Environmental Benefits to the Chesapeake Bay of a Poultry Litter Baling Facility in the Eastern Panhandle of West Virginia

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ABBREVIATIONS

CAFO	concentrated animal feeding operation
CPGAV	Contract Poultry Growers Association of the Virginias
CSO	combined sewer overflow
CSR	Code of State Rules
LA	load allocation
MHP	mobile home park
N	nitrogen
NA	no action
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
P	phosphorus
PADEP	Pennsylvania Department of Environmental Protection
PENNVEST	Pennsylvania Infrastructure Investment Authority
PSSD	public service sewer district
TMDL	total maximum daily load
US	United States
USDOI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
WIP	Watershed Implementation Plan
WLA	wasteload allocation
WVDA	West Virginia Department of Agriculture
WVDEP	West Virginia Department of Environmental Protection
WVDNR	West Virginia Division of Natural Resources.
WVU	West Virginia University
WWTP	wastewater treatment plant

1. INTRODUCTION

The Chesapeake Bay (the "Bay") is the largest estuary in the United States (US) and one of the world's most biologically productive estuaries. The Bay is impaired due to activities on land within its watershed—which stretches from Virginia to New York (See Figure 1)—and returning the Bay to health is an issue of national importance.

An executive order outlines strategies for cleaning up the Bay (1), and an ongoing planning process recently resulted in the release of a total maximum daily load (TMDL) (2). The TMDL was the culmination of many years of study and discussions, during which stakeholders first attempted to solve the Bay's problems through voluntary measures.

West Virginia's formal involvement in this process began in 2002, with the signing of the Chesapeake Bay Program Water Quality Initiative Memorandum of Understanding (3); the state was then committed to developing goals to reduce nutrient and sediment loads. Since then, West Virginia released several planning documents to refine the actions necessary for reducing pollutant loads from West Virginia to the Bay (4; 5; 6).

A poultry litter baling facility, such as the one investigated in this report, can play a role in reducing West Virginia's pollutant discharges to the Bay by creating compost, a value-added product that is more stable and consistent than fresh litter (7). When this compost is exported from the watershed, nutrient loads delivered to the Bay are reduced. Among poultry growers, private foundations, and others, there is an interest in creating a self-sustaining business that creates and sells a value-added product like compost to help reduce nutrient loads in the Bay watershed. This study investigates how to quantify the environmental benefits of a poultry litter baling facility.

The imbalance between nutrients generated and taken up by farms in West Virginia's Eastern Panhandle was documented long before the TMDL (8; 9; 10; 11; 12; 13). Best management practices and other techniques for addressing this nutrient imbalance—including establishing composting operations that facilitate the export of nutrients from the watershed—have been discussed as far back as 1993 (14; 15). West Virginia's Phase II Watershed Implementation Plan (WIP) also notes that composting can play a role in TMDL implementation. For example, it documents a poultry litter composting demonstration site that was established in the Potomac Valley Conservation District, which has exported more than 50,000 tons of poultry litter over seven years (6). According to the WIP, the West Virginia University (WVU) Extension Service and its partners hosted a workshop showcasing the baling technology, and technical assistance and support will continue for composting and other efforts such as baling (6). Further, West Virginia's Poultry Litter Transfer Program offers producers $10 per ton of litter from priority watersheds; the goal for this program is to transfer 12,000 tons by 2025 (6).

Recently, however, new momentum has been generated to consider again whether a composting or baling operation can not only address a portion of the region's nutrient excess, but also create a viable, self-sustaining local business (16; 17). In early 2012, with funding from blue moon fund and in collaboration with the Contract Poultry Growers Association of the Virginias (CPGAV), Downstream Strategies released a poultry litter composting feasibility study. This report demonstrated that a composting facility in the Potomac Valley Conservation District of West Virginia can be profitable, so long as the right balance is found between the price charged for finished compost, the price paid to growers for their poultry litter, and the amount of grant funding used to help establish the operation. (16)

Figure 1: Chesapeake Bay watershed and five-county study area

In late 2012, Delta Development Group ("Delta") furthered this effort by producing a more detailed feasibility study and business plan proposal to form a cooperative to process and sell a baled litter product. Delta also worked closely with CPGAV. According to the Delta report, an operation that bales poultry litter has advantages over a traditional composting operation that occurs in the open air. In addition, this report identified three target markets for finished, baled compost:

- farms within a competitive cost distance, estimated to be 467 miles from the operation;
- certified organic producers; and
- surface mines. (17)

While the Downstream Strategies and Delta reports made significant strides toward documenting the feasibility of a baling operation from a financial and organizational point of view, neither looked in detail into the environmental benefits. Quantifying the environmental benefits—or at least proposing methods such that the operation can quantify and capture the value of its environmental benefits—is the purpose of this report.

It is important to quantify the environmental benefits for three major reasons. First, if such an operation is to be built to help reduce loads to meet the Bay TMDL, it is important to document whether load reductions will actually occur. Second, if reductions are actually documented, then quantifying these reduced loads is important for measuring progress toward meeting the allocations assigned in the TMDL.

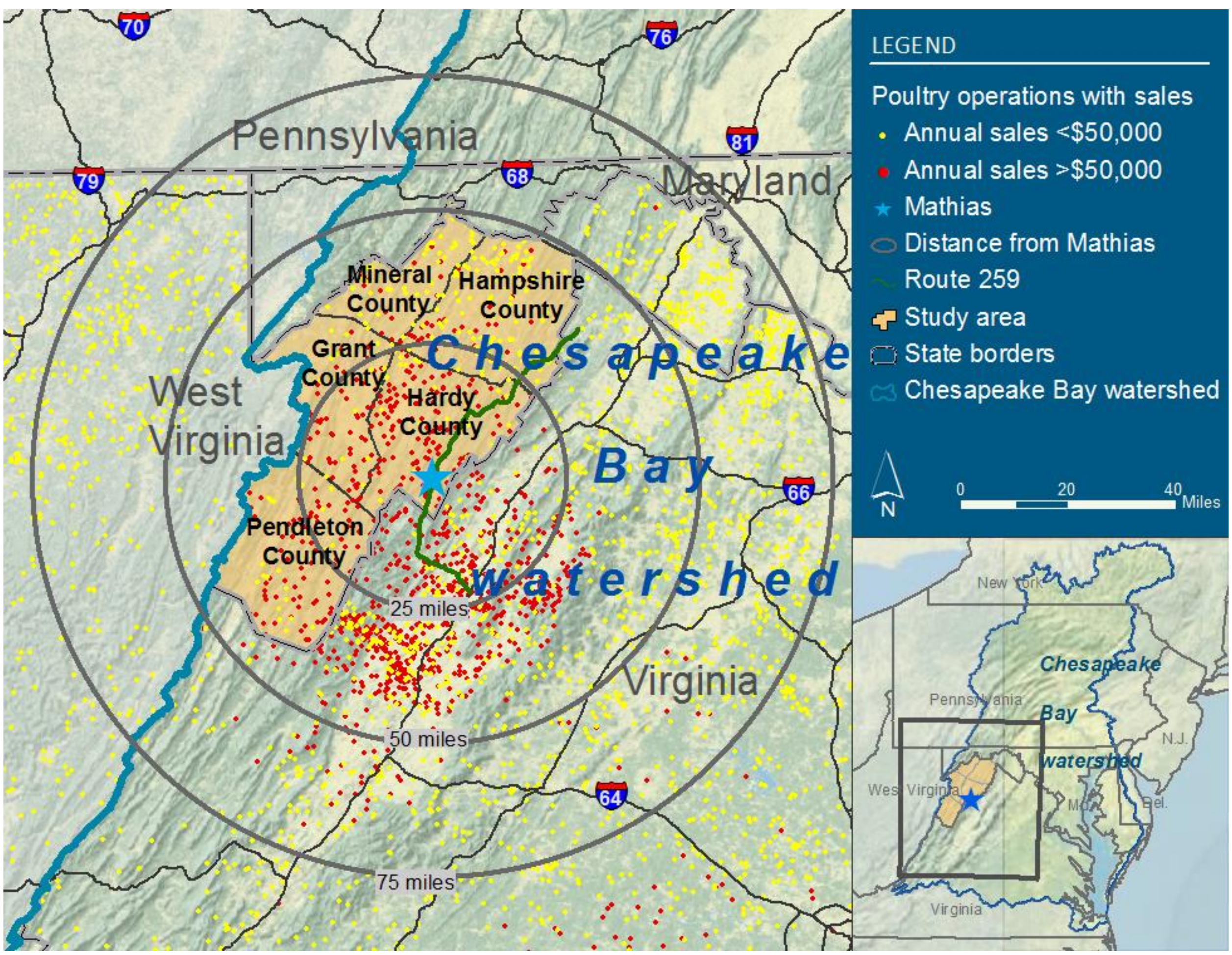
Finally, and perhaps more importantly from the perspective of potential project developers or investors, reductions in pollutant loads may have economic value that can help finance the operation. If environmental benefits are documented and well quantified, then it is possible that credits or offsets can be generated and sold through a water quality trading program.

2. BACKGROUND

Growers in West Virginia's Eastern Panhandle—and in the nearby counties in Virginia—collectively raise millions of broilers, turkeys, and other poultry each year on both small and large scale operations within the Bay watershed. As shown in Figure 2, the larger poultry growers are concentrated within Mineral, Hampshire, Grant, Hardy, and Pendleton counties in West Virginia, along with nearby counties in Virginia. The Delta business plan proposal envisions that a baling operation would be located near Mathias, depicted by the blue start, because it is centrally located and provides access via Route 259.

A fundamental challenge to this industry is its long-term nutrient balance. Because so many birds are raised in the watershed, poultry feed is largely imported from outside the watershed. The nutrients in this feed are excreted and mixed with bedding materials in poultry houses to create poultry litter. This litter, which contains significant quantities of nitrogen (N) and phosphorus (P), is usually applied as fertilizer to local crop land and pasture. Repeated applications over time can lead to losses of N and P into local streams. While the distances are great, a significant percentage of these loads are actually delivered to the Bay (See Figure 5). Particularly with P, nutrients may build in soils to levels higher than what can be removed by annual crop production. P, therefore, presents a particularly challenging problem related to water quality in the Bay.

Figure 2: West Virginia and Virginia poultry operations near the study area, 2007



Source: (18).

Reducing nutrient loads from agricultural operations in the Bay watershed can be accomplished through many methods. In fact, a combination of approaches will likely be needed to meet the load reductions called for in the TMDL.

One general approach would be to ensure that the generation of N and P in poultry litter is in balance with local agricultural needs. A 1999 report calculated the number of birds that each county in the five counties of interest in West Virginia could sustain while maintaining a nutrient balance (8). Appendix A discusses how the calculations have changed in the ensuing years. While such an approach helps identify the scale of the problem, limiting the number of birds raised in particular watersheds, counties, or farms is not a practical solution to the problem of excess nutrients.

A second general approach is to focus not on the birds themselves, but on solutions that ensure that poultry litter is managed to minimize or prevent water quality impacts. This approach encompasses a wide range of practices, many of which are already being implemented. Some practices control nutrient mobilization, such as on-farm nutrient management plans and the transport of litter to fields within the watershed that can accept litter with little risk of generating environmental damage. Other approaches actually remove nutrients from the Bay watershed so that it simply cannot reach the Bay. In theory, raw litter can be transported from the watershed; however, litter is very heavy, and transport costs have proven to be excessive. Aerobic composting or baling operations can minimize transport costs by reducing moisture content or preserving and concentrating nutrients.

The approach investigated in this report—the establishment of a poultry litter baling operation that exports nutrients from the watershed—fits into this second approach.

