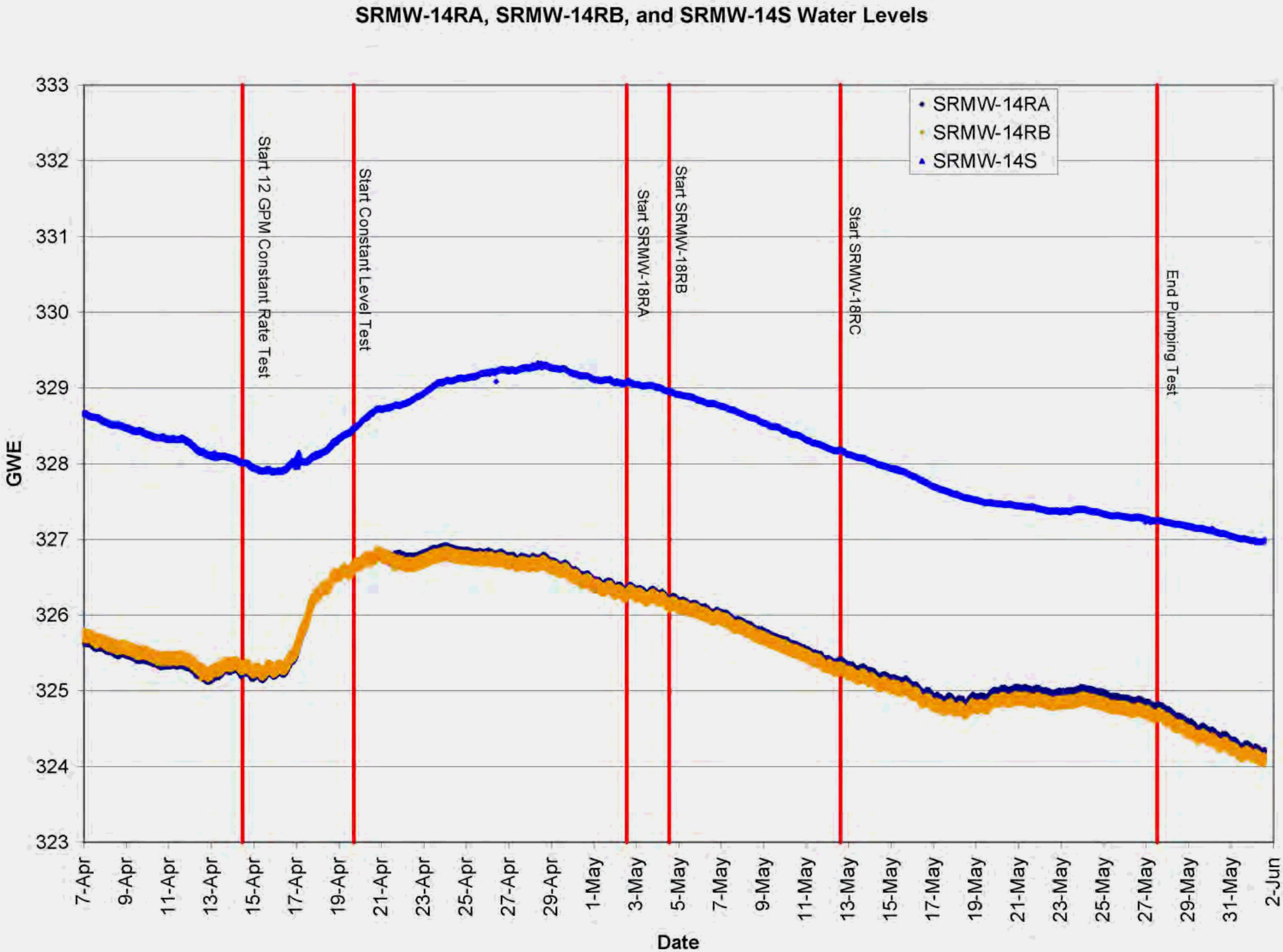

SRMW-14R, Port 2 Water Levels
GWE
Date
336
334
332
330
328
326
324
322
320
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



SRMW-14R, Port 3 Water Levels
GWE
Date
336
334
332
330
328
326
324
322
320
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



SRMW-14R, P4 Water Levels
GWE
336
334
332
330
328
326
324
322
320
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-14RA, SRMW-14RB, and SRMW-14S Water Levels
GWE
Date
SRMW-14RA
SRMW-14RB
SRMW-14S
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
333
332
331
330
329
328
327
326
325
324
323
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
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19-May
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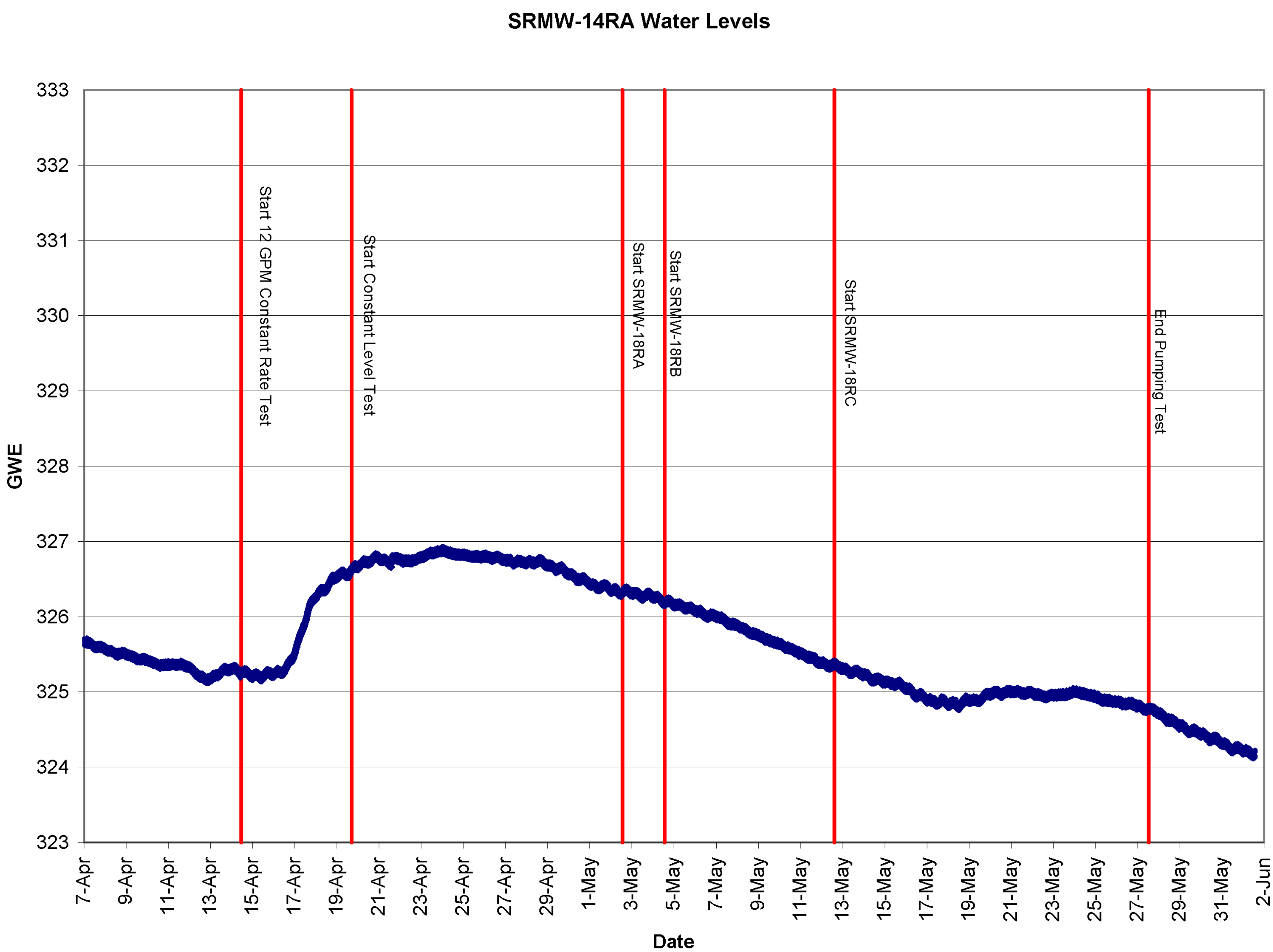
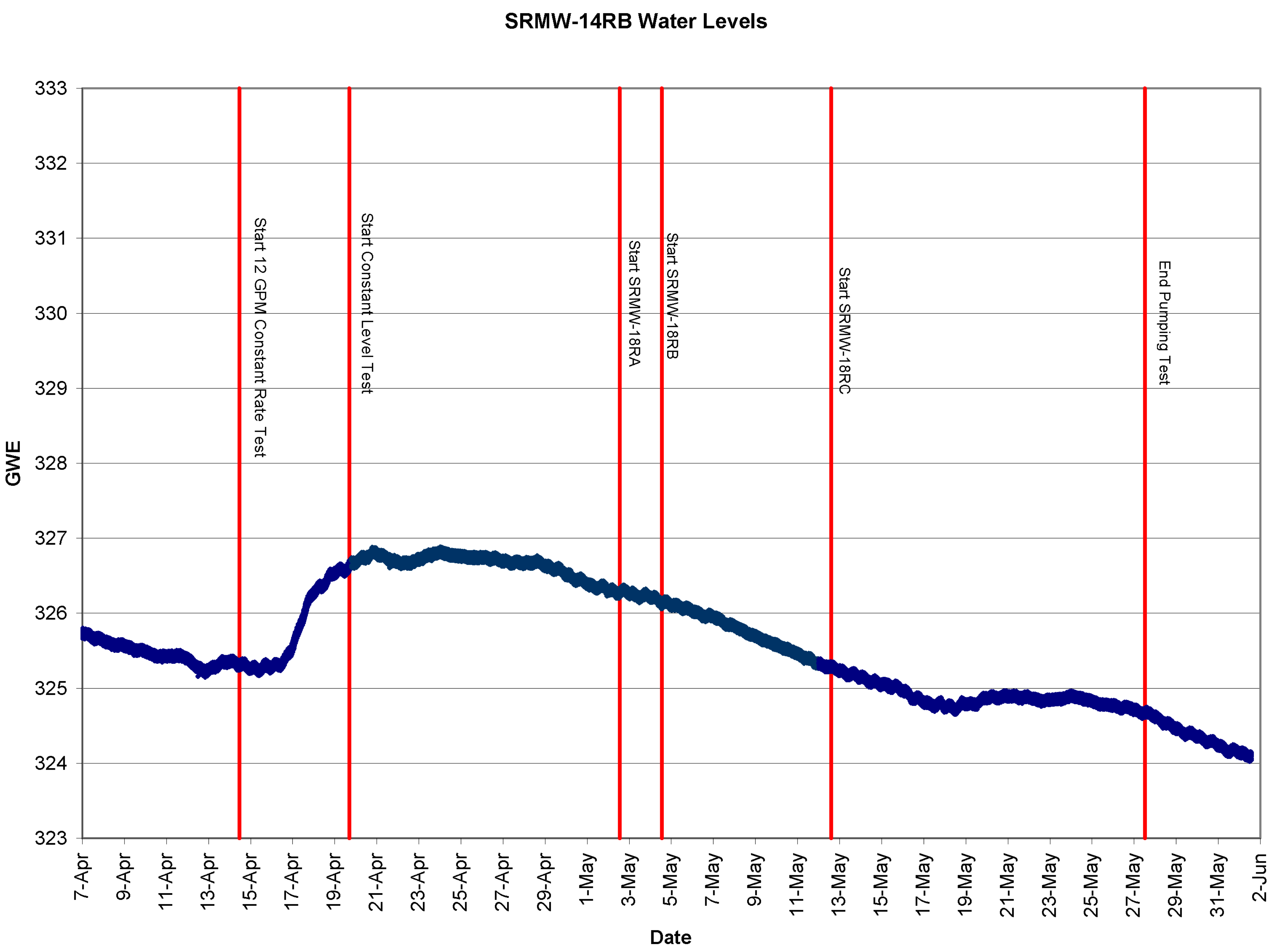
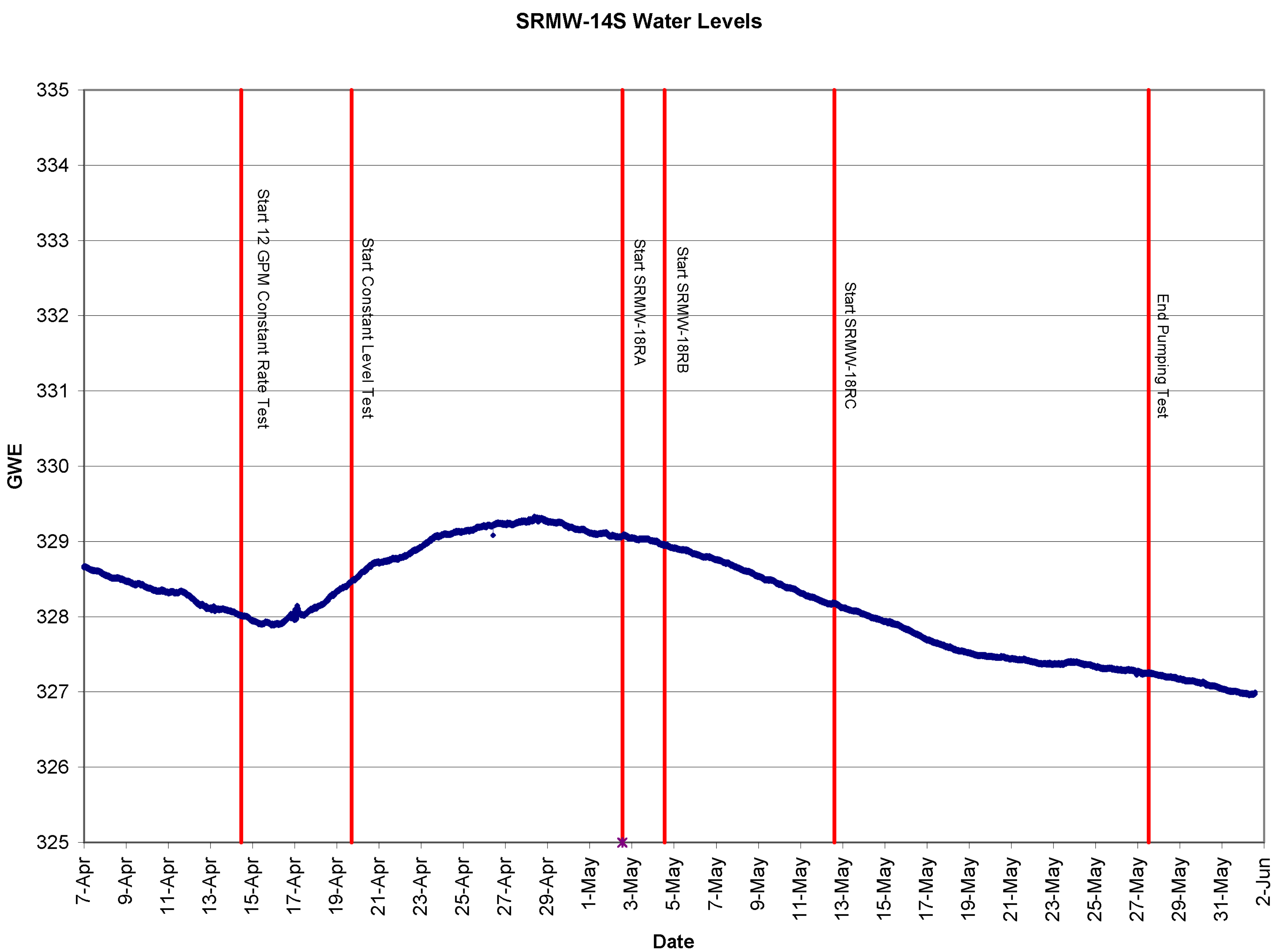
25-May
27-May
29-May
31-May
2-Jun

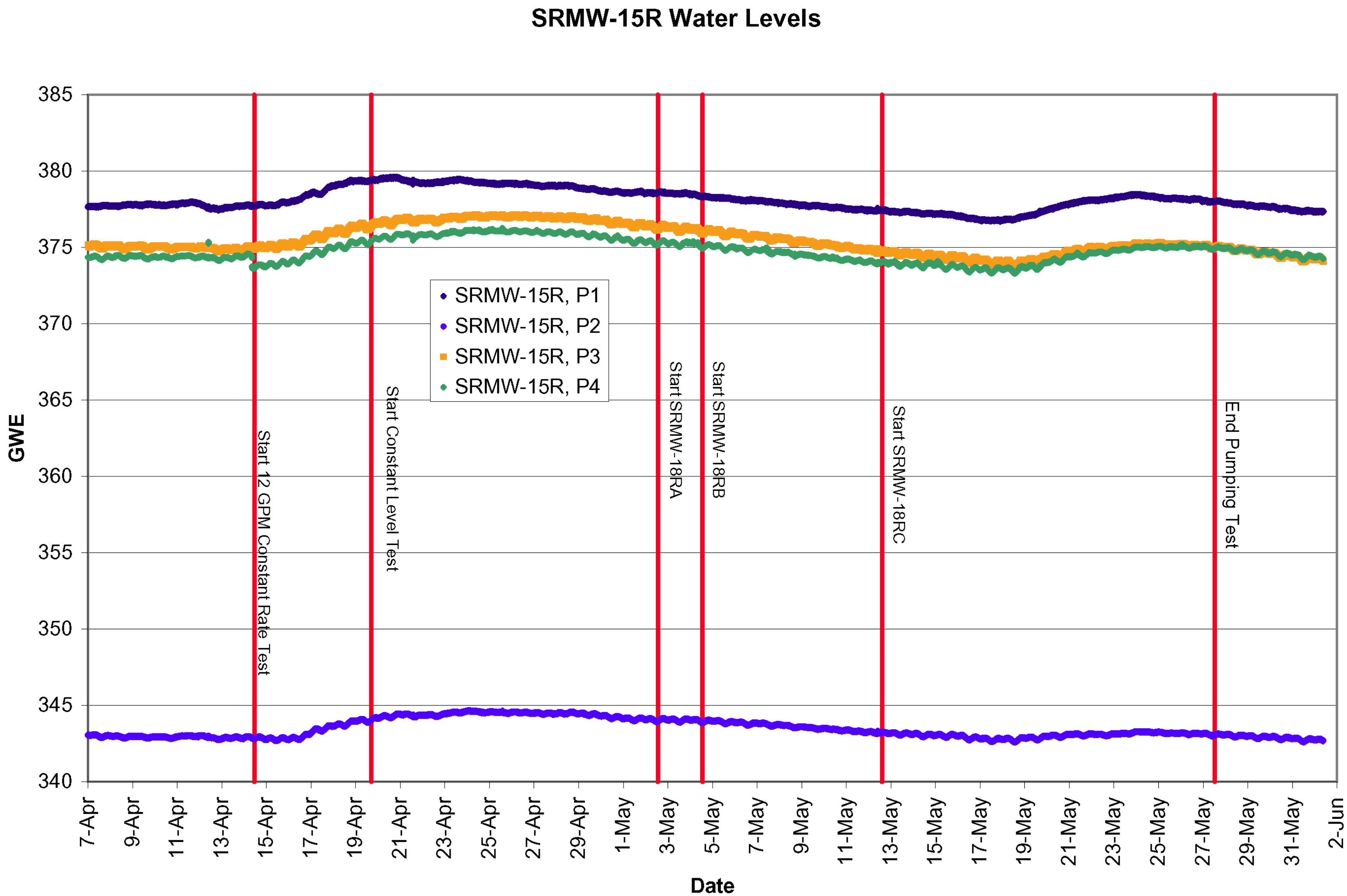


SRMW-14RA Water Levels
GWE
Date
333
332
331
330
329
328
327
326
325
324
323
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

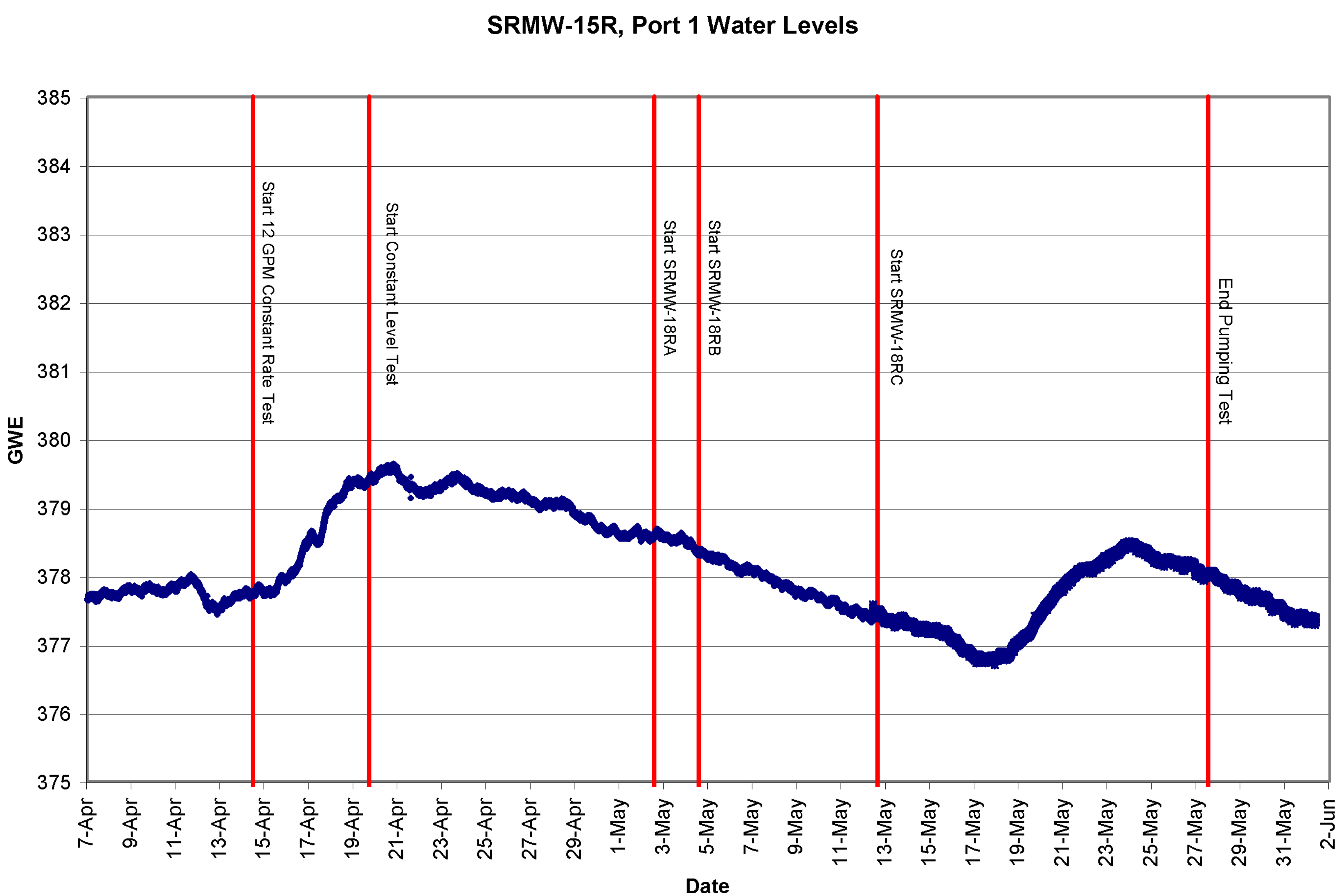


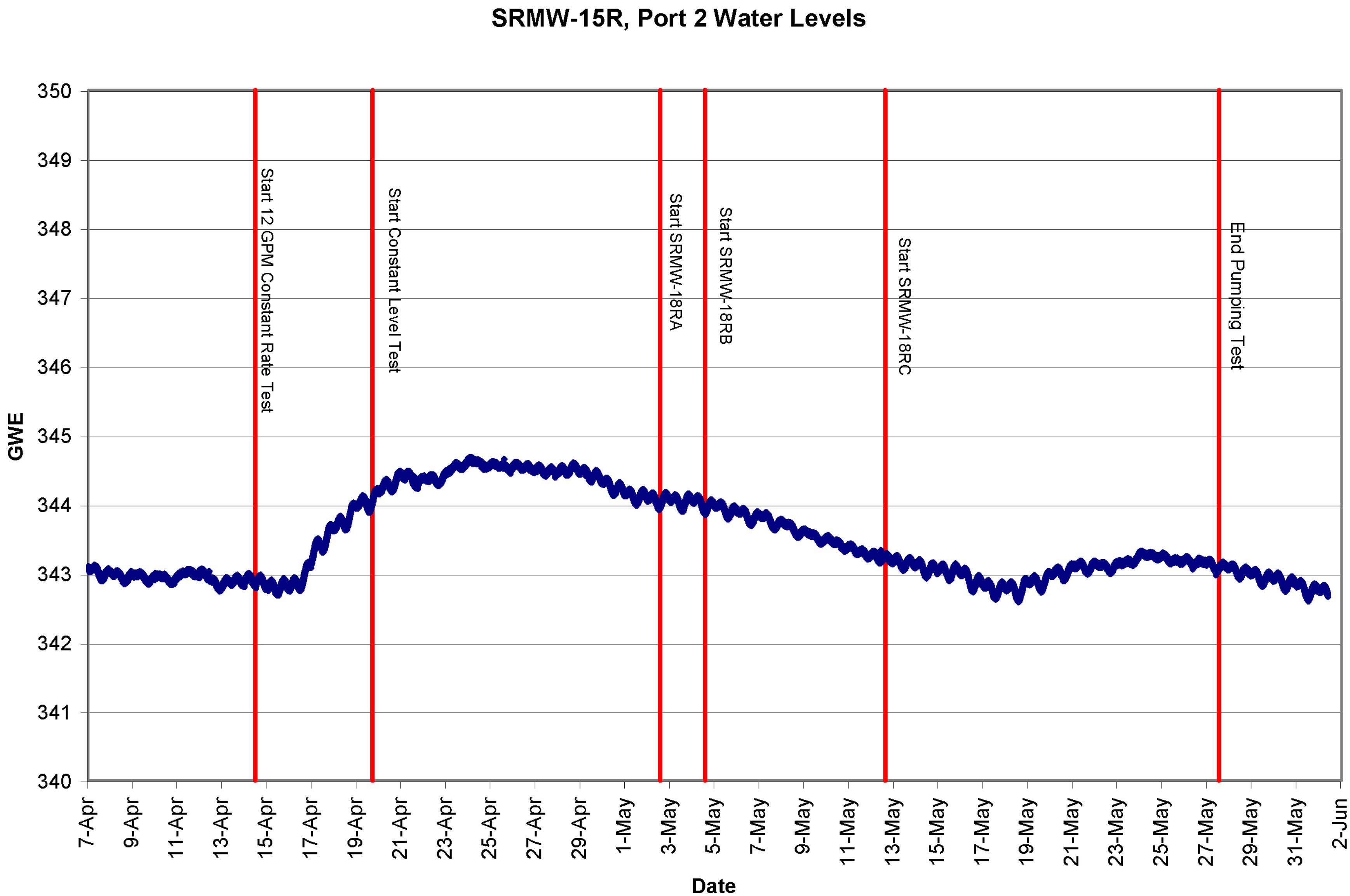
SRMW-14RB Water Levels
GWE
333
332
331
330
329
328
327
326
325
324
323
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

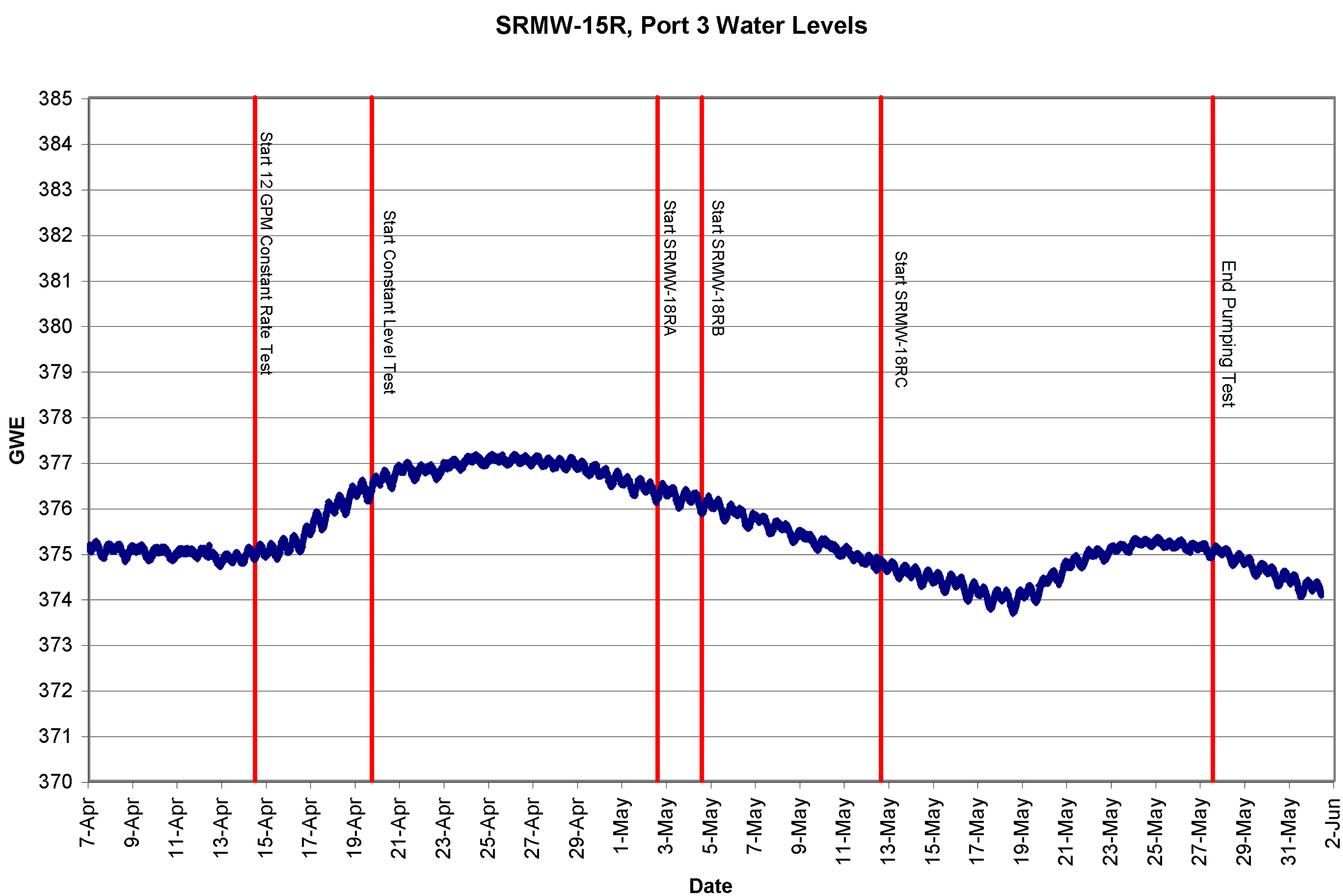

SRMW-14S Water Levels
GWE
335
334
333
332
331
330
329
328
327
326
325
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

