2020 Update

Three-Tiered Long Term Monitoring Network Optimization Evaluation

Prepared for:

Camp Stanley Storage Activity
Boerne, Texas

May 2020

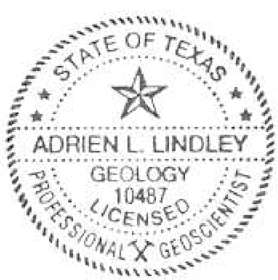
GEOSCIENTIST CERTIFICATION

2020 Update for
Three-Tiered
Long Term Monitoring Network
Optimization Evaluation

For

Department of the Army
Camp Stanley Storage Activity
Boerne, Texas

I, Adrien Lindley, P.G., hereby certify that the Updated Three-Tiered Long Term Monitoring Network Optimization Evaluation for the Camp Stanley Storage Activity installation in Boerne, Texas accurately represents the site conditions of the subject area. This certification is limited only to geoscientific products contained in the subject report and is made on the basis of written and verbal information provided by the CSSA Environmental Office, laboratory data provided by APPL Laboratory, and field data obtained during ongoing groundwater monitoring conducted at the site, and is true and accurate to the best of my knowledge and belief.



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9/14/2020
Date

Parsons Government Services, Inc.
Firm Registration No. 50316

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ACRONYMS AND ABBREVIATIONS

3TMO	three-tiered monitoring optimization
AFCEE	Air Force Center for Engineering and the Environment
AOC	area of concern
BDCME	bromodichloromethane
bgs	below ground surface
BZME	toluene
BS	Bexar Shale
CAO	Corrective Action Objectives
CC	Cow Creek
CMA	corrective measures alternative
CMD	Corrective Measures Design
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
COC	contaminant of concern
COV	coefficient of variation
CQA	Construction Quality Assurance
CSSA	Camp Stanley Storage Area
DCE	dichloroethene
DQO	data quality objective
FM	Farm to Market Road
GAC	granular-activated carbon
HCSM	hydrogeologic conceptual site model
HS	Hammett Shale
ID	identification
IH	Interstate Highway
ISCO	In-situ chemical oxidation
LGR	Lower Glen Rose
LTM	long-term monitoring
LTMO	Long Term Monitoring Optimization
µg/L	microgram(s) per liter
MCL	maximum contaminant level
MNO	Monitoring Network Optimization
PCE	tetrachloroethene
ppb	parts per billion
PQL	practical quantitation limit
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
RMU	range management unit
SAWS	San Antonio Water System
SWMU	solid waste management unit
SVE	soil vapor extraction
TBME	bromoform
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
UGR	Upper Glen Rose
USEPA	United States Environmental Protection Agency
UU/UE	unrestricted use/unrestricted exposure
VC	vinyl chloride
VOC	volatile organic compound
WB	Westbay™-equipped well

EXECUTIVE SUMMARY

Since volatile organic compounds (VOCs) were first reported in Camp Stanley Storage Activity (CSSA) groundwater in 1991, the U.S. Army has enacted a robust groundwater monitoring program to delineate two VOC plumes, Plume 1 and Plume 2, originating from two source areas, solid waste management unit (SWMU) B-3 and Area of Concern (AOC)-65, respectively, at CSSA. Numerous on-post wells and privately-owned off-post wells have been incorporated into a VOC detection and delineation network that was routinely sampled on a quarterly basis. By 2004, approximately 88 on- and off-post wells were regularly sampled on a quarterly basis to develop a large statistical database. At that time it became evident that most wells sampled contained no VOCs or concentrations well below the federally-mandated Maximum Contaminant Levels (MCLs). Therefore, CSSA initiated a Long-Term Monitoring Optimization (LTMO) process to evaluate if statistical and spatial parameters would support a reduction in sampling locations, analytes, and/or frequencies without sacrificing the monitoring objectives. Another objective of the LTMO process was to identify any data gaps with regards to location, analytes, or frequency.

Groundwater monitoring at CSSA has been organized into three general areas: 1) the large overall area of CSSA and surrounding off-post areas; 2) the localized area around SWMU B-3 and the bioreactor remediation system, the source of Plume 1; and 3) the localized area around AOC-65 and the in-situ chemical oxidation (ISCO) remediation system, the source of Plume 2. LTMO evaluations conducted in 2005 and 2010 analyzed data from the overall area, and in 2015 the SWMU B-3 bioreactor area was also evaluated. This year, the AOC-65 ISCO area was additionally evaluated.

No changes were recommended to the established DQOs as a result of the 2020 LTMO evaluation. The 2020 LTMO update is an evaluation of the monitoring program with respect to the DQOs established during the 2015 LTMO evaluation. The current total monitoring network consists of 126 wells containing 191 sampling locations. Additional wells on-post provide opportunity to monitor ongoing remediation operations as necessary.

Overall, since on-post LTMO was implemented in 2005, overall contaminant concentrations are trending downward, and there have not been any significant changes in plume size or location, indicating stability of both Plumes 1 and 2.

Following the implementation of the 2015 DQOs and LTMO recommendations, 42 wells were excluded from the groundwater monitoring program as a result of 5 years of consecutive non-detections or due to distance from CSSA boundary, and therefore are not included in the 2020 LTMO evaluation and five additional wells have been plugged and abandoned since the 2015 evaluation and are not evaluated. Due to the reductions implemented following the 2015 LTMO recommendations, neither sampling frequencies nor sampling locations are recommended for significant changes over the next five years.

Based on this 2020 LTMO evaluation, it is recommended groundwater monitoring frequencies the overall groundwater for Plume 1 and Plume 2 retained wells remain on a quarterly, 15-month, or 30-month basis, with no changes to the analytical parameters. No Plume 1 or Plume 2 wells are immediately excluded based on the 2020 LTMO; however, wells may be excluded in the future if DQO non-detection criteria are met.

Some modifications to the monitoring programs are recommended at AOC-65 and SWMU B-3, where corrective measures monitoring objectives include:

- Monitor groundwater within the treatment site, as a diagnostic tool, to determine if there are issues with the employed corrective measure and how best to rectify those issues;
- Regulatory permit compliance monitoring for respective Underground Injection Control (UIC) permits; and
- Monitor progress/efficacy of employed corrective measure.

Optimization recommendations include a decrease in frequency from 3 months (quarterly) to 6 months (semi-annual) at AOC-65. It is further recommended that a reduction in analytes at each of the two corrective measures sites may be enacted without jeopardizing the objectives of corrective measures monitoring.

Results of the 2020 LTMO evaluation have confirmed the recommendations from the 2015 LTMO evaluation are adequate for continued operation of the groundwater monitoring program at CSSA. Those recommendations and new recommendations include:

- The current 15- or 30-month sampling schedule for monitoring wells is retained for most wells.
- All off-post wells will continue to be evaluated by the approved Off-Post Wells DQOs) that dictate sampling frequencies and remedial actions based upon the VOC concentrations detected in a given well. At all times, the DQOs will supersede the recommended LTMO sampling frequency if conditions change.
- Bioreactor performance monitoring wells will continue on a 9-month sampling schedule with UIC permit-required sampling on a quarterly and semi-annual basis.
- AOC-65 performance monitoring well sampling will transition from quarterly to a semi-annual basis. This is adequate to ensure appropriate monitoring of cylinder status.
- The following analytes will be removed from regular SWMU B-3 bioreactor sampling and transition to an "as needed" basis:
  - Hydrogen;
  - Anions (Chloride, Sulfate, Sulfide); and
  - Ferrous Iron.
- The following analytes will be removed from regular AOC-65 ISCO performance monitoring and transitioned to an "as needed" basis:
  - Anions (Chloride and Sulfate).

The LTMO recommendations for Plume 1 and Plume 2 groundwater sampling proposed herein result in slight changes in the number of sampling events over a five-year period versus the current program, as shown below.

	Plume 1 Sampling Events Over 5-Year Period		Plume 2 Sampling Events Over 5-Year Period	
Frequency	**Current Program**	**Optimized Program**	**Current Program**	**Optimized Program**
Every 30 months	40	40	36	22
Every 15 months	28	24	196	220
Every 9 months*	0	0	0	0
Quarterly	80	80	120	120
Total	**148**	**144**	**352**	**362**
Change over 5 Years:		**- 3%**		**+ 3%**

* SWMU B-3 sampling (252 samples) included in the 2015 LTMO Report as part of the Plume 1 monitoring program have been moved to the Bioreactor Sampling Events for clarity.

The LTMO recommendations for corrective measures monitoring sampling proposed herein result in an overall decrease in sampling events over a five-year period versus the current program, as shown below.

	Bioreactor Sampling Events Over 5-Year Period		ISCO Sampling Events Over 5-Year Period	
Frequency	**Current Program**	**Optimized Program**	**Current Program**	**Optimized Program**
Quarterly	20	20	1020	0
Semi-annual	190	190	0	510
Every 9 months*	252	252	0	0
Total	**462**	**462**	**1020**	**510**
Change over 5 Years:		**0%**		**-50%**

* SWMU B-3 sampling (252 samples) included in the 2015 LTMO Report as part of the Plume 1 monitoring program have been moved to the Bioreactor Sampling Events for clarity.

1 INTRODUCTION

1.1 OVERVIEW

This report presents a description and evaluation of the groundwater monitoring program at CSSA in Boerne, TX. Groundwater monitoring programs have two primary objectives (U.S. Environmental Protection Agency [USEPA], 1994; Gibbons, 1994):

1. Evaluate long-term temporal trends in contaminant concentrations at one or more points within or outside of the remediation zone, as a means of monitoring the performance of the remedial measure (temporal objective); and
2. Evaluate the extent to which contaminant migration is occurring, particularly if a potential exposure point for a susceptible receptor exists (spatial objective).

The relative success of any remediation system and its components (including the monitoring network) must be judged based on the degree to which it achieves the stated objectives of the system. Designing an effective groundwater monitoring program involves locating monitoring points and developing a site-specific strategy for groundwater sampling and analysis to maximize the amount of relevant information that can be obtained while minimizing incremental costs. Relevant information are the data required to effectively address the temporal and spatial objectives of monitoring. The effectiveness of a monitoring network in achieving these two primary objectives can be evaluated quantitatively using statistical techniques. In addition, there may be other important considerations associated with a particular monitoring network that are most appropriately addressed through a qualitative assessment of the network. The qualitative evaluation may consider such factors as hydrostratigraphy, locations of potential receptor exposure points with respect to a dissolved contaminant plume, and the direction(s) and rate(s) of contaminant migration.

The current monitoring network was evaluated to identify opportunities to streamline monitoring activities while still maintaining an effective monitoring program. The long-term LTMO evaluation was performed using 3TMO software protocol, which was developed by Parsons and Environ International Corp. on behalf of the Air Force Center for Engineering and the Environment (AFCEE) in 2011. 3TMO is a comprehensive, public domain LTMO decision support tool that uses a combination of statistics and professional judgment in a structured protocol to optimize sampling locations, sampling frequency, and target analytes for monitoring wells with no loss of required information. Results of the 3TMO analysis were used to assess the optimal frequency of monitoring and the spatial distribution of the components of the monitoring network and were also used to develop recommendations for optimizing the monitoring program at CSSA.

1.2 LTMO HISTORY AT CSSA

In 2005, Parsons used validated analytical data spanning from 1992 through December 2004 from the monitoring well network to perform a Three-Tiered Long-Term Monitoring Optimization (LTMO) evaluation. USEPA and Texas Commission on Environmental Quality (TCEQ) approved the use of the LTMO recommendations for on-post monitoring wells and the Westbay® (WB) multi-port wells. In 2007, CSSA began the bioreactor treatability study at the SWMU B-3. This study involved the establishment of an extraction well network to provide contaminated water to the bioreactor to augment solvent de-chlorination. Groundwater monitoring associated with this study has a separate sampling plan/schedule and, until 2015, was not included in the LTMO studies.

An additional change to the LTMO sampling frequency was made in 2009 to provide for an additional 9-month “snapshot” event which had been identified as a sampling frequency data gap. This “snapshot,” in which all on- and off-post wells were sampled, was adopted to provide an area-wide status of the two VOC plumes at CSSA. The 9-month sampling interval was selected to provide long-term assurance that seasonal changes associated with the hydrologic cycle were identified.

In 2010, USEPA and TCEQ approved the updates to the 2005 LTMO report. An additional four years of analytical data from the existing and new wells were added to the three-tiered evaluation to determine if there had been changes in trends and if the sampling frequency could be further refined. The same qualitative, temporal/statistical, and spatial evaluations were conducted to provide recommendations to further enhance or streamline the monitoring network.

In 2015, data from the groundwater monitoring network were evaluated using updated Data Quality Objectives (DQOs) and the three-tiered monitoring optimization (3TMO) protocols used in both 2005 and 2010. Resulting recommendations included: excluding wells from future monitoring based on distance from the CSSA border, excluding wells exhibiting 5 years of non-detection history, extending the sampling frequency from 9-month to a 15-month basis for normal on-post monitoring wells with secondary well sampling frequency extended from 18-month to 30-month, and monitoring at wells closely associated with active remediation sites (Area of concern [AOC]-65 and solid waste management unit [SWMU] B-3) occurring on a more frequent basis (quarterly at AOC-65, and semi-annual to every 9 months at SWMU B-3).

Following the implementation of the 2015 (LTMO), and the subsequent five years of monitoring, 42 wells have been excluded from the original 152-well monitoring network, and sampling frequencies have been extended from every 9 or 18 months to 15 or 30 months, resulting in a 27% reduction in the number of wells sampled, and a 33% reduction in the number of sampling events over a 5-year period.

2 SITE BACKGROUND INFORMATION

The location, operational history, geology, and hydrogeology of CSSA are briefly described in the following subsections.

2.1 SITE DESCRIPTION

2.1.1 SITE BACKGROUND

CSSA is an active installation located in Bexar County, approximately 19 miles northwest of downtown San Antonio, Texas. The mission of CSSA is the receipt, storage, and issuance of ordnance materiel as well as quality assurance testing and maintenance of military weapons and ammunition. Because of its ordnance mission, CSSA is a restricted-access facility.

CSSA consists of 4,004 acres immediately east of Farm to Market Road (FM) 3351, and approximately half a mile east of Interstate Highway (IH) 10 (Figure 2.1). Camp Bullis borders CSSA on the north, east, and southeast. The land on which CSSA is located was used for ranching and agriculture until the early 1900s. Six tracts of land were purchased by the U.S. Government during 1906 and 1907 and designated the Leon Springs Military Reservation, which later evolved into Camp Stanley.

Prior to 2010, the lands surrounding CSSA were primarily a mix of residential developments and ranching properties. Legacy communities and subdivisions included Leon Springs, Leon Springs Villa, Hidden Springs Estates, The Dominion, Fair Oaks Ranch, and Jackson Woods. Although, the past five years has seen dramatic shift in demographics as the IH 10 corridor near CSSA has experienced significant suburban growth. In that time, three new subdivisions (Stonehaven, Lost Creek, and Sable Chase) and commercial properties have been developed to the west of CSSA on former ranching properties. For the most part, ranching and agricultural land use now only exists to the north of CSSA. The urbanization has also promoted the regionalization of the water supply system, such that most new development utilizes alternative water sources provided by the San Antonio Water System (SAWS), rather than the local groundwater system.

2.1.2 INVESTIGATIVE AND REMEDIAL ACTIVITIES

A total of 84 sites, including 39 SWMUs, 41 AOCs, and five range management units (RMUs), were identified at CSSA since 1993, and investigations and interim removal actions (if warranted) were conducted at a total of 83 of those sites (Figure 2.2). In total, 77 sites were either delisted or closed to unrestricted use/unrestricted exposure (UU/UE) in accordance with TCEQ requirements. In 2012, four SWMUs (B-2, B-8, B-20/21, and B-24) were combined with RMU-1 as they are part of the active firing range. Soils at the remaining open sites that were combined with the active firing range will be addressed under a separate investigation when the range is no longer active.

SWMU B-3, located near well CS-16, and AOC-65, located near the SW corner of the post, are the two remaining open sites considered source areas for groundwater contamination. Analytical data indicate that tetrachloroethene (PCE), trichloroethene (TCE), and *cis*-1,2-dichloroethene (DCE) are the primary contaminants of concern (COC) in groundwater at SWMU B-3. Additional information on these site investigations is included in the CSSA Environmental Encyclopedia (www.stanley.army.mil). The CSSA Environmental Encyclopedia is maintained as the Administrative Record for CSSA under provisions of the Administrative Order on Consent issued to CSSA on May 5, 1999, pursuant to §3008(h) of the Resource Conservation and Recovery Act (RCRA) (USEPA, 1999).

SWMU B-3. SWMU B-3 was a landfill area thought to have been used primarily for garbage disposal and trash burning, presumably during the 1980s. Subsequent source investigations identified an area of open burn pits and disposal trenches containing PCE and its degradation products. The six trenches varied in depth from 5 to 15 feet, and were approximately 350 to 400 feet long and 12 to 20 feet wide. Groundwater beneath the landfill footprint occurs within a fractured bedrock aquifer composed of limestone and shales. The depth to the water table is typically 150 feet below ground surface (bgs) but can vary from 70 to 300 feet bgs depending on rainfall and recharge. Numerous environmental investigations have occurred at SWMU B-3, including soil gas surveys, geophysical surveys, soil boring and groundwater well installations, and soil vapor extraction (SVE) pilot study.

To remediate contaminated groundwater, an in situ "bioreactor" was created in 2007 by removing the waste in the disposal trenches, backfilling with a gravel/mulch mixture, and infiltrating contaminated groundwater. Microbial activity was augmented with addition of the KB-1 commercial culture of *dehalococcoides*. The current system distributes contaminated groundwater collected from seven extraction wells (CS-EXW01-LGR, CS-EXW02-LGR, CS-EXW03-LGR, CS-EXW04-LGR, CS-EXW05-LGR, CS-MW16-LGR, and CS-MW16-CC) located around the perimeter of the site into the bioreactor trenches where the water encounters microbial activity which degrades the organic contaminants. Approximately 50,000 gallons of contaminated groundwater from extraction wells is treated within the bioreactor each day. Groundwater from the extraction wells typically includes PCE and TCE in concentrations exceeding 100 parts per billion (ppb).

Samples collected from within the bioreactor indicate reductive dechlorination is occurring resulting in the production of *cis*-1,2-DCE, vinyl chloride (VC), and ethene and low (~5 ppb) to non-detect concentrations of PCE and TCE. The decrease in VOC concentrations within the vadose zone beneath the bioreactor indicates the source material is being transformed within the system.

AOC-65. AOC-65, located along the southwestern side of CSSA, consists of Building 90 and potential source areas associated with Building 90. Building 90 was used for weapons cleaning and maintenance. A metal vat, used for cleaning with chlorinated liquid solvents such as PCE and TCE, was installed in the western vault at Building 90 (main portion of AOC-65) prior to 1966 and removed in 1995. In 1995, after removal of the former solvent vat, a metal plate was welded over the concrete vault, and PCE and TCE solvents were replaced with a citrus-based cleaner system.

In 1999, CSSA identified PCE-impacted drinking water off-post near AOC-65. The fractured nature of the underlying bedrock aquifer provides multiple flow paths for contamination within the vadose zone at AOC-65 to migrate laterally and vertically. As a result, VOC contamination in excess of the MCL was identified off-post in both private and public water well systems. In response, CSSA implemented a proactive community relations plan to provide clean, potable water to the affected community and engaged in aggressive remedial investigations and treatability studies for AOC-65. These studies included source area identifications, soil boring and well installations, and pilot scale treatability studies utilizing SVE and ISCO.

Use of the SVE system was discontinued after 10 years of operations due to diminishing returns of soil gas associated with elevated perched water within Upper Glen Rose (UGR). Perched water saturated fractures (soil gas flow paths) and accumulated in SVE wells covering their screens rendering vapor extraction efforts ineffective. An approach was designed for application of ISCO within AOC-65 by taking advantage of lessons learned from successful operation of the SWMU B-3 bioreactor. In 2012, the approach for injecting ISCO material at AOC-65 included the excavation of a trench within a suspected point of release (i.e., drainage swale) and backfilling this trench with alternating layers of ½-inch-sized gravel and compacted clay. Irrigation lines were installed within each of the gravel layers creating three separate infiltration galleries within the 15-foot-deep, 4.5-foot-wide, 320-foot-long trench. he infiltration galleries were configured to target injection in multiple fractures, some solutionally enlarged, that were identified on the exposed trench walls during construction. In 2013, four injection wells in the upper portion of the bedrock vadose zone were installed along the post boundary to create a reactive curtain for intercepting potential PCE migration off-post.

Three rounds of ISCO injections of 10, 22 and 66 tons of an alkaline-activated 20-percent sodium persulfate solution occurred in 2012, 2013 and 2014, respectively. Groundwater samples collected at AOC-65 indicate the ISCO solution followed preferential flow paths. This was inferred by the positive field identification of persulfate (oxidant) and elevated pH (activator), and the presence of reaction by-products within the monitoring well network. In 2015, persulfate oxidant was replaced with permanganate in order to reduce oxidant volumes injected. Additionally, shallow infiltration cells were installed adjacent to Building 90 and within a concrete vault located inside the building and liquid permanganate was applied. In 2016, permanganate-infused paraffin wax cylinders were installed within six wells to passively apply oxidant to the subsurface. In 2018, old cylinders were replaced and additional cylinders were installed in four more wells (total of 10 wells); and in 2019, liquid permanganate was re-applied to infiltration cells and injection wells around the site.

2.1.3 CORRECTIVE MEASURES STUDY AND IMPLEMENTATION

Under the Order, CSSA performed a Corrective Measures Study (CMS) to screen and develop corrective measures alternatives (CMAs) for removal, containment, treatment, and/or other remediation of groundwater contamination identified at SWMU B-3 and AOC-65 (Parsons 2014b). All potential technologies that may be used to achieve the Corrective Action Objectives (CAOs) outlined in the CMS were identified and evaluated for potential further consideration as part of CMAs.

The CMA chosen by USEPA in the Statement of Basis (USEPA, 2015) as the final remedy to address groundwater contamination at CSSA includes source area treatment (bioremediation and ISCO), point-of-use treatment (granular-activated carbon [GAC]), land use controls, and long-term monitoring (LTM). The remedy is protective of human health and the environment, complies with applicable waste management standards, provides both short- and long-term effectiveness for the protection of human health, and will attain media cleanup standards. Bioremediation and ISCO are already reducing source contamination at SWMU B-3 and AOC-65 at CSSA, and would continue to do so effectively in the future. It is therefore easily implementable since all of the elements for these alternatives are already in place at CSSA. The remedy also addresses CSSA's desire to choose environmentally sustainable remedial alternatives.

The final remedy selected by USEPA is implemented through the Corrective Measures Implementation (CMI) phase as outlined in the Order. In summary, the CMI process included:

1. A Decision Document was issued by USEPA (completed July 2015);
2. A CMI Program Plan was developed to document the overall management strategy for the corrective measures (November 2015);
3. A Corrective Measures Design (CMD) Report was prepared to address the requirements necessary to implement the corrective measures (November 2015);
4. A Construction Quality Assurance (CQA) Plan was developed to ensure that the completed corrective measures meet or exceed all design criteria, plans, and specifications (August 2016); and
5. A CMI Report was compiled that includes information such as inspection summary reports, problem identification, photographs, design engineers' acceptance reports, deviations from original designs, and as-built drawings (September 2017).

2.2 GEOLOGY AND HYDROGEOLOGY

At CSSA, the near-surface geology and aquifer are composed of Trinity Group carbonate bedrock, which includes the Glen Rose and Travis Peak Formations. In particular for CSSA, the units of interest are the Glen Rose Limestone, Bexar Shale (BS), and Cow Creek (CC) Limestone that form the Middle Trinity aquifer.

The upper member of the Trinity Group is the Glen Rose Limestone. The Glen Rose represents a thick sequence of shallow water marine shelf deposits. This formation is divided into the UGR and Lower Glen Rose (LGR) members. Underlying the Glen Rose Limestone is the Travis Peak Formation which is divided into five members, in descending order: the Hensell Sand (and BS facies), the CC Limestone, the Hammett Shale (HS), the Sligo Limestone, and the Hosston Sand. At CSSA, groundwater is produced from the LGR and CC intervals of the Middle Trinity Aquifer.

The geologic units present at CSSA were informally divided into hydrostratigraphic units to provide a framework for describing the local hydrogeology. Three aquifers are present in the area of CSSA: the Upper, Middle, and Lower Trinity. The Glen Rose Formation and the Travis Peak and Pearsall Formations are the principle water-bearing units. As depicted on **Figure 2.3**, the Upper Member of the Glen Rose Formation composes the Upper Trinity Aquifer, and the Lower Member, a portion of the Middle Trinity Aquifer. Only the Middle and Upper Trinity aquifers are addressed for this study. Detailed descriptions of the geologic and hydrogeologic conditions present at CSSA are available in the Hydrogeologic Conceptual Site Model for Camp Stanley Storage Activity (Parsons, 2008).

2.3 NATURE AND EXTENT OF GROUNDWATER CONTAMINATION

The COCs at CSSA are based on historically detected analytes (since the inception of the groundwater monitoring program in 1991) and process knowledge. Analytes detected above regulatory standards in soil and groundwater at CSSA are limited to a short list of chlorinated VOCs. Past releases resulted in contamination of the UGR and LGR Limestone member of the Middle Trinity aquifer. Detections of solvent contamination (PCE, TCE, and *cis*-1,2-DCE) were first reported in 1991. Since that time, solvent contamination has been detected in off-post private and public water supply wells.

At CSSA, the inorganic constituents in groundwater normally analyzed for include arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, and zinc. Although there have been some metals exceedances on-post, they have been sporadic and limited largely to wells located in the interior areas of the post and/or associated with heavy rainfall events. Hazards due to exposure to lead in groundwater may occur in some on-post locations. The highest lead hazard was calculated for wells CS-11 and CS-9 where lead has been consistently detected though the concentrations have only been sporadically above the action level. Lead detections in these two wells have been attributed to the materials used in well construction (remnants of broken casing, column pipe, and possibly equipment pumping at depths greater than 130 feet bgs). Neither well is used as a source of drinking water on-post, and because of the contamination, both wells were plugged and abandoned in August 2015. Currently metals are not sampled at off-post locations due to the minimal or lack of on-post metals detections exceeding MCLs, however, metals are sampled in support of ongoing corrective measures at select few off-post locations.

The groundwater plume associated with SWMU B-3 exists in the north-central area of the post (Plume 1) and has migrated to the south and west. The groundwater plume associated with AOC-65 at the southwestern boundary of the post (Plume 2) has also migrated south and west, and has impacted some off-post drinking water wells. These plumes are the focus of this Monitoring Network Optimization (MNO) evaluation. The COCs for both plumes include PCE, TCE, and *cis*-1,2-DCE. Groundwater contamination is most widespread within the LGR water-bearing unit. Although the highest concentrations of VOCs have been found in the UGR, previous investigations demonstrated that the largest aerial extent of VOC impact resides within the LGR.

Within Plume 1, concentrations above the MCL for PCE and/or TCE are detected in wells CS-4, CS-D, CS-MW1-LGR, CS-MW2-LGR, and the bioreactor extraction wells B3-EXW-01 through -05 and the CS-MW16 well cluster. Concentrations above 200 µg/L for PCE and/or TCE have been reported at CS-D, CS-16-LGR, CS-MW16-CC, and the extraction and multi-port wells at SWMU B-3. This plume has migrated to the south and west-southwest. In contrast, little to no contamination is detected in the BS and impacts to the CC is limited to the area immediately around CS-MW16-CC and CS-WB05.

Contamination at Plume 2 originated at or near AOC-65 and Building 90, and has migrated to the south and west. The highest concentrations of PCE have been reported adjacent to the source area at concentrations of 65,000 µg/L in Treatability Study Well 01 (TSW-01) and 30,000 µg/L in multi-port well CS-WB03-UGR-01. Within the CSSA boundary, concentrations greater than 100 µg/L have been reported in perched groundwater intervals above the main aquifer body. However, once the main aquifer body is penetrated, lower VOC levels are detected. Off-post, concentrations above the MCLs have been detected in private and public wells with open borehole completions. Concentrations greater than 30 µg/L have been reported 1,200 feet west-southwest of CSSA at RFR-10. Vertical profiling within that well shows that discrete intervals within uncased upper strata contribute PCE concentrations at over 90 µg/L. Only sporadic, trace concentrations of solvents have been detected in BS and CC wells within Plume 2. And following the 2015 LTMO, the BS wells have been excluded from the program as the BS is not a viable water bearing unit. The general extent of Plumes 1 and 2 are shown on **Figure 2.4**. The groundwater monitoring program at CSSA is fully described in Section 3.