2.1 Previous and ongoing composting efforts

The importance of transporting excess nutrients in poultry litter from the Bay watershed—and the benefits of composting the litter before transport—have been recognized for years. West Virginia's Poultry Litter Transfer Program was established in the 1990s; since then, the Natural Resources Conservation Service (NRCS) and the West Virginia Conservation Agency have tried a variety of approaches. The Phase II WIP, however, recognizes that these efforts have had variable success. Challenges include fluctuating commercial fertilizer prices, the cost of fuel and transportation, the seasonal supply and demand for litter, and the complexity of managing the effort via a government program. Despite these challenges, NRCS has committed $10 per ton for producers within priority watersheds and has set a goal of transferring 12,000 tons from the watershed by 2025. Agencies are also exploring the concept of a centralized storage facility in north-central West Virginia to facilitate movement of litter and to help match supply with demand. Further, NRCS may be able to make available certain incentive payments for producers and receivers in some situations. NRCS also explicitly recognizes that a poultry litter baling operation should be evaluated and promoted. (6)

A poultry litter composting demonstration site was established in the Potomac Valley Conservation District and has exported more than 50,000 tons of poultry litter over seven years. In 2008, this project entered into a partnership with Hampshire County Special Services, in which mentally disabled adults are provided with jobs in which they provide shredded paper to the project as a carbon source. These partners are also involved in the composting process. Finished compost is purchased by Hampshire County Special Services and is also bagged and sold to local businesses. (6)

In addition, WVU Extension Service and its partners hosted a workshop showcasing the poultry litter baling technology and have committed to continuing technical assistance and support for composting and other efforts such as baling (6).

While these past and ongoing efforts remain at a small scale, they have been extremely useful in identifying barriers that must be overcome for a baling operation to succeed in the Bay watershed in West Virginia.

2.2 Baling versus composting

There are two general options for transforming litter into a form in which it can be more easily transported out of the watershed: composting or baling. Composting is performed in the open air and relies on an appropriate mix of carbon, N, oxygen, and water. With poultry litter, carbon is typically provided by the bedding material, and N is provided by the poultry manure. Large-scale , aerobic composting facilities typically use heavy machinery to stack compost in windrows (See Figure 3).

Figure 3: Open-air agricultural composting facilities in Pennsylvania and Virginia

Source: (16). Note: The left-hand picture shows Oregon Dairy Organics, a commercial-scale composting operation in Lancaster County, Pennsylvania. The right-hand picture shows Panorama Pay-Dirt, a composting operation in Earlysville, Virginia.

An alternative approach seals poultry litter in discrete bales. As shown in Figure 4, White River Fertilizer Supply in Fayetteville, Arkansas has demonstrated the technology required to produce, store, and transport baled poultry litter to end-users.

Figure 4: A poultry baling operation

Source: (19).

This report focuses on a baling operation because of the momentum already generated to pursue this approach among members of CPGAV. Delta's feasibility study and business plan proposal looks specifically at the possibility that CPGAV would create a cooperative in order to establish a baling operation (17). This momentum is driven, at least in part, by the potential benefits of a baling operation over and above a traditional composting operation.

For example, nutrient losses are reduced with a baling operation. Once litter is baled, it no longer interacts with the atmosphere and N losses stop. Between the time that the litter is baled and spread, nutrient losses essential cease.[1] According to White River Fertilizer Supply, baled litter retains up to 98% of its nutrient value over a three-year period (20).

[1] While nutrients will not be lost from airtight bales, nutrients would still be lost during storage and handling before baling. In fact, storage and handling losses

A second benefit of a baling operation is related to the transformations that occur during the ensilage process. Studies show a 50% uptake rate for nutrients from raw litter, as compared with a 70% uptake rate for nutrients from baled litter (20).

A third benefit is the convenience of being able to store bales on the farm and to save them for later. In this way, baled compost can be applied at the most opportune time related to crop uptake and weather, maximizing plant uptake and minimizing post-application losses to water. While traditional compost can be stored under roof to reduce pre-application losses, bales can be stored outside and limit the need for dedicated infrastructure. Also, compost stored in bulk, even if under roof, will continue to lose N to the atmosphere.

Bales are also transportable over long distances and can be more easily tracked and quantified. Tracking and quantifying the litter and nutrients exported from the watershed are critical for verifying the environmental benefits of a baling operation. One method would be to weigh and track each bale; another option, if the weight of bales does not vary considerably, would be to simply track the bales and apply the average weight. Either way, the process of quantifying litter and nutrient exports would appear to be simpler than weighing bulk litter or compost in trucks. If exported nutrients can be more easily quantified, this will help the baling operation monetize these environmental benefits through a water quality trading program.

2.3 Water quality trading in the context of the Chesapeake Bay TMDL

“Water quality trading” is the general term that describes a system whereby one entity (in this case, a baling operation) reduces water pollution and sells the environmental benefits it generates to another party, such as a wastewater treatment plant with specific National Pollutant Discharge Elimination System (NPDES) permit limitations. Within the water quality trading context, the environmental benefits are generally called “nutrient credits.”

Under the TMDL, new wastewater treatment plants can be built—and existing plants expanded—so long as their additional nutrient discharges are offset. Offsets can be include better treatment at an existing plant, the assimilation of other pollutant sources, or other mechanisms such as a water quality trade (6). If a market exists in West Virginia to purchase credits generated by a baling operation, it will most likely be from a wastewater treatment plant required to offset its new or expanded nutrient loads.

The United States Environmental Protection Agency (USEPA) released a trading framework in 2003. Under this policy, USEPA clarifies that trades must be consistent with the Clean Water Act, that TMDL implementation can serve as a driver for trades, and that trading programs are implemented state-by-state (21). The Chesapeake Bay TMDL recognizes that trading can be a tool for TMDL implementation: Section 10.2 of the TMDL specifically discusses water quality trading, and Appendix S provides definitions and common elements that USEPA expects states to include in their Bay-related trading programs. (2)

Within and outside of the Bay watershed, water quality trading has been proposed and discussed since at least 2003, when USEPA released its trading policy (21). Still, very few trades have actually occurred. One reason is that, while agricultural operations often contribute a significant portion of the nonpoint source load and therefore present a high potential for generating nutrient and sediment credits, most currently operate outside of water regulatory programs. Engaging in trades would draw these operations into a regulatory program because pollution control projects on their farms would then become a part of a permit or other enforceable document. This hesitancy to move their operations into a regulatory framework, even in return for a financial benefit, is an important reality.

Potential trades that involve nonpoint sources of pollution such as agricultural discharges have also proven to be particularly vexing because of the difficulty in quantifying the effectiveness of best management practices that decrease nutrient loads from farms. Monitoring is impossible or impractical for many on-farm actions.

This challenge has forced the use of models to predict decreases in pollutant loads, and can be a potential source of opposition from stakeholders.

One interesting potential benefit of the litter baling operation is that the baling operation itself—as opposed to the poultry growers—would generate credits and engage in trades. This shift of regulatory responsibility from growers to a new company or cooperative may help break the logjam that has been witnessed regarding generating credits from the agricultural community.

The neighboring Bay states of Virginia, Maryland, and Pennsylvania have all implemented water quality trading programs for P, N, and sediment (22) to more cost-effectively reduce the discharge of these pollutants to streams within the watershed. While there is flexibility built into these programs, the typical trade envisioned by these programs involves an existing wastewater treatment plant faced with increasingly stringent nutrient wasteload allocations stemming from the Bay TMDL, an expanding wastewater plant, or a new plant. In each of these cases, operators may find it more cost-effective to finance pollution reduction activities elsewhere. The cost per pound of P removed will often be significantly less on a farm than at a wastewater treatment plant, thereby providing an incentive for plant operators to purchase credits or offsets rather than upgrade their systems. In theory, greater pollutant reductions can be achieved at less cost.

West Virginia has considered water quality trading and has opted not to implement a formal trading program (6). While regulators envision the possibility of trades such as those described above may be achievable, they intend to consider trades on a case-by-case basis. Because the proposed baling operation would be located in West Virginia, this report navigates West Virginia's current approach to evaluating trades.

In 2002, the West Virginia Department of Environmental Protection (WVDEP) established a stakeholder committee to explore the possibility of establishing a statewide water quality trading program. After approximately two years of meetings, the committee failed to reach consensus and the State did not adopt a formal program (23).

Other efforts have progressed in West Virginia, however. The state's antidegradation implementation procedures,[2] which aim to keep clean surface waters clean, provide for trading; a new or expanded point source can implement or finance upstream controls of point or nonpoint sources in order to offset the water quality effects of the proposed activity. Because these rules only apply in very specific situations, they do not provide the broad framework necessary to govern trades envisioned for a baling operation in the Bay watershed.

In 2009, the West Virginia Water Research Institute conducted a project with the World Resources Institute and NRCS to develop a West Virginia Potomac Water Quality Bank and Trade Program (24). Their final report, "APPENDIX A West Virginia Potomac River Basin Water Quality Nutrient Trading Program," is summarized in Appendix B but has not been formally adopted by WVDEP. Still, this report identifies key issues that would presumably need to be addressed when considering trades in the context of a baling operation.

Despite these efforts, WVDEP has chosen not to implement a formal statewide or Bay-watershed water quality trading program. The Phase II WIP (6) provides the most current guidance on how to quantify a trade to help implement the Bay TMDL. Because it does not answer every question required to quantify a trade, the major goal of this report is to propose potential methods to quantify a trade in a manner that is scientifically sound, does not have exorbitant transaction costs, and satisfies the requirements of the WIP and the Bay TMDL.

2 Code of State Rules Title 60, Series 5 (60 CSR 5): Antidegradation Implementation Procedures.

2.4 Conceptual calculations of environmental benefits

There is little debate that if nutrients in poultry litter are baled and exported from the Bay watershed, less P and N would ultimately be delivered to the Bay. However, quantifying these load reductions is challenging due to questions of science (How will post-application P loss rates change on P-rich soils if litter is diverted to a baling operation?) and behavior (Exactly which farmers will provide litter to the baling operation? Will they substitute chemical fertilizers?).

Because of this complexity, it is useful to start with a theoretical framework to help identify the key assumptions and issues. We apply a set of equations proposed by Dr. Kurt Stephenson, Professor of Environmental and Natural Resource Economics at Virginia Tech (25), who discusses the generation of nutrient credits for manure conversion projects such as composting or baling operations.

One important consideration is the boundary used for these calculations. Many different poultry growers generate litter, the baling operation will collect litter from many of these growers, and some portion of the bales will be exported from the watershed. Boundaries broader than the field or farm level may therefore be most appropriate:

> Some projects are regional in scope, substantially altering manure availability and application rates across the entire watershed and across multiple farms and management entities. Credit procedures that limit calculations only to the manure production facility and lands owned or controlled by the owner could potentially underestimate the number of credits generated (reductions achieved). On the other hand, expanding project boundaries to include the larger impact of the conversion project might make tracking and verifying credit generating activities more challenging. (25 p. 7)

To help conceptualize and quantify credits for a project such as a baling operation, this report proposes a series of equations to calculate the pounds of N or P delivered to the Bay per year.[3] Table 1 defines the key terms in the equations with respect to our model of a baling operation; the equations are then described in detail below. The subscript “b” stands for “before” and represents variables before implementation of the baling operation. The subscript “mp” stands for “manure project,” which in this case is the baling operation.

[3] While Stephenson (25) describes these loads as being delivered to the Bay, we apply these equations to represent loads that are discharged to nearby waters. Watershed-specific delivery factors, as shown in Figure 5, can then be used to calculate delivered loads.

Table 1: Terms and definitions for conceptual nutrient calculations

Term	Definition
Net Load Reduction	Pounds per year of N or P that are not discharged to water, as compared with the TMDL-consistent baseline load, following the implementation of the baling operation.
TMDL-consistent Baseline Load	Pounds per year of N or P that are allowed to be discharged to water according to the load allocations in the TMDL. These nutrients may be generated as losses from the application of commercial fertilizer to farm fields, losses from the application of manure to farm fields, and losses from manure before it is applied to farm fields.
Estimated Load with Manure Project	Pounds per year of N or P that are discharged to water after implementation of the baling operation. These nutrients may be generated as losses from the application of commercial fertilizer to farm fields, losses from the application of manure to farm fields, and losses from manure before it is applied to farm fields.
$FertLoad_b$	Pounds per year of N or P that are discharged to water as losses from the application of commercial fertilizer to farm fields ***before implementation*** of the baling operation.
$FertLoad_{mp}$	Pounds per year of N or P that are discharged to water as losses from the application of commercial fertilizer to farm fields ***after implementation*** of the baling operation.
$ManureAppLoad_b$	Pounds per year of N or P that are discharged to water as losses from the application of manure to farm fields ***before implementation*** of the baling operation.
$ManureAppLoad_{mp}$	Pounds per year of N or P that are discharged to water as losses from the application of manure to farm fields ***after implementation*** of the baling operation.
$PreAppLoad_b$	Pounds per year of N or P that are discharged to water from manure during storage and handling, before it is applied to farm fields, ***before implementation*** of the baling operation.
$PreAppLoad_{mp}$	Pounds per year of N or P that are discharged to water from manure during storage and handling, before it is applied to farm fields, ***after implementation*** of the baling operation.
BaleExportPercent	Percent of the poultry litter bales exported from the Bay watershed (or applied within the Bay watershed on land that has not received repeated litter applications in the past).