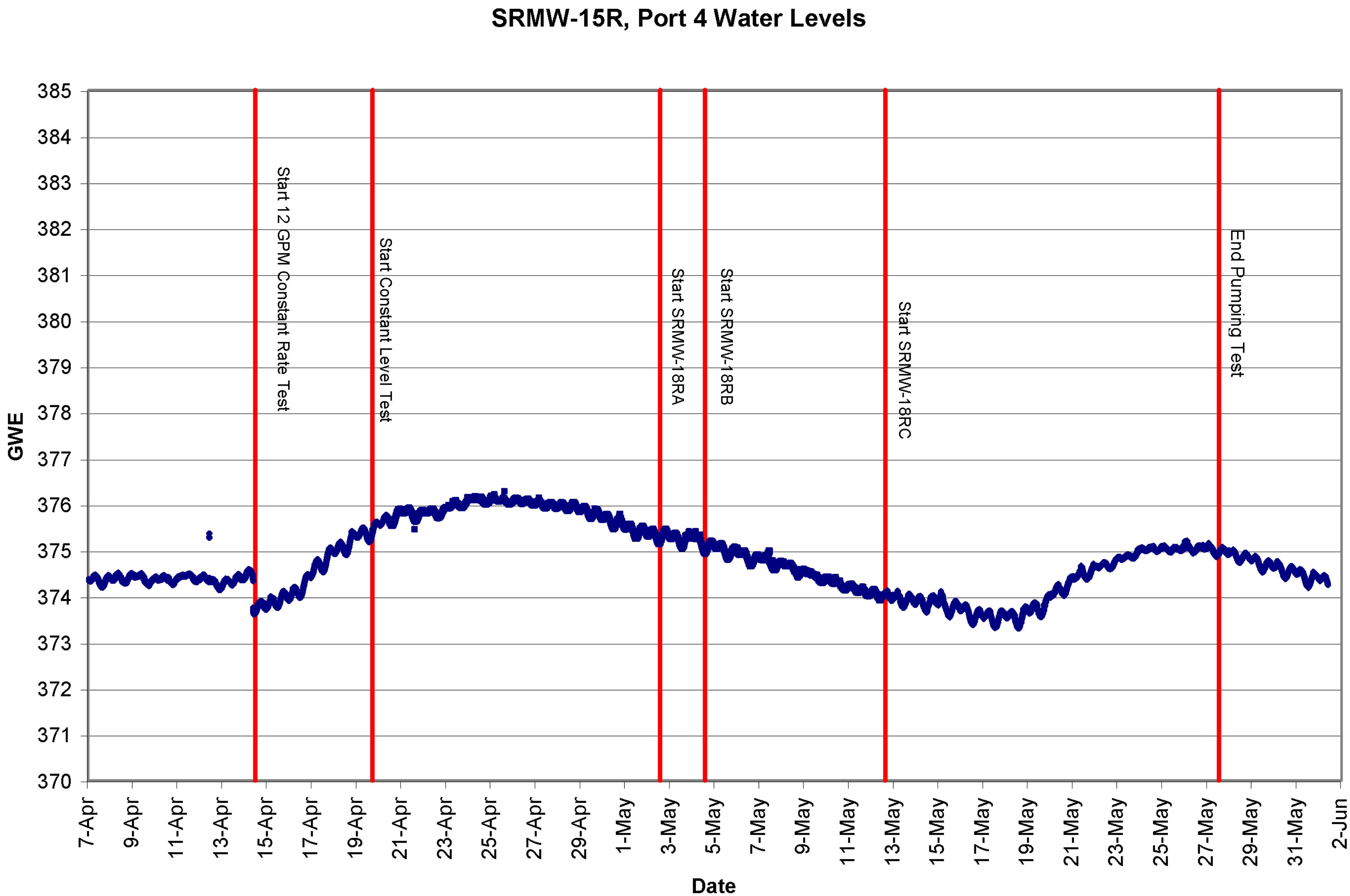


SRMW-15R Water Levels
GWE
385
380
375
370
365
360
355
350
345
340
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
SRMW-15R, P1
SRMW-15R, P2
SRMW-15R, P3
SRMW-15R, P4
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


SRMW-15R, Port 1 Water Levels
GWE
385
384
383
382
381
380
379
378
377
376
375
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

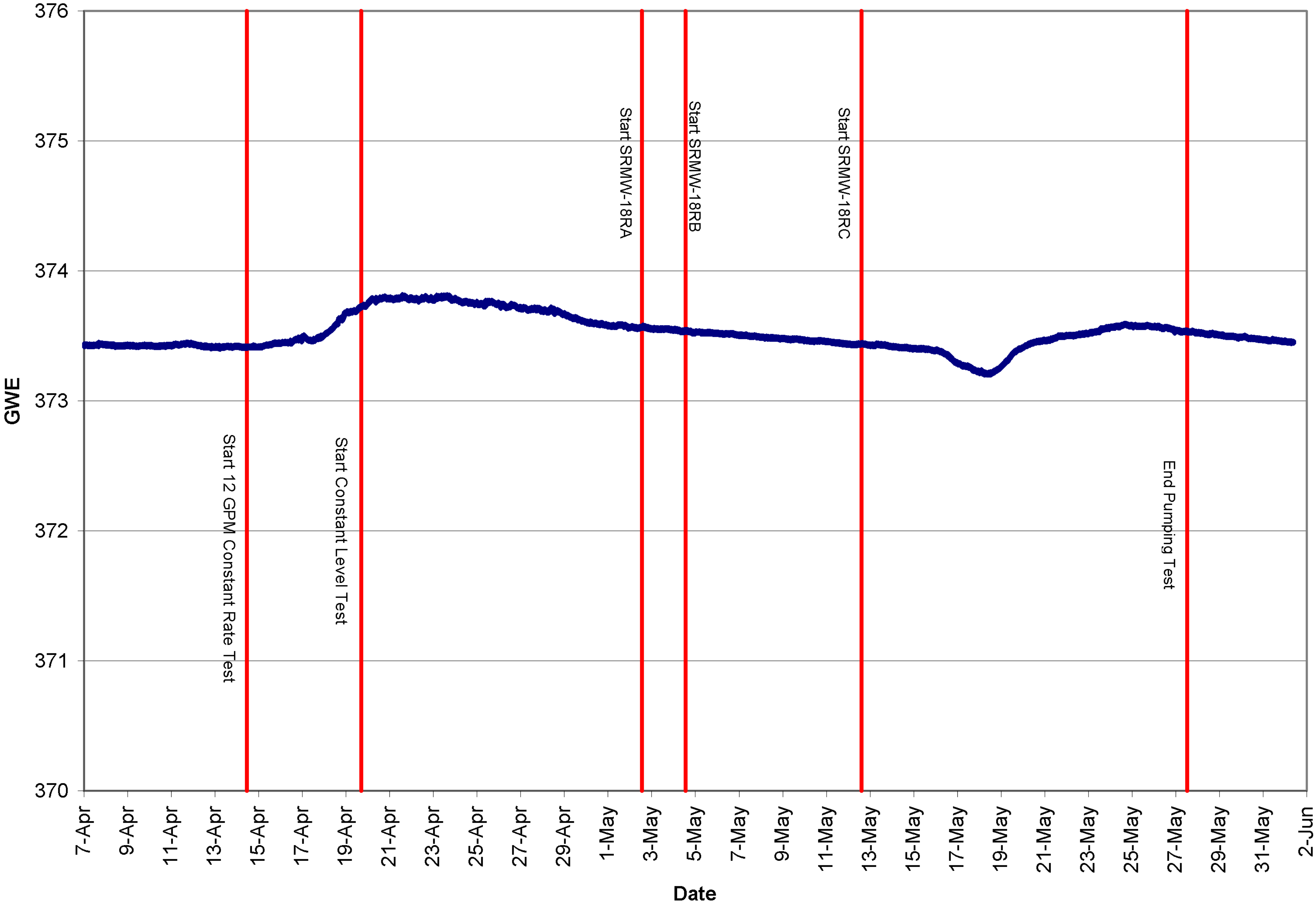

SRMW-15R, Port 2 Water Levels
GWE
350
349
348
347
346
345
344
343
342
341
340
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

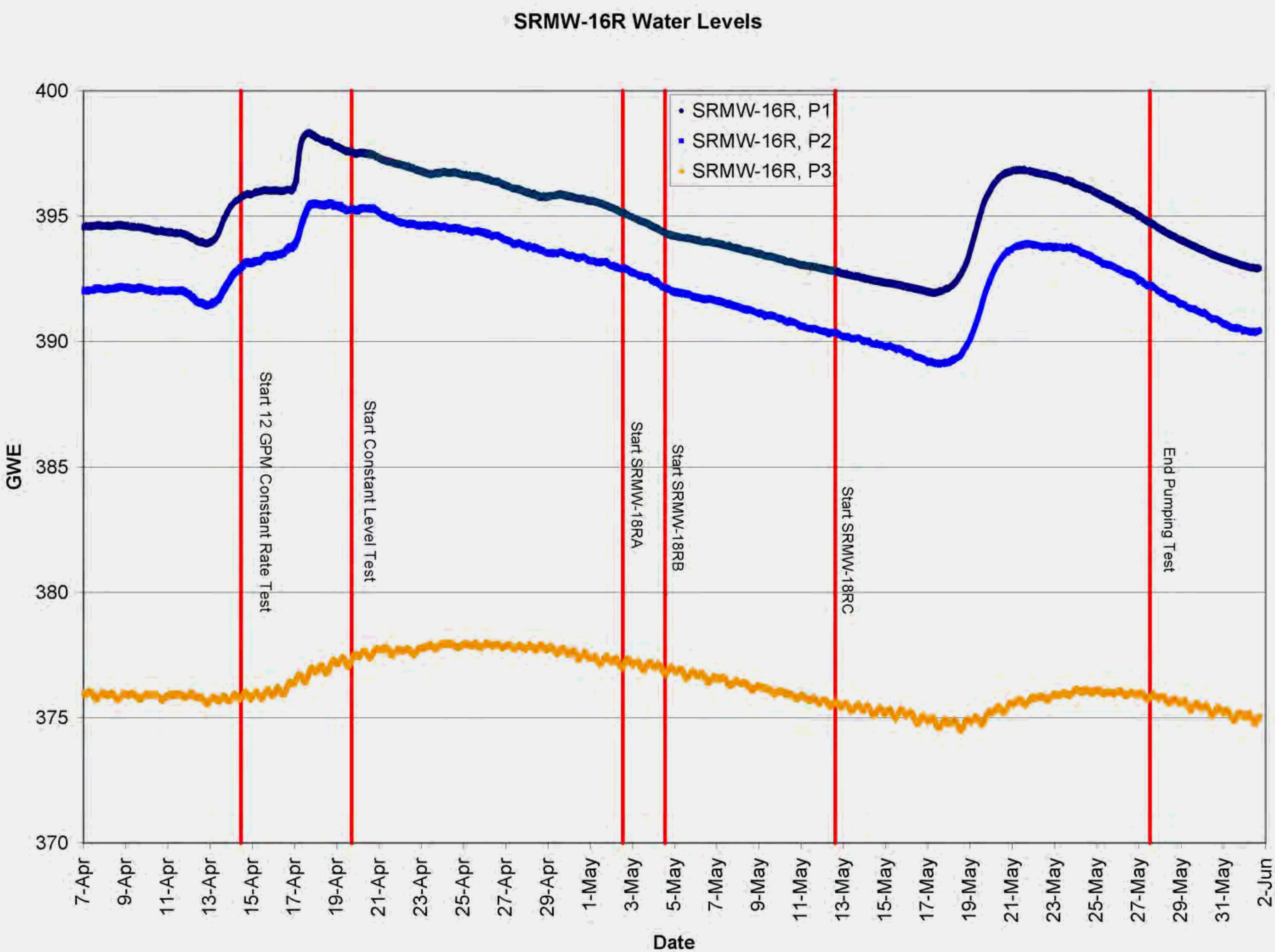

SRMW-15R, Port 3 Water Levels
GWE
Date
385
384
383
382
381
380
379
378
377
376
375
374
373
372
371
370
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



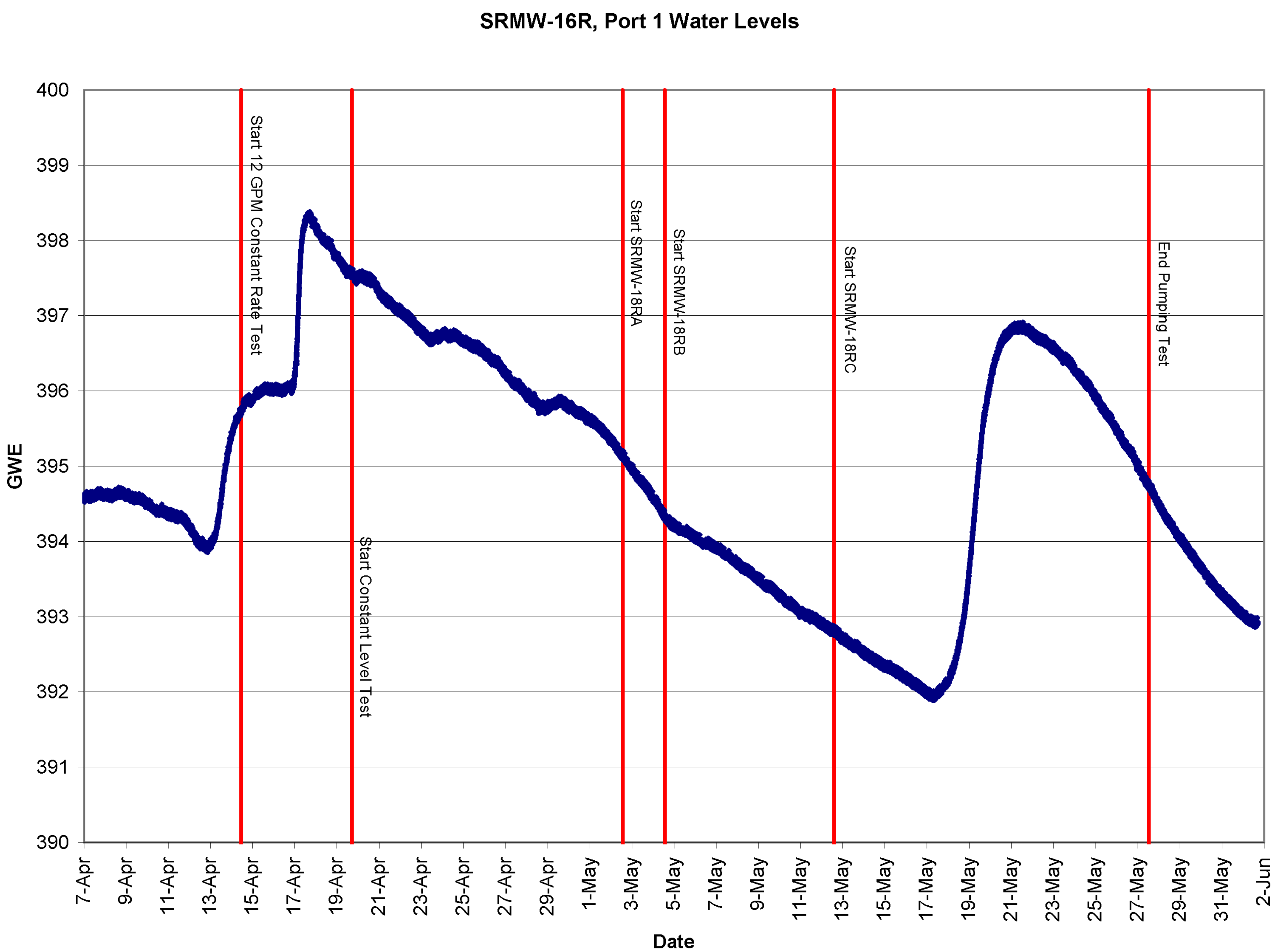
SRMW-15R, Port 4 Water Levels
GWE
385
384
383
382
381
380
379
378
377
376
375
374
373
372
371
370
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

SRMW-15S Water Levels

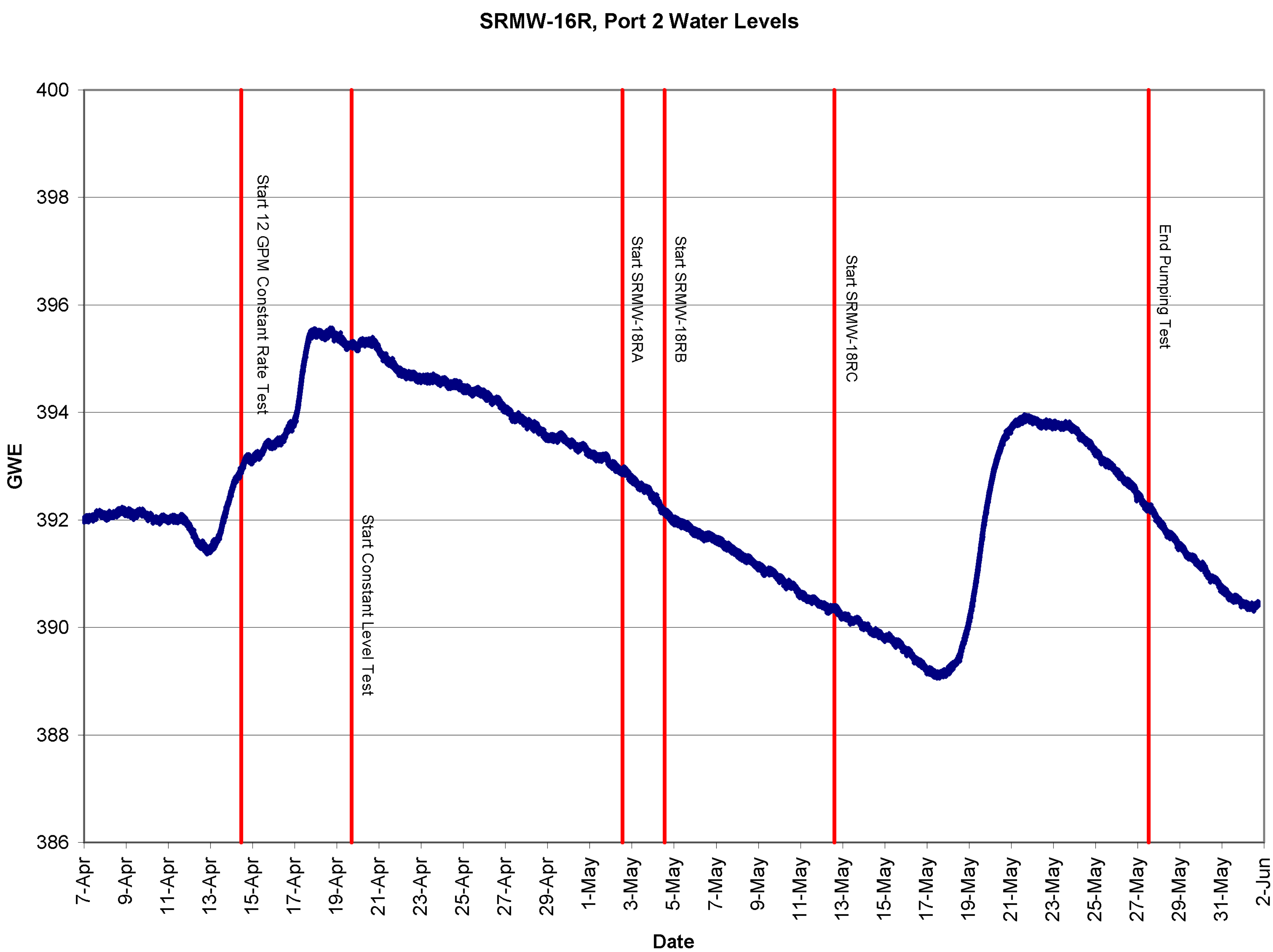




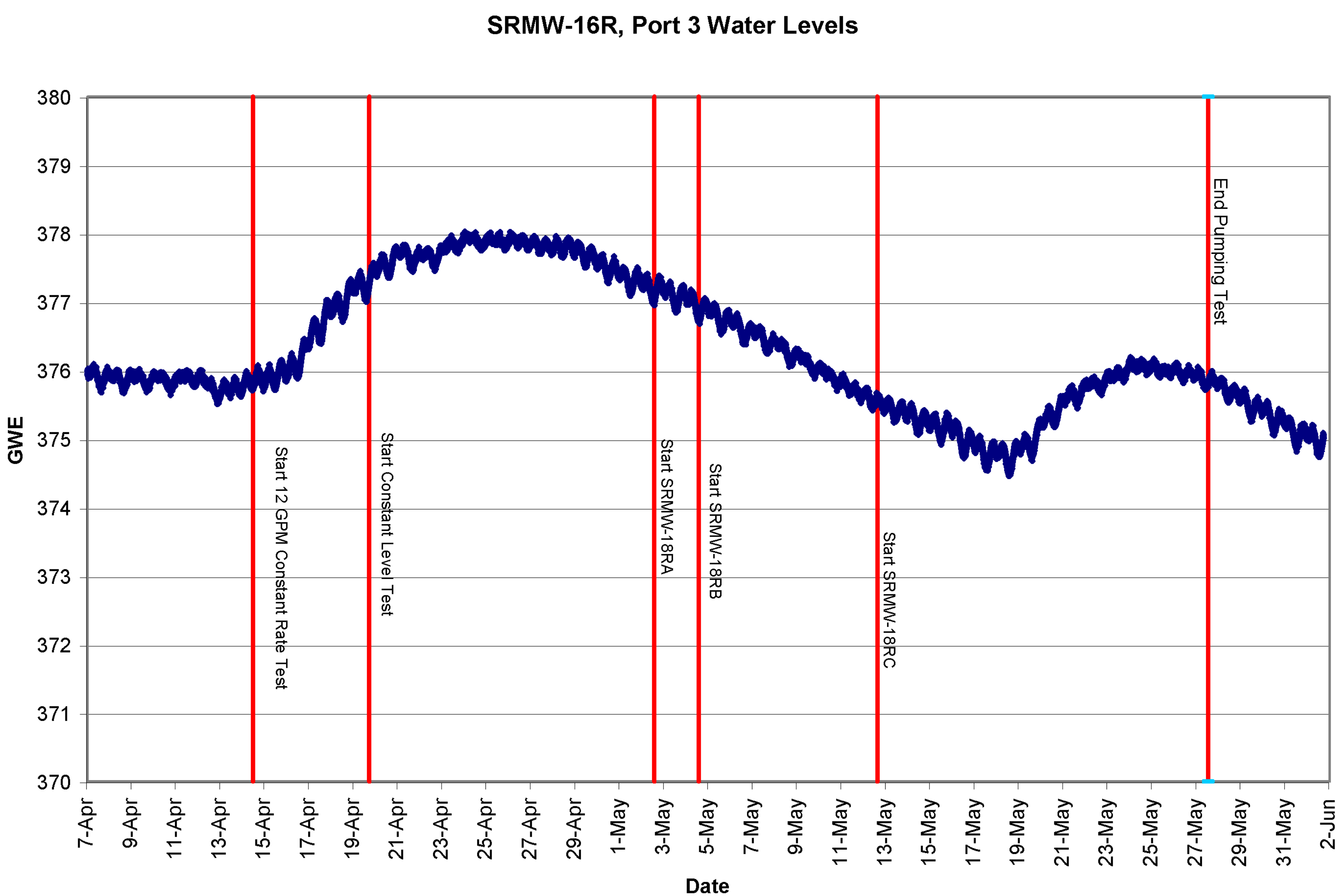
SRMW-16R Water Levels
GWE
400
395
390
385
380
375
370
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
SRMW-16R, P1
SRMW-16R, P2
SRMW-16R, P3
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



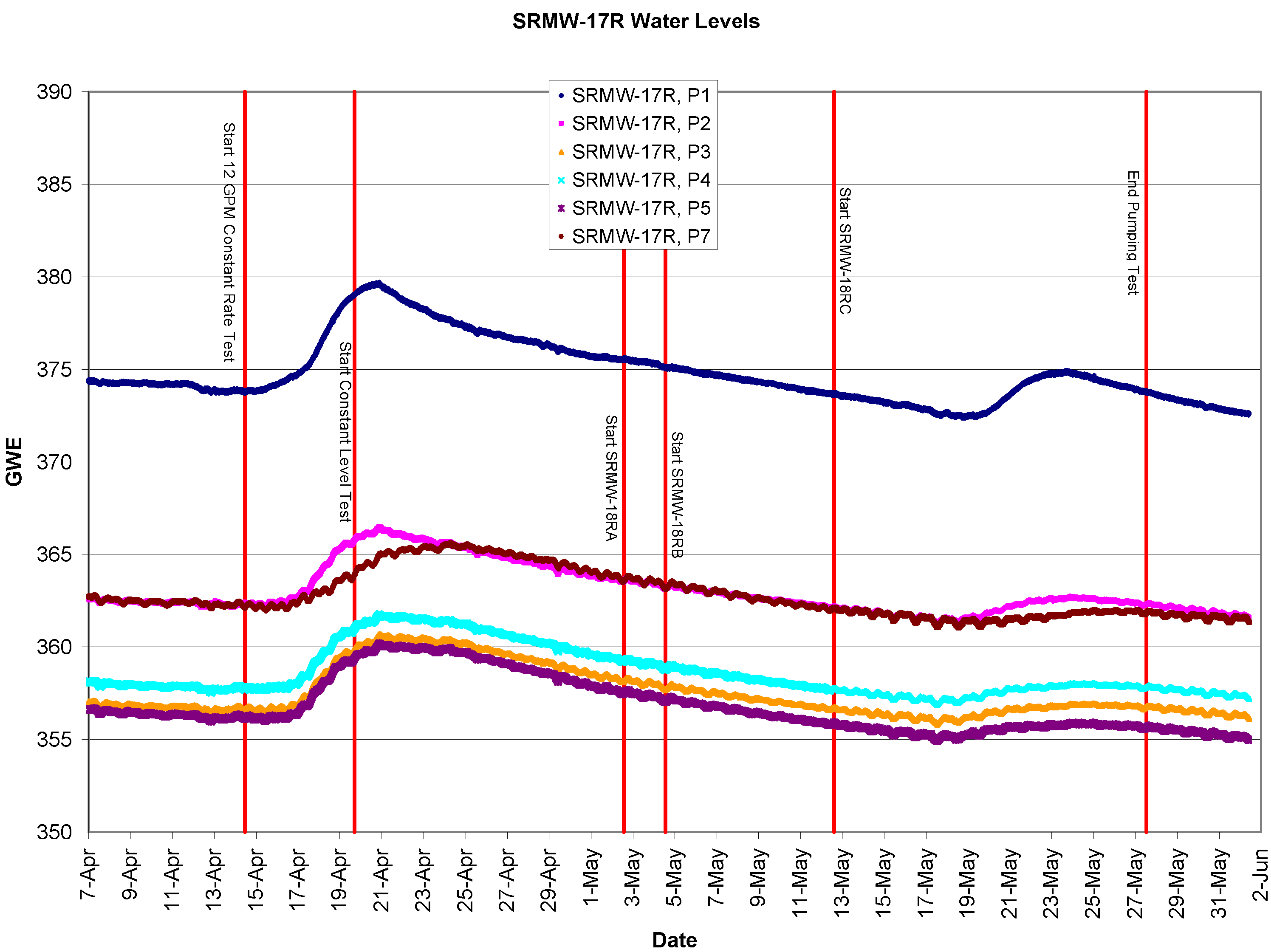
SRMW-16R, Port 1 Water Levels
GWE
Date
400
399
398
397
396
395
394
393
392
391
390
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



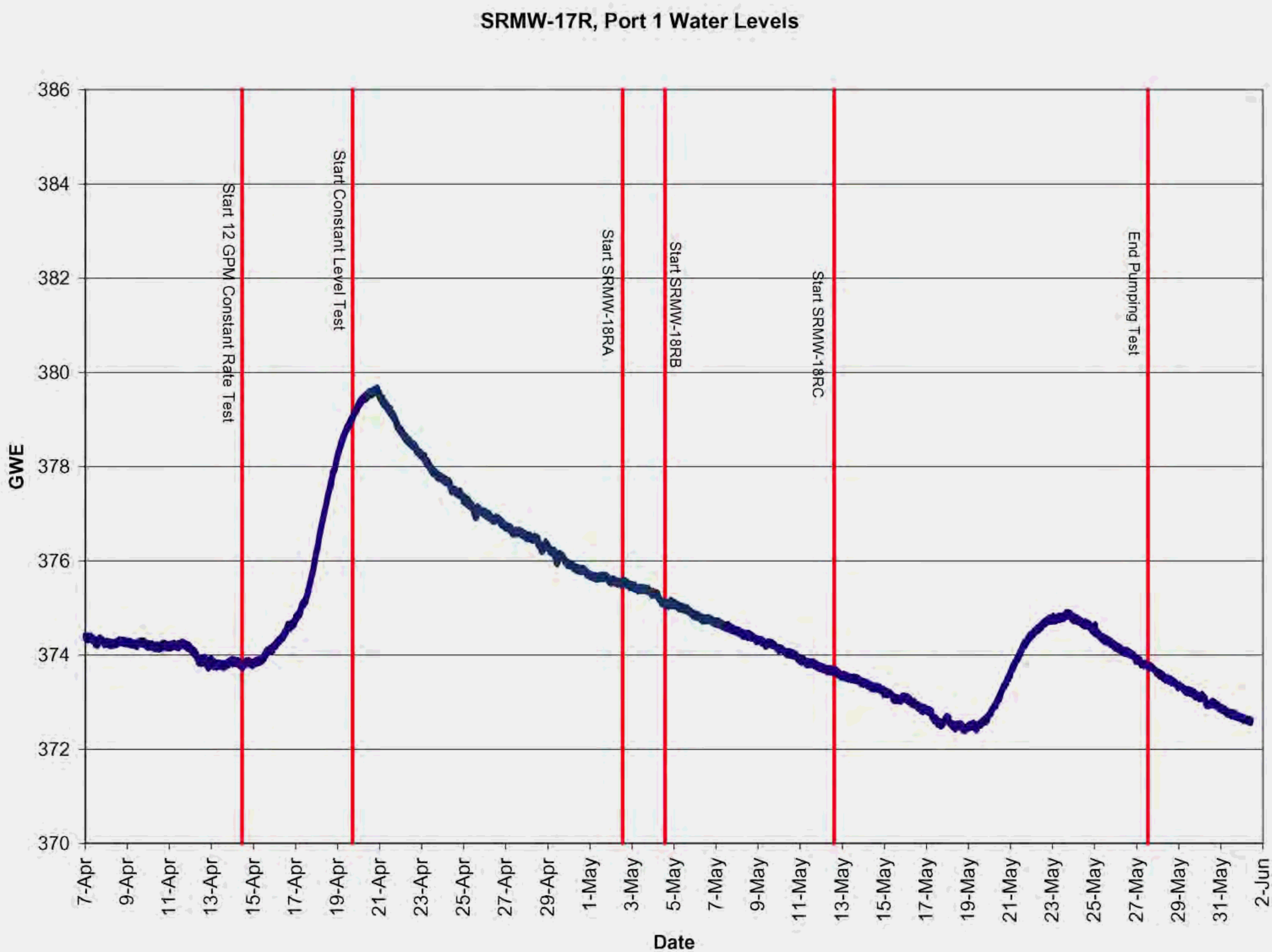
SRMW-16R, Port 2 Water Levels
GWE
400
398
396
394
392
390
388
386
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

