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# INTERIM SEEP REMEDIATION SYSTEM PLAN

## Chemours Fayetteville Works

*Prepared for*

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| | |
|---|---|
| °C | Celsius |
| AUR | absorbent utilization rate |
| CO Addendum | Addendum to Consent Order Paragraph 12 |
| CPT | Cone Penetrometer Testing |
| EBCT | empty bed contact time |
| E&SC | Erosion and sediment control |
| FCD | flow control devices |
| ft MSL | feet mean sea level |
| GAC | granular activated carbon |
| gpm | gallons per minute |
| HDPE | high density polyethylene |
| HFPO-DA | hexafluoropropylene oxide dimer |
| IP | Individual Permit |
| ISB | influent stilling basin |
| mg/L | milligrams per liter |
| ng/L | nanograms per liter |
| NCDEQ | North Carolina Department of Environmental Quality |
| NEA | Non-Encroachment Area |
| NCDPS | North Carolina Department of Public Safety |
| NPDES | National Pollutant Discharge Elimination System |
| NTU | nephelometric turbidity units |
| OM&M | operation, maintenance, and monitoring |
| PFAS | per- and polyfluoroalkyl substances |
| PFD | Process Flow Diagram |
| PFMOAA | perfluoro-2-methoxyaceticacid |
| PMPA | perfluoromethoxypropyl carboxylic acid |
| psi | pounds per square inch |
| S.U. | Standard Units |
| USACE | United States Army Corps of Engineers |

| | |
|---|---|
| USGS | United States Geological Survey |

# 1. INTRODUCTION

## 1.1 Background

Geosyntec Consultants of NC, PC (Geosyntec) has prepared this Interim Seep Remediation System Plan ("Interim Plan") on behalf of The Chemours Company FC, LLC (Chemours) to provide a design basis for the flow-through cells that are to be installed as the interim seep remediation system at four groundwater seeps at the Chemours Fayetteville Works Site (Figure 1; the Site). Pursuant to requirements of Paragraph 2 of the Addendum to Consent Order Paragraph 12 (CO Addendum), these interim systems shall intercept dry weather flow of Seeps A, B, C and D and achieve a minimum per- and polyfluoroalkyl substances (PFAS) removal efficiency of 80 percent (%) of the intercepted flow at each seep. This will be assessed on a monthly average basis using the indicator parameters hexafluoropropylene oxide dimer (HFPO-DA, i.e. GenX), perfluoromethoxypropyl carboxylic acid (PMPA), and perfluoro-2-methoxyaceticacid (PFMOAA).

This Interim Plan has been prepared to provide: (i) a design basis that documents the anticipated effectiveness and implementation of the proposed remedy; (ii) an operation and maintenance plan that details how the systems will be managed and monitored after construction; and (iii) a sampling plan that will evaluate the performance of the systems at achieving the PFAS removal goal.

## 1.2 Seep Characterization

The following sections discuss critical data inputs to the design: (i) Seep flow rates; (ii) Seep PFAS concentrations; and (iii) Seep water quality. This section focuses on the sources of these data inputs, and their role in design; design details are discussed in Section 2.

### 1.2.1 Flow Rate

The flow rates at each seep have been measured in various stages beginning in January 2019. Flumes have been installed at the terminus of each seep, as close as practical to the confluence of the Cape Fear River, as shown in Figure 2. For the larger seeps, notably A and B, several additional flumes have been installed at various tributaries that feed the main channel, and at various locations along the main channel itself. To determine the dry weather base flow at each seep, the dataset has been reduced to remove inundation events (when the Cape Fear River elevation rises and fills the seep channel, submerging the flume), unreliable data[1], and wet weather events[2]. The evaluation methodology and results are detailed in Appendix A. The summary table below presents the statistical results for each seep, including 25th percentile (considered seasonal low flow), the median (i.e. the 50th percentile flow) and 95th percentile of dry weather flow (considered seasonal high flow). The 95th percentile value will be used as the design basis flow rate, which is used in the design to estimate the usage rate of treatment media, size the media beds accordingly to a reasonable changeout frequency, and account for hydraulic head loss through the system.

| Seep | Calculated Dry Weather Flow (gallons per minute [(gpm]) | | |
|---|---|---|---|
| | 25th Percentile (seasonal low flow) | Median (50th Percentile) | 95th Percentile (seasonal high flow, and Design Basis) |
| SEEP A | 106 | 129 | 205 |
| SEEP B | 130 | 149 | 226 |
| SEEP C | 30 | 42 | 76 |
| SEEP D | 140 | 150 | 183 |
| TOTAL | 406 | 470 | 690 |

### 1.2.2 PFAS Loading Rate

The flume locations discussed above have been routinely sampled for Table 3+ compounds. The following table summarizes the median concentrations of the three indicator compounds for each seep terminal location, based on sample data from February 2019 to April 2020. These values have been used in conjunction with the design basis flow rate and isotherm column studies to estimate the potential adsorbent utilization rate (AUR) at each location.

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[1] Unreliable data include times when the data logger may have been moved by inundation events from the stilling well in the flume and periods of potential low bias potentially caused by seep flow being diverted around the flume rather than passing through the flume.

[2] Flow measurements within 24 hours after a rain event are considered wet weather flow.

| Sampling Location | Median Concentration in nanograms per liter (ng/L) | | |
|---|---|---|---|
| | HFPO-DA | PMPA | PFMOAA |
| SEEP-A-1 | 20,000 | 23,000 | 97,500 |
| SEEP-B-1 | 23,000 | 36,000 | 180,000 |
| SEEP-C-1 | 27,000 | 14,000 | 200,000 |
| SEEP-D-1 | 15,000 | 8,700 | 100,000 |

Notes: February 2019 through April 2020 data period. The number of samples varies by seep and by compound, ranging from 7 (for Seep D, all compounds) up to 10 (for Seep A, PMPA and PFMOAA).

### 1.2.3 Water Quality

During routine sampling of the seeps, water quality parameters were also measured in the field using calibrated water quality instruments, or in the case of dissolved iron, with additional laboratory analysis. The table below summarizes the most recent water quality data available for each seep. These data are utilized for selecting compatible materials for the remedy construction, evaluating the potential adverse effects of naturally occurring dissolved metals, and selecting design components that may mitigate these effects.

| Seep | pH (S.U.) | Temperature (°C) | Turbidity (NTU) | Dissolved Oxygen (mg/L) | Total Dissolved Iron (mg/L) |
|---|---|---|---|---|---|
| A | 5.2 | 18.4 | 12.5 | 5.8 | 2.7 |
| B | 4.9 | 18.0 | 10.7 | 7.4 | 2.8 |
| C | 4.6 | 17.7 | 28.3 | 8.6 | 2.3 |
| D | 4.1 | 18.2 | 4.8 | 8.6 | NM |

Notes:
Analytical laboratory data for Total Dissolved Iron from February 2019 represent the average across all Seep measurement locations.
All other field measurement parameters (reported as the average of a two-day sampling period in April 2-3, 2020) were collected from the furthest downstream location to the Cape Fear River.
NM = not measured (an updated sampling event for all of the above is planned for third quarter 2020)
NTU = nephelometric turbidity units
mg/L = milligrams per liter

# 2. DESIGN AND PLACEMENT PLAN

## 2.1 Interim Seep Remediation System Approach

The first interim seep remediation system, a flow-through cell, will be installed at Seep C (herein referred to as "the System"), and results from construction and operation will inform the design and installation of interim seep remediation systems at the remaining seeps (i.e., A, B, and D). This Interim Plan provides design details specific to the System, but narrative discussion of design and operation herein applies to all the flow-through cells, which will be sized to fit each seep based on the flow rates and morphology of the seep channel (see topographic maps in Figures 3A-3D). The 30% design drawings (Appendix B) and hydraulic and structural calculations (Appendix C) have been developed specifically for the Seep C installation, and are subject to changes based on final design, and from permitting input provided by the appropriate regulatory agencies.

As detailed in Sections 2.8 and 6, final designs for Seeps A, B, and D are anticipated to be submitted to United States Army Corps of Engineers (USACE) and North Carolina Department of Environmental Quality (NCDEQ) for permitting purposes by October 2020.

## 2.2 System Overview

The flow-through cells have been designed to achieve the following objectives, which are based upon Paragraph 2(a) in the CO Addendum:

- Intercept and hydraulically transmit base flow (during dry weather flow, i.e. groundwater) through the treatment media;
- Remove at least 80% of PFAS indicator compounds from intercepted base flow on a monthly average basis;
- Minimize base flow bypassing the flow-through cells;
- Maintain operation during higher flows (i.e., safely bypass stormwater flow without damaging the flow-through cells); and
- Minimize downtime due to clogging or fouling.

These objectives will be met by impounding seep flow[3], which will generate sufficient hydraulic head (approximately six feet) to allow the base flow to enter the flow-through cell and then percolate downward through granular activated carbon (GAC) beds in series and treat the PFAS impacts via adsorption. Treated water will be returned to the stream

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[3] An earthen dam is shown in the design drawings. Sheet piling is also being evaluated as a means to impound flow.

channel, and the GAC media will be periodically replaced. A spillway and weir will allow for safe bypass and flow measurement of additional flow volume from storm events (Drawing C-02). The System's general flow control process is as follows:

- Impounded water will flow from the impoundment basin through a rectangular opening into an inlet chamber where the seep flow will pass through a 4-ft thick gravel layer into the influent stilling basin (ISB). Flow control valves on inlet manifolds will allow for distribution to one of two GAC filter beds (depending on the lead/lag duty cycle) operating in series for improved treatment efficiency and reliability.
- Water will flow via gravity through the lead GAC filter bed and percolate into underdrains at the bottom of the bed, which will collect the water into a common manifold within an intermediate transfer basin. Water will then flow over another weir from the transfer basin into the lag GAC filter bed, again flowing via gravity to the bottom. As before, water will percolate into underdrains, collect into a similar manifold in the transfer basin, and then discharge into an effluent stilling basin.
- Water will flow over a weir from the effluent stilling basin into the discharge basin, where it will exit the System into the downstream seep channel (Drawings C-03 and C-04). A fiberglass grating platform will be installed over the System to provide operator access to flow control valves, weirs, and measurement/sampling points (Drawing C-05).

A Process Flow Diagram (PFD) that presents the overall System operation and operational modes is provided in Drawing D-01. Four operational modes exist: (i) Filter Bed-1 as lead and Filter Bed-2 as lag; (ii) Filter Bed-2 as lead and Filter Bed-1 as lag; (iii) only Filter Bed-1 operating (changeout of Filter Bed-2 GAC); and (iv) only Filter Bed-2 operating (changeout of Filter Bed-1 GAC).

The major components of the System, and a brief description of their design and function, are provided below.

- <u>Impoundment Basin</u>: The impoundment basin's function is to provide sufficient hydraulic head for the System to overcome head losses through the GAC media. It will be constructed with either earthen berms or sheet piling; a riprap armored slope will be installed on the front and back faces with either method.
- <u>Inlet Channel</u>: Impounded water enters the System through a rectangular inlet channel that can be shut/opened using a removable weir plate. During normal System operations, the weir plate will be removed permitting impounded water to enter the Inlet Chamber to be processed through the System. If non-routine

System maintenance is required, the weir plate will be installed and the elevation of impounded water will rise until it reaches the elevation of the Bypass Spillway (see below), facilitating seep flow bypass of the System.

- Inlet Chamber: The Inlet Chamber pools impounded water atop a gravel layer through which System flow is funneled into the ISB. The head differential between the Inlet Chamber and the ISB provides the driving force for flow through the Gravel Layer.
- Gravel Layer: A Gravel Layer, comprised of #5 stone, will be installed between the Inlet Chamber and the Influent Stilling Basin. The Gravel Layer will act as a "roughing filter" to minimize particulate loading to the GAC filter beds. Further, the gravel media provides additional surface area for iron and manganese to precipitate if the chemical equilibrium of dissolved species shifts towards conditions favorable for precipitation. The gravel layer will provide a robust filter media to protect the GAC filter beds.
- Influent Stilling Basin: Flow passing through the Gravel Layer collects in the ISB and will be diverted into the lead GAC filter bed through flow control devices (FCDs). The status of the FCDs (i.e., open or closed) for the different System operation modes is provided in Drawing D-01. The ISB will be equipped with a vertical flow baffle which will direct flow from the #5 stone layer into the primary ISB compartment that supplies flow to the FCDs.
- GAC Filter Beds: GAC filter beds will treat PFAS present in the System influent via adsorption. They will contain GAC media covered by a geotextile and underlain by a #5 stone draining layer. An underdrain collection system constructed of 6" perforated PVC pipe will be installed within the #5 stone draining layers; the underdrain collection systems will facilitate conveyance of water from the stone draining layers to the transfer basin manifolds. GAC was selected over ion exchange resin for several reasons, most notably due to the smaller particle size and lower hydraulic conductivity of the resin, which would pose hydraulic head losses that would not be practical to overcome.
- Transfer Basin: A transfer basin, situated between the two GAC filter beds, will allow for operation of the GAC filter beds in series. The transfer basin is a rectangular chamber that will accumulate seep flow that has passed through the lead GAC filter bed and divert it to the top of the lag GAC filter bed. The installation of two manifolds and two overflow weirs will provide the ability to reverse the flow path when the lead and lag filter bed positions are switched (i.e., when the GAC in the lead bed is spent and changed out, and the lag bed is placed in the lead position). As shown in the Design Drawings, each GAC filter bed is

connected to the transfer basin via two flow control features: 1) its underdrain collection system and its dedicated manifold which is equipped with two FCDs; and, 2) a dedicated overflow weir. For the manifold plumbed to filter bed in the lead position, the FCDs will be set such that water collected from the underdrain system will be diverted into the transfer basin chamber. The overflow weir between the lead filter bed and the transfer basin will be closed whereas the overflow weir between the lag bed and the transfer basin will be open. The water that accumulates in the transfer basin will be diverted into the lag filter bed via the open overflow weir. Water collected from the underdrain system of the lag filter bed will be diverted to the effluent stilling basin by the manifold plumbed to the lag filter bed. The heights of the overflow weirs will be set to maintain saturated GAC conditions in the lead filter bed.

- Effluent Stilling Basin: The effluent stilling basin will consolidate treated effluent from the lag GAC filter bed prior to discharge. It utilizes a weir to maintain sufficient water elevation in the lag GAC filter bed so they do not go dry during low flow events. The effluent stilling basin will transfer effluent to a common discharge basin.
- Discharge Basin: A common discharge basin will receive treated effluent from the effluent stilling basin and discharge treated effluent from the System, through an outlet pipe to the natural seep channel.
- Platform: A fiberglass grate platform will be installed over the full flow-through cell as a safety measure, with handrails on all sides except for the maintenance platform. The grating will include ports and/or access doors to allow for operator access to the flow control elements and sampling/measurement equipment, and for vacuum trucks to replace the GAC media.
- Maintenance Platform: The maintenance platform will serve as an area where support vehicles and personnel can be staged to support the maintenance and inspection of the System (e.g. GAC changeouts).
- Bypass Spillway: The bypass spillway will allow for a controlled release of excess flows, which exceed the design capacity of the System (e.g. during large rainfall events). The bypass spillway conveys flows around the System and to the downstream stream bed. A rectangular weir will be incorporated into the spillway to allow for flow measurement.
- Effluent Slope: The effluent slope's function is to provide structural stability to the System. It will be constructed with an earthen, riprap armored slope.

## 2.3 Hydraulics

The System has been designed to manage a range of seasonally variable flow, as measured with the Seep C flume over the previous 18 months. The System will impound and regulate inflow of the Seep C discharge, and in doing so, generate sufficient hydraulic head to overcome losses associated with the operational components outlined in this section (e.g. GAC media, piping, etc.).

The System will be installed such that the Inlet Channel crest is installed at 40.85 feet mean sea level (ft MSL). This will result in the creation of an impoundment basin with the same elevation. During routine operation, the System is designed to convey a minimum of 76 gpm through the ISB and into the System's GAC filter bed. When Seep C flows increase and the elevation of the impoundment basin is approximately 0.5 ft above the Inlet Channel crest, at an elevation of 41.35 ft MSL, water will begin to flow through the bypass spillway, so as not to overwhelm the System's ability to transmit flow.

The flow rate that results in this spillway elevation can be adjusted by manipulating the FCDs in the filter beds (e.g., closing or throttling valves and creating more back-pressure). To maintain the longevity of the GAC, the maximum flow through the system will be maintained at the seasonal high base flow value to the extent possible. The extents of the impoundment basin under normal operating conditions (between 40.85 and 41.35 ft MSL) are provided on Drawing C-02, and indicate that there should be no ponding upstream of the roadway near Seep C.

Head loss calculations, provided in Appendix C, consider various operational scenarios depending on seasonal flow rate, and changes to the integrity (cleanliness) of the GAC media. In total, eight scenarios were modeled, with a range of four flow rates (between 30 and 76 gpm) and two conductivity values for the GAC media (clean, unfouled Calgon F400, and fouled media where hydraulic conductivity is reduced by a factor of 4). Contributions to head loss include filtering through the gravel layer separating the inlet chamber and the ISB, geotextile layers, and GAC media; and restrictions through manifold piping, most notably the ISB distribution manifold to the filter beds. The calculations demonstrate that in the worst-case scenario (maximum base flow through fouled GAC media), the filter beds will function hydraulically.

## 2.4 Treatment Efficiency

The System was designed to have a GAC filter bed of sufficient dimensions to allow for an empty bed contact time (EBCT) of between 30 to 60 minutes, assuming the design flow rate of 76 gpm. A flow of 76 gpm through the 10 ft x 10 ft x 3 ft GAC filter bed results in an estimated EBCT of approximately 30 minutes, as presented in Appendix C. The EBCT at the median flow rate of 42 gpm results in an estimated EBCT of approximately 53 minutes.

Results from adsorption isotherm studies were used to estimate sorption rates to the GAC, the carbon utilization rate, and the GAC changeout frequency. The isotherm study results and relevant calculations are provided in Appendix C. At the median flow rate of 42 gpm, it is estimated that approximately 30,000 pounds (lbs) per year of GAC will be required for Seep C, corresponding to a GAC changeout frequency of approximately 91 days.

Treatment efficiency and breakthrough will be monitored through routine influent, midpoint, and effluent sampling, as described in Section 3.4. The rate of breakthrough and carbon utilization will be monitored to evaluate if the design needs to be modified for the remaining seeps.

## 2.5 Geotechnical and Structural

Calculations were performed to estimate potential settlement of the structures in the seep channel, the potential buoyant effects during a flooding condition, and to design the thickness and reinforcement requirements for the concrete slab and walls. Calculations are provided in Appendix C.

Settlement: To evaluate the engineering parameters of the foundation soils at the interim remedial seep channel locations, a Cone Penetrometer Testing (CPT) sounding was advanced July 28-29, 2020 at each seep location to a minimum depth of 40 feet. CPT is a direct push technology that allows for continuous data collection (every 2 inches) for tip resistance, sleeve friction, and dynamic pore pressure.

At this time of this report, the CPT data were not available for evaluation, therefore assumed engineering parameters were used in the calculations. Using conservative assumptions, a maximum of 8 inches of uniform settlement could develop during construction. This analysis will be updated once the CPT data is fully evaluated; it is anticipated that the expected settlement will be within design tolerances.

Uplift: During normal operation, the filter beds will have sufficient downward force to provide more than adequate factor of safety based on appropriate safety factors in USACE Engineering Manual 1110-2-2100 (USACE, 2005). Even in an extreme flooding event with the exterior walls fully submerged, the System components (water, GAC, stone, and concrete) will provide sufficient force to overcome buoyant uplift.

Concrete: Load calculations were performed based on potential critical points in the filter beds, for example when a filter bed is drained of GAC and water, while adjoining basins are full of water. Slabs and walls will be constructed of 8” thick concrete, cured to a compressive strength of 4,000 pounds per square inch (psi), with rebar reinforcement as shown in the calculation drawings[4].

## 2.6 Resiliency

This section describes how the System has been designed to overcome various adverse conditions that may be encountered during construction and operation:

Underflow: During the course of the geotechnical/civil design for each of the seep locations, underflow will be addressed. The type of underflow prevention method will be dependent on the expected flow rate, the type of impoundment selected, and the subsurface stratigraphy at each individual seep location. The results of the analysis and calculations will be incorporated in the design.

Scouring from High Flow Events: The System is designed to manage the 95th percentile flow rate at Seep C. As shown in Appendix A, the dry weather base flow varies both diurnally and seasonally. In addition, wet weather will cause stormwater to enter the seep channel, with flow rate depending on antecedent dry conditions and rainfall intensity. The spillway will allow for flow that exceeds the design basis to safely bypass the filter bed System. Also, riprap will be installed on both slopes to reduce surface water velocities that may be encountered during heavy rain events.

Integrity of GAC media: GAC installed within each GAC filter bed will be bounded by a layer of geotextile. The geotextile installed between the GAC and #5 stone will reduce GAC from settling into the drainage layer and assist in reducing #5 stone loss during GAC changeout. The geotextile installed on top of the GAC will provide initial filtration and protection. Both geotextiles will be secured to the walls of the GAC filter beds.

River Flooding: The Cape Fear River's water level is subject to seasonal variation and dam releases upriver from the Site. For Seep C, a Cape Fear River surface elevation of 38 ft msl or higher is considered the threshold where river inundation begins. This elevation threshold is where river levels can materially affect the operation of the flow through cell. The hydraulic head of water flowing through the flow through cell during low river stages is controlled by the rectangular weir separating the effluent stilling basin and the discharge basin with an elevation of approximately 38 ft msl. Cape Fear River surface levels below this elevation will not affect gradients or flow through the flow-through cell. River levels above the elevation will reduce the gradient through the flow-through cell and may potentially reduce flow rates through the system. Based on available data from 2007 to present, the river has been above the Seep C inundation threshold of

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[4] Calculations are provided for cast-in-place concrete structures. Precast concrete structures may be utilized for some or all seep locations to expedite construction schedule in the field.

38 ft msl only about 4% of the time with an average duration above 38 ft msl of approximately 5 days.

When Cape Fear River surface levels rise to or above 40.85 ft msl, the same elevation as the inlet weir, gradients and flow directions in the flow-through cells may potentially be reversed. When Cape Fear River surface elevations rise to or above 41.35 ft msl or greater, the same elevation as the bypass spillway, the Cape Fear River will inundate the impoundment basin and limited flow or no flow will occur through the flow-through cell as the bypass spillway presents less resistance to flow. When the river recedes, any impounded water will then flow through the filter beds as during normal operation provided no damage occurred to the flow-through cell.

The flow-through cell perimeter wall elevation is 42.35 ft msl. Based on available data from 2007 to present, the Cape Fear River has only exceeded this elevation about 1.4% of the time during extreme weather events. Structural calculations (discussed in Section 2.5) were performed to demonstrate that even in this extreme event with the flow-through cell fully under water, there is sufficient downward force to prevent flotation. Additionally, saturated GAC (covered by a geotextile) will have a density greater than water and will remain in place.

Iron Fouling: Based on available water quality data and observations of iron oxidation within the current seep channel, iron fouling is a potential concern for long-term integrity of the GAC media. To mitigate this risk, the riprap armored slope on the influent side of the filter beds was developed to provide oxidation sites for the dissolved iron in the water. Periodic maintenance or replacement of the rip rap may be required. The gravel layer that separates the System inlet chamber and the ISB provides additional surface area for iron and manganese to precipitate, providing additional protection of the GAC filter beds. The gravel layer will provide filtering capabilities which will be resilient to clogging due to the media's high conductivity.

Additionally, the GAC filter beds were sized to require GAC changeouts every few months. It is not anticipated that this is a sufficient timeframe for significant fouling of the media to occur. This relationship between EBCT, changeout frequency, and the extent of iron fouling will be a critical component to monitor during System operation, and the GAC loading/changeout frequency of the remaining flow-through cells may be adjusted upward or downward depending on observations at Seep C.

Debris/Clogging: The System is located in a wooded area; therefore, debris from the tree canopy may fall into the impoundment basin or treatment area. To reduce the introduction of debris from the impoundment basin into the treatment area, a skimming baffle may be installed to keep large, floating debris from entering the ISB. Additionally, to reduce the risk of falling debris entering the treatment area, a deployable protective cover (e.g. all-weather tarp) may be used to provide cover and intercept falling debris.

## 2.7 System Monitoring

The System design includes features to allow for the monitoring of System flow rates, local precipitation, and System performance, as summarized below.

Flow Rates: A pressure transducer will be installed within the Inlet Chamber, which will provide a measurement of the water level in the impoundment; this can be used to measure flow rate through the flow through cell, as well as through the bypass (bypass flows begin when the impoundment height is >0.5 ft above the inlet weir). Flow rates through the bypass spillway can also be recorded during inspection events with the rectangular weir in the spillway that adjoins the flow through cell.

A pressure transducer will also be installed in the Effluent Stilling Basin, to provide a confirmatory measure of flow through the structure, as well as a measurement of head loss through the System.

Transducers can log data at a set frequency (e.g., every 15 minutes) and be downloaded during routine weekly inspections.

Impoundment Height: A United States Geological Survey (USGS) staff gage will be installed within the impoundment for visual measurement of impoundment height.

Precipitation: Precipitation will be monitored by using the existing USGS weather monitoring station at the W.O. Huske Dam (gauge 02105500).

Performance Monitoring: The System's treatment efficacy will be monitored using a combination of dedicated autosamplers and grab samples collected by OM&M personnel. Details of the performance monitoring methods are provided in Section 4.1.

Should other System components need to be monitored in the future, methods and techniques will be developed on a case-by-case basis.

## 2.8 Permits

The following permits will be required to install the System:

Clean Water Act Section 404 Permit and 401 Certification under USACE and NCDEQ has been determined by those agencies to be required due to wetland and streambed impacts. An onsite agency review meeting was held June 30, 2020 to discuss the flow through cell concept, ongoing design improvements, and anticipated schedules. Per USACE communication from July 29, 2020, an Individual Permit (IP) may be required due to exceeding 300 linear feet of stream disturbances (cumulative for all four seeps); an IP typically requires a public comment period. The stream disturbance for Seep C is less than this threshold, and it has not yet been determined by the agencies whether a submittal for Seep C alone would qualify for an IP or a general Nationwide Permit. Subject to this determination, an IP for the Seep C System was submitted August 13, 2020. A modification to this IP is anticipated to be submitted by October 2020 for the remaining seeps.

A Land Disturbance Permit under NCDEQ will be required to permit construction[5]. Erosion and sediment control (E&SC) plans will be prepared in compliance with the latest 2013 updates to the Erosion and Sediment Control Planning and Design Manual and submitted to Bladen County representatives for review. A permit application for Seep C was submitted August 27, 2020.

A No-Rise certification will be required due to the emplacement of fill within the Non-Encroachment Area (NEA) of the floodplain. There is no regulated floodway at the eastern boundary of the Site, as Bladen County did not appear to participate in the National Flood Insurance Program that is managed by the Federal Emergency Management Agency. In communications over the course of August 2020 with County and Regional floodplain administrators within the North Carolina Department of Public Safety (NCDPS), it was confirmed that the proposed flow through cell locations are within the NEA. Hydraulic analyses will be prepared to evaluate if the proposed fill will result in any increase in the flood levels during the occurrence of the base flood. This evaluation is planned to be submitted to Bladen County and NCDPS by mid-September 2020. The analyses will include all four seeps (with conservative assumptions about flow-through cell sizing) to prepare a comprehensive application.

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[5] Note that work will also be conducted in accordance with the Soil and Material Waste Management Plan prepared by Chemours on July 3, 2020 for work conducted in non-manufacturing areas of the Site.

# 3. OPERATION AND MAINTENANCE PLAN

## 3.1 Overview

This section provides information on the System commissioning, routine inspections and operation, and maintenance. This work will be conducted to evaluate how the System is operating as compared to design parameters, so that potential optimizations can be completed. Performance monitoring is discussed in Section 4.

## 3.2 Commissioning and Startup

The System commissioning will be initiated upon completion of construction and will evaluate whether the System has been constructed as designed and operates as designed. The System commissioning will include: (i) inspecting each component of the System for construction defects; (ii) confirming that all valves are operational; (iii) the construction contractor certifying concrete water tightness; and (iv) introducing potable water to evaluate the piping distribution network and flow paths. It is estimated that approximately 15,000-20,000 gallons of potable water (roughly a half-day test at the design flow rate) will be used to evaluate that the piping distribution network operates correctly and adequately distributes influent into the leading GAC filter bed, and correctly diverts flow through the System. This will also prime the GAC filter beds for Seep C flow.

System startup will commence upon completion of the commissioning. The temporary seep bypass that will have been installed during construction will be removed to allow flow to enter the impoundment basin. Startup testing and monitoring will include:

- time required to fill the impoundment basin;
- horizontal and vertical extents of the impoundment basin;
- distribution of influent over the GAC filter beds;
- scouring or development of preferential pathways through the GAC filter beds;
- time to fill various System components;
- time to discharge; and
- influent flow rate.

Once the System is operating as designed, geochemical parameters will be measured and grab water samples will be collected from the inlet weir (influent), transfer basin (partially treated effluent), and discharge basin (effluent) to evaluate the initial operating conditions.

It is anticipated that System startup may take one to two days to complete. The commissioning and startup will be documented by OM&M personnel.

## 3.3 Inspections and Maintenance

Per the CO Addendum, inspections will occur on a weekly basis (minimum) and include regular inspections after rain events of 0.5 inches or greater within a 24-hour period. An Inspection Form will be filled out by OM&M personnel during each inspection. The routine inspections will include, but are not limited to:

- documenting the System duty cycle (i.e., lead/lag orientation of the GAC filter beds);
- measuring operational parameters, notably the influent and bypass (if any) flow rate and impoundment basin height;
- documenting any potential observed issues, such as sediment accumulation in the impoundment basin, structural problems, GAC fouling, and debris that is impairing flow through the System;
- inspecting the autosamplers (see Section 4.1 for details); and
- photographing the conditions observed, including any bypass flow.

Precipitation will be monitored remotely by using the existing USGS weather monitoring station at the W.O. Huske Dam (gauge 02105500). This station is approximately 1,200 feet from Seep C and records precipitation data every 15 minutes.

Routine preventative maintenance will be performed as needed during the inspections, and will include:

- removing debris (e.g., tree limbs) blocking the inlet weir or other feature
- cleaning and maintaining pressure transducers;
- cleaning and maintaining the autosamplers;
- general good housekeeping activities.

Some non-routine issues may be identified during inspections that cannot be managed by the operator, and will require coordination of equipment, materials, and other personnel. These could include:

- cleaning/clearing/maintaining/replacing of the System's protective cover and the geotextiles installed over the inlet basin #5 stone and GAC filter beds;
- repairing or replacing any flow through cell elements that are damaged;
- managing any accumulated sediment that settles upstream of the weir, and in the impoundment basin; and
- cleaning/clearing valves, notably the inlet manifold diaphragm valves.

Note that many of these maintenance activities could be scheduled to occur at the same time as GAC changeouts, to take advantage of equipment mobilization and limit downtime.

Some non-routine repairs may require an adjustment to the operating protocol. For example, if a storm damages one of the GAC filter beds, the System may have to temporarily operate with only a single GAC filter bed; or if significant storm damage requires the inlet weir to be closed, all seep flow will temporarily bypass through the spillway. If this occurs, Chemours will follow the reporting requirements in Section 5.

### 3.4 GAC Changeouts

As discussed in Section 2.4, GAC changeout frequencies were estimated using isotherm adsorption data, and the calculations are provided in Appendix C. It is estimated that the Seep C changeout frequency for one GAC filter bed will range between approximately 50 and 91 days (76 and 42 gpm, respectively). GAC changeouts will be conducted based on results from the System's influent, midpoint, and effluent performance monitoring data. Once initial PFAS indicator compound breakthrough has been observed, the sampling frequency may increase; the changeout will be scheduled for when the effluent from the lead GAC filter bed reaches approximately 30% of the influent concentration. By scheduling the changeout at this point, the actual changeout will occur before the midpoint concentration is 50% of the influent concentration. During the changeout operation, flow will be directed into the lag filter bed only, which will ultimately become the lead bed; after the GAC has been replaced in the lead filter bed, it will be put in service as the lag filter bed. The exact timing will be evaluated during the initial operation and is subject to optimization. Spent GAC will be removed with a vacuum truck that is staged at the maintenance platform.

### 3.5 Interim Remediation System Optimization

During System operation, results from the routine OM&M events (inspections, maintenance, and operation and performance monitoring) and non-routine inspections will be used to evaluate the System's operational efficacy. These evaluations will be used to inform potential optimizations to the System as well as the design and installation of the interim remedial systems to be installed at Seeps A, B, and D. The operational components and elements that will be monitored and evaluated may include:

- the construction of the System in an active seep channel and floodplain, and the bypass of the active seep's flow during construction;
- sediment accumulation and management within the impoundment basin and within the System;
- influent distribution from the ISB to the GAC filter beds;

- the mechanics and frequency of GAC changeouts;
- the mechanics for diverting and changing the effluent flow paths; and
- how the System manages increased seep flow rates during storms and elevated Cape Fear River stages.

Any proposed optimization to the Seep C System will be included as part of the bimonthly (once every two months) report discussed in Section 5.

# 4. SAMPLING AND EFFECTIVENESS PLAN

## 4.1 Operational and Performance Monitoring

Operational and performance monitoring of the System will be completed on a regular basis to evaluate:

- PFAS removal efficiency;
- breakthrough of PFAS compounds between GAC filter beds, using grab samples on an as needed basis;
- water quality parameters specified in the CO Addendum;
- potential effects of 0.5-inch rain events on PFAS concentrations; and
- flow measurements, via pressure transducers in the flow-through cell (which provide influent flow into the System and through the spillway). Flow rates through the bypass spillway can also be recorded during inspection events with the rectangular weir in the spillway that adjoins the flow through cell.

The operational and performance sampling plan is detailed in Table 1. Composite samples will be collected using portable, battery-powered autosamplers (e.g. ISCO sampler) consistent with other Site assessments. Sample aliquots will be collected in a common container where they will mix and be composited together. At the end of the sampling period, the OM&M personnel will fill laboratory-supplied sample containers from the common container within the autosampler. The autosamplers will be inspected during each inspection and maintenance event to evaluate if they are properly collecting samples and have suitable battery power remaining. Sampling will be conducted in accordance with the PFAS Quality Assurance Project Plan (AECOM, 2018). Any adjustments made to address potential deficiencies (e.g. low battery power, etc.) will be documented on the Inspection Form.

## 4.2 Effectiveness

System effectiveness defined by the percentage removal of the combined concentrations of the three indicator parameters (HFPO-DA, PFMOAA and PMPA) shall be determined on a monthly average basis for each flow-through cell system at each seep using composite influent and effluent samples as described in Table 1 and above in Section 4.1. Proposed influent and effluent autosampler locations are noted in Drawing C-03 of Appendix B.

The system effectiveness calculation uses volume weighted concentrations of the influent and effluent samples to calculate the percentage of mass removal. Volume weighted concentrations were developed in the event that either the influent and effluent autosamplers have different compositing durations or that the two composite sampling periods in the month have different durations (e.g. 14 days and 10 days). Both circumstances could arise due to a potential equipment malfunction or severe weather event. Weighting by volume provides a representative assessment of mass present in both the influent and effluent over time; samples corresponding to greater flow volumes will have a proportionately higher weight. However, it is anticipated that during normal operation of the system, the compositing durations will be the same and the effectiveness will be calculated using Equation 1 below:

***Equation 1: System Effectiveness***

$$\begin{aligned} System\ Effectiveness &= \left(1-\frac{c_{eff}}{c_{inf}}\right)\times 100\% \\ &= \left(1-\frac{\sum_{m=1}^{M}\sum_{i=1}^{\mathrm{i}=3} c_{eff,m,i}\times w_m}{\sum_{n=1}^{N}\sum_{i=1}^{\mathrm{i}=3} c_{inf,n,i}\times w_n}\right)\times 100\% \\ &= \left(1-\frac{\sum_{m=1}^{M}\sum_{i=1}^{\mathrm{i}=3} c_{eff,\mathrm{m},i}\times \frac{V_m}{\sum_{m=1}^{M} V_m}}{\sum_{n=1}^{N}\sum_{i=1}^{\mathrm{i}=3} c_{inf,n,i}\times \frac{V_n}{\sum_{n=1}^{N} V_n}}\right)\times 100\% \end{aligned}$$

where,

$c_{eff}$= is the volume weighted effluent concentration for a given month;

$c_{inf}$ = is the volume weighted influent concentration for a given month;

$m$ = represents an individual effluent composite sample time interval during a given month;

$M$ = is the total number of effluent composite sample time intervals during a given months (typically two, 14-day long composite samples);

$n$ = represents an individual influent composite sample time interval during a given month;

$N$ = is the total number of influent composite sample time intervals during a given month (typically two, 14-day long composite samples);

$i$ = represents the three indicator parameters HFPO-DA, PMPA, and PFMOAA.

$c_{eff,m,i}$ = is the measured concentration of the three indicator parameters for each monthly effluent composite samples[6];

$c_{inf,n,i}$ = is the measured concentration of the three indicator parameters for each monthly influent composite samples[6];

$w_m$ = is the effluent concentration volumetric weighting factor calculated for and applied individually to each effluent composite sample concentration;

$V_m$ = is the volume of water entering (and exiting) the flow-through cell system during the effluent composite sample collection period[7,8];

$w_n$ = is the influent concentration volumetric weighting factor calculated for and applied individually to each influent composite sample concentration; and

$V_n$ = is the volume of water entering (and exiting) the flow-through cell system during the influent composite sample collection period[7,8];

---

[6] Non-detect influent and effluent sample results will be assigned a value of zero for the calculation and the values from duplicate samples will be averaged together.

[7] A time length of 24 hours will be used to calculate influent and effluent volumes for effluent samples collected with composite sample durations less than 24 hours

[8] While not anticipated, sample durations of less than 24-hours may occur due to events such as the Cape Fear River inundating the flow-through cell.

# 5. DOCUMENTATION, REPORTING AND MODIFICATION

Interim Effectiveness Demonstration: For each seep System, an effectiveness report will be submitted within four months of startup that summarizes the construction, provides as-built drawings, and evaluates whether the System has consistently intercepted base flow and removes target PFAS indicator compounds at an efficiency of at least 80%, on a monthly average basis for each of the second and third full calendar months of operation.

Modification: If necessary, after six months of operation of the interim seep remediation systems at Seeps A through D, Chemours may submit a proposed modification to the Operation and Maintenance Plan and the Sampling and Effectiveness Plan.

OM&M Reports: Each routine OM&M event (inspection, maintenance, or performance monitoring) will be documented by the OM&M personnel conducting the OM&M event. Customized Inspection Forms and Sampling Logs will be developed to document the routine OM&M events and will be completed during each event. Non-routine inspection or maintenance events will be recorded as well.

Reports will be provided to NCDEQ and Cape Fear River Watch every two months with available analytical results, and operational data (e.g. flow, GAC consumption, PFAS treatment efficiency). The monthly reports will be submitted within 30 days of the end of the reporting month (i.e. the January/February 2021 monthly report will be submitted by 30 March 2021). A detailed reporting schedule is provided in Section 6.

Upset Conditions: In the case of an upset or other condition impeding the operation of the System, Chemours will notify NCDEQ, Cape Fear River Watch, and downstream drinking water utilities in writing within 24 hours of knowledge of such conditions.

# 6. SCHEDULE

## 6.1 Design, Permit and Construction Schedule

The anticipated flow-through cell design, permit, and construction schedule is as follows, with CO Addendum milestones noted. Best estimates are presented with the currently available information, and are subject to uncertainty based on permitting review periods (some of which may include public comment periods), extreme weather (i.e., Atlantic hurricane season), and potential work restrictions and supply chain disruptions as a result of the COVID-19 pandemic.

- August 13, 2020: Submittal of 401/404 IP for the Seep C interim remediation system *(completed)*
- August 27, 2020: Submittal of Seep C Land Disturbance permit to NCDEQ
- Mid-September 2020: Submittal of No-Rise Certification to Bladen County and Regional NCDPS Floodplain Management
- Mid- to Late-September 2020: Anticipated approvals from NCDEQ and USACE (note that this is subject to agency review timelines and potentially public comment periods, and difficult to reliably predict). Should permit approvals extend beyond this date, it is anticipated that Seep C construction completion could be delayed.
- Late September 2020: Construction setup at Seep C interim remediation system
- Mid-October 2020: Submittal of Seeps A, B, and D designs as modification to 401/404 IP
- November 16, 2020: Complete construction of Seep C interim remediation system (*CO Addendum Milestone*)
- Mid-December 2020: Submittal of Land Disturbance Permit to NCDEQ for Seeps A, B and D
- Late December 2020: Anticipated approvals from NCDEQ and USACE for Seeps A, B, and D (note that this is subject to agency review timelines and potentially public comment periods, and difficult to reliably predict). Should permit approvals extend beyond this date, it is anticipated that Seep A construction completion could be delayed.
- February 22, 2021: Complete construction of Seep A flow through cell *(CO Addendum Milestone*

- March 15, 2021: Complete construction of Seep B flow through cell *(CO Addendum Milestone*
- April 5, 2021: Complete construction of Seep D flow through cell *(CO Addendum Milestone*

## 6.2 <u>Reporting Schedule</u>

The anticipated reporting schedule through 2021 is as follows:

- Mid-October 2020: Submittal of final designs for Seeps A, B, and D to NCDEQ and USACE
- February 26, 2021: O&M Report #1
- March 16, 2021: Interim Effectiveness Report for Seep C
- April 30, 2021: O&M Report #2
- June 22, 2021: Interim Effectiveness Report for Seep A
- June 30, 2021: O&M Report #3
- July 15, 2021: Interim Effectiveness Report for Seep B
- August 5, 2021: Interim Effectiveness Report for Seep D
- August 31, 2021: O&M Report #4
- October 5, 2021: Potential submittal of Modification to Operation and Maintenance Plan and Sampling and Effectiveness Plan
- October 29, 2021: O&M Report #5
- December 31, 2021: O&M Report #6

The reporting schedule from 2022 until completion will consist of O&M Reports submitted once every two months.

# 7. REFERENCES

AECOM, 2018. Poly and Perfluoroalkyl Substance Quality Assurance Project Plan. August 2018.

Geosyntec, 2019a. Seeps and Creeks Investigation Report. Chemours Fayetteville Works. 26 August 2019.

Geosyntec, 2019b. Cape Fear River PFAS Loading Reduction Plan. Chemours Fayetteville Works. 26 August 2019.

Geosyntec, 2019c. Cape Fear River PFAS Loading Reduction Plan – Supplemental Information Report. Chemours Fayetteville Works. 4 November 2019.

Geosyntec, 2019d. Corrective Action Plan. Chemours Fayetteville Works. 31 December 2019.

United States Army Corps of Engineers, 2005. Stability Analysis of Concrete Structures. Engineer Manual 1110-2-2100. 1 December 2005.

# TABLES

# TABLE 1
# SAMPLING PLAN
# Chemours Fayetteville Works, North Carolina

| Parameter | Sample/Measurement Frequency[4] by Location | | | |
|---|---|---|---|---|
| | Influent | Midpoint | Effluent | Bypass Spillway |
| PFAS Removal and Water Quality Performance Monitoring[1] | Twice per month, 14-day composites, with aliquots every six hours | - | Twice per month, 14-day composites, with aliquots every six hours | - |
| PFAS Breakthrough Monitoring[2] | As needed, with rush turnaround to the extent practical. During startup of Seep C, could be as frequent as twice per month. Long-term frequency will depend on the results of the Seep C operation, and variable influent flow rate. | | | - |
| Wet Weather Bypass Monitoring | After rain events of 0.5 inches or more within a 24 hour period | - | After rain events of 0.5 inches or more within a 24 hour period | Not needed - influent samples for flow-through cell performance monitoring will suffice |
| Flow Rate[3] | Data automatically recorded every 15 minutes and downloaded weekly. | - | - | Data automatically recorded every 15 minutes and downloaded weekly. |

Notes:

1. Autosamplers in Inlet Chamber (influent) and Effluent Stilling Basin (effluent). Composite samples will be analyzed by TestAmerica laboratories for Table 3+ PFAS (see defined list below) and total suspended solids. The samples will also be measured in the field with a calibrated water quality meter for turbidity, dissolved oxygen, pH, conductivity, and temperature.

2. Grab samples will be submitted to the onsite laboratory, with an anticipated detection limit of approximately 100 nanograms per liter for the target indicator compounds. This resolution will be sufficient for purposes of breakthrough monitoring. The lowest concentration value for any indicator compound at any seep is PMPA at Seep D (8,700 ng/L in April 2020). 20% of this lowest value (indicating an 80% removal) would be 1,740 ng/L, thus the resolution of the onsite laboratory is sufficient.

