FEASIBILITY OF ON-SITE WATER QUALITY MONITORING AT CONCENTRATED ANIMAL FEEDING OPERATIONS

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I. Executive Summary

Pursuant to Chapter 760, Acts of 2019, the Maryland Department of the Environment (MDE) has studied the feasibility of requiring the installation and use of on-site water quality monitoring equipment at certain concentrated animal feeding operation (CAFO) sites as a condition for issuance of an animal feeding operation (AFO) discharge permit.

To conduct the study, MDE's Water and Science Administration (WSA) compiled technical guidelines for the collection and management of water quality samples at CAFOs. MDE's Land and Materials Administration (LMA) reviewed the technical guidelines provided by WSA, the existing water quality monitoring conditions of the General Discharge Permit for AFOs, and several other logistical and operational variables that influence the feasibility of implementing an on-site water quality monitoring requirement at CAFOs. Based on these considerations, LMA provided findings on the feasibility of requiring on-site water quality monitoring at certain CAFOs.

Certain equipment would need to be purchased to conduct on-site water quality monitoring at a CAFO. This equipment includes an automated sampler and associated equipment, accessory equipment to trigger the automated sampler during a significant rain event and potentially to enable remote communication of the monitoring equipment, a catchment basin, and a power supply for the automated sampler. In order to ensure reliable sampling and analysis, appropriate procedures must be followed to install the equipment, maintain and calibrate equipment periodically, properly collect and handle samples, and analyze samples for the relevant parameters.

In addition to the equipment and the procedures necessary to operate and maintain on-site monitoring, MDE identified several considerations and challenges that would need to be addressed further before implementing an on-site water quality monitoring requirement at certain CAFOs. Specifically:

- Any such requirement would need to account for the variations in animal type, production, and management operating systems, and on-site land application across AFOs;
- MDE would need to establish criteria to identify and prioritize the CAFOs required to install and use on-site water quality monitoring equipment. A variety of factors could be used in setting these criteria, and they would need to be carefully considered to ensure that they serve the goals of the monitoring program;
- The requirement for on-site monitoring would need to be incorporated into the existing CAFO permitting process, which would raise issues of potential permitting delays given that designing, installing, and operating a monitoring system at each CAFO would take time and involve considerable costs;
- The selection of an on-site monitoring location at a CAFO would require a site-specific technical assessment, as the monitoring location must allow for the capture and sampling of surface water flow from rain events;
- Background, legacy, and off-site impacts from past agricultural practices and surrounding residential and habitat areas may influence water quality and complicate any efforts to monitor water quality impacts attributable to a CAFO;
- AFO operators would incur significant costs to install, maintain, and operate the water quality monitoring equipment. Equipment costs are estimated at $7,900 to $21,300 per site, plus additional grading and excavation costs to prepare the site and install the equipment.

Sample analysis costs are estimated at over $100 per sample. These costs may exceed some operators' financial capacity and financial assistance would be needed; and

- Maintaining and operating a water quality monitoring system at a CAFO would require considerable technical knowledge and training on the part of the operator (or a consultant engaged by the operator). MDE's AFO Division would likely also need additional training to ensure compliance with the requirements.

For the installation and use of on-site water quality monitoring at CAFO sites, as a condition for issuance of a discharge permit to be feasible, further discussion and research would be necessary to facilitate reasonable and effective approaches. Additional consultation would be needed with the Maryland Department of Agriculture (MDA), Maryland Farm Bureau , Delmarva Chicken Association, U.S. Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), University of Maryland (UMD), and CAFO owners and operators to address the challenges and considerations identified above. In particular, it would be critical to develop criteria for applying on-site monitoring requirements to certain CAFOs, determine how best to identify appropriate on-site locations for water quality monitoring, identify and provide technical resources and training, plan for changes in AFO Permit coverage and compliance enforcement, and fund resources to support state cost share and other financial assistance.

II. Purpose and Scope

Chapter 760 (Senate Bill 546), Acts of 2019 directed MDE to study and make recommendations regarding the feasibility of requiring the installation and use of on-site water quality monitoring equipment at certain CAFO sites as a condition for issuance of a CAFO discharge permit. Section III of this report outlines technical requirements for installing and operating water quality monitoring equipment at a CAFO. Additionally, the section includes technical guidelines that were provided by the WSA for consideration in the collection and management of on-site water quality samples at CAFOs. Section IV of this report discusses considerations and challenges of implementing an on-site water quality monitoring requirement as a condition precedent to CAFO discharge permit coverage. In identifying these considerations and challenges, the LMA reviewed the technical guidelines provided by WSA, the existing water quality monitoring conditions of the General Discharge Permit for AFO Permit, and several other logistical and operational variables that influence the feasibility of implementing an on-site water quality monitoring requirement at CAFOs. Section V of this report provides recommendations based on the study's findings.