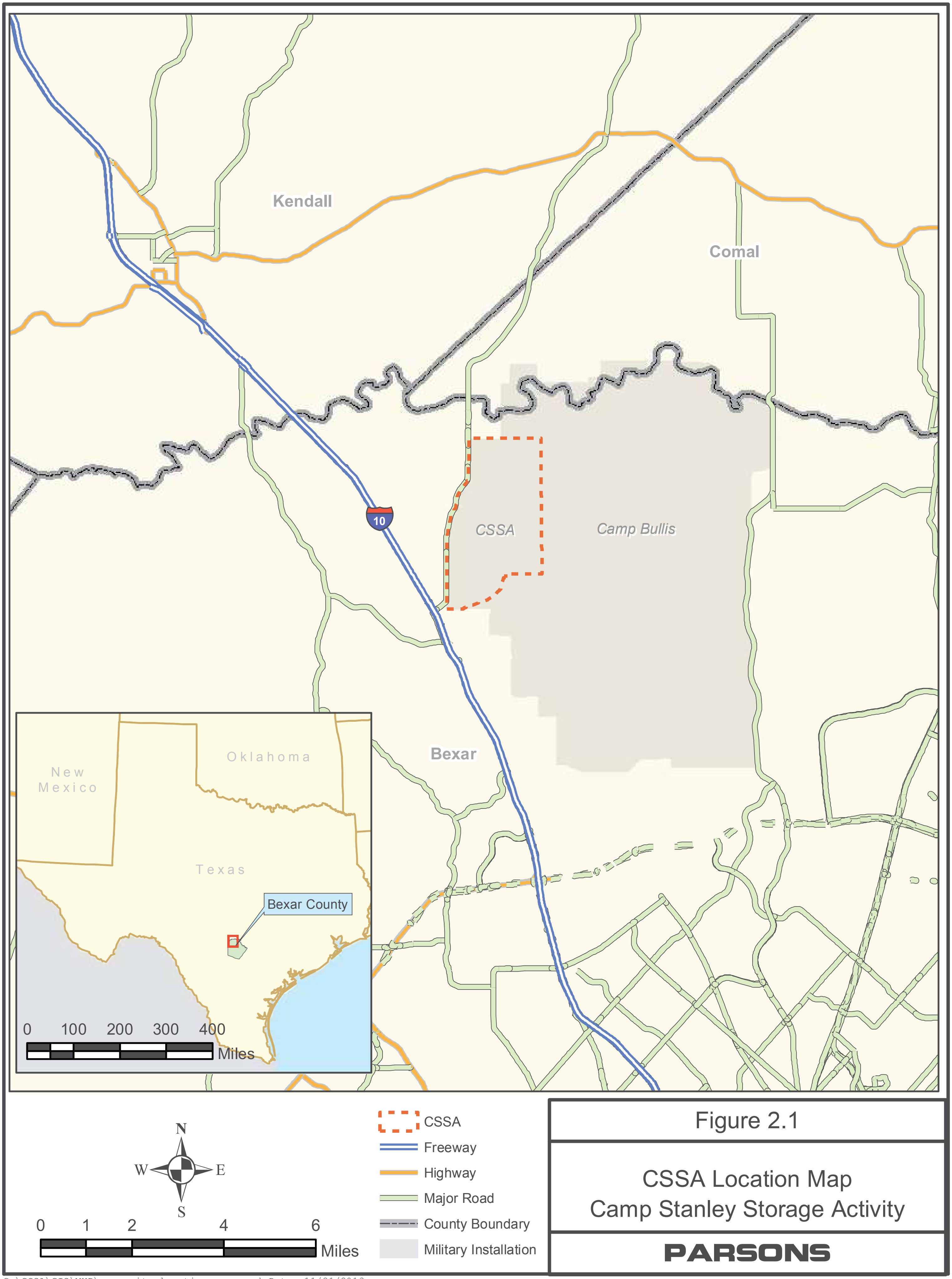

Figure 2.1

CSSA Location Map
Camp Stanley Storage Activity

PARSONS

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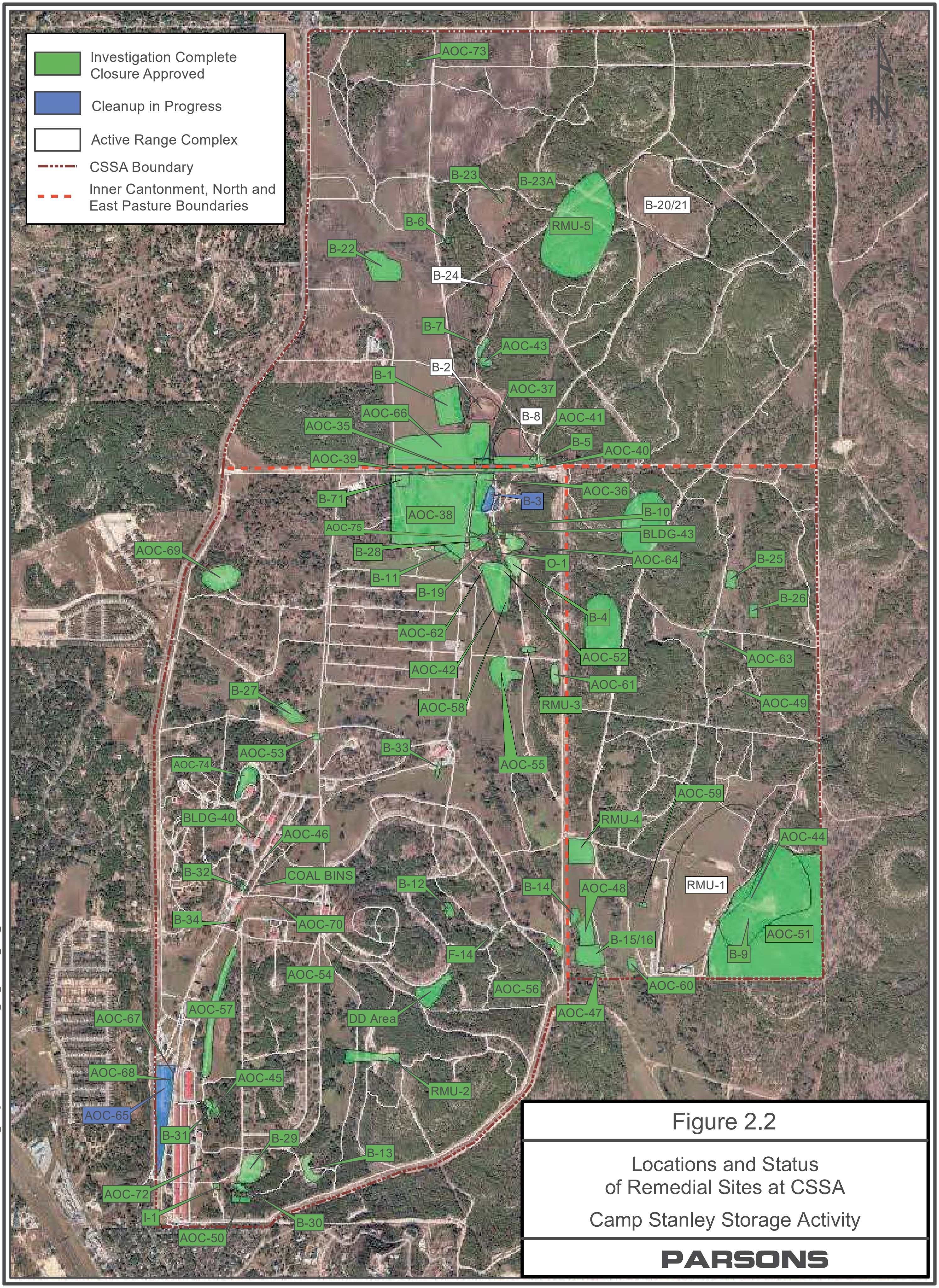

Figure 2.2

Locations and Status of Remedial Sites at CSSA

Camp Stanley Storage Activity

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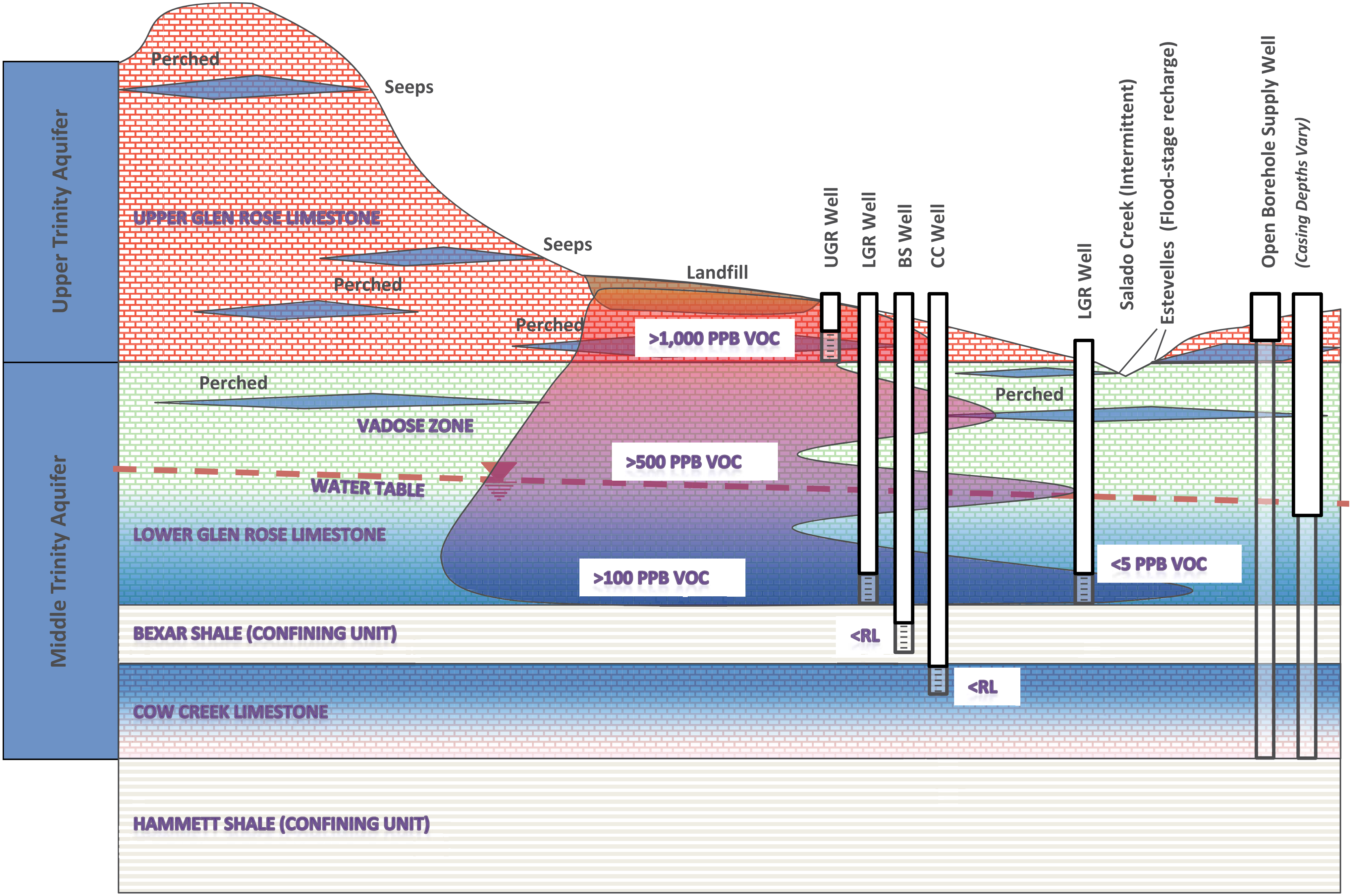
Figure 2.3 CSSA Hydrogeologic Conceptual Site Model



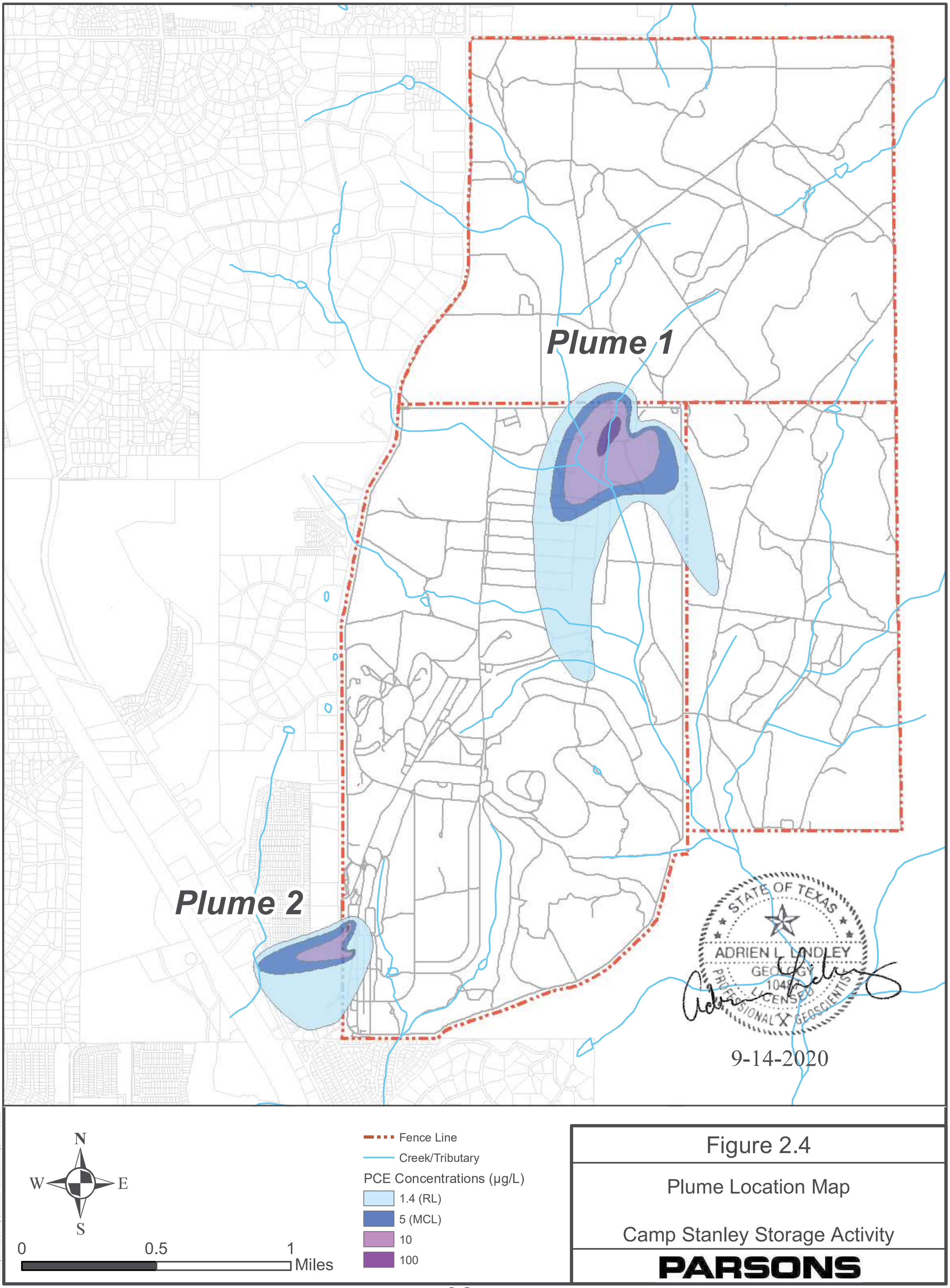


Figure 2.4

Plume Location Map

Camp Stanley Storage Activity

PARSONS

3 LONG-TERM MONITORING PROGRAM AT CSSA

The groundwater monitoring program at CSSA includes wells completed within the Middle Trinity aquifer (LGR and CC formations). These wells are located on- and off-post and include Westbay multi-port monitoring wells. Separate performance monitoring programs exist at each of the two groundwater remediation sites (SWMU B-3 and AOC-65). These corrective measure performance monitoring programs consist of wells most closely associated with monitoring progress at either of the two, however, some wells are used for both groundwater and corrective measure performance monitoring. Some of the corrective measure wells are installed within the UGR to monitor source area contamination as treatment progresses and others are installed for monitoring the dissolved-phase contamination present within the LGR.

3.1 DESCRIPTION OF GROUNDWATER MONITORING PROGRAM

The CSSA groundwater monitoring well network includes 126 wells, including on-post, off-post and multi-port Westbay® (WB)-equipped wells (Figure 3.1), and the program has monitored water quality on a quarterly basis for 22 years resulting in 84 sampling events. The WB wells have ports at multiple depths across the LGR, BS, and CC zones; the four wells included in the groundwater monitoring network contain 46 distinct sampling locations that are considered individually for the LTMO analysis. The groundwater monitoring program examined in this LTMO evaluation for Plumes 1 and 2 includes a total of 191 sampling locations (Table 3.1). The objectives of the monitoring program at CSSA are presented in both the Data Quality Objectives for the Groundwater Contamination Investigation (November 2010) and in the CSSA Off-post Groundwater Monitoring Response Plan (June 2002) and include, in part:

- Determine whether on- and off-post drinking water meets the standards for safe drinking water as prescribed under the USEPA and TCEQ rules;
- Determine if VOC concentrations in on-post and off-post drinking water wells exceed values stated in project DQOs and the CSSA off-post Monitoring Response Plan;
- Determine which formation(s) in the Middle Trinity aquifer are impacted by VOC contaminants;
- Determine the impacts of rain events, drought conditions, and groundwater recharge on concentrations and migration of VOCs in the aquifer and vadose zone.

The current CSSA LTM sampling frequency for a well is determined by the type, location, and detection history of the well. On-post drinking water wells, off-post private supply wells that exceed 80% of the MCL, and newly installed monitoring wells are sampled quarterly at minimum. Other on- and off-post wells are currently sampled every 15 or 30 months. Every 30 months, a simultaneous round of samples is collected from each well to provide a "snapshot" of groundwater concentrations and elevations across the installation. Wells that have previously been used for bioreactor performance monitoring (i.e., not part of the current LTM program) are sampled semi-annually or every 9 months, and wells used for ISCO performance monitoring are sampled quarterly.

3.2 SUMMARY OF ANALYTICAL DATA

The CSSA groundwater plumes are well-characterized both laterally and vertically. The groundwater monitoring program was summarized using results for sampling events performed from 2015 through January 2020. The database was processed to remove duplicate data by retaining the maximum result for each duplicate sample pair.

Other COCs have previously included bromoform (TBME) and bromodichloromethane (BDCME) because of their action levels of zero, and toluene (BZME) due to sporadic detections in screening level samples collected at discrete intervals during well installations. These three compounds were screened out following the first iteration of LTMO, and with the development and approval of a short list of VOC compounds, were subsequently dropped from the program in 2006. Following the 2015 LTMO, trans-DCE and 1,1-DCE were similarly dropped from the program. The VOC short list for groundwater sampling at CSSA includes the compounds: PCE, TCE, *cis*-1,2-DCE, and VC.

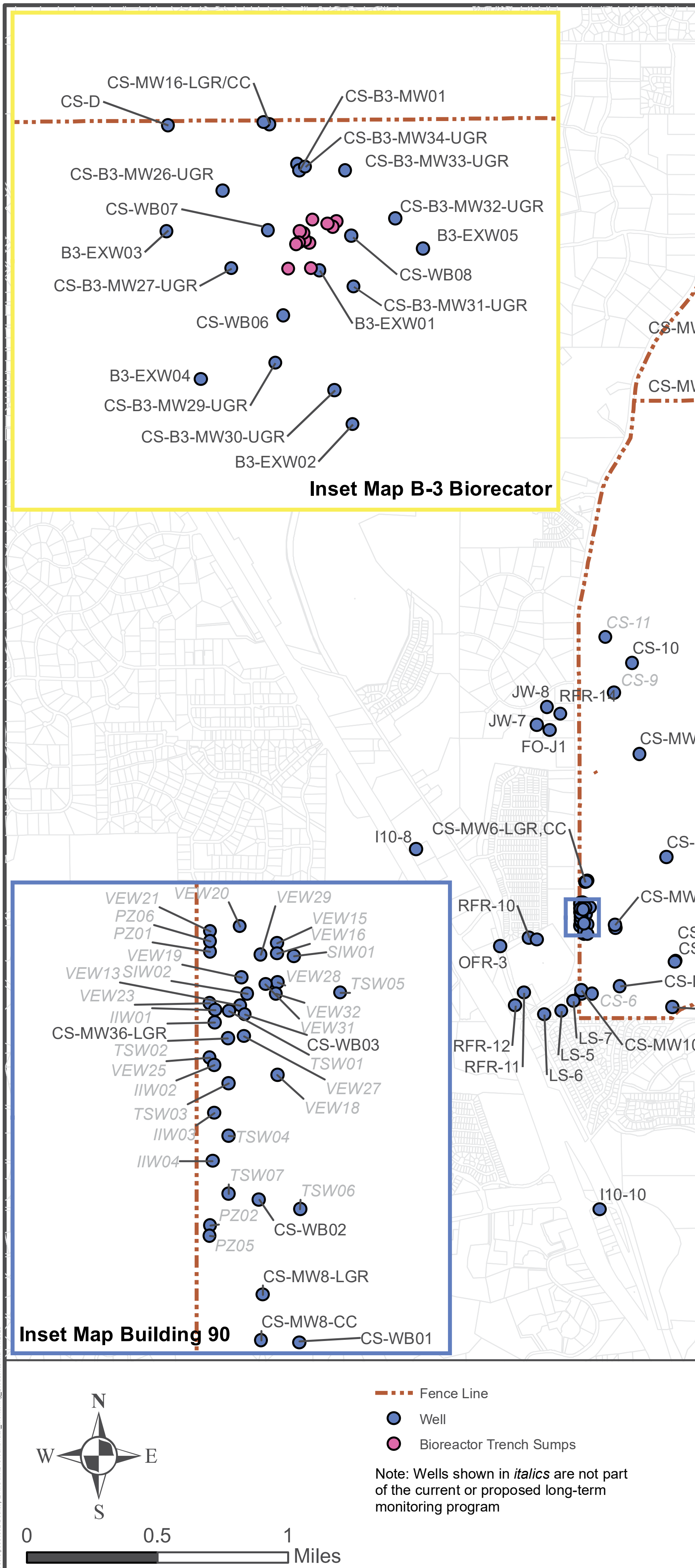


Figure 3.1

Groundwater Monitoring Well Locations

Camp Stanley Storage Activity

TABLE 3.1
CURRENT GROUNDWATER MONITORING PROGRAM
LONG TERM MONITORING OPTIMIZATION
CAMP STANLEY STORAGE ACTIVITY, TEXAS

Well ID	Vertical Zone	Current Sampling Frequency	First Sampling Event	Most Recent Data	Classification
On Post Monitoring Wells					
AOC65-PZ01-LGR	LGR(B)	ISCO	07/19/2002	01/06/2020	LGR[b/]
AOC65-PZ02-LGR	UGR(D)	ISCO	07/19/2002	01/06/2020	LGR
AOC65-PZ05-LGR	LGR(B)	ISCO	07/30/2002	01/06/2020	LGR
AOC65-PZ06-LGR	UGR(D)	ISCO	06/05/2003	01/06/2020	LGR
AOC65-TSW-01	UGR	ISCO	07/18/2012	01/09/2020	UGR
AOC65-TSW-03	UGR	ISCO	07/20/2012	01/08/2020	UGR
AOC65-TSW-04	UGR	ISCO	07/20/2012	01/08/2020	UGR
AOC65-TSW-05	UGR	ISCO	07/20/2012	01/09/2020	UGR
AOC65-TSW-06	UGR	ISCO	07/20/2012	01/08/2020	UGR
AOC65-TSW-07	UGR	ISCO	07/20/2012	01/08/2020	UGR
AOC65-VEW13-LGR	LGR	ISCO	07/03/2002	01/08/2020	LGR
AOC65-VEW15-UGR	UGR	ISCO	12/04/2002	01/09/2020	UGR
AOC65-VEW16-LGR	LGR	ISCO	12/04/2002	01/08/2020	LGR
AOC65-VEW18-LGR	LGR	ISCO	01/20/2004	01/09/2020	LGR
AOC65-VEW19-UGR	UGR	ISCO	12/04/2002	01/09/2020	UGR
AOC65-VEW20	UGR	ISCO	08/18/2011	01/08/2020	UGR
AOC65-VEW21	UGR	ISCO	08/18/2011	01/06/2020	UGR
AOC65-VEW23	UGR	ISCO	08/18/2011	01/06/2020	UGR
AOC65-VEW25	UGR	ISCO	08/18/2011	01/06/2020	UGR
AOC65-VEW27	UGR	ISCO	08/18/2011	01/09/2020	UGR
AOC65-VEW28A	LGR	ISCO	08/18/2011	01/08/2020	LGR
AOC65-VEW28B	LGR	ISCO	08/18/2011	01/08/2020	LGR
AOC65-VEW29	UGR	ISCO	08/18/2011	01/09/2020	UGR
AOC65-VEW31	UGR	ISCO	08/18/2011	01/09/2020	UGR
AOC65-VEW32	UGR	ISCO	08/18/2011	01/09/2020	UGR
AOC65-SIW-01	UGR	ISCO	09/03/2015	01/09/2020	UGR
B3-EXW01	LGR	Every 9 months	05/12/2009	01/06/2020	OPBHc/
B3-EXW02	LGR	Every 9 months	05/19/2010	12/31/2019	OPBH
B3-EXW03	LGR	Every 9 months	01/16/2013	12/31/2019	OPBH
B3-EXW04	LGR	Every 9 months	01/16/2013	12/31/2019	OPBH
B3-EXW05	LGR	Every 9 months	01/16/2013	12/31/2019	OPBH
B3-MW26-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
B3-MW27-UGR	UGR	Every 9 months	02/24/2010	01/02/2020	UGR
B3-MW29-UGR	UGR	Every 9 months	06/23/2010	03/07/2019	UGR
B3-MW30-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
B3-MW31-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
B3-MW32-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
B3-MW33-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
B3-MW34-UGR	UGR	Every 9 months	06/23/2010	01/02/2020	UGR
CS-1	LGR(D), LGR(E), LGR(F), BS(A), BS(B), CC(A), CC(B)	Quarterly	09/17/2001	12/10/2019	OPBH
CS-2	LGR(E), LGR(F), BS(A)	Every 30 months	09/13/2001	12/04/2019	OPBH
CS-3	LGR(E), LGR(F), BS(A)	Exclude	02/05/2010	02/05/2010	OPBH
CS-4	LGR(E)	Every 15 months	06/23/2003	09/07/2018	OPBH
CS-10	LGR(F), BS(A), BS(B), CC(A), CC(B)	Quarterly	09/17/2001	12/10/2019	OPBH