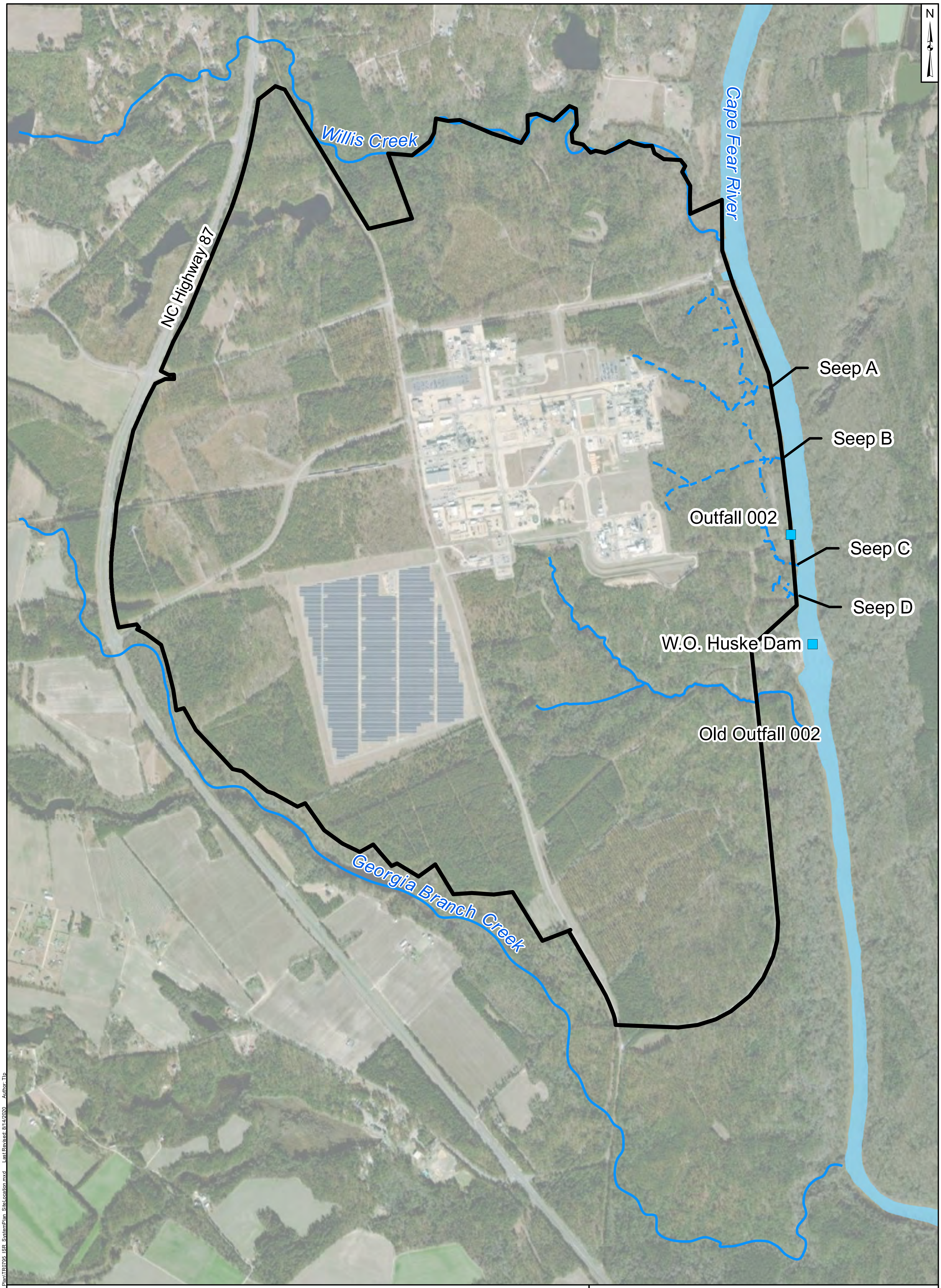
3. As detailed in the Design Drawings, the impoundment elevation will be measured with a transducer in the Inlet Chamber, which will provide flow rate measurements through the flow through cell and the bypass spillway (if elevated 0.5ft above the inlet weir). A transducer in the Effluent Stilling Basin will also measure influent flow rate, as well as head loss through the media. Bypass flow rate in the rectangular weir can also be recorded in the field during inspections.

4. After six months of operation of the interim seep remediation systems at Seeps A through D, Chemours may submit a proposed modification to the Operation and Maintenance Plan and the Sampling and Effectiveness Plan. Such modification could include adjustments to the frequency of sampling listed in this table.

List of 20 Table 3+ Parameters:

| Common Name | Chemical Name |
|---|---|
| HFPO-DA | Hexafluoropropylene oxide dimer acid |
| PFMOAA | Perfluoro-2-methoxyacetic acid |
| PFO2HxA | Perfluoro-3,5-dioxahexanoic acid |
| PFO3OA | Perfluoro-3,5,7-trioxaoctanoic acid |
| PFO4DA | Perfluoro-3,5,7,9-tetraoxadecanoic acid |
| PFO5DA | Perfluoro-3,5,7,9,11-pentaoxadodecanoic acid |
| PMPA | Perfluoro-2-methoxypropionic acid |
| PEPA | Perfluoro-2-ethoxypropionic acid |
| PS Acid | Ethanesulfonic acid, 2-[1-[difluoro[(1,2,2-trifluoroethenyl)oxy]methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro- |
| Hydro-PS Acid | Ethanesulfonic acid, 2-[1-[difluoro(1,2,2,2-tetrafluoroethoxy)methyl]-1,2,2,2-tetrafluoroethoxy]-1,1,2,2-tetrafluoro- |
| R-PSDCA | Ethanesulfonic acid, 1,1,2,2-tetrafluoro-2-[1,2,2,3,3-pentafluoro-1-(trifluoromethyl)propoxy]- |
| NVHOS | 1,1,2,2,4,5,5,5-heptafluoro-3-oxapentanesulfonic acid; or 2-(1,2,2,2-ethoxy)tetrafluoroethanesulfonic acid; or 1-(1,1,2,2-tetrafluoro-2-sulfoethoxy)-1,2,2,2-tetafluoroethane |
| EVE Acid | 2,2,3,3-tetrafluoro-3-({1,1,1,2,3,3-hexafluoro-3-[(1,2,2-trifluoroethenyl)oxy]propan-2-yl}oxy)propionic acid |
| Hydro-EVE Acid | 2,2,3,3-tetrafluoro-3-({1,1,1,2,3,3-hexafluoro-3-[(1,2,2,2-tetrafluoroethyl)oxy]propan-2-yl}oxy)propionic acid |
| PES | Perfluoro-2-ethoxyethanesulfonic acid |
| PFECA B | Perfluoro-3,6-dioxaheptanoic acid |
| PFECA-G | Perfluoro-4-isopropoxybutanoic acid |
| R-PSDA | Pentanoic acid, 2,2,3,3,4,5,5,5-octafluoro-4-(1,1,2,2-tetrafluoro-2-sulfoethoxy)- |
| Hydrolyzed PSDA | Acetic acid, 2-fluoro-2-[1,1,2,3,3,3-hexafluoro-2-(1,1,2,2-tetrafluoro-2-sulfoethoxy)propoxy]- |
| R-EVE | Pentanoic acid, 4-(2-carboxy-1,1,2,2-tetrafluoroethoxy)-2,2,3,3,4,5,5,5-octafluoro- |

# FIGURES



Legend

| | |
|---|---|
| 🟦 | Site Features |
| ▬ | Site Boundary |
| ─ | Nearby Tributary |
| ‐ ‐ | Observed Seep (Natural Drainage) |

Notes:
1. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS (MajorHydro shapefile).
2. Basemap sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEROGRID, IGN, and the GIS User Community

1,000 500 0 1,000 Feet

**Site Location Map**

Chemours Fayetteville Works, North Carolina

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C-3500 and C-295

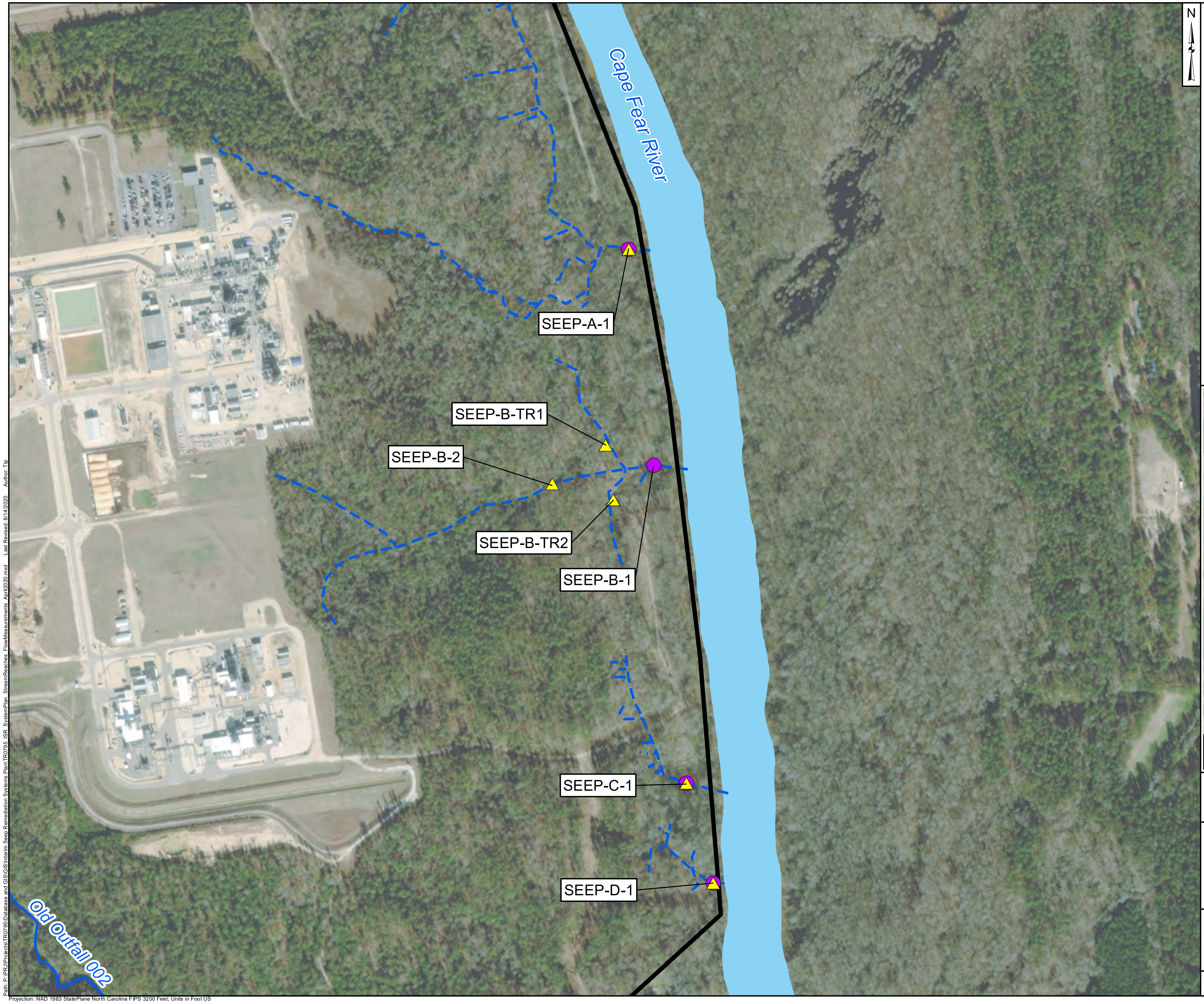
Figure
1

Raleigh

August 2020

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795_ISR_SystemPlan_SiteLocation.mxd Last Revised: 8/14/2020 Author: Tlp

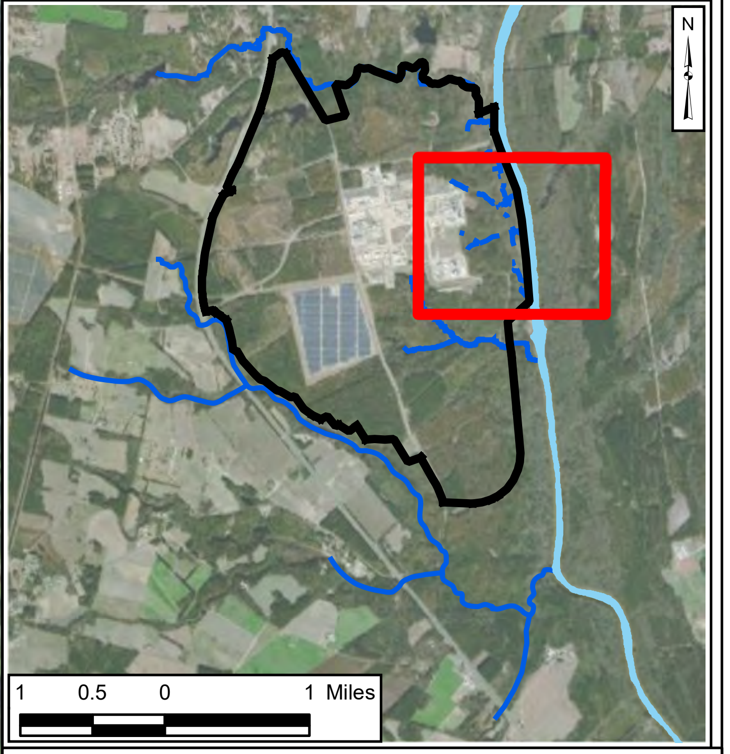
Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US



Legend

- △ Flow Measurement Location
- ● Sample Location
- - - Observed Seep
- — Nearby Tributary
- — Site Boundary

Notes:
* - Flow measurement was taken at W.O. Huske Dam - USGS Gauge Site No. 02105500
1. Flow at Old Outfall 002, Seep A, Seep B, Seep C, and Seep D locations were measured using flumes.
2. Flow at Willis Creek and Georgia Branch Creek were measured using flow velocity method.
3. Results of estimated flow at these locations are provided in Table 9 with supplemental flow measurement data included in Appendix E.
4. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS.
5. Basemap sources: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



500 250 0 500 Feet

## Sample and Flow Measurement Locations - April 2020

Chemours Fayetteville Works, North Carolina

Geosyntec consultants

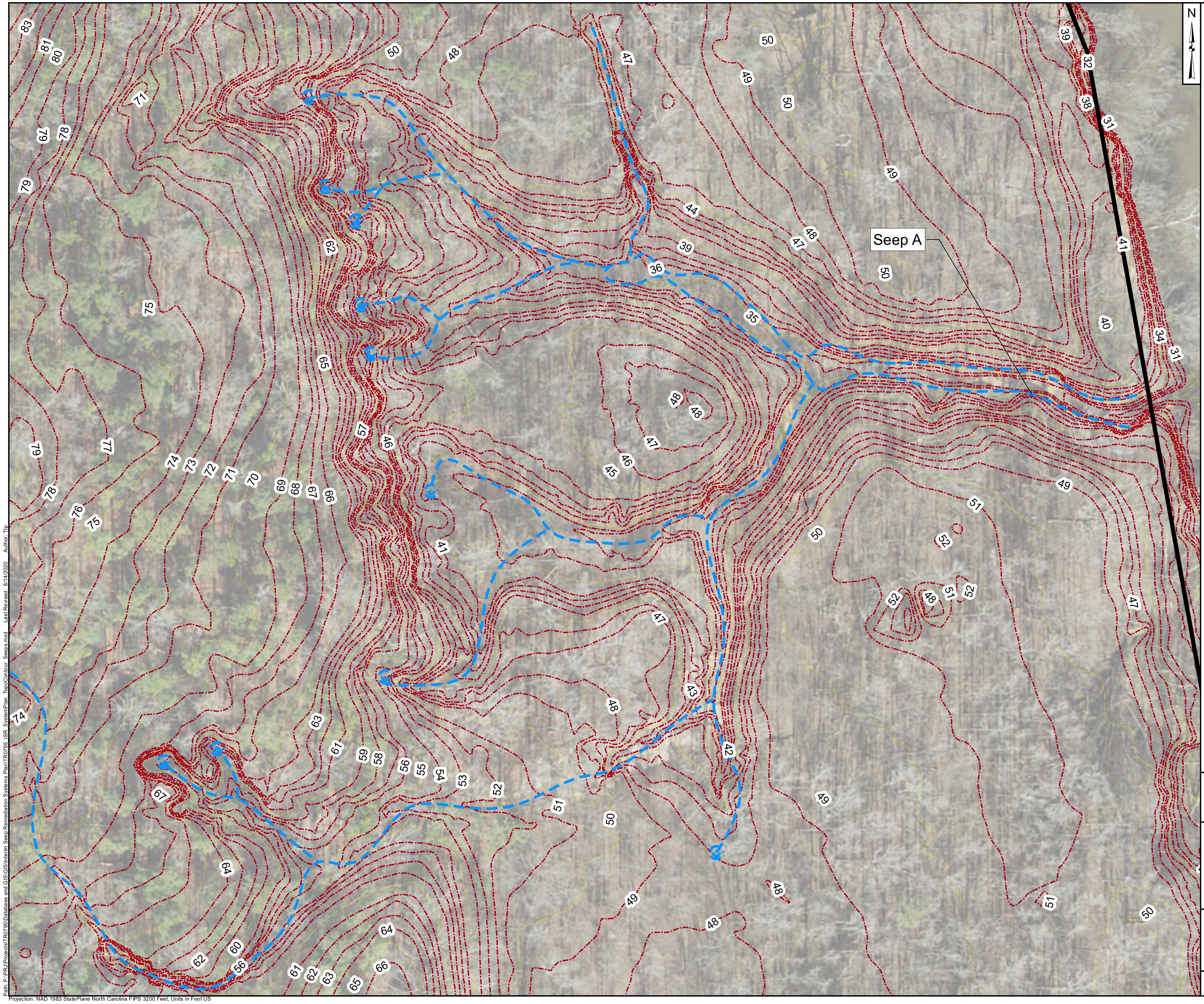
Geosyntec Consultants of NC, P.C.
NC License No.: C 3500 and C 295

Figure 2

Raleigh | August 2020

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795_ISR_SystemPlan_StreamReaches_FlowMeasurements_April2020.mxd Last Revised: 8/14/2020 Author: Tlp

Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US



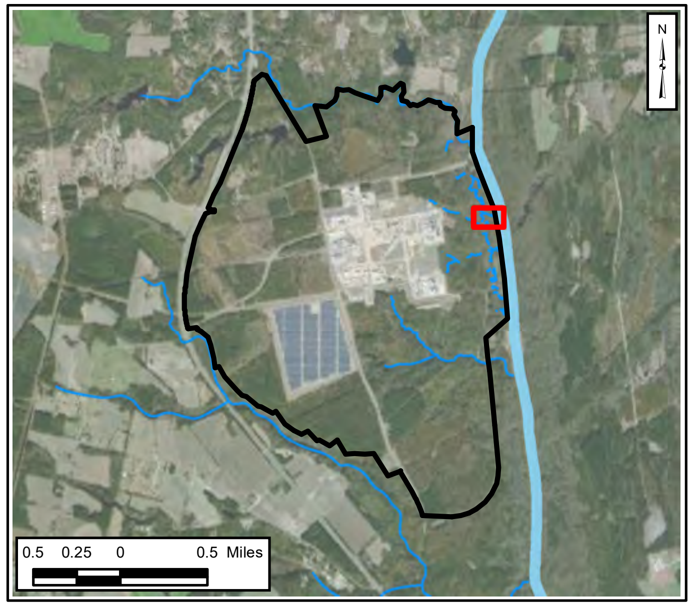
Legend

Topography Contours (ft NAVD88)

| | |
|---|---|
| | 5 Foot Interval |
| | 1 Foot Interval |
| | Observed Seep |
| | Nearby Tributary |
| | Site Boundary |

Notes:
ft NAVD88 - feet North American Vertical Datum 1988.

1. River Stage contours are derived from Lidar scans performed on December 1, 2019 and December 19, 2019 by Spectral Data Consultants, Inc.
2. Seep locations identified visually as reported in Geosyntec, 2019. Seeps and Creeks Investigation Report. Chemours Fayetteville Works. 26 August 2019.
3. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS (MajorHydro shapefile).
4. Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



50 25 0 50 Feet

## Seep A and Surrounding Topography

Chemours Fayetteville Works, North Carolina

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C 3500 and C 295

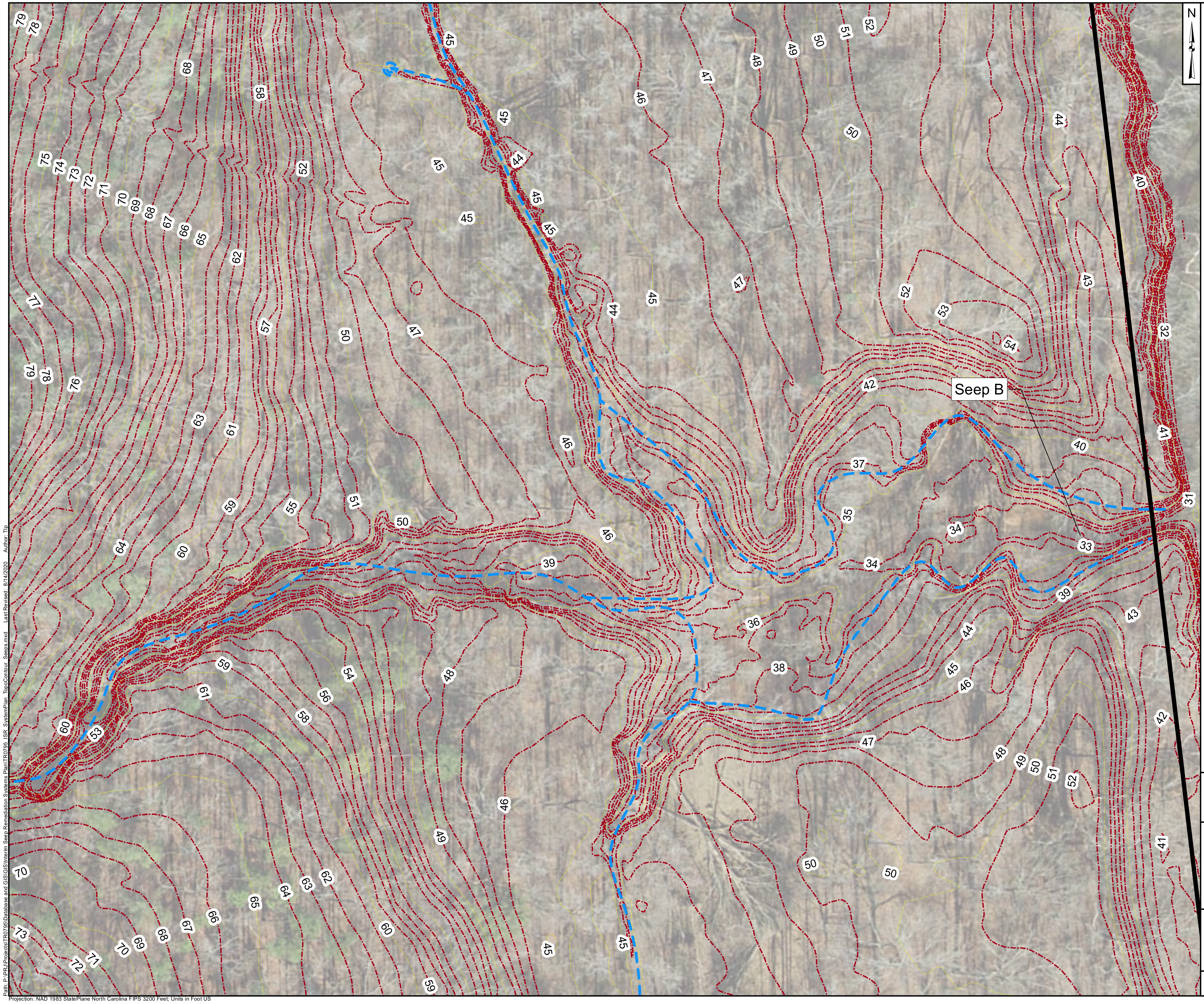
Figure
3A

Raleigh

August 2020

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795 ISR SystemPlan TopoContour Seeps.mxd Last Revised: 8/14/2020 Author: Tlp

Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US



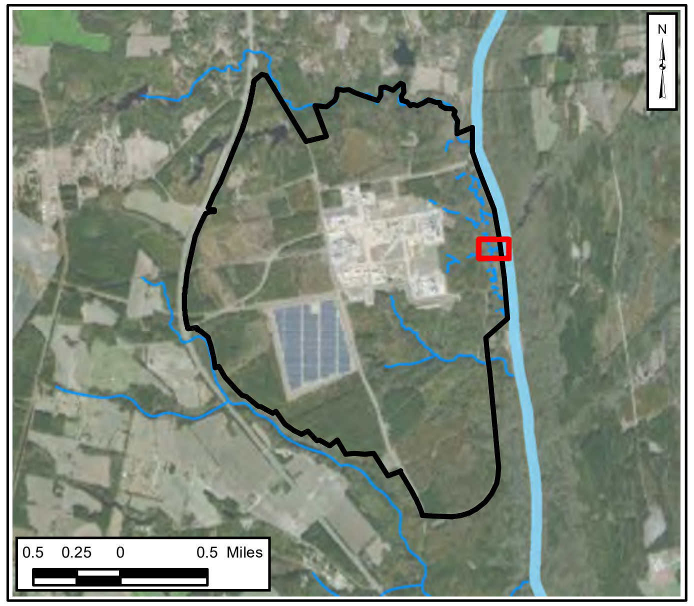
Legend

Topography Contours (ft NAVD88)

- 5 Foot Interval
- 1 Foot Interval
- Observed Seep
- Nearby Tributary
- Site Boundary

Notes:
ft NAVD88 - feet North American Vertical Datum 1988.

1. River Stage contours are derived from Lidar scans performed on December 1, 2019 and December 19, 2019 by Spectral Data Consultants, Inc.
2. Seep locations identified visually as reported in Geosyntec, 2019. Seeps and Creeks Investigation Report. Chemours Fayetteville Works. 26 August 2019.
3. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS (MajorHydro shapefile).
4. Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



50 25 0 50 Feet

## Seep B and Surrounding Topography

Chemours Fayetteville Works, North Carolina

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C 3500 and C 295

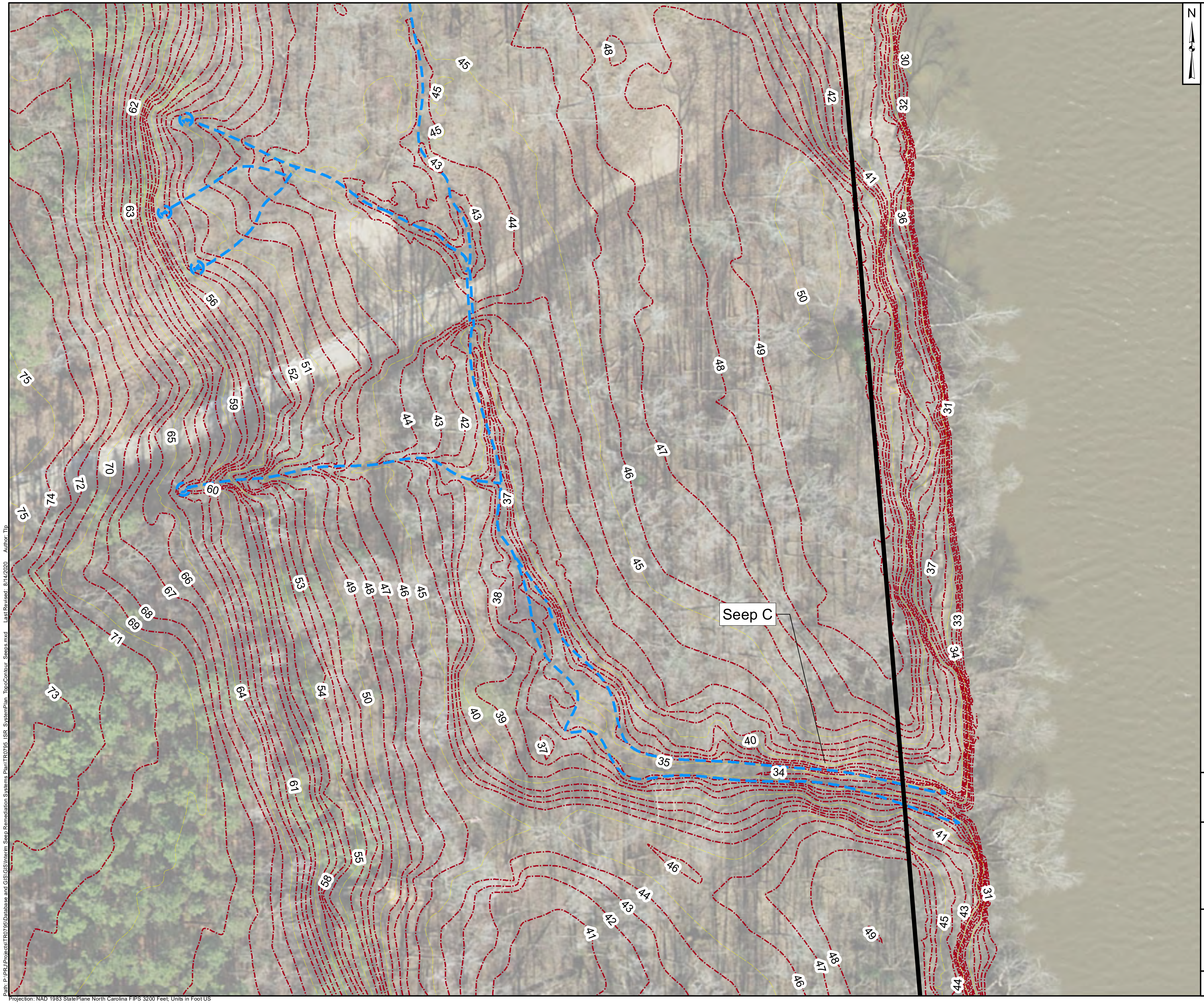
Figure
3B

Raleigh

August 2020

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795 ISR SystemPlan TopoContour Seeps.mxd Last Revised: 8/14/2020 Author: Tlp

Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US



Legend

Topography Contours (ft NAVD88)

5 Foot Interval

1 Foot Interval

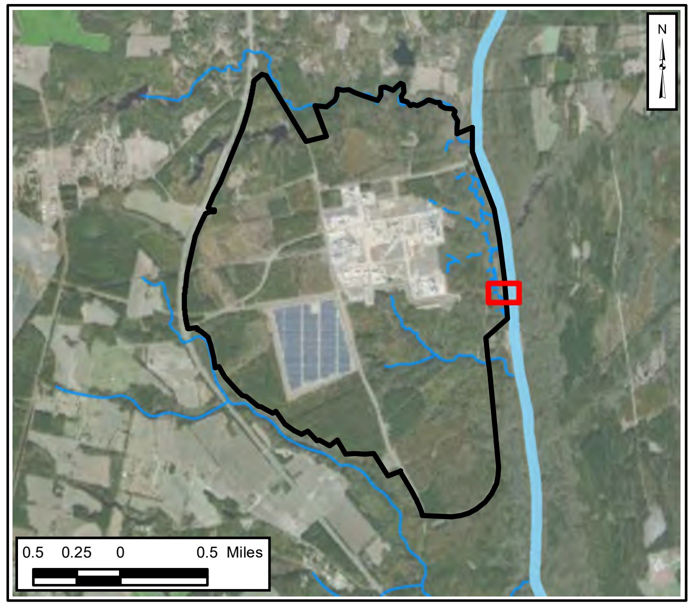
Observed Seep

Nearby Tributary

Site Boundary

Notes:
ft NAVD88 - feet North American Vertical Datum 1988.

1. River Stage contours are derived from Lidar scans performed on December 1, 2019 and December 19, 2019 by Spectral Data Consultants, Inc.
2. Seep locations identified visually as reported in Geosyntec, 2019. Seeps and Creeks Investigation Report. Chemours Fayetteville Works. 26 August 2019.
3. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS (MajorHydro shapefile).
4. Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



50 25 0 50 Feet

## Seep C and Surrounding Topography

Chemours Fayetteville Works, North Carolina

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C 3500 and C 295

Figure
3C

Raleigh

August 2020

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795_ISR_SystemPlan_TopoContour_Seeps.mxd Last Revised: 8/14/2020 Author: Tlp

Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US

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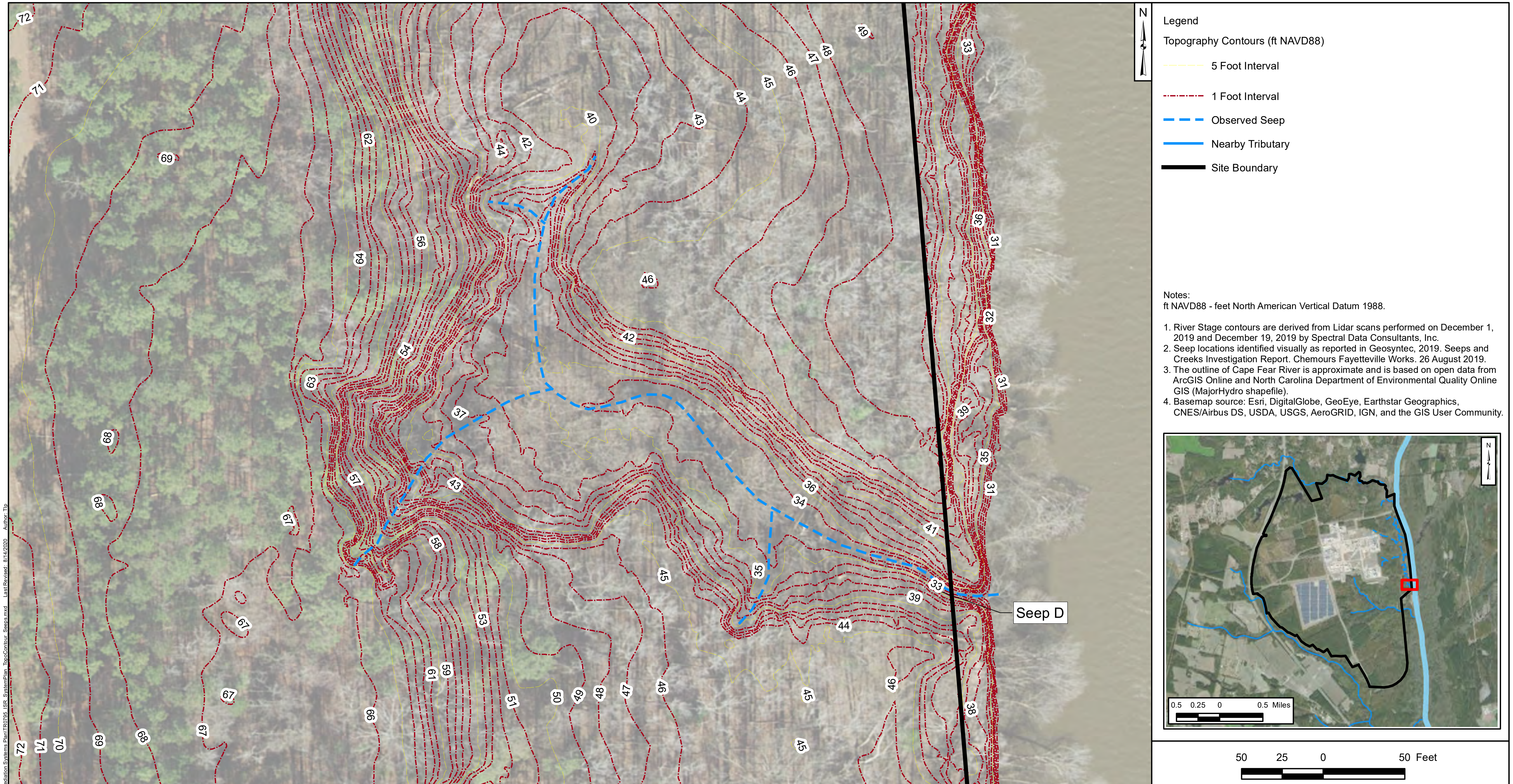

Legend

Topography Contours (ft NAVD88)

5 Foot Interval

1 Foot Interval

Observed Seep

Nearby Tributary

Site Boundary

Notes:
ft NAVD88 - feet North American Vertical Datum 1988.

1. River Stage contours are derived from Lidar scans performed on December 1, 2019 and December 19, 2019 by Spectral Data Consultants, Inc.
2. Seep locations identified visually as reported in Geosyntec, 2019. Seeps and Creeks Investigation Report. Chemours Fayetteville Works. 26 August 2019.
3. The outline of Cape Fear River is approximate and is based on open data from ArcGIS Online and North Carolina Department of Environmental Quality Online GIS (MajorHydro shapefile).
4. Basemap source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

**Seep D and Surrounding Topography**

Chemours Fayetteville Works, North Carolina

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Raleigh

August 2020

Figure
**3D**

Path: P:\PRJ\Projects\TR0795\Database and GIS\GIS\Interim Seep Remediation Systems Plan\TR0795 ISR SystemPlan TopoContour Seeps.mxd Last Revised: 8/14/2020 Author: Tlp

Projection: NAD 1983 StatePlane North Carolina FIPS 3200 Feet; Units in Foot US

# APPENDIX A
# Seeps A, B, C and D Dry Weather Flow Evaluation

# APPENDIX A

# SEEPS A, B, C AND D DRY WEATHER FLOW EVALUATION

## INTRODUCTION AND BACKGROUND

There are four onsite groundwater seeps A, B, C and D (Figure 1 of the main text) that emanate on the bluff face from the facility and discharge into the Cape Fear River. As required in the Addendum to Consent Order Paragraph 12, Chemours must install flow through cells at these four seeps and intercept base flow during dry weather. Chemours had previously installed flumes at the terminus of each seep, as close as practical to the confluence of the Cape Fear River (Figure 2 of the main text). For the larger seeps, notably A and B, several additional flumes were also installed at various tributaries that feed the main channel, and at various locations along the main channel itself. This appendix describes how the data collected from these flumes were evaluated to estimate the dry weather flow (i.e., base flow) and the wet weather flow.

The remainder of this appendix is organized as follows:

- **Data Collection** – describes how seep flow data were collected;
- **Methodology** – describes how seep flow data were organized and assessed;
- **Results** – describes the results of the assessment; and
- **Attachments** – tables and figures showing data assessed and results.

## DATA COLLECTION

Flow rates of water through a flume are estimated by recording the depth of water in the flume and converting this depth into a flow rate using a conversion formula based on the known geometry of the flume. The depths of water in the flumes were measured using a level logger (Solinst 3001 LT F30/M10) which recorded water elevation measurements on either fifteen- or thirty-minute intervals. The data from the loggers were periodically downloaded, adjusted for barometric pressure, and then used to calculate the depth of water in each flume. The depth data were then used to estimate the flow rates through the flumes.

Flumes at each of the seeps were periodically maintained and/or repaired to correct for observed bypass around the flume, which would result in low bias measurements. Maintenance activities included resetting sandbags and water diversion structures to direct waterflow from the seep through the flume. At other times, the flumes were inundated by elevated Cape Fear River water levels, leading to the flumes being unable to measure flows in the seeps.

## METHODOLOGY

Dry weather flow rates were estimated using the following steps listed below and described in the following sub-sections:

1. Organize Data;
2. Remove Unreliable Data;
3. Determine Weather Conditions for Usable Data; and
4. Calculate Flow Rate Statistics.

**Organize Data**

Data for each flume were organized to have the data set contain flow readings on 30-minute intervals. Interval lengths were kept constant across the analysis for each flume to reduce potential bias when calculating statistics[1].

Flow rate data were then paired with the corresponding precipitation data for that date and time. Precipitation data were taken from the onsite meteorological station and supplemented with precipitation data from the United States Geological Survey (USGS) monitoring station at the W.O. Huske Dam if there were no onsite precipitation data available.

**Remove Unreliable Data**

Unreliable data were removed from the data set from each flume. Unreliable data included data when (a) field records indicated the flume was not operational, (b) the flume was inundated by elevated Cape Fear River water levels, and (c) when the flume data exhibited a low bias. Field records were provided by Parsons of NC (Parsons) to determine when the flume was not operational.

Cape Fear River inundation events were identified by plotting the flow rate for each flume against the Cape Fear River water elevation. These plots are shown in Figures A-1 to A-6. Typically the Cape Fear River and the calculated flume flow rates are not correlated with each other. However, when the river inundates a flume, it causes the level logger in the flume to report an increased depth reading, and consequently higher flows will be calculated; often these flows are much greater than the range capacity of the flume. Inundation events were removed from the data sets.

Low bias data were identified as periods where the flume measurements were lower than typical for other periods and maintenance records indicated the status of the flume was unknown. Field observations have shown that water will flow around the flume if there is damage or erosion to the structures funneling water to the flumes, indicating that overtime flumes are potentially prone to develop a low bias.

The flow data for each flume, both the usable and the unreliable data, along with the amount of rain in the prior 24-hours for each interval are plotted in Figures A-7 to A-13.

---

[1] Constant interval periods for summary statistics are important since if there were periods with shorter intervals, there would be more intervals for this time period, leading to it being over-represented in the statistical assessment. The converse is true for periods with longer intervals.

## Determine Weather Conditions of Usable Data

With the data organized, and unreliable data removed (i.e. the data conditioned), the weather conditions for each 30-minute interval was determined based on the following criteria:

- Dry – any interval for which there was no precipitation during the given interval and during the prior 24-hours;
- Wet – any interval for which there is precipitation during the given interval or during the prior 24-hours;

## Calculate Flow Rate Statistics

With weather conditions specified for the usable data sets, flow rate statistics for each weather type were calculated.

## RESULTS

A statistical summary of the 95th, 50th, and 25th percentile flow rates for each weather condition for each flume is provided in Table A-1. The dry weather data have a consistently lower flow rate than the wet weather data. The dry weather data were all within the measurement ranges of the respective flumes. The Seep with the highest estimated base flow was Seep B, with a combined dry weather 95th percentile flow of 226 gallons per minute. The lowest flow was for Seep C, with a dry weather 95th percentile flow of 76 gallons per minute.