Consistent with the study requirement under Chapter 760, Acts of 2019, this report addresses feasibility of on-site water quality monitoring specific to CAFO sites. AFOs are feedlots or facilities where non-aquatic animals are confined, fed, and maintained for at least 45 days in any 12-month period. In addition, crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. CAFOs are medium or large AFOs that discharge or propose to discharge manure, litter, or process wastewater. Facilities that are designed, constructed, operated, or maintained such that a discharge to surface waters of the state may or will occur propose to discharge. Since CAFOs are point sources under the Clean Water Act, in Maryland, a large AFO must be covered under the AFO Permit whether or not the facility has a man-made ditch, flushing system, or other similar man-made device (such as a swale or pipe) to carry stormwater runoff containing manure, litter, or process wastewater from the production area to surface waters of the state. Medium AFOs are considered CAFOs if they either have a man-made ditch, flushing system, or other similar man-made device (such as a swale or pipe) to carry stormwater runoff containing manure, litter, or process wastewater from the production areas to surface waters of the state; or they directly discharge to surface waters of the state flowing onto or through the property. MDE has the authority to regulate a small AFO as a CAFO if the facility discharges or proposes to discharge manure, litter, or process wastewater to surface waters of the state.

III. Technical Requirements for Installing and Operating On-Site Water Quality Monitoring Equipment at a CAFO

Potential Equipment Needs

The equipment in Table 1 would likely be necessary for an on-site water quality monitoring program at a CAFO site. MDE has provided the most current available costs for this equipment.

Table 1: Potential Equipment Needs for On-Site Water Quality Monitoring at a CAFO

EQUIPMENT	ESTIMATED COST
Refrigerated Automated Sampler with all necessary equipment, including an external trigger using rain gauge, water detection, and/or area-velocity flow sensor	$4,000 - $15,000 This price range depends on whether the automated sampler has remote communication capabilities.
Basin catchment to pool stormwater runoff for automated sampler intake line and potential flow sensor trigger	$200 - $500 Alternative equipment: Parshall Flume-approximate cost $1,700.
Power supply for automated sampler	$600 - $1,500
External housing to protect all equipment for weather, theft, and vandalism	$3,100

Refrigerated Automated Sampler and Associated Equipment

Water quality monitoring at a CAFO requires storm/rain event sampling. Due to this requirement, an automated sampler would be the most practical means of sampling as it can be programmed to collect samples based on rainfall or a flow trigger. Sample collections can be programmed based on time sequence, volume, discrete and composite The alternative, manual sampling, is generally not practical for collection of unscheduled sampling events that can occur over an extended period. A refrigerated unit is necessary if the analytical parameters measured by the laboratory require samples to be chilled to a specific temperature. If parameters to be analyzed do not need to be chilled to a specific temperature, a non-refrigerated sampler system can be used.

There are several different models of automated sampler systems available (e.g., Global Waters, ISCO, and Huber KISS). Regardless of which model is used, automatic samplers must meet the following requirements:

- Sampling equipment must be properly cleaned to avoid cross-contamination, which could result from prior use;
- No plastic or metal parts of the sampler should come in contact with the water stream when parameters to be analyzed could be impacted by these materials;
- If required, the automatic sampler must be capable of providing adequate refrigeration during the sampling period. This can be accomplished in the field by using ice;
- The automatic sampler must be able to collect a large enough sample for all parameter analyses;
- The individual sample aliquot must be at least 100 milliliter if the sampler uses a peristaltic pump;
- The automatic sampler should be capable of providing a lift of at least 20 feet and the sample volume should be adjustable since the volume is a function of the pumping head;
- The pumping velocity must be at least 2 feet/second to transport solids and not allow solids to settle;
- The intake line leading to the pump must be purged before each sample is collected;
- The minimum inside diameter of the intake line should be 1/4 inch; and
- An adequate power source should be available to operate the sampler for the time required to complete the project.

Specific operating instructions, capabilities, capacities, and other pertinent information for automatic samplers are included in their respective operating manuals.

Automated Sampler Triggering Device

The automated sampler needs to be used in conjunction with an auto-drain rain gauge, water detection sensor, and/or area-velocity flow sensor. This accessory equipment will be needed to trigger the automated sampler during a significant rain event that results in overflow discharge of a stormwater pond, a man-made ditch, flushing system, or other similar man-made device on the CAFO property. It is important to ensure that the “trigger” sensor and the automated sampler can communicate properly.

If the sampling will occur based on a specified amount of rainfall, the automated sampler can be triggered by a rain gauge. A variety of quality instruments are available, but all require substantial maintenance to ensure consistent high-quality data. The rain gauge must be compatible with the automated sampler. Even if the sampler is not triggered by rainfall, the use of a localized rain gauge provides a better representation of conditions at the site.