The goal of these conceptual calculations is to calculate the net load reduction associated with the implementation of a baling operation. There are many assumptions required to calculate the net load reduction, and these assumptions are explicitly stated in Table 2. In some cases, assumptions can be refined in the future with additional research or with more knowledge regarding the location, specifications, and operational decisions associated with the baling operation.

Another overarching decision is the credit project boundary. To define our credit project boundary, we focus on the litter that is now applied to agricultural fields and that, in the future, will be transported to the baling operation. Our credit project boundary includes the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because it is transported to the baling operation.

Table 2: Important assumptions for conceptual nutrient calculations

Category	Assumption
Credit project boundary	Our credit project boundary includes the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because the litter is now transported to the baling operation.
Pre-application losses	Pre-application storage and handling losses will not change appreciably with or without a baling operation.
Soil P levels	Litter is typically applied to the same agricultural land within the Bay watershed that has repeatedly received litter in the past; therefore, soil P levels are high on agricultural land that is currently receiving litter applications or will become high if traditional practices continue.
Exported bales	Exported bales include those shipped out of the Bay watershed (or applied within the Bay watershed on land that has not received repeated litter applications in the past).
Distribution of non-exported bales	Non-exported bales are applied to the farm fields within our credit project boundary.
Application of commercial P fertilizer	No commercial P fertilizer is applied to fields that currently receive litter applications. For the foreseeable future (and certainly for the current year), no commercial P fertilizer will be needed for fields that have historically received poultry litter applications.
Application of commercial N fertilizer	Commercial N fertilizer may or may not be applied to fields that currently receive litter applications, depending on whether the field is cropland or pasture, the N needs of the crop or pasture, environmental considerations, and potentially other factors. Whether or not commercial N fertilizer is currently applied, it is assumed that after litter is diverted to a baling operation, N applications will be required in the amount that would have been provided by the litter without a baling operation.

The set of conceptual equations starts by describing the load reduction that would occur if a manure project is built. In this case, our manure project is a poultry litter baling operation.

$$\textit{Net Load Reduction} = (\textit{TMDL-consistent Baseline Load}) - (\textit{Estimated Load with Manure Project})$$

The baseline load, which is consistent with the TMDL, is comprised of three elements: nutrients lost from commercial fertilizer after application to farm fields, nutrients lost after application of litter, and nutrients lost before application of litter.

$$\textit{TMDL-consistent Baseline Load} = FertLoad_b + ManureAppLoad_b + PreAppLoad_b$$

After the baling operation starts, the load of nutrients is comprised of the same three elements.

$$\textit{Estimated Load with Manure Project} = FertLoad_{mp} + ManureAppLoad_{mp} + PreAppLoad_{mp}$$

After substituting the second and third equations into the first equation and rearranging the terms, the net load reduction can be expressed as follows:

$$\textit{Net Load Reduction} = (FertLoad_b - FertLoad_{mp}) + (ManureAppLoad_b - ManureAppLoad_{mp}) + (PreAppLoad_b - PreAppLoad_{mp})$$

Our first assumption is that pre-application storage and handling losses will not change appreciably with or without a baling operation; therefore, we assume that $PreAppLoad_b$ = $PreAppLoad_{mp}$. The previous equation can therefore be simplified as:

$$Net\ Load\ Reduction = (FertLoad_b - FertLoad_{mp}) + (ManureAppLoad_b - ManureAppLoad_{mp})$$

The change in fertilizer load and the change in manure application load can be either positive or negative, depending whether loads increase or decrease after a baling operation is built. The remainder of this section describes assumptions and values for these four terms—$FertLoad_b$, $FertLoad_{mp}$, $ManureAppLoad_b$, and $ManureAppLoad_{mp}$—for N and P.

A second broad assumption is that, currently, litter is typically applied to the same agricultural land within the Bay watershed that has repeatedly received litter in the past. Therefore, it is assumed that soil P levels are high on agricultural land that is currently receiving litter applications or will become high if traditional practices continue (26; 27).

2.4.1 *Phosphorus manure application loads*

The baseline manure application load, $ManureAppLoad_b$, is defined as the pounds per year of P that are discharged to water as losses from the application of manure to farm fields ***before implementation*** of the baling operation. It can be calculated as the P in the litter multiplied by the appropriate post-application loss rate.[4] Recall that our credit project boundary includes the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because the litter is now transported to the baling operation. Therefore, the litter used for this baseline calculation is that which is now applied to fields, but that in the future will be directed to a baling operation.

The manure application load after implementation of the baling operation, $ManureAppLoad_{mp}$, is defined as the pounds per year of P that are discharged to water as losses from the application of manure to farm fields after implementation of the baling operation.[5] This, in turn, will depend on the percentage of baled litter exported from the Bay watershed. We define a new variable, BaleExportPercent, as the percent of the poultry litter bales exported from the Bay watershed.

$ManureAppLoad_{mp}$ is then calculated as follows:

$$ManureAppLoad_{mp} = ManureAppLoad_b * (100\% - BaleExportPercent)$$

If 100% of the bales are exported, then the manure application load after implementation of the baling operation will be zero. In other words, no P will be lost to the Bay from the litter in our credit project boundary because all of this litter is baled and exported. If only a portion of the bales are exported, it is assumed that the non-exported bales are applied to the farm fields within our credit project boundary and, because these fields already have high P levels, the P load associated with this litter is proportional to the P load from the baseline litter application.

[4] There would be a separate rate for field crops and pasture.

[5] We recognize that, as P builds in soil after years of repeated application, it can continue be lost from field to water by runoff, sediment transport, and infiltration for extended periods and at variable rates. Losses are influenced by weather and dynamic site-specific characteristics, such as how the field is managed (36).

2.4.2 *Nitrogen manure application loads*

The baseline manure application N load, $ManureAppLoad_b$, is calculated using the same equation as for P, but using post-application loss rates appropriate for N.

The manure application N load after implementation of the baling operation, $ManureAppLoad_{mp}$, is calculated using the same equation as for P.

2.4.3 *Phosphorus commercial fertilizer loads*

The baseline fertilizer load, $FertLoad_b$, is defined as the pounds per year of P that are discharged to water as losses from the application of commercial fertilizer to farm fields before implementation of the baling operation. For P, this is assumed to be zero. In other words, it is assumed that no commercial P fertilizer is applied to fields that receive litter applications.

The fertilizer load after implementation of the baling operation, $FertLoad_{mp}$, is defined as the pounds per year of P that are discharged to water as losses from the application of commercial fertilizer to farm fields after implementation of the baling operation. Even with the baling operation, it is again assumed that for the foreseeable future (and certainly for the current year), no commercial P fertilizer will be needed for fields that have historically received poultry litter applications. $FertLoad_{mp}$ is therefore assumed to be zero.

Because both $FertLoad_b$ and $FertLoad_{mp}$ are assumed to be zero for P, these terms are removed from the equation.

2.4.4 *Nitrogen commercial fertilizer loads*

Without the baling operation, $FertLoad_b$ may or may not be zero; this will depend on whether the field is cropland or pasture, the N needs of the crop or pasture, environmental considerations, and potentially other factors.

With the baling operation, $FertLoad_{mp}$ will be greater than $FertLoad_b$ because commercial N fertilizer will be required for some fields when litter is no longer applied. In contrast to P, it is assumed that N will still need to be applied year after year. To estimate $FertLoad_{mp}$, we set it equal to the amount of N that would have been provided by the litter without a baling operation:

$$FertLoad_{mp} = FertLoad_b + (ManureAppLoad_b * BaleExportPercent)$$

Several assumptions are built into this equation:

1. After litter is diverted to the baling facility, the field that would have received the poultry litter requires the same amount of N, whether or not it is supplied by litter or commercial fertilizer.
2. The post-application loss rate for N applied via litter and via commercial fertilizer is approximately equal.
3. There are no changes in plant utilization of N that is applied in different forms.

To be clear, these assumptions do not necessarily reflect the actual conditions where poultry litter is applied in the Eastern Panhandle. The first assumption, for example, does not consider whether organic and inorganic forms of N from litter and commercial fertilizer are immediately available after application. Additional research is needed to understand whether the second assumption regarding N losses is applicable.

We are not asserting that these assumptions are true, nor does this report depend on these assumptions being true. We simply note them to be explicit as we work through the set of conceptual equations.

2.4.5 *Applying the conceptual equation for phosphorus*

With the assumptions described above, we now apply the conceptual equation to calculate the P load reduction association with the implementation of a baling operation:

$$\text{Net Load Reduction} = (FertLoad_b - FertLoad_{mp}) + (ManureAppLoad_b - ManureAppLoad_{mp})$$

$$\text{Net Load Reduction} = (0 - 0) + \{ManureAppLoad_b - [ManureAppLoad_b * (100\% - BaleExportPercent)]\}$$

$$\text{Net Load Reduction} = ManureAppLoad_b * BaleExportPercent$$

According to this equation, the P load reduction associated with the baling operation are directly tied to the export of bales from the watershed. For example, if all bales are exported (BaleExportPercent = 100%), then the net load reduction is exactly equal to the baseline load from the litter application. If only a portion of bales are exported, then the net load reduction is proportionally lower, because of our assumption that the non-exported bales are applied within our credit project boundary.

2.4.6 *Applying the conceptual equation for nitrogen*

With the assumptions described above, we also apply the conceptual equation to calculate the N load reduction association with the implementation of a baling operation:

$$\text{Net Load Reduction} = (FertLoad_b - FertLoad_{mp}) + (ManureAppLoad_b - ManureAppLoad_{mp})$$

$$\text{Net Load Reduction} = \{FertLoad_b - [FertLoad_b + (ManureAppLoad_b * BaleExportPercent)]\} + \{ManureAppLoad_b - [ManureAppLoad_b * (100\% - BaleExportPercent)]\}$$

$$\text{Net Load Reduction} = -(ManureAppLoad_b * BaleExportPercent) + (ManureAppLoad_b * BaleExportPercent)$$

$$\text{Net Load Reduction} = 0$$

These results clarify that a poultry litter baling operation will have no appreciable N benefit, no matter how many of the bales are exported. This conclusion is tied to the assumptions described above. In particular, it is tied to the assumption that after poultry litter is diverted from a fields to the baling operation, farmers will apply commercial fertilizer to make up for the N that otherwise would have been provided by the litter.[6]

[6] As described below in Chapter 3.1, we propose to use the Chesapeake Bay Watershed Model to calculate reductions in delivered loads to the Bay, and this model may calculate nonzero N benefits.

2.4.7 *Lessons learned from the conceptual equations*

Applying these equations to a poultry litter baling operation is an important exercise because it requires the clarification of assumptions and provides a conceptual framework for clarifying net load reductions. The results, in general, show that a baling operation will result in net P load reductions but may not result in net N load reductions. This is an important finding because it clarifies that potential credits generated by the baling operation will most likely be P reduction credits.[7] Even if a baling operation would only generate P reductions, these reductions could be very important because the TMDL allocations for P are so much more stringent than the allocations for N (See Table 3).

Further, these calculations clarify that the number of P reduction credits generated will depend entirely on the portion of bales that are exported from the watershed. Creating a system to track the disposition of each bale will therefore be an important part of verifying that the baling operation does, indeed, generate the nutrient reductions that are projected.