## ATTACHMENTS

### Tables

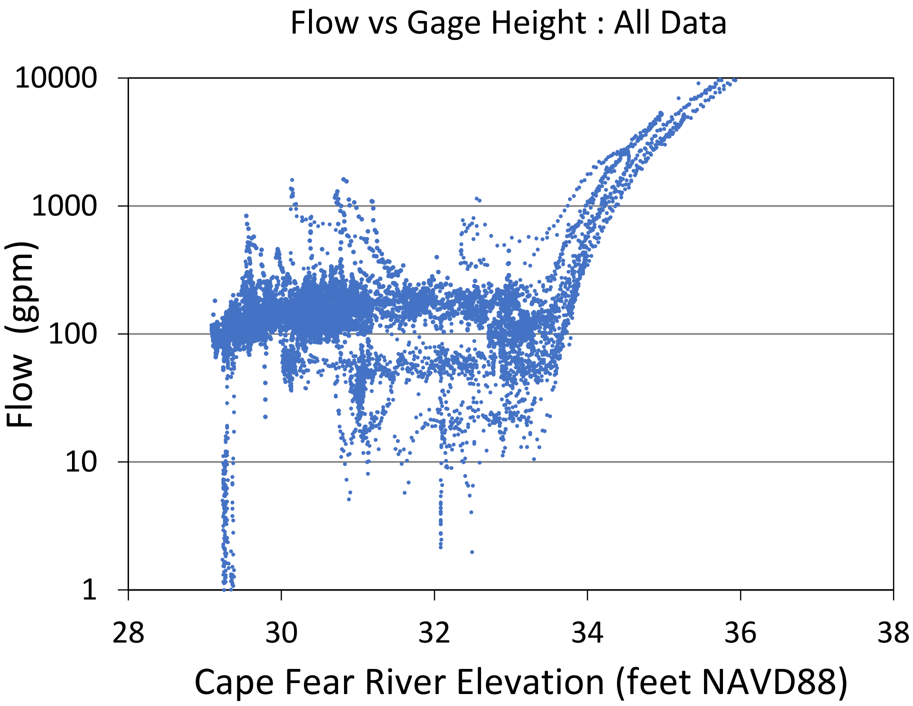
### Figures

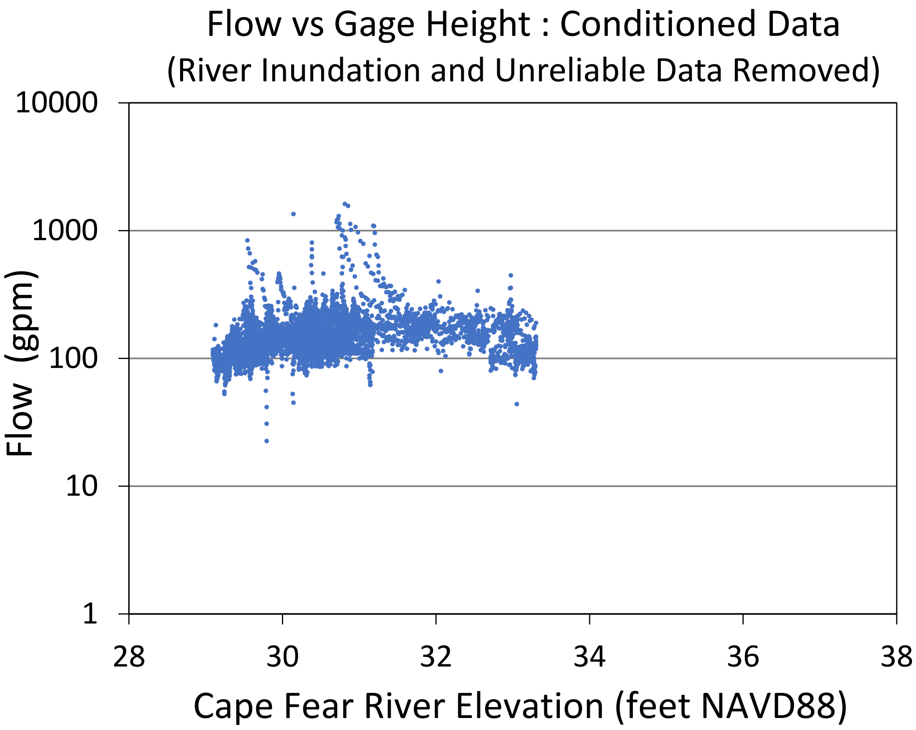
# TABLES

# TABLE A-1
# SEEP FLOW RATE STATISITCS SUMMARY
## Chemours Fayetteville Works, North Carolina

| Weather Condition | Data Points | Days with Weather Condition | Flow Rate Percentile Values (gallons per minute) | | |
|---|---|---|---|---|---|
| | | | **95%** | **50%** | **25%** |
| **Seep A, Flume A-1** | | | | | |
| **Dry Weather** | 5,087 | 106 | 205 | 129 | 106 |
| **Wet Weather** | 2,000 | 42 | 320 | 172 | 132 |
| **All Data** | 7,087 | 148 | 238 | 136 | 111 |
| **Seep B, Flume B2 (Mid)** | | | | | |
| **Dry Weather** | 6,302 | 131 | 145 | 87 | 74 |
| **Wet Weather** | 2,699 | 56 | 244 | 106 | 89 |
| **All Data** | 9,001 | 188 | 176 | 93 | 77 |
| **Seep B, Flume BTR1 (North)** | | | | | |
| **Dry Weather** | 4,449 | 93 | 52 | 29 | 23 |
| **Wet Weather** | 2,360 | 49 | 111 | 35 | 27 |
| **All Data** | 6,809 | 142 | 64 | 31 | 24 |
| **Seep B, Flume BTR2 (South)** | | | | | |
| **Dry Weather** | 4,591 | 96 | 45 | 27 | 20 |
| **Wet Weather** | 2,345 | 49 | 70 | 30 | 23 |
| **All Data** | 6,936 | 145 | 52 | 28 | 21 |
| **Seep B Data Combined** | | | | | |
| **Dry Weather** | 2,731 | 57 | 226 | 149 | 130 |
| **Wet Weather** | 1,647 | 34 | 329 | 167 | 145 |
| **All Data** | 4,378 | 91 | 257 | 155 | 135 |
| **Seep C** | | | | | |
| **Dry Weather** | 6,177 | 129 | 76 | 42 | 30 |
| **Wet Weather** | 2,659 | 55 | 119 | 57 | 43 |
| **All Data** | 8,836 | 184 | 86 | 46 | 33 |
| **Seep D** | | | | | |
| **Dry Weather** | 328 | 7 | 183 | 150 | 140 |
| **Wet Weather** | 343 | 7 | 225 | 159 | 154 |
| **All Data** | 671 | 14 | 208 | 157 | 146 |

# FIGURES





**Abbreviations:**

gpm: Gallons per minute

NAVD88: North American Vertical Datum of 1998

**Notes:**

-Gage height data are taken from the USGS Cape Fear River Gage at the W.O. Huske Dam, 02105500.

-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep A, Flume A-1:**
**Flow Data vs. Cape Fear River Gage Height**
Chemours Fayetteville Works, North Carolina

Geosyntec consultants

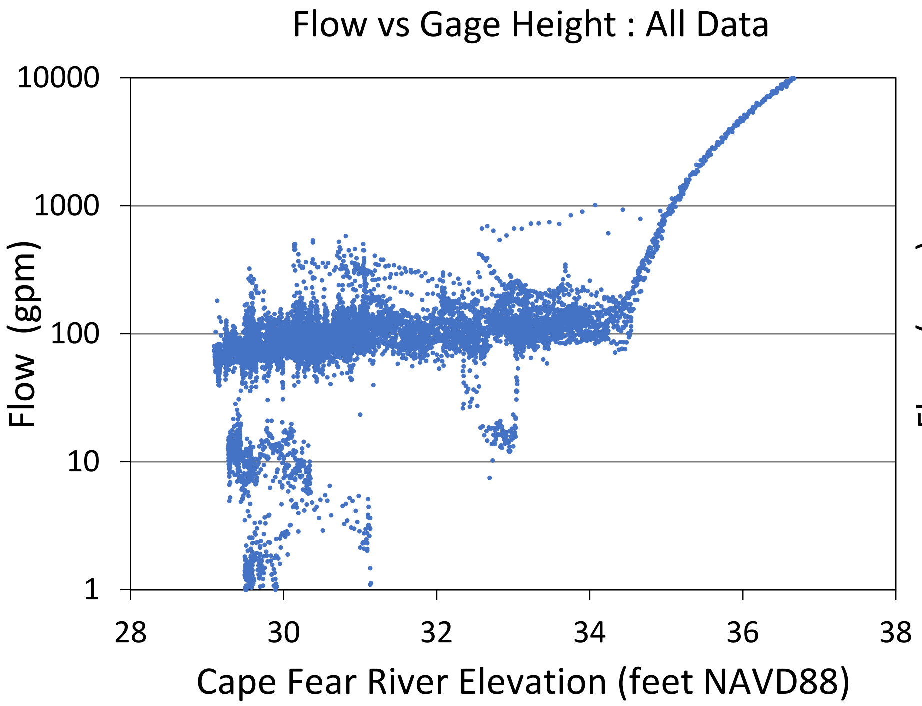
Geosyntec Consultants of NC, P.C.
NC License No.: C 3500 and C 295

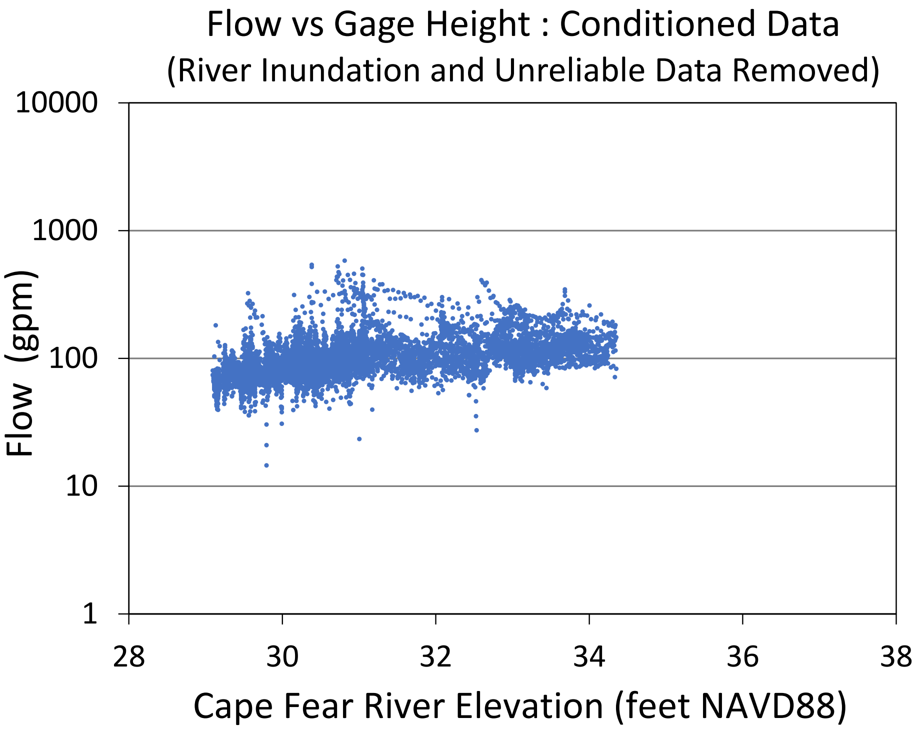
Figure

A-1

Raleigh

August 2020





**Abbreviations:**

gpm: Gallons per minute

NAVD88: North American Vertical Datum of 1998

**Notes:**

-Gage height data are taken from the USGS Cape Fear River Gage at the W.O. Huske Dam, 02105500.

-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep B, Flume B-2:**
**Flow Data vs. Cape Fear River Gage Height**
Chemours Fayetteville Works, North Carolina

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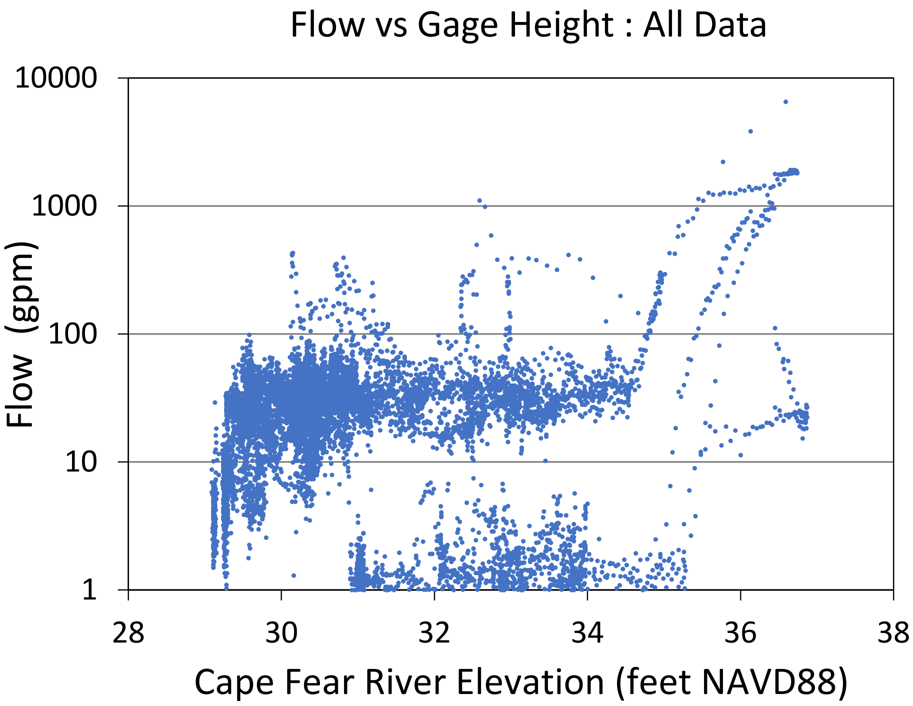
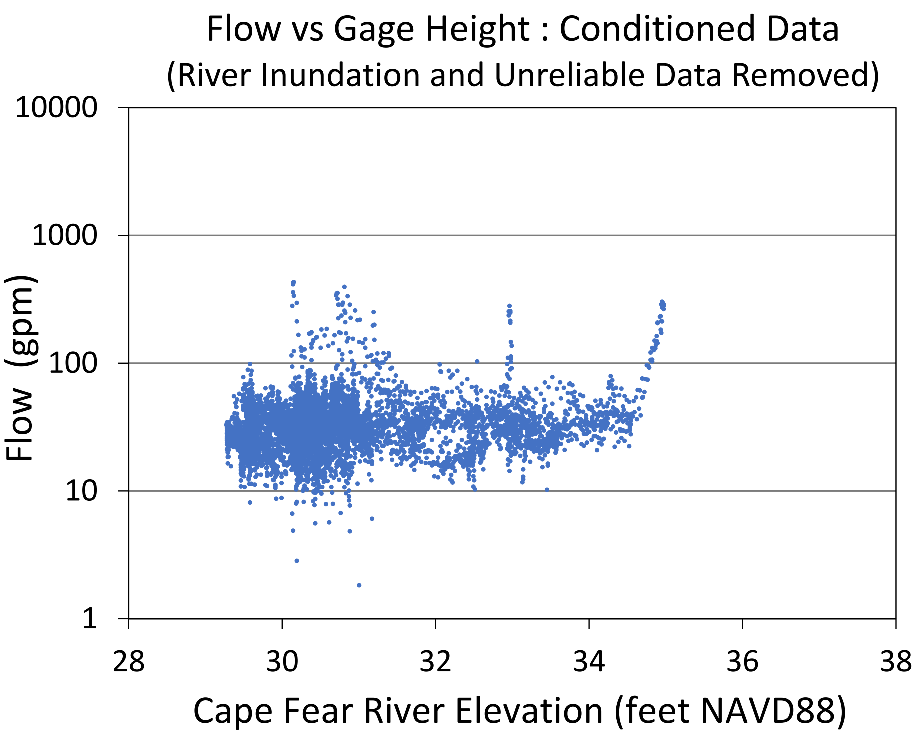
Figure A-2





**Abbreviations:**
gpm: Gallons per minute
NAVD88: North American Vertical Datum of 1998

**Notes:**
-Gage height data are taken from the USGS Cape Fear River Gage at the W.O. Huske Dam, 02105500.
-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep B, Flume B-TR1:**
**Flow Data vs. Cape Fear River Gage Height**
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Figure A-3

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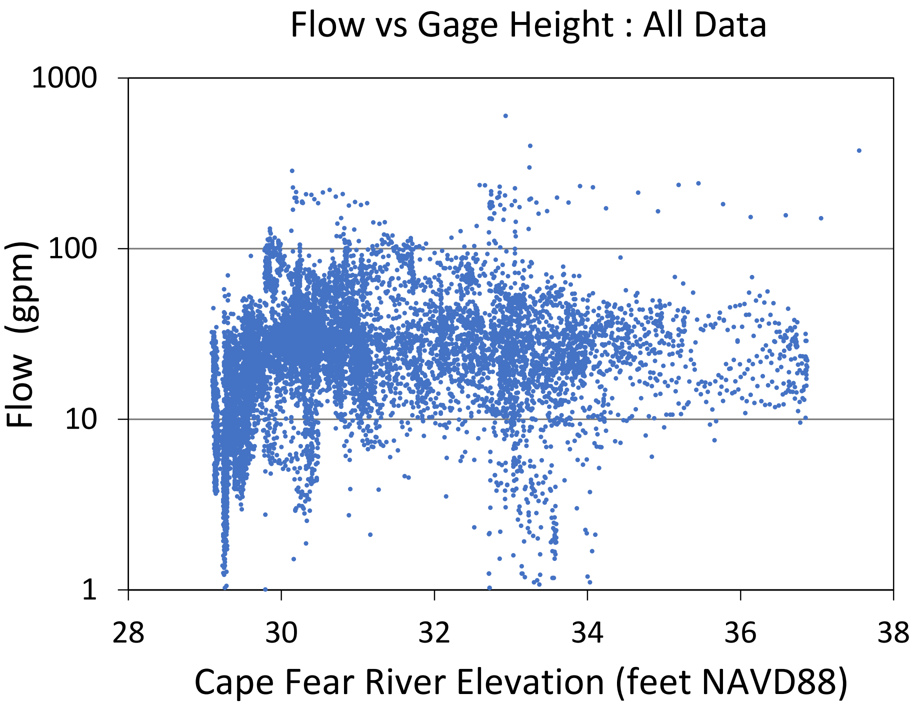

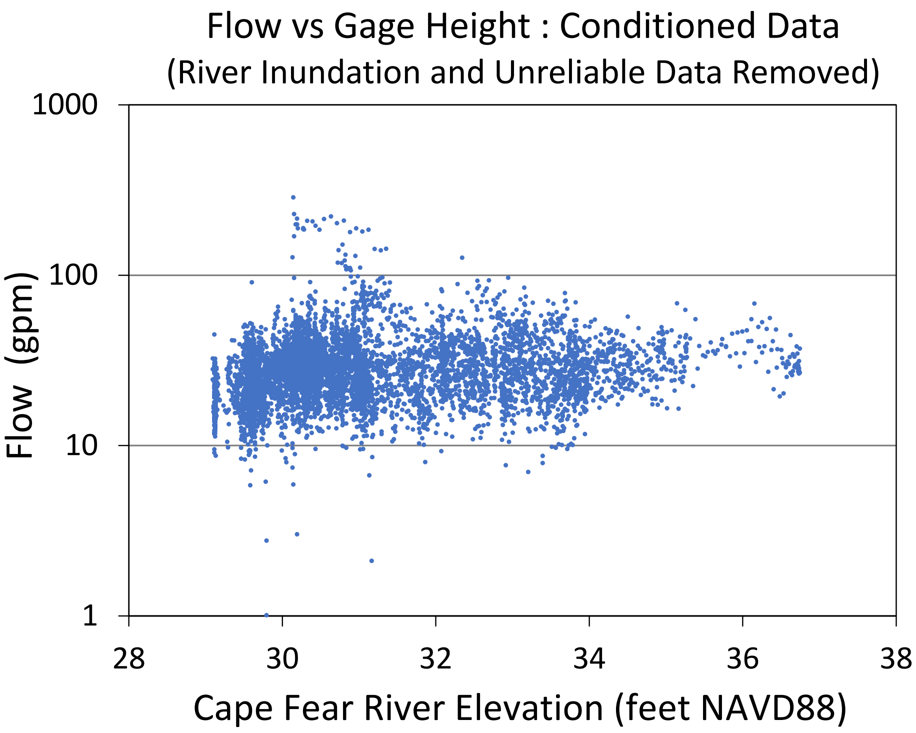

**Abbreviations:**
gpm: Gallons per minute
NAVD88: North American Vertical Datum of 1998

**Notes:**
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-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep B, Flume B-TR2:**
**Flow Data vs. Cape Fear River Gage Height**
Chemours Fayetteville Works, North Carolina

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consultants

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Figure
A-4

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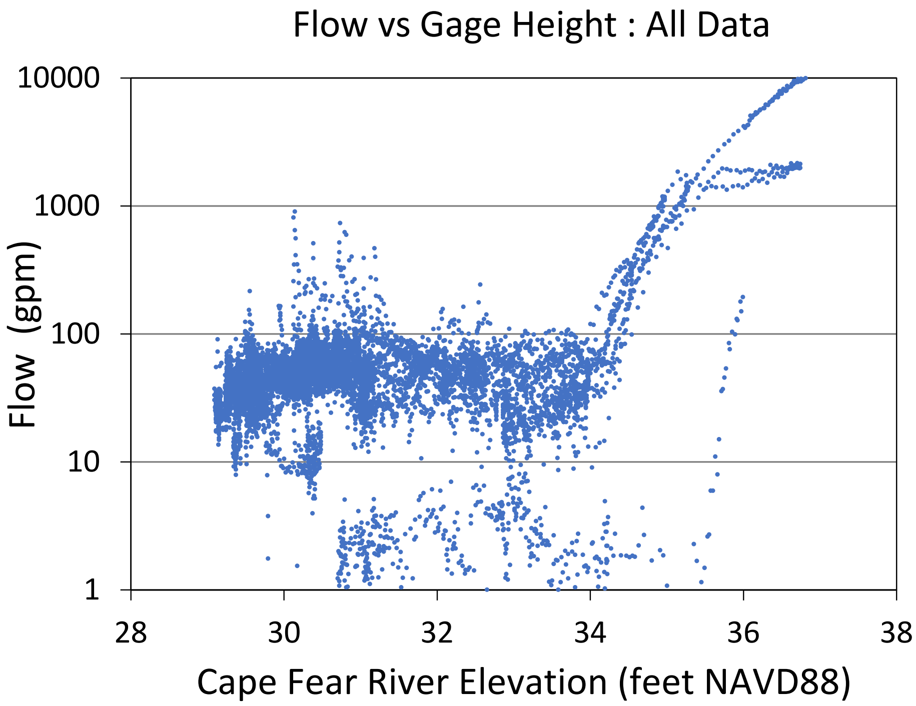
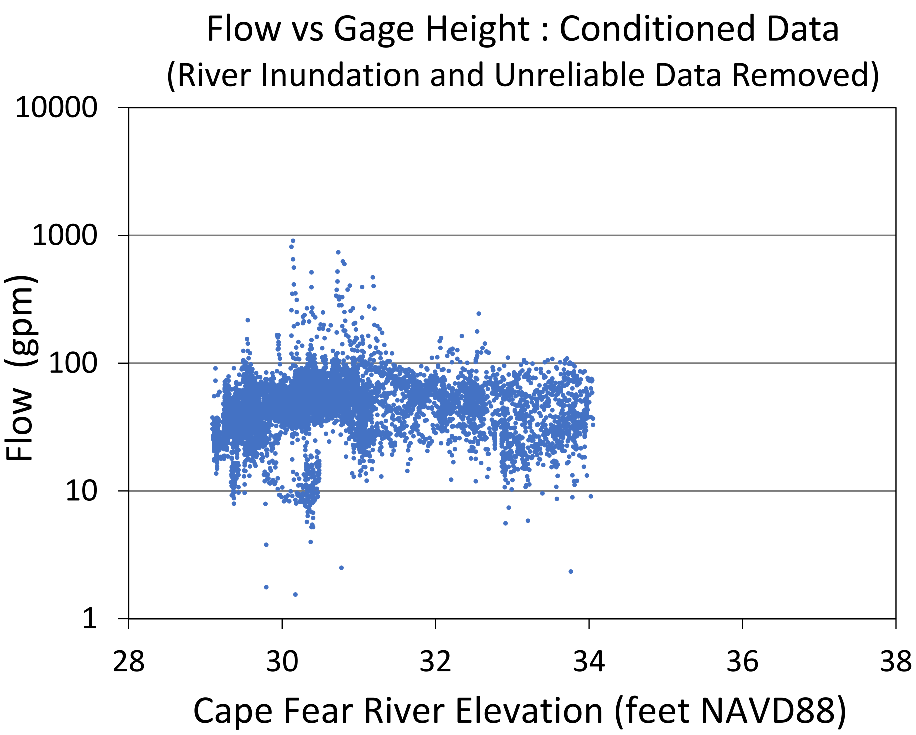
August 2020





**Abbreviations:**

gpm: Gallons per minute

NAVD88: North American Vertical Datum of 1998

**Notes:**

-Gage height data are taken from the USGS Cape Fear River Gage at the W.O. Huske Dam, 02105500.

-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep C:**
**Flow Data vs. Cape Fear River Gage Height**
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Figure

A-5

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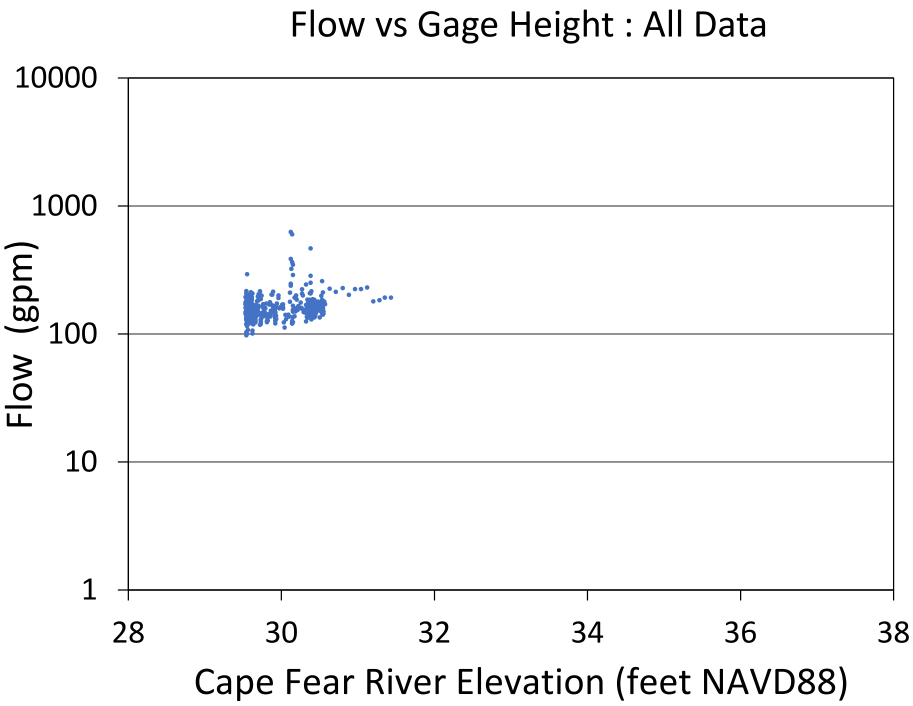

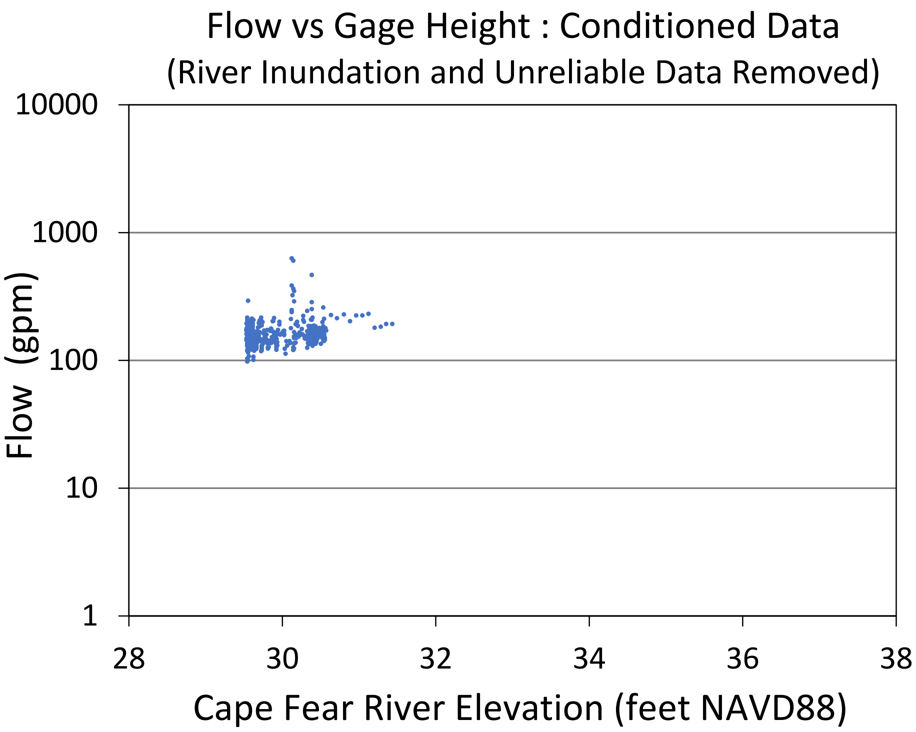

**Abbreviations:**
gpm: Gallons per minute
NAVD88: North American Vertical Datum of 1998

**Notes:**
-Gage height data are taken from the USGS Cape Fear River Gage at the W.O. Huske Dam, 02105500.
-Graphs indicate gage heights associated with river inundation. When increases in calculated flow are directly proportional to increases in gage height, this indicates that the river has submerged the flume and is resulting in erroneous readings.

**Seep D:**
**Flow Data vs. Cape Fear River Gage Height**
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Figure
A-6

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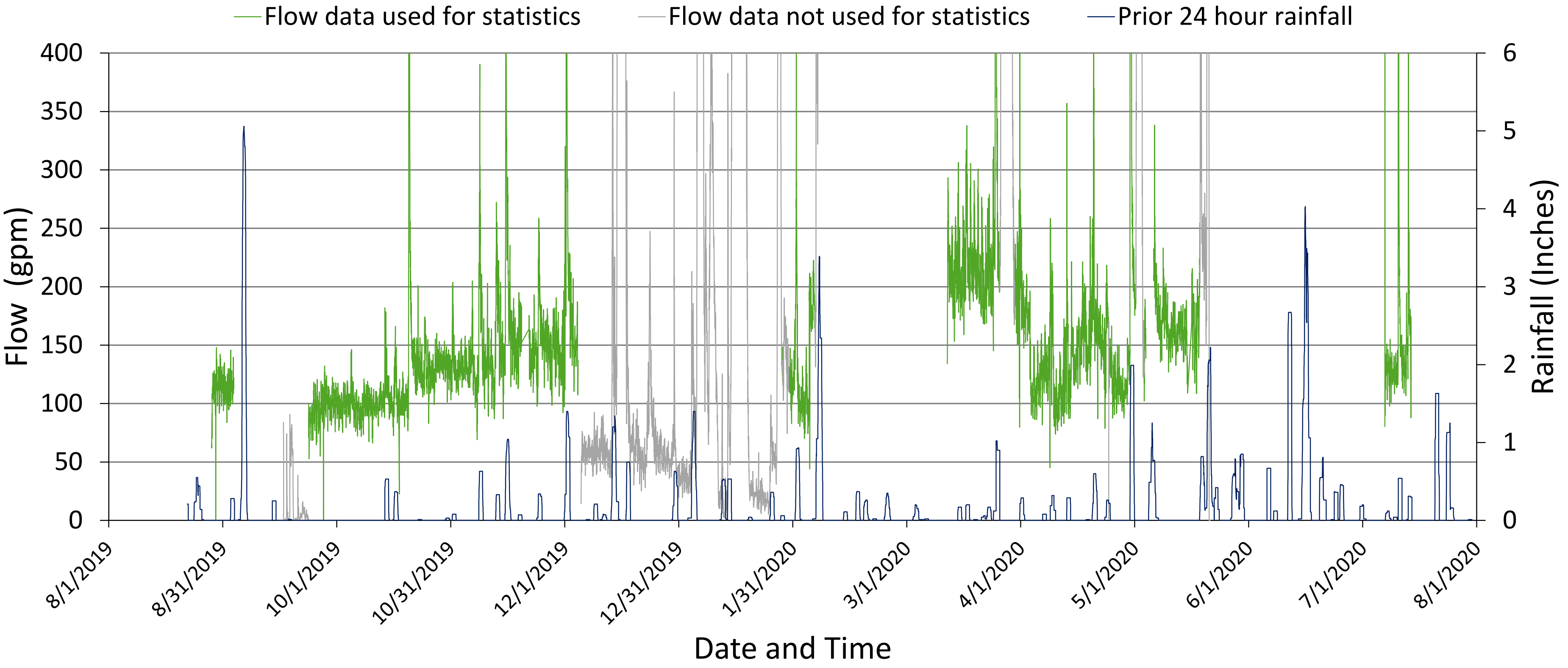

**Abbreviations:**
gpm: Gallons per minute

**Notes:**
- The green data series represents flow data used for assessing dry and wet weather flow statistics.
- The grey data series were excluded from the statistical assessment due to reasons including river inundation of the flume, unreliable data and/or data suspected of being low biased data.
- Prior 24 hour rainfall data are plotted only for dates where flow data are used for statistics. Rainfall data were taken from the onsite meteorological station and the USGS meteorological station at the W.O. Huske Dam.

**Seep A, Flume A-1 Flow Data**
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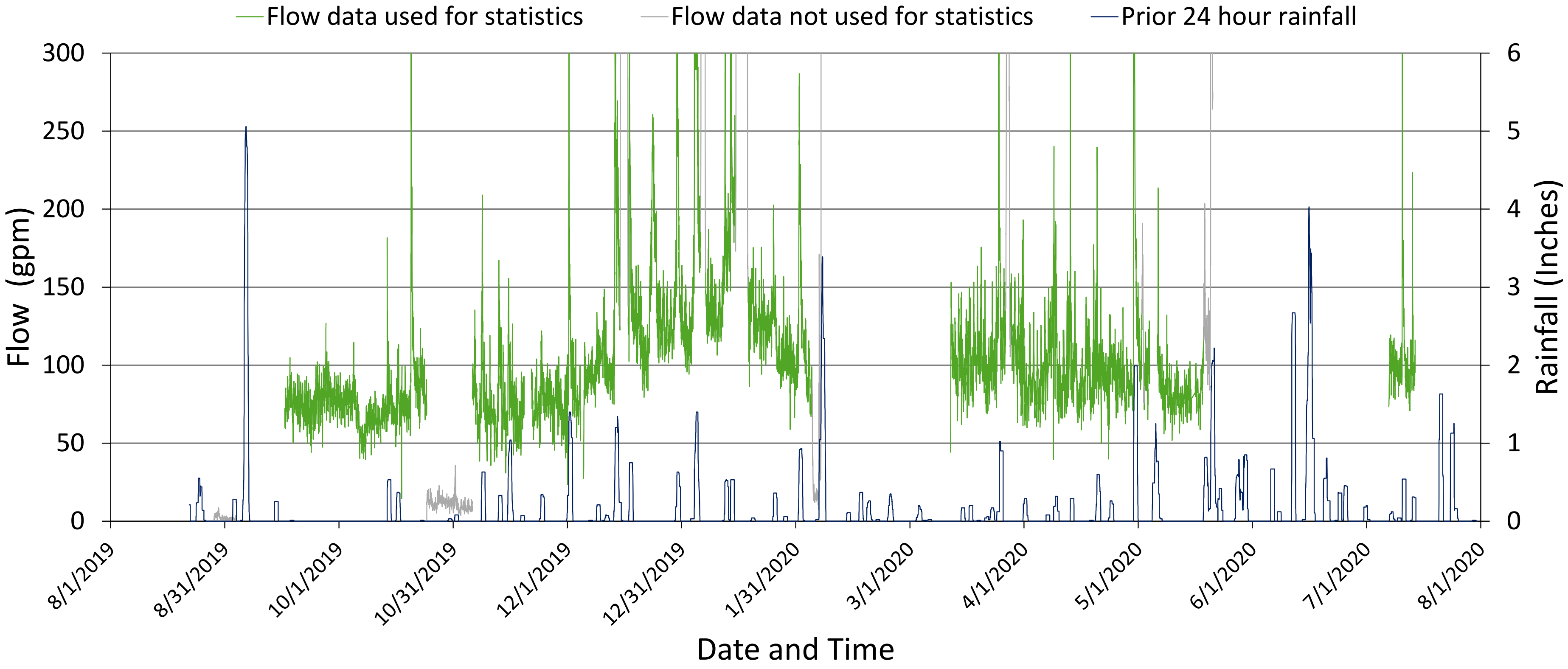
Figure
A-7



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**Seep B, Flume B-2: Flow Data**
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Figure
A-8

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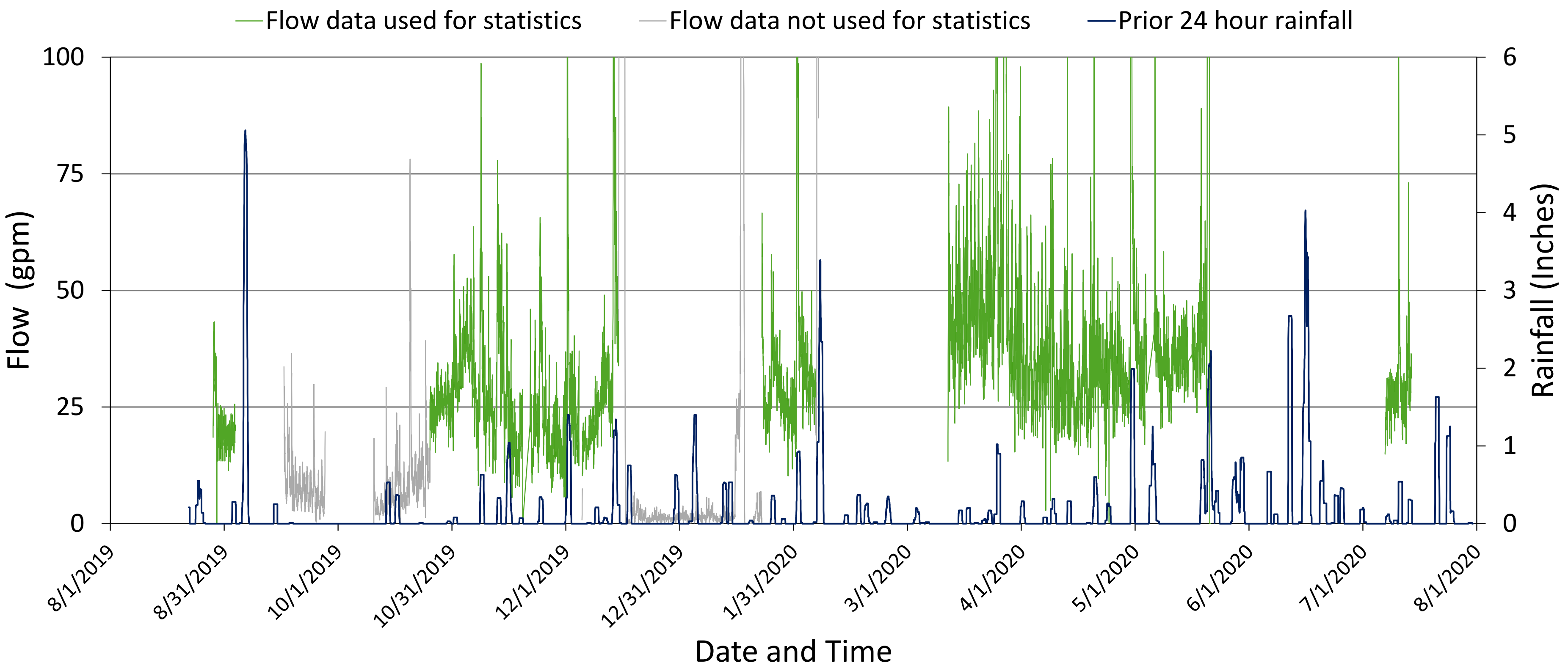
August 2020



**Abbreviations:**
gpm: Gallons per minute

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**Seep B, Flume B-TR1: Flow Data**
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Figure
A-9

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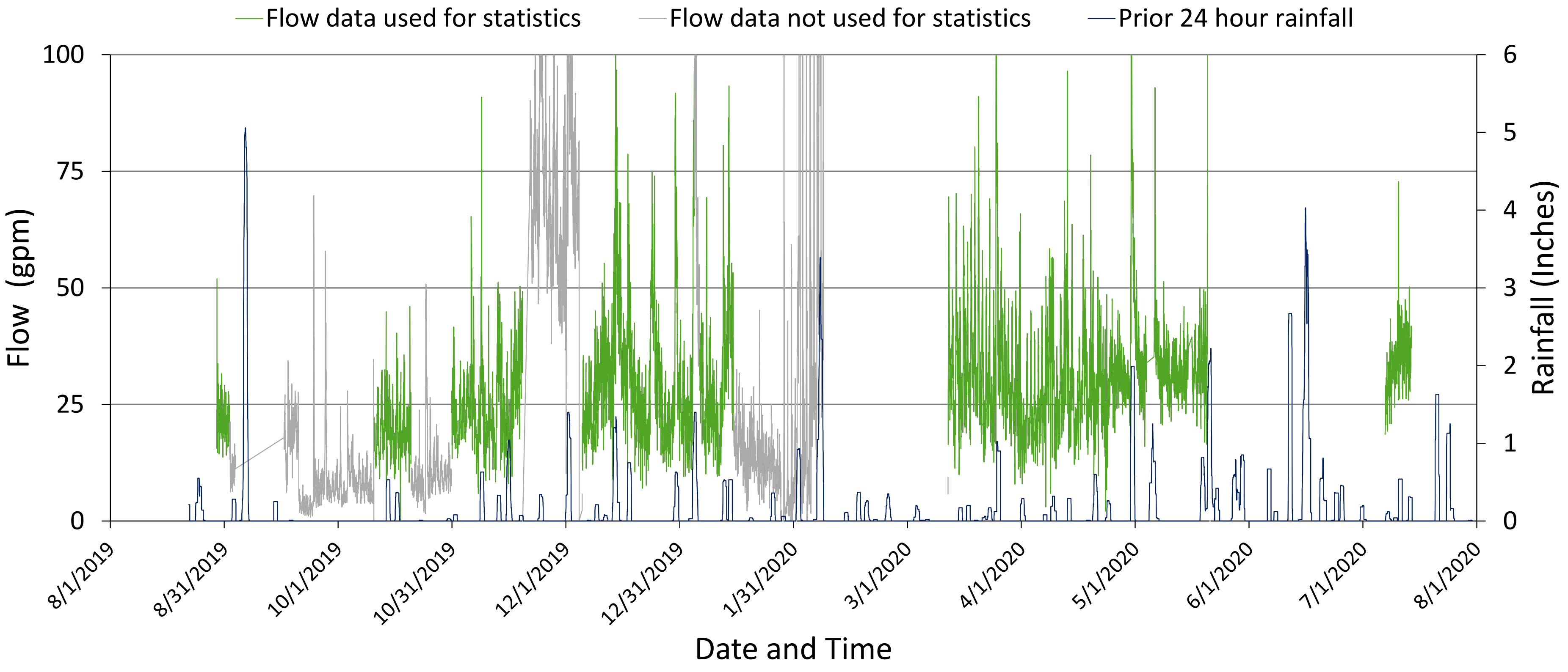
August 2020



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**Seep B, Flume B-TR2: Flow Data**
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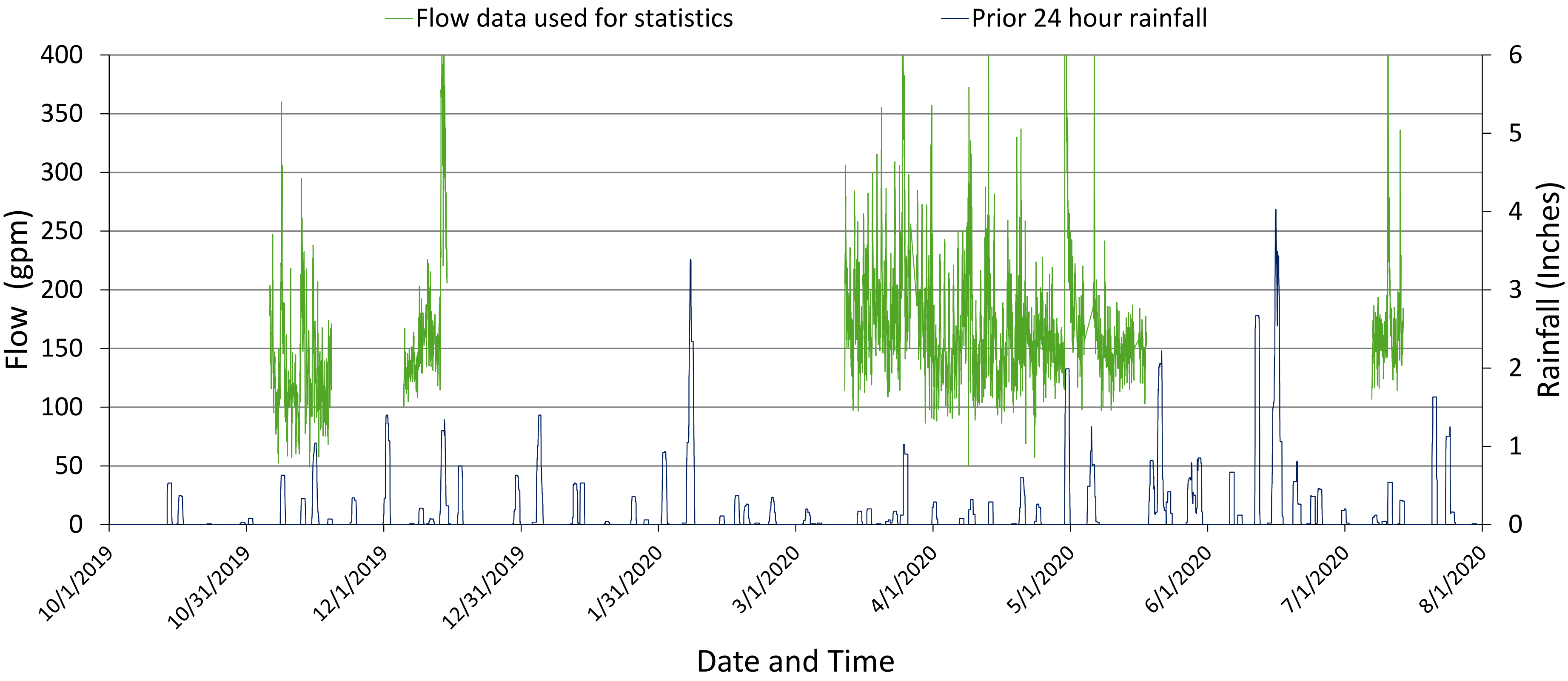
Figure
A-10

Raleigh
August 2020



**Abbreviations:**
gpm: Gallons per minute

**Notes:**
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**Seep B, Combined: Flow Data**
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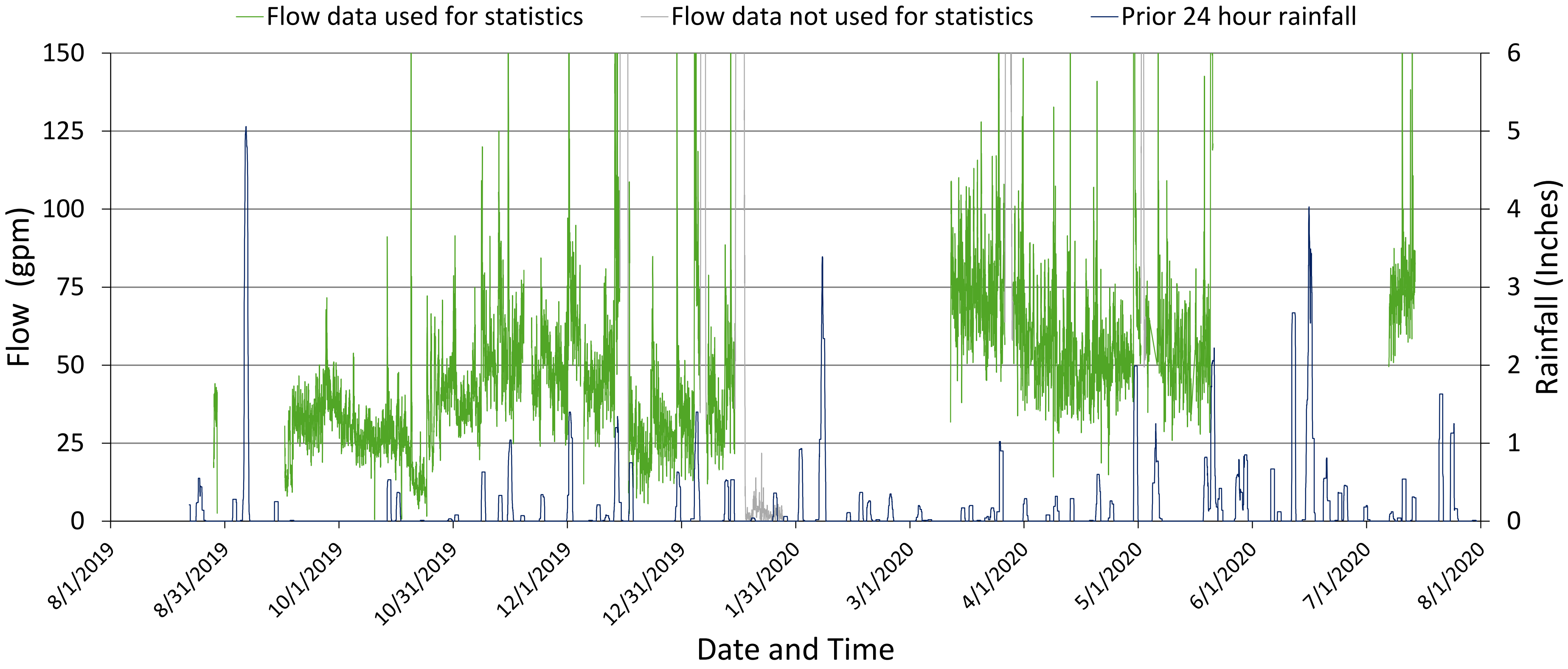
Figure
A-11

Raleigh
August 2020



**Abbreviations:**
gpm: Gallons per minute

**Notes:**
- The green data series represents flow data used for assessing dry and wet weather flow statistics.
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**Seep C: Flow Data**
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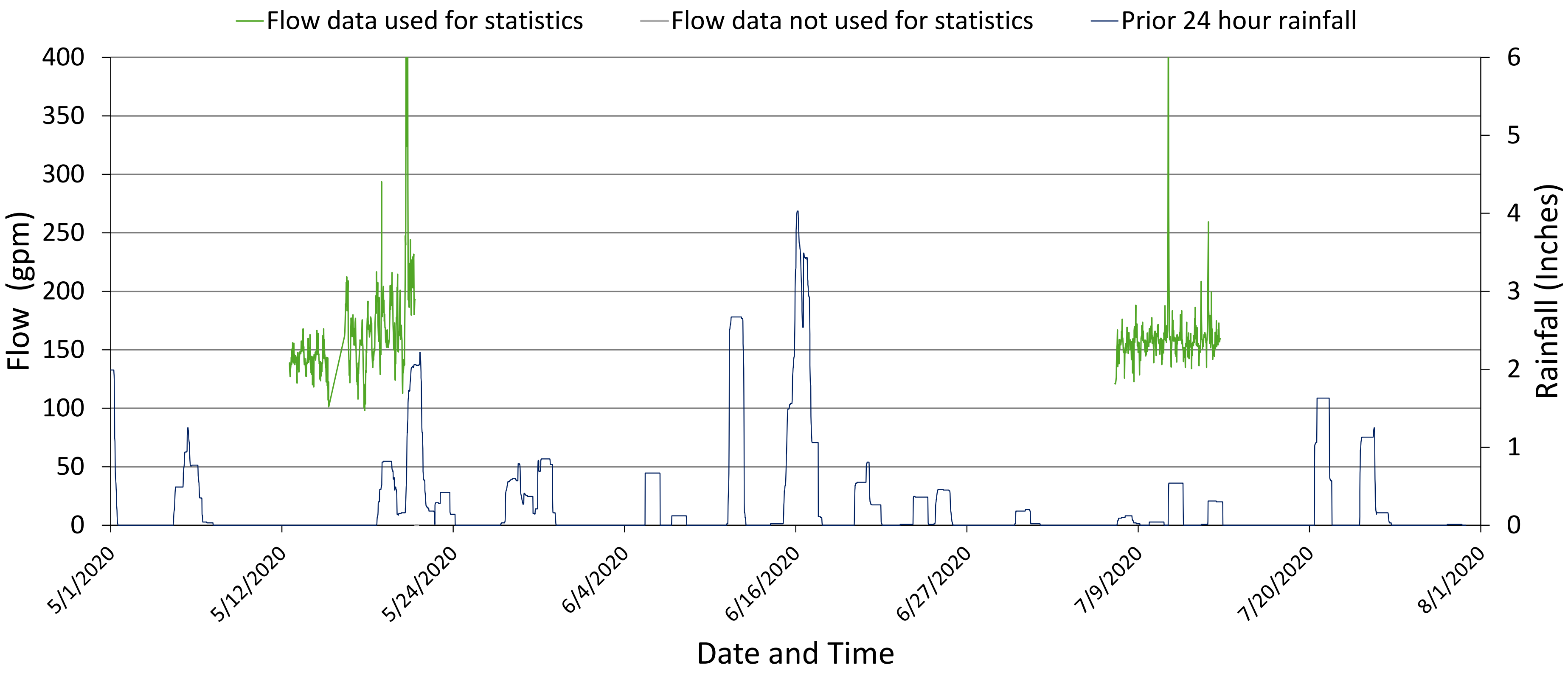
Figure
A-12



**Abbreviations:**
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**Notes:**
- The green data series represents flow data used for assessing dry and wet weather flow statistics.
- Prior 24 hour rainfall data are plotted only for dates where flow data are used for statistics. Rainfall data were taken from the onsite meteorological station and the USGS meteorological station at the W.O. Huske Dam.

