Lockheed Martin Corporation
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Bethesda, MD 20817
Telephone (301) 548-2227

March 30, 2017 **VIA PRIVATE CARRIER**

Mr. James R. Carroll
Program Administrator
Land Restoration Program
Land Management Administration
Maryland Department of the Environment
1800 Washington Boulevard, Suite 625
Baltimore, Maryland 21230

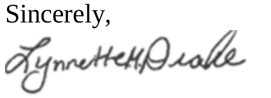
Subject: Transmittal of the Groundwater Response Action Plan Addendum 3: Remedy Modifications for Block I, Middle River Complex
2323 Eastern Boulevard, Middle River, Baltimore County, Maryland

Dear Mr. Carroll:

For your review please find enclosed two hard copies with a CD of the above-referenced document. This addendum recommends changes to the ongoing groundwater remedy in Block I of the Lockheed Martin Middle River Complex in Middle River, Maryland. If possible, we respectfully request to receive MDE's comments by May 11, 2017.

Please let me know if you have any questions. My office phone is (301) 548-2227.

Sincerely,



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Remediation Analyst, Environmental Remediation

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Final Groundwater Response Action Plan Addendum 3: Remedy Modifications for Block I Lockheed Martin Middle River Complex 2323 Eastern Boulevard Middle River, Maryland

Prepared for:

Lockheed Martin Corporation

Prepared by:

Tetra Tech, Inc.

March 2017

Michael Martin, P.G.
Regional Manager

Christopher Pike
Project Manager

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ACRONYMS AND ABBREVIATIONS

cis-1,2-DCE	*cis*-1,2-dichloroethene
DHC	*Dehalococcoides ethenogenes*
GAC	granular activated-carbon
g/L	gram(s) per liter
gpm	gallon(s) per minute
IW	injection well
lbs	pounds
Lockheed Martin	Lockheed Martin Corporation
LMC	Lockheed Martin Corporation
MCL	maximum contaminant level
MDE	Maryland Department of the Environment
µg/L	microgram(s) per liter
mg/L	milligram(s) per liter
MPE	multi-phase extraction
MRC	Middle River Complex
NMW	north monitoring well
ORP	oxidation-reduction potential
ppm_v	parts per million-volume
PVC	polyvinyl chloride
RAP	response action plan
SCFM	standard cubic feet per minute
TCE	trichloroethene
Tetra Tech	Tetra Tech, Inc.
TOC	total organic carbon
VC	vinyl chloride
VDC	volts direct-current
VOC	volatile organic compound

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Section 1
Introduction

This document is Addendum 3 to the August 2012 groundwater-response action plan (RAP) for the Lockheed Martin Corporation (Lockheed Martin) Middle River Complex (MRC). This addendum recommends changes to the ongoing groundwater remedy in Block I of the Middle River Complex site. This document is designed to:

- evaluate current remedy performance
- present new data obtained by pumping tests
- propose remedy modifications to improve remedy performance
- describe implementation of the modified remedy

1.1 SITE LOCATION AND BACKGROUND

The Middle River Complex is at 2323 Eastern Boulevard in Middle River, Maryland (Figure 1-1). It consists of multiple land parcels designated as tax blocks (Figure 1-2, referred to as blocks herein), all owned by LMC Properties, Inc., a subsidiary of Lockheed Martin. Block I contains currently operating facilities; surrounding Block I are the external Blocks A, B, D, E, F, G, and H. Some of these external blocks are used by Lockheed Martin for offices and parking, and others are leased by tenants for parking or operations.

The groundwater response action at the Middle River Complex site is described in the *Groundwater Response Action Plan* (Tetra Tech, Inc. [Tetra Tech], 2012) and in the *Groundwater Response Action 100% Design-Basis Report* (Tetra Tech, 2013). This response action is being conducted in accordance with the "Administrative Consent Order and Settlement Agreement" ACO-SAR-MDE0746-2015-1-01 between the Maryland Department of the Environment (MDE) and Lockheed Martin Corporation. The groundwater response action includes enhanced anaerobic-bioremediation in three areas with high groundwater concentrations of trichloroethene (TCE): the southeastern trichloroethene area (Block E), the southwestern trichloroethene area (Block G), and the northern trichloroethene area (Block I). These three areas are shown on

Figure 1-3. Note that the trichloroethene plumes shown on Figure 1-3 are shown as in the 2012 *Groundwater Response Action Plan.*

Semi-permanent injection wells were installed at the Middle River Complex to inject biological amendments into the subsurface; these wells are arranged in rows and connected via underground piping to injection equipment in each of the three trichloroethene areas. The injection equipment and controls are housed in two modified shipping containers (equipment modules). The system allows flexibility in selecting and setting system parameters (e.g., the number of operational injection wells; substrate type and dosage; and injection rates, volumes, and durations). Each equipment module can be used at any one of the three areas during active injection. Only two areas can undergo active injection at any time.

The first injection event was in Blocks G and I from February 2015–June 2015 (Tetra Tech, 2015). The second injection event in Blocks G and I was from September 2015–February 2016 (Tetra Tech, 2016). Block G injections have substantially reduced concentrations of trichloroethene and its breakdown products. Post-injection monitoring is in progress. Block I injections have been less successful. This addendum evaluates the results obtained from these injections and proposes modifications to the Block I injection program.

Amendment injection in Block E has been delayed by the need to address a trichloroethene source associated with an underground storage tank found in the injection area, and to better investigate a downgradient portion of the associated trichloroethene plume near Dark Head Cove. The results of the trichloroethene source-reduction remedial program in Block E and the downgradient trichloroethene plume investigations are described in the following documents:

- *UST 2 TCE-Source Remedial Action Summary of MPE System Operation* (Tetra Tech, 2016)
- *Block E Downgradient Groundwater Investigation* (Tetra Tech, 2017a)
- *Final 2016 Surface Water Sampling Report* (Tetra Tech, 2017b)

The general operational procedures and details of system operation are in *Operation and Maintenance Plan for Groundwater Remediation System* (Tetra Tech, 2014).

1.2 PURPOSE AND ORGANIZATION

This document recommends modifications to the groundwater remedy that should be made for the third full-scale injection event to be conducted at Block I in the Middle River Complex. This report is organized as follows:

Section 2—Block I Remedy Performance Evaluation: Discusses the remedy performance and makes recommendations for future remedy implementation.

Section 3—Pumping Test Results: Presents the pumping test methodology and results, along with conclusions regarding the feasibility of adding a pumping component to the Block I remedy.

Section 4—Pumping Component Design: Describes the design of the pumping component and presents selected process equipment and layouts.

Section 5—Implementation: Presents the implementation plan for the modified Block I remedy.

Section 6—Reporting: Describes the contents of the third-injection-event progress report that will ultimately be submitted to MDE.

Section 7—References: Lists the references used to compile this report.

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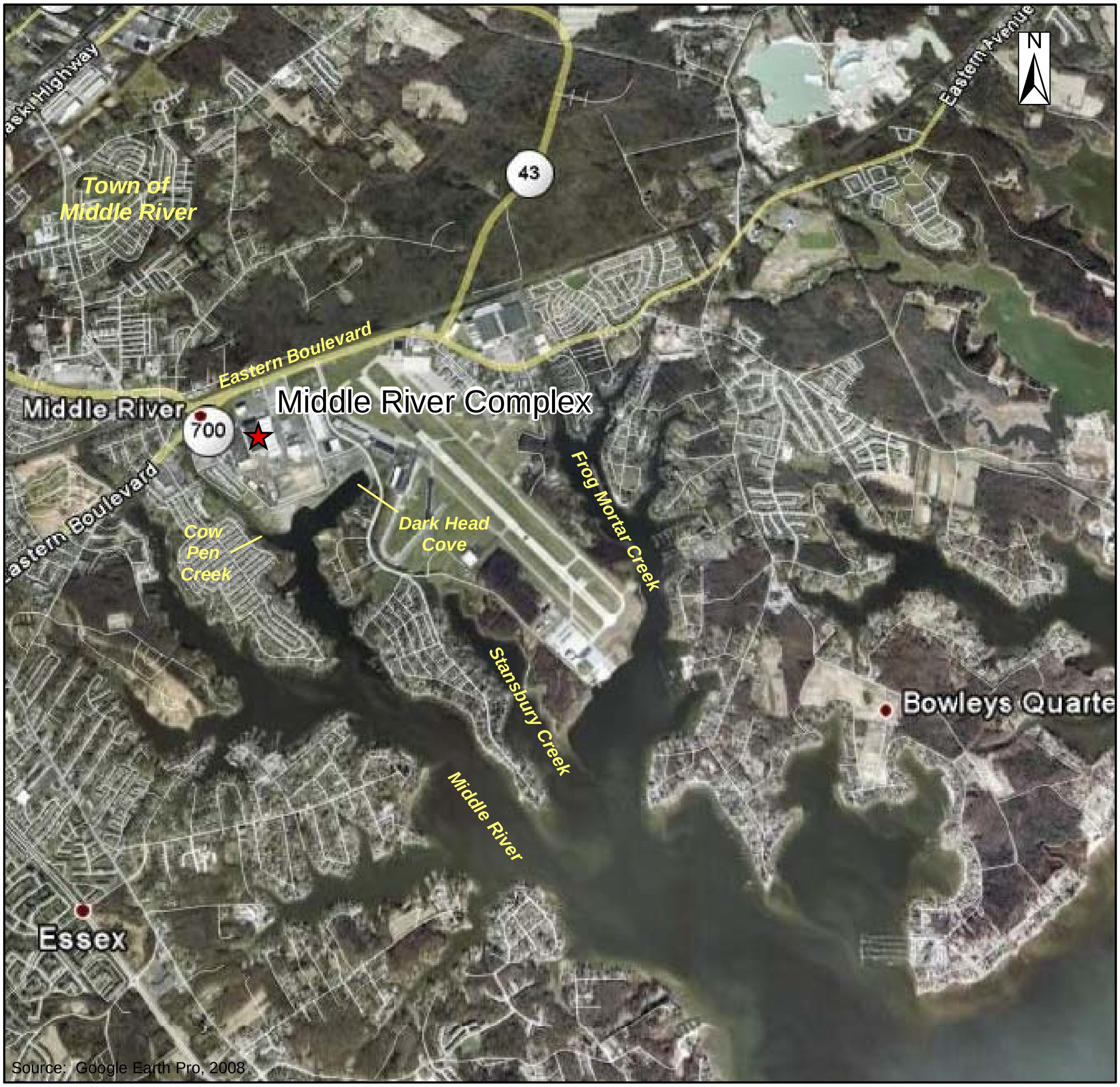

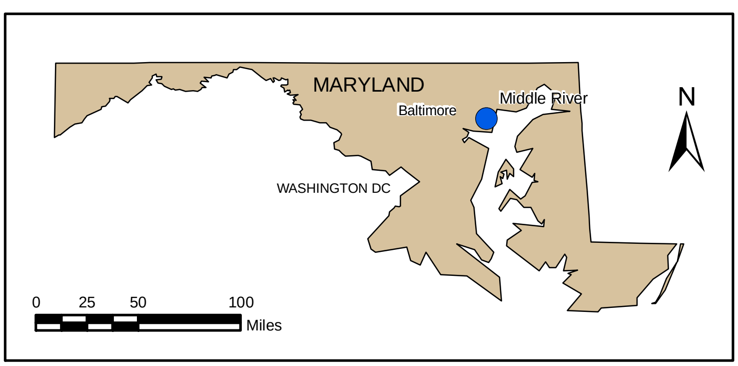

Figure 1-1

Middle River Complex Location Map

Lockheed Martin Middle River Complex
Middle River, Maryland

DATE MODIFIED:	12/15/08	CREATED BY:	BJ

Tetra Tech, Inc.

FIGURE 1-2

MIDDLE RIVER COMPLEX
SITE LAYOUT AND TAX BLOCKS

LEGEND

MIDDLE RIVER COMPLEX TAX BLOCK BOUNDARY

STRUCTURE

RAILROAD TRACKS

Lockheed Martin Middle River Complex
Middle River, Maryland

0 150 300 600 Feet

N

DATE MODIFIED: 11/30/11

CREATED BY: MP

TETRA TECH

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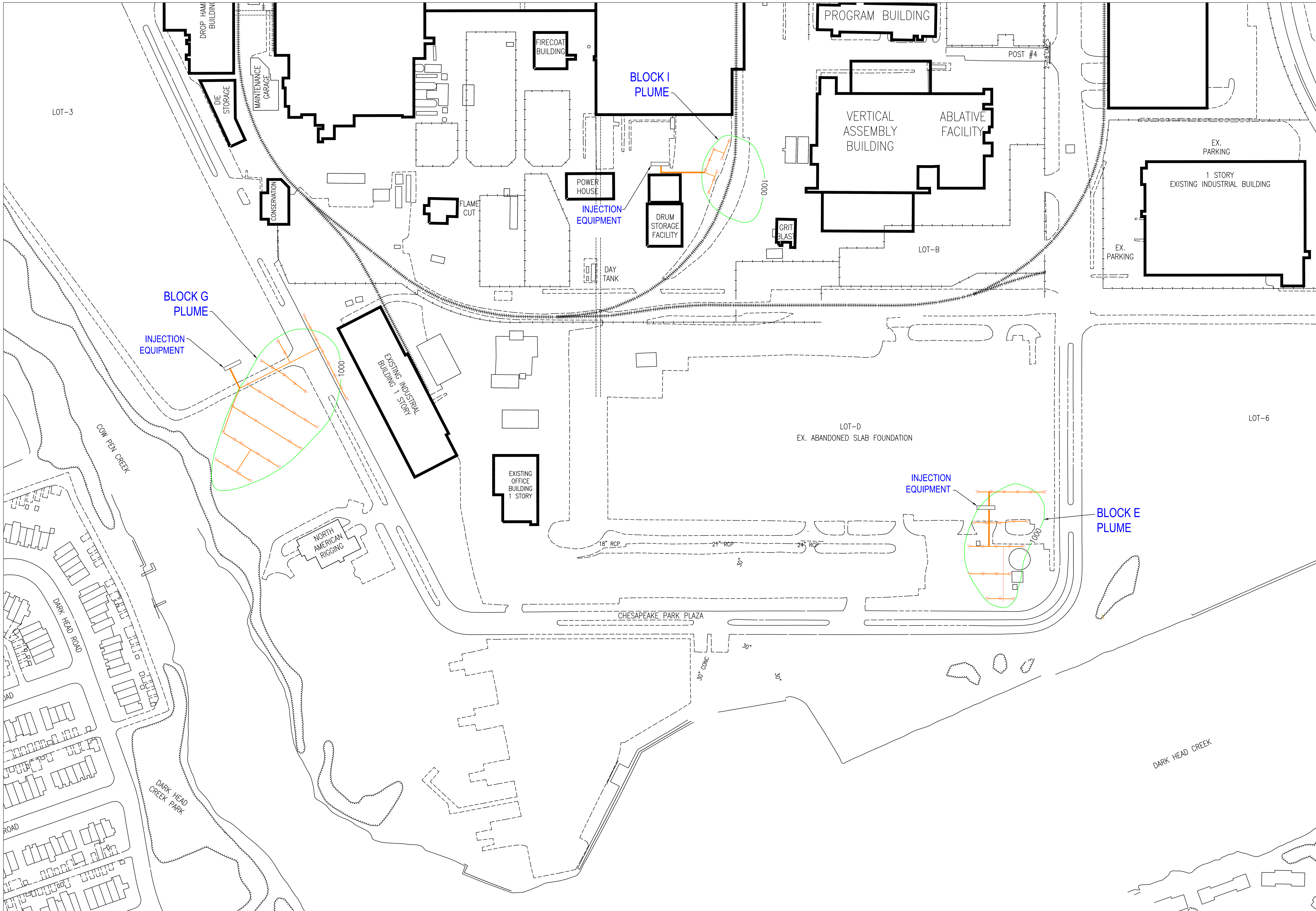


SCALE

0' 125' 250' 500'

LEGEND

	PIPING BUNDLE
	INJECTION WELL
	PIPING TO INJECTION WELLS
1000	1000 ug/L TCE CONTOUR BASED ON 2012 GW RAP

BASE MAP: BASED ON DRAWING PREPARED BY TAI CONSULTING ENGINEERS, INC.