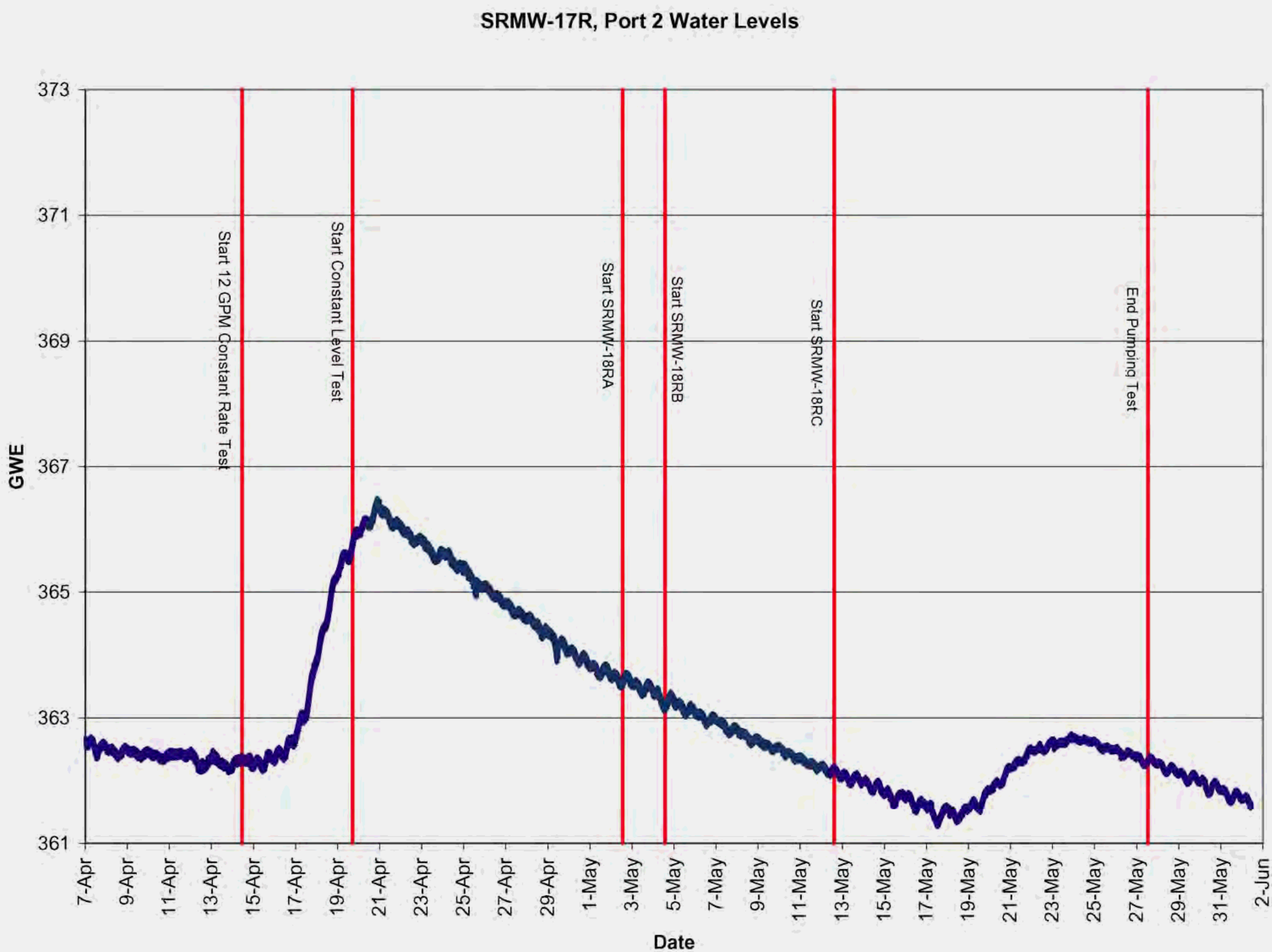


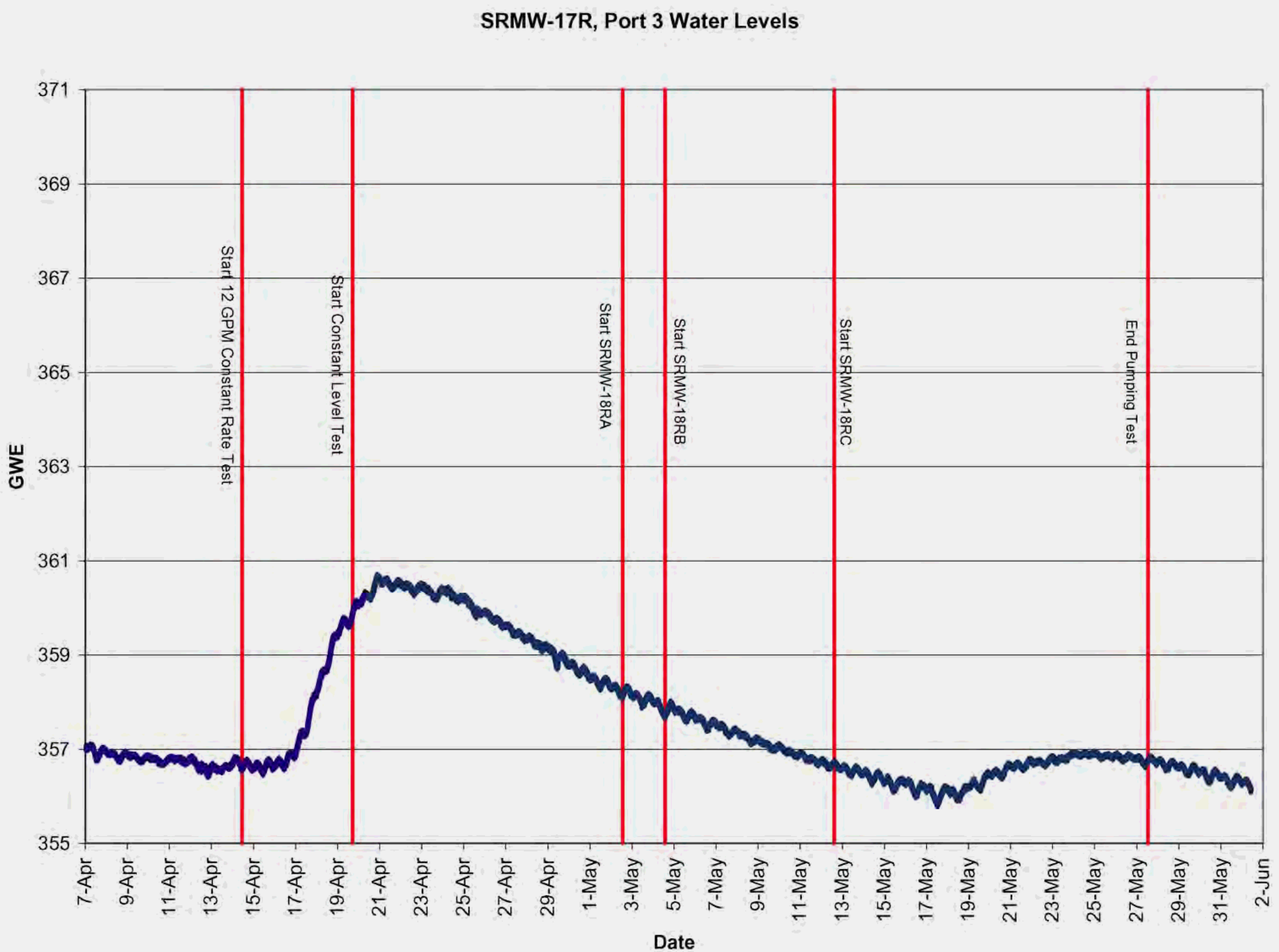
SRMW-16R, Port 3 Water Levels
GWE
380
379
378
377
376
375
374
373
372
371
370
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



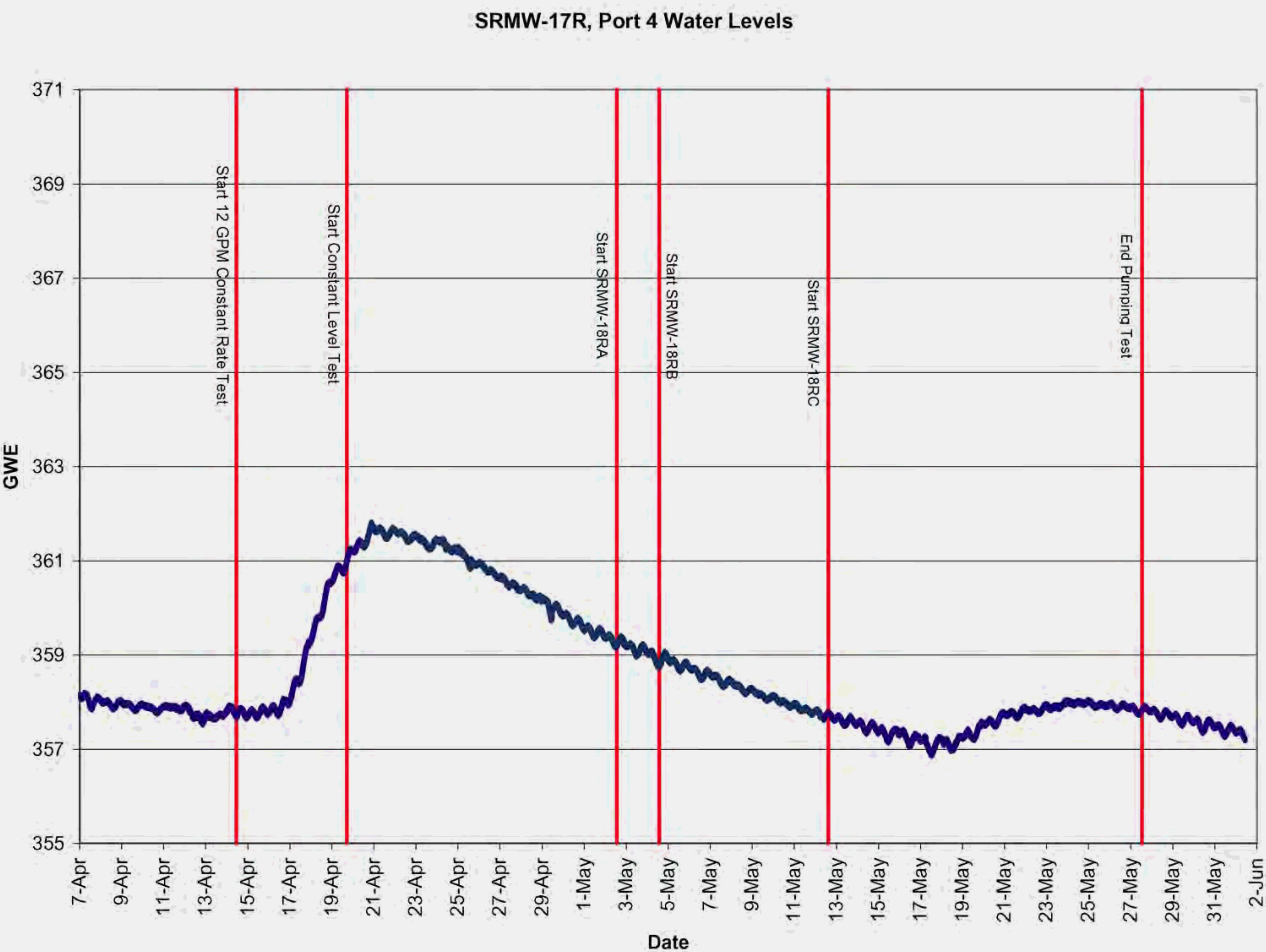
SRMW-17R Water Levels
SRMW-17R, P1
SRMW-17R, P2
SRMW-17R, P3
SRMW-17R, P4
SRMW-17R, P5
SRMW-17R, P7
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
GWE
390
385
380
375
370
365
360
355
350
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun


SRMW-17R, Port 1 Water Levels
GWE
Date
386
384
382
380
378
376
374
372
370
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun

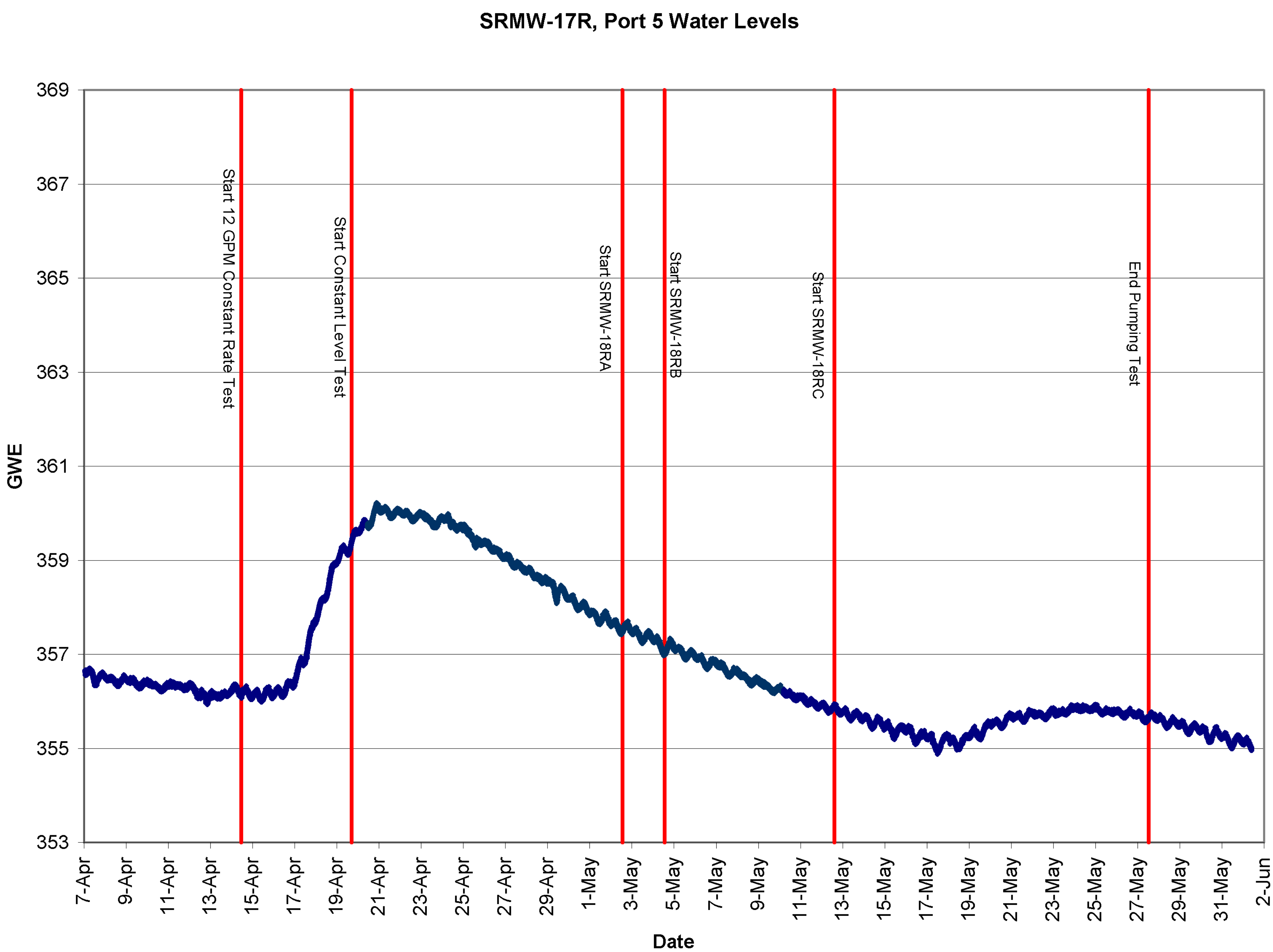

SRMW-17R, Port 2 Water Levels
GWE
Date
373
371
369
367
365
363
361
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



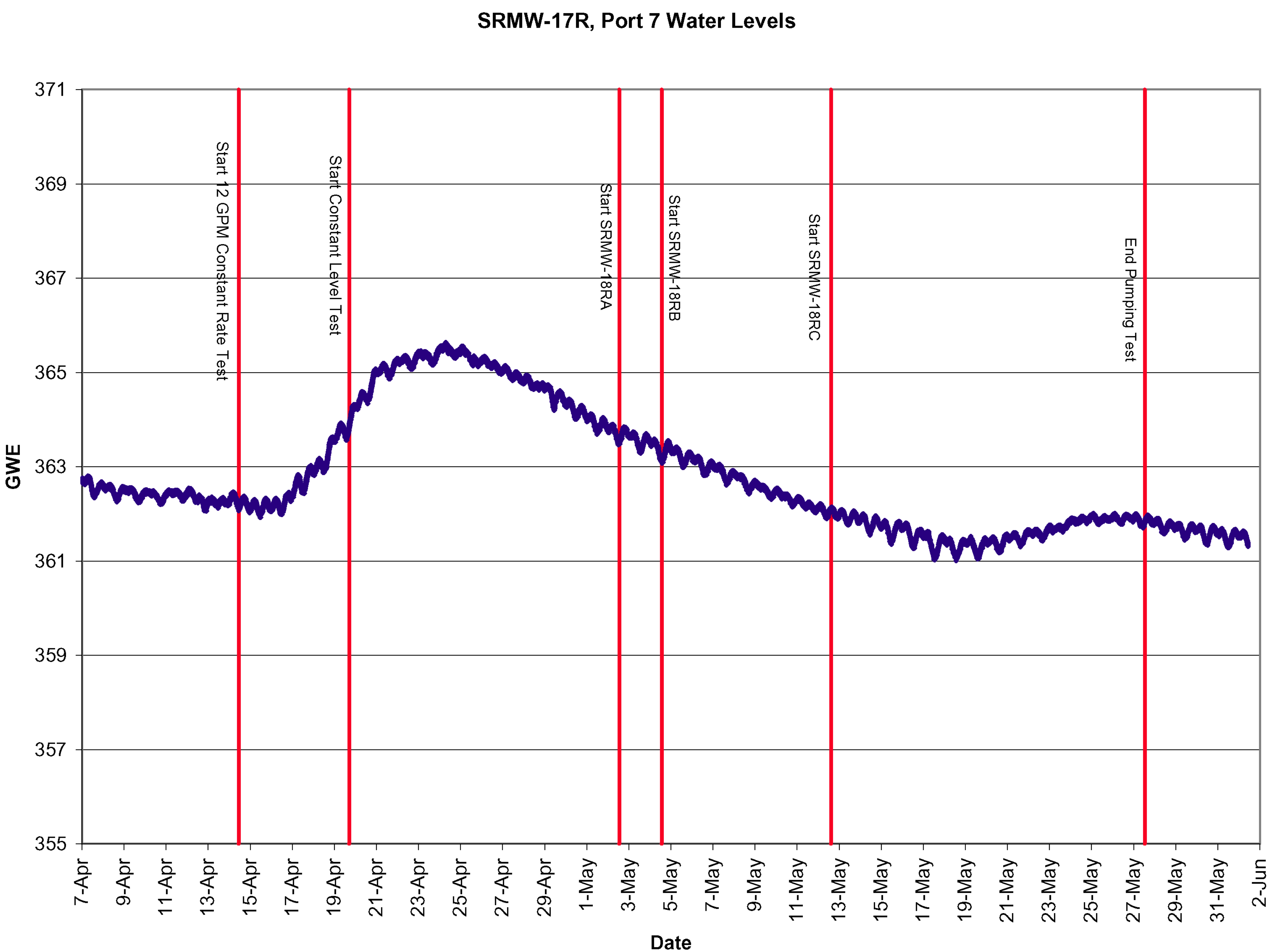
SRMW-17R, Port 3 Water Levels
GWE
Date
371
369
367
365
363
361
359
357
355
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



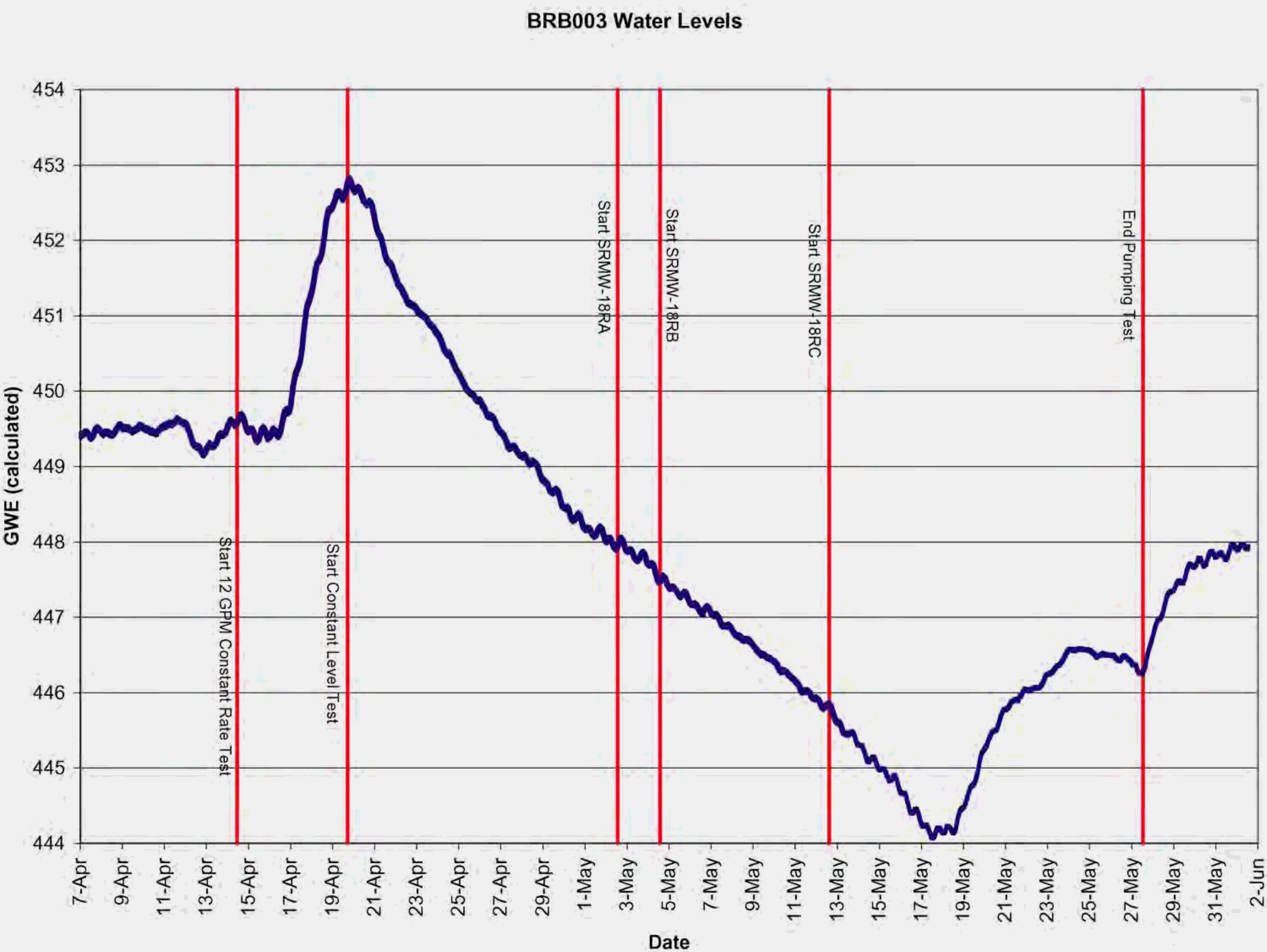
SRMW-17R, Port 4 Water Levels
GWE
371
369
367
365
363
361
359
357
355
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



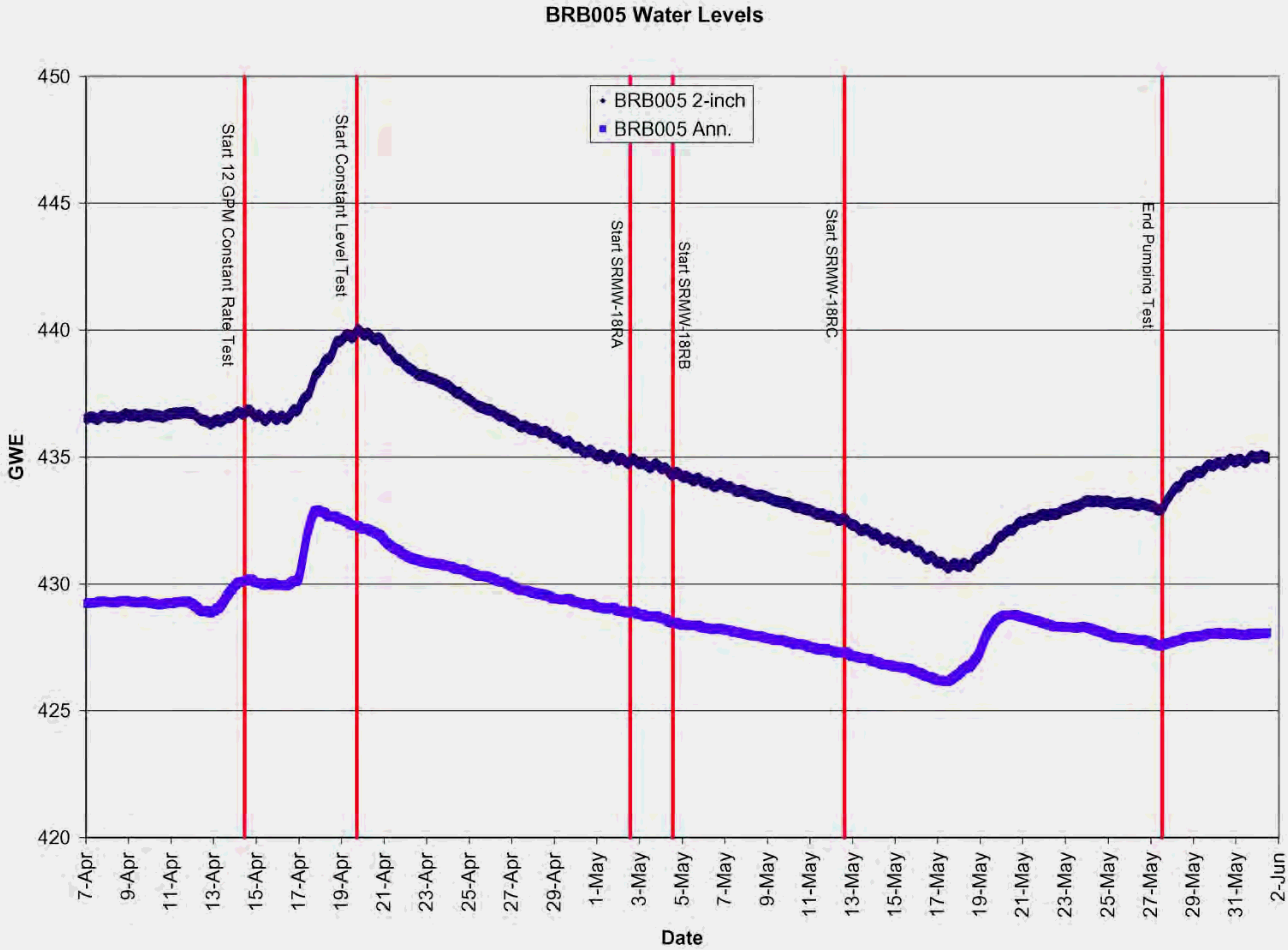
SRMW-17R, Port 5 Water Levels
GWE
Date
369
367
365
363
361
359
357
355
353
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