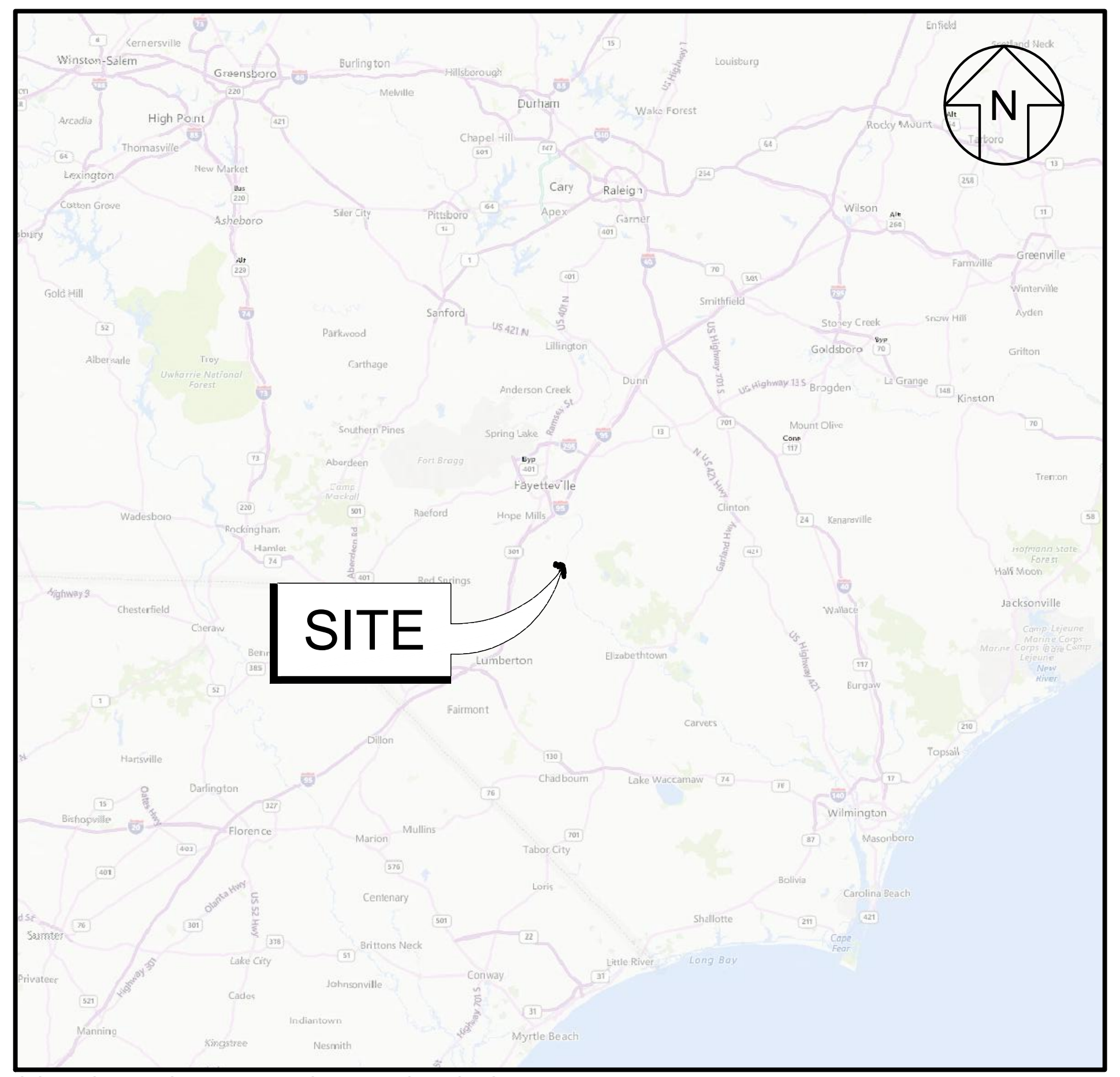
| | | |
|---|---|---|
| **Seep D: Flow Data**<br>Chemours Fayetteville Works, North Carolina | | |
| Geosyntec consultants | Geosyntec Consultants of NC, P.C.<br>NC License No.: C 3500 and C 295 | Figure<br>A-13 |
| Raleigh | August 2020 | |

# APPENDIX B
# 30% Design Drawings

DRAFT - NOT FOR CONSTRUCTION

# THE CHEMOURS COMPANY
# FAYETTEVILLE WORKS PROJECT
# SEEP C INTERIM REMEDIATION SYSTEM

## WILLIS CREEK AND CAPE FEAR RIVER CORRIDOR
## FAYETTEVILLE, BLADEN AND CUMBERLAND COUNTIES
## STATE OF NORTH CAROLINA
## AUGUST 2020



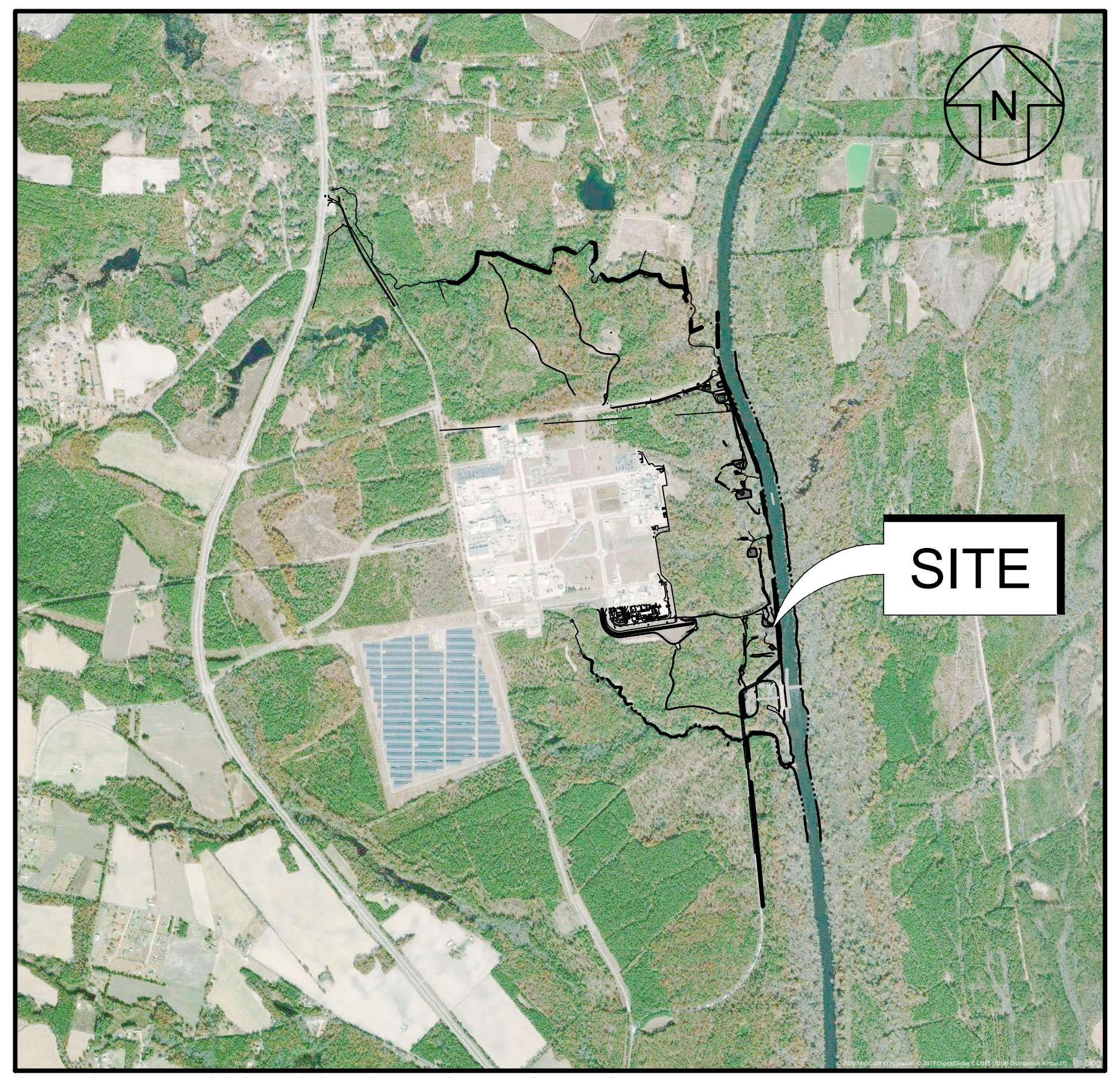
SOURCE: U.S. BUREAU OF THE CENSUS

VICINITY MAP

SCALE: 1" = 30 MILES

INDEX OF DRAWINGS

| DRAWING NO. | DRAWING TITLE |
|---|---|
| G-01 | COVER SHEET |
| G-02 | NOTES AND SYMBOLS |
| C-01 | OVERALL SITE PLAN |
| C-02 | SEEP C INTERIM REMEDIATION SYSTEM PLAN |
| C-03 | SEEP C INTERIM REMEDIATION SYSTEM CONSTRUCTION DETAILS I |
| C-04 | SEEP C INTERIM REMEDIATION SYSTEM CONSTRUCTION DETAILS II |
| C-05 | PLATFORM AND LADDER STRUCTURAL DETAILS |
| D-01 | SEEP C INTERIM REMEDIATION SYSTEM PROCESS FLOW DIAGRAM |



SOURCE: MICROSOFT CORPORATION BING MAPS 2017

LOCATION MAP

SCALE: 1" = 3,000'

0 3,000
SCALE IN FEET

PREPARED FOR:

Chemours™

22828 NC-87
FAYETTEVILLE, NC 28306
910.483.4681

PREPARED BY:

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C-3500 and C-295

ATRIUM AT BLUE RIDGE
2501 BLUE RIDGE ROAD, SUITE 430
RALEIGH, NC 27607
919.870.0576

30% DESIGN DRAWINGS
NOT FOR CONSTRUCTION

| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|
| | | | | |
| A | 08.14.20 | 30% DESIGN SUBMITTAL | JFH | CAS |

Geosyntec consultants

Geosyntec Consultants of NC, P.C.
NC License No.: C-3500 and C-295

ATRIUM AT BLUE RIDGE
2501 BLUE RIDGE ROAD, SUITE 430
RALEIGH, NC 27607
919.870.0576

TITLE:
COVER SHEET

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-G001.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | G-01 |
| APPROVED BY: | CAS | | |

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## LINETYPE LEGEND

| | |
|---|---|
| ——— | EDGE OF ROAD / EXISTING BUILDINGS |
| – – – – | EXISTING GROUND (NOTE 1) |
| ——— | FINISHED GRADE |
| — — — — | NON-WOVEN GEOTEXTILE SEPARATOR |
| ∿∿∿∿ | GEOCOMPOSITE |
| —— – – —— | PROPERTY BOUNDARY (NOTE 2) |
| ├——► | STORMWATER DIVERSION / CHANNEL |
| ══>══ | STORMWATER PIPE AND FLOW DIRECTION |
| ⌒⌒⌒⌒ | TREELINE |
| – – – – | EXISTING CLEARED AREA |
| —— LOD —— | LIMIT OF DISTURBANCE |
| —— SF —— SF —— | SILT FENCE |

## HATCH PATTERN LEGEND

| | |
|---|---|
| ▨ | ACCESS ROAD (EXISTING AND PROPOSED) |
| ▨ | CONCRETE |
| ▩ | GRAVEL |
| ▨ | PIPE EMBEDMENT FILL |
| ▩ | RIPRAP |
| ■ | STREAM (NOTE 1) |
| ▩ | SUBGRADE |
| ▦ | TRENCH BACKFILL / EARTHEN FILL |
| ▨ | WETLANDS (NOTE 3) |

## ABBREVIATIONS

| | |
|---|---|
| AASHTO | AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS |
| APP | APPROVED BY |
| ℄ | CENTER LINE |
| DRN | DRAWN BY |
| DWG | DRAWING |
| E | EAST OR EASTING |
| EL | ELEVATION |
| FT | FEET |
| HDPE | HIGH DENSITY POLYETHYLENE |
| H:V | HORIZONTAL TO VERTICAL LENGTH RATIO FOR A SLOPE |
| HWY | HIGHWAY |
| IN | INCH |
| INV | INVERT |
| MAX | MAXIMUM |
| MIN | MINIMUM |
| MSL | MEAN SEA LEVEL |
| N | NORTH OR NORTHING |
| NAD | NORTH AMERICAN DATUM |
| NAVD88 | NORTH AMERICAN VERTICAL DATUM OF 1988 |
| NCDEQ | NORTH CAROLINA DEPARTMENT OF ENVIRONMENTAL QUALITY |
| NO. | NUMBER |
| NPDES | NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM |
| N.S.A. | NATIONAL STONE ASSOCIATION |
| NTS | NOT TO SCALE |
| OC | ON CENTER |
| OZ | OUNCE |
| PFAS | PER- AND POLYFLUOROALKYL SUBSTANCES |
| PROJ | PROJECT |
| RCP | REINFORCED CONCRETE PIPE |
| RD | ROAD |
| REV | REVISION |
| S | SOUTH |
| SWP | STORMWATER PIPE |
| TYP | TYPICAL |
| U.S. | UNITED STATES |
| USEPA | UNITED STATES ENVIRONMENTAL PROTECTION AGENCY |
| W | WEST |
| W.S. | WATER SURFACE |
| % | PERCENT OR PERCENTILE |

## REFERENCE NOTES

NOTES:

1. THE BASIS OF BEARINGS FOR THIS SURVEY IS NC GRID BASED ON NAD83. THE BASIS OF ELEVATIONS FOR THIS SURVEY IS NAVD88 BASED ON AN OPUS SESSION PERFORMED ON NOVEMBER 16, 2019. THE TOPOGRAPHY OF THIS SURVEY HAS A CONTOUR INTERVAL OF ONE FOOT AND WAS PRODUCED FROM TWO LIDAR SCANS OF THE AREA. THE SCANS WERE PERFORMED ON DECEMBER 1, 2019 AND DECEMBER 19, 2019 BY SPECTRAL DATA CONSULTANTS, INC. PROJECT NO. 19085. THIS SURVEY WAS MADE IN ACCORDANCE WITH LAWS AND/OR MINIMUM STANDARDS OF THE STATE OF NORTH CAROLINA.

2. SAID DESCRIBED PROPERTY IS LOCATED WITHIN AN AREA HAVING A ZONE DESIGNATION "X" & "AE" BY THE FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA), ON FLOOD INSURANCE RATE MAP NO. 3720035900J, WITH A DATE OF IDENTIFICATION OF JANUARY 5, 2007, IN BLADEN COUNTY, STATE OF NORTH CAROLINA AND ON FLOOD INSURANCE RATE MAP NO. 3720044000J, WITH A DATE OF IDENTIFICATION OF JANUARY 5, 2007, IN CUMBERLAND COUNTY, STATE OF NORTH CAROLINA, WHICH ARE THE CURRENT FLOOD INSURANCE RATE MAP FOR THE COMMUNITY IN WHICH SAID PREMISES IS SITUATED. THE BASE FLOOD ELEVATION FOR THE AREA IS 68' MSL.

3. APPROXIMATE EXTENT OF DELINEATED WETLANDS. (WATERS OF THE UNITED STATES TECHNICAL REPORT, THE CHEMOURS COMPANY FAYETTEVILLE WORKS PROJECT: FLOW-THROUGH CELLS, SEEP C PILOT STUDY, AND REVISED SEEP A. PARSONS, AUGUST 2020)

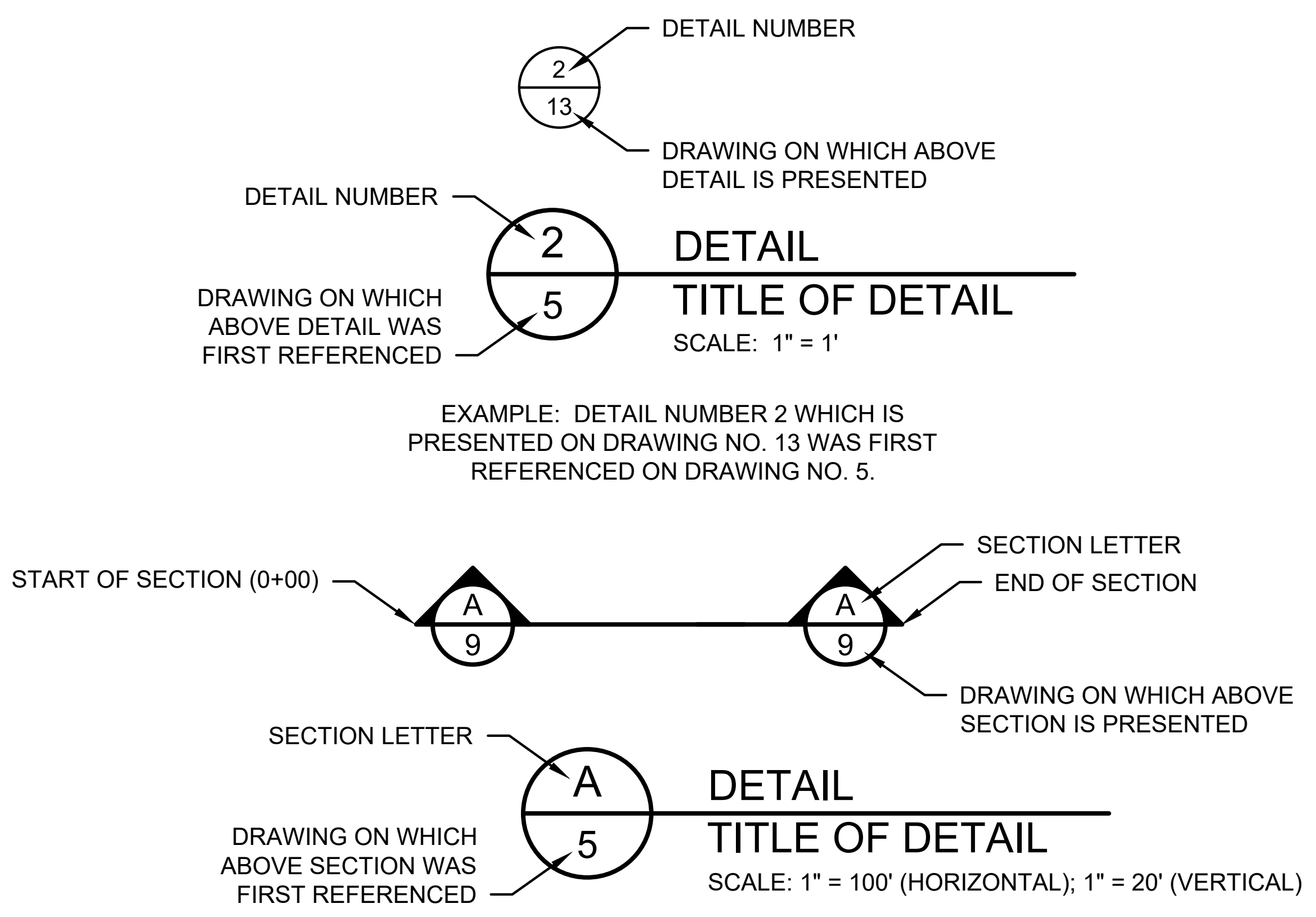
## SYMBOL LEGEND

| | |
|---|---|
| △ | CONTROL MARKER (NOTE 2) |
| ⌖ | GROUNDWATER PIEZOMETER |
| ✢ | GUY WIRE |
| ⌒ | HEADWALL |
| ⟁ | HISTORICAL WELL / PIEZOMETER |
| ✦ | MONITORING NETWORK WELL |
| ⊕ | POWER POLE |
| ▫ | PRINCIPAL SPILLWAY RISER |
| ⏚ | RELIEF WELL |
| ◄— 4% | SLOPE GRADE |
| CREST<br>TOE | SLOPE INDICATOR |
| 3<br>1 | SLOPE LABEL |
| ▭ | TRAILER OR BUILDING |
| ψ | VEGETATION |
| ▼ | WATER SURFACE |
| ⬢ | ROCK CHECK DAM |

## CONTOUR LEGEND

| | |
|---|---|
| —— 40 —— | EXISTING GROUND ELEVATION (FEET) (NOTE 1) |
| —— 40 —— | FINISHED GRADE SURFACE ELEVATION (FEET) |

## DETAIL AND SECTION IDENTIFICATION LEGEND



EXAMPLE: DETAIL NUMBER 2 WHICH IS PRESENTED ON DRAWING NO. 13 WAS FIRST REFERENCED ON DRAWING NO. 5.

EXAMPLE: SECTION LETTER "A" WHICH IS PRESENTED ON DRAWING NO. 9 WAS FIRST REFERENCED ON DRAWING NO. 5.

30% DESIGN DRAWINGS
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| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|
| | | | | |
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ATRIUM AT BLUE RIDGE
2501 BLUE RIDGE ROAD, SUITE 430
RALEIGH, NC 27607
919.870.0576

TITLE:
NOTES AND SYMBOLS

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-G002.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | G-02 |
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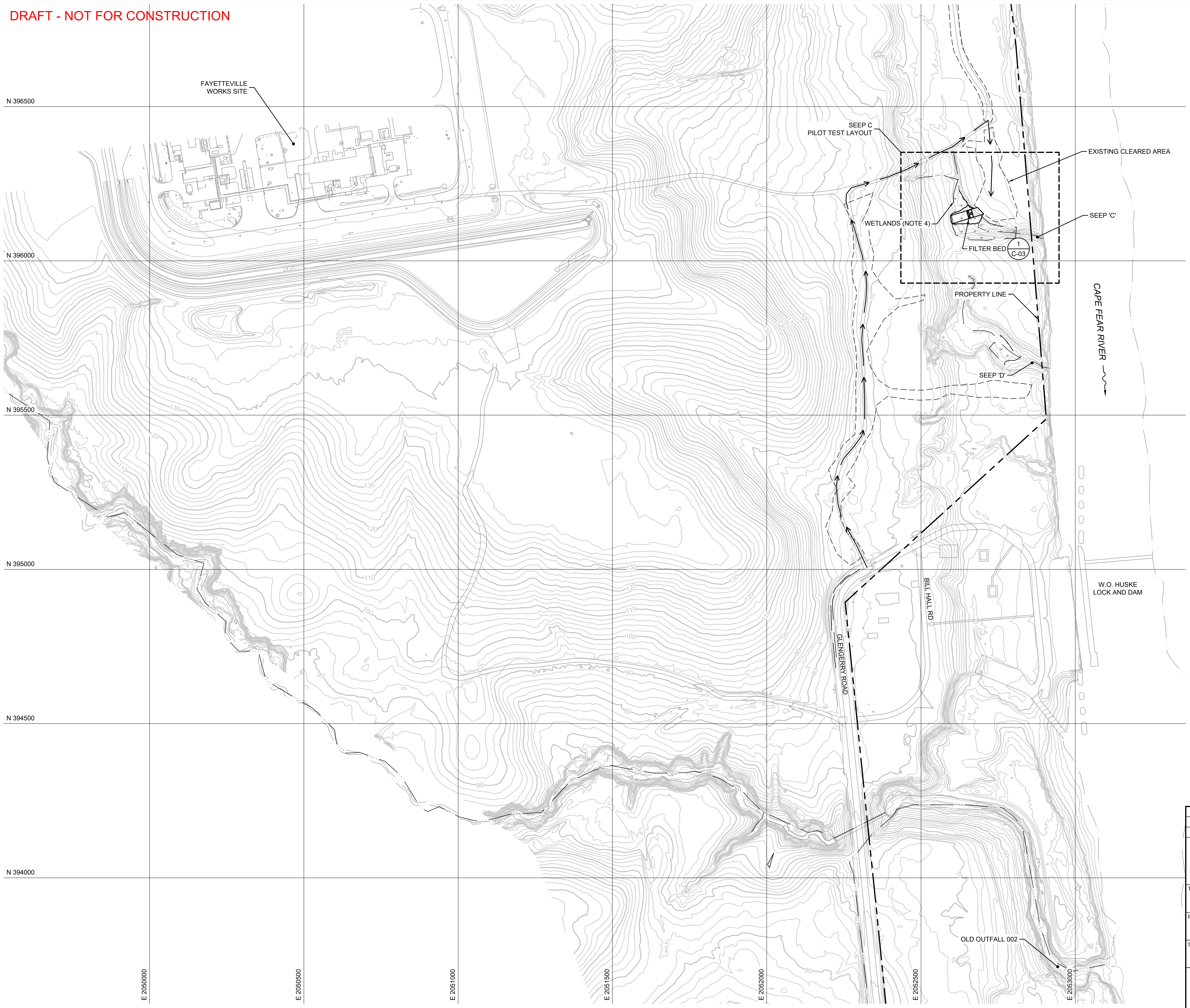

N

LEGEND

- EXISTING CONTOUR
- EXISTING CLEARED AREA
- PROPERTY LINE
- EXISTING ROAD
- EXISTING STRUCTURE
- SEEP CHANNEL / RIVER
- CONSTRUCTION ROUTE
- WETLANDS

NOTES:

1. GRID COORDINATE SYSTEM CORRESPONDS TO NAD83, NORTH CAROLINA.
2. ELEVATIONS PRESENTED ARE IN FEET, NAVD 88.
3. TOPOGRAPHIC, ROADS, BUILDINGS, AND PROPERTY LINE INFORMATION OBTAINED FROM FREELAND-CLINK SCALES & ASSOCIATES, INC. OF NC. SURVEY OF THE CHEMOURS FAYETTEVILLE WORKS SITE DATE 7 JANUARY 2019.
4. APPROXIMATE EXTENT OF DELINEATED WETLANDS. (WATERS OF THE UNITED STATES TECHNICAL REPORT, THE CHEMOURS COMPANY FAYETTEVILLE WORKS PROJECT: FLOW-THROUGH CELLS, SEEP C PILOT STUDY, AND REVISED SEEP A. PARSONS, AUGUST 2020)

0 150 300
SCALE IN FEET

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919.870.0576

TITLE:

OVERALL SITE PLAN

PROJECT:

THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:

FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
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| CHECKED BY: | JWE | FILE: | TR0795-C101.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | |
| APPROVED BY: | CAS | | C-01 |

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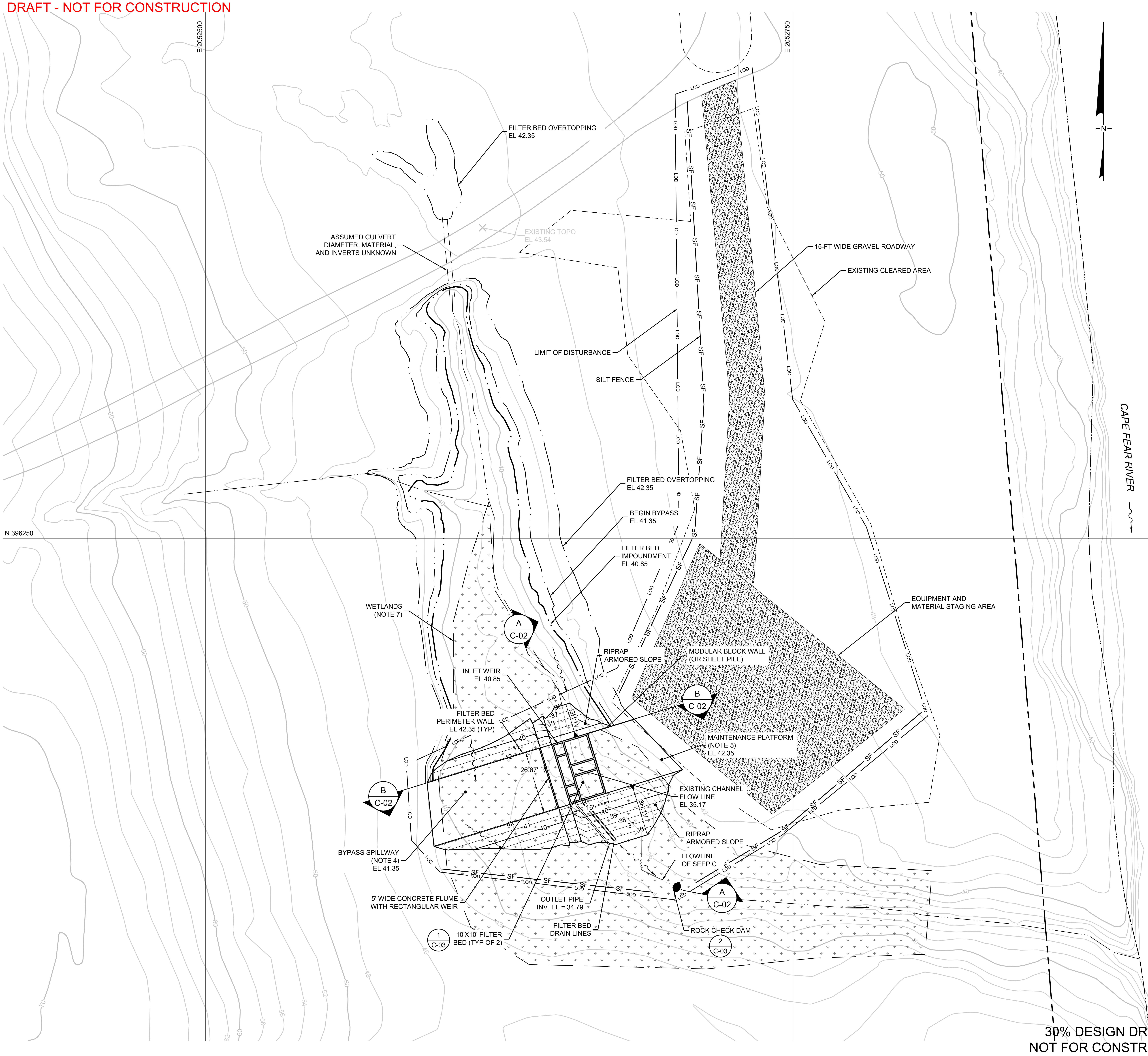

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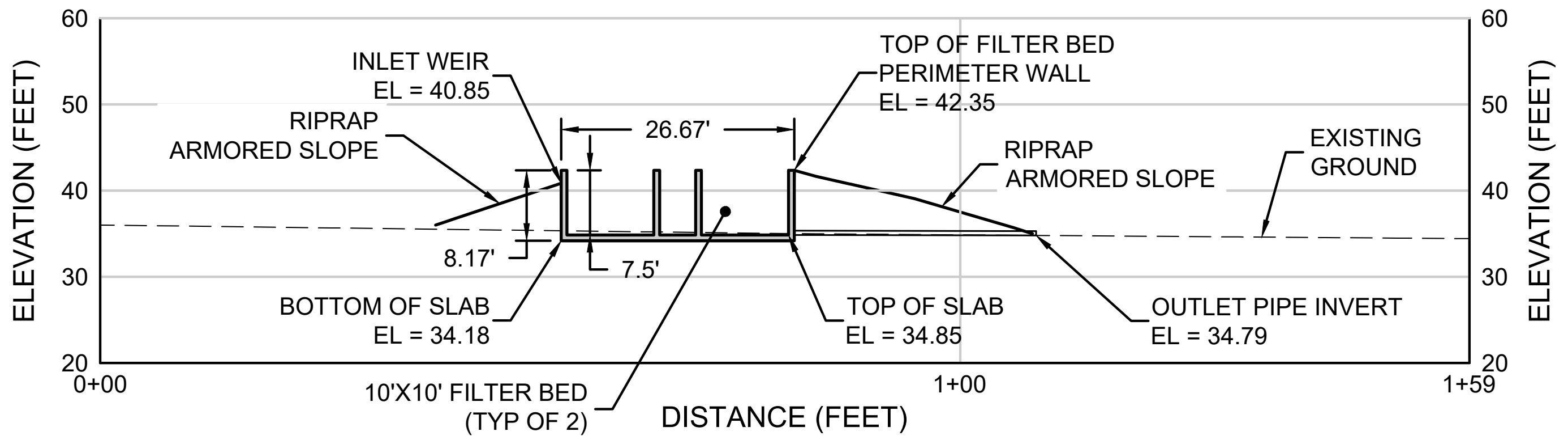
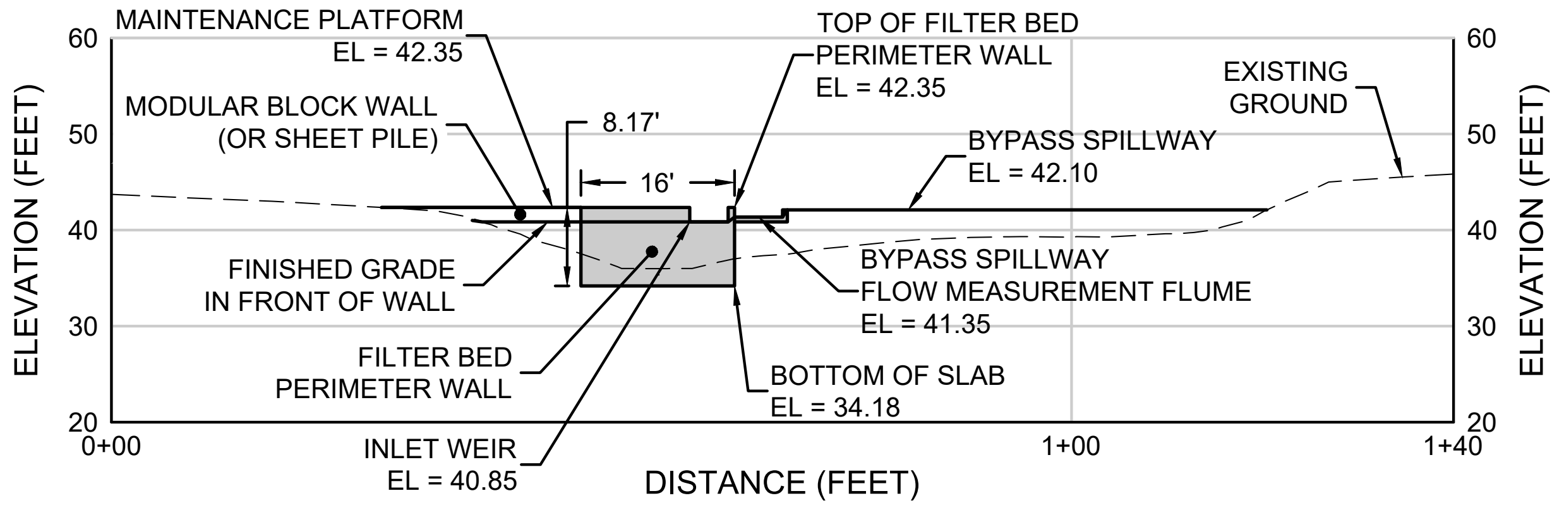


SECTION A
HORIZONTAL: 1" =20'
VERTICAL: 1" =20'



SECTION B
HORIZONTAL: 1" =20'
VERTICAL: 1" =20'

LEGEND

| | |
|---|---|
| —— 40 —— | EXISTING CONTOUR |
| —— 40 —— | FINISHED GRADE CONTOUR |
| – – – – | EXISTING CLEARED AREA |
| —— — —— | PROPERTY LINE |
| ——— | EXISTING ROAD |
| ☐ | EXISTING STRUCTURE |
| —— · · · —— | SEEP CHANNEL / RIVER |
| ▨ | WETLANDS |

NOTES:

1. GRID COORDINATE SYSTEM CORRESPONDS TO NAD83, NORTH CAROLINA.
2. ELEVATIONS PRESENTED ARE IN FEET, NAVD 88.
3. TOPOGRAPHIC, ROADS, BUILDINGS, AND PROPERTY LINE INFORMATION OBTAINED FROM FREELAND-CLINK SCALES & ASSOCIATES, INC. OF NC. SURVEY OF THE CHEMOURS FAYETTEVILLE WORKS SITE DATE 7 JANUARY 2019.
4. BYPASS SPILLWAY AND SLOPES SHALL BE ARMORED WITH 12-INCH THINK (MIN) LAYER OF RIPRAP AND UNDERLAIN WITH A GEOTEXTILE SEPARATOR.
5. MAINTENANCE PLATFORM SHALL BE SURFACED WITH A 6-INCH (MIN) LAYER OF AGGREGATE AND UNDERLAIN WITH A GEOTEXTILE SEPARATOR.
6. DISTURBED AREAS NOT SURFACED WITH AGGREGATE OR CONCRETE WILL BE SEEDED AND MULCHED.
7. APPROXIMATE EXTENT OF DELINEATED WETLANDS. (WATERS OF THE UNITED STATES TECHNICAL REPORT, THE CHEMOURS COMPANY FAYETTEVILLE WORKS PROJECT: FLOW-THROUGH CELLS, SEEP C PILOT STUDY, AND REVISED SEEP A. PARSONS, AUGUST 2020)

0 20 40
SCALE IN FEET

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RALEIGH, NC 27607
919.870.0576