If the sampling will occur based on a specific flow volume, the sampler can be triggered by a flow sensor. Area-velocity (flow) sensors use Doppler-based sensors to measure the velocity of water in the conveyance and a pressure sensor to measure water depth. With the addition of channel depth information, this can allow for real-time flow measurements to trigger and pace the sampler.

Remote Communication

The ability to remotely communicate with the monitoring equipment provides more efficiency

when sampling stormwater runoff. Telemetry communication with sites reduces the number of field visits by personnel. It allows the person managing the sampling program to make informed decisions during storms to best allocate human resources. By remotely monitoring the status of each site, the manager can more accurately estimate when composite bottles will fill and direct field crews to the site to avoid disruptions in the sampling. Real time access to sampling, flow, and rainfall data also provides important information for determining when sampling should be terminated, and crews directed to collect and process the samples. Increases in both efficiency and sample quality make remote telemetry communication a necessity for most stormwater monitoring programs.

Catchment Basin

Flow-weighted stormwater sampling requires the ability to accurately measure flow over the full range of conditions that occur at the monitoring site. The ability to accurately measure flow at an outfall site should be carefully considered during the initial site selection process. Hydraulic characteristics of a site for accurate flow measurement include a relatively straight, uniform, and sufficient depth of water so as to not disrupt establishment of uniform flow conditions. Resources such as the latest edition of the Isco Open Channel Flow Measurement Handbook can be helpful in selecting the most appropriate approach for flow measurements and information on the constraints of each method. Most likely some physical alterations would be required to create an adequate site for accurate flow measurement. This may require installation of a man-made channel, piping, stilling well, or catchment basin (Figure 1). In addition to an area-velocity flow sensor, installation of a staff gauge at the monitoring site would be recommended.

Automated samplers typically use a ¼ inch polyethylene flexible tubing with an intake strainer to draw water into the sample bottles (Figure 2). Discharge from a stormwater pond or man-made ditch or swale would need to be deep enough to completely submerge the intake strainer or the sampler’s pump will not work properly. If needed, a basin catchment can be installed to pool the surface water flow to the requisite depth to submerge the intake strainer.

Figure 1: Catchment Basin
Figure 2: Sampler Intake Strainer

Power Source

Automated sampling systems can generally be powered by battery or standard 120VAC. Since the monitoring sites for this type of project are typically located outdoors on agricultural sites, there may not be a readily available 120VAC power source. Most automated samplers can be powered by external, sealed deep-cycle marine batteries. All batteries would need to be placed in plastic marine battery cases to isolate the terminals and wiring. Sites relying on battery power would also need to be equipped with solar panels to assure that a full charge is available when equipment is needed for a storm event. There are several different power source options available depending on the type of automated sampler being used and its energy requirements.

Enclosure

Due to the cost and sensitivity of sampling equipment, it is recommended the automated sampler system be housed in a protective fiberglass enclosure (Figure 3). Typically, the most economical full enclosures are made of fiberglass and can be purchased from various companies.

Figure 3: Enclosure

Installation of Monitoring Equipment

Monitoring the water quality of a point source discharge from a CAFO would typically require sampling during a significant storm or rain event, which results in overflow from a stormwater pond, man-made ditch, flushing system, or other similar man-made devices. This overflow runoff could contain manure, litter, or process wastewater from the production areas to surface waters of the state. However, every CAFO property would have to be assessed individually to identify the potential water quality monitoring sites. Once the sampling site location(s) have been identified on the property, installation of monitoring equipment can begin.

Installation of Enclosure

The area around the sampling site may need to be altered to accommodate an automated sampler system and enclosure. The enclosure must be level and securely attached to the ground. For long-term deployment, it may be advantageous to create a concrete pad or wood deck to sit the enclosure on. Once the enclosure system has been installed, all necessary equipment must be placed inside the enclosure in a way that is secure, accessible, and can be maintained properly. Any required accessory equipment such as rainfall gauges and/or solar panels need to securely attach to the outside of the enclosure.

Installation of Automated Sampler

The automated sampler system would be protected in the enclosure, but would need to be placed where the sampler can be accessed for sampling activities. This includes room for proper function, programming, retrieval of samples, maintenance and cleaning. The sampler intake line and accessory equipment cables that need access to outside the enclosure must be routed through access holes. Sensitive power sources like deep cycle batteries and chargers also need to be stored properly within the enclosure.

The intake line strainer for the automated sampler must be deployed in the discharge water and will need sufficient water depth to work properly, a water catchment basin or stilling well can be installed. The catchment basin would need to be installed either at the stormwater pond overflow or within man made ditch/swale below the area-velocity flow sensor. This may require digging out a specified area, placement of a basin, and installation of all needed piping to ensure proper water retention.