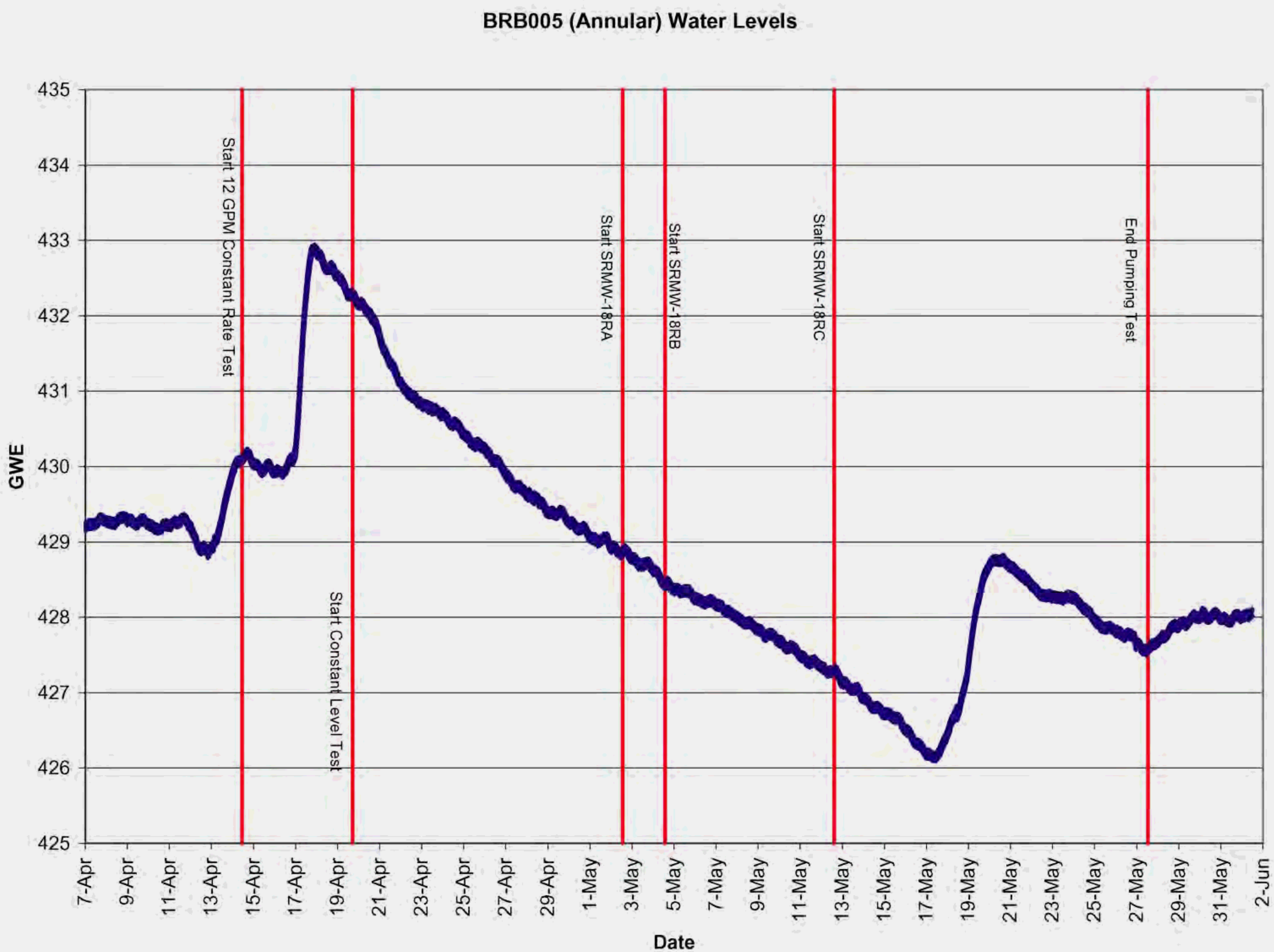
SRMW-17R, Port 7 Water Levels
GWE
371
369
367
365
363
361
359
357
355
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



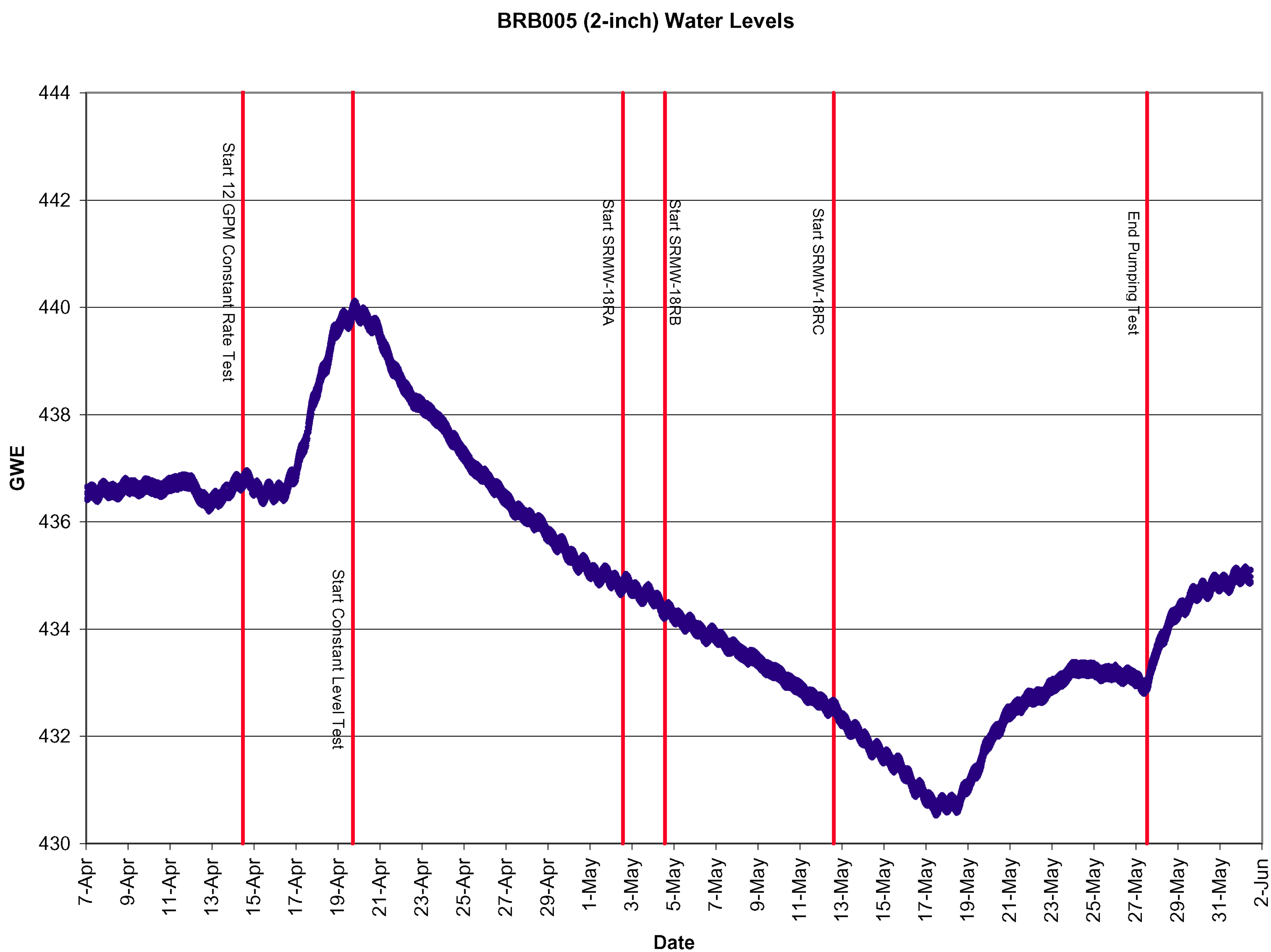
BRB003 Water Levels
GWE (calculated)
454
453
452
451
450
449
448
447
446
445
444
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



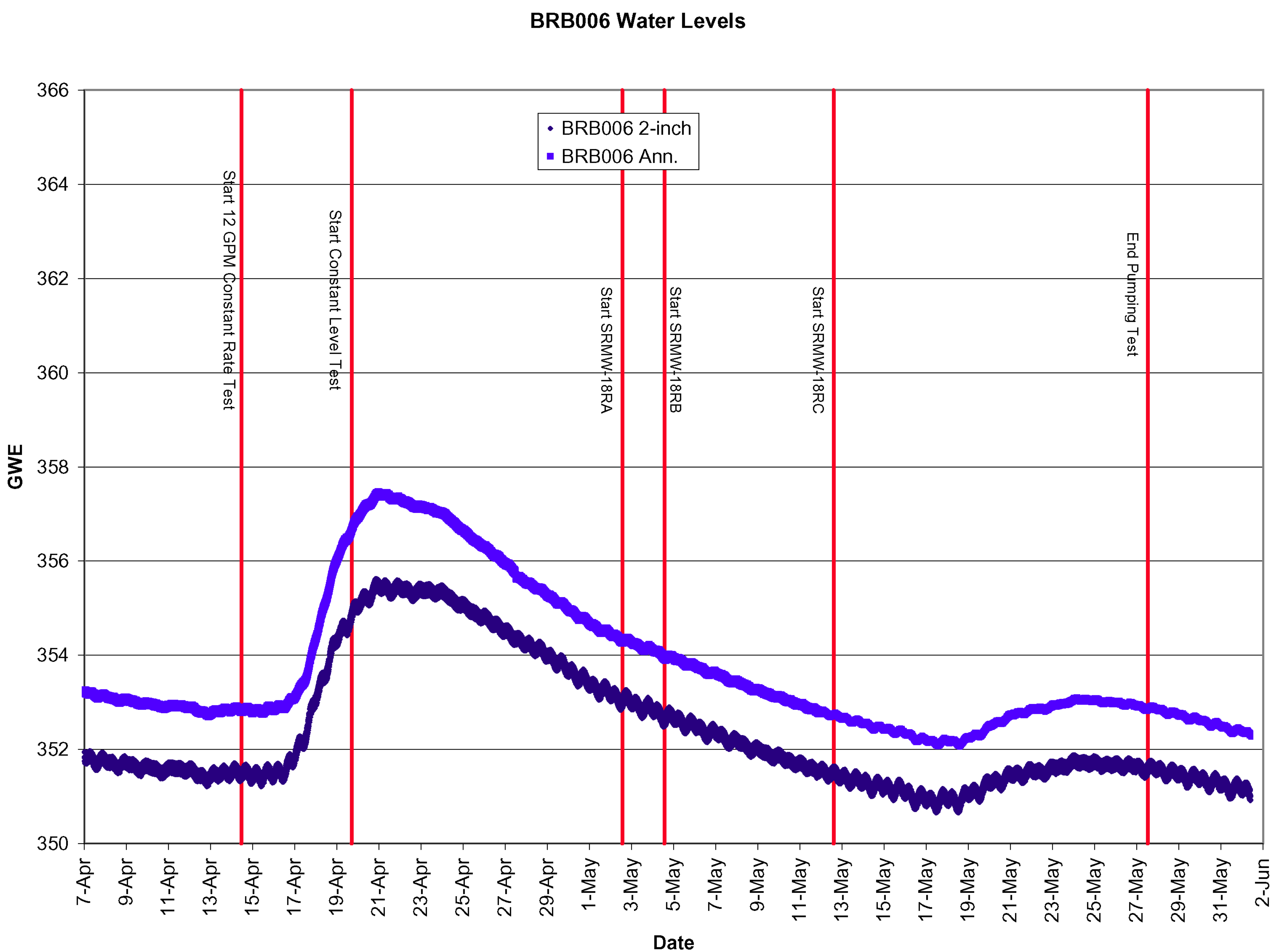
BRB005 Water Levels
BRB005 2-inch
BRB005 Ann.
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
GWE
450
445
440
435
430
425
420
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun



BRB005 (Annular) Water Levels
GWE
435
434
433
432
431
430
429
428
427
426
425
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

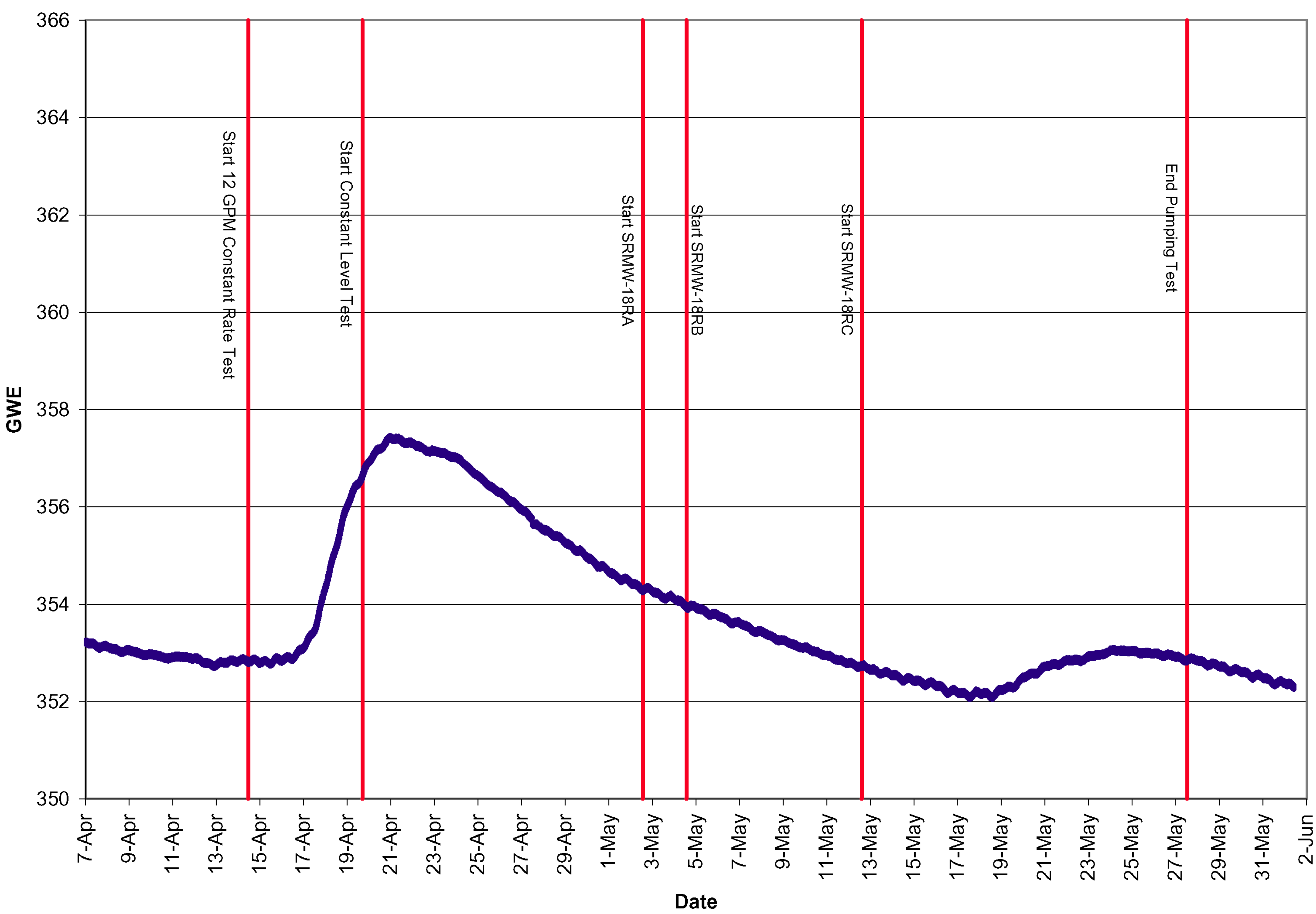


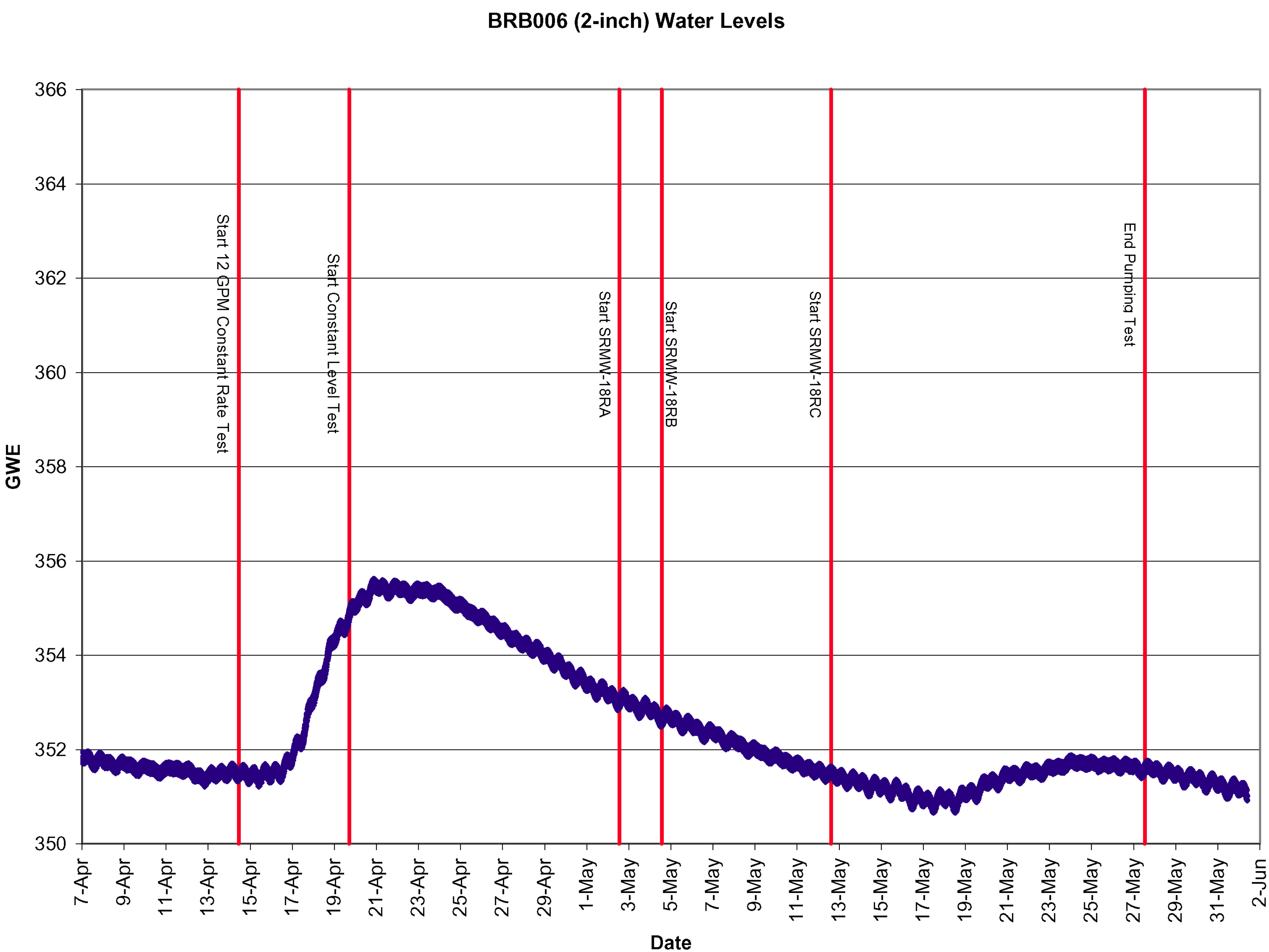
BRB005 (2-inch) Water Levels
GWE
Date
444
442
440
438
436
434
432
430
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



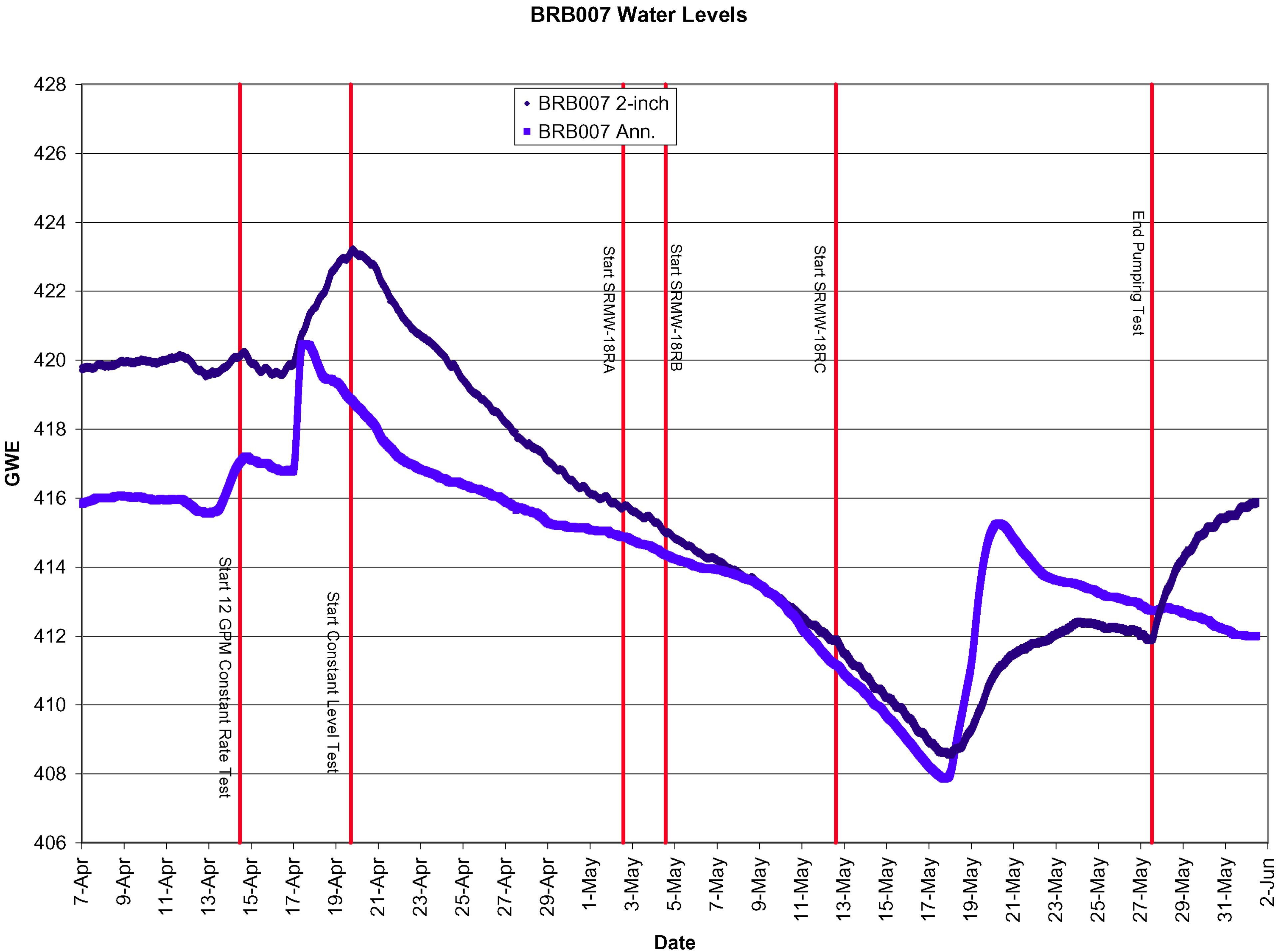
BRB006 Water Levels
BRB006 2-inch
BRB006 Ann.
GWE
366
364
362
360
358
356
354
352
350
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

BRB006 (Annular) Water Levels

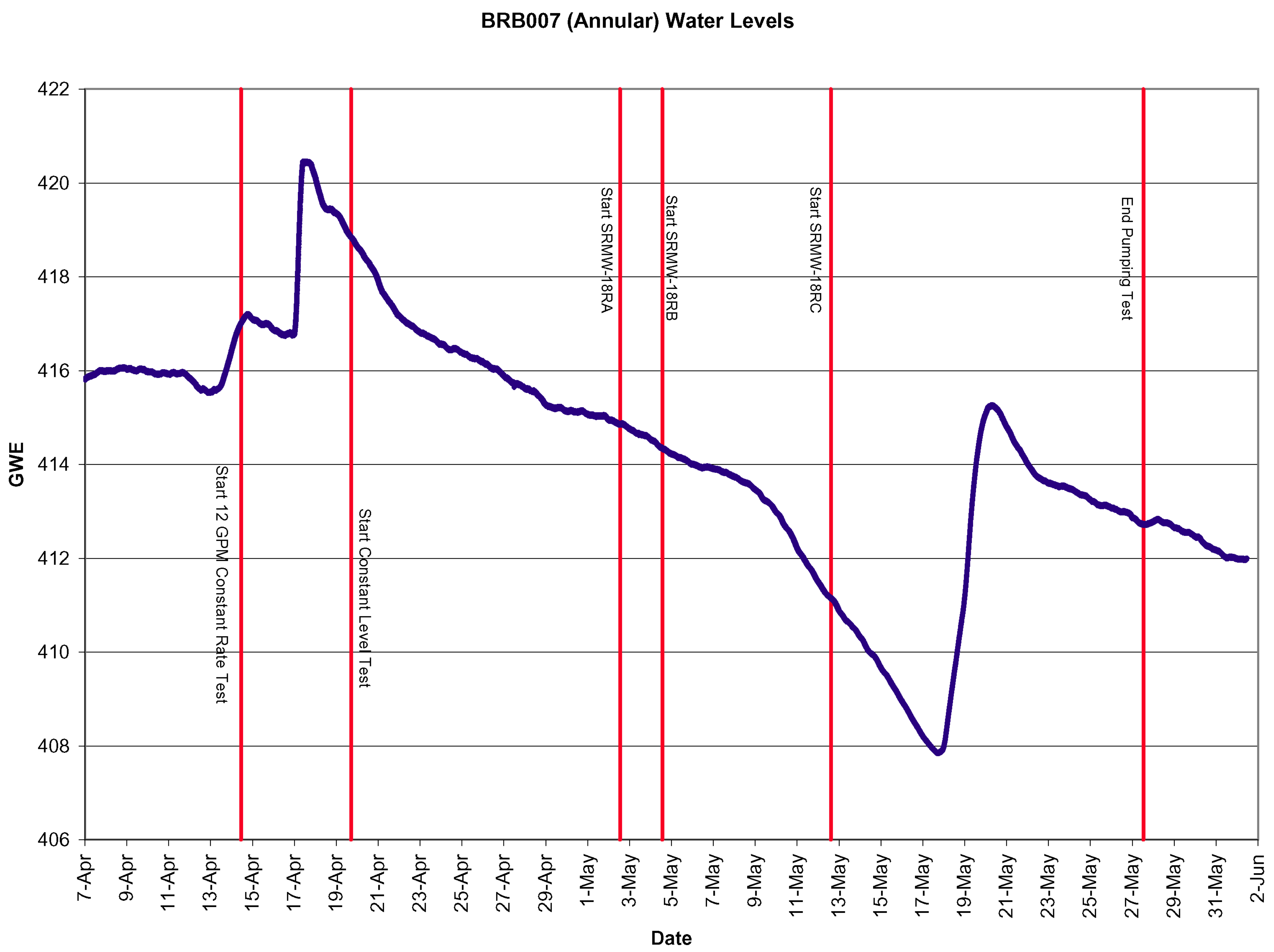


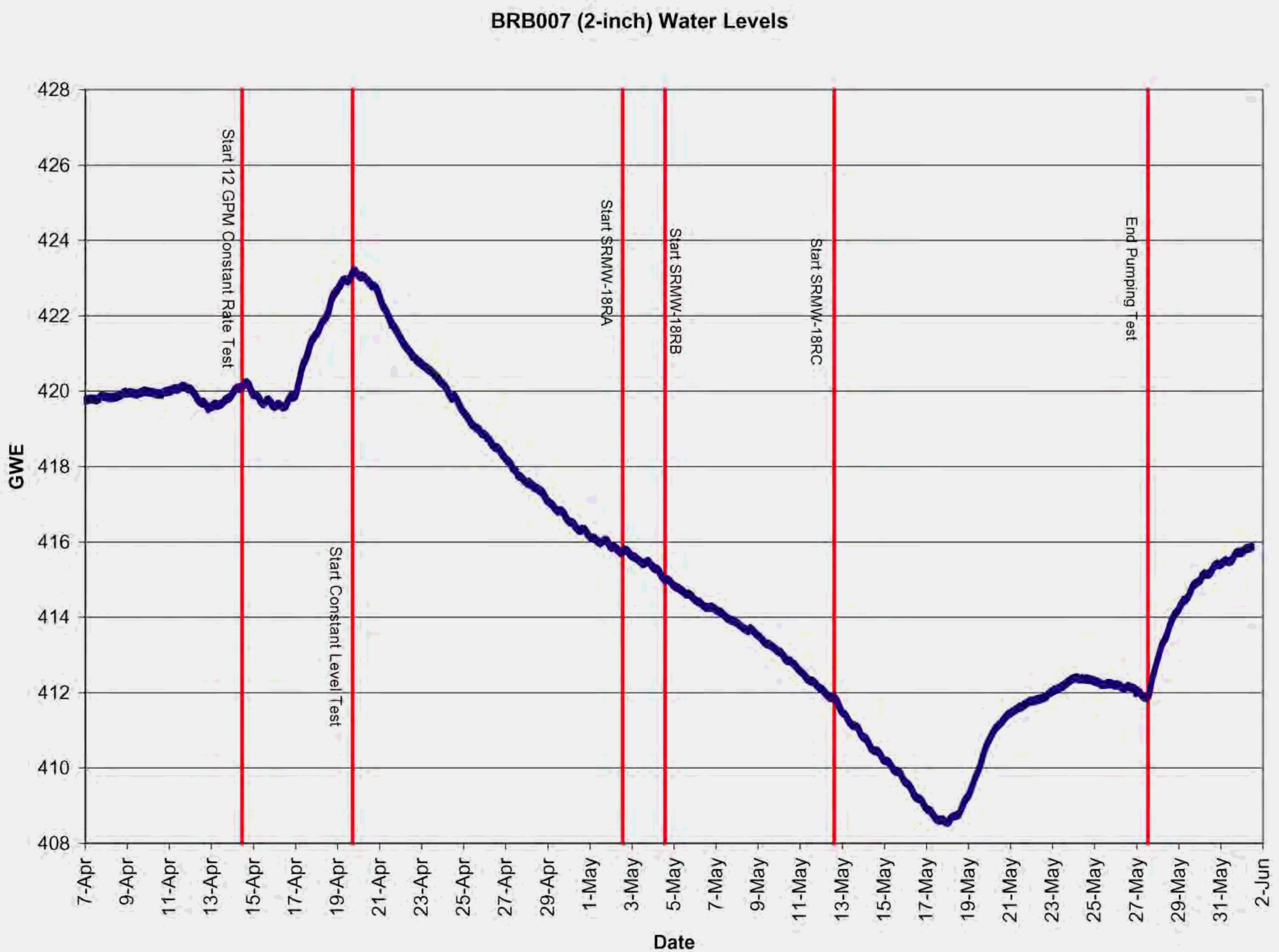


BRB006 (2-inch) Water Levels
GWE
366
364
362
360
358
356
354
352
350
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