TITLE:
SEEP C INTERIM REMEDIATION SYSTEM
PLAN

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-C102.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | C-02 |
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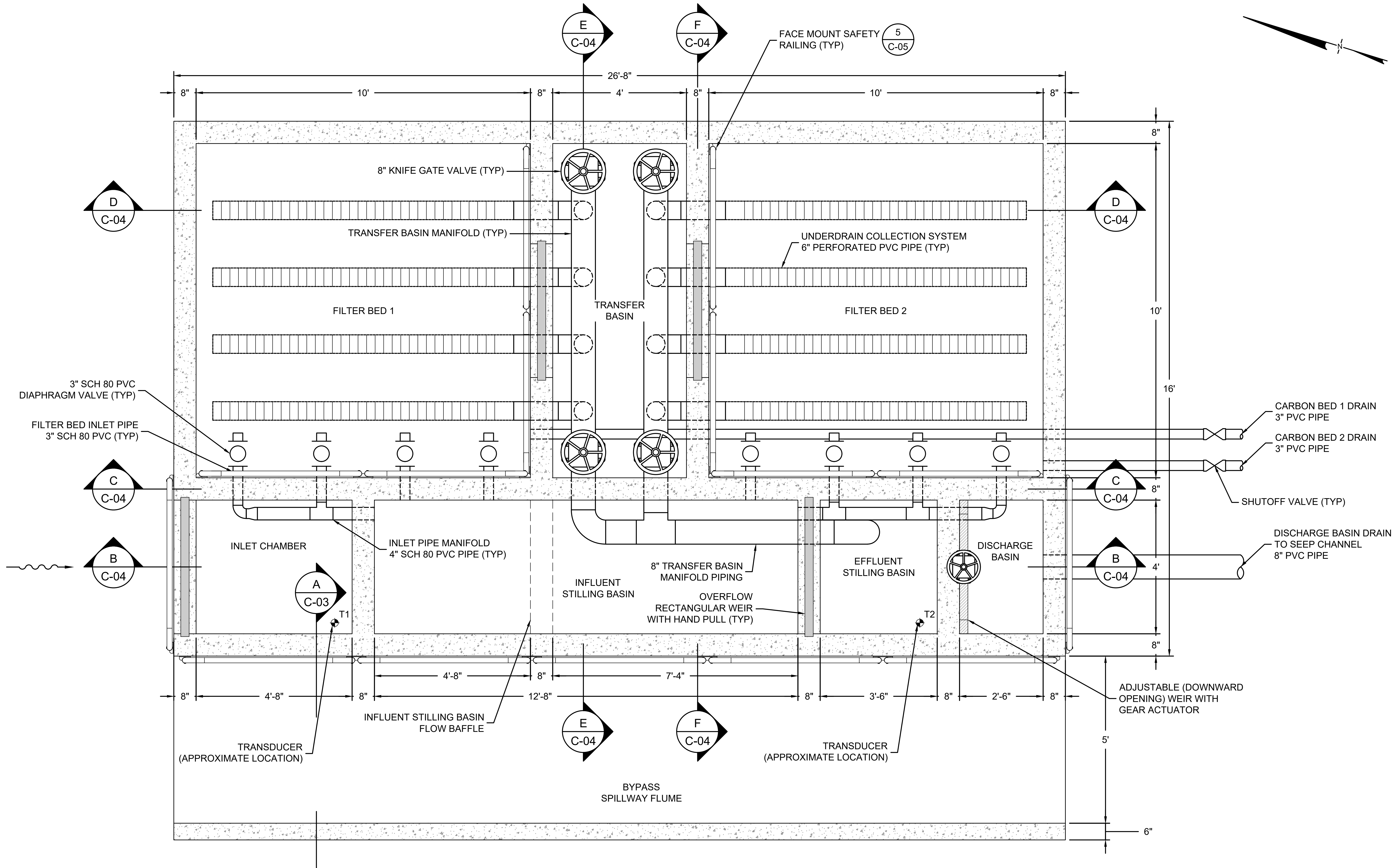
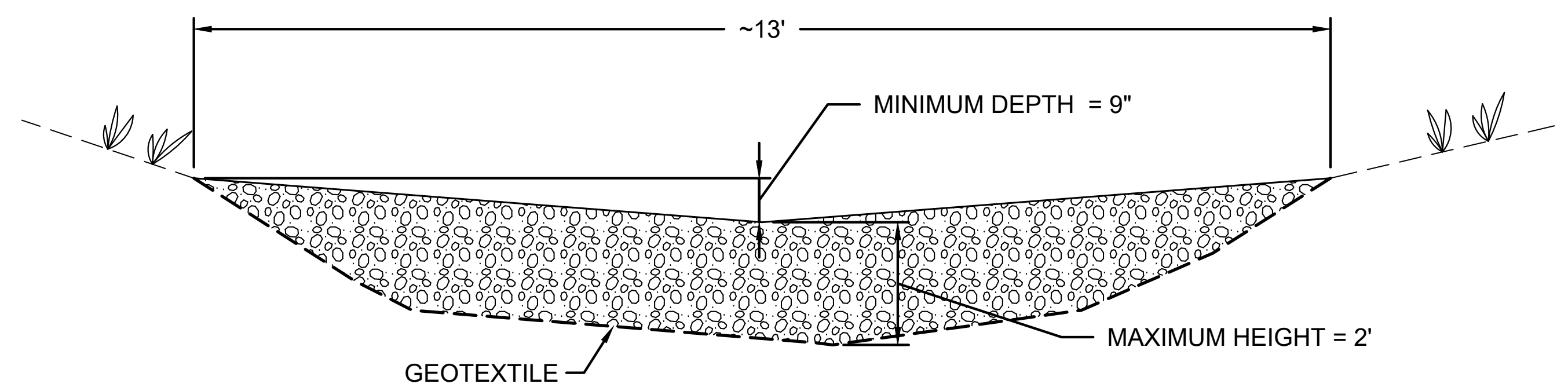


1
C-02

## DETAIL
## FILTER BED

SCALE: 1" = 2'



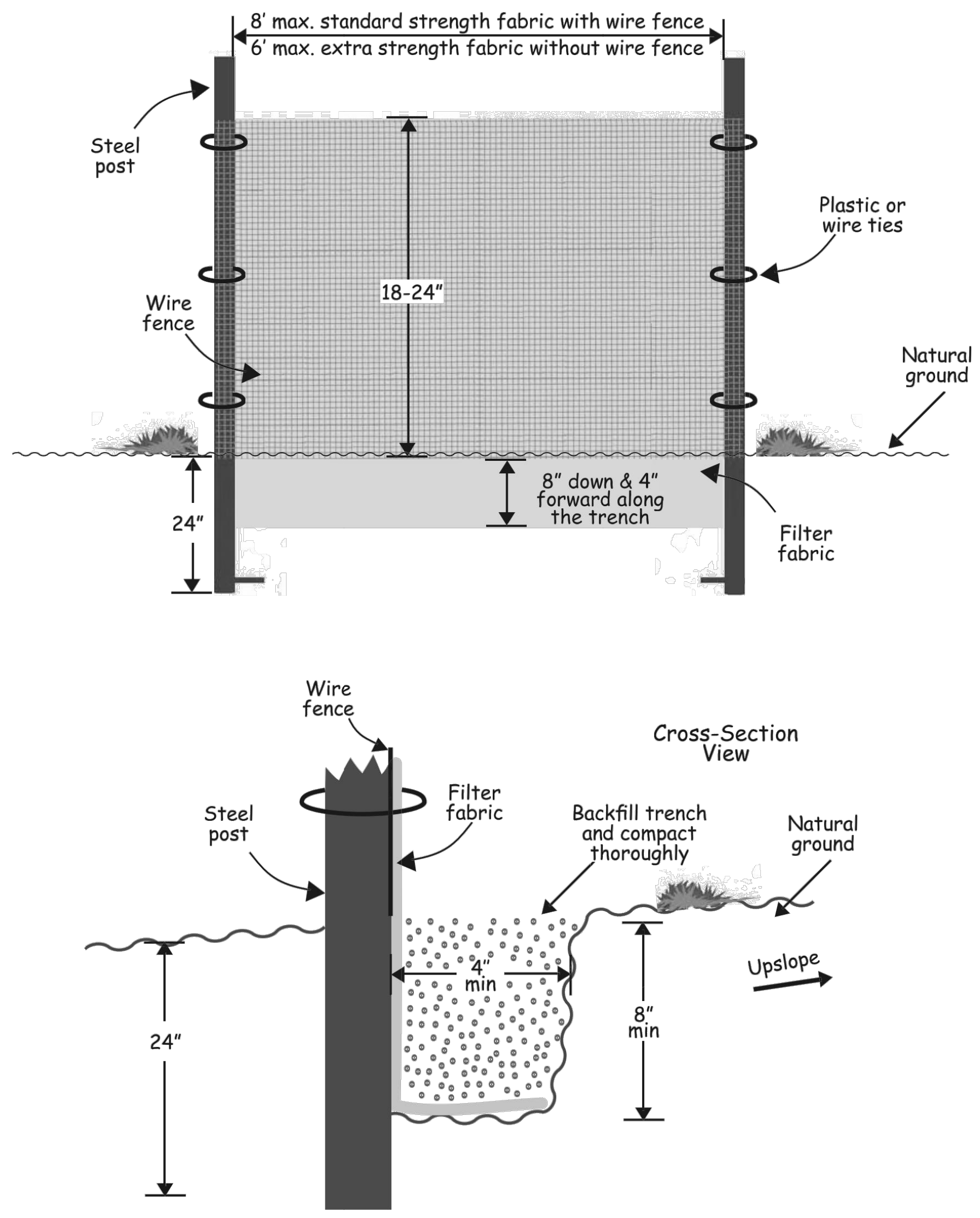
NOTES:

1. STONE CHECK DAMS SHOULD BE CONSTRUCTED USING USING NC DOT CLASS B STONE. THE UPSTREAM FACE OF THE ROCK STRUCTURE SHOULD BE COVERED WITH FINE GRAVEL (NCDOT #57 OR #5 WASH STONE) A MINIMUM OF 1 FOOT THICK TO REDUCE THE DRAINAGE RATE.
2. GEOTEXTILE SHALL BE SELECTED IN ACCORDANCE WITH AASHTO M288-96 SECTION 7.3, SEPARATION REQUIREMENTS.

2
C-02

## DETAIL
## ROCK CHECK DAM

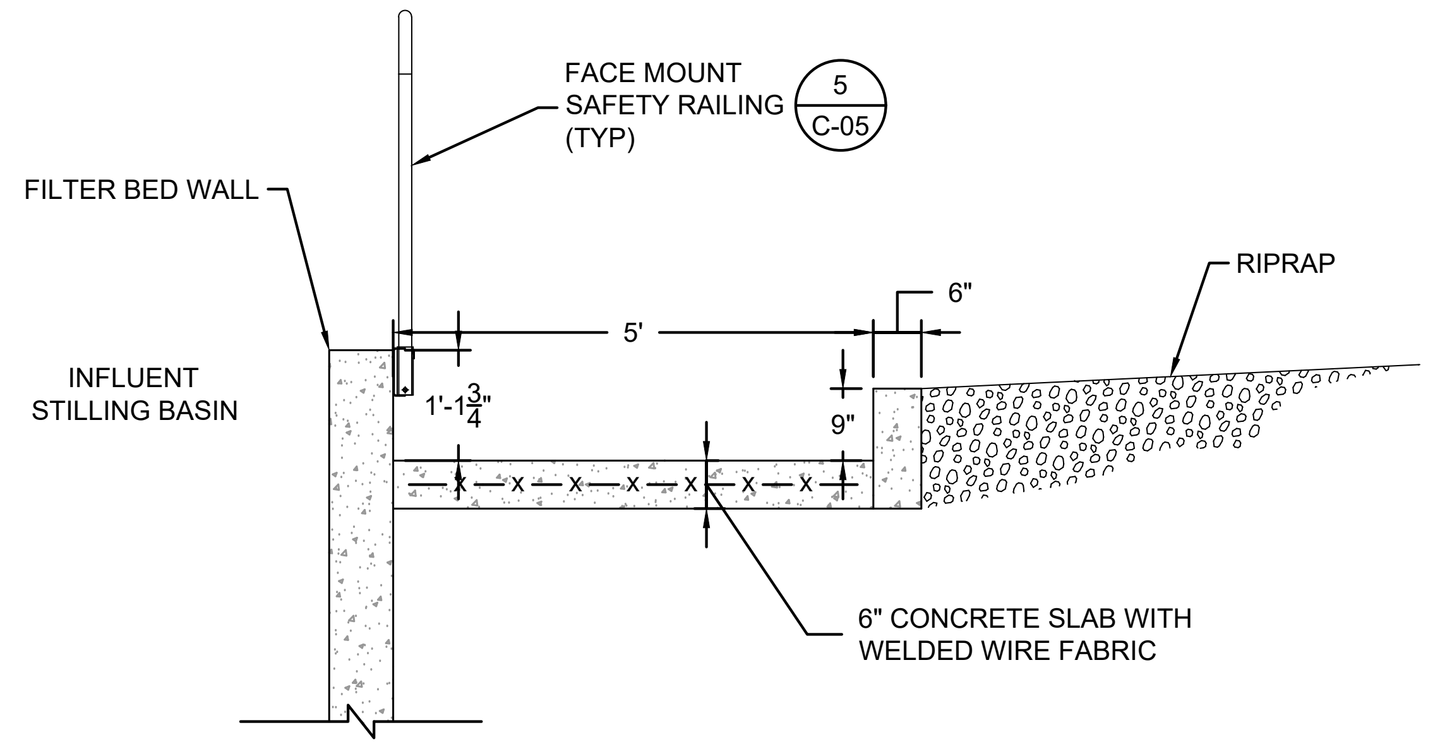
SCALE: 1" = 2'



3
C-03

## DETAIL
## SILT FENCE

(SOURCE: NC DEQ)
SCALE: NTS



A
C-03

## SECTION
## BYPASS SPILLWAY FLOW MEASUREMENT FLUME

SCALE: 1" = 2'

NOTES:

1. A FIBERGLASS GRATE WILL BE INSTALLED OVER THE INFLUENT STILLING BASIN AND TRANSFER BASIN TO PROVIDE OPERATOR ACCESS TO FLOW CONTROL VALVES AND SAMPLE LOCATIONS. SEE DRAWING C-05 FOR DETAILS
2. TRANSDUCERS WILL BE INSTALLED IN THE INLET CHAMBER AND THE EFFLUENT STILLING BASIN TO MONITOR WATER LEVELS. THE FLOW RATES THROUGH THE BYPASS SPILLWAY FLUME AND THE FILTER BED SYSTEM WILL BE CALCULATED BASED ON THE WATER LEVELS MEASURED IN THE INLET CHAMBER AND THE EFFLUENT STILLING BASIN, RESPECTIVELY.
3. COMPOSITE SAMPLERS WILL BE PLACED WITHIN THE INLET CHAMBER, THE EFFLUENT STILLING BASIN, AND THE BYPASS SPILLWAY FOR PERFORMANCE MONITORING. GRAB SAMPLES WILL ALSO BE PERFORMED AS NECESSARY, INCLUDING FROM WITHIN THE TRANSFER BASIN, TO EVALUATE BREAKTHROUGH.
4. SAFETY RAILING SHALL BE FACE-MOUNTED AND REMOVABLE.

0 2 4
SCALE IN FEET

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| | | | | |
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| | | | | |
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2501 BLUE RIDGE ROAD, SUITE 430
RALEIGH, NC 27607
919.870.0576

TITLE:
SEEP C INTERIM REMEDIATION SYSTEM
CONSTRUCTION DETAILS I

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
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| REVIEWED BY: | JJD | DRAWING NO.: | C-03 |
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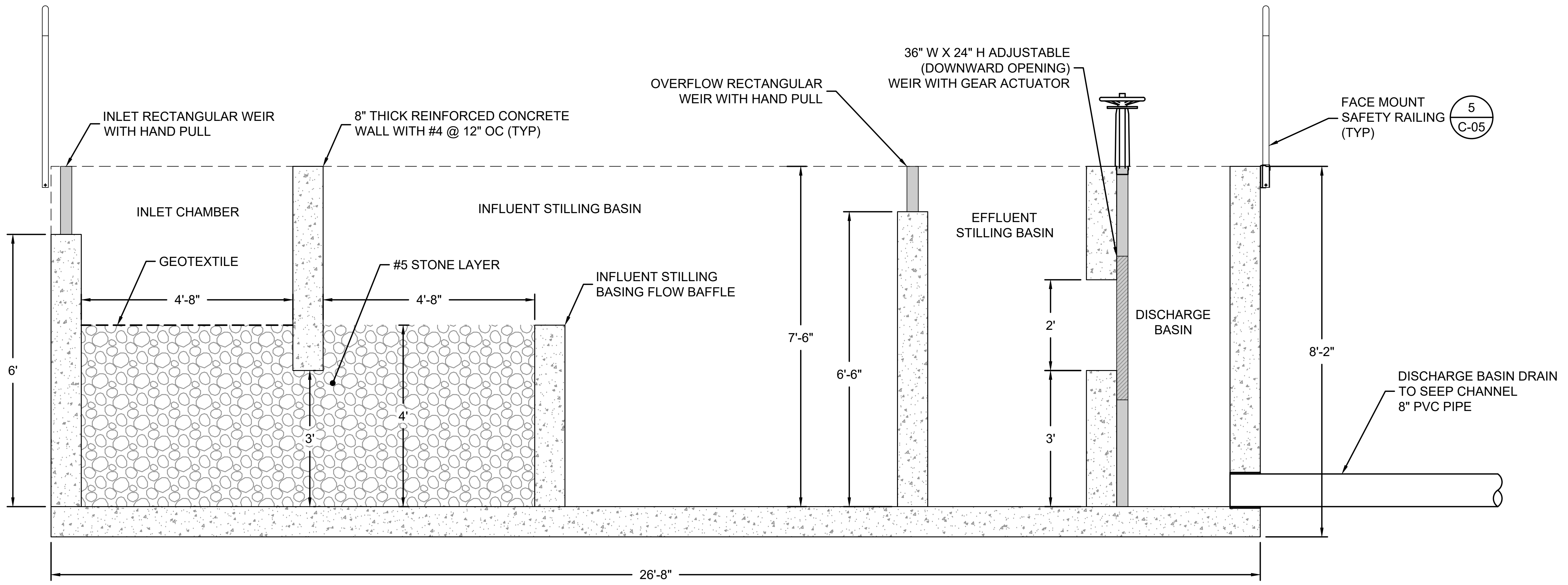
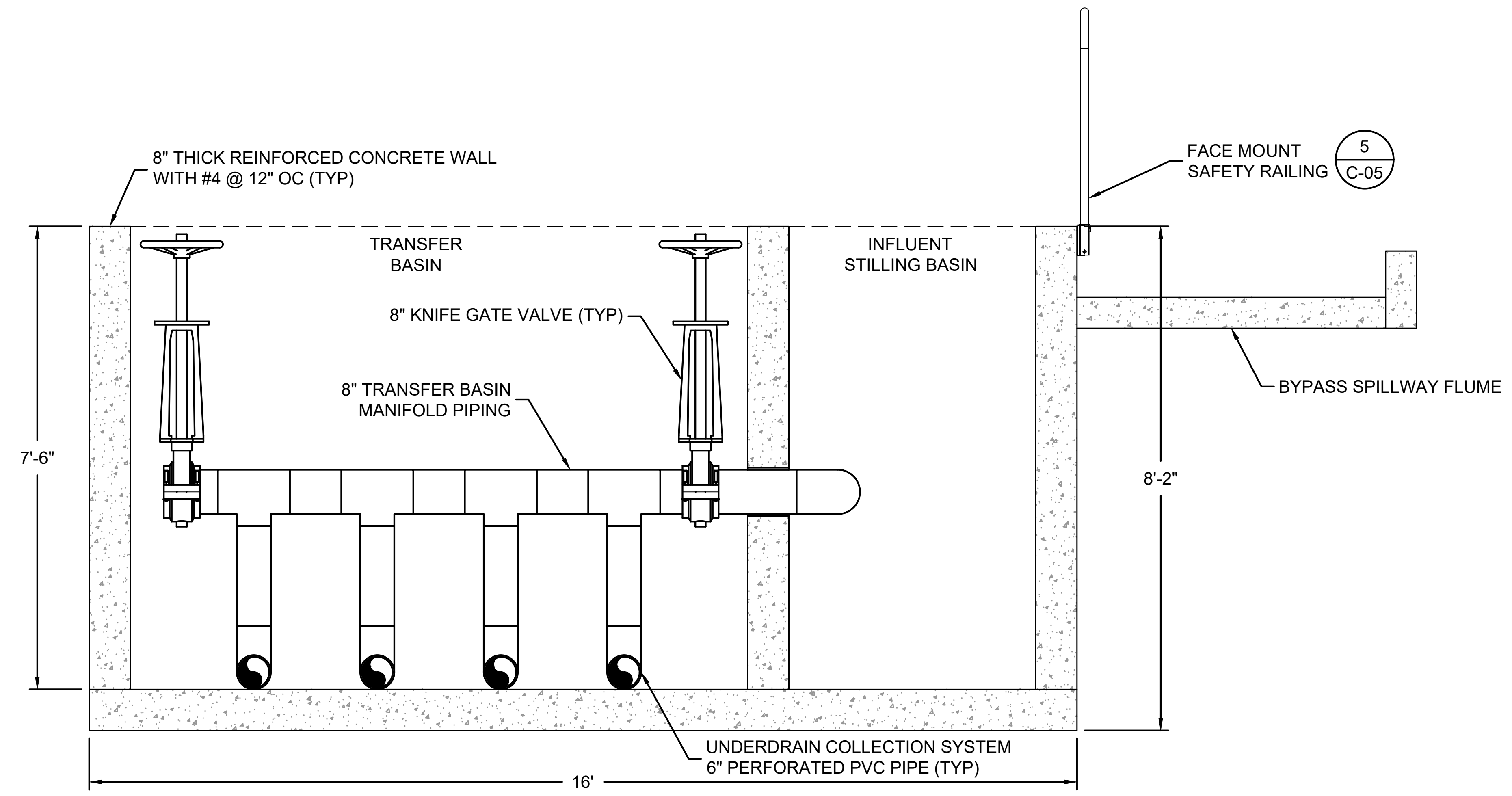


B C-03 SECTION

FILTER BED SECTION B

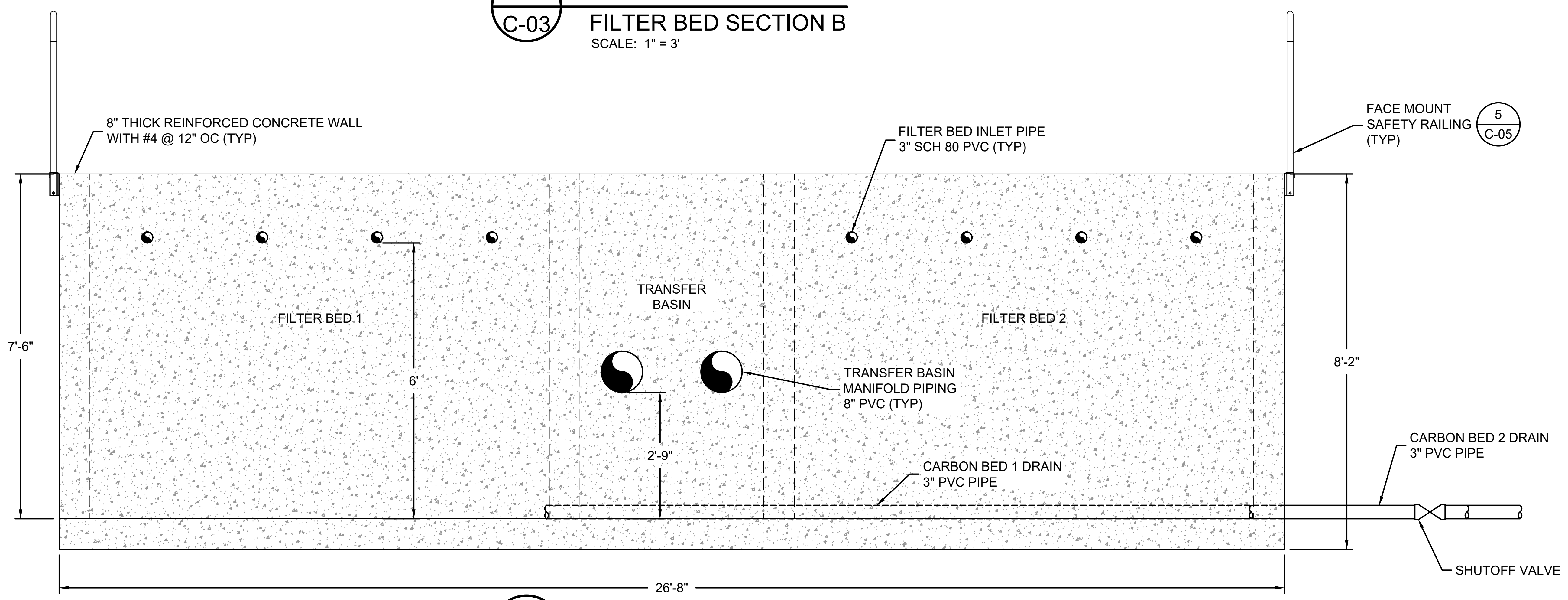
SCALE: 1" = 3'



E C-03 SECTION

FILTER BED SECTION E

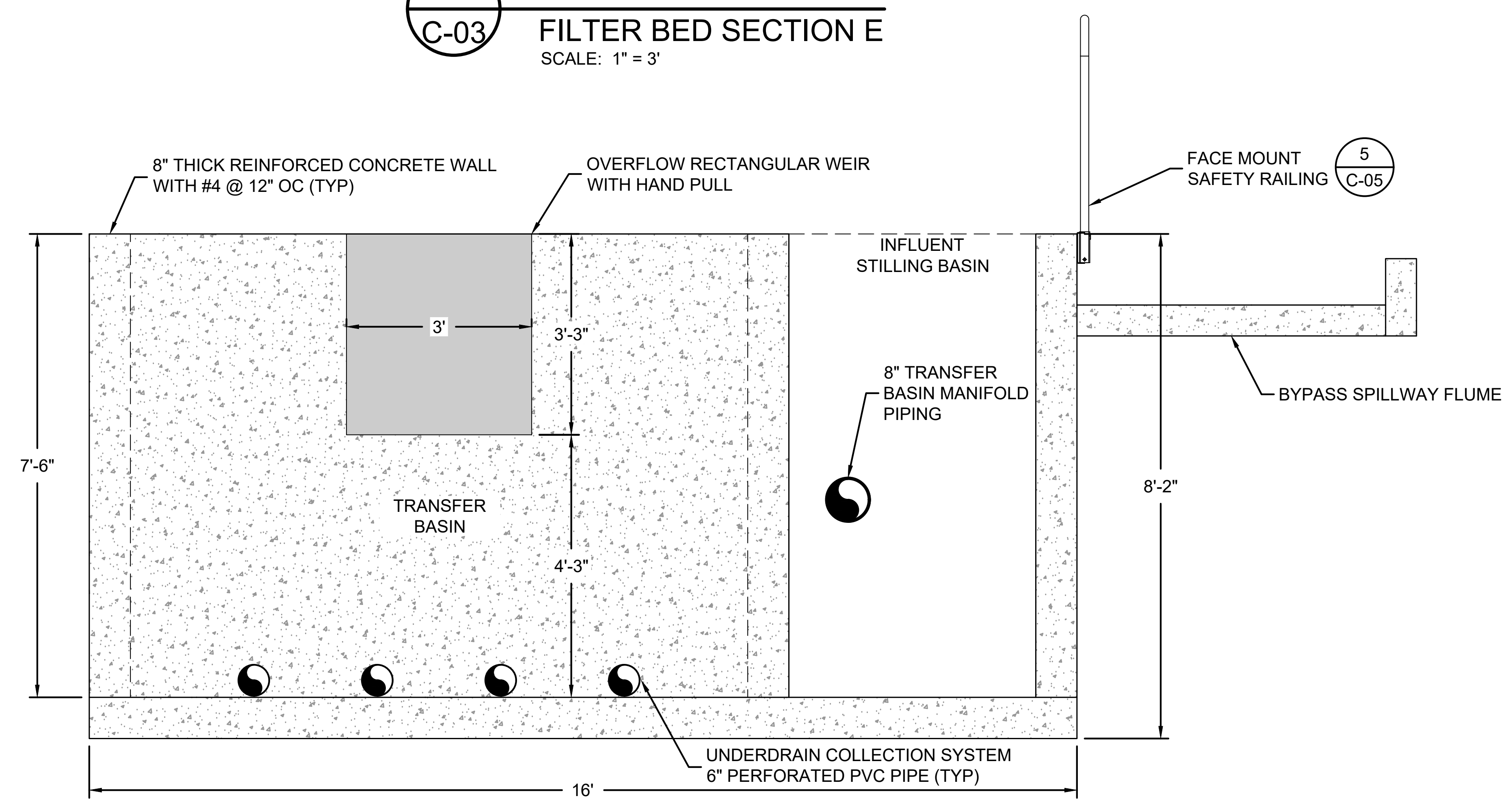
SCALE: 1" = 3'



C C-03 SECTION

FILTER BED SECTION C

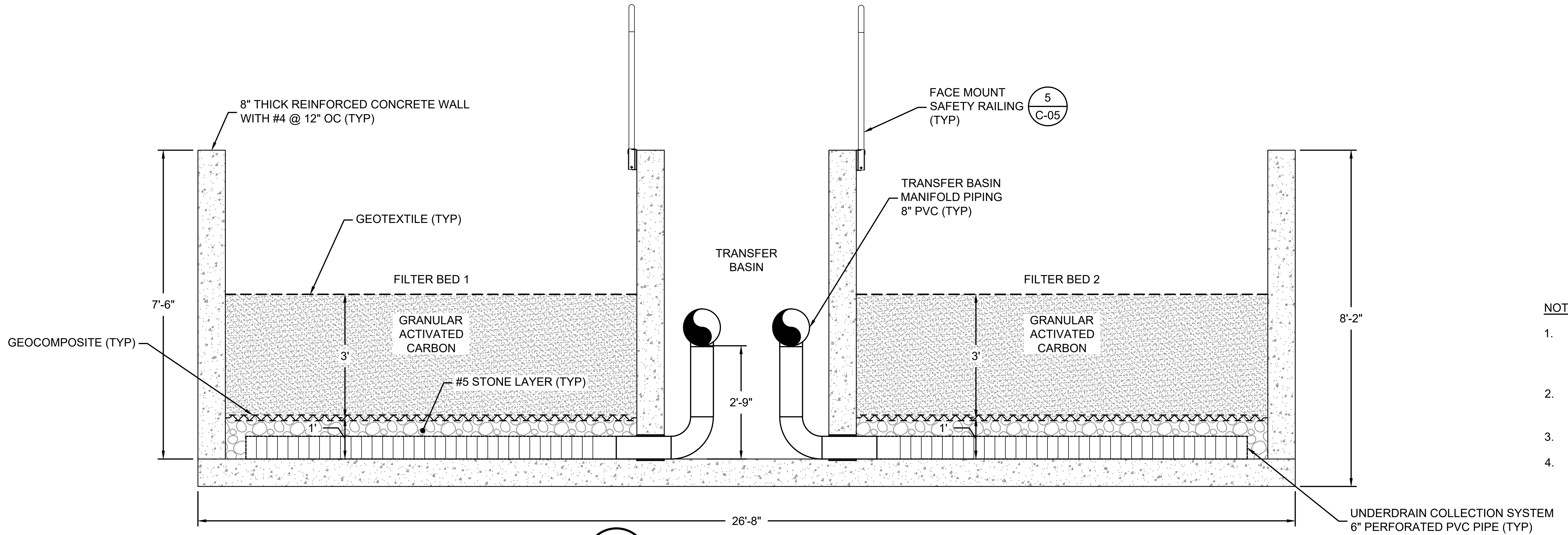
SCALE: 1" = 3'



F C-03 SECTION

FILTER BED SECTION F

SCALE: 1" = 3'



D C-03 SECTION

FILTER BED SECTION D

SCALE: 1" = 3'

NOTES:

1. FIBERGLASS GRATING SHALL BE INSTALLED OVER THE INFLUENT STILLING BASIN AND TRANSFER BASIN TO PROVIDE OPERATOR ACCESS TO FLOW CONTROL VALVES AND SAMPLE LOCATIONS.
2. PIPE PENETRATIONS THROUGH CONCRETE WALLS WILL BE SEALED WITH GROUT TO PREVENT LEAKAGE FROM CHAMBER TO CHAMBER.
3. PIPE SUPPORTS WILL BE INSTALLED TO SUPPORT PIPING AND VALVES AS NEEDED.
4. SAFETY RAILING SHALL BE FACE MOUNTED AND REMOVABLE.

0 2 4
SCALE IN FEET

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2501 BLUE RIDGE ROAD, SUITE 430
RALEIGH, NC 27607
919.870.0576

TITLE:
## SEEP C INTERIM REMEDIATION SYSTEM CONSTRUCTION DETAILS II

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-C502.dwg |
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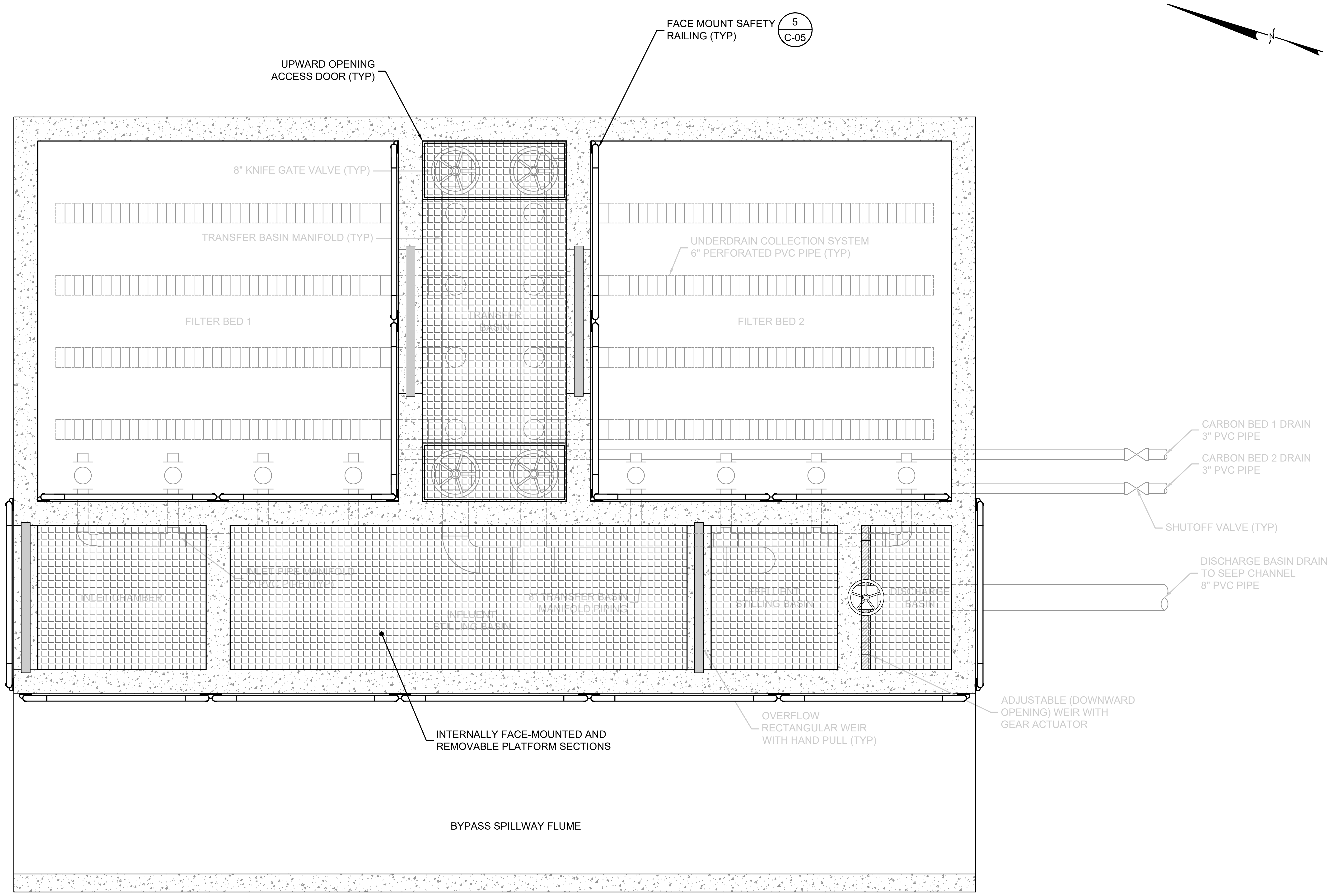
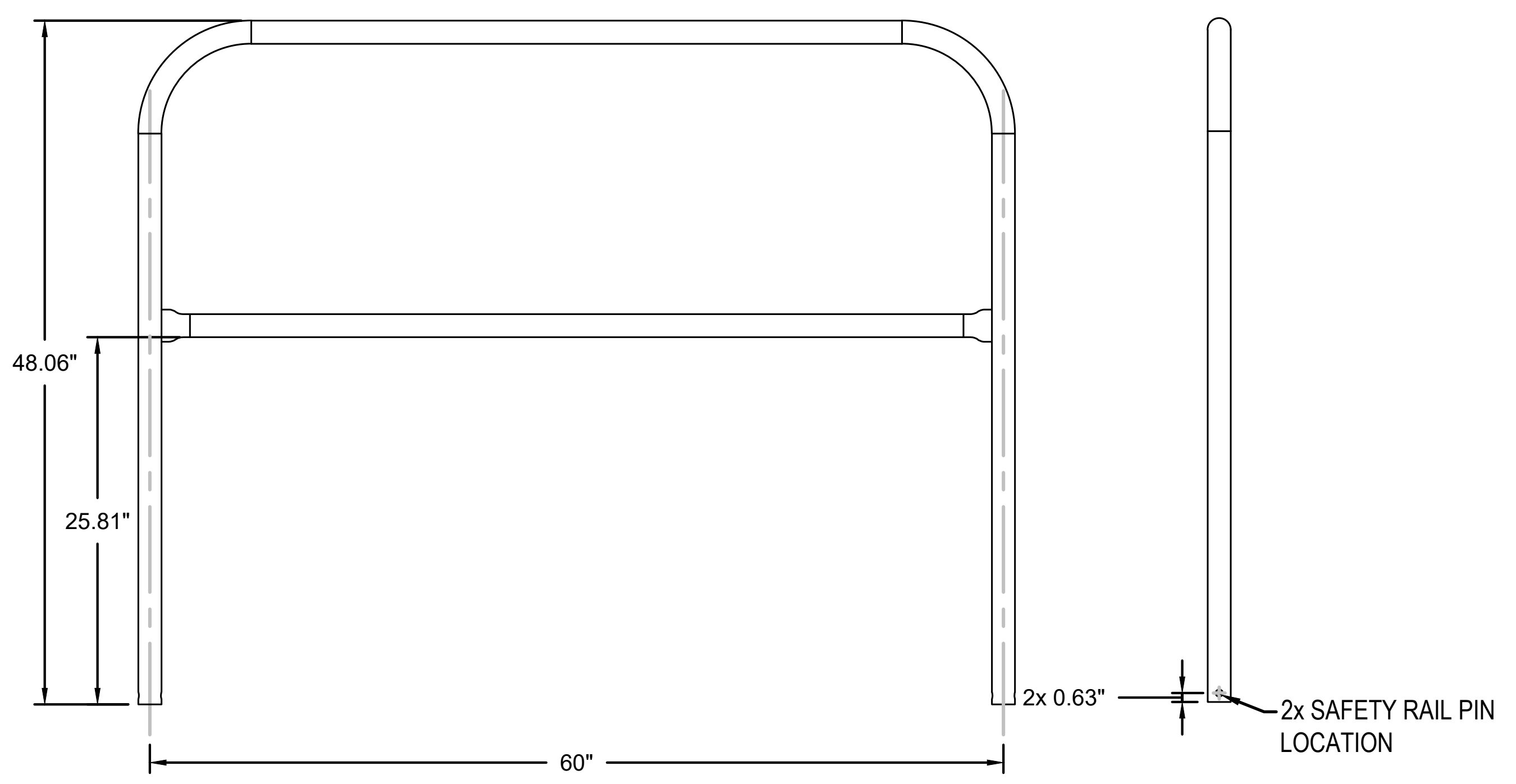


4
C-03
PLAN
SAFETY RAILING AND PLATFORM
SCALE: 1" = 2'

NOTES:

1. SAFETY RAILING SHALL BE FACE MOUNTED AND REMOVABLE.



5
C-05
DETAIL
SAFETY RAILING
(NOTE 1)
SCALE: 1" = 1'

0 3 6
SCALE IN FEET

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2501 BLUE RIDGE ROAD, SUITE 430
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919.870.0576

TITLE:
PLATFORM AND LADDER STRUCTURAL DETAILS

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-C503.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | C-05 |
| APPROVED BY: | CAS | | |

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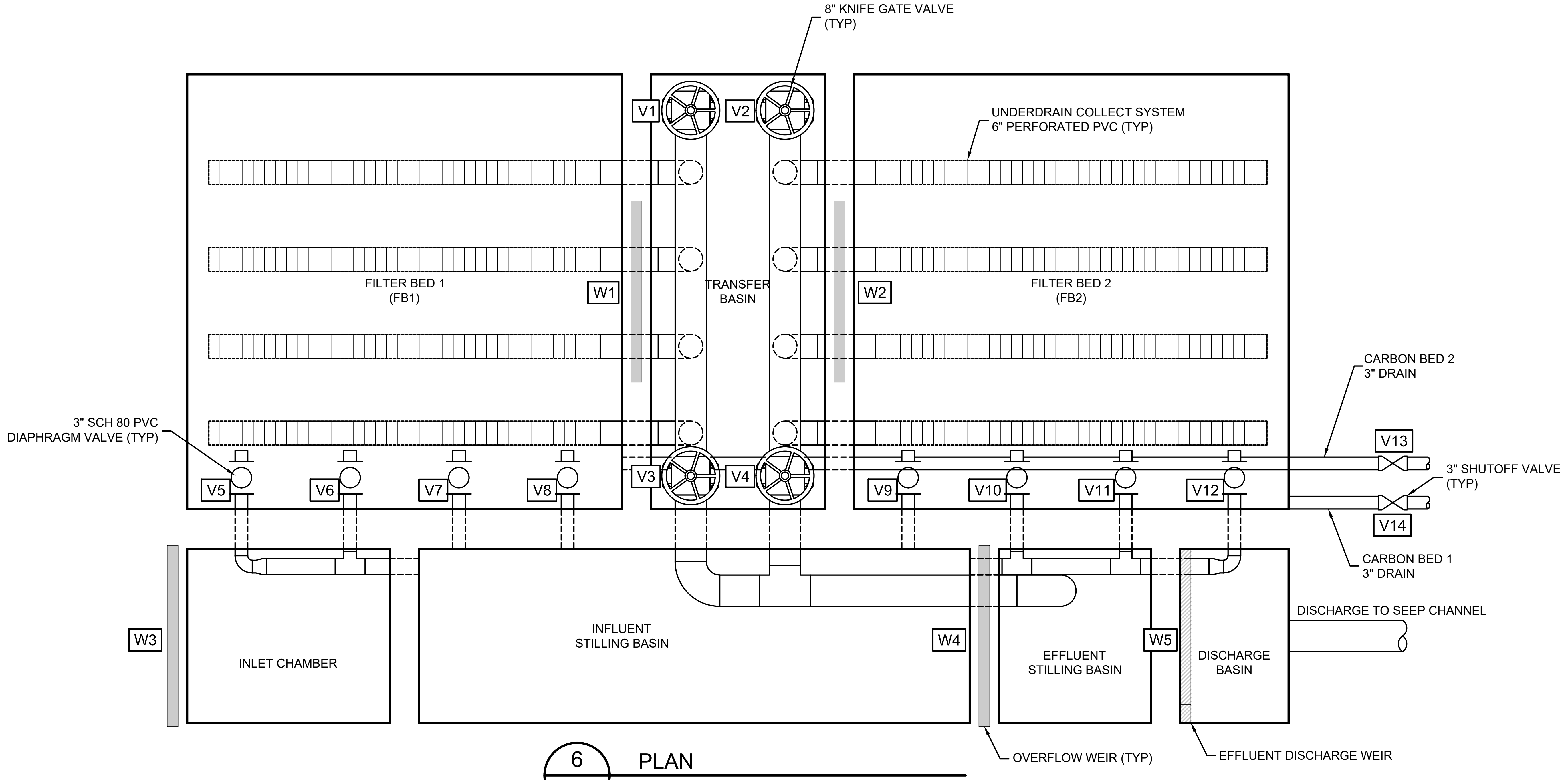
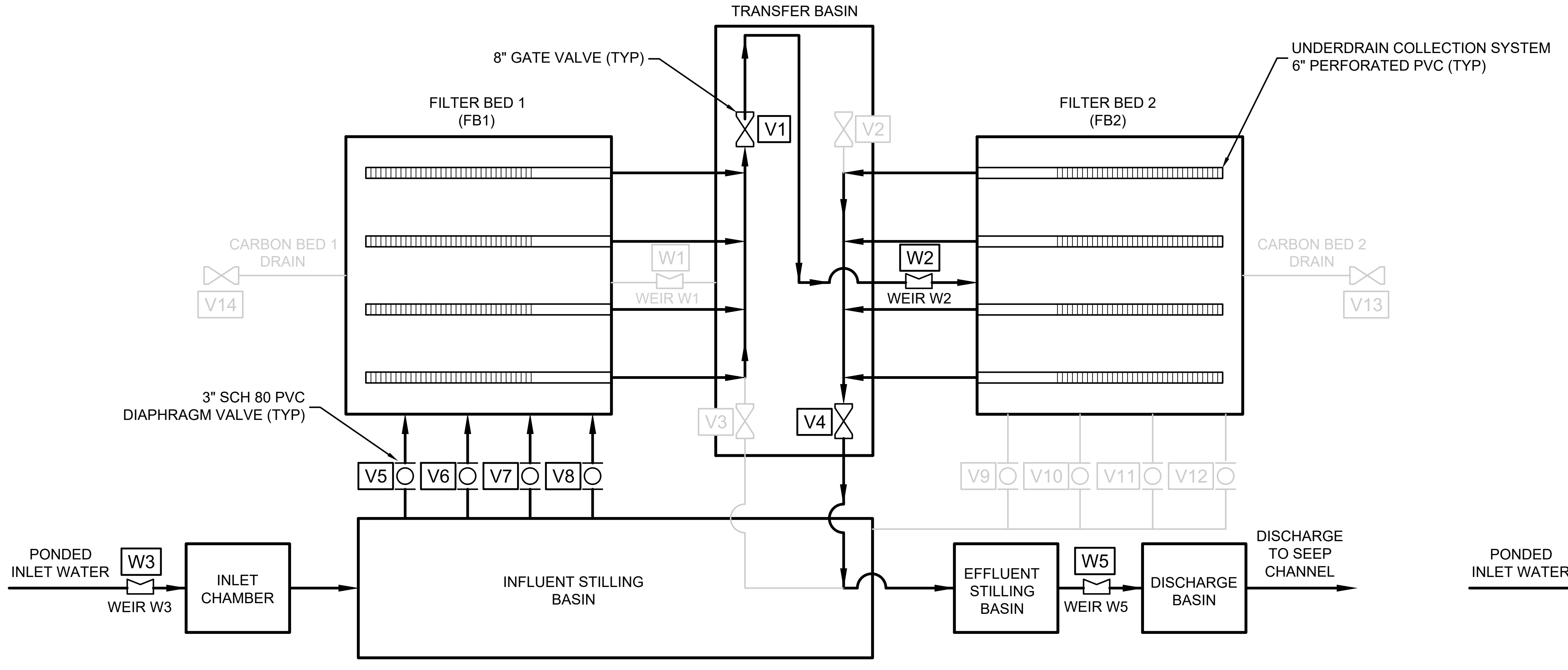