Installation of Automated Sampler Triggering Device

Precipitation data is intrinsically difficult to measure accurately and easy to misinterpret. Therefore, a great deal of care must be taken to collect precipitation data in a consistent and precise way, while annotating the data with as much background detail as possible. Poor equipment maintenance and calibration practices can cause significant errors in data that may be very difficult to identify. To ensure a well-designed and maintained data collection network, these factors must be taken into consideration. The following methods are to be used to install and maintain rainfall monitoring stations. The rainfall gauge requires a clear and unobstructed mounting location to obtain accurate rainfall readings. The gauge should be installed on a stable structure with solid support that does not shake or sway in the wind and in accordance with the manufacturer's instructions. The tipping-bucket type rainfall gauge is the preferred standard for rainfall measurements.

Flow-weighted stormwater sampling requires the ability to accurately measure flow over the full range of conditions that may occur at a monitoring site. Most likely, some physical alterations would be required to record accurate flow measurements. Each monitoring site would need to be assessed individually to determine the most appropriate alterations. The optimal site to install an area-velocity flow transducer is in a pool, stilling well, or catchment basin, which minimizes turbulence to ensure equipment will be submerged during low flows.

In addition to an area-velocity flow sensor, installation of a staff gauge at the monitoring site is recommended. A vertical staff gauge is the preferred instrument for manually measuring surface water levels. Staff gauges must conform to either U.S. Geological Survey Style A (preferred) or Style C standards, and be constructed of 16-gauge porcelain-enameled iron or steel. Staff gauges must be attached to a backing plate and mounted to a stable structure in the water body. The staff gauge must be mounted vertical and plumb to the water surface. The location should be one that allows the instrumentation to record all likely ranges of water levels, are relatively turbulence free, and allows an observer to read the staff gauge with the naked eye.

The project manager may choose to use additional automated recording instruments, which record and store hydrological and meteorological data. The automated recording instruments should be installed inside of the enclosure protecting sensitive electronic instrumentation from weather, theft/vandalism, fire damage, ultraviolet radiation degradation, and/or other detrimental field conditions.

Installation of Remote Communications

Telemetry-equipped stations transmit and receive information on surface water levels, rainfall, automated sampler activity, and other hydro-meteorological data from field locations. Telemetry equipment, such as modems, radio transmitter, antenna, wireless cellular equipment, and other accessory equipment, should be installed in accordance with established procedures and the manufacturer's instructions. All equipment except for the antenna should be installed in the enclosure to protect the recording and telemetry instrumentation from weather conditions, vandalism, fire damage, ultraviolet radiation degradation, and/or other detrimental field conditions. The antenna should be securely mounted to the outside of the enclosure. Telemetry equipment deployed at monitoring stations can vary depending on ever changing and rapid advances in technology, as well as site-specific conditions.

Recommended installation instructions could be different for each specific manufacturer's model. Before purchasing, installing, and using any scientific equipment it is crucial to read all instruction manuals.

Monitoring Equipment Maintenance, Calibration and Quality Control

The collection of high-quality field data is partly a function of the quality of the installation and maintenance of the instruments used to measure the data. To ensure proper operation of automatic samplers, and thus the collection of representative samples, the following regular maintenance and calibration procedures should be used. In general, once per year each instrument should be replaced with a calibrated instrument.

Automated Sampler

Prior to being used, the sampler operation should be checked to ensure it is functioning properly. This includes operation (forward, reverse, and automatic) of at least one purge-pump-purge cycle, checking desiccant (and replacing if necessary), checking the 12-volt batteries to be used with the sampler, and repairing any item as/if necessary. During each field trip, prior to initiating the automatic sampler, the rinse and purge-pump-purge cycle shall be checked at least once. The pumping volume should be checked at least twice using a graduated cylinder or other calibrated container prior to initiating the sampler. For flow proportional sampling, the flow meter that activates the sampler should be checked to ensure that it operates properly. The automatic sampler should be checked against the manufacturer's specifications and documented whenever one or more of the sampler functions appear to be operating improperly.

The sampler would need to be cleaned before and between each sampling event to minimize the transfer risk of contaminants between sampling events. Sampling and field equipment must be cleaned in accordance with proper procedures to meet the minimum requirements for quality control objectives of the monitoring project. Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment.

Rain Gauge

General cleanliness is very important to ensure trouble-free operation of rainfall gauges. Gauges must be kept clean so that measurements can be read accurately. The receiver of the instrument should be checked for horizontal alignment and levelness, as a leaning gauge can compromise measurement accuracy. If the gauge does not appear to be exposed in a level horizontal plane, repairs should be immediately performed and documented. At each site visit, the instrument should be closely inspected for problems that would affect the accuracy of the measurement. If a problem is found, the technician must enter this information into their field notes so maintenance can be scheduled. Manufacturer’s specific guidelines for maintenance and calibration should be observed. Once every six months, the following maintenance should be performed in addition to the preventative maintenance work referenced above:

- Perform a field calibration test with a known volume of water in accordance with established field operating procedures;
- If the instrument is found to be out of calibration, it should be replaced with a calibrated instrument (no adjustments should be made in the field); and
- Timing intervals and dates of records must be checked.