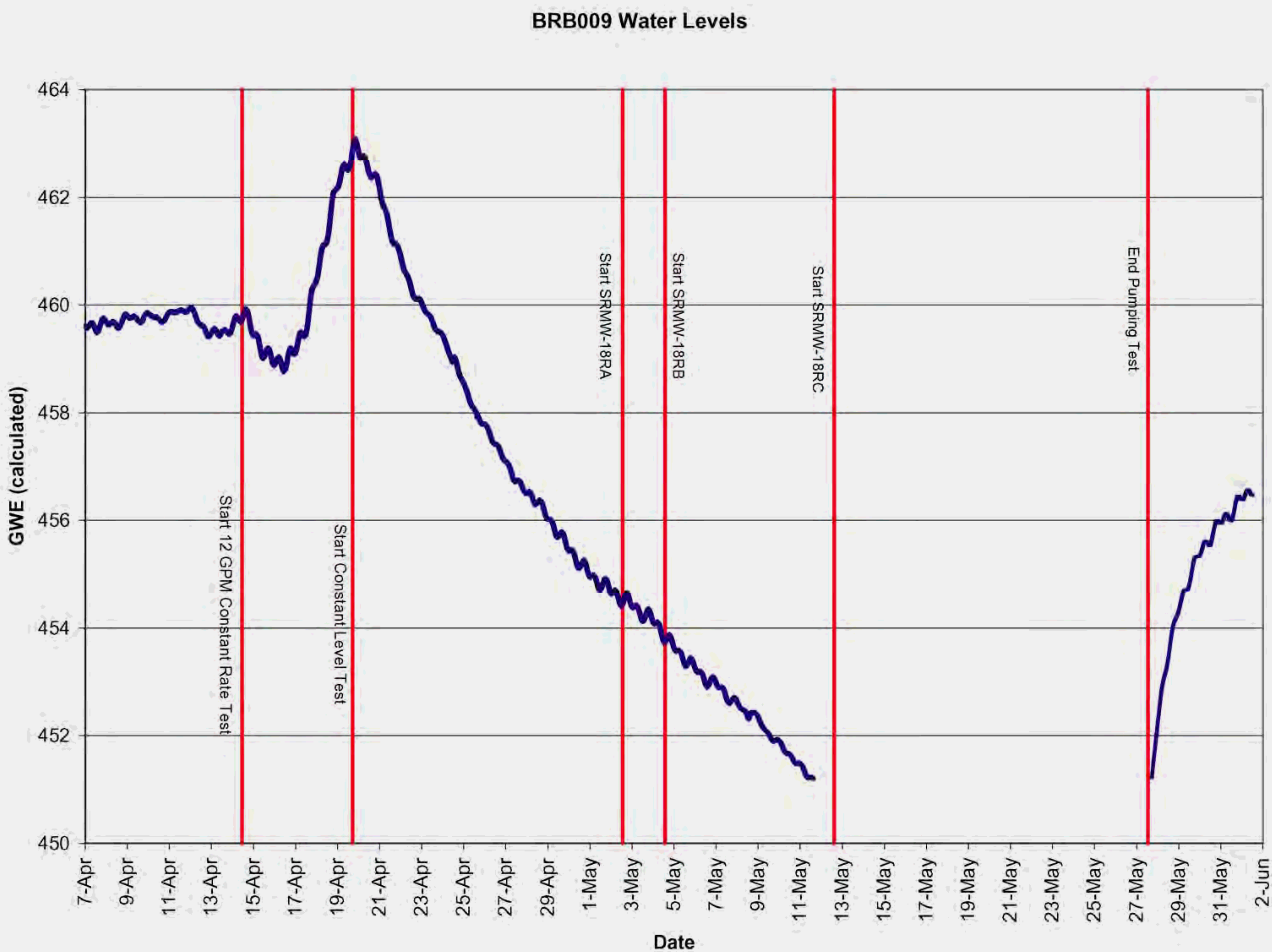


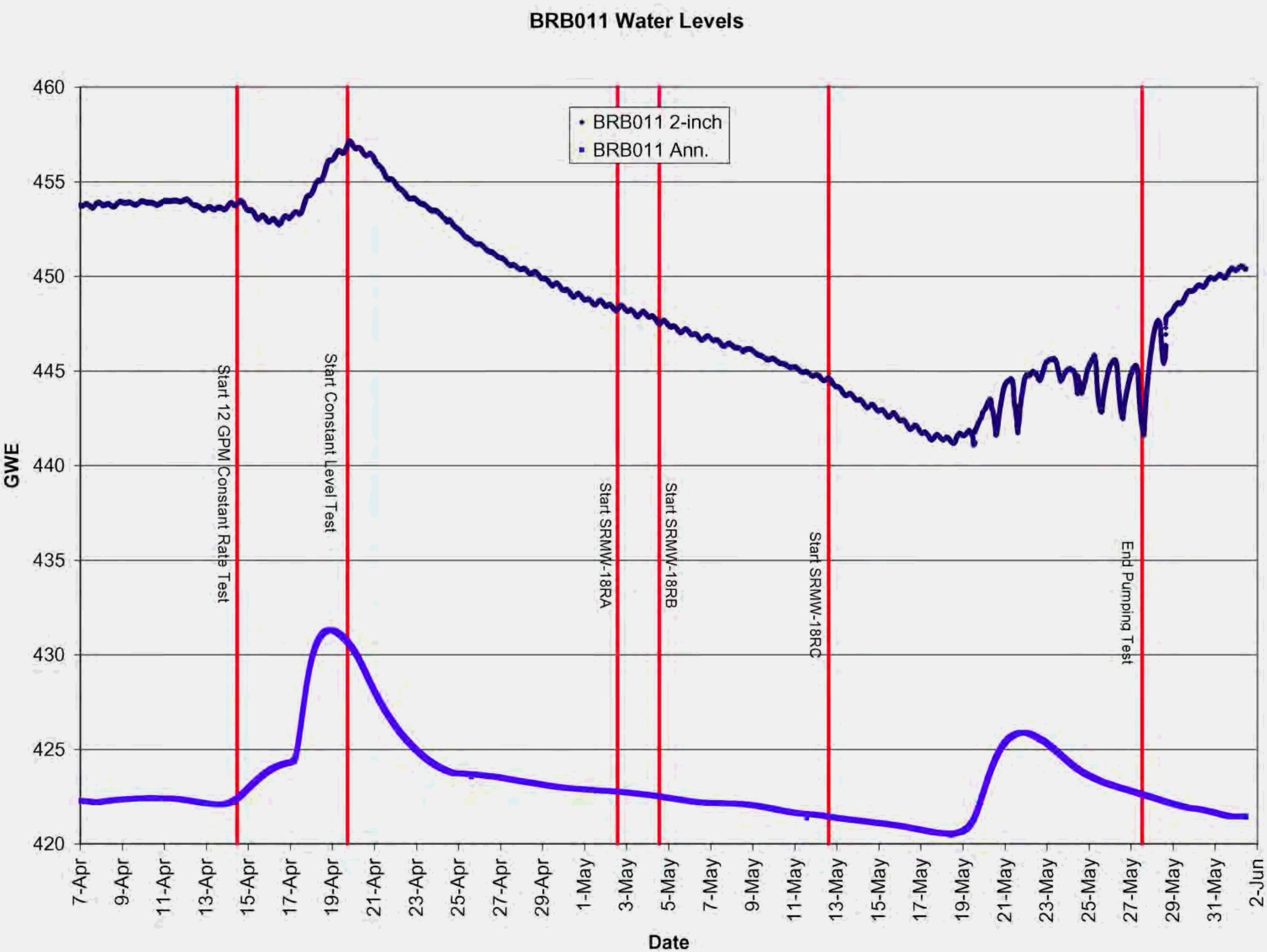
BRB007 Water Levels
BRB007 2-inch
BRB007 Ann.
GWE
Date
428
426
424
422
420
418
416
414
412
410
408
406
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

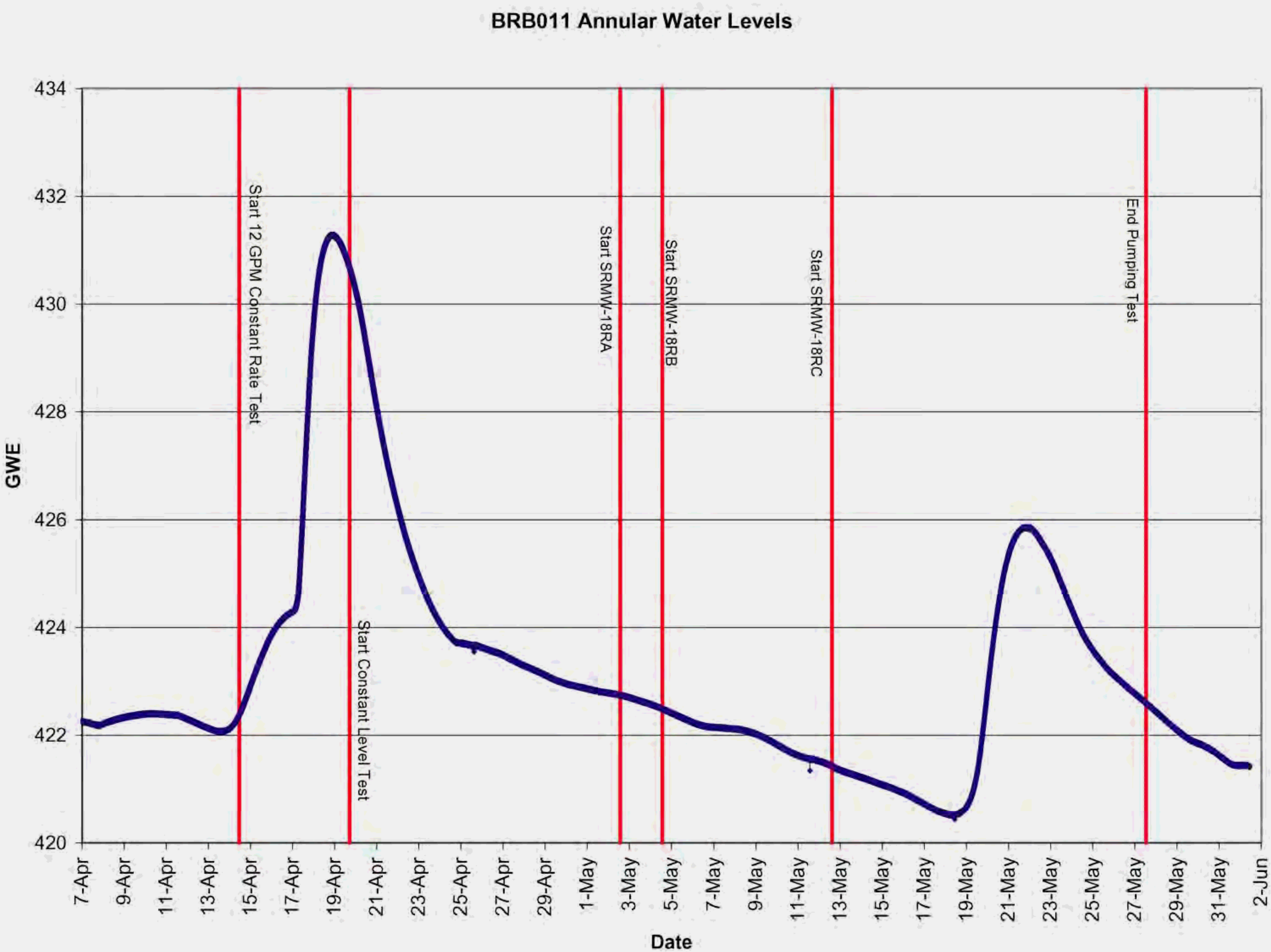

BRB007 (Annular) Water Levels
GWE
422
420
418
416
414
412
410
408
406
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



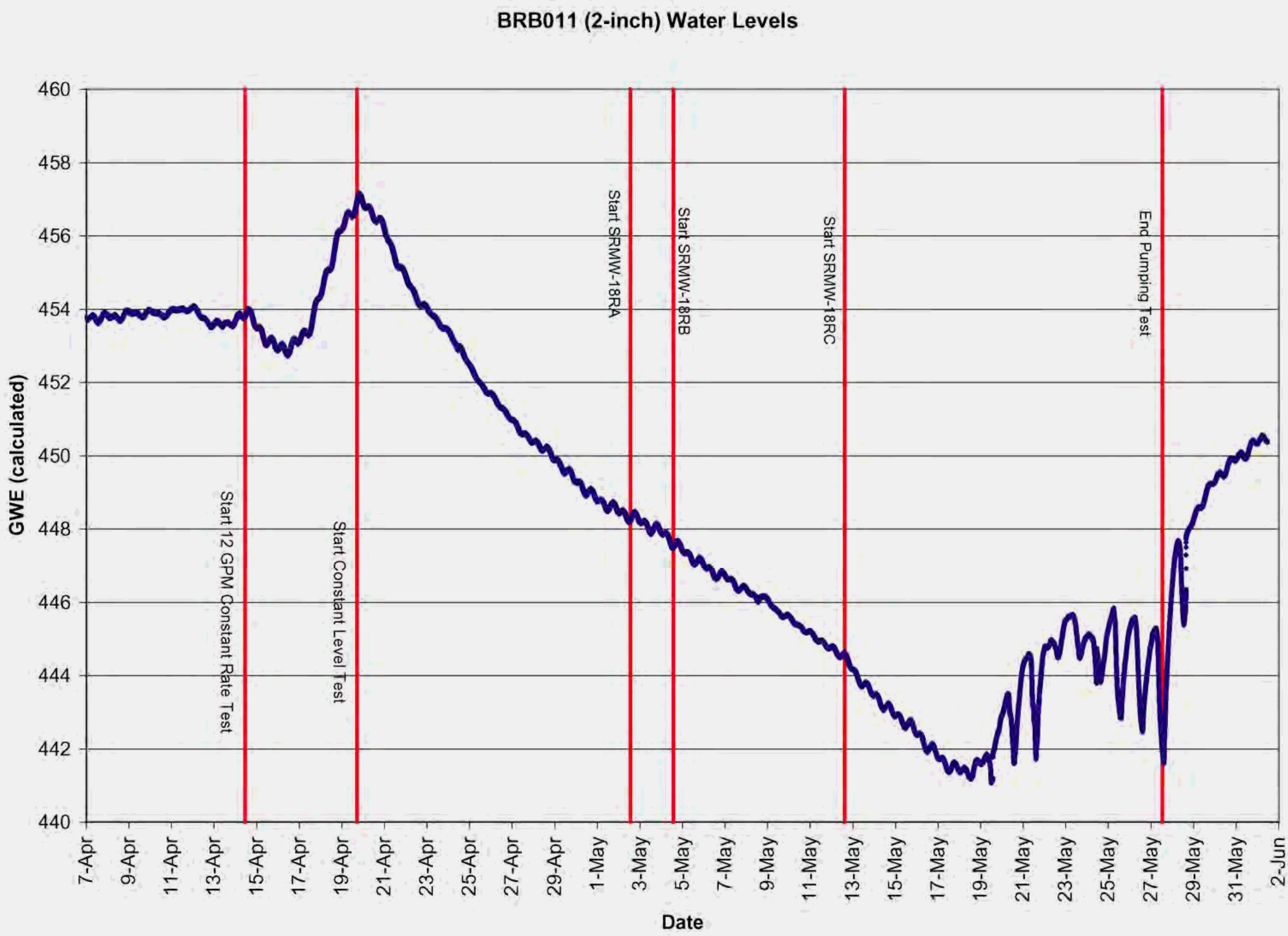
BRB007 (2-inch) Water Levels
GWE
Date
428
426
424
422
420
418
416
414
412
410
408
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test


BRB009 Water Levels
GWE (calculated)
Date
464
462
460
458
456
454
452
450
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

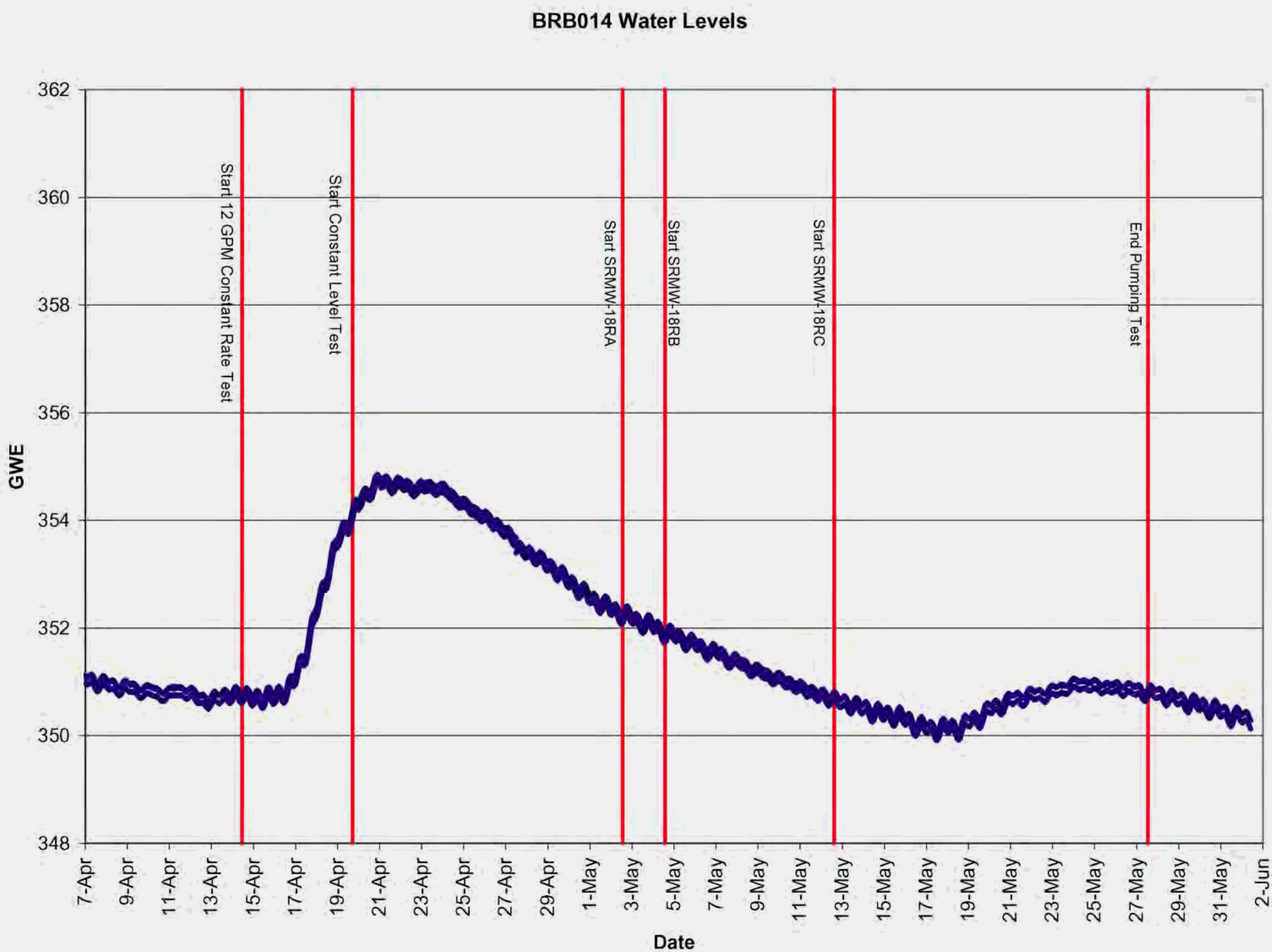

BRB011 Water Levels
BRB011 2-inch
BRB011 Ann.
GWE
460
455
450
445
440
435
430
425
420
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



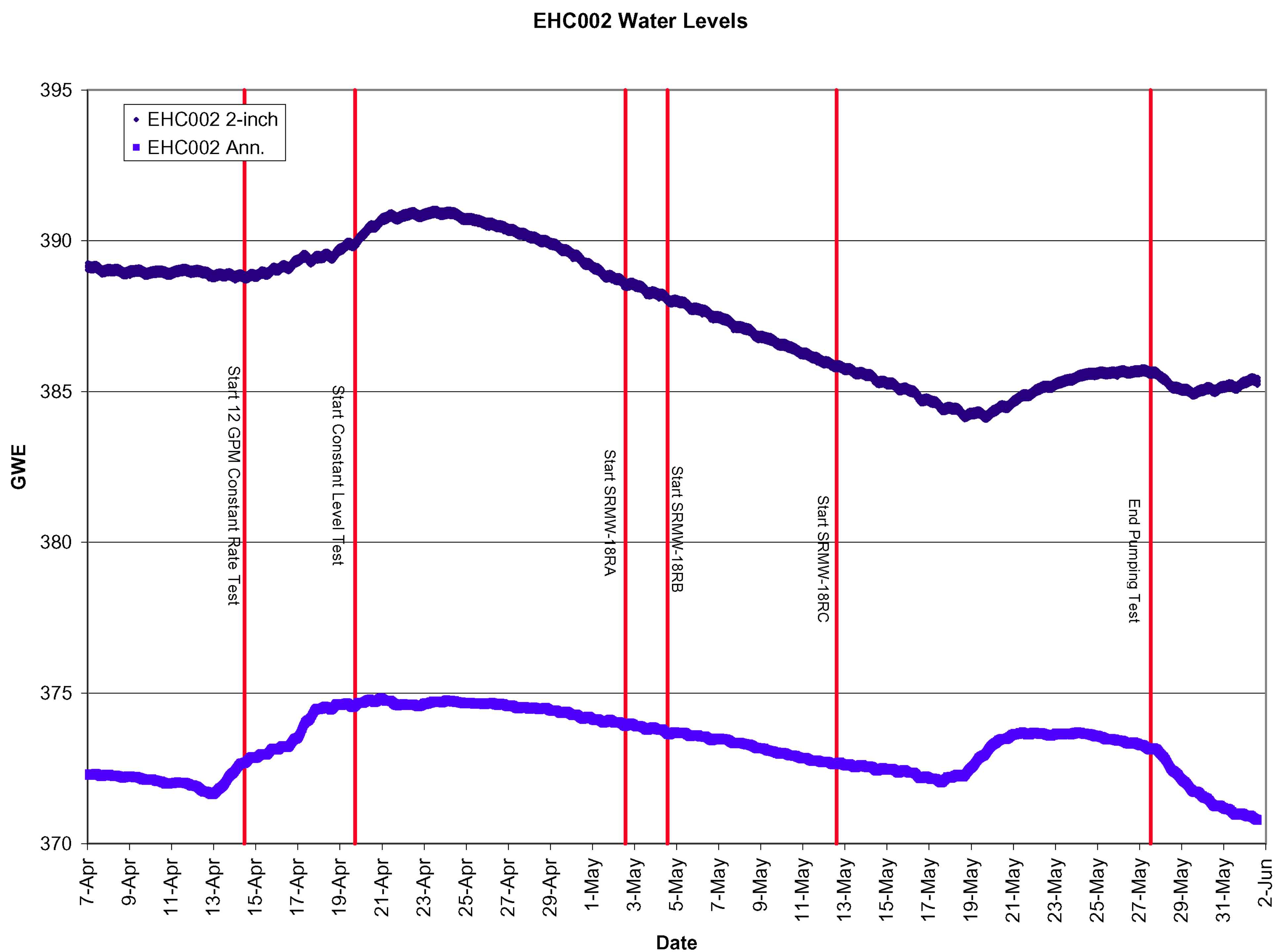
BRB011 Annular Water Levels
GWE
Date
434
432
430
428
426
424
422
420
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

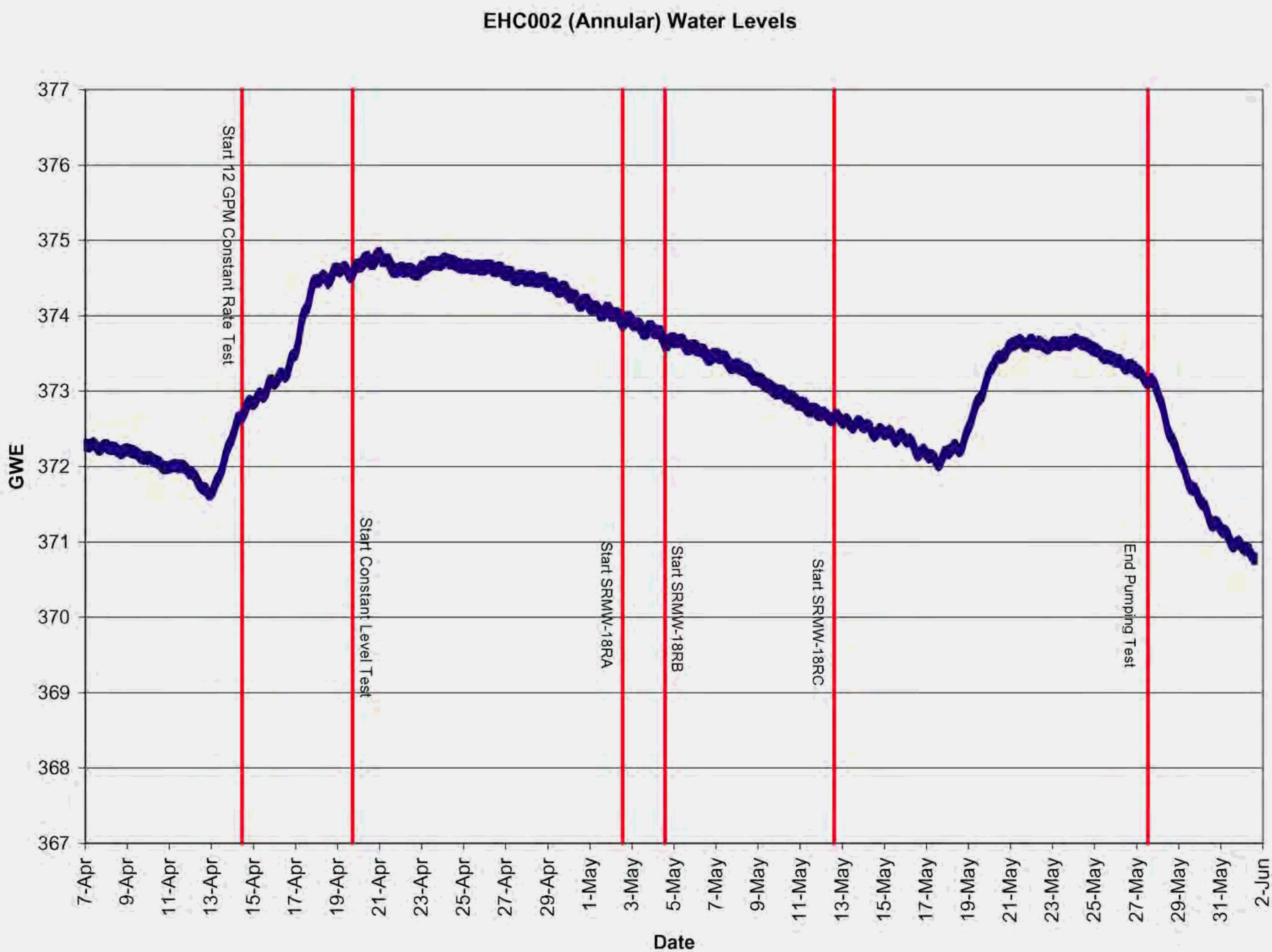


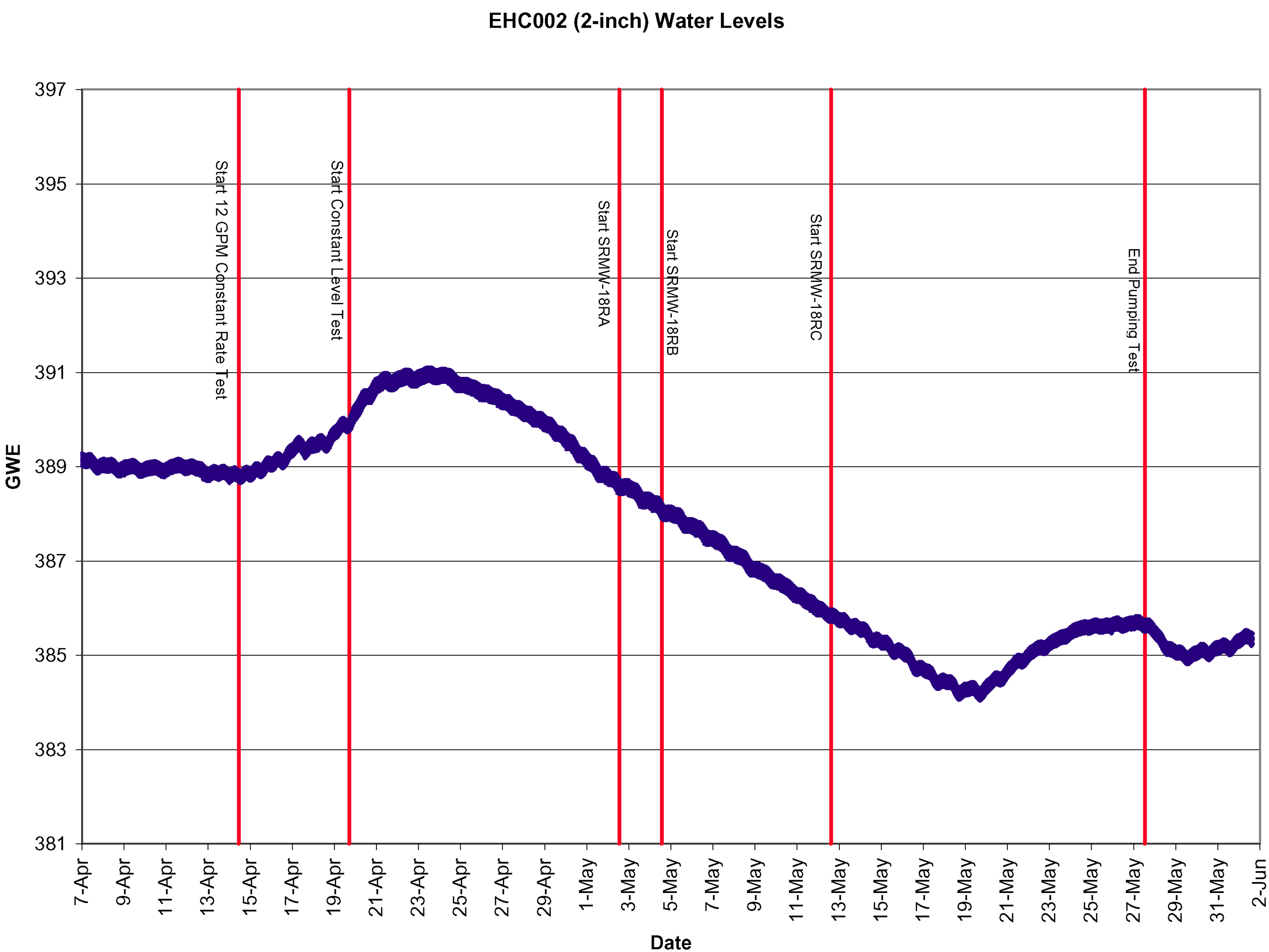
BRB011 (2-inch) Water Levels
GWE (calculated)
460
458
456
454
452
450
448
446
444
442
440
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