TABLE 3.1
CURRENT GROUNDWATER MONITORING PROGRAM
LONG TERM MONITORING OPTIMIZATION
CAMP STANLEY STORAGE ACTIVITY, TEXAS

Well ID	Vertical Zone	Current Sampling Frequency	First Sampling Event	Most Recent Data	Classification
CS-12	LGR(D), LGR(E), LGR(F), BS(A), BS(B), CC(A), CC(B)	Quarterly	03/25/2009	12/10/2019	OPBH
CS-13	LGR, CC	Quarterly	03/15/2012	12/10/2019	OPBH
CS-B3-MW01	LGR	As Needed	07/27/2007	10/04/2018	LGR
CS-B3-MW02	LGR	As Needed	03/21/2017	10/04/2018	LGR
CS-B3-MW03	LGR	As Needed	10/04/2018	10/04/2018	UGR
CS-B3-MW04	LGR	As Needed	03/28/2017	10/04/2018	LGR
CS-D	LGR(D), LGR(E), LGR(F)	Every 15 months, Bioreactor	09/13/2001	12/04/2019	OPBH
CS-I	LGR(E), LGR(F)	Every 30 months	09/12/2001	12/03/2019	OPBH
CS-MW1-CC	CC(A)	Every 30 months	11/10/2002	12/04/2019	CC[e/]
CS-MW1-LGR	LGR(F)	Every 15 months, Bioreactor	09/13/2001	12/04/2019	LGR
CS-MW2-CC	CC(A)	Every 30 months	03/02/2003	12/05/2019	CC
CS-MW2-LGR	LGR(F)	Every 30 months	09/13/2001	12/05/2019	LGR
CS-MW3-LGR	LGR(F)	Every 30 months	09/12/2001	12/03/2019	LGR
CS-MW4-LGR	LGR(F)	Every 30 months	09/13/2001	12/05/2019	LGR
CS-MW5-LGR	LGR(F)	Every 15 months, Bioreactor	09/12/2001	12/05/2019	LGR
CS-MW6-CC	CC(A)	Every 30 months	09/13/2001	12/11/2019	CC
CS-MW6-LGR	LGR(F)	Every 15 months, ISCO	09/13/2001	12/11/2019	LGR
CS-MW7-CC	CC(A)	Every 30 months	09/13/2001	12/11/2019	CC
CS-MW7-LGR	LGR(F)	Every 15 months, ISCO	09/13/2001	12/11/2019	LGR
CS-MW8-CC	CC(A)	Every 15 months	09/13/2001	12/11/2019	CC
CS-MW8-LGR	LGR(F)	Every 15 months, ISCO	09/13/2001	12/11/2019	LGR
CS-MW9-CC	CC(A)	Every 30 months	09/12/2001	12/04/2019	CC
CS-MW9-LGR	LGR(F)	Every 30 months	09/12/2001	12/04/2019	LGR
CS-MW10-CC	CC(A)	Every 30 months	09/26/2001	12/09/2019	CC
CS-MW10-LGR	LGR(F)	Every 15 months	09/26/2001	12/11/2019	LGR
CS-MW11A-LGR	LGR(F)	Every 15 months	03/19/2003	12/11/2019	LGR
CS-MW11B-LGR	LGR(B)	Every 15 months	04/04/2003	09/24/2018	LGR
CS-MW12-CC	CC(A)	Every 30 months	09/26/2002	12/05/2019	CC
CS-MW12-LGR	LGR(F)	Every 15 months	09/13/2002	12/05/2019	LGR
CS-MW16-CC	CC(A)	Every 9 months	04/21/2003	12/31/2019	CC
CS-MW16-LGR	LGR(E), LGR(F)	Every 9 months	09/13/2001	01/06/2020	OPBH
CS-MW17-LGR	LGR(F)	Every 15 months	09/12/2002	12/04/2019	LGR
CS-MW18-LGR	LGR(F)	Every 30 months	07/24/2002	12/11/2019	LGR
CS-MW19-LGR	LGR(F)	Every 30 months	08/06/2002	12/09/2019	LGR
CS-MW20-LGR	LGR(F)	Every 30 months	10/18/2006	12/09/2019	LGR
CS-MW21-LGR	LGR(F)	Every 30 months	12/12/2006	12/09/2019	LGR
CS-MW22-LGR	LGR(F)	Every 30 months	11/09/2006	12/09/2019	LGR
CS-MW23-LGR	LGR(F)	Every 30 months	06/05/2007	12/09/2019	LGR
CS-MW24-LGR	LGR(F)	Every 30 months	12/26/2006	12/04/2019	LGR
CS-MW25-LGR	LGR(F)	Every 30 months	01/03/2007	12/03/2019	LGR
CS-MW35-LGR	LGR	Every 15 months	03/31/2011	12/09/2019	LGR
CS-MW36-LGR	LGR	Every 15 months, ISCO	04/08/2011	12/11/2019	LGR
CS-MW37-LGR	LGR	Every 15 months	07/12/2017	12/12/2019	LGR
CS-MWG-LGR	LGR(C), LGR(D), LGR(E)	Every 30 months	09/12/2001	12/03/2019	OPBH
CS-MWH-LGR	LGR(F)	Every 30 months	09/12/2001	06/20/2017	LGR
Off Post Monitoring Wells					
FO-J1	LGR, CC	Every 30 months	09/18/2001	12/02/2019	OffBH

TABLE 3.1
CURRENT GROUNDWATER MONITORING PROGRAM
LONG TERM MONITORING OPTIMIZATION
CAMP STANLEY STORAGE ACTIVITY, TEXAS

Well ID	Vertical Zone	Current Sampling Frequency	First Sampling Event	Most Recent Data	Classification
I10-8	LGR, CC	Every 30 months	12/19/2005	12/02/2019	OffBH
I10-10		Every 15 months	09/11/2013	12/02/2019	OffBH
JW-7	LGR, CC	Every 30 months	09/08/2003	06/07/2017	OffBH
JW-8	LGR, CC	Every 30 months	06/18/2003	12/11/2019	OffBH
LS-5	LGR, CC	Quarterly	10/25/2001	12/02/2019	OffBH
LS-6	LGR, CC	Quarterly	09/19/2001	12/02/2019	OffBH
LS-7	LGR, CC	Quarterly	09/19/2001	12/02/2019	OffBH
OFR-3	LGR, CC	Quarterly	10/25/2001	12/02/2019	OffBH
RFR-10	LGR, CC	Quarterly	09/19/2001	12/02/2019	OffBH
RFR-11	LGR, CC	Quarterly	10/04/2001	12/02/2019	OffBH
RFR-12	LGR, CC	Every 15 months	12/18/2001	12/04/2019	OffBH
RFR-14	LGR, CC	Every 30 months	03/23/2006	12/02/2019	OffBH
WestBay Wells					
CS-WB01-LGR-01	LGR-01	Every 15 months, ISCO	09/09/2003	12/16/2019	LGR
CS-WB01-LGR-02	LGR-02	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB01-LGR-03	LGR-03	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB01-LGR-04	LGR-04	Every 15 months	09/08/2003	12/16/2019	LGR
CS-WB01-LGR-05	LGR-05	Every 15 months	09/08/2003	12/16/2019	LGR
CS-WB01-LGR-06	LGR-06	Every 15 months	09/08/2003	12/16/2019	LGR
CS-WB01-LGR-07	LGR-07	Every 15 months	09/08/2003	12/16/2019	LGR
CS-WB01-LGR-08	LGR-08	Every 15 months	09/08/2003	12/16/2019	LGR
CS-WB01-LGR-09	LGR-09	Every 15 months, ISCO	09/08/2003	12/16/2019	LGR
CS-WB01-UGR-01	UGR-01	Every 15 months, ISCO	11/18/2004	09/12/2018	UGR
CS-WB02-LGR-01	LGR-01	Every 15 months, ISCO	09/09/2003	09/12/2018	LGR
CS-WB02-LGR-02	LGR-02	Every 15 months	04/16/2004	09/12/2018	LGR
CS-WB02-LGR-03	LGR-03	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-04	LGR-04	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-05	LGR-05	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-06	LGR-06	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-07	LGR-07	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-08	LGR-08	Every 15 months	09/09/2003	12/16/2019	LGR
CS-WB02-LGR-09	LGR-09	Every 15 months, ISCO	09/09/2003	12/16/2019	LGR
CS-WB02-UGR-01	UGR-01	Every 15 months, ISCO	07/02/2004	12/02/2004	UGR
CS-WB03-LGR-01	LGR-01	Every 15 months, ISCO	11/18/2004	12/17/2019	LGR
CS-WB03-LGR-02	LGR-02	Every 15 months	11/30/2004	06/16/2016	LGR
CS-WB03-LGR-03	LGR-03	Every 15 months	09/10/2003	12/17/2019	LGR
CS-WB03-LGR-04	LGR-04	Every 15 months	09/10/2003	12/17/2019	LGR
CS-WB03-LGR-05	LGR-05	Every 15 months	09/10/2003	12/17/2019	LGR
CS-WB03-LGR-06	LGR-06	Every 15 months	09/10/2003	12/17/2019	LGR
CS-WB03-LGR-07	LGR-07	Every 15 months	09/10/2003	12/17/2019	LGR
CS-WB03-LGR-08	LGR-08	Every 15 months	09/10/2003	12/16/2019	LGR
CS-WB03-LGR-09	LGR-09	Every 15 months, ISCO	09/10/2003	12/16/2019	LGR
CS-WB03-UGR-01	UGR-01	Every 15 months, ISCO	11/18/2004	12/17/2019	UGR
CS-WB04-BS-01	BS-01	Every 30 months	09/18/2003	12/18/2019	BS
CS-WB04-BS-02	BS-02	Every 30 months	09/18/2003	12/18/2019	BS
CS-WB04-CC-01	CC-01	Every 30 months	09/18/2003	12/18/2019	CC
CS-WB04-CC-02	CC-02	Every 30 months	09/18/2003	12/18/2019	CC
CS-WB04-CC-03	CC-03	Every 30 months	09/18/2003	12/18/2019	CC
CS-WB04-LGR-01	LGR-01	Every 15 months, ISCO	10/16/2003	12/18/2019	LGR
CS-WB04-LGR-02	LGR-02	Every 30 months	05/12/2004	05/19/2015	LGR
CS-WB04-LGR-03	LGR-03	Every 30 months	10/16/2003	12/18/2019	LGR
CS-WB04-LGR-04	LGR-04	Every 30 months	09/19/2003	12/18/2019	LGR
CS-WB04-LGR-06	LGR-06	Every 15 months	09/19/2003	12/18/2019	LGR

TABLE 3.1
CURRENT GROUNDWATER MONITORING PROGRAM
LONG TERM MONITORING OPTIMIZATION
CAMP STANLEY STORAGE ACTIVITY, TEXAS

Well ID	Vertical Zone	Current Sampling Frequency	First Sampling Event	Most Recent Data	Classification
CS-WB04-LGR-07	LGR-07	Every 15 months	09/19/2003	12/18/2019	LGR
CS-WB04-LGR-08	LGR-08	Every 15 months	09/19/2003	12/18/2019	LGR
CS-WB04-LGR-09	LGR-09	Every 15 months	09/19/2003	12/18/2019	LGR
CS-WB04-LGR-10	LGR-10	Every 15 months	09/18/2003	12/18/2019	LGR
CS-WB04-LGR-11	LGR-11	Every 15 months, ISCO	09/18/2003	12/18/2019	LGR
CS-WB04-UGR-01	UGR-01	Every 15 months, ISCO	11/18/2004	11/18/2004	UGR
CS-WB05-BS-01	BS-01	Every 9 months	11/21/2005	12/19/2019	BS
CS-WB05-CC-01	CC-01	Every 9 months	11/21/2005	12/18/2019	CC
CS-WB05-CC-02	CC-02	Every 9 months	11/21/2005	12/18/2019	CC
CS-WB05-LGR-01	LGR-01	Every 9 months	07/17/2007	12/19/2019	LGR
CS-WB05-LGR-02	LGR-02	Every 9 months	07/17/2007	03/20/2019	LGR
CS-WB05-LGR03A	LGR-03	Every 9 months	07/17/2007	03/20/2019	LGR
CS-WB05-LGR03B	LGR-03	Semi-annual	12/29/2005	09/12/2019	LGR
CS-WB05-LGR-04A	LGR-04	Every 9 months	11/21/2005	12/19/2019	LGR
CS-WB05-LGR-04B	LGR-04	Every 9 months	11/21/2005	12/19/2019	LGR
CS-WB06-LGR-01	LGR-01	Every 9 months	12/27/2005	12/23/2019	LGR
CS-WB06-LGR-02	LGR-02	Every 9 months	12/27/2005	12/23/2019	LGR
CS-WB06-LGR03A	LGR-03	Every 9 months	12/27/2005	12/23/2019	LGR
CS-WB06-LGR03B	LGR-03	Semi-annual	12/27/2005	09/23/2019	LGR
CS-WB06-LGR-04	LGR-04	Every 9 months	12/27/2005	12/23/2019	LGR
CS-WB06-UGR-01	UGR-01	Every 9 months	07/25/2007	12/30/2019	UGR
CS-WB07-LGR-01	LGR-01	Every 9 months	12/28/2005	12/23/2019	LGR
CS-WB07-LGR-02	LGR-02	Every 9 months	12/28/2005	12/23/2019	LGR
CS-WB07-LGR03A	LGR-03	Every 9 months	12/28/2005	03/21/2019	LGR
CS-WB07-LGR03B	LGR-03	Semi-annual	12/28/2005	09/12/2019	LGR
CS-WB07-LGR-04	LGR-04	Every 9 months	12/28/2005	12/23/2019	LGR
CS-WB07-UGR-01	UGR-01	Every 9 months	07/19/2007	02/01/2011	UGR
CS-WB08-LGR-01	LGR-01	Every 9 months	12/29/2005	12/30/2019	LGR
CS-WB08-LGR-02	LGR-02	Every 9 months	12/29/2005	12/30/2019	LGR
CS-WB08-LGR03A	LGR-03	Every 9 months	07/26/2007	03/26/2019	LGR
CS-WB08-LGR03B	LGR-03	Semi-annual	12/28/2005	09/23/2019	LGR
CS-WB08-LGR-04	LGR-04	Every 9 months	12/28/2005	12/30/2019	LGR
CS-WB08-UGR-01	UGR-01	Every 9 months	07/26/2007	12/30/2019	UGR

[a/] UGR = On Post monitoring well, AOC-65 area well, or WestBay-equipped well screened in the UGR zone; included in vertical analys

[b/] LGR = On Post monitoring well, AOC-65 area well, or WestBay-equipped well screened in the LGR zone; included in vertical analys

[c/] OPBH = On Post Borehole; included in vertical analysis.

[d/] BS = On Post monitoring well or WestBay-equipped well screened in the Bexar Shale zone; included in vertical analysis.

[e/] CC = On Post monitoring well or WestBay-equipped well screened in the Cow Creek zone; included in vertical analysis.

[f/] OffBH = Off Base Borehole; included in vertical analysis.

4 LTM EVALUATION

An effective groundwater monitoring program will provide information regarding contaminant plume migration and changes in chemical concentrations through time at appropriate locations, enabling decision-makers to verify that contaminants are not endangering potential receptors, and that remediation is occurring at rates sufficient to achieve CAOs within a reasonable time frame. The design of the monitoring program should therefore include consideration of existing receptor exposure pathways, as well as exposure pathways arising from potential future use of the groundwater.

Performance monitoring wells located within and downgradient from a plume provide a means of evaluating the effectiveness of a groundwater remedy relative to performance criteria. LTM of these wells also provides information about migration of the plume and temporal trends in chemical concentrations. Groundwater monitoring wells located downgradient from the leading edge of a plume (i.e., sentry wells) are used to evaluate possible changes in the extent of the plume and, if warranted, to trigger a contingency response action if contaminants are detected.

- Primary factors to consider when developing a groundwater monitoring program include at a minimum:
- Aquifer heterogeneity;
- Types of contaminants;
- Distance to potential receptor exposure points;
- Groundwater seepage velocity and flow direction(s);
- Potential surface-water impacts; and
- The effects of the remediation system.

These factors will influence the locations and spacing of monitoring points and the sampling frequency. Typically, the greater the seepage velocity and the shorter the distance to receptor exposure points, the more frequently groundwater sampling should be conducted.

One of the most important purposes of LTM is to confirm that the contaminant plume is behaving as predicted. Graphical and statistical tests can be used to evaluate plume stability. If a groundwater remediation system or strategy is effective, then over the long term, groundwater-monitoring data should demonstrate a clear and meaningful decreasing trend in concentrations at appropriate monitoring points. The CSSA Groundwater Monitoring Program is conducted under the provisions of the Off-post Groundwater Monitoring Program Response Plan (CSSA, 2002) and the Data Quality Objectives for the Groundwater Monitoring Program (Parsons, 2015).

4.1 THREE-TIERED OPTIMIZATION APPROACH USING 3TMO

The current groundwater monitoring program at CSSA was evaluated using 3TMO protocol. This LTMO decision support tool uses a combination of statistics and professional judgment in a structured protocol to optimize sampling locations, sampling frequency, and target analytes for monitoring wells while maintaining an effective performance and compliance monitoring program with no loss of required information. It is intended to facilitate more efficient performance and successful implementation of long-term groundwater monitoring optimization evaluations through the following capabilities:

- Embedded decision-making frameworks for conducting multi-tiered qualitative and quantitative optimization evaluations;
- On-demand graphs of chemical concentrations over time with user-selected chemical and time range parameters;
- Map-based display of relevant information;
- Well-by-well optimization recommendations and reports; and
- LTMO best practices guidance and documentation.

3TMO is based on the three-tiered approach to evaluating and optimizing LTM programs that was developed by Parsons in 2001 (Nobel and Anthony 2004; USEPA 2005). The three tiers consist of:

1. A qualitative evaluation of the monitoring program;
2. A statistical evaluation of temporal trends in contaminant concentration;
3. A qualitative analysis of the spatial importance of each monitoring location.

Each of the three evaluation tiers is performed separately to yield three distinct sets of optimization recommendations. The results of the three evaluations are then combined to assess the degree to which the existing monitoring network addresses the primary objectives of monitoring. A decision algorithm is applied to assess the optimal frequency of monitoring, to assess the optimal spatial distribution of the components of the monitoring network, and to develop final recommendations for monitoring program optimization. The three-tiered LTMO approach is unique when compared with existing LTMO statistical applications due to its focus on qualitative factors that are supported by quantitative statistical analysis. The spatial analysis incorporated into 3TMO is qualitative rather than statistical. The user enters a recommendation to retain or exclude each well based on qualitative spatial analysis facilitated by plume maps, time-versus-concentration charts, and well parameter information (e.g. screened interval).

This report presents the results of two separate optimization evaluations that were performed for the groundwater monitoring program for Plumes 1 and 2 and two evaluations of the performance monitoring programs at the two corrective measures sites at CSSA. Individual wells that are a component of multiple monitoring programs (i.e. Groundwater Plume 1 and bioreactor performance monitoring) were considered in each of 3TMO optimization evaluations of which they are a part. The components of these evaluations are described in greater detail in Section 5.

4.2 OPTIMIZATION METHODS

4.2.1 IDENTIFICATION OF KEY CONSTITUENTS OF CONCERN

The 2013 Baseline Risk Assessment identified the COCs in groundwater as PCE, TCE, *cis*-1,2-DCE, and VC (Parsons, 2014a). The groundwater DQOs address these COCs (Parsons, 2015). Of all the COCs listed, PCE is the most widely distributed compound above its respective MCL. Limited exceptions include areas where chemical biodegradation/natural attenuation processes are occurring near the plume source areas and the associated active remediation efforts.

To simplify the 3TMO evaluation and presentation of findings, PCE was selected as the “indicator” compound for which to conduct the LTMO process. Because PCE has historically exceeded its MCL in a relatively large percentage of samples collected over the greatest aerial extent, its relatively high concentration and distribution as compared to the other COCs are the primary influences on the scope of the groundwater monitoring program.

4.2.2 DATA INPUT

Data input to 3TMO included well parameters and sample data as described below.

Well parameters included well identification numbers, survey coordinates (northing and easting), screen intervals, the hydrogeologic zone in which the screen was placed, the well functional category (described below), the current sampling frequency, and a qualitative assessment of the current or potential future importance of the monitoring location (low, moderate, or high) based on multiple factors (described below).

The well functional category was assigned based on the location of each well with regard to the contaminant plume, potential receptors, and/or the Site boundary. Potential functional categories available in 3TMO include background, upgradient, cross-gradient or cross-gradient plume edge, downgradient or downgradient plume edge, in-plume, source area, point of compliance, sentinel, and distant/offsite.

The assignment of the importance of the monitoring location was based on the magnitude of COC concentrations, plume dynamics (i.e., receding, stable, expanding), the estimated contaminant transport velocity between the well and any downgradient receptors, the proximity of the well to potential receptors, and predictability of COC concentrations at the well as shown below.

Assessing the Importance of the Monitoring Location

Lower Importance	Higher Importance
Lower COC concentrations	Higher COC concentrations
Stable to receding plume	Expanding plume or plume dynamics unknown
Lower groundwater and contaminant transport velocities	Higher groundwater and contaminant transport velocities
Well is not located in a preferential groundwater flow pathway (e.g., well is located in a less-permeable portion of the water-bearing zone)	Well is located in a preferential groundwater flow pathway (e.g., more-permeable portion of the water-bearing zone such as a gravel or cobble zone with relatively permeable sediments)
No nearby receptors	Nearby receptors
COC concentrations are stable over time or vary in a predictable manner. This criterion could apply to stable, high-concentration, in-plume wells or stable, low-concentration wells that are along the exterior of the plume, either upgradient or cross-gradient of the plume axis.	COC concentrations are variable and unpredictable; this criterion is especially applicable to wells in sensitive locations such as downgradient plume-edge wells where a change in concentration could alter a decision or course of action.

Some in-plume wells were assigned a relatively “high” importance because they:

- Are installed in key locations such as near potential surface water discharge areas or downgradient of plume “hotspots” (and therefore useful to monitor for downgradient migration of COC mass that could result in plume expansion); or
- Had increasing or unpredictable concentration trends that warrant relatively frequent sampling to monitor the trends, understand plume dynamics (expanding, stable, decreasing), and determine whether additional response action is called for to maintain protectiveness of human health and the environment.

Other in-plume wells that do not exhibit the characteristics identified above were mostly assigned a “moderate” importance. Some in-plume wells that are located near the upgradient or cross-gradient fringes of plumes and are hydraulically distant from surface water were assigned a “low” importance.

A relatively small number of cross-gradient or upgradient wells that are minimally contaminated (i.e., near or below MCLs) or uncontaminated and considered to be exterior to the plume were also assigned a “low” importance. In these cases, there is no evidence to indicate that cross-gradient or upgradient plume expansion is occurring at these locations, and therefore there is no reason to expect that contaminant concentrations at these wells would substantially change from year to year.

Sample data included historical laboratory analytical results for PCE within varying timeframes for each plume. Plume 1 data included in the 3TMO evaluation consisted of data collected since the last LTMO evaluation (September 2015), or the last four samples collected. Mann-Kendall trend analysis requires a minimum of four data points. Wells currently sampled every 30 months, or were sampled infrequently due to low water levels, do not include the requisite number of data points to perform trend analysis, therefore data prior to September 2015 are included. Most corrective measure performance monitoring wells are not a component of the current (2015) LTM program. The corrective measures performance monitoring wells are evaluated separately from the LTM monitoring network as the bioreactor and ISCO performance monitoring programs.

Well data used for Plume 2 3TMO analyses were also limited to the period following the implementation of the 2015 LTMO recommendations. Data collected prior to 2015 were included for wells that did not meet the minimum number of data points for trend analysis.

Well data used for the corrective measure performance monitoring programs (bioreactor and ISCO) includes those data collected since September 2015. The typical sampling frequencies for these two programs is much shorter (semi-annual and 9-month bioreactor and quarterly ISCO) than that of the groundwater monitoring program, thus, the inclusion of data prior to September 2015 is not necessary.

4.3 WELL RETENTION EVALUATION

The 3TMO Well Retention evaluation consisted of the following components:

- **Qualitative Evaluation:** Each well was evaluated using an interactive decision tree embedded within 3TMO (**Figure 4.1**) that examines whether the well is needed to meet any of the common monitoring objectives listed below:
    - Monitor water quality near a compliance point (e.g., the facility boundary) or a potential receptor exposure point (e.g., edge of wetlands, surface water body, residential area)
    - Monitor upgradient or background water quality or biogeochemistry
    - Monitor the lateral or vertical extent of contamination or the magnitude of contaminant concentrations within the plume over time
    - Monitor to satisfy regulatory or community concerns
- **Temporal Trend Evaluation**: 3TMO calculates Mann-Kendall trend results based on user-defined date ranges and applies specific decision logic (**Figure 4.2**) to recommend retention or exclusion/frequency reduction for each well based on the functional category of the well and the temporal trend result. The Mann-Kendall test for trends (Gilbert 1987; USEPA 2000) is well suited for evaluation of environmental data because the sample size can be small (as few as four data points), and no assumptions are made regarding the underlying statistical distribution of the data (it is nonparametric).
- Potential trend outcomes that 3TMO provides include:
    - **Increasing:** statistically significant (>95% confidence) increasing trend in concentrations
    - **Probably Increasing:** statistically significant (90-95% confidence) increasing trend in concentrations
    - **Stable:** no statistically significant (<90% confidence) temporal trend in concentrations; low variability of results (coefficient of variation [COV] < 1)
    - **No Trend:** no statistically significant (<90% confidence) temporal trend in concentrations; high variability of results (COV> 1)
    - **Probably Decreasing:** statistically significant (90-95% confidence) decreasing trend in concentrations
    - **Decreasing:** statistically significant (>95% confidence) decreasing trend in concentrations
    - **ND (i.e., non-detect):** constituent has not been detected during the history of monitoring at the indicated well
    - **Less than (<) PQL:** all sample results are below the practical quantitation limit (PQL), or the results are a mixture of non-detects and results less than the PQL
    - **<4 Results**: Fewer than four measurements for the parameter; no trend evaluated
- **Spatial Evaluation:** The spatial evaluation was performed in addition to the qualitative and temporal evaluations to provide an additional line of evidence to determine which wells should be retained or excluded from the monitoring program based solely on spatial considerations. Retention or exclusion of each well was recommended based solely on a qualitative (map-based) analysis of whether there are any spatial redundancies in the monitoring well network and whether a particular well is located in an area that should be monitored to meet one or both of the objectives listed in Section 1.
- **Combined Evaluation Summary:** 3TMO provides a program-generated retention or exclusion recommendation based on the results of the qualitative, temporal, and spatial evaluation results for each well in accordance with embedded decision logic (**Figure 4.3**). A final retention or exclusion

recommendation was then made based on the combination of qualitative, temporal, and spatial evaluation results for each well and the 3TMO preliminary recommendation.

Mann-Kendall trends were not derived for wells that had an insufficient number of sampling events to determine a statistical trend with sufficient confidence (i.e., less than four events).

4.4 MONITORING FREQUENCY EVALUATION

The 3TMO Monitoring Frequency Evaluation consisted of the following components:

- **Qualitative Evaluation**: An appropriate generic monitoring frequency for each well was identified using an interactive decision tree **(Figure 4.4**) that takes into account the functional category of the well (Section 4.2), plume dynamics (i.e., is the plume expanding, stable, or retreating), the magnitude of contaminant concentrations, temporal concentration trends, and the location of the well with respect to potential receptors. Potential generic frequency outcomes available in the decision tree include low, moderate, high, or "estimate a conservative solute transport velocity to determine the appropriate frequency for unimpacted downgradient wells based on distance from plume to well(s)." 3TMO then uses the generic frequency result from the decision tree in combination with the importance assigned to each well (Section 4.2) to recommend a specific monitoring frequency using the following embedded decision logic:

	Low Importance	**Moderate Importance**	**High Importance**
High Sampling Frequency	Annual	Semi-annual	Monthly to quarterly
Moderate Sampling Frequency	Biennial	Annual	Semi-annual
Low Sampling Frequency	Less than biennial	Biennial	Annual

- **Temporal Trend Evaluation:** 3TMO calculates Mann-Kendall trend results based on user-defined date ranges and applies an embedded decision logic (Figure 4.2) to recommend retention or exclusion/frequency reduction for each well (same interface used in the Well Retention evaluation described in Section 4.3).
- **Combined Evaluation Summary:** A final frequency recommendation was made based on the combination of the qualitative and temporal evaluation results.

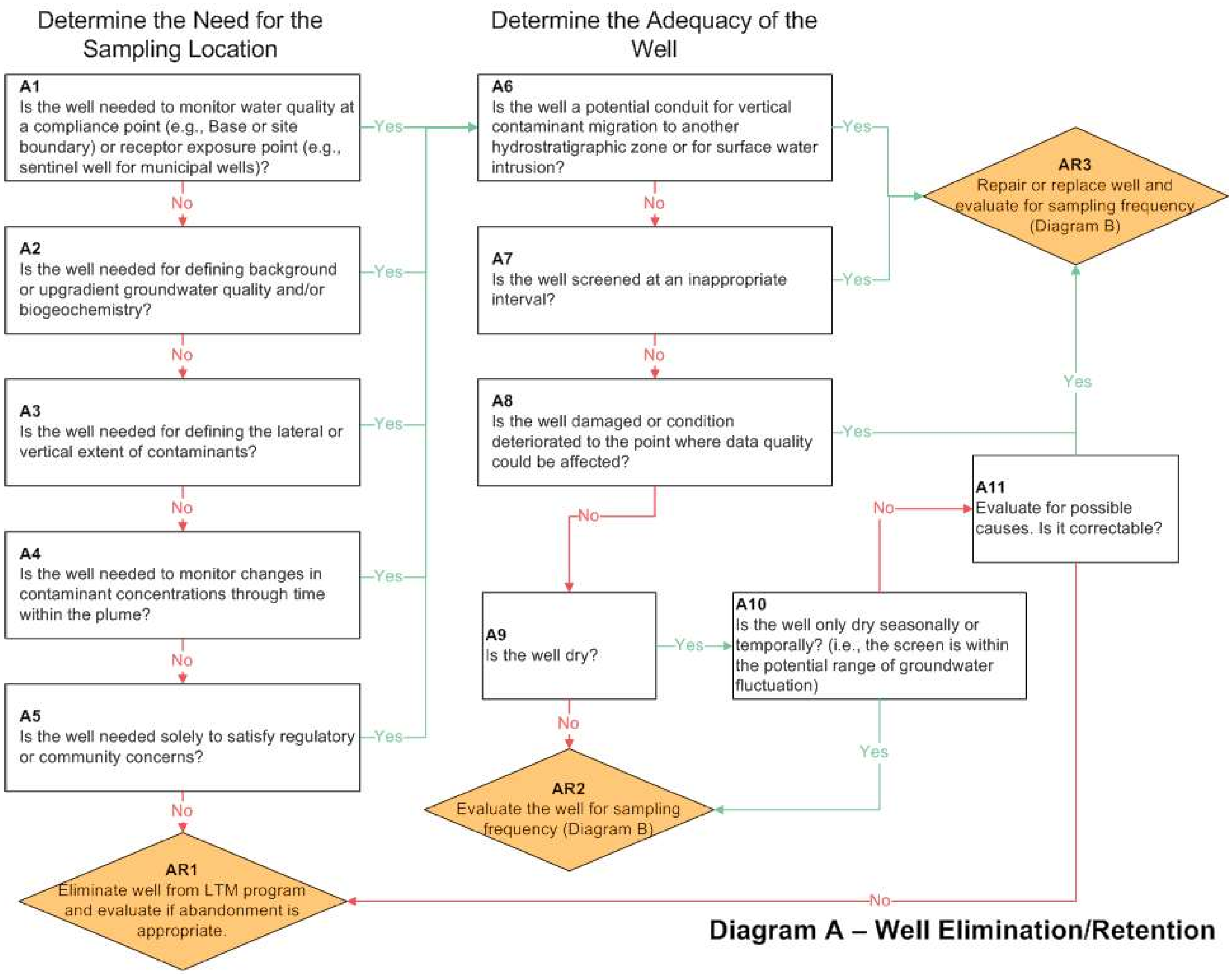
Contaminant mass and concentrations in groundwater at CSSA are expected to decrease in the future as PCE naturally attenuates and engineered remedial actions are performed. Therefore, the groundwater monitoring program recommendations for some areas outlined in this report are likely conservative in that they are based on current conditions and do not take into account the beneficial impact of future natural attenuation and engineered remedial actions. In some instances, groundwater monitoring frequencies for some wells may need to be temporarily increased to monitor the effectiveness of a short-term remedial action (e.g., enhanced in situ bioremediation). The remedial action work plans outline the specific groundwater monitoring plans that are implemented in localized areas to monitor the impact of the remedial actions.