TOPOGRAPHY: TOPOGRAPHY WITHIN AREA OF DISTURBANCE FROM FIELD RUN SURVEY CONDUCTED BY DMW, INC. IN JUNE 1999 FLOATED TO STATE GRID.

HORIZONTAL INFORMATION OUTSIDE OF LIMIT OF DISTURBANCE FROM BALTIMORE COUNTY OFFICE OF INFORMATION TECHNOLOGY GIS SERVICES UNIT. DATE OF CAPTURE: MARCH 1995

EXISTING UTILITIES: FIELD INFORMATION OBTAINED FROM DMW FIELD RUN SURVEY AND LOCKHEED MARTIN ENTITLED "EXHIBIT #6 EXISTING UTILITIES PLAN."

BOUNDARY LINES: BOUNDARY INFORMATION TAKEN FROM RECORDED PLAT E.H.K., JR. 51 FOLIO 43 "1ST AMENDED CHESAPEAKE PARK RE-SUBDIVISION" PREPARED BY MARYLAND SURVEYING AND ENGINEERING CO., INC. 4/24/84. BOUNDARY HAS BEEN ORIENTED TO THE BALTIMORE COUNTY METROPOLITAN DISTRICT GRID, BUT SHOULD NOT BE CONSIDERED A BOUNDARY SURVEY.

TETRA TECH

MRC GROUNDWATER REMEDY LAYOUT

LOCKHEED MARTIN MIDDLE RIVER COMPLEX
MIDDLE RIVER, MARYLAND

DATE:	9-29-2015
PROJECT NO.:	
DESIGNED BY:	BD
DRAWN BY:	BD
CHECKED BY:	CP

FIGURE 1-3

Section 2

Block I Remedy Performance Evaluation

The first injection event at Block I at the Middle River Complex (MRC) began on March 13, 2015 and concluded on April 15, 2015. The second injection event at Block I began on October 5, 2015 and concluded on December 22, 2015. Eight Block I injection wells were used for both injection events. Refer to the *Groundwater Response Action 100% Design-Basis Report* (Tetra Tech, 2013) for construction details and the screened depth-intervals of the injection wells used. Well performance was monitored as described in the performance-monitoring plan (Tetra Tech, 2014). The monitoring wells were sampled before and after the injection, and additional total organic carbon (TOC) samples were taken from nearby utility locations. Implementation of the remedy and evaluation of its performance followed the design objectives established in the design-basis report (Tetra Tech, 2013). Remedy performance evaluation and recommendations are summarized in the first and second injection reports (Tetra Tech, 2015 and 2016).

2.1 REMEDY PERFORMANCE SUMMARY

The Block I remedy performance-evaluation (the first and second injection-completion reports, Tetra Tech, 2015 and 2016) indicates that the injections at Block I met few of the design objectives, because sufficient distribution of the amended fluid (substrate and a sodium-bicarbonate buffering solution) could not be achieved. Likely reasons for this are:

- the low permeability of the geological formation at Block I
- the high degree of subsurface heterogeneity
- low natural groundwater flow velocities
- multiple underground utilities that could serve as preferential channels for the injected fluid
- the need to limit injection pressure to control groundwater mounding and substrate release through the preferential channels

However, as described in the *Second Injection-Event Completion Report* (Tetra Tech, 2016), a partial distribution of substrate was achieved, primarily near MW-81S, and the design goal of creating an environment in which the oxidation-reduction potential (ORP) was sufficiently low for reduction was met in some areas of the site. Note that conditions were not optimal, because the substrate was not sufficiently delivered to a significant portion of the injection area, and sodium bicarbonate buffering was insufficiently effective to raise pH to meet the design goal.

2.2 RECOMMENDATIONS

To improve substrate distribution and better control preferential channeling of the injection fluids, Tetra Tech proposed (in the second injection completion report; Tetra Tech, 2016) modifying the third injection event by including a groundwater-pumping component. To implement this approach, groundwater would be extracted from several existing injection wells, while the amended solution (potable water treated with sodium lactate and added sodium bicarbonate) would be simultaneously injected into the remaining injection wells. The existing injection-equipment would be used, and the configuration of the extraction/injection wells would be selected such that the amended solution will be pulled toward the extraction wells (i.e., across the Block I treatment area).

This approach is hydraulically similar to recirculating amendment, except that extracted water will be treated and discharged to the sanitary sewer (or temporarily stored and disposed of off-site), and the injection solution will be prepared using treated potable water. This approach is more flexible as compared to conventional recirculation, because it does not require a balance of extracted and injected water, which would likely require additional controls. Added advantages include controlling groundwater flow direction and velocity within the treatment zone, and the potential to reduce potential flow into existing preferential pathways. To determine the feasibility of adding such a pumping component, a pumping test was performed using the wells intended as groundwater extraction locations, and design data such as pumping rates and radii of influence were obtained. The pumping test methodology and results are described in the following section.

Section 3
Pumping Test Results

Fieldwork consisted of a pumping test using several existing injection wells (IWN-1, 2, 3, 4, 5, 6, and 8; refer to Figure 3-1) as pumping locations. Injection well IWN-7 was inaccessible at the time of the pumping test due to pooled rainwater, and thus was not used in the test[1]. Wells used in the pumping test (IWN-1, 2, 3, 4, 5, 6, and 8) were four-inch-diameter polyvinyl chloride (PVC) schedule-80 wells screened from 20–35 feet below the surface grade.

Extracted groundwater was temporarily stored near the former location of the injection-system equipment container, as shown on Figure 3-1. The geologic formation's hydraulic response to pumping was measured in the available monitoring wells (NMW-1I, NMW-2I, NMW-2S, IMW-3I, MW-81B, OW-1, and MPN-2). The pumping wells were tested at maximum pumping rates: the well pumps were lowered to the bottom of the wells and the pumping rates were adjusted to keep water levels in the wells approximately two feet above the pump intakes.

The pumping tests indicate that well yields were generally low, which is consistent with the low permeability geology at Block I. The summary of the sustained yields for the tested wells is in Table 3-1. The pumping tests indicate that wells IWN-3 and IWN-6 are the only locations where pumping would be feasible. The maximum yield of IWN-3 was approximately 0.3 gallons per minute (gpm), and the maximum yield of IWN-6 was approximately 0.1 gpm. The combined sustained yield from these two locations (IWN-3 and IWN-6) could approach 0.5 gpm. For the rest of the tested wells, the yields were too low to be used as pumping locations.

The geologic formation's hydraulic response to pumping was determined by measuring changes in groundwater elevations before, during, and after pumping. Groundwater-table elevations were measured in seven locations: by pressure transducers in four locations (NMW-1I, NMW-2I,

[1] Injection well IWN-7 will be available for use in future injections.

NMW-3I, and MW-81B) and by manual gauging in three locations (MPN-2, NMW-2S, and OW-1). Refer to Figure 3-1 for the monitoring locations.

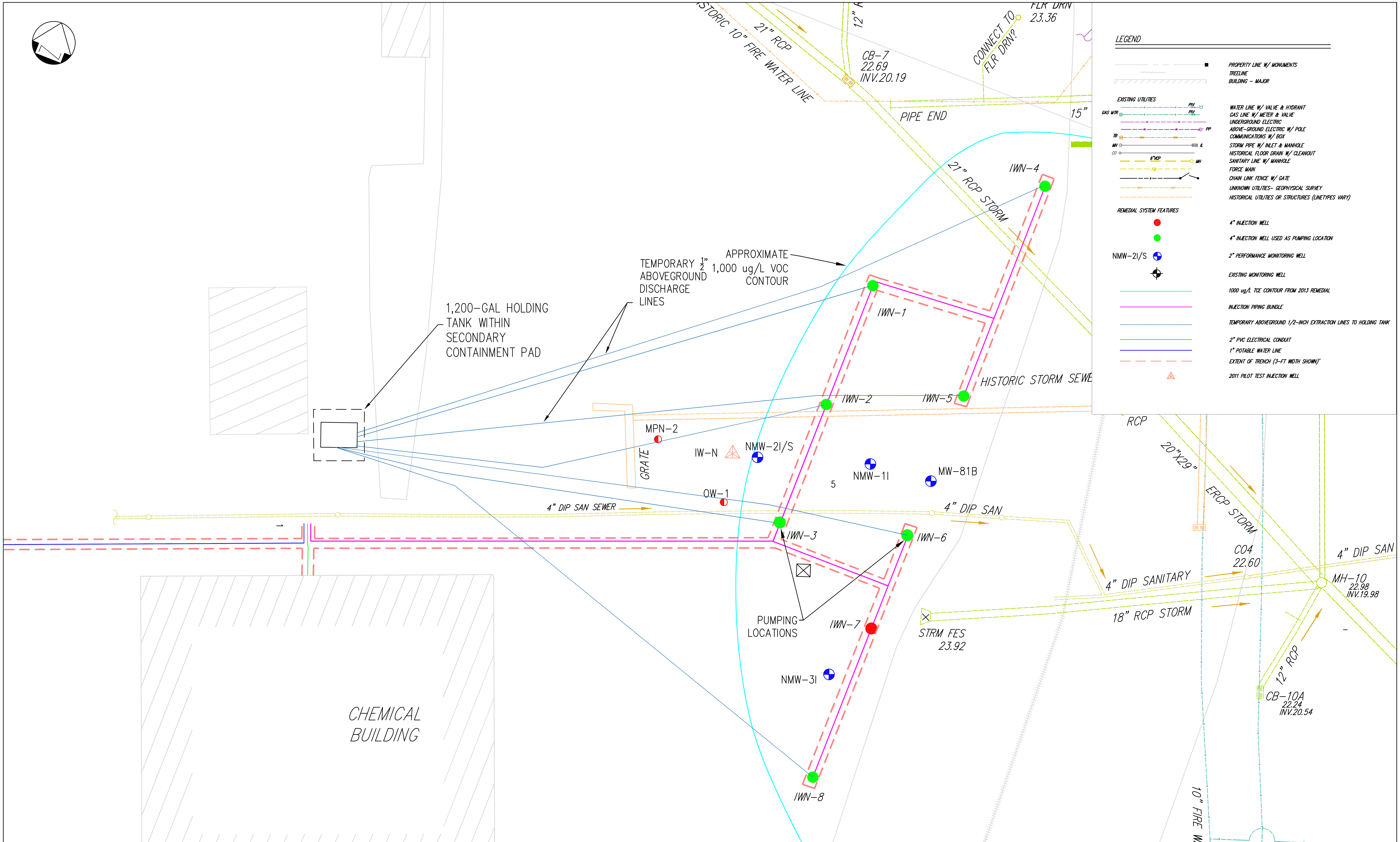
Results for the pressure-transducer measurements, shown on Figure 3-2, show that a hydraulic response to pumping was measured in all four locations. The strongest responses were observed in MW-81B and NMW-2I, where the water levels decreased by approximately 1.5 feet and one foot, respectively, after pumping began. Results for the manual gauging, shown on Figure 3-3, indicate that a hydraulic response to pumping was observed at all three locations. The strongest response was observed in MPN-2, where the water level decreased by approximately one foot after pumping began.

The pumping tests' results lead us to the following conclusions regarding the feasibility of adding a pumping component to the Block I remedy:

- Existing wells IWN-3 and IWN-6 can be used as pumping locations. A combined sustained yield from these pumping locations could be up to 0.5 gpm.
- Hydraulic response to pumping was observed at all measurement locations. Pumping locations (IWN-3 and IWN-6) are in the general center of the injection wells, which is favorable for hydraulic control of injected amendments.
- Adding a pumping component is feasible; this pumping component could, by lowering the groundwater table, be used to improve distribution of the injected amendment and could reduce amendment migration away from the injection area.

Table 3-1
Block I Pump Test Well Yields Summary
Lockheed Martin Middle River Complex
Middle River, Maryland

Pumping Well ID	Sustained Yield at Maximum Drawdown (gallons per minute)	Recovery in 20 hours
IWN-1	<0.025	65%
IWN-2	0.05	near 100%
IWN-3	0.27	near 100%
IWN-4	<0.025	71%
IWN-5	<0.025	57%
IWN-6	0.1	near 100%
IWN-8	<0.025	45%



REFERENCE PLANS & DATA:

1. UTILITY CROSS CONNECTION SURVEY PERFORMED BY TETRA TECH CREW: RAB & AN, DATED 10/6,10/10 & 10/11/2011
2. SURVEYED LOCATIONS OF UNDERGROUND ELECTRIC, WATER, COMMUNICATION LINES, ARE BASED ON GEOPHYSICAL SURVEYS CONDUCTED BY ENVIROSCAN, INC. LANCASTER, PA, AND UNKNOWN FEATURES.
3. SEWER PIPE CCTV REPORTS PREPARED BY VIDEO PIPE SERVICES, INC. DATED 9/26 & 10/12/2011
4. BLOCK G TOPOGRAPHIC SURVEY UPDATE PREPARED BY TETRA TECH CREW: RAB & AN, DATED: 06/07 & 06/08/2011
5. PRE-CONSTRUCTION SURVEY OF STORM DRAIN LINES FOR BLOCK E PREPARED BY TETRA TECH CREW: RAB & AN, DATED 08/15 & 08/16/ 2011.
6. BACKGROUND BASEMAP AND PROPERTY LINES ARE FROM CHESAPEAKE PARK SITE PLAN - LMC PROPERTIES, INC PREPARED BY TAI CONSULTING ENGINEERS, DATED 4/15/01. BACKGROUND DATA IS NOT FIELD VERIFIED AND FOR REFERENCE ONLY.