2.5 Nutrient exports from a baling operation in the context of the TMDL

The TMDL provides a detailed model and assessment of the nutrient and sediment loads generated by each sector, state, and watershed, and it outlines reductions required to return the Bay to health (2). As shown in Table 3, West Virginia's allocations total 0.59 and 5.45 million pounds of P and N, respectively. These figures represent delivered loads to the Bay; actual loads generated within West Virginia are higher because only a portion of the loads are actually delivered to the Bay. These allocations represent approximately 5% and 3% of the total Chesapeake Bay watershed allocations for P and N, respectively.

[7] As described below in Chapter 3.1, we propose to use the Chesapeake Bay Watershed Model to calculate reductions in delivered loads to the Bay, and this model may calculate nonzero N benefits.

Table 3: Chesapeake Bay TMDL allocations (million pounds/year)

Jurisdiction/Major river basin	Phosphorus	Nitrogen
Pennsylvania		
Susquehanna	2.49	68.9
Potomac	0.42	4.72
Eastern Shore	0.01	0.28
Western Shore	0	0.02
Subtotal	2.93	73.93
Maryland		
Susquehanna	0.05	1.09
Eastern Shore	1.02	9.71
Western Shore	0.51	9.04
Patuxent	0.24	2.86
Potomac	0.9	16.38
Subtotal	2.72	39.09
Virginia		
Eastern Shore	0.14	1.31
Potomac	1.41	17.77
Rappahannock	0.9	5.84
York	0.54	5.41
James	2.37	23.09
Subtotal	5.36	53.42
District of Columbia		
Potomac	0.12	2.32
Subtotal	0.12	2.32
New York		
Susquehanna	0.57	8.77
Subtotal	0.57	8.77
Delaware		
Eastern Shore	0.26	2.95
Subtotal	0.26	2.95
West Virginia		
Potomac	0.58	5.43
James	0.01	0.02
Subtotal	0.59	5.45
Preliminary total	**12.54**	**185.93**
Atmospheric deposition allocation	N/A	15.7
Grand total	**12.54**	**201.63**

Source: Table 8-5 from (2). Note: These are delivered loads.

The TMDL provides further detail regarding these allocations for each of the 92 segments that are used in the TMDL model. Only two of these 92 segments are in West Virginia: one that drains toward the Upper Potomac River, MD segment (segment ID POTTF_MD) and one that drains toward the Upper James River Upper segment (segment ID JMSTF2). As shown in Table 4, most of the TMDL is allocated for nonpoint sources, which are called "land-based load allocations" in the TMDL. Much smaller loads are allocated for point sources via wasteload allocations.

Table 4: Segment-by-segment TMDL allocations for West Virginia segments (pounds/year)

Segment ID	303(d) segment	Wasteload allocation	Land-based load allocation	TMDL	2009 existing load
Phosphorus					
POTTF_MD	Upper Potomac River, MD	63,734	519,726	583,459	819,300
JMSTF2	Upper James River Upper	107	9,645	9,752	13,917
Nitrogen					
POTTF_MD	Upper Potomac River, MD	472,895	4,961,651	5,434,546	5,909,347
JMSTF2	Upper James River Upper	376	17,325	17,701	23,854

Source: Table 9-1 from (2). Note: These are delivered loads. The TMDL segments shown in this table are different from the land, river, and land-river segments used in the Chesapeake Bay Watershed Model, version 5.3.2.

Against this backdrop of the TMDL allocations, it is useful to consider the potential scale of impacts from transporting nutrients from the Bay watershed in baled litter. There are several pathways for N and P to be lost from poultry manure between the time that it is excreted, cleaned out from poultry houses, stored, and handled. These pre-application losses are not of concern when quantifying the environmental benefits of a baling operation. The primary reason is that, as a first approximation, each of these steps will still occur whether or not a baling operation is built. As currently proposed in Delta's business plan, the baling operation will collect litter after it is cleaned out from the poultry house, stored, and handled.

The main environmental benefits from a baling operation are generated when the baled litter is transported out of the watershed. Less litter is therefore applied to land within the Chesapeake Bay watershed, and the N and P in each bale cannot reach surface waters or groundwater that ultimately drains toward the Bay.

This section presents more generalized calculations of the N and P transported from the Bay watershed, if a new baling operation were opened. As currently envisioned, the facility would be located near Mathias in Hardy County, West Virginia (See Figure 2). This facility would bale approximately 45,000 tons of broiler and turkey litter each year at the start; the baling machine contemplated in the business plan could process up to 60,000 tons each year (17).

According to the business plan, 70% of the baled litter (31,500 tons) is to be sold to Ohio agricultural producers, 20% (9,000 tons) to certified organic producers, and 10% (4,500 tons) for use in reclaiming surface coal mines. All bales sold to Ohio will be applied outside of the Bay watershed. Of the remaining 30%, some customers may be located within the watershed. (17)

We capture this variation by presenting scenarios. Our first scenario ("Delta high") considers the scenario where 100% of the bales are sold outside of the Chesapeake Bay watershed. This scenario is instructive because it represents the best case scenario in terms of the environmental benefits from a baling operation. Essentially, in assumes that, in addition to the 70% of bales sold to Ohio, all sales to certified organic producers and sales for use in reclaiming surface mines either send the litter outside of the Bay watershed, or result in litter applications within the Bay watershed but on land that has low to moderate levels of P. As a first approximation, these nutrient applications can be handled the same as exports from the Bay watershed.

Our second scenario ("Delta low") assumes that 30% of the bales remain within the Bay watershed and are applied to land that has received repeated litter applications in recent years.

Our third and fourth scenarios contemplate the growth of a baling operation to three times the size envisioned in the business plan. This 300% growth is not specified in Delta's business plan proposal, but instead is simply meant to be illustrative of what could be accomplished should a baling operation take hold and grow significantly. In the third scenario ("Three times Delta high"), the baling operation is expanded and all of the bales are sold outside of the Bay watershed. In the fourth scenario ("Three times Delta low"), the operation is expanded to the same level, but only 70% of the bales are sold outside of the watershed.

Table 5 summarizes these four scenarios and calculates the pounds of N and P that would be transported out of the Bay watershed in each scenario. N exports range from approximately 2 to 8 million pounds per year, and P exports range from approximately 1 to 4 million pounds per year.

Table 5: Nutrients removed from the Chesapeake Bay watershed

Scenario	Total tons litter per year in bales	Percent of bales transported from Bay watershed	Tons litter per year transported from Bay watershed	Nitrogen transported from Bay watershed (million pounds)	Phosphorus transported from Bay watershed (million pounds)
1. Delta high	45,000	100%	45,000	2.7	1.2
2. Delta low	45,000	70%	31,500	1.9	0.8
3. Three times Delta high	135,000	100%	135,000	8.1	3.5
4. Three times Delta low	135,000	70%	94,500	5.7	2.5

Note: Tons litter per year in Scenarios 1 and 2 from (17). Note: The N and P content of poultry litter vary considerably among published sources. Some of this variation is likely due to the nutrient losses that occur during the variable time that passes between excretion and measurement and the final moisture content of the litter that is analyzed. Because this table simply presents illustrative results, it is based on N and P content of poultry litter consistent with broilers in Table 9.2 from (28), which reports 59 pounds total N/ton litter and 63 pounds P_2O_5/ton litter. In the table, both values are rounded to 60, and the P value is converted from P_2O_5 to total P.

There are several reasons why the N and P results in Table 5 do not provide direct answers to the fundamental question posed in this report: What are the environmental benefits of a poultry litter baling facility? The first reason is that, in the context of the Bay TMDL and potential water quality trades, the currency of the environmental benefits is pounds of nutrients delivered to the Bay. The TMDL allocations in Table 3 and Table 4 represent pounds delivered to the Bay; however, the exports in Table 5 represent pounds of nutrients in the bales that are exported. The environmental benefits realized by not applying these nutrients within the Bay watershed are not directly comparable to the pounds of nutrients exported. If these nutrients were applied within the Bay watershed, only a portion would reach the Bay due to losses on the land and in the water before nutrients reach the Bay.

A second difference is that the exported nutrients, if they were applied in the Bay watershed, would not all travel toward the Bay. Some would be taken up by crops or pastures, and some would build the soil P pool.

Further, when nutrients are exported via bales, farmers that otherwise would have applied those nutrients will substitute chemical fertilizers for some portion of the nutrients that are now exported. This is more likely to occur for N than for P and for crops than for pasture.

Another complication is that the baling facility, as envisioned, would accept litter from poultry growers in both West Virginia and Virginia. Because the facility is located in West Virginia, we consider how it could generate nutrient reduction credits within the West Virginia regulatory framework and therefore do not consider the nutrients exported that originated in Virginia. Section 3.1 considers this question in more detail.

Further complications may arise based on how loss rates vary based on the form of nutrients applied (litter, compost, or chemical fertilizer) and based on the specific conditions found on the fields from which litter is diverted to a baling operation. For example, farmers will likely make different decisions for fields that have received repeated litter applications and have high soil P levels, versus fields that have not built up high soil P levels in the past.

While the estimates of exported nutrients in Table 5 do not answer the fundamental question posed in this report, they are still useful for placing upper bounds on the environmental benefits that could be realized under different assumptions regarding the size of the baling operation and the percent of bales that are exported.

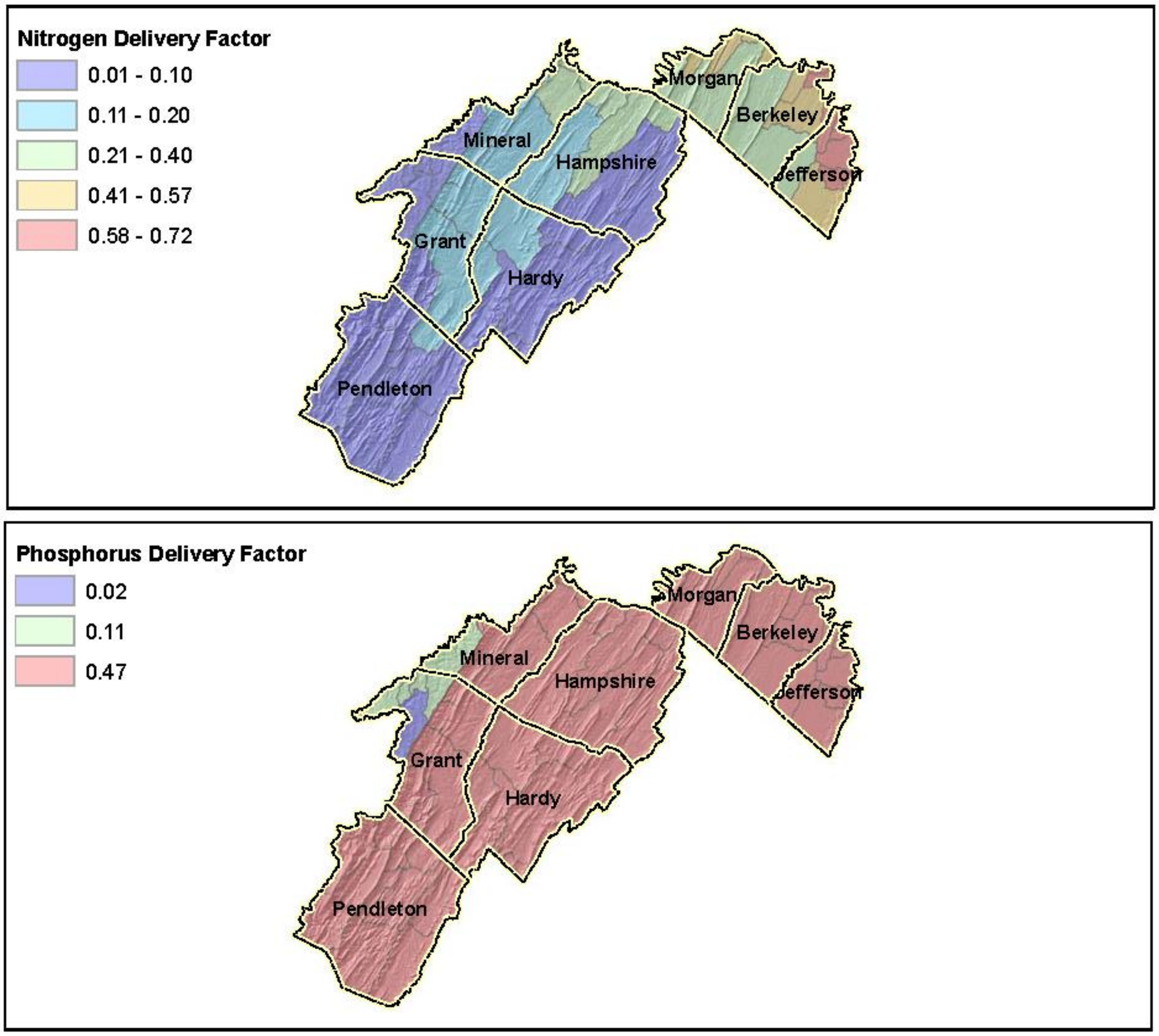
Answering the fundamental question asked in this report requires a model that integrates the highly complex interactions governing nutrient uptake, nutrient losses, and nutrient transport. In addition, a model must be accepted by agencies that oversee TMDL implementation and water quality trading; otherwise, the results would not gain regulatory approval via a water quality trading program. Given these considerations, the Chesapeake Bay Watershed Model is the only tool currently available for calculating environmental benefits (29).