Figure 4.1

3TMO Decision Diagram for Qualitative Evaluation of Well Elimination/Retention

Long-Term Monitoring Network Optimization Evaluation

Camp Stanley Storage Activity, Boerne, TX



Source: 3TMO User's Guide

"AR" indicates a recommendation endpoint for Decision Diagram A (Well Elimination/Retention Evaluation)

FIGURE 4.2
Temporal Trend Decision Flowchart
Long-Term Monitoring Network Optimization Evaluation
Camp Stanley Storage Activity, Boerne, TX

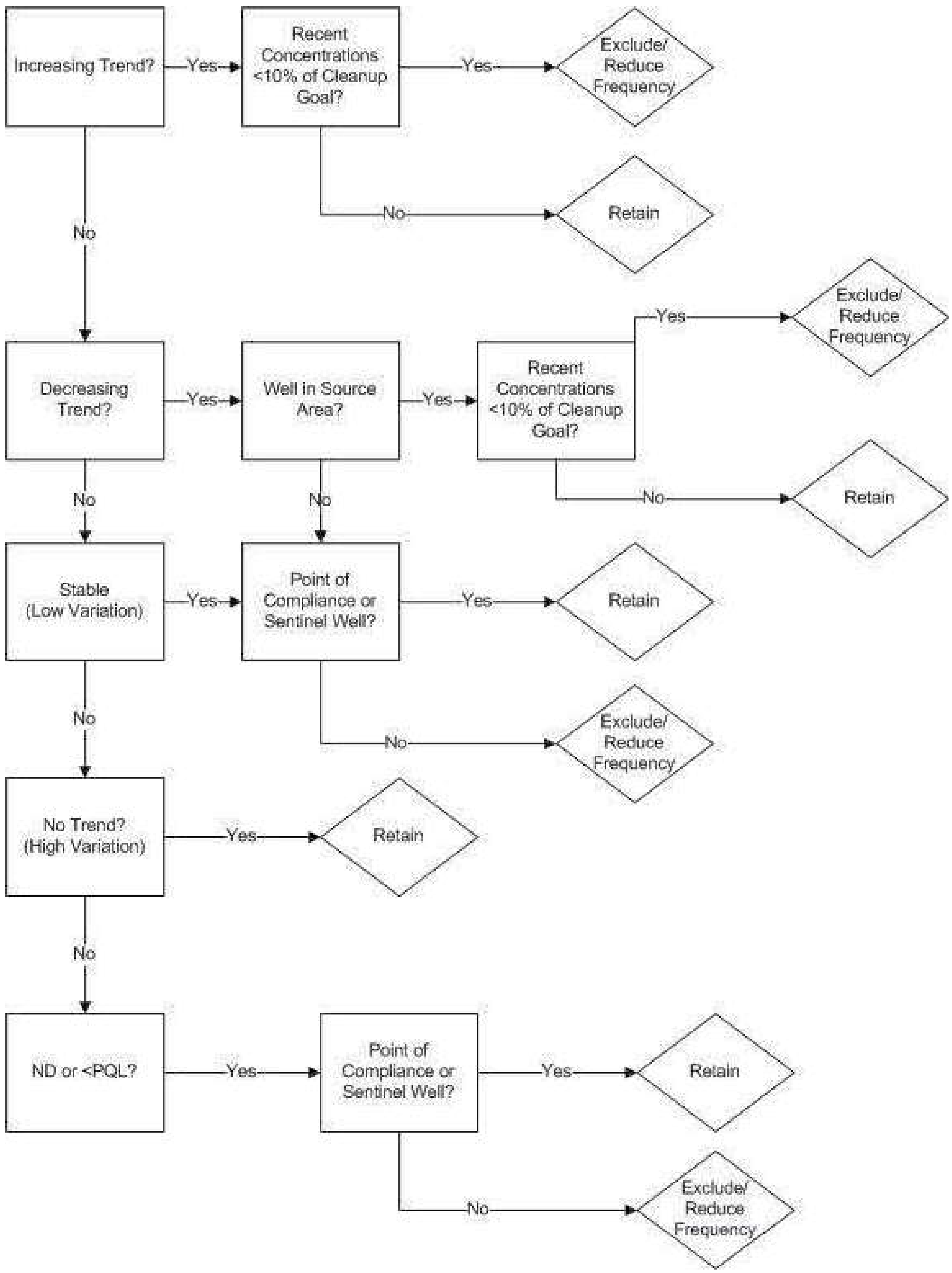


Figure 4.3
3TMO Retain/Exclude Recommendation Logic
Long-Term Monitoring Network Optimization Evaluation
Camp Stanley Storage Activity, Boerne, TX

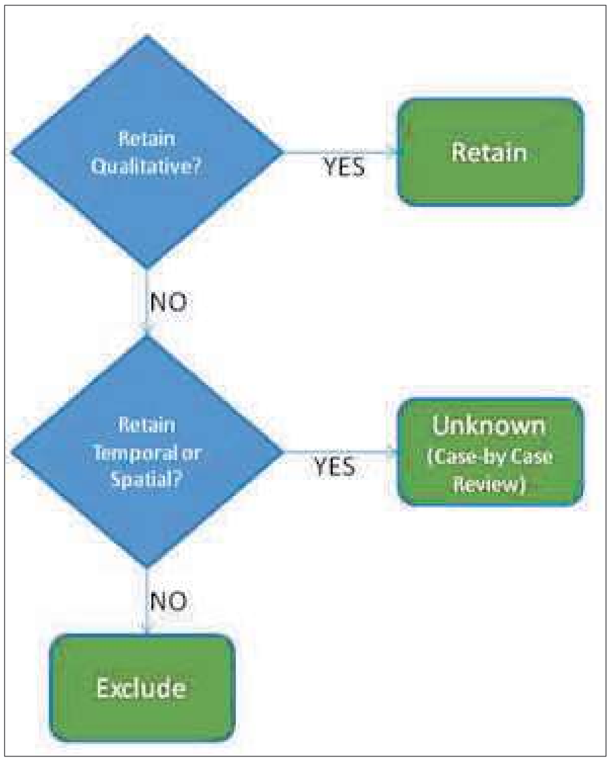
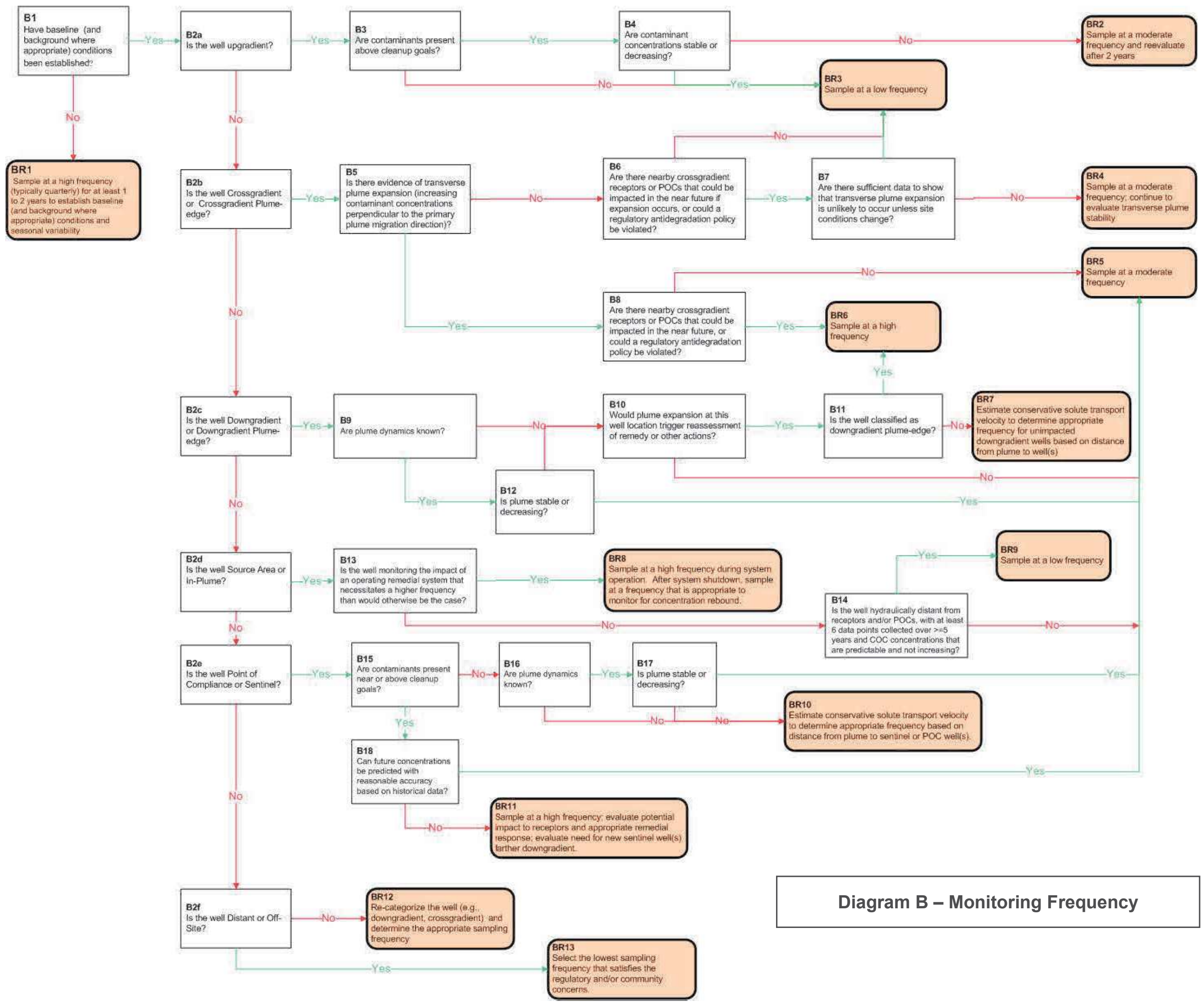


Figure 4.4
3TMO Decision Diagram For Monitoring Frequency Evaluation
Long-Term Monitoring Network Optimization Evaluation
Camp Stanley Storage Activity, Boerne, TX



Source: 3TMO User's Guide.
"BR" indicates a recommendation endpoint for Decision Diagram B (Monitoring Frequency)

5 LTMO RESULTS FOR PLUMES 1 AND 2 AND CORRECTIVE MEASURES MONITORING PROGRAMS

A total of 126 sampling locations were included in the LTMO evaluation. LTMO results for the Plume 1 and 2 areas as well as the corrective measures sites (SWMU B-3/bioreactor and AOC-65/ISCO) are presented and discussed in the following sections. Sampling locations for Plumes 1 and 2 and corrective measures sites are shown on **Figure 5.1**. Wells labeled as "Excluded" on Figure 5.1 are explained further in Sections 5.1.2 and 5.2.2.

5.1 PLUME 1

For this LTMO evaluation, wells associated with corrective measures monitoring were evaluated separately from groundwater monitoring program wells. In total, 88 sampling locations are located within the Plume 1 area. A total of 30 wells were evaluated for Plume 1 trends and 61 sampling locations were evaluated for bioreactor corrective measures trends (three sampling locations fall within both the Plume 1 and bioreactor evaluations). This differs from the 2015 LTMO evaluation where a total of 77 sampling locations were considered for the entire Plume 1 area. Those 77 sampling locations were a combination of wells associated with the groundwater monitoring program for Plume 1 as well as wells associated with performance monitoring of the bioreactor corrective measure.

Well-specific details for the evaluation of Plume 1 sampling locations with 3TMO are provided in **Table 5.1**. Well-specific details for the evaluation of Plume 1 sampling locations with 3TMO are provided in **Table 5.1**. In summary, Plume 1 is currently monitored with the following number of points (wells/Westbay zones) and frequencies, excluding the SWMU B-3 sampling points:

- 4 water supply wells sampled quarterly,
- 7 monitoring points sampled every 15 months, and
- 20 monitoring points sampled every 2.5 years (30 months).

5.1.1 PLUME 1 TREND ANALYSIS RESULTS

As described in Section 4.2, the data set used for temporal trend analysis incorporated COC analytical data collected between 2014 and 2019. The calculated Mann-Kendall trends for Plume 1 wells is provided in Table 5.2.

In general, the Mann-Kendall trends for Plume 1 sampling locations indicate that the PCE plume is stable or decreasing. Of the 30 wells included within the Plume 1 well group:

- 18 wells had no PCE detected in samples collected during the assessment period;
- 7 wells are described as below the PQL, meaning there has been at least one detection above the method detection limit but below the reporting limit (RL) during the assessment period;
- 1 well is described as having a stable trend,
- 2 wells with detections above the DQO-defined cleanup goal of 4.5 µg/L had decreasing trends;
- 1 well with detections above the cleanup goal had a probably decreasing trend; and
- 1 well had no trend.

TCE and *cis*-DCE trends are similar to the PCE trends for the Plume 1 well group with most of the wells having no detections, a few wells are below the PQL, and three wells indicate either a stable or decreasing contaminant trend. No detections of VC were present in Plume 1 monitoring wells during the assessment period.

5.1.2 PLUME 1 WELL RETENTION EVALUATION RESULTS

The 3TMO well retention recommendations are based on results from the qualitative, temporal, and spatial evaluations. Based on all three 3TMO evaluations, only three wells were recommended for exclusion across all three individual evaluations. A summary of the evaluation results is presented below:

	Qualitative Evaluation	Temporal Evaluation	Spatial Evaluation
No. of Sampling points recommended for retention	21	5	23
No. of sampling points recommended for exclusion/reduction	9	25	7

The three wells recommended for exclusion across all three categories were CS-MW9-CC and CS-MW12-CC, which are both on a 30-month sampling frequency, and CS-MW12-LGR, which is on a 15-month sampling frequency.

However, it is left up to the user to determine the final well retention status by taking into consideration all of the results from the individual evaluations as well as the overall objectives of the monitoring program. Wells CS-MW9-CC and CS-MW12-CC are two of only four CC wells around Plume 1, and CS-MW12-LGR is situated along a fault between the SWMU B-3 source and the CSSA boundary. In addition, removing these three wells from the Plume 1 sampling program would result in a reduction of only 8 samples over a 5-year period. As such, all currently sampled Plume 1 wells are recommended for retention.

Sixty-one sampling locations within the current Plume 1 groundwater monitoring program are well suited to evaluate the performance monitoring of the bioreactor corrective measure within the Plume 1 source area (SWMU B-3). These sampling locations were therefore classified as bioreactor performance monitoring locations and included within the optimized SWMU B-3 corrective measure performance monitoring program. As a result, 30 sampling wells are retained in the Plume 1 groundwater monitoring program, and the remaining 24 wells (47 sampling locations) are grouped within the bioreactor performance monitoring program going forward (Section 5.3).

5.1.3 PLUME 1 MONITORING FREQUENCY EVALUATION RESULTS

Twenty-five of the 30 Plume 1 sampling locations retained are recommended by 3TMO for a reduction in monitoring frequency (Table 5.3). The primary reasons for recommending an overall reduction in monitoring intensity for the Plume 1 area are as follows:

- The area has been intensely monitored for many years, and the conceptual site model, including plume footprints and temporal concentration trends, has been well-defined;
- Human and ecological health risks in the Plume 1 area are low due to a lack of receptors (Parsons 2014a); and
- Most temporal trends for PCE are not increasing (i.e., they are stable, decreasing, or do not exhibit a statistically defensible trend [i.e., "no trend]), indicating that contaminant plumes are primarily stable or diminishing.

Of the 25 wells recommended for reduced frequency, 18 of the wells are already only being sampled once every 2.5 years (30 months). Of the remaining 7, three wells are water supply wells being sampled quarterly, and four wells (CS-D, CS-MW1-LGR, CS-MW5-LGR, and CS-MW12-LGR) are sampled every 15 months. While the 3TMO evaluation recommends a decrease in monitoring frequencies for many wells, the current 15- or 30- month sampling schedule is considered to be of sufficient duration to maintain the integrity of the monitoring program and should be retained. Additionally, no changes to the quarterly monitoring of on-post drinking water wells is recommended. Recommended monitoring frequencies for retained Plume 1 area wells range from quarterly to every 30 months. The current 15- or 30-month sampling schedule allows for observation of potential seasonal influences on contaminant concentrations and water levels.

In summary, the final recommendation for the 30 Plume 1 groundwater sampling locations includes no changes to either the retention/exclusion of wells or to the current monitoring schedule for individual wells other than those wells that are assigned to the SWMU B-3 corrective measure performance monitoring program going forward.

5.1.4 PLUME 1 COMPARISON OF CURRENT AND OPTIMIZED MONITORING PROGRAMS

The scopes of the current and optimized monitoring programs for the Plume 1 area are summarized below. Periodic monitoring of 30 sampling locations is recommended in the optimized monitoring program versus 73 in the current (2015) program. The reduction in the number of sampling locations is strictly categorical, in that

58 sampling locations included in the current Plume 1 will become part of the SWMU B-3 corrective measure performance monitoring program.

As a result of the reclassifications, the optimized monitoring program for Plume 1 groundwater includes 144 well sampling events over a five-year period versus 400 sampling events in the current program. This equates to a reduction of 64 percent (%) over the five years. A well sampling event is defined as a single sampling event at a single well. However, as most of the reduced sampling events are recaptured within the bioreactor performance monitoring program, the actual reduction over five years is approximately 3%.

	Plume 1 Summary Comparison			
	Number of Sampling Points (Well or WB Zone)		Sampling Events Over 5-Year Period	
Frequency	Current Program	Optimized Program	Current Program	Optimized Program
Every 30 months	20	20	40	40
Every 15 months	7	6	28	24
Every 9 months	42	0	252	0
Quarterly	4	4	80	80
Total	**73**	30	**400**	**144**
			Reduction over 5 Years	64%

5.2 PLUME 2

A total of 73 sampling locations were analyzed in the 2020 LTMO evaluation for Plume 2. Well-specific details input to 3TMO are provided in **Table 5.4**. Temporal trend analysis results are included in **Table 5.5** and **Figures 5.2** through **5.4.** Well data used in the 3TMO analyses for Plume 2 were limited to the period following the 2015 LTMO evaluation or the last four sampling results for wells with fewer than four results following the 2015 LTMO evaluation. In summary, Plume 2 is currently monitored with the following number of wells/Westbay zones and frequencies:

- 6 private water supply wells sampled quarterly,
- 49 monitoring points sampled every 15 months, and
- 18 monitoring points sampled every 2.5 years (30 months).

5.2.1 PLUME 2 TREND ANALYSIS RESULTS

In general, the Mann-Kendall trend analyses for Plume 2 wells indicate stable or decreasing PCE trends within on- and off-post wells. The majority of sampling results were non-detect or detections below the RL. Only one monitoring location within the existing plume boundary indicated an increasing PCE trend and eight monitoring locations indicated decreasing or probably decreasing trends. Decreasing trends included Westbay well zones (in-plume) and two on-post in-plume wells. Stable PCE concentration trends were observed at in-plume sampling locations including: Westbay well zones, off-post supply wells, and on-post monitoring wells. Two Westbay well zone locations have fewer than four sampling results. This is primarily due to the typically low water levels within the UGR and current sampling frequencies (15 months) for these zones.

Mann-Kendall trend analyses results for TCE generally indicate decreasing or stable trends. Thirty-nine of the 73 Plume 2 sampling locations were ND or below the PQL. Of the remaining 34 locations:

- 13 indicate decreasing or probably decreasing trends;
- 12 indicate stable trends;
- 4 indicate increasing or probably increasing trends;
- 3 had no trend; and
- 2 had fewer than four results and could not be evaluated.

Few trends are available for *cis*-DCE and VC. For *cis*-DCE, of the 73 monitoring locations:

- 39 included no detections;
- 12 had results below the PQL;
- 10 indicate stable trends;
- 2 indicate decreasing trends;
- 2 indicate increasing trends;
- 1 is probably increasing;
- 5 had no trend; and
- 2 had fewer than four results and could not be evaluated.

Mann-Kendall trend analysis for VC concentrations within Plume 2 monitoring locations resulted in no trend determinations as no VC was detected in 65 of the 73 locations, four locations had fewer than 4 results, and no trend was determined for the remaining four locations.

Based on the results of the 3TMO Mann-Kendall trend analyses, 52 locations are recommended for either exclusion from the program or reduced sampling frequencies and 19 locations are recommended for retention. No recommendation is provided for two locations with fewer than four samples collected during the assessment period.

5.2.2 PLUME 2 WELL RETENTION EVALUATION RESULTS

The 3TMO well retention recommendations are based on results from the qualitative, temporal, and spatial evaluations, summarized below, and described in detail in **Table 5.6**.

	Qualitative Evaluation	Temporal Evaluation*	Spatial Evaluation
No. of sampling points recommended for retention	70	19	73
No. of sampling points recommended for exclusion/reduction	3	52	0
No. of sampling points not analyzed (no water)	0	2	0

Following the 3TMO evaluations, summarized below, all 73 sampling locations are recommended for retention. None of the thirty-one Plume 2 wells (73 monitoring locations) currently monitored are recommended for immediate exclusion from future monitoring.

Following the 3TMO evaluations, summarized below, all 73 sampling locations are recommended for retention. None of the thirty-one Plume 2 wells (73 monitoring locations) currently monitored are recommended for immediate exclusion from future monitoring.The DQO flowchart in **Figure 5.5** shows the potential monitoring paths for off-post wells. Based on the DQO flowchart, wells that are greater than 1.5 miles from the CSSA boundary or have consecutive non-detects over a 5-year period may be dropped from the sampling program but retained for possible future sampling if conditions change or warrant further sampling. Off-post wells that met the distance or 5-year criteria of non-detect were excluded immediately following the implementation of the revised DQOs in 2015. Monitoring at off-post wells following the implementation of the 2015 DQOs allowed for the exclusion of six off-post wells (listed in the below table) once they individually met the 5-year ND criteria. The remaining off-post wells are retained at their recommended frequency until they satisfy the DQO of 5 years without a reportable detection.

Well ID(s)	**Reason for Exclusion / Date Excluded**
JW-5, OW-HH2, and OW-BARNOWL	ND History / September 2016
BSR-04 and HS-1	ND History / September 2017
JW-20	ND history / March 2019

Off-post well owners will be notified by mail using a public fact sheet followed by a personal notification letter if their well is slated for removal from the sampling network. Each notification letter will include a graph or other visual representation of all past sampling results for the well. Additional details on well owner notification are included **Appendix A**. CSSA will maintain a list of well owner information, verified on a regular basis with the county appraisal district, for all off-post wells in the sampling program even if they are removed from the program in the future.

New off-post drinking water wells may be added to the program in the future. Locations of new wells to be sampled will be based on the inferred-flow direction of the off-post VOC plume derived from historical data. Concerns of area residential well owners will be dealt with on a case-by-case basis. If a well owner outside of the 1.5-mile radius of CSSA requests a sample, that sampling, if done, would not be part of the DQO program.

5.2.3 PLUME 2 MONITORING FREQUENCY EVALUATION RESULTS

Recommended monitoring frequencies for retained Plume 2 area wells range from quarterly to every 30 months. The current quarterly, 15-month, or 30-month sampling schedule allows for monitoring of seasonal influences on contaminant concentrations and water levels. Wells on a 15-month sampling schedule allow for observation of potential seasonal influences on contaminant concentrations and water levels.

Forty-nine locations are recommended for sampling every 15 months, and 18 locations are recommended for sampling every 30 months (**Table 5.6**). The primary reasons for recommending no change to the current monitoring frequencies for the Plume 2 area are as follows:

- The area has been intensely monitored for many years, and the conceptual site model, including plume footprints and temporal concentration trends, has been well-defined.
- Both ecological and human health risks to receptors in the Plume 2 area are low. All private groundwater wells with solvents present at concentrations greater than 90 percent of the MCL have been equipped with GAC units and wells in the area are sampled quarterly. Only sporadic, trace concentrations of VOCs have been detected in BS and CC wells within Plume 2 (Parsons 2014a).
- Most temporal trends, especially those measured over the most recent five years of sampling are not increasing (i.e., they are stable, decreasing, or do not exhibit a statistically defensible trend [i.e., “no trend”]), indicating that contaminant plumes are primarily stable or diminishing.
- Despite the plume’s spatial stability and stable to decreasing concentrations, it is located on CSSA’s boundary, and several private water wells have been impacted with above-MCL concentrations; therefore, additional reductions beyond those resulting from previous LTMO evaluations are not recommended.

As a result of the above, the intensity of monitoring at Plume 2 can be maintained while still achieving monitoring objectives and being protective of human health and the environment. Recommended monitoring frequencies for retained Plume 2 wells range from quarterly to every 30 months. Six of the 31 wells recommended for continued monitoring are recommended for continued quarterly sampling. These six wells are private domestic water supply wells with GAC wellhead protection units. Five monitoring locations are recommended for an increase in monitoring frequency (from every 30 months to every 15 months). These include the lowest zones within the CS-WB04 Westbay well (BS-01, BS-02, CC-01, CC-02, and CC-03 zones). No trend was determined for 4 of these zones and the uppermost of these (BS-01) was below the PQL; however, recent PCE concentrations within the lowest BS zone (BS-02) and all of the CC zones are at a historic high level including one result above the MCL for PCE within the lowest CS-WB04-CC-03 zone (9.2 μg/L).

5.2.4 PLUME 2 COMPARISON OF CURRENT AND OPTIMIZED MONITORING PROGRAMS

The scopes of the current and optimized monitoring programs for the Plumes 2 area are summarized below. Periodic monitoring of 73 sampling locations is recommended in both the current and optimized monitoring programs. As a result of frequency increases within 5 of the WB04 zones, the optimized monitoring program includes 362 well sampling events over a five-year period versus 352 sampling events in the current program. This equates to an increase of approximately 3%. A well sampling event is defined as a single sampling event at a single well. As described in Section 5.2.3, the intensity of monitoring can be maintained while still achieving monitoring objectives and being protective of human health and the environment.

	Plume 2 Summary Comparison			
	Number of Sampling Points (Well or WB Zone)		Sampling Events Over 5-Year Period	
Frequency	Current Program	Optimized Program	Current Program	Optimized Program
Every 30 months	18	11	36	22
Every 15 months	49	55	196	220
Quarterly	6	6	120	120
Total	**73**	**73**	**352**	**362**
			Increase over 5 Years	2.84%

5.3 SWMU B-3 CORRECTIVE MEASURE

5.3.1 BIOREACTOR TREND ANALYSIS RESULTS

A total of 61 sampling locations were included in the LTMO evaluation for the bioreactor corrective measure. These locations include monitoring wells, extraction wells, injection wells, Westbay well zones, and bioreactor trench sumps. Four locations (3 injection wells and 1 WB well zone) included less than 4 results for the total history of the monitoring location thus no Mann-Kendall trend was obtained. Therefore, a total of 57 locations were used for trend analyses. Well-specific details input into 3TMO are provided in **Table 5.7**.

Temporal trend analysis results are included in **Table 5.8** and **Figures 5.2** through **5.4**. Well data used for 3TMO analyses for the bioreactor were limited to the period following the 2015 LTMO or the last four sampling results if fewer than four results are available after the 2015 LTMO evaluation. Including the most recent data reduces the bias inherent in older data due to the typically shorter sampling frequencies and would therefore not accurately depict more recent conditions.

The bioreactor remediates groundwater via enhanced anaerobic bioremediation (EAB) and the process of sequential reductive dechlorination where the most chlorinated species (PCE) are reduced first by microbes as they remove of a chlorine ion creating a lower tier species (TCE). When PCE has been reduced, microbes then target the reduced species (TCE), again removing a chlorine ion and creating DCE. The process continues from DCE to VC, which then is ultimately reduced to ethene.