TETRA TECH
www.tetratech.com

MARK	DATE	DESCRIPTION	BY

BLOCK I PUMP TEST LAYOUT

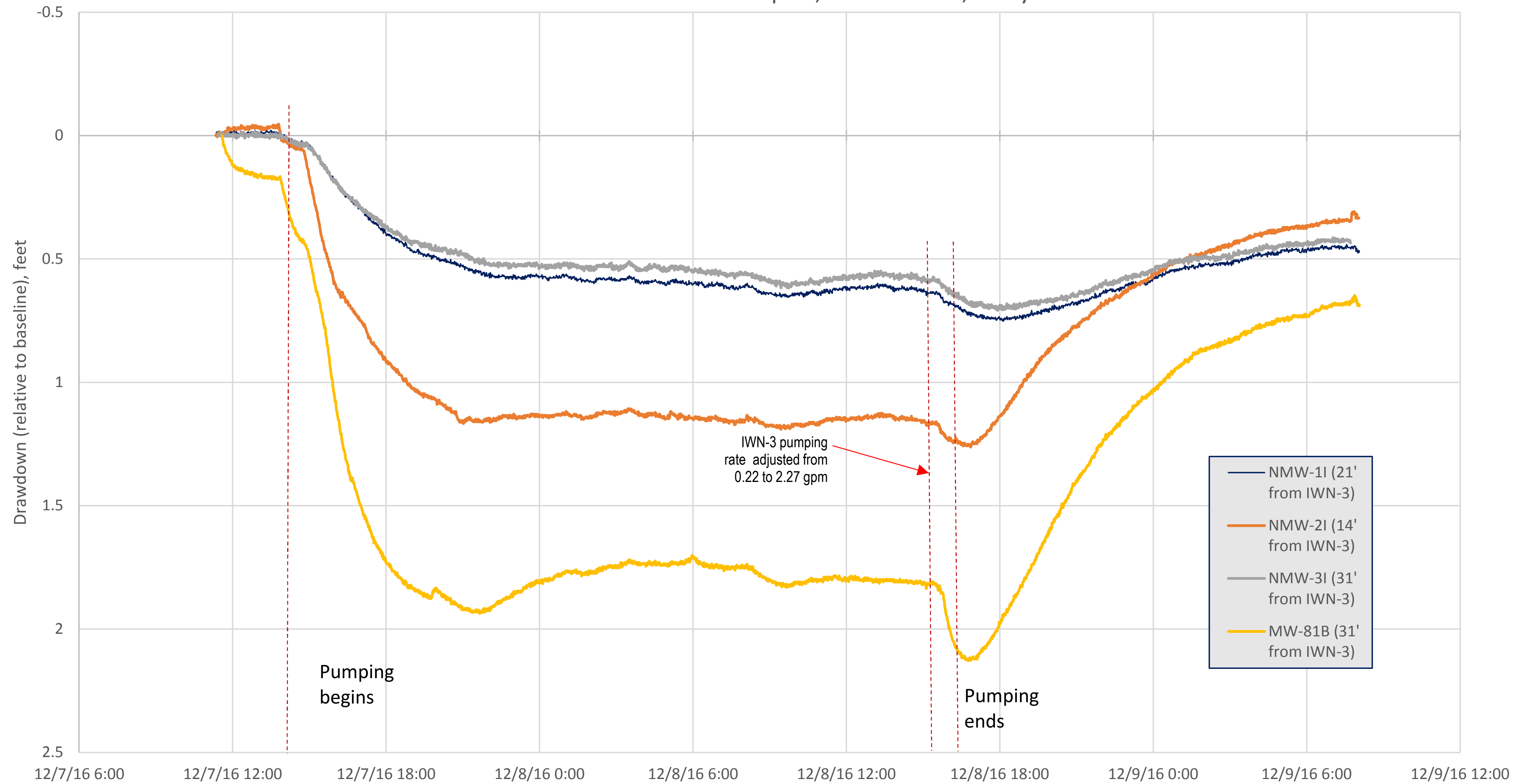
LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/13/2017
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH D
DRAWN BY:	DWM
CHECKED BY:	BD

FIGURE 3-1

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 3-1 PUMP TEST LAYOUT.DWG DWM 2/12/17

Figure 3-2
Block I Pump Test Hydraulic Response to Pumping - Pressure Transducers
Lockheed Martin Middle River Complex, Middle River, Maryland



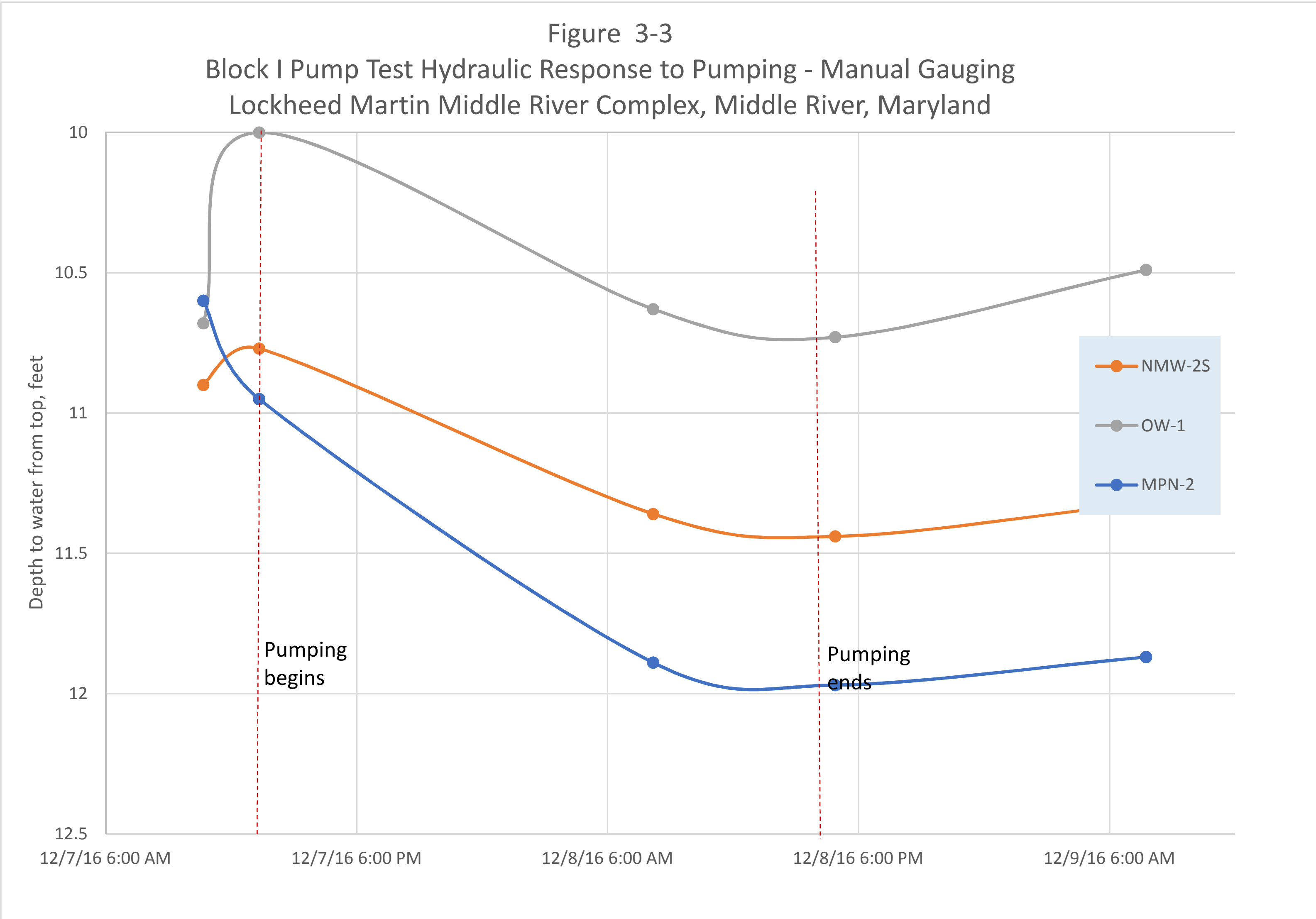


Figure 3-3
Block I Pump Test Hydraulic Response to Pumping - Manual Gauging
Lockheed Martin Middle River Complex, Middle River, Maryland
Depth to water from top, feet
10
10.5
11
11.5
12
12.5
12/7/16 6:00 AM
12/7/16 6:00 PM
12/8/16 6:00 AM
12/8/16 6:00 PM
12/9/16 6:00 AM
Pumping begins
Pumping ends
NMW-2S
OW-1
MPN-2

Section 4
Pumping Component Design

The modified Block I remedy layout is shown on Figure 4-1. The design of the pumping component is described in this section, and includes the following:

- pumping component details (well pumps and controls)
- power and discharge piping for well pumps
- groundwater treatment equipment
- air emissions
- process controls
- sewer discharge arrangements

4.1 WELL PUMPS AND CONTROLS

The selected well pumps are 12-volt direct-current (VDC) pumps manufactured by Proactive Environmental Products®. Low voltage (12-VDC) pumps are selected, as they best match the low-flow pumping requirements at Block I, and provide additional safety in the field. Low-voltage direct-current (12-VDC) electrical lines can be installed at shallow depths in narrow trenches, or directly on the surface. The selected pump model is Poseidon™ 60 (see Appendix A), with the following specifications:

- pumping rate at 60 feet of discharge pressure: 0.5 gallons per minute (gpm)
- pumping rate at 50 feet of discharge pressure: 1 gpm
- replaceable motor module: yes
- voltage: 12-VDC
- power consumption: 150 watts (maximum)
- maximum amp output: 10 amps
- length: 7.5 inches
- diameter: 1.82 inches

Each well pump is configured and controlled as follows:

- The pump is lowered to approximately one foot above the bottom of an extraction well at 34 feet and a low-liquid-level switch is placed near the top of the pump to maximize groundwater recovery (see Figure 4-2).
- While the pump is energized and running, the liquid level in the well decreases. When the liquid level reaches the level switch, the pump is deactivated for a predetermined time interval to allow groundwater in the well to recover approximately two feet.
- A control panel with adjustable time relay is used to set the time interval for deactivating the pump. This control panel uses 12-VDC and is inside a well box in a waterproof housing (see Figure 4-2).

4.2 ELECTRICAL LINES AND DISCHARGE TUBING

The electrical lines and the discharge tubing for the well pumps will be placed in narrow shallow trenches, as shown on Figure 4-1. The trenches will be installed eight inches deep by cutting approximately 0.75-inch-wide slots in the pavement using a conventional pavement cutter. Each well pump will have its own 0.5-inch-inside-diameter polyethylene discharge tubing, as shown on Figure 4-3, "Process and Instrumentation Diagram." Electrical lines will use gauge-10 wires. After electrical wiring and tubing have been installed, the pavement cuts will be sealed using appropriate patching material. Note that due to the use of shallow trenches, pumping will not be performed when temperatures are near or below freezing. See the trench section (Figure 4-2) for construction details.

Hydraulic calculations (see Appendix C) were indicate that a pumping configuration using the following parameters will be adequate for Block I pumping requirements:

- tubing inside diameter: 0.5 inches
- length of tubing for most distant well: 150 feet
- pumping lift requirements from well bottom to top of air stripper: 45 feet
- pump model: Poseidon™ 60
- calculated flow (when pump is active): 1 gpm
- maximum well yield: 0.3 gpm
- calculated pipe-friction losses: 5 feet

Note that the information that follows in Sections 4.3, 4.4, and 4.5 only applies if a decision is made to treat the water on-site and dispose of it in the sanitary sewer. If the water is pumped directly to a storage tank for off-site disposal, the only portion of the following sections that applies will be the controls associated with the well pumps and the on-site frac tank. Both disposal methods (on-site treatment and off-site disposal) are technically and economically feasible, and the actual disposal method will be selected by Lockheed Martin based on cost, logistics, and sustainability considerations.

4.3 ON-SITE GROUNDWATER TREATMENT

The groundwater treatment equipment selected is based on the expected groundwater influent quality and anticipated sanitary-sewer discharge requirements for Baltimore County. A shallow-tray air stripper is the main process unit to remove dissolved volatile organic compounds (VOCs) from the liquid stream. The selected air-stripper model (Carbonair Stat 15) will be skid-mounted with the blower, transfer pump (with level controls), high sump-liquid-level alarm, the control panel, and all gauges and instrumentation. Appendix A contains layout drawings and other details for the air-stripper skid. The selected air-stripper model has the following key characteristics:

- maximum flow: 15 gpm
- airflow (fixed): 80 standard cubic feet per minute (SCFM)
- tray dimensions: 24-inches long, by 10 inches wide, by 10 inches high
- sump capacity: 16 gallons
- number of trays: six
- construction: 304SS

The selected air-stripper's performance was evaluated using influent concentrations based on the maximum VOC concentrations detected after the second injection in March 2016 (2,300 micrograms per liter [µg/L] of trichloroethene [TCE], 6,500 µg/L of *cis*-1,2-dichloroethene [*cis*-1,2-DCE], 530 µg/L of vinyl chloride [VC] in NMW-2I,), two gpm flow (maximum flow from both pumps, for conservatism) and temperatures of 55 degrees Fahrenheit for inlet water and air. The air-stripper manufacturer's software was used for this evaluation. Modeling results (Appendix B) indicate that with four trays the effluent concentrations will be as follows:

- TCE: 0.01 µg/L
- *cis*-1,1-DCE: 0.19 µg/L

- VC: 0.00013 µg/L
- Total VOCs: 0.2 µg/L

Modeled effluent values for all compounds are well below maximum contaminant level (MCL) levels. The performance evaluation (Appendix B) for the selected air-stripper suggests that effluent polishing by liquid-phase granular activated-carbon (GAC) will not be required to meet sanitary-sewer discharge requirements for VOCs (2.13 milligrams per liter [mg/L] for total toxic organics, based on the anticipated requirements). Treated effluent from the air stripper will be collected in the frac tank (Figures 4-1 and 4-3) and transferred to the sanitary-sewer discharge location after a confirmatory sample has been analyzed to ensure that the treated groundwater meets discharge requirements. The air stripper will be placed in secondary containment designed to contain any leaks or spills.

4.4 AIR EMISSIONS CONTROL FROM ON-SITE TREATMENT

Air-stripper emissions containing vapor-phase VOCs (if on-site treatment is used) will be treated via vapor-phase GAC. The total amount of activated carbon needed can be estimated by the following procedure:

1) Estimate total airflow (80 SCFM maximum, Stat 15 air stripper)

2) Estimate maximum sustained total pumping rate (0.5 gpm for IWN-3 and IWN-6)

3) Use the maximum VOC concentrations (9,330 g/L of total VOCs in NMW-2I) detected after the second injection in March 2016 and the parameters estimated in steps 1 and 2 to calculate the vapor-phase inlet concentration for VOCs (result: 1.4 parts per million-volume [ppm_v]—see the calculation spreadsheet in Appendix C).

4) Estimate the carbon-loading capacity at the concentration calculated in step 3 (result: 0.1) (Appendix D).

5) Calculate a total required amount of vapor-phase carbon based on the GAC-loading capacity (step 4) and a conservative time-estimate for pumping duration of three months (result: 50 pounds of GAC).