The Chesapeake Bay Watershed Model, version 5.3.2, simulates the watershed, river flows, and the transport and fate of nutrients and sediment that contribute toward the degradation of water quality in the Bay. It divides the region into 309 land segments, which are primarily based on county and incorporated city boundaries, but which also incorporate physiography and topography. The model also simulates river segments, which include river reaches and the land that immediately drains to the reach. The model includes 1,063 river segments. Land-river segments, which were created by intersecting land segments with river segments, are used to route flow and loads from land to the appropriate receiving streams. (30)

After the model calculates the nutrient loads that reach the nearest waterbody, it applies delivery factors. Figure 5 illustrates the N and P delivery factors for the West Virginia counties within the Bay watershed. N delivery factors vary considerably. In all of Pendleton, Grant, and Hardy counties—and in most of Mineral and Hampshire counties—the N delivery factors are less than 0.2. In other words, for every pound of N discharged at the edge-of-stream in these locations, 20% or less of the N is delivered to the Bay. Further downstream, N delivery factors in West Virginia range up to 0.72.

P delivery factors also range considerably, but the lowest P delivery factors are found in the western portion of Mineral and Grant counties. All remaining areas in West Virginia within the Bay watershed have a P delivery factor of 0.47, meaning that 47% of edge-of-stream P discharges will be delivered to the Bay.

Figure 5: Nitrogen and phosphorus delivery factors



Source: Appendix D from (6), which credits the Chesapeake Bay Program.

3. STEPS FOR CAPTURING THE ECONOMIC BENEFITS

Quantifying the environmental benefits of a baling operation is of interest because nutrient reductions may be able to be sold as nutrient credits. Funds generated by selling credits could then help pay for capital expenses or ongoing operations. Therefore, understanding how the nutrient reductions attributable to the baling operation fit into a nutrient credit trading structure is important so that project developers and funders can understand whether, and how, such credits can be monetized. This chapter describes the steps necessary to quantify the environmental benefits and capture the economic benefits tied to reduced nutrient loads delivered to the Chesapeake Bay.

While it would be ideal to precisely calculate the value of the load reductions in this report, this is not yet possible. As described in Section 3.1, the number of offsets generated by the baling operation must first be calculated using the Chesapeake Bay Watershed Model, and it takes many months for modelers at the Chesapeake Bay Program to run a specific model. A second reason why a precise calculation cannot be presented now is that the price of these offsets will be set through a negotiation process between seller and buyer. We describe the most likely buyers in Section 3.2 and present suggestive prices in Section 3.3.

Sections 3.1 through 3.6 describe the steps that will need to be accomplished in order to monetize the load reductions achieved by the baling operation:

1. calculate the number of offsets,
2. find purchasers of offsets,
3. agree on a price for the offsets,
4. gain regulatory approval,
5. perform the transaction, and
6. monitor and verify performance.

3.1 Calculate the number of offsets

The environmental benefits are realized by reducing the amount of litter applied in the Bay watershed, and thereby reducing the amount of post-application nutrient losses to streams, and ultimately the N and P loads delivered to the Bay. Figure 6 illustrates how the loads generated on agricultural fields change from the 2010 No Action (NA) scenario to the baling scenario, in which a poultry litter baling operation is built. The 2010 NA terminology is taken from the Phase II WIP (6) because the offset baseline required to be used in West Virginia is related to this specific scenario.

Section 2.4, above, presents conceptual equations for calculating these environmental benefits. A key concept is our credit project boundary, which is defined as the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because the litter is now transported to the baling operation. In Figure 6, the credit project boundary is represented by the blue polygon.

On the fields within this boundary, poultry litter has typically been applied for many years, and the P in the poultry litter (“fertilizer P”) is transformed to dissolved, active, and stable P. The fertilizer, dissolved, and active P can then be lost from these fields to local waters and ultimately delivered to the Bay.

In the baling scenario, some litter may still be applied to the fields within the credit project boundary (represented by the dashed red line), but thousands of tons of litter would be diverted to a baling operation. Some percentage of the bales would then be exported from the watershed. The scenarios described above in Table 5 contemplate that between 70% and 100% of bales would be exported. Some bales might be returned to fields that provided the litter in the first place (the fields within the credit project boundary). Some other bales might be returned to the watershed, but sent to fields with low P levels. These two possible pathways for baled litter to return to the watershed are also shows as red lines in the figure.

The reduction in P losses to local streams is the difference between the edge-of-stream losses in the baling scenario and in the 2010 No Action scenario. Then, based on the delivery factor for the fields in the credit project boundary, this reduction translates to a reduction in delivered loads to the Bay.

The baling operation is proposed to be located in Hardy County, near Mathias, West Virginia; therefore, the West Virginia water quality trading procedures apply. Section 2.3, above, introduces the concept of water quality trading in the context of the Chesapeake Bay TMDL. As described, WVDEP has not pursued a formal trading framework (29) and, instead, West Virginia's Phase II WIP (6) provides certain guidelines in a chapter on trading and offsets: "The concepts described in this section may be used in case-by-case offset evaluations or as the foundation for a future comprehensive trading program." (6 p. 114)

According to the WIP, the most comment type of trade envisioned would be for a new or expanding wastewater treatment plant—a point source—to offset new loads. While a comprehensive trading and offset program has not been established, the WIP recognizes that any trades would be evaluated on a case-by-case basis and must adhere to the principles in Appendix S of the TMDL. (6)

While the WIP does not propose a comprehensive trading and offset program, it does describe the methods required for establishing baselines for specific sectors. The TMDL defines "offsets baseline" as follows:

> Offsets Baseline. For purposes of the Chesapeake Bay TMDL, means the amount of pollutant loading allowed by wasteload allocation (WLA) or load allocation (LA) that applies to individual credit generators in the absence of offsets. Sources generating credits are expected to first achieve their applicable offset baselines before credits may be generated. (2 pp. S-2)

According to West Virginia's Phase II WIP, baselines for agriculture are as follows:

> The baseline for individual non-regulated agriculture operations, inclusive of manure transport, is 21 % N and 29 % P edge-of-stream reduction from 2010NA loadings. The specified reduction rates were determined by the average reduction from 2010 NA prescribed for the agriculture sector exclusive of the CFO[8] land use in the final Phase II WIP 2025 model scenario (2010WVP2WIP525N122011).
>
> The baselines for operations meeting medium or large [concentrated animal feeding operation, or] CAFO animal thresholds are the loading reductions from 2010NA on production areas that result from the application of the Animal Waste Management System, Barnyard Runoff Control, Loafing Lot Management and Mortality Composting BMPs, as appropriate to the operation. Additionally, the baselines include reductions associated with the development and implementation of Nutrient Management Plans for manure application to lands under the control of the owner/operator. (6 pp. 115-116)

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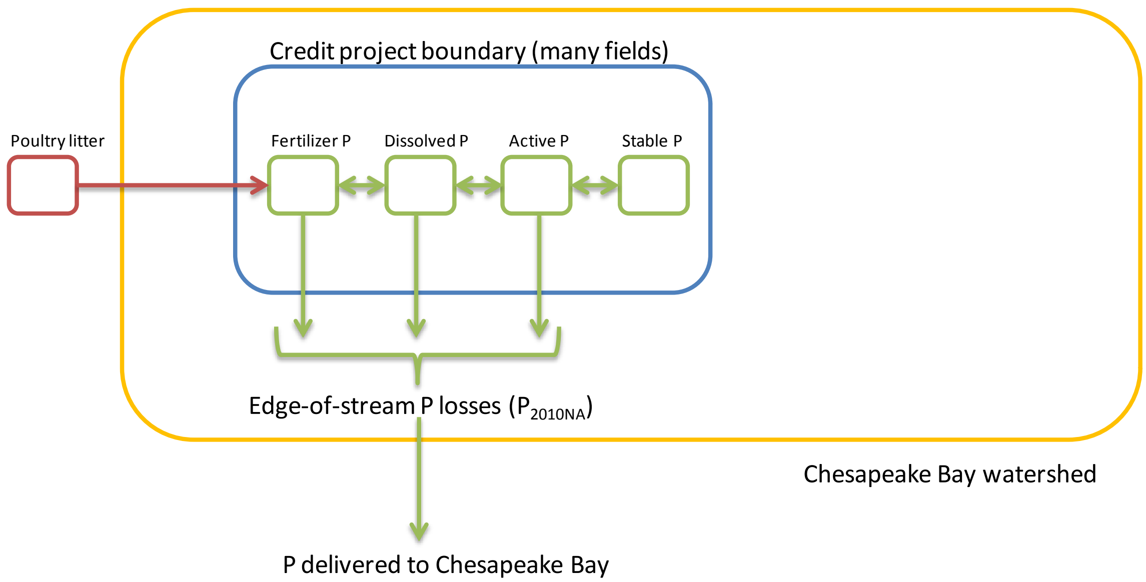
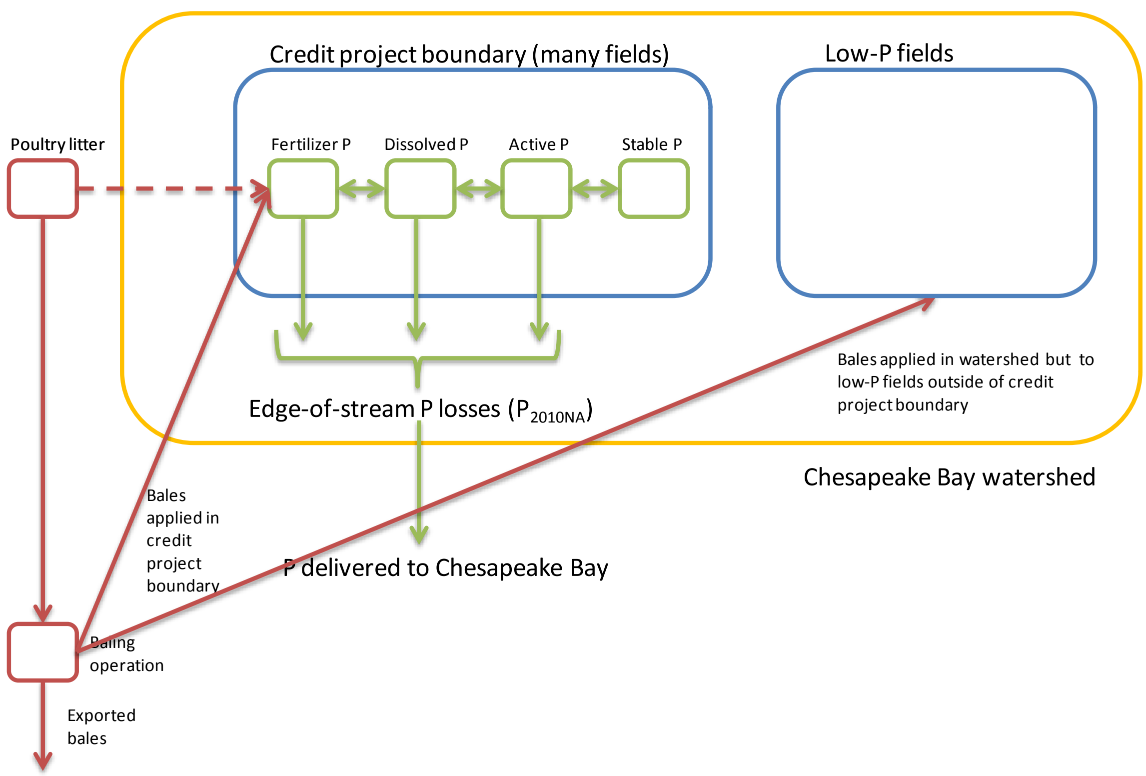
8 The Phase II WIP clarifies that, in the Chesapeake Bay Watershed Model, version 5.3.2, concentrated animal feeding operations were split into two components: CFO and AFO (6).