In general, Mann-Kendall trend analyses from the bioreactor indicate stable or decreasing trends for PCE. Of the 57 locations, 17 indicated a stable trend and 10 locations indicated decreasing (6) or probably decreasing (4) trends. Only 2 locations indicate probably increasing PCE concentration trends. Twelve locations indicated results less than the PQL, and 2 locations indicated no detections of PCE within the last 5 years. No trend was discernable for 14 of the bioreactor monitoring locations.

Mann-Kendall TCE trends similarly indicate stable or decreasing concentration trends. Twenty-four monitoring locations indicate stable conditions and 12 locations indicate decreasing (10) or probably decreasing (2) trends. Two locations indicated increasing TCE concentration trends and one location indicated a probably increasing trend. No trend was discernable from the data from 7 locations, and 9 locations were less than the PQL.

Mann-Kendall cis-DCE trends indicate predominately stable conditions within bioreactor monitoring locations. Thirty-two of the 57 locations analyzed indicate stable conditions. Another 11 locations indicate decreasing (9) or probably decreasing (2) trends. Three locations indicate increasing concentration trends, one location includes results below the PQL, and one location had no detections.

Trend analysis for VC from bioreactor monitoring locations was variable. No trend was discernible for 20 of the 57 locations. Sixteen locations had no detections of VC and 13 locations indicated stable concentrations.

5.3.2 BIOREACTOR MONITORING LOCATION RETENTION EVALUATION RESULTS

Sixty-one bioreactor monitoring locations were evaluated for retention via 3TMO. The 3TMO results summary table (Table 5.9) includes individual qualitative, temporal, and spatial evaluation results as well as the 3TMO recommendation. Taking into consideration the individual results as well as the 3TMO recommendation, a final evaluation is determined by the user. The 3TMO retention recommendation for bioreactor monitoring locations included retaining 57 locations, and the remaining 4 locations were listed as "unknown". These locations include 4 injection wells at the bioreactor that are sampled as needed. The final evaluation, taking qualitative, temporal, and spatial evaluation results into consideration, includes the retention of all 61 monitoring locations.

5.3.3 BIOREACTOR MONITORING FREQUENCY EVALUATION RESULTS

Monitoring frequencies for corrective measure monitoring are anticipated to be more frequent than the broader Plume 1 groundwater monitoring so that remedy progress can be evaluated and changes to the operation of the corrective measure can be performed in a timely fashion. The current performance monitoring frequencies at the bioreactor include quarterly, semi-annual, and every 9-months. Monitoring locations that are sampled on a quarterly or semi-annual basis, are sampled to meet the State-directed requirements for operating the system as it is intended, via the injection of fluids, and no deviation from these set sampling frequencies is allowed. Recommended monitoring frequency for the remaining retained bioreactor corrective measure monitoring locations is every 9-months. Wells on a 9-month sampling schedule are sampled frequently enough that: 1) changes to bioreactor performance criteria can be identified and optimizations made to the system to ensure it is functioning as intended and; 2) observation of potential seasonal influences on contaminant concentrations and water levels can be achieved.

5.3.4 BIOREACTOR ANALYSES OPTIMIZATION

The bioreactor corrective measure performance monitoring program at SWMU B-3 includes a suite of analyses for monitoring the reductive dechlorination of contaminants, status of microbial populations, geochemical conditions, and various reaction byproducts. The full list of analytes monitored to determine bioreactor performance include:

- VOCs – Primary COCs (PCE and TCE) and reductive dechlorination products (cis-DCE and VC); UIC permit requirement for operation of the bioreactor
- Metals – Arsenic and Manganese indicator of geochemical conditions and secondary COC (As) resulting from changing conditions in groundwater and interactions with the limestone bedrock
- Ferrous Iron – an indicator of iron-reducing conditions
- Anions – Chloride is an indicator of the reduction of VOCs and Sulfate (along with Sulfide) for monitoring sulfate-reducing conditions
- Sulfide – an indicator of sulfate-reducing conditions
- TOC – an indicator of the total organic carbon available for fermentation
- Methane, Ethane, Ethene, and CO2 – indicators of methanogenesis (methane, ethane, and CO2) and the final product of complete reductive dechlorination of VOCs (ethene) by anaerobic bioremediation
- Hydrogen – required for microbes to reductively dechlorinate VOCs
- Microbial population census – indicator of *dehalococcoides* population size and functional genes responsible for reductive dechlorination of VOCs
- Total Dissolved Solids (TDS) – parameter required for maintenance of UIC permit for injection of recovered groundwater.

The collection of VOCs and TDS are required for continued maintenance of the UIC permit for operation of the bioreactor and cannot be optimized. Analysis of secondary COCs like metals and the final product of reductive dechlorination (ethene) should not be optimized. Additionally, organic carbon is a critical for the operation of the corrective measure, therefore, monitoring TOC is considered essential. Likewise, monitoring the microbial population and functional genes present at various locations may help determine if and when additional bioaugmentations are necessary to improve bioreactor performance.

Less critical is the monitoring of what types of reducing conditions are present, therefore, anions (chloride and sulfate), sulfide, and ferrous iron are recommended for reduction to an "As Needed" basis. Hydrogen is necessary for microbes to reduce VOCs, however, it is redundant if it is known that organic carbon is available for fermentation (TOC), fermentation is occurring (CO2), and that anaerobic bioremediation is occurring (microbes are present and the end product ethene is formed), therefore, hydrogen is recommended for optimization and reduced to sampling on an "As Needed" basis.

5.3.5 BIOREACTOR COMPARISON OF CURRENT AND OPTIMIZED MONITORING PROGRAMS

Bioreactor monitoring is currently included within the Plume 1 monitoring program rather than as a standalone program and is identified as the 42 locations sampled every 9-months in the Plume 1 current program table. Quarterly and semi-annual permit-required samples are not currently captured within the Plume 1 monitoring program. The scopes of the current and optimized monitoring programs for bioreactor corrective measure performance monitoring are summarized below. Periodic monitoring of 61 sampling locations is recommended in the optimized monitoring program versus 42 locations currently included within the current Plume 1 groundwater program and including permit required that are currently sampled separately from Plume 1 evaluation. No frequency reductions are recommended at this time. The optimized monitoring program includes 462 well sampling events over a five-year period. A well sampling event is defined as a single sampling event at a single well. As described in Section 5.2.3, the intensity of monitoring can be reduced while still achieving monitoring objectives and being protective of human health and the environment.

While no reductions in sampling location or frequencies are recommended, a reduced suite of analyses is recommended as an optimization of the bioreactor performance monitoring program at SWMU B-3. The recommendation going forward is VOCs, TDS, metals, TOC, methane, ethane, ethene, and CO2 analyses will be performed at all monitoring locations; microbial populations will be performed at select locations; and ferrous iron, sulfide, anions, and hydrogen analyses will be performed on an as needed basis in the optimized performance monitoring program for the bioreactor at SWMU B-3.

	Bioreactor Performance Monitoring Summary Comparison			
	Number of Sampling Points		Sampling Events Over 5-Year Period	
Frequency	Current Program Plume 1/Permit required	Optimized Program	Current Program Plume 1/Permit required	Optimized Program
Every 9 months	42	42	252	252
Quarterly	1	1	20	20
Semi-annual	19	19	190	190
Total	**61**	**61**	**462**	**462**
			Reduction over 5 Years	0%

	Bioreactor Performance Monitoring Analytical Suite	
Analyses	Current Program	Optimized Program
Volatile Organic Compounds (VOCs)	All locations	All locations
Total Dissolved Solids (TDS)	All locations	All locations
Metals (As, Mn)	All locations	All locations
Ferrous Iron	All locations	As Needed
Anions (Chloride, Sulfate)	All locations	As Needed

Sulfide	All locations	As Needed
Total Organic Carbon (TOC)	All locations	All locations
Methane, Ethane, Ethene, CO_2	All locations	All locations
Hydrogen	Select locations	As Needed
Microbial Population	Select locations	Select locations

5.4 AOC-65 CORRECTIVE MEASURE

5.4.1 ISCO TREND ANALYSIS RESULTS

A total of 45 wells (51 monitoring locations) were included in the LTMO evaluation for the AOC-65 ISCO corrective measure. These locations include on-post monitoring wells, ISCO injection wells, treatability study wells, off-post wells, Westbay wells, and wells installed as part of previous treatability studies including vapor extraction wells, steam injections wells, and piezometers. Four Westbay wells are included in the total number of 45 wells and those 4 wells include a total of 10 individual sampling locations monitored for ISCO performance criteria thereby resulting in a total of 51 sampling locations are included in the 2020 LTMO evaluation. The ISCO performance monitoring network includes wells that are also a part of the Plume 2 groundwater monitoring network. These include on- and off-post wells and Westbay well monitoring locations, and though they are evaluated with respect to Plume 2 in Section 5.2, they are also evaluated within the context of ISCO performance monitoring.

Well-specific details input into 3TMO are provided in **Table 5.10**. Temporal trend analysis results are included in **Table 5.11** and Figures 5.2 through 5.4. Well data used in the 3TMO analyses for ISCO performance monitoring are limited to the period following the 2015 LTMO evaluation or the last four sampling results for wells with fewer than four results following the 2015 LTMO evaluation.

Mann Kendall trend analyses for ISCO wells indicate an almost equal number of stable (17) or decreasing and probably decreasing (16) PCE trends within monitoring locations. Nine locations indicate increasing (7) or probably increasing (2) PCE concentration trends, five locations included results less than the PQL and no trend was discernible at four locations. Notably, 38 of the 51 locations analyzed included at least one value above the specified cleanup goal of 90% of the MCL for PCE (4.5 μg/L).

TCE concentration trends for AOC-65 corrective measure monitoring locations are generally decreasing, with 14 locations exhibiting decreasing (8) or probably decreasing (6) trends and 10 locations with stable trends. Nine locations indicate increasing (7) or probably increasing trends, 12 locations had results below the PQL and three locations had no detections of TCE. No trend was determined for three locations.

Low occurrences of *cis*-DCE were observed at AOC-65, and the majority of monitoring locations (27) included no detections or include results below the PQL (9). Seven locations indicate decreasing (4) or probably decreasing trends (3), four locations indicate stable *cis*-DCE trends, and no trend was determined for four locations.

VC is generally not present within AOC-65 monitoring wells. Of the 51 sampling locations analyzed, 45 had no detections, no trend could be determined for four locations, one location had fewer than four data points, and one location included a probably increasing trend.

Currently, the application of chemical oxidants at AOC-65 is performed both passively and actively via the installation of oxidant infused cylinders within wells and injection of an oxidant solution within infiltration cells. As expected, most of the wells where oxidant cylinders are installed include decreasing, probably decreasing trends or include results below the PQL or have no detections.

5.4.2 ISCO WELL RETENTION EVALUATION RESULTS

None of the 51 monitoring locations currently in use for ISCO performance monitoring are recommended for immediate exclusion from future monitoring.

ISCO performance monitoring locations were evaluated via 3TMO to determine if they should be retained for future monitoring or excluded from the corrective measure performance monitoring program. The 3TMO results summary table (**Table 5.12**) includes individual qualitative, temporal, and spatial evaluation results as well as the 3TMO recommendation and the final recommendation for ISCO well retention and monitoring frequency. While the temporal evaluation recommended the exclusion or reduction of sampling at 27 locations, both the qualitative and spatial evaluations recommended the retention of all 51 monitoring locations. The overall 3TMO well retention recommendation includes the retention of all current monitoring locations as does the final recommendation.

5.4.3 ISCO MONITORING FREQUENCY EVALUATION RESULTS

Monitoring frequencies for corrective measure monitoring are anticipated to be more frequent than that of the groundwater monitoring programs so that remedy progress can be evaluated, and changes to the operation of the corrective measure can be performed in a timely manner. The current monitoring frequency at all ISCO performance monitoring locations is quarterly. 3TMO qualitative analysis results for ISCO monitoring frequencies are based on the qualitative questionnaire results for individual locations. For ISCO monitoring, 49 of 51 locations include a recommendation to sample at a high frequency, as these locations monitor the impact of an operating remedial system. Recommendations included monthly to quarterly sampling at 6 locations, semi-annual sampling at 9 locations, annual sampling at 34 locations, biennial sampling at 1 location, and less than biennial monitoring at one location.

The final monitoring frequency recommendation is performed by the user, taking into consideration results from the qualitative analysis and temporal trend evaluation. While a reduction in sampling frequency at ISCO monitoring locations is warranted, annual monitoring may be too infrequent to ensure the remedial system is operating as intended, therefore, a semi-annual monitoring frequency is recommended. Locations monitored on a semi-annual sampling schedule are frequent enough that ISCO performance criteria can be assessed and any necessary changes can be made to the system to ensure it is functioning as intended. Additionally, the collection of field parameters on a quarterly basis will ensure that changes in water levels are identified and cylinders are appropriately deployed within wells.

5.4.4 ISCO ANALYSES OPTIMIZATION

The ISCO corrective measure performance monitoring program at AOC-65 includes a suite of analyses for monitoring the oxidation contaminants, geochemical conditions, and various reaction byproducts. The full list of analytes monitored to determine bioreactor performance include:

- VOCs – Primary contaminant of concern (PCE)
- Metals – 16 different metals. Manganese is an indicator of interactions between oxidants (permanganate) and organic compounds (VOCs), additional metals may be mobilized from the limestone bedrock due to changes in the geochemical conditions in groundwater as a result of ISCO applications
- Anions – Chloride is an indicator of the destruction of VOCs and sulfate a breakdown product of persulfate oxidant

VOCs and metals are the primary analytes for ISCO performance monitoring at AOC-65. VOC concentrations are used to determine where (which well or infiltration cell) oxidant should be applied, when new oxidant cylinders should be installed or readjusted within wells or when liquid applications of oxidant solution is required within infiltration cells, as well as the overall effectiveness of the corrective measure. Metals monitoring is also necessary due to the potential to mobilize metals from the limestone bedrock as a result of changes in the geochemical conditions in groundwater. Less critical is the monitoring of anions (chloride and sulfate). Chloride is a product of the complete destruction of VOCs, thus, increases in chloride concentration may indicate the occurrence of VOC oxidation. However, it is less critical to monitor chloride and other anions (such as sulfate) as anions are typically reactive in solution and are difficult to quantify in a dynamic system. Thus, anion concentrations are at best, an underrepresentation of oxidized VOCs.

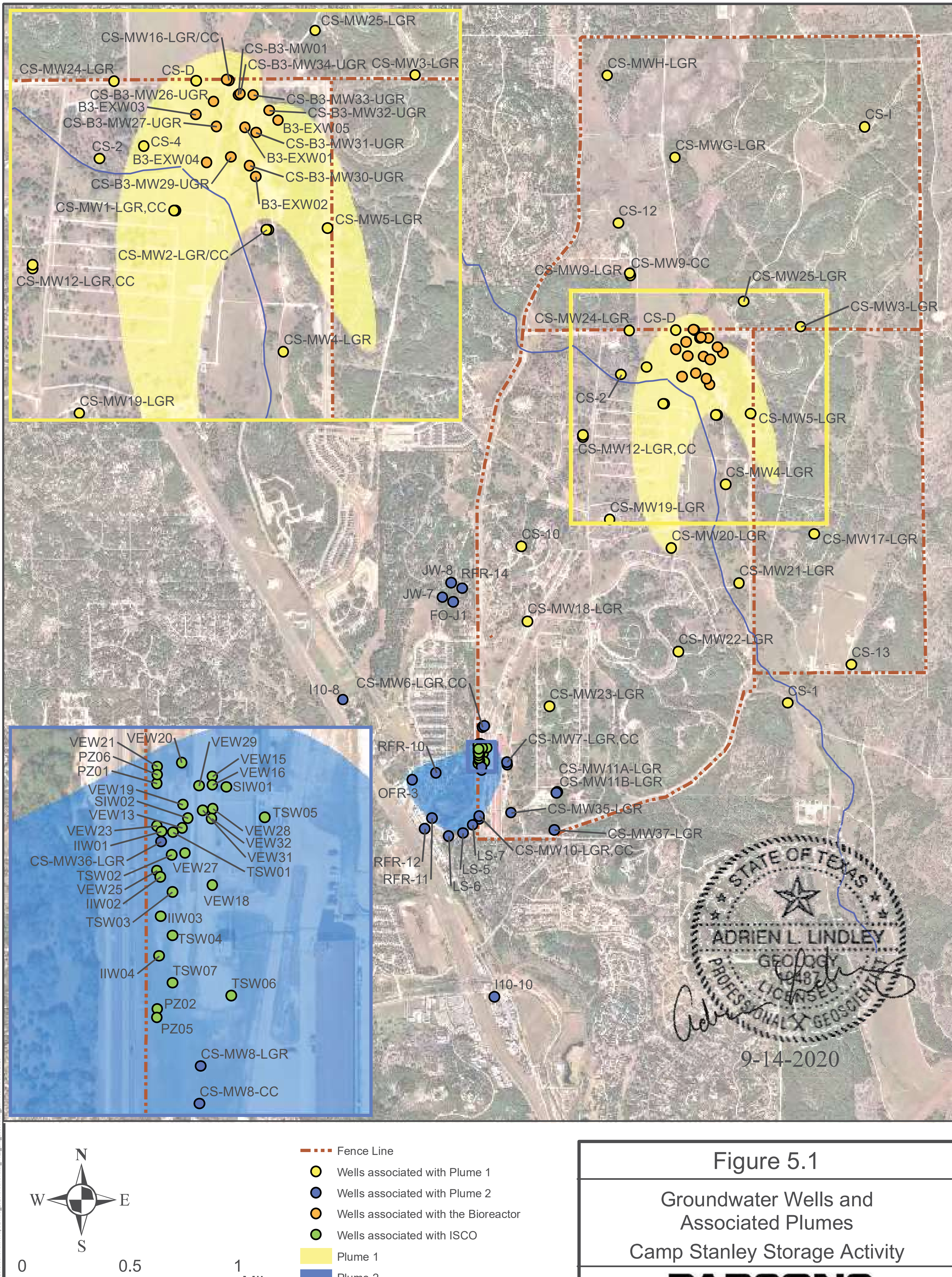
5.4.5 ISCO COMPARISON OF CURRENT AND OPTIMIZED MONITORING PROGRAMS

The current and optimized programs for ISCO performance monitoring are summarized below. Periodic monitoring of 51 sampling locations is recommended in both the current and optimized monitoring programs. As a result of a frequency reduction from quarterly to semi-annual, the optimized monitoring program includes 510 well sampling events over a five-year period versus 1,020 sampling events in the current program. This equates to a 50% reduction. A well sampling event is defined as a single sampling event at a single well. As described in Section 5.2.3, the intensity of monitoring can be reduced while still achieving monitoring objectives and being protective of human health and the environment.

In addition to the reduction in sampling frequency, reduced analytical data will be collected for monitoring the performance of the ISCO corrective measure at AOC-65. The collection of groundwater samples for analysis of anions will be performed on an as needed basis in the optimized monitoring program. VOC and metals analysis will continue to be performed at all performance monitoring locations.

	ISCO Summary Comparison			
	Number of Sampling Points (Well or WB Zone)		Sampling Events Over 5-Year Period	
Frequency	**Current Program**	**Optimized Program**	**Current Program**	**Optimized Program**
Quarterly	51	0	1020	0
Semi-annual	0	51	0	510
Total	**51**	**51**	**1020**	**510**
			Reduction over 5 Years	50%

	ISCO Performance Monitoring Analytical Suites	
Analyses	**Current Program**	**Optimized Program**
Volatile Organic Compounds (VOCs)	All locations	All locations
Metals 16	All locations	All locations
Anions (Chloride, Sulfate)	All locations	As Needed



Fence Line
Wells associated with Plume 1
Wells associated with Plume 2
Wells associated with the Bioreactor
Wells associated with ISCO
Plume 1
Plume 2