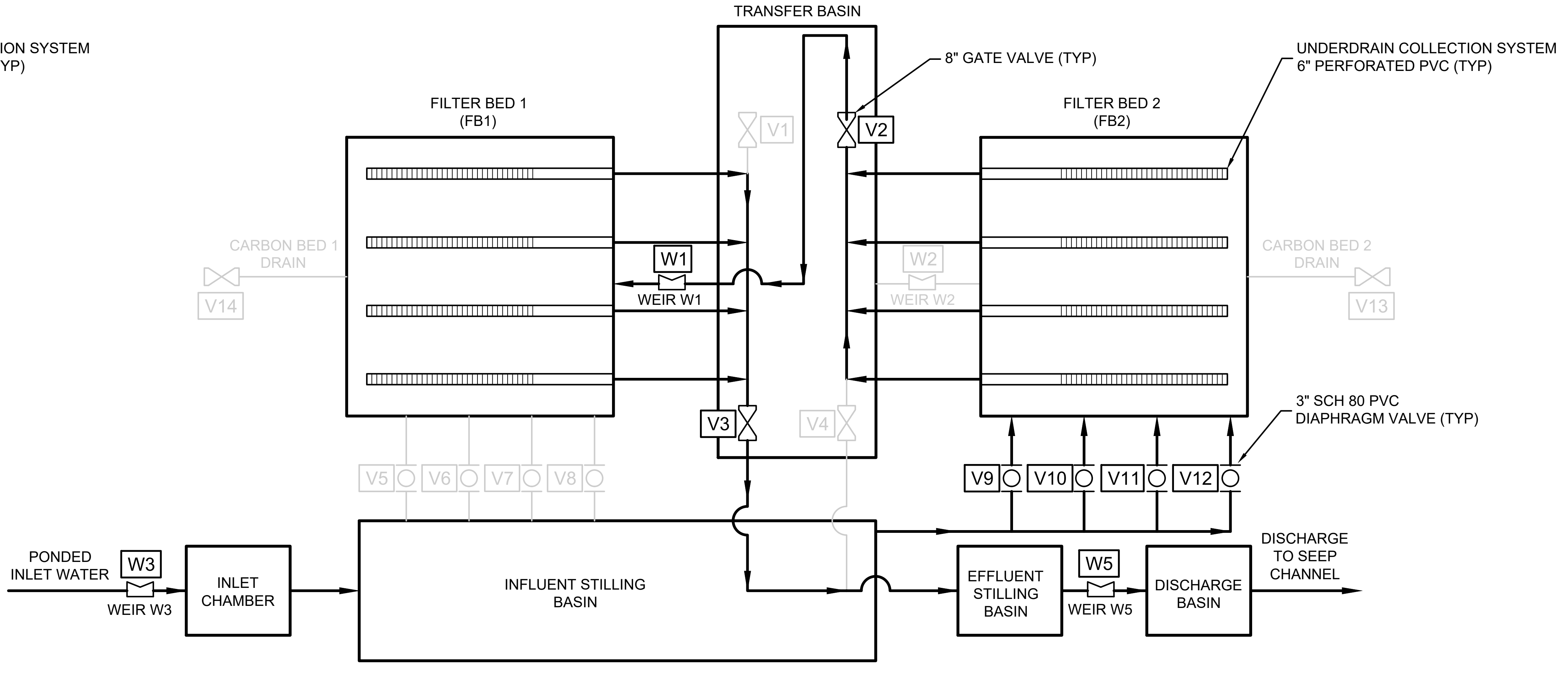
6
D-01
PLAN
FILTER BED VALVE SCHEMATIC

| OPERATIONAL MODE | | | | |
|---|---|---|---|---|
| FLOW CONTROL DEVICE | FB1 LEAD/ FB2 LAG | FB1 LAG/ FB2 LEAD | FB1 CHANGEOUT (FB2 OPEN) | FB2 CHANGEOUT (FB1 OPEN) |
| VALVE V1 | OPEN | CLOSED | CLOSED | CLOSED |
| VALVE V2 | CLOSED | OPEN | CLOSED | CLOSED |
| VALVE V3 | CLOSED | OPEN | CLOSED | OPEN |
| VALVE V4 | OPEN | CLOSED | OPEN | CLOSED |
| VALVE V5 | OPEN | CLOSED | CLOSED | OPEN |
| VALVE V6 | OPEN | CLOSED | CLOSED | OPEN |
| VALVE V7 | OPEN | CLOSED | CLOSED | OPEN |
| VALVE V8 | OPEN | CLOSED | CLOSED | OPEN |
| VALVE V9 | CLOSED | OPEN | OPEN | CLOSED |
| VALVE V10 | CLOSED | OPEN | OPEN | CLOSED |
| VALVE V11 | CLOSED | OPEN | OPEN | CLOSED |
| VALVE V12 | CLOSED | OPEN | OPEN | CLOSED |
| VALVE V13 | CLOSED | CLOSED | CLOSED | CLOSED |
| VALVE V14 | CLOSED | CLOSED | CLOSED | CLOSED |
| WEIR W1 | CLOSED | OPEN | CLOSED | CLOSED |
| WEIR W2 | OPEN | CLOSED | CLOSED | CLOSED |
| WEIR W3 | OPEN | OPEN | OPEN | OPEN |
| WEIR W4 | OPEN | OPEN | OPEN | OPEN |
| WEIR W5 | OPEN | OPEN | OPEN | OPEN |

7
D-01
TABLE
OPERATIONAL MODE



8
D-01
SCHEMATIC
FILTER BED SYSTEM FLOW WITH CARBON BED 1 IN LEAD POSITION AND CARBON BED 2 IS LAG POSITION



9
D-01
SCHEMATIC
FILTER BED SYSTEM FLOW WITH CARBON BED 2 IN LEAD POSITION AND CARBON BED 1 IS LAG POSITION

| REV | DATE | DESCRIPTION | DRN | APP |
|---|---|---|---|---|
| | | | | |
| A | 08.14.20 | 30% DESIGN SUBMITTAL | JFH | CAS |

Geosyntec consultants

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NC License No.: C-3500 and C-295

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919.870.0576

TITLE:
SEEP C INTERIM REMEDIATION SYSTEM
PROCESS FLOW DIAGRAM

PROJECT:
THE CHEMOURS COMPANY
SEEP C INTERIM REMEDIATION SYSTEM

SITE:
FAYETTEVILLE WORKS SITE

| | | | |
|---|---|---|---|
| DESIGN BY: | CMDS | DATE: | AUGUST 2020 |
| DRAWN BY: | JFH | PROJECT NO.: | TR0795 |
| CHECKED BY: | JWE | FILE: | TR0795-D601.dwg |
| REVIEWED BY: | JJD | DRAWING NO.: | D-01 |
| APPROVED BY: | CAS | | |

30% DESIGN DRAWINGS
NOT FOR CONSTRUCTION

L:\CADD\C\CHEMOURS\INTERIM SEEP REMEDY\DRAWINGS\TR0795-D601

# APPENDIX C-1
# Hydraulic Calculations

# Summary of Dry Weather Seep Flow Data
# Chemours, Fayetteville Works, North Carolina

| Summary of Dry Weather Seep Flow | | | |
|---|---|---|---|
| **Seep Measurement Location** | **Measured Dry Weather Flow (gpm)** | | |
| | **25th Percentile (seasonal low flow)** | **Median (50th Percentile)** | **95th Percentile (seasonal high flow, and Design Basis)** |
| SEEP-A-1 | 106 | 129 | 205 |
| SEEP-B-1 | 130 | 149 | 226 |
| SEEP-C-1 | 30 | 42 | 76 |
| SEEP-D-1 | 140 | 150 | 183 |

Notes:
1. Results for Seeps A, B, and C based on dry weather flow from 1/5/2019 through 5/17/2020.
2. Results for Seep D based on dry weather flow from 4/25/2020 to 5/17/2020.

# Table 2.0 Series
# Calculated System Head Losses Through the Inlet Chamber and Influent Stilling Basin
# Chemours, Fayetteville Works, North Carolina

| Sheet | Title |
|---|---|
| 2.1.C | SEEP-C-1: Calculated System Head Losses Through the Inlet Chamber and Influent Stilling Basin |
| 2.2.C | SEEP-C-1: Calculated System Head Losses Through Piping in the Inlet Chamber and Influent Stilling Basin |

**Table 2.1.C**
**Calculated System Head Losses Through the Inlet Chamber and Influent Stilling Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of overflow weir to DB | (ft) | 6.5 | 6.5 | 6.5 | Design Parameters |
| | | Height of emergency spillway | (ft) | 6.5 | 6.5 | 6.5 | |
| | | Width of emergency spillway | (ft) | 5 | 5 | 5 | |
| | | Width of overflow weir | (ft) | 3 | 3 | 3 | |
| Inlet Chamber (IC) | IC Weir | Height of weir crest in inlet chamber | (ft) | 6 | 6 | 6 | |
| | | Width of weir crest in inlet chamber | (ft) | 3 | 3 | 3 | |
| | IC Sizing | Length of inlet chamber | (ft) | 4.67 | 4.67 | 4.67 | |
| | | Width of inlet chamber | (ft) | 4 | 4 | 4 | |
| | | Depth of stone in inlet chamber | (ft) | 4 | 4 | 4 | |
| | | Number of geotextiles in inlet chamber | (no.) | 1 | 1 | 1 | |
| | ISB Baffle Wall | Length of gravel bed in ISB on baffle wall side | (ft) | 4.67 | 4.67 | 4.67 | |
| | | Width of gravel bed in ISB on baffle wall side | (ft) | 4 | 4 | 4 | |
| | | Depth of gravel bed in ISB on baffle wall side | (ft) | 4 | 4 | 4 | |
| | ISB to Filter Basin (FB) Piping | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| Flow Characteristics | Influent Chamber | Inlet Chamber plan view area | (ft2) | 18.67 | 18.67 | 18.67 | Length x Width of Inlet Chamber |
| | | Average Inlet Chamber particle flow length | (ft) | 12 | 12 | 12 | Anticipated average particle flow length through the IC and upstream of ISB baffle wall. |
| | | Surface loading rate, L | (gpm/ft2) | 1.61 | 2.25 | 4.07 | Calculated based on Q[Total] divided by the Filter bed area, where Q[Total] = Q[seep]+Q[overflow weir] |
| | | Specific discharge velocity, V | ft/day | 309.4 | 433.1 | 783.8 | Calculated based on L (unit conversions) |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height into IC | ft | 6.035 | 6.044 | 6.066 | Height of the inlet chamber weir plus the height of the water overtopping the weir |

| **High K GAC** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Head Losses | Influent Chamber / Influent Stilling Basin | K | (ft/day) | 39,360 | 39,360 | 39,360 | Average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005). |
| | | i (Vertical Gradient) | (ft/ft) | 0.0079 | 0.0110 | 0.0199 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Inlet Chamber gravel bed HL | (ft) | 0.094 | 0.132 | 0.239 | Total head loss across gravel bed calculated by multiplying the gravel bed depth by the vertical gradient. |
| | | Geotextile permittivity | ($sec^{-1}$) | 1.4 | 1.4 | 1.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile. |
| | | Geotextile HL total | (ft) | 0.0026 | 0.0036 | 0.0065 | Head losses due to nonwoven geotextile (above gravel). |
| | | Head losses through piping network | (ft) | 0.02 | 0.03 | 0.11 | See Table 2.2 series for estimated head losses through piping network |
| | | Water flow height into IC | (ft) | 6.035 | 6.044 | 6.066 | Height of the inlet chamber weir plus the height of the water overtopping the weir. |
| | | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | Invert elevation of the transfer pipes feeding the lead filter bed. |
| | | Height of water in lead filter basin | (ft) | 4.36 | 4.40 | 4.52 | Height of water in lead filter basin under anticipated high K GAC conditions (see Table 3.1 Series). |
| | | Height of water in Influent Stilling Basin (ISB) | (ft) | 6.02 | 6.03 | 6.11 | (i) If the water level in the lead filter bed exceeds the ISB transfer piping invert, the water height in the ISB is equal to water height in the lead filter bed plus the anticipated head losses through ISB piping network.<br>(ii) If the water level in the lead filter basin is below the ISB transfer piping invert, the ISB water height is equal to the pipe invert plus the anticipated head losses through the ISB piping network. |
| IC Water Height | Design Objective | Height of water in Inlet Chamber (IC) | (ft) | 6.11 | 6.17 | 6.35 | The ISB water height plus the sum of the head losses associated with the inlet chamber gravel bed and geotextile. |
| | | Maximum allowable height of water in IC | (ft) | 6.5 | 6.5 | 6.5 | Height of spillway |
| | | Target minimum height of water in IC | (ft) | 6.00 | 6.00 | 6.00 | Minimum is set to provide sufficient elevation head for gravity flow through filter bed and associated piping network. Minimum height is set at height of weir crest in inlet chamber. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Water height in inlet chamber must be between the minimum and maximum thresholds. |
| Spillway/Overflow Weir Engagement | Design Objective | Height of water in spillway | (ft) | 0.00 | 0.00 | 0.00 | Height of water overtopping spillway (if applicable). |
| | | Spillway volumetric flow rate | (gpm) | 0 | 0 | 0 | Flow rate through bypass spillway, given by Q=C*(Channel Width)*(Water Height)^1.5, where the weir constant C is 2.65. |
| | | Height of water over overflow weir | (ft) | 0.00 | 0.00 | 0.00 | Water height over overflow weir. |
| | | Overflow weir volumetric flow rate | (gpm) | 0 | 0 | 0 | Calculated following the Francis formula for rectangular weirs, where Q = 3.367*(Weir Width)*(Water Height)^1.5 |
| | | Maximum allowable spillway flow rate | (gpm) | 1,500 | 1,500 | 1,500 | Maximum design flow rate for the bypass spillway. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | |

**Table 2.1.C**
**Calculated System Head Losses Through the Inlet Chamber and Influent Stilling Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

**Flow-Through Cell Design Basis**

| Description | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
|---|---|---|---|---|---|---|---|
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of overflow weir to DB | (ft) | 6.5 | 6.5 | 6.5 | Design Parameters |
| | | Height of emergency spillway | (ft) | 6.5 | 6.5 | 6.5 | |
| | | Width of emergency spillway | (ft) | 5 | 5 | 5 | |
| | | Width of overflow weir | (ft) | 3 | 3 | 3 | |
| Inlet Chamber (IC) | IC Weir | Height of weir crest in inlet chamber | (ft) | 6 | 6 | 6 | |
| | | Width of weir crest in inlet chamber | (ft) | 3 | 3 | 3 | |
| | IC Sizing | Length of inlet chamber | (ft) | 4.67 | 4.67 | 4.67 | |
| | | Width of inlet chamber | (ft) | 4 | 4 | 4 | |
| | | Depth of stone in inlet chamber | (ft) | 4 | 4 | 4 | |
| | | Number of geotextiles in inlet chamber | (no.) | 1 | 1 | 1 | |
| | ISB Baffle Wall | Length of gravel bed in ISB on baffle wall side | (ft) | 4.67 | 4.67 | 4.67 | |
| | | Width of gravel bed in ISB on baffle wall side | (ft) | 4 | 4 | 4 | |
| | | Depth of gravel bed in ISB on baffle wall side | (ft) | 4 | 4 | 4 | |
| | ISB to Filter Basin (FB) Piping | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| Flow Characteristics | Influent Chamber | Inlet Chamber plan view area | (ft2) | 18.67 | 18.67 | 18.67 | Length x Width of Inlet Chamber |
| | | Average Inlet Chamber particle flow length | (ft) | 12 | 12 | 12 | Anticipated average particle flow length through the IC and upstream of ISB baffle wall. |
| | | Surface loading rate, L | (gpm/ft2) | 1.61 | 2.25 | 4.07 | Calculated based on Q[Total] divided by the Filter bed area, where Q[Total] = Q[seep]+Q[overflow weir] |
| | | Specific discharge velocity, V | ft/day | 309.4 | 433.1 | 783.8 | Calculated based on L (unit conversions) |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height into IC | ft | 6.035 | 6.044 | 6.066 | Height of the inlet chamber weir plus the height of the water overtopping the weir |

**Low K GAC**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Head Losses | Influent Chamber / Influent Stilling Basin | K | (ft/day) | 39,360 | 39,360 | 39,360 | Average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005). |
| | | i (Vertical Gradient) | (ft/ft) | 0.0079 | 0.0110 | 0.0199 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Inlet Chamber gravel bed HL | (ft) | 0.094 | 0.132 | 0.239 | Total head loss across gravel bed calculated by multiplying the gravel bed depth by the vertical gradient. |
| | | Geotextile permittivity | ($sec^{-1}$) | 1.4 | 1.4 | 1.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile. |
| | | Geotextile HL total | (ft) | 0.0026 | 0.0036 | 0.0065 | Head losses due to nonwoven geotextile (above gravel). |
| | | Head losses through piping network | (ft) | 0.02 | 0.03 | 0.11 | See Table 2.2 series for estimated head losses through piping network |
| | | Water flow height into IC | (ft) | 6.035 | 6.044 | 6.066 | Height of the inlet chamber weir plus the height of the water overtopping the weir. |
| | | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | Invert elevation of the transfer pipes feeding the lead filter bed. |
| | | Height of water in lead filter basin | (ft) | 4.64 | 4.89 | 5.61 | Height of water in lead filter basin under anticipated high K GAC conditions (see Table 3.1 Series). |
| | | Height of water in Influent Stilling Basin (ISB) | (ft) | 6.02 | 6.03 | 6.11 | (i) If the water level in the lead filter bed exceeds the ISB transfer piping invert, the water height in the ISB is equal to water height in the lead filter bed plus the anticipated head losses through ISB piping network.<br>(ii) If the water level in the lead filter basin is below the ISB transfer piping invert, the ISB water height is equal to the pipe invert plus the anticipated head losses through the ISB piping network. |
| IC Water Height | Design Objective | Height of water in Inlet Chamber (IC) | (ft) | 6.11 | 6.17 | 6.35 | The ISB water height plus the sum of the head losses associated with the inlet chamber gravel bed and geotextile. |
| | | Maximum allowable height of water in IC | (ft) | 6.5 | 6.5 | 6.5 | Height of spillway |
| | | Target minimum height of water in IC | (ft) | 6.00 | 6.00 | 6.00 | Minimum is set to provide sufficient elevation head for gravity flow through filter bed and associated piping network. Minimum height is set at height of weir crest in inlet chamber. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Water height in inlet chamber must be between the minimum and maximum thresholds. |
| Spillway/Overflow Weir Engagement | Design Objective | Height of water in spillway | (ft) | 0.00 | 0.00 | 0.00 | Height of water overtopping spillway (if applicable). |
| | | Spillway volumetric flow rate | (gpm) | 0 | 0 | 0 | Flow rate through bypass spillway, given by Q=C*(Channel Width)*(Water Height)^1.5, where the weir constant C is 2.65. |
| | | Height of water over overflow weir | (ft) | 0.00 | 0.00 | 0.00 | Water height over overflow weir. |
| | | Overflow weir volumetric flow rate | (gpm) | 0 | 0 | 0 | Calculated following the Francis formula for rectangular weirs, where Q = 3.367*(Weir Width)*(Water Height)^1.5 |
| | | Maximum allowable spillway flow rate | (gpm) | 1,500 | 1,500 | 1,500 | Maximum design flow rate for the bypass spillway. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | |

**Table 2.2.C**
**Calculated System Head Losses Through Piping in the Inlet Chamber and Influent Stilling Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | (ft$^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Influent Still Basin (ISB) Design | ISB to Filter Basin (FB) Piping | Number of transfer pipes from ISB to Lead FB | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Number of transfer pipes in ISB connected to manifold (FB-1 in lead) | (no.) | 2 | 2 | 2 | |
| | | Number of transfer pipes in ISB connected to manifold (FB-2 in lead) | (no.) | 3 | 3 | 3 | |
| | | Dia. of ISB transfer pipes | (in) | 2.9 | 2.9 | 2.9 | |
| | | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| | | Length of ISB transfer pipes | (ft) | 2 | 2 | 2 | |
| | | Dia. of ISB lead manifold pipe (FB-1 in lead) | (in) | 3.786 | 3.786 | 3.786 | |
| | | Invert of ISB lead manifold pipe (FB-1 in lead) | (ft) | 5.96 | 5.96 | 5.96 | |
| | | Length of ISB lead manifold pipe (FB-1 in lead) | (ft) | 5 | 5 | 5 | |
| | | Dia. of ISB lead manifold pipe (FB-2 in lead) | (in) | 3.786 | 3.786 | 3.786 | |
| | | Invert of ISB lead manifold pipe (FB-2 in lead) | (ft) | 5.96 | 5.96 | 5.96 | |
| | | Length of ISB lead manifold pipe (FB-2 in lead) | (ft) | 7.4 | 7.4 | 7.4 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting (straight flow) | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open ball valve | (unitless) | 0.05 | 0.05 | 0.05 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| | | Head loss coefficient for half closed gate valve | (unitless) | 2.1 | 2.1 | 2.1 | |
| | | Head loss coefficient for 1/4 closed gate valve | (unitless) | 0.26 | 0.26 | 0.26 | |
| Influent Still Basin (ISB) Design | ISB Transfer Pipe | Pipe cross sectional area | (ft2) | 0.046 | 0.046 | 0.046 | Cross sectional area of fluid flow through transfer pipes |
| | | Pipe velocity | (ft/s) | 0.36 | 0.51 | 0.92 | Volumetric flow rate divided by pipe cross sectional area; assumed even flow distribution through piping network. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 7,300 | 10,300 | 18,600 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.034 | 0.031 | 0.026 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.001 | 0.001 | 0.003 | Friction from fluid flow along walls in pipe |
| | | Exit Losses | (ft) | 0.002 | 0.004 | 0.013 | Head losses due to fluid exiting transfer pipes |
| | | Valve Losses | (ft) | 0.0003 | 0.0006 | 0.0020 | Head losses due to fully gate valve (1 per pipe) |
| | | Dynamic + Minor Losses | (ft) | 0.003 | 0.006 | 0.018 | Summation of pipe losses in ISB transfer pipe |
| | ISB Manifold Pipe (FB-1 Lead) | Pipe cross sectional area | (ft2) | 0.078 | 0.078 | 0.078 | Cross sectional area of fluid flow through manifold pipe |
| | | Pipe velocity | (ft/s) | 0.43 | 0.60 | 1.08 | Total flow through manifold pipe assumed proportional flow distribution through piping network. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 11,200 | 15,700 | 28,500 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.030 | 0.028 | 0.024 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.0014 | 0.0024 | 0.007 | Friction from fluid flow along walls in pipe |
| | | Fitting Losses | (ft) | 0.0028 | 0.0056 | 0.0182 | Maximum head losses due to fluid traveling through elbow and tee fittings in the ISB manifold to the filter beds. |
| | | Entrance Losses | (ft) | 0.0014 | 0.0028 | 0.009 | Head losses due to fluid entry into manifold pipe (fluid exit into transfer pipe accounted for in ISB Transfer Pipe section). |
| | | Dynamic + Minor Losses | (ft) | 0.006 | 0.011 | 0.0342 | Summation of pipe losses in ISB manifold pipe (FB-1 lead) |

**Table 2.2.C**
**Calculated System Head Losses Through Piping in the Inlet Chamber and Influent Stilling Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Influent Still Basin (ISB) Design | ISB to Filter Basin (FB) Piping | Number of transfer pipes from ISB to Lead FB | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Number of transfer pipes in ISB connected to manifold (FB-1 in lead) | (no.) | 2 | 2 | 2 | |
| | | Number of transfer pipes in ISB connected to manifold (FB-2 in lead) | (no.) | 3 | 3 | 3 | |
| | | Dia. of ISB transfer pipes | (in) | 2.9 | 2.9 | 2.9 | |
| | | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| | | Length of ISB transfer pipes | (ft) | 2 | 2 | 2 | |
| | | Dia. of ISB lead manifold pipe (FB-1 in lead) | (in) | 3.786 | 3.786 | 3.786 | |
| | | Invert of ISB lead manifold pipe (FB-1 in lead) | (ft) | 5.96 | 5.96 | 5.96 | |
| | | Length of ISB lead manifold pipe (FB-1 in lead) | (ft) | 5 | 5 | 5 | |
| | | Dia. of ISB lead manifold pipe (FB-2 in lead) | (in) | 3.786 | 3.786 | 3.786 | |
| | | Invert of ISB lead manifold pipe (FB-2 in lead) | (ft) | 5.96 | 5.96 | 5.96 | |
| | | Length of ISB lead manifold pipe (FB-2 in lead) | (ft) | 7.4 | 7.4 | 7.4 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting (straight flow) | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open ball valve | (unitless) | 0.05 | 0.05 | 0.05 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| | | Head loss coefficient for half closed gate valve | (unitless) | 2.1 | 2.1 | 2.1 | |
| | | Head loss coefficient for 1/4 closed gate valve | (unitless) | 0.26 | 0.26 | 0.26 | |
| Influent Still Basin (ISB) Design | ISB Manifold Pipe (FB-2 Lead) | Pipe cross sectional area | (ft2) | 0.078 | 0.078 | 0.078 | Cross sectional area of fluid flow through manifold pipe |
| | | Pipe velocity | (ft/s) | 0.64 | 0.90 | 1.62 | Total flow through manifold pipe assumed proportional flow distribution through piping network. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 16,900 | 23,600 | 42,700 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.027 | 0.025 | 0.022 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.004 | 0.007 | 0.021 | Friction from fluid flow along walls in pipe |
| | | Fitting Losses | (ft) | 0.0077 | 0.0150 | 0.0492 | Maximum head losses due to fluid traveling through elbow and tee fittings in the ISB manifold to the filter beds. |
| | | Entrance Losses | (ft) | 0.003 | 0.006 | 0.020 | Head losses due to fluid entry into manifold pipe (fluid exit into transfer pipe accounted for in ISB Transfer Pipe section). |
| | | Dynamic + Minor Losses | (ft) | 0.015 | 0.029 | 0.090 | Summation of pipe losses in ISB manifold pipe (FB-2 lead) |
| | Sum of Pipe Losses | Sum of Head Losses in Piping Network from ISB to FB | (ft) | 0.02 | 0.03 | 0.11 | Design to account for the maximum anticipated head losses considering either FB-1 or FB-2 is in lead position. |

# Table 3.0 Series
# Calculated System Head Losses Through the Lead Filter Basin
# Chemours, Fayetteville Works, North Carolina

| Sheet | Title |
|---|---|
| 3.1.C | SEEP-C-1: Calculated System Head Losses Through the Lead Filter Basin |
| 3.2.C | SEEP-C-1: Calculated System Head Losses Through Through Piping in the Filter Beds |

**Table 3.1.C**
**Calculated System Head Losses Through the Lead Filter Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

**Flow-Through Cell Design Basis**

| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
|---|---|---|---|---|---|---|---|
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of cell in basin | (ft) | 7.5 | 7.5 | 7.5 | Design Parameters |
| | | Assumed density of carbon | (lb/ft3) | 25 | 25 | 25 | |
| Filter Bed (FB) Design: Lead | Filter Bed Weir | Height of weir crest in lead filter bed, H | (ft) | 4.25 | 4.25 | 4.25 | |
| | | Width of weir crest in lead filter bed | (ft) | 3 | 3 | 3 | |
| | Filter Bed Sizing | Width of lead filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of lead filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in lead filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in lead filter basin | (ft) | 1 | 1 | 1 | |
| | | No. of geotextiles in lead filter basin | (no.) | 2 | 2 | 2 | |
| | ISB to Filter Basin Piping | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| | Carbon Utilization Rates | Anticipated carbon utilization rate (AUR) of PFMOAA | (g/L) | 0.157 | 0.157 | 0.157 | |
| | | Anticipated carbon utilization rate (AUR) of PMPA | (g/L) | 0.163 | 0.163 | 0.163 | |
| Flow Characteristics | Lead Filter Basin | Filter bed plan view area | (ft2) | 100 | 100 | 100 | Length x Width of filter bed |
| | | Surface loading rate, L | (gpm/ft2) | 0.30 | 0.42 | 0.76 | Calculated based on Q and Filter Bed Area.<br>Objective: 0.8 gpm/ft > L > 0.3 gpm/ft2 |
| | | Specific discharge velocity, V | ft/day | 57.8 | 80.9 | 146.3 | Calculated based on L (unit conversions) |
| | | Empty Bed Contact Time, EBCT | (min) | 74.8 | 53.4 | 29.5 | Calculated by dividing carbon volume by flow rate.<br>Objective: 60 minutes > EBCT > 30 minutes |
| | | Carbon utilization | (lb/yr) | 21,449 | 30,029 | 54,338 | Calculated by multiplying AUR and Q (units conversions applied). See Attachment A Isotherm Data. |
| | | Changeout Frequency | (days) | 128 | 91 | 50 | Calculated by dividing carbon mass by carbon utilization (units conversions applied).<br>Objective: 45 days < Average changeout frequency < 90 days |
| | | Porosity of GAC | (unitless) | 0.4 | 0.4 | 0.4 | Assumed porosity of GAC. |
| | | Effective grain size | (mm) | 0.65 | 0.65 | 0.65 | Effective grain size based on Calgon F400 literature. |
| | | Reynolds Number | (unitless) | 0.30 | 0.42 | 0.75 | Reynolds Number to verify validity of applying Darcy's Law for estimating head losses. Assumption valid for Re # < 1. |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height, H + h | ft | 4.285 | 4.294 | 4.316 | Height of the lead transfer basin weir plus the height of the water overtopping the weir |

**High K GAC**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Head Losses | Lead Filter Basin | K | (ft/day) | 2,400 | 2,400 | 2,400 | K values based on Calgon F400 literature for clean bed. |
| | | i (Vertical Gradient) through carbon | (ft/ft) | 0.0241 | 0.0337 | 0.0610 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Carbon bed HL | (ft) | 0.072 | 0.101 | 0.183 | Total head loss across carbon bed calculated by multiplying the carbon bed depth by the minimum vertical gradient. |
| | | Gravel bed HL | (ft) | 0.001 | 0.002 | 0.004 | Average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005). |
| | | Geotextile permittivity | ($sec^{-1}$) | 1.4 | 1.4 | 1.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile. |
| | | Geotextile HL total | (ft) | 0.0010 | 0.0013 | 0.0024 | Head losses due to nonwoven geotextile (one above carbon + one above gravel). |
| | | Head losses through piping network | (ft) | 0.003 | 0.005 | 0.016 | See Table 3.2 series for estimated head losses through piping network from the lead filter basin to the transfer basin |
| | | Flow Through Cell HL Total | (ft) | 0.077 | 0.110 | 0.205 | Cumulative head losses across flow-through cell. |
| | | Height of water in lag filter basin | (ft) | 4.11 | 4.15 | 4.27 | Height of water in lag filter basin under anticipated high K GAC conditions |
| | | Height of water in lead filter basin | (ft) | 4.36 | 4.40 | 4.52 | (i) If the water height in lag basin exceeds the height of the lead filter basin weir, then the height equals the sum of water height in the lag basin plus the anticipated head losses through filter basin and transfer basin piping.<br>(ii) If the water height in the lag basin is less than the height of lead filter basin weir, then the height equals the sum of the water height over the weir plus the anticipated head losses through the filter basin and transfer basin piping. |
| | Design Objective | Height of water in Influent Stilling Basin (ISB) | (ft) | 6.02 | 6.03 | 6.11 | Height of water in influent stilling basin (see Table 2.1 series) |
| | | Head losses through ISB piping network | (ft) | 0.02 | 0.03 | 0.11 | See Table 2.2 series for estimated head losses through ISB piping network |
| | | Hydraulic gradient between ISB and lead filter basin | (ft) | 1.64 | 1.60 | 1.48 | Head difference between the influent stilling basin and the lead filter basin. |
| | | Minimum height of water in lead filter basin | (ft) | 4.25 | 4.25 | 4.25 | To maintain saturated carbon cell and allow for sufficient elevation head for gravity flow through lag filter bed. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Height of water must exceed minimum allowable height and a positive hydraulic gradient (i.e., >0 ft) exist between the ISB and filter basin |

**Table 3.1.C**
**Calculated System Head Losses Through the Lead Filter Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

**Flow-Through Cell Design Basis**

| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
|---|---|---|---|---|---|---|---|
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of cell in basin | (ft) | 7.5 | 7.5 | 7.5 | Design Parameters |
| | | Assumed density of carbon | (lb/ft3) | 25 | 25 | 25 | |
| Filter Bed (FB) Design: Lead | Filter Bed Weir | Height of weir crest in lead filter bed, H | (ft) | 4.25 | 4.25 | 4.25 | |
| | | Width of weir crest in lead filter bed | (ft) | 3 | 3 | 3 | |
| | Filter Bed Sizing | Width of lead filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of lead filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in lead filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in lead filter basin | (ft) | 1 | 1 | 1 | |
| | | No. of geotextiles in lead filter basin | (no.) | 2 | 2 | 2 | |
| | ISB to Filter Basin Piping | Invert of ISB transfer pipes | (ft) | 6.00 | 6.00 | 6.00 | |
| | Carbon Utilization Rates | Anticipated carbon utilization rate (AUR) of PFMOAA | (g/L) | 0.157 | 0.157 | 0.157 | |
| | | Anticipated carbon utilization rate (AUR) of PMPA | (g/L) | 0.163 | 0.163 | 0.163 | |
| Flow Characteristics | Lead Filter Basin | Filter bed plan view area | (ft2) | 100 | 100 | 100 | Length x Width of filter bed |
| | | Surface loading rate, L | (gpm/ft2) | 0.30 | 0.42 | 0.76 | Calculated based on Q and Filter Bed Area.<br>Objective: 0.8 gpm/ft > L > 0.3 gpm/ft2 |
| | | Specific discharge velocity, V | ft/day | 57.8 | 80.9 | 146.3 | Calculated based on L (unit conversions) |
| | | Empty Bed Contact Time, EBCT | (min) | 74.8 | 53.4 | 29.5 | Calculated by dividing carbon volume by flow rate.<br>Objective: 60 minutes > EBCT > 30 minutes |
| | | Carbon utilization | (lb/yr) | 21,449 | 30,029 | 54,338 | Calculated by multiplying AUR and Q (units conversions applied). See Attachment A Isotherm Data. |
| | | Changeout Frequency | (days) | 128 | 91 | 50 | Calculated by dividing carbon mass by carbon utilization (units conversions applied).<br>Objective: 45 days < Average changeout frequency < 90 days |
| | | Porosity of GAC | (unitless) | 0.4 | 0.4 | 0.4 | Assumed porosity of GAC. |
| | | Effective grain size | (mm) | 0.65 | 0.65 | 0.65 | Effective grain size based on Calgon F400 literature. |
| | | Reynolds Number | (unitless) | 0.30 | 0.42 | 0.75 | Reynolds Number to verify validity of applying Darcy's Law for estimating head losses. Assumption valid for Re # < 1. |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height, H + h | ft | 4.285 | 4.294 | 4.316 | Height of the lead transfer basin weir plus the height of the water overtopping the weir |

**Low K GAC**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Head Losses | Lead Filter Basin | K | (ft/day) | 600 | 600 | 600 | Assumes that the conductivity of the clean carbon bed could decrease by a factor of 4 during operation. |
| | | i (Vertical Gradient) through carbon | (ft/ft) | 0.0963 | 0.1348 | 0.2438 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Carbon bed HL | (ft) | 0.289 | 0.404 | 0.732 | Total head loss across carbon bed calculated by multiplying the carbon bed depth by the minimum vertical gradient. |
| | | Gravel bed HL | (ft) | 0.006 | 0.008 | 0.015 | The average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005) reduced by a factor of 4 during operation. |
| | | Geotextile permittivity | ($sec^{-1}$) | 0.4 | 0.4 | 0.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile, reduced by a factor of 4. |
| | | Geotextile HL total | (ft) | 0.0038 | 0.0053 | 0.0097 | Head losses due to nonwoven geotextile (one above carbon + one above gravel). |
| | | Head losses through piping network | (ft) | 0.003 | 0.005 | 0.016 | See Table 3.2 series for estimated head losses through piping network from the lead filter basin to the transfer basin |
| | | Flow Through Cell HL Total | (ft) | 0.301 | 0.423 | 0.772 | Cumulative head losses across flow-through cell. |
| | | Height of water in lag filter basin | (ft) | 4.34 | 4.47 | 4.84 | Height of water in lag filter basin under anticipated low K GAC conditions |
| | | Height of water in lead filter basin | (ft) | 4.64 | 4.89 | 5.61 | (i) If the water height in lag basin exceeds the height of the lead filter basin weir, then the height equals the sum of water height in the lag basin plus the anticipated head losses through filter basin and transfer basin piping.<br>(ii) If the water height in the lag basin is less than the height of lead filter basin weir, then the height equals the sum of the weir height plus the anticipated head losses through the filter basin and transfer basin piping. |
| | Design Objective | Height of water in Influent Stilling Basin (ISB) | (ft) | 6.02 | 6.03 | 6.11 | Height of water in influent stilling basin (see Table 2.1 series) |
| | | Head losses through ISB piping network | (ft) | 0.02 | 0.03 | 0.11 | See Table 2.2 series for estimated head losses through ISB piping network |
| | | Hydraulic gradient between ISB and lead filter basin | (ft) | 1.36 | 1.11 | 0.39 | Head difference between the influent stilling basin and the lead filter basin. |
| | | Minimum height of water in lead filter basin | (ft) | 4.25 | 4.25 | 4.25 | To maintain saturated carbon cell and allow for sufficient elevation head for gravity flow through lag filter bed. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Height of water must exceed minimum allowable height and a positive hydraulic gradient (i.e., >0 ft) must exist between the ISB and filter basin. |

**Table 3.2.C**
**Calculated System Head Losses Through Piping in the Filter Beds**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Filter Bed (FB) Design: Lead/Lag | Filter Bed Piping | No. of pipes to transfer basin (TB) | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Dia. of transfer pipes | (in) | 5.709 | 5.709 | 5.709 | |
| | | Offset distance between each pipe in filter bed | (ft) | 1.6 | 1.6 | 1.6 | |
| | | Length of perf. pipe from filter bed to TB (horizontal) | (ft) | 12 | 12 | 12 | |
| | | Length of solid pipe from filter bed to TB (vertical) | (ft) | 2.75 | 2.75 | 2.75 | |
| | | No. of perforations per foot | (no./ft) | 12 | 12 | 12 | |
| | | Dia. of perforations | (in) | 0.25 | 0.25 | 0.25 | |
| | | No. of feeder pipes to manifold in transfer basin per bed | (no.) | 4 | 4 | 4 | |
| | | Dia. of TB manifold pipe | (in) | 7.57 | 7.57 | 7.57 | |
| | | Length of TB manifold pipe | (ft) | 12 | 12 | 12 | |
| | | Invert of TB manifold pipe | (ft) | 2.75 | 2.75 | 2.75 | |
| | | Length of manifold from TB to ESB | (ft) | 11.7 | 11.7 | 11.7 | |
| | | Width of filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in filter basin | (ft) | 1 | 1 | 1 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| Filter Bed (FB) Design: Lead | Filter Bed Conveyance Piping (Lead Bed) | Pipe cross sectional area | (ft2) | 0.178 | 0.178 | 0.178 | Cross sectional area of conveyance pipe leading to manifold in transfer basin |
| | | Perforation cross sectional area | (ft2) | 0.00034 | 0.00034 | 0.00034 | Cross sectional area of fluid flow through conveyance pipe perforations |
| | | Pipe velocity | (ft/s) | 0.09 | 0.13 | 0.24 | Volumetric flow rate dived by pipe cross sectional area; assumed even flow distribution through piping network. |
| | | Average Hydraulic Residence Time | (days) | 14.4 | 20.2 | 36.6 | Calculated by dividing volume of carbon + gravel by flow rate. |
| | | Volumetric Flow Rate at each perforation, per unit length of pipe; Q_0 | (ft3/s) | 7.7E-07 | 5.5E-07 | 3.0E-07 | Volume of water equally distributed in flow cell per unit length of pipe (1-ft) divided by average hydraulic residence time in the flow through cell. This value is divided by the number of perforations in a unit length of pipe. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 3,700 | 5,200 | 9,400 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.042 | 0.037 | 0.032 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.0002 | 0.0003 | 0.0009 | Friction from fluid flow along walls in pipe |
| | | Entrance Loss | (ft) | 0.0001 | 0.0001 | 0.0004 | Head losses due to fluid entering the conveyance pipe |
| | | Fittings Losses | (ft) | 0.00004 | 0.00008 | 0.00026 | Head losses due to fluid traveling through elbow fittings to the manifold in the transfer basin. |
| | | Losses due to piping perforations | (ft) | 1.1E-05 | 5.8E-06 | 1.8E-06 | Head losses due to water entering the piping perforations |
| | | Dynamic + Minor Losses | (ft) | 0.0003 | 0.001 | 0.002 | Summation of pipe losses in filter bed conveyance pipes |

**Table 3.2.C**
**Calculated System Head Losses Through Piping in the Filter Beds**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Filter Bed (FB) Design: Lead/Lag | Filter Bed Piping | No. of pipes to transfer basin (TB) | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Dia. of transfer pipes | (in) | 5.709 | 5.709 | 5.709 | |
| | | Offset distance between each pipe in filter bed | (ft) | 1.6 | 1.6 | 1.6 | |
| | | Length of perf. pipe from filter bed to TB (horizontal) | (ft) | 12 | 12 | 12 | |
| | | Length of solid pipe from filter bed to TB (vertical) | (ft) | 2.75 | 2.75 | 2.75 | |
| | | No. of perforations per foot | (no./ft) | 12 | 12 | 12 | |
| | | Dia. of perforations | (in) | 0.25 | 0.25 | 0.25 | |
| | | No. of feeder pipes to manifold in transfer basin per bed | (no.) | 4 | 4 | 4 | |
| | | Dia. of TB manifold pipe | (in) | 7.57 | 7.57 | 7.57 | |
| | | Length of TB manifold pipe | (ft) | 12 | 12 | 12 | |
| | | Invert of TB manifold pipe | (ft) | 2.75 | 2.75 | 2.75 | |
| | | Length of manifold from TB to ESB | (ft) | 11.7 | 11.7 | 11.7 | |
| | | Width of filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in filter basin | (ft) | 1 | 1 | 1 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| Filter Bed (FB) Design: Lead | Filter Bed Manifold Piping (Lead Bed) | Pipe cross sectional area | (ft2) | 0.312 | 0.312 | 0.312 | Cross sectional area of manifold pipe in transfer basin |
| | | Pipe velocity | (ft/s) | 0.21 | 0.30 | 0.54 | Total flow within basin is assumed to travel through the entire manifold pipe. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 11,200 | 15,700 | 28,500 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.030 | 0.027 | 0.024 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.0004 | 0.001 | 0.002 | Friction from fluid flow along walls in pipe |
| | | Exit Losses | (ft) | 0.001 | 0.001 | 0.005 | Head losses due to fluid exiting out of manifold pipe (fluid entry accounted for in Filter Bed Conveyance Piping section). |
| | | Valve Losses | (ft) | 0.0001 | 0.0002 | 0.0007 | Head losses due to fluid traveling through fully open gate valve to the transfer basin. |
| | | Fittings Losses | (ft) | 0.0011 | 0.0022 | 0.0073 | Head losses due to fluid traveling through tee fittings in the manifold in the transfer basin. |
| | | Dynamic + Minor Losses | (ft) | 0.002 | 0.005 | 0.015 | Summation of pipe losses in transfer basin manifold pipe (lead bed) |
| | Combined Filter Bed Piping (Lead Bed) | Sum of Head Losses in Piping Network From FB to TB | (ft) | 0.003 | 0.005 | 0.016 | Summation of pipe losses in conveyance piping of FB including manifold in TB (lead bed) |