Once per year, the rain gauge should be taken out-of-service and brought to the project office for annual maintenance activities. This includes cleaning and calibrating components of the gauge. Manufacturer's specific guidelines for maintenance and calibration should be observed.

Area-Velocity Flow Transducer

The location where the area-velocity flow transducer is installed must be inspected and maintained on a regular basis. The physical integrity of the transducer, including the support structure, should be checked during each site visit. The location and transducer should be kept free of debris, encrustation, any foreign objects, and the buildup of sand and silt. Any obvious signs of damage or degradation to the support structure, transducer, or other components shall be documented, reported, and corrective action(s) taken.

Staff Gauge

Staff gauges are designed for lengthy service and, as such, general cleanliness is very important to ensure trouble-free operation. Staff gauges must be kept clean so that all graduations can be read accurately and be handled in a manner that the calibration is not altered. Periodic brushing will keep the gauge readable. At each site visit, the instrument should be closely inspected for problems that would affect the readability, such as corrosion, and perform maintenance as needed.

Automated Recording & Telemetry Equipment

Any automated recording and telemetry equipment must be checked on a regular basis to make sure it is working properly and has sufficient power supply. If a malfunctioning data-logger unit or corrupted data-logger memory is encountered, the unit should be replaced with a new unit and the problem unit sent back to the manufacturer for repair or replacement. If two-way communication to the monitoring site is not working properly, troubleshooting with specific manufacturer's protocols must be done immediately.

Analytical Parameters and Sample Handling

To assess nutrient loadings from CAFO sites to surface waters the following analytical parameters could be considered; however, parameter decisions may be made on a site-specific basis. Table 2 lists the recommended analytical parameters to be measured, analysis reference, holding times, type of sample container, and process of sample.

PARAMETER	ABBR	METHOD/REFERENCE	MAXIMUM HOLDING TIME	SAMPLE CONTAINER	FILTERED/WHOLE WATER
Nitrate- + Nitrite-N	NO23	EPA (1993) Method 353.2; Rev. 2.0 and/or enzymatic nitrate method. Aquakem 250	(M) 28 days at -20°C	Plastic	Filtered
Ammonium-N	NH4	EPA, (1993) (Method 350.1; Rev. 2.) Aquakem 250 (automated phenate)	28 days at -20°C	Plastic	Filtered
Total Dissolved Nitrogen	TDN	Alkaline persulfate digestion followed by EPA 353.2, 1993	48 hrs. at 4C/ 28 days at -20C	Plastic	Filtered
Orthophosphate	PO4	EPA (1993) (Method 365.1 Rev. 2.0) Aquakem 250, automated ascorbic acid	28 days at -20°C	Plastic	Filtered
Total Nitrogen	TN	APHA 4500-N persulfate digestion followed by enzymatic nitrate method	28 days at -20°C	Plastic	Whole
Total Phosphorus	TP	APHA 4500-P persulfate digestion followed by EPA 365.1 Rev. 02 (1993)	28 days at -20°C	Plastic	Whole
Total Suspended Solids	TSS	Standard methods for the examination of water and wastewater (15th ed.) sect. 209D p. 94. (Gravimetric)	14 days at -20°C	Foil pouch	Whole, particles retained on a filter pad
Particulate Inorganic Phosphorus	PIP	Aspilla et al. (1976) (High temperature oxidative combustion) and EPA method no. 160.2-1	28 days at -20°C	Foil pouch	Whole, particles retained on a filter pad

Table 2: Analytical Parameters

An analytical laboratory must be chosen to perform analysis on water quality samples collected by the automated sampler. All analyses should be conducted in accordance with 40 CFR Part 136. To assure quality control the laboratory should be accredited by the state or the federal government. The proper sample containers should be identified or provided by the laboratory conducting the analysis and meet State of Maryland quality assurance protocols. Approximate cost for associated sample analysis is depicted in Table 3.

Table 3: Approximate Cost of Sample Analysis

PARAMETER	ABBR	Approximate Cost of Analysis per Sample
Nitrate- + Nitrite-N	NO23	$8.03
Ammonium-N	NH4	$8.03
Total Dissolved Nitrogen	TDN	$15.24
Orthophosphate	PO4	$8.03
Total Phosphorus & Nitrogen	TP	$21.34
Total Suspended Solids	TSS	$9.15
Particulate Inorganic Phosphorus	PIP	$12.20
Phosphorus	PP	$21.24

Sample Methods

Proper operating procedures should be followed to collect water quality samples from the automated sampler. Depending on the parameters being analyzed some samples may need to be filtered in the field. Trained field staff can process whole water samples in the field to generate filtrate water to be analyzed for chemical parameters. The filtrate water is transported to the corresponding laboratories for analysis. Filtering kits can be constructed and used to promptly process the whole water samples on-site in the field.