Figure 5.1

Groundwater Wells and Associated Plumes

Camp Stanley Storage Activity

PARSONS

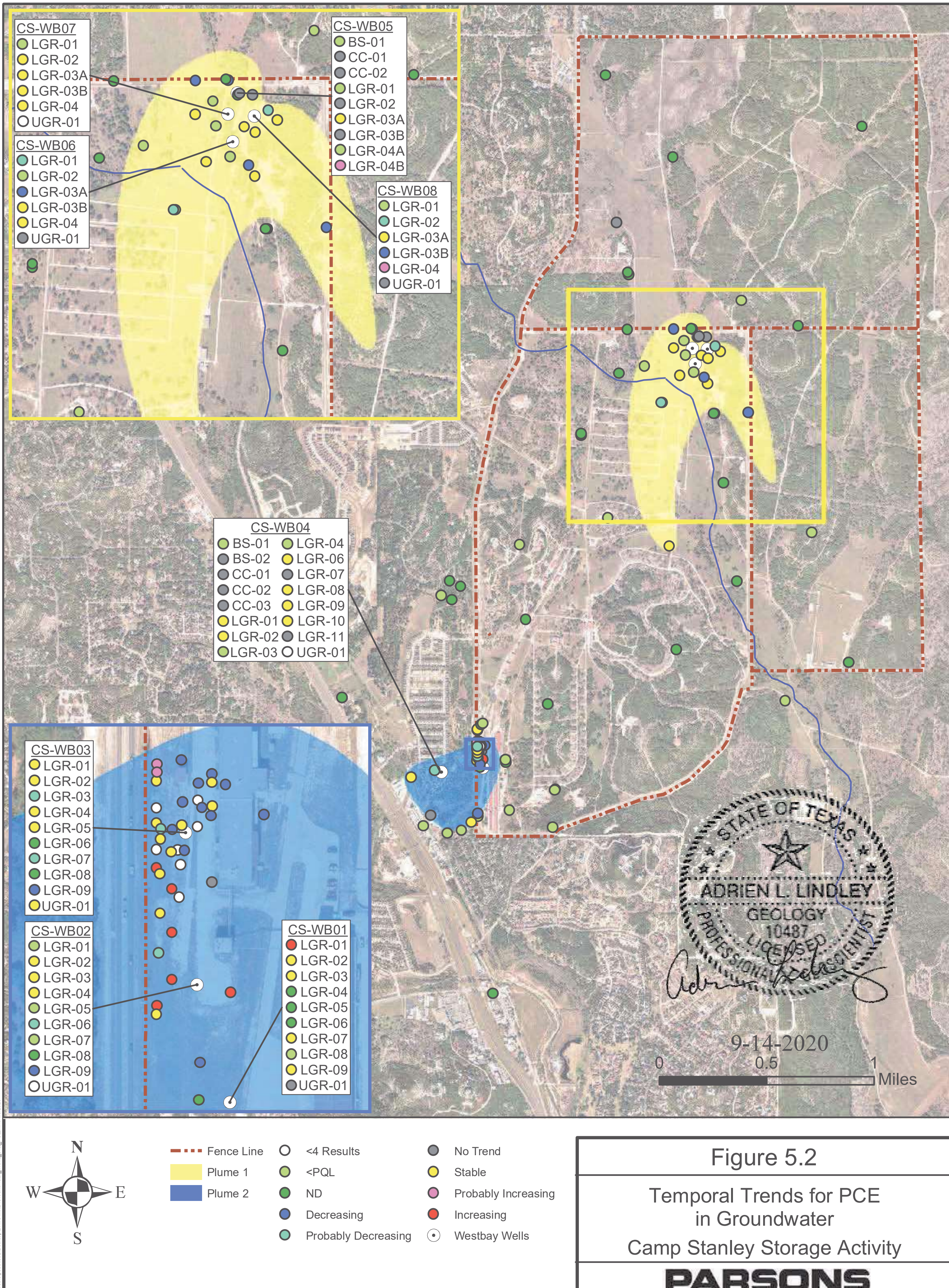


Figure 5.2

Temporal Trends for PCE in Groundwater

Camp Stanley Storage Activity

PARSONS

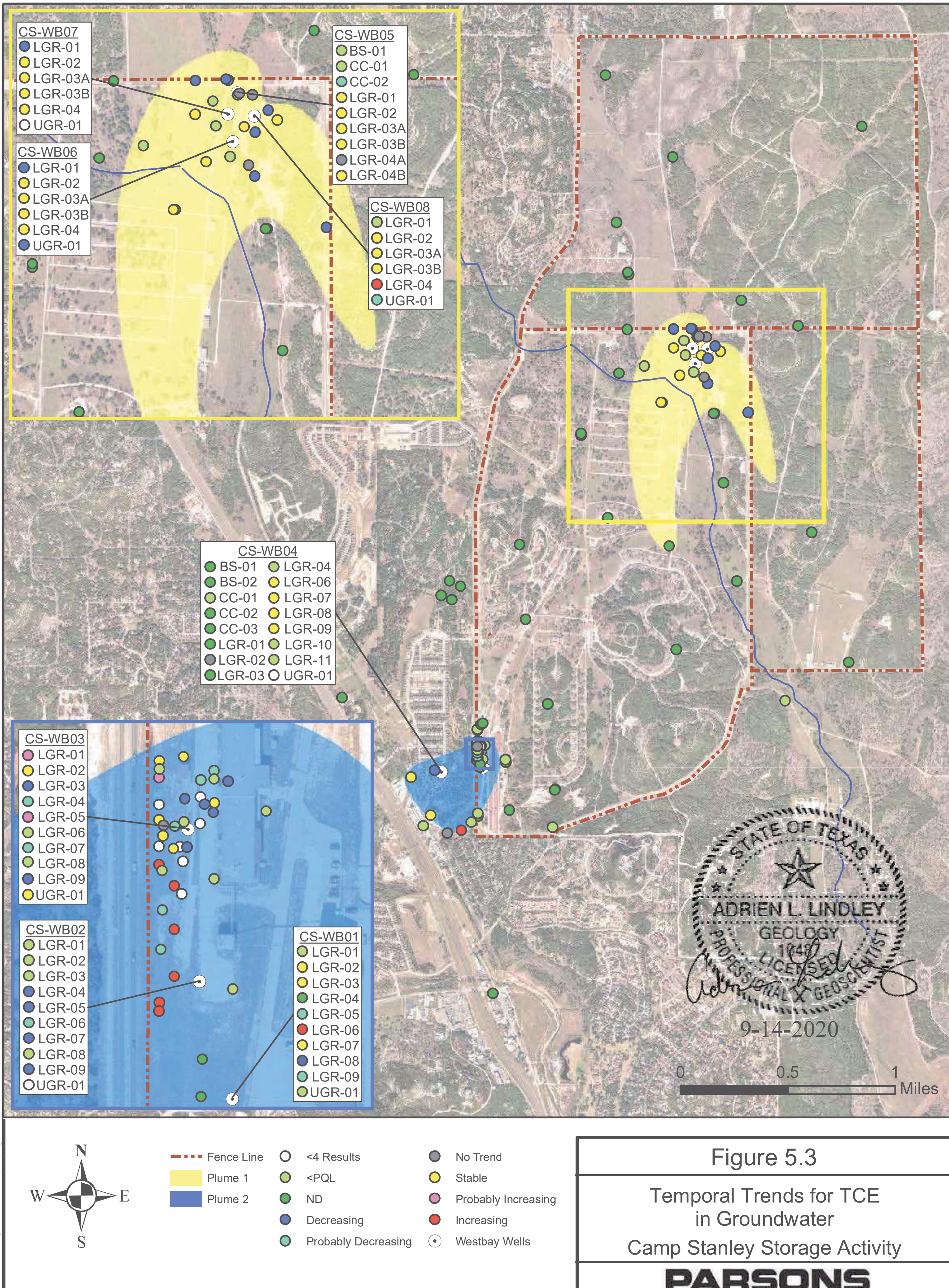


Figure 5.3

Temporal Trends for TCE in Groundwater

Camp Stanley Storage Activity

PARSONS

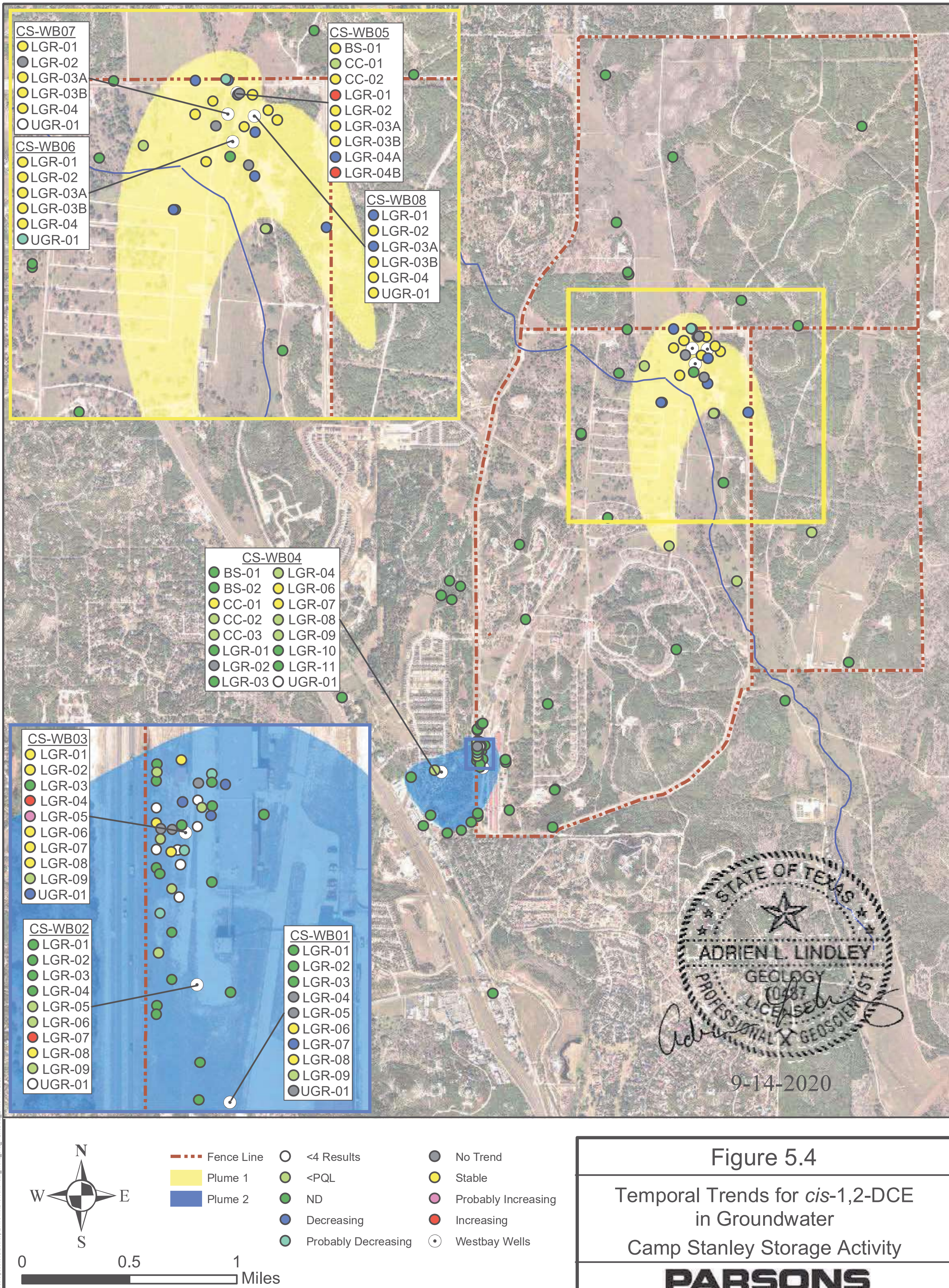


Figure 5.4

Temporal Trends for *cis*-1,2-DCE in Groundwater

Camp Stanley Storage Activity

FIGURE 5.4 - OFF-POST WELLS DECISION TREE

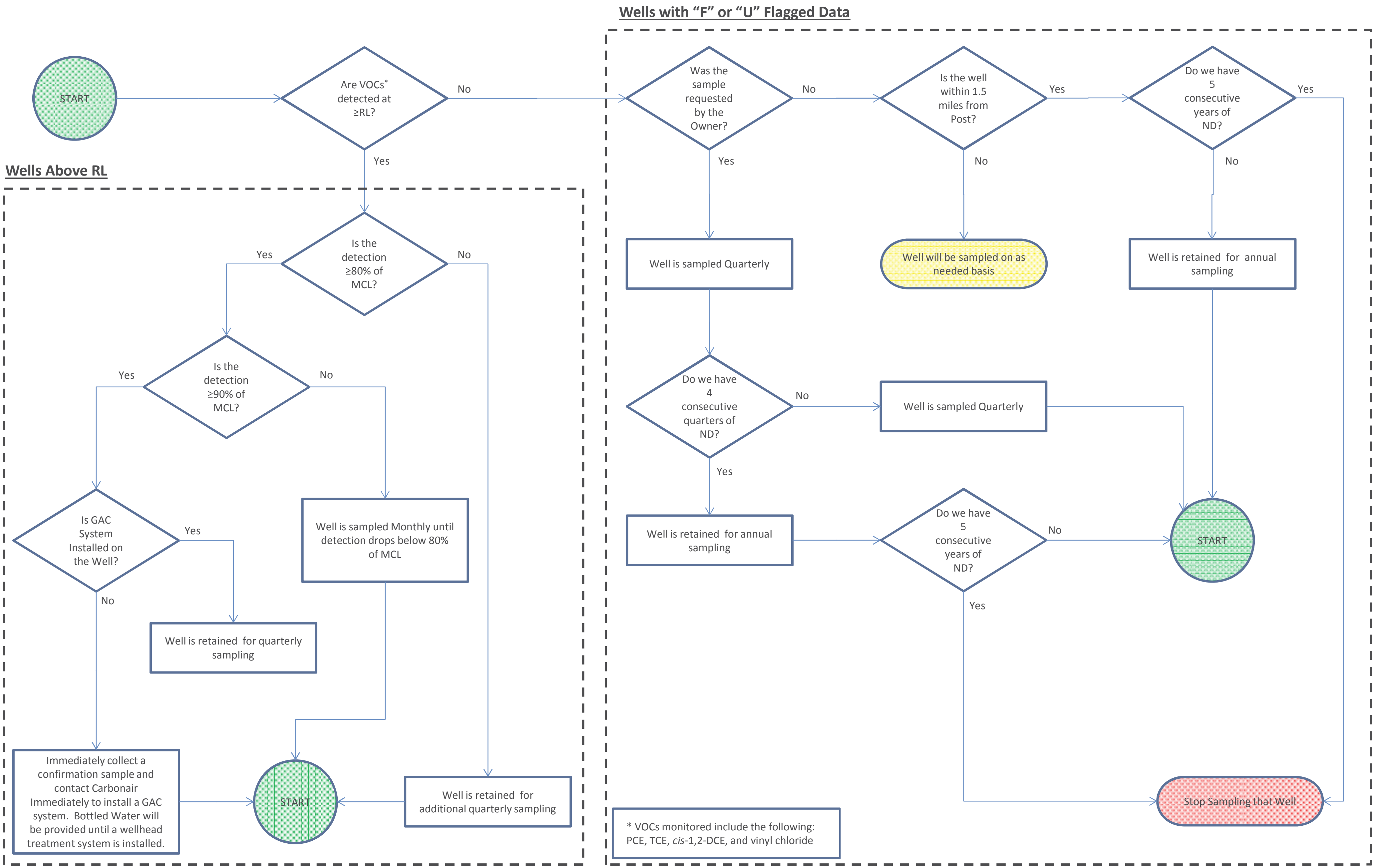


Table 5.1
Plume 1 Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

Well ID	X Coordinates	Y Coordinates	Top of Screen (bgs)[a/]	Bottom of Screen (bgs)	Zone[b/]	Functional Category	Current Sampling Frequency (months)	Risk to Receptors	Predictability of COC Concentrations
CS-1	537,981.325	3,284,051.974	126	432	LGR	Downgradient	3	High	Predictable
CS-2	536,734.986	3,286,508.539	205	350	LGR	In-Plume	30	Low	Predictable
CS-4	536,924.813	3,286,561.387	200	251.5	LGR	In-Plume	15	Low	Predictable
CS-10	535,990.386	3,285,222.523	392	580	LGR + CC	Crossgradient	3	Moderate	Predictable
CS-12	536,715.129	3,287,637.248	149	460	LGR + CC	Upgradient	3	Low	Predictable
CS-13	538,456.824	3,284,340.274	300	579.5	LGR + CC	Downgradient	3	High	Predictable
CS-D	537,147.068	3,286,839.895	205	263	LGR	In-Plume	15	Moderate	Predictable
CS-MWG-LGR	537,134.055	3,288,139.147	155	339	LGR	Upgradient	30	Low	Predictable
CS-MWH-LGR	536,634.309	3,288,741.135	314.5	364.5	LGR	Upgradient	30	Low	Predictable
CS-I	538,556.568	3,288,359.354	258	361.7	LGR	Upgradient	30	Low	Predictable
CS-MW1-LGR	537,052.727	3,286,288.001	288	313	LGR	In-Plume	15	Moderate	Predictable
CS-MW1-CC	537,060.274	3,286,287.112	394.7	419.7	CC	Downgradient	30	Moderate	Predictable
CS-MW2-LGR	537,445.734	3,286,205.856	318	343	LGR	In-Plume	30	Low	Predictable
CS-MW2-CC	537,454.016	3,286,207.172	425.7	450.7	CC	Downgradient	30	Low	Predictable
CS-MW3-LGR	538,077.889	3,286,863.946	402	427	LGR	Crossgradient	30	Low	Predictable
CS-MW4-LGR	537,517.318	3,285,687.194	299	324	LGR	Downgradient	30	Low	Predictable
CS-MW5-LGR	537,704.585	3,286,213.329	420	445	LGR	In-Plume	15	Moderate	Predictable
CS-MW9-LGR	536,801.781	3,287,263.360	296	321	LGR	Upgradient	30	Low	Predictable
CS-MW9-CC	536,807.382	3,287,247.326	425	450	CC	Upgradient	30	Low	Predictable
CS-MW12-LGR	536,451.946	3,286,057.765	333	358	LGR	Downgradient	15	Low	Predictable
CS-MW12-CC	536,450.706	3,286,041.508	440	465	CC	Downgradient	30	Low	Predictable
CS-MW17-LGR	538,177.981	3,285,314.293	367	392	LGR	Sentinel	15	Low	Predictable
CS-MW18-LGR	536,037.378	3,284,664.459	385	410	LGR	Sentinel	30	Low	Predictable
CS-MW19-LGR	536,650.954	3,285,425.697	340	365	LGR	In-Plume	30	Low	Predictable
CS-MW20-LGR	537,111.877	3,285,210.644	305	330	LGR	In-Plume	30	Low	Predictable
CS-MW21-LGR	537,618.542	3,284,950.017	289	314	LGR	Sentinel	30	Low	Predictable
CS-MW22-LGR	537,163.077	3,284,436.585	392	417	LGR	Sentinel	30	Low	Predictable
CS-MW23-LGR	536,199.409	3,284,027.777	372	397	LGR	Downgradient	30	Low	Predictable
CS-MW24-LGR	536,797.414	3,286,837.705	300	325	LGR	Crossgradient	30	Low	Predictable
CS-MW25-LGR	537,652.534	3,287,052.589	352	377	LGR	Upgradient	30	Low	Predictable

[a/] bgs = below ground surface;
[b/] LGR = Lower Glen Rose, CC = Cow Creek, BS = Bexar Shale;
"--" = Not Available or Not Applicable

Table 5.2
Plume 1 Temporal Trend Evaluation
Camp Stanley Storage Activity, Boerne, TX

Well ID	Recommendation	Start Date	End Date	Number of Samples	Category	Contaminants of Concern[a/]			
						PCE	TCE	DCE12C	VC
CS-1	Exclude/Reduce	9/15/2015	12/10/2019	19	Downgradient	<PQL	<PQL	ND	ND
CS-2	Exclude/Reduce	12/14/2015	12/4/2019	4	In-Plume	ND	ND	ND	ND
CS-4	Exclude/Reduce	12/14/2015	9/7/2018	4	In-Plume	<PQL	<PQL	<PQL	ND
CS-10	Exclude/Reduce	9/15/2015	12/10/2019	19	Crossgradient	<PQL	ND	ND	ND
CS-12	Retain	9/15/2015	12/10/2019	20	Upgradient	No Trend	ND	ND	ND
CS-13	Exclude/Reduce	9/14/2015	12/10/2019	16	Downgradient	ND	ND	ND	ND
CS-D	Exclude/Reduce	12/17/2015	12/4/2019	9	In-Plume	Decreasing*	Decreasing*	Decreasing	ND
CS-MWG-LGR	Exclude/Reduce	6/11/2014	12/3/2019	4	Upgradient	ND	ND	ND	ND
CS-MWH-LGR	Exclude/Reduce	12/18/2012	6/20/2017	4	Upgradient	ND	ND	ND	ND
CS-I	Exclude/Reduce	6/11/2014	12/3/2019	4	Upgradient	ND	ND	ND	ND
CS-MW1-LGR	Exclude/Reduce	10/20/2015	12/4/2019	12	In-Plume	Prob. Decreasing*	Stable*	Decreasing	ND
CS-MW1-CC	Exclude/Reduce	9/8/2014	12/4/2019	4	Downgradient	<PQL	ND	ND	ND
CS-MW2-LGR	Exclude/Reduce	12/8/2015	12/5/2019	4	In-Plume	ND	ND	<PQL	ND
CS-MW2-CC	Exclude/Reduce	6/16/2014	12/5/2019	4	Downgradient	ND	ND	ND	ND
CS-MW3-LGR	Exclude/Reduce	12/8/2015	12/3/2019	4	Crossgradient	ND	ND	ND	ND
CS-MW4-LGR	Exclude/Reduce	12/8/2015	12/5/2019	4	Downgradient	ND	ND	ND	ND
CS-MW5-LGR	Exclude/Reduce	2/3/2016	12/5/2019	13	In-Plume	Decreasing*	Decreasing*	Decreasing	ND
CS-MW9-LGR	Exclude/Reduce	12/15/2015	12/4/2019	4	Upgradient	ND	ND	ND	ND
CS-MW9-CC	Exclude/Reduce	6/11/2014	12/4/2019	4	Upgradient	ND	ND	ND	ND
CS-MW12-LGR	Exclude/Reduce	12/14/2015	12/5/2019	5	Downgradient	ND	ND	ND	ND
CS-MW12-CC	Exclude/Reduce	6/12/2014	12/5/2019	4	Downgradient	ND	ND	ND	ND
CS-MW17-LGR	Retain	12/16/2015	12/4/2019	5	Sentinel	<PQL	ND	<PQL	ND
CS-MW18-LGR	Retain	12/14/2015	12/11/2019	4	Sentinel	ND	ND	ND	ND
CS-MW19-LGR	Exclude/Reduce	12/14/2015	12/9/2019	4	In-Plume	<PQL	ND	ND	ND
CS-MW20-LGR	Exclude/Reduce	12/17/2015	12/9/2019	4	In-Plume	Stable	ND	<PQL	ND
CS-MW21-LGR	Retain	12/17/2015	12/9/2019	4	Sentinel	ND	ND	<PQL	ND
CS-MW22-LGR	Retain	12/18/2015	12/9/2019	4	Sentinel	ND	ND	ND	ND
CS-MW23-LGR	Exclude/Reduce	12/14/2015	12/9/2019	4	Downgradient	ND	ND	ND	ND
CS-MW24-LGR	Exclude/Reduce	12/14/2015	12/4/2019	4	Crossgradient	ND	ND	ND	ND
CS-MW25-LGR	Exclude/Reduce	2/3/2016	12/3/2019	4	Upgradient	<PQL	ND	ND	ND

[a/] = PCE = tetrachloroethene, TCE = trichloroethene, DCE12C = *cis*-dichloroethene, VC = vinyl chloride, ND = not detected;
* = Trends contain a sample result that exceeds the cleanup goal entered in the COC information for that parameter (90% of the MCL)
< PQL = all sample results are less than the practical quantitation limit (PQL), or are a mixture of non-detects and detections less than the PQL;
< 4 Results = fewer than four measurements, no trend evaluated

Table 5.3
Plume 1 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-1	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	DWW	3	Drinking water well
CS-2	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor plume edge	30	Provide back up for CS-4 as plume edge monitoring point
CS-4	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor plume	30	Plume edge monitoring point
CS-10	LGR	3	Retain	Biennial	Exclude/Reduce	Retain	Retain	DWW	3	Drinking water well
CS-12	LGR	3	Retain	Less than Biennial	Retain	Exclude	Retain	DWW	3	Drinking water well
CS-13	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	DWW	3	Drinking water well
CS-D	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor plume	15	In-plume monitoring point
CS-MWG-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Exclude	Retain	Provides background in uneffected area	30	Retain as upgradient/background monitoring point, distant from Plume 1
CS-MWH-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Exclude	Retain	Provides background in uneffected area	30	Retain as upgradient/background monitoring point, distant from Plume 1
CS-I	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Exclude	Retain	Provides background/ upgradient well	30	Retain as upgradient/background monitoring point, distant from Plume 1
CS-MW1-LGR	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, downgradient source	15	Downgradient well with predictable/ decreasing or stable COC concentrations
CS-MW1-CC	CC	30	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, downgradient source	30	Historically ND, downgradient of Plume 1 source area
CS-MW2-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor SE plume/plume-edge	30	In-plume well with historical ND/ trace detections
CS-MW2-CC	CC	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor SE plume-edge in CC	30	Downgradient well with historical ND
CS-MW3-LGR	LGR	30	Exclude	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor up/cross-gradient of plume	30	Cross-gradient well with historical ND
CS-MW4-LGR	LGR	30	Exclude	Biennial	Exclude/Reduce	Retain	Retain	Monitor cross-gradient near southern plume toe	30	Cross-gradient well with historical ND/ trace detections
CS-MW5-LGR	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor in-plume	15	In-plume well with decreasing COC concentrations
CS-MW9-LGR	LGR	30	Exclude	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor LGR background	30	Upgradient and cross-gradient of Plume 1, historical ND
CS-MW9-CC	CC	30	Exclude	Less than Biennial	Exclude/Reduce	Exclude	Retain	Monitor CC background	30	Upgradient and cross-gradient of Plume 1, historical ND
CS-MW12-LGR	LGR	15	Exclude	Biennial	Exclude/Reduce	Exclude	Retain	Downgradient/cross-gradient well in LGR	15	Well down/cross gradient, along a fault between source and CSSA boundary; Between plume and fenceline; ND COC concentrations
CS-MW12-CC	CC	30	Exclude	Biennial	Exclude/Reduce	Exclude	Retain	Downgradient/cross-gradient well in CC	30	Well down/cross gradient, along a fault between source and CSSA boundary; Between plume and fenceline; ND COC concentrations
CS-MW17-LGR	LGR	15	Retain	Biennial	Retain	Retain	Retain	Sentinel, upgradient of DWW CS-13	15	Well down/cross gradient of plume and upgradient of CS-13; Only monitoring well in the east pasture; down gradient and ND or trace detections. Retain as sentinel for CS-13

Table 5.3
Plume 1 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

CS-MW18-LGR	LGR	30	Retain	Biennial	Retain	Retain	Retain	Sentinel, downgradient Plume 1 and upgradient of Plume 2	30	Distant downgradient Plume 1 and well CS-10/Upgradient Plume 2 well
CS-MW19-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor in-plume; between plume 1 and CS-10	30	Downgradient well with ocassional trace detections
CS-MW20-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	In-plume, near toe of Plume 1	30	Downgradient well with predictable/ stable COC concentrations
CS-MW21-LGR	LGR	30	Retain	Biennial	Retain	Retain	Retain	Sentinel, upgradient of DWW CS-1	30	Well down gradient of Plume 1 and upgradient of CS-1 with historical ND or trace detections
CS-MW22-LGR	LGR	30	Retain	Biennial	Retain	Retain	Retain	Sentinel	30	Well down gradient of Plume 1 and upgradient of southern CSSA boundary with historical ND
CS-MW23-LGR	LGR	30	Exclude	Biennial	Exclude/Reduce	Retain	Retain	Downgradient	30	Downgradient well, historical ND
CS-MW24-LGR	LGR	30	Exclude	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor western plume-edge	30	Cross-gradient well, historical ND
CS-MW25-LGR	LGR	30	Exclude	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor upgradient of Plume 1	30	Upgradient of Plume 1, historical ND

Table 5.4
Plume 2 Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

Well ID	X Coordinates	Y Coordinates	Top of Screen (bgs)[a/]	Bottom of Screen (bgs)	Zone[b/]	Functional Category	Current Sampling Frequency (months)	Risk to Receptors	Predictability of COC Concentrations
CS-MW10-CC	535,676.797	3,283,185.962	470	495	CC	Downgradient	30	Low	Predictable
CS-MW10-LGR	535,675.595	3,283,209.090	370	395	LGR	In-Plume	15	Moderate	Predictable
CS-MW11A-LGR	536,257.579	3,283,387.196	420.3	445.3	LGR	Crossgradient Plume-Edge	15	Low	Predictable
CS-MW11B-LGR	536,253.156	3,283,382.350	182	207	LGR	Crossgradient Plume-Edge	15	Low	Predictable
CS-MW23-LGR	536,199.409	3,284,027.777	372	397	LGR	Upgradient	30	Low	Predictable
CS-MW35-LGR	535,913.650	3,283,233.943	405	430	LGR	Crossgradient Plume-Edge	15	Low	Predictable
CS-MW36-LGR	535,673.212	3,283,702.697	345	370	LGR	In-Plume	15	Moderate	Predictable
CS-MW37-LGR	536,236.393	3,283,105.875	447	472	LGR	Sentinel	15	Low	Predictable
CS-MW6-CC	535,701.478	3,283,873.245	451	476	CC	Upgradient	30	Low	Predictable
CS-MW6-LGR	535,711.319	3,283,882.507	340	365	LGR	Upgradient	15	Low	Predictable
CS-MW7-CC	535,885.458	3,283,593.004	430	455	CC	Crossgradient Plume-Edge	30	Low	Predictable
CS-MW7-LGR	535,884.568	3,283,611.409	322	347	LGR	Crossgradient Plume-Edge	15	Low	Predictable
CS-MW8-CC	535,695.084	3,283,554.080	439.5	464.5	CC	In-Plume	15	Moderate	Predictable
CS-MW8-LGR	535,695.762	3,283,575.281	332	357	LGR	In-Plume	15	Moderate	Predictable
CS-WB01-LGR-01	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-02	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-03	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-04	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-05	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-06	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-07	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB01-LGR-08	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB01-LGR-09	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB01-UGR-01	535,712.781	3,283,552.968	--	--	UGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-01	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-02	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-03	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-04	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-05	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-06	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-07	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB02-LGR-08	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB02-LGR-09	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB02-UGR-01	535,693.987	3,283,619.881	--	--	UGR	In-Plume	15	Low	Predictable
CS-WB03-LGR-01	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-02	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-03	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB03-LGR-04	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB03-LGR-05	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB03-LGR-06	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB03-LGR-07	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-08	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-09	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable

Table 5.4
Plume 2 Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

CS-WB03-UGR-01	535,687.504	3,283,706.512	--	--	UGR	In-Plume	15	Moderate	Unpredictable
CS-WB04-BS-01	535,402.031	3,283,519.471	--	--	BS	In-Plume	30	Low	Predictable
CS-WB04-BS-02	535,402.031	3,283,519.471	--	--	BS	In-Plume	30	Low	Predictable
CS-WB04-CC-01	535,402.031	3,283,519.471	--	--	CC	In-Plume	30	Low	Predictable
CS-WB04-CC-02	535,402.031	3,283,519.471	--	--	CC	In-Plume	30	Low	Unpredictable
CS-WB04-CC-03	535,402.031	3,283,519.471	--	--	CC	In-Plume	30	Low	Unpredictable
CS-WB04-LGR-01	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-02	535,402.031	3,283,519.471	--	--	LGR	In-Plume	30	Low	Predictable
CS-WB04-LGR-03	535,402.031	3,283,519.471	--	--	LGR	In-Plume	30	Low	Predictable
CS-WB04-LGR-04	535,402.031	3,283,519.471	--	--	LGR	In-Plume	30	Low	Predictable
CS-WB04-LGR-06	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-07	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-08	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-09	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-10	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-11	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Unpredictable
CS-WB04-UGR-01	535,402.031	3,283,519.471	--	--	UGR	In-Plume	15	Moderate	Unpredictable
FO-J1	535480	3284810	297	--	CC	Crossgradient Plume-Edge	30	High	Predictable
I10-10	535788.2173	3281859.086	--	--	--	Downgradient	15	Low	Predictable
I10-8	534657.43	3284077.475	--	--	--	Crossgradient	30	Low	Predictable
JW-7	535403	3284842	--	--	--	Crossgradient Plume-Edge	30	Moderate	Predictable
JW-8	535466	3284954	187		LGR/CC/HS	Crossgradient Plume-Edge	30	Moderate	Predictable
LS-5	535555	3283080	--	--	--	In-Plume	3	High	Predictable
LS-6	535447.3125	3283059.5	--	--	--	In-Plume	3	High	Predictable
LS-7	535,627.419	3,283,140.991	--	--	--	In-Plume	3	High	Predictable
OFR-3	535177.5	3283478.75	--	--	LGR/CC	In-Plume	3	High	Predictable
RFR-10	535,354.186	3,283,530.660	--	--	--	In-Plume	3	High	Predictable
RFR-11	535322	3283195	--	--	--	In-Plume	3	High	Predictable
RFR-12	535269	3283115	--	--	LGR/CC/HS	Downgradient Plume-Edge	15	Moderate	Predictable
RFR-14	535544.0051	3284906.059	--	--	LGR/CC	Downgradient Plume-Edge	30	Moderate	Predictable

[a/] bgs = below ground surface;

[b/] LGR = Lower Glen Rose, CC = Cow Creek, BS = Bexar Shale, UGR = Upper Glen Rose, HS = Hensel Sand;

"--" = Not Available or Not Applicable

Table 5.5
Plume 2 Temporal Trend Evaluation
Camp Stanley Storage Activity, Boerne, TX

Well ID	Recommendation	Start Date	End Date	Number of Samples	Category	Contaminants of Concern[a/]			
						PCE	TCE	DCE12C	VC
CS-MW10-CC	Exclude/Reduce	1/10/2013	12/9/2019	4	Downgradient	<PQL	ND	ND	ND
CS-MW10-LGR	Exclude/Reduce	12/10/2015	12/11/2019	5	In-Plume	Decreasing	<PQL	ND	ND
CS-MW11A-LGR	Exclude/Reduce	12/10/2015	12/11/2019	5	Crossgradient Plume-edge	<PQL	ND	ND	ND
CS-MW11B-LGR	Exclude/Reduce	12/14/2015	9/24/2018	4	Crossgradient Plume-edge	<PQL	ND	ND	ND
CS-MW23-LGR	Exclude/Reduce	12/14/2015	12/9/2019	4	Upgradient	ND	ND	ND	ND
CS-MW35-LGR	Exclude/Reduce	12/14/2015	12/9/2019	5	Crossgradient Plume-edge	<PQL	ND	ND	ND
CS-MW36-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	In-Plume	Stable*	Stable*	<PQL	ND
CS-MW37-LGR	Retain	7/12/2017	12/12/2019	6	Sentinel	<PQL	<PQL	ND	ND
CS-MW6-CC	Exclude/Reduce	6/19/2014	12/11/2019	4	Upgradient	ND	ND	ND	ND
CS-MW6-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	Upgradient	<PQL	ND	ND	ND
CS-MW7-CC	Exclude/Reduce	6/19/2014	12/11/2019	4	Crossgradient Plume-edge	ND	ND	ND	ND
CS-MW7-LGR	Exclude/Reduce	9/14/2015	12/11/2019	18	Crossgradient Plume-edge	<PQL	<PQL	ND	ND
CS-MW8-CC	Exclude/Reduce	12/9/2015	12/11/2019	4	In-Plume	ND	ND	ND	ND
CS-MW8-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	In-Plume	Decreasing	ND	ND	ND
CS-WB01-LGR-01	Retain	9/16/2015	12/16/2019	18	In-Plume	Increasing	<PQL	ND	ND
CS-WB01-LGR-02	Exclude/Reduce	9/16/2015	12/16/2019	6	In-Plume	Stable*	Stable	ND	ND
CS-WB01-LGR-03	Exclude/Reduce	9/16/2015	12/16/2019	6	In-Plume	Stable*	Stable*	ND	ND
CS-WB01-LGR-04	Retain	9/16/2015	12/16/2019	6	In-Plume	ND	ND	No Trend	ND
CS-WB01-LGR-05	Retain	9/16/2015	12/16/2019	6	In-Plume	ND	Prob. Decreasing	No Trend	ND
CS-WB01-LGR-06	Retain	9/16/2015	12/16/2019	6	In-Plume	ND	Increasing*	Stable	ND
CS-WB01-LGR-07	Exclude/Reduce	9/16/2015	12/16/2019	6	In-Plume	Stable*	Stable*	Decreasing	ND
CS-WB01-LGR-08	Retain	9/16/2015	12/16/2019	6	In-Plume	<PQL	Decreasing*	Stable	No Trend
CS-WB01-LGR-09	Retain	9/16/2015	12/16/2019	18	In-Plume	Stable*	Prob. Decreasing*	<PQL	No Trend*
CS-WB01-UGR-01	Retain	11/18/2004	9/12/2018	4	In-Plume	No Trend*	No Trend	No Trend	<4 Results
CS-WB02-LGR-01	Exclude/Reduce	6/22/2015	9/12/2018	4	In-Plume	<PQL	<PQL	ND	ND
CS-WB02-LGR-02	Exclude/Reduce	3/11/2010	9/12/2018	4	In-Plume	Stable	<PQL	ND	ND
CS-WB02-LGR-03	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	Stable	<PQL	ND	ND
CS-WB02-LGR-04	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	Stable	Decreasing*	ND	ND
CS-WB02-LGR-05	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	<PQL	Decreasing	<PQL	ND
CS-WB02-LGR-06	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	Prob. Decreasing*	Prob. Decreasing	<PQL	ND
CS-WB02-LGR-07	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	<PQL	Decreasing	Increasing	ND
CS-WB02-LGR-08	Exclude/Reduce	9/23/2015	12/16/2019	6	In-Plume	ND	<PQL	Stable	ND
CS-WB02-LGR-09	Exclude/Reduce	9/23/2015	12/16/2019	18	In-Plume	Decreasing*	Decreasing*	<PQL	ND
CS-WB02-UGR-01	No Recommendation, < 4 samples	1/1/0001	12/31/9999	0	In-Plume	<4 Results	<4 Results	<4 Results	<4 Results
CS-WB03-LGR-01	Retain	9/21/2015	12/17/2019	15	In-Plume	Stable*	Prob. Increasing*	Stable	ND
CS-WB03-LGR-02	Retain	5/25/2005	6/16/2016	4	In-Plume	Stable*	Stable*	No Trend	<4 Results
CS-WB03-LGR-03	Exclude/Reduce	9/21/2015	12/17/2019	6	In-Plume	Prob. Decreasing*	Decreasing	ND	ND
CS-WB03-LGR-04	Exclude/Reduce	9/21/2015	12/17/2019	6	In-Plume	Stable*	Prob. Decreasing*	Increasing	ND
CS-WB03-LGR-05	Retain	9/21/2015	12/17/2019	6	In-Plume	Stable*	Prob. Increasing*	Prob. Increasing	ND
CS-WB03-LGR-06	Exclude/Reduce	9/21/2015	12/17/2019	6	In-Plume	ND	<PQL	Stable	ND
CS-WB03-LGR-07	Exclude/Reduce	9/21/2015	12/17/2019	6	In-Plume	Prob. Decreasing*	Prob. Decreasing*	Stable	ND
CS-WB03-LGR-08	Retain	9/21/2015	12/16/2019	6	In-Plume	ND	<PQL	Stable	No Trend
CS-WB03-LGR-09	Exclude/Reduce	9/17/2015	12/16/2019	18	In-Plume	Decreasing*	Decreasing*	<PQL	ND
CS-WB03-UGR-01	Exclude/Reduce	9/21/2015	12/17/2019	18	In-Plume	Stable*	Stable*	Decreasing	ND
CS-WB04-BS-01	Exclude/Reduce	5/18/2015	12/18/2019	4	In-Plume	<PQL	ND	ND	ND
CS-WB04-BS-02	Retain	5/18/2015	12/18/2019	4	In-Plume	No Trend	ND	ND	ND