**Table 3.2.C**
**Calculated System Head Losses Through Piping in the Filter Beds**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Filter Bed (FB) Design: Lead/Lag | Filter Bed Piping | No. of pipes to transfer basin (TB) | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Dia. of transfer pipes | (in) | 5.709 | 5.709 | 5.709 | |
| | | Offset distance between each pipe in filter bed | (ft) | 1.6 | 1.6 | 1.6 | |
| | | Length of perf. pipe from filter bed to TB (horizontal) | (ft) | 12 | 12 | 12 | |
| | | Length of solid pipe from filter bed to TB (vertical) | (ft) | 2.75 | 2.75 | 2.75 | |
| | | No. of perforations per foot | (no./ft) | 12 | 12 | 12 | |
| | | Dia. of perforations | (in) | 0.25 | 0.25 | 0.25 | |
| | | No. of feeder pipes to manifold in transfer basin per bed | (no.) | 4 | 4 | 4 | |
| | | Dia. of TB manifold pipe | (in) | 7.57 | 7.57 | 7.57 | |
| | | Length of TB manifold pipe | (ft) | 12 | 12 | 12 | |
| | | Invert of TB manifold pipe | (ft) | 2.75 | 2.75 | 2.75 | |
| | | Length of manifold from TB to ESB | (ft) | 11.7 | 11.7 | 11.7 | |
| | | Width of filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in filter basin | (ft) | 1 | 1 | 1 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| Filter Bed (FB) Design: Lag | Filter Bed Conveyance Piping (Lag Bed) | Pipe cross sectional area | (ft2) | 0.178 | 0.178 | 0.178 | Cross sectional area of conveyance pipe leading to manifold in transfer basin |
| | | Perforation cross sectional area | (ft2) | 0.00034 | 0.00034 | 0.00034 | Cross sectional area of fluid flow through conveyance pipe perforations |
| | | Pipe velocity | (ft/s) | 0.09 | 0.13 | 0.24 | Volumetric flow rate dived by pipe cross sectional area; assumed even flow distribution through piping network. |
| | | Average Hydraulic Residence Time | (days) | 14.4 | 20.2 | 36.6 | Calculated by dividing volume of carbon + gravel by flow rate. |
| | | Volumetric Flow Rate at each perforation, per unit length of pipe; Q_0 | (ft3/s) | 7.7E-07 | 5.5E-07 | 3.0E-07 | Volume of water equally distributed in flow cell per unit length of pipe (1-ft) divided by average hydraulic residence time in the flow through cell. This value is divided by the number of perforations in a unit length of pipe. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 3,700 | 5,200 | 9,400 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.042 | 0.037 | 0.032 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.0002 | 0.0003 | 0.0009 | Friction from fluid flow along walls in pipe |
| | | Entrance Loss | (ft) | 0.0001 | 0.0001 | 0.0004 | Head losses due to fluid entering the conveyance pipe |
| | | Fittings Losses | (ft) | 0.00004 | 0.00008 | 0.00026 | Head losses due to fluid traveling through elbow fittings to the manifold in the transfer basin. |
| | | Losses due to piping perforations | (ft) | 1.1E-05 | 5.8E-06 | 1.8E-06 | Head losses due to water entering the piping perforations |
| | | Dynamic + Minor Losses | (ft) | 0.0003 | 0.0005 | 0.002 | Summation of pipe losses in filter bed conveyance pipes |

**Table 3.2.C**
**Calculated System Head Losses Through Piping in the Filter Beds**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| Flow-Through Cell Design Basis | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Filter Bed (FB) Design: Lead/Lag | Filter Bed Piping | No. of pipes to transfer basin (TB) | (no.) | 4 | 4 | 4 | Design Parameters |
| | | Dia. of transfer pipes | (in) | 5.709 | 5.709 | 5.709 | |
| | | Offset distance between each pipe in filter bed | (ft) | 1.6 | 1.6 | 1.6 | |
| | | Length of perf. pipe from filter bed to TB (horizontal) | (ft) | 12 | 12 | 12 | |
| | | Length of solid pipe from filter bed to TB (vertical) | (ft) | 2.75 | 2.75 | 2.75 | |
| | | No. of perforations per foot | (no./ft) | 12 | 12 | 12 | |
| | | Dia. of perforations | (in) | 0.25 | 0.25 | 0.25 | |
| | | No. of feeder pipes to manifold in transfer basin per bed | (no.) | 4 | 4 | 4 | |
| | | Dia. of TB manifold pipe | (in) | 7.57 | 7.57 | 7.57 | |
| | | Length of TB manifold pipe | (ft) | 12 | 12 | 12 | |
| | | Invert of TB manifold pipe | (ft) | 2.75 | 2.75 | 2.75 | |
| | | Length of manifold from TB to ESB | (ft) | 11.7 | 11.7 | 11.7 | |
| | | Width of filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in filter basin | (ft) | 1 | 1 | 1 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| | | Head loss coefficient for 90-degree regular elbow | (unitless) | 0.3 | 0.3 | 0.3 | |
| | | Head loss coefficient for regular tee fitting | (unitless) | 0.2 | 0.2 | 0.2 | |
| | | Head loss coefficient for regular tee fitting (branch flow) | (unitless) | 1.0 | 1.0 | 1.0 | |
| | | Head loss coefficient for fully open gate valve | (unitless) | 0.15 | 0.15 | 0.15 | |
| Filter Bed (FB) Design: Lag | Filter Bed Manifold Piping (Lag Bed) | Pipe cross sectional area | (ft2) | 0.312 | 0.312 | 0.312 | Cross sectional area of manifold pipe in transfer basin |
| | | Pipe velocity | (ft/s) | 0.21 | 0.30 | 0.54 | Total flow within basin is assumed to travel through the entire manifold pipe. |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 11,200 | 15,700 | 28,500 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.030 | 0.027 | 0.024 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.001 | 0.001 | 0.004 | Friction from fluid flow along walls in pipe |
| | | Exit Losses | (ft) | 0.001 | 0.001 | 0.005 | Head losses due to fluid exiting out of manifold pipe into effluent stilling basin (fluid entry accounted for in Filter Bed Conveyance Piping section). |
| | | Valve Losses | (ft) | 0.0001 | 0.0002 | 0.0007 | Head losses due to fluid traveling through fully open gate valve to the effluent stilling basin. |
| | | Fittings Losses | (ft) | 0.0011 | 0.0022 | 0.0073 | Head losses due to fluid traveling through tee fittings in the manifold in the transfer basin. |
| | | Dynamic + Minor Losses | (ft) | 0.003 | 0.005 | 0.017 | Summation of pipe losses in transfer basin manifold pipe (lag bed) |
| | Combined Filter Bed Piping (Lag Bed) | Sum of Head Losses in Piping Network From FB to TB | (ft) | 0.003 | 0.006 | 0.018 | Summation of pipe losses in conveyance piping of FB including manifold in TB to effluent stilling basin (lag bed) |

# Table 4.0 Series
# Calculated System Head Losses Through the Lag Filter Basin
# Chemours, Fayetteville Works, North Carolina

| Sheet | Title |
|---|---|
| 4.1.C | SEEP-C-1: Calculated System Head Losses Through the Lag Filter Basin |

**Table 4.1.C**
**Calculated System Head Losses Through the Lag Filter Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Flow-Through Cell Design Basis** | | | | | | | |
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of cell in basin | (ft) | 7.5 | 7.5 | 7.5 | Design Parameters |
| | | Assumed density of carbon | (lb/ft3) | 25 | 25 | 25 | |
| Filter Bed (FB) Design: Lag | Effluent Stilling Basin | Minimum height of weir crest in ESB | (ft) | 4 | 4 | 4 | |
| | | Width of weir crest in ESB | (ft) | 3 | 3 | 3 | |
| | Filter Bed Sizing | Width of lag filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of lag filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in lag filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in lag filter basin | (ft) | 1 | 1 | 1 | |
| | | No. of geotextiles in lag filter basin | (no.) | 2 | 2 | 2 | |
| | Carbon Utilization Rates | Anticipated carbon utilization rate (AUR) of PFMOAA | (g/L) | 0.157 | 0.157 | 0.157 | |
| | | Anticipated carbon utilization rate (AUR) of PMPA | (g/L) | 0.163 | 0.163 | 0.163 | |
| Flow Characteristics | Lag Filter Basin | Filter bed plan view area | (ft2) | 100 | 100 | 100 | Length x Width of filter bed |
| | | Surface loading rate, L | (gpm/ft2) | 0.30 | 0.42 | 0.76 | Calculated based on Q and Filter Bed Area.<br>Objective: 0.8 gpm/ft > L > 0.3 gpm/ft2 |
| | | Specific discharge velocity, V | ft/day | 57.8 | 80.9 | 146.3 | Calculated based on L (unit conversions) |
| | | Empty Bed Contact Time, EBCT | (min) | 74.8 | 53.4 | 29.5 | Calculated by dividing carbon volume by flow rate.<br>Objective: 60 minutes > EBCT > 30 minutes |
| | | Carbon utilization | (lb/yr) | 21,449 | 30,029 | 54,338 | Calculated by multiplying AUR and Q (units conversions applied). See Attachment A Isotherm Data. |
| | | Changeout Frequency | (days) | 128 | 91 | 50 | Calculated by dividing carbon mass by carbon utilization (units conversions applied).<br>Objective: 45 days < Average changeout frequency < 90 days |
| | | Porosity of GAC | (unitless) | 0.4 | 0.4 | 0.4 | Assumed porosity of GAC. |
| | | Effective grain size | (mm) | 0.65 | 0.65 | 0.65 | Effective grain size based on Calgon F400 literature. |
| | | Reynolds Number | (unitless) | 0.30 | 0.42 | 0.75 | Reynolds Number to verify validity of applying Darcy's Law for estimating head losses. Assumption valid for Re # < 1. |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height, H + h | ft | 4.035 | 4.044 | 4.066 | Height of the effluent stilling basin weir plus the height of the water overtopping the weir |
| | | | | | | | |
| **High K GAC** | | | | | | | |
| Head Losses | Lag Filter Basin | K | (ft/day) | 2,400 | 2,400 | 2,400 | K values based on Calgon F400 literature for clean bed. |
| | | i (Vertical Gradient) through carbon | (ft/ft) | 0.0241 | 0.0337 | 0.0610 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Carbon bed HL | (ft) | 0.072 | 0.101 | 0.183 | Total head loss across carbon bed calculated by multiplying the carbon bed depth by the minimum vertical gradient. |
| | | Gravel bed HL | (ft) | 0.001 | 0.002 | 0.004 | Average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005). |
| | | Geotextile permittivity | (sec$^{-1}$) | 1.4 | 1.4 | 1.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile. |
| | | Geotextile HL total | (ft) | 0.0010 | 0.0013 | 0.0024 | Head losses due to nonwoven geotextile (one above carbon + one above gravel). |
| | | Head losses through piping network | (ft) | 0.003 | 0.006 | 0.018 | See Table 3.2 series for estimated head losses through piping network from the lag filter basin to the effluent stilling basin |
| | | Height of water in lag filter basin | (ft) | 4.11 | 4.15 | 4.27 | Sum of water height over effluent stilling basin weir plus anticipated head losses through lag filter basin to the effluent stilling basin |
| | Design Objective | Height of water in lead filter basin | (ft) | 4.36 | 4.40 | 4.52 | Height of water in lead basin (see Table 3.1 series) under high K GAC conditions. |
| | | Minimum height of water in lag filter basin | (ft) | 4 | 4 | 4 | To maintain saturated carbon in lag filter basin. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Height of water must exceed minimum allowable height. |

**Table 4.1.C**
**Calculated System Head Losses Through the Lag Filter Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | ($ft^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of cell in basin | (ft) | 7.5 | 7.5 | 7.5 | Design Parameters |
| | | Assumed density of carbon | (lb/ft3) | 25 | 25 | 25 | |
| Filter Bed (FB) Design: Lag | Effluent Stilling Basin | Minimum height of weir crest in ESB | (ft) | 4 | 4 | 4 | |
| | | Width of weir crest in ESB | (ft) | 3 | 3 | 3 | |
| | Filter Bed Sizing | Width of lag filter basin | (ft) | 10 | 10 | 10 | |
| | | Length of lag filter basin | (ft) | 10 | 10 | 10 | |
| | | Carbon depth in lag filter basin | (ft) | 3 | 3 | 3 | |
| | | Gravel depth in lag filter basin | (ft) | 1 | 1 | 1 | |
| | | No. of geotextiles in lag filter basin | (no.) | 2 | 2 | 2 | |
| | Carbon Utilization Rates | Anticipated carbon utilization rate (AUR) of PFMOAA | (g/L) | 0.157 | 0.157 | 0.157 | |
| | | Anticipated carbon utilization rate (AUR) of PMPA | (g/L) | 0.163 | 0.163 | 0.163 | |
| Flow Characteristics | Lag Filter Basin | Filter bed plan view area | (ft2) | 100 | 100 | 100 | Length x Width of filter bed |
| | | Surface loading rate, L | (gpm/ft2) | 0.30 | 0.42 | 0.76 | Calculated based on Q and Filter Bed Area.<br>Objective: 0.8 gpm/ft > L > 0.3 gpm/ft2 |
| | | Specific discharge velocity, V | ft/day | 57.8 | 80.9 | 146.3 | Calculated based on L (unit conversions) |
| | | Empty Bed Contact Time, EBCT | (min) | 74.8 | 53.4 | 29.5 | Calculated by dividing carbon volume by flow rate.<br>Objective: 60 minutes > EBCT > 30 minutes |
| | | Carbon utilization | (lb/yr) | 21,449 | 30,029 | 54,338 | Calculated by multiplying AUR and Q (units conversions applied). See Attachment A Isotherm Data. |
| | | Changeout Frequency | (days) | 128 | 91 | 50 | Calculated by dividing carbon mass by carbon utilization (units conversions applied).<br>Objective: 45 days < Average changeout frequency < 90 days |
| | | Porosity of GAC | (unitless) | 0.4 | 0.4 | 0.4 | Assumed porosity of GAC. |
| | | Effective grain size | (mm) | 0.65 | 0.65 | 0.65 | Effective grain size based on Calgon F400 literature. |
| | | Reynolds Number | (unitless) | 0.30 | 0.42 | 0.75 | Reynolds Number to verify validity of applying Darcy's Law for estimating head losses. Assumption valid for Re # < 1. |
| | | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| | | Water flow height, H + h | ft | 4.035 | 4.044 | 4.066 | Height of the effluent stilling basin weir plus the height of the water overtopping the weir |
| | | | | | | | |
| **Low K GAC** | | | | | | | |
| Head Losses | Lag Filter Basin | K | (ft/day) | 600 | 600 | 600 | Assumes that the conductivity of the clean carbon bed could decrease by a factor of 4 during operation. |
| | | i (Vertical Gradient) through carbon | (ft/ft) | 0.0963 | 0.1348 | 0.2438 | Based upon Darcy's Law: Minimum required vertical gradient calculated by dividing K (ft/day) by V (ft/day); values provided in ft/ft. |
| | | Carbon bed HL | (ft) | 0.289 | 0.404 | 0.732 | Total head loss across carbon bed calculated by multiplying the carbon bed depth by the minimum vertical gradient. |
| | | Gravel bed HL | (ft) | 0.006 | 0.008 | 0.015 | The average estimate of hydraulic conductivity of ASTM #5 stone (12,000 m/day) as reported by Mulqueen (The flow of water through gravels, 2005) reduced by a factor of 4 during operation. |
| | | Geotextile permittivity | (sec$^{-1}$) | 0.4 | 0.4 | 0.4 | Permittivity of "typical" 6 oz/sy nonwoven geotextile, reduced by a factor of 4. |
| | | Geotextile HL total | (ft) | 0.0038 | 0.0053 | 0.0097 | Head losses due to nonwoven geotextile (one above carbon + one above gravel). |
| | | Head losses through piping network | (ft) | 0.003 | 0.006 | 0.018 | See Table 3.2 series for estimated head losses through piping network from the lag filter basin to the effluent stilling basin |
| | | Height of water in lag filter basin | (ft) | 4.34 | 4.47 | 4.84 | Sum of water height over effluent stilling basin weir plus anticipated head losses through lag filter basin to the effluent stilling basin |
| | Design Objective | Height of water in lead filter basin | (ft) | 4.64 | 4.89 | 5.61 | Height of water in lead basin (see Table 3.1 series) under low K GAC conditions. |
| | | Minimum height of water in lag filter basin | (ft) | 4 | 4 | 4 | To maintain saturated carbon in lag filter basin. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | Height of water must exceed minimum allowable height. |

# Table 5.0 Series
# Calculated System Head Losses Through the Discharge Basin
# Chemours, Fayetteville Works, North Carolina

| Sheet | Title |
|---|---|
| 5.1.C | SEEP-C-1: Calculated System Head Losses Through the Discharge Basin |
| 5.2.C | SEEP-C-1: Calculated System Head Losses Through Through Piping in the Discharge Basin |

**Table 5.1.C**
**Calculated System Head Losses Through the Discharge Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | (ft$^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| General | | Height of cell in basin | (ft) | 7.5 | 7.5 | 7.5 | Design Parameters |
| Effluent Stilling Basin Design | Effluent Stilling Basin | Minimum height of weir crest in ESB | (ft) | 4 | 4 | 4 | |
| | | Width of weir crest in ESB | (ft) | 3 | 3 | 3 | |
| Discharge Basin Design | Discharge Basin Sizing | Width of discharge basin | (ft) | 4 | 4 | 4 | |
| | | Length of discharge basin | (ft) | 2.5 | 2.5 | 2.5 | |
| | Discharge Basin Pipe Sizing | Diameter of DB piping | (in) | 7.565 | 7.565 | 7.565 | |
| | | Length of DB piping | (ft) | 24 | 24 | 24 | |
| | | Invert of DP piping | (ft) | 0 | 0 | 0 | |

| **Flow through Discharge Basin Pipe: High K GAC** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow Characteristics | Effluent Basin | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| Head Losses | Discharge Basin | Head losses through piping network | (ft) | 0.002 | 0.004 | 0.011 | See Table 5.2 series for estimated head losses through piping network from the discharge basin to the river |
| | | Height of water in effluent stilling basin | (ft) | 4.035 | 4.044 | 4.066 | Height of the effluent stilling basin weir plus the height of the water overtopping the weir |
| | Design Objective | Available head for transfer through discharge piping | (ft) | 4.03 | 4.04 | 4.05 | Height of water in effluent stilling basin minus anticipated head losses through discharge piping network. Available head should be greater than 0 ft. |
| | | Satisfy design constraints? | -- | Pass | Pass | Pass | |

| **Flow through Discharge Basin Pipe: Low K GAC** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow Characteristics | Effluent Basin | Water height over weir, h | ft | 0.035 | 0.044 | 0.066 | Calculated following the Francis formula for rectangular weirs, where h = (Q/(3.367*Weir Width))^(2/3) |
| Head Losses | Discharge Basin | Head losses through piping network | (ft) | 0.002 | 0.004 | 0.011 | See Table 5.2 series for estimated head losses through piping network from the discharge basin to the river |
| | | Height of water in effluent stilling basin | (ft) | 4.035 | 4.044 | 4.066 | Height of the effluent stilling basin weir plus the height of the water overtopping the weir |
| | Design Objective | Available head for transfer through discharge piping | (ft) | 4.03 | 4.04 | 4.05 | Height of water in effluent stilling basin minus anticipated head losses through discharge piping network. Available head should be greater than 0 ft. |
| | | Satisfy design constraints? | (ft) | Pass | Pass | Pass | |

**Table 5.2.C**
**Calculated System Head Losses Through Piping in the Discharge Basin**
**SEEP-C-1**
**Chemours, Fayetteville Works, North Carolina**

| **Flow-Through Cell Design Basis** | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variable | | 25% Flow | 50% Flow | 95% Flow | Comments |
| Flow Dynamics | | Volumetric Flow Rate, Q | (gpm) | 30 | 42 | 76 | Range of flows based upon dry weather seep flow data (Table 1) |
| | | Volumetric Flow Rate, Q | (ft$^3$/day) | 5,775 | 8,085 | 14,630 | Units conversion |
| Discharge Basin (DB) Design | Discharge Basin Piping | Diameter of DB piping | (in) | 7.565 | 7.565 | 7.565 | Design Parameters |
| | | Length of DB piping | (ft) | 24 | 24 | 24 | |
| | | Invert of DP piping | (ft) | 0 | 0 | 0 | |
| | Pipe Loss Coefficients | Head loss coefficient for entrance pipe losses | (unitless) | 0.5 | 0.5 | 0.5 | Typical energy loss coefficients for fluid flow through pipes (Hydraulic Losses in Pipes, Kudela) |
| | | Head loss coefficient for exit pipe losses | (unitless) | 1 | 1 | 1 | |
| Discharge Basin (DB) Design | Discharge Basin Piping | Pipe cross sectional area | (ft2) | 0.312 | 0.312 | 0.312 | Cross sectional area of discharge pipe leading river basin |
| | | Pipe velocity | (ft/s) | 0.21 | 0.30 | 0.54 | Volumetric flow rate dived by pipe cross sectional area |
| | | Kinematic Viscosity | (ft2/s) | 1.20E-05 | 1.20E-05 | 1.20E-05 | Viscosity of water at standard temperature and pressure |
| | | Reynolds Number | (unitless) | 11,200 | 15,700 | 28,500 | Ratio of inertial forces to viscous forces in fluid flow |
| | | Flow Roughness Coefficient | (ft) | 8.E-06 | 8.E-06 | 8.E-06 | Coefficient of fluid resistance to flow along pipe walls |
| | | Flow Friction Factor, f | (unitless) | 0.030 | 0.027 | 0.024 | Empirical factor for calculating head losses following Darcy-Weisbach head loss equation |
| | | Dynamic Energy Loss- Darcy EQ | (ft) | 0.001 | 0.001 | 0.004 | Friction from fluid flow along walls in pipe |
| | | Entrance Losses | (ft) | 0.001 | 0.002 | 0.007 | Head losses due to fluid entering and exiting the discharge basin pipe |
| | | Dynamic + Minor Losses | (ft) | 0.002 | 0.004 | 0.011 | Summation of pipe losses in discharge basin pipe |

# Attachment A
# Isotherm Data Summary
# Chemours, Fayetteville Works, North Carolina

## Isotherm Studies Performed by Others

| IS-01 (Perched Zone) | | | | |
|---|---|---|---|---|
| Compound | Concentration (µg/L) | Kf (mg/g) | 1/n (unitless) | % of Total PFAS (percentage) |
| PEPA | 17 | 2.0962 | 0.5263 | 1.4% |
| PFMOAA | 750 | 3.8074 | 0.7289 | 61.2% |
| PFO2HxA | 240 | 31.833 | 0.6802 | 19.6% |
| PFO3OA | 67 | -- | -- | 5.5% |
| PFO4DA | 19 | -- | -- | 1.6% |
| PMPA | 40 | 4.4852 | 0.8421 | 3.3% |
| HFPO-DA | 88 | 38.685 | 0.6245 | 7.2% |
| PFBA | 1.5 | 0.5476 | 0.6594 | 0.1% |
| PFPeA | 2.8 | 1.6392 | 0.5375 | 0.2% |
| **Total** | 1225.3 | | | |

| IS-04 through IS-07 (Upper OOF2) | | | | |
|---|---|---|---|---|
| Compound | Concentration (µg/L) | Kf (mg/g) | 1/n (unitless) | % of Total PFAS (percentage) |
| PEPA | 1.9 | 0.49 | 0.396 | 1.6% |
| | | 1.1563 | 0.4853 | |
| PFMOAA | 85 | 4.0573 | 0.6786 | 69.5% |
| | | 4.6276 | 0.7461 | |
| PFO2HxA | 17 | 6.1244 | 0.4413 | 13.9% |
| | | 14.438 | 0.5561 | |
| PFO3OA | 5.1 | -- | -- | 4.2% |
| PFO4DA | 1.6 | -- | -- | 1.3% |
| PMPA | 5.4 | 1.3626 | 0.6565 | 4.4% |
| | | 1.1897 | 0.6386 | |
| HFPO-DA | 6 | 3.7049 | 0.3885 | 4.9% |
| | | 10.292 | 0.4878 | |
| PFBA | 0.072 | -- | -- | 0.06% |
| PFPeA | 0.15 | -- | -- | 0.12% |
| **Total** | 122.2 | | | |

| Constituent of Concern (COC) | Seep A | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Concentration (µg/L) | % | IS-01 (Perched Zone) | | IS-04 through IS-07 (Upper OOF2) | | | |
| | | | x/m (mg/g) | AUR (g/L) | x/m (mg/g) | AUR (g/L) | x/m | AUR |
| PEPA | 6.9 | 3.1% | 0.153 | 0.045 | 0.068 | 0.101 | 0.103 | 0.067 |
| PFMOAA | 97.5 | 43.3% | 0.698 | **0.140** | 0.836 | 0.117 | 0.815 | 0.120 |
| PFO2HxA | 50 | 22.2% | 4.149 | 0.012 | 1.633 | 0.031 | 2.729 | 0.018 |
| PFO3OA | 18 | 8.0% | -- | -- | -- | -- | -- | -- |
| PFO4DA | 9.7 | 4.3% | -- | -- | -- | -- | -- | -- |
| PMPA | 23 | 10.2% | 0.187 | 0.123 | 0.115 | 0.201 | 0.107 | **0.215** |
| HFPO-DA | 20 | 8.9% | 3.362 | 0.006 | 0.810 | 0.025 | 1.527 | 0.013 |
| PFBA | -- | -- | -- | -- | -- | -- | -- | -- |
| PFPeA | -- | -- | -- | -- | -- | -- | -- | -- |
| | 225.1 | 100.0% | -- | -- | -- | -- | -- | -- |

Notes:
1. @ 97.5 µg/L, the AUR for PFMOAA is likely within the 0.117 to 0.140 range, given that the isotherms for these two estimates were based on concentrations of 85 and 750 µg/L, respectively. The value is likely closer to the 0.117 value given that 97.5 µg/L is closer to the 85 µg/L isotherm conditions; assume 0.125 g/L.
2. @ 23 µg/L, the AUR for PMPA is likely within the 0.123 to 0.215 range given that the isotherms for these two estimates were based on concentrations of 40 and 5.4 µg/L, respectively; assume 0.169 g/L (mid-range).
3. IS-01 (Perched Zone) corresponds to isotherm pilot study performed by others.
4. IS-04 through IS-07 (Upper OOF2) corresponds to a dual-test isotherm pilot study performed by others.
5. For a given isotherm pilot test, bold indicates upper-end AUR estimate for the COCs considered.

# Attachment A
# Isotherm Data Summary
# Chemours, Fayetteville Works, North Carolina

## Isotherm Studies Performed by Others

| IS-01 (Perched Zone) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 17 | 2.0962 | 0.5263 | 1.4% |
| PFMOAA | 750 | 3.8074 | 0.7289 | 61.2% |
| PFO2HxA | 240 | 31.833 | 0.6802 | 19.6% |
| PFO3OA | 67 | -- | -- | 5.5% |
| PFO4DA | 19 | -- | -- | 1.6% |
| PMPA | 40 | 4.4852 | 0.8421 | 3.3% |
| HFPO-DA | 88 | 38.685 | 0.6245 | 7.2% |
| PFBA | 1.5 | 0.5476 | 0.6594 | 0.1% |
| PFPeA | 2.8 | 1.6392 | 0.5375 | 0.2% |
| **Total** | 1225.3 | | | |

| IS-04 through IS-07 (Upper OOF2) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 1.9 | 0.49 | 0.396 | 1.6% |
| | | 1.1563 | 0.4853 | |
| PFMOAA | 85 | 4.0573 | 0.6786 | 69.5% |
| | | 4.6276 | 0.7461 | |
| PFO2HxA | 17 | 6.1244 | 0.4413 | 13.9% |
| | | 14.438 | 0.5561 | |
| PFO3OA | 5.1 | -- | -- | 4.2% |
| PFO4DA | 1.6 | -- | -- | 1.3% |
| PMPA | 5.4 | 1.3626 | 0.6565 | 4.4% |
| | | 1.1897 | 0.6386 | |
| HFPO-DA | 6 | 3.7049 | 0.3885 | 4.9% |
| | | 10.292 | 0.4878 | |
| PFBA | 0.072 | -- | -- | 0.06% |
| PFPeA | 0.15 | -- | -- | 0.12% |
| **Total** | 122.2 | | | |

| **Constituent of Concern (COC)** | **Seep B** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Concentration (µg/L)** | **%** | **IS-01 (Perched Zone)** | | **IS-04 through IS-07 (Upper OOF2)** | | | |
| | | | **x/m (mg/g)** | **AUR (g/L)** | **x/m (mg/g)** | **AUR (g/L)** | **x/m** | **AUR** |
| PEPA | 12 | 3.9% | 0.204 | 0.059 | 0.085 | 0.141 | 0.135 | 0.089 |
| PFMOAA | 180 | 58.0% | 1.091 | **0.165** | 1.267 | 0.142 | 1.287 | 0.140 |
| PFO2HxA | 48 | 15.5% | 4.035 | 0.012 | 1.604 | 0.030 | 2.668 | 0.018 |
| PFO3OA | 10 | 3.2% | -- | -- | -- | -- | -- | -- |
| PFO4DA | 1.5 | 0.5% | -- | -- | -- | -- | -- | -- |
| PMPA | 36 | 11.6% | 0.273 | 0.132 | 0.154 | 0.234 | 0.142 | **0.253** |
| HFPO-DA | 23 | 7.4% | 3.668 | 0.006 | 0.856 | 0.027 | 1.634 | 0.014 |
| PFBA | -- | -- | -- | -- | -- | -- | -- | -- |
| PFPeA | -- | -- | -- | -- | -- | -- | -- | -- |
| | 310.5 | 100.0% | -- | -- | -- | -- | -- | -- |

Notes:

1. @ 180 µg/L, the AUR for PFMOAA is likely in the middle of the 0.14 to 0.165 range, given that the isotherms for these two estimates were based on concentrations of 85 and 750 µg/L, respectively; assume 0.156 g/L.
2. @ 36 µg/L, the AUR for PMPA is likely closer to the 0.132 value than the 0.253 given that the isotherms for these two estimates were based on concentrations of 40 and 5.4 µg/L, respectively; assume 0.14 g/L.

3. IS-01 (Perched Zone) corresponds to isotherm pilot study performed by others.
4. IS-04 through IS-07 (Upper OOF2) corresponds to a dual-test isotherm pilot study performed by others.
5. For a given isotherm pilot test, bold indicates upper-end AUR estimate for the COCs considered.

## Attachment A
## Isotherm Data Summary
## Chemours, Fayetteville Works, North Carolina

### Isotherm Studies Performed by Others

| IS-01 (Perched Zone) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 17 | 2.0962 | 0.5263 | 1.4% |
| PFMOAA | 750 | 3.8074 | 0.7289 | 61.2% |
| PFO2HxA | 240 | 31.833 | 0.6802 | 19.6% |
| PFO3OA | 67 | -- | -- | 5.5% |
| PFO4DA | 19 | -- | -- | 1.6% |
| PMPA | 40 | 4.4852 | 0.8421 | 3.3% |
| HFPO-DA | 88 | 38.685 | 0.6245 | 7.2% |
| PFBA | 1.5 | 0.5476 | 0.6594 | 0.1% |
| PFPeA | 2.8 | 1.6392 | 0.5375 | 0.2% |
| **Total** | 1225.3 | | | |

| IS-04 through IS-07 (Upper OOF2) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 1.9 | 0.49 | 0.396 | 1.6% |
| | | 1.1563 | 0.4853 | |
| PFMOAA | 85 | 4.0573 | 0.6786 | 69.5% |
| | | 4.6276 | 0.7461 | |
| PFO2HxA | 17 | 6.1244 | 0.4413 | 13.9% |
| | | 14.438 | 0.5561 | |
| PFO3OA | 5.1 | -- | -- | 4.2% |
| PFO4DA | 1.6 | -- | -- | 1.3% |
| PMPA | 5.4 | 1.3626 | 0.6565 | 4.4% |
| | | 1.1897 | 0.6386 | |
| HFPO-DA | 6 | 3.7049 | 0.3885 | 4.9% |
| | | 10.292 | 0.4878 | |
| PFBA | 0.072 | -- | -- | 0.06% |
| PFPeA | 0.15 | -- | -- | 0.12% |
| **Total** | 122.2 | | | |

| **Constituent of Concern (COC)** | **Seep C** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Concentration (µg/L)** | **%** | **IS-01 (Perched Zone)** | | **IS-04 through IS-07 (Upper OOF2)** | | | |
| | | | **x/m (mg/g)** | **AUR (g/L)** | **x/m (mg/g)** | **AUR (g/L)** | **x/m** | **AUR** |
| PEPA | 3.5 | 1.1% | 0.107 | 0.033 | 0.052 | 0.067 | 0.074 | 0.047 |
| PFMOAA | 200 | 61.1% | 1.178 | **0.170** | 1.361 | 0.147 | 1.393 | 0.144 |
| PFO2HxA | 60 | 18.3% | 4.697 | 0.013 | 1.770 | 0.034 | 3.020 | 0.020 |
| PFO3OA | 19 | 5.8% | -- | -- | -- | -- | -- | -- |
| PFO4DA | 4.1 | 1.3% | -- | -- | -- | -- | -- | -- |
| PMPA | 14 | 4.3% | 0.123 | 0.114 | 0.083 | 0.169 | 0.078 | **0.180** |
| HFPO-DA | 27 | 8.2% | 4.054 | 0.007 | 0.911 | 0.030 | 1.767 | 0.015 |
| PFBA | -- | -- | -- | -- | -- | -- | -- | -- |
| PFPeA | -- | -- | -- | -- | -- | -- | -- | -- |
| | 327.6 | 100.0% | -- | -- | -- | -- | -- | -- |

Notes:
1. @ 200 µg/L, the AUR for PFMOAA is likely in the middle of the 0.144 to 0.170 range, given that the isotherms for these two estimates were based on concentrations of 85 and 750 µg/L, respectively; assume 0.157 g/L.
2. @ 14 µg/L, the AUR for PMPA is likely in the middle of the 0.114 to 0.180 range, but closer to 0.180 given that the isotherms for these two estimates were based on concentrations of 40 and 5.4 µg/L, respectively; assume 0.163 g/L.
3. IS-01 (Perched Zone) corresponds to isotherm pilot study performed by others.
4. IS-04 through IS-07 (Upper OOF2) corresponds to a dual-test isotherm pilot study performed by others.
5. For a given isotherm pilot test, bold indicates upper-end AUR estimate for the COCs considered.

# Attachment A
# Isotherm Data Summary
# Chemours, Fayetteville Works, North Carolina

## Isotherm Studies Performed by Others

| IS-01 (Perched Zone) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 17 | 2.0962 | 0.5263 | 1.4% |
| PFMOAA | 750 | 3.8074 | 0.7289 | 61.2% |
| PFO2HxA | 240 | 31.833 | 0.6802 | 19.6% |
| PFO3OA | 67 | -- | -- | 5.5% |
| PFO4DA | 19 | -- | -- | 1.6% |
| PMPA | 40 | 4.4852 | 0.8421 | 3.3% |
| HFPO-DA | 88 | 38.685 | 0.6245 | 7.2% |
| PFBA | 1.5 | 0.5476 | 0.6594 | 0.1% |
| PFPeA | 2.8 | 1.6392 | 0.5375 | 0.2% |
| **Total** | 1225.3 | | | |

| IS-04 through IS-07 (Upper OOF2) | | | | |
|---|---|---|---|---|
| **Compound** | **Concentration** | **Kf** | **1/n** | **% of Total PFAS** |
| | **(µg/L)** | **(mg/g)** | **(unitless)** | **(percentage)** |
| PEPA | 1.9 | 0.49 | 0.396 | 1.6% |
| | | 1.1563 | 0.4853 | |
| PFMOAA | 85 | 4.0573 | 0.6786 | 69.5% |
| | | 4.6276 | 0.7461 | |
| PFO2HxA | 17 | 6.1244 | 0.4413 | 13.9% |
| | | 14.438 | 0.5561 | |
| PFO3OA | 5.1 | -- | -- | 4.2% |
| PFO4DA | 1.6 | -- | -- | 1.3% |
| PMPA | 5.4 | 1.3626 | 0.6565 | 4.4% |
| | | 1.1897 | 0.6386 | |
| HFPO-DA | 6 | 3.7049 | 0.3885 | 4.9% |
| | | 10.292 | 0.4878 | |
| PFBA | 0.072 | -- | -- | 0.06% |
| PFPeA | 0.15 | -- | -- | 0.12% |
| **Total** | 122.2 | | | |

| | **Seep D** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Constituent of Concern (COC)** | **Concentration (µg/L)** | **%** | **IS-01 (Perched Zone)** | | **IS-04 through IS-07 (Upper OOF2)** | | | |
| | | | **x/m (mg/g)** | **AUR (g/L)** | **x/m (mg/g)** | **AUR (g/L)** | **x/m** | **AUR** |
| PEPA | 2.3 | 1.4% | 0.086 | 0.027 | 0.044 | 0.052 | 0.061 | 0.038 |
| PFMOAA | 100 | 58.9% | 0.711 | **0.141** | 0.850 | 0.118 | 0.830 | 0.120 |
| PFO2HxA | 33 | 19.4% | 3.127 | 0.011 | 1.359 | 0.024 | 2.166 | 0.015 |
| PFO3OA | 8.5 | 5.0% | -- | -- | -- | -- | -- | -- |
| PFO4DA | 2.4 | 1.4% | -- | -- | -- | -- | -- | -- |
| PMPA | 8.7 | 5.1% | 0.083 | 0.105 | 0.060 | 0.144 | 0.057 | **0.151** |
| HFPO-DA | 15 | 8.8% | 2.809 | 0.005 | 0.725 | 0.021 | 1.327 | 0.011 |
| PFBA | -- | -- | -- | -- | -- | -- | -- | -- |
| PFPeA | -- | -- | -- | -- | -- | -- | -- | -- |
| | 169.9 | 100.0% | -- | -- | -- | -- | -- | -- |

Notes:

1. @ 100 µg/L, the AUR for PFMOAA is likely within the 0.118 to 0.141 range, given that the isotherms for these two estimates were based on concentrations of 85 and 750 µg/L, respectively. The value is likely closer to the 0.118 value given that 100 µg/L is close to the 85 µg/L isotherm conditions; assume 0.125 g/L.
2. @ 8.7 µg/L, the AUR for PMPA is likely in the middle of the 0.105 to 0.151 range, but closer to 0.151 given that the isotherms for these two estimates were based on concentrations of 40 and 5.4 µg/L, respectively; assume 0.15 g/L.
3. IS-01 (Perched Zone) corresponds to isotherm pilot study performed by others.
4. IS-04 through IS-07 (Upper OOF2) corresponds to a dual-test isotherm pilot study performed by others.
5. For a given isotherm pilot test, bold indicates upper-end AUR estimate for the COCs considered.

# APPENDIX C-2
# Structural Calculations

**APPENDIX C STRUCTURAL CALCULATIONS**
**UPLIFT - SEEP C**
**Chemours Fayetteville Works, North Carolina**

**STEP 1: CALCULATE UPLIFT FORCE**

water weight (pcf) 62.4

| Chamber | length (ft) | width (ft) | height (ft) | vol (ft$^3$) | bouyant force (lbs) |
|---|---|---|---|---|---|
| 1 | 4.67 | 3.99 | 7.50 | 140 | 8,720 |
| 2 | 10 | 10 | 7.50 | 750 | 46,800 |
| 3 | 10 | 3.99 | 7.50 | 299 | 18,673 |
| 4 | 10 | 10 | 7.50 | 750 | 46,800 |
| 5 | 12.67 | 3.99 | 7.50 | 379 | 23,659 |
| 6 | 3.5 | 3.99 | 7.50 | 105 | 6,536 |
| 7 | 2.48 | 3.99 | 7.50 | 74 | 4,631 |
| concrete | | | | 998 | 62,269 |
| | | | | | 218,088 total uplift (lbs.) |

**STEP 2: CALCULATE DOWNWARD FORCE**

**2A: Concrete**

conc weight (pcf) 150

| Concrete Section | length (ft) | width (ft) | height (ft) | vol (ft$^3$) | weight (lbs) |
|---|---|---|---|---|---|
| wall 1 | 26.67 | 0.67 | 7.50 | 133.35 | 20,003 |
| wall 2 | 26.67 | 0.67 | 7.50 | 133.35 | 20,003 |
| wall 3 | 26.67 | 0.67 | 7.50 | 133.35 | 20,003 |
| wall 4 | 10.00 | 0.67 | 7.50 | 50.25 | 7,538 |
| wall 5 | 10.00 | 0.67 | 7.50 | 50.25 | 7,538 |
| wall 6 | 10.00 | 0.67 | 7.50 | 50.25 | 7,538 |
| wall 7 | 10.00 | 0.67 | 7.50 | 50.25 | 7,538 |
| wall 8 | 3.99 | 0.67 | 7.50 | 20.05 | 3,007 |
| wall 9 | 3.99 | 0.67 | 7.50 | 20.05 | 3,007 |
| wall 10 | 3.99 | 0.67 | 4.00 | 10.69 | 1,604 |
| wall 11 | 3.99 | 0.67 | 7.50 | 20.05 | 3,007 |
| wall 12 | 3.99 | 0.67 | 7.50 | 20.05 | 3,007 |
| wall 13 | 3.99 | 0.67 | 7.50 | 20.05 | 3,007 |
| slab | 26.67 | 16.00 | 0.67 | 285.90 | 42,885 |
| | | | | | 149,684 total concrete (lbs.) |

**2B: Gravel and Carbon (Dry Contents)**

| Content Weight | |
|---|---|
| gravel (pcf) | 140 |
| water weight (pcf) | 62.4 |
| Carbon (pcf) | 30 |

| Chamber No. | item | length (ft) | width (ft) | height (ft) | vol (ft$^3$) | weight (lbs) | |
|---|---|---|---|---|---|---|---|
| 2 | gravel | 10 | 10 | 1 | 100 | 14,000 | |
| 4 | gravel | 10 | 10 | 1 | 100 | 14,000 | |
| 2 | carbon | 10 | 10 | 3 | 300 | 9,000 | |
| 4 | carbon | 10 | 10 | 3 | 300 | 9,000 | |
| | | | | | | 46,000 | total dry content (lbs.) |

**2C: Wet Contents**

| Chamber No. | item | length (ft) | width (ft) | height (ft) | vol (ft$^3$) | weight (lbs) | comment |
|---|---|---|---|---|---|---|---|
| 1 | free water | 4.67 | 3.99 | 6.5 | 121 | 7,558 | |
| 2 | gravel pore space water | 10 | 10 | 1 | 30 | 1,872 | |
| 2 | carbon pore space water | 10 | 10 | 3 | 240 | 14,976 | |
| 2 | free water | 10 | 10 | 2.25 | 225 | 14,040 | |
| 3 | free water | 10 | 3.99 | 5 | 199.5 | 12,449 | |
| 4 | gravel pore space water | | | | | 1,872 | same as 2 |
| 4 | carbon pore space water | | | | | 14,976 | same as 2 |
| 4 | free water | | | | | 14,040 | same as 2 |
| 5 | free water | 12.67 | 3.99 | 4 | 202 | 12,618 | |
| 6 | free water | 3.5 | 3.99 | 4 | 56 | 3,486 | |
| 7 | free water | 2.48 | 3.99 | 1 | 10 | 617 | |
| | | | | | | 98,504 | total wet content when all chambers are full (lbs.) |

| | | |
|---|---|---|
| **TOTAL DOWNWARD FORCE** | 294,188 | Total weight of concrete, gravel, carbon, and water contents |
| **ESTIMATED FACTOR OF SAFETY (DOWNWARD / UPLIFT)[1]** | 1.35 | |

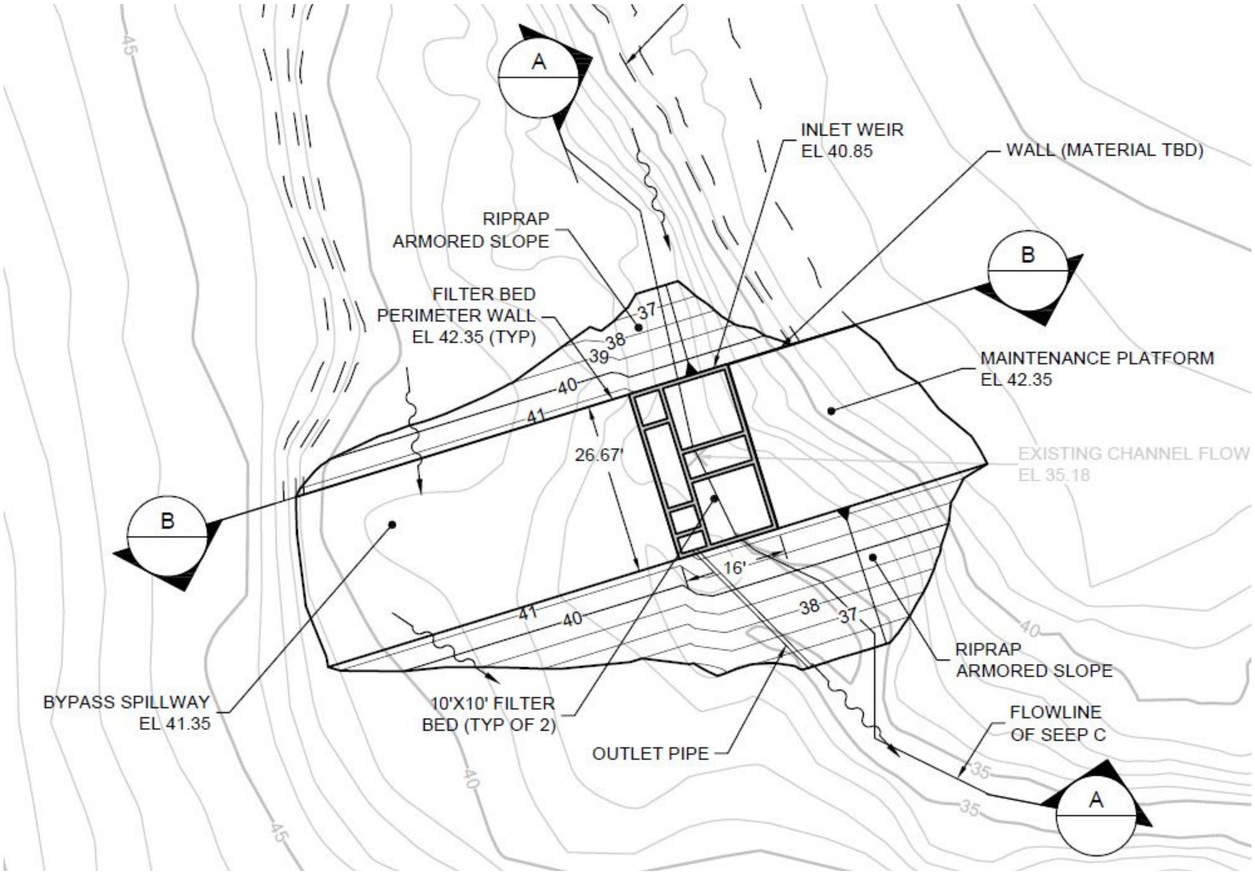
Note:

1) $FS_{required}$ = 1.3 (USACE EM 1110-2-2100, 2005)

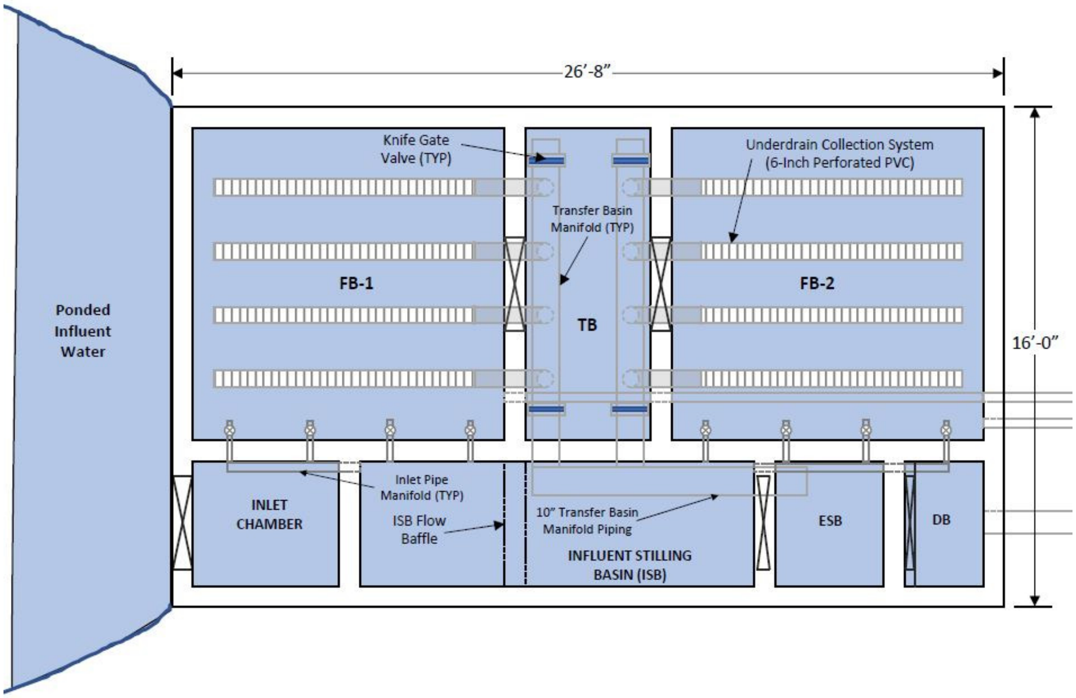
2) Uplift calculations are performed considering a worst-case flood event with the flow-through cell fully submerged in water.