The vapor-phase GAC vessel is selected based on the above estimates of the total GAC required and the inlet airflow. The selected vessel (VGAC-1) will have 270 SCFM maximum air-flow capacity, steel construction, 24-inch-diameter by 36-inch-high dimensions, with four-inch connections (Carbonair model GPC 3H or similar; see Appendix A). The selected GAC vessel will have 180 pounds of GAC and will have capacity for the entire injection duration (based on the calculated GAC consumption rate). Air-stripper airflows will be measured using a pitot-tube-based flow meter (PT-1 on Drawing 4-3). The sampling ports will be used to measure vapor concentrations in the vapor stream at the air-stripper effluent and at the VGAC-1 effluent (treated effluent).

The GPC-3H pressure-drop curve (Appendix A) suggests that the pressure drop across the vessel will be minimal (approximately 3.5-inches water column). Refer to Appendix A for more details regarding the features of the selected VGAC vessel. The piping and instrumentation for the vapor-phase GAC vessels and the piping and installation layout details are shown on Figure 4-3.

4.5 PROCESS CONTROLS

The pumping-system process controls (Figure 4-3) and the control logic can be summarized as follows:

- Power source (12-VDC power supply) for the well pumps (DP-1 and DP-2 on Figure 4-4) with On/Off switches to activate and deactivate the well pumps will be located in the injection equipment container. This applies to both on-site treatment and off-site treatment and discharge.

- Three safety interlocks will be used to deactivate the well pumps when necessary:

  1) *Air-stripper failure:* Well pumps DP-1 and DP-2 will be deactivated if the air-stripper fails (AS-1 on Figure 4-3).

  2) *Secondary-containment liquid-level alarm:* Both air stripper AS-1 and well pumps DP-1 and DP-2 will be deactivated when the liquid-level switch (LSHH-1 in Figure 4-3) detects liquid in the secondary-containment system.

  3) *Frac-tank high liquid-level alarm:* Both air stripper AS-1 and well pumps DP-1 and DP-2 are deactivated when the high-liquid-level switch in frac tank T-1 (LSHH-2 in Figure 4-3) detects a high-liquid-level condition. Shutdown of pumps based on the frac-tank high-level switch applies to both on-site treatment and off-site treatment and discharge.

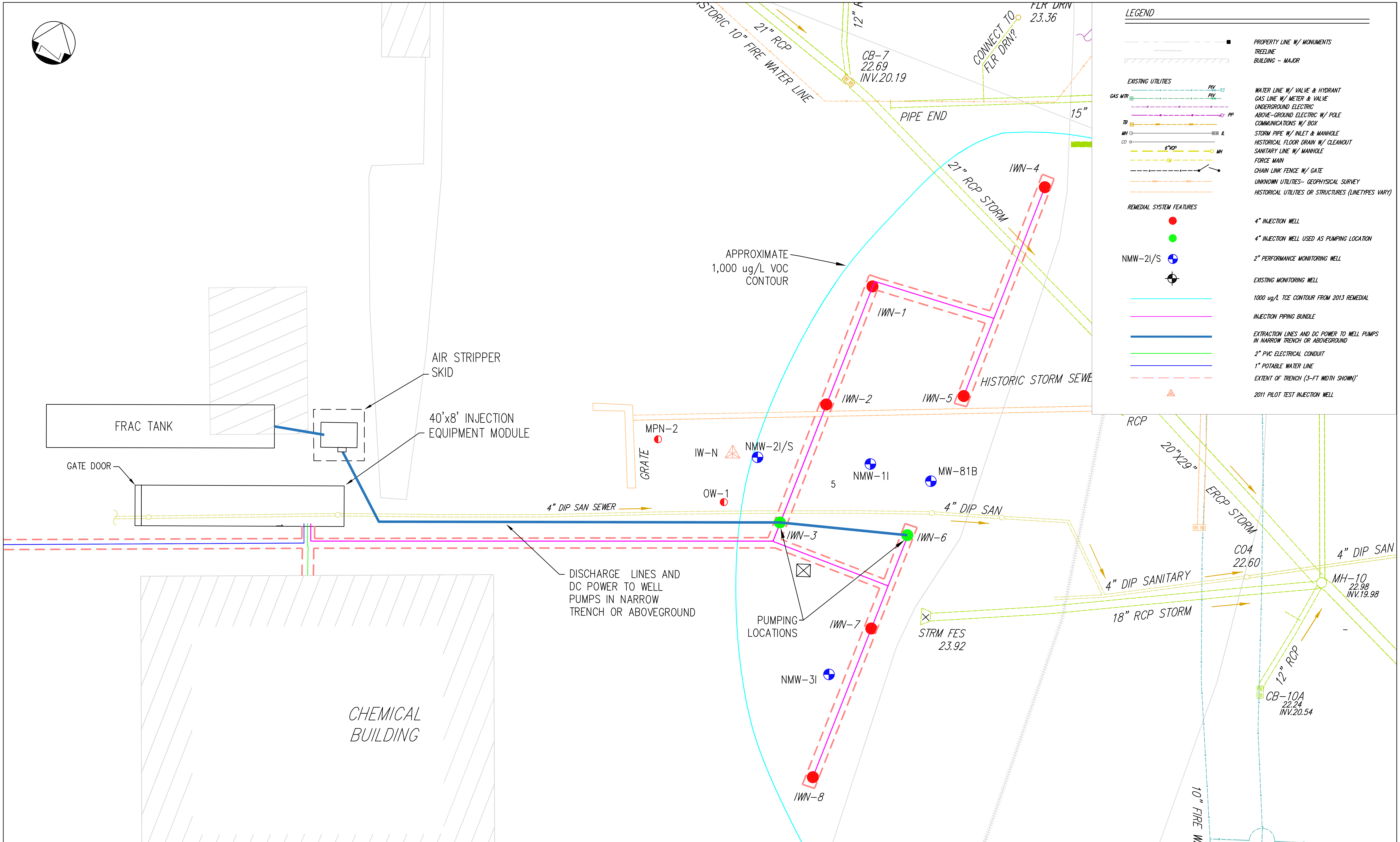
4.6 SANITARY-SEWER DISCHARGE

We assume that extracted groundwater will be treated and discharged on-site into the Baltimore County sanitary sewer. However, Lockheed Martin may elect to treat and dispose of the extracted groundwater off-site. Both methods are technically and economically feasible. Treated groundwater will be stored in a single frac tank with 20,000 gallons storage capacity (T-1 on Figure 4-3, and the information sheet in Appendix A). Once full, the accumulated fluid will be transferred from tank T-1, transported by a tanker trailer to a sanitary-sewer discharge location, and discharged by gravity into a sanitary-sewer manhole.

Alternatively, the fluid may be transported to an off-site facility for treatment and disposal. Assuming 0.5 gpm as a sustained total Block I-system pumping rate from the two wells, storage tank T-1 will have enough capacity to last approximately four weeks of continuous system operation. Assuming a standard tanker trailer capacity of 5,000 gallons, approximately four trips will be needed to transport the stored water volume to the discharge location.

The treated-groundwater discharge location (if a sanitary-sewer discharge permit is granted) is a sanitary sewer manhole approximately 500 feet southwest of the Block I treatment system location (Figure 4-5). The discharge location and configuration discussed in this paragraph are based on previously approved permits for the multi-phase extraction (MPE) system in Block E, as described in *UST 2 TCE Source Remedial Action Summary of MPE System Operation* (Tetra Tech, 2016). One 20,000-gallon frac tank (T-2 discharge tanks, Figure 4-7) will be positioned near the manhole.

The discharge-tank effluent will be connected to the manhole via a temporary aboveground line (one-inch-diameter high-pressure, steel-reinforced hose, all metal high-strength Schedule-40 steel pipe fittings). Treated groundwater will be transferred from the frac tank and discharged under gravity to the manhole. The discharge flow will be adjusted such that the entire volume of the tank would be drained before the next batch of treated groundwater needs to be transferred to the frac tank. The flow control valve (FV-1, Figure 4-6) and discharge-flow totalizer (FTD-1, Figure 4-6) will be used to adjust and measure the discharge flow from the tank. Figure 4-6 depicts the discharge process diagram. We expect that the sewer-discharge analytical sampling parameters (for VOCs and pH) will be similar to the MPE system in Block E; refer to *UST 2 TCE-Source Remedial Action Summary of MPE System Operation* (Tetra Tech, 2016).



REFERENCE PLANS & DATA:

1. UTILITY CROSS CONNECTION SURVEY PERFORMED BY TETRA TECH CREW: RAB & AN, DATED 10/6,10/10 & 10/11/2011
2. SURVEYED LOCATIONS OF UNDERGROUND ELECTRIC, WATER, COMMUNICATION LINES, ARE BASED ON GEOPHYSICAL SURVEYS CONDUCTED BY ENVIROSCAN, INC. LANCASTER, PA, AND UNKNOWN FEATURES.
3. SEWER PIPE CCTV REPORTS PREPARED BY VIDEO PIPE SERVICES, INC. DATED 9/26 & 10/12/2011
4. BLOCK G TOPOGRAPHIC SURVEY UPDATE PREPARED BY TETRA TECH CREW: RAB & AN, DATED: 06/07 & 06/08/2011
5. PRE-CONSTRUCTION SURVEY OF STORM DRAIN LINES FOR BLOCK E PREPARED BY TETRA TECH CREW: RAB & AN, DATED 08/15 & 08/16/ 2011.
6. BACKGROUND BASEMAP AND PROPERTY LINES ARE FROM CHESAPEAKE PARK SITE PLAN - LMC PROPERTIES, INC PREPARED BY TAI CONSULTING ENGINEERS, DATED 4/15/01. BACKGROUND DATA IS NOT FIELD VERIFIED AND FOR REFERENCE ONLY.

TETRA TECH
www.tetratech.com

MARK	DATE	DESCRIPTION	BY

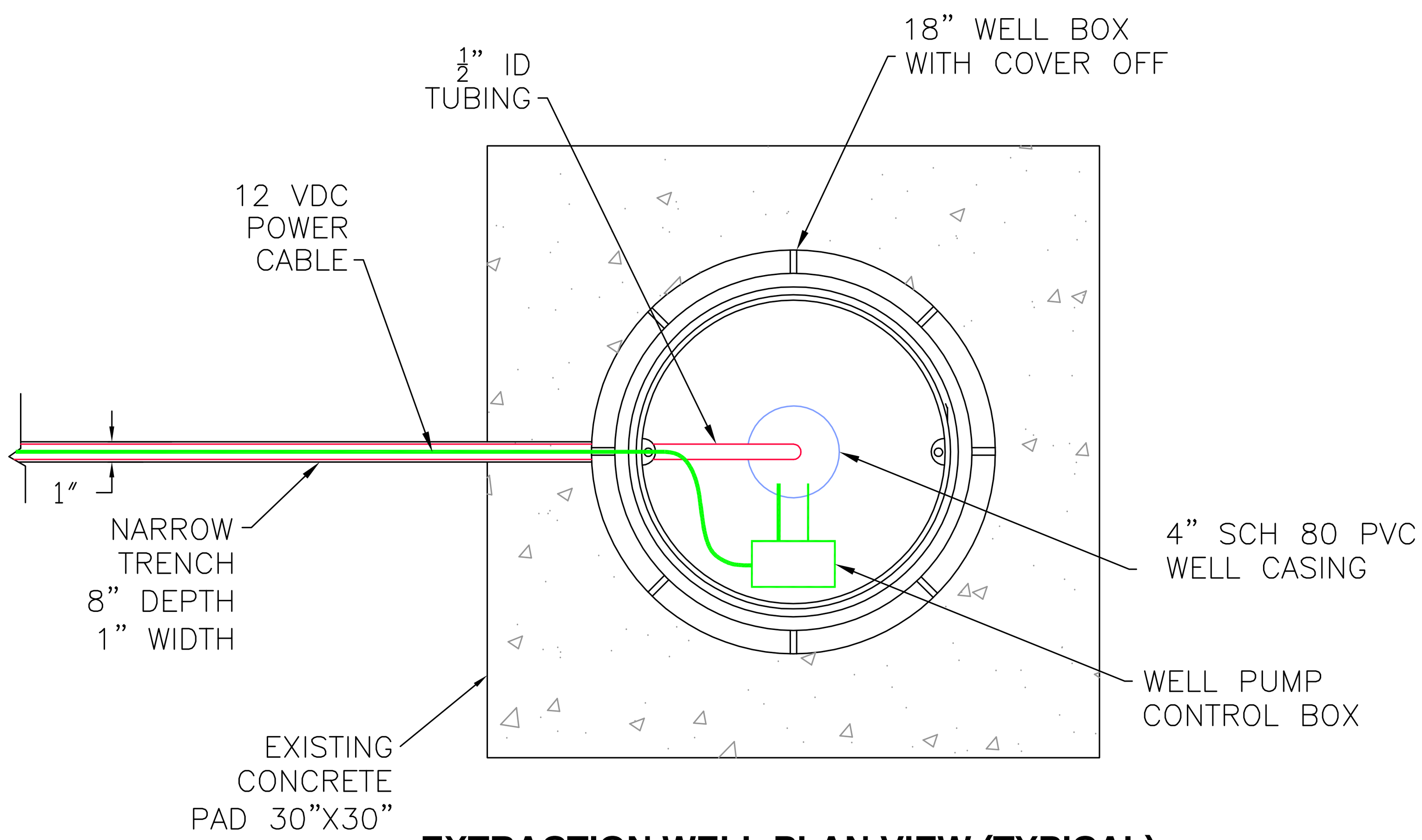
MODIFIED BLOCK I REMEDY LAYOUT)