Sample Handling and Chain of Custody

Upon collection, water quality samples to be analyzed by a laboratory should be placed on ice and maintained at 4^{o} C until the end of sample collections for that day. If samples are temporarily stored at a field office, the samples are then either refrigerated to 4^{o} C or frozen to a minimum of -20^{o} C (based on parameter protocol) and maintained at that temperature until delivered to the analytical laboratory. Frozen samples that are stored should be delivered to the analytical laboratory within two weeks of sample collection with appropriate chain of custody documentation.

IV. Considerations and Challenges for On-Site Water Quality Monitoring at CAFOs

The following is a discussion of factors MDE considered when evaluating the feasibility of requiring the installation and use of on-site water quality monitoring equipment at certain CAFOs as a condition of discharge permit coverage, and the challenges to implementation of such an approach.

Differences in CAFO Animal Types, Operating Systems, and Production and Land Application Areas

One challenge in requiring the on-site water quality monitoring at certain CAFOs is that there is significant variation among CAFOs in ways that may affect the design or operation of any monitoring program. The amount of animal waste and processed wastewater generated and the nutrient concentration within the waste is a function of several variables: the number and type of animal units, the composition of their diet, their growth rate, how animal waste is managed, and the physical and chemical properties of the animal waste. Animal types include cattle, dairy cattle, horses, veal, swine, sheep and lambs, ducks, chickens, laying hens and turkeys. The production and management operating systems for each of these animal types vary based on animal type and density, growth and development, movement patterns, confined animal lot and housing requirements, and desirable product values such as milk, meat, or racing purposes. Under the AFO Permit, the CAFO production area includes the animal confinement area, the manure storage area, the raw materials storage area, the waste containment areas, any egg washing or egg processing operation, and any area used in the storage, handling, treatment, or disposal of mortalities. The CAFO land application area includes land on which manure, litter, or processed wastewater from the production area is or may be applied. CAFOs that land apply nutrients are generally referred to as “land CAFOs” and those that do not have land application areas or do not land apply nutrients are generally referred to as “no land CAFOs”.

Due to these differences in animal production and management operating systems, the facility design and the structures utilized to control surface water discharges may vary from one CAFO to another. Further exploration and study are advisable to address differences in CAFO production and management operating systems and how those influence the effectiveness, usefulness, and proper design and operation of any on-site water quality monitoring program. At a minimum, factors such as the animal type, location and type of structures used, and whether the CAFO land applies animal manure are key factors in determining the appropriate location on a CAFO property where on-site water monitoring would take place to yield the most reliable sampling data.

Identifying CAFOs Subject to the Requirement for On-Site Water Quality Monitoring

Criteria would need to be established to identify and prioritize the CAFO facilities required to install and use on-site water quality monitoring equipment as a condition of discharge permit issuance. These criteria could be established based on a variety of factors, so it would be important to first determine the goals of the monitoring program. For example, if the goal is to assess potential water quality impacts in areas that may be especially environmentally sensitive, criteria based on the location of CAFO facilities could be used, such as Tier 2 watershed status; Total Maximum Daily Load (TMDL) impairments criteria, location within 100- and 500-year floodplains; for older constructed CAFO facilities, location within 100 feet of waters of the state; proximity to natural resource concerns, or other factors. Alternatively, criteria could take into account the standards and practices already in place at CAFOs to avoid water quality impacts. For example, newly constructed CAFO facilities are designed with Best Management Practices (BMPs), and current industry equipment standards to effectively improve water quality and mitigate any potential pollutants from being mixed with stormwater and entering surface waters of the state.

While any of these criteria could be used to categorize CAFOs for the purpose of applying water quality monitoring requirements to certain CAFOs, it is important to note that there is still considerable variation among individual CAFOs based on the factors described above. This may complicate efforts to establish uniform criteria that would achieve the desired goal.

Incorporating On-Site Water Quality Monitoring into the Existing Permitting Process

Requiring the installation and use of on-site water quality monitoring equipment at certain CAFO sites as a condition for issuance of a discharge permit would impact current CAFO permitting procedures and may result in permitting delays. CAFO operations' Comprehensive Nutrient Management Plan (CNMP) implementation schedules generally establish timeframes and other criteria for the installation, repair, or replacement of water quality, nutrient management, and pollution prevention BMPs and equipment. If certain CAFOs are required to install and use on-site water quality monitoring equipment as a condition for discharge permit issuance, that requirement would need to be integrated into the CNMP. Specifically, the CNMP may need to account for the timing of the installation, use of the equipment, and the roles and responsibilities of the operator and third parties (such as technical consultants) in operating the monitoring equipment. Given the significant costs associated with on-site monitoring equipment and lab analysis of water samples, technical expertise is required to properly collect water samples. Discussions with stakeholders such as CAFO owners and operators, industry, MDA, NRCS, and UMD would be needed prior to any on-site monitoring requirement.