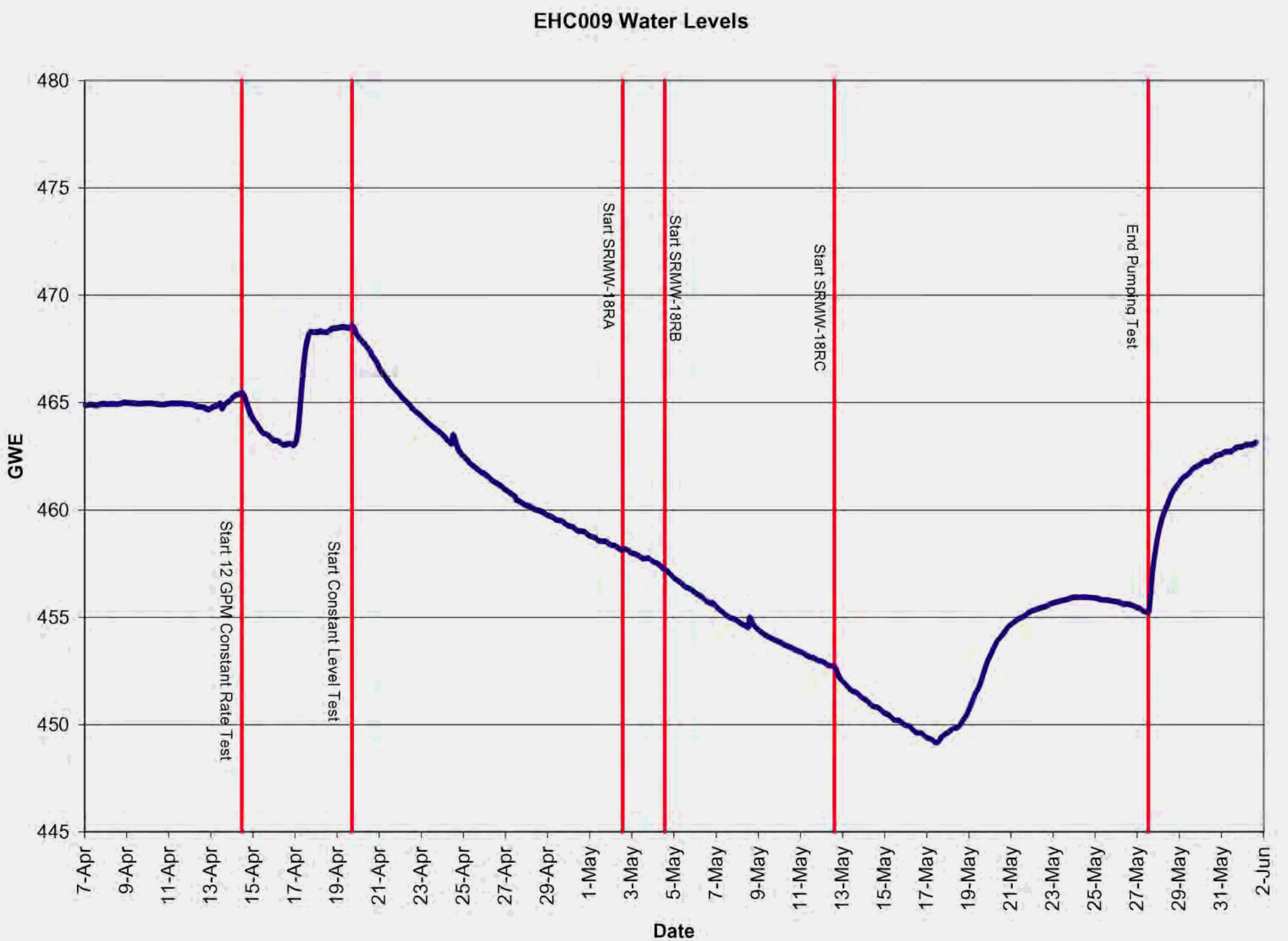
BRB014 Water Levels
362
360
358
356
354
352
350
348
GWE
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date


EHC002 Water Levels
EHC002 2-inch
EHC002 Ann.
GWE
395
390
385
380
375
370
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

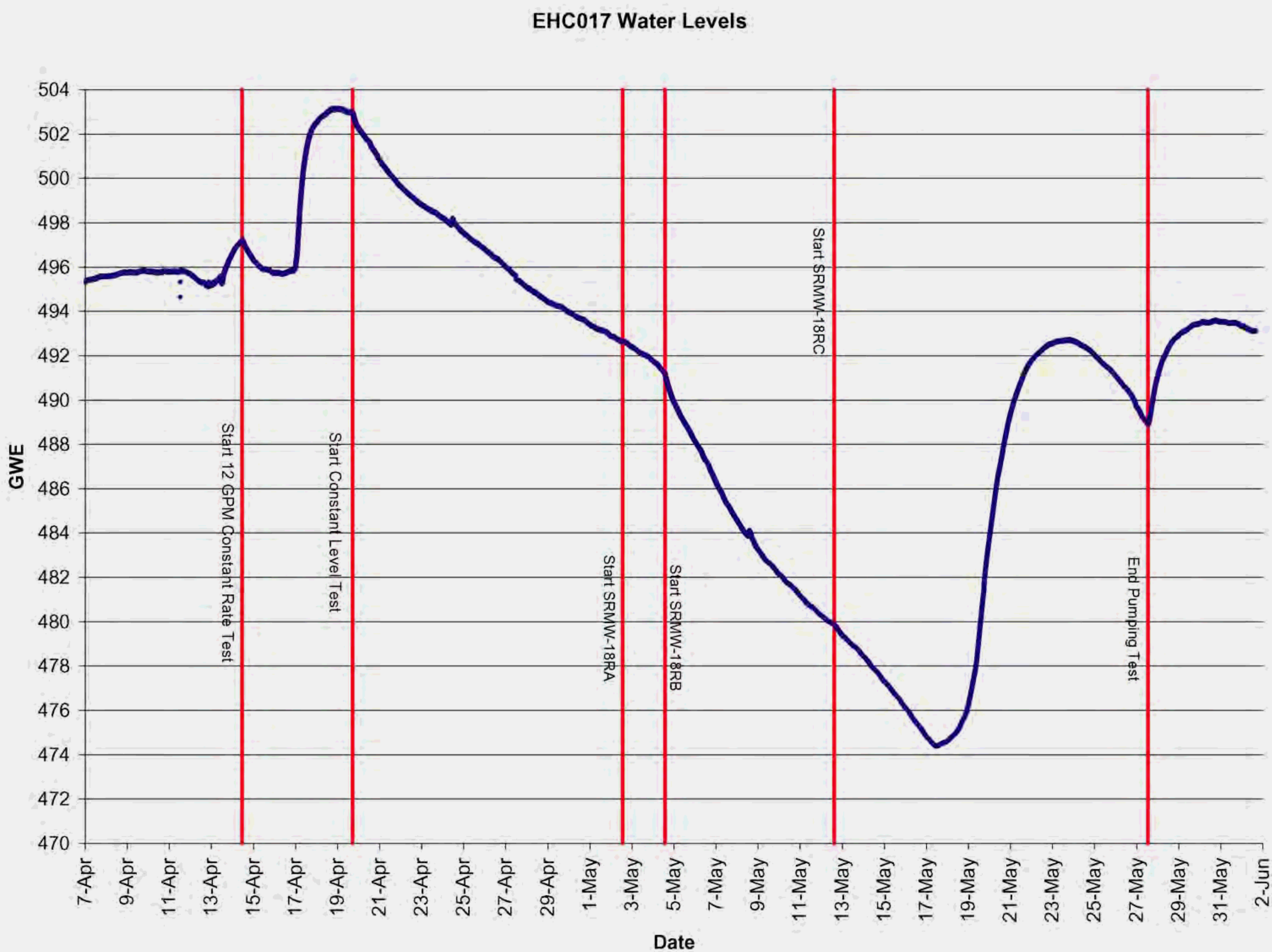

EHC002 (Annular) Water Levels
GWE
377
376
375
374
373
372
371
370
369
368
367
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



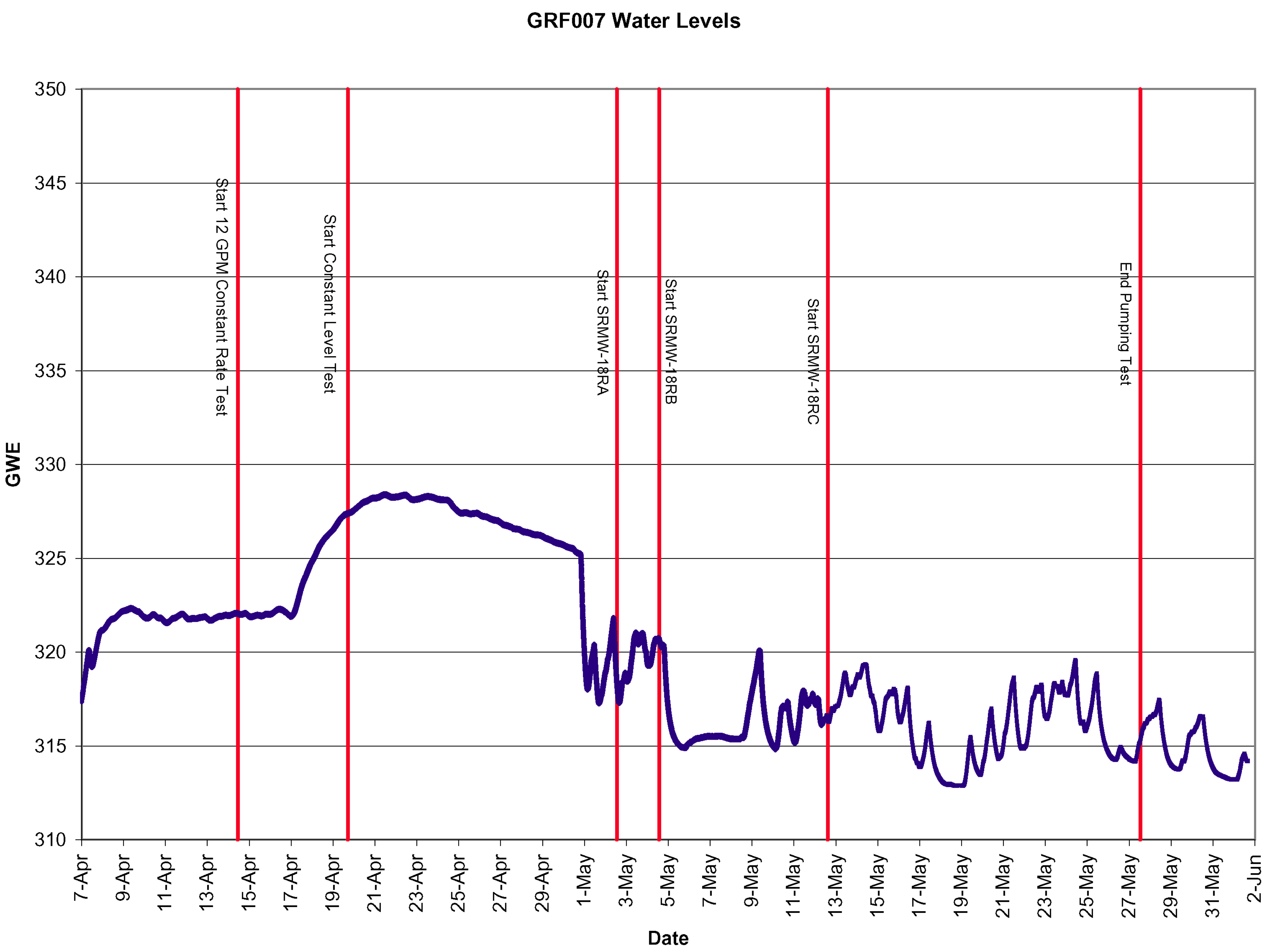
EHC002 (2-inch) Water Levels
GWE
Date
397
395
393
391
389
387
385
383
381
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



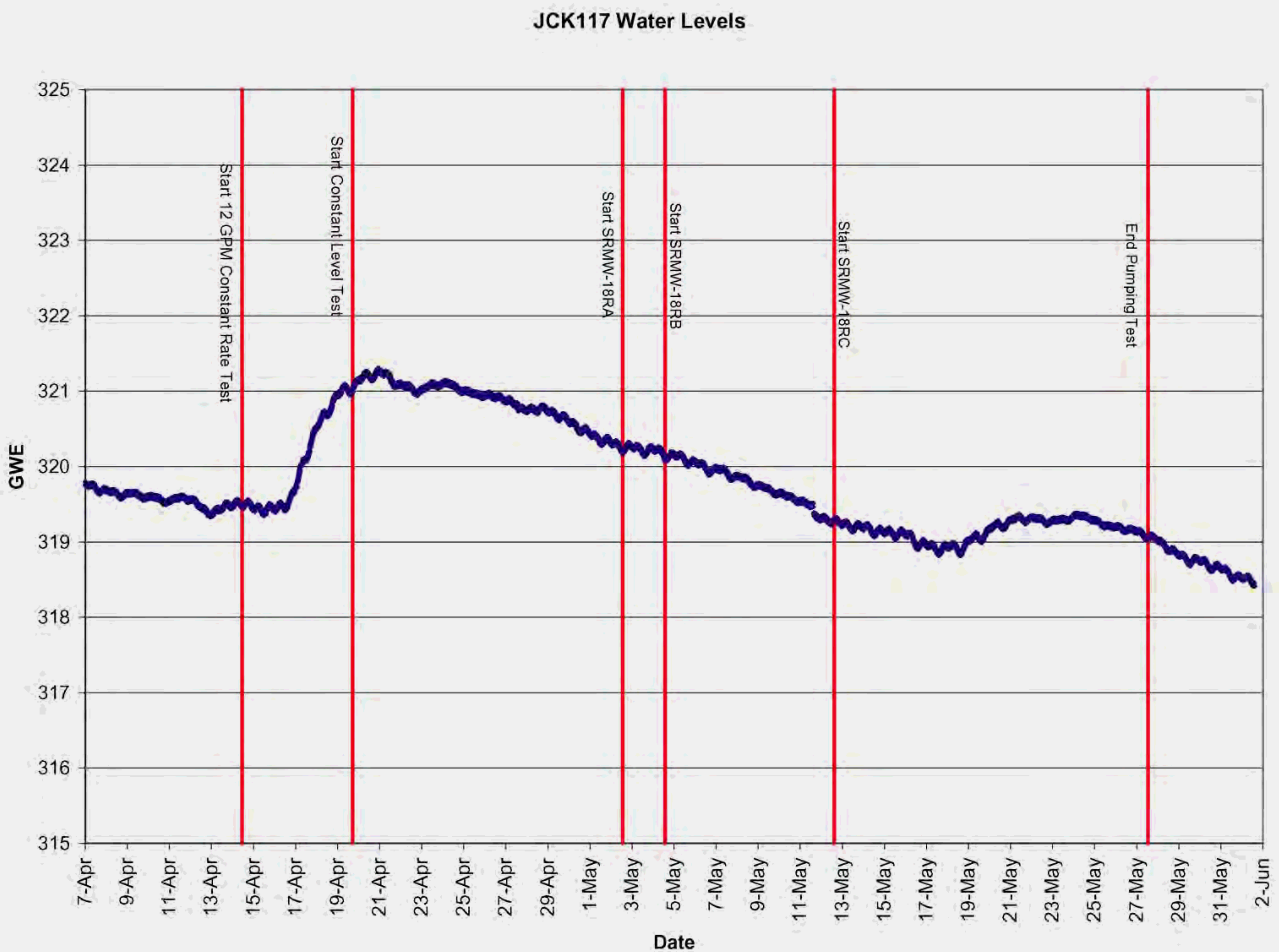
EHC009 Water Levels
GWE
Date
480
475
470
465
460
455
450
445
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



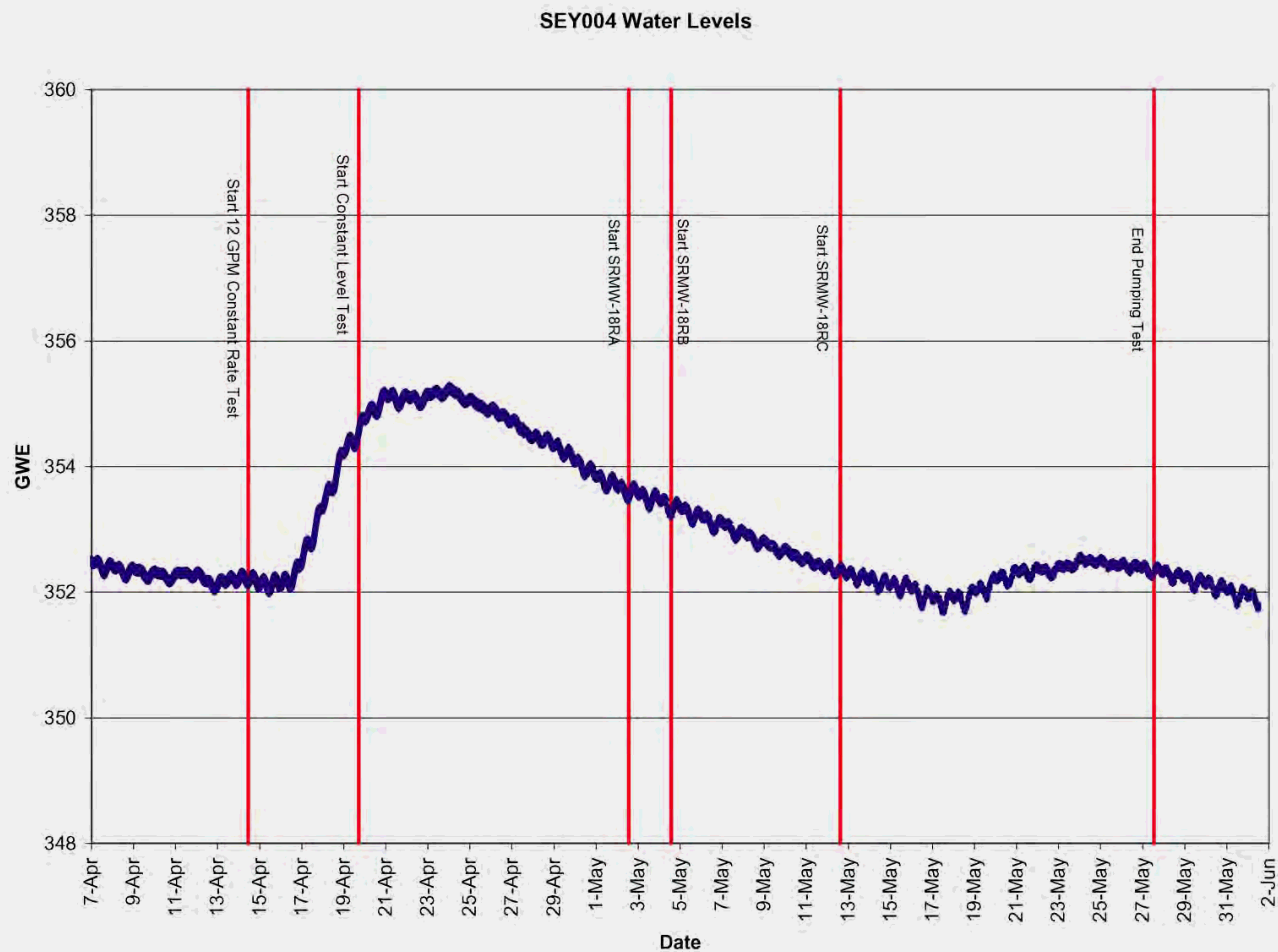
EHC017 Water Levels
GWE
Date
504
502
500
498
496
494
492
490
488
486
484
482
480
478
476
474
472
470
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



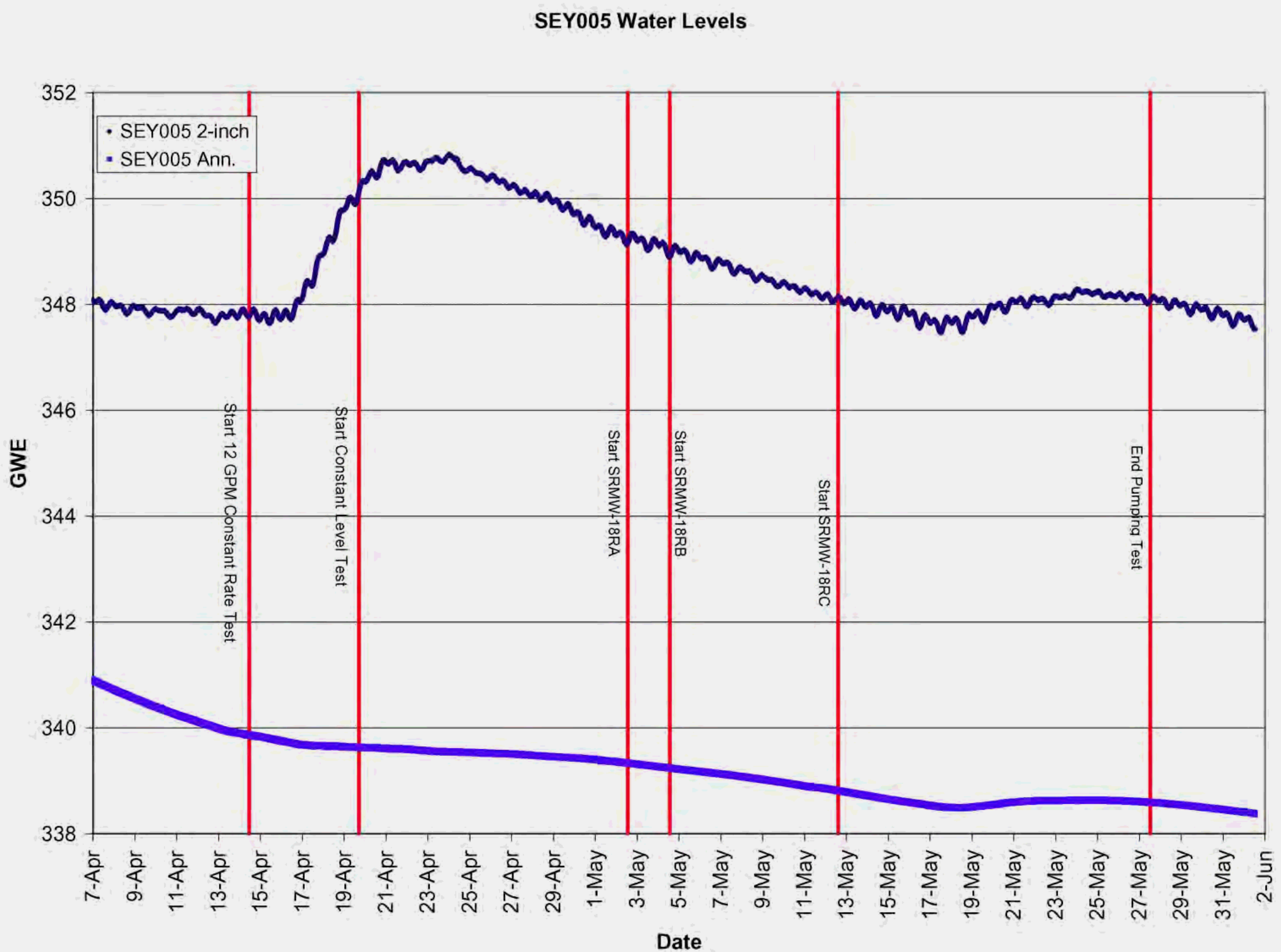
GRF007 Water Levels
GWE
350
345
340
335
330
325
320
315
310
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

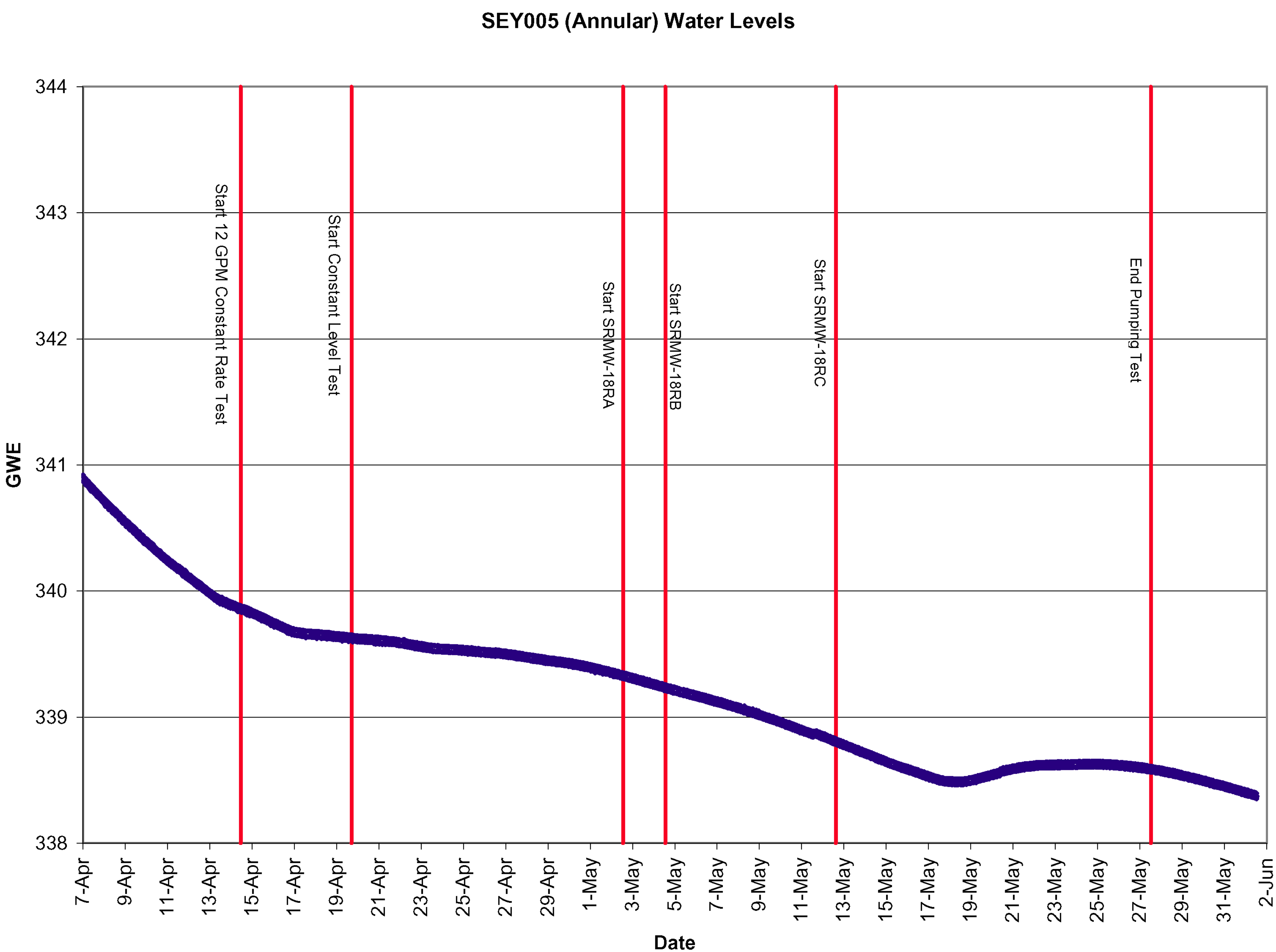


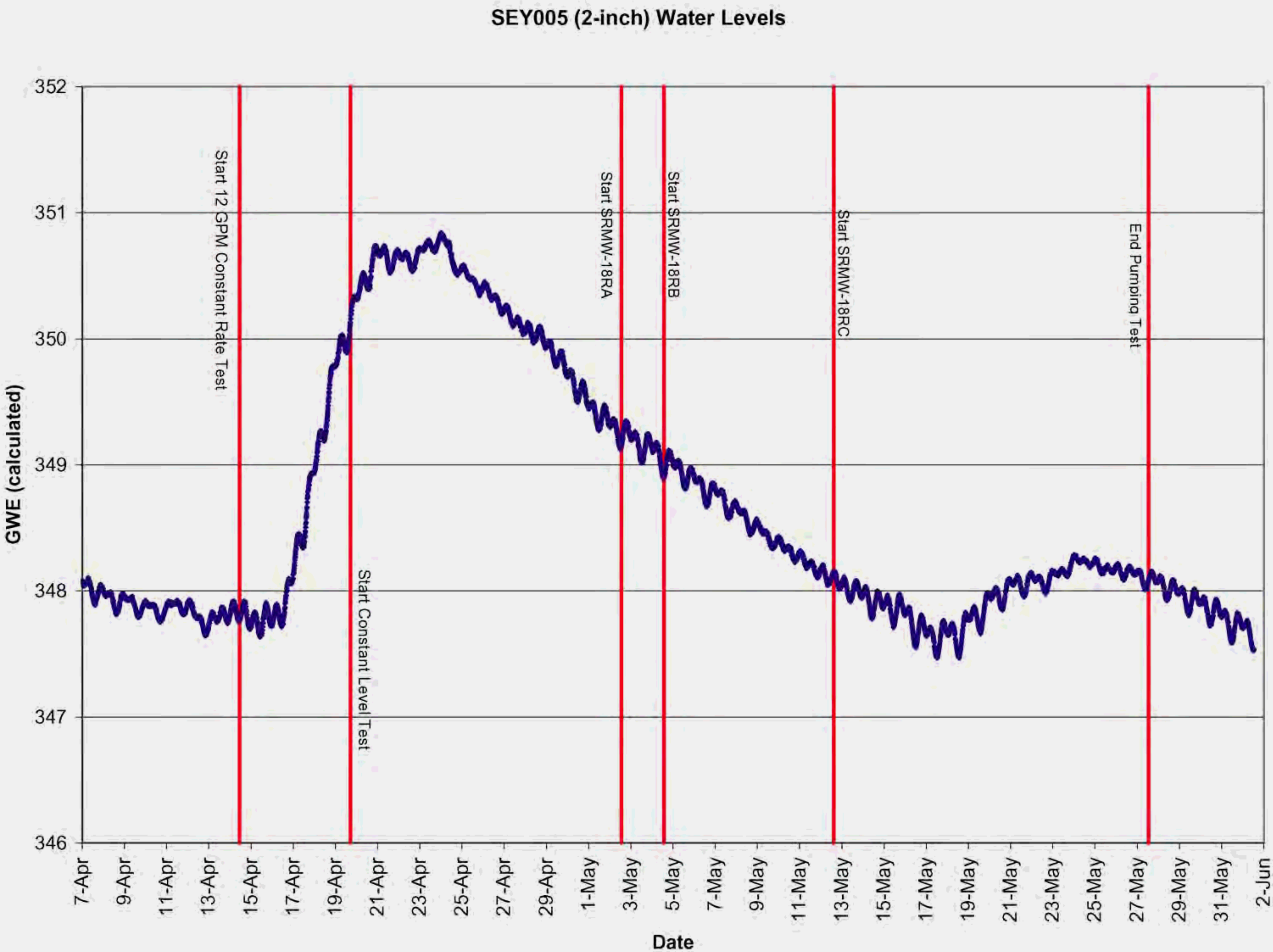
JCK117 Water Levels
GWE
Date
325
324
323
322
321
320
319
318
317
316
315
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