Table 5.5
Plume 2 Temporal Trend Evaluation
Camp Stanley Storage Activity, Boerne, TX

CS-WB04-CC-01	Retain	5/18/2015	12/18/2019	4	In-Plume	No Trend	<PQL	Stable	ND
CS-WB04-CC-02	Retain	5/18/2015	12/18/2019	4	In-Plume	No Trend	ND	<PQL	ND
CS-WB04-CC-03	Retain	5/18/2015	12/18/2019	4	In-Plume	No Trend*	ND	<PQL	ND
CS-WB04-LGR-01	Exclude/Reduce	9/22/2015	12/18/2019	18	In-Plume	Stable	ND	ND	ND
CS-WB04-LGR-02	Retain	10/3/2007	5/19/2015	4	In-Plume	Stable	No Trend	No Trend	ND
CS-WB04-LGR-03	Exclude/Reduce	5/19/2015	12/18/2019	4	In-Plume	<PQL	ND	ND	ND
CS-WB04-LGR-04	Exclude/Reduce	5/19/2015	12/18/2019	4	In-Plume	<PQL	<PQL	<PQL	ND
CS-WB04-LGR-06	Exclude/Reduce	9/22/2015	12/18/2019	7	In-Plume	Stable*	Stable*	Stable	ND
CS-WB04-LGR-07	Retain	9/22/2015	12/18/2019	7	In-Plume	No Trend*	Stable*	Stable	ND
CS-WB04-LGR-08	Exclude/Reduce	9/22/2015	12/18/2019	6	In-Plume	Stable	Stable	<PQL	ND
CS-WB04-LGR-09	Exclude/Reduce	9/22/2015	12/18/2019	7	In-Plume	Stable*	Stable*	<PQL	ND
CS-WB04-LGR-10	Exclude/Reduce	9/22/2015	12/18/2019	7	In-Plume	Stable	<PQL	ND	ND
CS-WB04-LGR-11	Retain	9/22/2015	12/18/2019	18	In-Plume	No Trend*	<PQL	ND	ND
CS-WB04-UGR-01	No Recommendation, < 4 samples	1/1/0001	12/31/9999	0	In-Plume	<4 Results	<4 Results	<4 Results	<4 Results
FO-J1	Exclude/Reduce	3/5/2015	12/2/2019	4	Crossgradient Plume-edge	ND	ND	ND	ND
I10-10	Exclude/Reduce	9/7/2016	12/2/2019	4	Downgradient	ND	ND	ND	ND
I10-8	Exclude/Reduce	12/2/2015	12/2/2019	4	Crossgradient	ND	ND	ND	ND
JW-7	Exclude/Reduce	3/3/2015	6/7/2017	4	Crossgradient Plume-edge	<PQL	ND	ND	ND
JW-8	Exclude/Reduce	12/2/2015	12/11/2019	4	Crossgradient Plume-edge	ND	ND	ND	ND
LS-5	Retain	9/8/2015	12/2/2019	18	In-Plume	<PQL	Increasing	ND	ND
LS-6	Retain	9/8/2015	12/2/2019	18	In-Plume	<PQL	No Trend	ND	No Trend
LS-7	Exclude/Reduce	9/8/2015	12/2/2019	19	In-Plume	Stable	<PQL	ND	ND
OFR-3	Exclude/Reduce	9/8/2015	12/2/2019	18	In-Plume	Stable*	Stable	ND	ND
RFR-10	Exclude/Reduce	9/8/2015	12/2/2019	20	In-Plume	Prob. Decreasing*	Decreasing*	<PQL	ND
RFR-11	Retain	9/8/2015	12/2/2019	18	In-Plume	No Trend*	Stable*	ND	ND
RFR-12	Exclude/Reduce	12/2/2015	12/4/2019	5	Downgradient Plume-edge	<PQL	<PQL	ND	ND
RFR-14	Exclude/Reduce	12/4/2015	12/2/2019	4	Downgradient Plume-edge	ND	ND	ND	ND

[a/] = PCE = tetrachloroethene, TCE = trichloroethene, DCE12C = *cis*-dichloroethene, VC = vinyl chloride, ND = not detected;
* = Trends contain a sample result that exceeds the cleanup goal entered in the COC information for that parameter (90% of the MCL)
< PQL = all sample results are less than the practical quantitation limit (PQL), or are a mixture of non-detects and detections less than the PQL;
< 4 Results = fewer than four measurements, no trend evaluated

Table 5.6
Plume 2 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-MW10-CC	CC	30	Exclude	Biennial	Exclude/Reduce	Retain	Retain	Downgradient and adjacent to boundary	30	Monitor Plume 2 in CC downgradient of source area
CS-MW10-LGR	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Downgradient and adjacent to boundary	15	Monitor Plume 2 in LGR downgradient of source area
CS-MW11A-LGR	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor plume edge	15	Cross-gradient well with predictable trace detections
CS-MW11B-LGR	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Monitor plume edge	15	Cross-gradient well with predictable trace detections
CS-MW23-LGR	LGR	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Upgradient	30	Upgradient, predictible ND history
CS-MW35-LGR	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Cross-gradient plume edge well	15	Cross-gradient well with predictable trace detections
CS-MW36-LGR	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor LGR In-plume	15	Monitor the LGR within the source area, predictable COC concentrations, stable COC trends
CS-MW37-LGR	LGR	15	Retain	Biennial	Retain	Retain	Retain	Sentinel	15	Cross-gradient Plume 2 and upgradient CSSA boundary, trace detections
CS-MW6-CC	CC	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Upgradient Plume 2 in CC	30	Upgradient, predictible ND history
CS-MW6-LGR	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Upgradient Plume 2 in LGR	15	Upgradient, predictible trace and ND history
CS-MW7-CC	CC	30	Exclude	Less than Biennial	Exclude/Reduce	Retain	Retain	Cross-gradient plume edge CC well	30	Cross-gradient CC well, predictible ND history
CS-MW7-LGR	LGR	15	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Cross-gradient plume edge LGR well	15	Cross-gradient LGR well, predictible trace detection history
CS-MW8-CC	CC	15	Exclude	Annual	Exclude/Reduce	Retain	Retain	Downgradient In-plume CC well	15	Downgradient CC well with ND history
CS-MW8-LGR	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Downgradient In-plume LGR well	15	Downgradient LGR well with predictable detections, decreasing trend
CS-WB01-LGR-01	LGR	15	Retain	Unknown	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, predictable detections
CS-WB01-LGR-02	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detections
CS-WB01-LGR-03	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detections
CS-WB01-LGR-04	LGR	15	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, predictable, trace and ND history
CS-WB01-LGR-05	LGR	15	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, predictable, trace and ND history
CS-WB01-LGR-06	LGR	15	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, ND and detections with increasing trend
CS-WB01-LGR-07	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, predictable detections with stable and decreasing trends
CS-WB01-LGR-08	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, predictable detections with stable and decreasing trends
CS-WB01-LGR-09	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable and decreasing trends
CS-WB01-UGR-01	UGR	15	Retain	Unknown	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, within the shallow subsurface

Table 5.6
Plume 2 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

CS-WB02-LGR-01	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, ND and trace detection history
CS-WB02-LGR-02	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detections, and trace and ND history
CS-WB02-LGR-03	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detections, and trace and ND history
CS-WB02-LGR-04	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable and decreasing detections, and trace and ND history
CS-WB02-LGR-05	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, decreasing detections and ND and trace detection history
CS-WB02-LGR-06	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, probably decreasing detections and ND and trace detection history
CS-WB02-LGR-07	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, increasing and decreasing detections and ND and trace detection history
CS-WB02-LGR-08	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection, and ND and trace detection
CS-WB02-LGR-09	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, decreasing detections and ND and trace detection history
CS-WB02-UGR-01	UGR	15	Retain	Exclude	Not Analyzed	Retain	Exclude	Monitor vertical distribution of contaminants In-Plume	15	Typically dry, however, in-plume and within the shallow subsurface
CS-WB03-LGR-01	LGR	15	Retain	Unknown	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, increasing and stable detection trends
CS-WB03-LGR-02	LGR	15	Retain	Annual	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trends
CS-WB03-LGR-03	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume,decreasing and probably decreasing detections and ND history
CS-WB03-LGR-04	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, increasing, probably decreasing, and stable detection trends
CS-WB03-LGR-05	LGR	15	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable and probably increasing detection trends
CS-WB03-LGR-06	LGR	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trends and ND and trace detection history
CS-WB03-LGR-07	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, probably decreasing and stable detections and ND history
CS-WB03-LGR-08	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, ND and trace detection history
CS-WB03-LGR-09	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, decreasing detections and ND and trace detection history
CS-WB03-UGR-01	UGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, within the shallow subsurface near point of release, typically high concentrations with stable or decreasing trends
CS-WB04-BS-01	BS	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, ND and trace detections, however additional BS zone included a marked increase in concentrations
CS-WB04-BS-02	BS	30	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, no trend for PCE due to high variation/recent increase in concentration
CS-WB04-CC-01	CC	30	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, no trend for PCE due to high variation/recent increase in concentration
CS-WB04-CC-02	CC	30	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, no trend for PCE due to high variation/recent increase in concentration

Table 5.6
Plume 2 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

CS-WB04-CC-03	CC	30	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, no trend for PCE due to high variation/recent increase in concentration
CS-WB04-LGR-01	LGR	15	Retain	Unknown	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend and ND history
CS-WB04-LGR-02	LGR	30	Retain	Biennial	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	30	In-plume, stable trend
CS-WB04-LGR-03	LGR	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	30	In-plume, ND and trace detection
CS-WB04-LGR-04	LGR	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	30	In-plume, ND and trace detection
CS-WB04-LGR-06	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend
CS-WB04-LGR-07	LGR	15	Retain	Annual	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend and no trend due to variation in concentrations
CS-WB04-LGR-08	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend and ND and trace detection history
CS-WB04-LGR-09	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend and ND and trace detection history
CS-WB04-LGR-10	LGR	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, stable detection trend and ND and trace detection history
CS-WB04-LGR-11	LGR	15	Retain	Unknown	Retain	Retain	Retain	Monitor vertical distribution of contaminants In-Plume	15	In-plume, no trend due to variation in concentrations and ND and trace detection history
CS-WB04-UGR-01	UGR	15	Retain	Exclude	Not Analyzed	Retain	Exclude	Monitor vertical distribution of contaminants In-Plume	15	Typically dry, however, in-plume and within the shallow subsurface
FO-J1	CC	30	Retain	Annual	Exclude/Reduce	Retain	Retain	Cross-gradient off-post well	30	Upgradient Plume 2, cross-gradient Plume 1
I10-10	--	15	Retain	Biennial	Exclude/Reduce	Retain	Retain	Downgradient, replacement for LS-4	15	Most southern downgradient monitoring point, ND history
I10-8	--	30	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	Cross-gradient	30	Most western monitoring point, cross-gradient Plume 2, off-post, ND history
JW-7	--	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	History of trace detections, off-post well	30	Upgradient Plume 2, cross-gradient Plume 1, trace detection
JW-8	LGR/CC/HS	30	Retain	Biennial	Exclude/Reduce	Retain	Retain	Cross-gradient off-post well	30	Upgradient Plume 2, cross-gradient Plume 1
LS-5	--	3	Retain	Unknown	Retain	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
LS-6	--	3	Retain	Unknown	Retain	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
LS-7	--	3	Retain	Unknown	Exclude/Reduce	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
OFR-3	LGR/CC	3	Retain	Unknown	Exclude/Reduce	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
RFR-10	--	3	Retain	Unknown	Exclude/Reduce	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
RFR-11	--	3	Retain	Unknown	Retain	Retain	Retain	In-plume, off-post GAC well	3	In-plume, off-post GAC well
RFR-12	LGR/CC/HS	15	Retain	Annual	Exclude/Reduce	Retain	Retain	Downgradient plume-edge, off-post well	15	Downgradient off-post well with trace detections
RFR-14	LGR/CC	30	Retain	Annual	Exclude/Reduce	Retain	Retain	Downgradient plume-edge, off-post well	15	Downgradient off-post well, ND

Table 5.7
Bioreactor Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

Well ID	X Coordinates	Y Coordinates	Top of Screen (bgs)[a/]	Bottom of Screen (bgs)	Zone[b/]	Functional Category	Current Sampling Frequency (months)	Risk to Receptors	Predictability of COC Concentrations
CS-MW16-LGR	537,285.897	3,286,841.192	199	310	LGR	In-Plume	9	Low	Predictable
CS-MW16-CC	537,277.448	3,286,844.086	406	431	CC	In-Plume	9	Low	Predictable
CS-B3-MW01	537,326.480	3,286,778.360	277	287	LGR	In-Plume	As-needed	Low	Predictable
CS-B3-MW02	537,393.331	3,286,674.552	260	300	LGR	In-Plume	As-needed	Low	Unpredictable
CS-B3-MW03	537,382.681	3,286,691.231	17	37	UGR	In-Plume	As-needed	Low	Unpredictable
CS-B3-MW04	537,295.346	3,286,699.351	260	300	LGR	In-Plume	As-needed	Low	Unpredictable
B3-EXW01	537,354.116	3,286,642.159	199	345	LGR	In-Plume	9	Low	Predictable
B3-EXW02	537,399.530	3,286,431.654	65	358	LGR	In-Plume	9	Low	Predictable
B3-EXW03	537,145.031	3,286,694.994	65	340	LGR	In-Plume	9	Low	Predictable
B3-EXW04	537,191.735	3,286,493.127	55	335	LGR	In-Plume	9	Low	Predictable
B3-EXW05	537,495.283	3,286,671.945	90	380	LGR	In-Plume	9	Low	Predictable
B3-MW26-UGR	537,221.125	3,286,751.008	7.5	17.5	UGR	In-Plume	9	Low	Predictable
B3-MW27-UGR	537,233.758	3,286,644.368	7	17	UGR	In-Plume	9	Low	Predictable
B3-MW29-UGR	537,293.645	3,286,515.453	7.5	17.5	UGR	In-Plume	9	Low	Predictable
B3-MW30-UGR	537,374.479	3,286,478.375	10.8	20.8	UGR	In-Plume	9	Low	Predictable
B3-MW31-UGR	537,400.902	3,286,619.711	16	36	UGR	In-Plume	9	Low	Predictable
B3-MW32-UGR	537,457.707	3,286,713.060	26	56	UGR	In-Plume	9	Low	Predictable
B3-MW33-UGR	537,389.399	3,286,778.414	6	26	UGR	In-Plume	9	Low	Predictable
B3-MW34-UGR	537,334.222	3,286,783.610	12	22	UGR	In-Plume	9	Low	Unpredictable
CS-WB05-LGR-01	537,323.360	3,286,787.530	--	--	LGR	In-Plume	9	Low	Unpredictable
CS-WB05-LGR-02	537,323.360	3,286,787.530	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB05-LGR-03A	537,323.360	3,286,787.530	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB05-LGR-03B	537,323.360	3,286,787.530	--	--	LGR	In-Plume	6	Low	Predictable
CS-WB05-LGR-04A	537,323.360	3,286,787.530	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB05-LGR-04B	537,323.360	3,286,787.530	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB05-BS-01	537,323.360	3,286,787.530	--	--	BS	In-Plume	9	Low	Predictable
CS-WB05-CC-01	537,323.360	3,286,787.530	--	--	CC	In-Plume	9	Low	Predictable
CS-WB05-CC-02	537,323.360	3,286,787.530	--	--	CC	In-Plume	9	Low	Predictable
CS-WB06-UGR-01	537,304.500	3,286,580.070	--	--	UGR	In-Plume	9	Low	Predictable
CS-WB06-LGR-01	537,304.500	3,286,580.070	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB06-LGR-02	537,304.500	3,286,580.070	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB06-LGR-03A	537,304.500	3,286,580.070	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB06-LGR-03B	537,304.500	3,286,580.070	--	--	LGR	In-Plume	6	Low	Predictable
CS-WB06-LGR-04	537,304.500	3,286,580.070	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB07-UGR-01	537,283.850	3,286,696.392	--	--	UGR	In-Plume	9	Low	Predictable
CS-WB07-LGR-01	537,283.850	3,286,696.392	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB07-LGR-02	537,283.850	3,286,696.392	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB07-LGR-03A	537,283.850	3,286,696.392	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB07-LGR-03B	537,283.850	3,286,696.392	--	--	LGR	In-Plume	6	Low	Predictable
CS-WB07-LGR-04	537,283.850	3,286,696.392	--	--	LGR	In-Plume	9	Low	Predictable

Table 5.7
Bioreactor Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

CS-WB08-UGR-01	537,397.170	3,286,689.260	--	--	UGR	In-Plume	9	Low	Unpredictable
CS-WB08-LGR-01	537,397.170	3,286,689.260	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB08-LGR-02	537,397.170	3,286,689.260	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB08-LGR-03A	537,397.170	3,286,689.260	--	--	LGR	In-Plume	9	Low	Predictable
CS-WB08-LGR-03B	537,397.170	3,286,689.260	--	--	LGR	In-Plume	6	Low	Predictable
CS-WB08-LGR-04	537,397.170	3,286,689.260	--	--	LGR	In-Plume	9	Low	Predictable
CS-MW5-LGR	537,704.585	3,286,213.329	420	445	LGR	In-Plume	6	Moderate	Predictable
CS-MW1-LGR	537,052.727	3,286,288.001	288	313	LGR	In-Plume	6	Moderate	Predictable
CS-D	537,147.068	3,286,839.895	205	263	LGR	In-Plume	6	Moderate	Predictable
B3-T1-1	537,327.028	3,286,694.776	5	10	UGR	In-Plume	6	Low	Unpredictable
B3-T1-2	537,322.266	3,286,677.706	5	10	UGR	In-Plume	6	Low	Unpredictable
B3-T1-3	537,310.365	3,286,644.104	5	10	UGR	In-Plume	6	Low	Predictable
B3-T2-1	537,332.597	3,286,692.601	5	10	UGR	In-Plume	6	Low	Predictable
B3-T2-2	537,324.666	3,286,679.964	5	10	UGR	In-Plume	6	Low	Predictable
B3-T3-1	537,344.606	3,286,711.503	5	10	UGR	In-Plume	6	Low	Predictable
B3-T3-2	537,334.489	3,286,683.712	5	10	UGR	In-Plume	6	Low	Predictable
B3-T4-1	537,340.298	3,286,679.590	5	10	UGR	In-Plume	6	Low	Predictable
B3-T5-1	537,365.344	3,286,705.422	5	10	UGR	In-Plume	6	Low	Predictable
B3-T5-2	537,342.991	3,286,644.248	5	10	UGR	In-Plume	6	Low	Unpredictable
B3-T6-1	537,376.359	3,286,709.167	5	10	UGR	In-Plume	6	Low	Unpredictable
B3-T6-2	537,372.215	3,286,701.588	5	10	UGR	In-Plume	6	Low	Unpredictable

[a/] bgs = below ground surface;

[b/] LGR = Lower Glen Rose, CC = Cow Creek, BS = Bexar Shale; UGR = Upper Glen Rose

"--" = Not Available or Not Applicable

Table 5.8
Bioreactor Temporal Trends
Camp Stanley Storage Activity, Boerne, TX

Well ID	Recommendation	Start Date	End Date	Number of Samples	Category	Contaminants of Concern[a]			
						PCE	TCE	DCE12C	VC
CS-MW16-LGR	Exclude/Reduce	10/19/2015	1/6/2020	7	In-Plume	Decreasing*	Decreasing*	Decreasing*	ND
CS-MW16-CC	Exclude/Reduce	10/19/2015	12/31/2019	8	In-Plume	ND	Decreasing	Prob. Decreasing	ND
CS-B3-MW01	Retain	4/9/2015	12/28/2016	4	In-Plume	ND	<PQL	No Trend	Increasing*
CS-B3-MW02	No Recommendation,	3/21/2017	3/21/2017	1	In-Plume	<4 Results*	<4 Results*	<4 Results	<4 Results
CS-B3-MW03	No Recommendation,	1/1/0001	12/31/9999	0	In-Plume	<4 Results	<4 Results	<4 Results	<4 Results
CS-B3-MW04	No Recommendation,	3/28/2017	3/28/2017	1	In-Plume	<4 Results	<4 Results	<4 Results	<4 Results*
B3-EXW01	Exclude/Reduce	10/19/2015	1/6/2020	7	In-Plume	Stable*	Stable*	Stable*	ND
B3-EXW02	Exclude/Reduce	10/19/2015	12/31/2019	6	In-Plume	Stable*	Decreasing*	Decreasing*	ND
B3-EXW03	Exclude/Reduce	10/19/2015	12/31/2019	7	In-Plume	Stable*	Stable*	Stable*	ND
B3-EXW04	Exclude/Reduce	10/19/2015	12/31/2019	7	In-Plume	Stable*	Stable*	Stable*	ND
B3-EXW05	Exclude/Reduce	10/27/2015	12/31/2019	6	In-Plume	Stable*	Stable*	Stable*	ND
B3-MW26-UGR	Exclude/Reduce	10/26/2015	1/2/2020	7	In-Plume	<PQL	<PQL	Stable	Stable*
B3-MW27-UGR	Retain	10/26/2015	1/2/2020	7	In-Plume	<PQL	<PQL	No Trend	Stable*
B3-MW29-UGR	Exclude/Reduce	10/26/2015	3/7/2019	5	In-Plume	<PQL	<PQL	ND	ND
B3-MW30-UGR	Retain	10/26/2015	1/2/2020	7	In-Plume	Decreasing*	No Trend*	No Trend	ND
B3-MW31-UGR	Exclude/Reduce	10/26/2015	1/2/2020	7	In-Plume	Stable	Decreasing*	Decreasing	Decreasing*
B3-MW32-UGR	Retain	10/26/2015	1/2/2020	6	In-Plume	Prob. Decreasing*	Decreasing*	Stable	No Trend*
B3-MW33-UGR	Retain	10/26/2015	1/2/2020	7	In-Plume	No Trend*	No Trend*	Stable*	No Trend*
B3-MW34-UGR	Retain	10/26/2015	1/2/2020	7	In-Plume	No Trend	No Trend	No Trend	No Trend*
CS-WB05-LGR-01	Retain	10/19/2015	12/19/2019	7	In-Plume	<PQL	Stable	Increasing	No Trend
CS-WB05-LGR-02	Retain	7/26/2010	3/20/2019	4	In-Plume	No Trend*	Stable*	Stable	No Trend*
CS-WB05-LGR-03A	Exclude/Reduce	4/18/2012	3/20/2019	4	In-Plume	Stable*	Stable*	Stable*	Stable*
CS-WB05-LGR-03B	Retain	10/15/2015	9/12/2019	9	In-Plume	No Trend*	Stable*	Stable*	Prob. Increasing*
CS-WB05-LGR-04A	Retain	10/15/2015	12/19/2019	7	In-Plume	<PQL	No Trend*	Decreasing*	Decreasing*
CS-WB05-LGR-04B	Retain	10/14/2015	12/19/2019	7	In-Plume	Prob. Increasing*	Stable*	Increasing*	Prob. Decreasing*
CS-WB05-BS-01	Exclude/Reduce	10/14/2015	12/19/2019	7	In-Plume	<PQL	<PQL	Stable	Stable*
CS-WB05-CC-01	Retain	10/14/2015	12/18/2019	7	In-Plume	No Trend	<PQL	<PQL	ND
CS-WB05-CC-02	Retain	10/13/2015	12/18/2019	7	In-Plume	No Trend*	Prob. Decreasing	Stable	No Trend
CS-WB06-UGR-01	Retain	10/8/2015	12/30/2019	7	In-Plume	No Trend	Decreasing*	Prob. Decreasing*	Decreasing*
CS-WB06-LGR-01	Retain	10/7/2015	12/23/2019	7	In-Plume	Prob. Decreasing*	Decreasing*	Stable	No Trend
CS-WB06-LGR-02	Retain	10/7/2015	12/23/2019	7	In-Plume	<PQL	Stable	Stable	Increasing*
CS-WB06-LGR-03A	Retain	10/7/2015	12/23/2019	7	In-Plume	Decreasing*	Stable*	Stable*	No Trend
CS-WB06-LGR-03B	Exclude/Reduce	10/6/2015	9/23/2019	9	In-Plume	Stable*	Stable*	Stable*	ND
CS-WB06-LGR-04	Retain	10/6/2015	12/23/2019	7	In-Plume	Stable*	Stable*	Stable*	No Trend*
CS-WB07-UGR-01	No Recommendation,	1/1/0001	12/31/9999	0	In-Plume	<4 Results	<4 Results	<4 Results	<4 Results
CS-WB07-LGR-01	Exclude/Reduce	10/13/2015	12/23/2019	7	In-Plume	<PQL	Decreasing*	Stable*	Stable*
CS-WB07-LGR-02	Retain	10/13/2015	12/23/2019	7	In-Plume	Stable	Stable	No Trend	Stable*
CS-WB07-LGR-03A	Exclude/Reduce	10/13/2015	3/21/2019	4	In-Plume	Stable*	Stable*	Stable*	Stable
CS-WB07-LGR-03B	Retain	10/8/2015	9/12/2019	9	In-Plume	Stable*	Stable*	Stable*	No Trend
CS-WB07-LGR-04	Retain	10/8/2015	12/23/2019	7	In-Plume	Stable*	Stable*	Stable*	No Trend*
CS-WB08-UGR-01	Retain	10/6/2015	12/30/2019	7	In-Plume	No Trend	Prob. Decreasing	Stable*	Decreasing*
CS-WB08-LGR-01	Exclude/Reduce	10/5/2015	12/30/2019	7	In-Plume	<PQL	<PQL	Decreasing	Stable*
CS-WB08-LGR-02	Retain	10/5/2015	12/30/2019	7	In-Plume	Prob. Decreasing*	Stable*	Stable	No Trend
CS-WB08-LGR-03A	Exclude/Reduce	1/25/2011	3/26/2019	4	In-Plume	Stable*	Stable*	Decreasing*	ND
CS-WB08-LGR-03B	Exclude/Reduce	10/5/2015	9/23/2019	8	In-Plume	Decreasing*	Stable*	Stable*	ND
CS-WB08-LGR-04	Retain	10/5/2015	12/30/2019	7	In-Plume	Prob. Increasing*	Increasing*	Stable	No Trend