Figure 6: Phosphorus delivered to the Chesapeake Bay in the 2010 No Action and Baling scenarios

2010 No Action Scenario



Baling Scenario



In other words, in order for a non-regulated agricultural operation to generate credits that can be sold via a trade, it must first reduce N by 21% and P by 29%, as compared to a specific past loading rate. For regulated agricultural operations, certain best management practices must first be applied.

It is a challenge to perform such baseline calculations. According to the WIP, the Chesapeake Bay Watershed Model, version 5.3.2 is the primary tool available through 2017, despite being cumbersome and time-consuming and having documented flaws. WVDEP maintains some flexibility in approving offset calculations: "As such, alternative mechanisms for offset calculation will only be authorized if their pollutant reduction value can by scientifically documented by WVDEP with EPA concurrence." (6 p. 116)

While the WIP provides for some flexibility, WVDEP has clarified that the Chesapeake Bay Watershed Model is the preferred approach (31). As such, we pursue this approach in this report.

The Chesapeake Bay Watershed Model simulates the generation of nutrients across the entire Bay watershed; after nutrients are generated, it then models the fate and transport of these nutrients as they are delivered to the Bay. The model divides the watershed into land segments, river segments, and land/river segments; however, it also allows users to specify certain aspects of model runs at the county level. (30)

This feature is applicable when calculating the reduction in loads due to a baling operation. In this case, load reductions are primarily driven by identifying which fields across the region are within the credit project boundary (which, again, is defined as the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because the litter is now transported to the baling operation). Before a baling operation is built and agreements are secured with farmers to provide litter, it is not possible to know exactly which litter will be diverted to the baling operation. It is therefore most reasonable to run the model based on assumptions of which counties will be providing litter, rather than which specific fields.

According to Delta's business plan proposal, raw poultry litter would be collected from a 60-mile driving distance range from the baling operation. The tentative location of the operation, Mathias, was chosen because it is in West Virginia but on Route 259, thereby providing easy access to poultry farms in Virginia. According to the business plan proposal, all five Eastern Panhandle counties in West Virginia (Grant, Hampshire, Hardy, Mineral, and Pendleton counties) as well as four counties in Virginia (Augusta, Page, Rockingham, and Shenandoah counties) are entirely or partially within a 60-mile driving distance range of Mathias. (17)

For consistency, we split the source counties for raw litter based on information provided in the business plan proposal, as shown in Table 6. According to these figures, approximately 204 million broilers and 15 million turkeys were sold within a 60-mile driving range of Mathias. Applying the amount of litter produced per bird, which differs considerably between broilers and turkeys, allows an estimate of the percent of total manure produced in each of these nine counties. Multiplying these percentages by the total amount of litter estimated to be baled—45,000 tons—provides the estimates per county in the final column of this table.

Of the 45,000-ton total, it is estimated that only 30%, or almost 14,000 tons, would be generated by poultry farmers in West Virginia. The remaining 70% would be produced in Virginia. On a county-by-county basis, Rockingham County in Virginia would provide the most litter. Hardy County would provide, by far, the most litter of any West Virginia county: 15% of the total.

Table 6: Estimated tons of manure sent to baling operation by county

County	Broiler sales within range	Turkey sales within range	Manure generation as percentage of total	Tons of manure sent to baling operation
West Virginia				
Grant	12,903,419	-	4%	1,610
Hampshire	7,180,620	-	2%	896
Hardy	39,960,777	1,207,768	15%	6,580
Mineral	4,086,087	-	1%	510
Pendleton	14,390,662	1,677,480	9%	4,011
Subtotal, West Virginia	**78,521,565**	**2,885,248**	**30%**	**13,606**
Virginia				
Augusta	5,523,988	1,517,628	6%	2,694
Page	26,947,968	1,661,702	12%	5,557
Rockingham	71,404,960	7,580,256	42%	18,920
Shenandoah	21,114,276	1,203,426	9%	4,223
Subtotal, Virginia	**124,991,192**	**11,963,012**	**70%**	**31,394**
Total	**203,512,757**	**14,848,260**	**100%**	**45,000**

Source: (17). Note: For consistency with Delta's business plan proposal, manure generation is calculated by multiplying broiler sales by 1.7 pounds per head and turkey sales by 18 pounds per head.

The Chesapeake Bay Watershed Model can only be run by trained modelers at the Chesapeake Bay Program. Because of the length of time it takes for each model run and the dozens of requests already in the queue, it will take several months from the time that the run is requested until the results can be calculated (32). It is therefore important to specify and this run as soon as possible. WVDEP has pledged its cooperation to properly specify the model run and expedite the calculation process (33).

3.2 Find purchasers of offsets

The baling operation can only realize a financial benefit if it sells the offsets that it generates. As described in the WIP, WVDEP anticipates that offset purchasers would include new or expanding wastewater treatment plants that need to offset new loads. Two sources provide slightly different information about the most likely set of offset purchasers in West Virginia: the TMDL (Table 7) and the Phase II WIP (Table 8).

The TMDL provides detailed WLAs for significant permitted dischargers. According to the TMDL, significant municipal dischargers in West Virginia are those with design flows of 4 million gallons per day or more, and significant industrial dischargers across all Bay states are those with estimated loads of 3,800 or more pounds per year of P and 27,000 or more pounds per year of N. As show in Table 7, a total of 17 significant dischargers are located in West Virginia—including both municipal and industrial dischargers.

Table 7: Edge-of-stream wasteload allocations for significant permitted dischargers (pounds/year)

Permittee	Permit ID	Phosphorus	Nitrogen
Pilgrim's Pride	WV0005495	1,310	13,096
Virginia Electric & Power	WV0005525	0	0
Leetown Science Center	WV0005649	1,827	18,273
Moorefield	WV0020150	914	9,137
Romney	WV0020699	761	7,614
Petersburg	WV0021792	2,056	20,558
Charles Town	WV0022349	2,665	26,649
Martinsburg	WV0023167	4,568	45,683
Keyser	WV0024392	3,655	36,547
Shepherdstown	WV0024775	609	6,091
Warm Springs PSD	WV0027707	2,650	26,496
Fort Ashby PSD	WV0041521	761	7,614
Hester Industries, Inc.	WV0047236	761	7,614
Berkeley County PSSD	WV0082759	8,984	89,844
Reeds Creek Hatchery	WV0111821	2,630	26,298
Spring Run Hatchery	WV0112500	6,548	65,480
The Conservation Fund Freshwater Inst.	WV0116149	1,538	15,380
Total		**42,237**	**422,374**

Source: (2), Table 9-4. Note: All significant dischargers in West Virginia are in the POTTF_MD TMDL segment. Berkeley County PSSD (WV0082759) includes four facilities under the same permit. These are edge-of-stream loads. The Virginia Electric & Power permit is listed in the Phase II WIP as nonsignificant. PSSD = Public Service Sewer District.

West Virginia's Phase II WIP provides more detail about West Virginia's significant permitted dischargers, as well as about the state's nonsignificant municipal and industrial dischargers and its combined sewer overflow (CSO) dischargers in the Bay watershed. These allocations are provided in Table 8 through Table 12.

Table 8: Edge-of-stream wasteload allocations for significant permitted municipal dischargers (pounds/year)

Permittee	Permit ID	Outlet	Phosphorus	Nitrogen	Latest expected compliance date
Moorefield	WV0020150	001	913	9,132	6/30/15
Romney	WV0020699	001	761	7,610	6/30/17
Petersburg	WV0021792	002	2,055	20,548	6/30/17
Charles Town	WV0022349	001	2,664	26,636	6/30/15
Martinsburg	WV0023167	001	4,566	45,662	6/30/17
Keyser	WV0024392	001	3,653	36,529	6/30/17
Shepherdstown	WV0024775	001	609	6,088	6/30/13
Warm Springs PSD - BS	WV0027707	001	2,648	26,484	Compliant
Fort Ashby/Frankfort	WV0041521	001	761	7,610	6/30/13
BCPSSD - O/H	WV0082759	001	2,435	24,353	6/30/17
BCPSSD - Inwood	WV0082759	002	2,283	22,831	6/30/17
BCPSSD - Baker Heights	WV0082759	003	2,740	27,397	6/30/17
BCPSSD - North End	WV0082759	004	1,522	15,221	6/30/17

Source: (6). Wasteload allocations from Appendix A.1 and compliance dates from Appendix A.2.

Table 9: Edge-of-stream wasteload allocations for nonsignificant permitted municipal dischargers (pounds/year)

Permittee	Permit ID	Phosphorus	Nitrogen
The Woods Resort	WVG550581	132	789
Springer Run Park	WVG551048	274	1,644
Berkeley County PSSD (Tomahawk Elementary)	WVG551078	55	329
Hickory Run Subdivision	WVG551311	102	614
Thomas Stollings	WVG413117	5	27
Tilhance Farm Subdivision	WVG413235	5	27
Douglas Oaks, Sandpiper Fly-in Community	WVG551415	183	1,096
Powell's Patch	WVG550656	228	1,370
Judy Lynn Mobile Home Park	WVG550815	46	274
Berkeley Co PSSD Ghant MHP	WVG550858	68	411
Antietam, LLC	WVG551257	82	493
Willowbrook Section 3	WVG551416	192	1,151
BCPSSD - Woods II	WV0103161	685	4,110
Panhandle Homes of Berkeley County	WV0105708	457	2,740
Whitmore Homes, Inc.	WV0105937	57	571
Beards Farm Estates	WVG551430	297	1,781
Fountainhead Subdivision	WVG551421	228	1,370
Priestfield Pastoral Ctr	WVG550345	155	931
Highpointe Subdivision	WVG550964	102	614
The Corners At Arden WWTP	WVG550966	120	721
Union Gap Subdivision	WVG551055	84	506
Gerrardstown (Mtn Ridge) Intermediate School	WVG551369	73	438
BCPSSD - Forest Heights (001)	WV0105830	228	1,370
BCPSSD - Forest Heights (002)	WV0105830	475	2,849
BCPSSD - Honeywood	WVG551294	457	2,740
Riverbend Membership Corp	WV0105384	913	5,479
Panhandle Business Services Inc.	WVG551020	228	1,370
BCPSSD - Nestle Woods	WV0105864	76	761
BCPSSD - Marlowe	WV0105791	457	2,740
Link, Joseph	WV0105881	183	1,826
Cherry Run MHP	WVG550357	119	712
Morgan Village MHP	WVG551263	320	1,918
Falling Waters Estates	WVG550132	164	986
Evergreen Center	WVG550733	91	548
Broad Lane MHP	WVG550778	247	1,479
Berkeley County PSSD (Northwind WWTP)	WVG551199	192	1,151
Pepper Tree MHP	WVG550854	11	66
Midway Mobile Home Park	WVG550856	210	1,260
Potomac Park Camp Inc	WVG550911	228	1,370
Marlowe Garden Apts - Phase I	WVG550914	137	822
Whitebush Landing Subdivision	WVG551160	102	614
Potomac Rock Estates	WVG551450	82	493
John G. Dobbie	WVG414126	5	28
Potomac Plaza	WVG551208	9	55
Mount Storm Village	WVG550455	61	367
Union Educational	WVG550690	73	438
Mount Storm Ind. Park	WVG550793	137	822
Mountain Top PSD- Bayard (001)	WV0101524	457	2,740
Mountain Top PSD - Gormania (002)	WV0101524	91	548
Smoke Hole Caverns	WVG550529	46	274
Allen's Mobile Village	WVG550766	91	548
C&J Utilities, LLC	WVG550140	102	614
Potomac Administrative Site	WVG550433	14	82
Kim-Sue Corporation	WVG413769	5	27