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

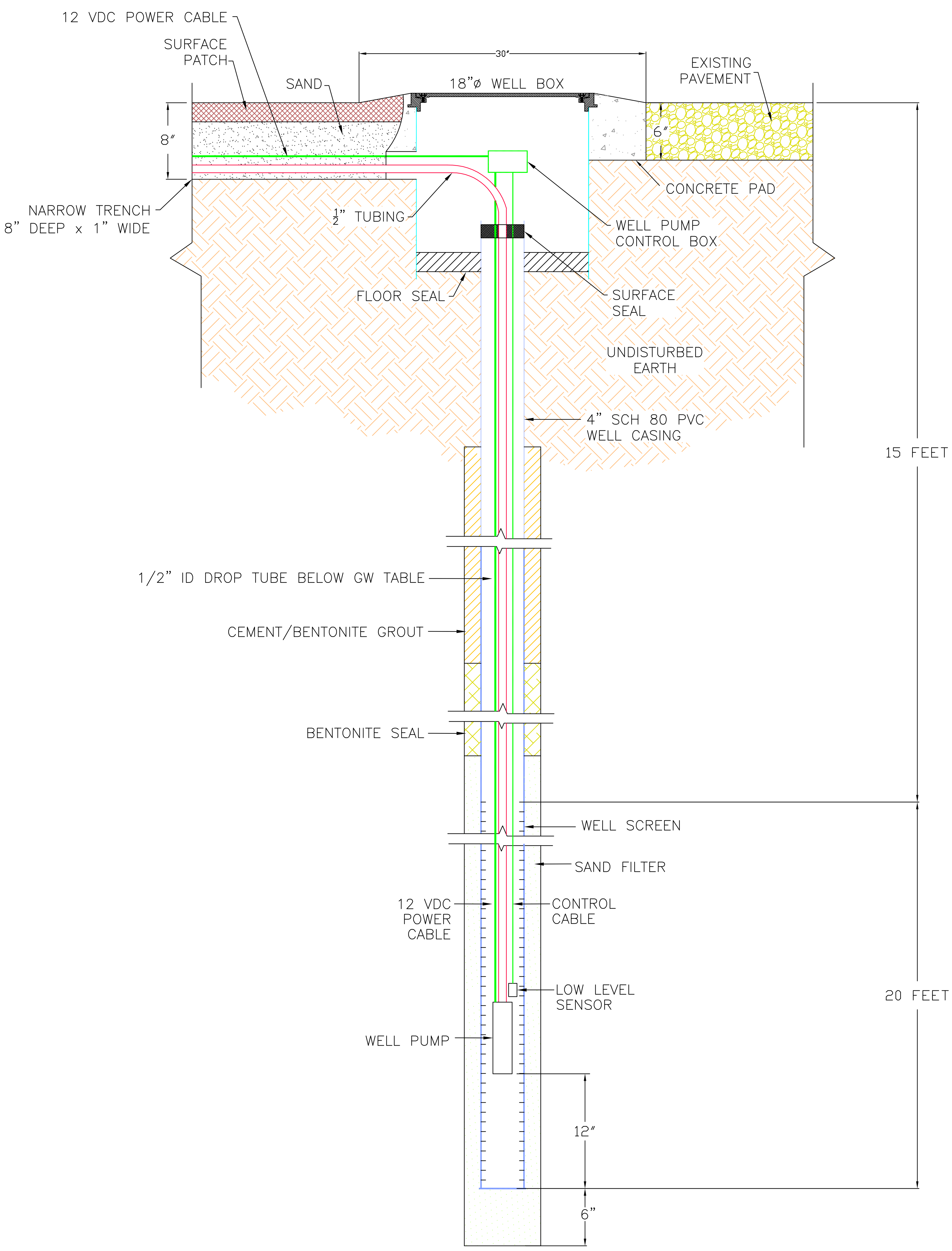
DATE:	2/13/2017
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH D
DRAWN BY:	DWM
CHECKED BY:	BD

FIGURE 4-1

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 4-1 MODIFIED BLOCK I LAYOUT.DWG DWM 2/15/17



EXTRACTION WELL PLAN VIEW (TYPICAL)



EXTRACTION WELL SIDE VIEW (TYPICAL)

DRAWING SCALE

0" 12" 0"

TETRA TECH

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MARK	DATE	DESCRIPTION	BY

RECOVERY WELL DESIGN
BLOCK I PUMPING COMPONENT REMEDIAL DESIGN

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/15/17
PROJECT NO.:	112IC03835
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FIGURE 4-2

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 4-2 WELL DESIGN.DWG DWM 2/15/17

LEGEND

BLOWER WITH MOTOR	PROCESS VALVE (BALL)
TRANSFER PUMP WITH MOTOR	CHECK VALVE (SPRING)
FIELD MOUNTED INSTRUMENT	LINE SIZE CHANGE
PROCESS INDICATOR LIGHT	MOTOR STARTER
INTERLOCK	SOIL VAPORS PIPING
GROUNDWATER PIPING	ANALOG SIGNAL
	ELECTRICAL

ABBREVIATIONS

AS	AIR STRIPPER
TP	AIR STRIPPER TRANSFER PUMP
B	AIR STRIPPER BLOWER
VGAC	VAPOR PHASE CARBON VESSEL
T	FRAC TANK
DP	SUBMERSIBLE WELL PUMP
LSL	LOW LEVEL SENSOR
FT	FLOW TOTALIZER (MECHANICAL)
LSHH	HIGH LIQUID LEVEL SWITCH
LPS	LOW PRESSURE SWITCH
V	PROCESS VALVE
CV	CHECK VALVE
LPG	LOW PRESSURE (AIR) GAUGE
WSP	GROUNDWATER SAMPLING PORT
VSP	VAPOR SAMPLING PORT
ALR	ALARM
HOA	HAND/AUTO/OFF SWIITCH

NOTES

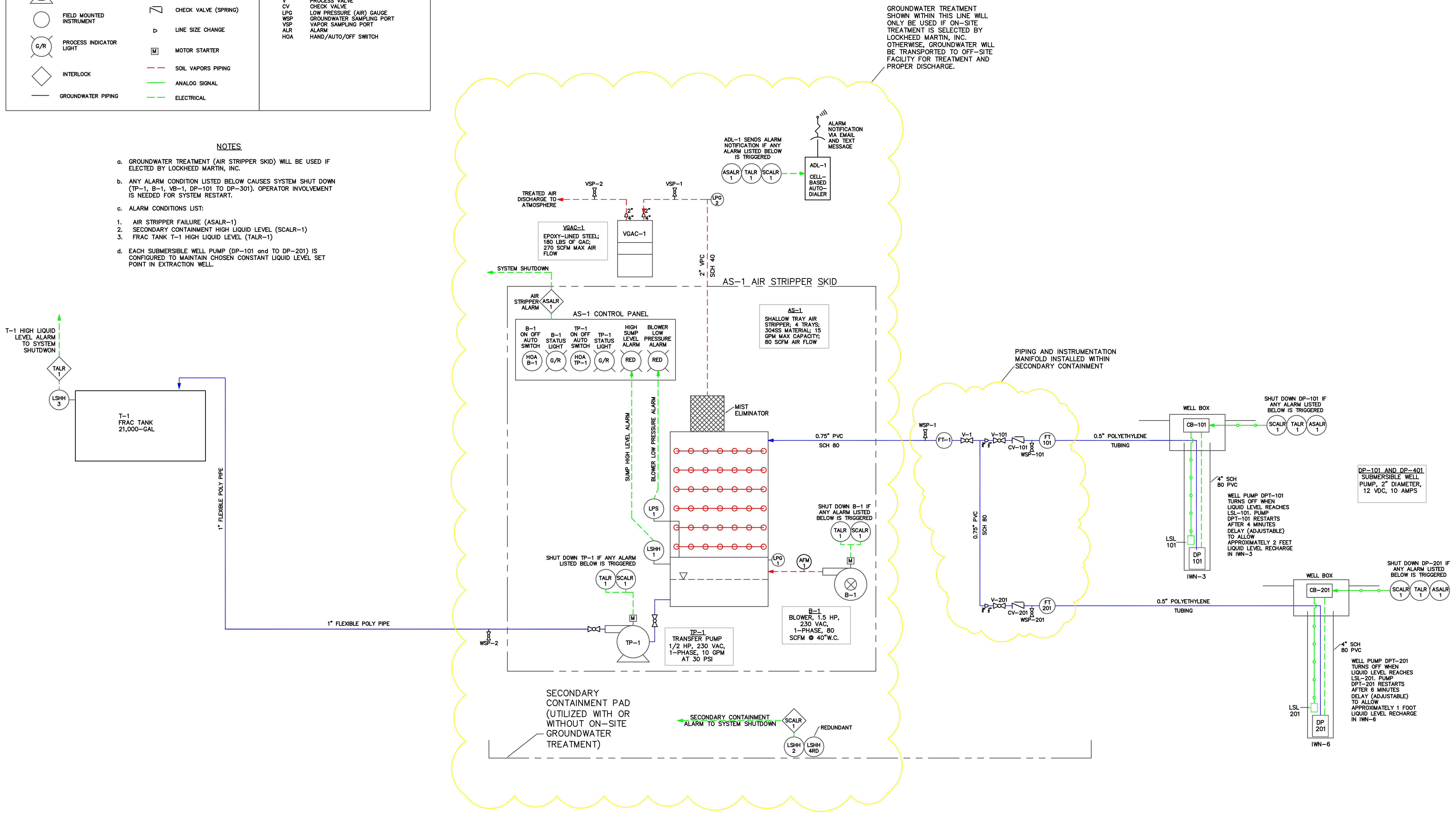
a. GROUNDWATER TREATMENT (AIR STRIPPER SKID) WILL BE USED IF ELECTED BY LOCKHEED MARTIN, INC.

b. ANY ALARM CONDITION LISTED BELOW CAUSES SYSTEM SHUT DOWN (TP-1, B-1, VB-1, DP-101 TO DP-301). OPERATOR INVOLVEMENT IS NEEDED FOR SYSTEM RESTART.

c. ALARM CONDITIONS LIST:

1. AIR STRIPPER FAILURE (ASALR-1)
2. SECONDARY CONTAINMENT HIGH LIQUID LEVEL (SCALR-1)
3. FRAC TANK T-1 HIGH LIQUID LEVEL (TALR-1)

d. EACH SUBMERSIBLE WELL PUMP (DP-101 and TO DP-201) IS CONFIGURED TO MAINTAIN CHOSEN CONSTANT LIQUID LEVEL SET POINT IN EXTRACTION WELL.



TETRA TECH
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MARK	DATE	DESCRIPTION	BY

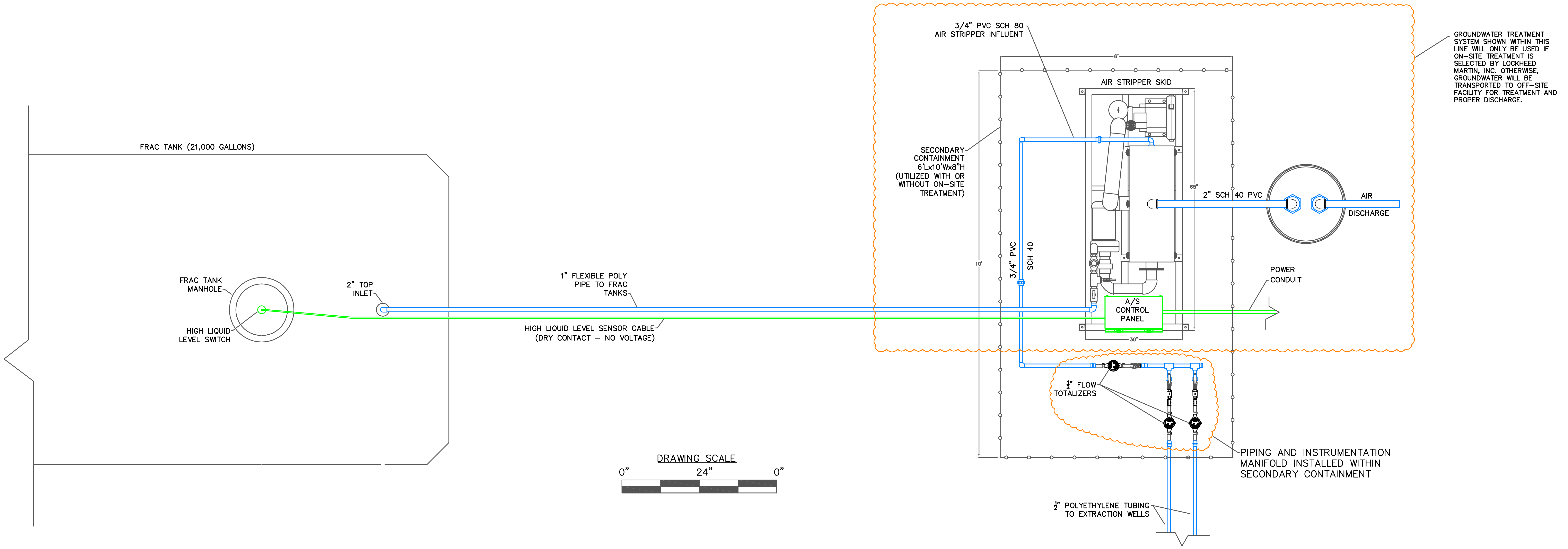
PROCESS & INSTRUMENTATION DIAGRAM
BLOCK I PUMPING COMPONENT REMEDIAL DESIGN

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/15/17
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH D
DRAWN BY:	BD
CHECKED BY:	CP

FIGURE 4-3

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 4-3 AND 4-6 P&IDS.DWG DWM 2/15/17



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MARK	DATE	DESCRIPTION	BY

EQUIPMENT LAYOUT PLAN
BLOCK I PUMPING COMPONENT REMEDIAL DESIGN

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/15/17
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH D
DRAWN BY:	BD
CHECKED BY:	CP

FIGURE 4-4

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 4–4 EQUIPMENT LAYOUT.DWG DWM 2/15/17

SCALE

0' 25' 50'

PIPE CAPACITY FLOW CALCULATION NOTES

EQUATION USED:	MANNING
ROUGHNESS:	0.014 (MEDIAN FOR VCP)
PIPE DIAMETER:	15 INCHES
SLOPE:	SECTION 1: 0.0113
	SECTION 2: 0.0104
ADDED INFLOW:	6,000 GPD