Additional considerations that could result in permitting delays include available cost share financial assistance, grants, or other funding sources for CAFO owners or operators to purchase on-site water quality monitoring equipment, the availability of this equipment, weather/ground conditions for grading/installation work, and contractor scheduling for installation servic

CAFO On-Site Monitoring Location

Most CAFOs are older constructed facilities and as a result, there is no consistent standard in their construction and location relative to natural resources and neighboring residences and communities. In contrast, newly constructed CAFO facilities are located with approved state and county setback or distance requirements with forebays, vegetated buffers, and sediment ponds that are well defined as BMPs. Most of the older constructed CAFOs only have grass swales between the houses that have surface water flow directed into forested buffer areas and do not have a stream or water resource to collect water samples. Therefore, the ability to perform on-site water quality monitoring at a CAFO site would be reliant on a significant rain event to characterize any nutrient and pollutant levels potentially discharged to surface waters of the state.

Selecting an appropriate location on a CAFO site may be difficult and would likely require a site-specific technical assessment. For example, a no land CAFO production area may have multiple man-made flushing systems, ditches, or diversion devices designed and constructed to navigate flow and energy of potential surface water discharges to waters of the state. Selecting a monitoring site for land application areas would also require a site-specific technical assessment as specific crop fields that may receive the application of animal waste or process wastewater are subject to change seasonally and annually due to changed crop fertility recommendations, Phosphorus Management Tool restrictions, and field availability following crop harvests. This technical assessment must also ensure that the surface discharge point selected for a land application area will not receive water from an agricultural field not under the control of the operator.

To identify the optimal location from which surface water discharges, samples would be taken and that would yield the most beneficial water quality data. Further research and study would be needed to establish appropriate technical criteria.

Background and Legacy Effects on Surface Water Samples

Surface water discharge samples collected on a CAFO site have the potential to contain certain nutrients and pollutants as the result of land use and activities pre-existing to the production and land application uses of a certain CAFO. Unless background\legacy values potentially sourced from available data of regional nutrient and pollutant levels could be established, the background\legacy contributions to a surface water sample result are unknown and water sample analytical results would include contributions from pre-existing production and land application uses, not attributable to the current operation. These background/legacy contributions could inaccurately suggest that BMPs at the CAFO are not effective.

Off-Site Considerations for On-Site Water Quality Monitoring

A research project conducted by the Virginia Institute of Marine Science (VIMS) was reviewed by MDE and considered in this report. The project involved water quality sampling in watersheds at the locations of streams and roadside ditch crossings in Accomack County, Virginia in 2018. "Dry" samples from stagnant pools of water were taken from these water resources when they were not flowing. During wet weather events, samples were collected from flowing storm water.

The VIMS research project analyzed the water samples for Enterococcus levels, which are indicative of warm-blooded animal or human fecal contamination. Enterococcus was not part of WSA's parameters for water sampling at CAFOs (see Table 2: Analytical Parameters). High fecal indicator counts are common in wooded stream basins and wooded swamps characteristic of the Eastern Shore of Virginia (ESVA) watersheds that provide habitat for wildlife and would contribute to high Enterococcus levels. An additional source of high Enterococcus levels would be homes within the watersheds and water resources that are on septic systems with drain fields that have the potential to contribute to fecal loadings. The potential parameter to analyze collected water samples for Enterococcus is an important consideration as many older constructed poultry CAFOs on the Eastern Shore of Maryland (ESMD) may be in close proximity to residential homes with septic drain fields that could contribute to fecal loadings. The siting of a water monitoring station at a CAFO site would equally need to consider the proximity to wooded stream basins and wooded swamps existing on the ESMD.

The VIMS research project also analyzed collected water samples for ammonia nitrogen (NH_4), Total Nitrogen (TN), and Total Phosphorus (TP). Seaside bays and marshes of the ESVA and the ESMD tend to be nitrogen (N) limited, so excess ammonia and other N sources would be of concern. In all water samples collected and analyzed, ammonia threshold values were exceeded from two samples sourced from flowing streams and one sample from a stagnant pool of water from a drainage ditch receiving water from an agricultural field. In all three examples, there were no associated poultry operations, or in the case of the agricultural field, no poultry manure was used.

An Observed Effects Concentration (OEC) threshold in Virginia streams for TN and TP was established in this research project. TN values from water samples collected in streams that did not have associated poultry sites exceeded the OEC threshold for several locations. One TP sample exceeded the OEC threshold sourced from a stagnant pool of water in a ditch draining an agricultural field with no associated poultry used and another sample was collected from a stream associated with a flooded woodland swamp downstream from a poultry operation not yet raising birds. Water samples were collected under differing sampling conditions such as wet and dry periods, water resource types, and proximity to active and inactive poultry sites. Based on the OEC threshold used, the analytical results did not suggest storm water runoff impacts from poultry operations.