Permittee	Permit ID	Phosphorus	Nitrogen
John E Russel	WVG412886	5	27
Avalon Village Condo.	WVG550938	58	345
Camp Timberridge	WVG550189	192	1,151
Capon Springs and Farm	WVG550786	365	2,192
S.O.M.E. Inc.	WVG550792	55	329
Burgundy Center For Wildlife Studies	WVG550823	32	192
Concord Retreat LLC	WVG551105	56	334
Capon Bridge Technology Park	WVG551283	228	1,370
Leonard & Peg Mc Masters	WVG412299	5	27
Julie Sheets & Issac Crouse	WVG413357	5	27
Capon Bridge	WVG551350	457	2,740
Michael Hockman	WVG413868	5	28
Walnut Lane Estates	WVG550375	68	411
Crystal Valley Ranch	WVG550499	27	164
Buffalo Run Trailer Court	WVG550827	55	329
Colonial Motel	WVG551230	21	123
Peterkin Camp & Conference Ctr	WVG551285	183	1,096
T&S Market	WVG551343	46	274
Central Hampshire PSD No. 2	WVG551390	365	2,192
Central Hampshire PSD	WV0081850	1,826	10,959
Sleepy Knolls Subdivision	WVG551424	192	1,151
E A Hawse Nursing & Rehab Center	WVG550120	187	1,123
Trout Pond Recreation Area	WVG550214	121	723
Lost River State Park	WVG550937	82	493
East Hardy Early Middle School	WVG551348	55	329
Hardy County High School	WVG551349	46	274
N & S Family Restaurant	WVG551367	18	110
Wardensville	WV0045501	1,096	6,575
Hardy Co. PSD	WVG551422	365	2,192
Hardy Co. PSD	WVG551428	5	27
Caledonia Heights Subd.	WVG550723	196	1,178
Juniper Ridge Mobile Home Court	WVG551342	82	493
Harpers Ferry Koa	WVG550411	320	1,918
Cliffside Inn, LLC	WVG550828	155	931
C&R Development	WVG412046	6	33
Harpers Ferry-Bolivar PSD	WV0039136	2,740	16,438
Willow Springs PSC	WV0086452	913	5,479
Old Standard, LLC	WV0105724	190	1,903
B.C. Partners	WV0105872	265	2,648
Rahmi, Alex	WV0105155	685	4,110
US Customs and Border Protection	WVG551448	365	2,192
Oakhill MHC	WVG550137	137	822
Cave Quarter WWTP	WVG550636	146	877
Blue Ridge Elementary	WVG551158	110	658
Page Jackson Elementary School	WVG551159	110	658
Charles Town	WV0088013	1,790	10,740
Huntfield, LLC	WV0105821	913	5,479
PNGI Charles Town Gaming LLC	WV0105856	381	3,805
Highland Farms, LLC	WV0105767	457	2,740
Shenandoah Junction WWTP	WVG550533	164	986
Gloria Ryals	WVG410499	5	28
Mountain Top PSD - Elk Garden (003)	WV0101524	457	2,740
Jeffrey and Amy Smith	WVG414260	5	28
Graceland Homeowners Assoc	WVG550200	190	1,140
Sherwood Acres Subd.	WVG550273	196	1,178
Hunt Club Subdivision	WVG550507	110	658
Volunteer Fire Dept.	WVG550817	11	66

Permittee	Permit ID	Phosphorus	Nitrogen
Pownall's Addition Comm Assoc	WVG550915	393	2,356
Frankfort Middle School	WVG551018	91	548
Frankfort High School	WVG551060	183	1,096
Green Gables	WVG551148	114	687
Moreland's Mobile Home Park	WVG551363	192	1,151
Knobley Estates Sanitary Corporation	WV0088897	548	3,288
Burlington Um Fam. Serv.	WVG550023	46	274
Fountainhead Sewerage System	WVG550524	119	712
Mountainaire Village Utilities	WVG550462	274	1,644
Lakewood Utilites Water Reclamation Plant	WVG550775	452	2,712
Berkeley Springs Rehab & Nursing	WVG550373	320	1,918
Tri-Lake Park	WVG550387	457	2,739
Waugh's Community Home Park	WVG550673	134	805
522 Industrial Park	WVG550694	228	1,370
Valley Dale Maint. Assoc.	WVG550862	91	548
Cacapon East, Inc	WVG551122	91	548
Cacapon South Utility	WVG551222	347	2,082
Cacapon Investments, LLC	WVG551338	18	110
Skyline Village Treatment Plant	WVG551400	100	603
Shadow Valley Farm Subdivision	WVG551401	166	997
WV Div of Nat Resources - Cacapon State Park	WVG551181	457	2,740
Ridge View Subdivision	WVG551163	247	1,479
Lagoon No. 1,2 and 3	WVG550884	178	1,068
Berkeley Springs Development, LLC	WV0105953	304	3,044
Warm Springs PSD - GC (002)	WV0027707	548	3,288
Paw Paw	WV0027405	1,826	10,959
Franklin	WV0024970	1,826	10,959
Pendleton Business Ctr	WVG550812	183	1,096
Upper Tract Pendelton Cnty Ind. Pk	WVG550699	137	822
South Fork Crossing Subdivision	WVG551394	31	184
US Department of Navy - Sugar Grove	WVG551203	457	2,740
William W. Hartman	WVG410613	5	33
Ruby M. Kisamore	WVG412450	5	33
Woodsedge MHP	WVG550629	73	438
Seneca Shadows Campground	WVG551371	121	723
Seneca Rocks Mini Mall	WVG550292	16	99

Source: (6), Appendix A.4. Note: MHP = mobile home park. WWTP = wastewater treatment plant.

Table 10: Edge-of-stream wasteload allocations for combined sewer overflow dischargers (pounds/year)

Permittee	Permit ID	Phosphorus	Nitrogen
Keyser CSO	WV0024392	189	1,512
Martinsburg CSO	WV0023167	810	6,481
Moorefield CSO	WV0020150	76	607
Piedmont CSO	WV0105279	192	1,537

Source: (6), Appendix A.5.

Table 11: Edge-of-stream wasteload allocations for significant industrial dischargers (pounds/year)

Permittee	Permit ID	Phosphorus	Nitrogen	Latest expected compliance date
Pilgrim's Pride Corporation	WV0005495	3,349	33,485	6/30/15
Pilgrim's Pride Corporation	WV0047236	761	7,610	6/30/15
USDOI - Leetown	WV0005649	1,826	18,265	Compliant
WVDNR - Reeds Creek	WV0111821	2,629	26,286	6/30/13
WVDNR - Spring Run	WV0112500	6,545	65,448	Compliant
Conservation Fund	WV0116149	1,537	15,373	Compliant

Source: (6). Wasteload allocations from Appendix B.1 and compliance dates from Appendix A.2. Note: WVDNR = West Virginia Division of Natural Resources. USDOI = United States Department of the Interior.

Table 12: Edge-of-stream wasteload allocations for nonsignificant industrial dischargers (pounds/year)

Permittee	Permit ID	Phosphorus	Nitrogen
DSI Underground Systems	WV0005509	274	1,644
WV Department of Transportation	WVG980141	183	1,096
VEPCO - North Branch Power Station	WV0115321	14	82
WV Department of Transportation	WVG980098	25	-
WV Department of Transportation	WVG980099	25	-
Polino Contracting, Inc.	WVG990129	90	-
Roth, Jeffrey R	WVG990075	77	-
Virginia Electric & Power Co	WV0005525	6,088	121,764
Perdue Farms Inc	WVG990109	50	-
WV Department of Transportation	WVG980070	25	-
Ox Paperboard, LLC	WV0005517	609	2,435
US Fish & Wildlife Service	WV0105112	749	4,493
National Park Service	WVG990120	195	-
Naval Sea Systems Command / Alliant Techsystems, Inc.	WV0020371	350	3,498
Burlington Volunteer Fire Dept	WVG990023	56	-
Classic Car Wash	WVG990038	77	-
WV Department of Transportation	WVG980150	53	170
WV Department of Transportation	WVG980093	25	-

Source: (6), Appendix B.2. Note: The NPDES permit for Naval Sea Systems Command/Alliant Techsystems, Inc. has co-permittees, and the allocations apply to combined loadings.

The significant municipal (Table 8) and significant industrial (Table 11) dischargers in the Bay watershed generally have the largest P and N wasteload allocations; these facilities, should they expand, might be interested in purchasing nutrient credits generated by a poultry litter baling facility. The nonsignificant municipal and industrial dischargers, as well as the CSO facilities, might also be interested in purchasing credits; however, it is likely that the amount of credits that these facilities might be interested in would be smaller.

For the significant dischargers listed in Table 8 and Table 11, the Phase II WIP provides estimated compliance dates. Most of these facilities are not yet compliant with their WLAs; however, installation of necessary nutrient reduction treatment technology is expected at all facilities by 2015, and all facilities are anticipated to be compliant by 2017 (6).

While the WIP does not preclude wastewater sources from purchasing credits to meet their WLAs, municipal facilities are under compliance schedules to have upgrades in place by December 31, 2015. Further, WVDEP has strongly encouraged these facilities to take advantage of grant funding that is available now for these upgrades. (34) For these reasons, it is unlikely that wastewater treatment plants will purchase credits to meet their new WLAs.

Expansions of existing plants or construction of new plants, however, would need to offset their additional nutrient loads—these plants would then be candidates for purchasing offsets from the baling operation.

3.3 Agree on a price for the offsets

In order to sell credits, the buyer and seller must agree on a price. Because trades have not been completed in West Virginia, nutrient credit trades that have occurred in adjacent Chesapeake Bay states—Maryland, Virginia, and Pennsylvania—were analyzed to provide insight into the possible value of N and P credits in the region.

In Maryland, no trades have occurred (35). In Virginia, virtually all trades have occurred only between point sources (36). Of these three states, Pennsylvania is the only state where nutrient credits have been generated by an agricultural nonpoint source discharger and purchased by a point source discharger (35; 36). Thus, this section analyzes nutrient transactions in Pennsylvania.

In Pennsylvania, nutrient trades are transacted through a free-market system regulated by the Pennsylvania Department of Environmental Protection (PADEP). The Pennsylvania Infrastructure Investment Authority (PENNVEST) hosts periodic auctions where nutrient credits are traded; currently approximately 30% of all nutrient credit trades in Pennsylvania have occurred at PENNVEST auctions (37; 38). N and P credit trading began in 2006 in Pennsylvania, and since then, 604,033 pounds of N and 5,423 pounds of P have been traded (39; 40). More than 100 times more N credits have been sold in Pennsylvania, as compared with P credits.

Almost all N and P credits sold thus far have been generated through the transport of manure out of the watershed by agricultural operations or by technological improvements at wastewater treatment facilities. Manure transport generated 53% of N credits and 58% of P credits, and wastewater treatment plants generated 46% and 42% of N and P credits respectively (39; 40).[9]

Wastewater treatment plants have been the most common buyers of nutrient credits in Pennsylvania (39; 40), purchasing 52% of N credits and 99% of P credits. PPL Energy, LLC has also been a regular purchaser of nitrogen credits (41%), which are used to offset N discharges to receiving streams generated by removing nitrous oxides from its air emissions (39; 40; 41).

As shown in Table 13, the price paid per credit (or pound) of N in Pennsylvania ranged from $1.22 to $15.00, with a weighted average of $3.50. The average price paid for N credits reached its peak in 2009 and has steadily declined since (See Figure 8).