TETRA TECH

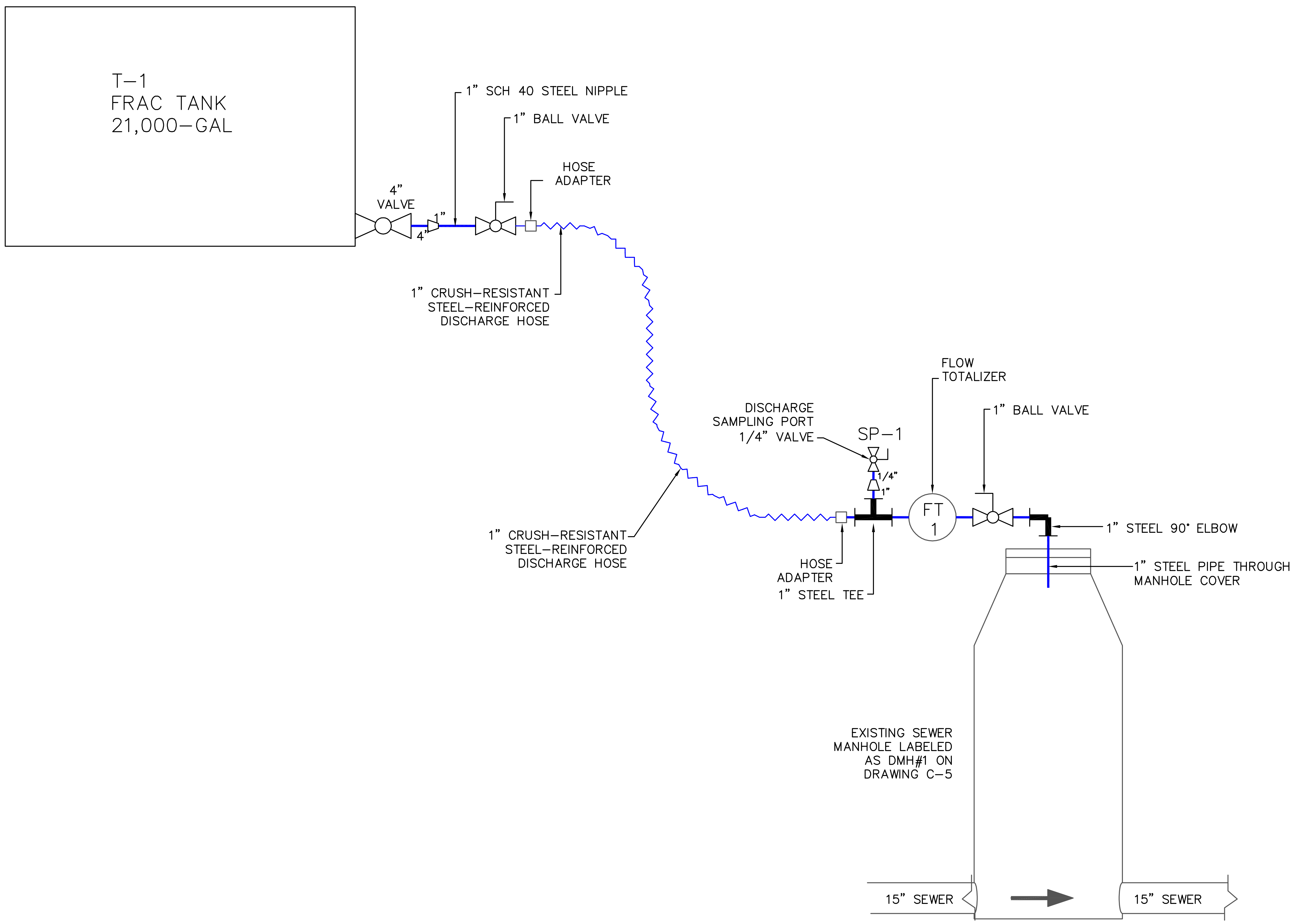
MARK	DATE	DESCRIPTION	BY

SANITARY SEWER DISCHARGE LOCATION
BLOCK I PUMPING COMPONENT REMEDIAL DESIGN

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/12/17
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH C
DRAWN BY:	DWM
CHECKED BY:	BD

FIGURE 4-5



TETRA TECH

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MARK	DATE	DESCRIPTION	BY

SANITARY SEWER DISCHARGE SCHEMATIC
BLOCK I PUMPING COMPONENT REMEDIAL DESIGN

LOCKHEED MARTIN CORPORATION
MIDDLE RIVER COMPLEX, MIDDLE RIVER, MARYLAND

DATE:	2/15/17
PROJECT NO.:	112IC03835
DRAWING SIZE:	ARCH D
DRAWN BY:	BD
CHECKED BY:	CP

FIGURE 4-6

C:\USERS\BORIS.DYNKIN\DOCUMENTS\LMC MRC\BIO SYSTEM OPERATION\BLOCK I 3RD INJECTION\RAP ADDENDUM\FIGURES\FIGURE 4–3 AND 4–6 P&IDS.DWG DWM 2/15/17

Section 5
Implementation

The Block I modified remedy implementation can be summarized as follows:

- install temporary electrical lines and discharge tubing from existing wells IWN-3 and IWN-6 to the system equipment area (see Figure 4-1); mobilize, assemble, and test all equipment, piping, and controls required to extract groundwater
- move the amendment-injection equipment container to the same Block I location as was used for previous injections (see Figure 4-1); connect electrical power, the potable water line, and the injection tubing to the injection equipment container
- pump groundwater from IWN-3 and IWN-6; begin pumping approximately two to four weeks before the amendment injection to better dewater the formation; collect treated groundwater in a frac tank at Block I (see Figure 4-1)
- inject amendments (sodium lactate and sodium-bicarbonate solution, using treated potable water to make the solution) into six injection wells (IWN-1, IWN-2, IWN-4, IWN-5, IWN-7, IWN-8) while pumping from IWN-3 and IWN-6 (see Figure 4-1). The injection methodology will be similar to that used in the first and second injection events.
- Groundwater in the frac tank will be either treated on-site (using a small air stripper) and discharged into a sanitary sewer, or transported to an off-site treatment facility for treatment and disposal. We have assumed herein that extracted groundwater will be treated and discharged on-site. However, Lockheed Martin may elect to use off-site treatment and disposal of the extracted groundwater.

5.1 INJECTION METHODOLOGY

Injection parameters for the third injection event will be similar to those of the second injection event, except that six wells will be used for the injection instead of eight. The design injection-volume will be 5,030 gallons per well. Planned volumes of 1,460 pounds of sodium lactate substrate (as pure ingredient, or 2,433 pounds [as 60% syrup]) and 450 pounds of sodium bicarbonate will be injected. Sodium lactate and sodium bicarbonate dosages per injection well will be slightly higher compared to the second injection event, because fewer injection wells (six instead of eight) will be used. The average lactate concentration (as pure ingredient) will be 0.58% by weight, and the average sodium bicarbonate concentration will be 1.78 grams per liter (g/L).

The average injected sodium lactate and sodium bicarbonate quantities per well will be 243 pounds and 75 pounds, respectively. This information is summarized in Table 5-1.

Injection rates are expected to be similar to the levels achieved during the first and second injection events (0.1–0.15 gallons per minute per well). This experience suggests that the anticipated injection duration will be 20–35 days. This does not include downtime due to system cleaning, maintenance, and malfunctions. As mentioned before, the pumping component will begin operating approximately two to four weeks before the injection, and will continue operating during the entire injection period.

5.2 PERFORMANCE MONITORING

Three injection monitoring events and three post-injection monitoring events will be completed, as described below:

- injection-process monitoring: during pumping and injection
- first monitoring event: one month after third injection completion
- second monitoring event: three months after third injection completion
- third monitoring event: six months after third injection completion

The following analytical and field parameters will be collected from the Block I monitoring wells (Table 5-2):

- total organic carbon (TOC)
- volatile organic compounds (VOCs)
- dechlorinating bacteria (DHC)
- dissolved gases (methane, ethene, ethane)
- general chemistry (selected anion/cations and alkalinity)
- field parameters (oxidation reduction potential, dissolved oxygen, pH, specific conductivity, turbidity)

In addition to the monitoring wells and two pumping locations (IWN-3 and IWN-6), the existing storm-sewer utilities in the Block I injection area and storm-sewer Outfall 009 will be monitored for VOCs (Outfall 009 only), TOC, and field parameters to determine if injected fluid is present. The pumping locations (IWN-3 and IWN-6) will be monitored three times during pumping. Storm-sewer utilities and Outfall 009 will be monitored once during injection and during each post-injection monitoring event. Performance monitoring parameters, sampling locations, and frequency are outlined in Table 5-2.

Table 5-1
Summary of Third Injection Event in Block I
Lockheed Martin Middle River Complex
Middle River, Maryland

Parameter	1st Injection	2nd Injection	3rd Injection (plan)	Units
Injection start:	3/13/2015	10/5/2015	-	
Injection end:	4/15/2015	12/22/2015	-	
Total injection wells:	8	8	6	
Injection wells that did not accepted flow:	0	0	-	
Total injected volume:	39607	39,300	-	gallons
Average injected volume per well:	4950	4,910	-	gallons
Design injection volume per well:	5030	5,030	5,030	gallons
Total design sodium lactate:		1460	1460	pounds (as 100% active ingredients)
Total injected sodium lactate:	730	1470	-	pounds (as 100% active ingredients)
Average sodium lactate per well:	91	184	243	pounds (as 100% active ingredients)
Average lactate concentration as injected:	0.22%	0.45%	-	
Design lactate concentration:		0.50%	0.58%	
Total injected sodium bicarbonate:	465	510	-	pounds
Total design sodium bicarbonate:	360	450	450	pounds
Average sodium bicarbonate per well:	58	64	75	pounds
Average sodium bicarbonate as injected:	1.4	1.56	1.78	grams per liter

Table 5-2
Performance Monitoring for the Third Injection Event in Block I
Lockheed Martin Middle River Complex
Middle River, Maryland

Sampling event	During Operation			1 Month						3 Months						6 Months					
Monitoring Well	VOCs	TOC	Field	VOCs	TOC	ACA	MEE	DHC[1]	Field	VOCs	TOC	ACA	MEE	DHC[1]	Field	VOCs	TOC	ACA	MEE	DHC[1]	Field
MW-81B				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
NMW-1I				1	1	1	1		1	1	1	1			1	1	1	1			1
NMW-2S				1	1	1	1		1	1	1	1			1	1	1	1			1
NMW-2I				1	1	1	1		1	1	1	1			1	1	1	1			1
NMW-3I				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
IWN-3	3	3	3																		
IWN-6	3	3	3																		
CB-8		1	1		1				1		1				1		1				1
CB-8B		1	1		1				1		1				1		1				1
CB-10A		1	1		1				1		1				1		1				1
MH-10		1	1		1				1		1				1		1				1
Outfall 9	1	1	1	1	1				1	1	1				1	1	1				1
Totals	7	11	11	6	10	5	5	2	10	6	10	5	2	2	10	6	10	5	2	2	10

Sample Quantities

VOCs	18
TOC	30
ACA	15
MEE	9
DHC	6
Field	30

[1]Sampling locations for DHC may be adjusted depending on TOC results

ACA - anions, cations, alkalinity
DHC and functional genes - dehalococcoides, tceA reductase, vcrA reductase, bvcA reductase
Field - pH, oxidation-reduction potential, dissolved oxygen, specific conductance
MEE - gases (methane, ethane, ethene)
TOC - total organic carbon
VOCs - volatile organic compounds

Section 6
Reporting

Post-third-injection performance results and recommendations for additional activities at Block I will be submitted in a progress report. This report will include:

- injection fluid volumes and average injection rates for the monitoring period, and cumulative injection volumes to date (total and per injection well)
- extracted groundwater-fluid volumes and pumping rates for the monitoring period, and cumulative extraction volumes to date (total and per extraction well). Total volumes of water transferred to off-site treatment and disposal will be included if off-site treatment and disposal are used.
- groundwater analytical results for the sanitary sewer discharge (if on-site treatment is used)
- any instances of injected-fluid daylighting, preferential channeling, surface-water intrusion event(s), and their mitigation
- injected substrate quantities for the monitoring period, and cumulative substrate quantities to date (total and per injection well)
- injected sodium bicarbonate quantities for the monitoring period, and cumulative sodium bicarbonate quantities to date (total and per injection well)
- equipment process-parameters
- individual injection-well flow rates and operating pressures
- summary of activities performed during the reporting period
- field notes/daily activity logs
- system down times and causes
- laboratory analytical results of samples
- recommendations for continued operation

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Section 7
References

1. Maryland Department of the Environment (MDE), 2006. *Maryland Department of the Environment Voluntary Cleanup Program. Revision 03/17/06*. March.

2. Tetra Tech Inc. (Tetra Tech), 2012. *Groundwater Response Action Plan, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. August.

3. Tetra Tech Inc. (Tetra Tech), 2013. *Groundwater Response Action 100% Design-Basis Report, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland.

4. Tetra Tech, Inc. (Tetra Tech), 2014. *Operation and Maintenance Plan for the Groundwater Remediation System at Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland. Revision 1*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. October.

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9. Tetra Tech Inc. (Tetra Tech), 2017b. *Final 2016 Surface Water Sampling Report, Lockheed Martin Middle River Complex, 2323 Eastern Boulevard Middle River, Maryland*. Report prepared by Tetra Tech, Inc., Germantown, Maryland for Lockheed Martin Corporation, Bethesda, Maryland. March.

APPENDIX A—EQUIPMENT INFORMATION

Shallow Tray Air Stripper STAT 15

More Efficient Off-Gas Treatment

Because STAT low profile air strippers operate at the lowest air flow rate of any low profile air strippers for a given removal efficiency, the off-gas from a STAT contains a higher concentration of contaminants and is at a lower air flow rate. This makes any off-gas treatment that may be required more cost efficient, whether you are using an oxidizer or granular activated carbon.





Model	STAT 15
Tray Dimensions	24″L x 10″W x 10″H
Sump Capacity	16 gallons
Max. Height	7′-7″
Water Flow Range(gpm)	0.5 – 15
Air Flow (cfm)	80
Skid Dimensions	48″L x 30″W x 6″H

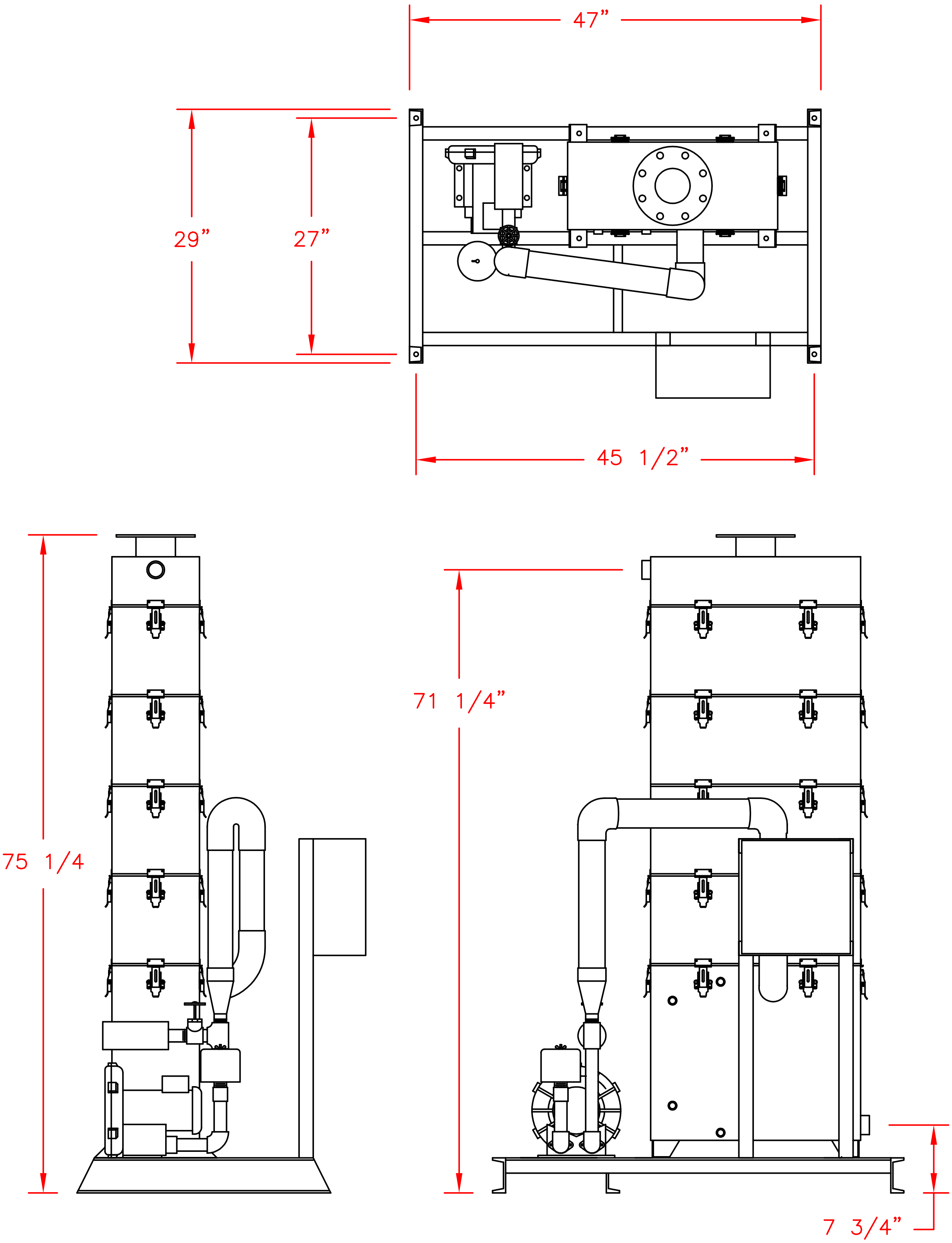
Standard Features

- 304 stainless steel construction
- Polypropylene demister material capable of removing 95% of droplets 5 microns or larger
- Flanged (125 pound) inlet and outlet configuration to maximize the integrity of piping connections
- Anti-Bypass valve* eliminates need for priming prior to system start-up, ensuring that the first gallon to enter the unit will be treated as well as the last gallon
- Flapper valve* (Gravity units) prevents air from bypassing the sieve trays through the water effluent port
- Weir type square downcomer flow distribution system ensures uniform water distribution over the trays
- Tray fastened by over-center latching stainless steel clips
- Collection sump minimizes pump cycling requirements and maintains sufficient turbulence
- Low pressure switch mounted in the blower discharge piping to shut down unit in the event of blower failure
- Direct coupled blower to maintain high pressure air at low flow rates

Optional Components

- Air temperature gauges
- 316 stainless steel construction
- Air Flow meters
- Water temperature gauges
- Water flow meters
- Discharge pump with level controls
- Sample ports
- Explosion-proof controls

STAT 15



NOTE: Adjust overall height by 10 1/4" for each aeration tray added or deleted.
Influent flange on the same side as effluent with odd number of trays.