The VIMS research project illustrates the consideration that conditions off-site of a CAFO could affect water sample analytical results of on-site monitoring. If the goal of a monitoring requirement is to determine water quality impacts, if any, of a CAFO, the interpretation of analytical results must allow for association with a certain CAFO in order to avoid any potential off-site influence of analytical results from residential and natural habitat conditions. Technical assessment to locate a water quality monitoring station on certain CAFOs will need to consider off-site conditions and further research is needed to determine how to obtain water quality data attributed to CAFO sites.

Water Monitoring Costs Estimates and Cost Sharing Financial Assistance

Equipment/Operation and Maintenance

MDE reviewed the estimated cost for an automated sampler system and found that projected costs associated with initial equipment purchase would be between $7,900-$21,300, plus additional costs not estimated here related to sampling site excavation and grading modification, installation, power source, ongoing maintenance, insurance of equipment, and other long-term project needs.

Water Sampling and Analysis

Water samples would need to be preserved in a viable condition and sent to an approved laboratory for analysis based on established surface water discharge parameters. The estimated cost per sample for an approved laboratory to analyze water samples for surface water discharge parameters can be approximately $103.26 in total (see Table 3 for the cost per sample for each parameter). Certain parameter-based analytical methods require additional equipment, containers, and disposable products to collect viable storm water samples at the monitoring site.

Cost Sharing Financial Assistance

The costs associated with obtaining reliable hydrological and meteorological data from on-site monitoring of surface water discharge points at a CAFO would be significant and possibly cost prohibitive for certain CAFO owners or operators. MDE is presently not aware of state financial programs that could help offset the costs for installation, maintenance, and laboratory fees for implementation of on-site water quality monitoring at certain CAFOs. Financial assistance to address these costs would either need to be identified or developed prior to the implementation of any CAFO on-site water quality monitoring requirement as a condition to discharge permit issuance.

Qualifications and Responsibilities for Water Sampling

Operator Training and Certification

The management and use of on-site water quality monitoring equipment would require persons that are qualified with training and skills to design the monitoring system, collect samples of surface water discharges, properly store samples, and safely conduct routine maintenance and performance checks based on manufacturer specifications. The ultimate objective of the collection of surface water discharge samples is to ensure that all collected data is reliable and would accurately characterize the samples of surface water discharges. At this time, a CAFO owner/operator or operator may not be qualified and/or possess credentials to perform surface water discharge sampling and interpret laboratory results from the samples. CAFO owners or operators would need opportunities to be trained and receive certification or would need to hire an environmental services contractor to perform sampling and maintain on-site monitoring equipment.

MDE Personnel Training and Certification

In addition to the need for CAFO owner or operator training and certification to properly use and maintain on-site water quality monitoring equipment, and to take and preserve viable water samples, MDE AFO Division compliance staff would likely need training to ensure staff are able to conduct proper reviews and inspections to verify CAFO owner or operator compliance with on-site water quality monitoring requirements.

V. Recommendations

There are significant technical, logistical, and economic considerations and challenges that would need to be addressed as part of determining the feasibility of requiring the installation and use of on-site water quality monitoring at certain CAFO sites as a condition to discharge permit issuance. Specific factors include the need to develop, with regulated community, industry, and state and federal government stakeholder input, specific criteria to identify which CAFOs, if any, would have suitable on-site locations for the installation and use of the water quality monitoring equipment. Additional factors include the diversity of CAFO operations based on: size, animal type, operation systems including animal waste management and systems, the identification of discharge monitoring points and stormwater flow measurement, consideration of background/legacy land uses and their relation to water sampling on CAFO sites, off-site water resources and non-CAFO related impacts and influence on water sampling at CAFO sites, the need for site-specific technical assessment, and the overall costs and specialized training needed to install, operate, and maintain water quality monitoring equipment at CAFO sites.

The feasibility of implementing a CAFO on-site water quality monitoring requirement is largely dependent on CAFO owner and operator ability to obtain technical training to operate and maintain monitoring equipment, take viable water samples and employ proper preservation procedures and protocols when preparing and delivering water samples to a laboratory for analysis. MDE would also need to be trained on the operation and maintenance of specific monitoring equipment used at a CAFO as part of the records review process. Moreover, the estimated costs to purchase water monitoring equipment, grading and installation services for equipment, equipment replacement needs, maintenance requirements, safety measures, and laboratory analysis fees may be challenging. The development of financial cost share assistance to owners and operators of CAFOs required to install and use water quality monitoring equipment may offset some of these costs.

For the installation and use of on-site water quality monitoring at CAFO sites as a condition for issuance of a discharge permit to be feasible, further research and discussion would be necessary to facilitate reasonable and effective approaches to the development defined criteria to determine which CAFOs would be required to implement the monitoring requirement, technical resources and training, funding and planning for changes in AFO Permit coverage and compliance enforcement, and funding resources to support state cost share and other financial assistance.