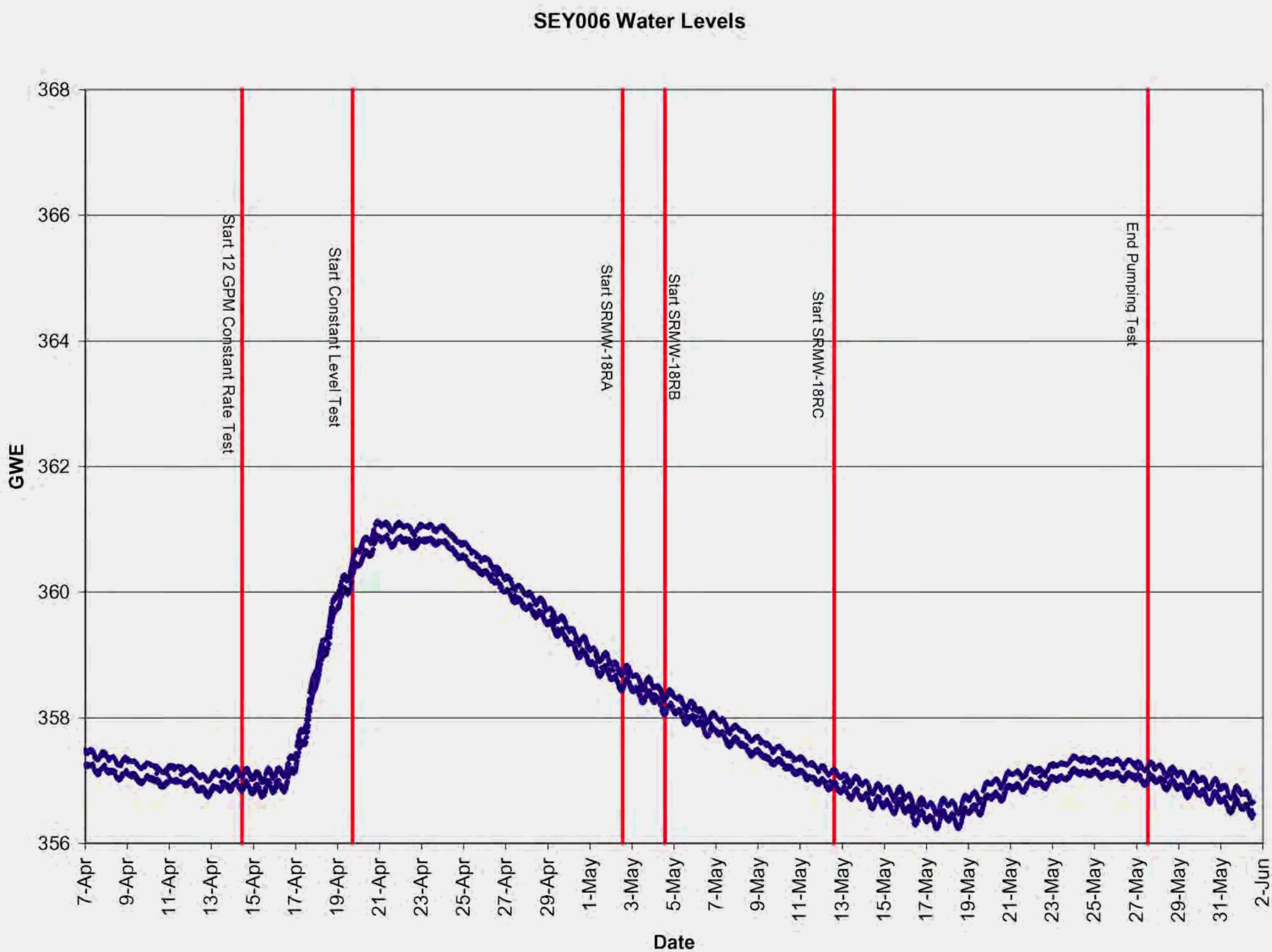
SEY004 Water Levels
GWE
360
358
356
354
352
350
348
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

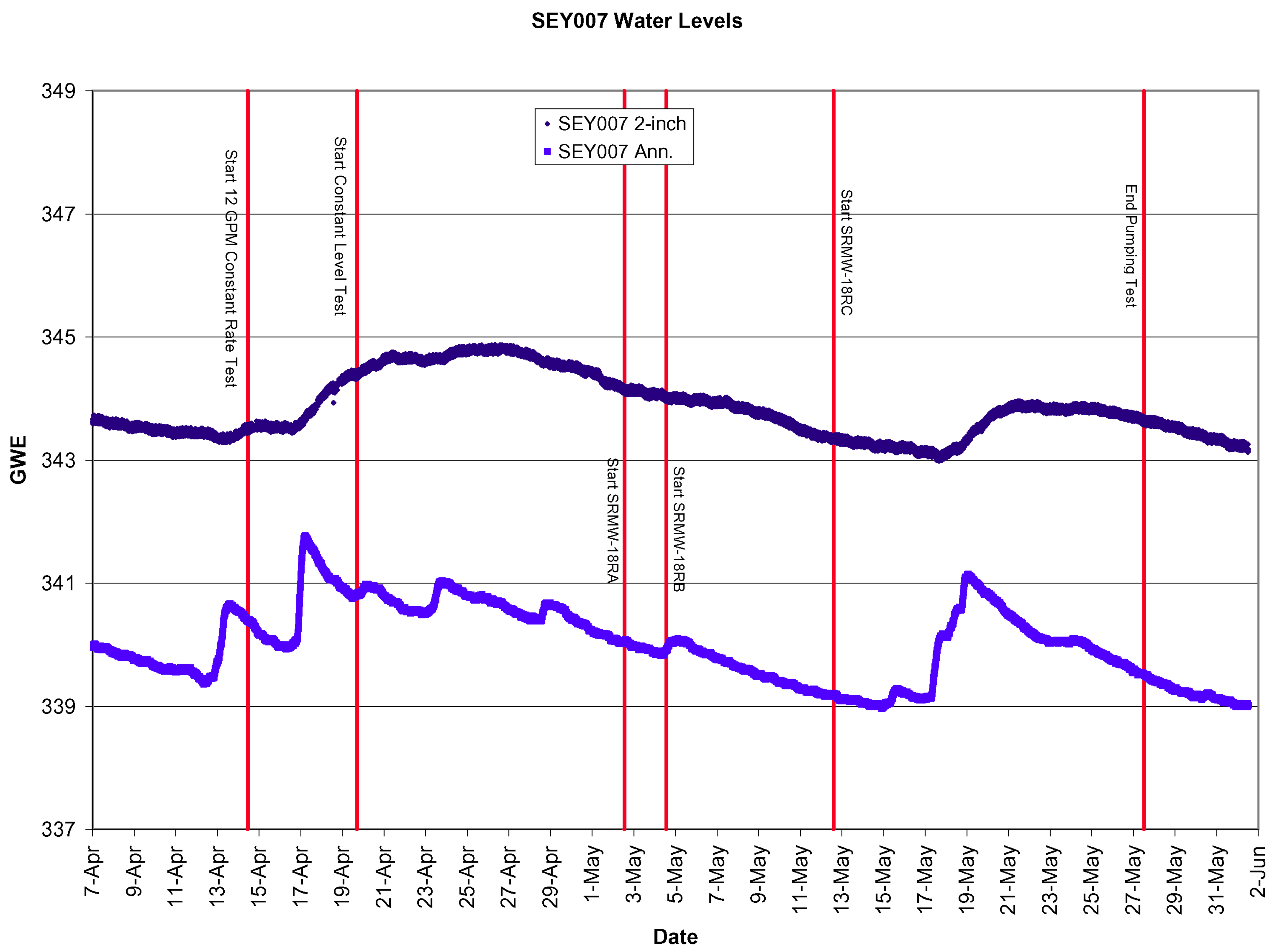

SEY005 Water Levels
SEY005 2-inch
SEY005 Ann.
GWE
352
350
348
346
344
342
340
338
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date


SEY005 (Annular) Water Levels
GWE
344
343
342
341
340
339
338
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

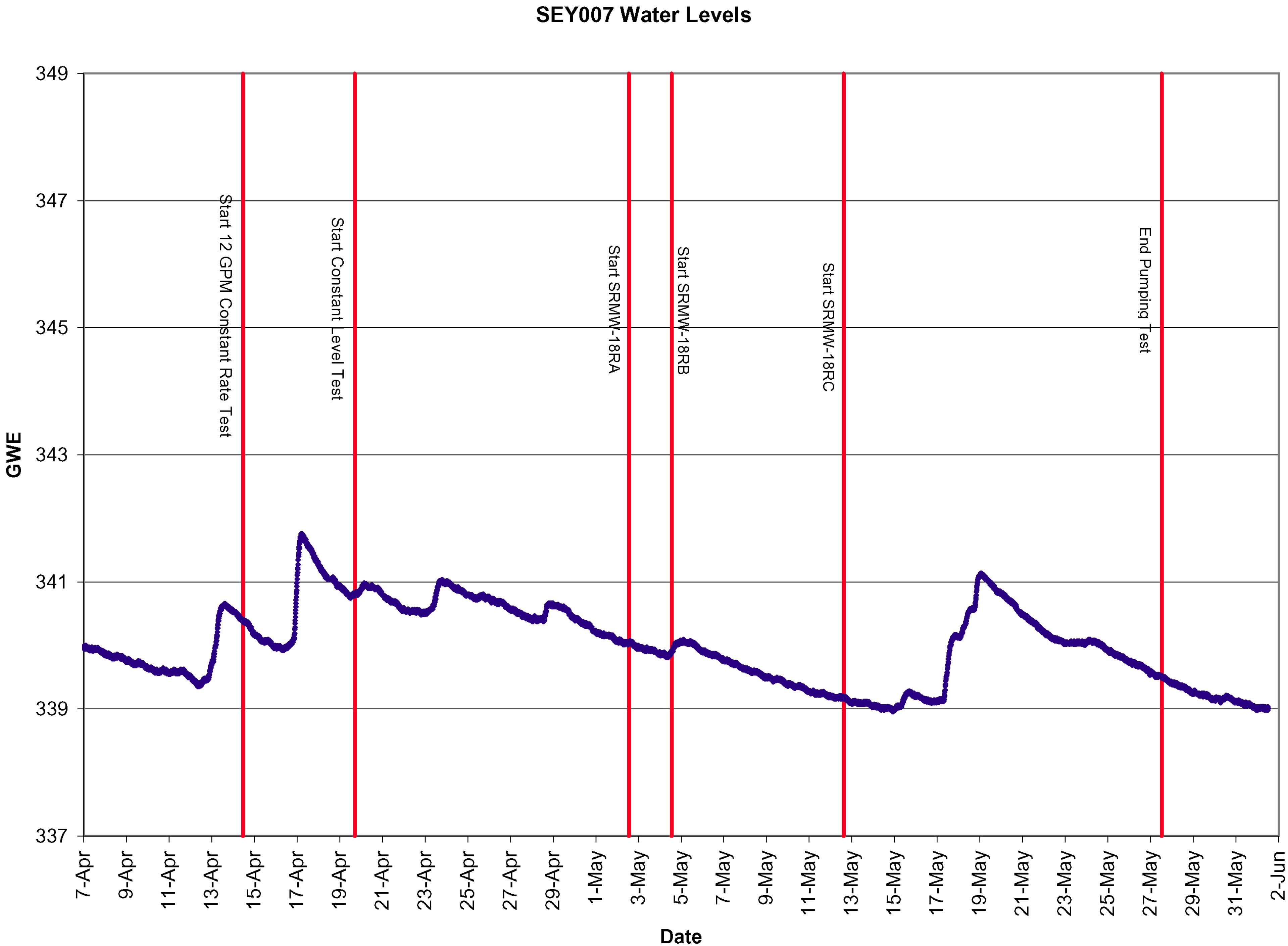


SEY005 (2-inch) Water Levels
GWE (calculated)
352
351
350
349
348
347
346
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

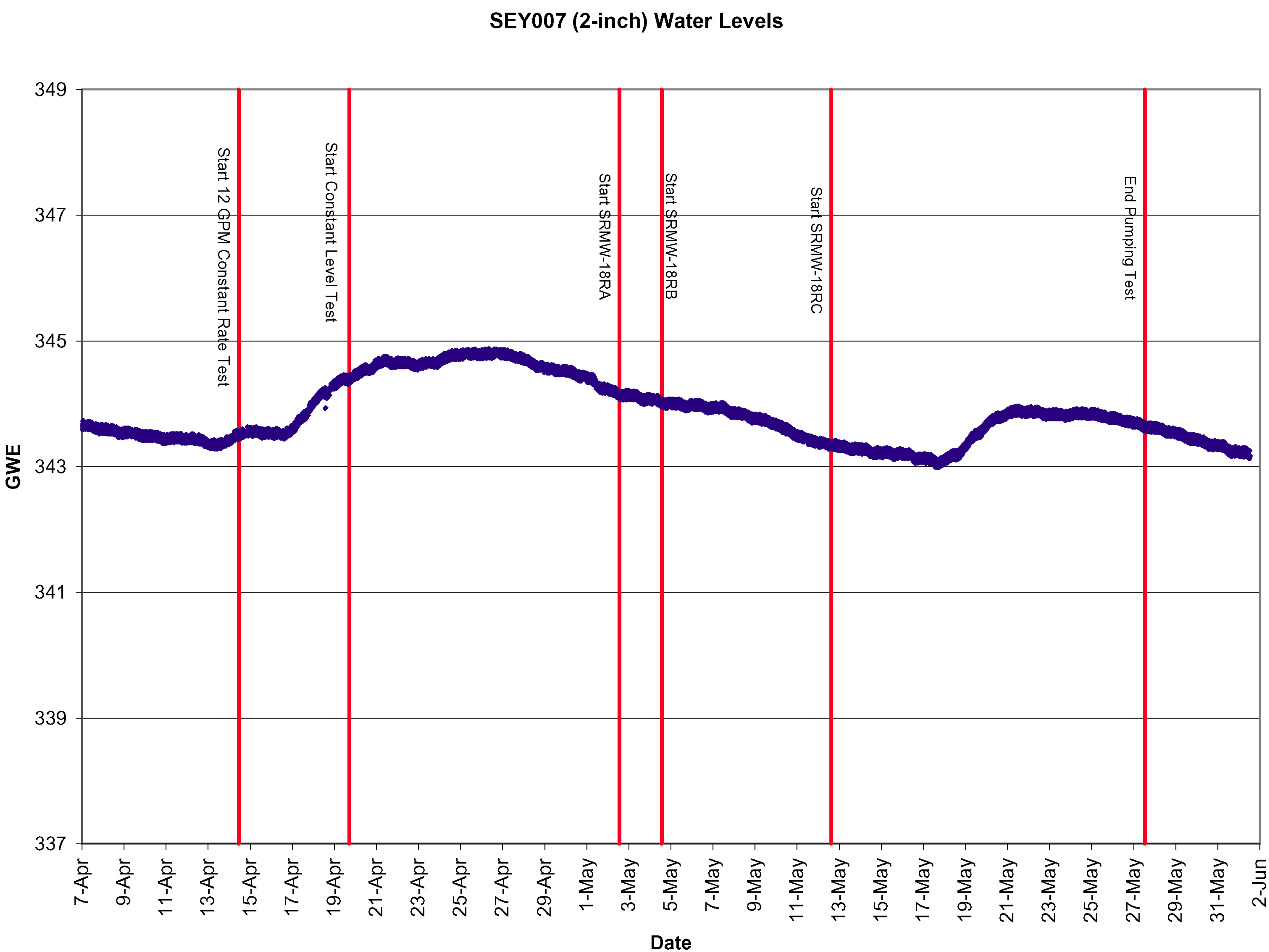

SEY006 Water Levels
GWE
Date
368
366
364
362
360
358
356
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



SEY007 Water Levels
SEY007 2-inch
SEY007 Ann.
GWE
349
347
345
343
341
339
337
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

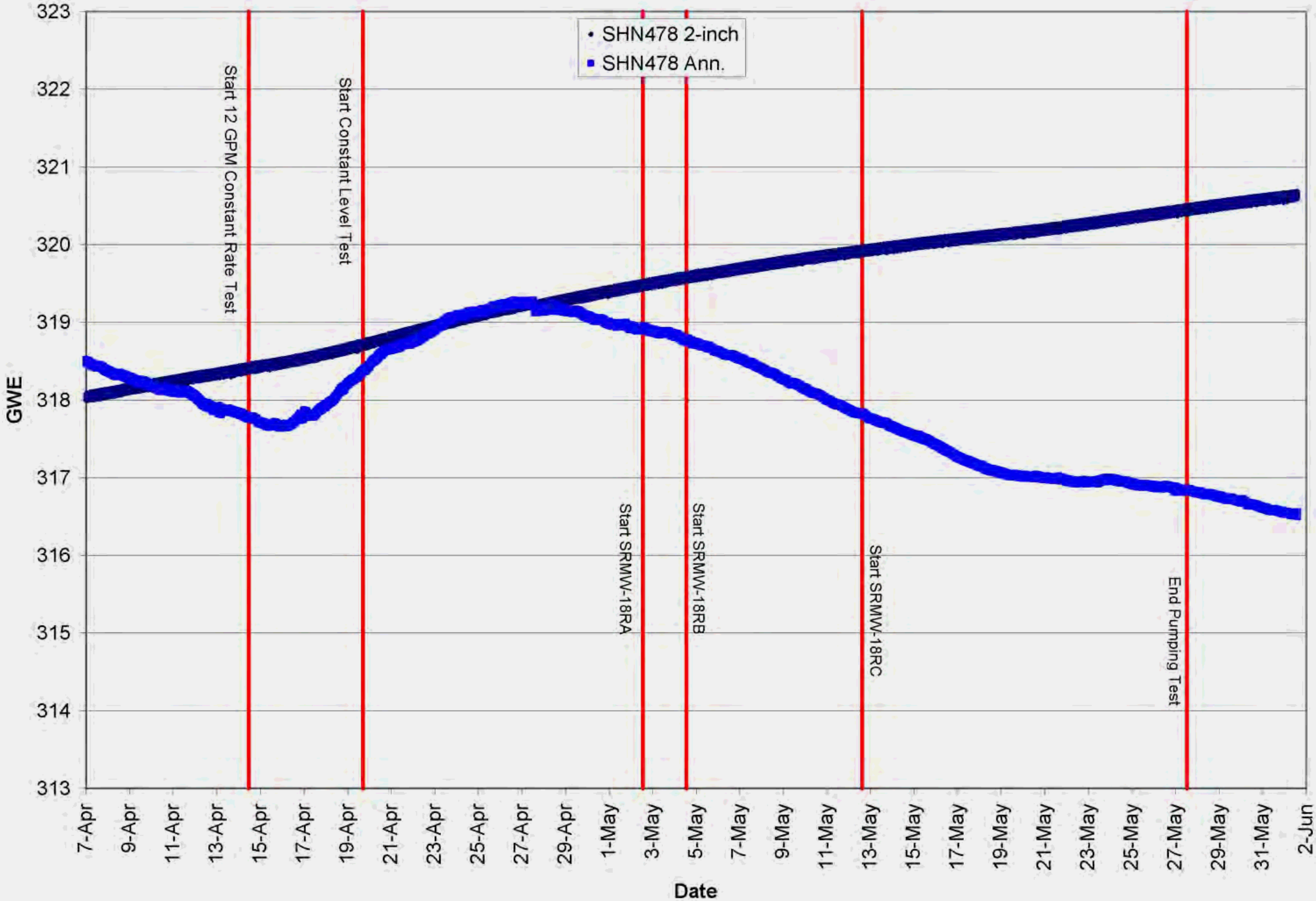


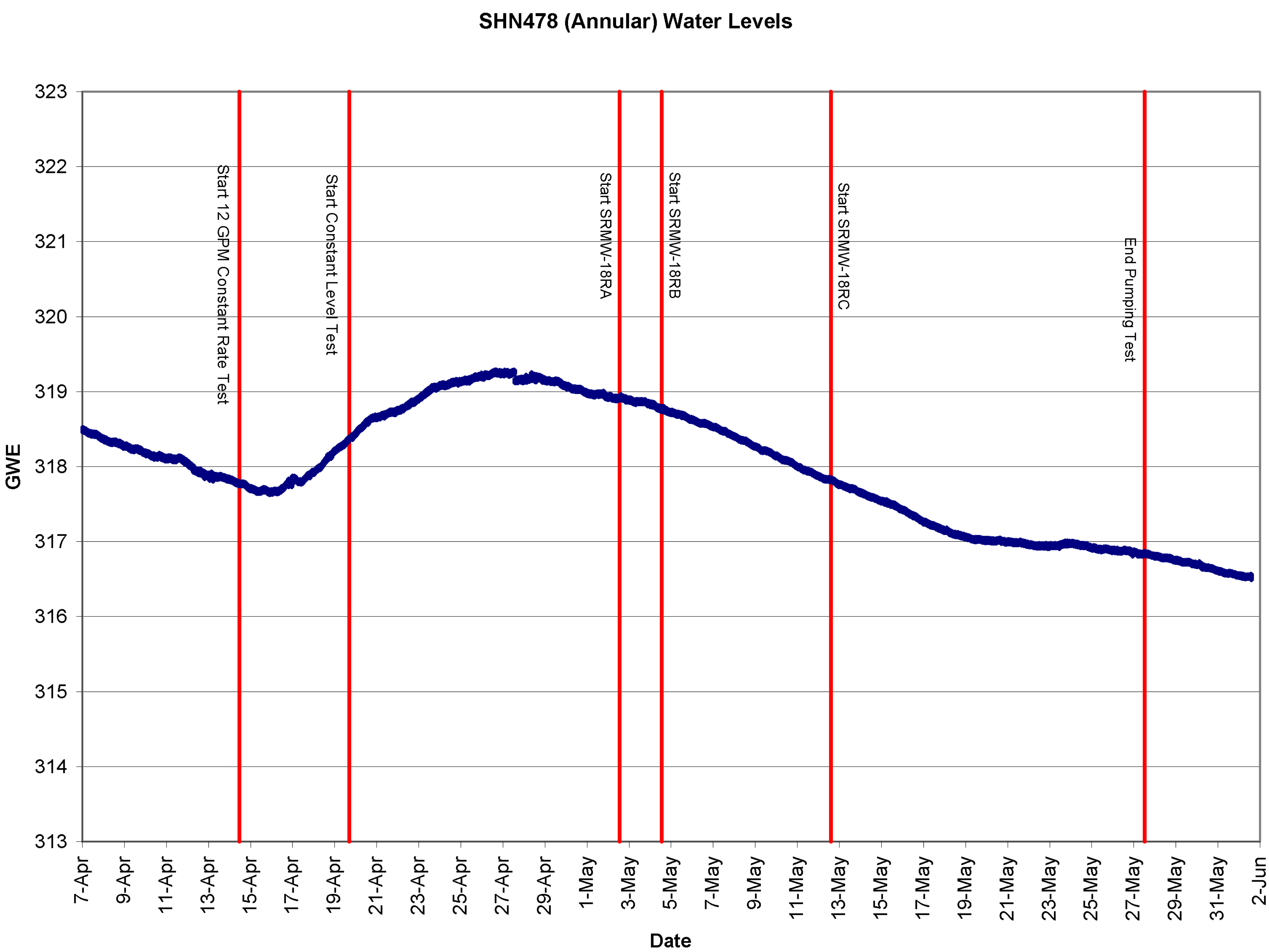
SEY007 Water Levels
GWE
349
347
345
343
341
339
337
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

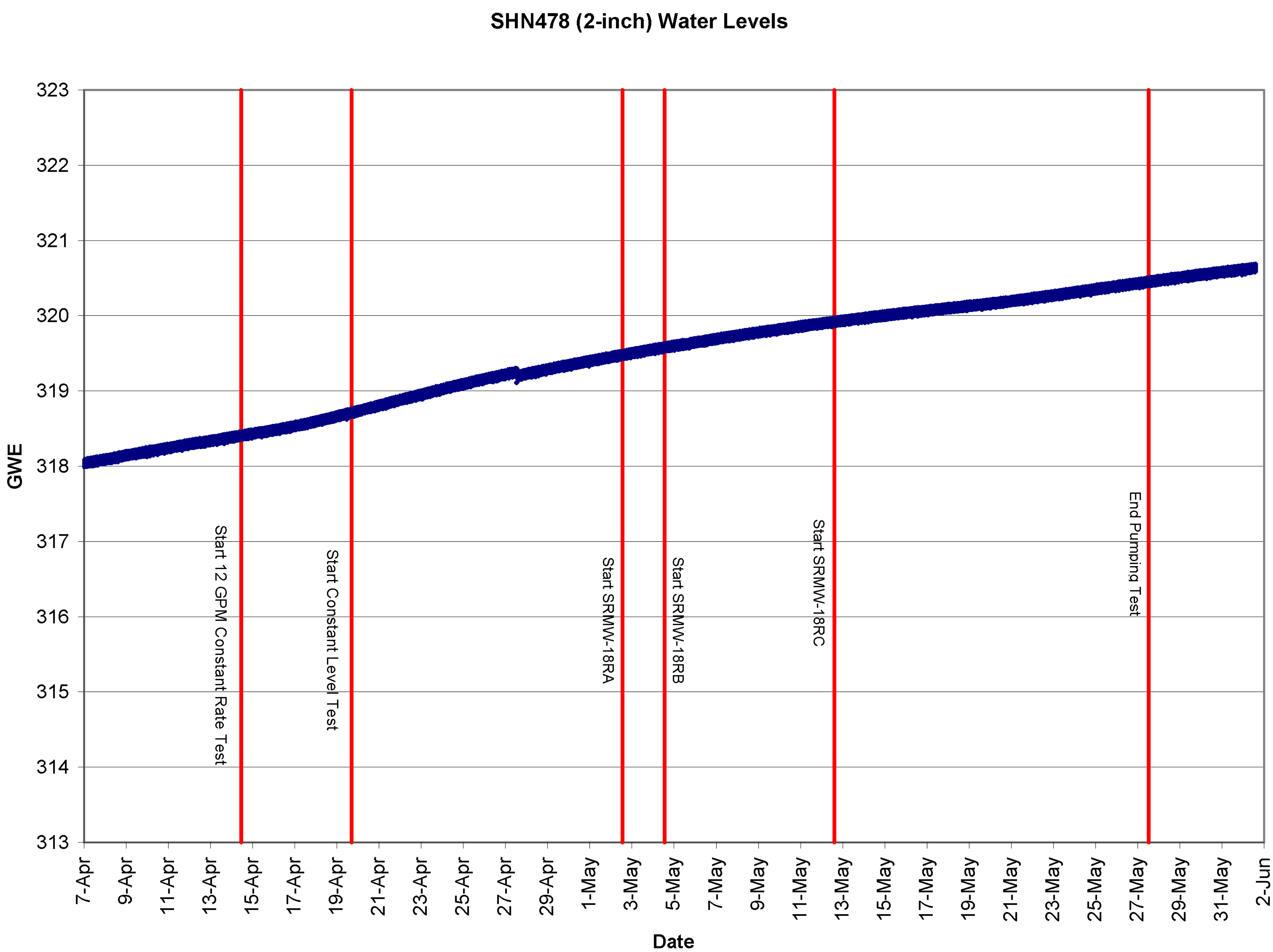


SEY007 (2-inch) Water Levels
GWE
349
347
345
343
341
339
337
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