Sales Drawing #133534
8/2/02

Well Pumps

ProActive Environmental Products Poseidon™ 60 12 Volt Pump

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The revolutionary Poseidon™ 60 is a 12-volt submersible pump that is designed for pumping tests or groundwater remediation. This pump is sized perfectly to fit into schedule 40 and 80 2-inch wells. Choose the Poseidon 60 when you need a pumping depth up to 60 feet. This remediation pump features quick installation, easy operation and long life expectancy. For deeper wells, choose the Poseidon™ 80 or Poseidon™ 100. Simple to install and operate: just clamp 3/8IN I.D. tubing to the pump and secure it with suspension rope or cable to the desired depth. You can power the pump with a deep cycle marine battery or one of our solar systems. You can also use the Poseidon 60 pump with the 110 volt Step Down Transformer.

Order Below

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Have A Question?

	Part Number	Price	
Pump	**51910**	**$ 289.00**	Order »
Motor Module	**51911**	**$ 169.00**	Order »

Performance

Pumping Depth	Gallons Per Minute
10	2.25
20	2.0
30	1.65
40	1.3
50	1.00
60	.50
70	0.00
80	0.00
90	End of Wire

Specifications

POWER CONSUMPTION:	**150 WATTS (MAX)**
VOLT RECOMMENDATION:	**12 - 15 At Source**
MAXIMUM AMP OUTPUT:	**10 AMPS**
MEASUREMENTS:	**LENGTH 7.5" / DIAMETER: 1.82"**
OPTIONAL CONTROLLER OR BOOSTER:	**NONE**
REQUIRED TUBING:	**3/8" ID LOW DENSITY POLYETHYLENE TUBING**
SUPPLIED WITH:	**90 FEET OF HEAVY DUTY 10 GAUGE WIRE WITH ALLIGATOR CLAMPS**

Options	Part Number	Price	
Pro Controller-Low Flow w/ Liquid Detector/Float	51918	$ 620.00	Order »
Solar Charger with Low Flow & Level Control	51919	$ 949.00	Order »
Stepdown Transformer	51920	$ 510.00	Order »
Stepdown Transformer with Timer, Liquid Detector/Flat & Low Flow Controller	51921	$ 755.00	Order »

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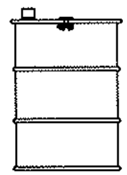
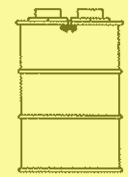
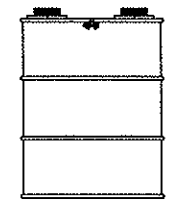
GPC Drum Series Carbon Vessels

Carbonair's gas phase carbon absorbers are designed to provide an efficient and economical means to control odor, toxic vapors, and corrosive gases. Several types of activated carbons are available for a variety of applications.

Specifications*

Model	GPC 3	GPC 3H	GPC 3.85
Flow Range (cfm)	20 - 100	20 - 270	36 - 360
Carbon Capacity (lb)	200	180	250
Vessel Diameter or Plot Size	2'	2'	2'-4"
Vessel Height	3'-0"	3'-0"	3'-6"
Bed Area (ft²)	2.7	2.7	3.7
Empty Weight (lb)	65	65	100
Operating Weight (lb)	265	265	350
Influent Connection	2" FPT	4" FPT	4" FPT
Effluent Connection	2" FPT	4" FPT	4" FPT

Design Features

- **Drums meet UN standards**
- **Baked enamel exterior**
- **Epoxy-phenolic interior lining**

Options

- ☐ Influent/effluent sample and pressure taps
- ☐ Influent/effluent ducting
- ☐ Humidity control
- ☐ Discharge stack
- ☐ Blowers
- ☐ Complete line of granular activated carbon

Service Centers

FLORIDA
4710 Dignan Street
Jacksonville, FL 32254
800.241.7833
904.387.4465
904.387.5058 Fax

MINNESOTA
7500 Boone Ave N #101
Brooklyn Park, MN 55428
800.526.4999
763.315.4771
763.315.4614 Fax

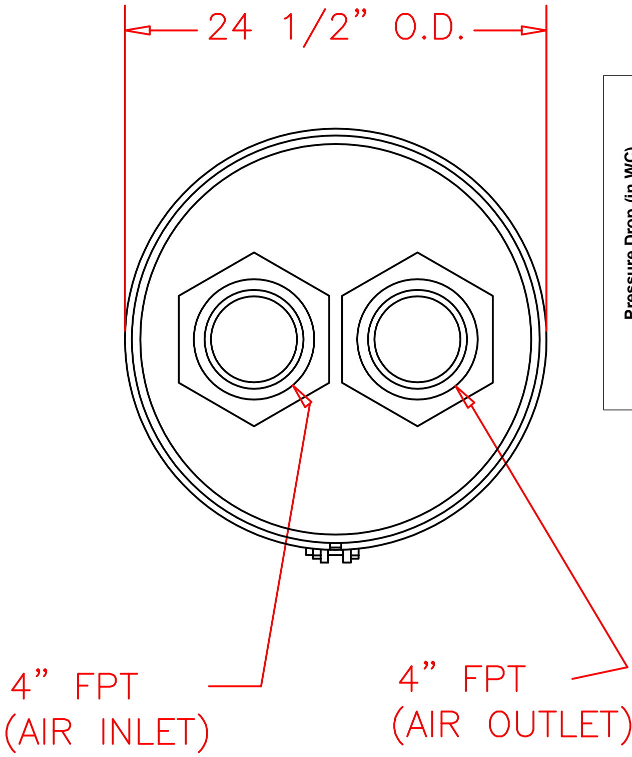
TEXAS
4889 Hunter Rd. Bldg 1-C
San Marcos, TX 78666
800.893.5937
512.392.0085
512.392.0066 Fax

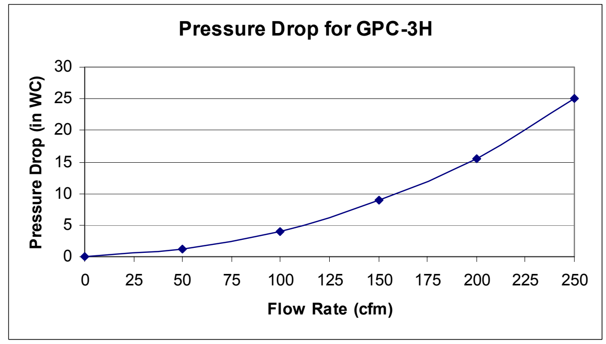
VIRGINIA
4003 West Main Street
Salem, VA 24153
800.204.0324
540.380.5913
540.380.5920 Fax

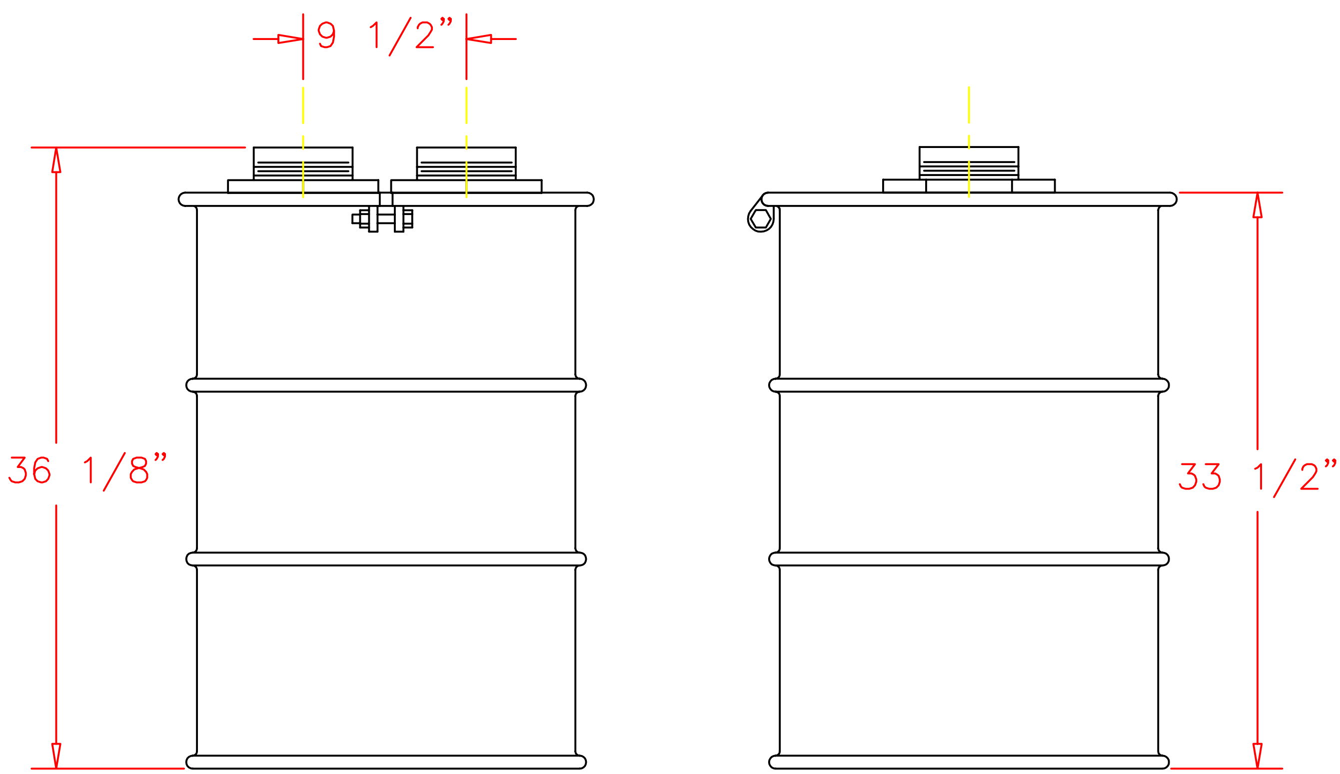
*Specifications subject to change without notice.

Dwg # 217357 Drum

Carbon Adsorber—Vapor Phase
GPC 3H







Sales Drawing #116632
03/22/05

Holding (“Frac”) Tank

Steel Tank
Flat Top Corrugated Wall Tank

Overview:

Store liquids with confidence with Rain for Rent's 21,000-gallon Flat Top Corrugated Wall tank. Permanently attached axles, for maximum maneuverability, allows this tank to be moved with ease on the jobsite. The staircase ensures proper protection for workers on site. The tank also offers optional epoxy coating, which offers chemical resistance and additional cleanliness for sensitive environmental applications.

Features:

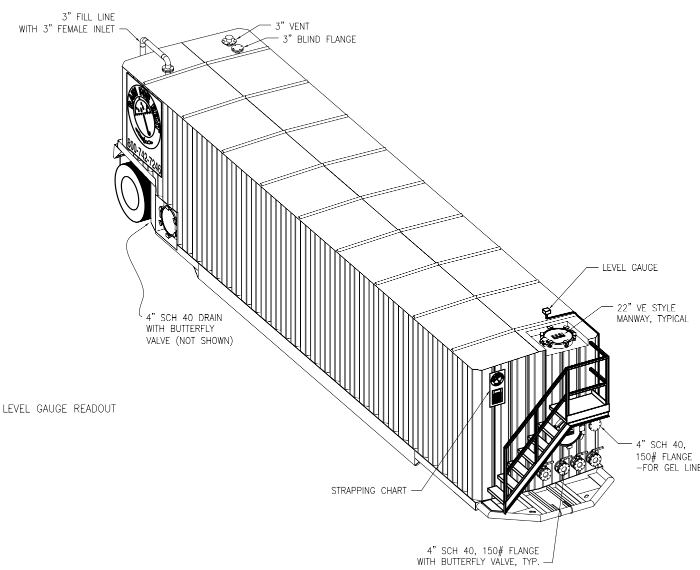
- Vapor Tight Tanks: rated to 16oz/in^2 of pressure and 0.4oz/in^2 of vacuum
- V-drain floor with front and rear 4" 150-lb flanges with valves
- OSHA Compliant Stairway
- 1.5" SCH80 level gauge port
- 8" External manifold or internal manifold
- Rear 3" or 6" SCH40 fill line
- Optional: Epoxy Coating - chemical resistance for a wide variety of chemical compatibility and keeps stored product within the tank cleaner
- Optional: Steam Coils

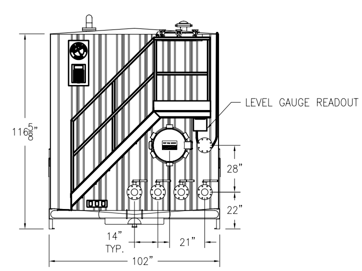
Accessories:

- E-CONTAIN® Spillguards
- SolidGround® Traction Mats
- Radar Level Gauge
- Mechanical Level Gauge
- PipeStax®
- HoseTrax®
- Suction and Discharge Hose

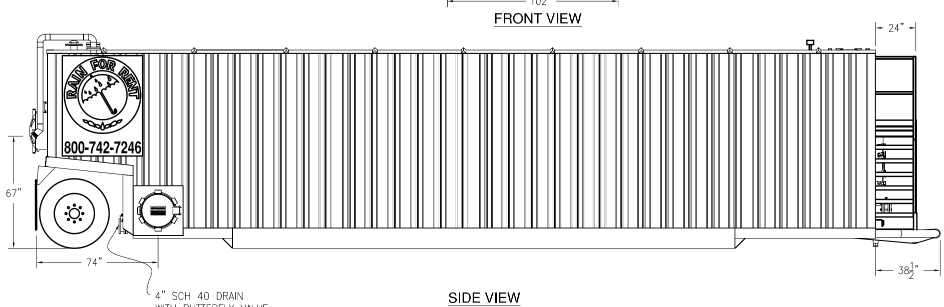
Specs:

Material	Steel, Epoxy Coated (Option)
Capacity	21,000 gallons
Manways	Four 22" hatches
Dry weight	27,000 lbs.
Footprint (LxWxH):	560" x 102" x 120"





FRONT VIEW



SIDE VIEW

Liquid Ingenuity®
800-742-7246
rainforrent.com

PUMPS • TANKS • FILTRATION • PIPE • SPILLGUARDS

Secondary Containment

Spillguard

E-CONTAIN®

Overview:

Spillguards provide a safe and easy solution for secondary containment to help prevent costly incidents. Available in sizes from 6' to 50' with custom sizes available, the portable, lightweight, polyurethane Spillguards are puncture resistant and come with Rigid-Lock supports. The E-CONTAIN® Spillguard features safety improvements, space savings, ease and reduced clean-up costs. The E-CONTAIN® Spillguard is also lighter and easier to maintain, deploy and repair.