3) The factor of safety would be under acceptable USACE limits if the flow-through cells were emptied/drained of dry and wet contents in a submergence event, i.e., changeouts and maintenance events should be performed during dry weather.

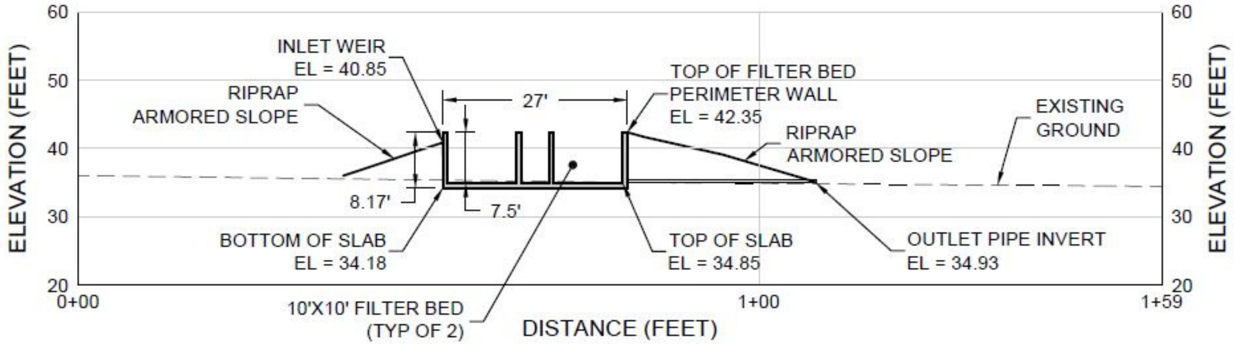
## PLAN VIEW



## BASIN DESIGNATION



## SECTION A-A'



## DESIGN INPUTS

| | | | |
|---|---|---|---|
| Unsupported Wall Height | $H := 42.35 - 34.85 = 7.5$ | $ft$ | |
| Unit Width of Wall | $b := 1$ | $ft$ | |
| Unit Weight of Water | $\gamma_w := 62.4$ | $pcf$ | |
| Unit Weight of Gravel/Riprap | $\gamma_{gravel} := 140$ | $pcf$ | |
| Unit Weight of Concrete | $\gamma_{conc} := 150$ | $pcf$ | |
| Compressive Strength of Concrete | $f'_c := 4000$ | $psi$ | |
| Yield Strength of Reinforcement | $f_y := 60000$ | $psi$ | |
| Minimum Clear Cover for Reinforcement | $c_b := 2$ | $in.$ | (ACI 318-14 20.6.1.3.1) |

## DESIGN CALCULATIONS

The most critical loading case for the design of the reinforced retaining wall is the exterior wall of basin DB adjacent to the riprap armored slope. For this loading case, the full unsupported height of the wall is loaded by the riprap on the exterior and only 1 foot of water on the interior resists the loading. The design calculations below are performed for this loading case and conservatively used for the reinforced concrete design for the remainder of the basin walls.

### Load Calculations

For the load calculations the following assumptions are made:

- The riprap on the exterior is assumed to have a flat slope (i.e., slope effects are not considered in the calculation of the lateral earth pressure diagrams)
- The riprap on the exterior of the wall is fully saturated to represent a flood condition
- The wall is assumed to be in an at-rest condition (i.e., minimal deflection)
- The wall acts as a cantilever (i.e., base is fixed and top is free)
- The critical load combination is 1.2D + 1.6L, where D represents the dead load and L represents the live load. The riprap on the exterior of the wall is a dead load and the water saturating the riprap on the exterior and in the basin is a live load

| | | |
|---|---|---|
| Height of Water in Basin | $h_w := 1$ | $ft$ |
| Effective Friction Angle of Gravel/Riprap | $\phi'_{gravel} := 35$ | $deg$ |

At-Rest Lateral Earth Pressure Coefficient (Jaky, 1944) $K_0 := 1 - \sin\left(\phi'_{gravel} \cdot \frac{\pi}{180}\right) = 0.43$

Exterior of Wall

Effective Vertical Stress at Base of Wall $\sigma'_{v.e} := H \cdot \left(\gamma_{gravel} - \gamma_w\right) = 582$ $psf$

Horizontal Stress at Base of Wall due to Riprap $\sigma_{D.e} := 1.2 \cdot K_0 \cdot \sigma'_{v.e} = 297.8$ $psf$

Horizontal Stress at Base of Wall due to Water $\sigma_{L.e} := 1.6 \cdot H \cdot \gamma_w = 748.8$ $psf$

Resultant Horizontal Load $P_{h.e} := 0.5 \cdot \left(\sigma_{D.e} + \sigma_{L.e}\right) \cdot H \cdot b = 3924.8$ $lb$

Location of Resultant from Base $h_{Ph.e} := \frac{H}{3} = 2.5$ $ft$

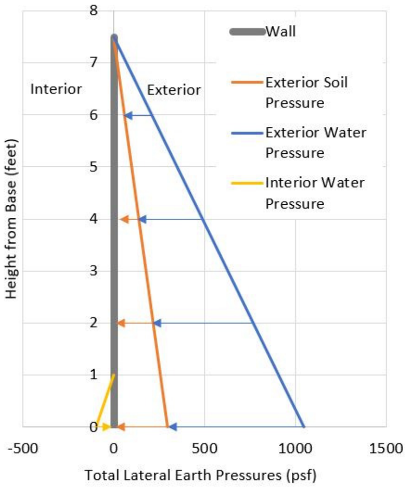
Interior of Wall

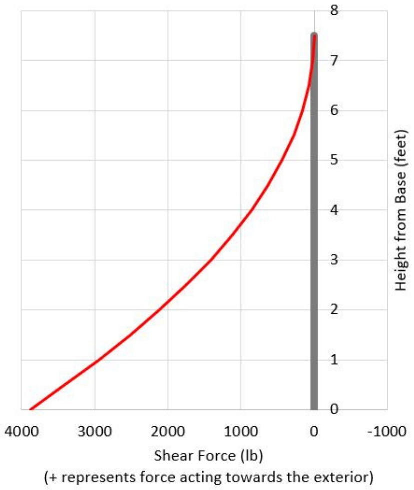
Horitzontal Stress at Base of Wall due to Water $\sigma_{L.i} := 1.6 \cdot h_w \cdot \gamma_w = 99.8$ $psf$

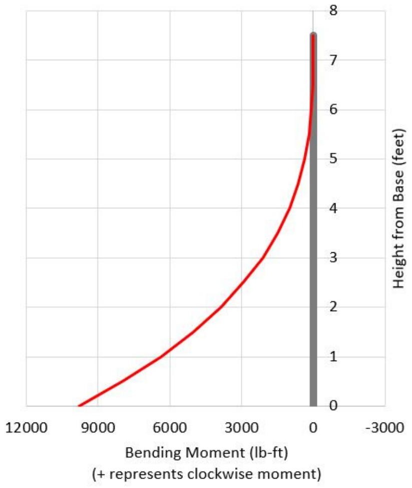
Resultant Horizontal Load $P_{h.i} := 0.5 \cdot \sigma_{L.i} \cdot h_w \cdot b = 49.9$ $lb$

Location of Resultant from Base $h_{Ph.i} := \frac{h_w}{3} = 0.33$ $ft$

Horizontal pressure diagrams and resulting shear force and bending moment diagrams are shown below







The ultimate factored shear force and bending moment occur at the base of the wall and are calculated as below

**Ultimate Shear Force** $V_u := P_{h.e} - P_{h.i} = 3874.9$ $lb$ to the right

**Ultimate Bending Moment at Base** $M_u := P_{h.e} \cdot h_{Ph.e} - P_{h.i} \cdot h_{Ph.i} = 9795.4$ $lb-ft$ clockwise

Wall Design

Initially assume 8-inch thick concrete wall with #4 reinforcement with 12-inch center-to-center spacing on both faces in both vertical and horizontal directions

Thickness of Wall $t_{wall} := \frac{8}{12} = 0.67$ $ft$

Diameter of Reinforcement Bar $d_b := 0.5$ $in.$

Effective Depth of Wall $d_{wall} := t_{wall} \cdot 12 - c_b - \frac{d_b}{2} = 5.75$ $in.$

Spacing of Bars $s_b := 12$ $in.$

Area of Reinforcement Bar $A_b := \pi \cdot \frac{{d_b}^2}{4} = 0.2$ $in.^2$

Area of Reinforcement per Foot $A_{s.v} := \frac{A_b}{\frac{s_b}{12}} = 0.196$ $\frac{in.^2}{ft}$ $A_{s.h} := A_{s.v}$

Moment Design

Depth of Compression Block $a := \frac{A_{s.v} \cdot f_y}{0.85 \cdot (b \cdot 12) \cdot f'_c} = 0.29$ $in.$

Depth to Neutral Axis $c := \frac{a}{0.85} = 0.34$ $in.$

Strain at Extreme Tensile Fiber $\varepsilon_t := \frac{0.003}{c} \cdot d_{wall} - 0.003 = 0.048$

Section is tension-controlled because $\varepsilon_t$ > 0.005

Reduction Factor for Bending $\phi_b := 0.9$ (ACI 318-14 21.2.1)

Area of Flexural Steel Required to Resist Bending Moment $A_{s.reqd} := \frac{M_u \cdot 12}{\phi_b \cdot f_y \cdot \left(d_{wall} - \frac{a}{2}\right)} = 0.388 \frac{in.^2}{ft}$

The area of flexural steel required (0.388 sq. in.) is greater than the area of steel provided by #4 reinforcement spaced at 12 inches (0.196 sq. in.). Therefore, change vertical reinfrocement to #6 reinforcement with 12-inch center-to-center spacing.

Diameter of Reinforcement Bar $d_b := 0.75$ $in.$

Effective Depth of Wall $d_{wall} := t_{wall} \cdot 12 - c_b - \frac{d_b}{2} = 5.63$ $in.$

Spacing of Bars $s_b := 12$ $in.$

Area of Reinforcement Bar $A_b := \pi \cdot \frac{{d_b}^2}{4} = 0.44$ $in.^2$

Area of Reinforcement per Foot $A_{s.v} := \frac{A_b}{\frac{s_b}{12}} = 0.442$ $\frac{in.^2}{ft}$

Moment Design - 2nd Iteration

Depth of Compression Block $a := \frac{A_{s.v} \cdot f_y}{0.85 \cdot (b \cdot 12) \cdot f'_c} = 0.65$ $in.$

Depth to Neutral Axis $c := \frac{a}{0.85} = 0.76$ $in.$

Strain at Extreme Tensile Fiber $\varepsilon_t := \frac{0.003}{c} \cdot d_{wall} - 0.003 = 0.019$

Section is tension-controlled because $\varepsilon_t$ > 0.005

Reduction Factor for Bending $\phi_b := 0.9$ (ACI 318-14 21.2.1)

Area of Flexural Steel Required to Resist Bending Moment $A_{s.reqd} := \dfrac{M_u \cdot 12}{\phi_b \cdot f_y \cdot \left(d_{wall} - \dfrac{a}{2}\right)} = 0.411\ \dfrac{in.^2}{ft}$

**The area of flexural steel required (0.411 sq. in.) is less than the area of steel provided by #6 reinforcement spaced at 12 inches (0.442 sq. in.)**

Shear Design

Reduction Factor for Bending $\phi_v := 0.75$ (ACI 318-14 21.2.1)

Lightweight Concrete Factor (for normalweight concrete) $\lambda := 1$

Shear Capacity of Concrete $V_c := 2 \cdot \lambda \cdot \sqrt{f'_c} \cdot (b \cdot 12) \cdot d_{wall} = 8538.1\ lb$

(ACI 318-14 22.5.5.1)

Check Cross-Sectional Dimensions $\phi_v \cdot \left(V_c + 8 \cdot \sqrt{f'_c} \cdot (b \cdot 12) \cdot d_{wall}\right) = 32018.1\ lb$

which is greater than $V_u$ (ACI 318-14 22.5.1.2)

Check for Transverse Reinforcement $\phi_v \cdot V_c = 6403.6\ lb$ $V_u = 3874.9\ lb$

**Because $\phi_v \cdot V_c$ is greater than $V_u$, no transverse reinforcement is required for shear**

Reinforcement Detailing

Minimum Vertical Reinforcement (ACI 318-14 11.6.1) $A_{s.min.v} := 0.0015 \cdot (b \cdot 12) \cdot t_{wall} = 0.012\ \dfrac{in.^2}{ft}$

$A_{s.min.v} < A_{s.v}$

Minimum Horizontal Reinforcement (ACI 318-14 11.6.1) $A_{s.min.h} := 0.0025 \cdot (b \cdot 12) \cdot t_{wall} = 0.02\ \dfrac{in.^2}{ft}$

$A_{s.min.h} < A_{s.h}$

Note: The reinforcement ratios required for shrinkage and temperature reinforcement (0.0018) are less than the reinforcement ratios above. Shrinkage and temperature reinforcement are satisfied.

Development Length

Modification Factor for Epoxy $\Psi_e := 1.5$ (ACI 318-14 25.4.2.4)

Modification Factor for Casting Position $\Psi_t := 1$ (ACI 318-14 25.4.2.4)

Straight Development Length for #6 Reinforcement with Spacing Greater Than 2d_b and Cover Greater Than d_b (ACI 318-14 25.4.2.2)

for #6 Reinforcement $l_{d.6} := \left(\dfrac{f_y \cdot \Psi_t \cdot \Psi_e}{25 \cdot \lambda \cdot \sqrt{f'_c}}\right) \cdot 0.75 = 42.7\ in.$

for #4 Reinforcement $l_{d.4} := \left(\dfrac{f_y \cdot \Psi_t \cdot \Psi_e}{25 \cdot \lambda \cdot \sqrt{f'_c}}\right) \cdot 0.5 = 28.5\ in.$

Splice Length

Tension Lap Splice Length for Class A Splice (ACI 318-14 25.5.2.1)

for #6 Reinforcement $l_{st.6} := l_{d.6} = 42.7 \ in.$ greater than 12 in.

for #4 Reinforcement $l_{st.4} := l_{d.4} = 28.5 \ in.$ greater than 12 in.

Spacing of Reinforcement

Maximum Spacing of Longitudinal Reinforcement (ACI 318-14 11.7.2.1)

$$s_{max.v} := \min\left(3 \cdot t_{wall} \cdot 12 , 18\right) = 18 \ in.$$

Maximum Spacing of Transverse Reinforcement (ACI 318-14 11.7.3.1)

$$s_{max.h} := \min\left(3 \cdot t_{wall} \cdot 12 , 18\right) = 18 \ in.$$

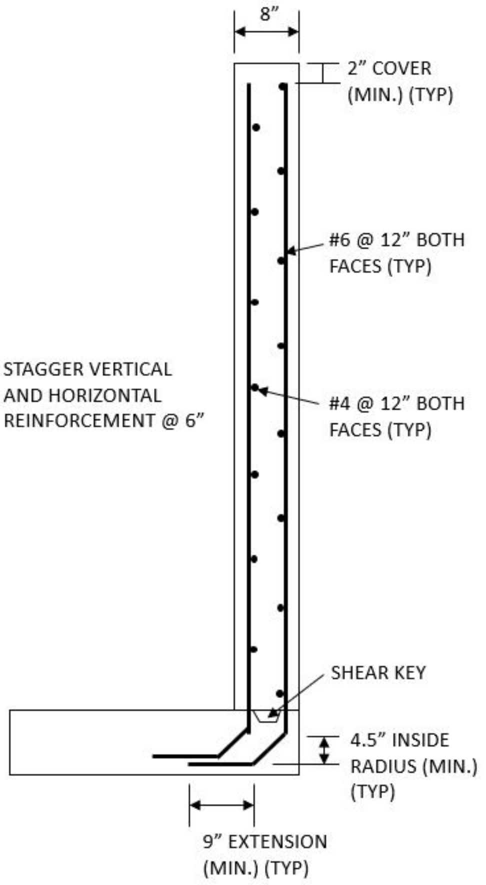
Spacing of 12 inches for vertical and transverse reinforcement is less than 18 inches

Hook Details for 90-Degree Hooks (ACI 318-14 25.3.1)

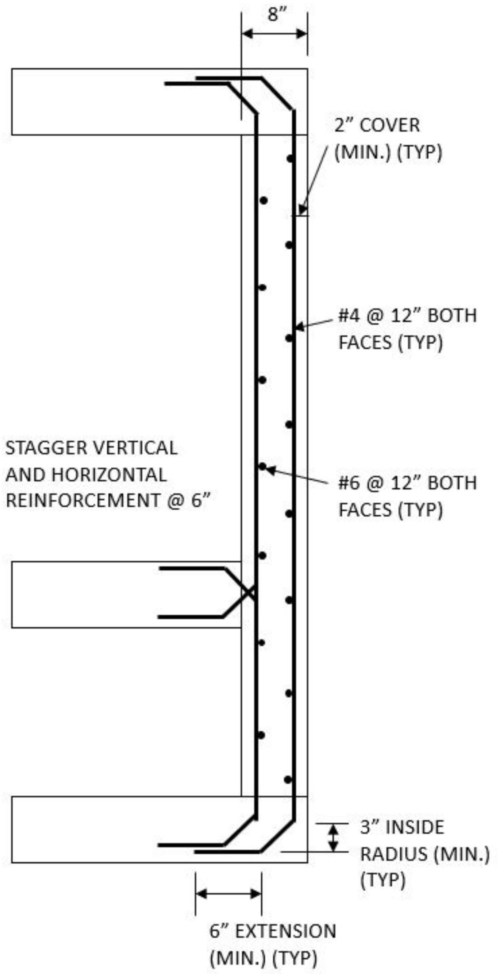
| | | | |
|---|---|---|---|
| Inside Bend Diameter | #4 | $6 \cdot 0.5 = 3$ | in. |
| | #6 | $6 \cdot 0.75 = 4.5$ | in. |
| Straight Extension | #4 | $12 \cdot 0.5 = 6$ | in. |
| | #6 | $12 \cdot 0.75 = 9$ | in. |

## PRELIMINARY DETAILS

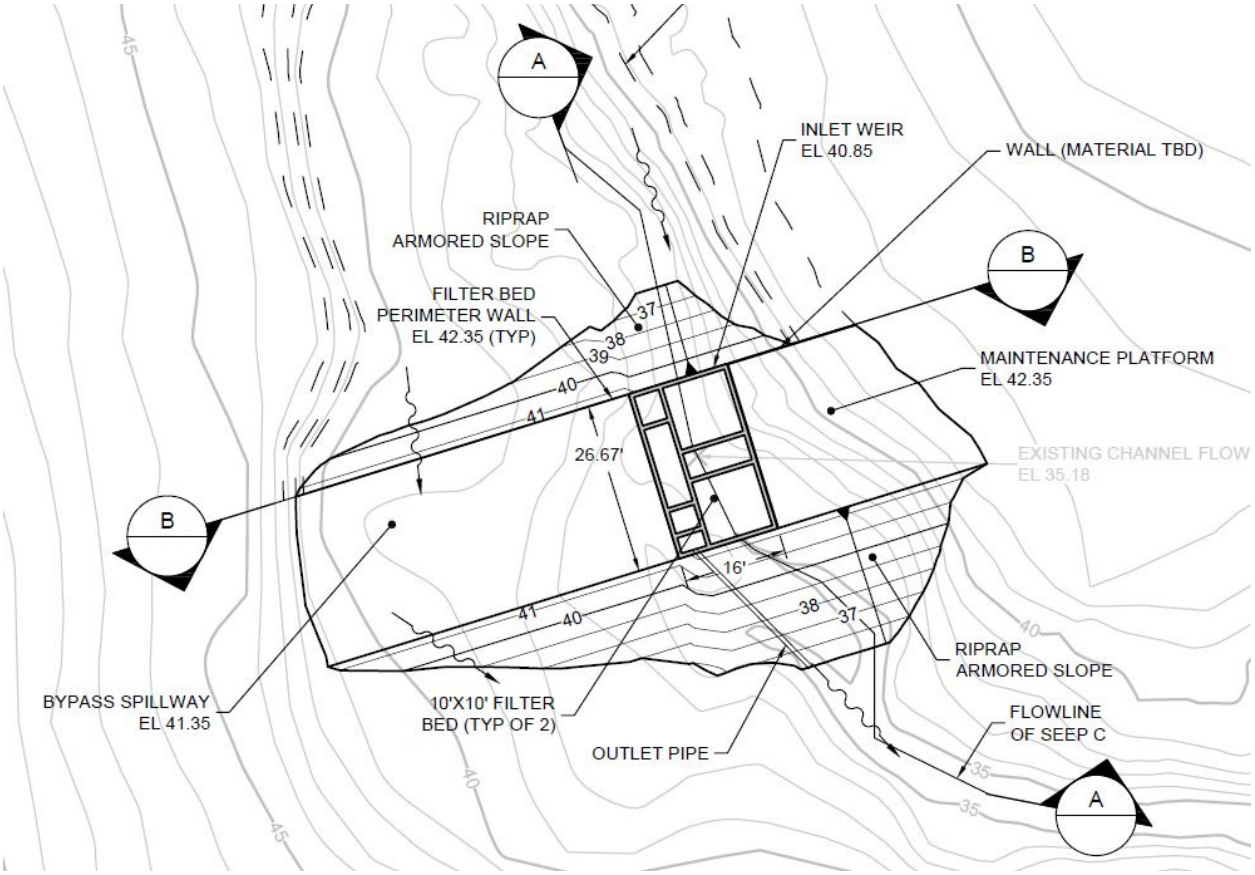
Section View (NOT TO SCALE)



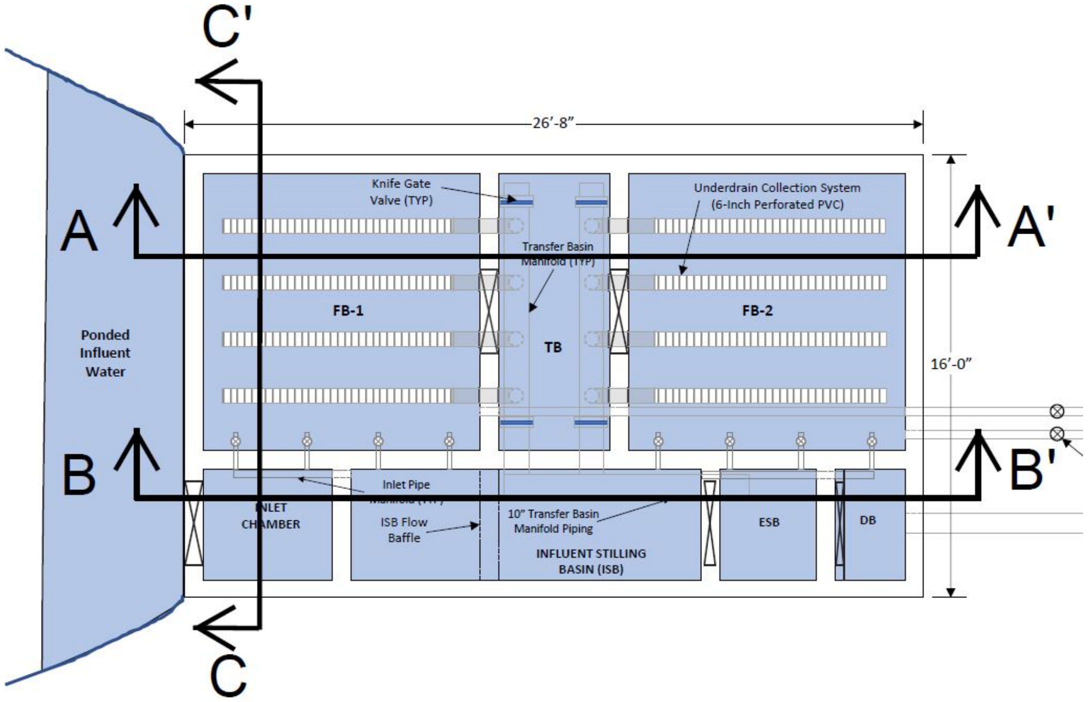
Plan View (NOT TO SCALE)



## PLAN VIEW



## BASIN DESIGNATION



## DESIGN INPUTS

| | | | |
|---|---|---|---|
| Unit Width of Slab | $b := 1$ | *ft* | |
| Unit Weight of Water | $\gamma_w := 62.4$ | *pcf* | |
| Unit Weight of Carbon | $\gamma_{carbon} := 88$ | *pcf* | |
| Unit Weight of Gravel/Riprap | $\gamma_{gravel} := 140$ | *pcf* | |
| Unit Weight of Concrete | $\gamma_{conc} := 150$ | *pcf* | |
| Compressive Strength of Concrete | $f'_c := 4000$ | *psi* | |
| Yield Strength of Reinforcement | $f_y := 60000$ | *psi* | |
| Minimum Clear Cover for Reinforcement | $c_b := 2$ | *in.* | (ACI 318-14 20.6.1.3.1) |

Initially, assume a slab thickness of 8 inches

| | | |
|---|---|---|
| Thickness of Slab | $t_{slab} := \frac{8}{12} = 0.67$ | *ft* |

Assume the foundation soils are sands with clays or stiff clays

| | | |
|---|---|---|
| Modulus of Subgrade Reaction | $K := 300000$ | *pcf* |

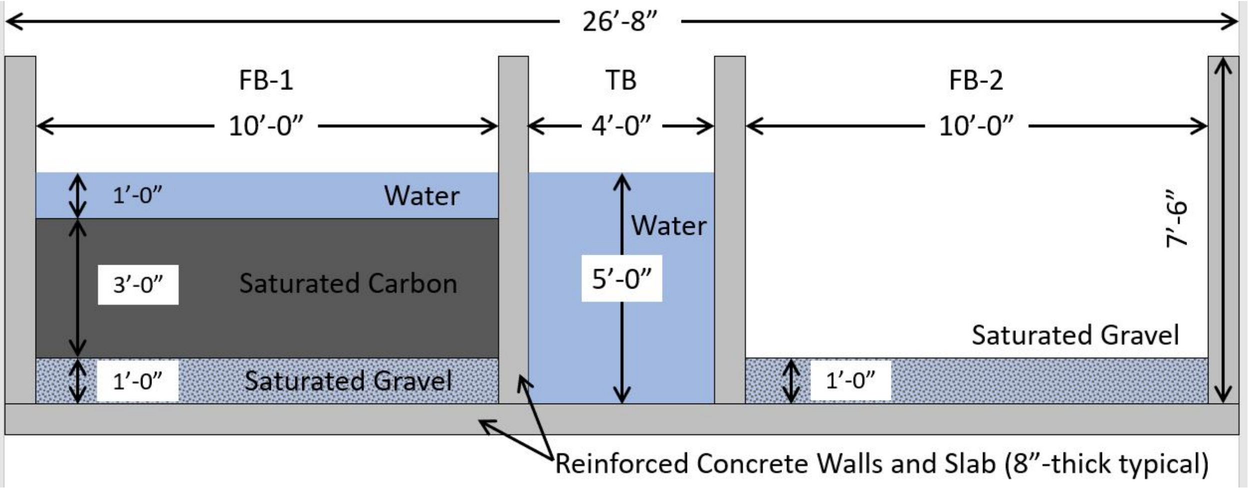
## CRITICAL SECTIONS

Variations in materials and water levels within adjacent basins causes shear forces and bending moments on the slab. Critical sections were identified based on largest differences between materials and water levels in adjacent basins. Three critical sections were evaluated to identify the ultimate factored shear forces and bending moments.

The critical load combination is assumed to be 1.2D + 1.6L where D represents the dead load and L represents the live load. The concrete, gravel, and carbon are considered as dead loads while the water is considered as a live load.

### Section A-A'

For Section A-A', the critical loading represents conditions during the change out of FB-2 where the spent carbon is removed. The maximum water level in FB-1 is considered.



Distributed Loads

Full-Height Concrete Wall $w_{conc} := 1.2 \cdot \left(7.5 \cdot b \cdot \gamma_{conc}\right) = 1350$ plf

FB-1 $w_{FB1.A} := 1.2 \cdot \left(1 \cdot b \cdot \left(\gamma_{gravel} - \gamma_w\right) + 3 \cdot b \cdot \left(\gamma_{carbon} - \gamma_w\right)\right) + 1.6 \cdot \left(5 \cdot b \cdot \gamma_w\right)$

$w_{FB1.A} = 684.5$ plf

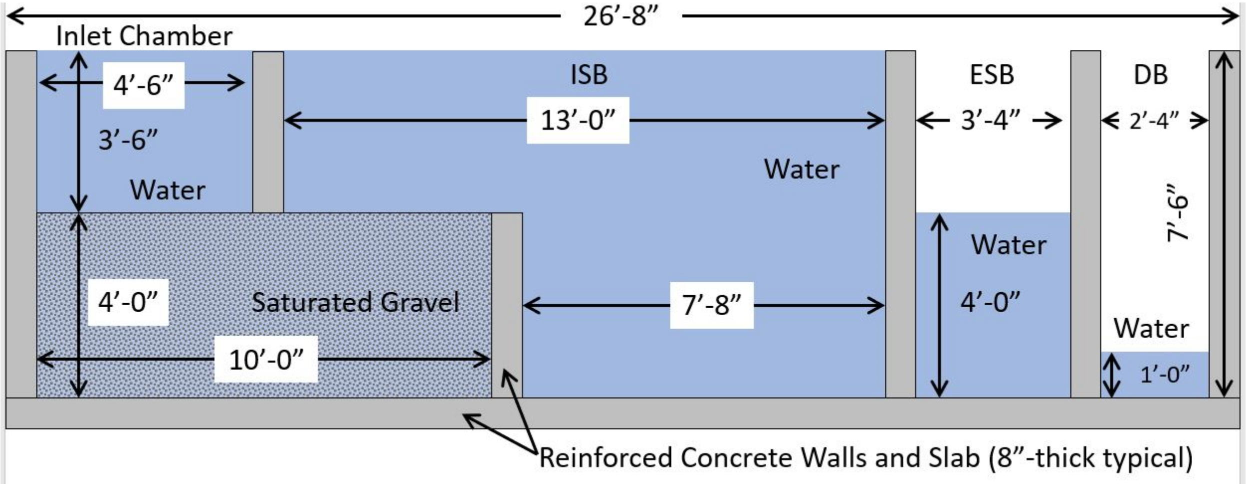
TB $w_{TB.A} := 1.6 \cdot \left(5 \cdot b \cdot \gamma_w\right) = 499.2$ plf

FB-2 $w_{FB2.A} := 1.2 \cdot \left(1 \cdot b \cdot \left(\gamma_{gravel} - \gamma_w\right)\right) + 1.6 \cdot \left(1 \cdot b \cdot \gamma_w\right)$

$w_{FB2.A} = 193$ plf

## Section B-B'

For Section B-B', the critical loading represents conditions through the Inlet Chamber, ISB, ESB, and DB. The maximum water levels in the Inlet Chamber and ISB and the minimum water level in the DB are considered. The partial concrete wall separating the Inlet Chamber and ISB is not considered as the loads are transfered to the perimeter walls of the basin.



Distributed Loads

Gravel Bed $w_{gb} := 1.2 \cdot \left(4 \cdot b \cdot \left(\gamma_{gravel} - \gamma_w\right)\right) + 1.6 \cdot \left(7.5 \cdot b \cdot \gamma_w\right)$

$w_{gb} = 1121.3$ plf

Partial Wall in ISB $w_{ISB.wall} := 1.2 \cdot \left(4 \cdot b \cdot \gamma_{conc}\right) + 1.6 \cdot \left(3.5 \cdot b \cdot \gamma_w\right)$

$w_{ISB.wall} = 1069.4$ plf

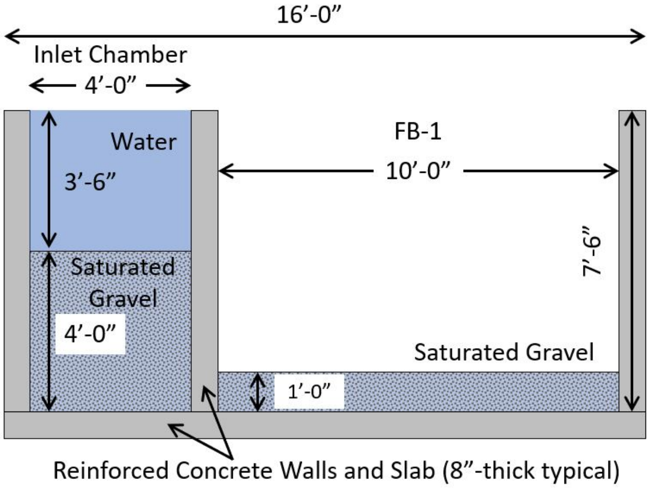
ISB Water $w_{ISB.water} := 1.6 \cdot \left(7.5 \cdot b \cdot \gamma_w\right) = 748.8$ plf

ESB $w_{ESB} := 1.6 \cdot \left(4 \cdot b \cdot \gamma_w\right) = 399.4$ plf

DB $w_{DB} := 1.6 \cdot \left(1 \cdot b \cdot \gamma_w\right) = 99.8$ plf

Section C-C'

For Section C-C', the critical loading represents conditions during the change out of FB-1 where the spent carbon is removed. The maximum water level in the Inlet Chamber is considered.



Distributed Loads

Inlet Chamber $w_{IC.C} := 1.2 \cdot (4 \cdot b \cdot (\gamma_{gravel} - \gamma_w)) + 1.6 \cdot (7.5 \cdot b \cdot \gamma_w)$

$w_{IC.C} = 1121.3$ plf

FB-1 $w_{FB1.C} := 1.2 \cdot (1 \cdot b \cdot (\gamma_{gravel} - \gamma_w)) + 1.6 \cdot (1 \cdot b \cdot \gamma_w)$

$w_{FB1.C} = 193$ plf

The ultimate factored shear force and bending moment occur along Section C-C' within the slab below FB-1.

**Ultimate Shear Force** $V_u := 765$ lb

**Ultimate Bending Moment at Base** $M_u := 1339.4$ lb−ft

Slab Design

Initially assume #4 reinforcement with 12-inch center-to-center spacing on both faces in both directions

Diameter of Reinforcement Bar $d_b := 0.5$ in.

Effective Depth of Wall $d_{slab} := t_{slab} \cdot 12 - c_b - \frac{d_b}{2} = 5.75$ in.

Spacing of Bars $s_b := 12$ in.

Area of Reinforcement Bar $A_b := \pi \cdot \frac{d_b^{\,2}}{4} = 0.2$ in.$^2$

Area of Reinforcement per Foot $A_{s.ns} := \frac{A_b}{\frac{s_b}{12}} = 0.196$ $\frac{in.^2}{ft}$ $A_{s.ew} := A_{s.ns}$

## Moment Design

Depth of Compression Block $a := \frac{A_{s.ns} \cdot f_y}{0.85 \cdot (b \cdot 12) \cdot f'_c} = 0.29$ $in.$

Depth to Neutral Axis $c := \frac{a}{0.85} = 0.34$ $in.$

Strain at Extreme Tensile Fiber $\varepsilon_t := \frac{0.003}{c} \cdot d_{slab} - 0.003 = 0.048$

Section is tension-controlled because $\varepsilon_t$ > 0.005

Reduction Factor for Bending $\phi_b := 0.9$ (ACI 318-14 21.2.1)

Area of Flexural Steel Required to Resist Bending Moment $A_{s.reqd} := \frac{M_u \cdot 12}{\phi_b \cdot f_y \cdot \left(d_{slab} - \frac{a}{2}\right)} = 0.053 \frac{in.^2}{ft}$

**The area of flexural steel required (0.053 sq. in.) is less than the area of steel provided by #4 reinforcement spaced at 12 inches (0.196 sq. in.)**

## Shear Design

Reduction Factor for Bending $\phi_v := 0.75$ (ACI 318-14 21.2.1)

Lightweight Concrete Factor (for normalweight concrete) $\lambda := 1$

Shear Capacity of Concrete $V_c := 2 \cdot \lambda \cdot \sqrt{f'_c} \cdot (b \cdot 12) \cdot d_{slab} = 8727.9$ $lb$

(ACI 318-14 22.5.5.1)

Check Cross-Sectional Dimensions $\phi_v \cdot \left(V_c + 8 \cdot \sqrt{f'_c} \cdot (b \cdot 12) \cdot d_{slab}\right) = 32729.6$ $lb$

which is greater than $V_u$ (ACI 318-14 22.5.1.2)

Check for Transverse Reinforcement $\phi_v \cdot V_c = 6545.9$ $lb$ $V_u = 765$ $lb$

**Because $\phi_v \cdot V_c$ is greater than $V_u$, no transverse reinforcement is required for shear**

## Reinforcement Detailing

Minimum Reinforcement (ACI 318-14 8.6.1.1) $A_{s.min} := 0.0018 \cdot (b \cdot 12) \cdot t_{slab} = 0.014$ $\frac{in.^2}{ft}$

$A_{s.min.v} < A_{s.ns}$ and $A_{s.min.v} < A_{s.ew}$

Note: The reinforcement ratios required for shrinkage and temperature reinforcement (0.0018) equal the reinforcement ratios above. Shrinkage and temperature reinforcement are satisfied.

Development Length

Modification Factor for Epoxy $\Psi_e := 1.5$ (ACI 318-14 25.4.2.4)

Modification Factor for Casting Position $\Psi_t := 1$ (ACI 318-14 25.4.2.4)

Straight Development Length for #6 Reinforcement with Spacing Greater Than 2d_b and Cover Greater Than d_b (ACI 318-14 25.4.2.2) for #4 Reinforcement $l_{d.4} := \left( \dfrac{f_y \cdot \Psi_t \cdot \Psi_e}{25 \cdot \lambda \cdot \sqrt{f'_c}} \right) \cdot 0.5 = 28.5$ in.

Splice Length

Tension Lap Splice Length for Class A Splice (ACI 318-14 25.5.2.1)

for #4 Reinforcement $l_{st.4} := l_{d.4} = 28.5$ in. greater than 12 in.

Spacing of Reinforcement

Maximum Spacing of Longitudinal Reinforcement (ACI 318-14 8.7.2.2)

$$s_{max} := \min\left(2 \cdot t_{slab} \cdot 12\,,\, 18\right) = 16 \quad in.$$

Spacing of 12 inches for both directions of reinforcement is less than 16 inches

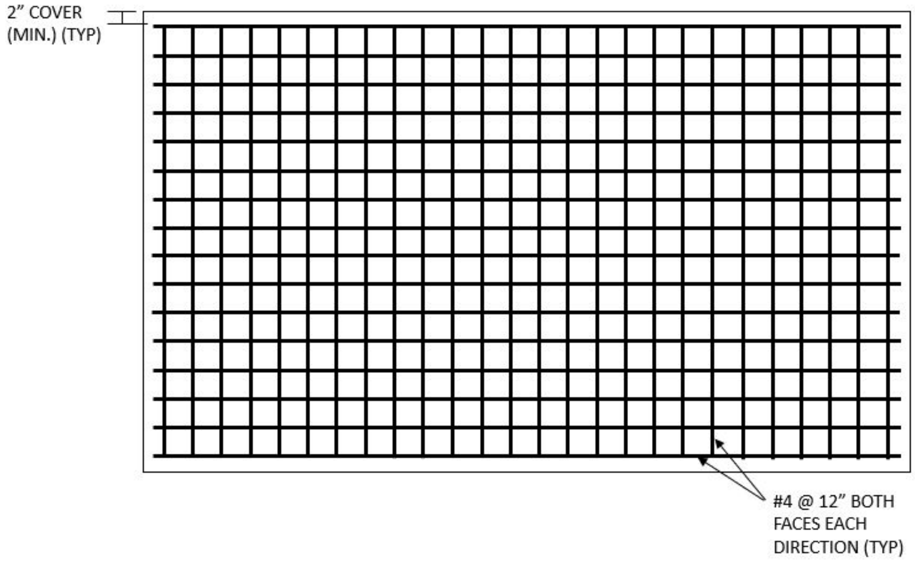
Hook Details for 90-Degree Hooks (ACI 318-14 25.3.1)

Inside Bend Diameter #4 $6 \cdot 0.5 = 3$ in.

Straight Extension #4 $12 \cdot 0.5 = 6$ in.

**PRELIMINARY DETAILS**

Plan View (NOT TO SCALE)



Section View (NOT TO SCALE)