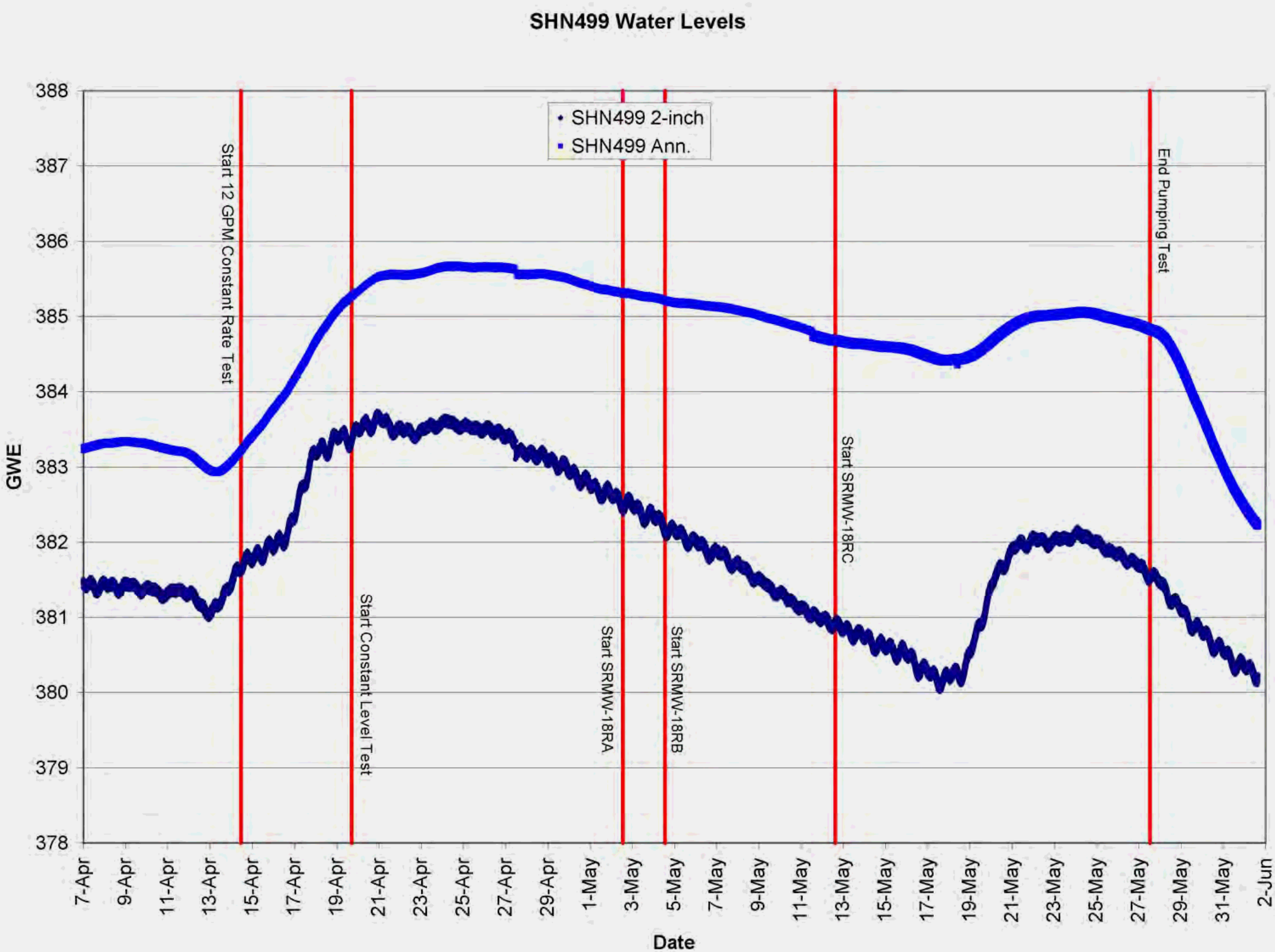
SHN478 Water Levels



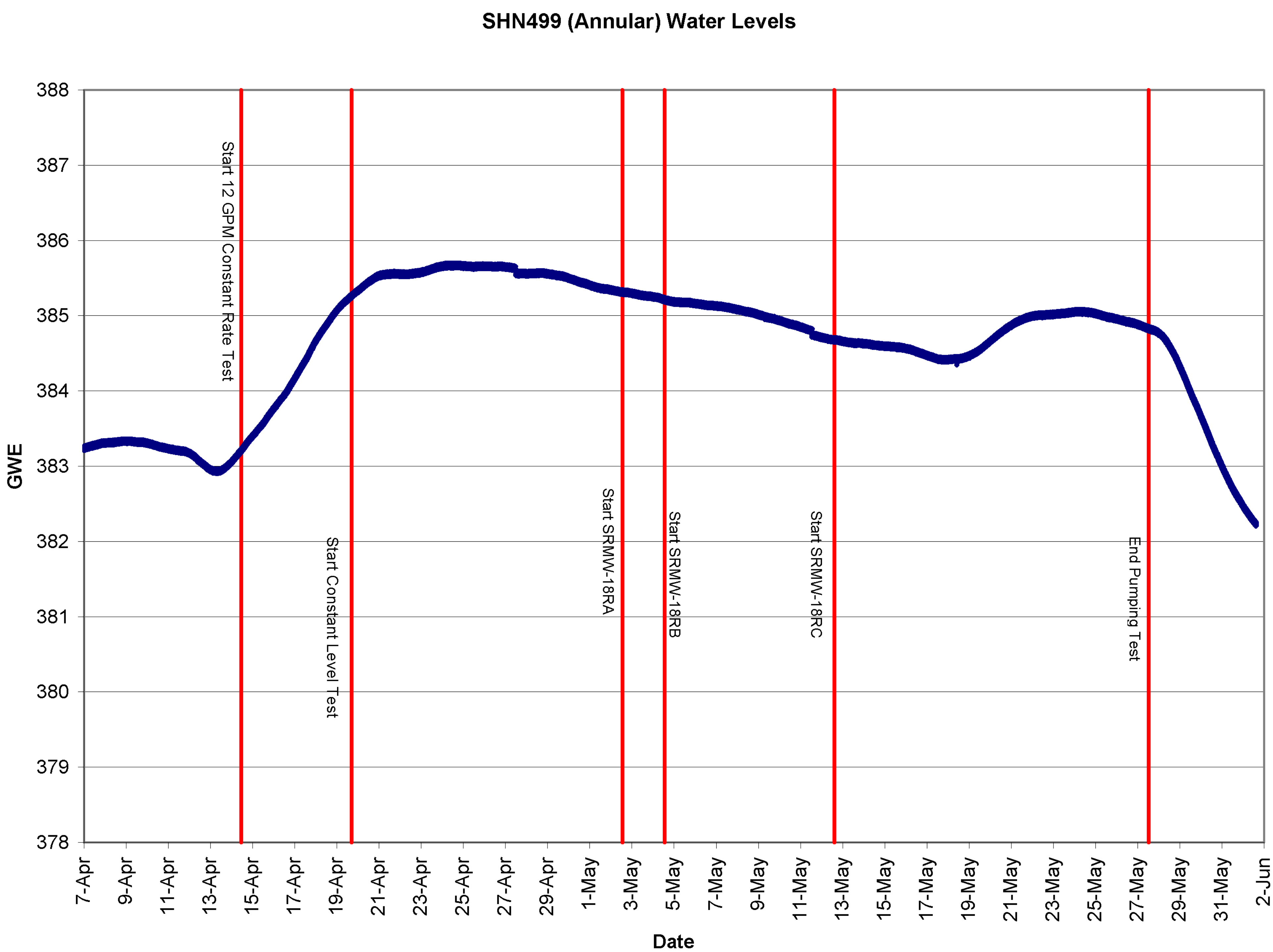

SHN478 (Annular) Water Levels
323
322
321
320
319
318
317
316
315
314
313
GWE
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date

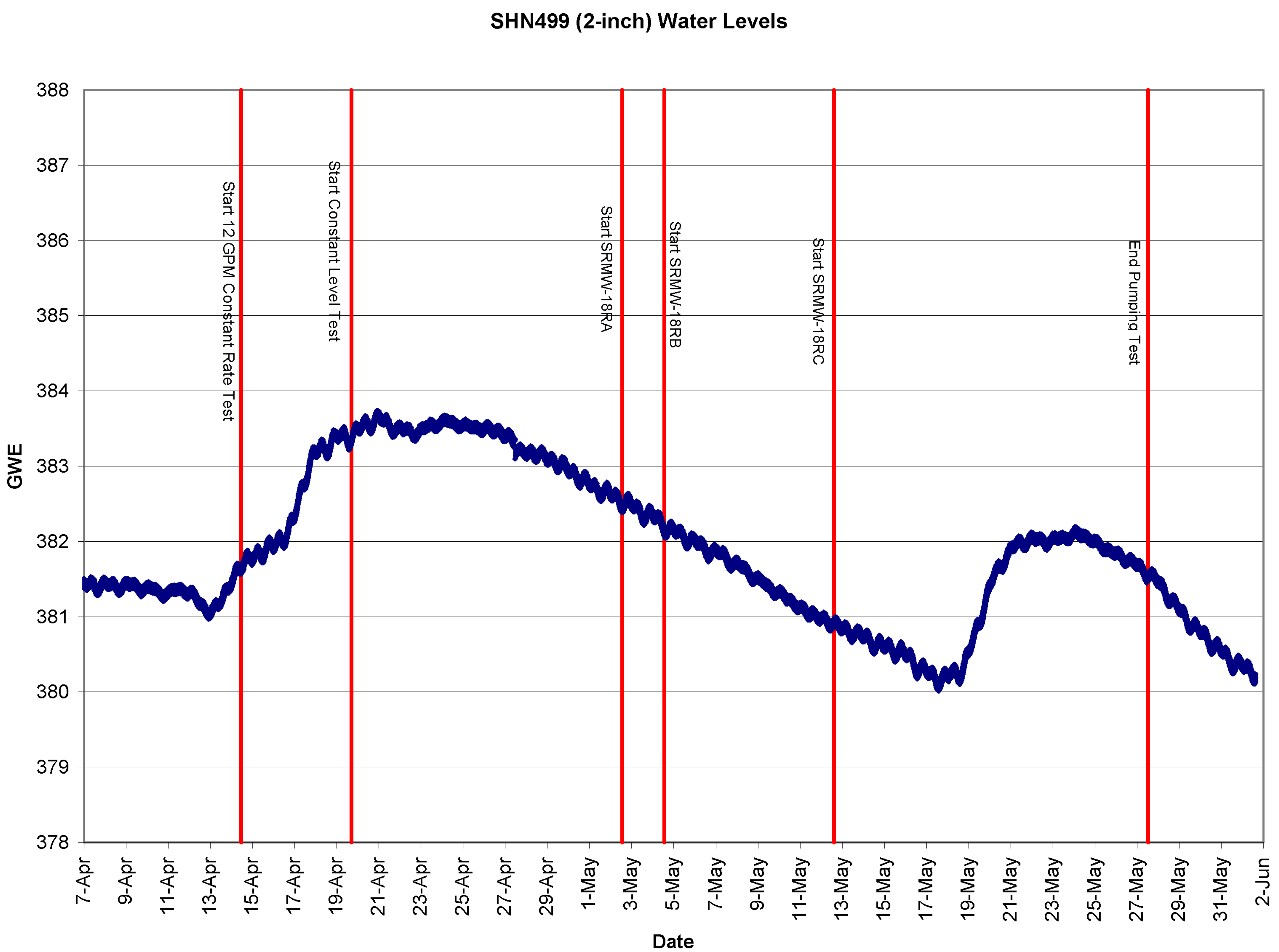


SHN478 (2-inch) Water Levels
GWE
323
322
321
320
319
318
317
316
315
314
313
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



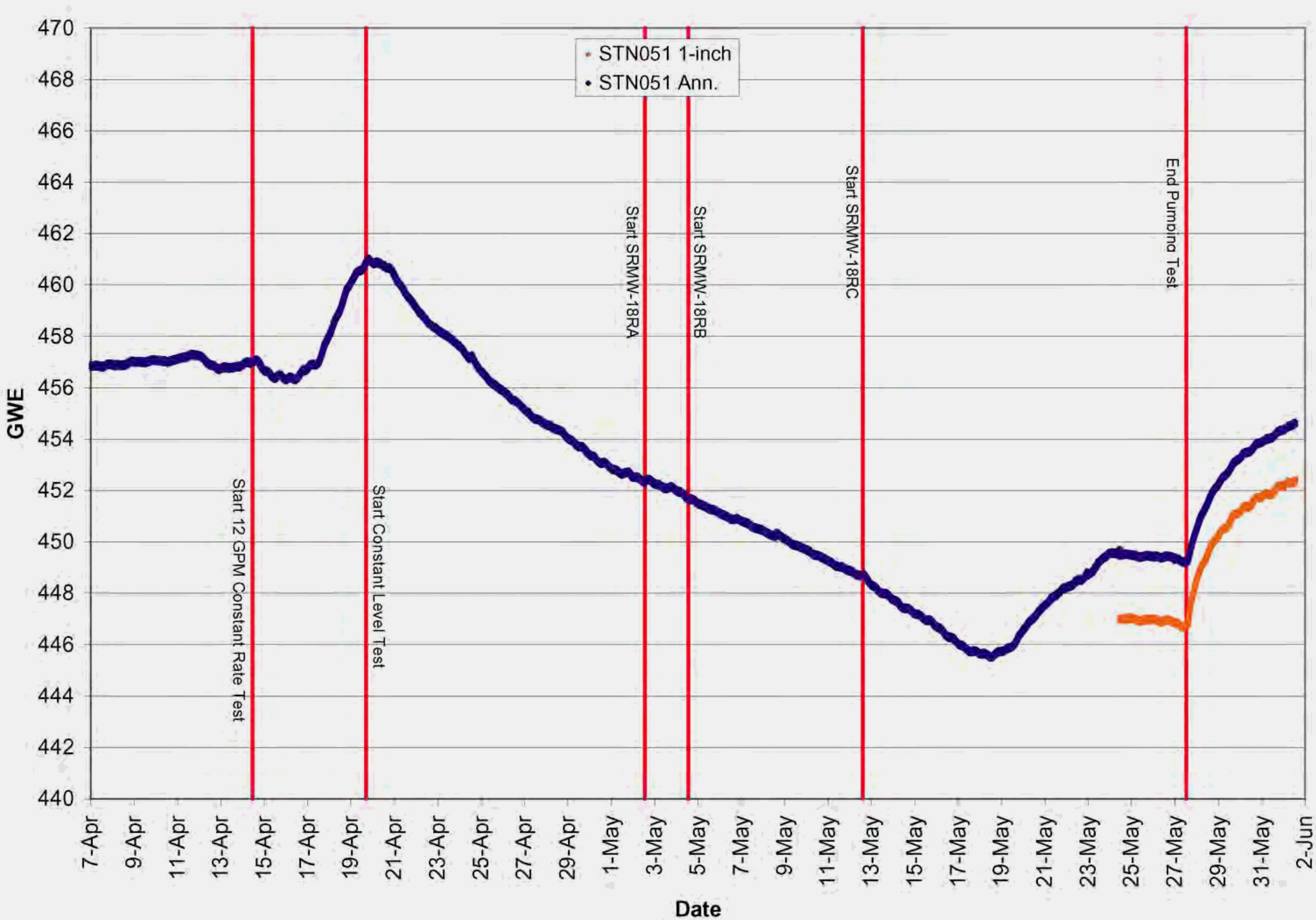
SHN499 Water Levels
SHN499 2-inch
SHN499 Ann.
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
GWE
388
387
386
385
384
383
382
381
380
379
378
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun

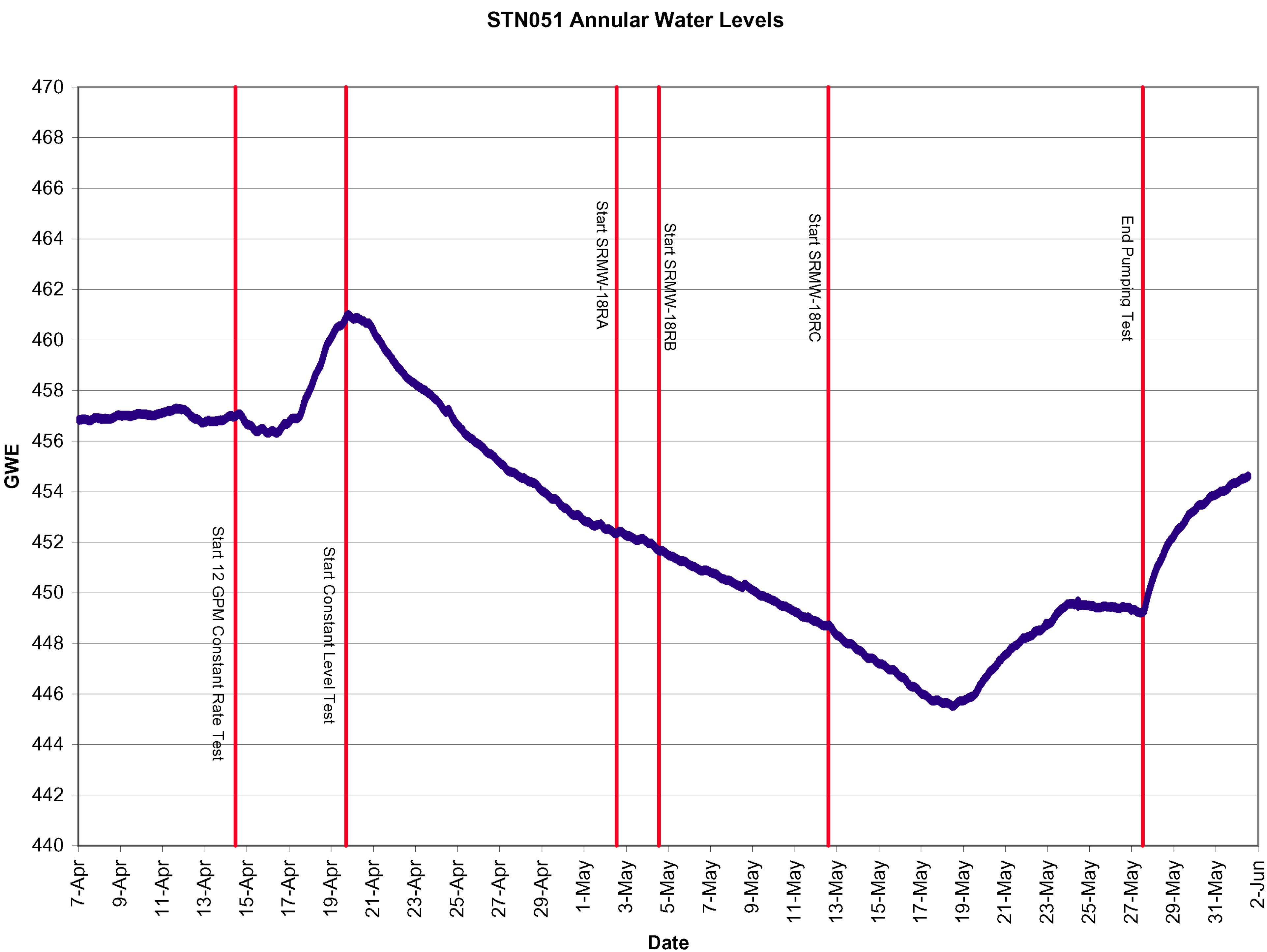

SHN499 (Annular) Water Levels
GWE
388
387
386
385
384
383
382
381
380
379
378
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Date



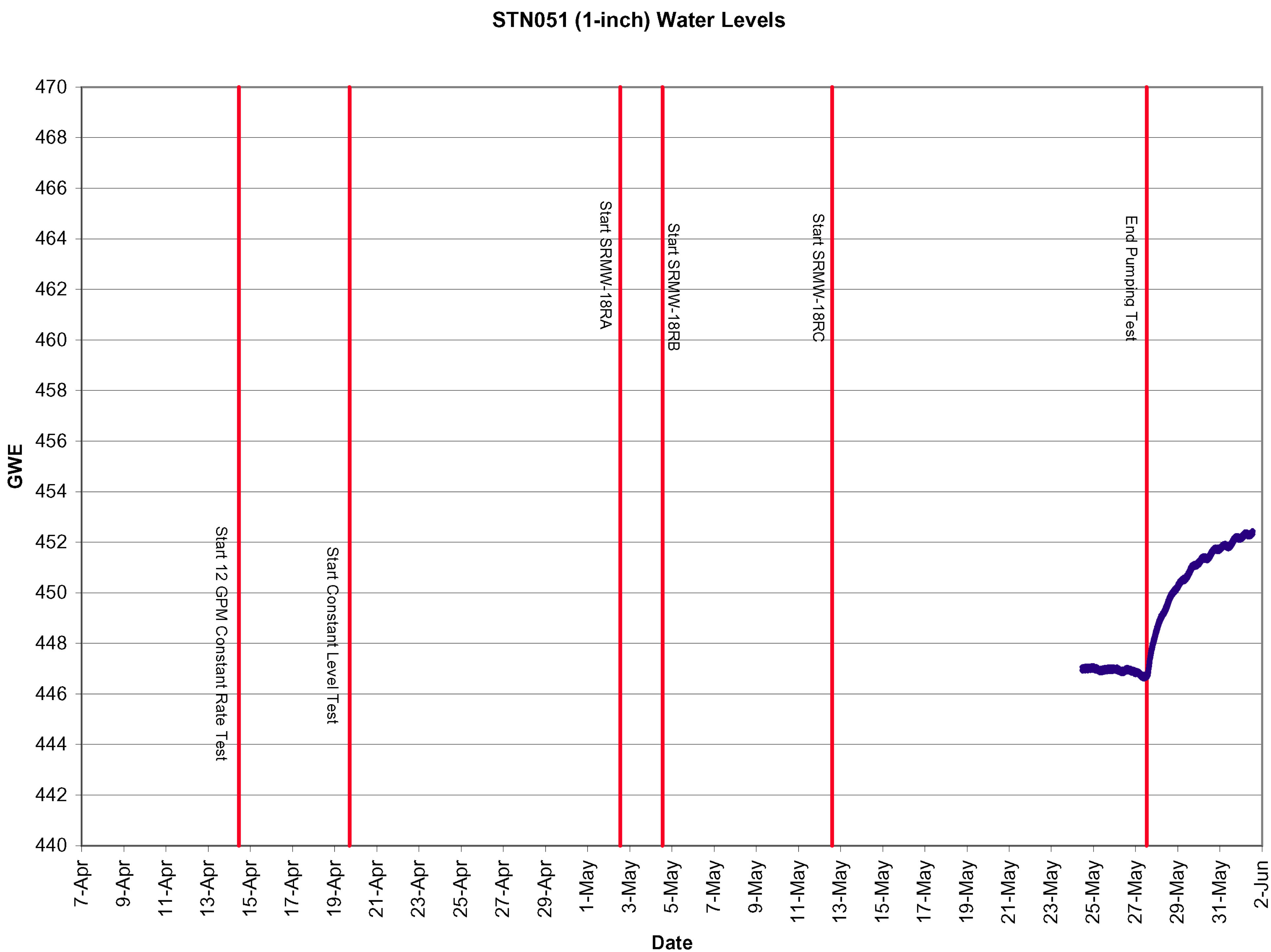
SHN499 (2-inch) Water Levels
GWE
388
387
386
385
384
383
382
381
380
379
378
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

STN051 Water Levels





STN051 Annular Water Levels
GWE
470
468
466
464
462
460
458
456
454
452
450
448
446
444
442
440
Date
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test



STN051 (1-inch) Water Levels
GWE
Date
470
468
466
464
462
460
458
456
454
452
450
448
446
444
442
440
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
Start 12 GPM Constant Rate Test
Start Constant Level Test
Start SRMW-18RA
Start SRMW-18RB
Start SRMW-18RC
End Pumping Test

Appendix D

Cost Analysis of Alternative

Appendix D.1a
Shenandoah Road - Groundwater Treatment System Costs
Alternative #1 - Aqueous Phase Carbon

ITEM	Unit	Qty	Unit Cost	COST
Aqueous Phase Carbon Vessels (Calgon LM-36)	ea	2	5506	$11,012
Carbon	pounds	2000	0.67	$1,340
Piping	ls	1	25000	$25,000
Filters	each	2	2200	$4,400
Controls and Instrumentation	ls	1	70000	$70,000
Concrete Structure and Foundation	each	1	54000	$54,000
12' x 20' x 10' high				
Excavation and Piping/Conduit To/From Building	ls	1	275000	$275,000
Assume 500 feet from existing piping to building				
Assume 500 feet from building to discharge point				
Soils Sampling/Testing	ls	1	15000	$15,000
Mechanical Design	MH	160	150	$24,000
Electrical Design	MH	80	150	$12,000
Soil Disposal as Hazardous Waste	LS	1	15000	$15,000
System Startup	MH	40	150	$6,000
CAD	MH	48	100	$4,800
As-Builts	MH	12	100	$1,200
Manuals	EA	1	2500	$2,500
Operator Training	MH	8	100	$800
Construction Management	LS	1	48000	$48,000
Total Capital Cost				$570,052
15-yr Operating Costs				
Carbon (1200 pounds/yr at $804/yr)	each	15	804	$12,060
Electricity (78,843 kw-hr/yr at $0.14/kw-hr)	each	15	11038	$165,570
Maintenance (600 manhours/yr)	each	15	48000	$720,000
O&M Project Management (25 manhours/yr)	each	15	3750	$56,250
Waste Disposal (2 drums/yr at $150/drum)	each	15	300	$4,500
Equipment Maintenance/Parts/Repairs (5% of Capital Cost per year)	each	15	$28,502.60	$427,539
Task 1 - Monthly Extraction Well Sampling (total yrs 1-5)	ls	1	121582	$121,582
Task 1 - Monthly Extraction Well Sampling (total yrs 6-15)	ls	1	243164	$243,164
Task 2 - Monitoring Well Sampling (total yrs 1-5)	ls	1	40614	$40,614
Task 3 - Monitoring Well Sampling (total yrs 6-15)	ls	1	203068	$203,068
Total Estimated 15-Yr Costs				$1,994,347
Present Worth (1.7% discount rate, 15 year project life) **Discount rate based on OMB Circular A-94 Appendix C, December 2010**				$2,467,348

Appendix D.1b
Shenandoah Road - Groundwater Treatment System Costs
Alternative #2 - Air Stripping/Vapor Phase Carbon

ITEM	Unit	Qty	Unit Cost	COST
Shallow Tray Model 2341	ls	1	28000	$28,000
Vapor Phase Carbon Vessels	ea	2	5800	$11,600
Carbon	pounds	4000	1.58	$6,320
Pumps	each	2	4000	$8,000
Piping	ls	1	25000	$25,000
Ductwork	ls	1	5000	$5,000
Controls and Instrumentation	ls	1	70000	$70,000
Bag Filters	each	2	2200	$4,400
Concrete Structure and Foundation	each	1	54000	$54,000
12' x 20' x 10' high				
Excavation and Piping/Conduit To/From Building	ls	1	275000	$275,000
Assume 500 feet from existing piping to building				
Assume 500 feet from building to discharge point				
Soils Sampling/Testing	ls	1	15000	$15,000
Mechanical Design	MH	160	150	$24,000
Electrical Design	MH	80	150	$12,000
Soil Disposal as Hazardous Waste	LS	1	15000	$15,000
System Startup	MH	40	150	$6,000
CAD	MH	48	100	$4,800
As-Builts	MH	12	100	$1,200
Manuals	EA	1	2500	$2,500
Operator Training	MH	8	100	$800
Construction Management	LS	1	48000	$48,000
Total Capital Cost				$616,620
15-yr Operating Costs				
Carbon (730 pounds/yr at $1278/yr)	each	15	1278	$19,170
Electricity (213,521 kw-hr/yr at $0.14/kw-hr)	each	15	29893	$448,395
Maintenance (1000 manhours/yr)	each	15	80000	$1,200,000
O&M Project Management (25 manhours/yr)	each	15	3750	$56,250
Waste Disposal (2 drums/yr at $150/drum)	each	15	300	$4,500
Equipment Maintenance/Parts/Repairs (5% of Capital Cost per year)	each	15	$30,831.00	$462,465
Task 1 - Monthly Extraction Well Sampling (total yrs 1-5)	ls	1	121582	$121,582
Task 1 - Monthly Extraction Well Sampling (total yrs 6-15)	ls	1	243164	$243,164
Task 2 - Monitoring Well Sampling (total yrs 1-5)	ls	1	40614	$40,614
Task 3 - Monitoring Well Sampling (total yrs 6-15)	ls	1	203068	$203,068
Total Estimated 15-Yr Costs				$2,799,208
Present Worth (1.7% discount rate, 15 year project life) **Discount rate based on OMB Circular A-94 Appendix C, December 2010**				$3,219,103

Appendix D.1c
Shenandoah Road - Groundwater Treatment System Costs
Alternative #3 - Osorb VOCEater Nanotechnology System

ITEM	Unit	Qty	Unit Cost	COST
Osorb Treatment System (Chaos Capture Unit plus VOCEater) System Includes 500 Gallon Feed Tank, Control System, Hydrogen Detector, Hydrogen Generators, Conductivity Sensors and Analyzer and Water Flow Totalizer	ls	1	395000	$395,000
Osorb System Installation by ABS	ls	1	14000	$14,000
Bag Filters	each	2	2200	$4,400
Concrete Structure and Foundation 12' x 20' x 10' high	ls	1	54000	$54,000
Electrical - Supply/Install 100 amp/230v/1 ph Service for New Building Plus Space Heater, Lights, Building Fan	each	1	17500	$17,500
Excavation and Piping/Conduit To/From Building Assume 500 feet from existing piping to building Assume 500 feet from building to discharge point	ls	1	275000	$275,000
Soils Sampling/Testing	ls	1	15000	$15,000
Supplemental Controls & Instrumentation (Flow Meters, Leak/Temperature Alarms)	ls	1	15000	$15,000
Mechanical Design	mh	160	150	$24,000
Electrical Design	mh	160	150	$24,000
Inlet Piping Manifold	ls	1	500	$500
Building Electrical (XP Fan, XP Lights, XP Receptacles, Class 1, Div. II)	ls	1	9500	$9,500
Soil Disposal as Hazardous Waste	LS	1	15000	$15,000
System Startup	MH	40	150	$6,000
CAD	MH	48	100	$4,800
As-Builts	MH	12	100	$1,200
Manuals	EA	1	2500	$2,500
Operator Training	MH	8	100	$800
Construction Management	LS	1	48000	$48,000
Total Capital Cost				$926,200
15-yr Operating Costs				
Carbon (1200 pounds/yr at $804/yr)	each	15	804	$12,060
Electricity (102,761 kw-hr/yr at $0.14/kw-hr)	each	15	14387	$215,805
Maintenance (1200 manhours/yr)	each	15	96000	$1,440,000
O&M Project Management (25 manhours/yr)	each	15	3750	$56,250
Waste Disposal (2 drums/yr at $150/drum)	each	15	300	$4,500
Equipment Maintenance/Parts/Repairs (5% of Capital Cost per year)	each	15	$46,310.00	$694,650
Task 1 - Monthly Extraction Well Sampling (total yrs 1-5)	ls	1	121582	$121,582
Task 1 - Monthly Extraction Well Sampling (total yrs 6-15)	ls	1	243164	$243,164
Task 2 - Monitoring Well Sampling (total yrs 1-5)	ls	1	40614	$40,614
Task 3 - Monitoring Well Sampling (total yrs 6-15)	ls	1	203068	$203,068
Total Estimated 15-Yr Costs				$3,031,693
Present Worth (1.7% discount rate, 15 year project life) **Discount rate based on OMB Circular A-94 Appendix C, December 2010**				$3,732,378