Features:

- No inside or outside support straps, which decreases tripping hazards and strap damage from vehicle drive-over
- One piece Spillguard, no assembly required
- Smaller footprint
- Easy to clean and repair damaged supports in the field
- Strong wind resistance
- Puncture resistant track belts and ground mats come standard with each Spillguard
- Patent pending design

Specs:

- Sizes from 6'x10'x8" to 48'x50'x1'
- Acid model (black) Spillguards approved for a temperature range of -10°F to 160°F
- Standard model (tan) Spillguards are approved for use in temperatures ranging from -50°F to 160°F
- Can be used in numerous applications to contain acids, caustics, hydrocarbons, fuels, fertilizers and many other hazardous materials
- Acid Spillguard models can be used in applications with Sulfuric acid, Sodium Hydroxide, Hydrochloric acid and Sodium Hypochlorite
- Spillguards require engineering review prior to use with Diesel, Gasoline, Crude oil and Mineral-based Hydraulic Fluid

Accessories:

- SolidGround® Traction Mat
- Spillguard Hose Bridge
- Pipe & Hoses
- PipeStax®
- PipeStax® XL
- HoseTrax™
- Puncture resistant track belts (Standard)
- Puncture resistant ground mats (Standard)

E-CONTAIN® SPILLGUARD AVAILABLE SIZES		
LENGTH (FT)	WIDTH (FT)	WALL HEIGHT (IN)
6'	10'	8"
8'	14'	8"
10'	18'	8"
10'	30'	12"
10'	50'	12"
12'	16'	12"
28'	50'	12"
48'	50'	12"

Liquid Ingenuity®
800-742-7246
rainforrent.com

APPENDIX B—AIR-STRIPPER PERFORMANCE MODELING

CARBONAIR ENVIRONMENTAL SYSTEMS
1480 County Road C West, Roseville, MN 55113
PHONE: 800-526-4999 FAX: 651-202-2985

STAT MODEL CALCULATIONS
Fri Feb 10 12:58:31 CST 2017

UNIT MODEL:	STAT 15
WATER FLOW RATE (GPM):	2.00
AIR FLOW RATE (ACFM):	80.00
AIR-TO-WATER RATIO:	299:1
WATER TEMPERATURE (F):	55.00
AIR TEMPERATURE (F):	55.00
OPERATING PRESS (ATM):	1.00
SAFETY FACTOR (%):	0.00

Influent Conc. for TRICHLOROETHENE 2300.00000 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	95.43968	104.88728	7.34151	0.05271
2	99.78963	4.83843	7.67613	0.05511
3	99.99029	0.22331	7.69156	0.05522
4	99.99955	0.01031	7.69227	0.05522
5	99.99998	0.00048	7.69231	0.05522
6	100.00000	0.00002	7.69231	0.05522

Influent Conc. for CIS-1,2-DICHLOROETHENE 6500.00000 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	92.84034	465.37761	20.18268	0.14489
2	99.47392	34.19510	21.62477	0.15525
3	99.96127	2.51732	21.73071	0.15601
4	99.99715	0.18534	21.73851	0.15606
5	99.99979	0.01365	21.73908	0.15607
6	99.99998	0.00100	21.73913	0.15607

Influent Conc. for VINYL CHLORIDE 530.00000 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	97.76412	11.85016	1.73294	0.01244
2	99.94975	0.26630	1.77168	0.01272
3	99.99887	0.00599	1.77256	0.01273
4	99.99997	0.00013	1.77257	0.01273
5	100.00000	0.00000	1.77258	0.01273
6	100.00000	0.00000	1.77258	0.01273

Influent Conc. for TOTAL VOCs 9330.00000 ppb

NO OF TRAY	REMOVAL EFF %	EFF CONC ppb	OFF-GAS CONC ug/l	AIR EMISSION lb/d
1	93.76082	582.11505	29.25714	0.21004
2	99.57878	39.29984	31.07258	0.22308
3	99.97056	2.74662	31.19483	0.22395
4	99.99790	0.19578	31.20336	0.22401
5	99.99985	0.01412	31.20397	0.22402
6	99.99999	0.00103	31.20401	0.22402

STAT Modeler Disclaimer

Carbonair's STAT Modeler is accurate only when contaminants are completely dissolved in water in the absence of substances, which may significantly affect the stripper capabilities of contaminants, such as oil & grease, surface active and foaming agents, alcohols, ketones, and other potential Henry's constant altering contaminants. Although the effluent concentration predictions made by the STAT Modeler are accurate predictions of field performance, they do not constitute a guarantee that these concentrations will be met in the field. Please contact your Carbonair representative for a design review and confirmation.

APPENDIX C—CALCULATIONS

Tetra Tech NUS			*STANDARD CALCULATION SHEET*
CLIENT- LMC (LMC Middle River) Block I Pumping Componenet	Job No:	BY: B. Dynkin	PAGE: 1 of 1
SUBJECT: VGAC consumption		CHECKED BY: C.Pike	DATE: 5/5/2014

References

ref 1 2001, Activated Carbon Adsorption for Treatment of VOC Emissions, A. Shepherd, CARBTROL

BASIS & ASSUMPTIONS

Notation	Description	Value	Unit	Reference/Assumptions
Q	Air flow	80	SCFM	STAT 15 air stripper
q	GW pumping rate	0.5	gpm	based on 2016 pump test
Caq	Maximum influent VOCs	9.33	mg/L	March 2016 sampling
T	vapor stream tempertature	60	degF	Assumption
t	pumping duration	90	days	Conservative value
MW	VOCs molecular weight	131	lbs/lbmol	Assumed as TCE
MV	Gas molar volume at vapor stream temperature and atm. pressure	380	ft^3/lbmol	

Calculations

Notation	Description	Value	Unit	Equation
M	VOCs mass removal rate	0.000039	lbs/min	M= q * 8.34 lbs/gal * Caq * 10^{-6}
V	Total vapor volume treated	1.07E+06	ft^3	V=Q * t * 1440 min/day
Cv	Maximum VOCs vapor inlet concentration	1.4	ppm_v	C= 10^6*M*MV/(V*MW)
LC	VGAC loading capacity	10%	unitless	VGAC isotherm graph
VGAC	Estimated VGAC consumption	50	lbs	VGAC = t * 1440 min/day * M/LC

Tetra Tech NUS			*STANDARD CALCULATION SHEET*
CLIENT- LMC (LMC Middle River) Block I Pumping Componenet	Job No:	BY: B. Dynkin	PAGE: 1 of 1
SUBJECT: Pressure loss calculaitons: liquid lines		CHECKED BY: C. Pike	DATE: 2/13/2017

References

ref 1 Practical hydraulics handbook By Barbara A. Hauser

BASIS & ASSUMPTIONS

Notation	Description		Value	Unit	Reference/Assumptions
q	volume flow		1	gal per minute	Double expected MPE well pumping rate
d_h	Inside pipe diameter		0.500	inches	1/2" poly tubing
c	Hazen-Williams roughness constant		140		ref 1
L	total pipe length		150	feet	To furthest well (MPE-4)

Calculations

Notation	Description		Value	Unit	Equation
f	friction head loss in feet of water per 100 feet of pipe (fth20/100 ft pipe)		3.3	feet	$f = 0.2083\ (100/c)^{1.852}\ q^{1.852} / d_h^{4.8655}$
Δh_f	total friction head loss in feet of water		5	feet	$\Delta h_f = F * L / 100$

APPENDIX D—VAPOR-PHASE-CARBON TCE-ADSORPTION ISOTHERM

TRICHLOROETHYLENE ISOTHERM

The adsorption isotherm plot shows the influence of concentration on adsorption capacity. *Figure II* presents an adsorption isotherm used to predict adsorption capacity for trichloroethylene. Note how the adsorption capacity varies from 20 to 65 percent over the concentration range of 10 to 10000 ppm in the gas stream.

A series of isotherms at differing temperatures shows the influence of temperature on adsorption capacity. In Figure III you can see the effect of temperature on the same trichloroethylene compound. At 100ppm the capacity of activated carbon for trichloroethylene varies from 17 to 40 percent as the temperature changes from 140 to 32 degrees F.

Fortunately, most carbon suppliers have developed isotherms for a range of environmental contaminants. At Carbtrol we have built a computerized database of adsorption isotherms so that we can easily model most environmental applications. By supplying to us the gas flow rate, the contaminant concentration and the temperature of the gas stream, a carbon usage prediction can be made.

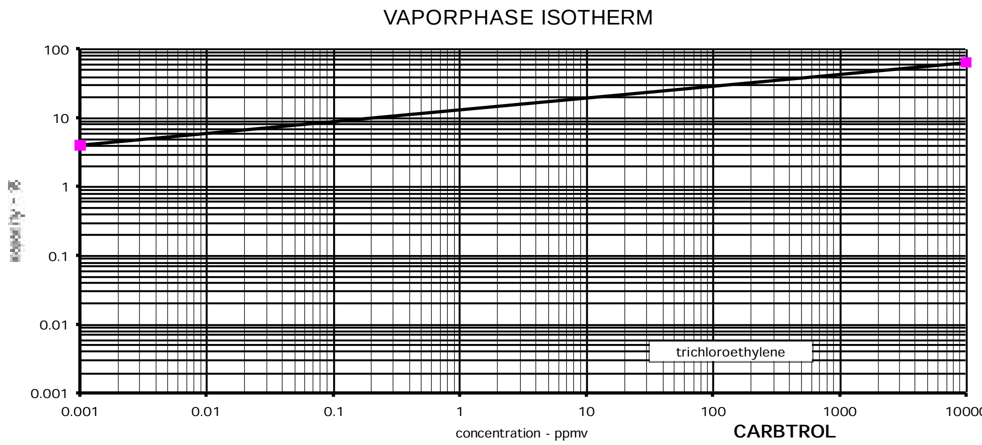


FIGURE II

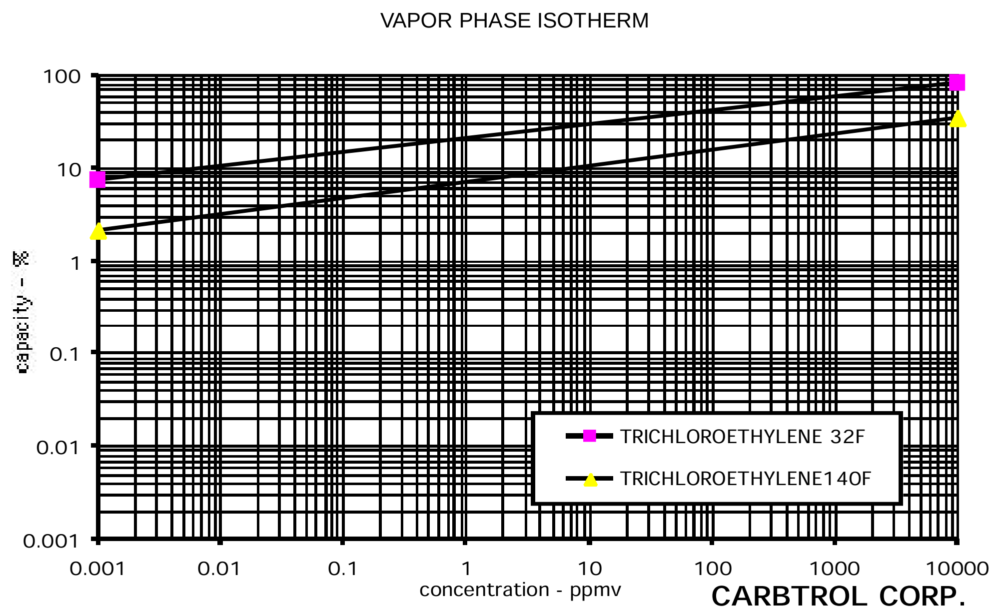
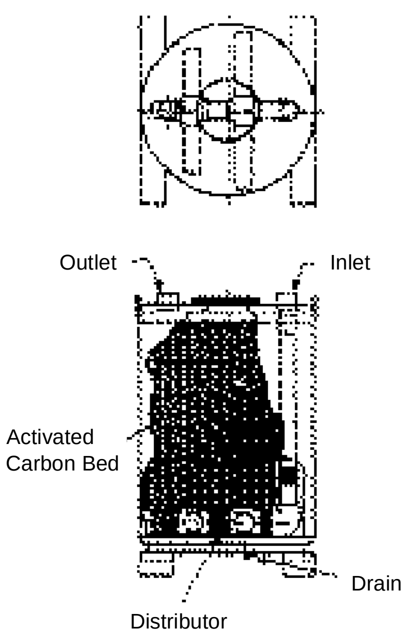


FIGURE III

DESIGN CONSIDERATIONS



CARBTROL G-4 ADSORBER

FIGURE IV

Activated carbons used in the air pollution control field are normally supplied in a granular form with a particle size ranging from 1 to 5 millimeters. In the granular form activated carbon can easily be packed into a containment device through which a contaminated gas stream can be processed for purification.

Figure IV shows the cross section of a typical fixed bed vapor phase adsorber. An adsorption system in its simplest form is made of a containment device (drum or vessel), distribution and collection devices to effect proper circulation of the gas stream through the activated carbon bed, and a means for moving the gas stream through the bed (such as a fan, a blower, or pressurized gas displacement). Packed activated carbon beds can be conveniently config-