Table 5.8
Bioreactor Temporal Trends
Camp Stanley Storage Activity, Boerne, TX

CS-MW5-LGR	Exclude/Reduce	2/3/2016	12/5/2019	13	In-Plume	Decreasing*	Decreasing*	Decreasing	ND
CS-MW1-LGR	Exclude/Reduce	10/20/2015	12/4/2019	12	In-Plume	Prob. Decreasing*	Stable*	Decreasing	ND
CS-D	Exclude/Reduce	12/17/2015	12/4/2019	9	In-Plume	Decreasing*	Decreasing*	Decreasing	ND
B3-T1-1	Retain	10/21/2015	9/26/2019	9	In-Plume	No Trend	Increasing*	Increasing	Stable*
B3-T1-2	Retain	10/21/2015	9/25/2019	9	In-Plume	<PQL	No Trend*	No Trend	Stable*
B3-T1-3	Retain	10/21/2015	9/26/2019	9	In-Plume	<PQL	<PQL	No Trend	No Trend*
B3-T2-1	Retain	10/21/2015	9/25/2019	7	In-Plume	No Trend*	Stable*	Stable	Stable*
B3-T2-2	Retain	10/21/2015	9/26/2019	7	In-Plume	<PQL	<PQL	No Trend	No Trend*
B3-T3-1	Retain	4/21/2016	9/19/2017	4	In-Plume	Stable*	Stable*	Stable*	No Trend
B3-T3-2	Retain	4/20/2016	9/19/2017	4	In-Plume	Stable*	Stable*	Stable	No Trend*
B3-T4-1	Retain	4/20/2016	9/19/2017	4	In-Plume	No Trend*	Stable*	Stable*	Stable*
B3-T5-1	Exclude/Reduce	4/20/2016	9/18/2017	4	In-Plume	Stable*	Stable*	Stable*	Stable*
B3-T5-2	Retain	4/19/2016	9/18/2017	4	In-Plume	No Trend	No Trend	No Trend	No Trend*
B3-T6-1	Retain	10/21/2015	9/26/2019	9	In-Plume	No Trend*	Prob. Increasing*	Stable*	No Trend*
B3-T6-2	Retain	10/21/2015	9/25/2019	9	In-Plume	No Trend*	No Trend*	Stable	No Trend*

[a/] = PCE = tetrachloroethene, TCE = trichloroethene, DCE12C = *cis*-dichloroethene, VC = vinyl chloride, ND = not detected;
* = Trends contain a sample result that exceeds the cleanup goal entered in the COC information for that parameter (90% of the MCL)
< PQL = all sample results are less than the practical quantitation limit (PQL), or are a mixture of non-detects and detections less than the PQL;
< 4 Results = fewer than four measurements, no trend evaluated

Table 5.9
Bioreactor 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-MW16-LGR	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
CS-MW16-CC	CC	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
CS-B3-MW01	LGR	As-needed	Exclude	Exclude	Retain	Retain	Retain	Bioreactor injection well	As-needed	Sample as-needed to monitor conditions prior to and following substrate injections
CS-B3-MW02	LGR	As-needed	Exclude	Less than Biennial	Not Analyzed	Retain	Retain	Bioreactor injection well	As-needed	Sample as-needed to monitor conditions prior to and following substrate injections
CS-B3-MW03	UGR	As-needed	Exclude	Less than Biennial	Not Analyzed	Retain	Retain	Bioreactor injection well	As-needed	Sample as-needed to monitor conditions prior to and following substrate injections
CS-B3-MW04	LGR	As-needed	Exclude	Less than Biennial	Not Analyzed	Retain	Retain	Bioreactor injection well	As-needed	Sample as-needed to monitor conditions prior to and following substrate injections
B3-EXW01	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
B3-EXW02	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
B3-EXW03	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
B3-EXW04	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
B3-EXW05	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	Bioreactor extraction well	9	Bioreactor extraction well; monitor VOC concentrations in system influent
B3-MW26-UGR	UGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW27-UGR	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW29-UGR	UGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW30-UGR	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW31-UGR	UGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW32-UGR	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW33-UGR	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
B3-MW34-UGR	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance within the UGR
CS-WB05-LGR-01	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-LGR-02	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-LGR-03A	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs

Table 5.9
Bioreactor 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-WB05-LGR-03B	LGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
CS-WB05-LGR-04A	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-LGR-04B	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-BS-01	BS	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, BS monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-CC-01	CC	9	Retain	Annual	Retain	Retain	Retain	In-plume, CC monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB05-CC-02	CC	9	Retain	Annual	Retain	Retain	Retain	In-plume, CC monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB06-UGR-01	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB06-LGR-01	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB06-LGR-02	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB06-LGR-03A	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB06-LGR-03B	LGR	6	Retain	Annual	Exclude/Reduce	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
CS-WB06-LGR-04	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB07-UGR-01	UGR	9	Retain	Annual	Not Analyzed	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB07-LGR-01	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB07-LGR-02	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB07-LGR-03A	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB07-LGR-03B	LGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
CS-WB07-LGR-04	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB08-UGR-01	UGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, UGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB08-LGR-01	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB08-LGR-02	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB08-LGR-03A	LGR	9	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs
CS-WB08-LGR-03B	LGR	6	Retain	Annual	Exclude/Reduce	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
CS-WB08-LGR-04	LGR	9	Retain	Annual	Retain	Retain	Retain	In-plume, LGR monitoring	9	Monitor Bioreactor performance, vertical distribution of COCs

Table 5.9
Bioreactor 3TMO Results Summary
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-MW5-LGR	LGR	6	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	In-plume downgradient, LGR monitoring	6	Monitor Bioreactor performance, lateral distribution of COCs
CS-MW1-LGR	LGR	6	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	In-plume downgradient, LGR monitoring	6	Monitor Bioreactor performance, lateral distribution of COCs
CS-D	LGR	6	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	In-plume cross-gradient, LGR monitoring	6	Monitor Bioreactor performance, lateral distribution of COCs
B3-T1-1	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T1-2	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T1-3	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T2-1	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T2-2	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T3-1	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T3-2	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T4-1	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T5-1	UGR	6	Retain	Annual	Exclude/Reduce	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T5-2	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T6-1	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency
B3-T6-2	UGR	6	Retain	Annual	Retain	Retain	Retain	UIC Permit required monitoring point	6	UIC Permit required monitoring frequency

Table 5.10
ISCO Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

Well ID	X Coordinates	Y Coordinates	Top of Screen (bgs)[a/]	Bottom of Screen (bgs)	Zone[b/]	Functional Category	Current Sampling Frequency (months)	Risk to Receptors	Predictability of COC Concentrations
AOC65-TSW-01	535,679.940	3,283,708.128	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-02	535,679.417	3,283,695.364	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-03	535,679.703	3,283,674.248	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-04	535,679.802	3,283,649.597	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-05	535,732.137	3,283,716.576	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-06	535,713.230	3,283,615.344	19	49	UGR	In-Plume	3	Low	Predictable
AOC65-TSW-07	535,679.732	3,283,622.527	10	40	UGR	In-Plume	3	Low	Predictable
AOC65-PZ01-LGR	535,671.094	3,283,735.988	105	130	LGR	In-Plume	3	Low	Predictable
AOC65-PZ02-LGR	535,671.114	3,283,607.762	23	48	LGR	In-Plume	3	Low	Predictable
AOC65-PZ05-LGR	535,671.032	3,283,603.005	89	124	LGR	In-Plume	3	Low	Predictable
AOC65-PZ06-LGR	535,671.118	3,283,740.738	16	41	LGR	In-Plume	3	Low	Predictable
AOC65-SIW-01	535,710.358	3,283,733.729	13	27	UGR	In-Plume	3	Low	Predictable
AOC65-VEW13-LGR	535,685.387	3,283,710.708	15	40	LGR	In-Plume	3	Low	Predictable
AOC65-VEW15-UGR	535,702.442	3,283,739.793	5	12	UGR	In-Plume	3	Low	Predictable
AOC65-VEW16-LGR	535,702.486	3,283,734.935	15	40	LGR	In-Plume	3	Low	Predictable
AOC65-VEW18-LGR	535,702.566	3,283,678.233	15.5	55.5	LGR	In-Plume	3	Low	Predictable
AOC65-VEW19-UGR	535,685.730	3,283,723.772	5	25	UGR	In-Plume	3	Low	Predictable
AOC65-VEW20	535,685.021	3,283,747.677	10	25	UGR	In-Plume	3	Low	Predictable
AOC65-VEW21	535,671.202	3,283,745.429	12	27	UGR	In-Plume	3	Low	Predictable
AOC65-VEW23	535,670.983	3,283,711.861	6	21	UGR	In-Plume	3	Low	Predictable
AOC65-VEW25	535,671.047	3,283,686.300	6	21	UGR	In-Plume	3	Low	Predictable
AOC65-VEW27	535,686.886	3,283,696.332	6	21	UGR	In-Plume	3	Low	Predictable
AOC65-VEW28A	535,702.727	3,283,721.444	80	120	LGR	In-Plume	3	Low	Predictable
AOC65-VEW28B	535,702.727	3,283,721.444	139.3	179.3	LGR	In-Plume	3	Low	Predictable
AOC65-VEW29	535,694.814	3,283,734.530	5	40	UGR	In-Plume	3	Low	Predictable
AOC65-VEW31	535,697.010	3,283,720.691	5	40	UGR	In-Plume	3	Low	Predictable
AOC65-VEW32	535,702.087	3,283,716.081	5	20	UGR	In-Plume	3	Low	Predictable
AOC65-IIW-01	535,672.849	3,283,708.008	10	125	LGR	In-Plume	3	Low	Predictable
AOC65-IIW-02	535,672.322	3,283,682.177	10	125	LGR	In-Plume	3	Low	Predictable
AOC65-IIW-03	535,672.375	3,283,659.767	10	125	LGR	In-Plume	3	Low	Predictable
AOC65-IIW-04	535,671.661	3,283,637.235	10	125	LGR	In-Plume	3	Low	Predictable
CS-MW6-LGR	535,711.319	3,283,882.507	340	365	LGR	Upgradient	15	Low	Predictable
CS-MW7-LGR	535,884.568	3,283,611.409	322	347	LGR	Crossgradient Plume-Edge	15	Low	Predictable
CS-MW8-LGR	535,695.762	3,283,575.281	332	357	LGR	In-Plume	15	Moderate	Predictable
CS-MW36-LGR	535,673.212	3,283,702.697	345	370	LGR	In-Plume	15	Moderate	Predictable
LS-5	535555	3283080	--	--	--	In-Plume	3	High	Predictable
LS-6	535447.3125	3283059.5	--	--	--	In-Plume	3	High	Predictable
LS-7	535,627.419	3,283,140.991	--	--	--	In-Plume	3	High	Predictable
OFR-3	535177.5	3283478.75	--	--	LGR/CC	In-Plume	3	High	Predictable
RFR-10	535,354.186	3,283,530.660	--	--	--	In-Plume	3	High	Predictable
RFR-11	535322	3283195	--	--	--	In-Plume	3	High	Predictable

Table 5.10
ISCO Well Parameter Inputs
Camp Stanley Storage Activity, Boerne, TX

Well ID	X Coordinates	Y Coordinates	Top of Screen (bgs)[a/]	Bottom of Screen (bgs)	Zone[b/]	Functional Category	Current Sampling Frequency (months)	Risk to Receptors	Predictability of COC Concentrations
CS-WB01-LGR-01	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB01-LGR-09	535,712.781	3,283,552.968	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB01-UGR-01	535,712.781	3,283,552.968	--	--	UGR	In-Plume	15	Low	Unpredictable
CS-WB02-LGR-01	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Low	Predictable
CS-WB02-LGR-09	535,693.987	3,283,619.881	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-01	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-LGR-09	535,687.504	3,283,706.512	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB03-UGR-01	535,687.504	3,283,706.512	--	--	UGR	In-Plume	15	Moderate	Unpredictable
CS-WB04-LGR-01	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Predictable
CS-WB04-LGR-11	535,402.031	3,283,519.471	--	--	LGR	In-Plume	15	Moderate	Unpredictable

[a/] bgs = below ground surface;

[b/] LGR = Lower Glen Rose, CC = Cow Creek, UGR = Upper Glen Rose

"--" = Not Available or Not Applicable

Table 5.11
ISCO Temporal Trends
Camp Stanley Storage Activity, Boerne, TX

Well ID	Recommendation	Start Date	End Date	Number of Samples	Category	Contaminants of Concern[a/]			
						PCE	TCE	DCE12C	VC
AOC65-TSW-01	Retain	9/24/2015	1/9/2020	20	In-Plume	Decreasing*	Prob. Decreasing*	No Trend	ND
AOC65-TSW-02	Exclude/Reduce	9/26/2018	1/8/2020	6	In-Plume	Stable*	Stable*	Stable	ND
AOC65-TSW-03	Retain	9/24/2015	1/8/2020	20	In-Plume	Increasing*	Increasing	<PQL	ND
AOC65-TSW-04	Retain	9/24/2015	1/8/2020	20	In-Plume	Increasing*	Increasing	ND	ND
AOC65-TSW-05	Exclude/Reduce	9/24/2015	1/9/2020	20	In-Plume	Decreasing*	<PQL	ND	ND
AOC65-TSW-06	Retain	9/24/2015	1/8/2020	20	In-Plume	Increasing*	<PQL	ND	ND
AOC65-TSW-07	Retain	9/24/2015	1/8/2020	20	In-Plume	Increasing*	Increasing*	ND	ND
AOC65-PZ01-LGR	Retain	9/24/2015	1/6/2020	19	In-Plume	Stable*	Prob. Increasing	ND	ND
AOC65-PZ02-LGR	Retain	9/24/2015	1/6/2020	19	In-Plume	Increasing*	Increasing	ND	ND
AOC65-PZ05-LGR	Retain	9/24/2015	1/6/2020	20	In-Plume	Stable	Increasing	ND	ND
AOC65-PZ06-LGR	Retain	9/24/2015	1/6/2020	20	In-Plume	Prob. Increasing*	<PQL	<PQL	ND
AOC65-SIW-01	Exclude/Reduce	9/3/2015	1/9/2020	22	In-Plume	Decreasing*	Decreasing*	Decreasing*	ND
AOC65-VEW13-LGR	Exclude/Reduce	9/26/2018	1/8/2020	6	In-Plume	Stable*	<PQL	ND	ND
AOC65-VEW15-UGR	Exclude/Reduce	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Prob. Decreasing*	Prob. Decreasing	ND
AOC65-VEW16-LGR	Exclude/Reduce	9/27/2018	1/8/2020	6	In-Plume	Stable*	<PQL	ND	ND
AOC65-VEW18-LGR	Retain	9/24/2015	1/9/2020	20	In-Plume	No Trend*	<PQL	ND	ND
AOC65-VEW19-UGR	Retain	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Decreasing*	Decreasing	Prob. Increasing
AOC65-VEW20	Exclude/Reduce	9/26/2018	1/8/2020	6	In-Plume	Decreasing	Stable*	Stable*	ND
AOC65-VEW21	Retain	9/26/2018	1/6/2020	6	In-Plume	Prob. Increasing	Stable	ND	ND
AOC65-VEW23	Exclude/Reduce	11/30/2015	1/6/2020	12	In-Plume	Stable*	Stable*	Stable	ND
AOC65-VEW25	Retain	9/24/2015	1/6/2020	19	In-Plume	Increasing*	Increasing	ND	ND
AOC65-VEW27	Retain	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Decreasing*	Prob. Decreasing	No Trend*
AOC65-VEW28A	Exclude/Reduce	9/27/2018	1/8/2020	6	In-Plume	Stable*	Stable	ND	ND
AOC65-VEW28B	Exclude/Reduce	9/27/2018	1/8/2020	6	In-Plume	Stable*	Stable	ND	ND
AOC65-VEW29	Retain	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Prob. Decreasing*	No Trend	No Trend
AOC65-VEW31	Exclude/Reduce	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Decreasing*	<PQL	ND
AOC65-VEW32	Exclude/Reduce	9/24/2015	1/9/2020	19	In-Plume	Decreasing*	Decreasing*	Decreasing	ND
AOC65-IIW-01	Retain	9/26/2018	1/6/2020	6	In-Plume	Prob. Decreasing*	No Trend*	No Trend	ND
AOC65-IIW-02	Exclude/Reduce	9/26/2018	1/6/2020	6	In-Plume	Stable*	<PQL	ND	ND
AOC65-IIW-03	Exclude/Reduce	9/26/2018	1/6/2020	6	In-Plume	Stable*	Prob. Decreasing	Prob. Decreasing	ND
AOC65-IIW-04	Exclude/Reduce	9/26/2018	1/6/2020	6	In-Plume	Prob. Decreasing	Prob. Decreasing*	<PQL	ND
CS-MW6-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	Upgradient	<PQL	ND	ND	ND
CS-MW7-LGR	Exclude/Reduce	9/14/2015	12/11/2019	18	Crossgradient Plume-edge	<PQL	<PQL	ND	ND
CS-MW8-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	In-Plume	Decreasing	ND	ND	ND
CS-MW36-LGR	Exclude/Reduce	9/11/2015	12/11/2019	18	In-Plume	Stable*	Stable*	<PQL	ND
LS-5	Retain	9/8/2015	12/2/2019	18	In-Plume	<PQL	Increasing	ND	ND
LS-6	Retain	9/8/2015	12/2/2019	18	In-Plume	<PQL	No Trend	ND	No Trend
LS-7	Exclude/Reduce	9/8/2015	12/2/2019	19	In-Plume	Stable	<PQL	ND	ND
OFR-3	Exclude/Reduce	9/8/2015	12/2/2019	18	In-Plume	Stable*	Stable	ND	ND
RFR-10	Exclude/Reduce	9/8/2015	12/2/2019	20	In-Plume	Prob. Decreasing*	Decreasing*	<PQL	ND
RFR-11	Retain	9/8/2015	12/2/2019	18	In-Plume	No Trend*	Stable*	ND	ND
CS-WB01-LGR-01	Retain	9/16/2015	12/16/2019	18	In-Plume	Increasing	<PQL	ND	ND
CS-WB01-LGR-09	Retain	9/16/2015	12/16/2019	18	In-Plume	Stable*	Prob. Decreasing*	<PQL	No Trend*
CS-WB01-UGR-01	Retain	11/18/2004	9/12/2018	4	In-Plume	No Trend*	No Trend	No Trend	<4 Results
CS-WB02-LGR-01	Exclude/Reduce	6/22/2015	9/12/2018	4	In-Plume	<PQL	<PQL	ND	ND

Table 5.11
ISCO Temporal Trends
Camp Stanley Storage Activity, Boerne, TX

Well ID	Recommendation	Start Date	End Date	Number of Samples	Category	Contaminants of Concern[a/]			
						PCE	TCE	DCE12C	VC
CS-WB02-LGR-09	Exclude/Reduce	9/23/2015	12/16/2019	18	In-Plume	Decreasing*	Decreasing*	<PQL	ND
CS-WB03-LGR-01	Retain	9/21/2015	12/17/2019	15	In-Plume	Stable*	Prob. Increasing*	Stable	ND
CS-WB03-LGR-09	Exclude/Reduce	9/17/2015	12/16/2019	18	In-Plume	Decreasing*	Decreasing*	<PQL	ND
CS-WB03-UGR-01	Exclude/Reduce	9/21/2015	12/17/2019	18	In-Plume	Stable*	Stable*	Decreasing	ND
CS-WB04-LGR-01	Exclude/Reduce	9/22/2015	12/18/2019	18	In-Plume	Stable	ND	ND	ND
CS-WB04-LGR-11	Retain	9/22/2015	12/18/2019	18	In-Plume	No Trend*	<PQL	ND	ND

[a/] = PCE = tetrachloroethene, TCE = trichloroethene, DCE12C = *cis*-dichloroethene, VC = vinyl chloride, ND = not detected;
* = Trends contain a sample result that exceeds the cleanup goal entered in the COC information for that parameter (90% of the MCL)
< PQL = all sample results are less than the practical quantitation limit (PQL), or are a mixture of non-detects and detections less than the PQL;
< 4 Results = fewer than four measurements, no trend evaluated

Table 5.12
ISCO 3TMO Detailed Results
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
AOC65-TSW-01	UGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-TSW-02	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-TSW-03	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-TSW-04	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-TSW-05	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-TSW-06	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-TSW-07	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-PZ01-LGR	LGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-PZ02-LGR	LGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-PZ05-LGR	LGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-PZ06-LGR	LGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-SIW-01	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW13-LGR	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW15-UGR	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-VEW16-LGR	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-VEW18-LGR	LGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW19-UGR	UGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW20	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-VEW21	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-VEW23	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-VEW25	UGR	3	Retain	Annual	Retain	Retain	Retain	In-plume	6	Monitor UGR in treatment area
AOC65-VEW27	UGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW28A	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-VEW28B	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
AOC65-VEW29	UGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW31	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-VEW32	UGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-IIW-01	LGR	3	Retain	Annual	Retain	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-IIW-02	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-IIW-03	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
AOC65-IIW-04	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	In-Plume; ISCO oxidant application well	6	Monitor oxidant effectiveness
CS-MW6-LGR	LGR	3	Retain	Less than Biennial	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
CS-MW7-LGR	LGR	3	Retain	Biennial	Exclude/Reduce	Retain	Retain	In-plume, plume-edge	6	Monitor LGR in treatment area

Table 5.12
ISCO 3TMO Detailed Results
Camp Stanley Storage Activity, Boerne, TX

Well Name	Zone	Current Sampling Frequency	Qualitative Evaluation		Temporal Evaluation	Spatial Evaluation	Summary			
			Retention Evaluation	Recommended Monitoring Frequency			Final Retention Evaluation	Retention Rationale	Recommended Monitoring Frequency	Frequency Rationale
CS-MW8-LGR	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
CS-MW36-LGR	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	In-plume	6	Monitor LGR in treatment area
LS-5	--	3	Retain	Monthly to Quarterly	Retain	Retain	Retain	wellhead protection	6	GAC treatment
LS-6	--	3	Retain	Monthly to Quarterly	Retain	Retain	Retain	Off-post DWW with GAC	6	Monitor for ISCO byproducts pre and post
LS-7	--	3	Retain	Monthly to Quarterly	Exclude/Reduce	Retain	Retain	wellhead protection	6	GAC treatment
OFR-3	LGR/CC	3	Retain	Monthly to Quarterly	Exclude/Reduce	Retain	Retain	Off-post DWW with GAC	6	Monitor for ISCO byproducts pre and post
RFR-10	--	3	Retain	Monthly to Quarterly	Exclude/Reduce	Retain	Retain	wellhead protection	6	GAC treatment
RFR-11	--	3	Retain	Monthly to Quarterly	Retain	Retain	Retain	Off-post DWW with GAC	6	Monitor for ISCO byproducts pre and post
CS-WB01-LGR-01	LGR	3	Retain	Annual	Retain	Retain	Retain	distribution of COCs	6	Monitor LGR in treatment area
CS-WB01-LGR-09	LGR	3	Retain	Semi-Annual	Retain	Retain	Retain	Monitor vertical	6	Monitor LGR in treatment area
CS-WB01-UGR-01	UGR	3	Retain	Annual	Retain	Retain	Retain	distribution of COCs	6	Monitor UGR in treatment area
CS-WB02-LGR-01	LGR	3	Retain	Annual	Exclude/Reduce	Retain	Retain	Monitor vertical	6	Monitor LGR in treatment area
CS-WB02-LGR-09	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	distribution of COCs	6	Monitor LGR in treatment area
CS-WB03-LGR-01	LGR	3	Retain	Semi-Annual	Retain	Retain	Retain	Monitor vertical	6	Monitor LGR in treatment area
CS-WB03-LGR-09	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	distribution of COCs	6	Monitor LGR in treatment area
CS-WB03-UGR-01	UGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	Monitor vertical	6	Monitor UGR in treatment area
CS-WB04-LGR-01	LGR	3	Retain	Semi-Annual	Exclude/Reduce	Retain	Retain	distribution of COCs	6	Monitor LGR in treatment area
CS-WB04-LGR-11	LGR	3	Retain	Semi-Annual	Retain	Retain	Retain	Monitor vertical distribution of COCs	6	Monitor LGR in treatment area

6 SUMMARY

The groundwater monitoring program for the CSSA Plume 1 and Plume 2 areas was evaluated for optimization opportunities using 3TMO, a public domain LTMO decision support tool. The overall evaluation determined that the intensity of monitoring can be reduced while still achieving the monitoring objectives and being protective of human health and the environment.

Periodic monitoring of 61 Plume 1 sampling locations (30 wells) is recommended in the optimized monitoring program versus 77 wells in the current program. As a result of well reclassifications, the optimized monitoring program for Plume 1 includes 144 well sampling events over a five-year period versus 400 sampling events in the current program. This equates to a reduction in sampling of 64%. The reclassed wells will continue to be monitored within the bioreactor corrective measure performance monitoring program. The bioreactor performance monitoring program includes the periodic monitoring of 61 sampling locations (462 sampling events over a 5-year period). Optimization of the bioreactor performance monitoring program includes a reduction in analytical suites. The optimized list of analyses to be performed include VOCs, TDS, metals, total organic carbon, methane, ethane, ethene, and CO2, and microbial population and functional gene assay.

Periodic monitoring of 73 Plume 2 sampling locations is recommended in the optimized monitoring program. The optimized monitoring program includes 362 well sampling events over a five-year period versus 352 sampling events in the current program. This equates to a nearly 3% increase in sampling events. Additional monitoring within the source area of Plume 2 will be performed as part of the operations of the ISCO corrective measure at AOC-65. The current ISCO performance monitoring program includes the periodic monitoring of 51 sampling locations (1020 sampling events over a 5-year period). Optimization of the ISCO performance monitoring program includes an overall reduction in sampling frequency from a quarterly to a semi-annual basis resulting in a 50% reduction in sampling events to 510 over a 5-year period. Optimization of the program also includes a reduced list of analyses performed. The optimized list for ISCO performance monitoring includes VOCs and metals.

Figure 6.1 shows a conceptual sampling schedule should the proposed LTMO recommendations be implemented at CSSA. The schedule not only meets the objectives listed in Section 3.1, it allows for the greatest number of sampling events, including a full “snapshot” event, and therefore the most comprehensive data set, prior to the Five-Year Review scheduled for July 2025.

Figure 6.1
Conceptual 5-Year Sampling Schedule at the 2020 LTMO Recommended Frequency

			Current 2015 LTMO Schedule				Proposed 2020 LTMO Schedule																			
							Year 1				Year 2				Year 3				Year 4				Year 5			
Date			Sep-19	Dec-19	Mar-20	Jun-20	Sep-20	Dec-20	Mar-21	Jun-21	Sep-21	Dec-21	Mar-22	Jun-22	Sep-22	Dec-22	Mar-23	Jun-23	Sep-23	Dec-23	Mar-24	Jun-24	Sep-24	Dec-24	Mar-25	Jun-25
LTMO Life cycle month			87	90	93	96	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60
				30-Month Snapshot									30-Month Snapshot										30-Month Snapshot			
Plume 1	Groundwater	Quarterly	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
		15-Month		5				5					5					5					5			
		30-Month		21									21										21			
	Bioreactor	6-Month	19		19		19		19		19		19		19		19		19		19		19		19	
		9-Month		42				38			38			38			38			38			38			38
Plume 2	Groundwater	Quarterly	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
		15-month		50				56					56					56					56			
		30-month		17									11										11			
	ISCO	6-Month					51		51		51		51		51		51		51		51		51		51	
		Quarterly	51	51	51	51																				
			80	196	80	61	80	109	80	10	118	10	173	48	80	10	118	71	80	48	80	10	211	10	80	48
				30-Month Snapshot									30-Month Snapshot										30-Month Snapshot			
			Annual Total		417		Annual Total		279		Annual Total		349		Annual Total		279		Annual Total		218		Annual Total		349	

	5-yr total	Program total
Quarterly	80	Plume 1 Groundwater
15-Month	20	142
30-Month	42	
6-Month	190	Bioreactor
9-Month	266	456
Quarterly	120	Plume 2 Groundwater
15-month	224	366
30-month	22	
6-Month	510	ISCO
Quarterly	0	510

5-Year Total 1474

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APPENDIX A OFF-POST WELL EXCLUSION NOTIFICATION

Based on the DQO flowchart (see Figure 5.8), wells that have consecutive non-detects over the course of 5 years are dropped from the sampling program but retained for future sampling if conditions change or warrant further sampling. The remainder of the wells are retained at their recommended frequency until they satisfy the DQO of 5 years without a reportable detection.

Off-post well owners will be notified by mail using a public fact sheet followed by a personal notification letter that their well is slated for removal from the sampling network. Each notification letter will include a graph or other visual representation of all past sampling results for the well. The fact sheet will be sent out to the CSSA mailing list, which includes all well owners whose wells are currently part of the sampling program. The fact sheet will summarize the rationale and process for excluding a well from future sampling and will outline a comment period during which the public may provide feedback on the exclusion process.