The value of P credits ranged from $1.45 to $10.00 and averaged $4.05. P prices peaked in 2010 and have also declined in more recent years.

While the price per credit for N and P credits have been similar, many more N credits have been sold in Pennsylvania. This has resulted in the total value of N credits dwarfing the total value of P credits: $2.1 million for N credits versus approximately $22,000 for P credits.

[9] A small number of N credits were generated by conversion of farmland.

Table 13: Summary of nutrient credit trades in Pennsylvania

Nutrient	Average price	Price range	Average number of credits traded	Number of transactions	Total credits traded	Total value traded (thousand $)
Nitrogen	$3.50	$1.22 to $15.00	14,259	38	604,033	2,144
Phosphorus	$4.05	$1.45 to $10.00	339	16	5,423	22

Source: (39; 40). Note: One credit is equal to one pound. A transaction with a listed price of $2,520/credit was removed, with the assumption that this was a mistake. The average price is a weighted average. Some transactions note the number of credits traded, but do not provide the price. These transactions are included in the total credits traded but not in the average price. The total value traded is therefore an estimate.

Estimating the value of credits generated by a poultry litter baling operation requires a price per credit—as discussed in this section—to be multiplied by the number of credits generated. As discussed in the previous section, calculating the number of credits generated requires a run of the Chesapeake Bay Watershed Model and cannot be completed for several months. Therefore, it is not possible at this time to estimate the total potential value of credits generated by the poultry litter baling operation.

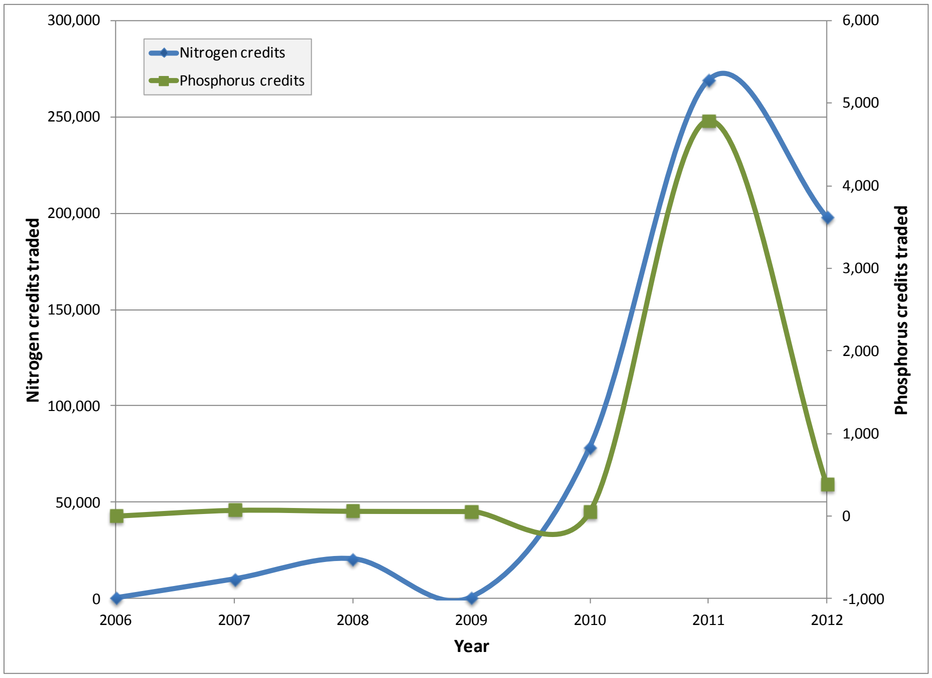
Once the model run is completed, however, it is suggested that low, medium, and high calculations be performed at the following credit prices for N and P:

- $1/pound (less than the lowest price paid for either N or P credits in Pennsylvania);
- $3/pound (similar to, but slightly less than, the average price paid in Pennsylvania); and
- $5/pound (similar to, but somewhat greater than the average price paid in Pennsylvania).

It will then be useful to compare this total dollar amount against the capital and operating costs of the baling facility to answer the questions:

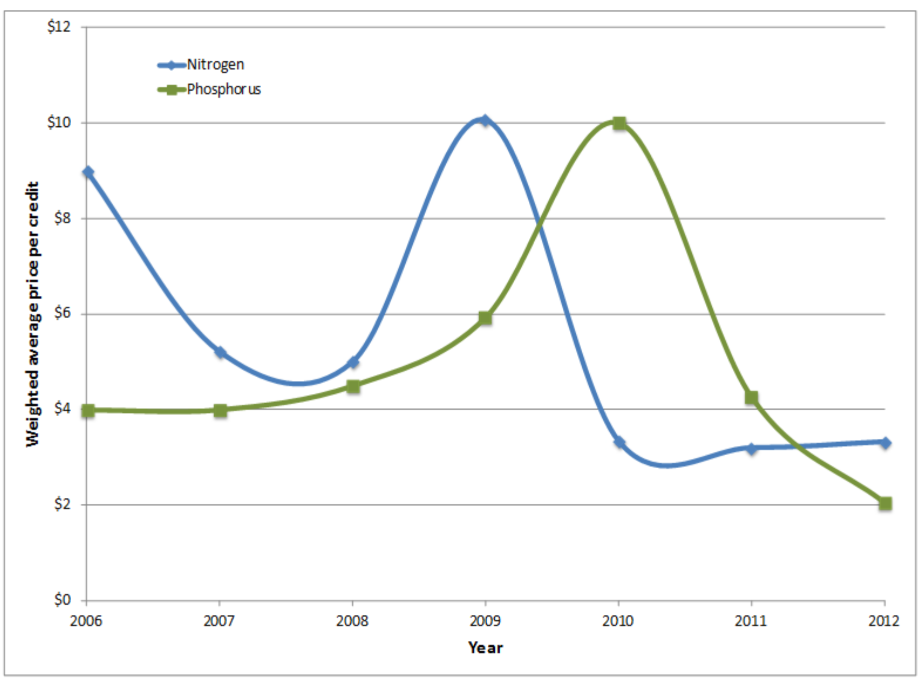
- What percentage of these costs can be covered by the sale of nutrient credits?
- How much more viable does this make a baling operation?

Figure 7: Number of nitrogen and phosphorus credits sold over time



Source: (39; 40). Note: One credit is equal to one pound.

Figure 8: Value of nitrogen and phosphorus credits sold over time



Source: (39; 40). Note: One credit is equal to one pound. The average price each year is a weighted average. Some transactions note the number of credits traded, but do not provide the price. These transactions are not included in the average price each year.

3.4 Gain regulatory approval

As described above, no comprehensive trading program has been developed in West Virginia, and it does not appear that a comprehensive trading program will be developed in the near future. Even absent a comprehensive program, trades may still gain regulatory approval; however, WVDEP must approve trades in West Virginia on a case-by-case basis (6).

Section 11 of West Virginia's Phase II WIP provides a roadmap for planning successful trades and includes a section with specific details on trading in the agricultural sector (6). Discussions with WVDEP and the West Virginia Department of Agriculture (WVDA) have provided reinforcement and further details. These discussions have also covered details of a potential trade of nutrient credits generated by a poultry litter baling operation. Regulatory approval cannot be granted until more details are known—including, for example, the number of credits generated, the identity of the credit purchaser, and the methods used to monitor and verify performance—but WVDEP is now aware of the potential for selling credits generated by a baling facility and is open to receiving documentation for a potential trade once this information is available (31; 33). Further, WVDEP has committed to filing a request with the Chesapeake Bay Program for a model run, in order to quantify the number of credits that would be generated by a baling facility.

One challenge in gaining regulatory approval is that WVDEP is not the only agency with authority. The Chesapeake Bay watershed crosses state lines, and as such, the TMDL was written by USEPA (2). While the TMDL document recognizes that trading can be a tool for TMDL implementation, trades will be closely monitored by USEPA. Section 10.2 of the TMDL specifically discusses water quality trading, and Appendix S provides definitions and common elements that USEPA expects states to include in their trading programs. (2) Any trade, therefore, must be able to withstand USEPA's review.

A second challenge in gaining regulatory approval is that the rules for generating credits for manure transport may change. Manure transport is explicitly recognized in West Virginia's Phase II WIP's discussion of trading in the agricultural sector: In its definition of a baseline for the agricultural sector, it clarifies that the baseline applies to "individual non-regulated agriculture operations, ***inclusive of manure transport***" (6 p. 115, emphasis added). And as described in Section 3.3, most N and P credits sold thus far in Pennsylvania have been generated through manure transport. However, there are signals that manure transport may not be an allowable practice for the generation of nutrient credits at some point in the future.

In Pennsylvania, for example, PADEP is currently reviewing new regulations, which would go into effect in 2015, and which would no longer allow credits to be generated by transporting manure out of the watershed (41). The majority of nutrient credits—52% of N and 58% of P credits—sold in Pennsylvania were generated via manure transport; therefore, approval of these regulations would greatly impact nutrient trading in Pennsylvania. Regulations approved during the planning process for nutrient trading in Maryland would not allow credits to be generated through the transport of manure (35).

There is no indication that such restrictions are imminent in West Virginia; however, should USEPA decide that manure transport is no longer eligible for generating credits, then manure transport activities within the entire Bay watershed—including the baling operation in West Virginia—would likely be impacted. Therefore, decisions by regulatory agencies regarding the future of manure transport as a credit-generating activity are of great importance to the baling operation.

Further research is required to clarify exactly why the rules in Pennsylvania and Maryland appear to be moving away from generating nutrient credits via manure transport. If their rationale is related to the difficulty in tracking and quantifying the nutrients that are exported from the watershed, then a baling facility—which provides unique possibilities for tracking each bale—could prove to be an exception and provide a path forward that satisfies regulators.

Even if the rules change and manure transport is phased out by WVDEP or USEPA, there may still be a window of opportunity to gain regulatory approval for a trade involving the poultry litter baling operation before the rules change.

3.5 Perform the transaction

Once regulatory approval is granted, the transaction must be performed. Because West Virginia does not have a comprehensive trading program, the specific steps involved in performing the transaction are not laid out in detail by WVDEP. However, the steps can still be generally described, and will likely include:

1. revising the NPDES permit for the credit purchaser,
2. enshrining the trade in a contract between the credit purchaser and the baling operation, and
3. transferring the funds.

A trade will most likely involve an existing wastewater treatment plant purchasing offsets for its expansion or a new wastewater treatment plant purchasing offsets for its construction. Wastewater treatment plants are point sources and will be operating under NPDES permits that specify discharge limitations for N and P (among other pollutants) and self-monitoring requirements. NPDES permits are legally binding under the Clean Water Act, and can also include special conditions. The NPDES permit is therefore an appropriate vehicle for documenting the detailed expectations in the trade and for holding the permit holder legally responsible for the trade.

The baling operation, on the other hand, is not a point source discharger and will not be operating under an NPDES permit. With no permit to modify to enshrine the terms of the trade, a new contract or other legal document will likely be required to ensure that the credit generator (the baling operation) and the credit purchaser (the wastewater treatment plant) are operating under the same assumptions and that responsibility for implementation is clearly described. It will also be important to clarify what steps are taken, and who is held responsible, should the required number of credits not actually be generated. The bottom line is that if a wastewater treatment plant is provided a permit that allows an expansion or new construction based on its purchase of credits, then those credits must actually be generated.

In addition to the legal questions of how to document the trade and hold the parties responsible, funds must be transferred. Again, because West Virginia does not have a comprehensive trading program, the arrangements for the transfer of funds will have to be worked out on a case-by-case basis. It is assumed that the specific arrangements will be described in a contract or other legal document described directly above.

3.6 Monitor and verify performance

As described in Section 3.1, the number of credits generated by the baling facility will be calculated by running the Chesapeake Bay Watershed Model. The model run will be based on a specified number of tons of litter being diverted from fields in the Bay watershed to the baling operation, and by a certain percentage of the bales being exported from the watershed. These two aspects of the operation—the tons of litter diverted and the percentage of bales exported—must be tracked in order to monitor success and verify that the credits predicted by the model will actually be generated.

To document the amount of litter diverted from applications on farmers' fields, the baling operation will have to set up a tracking system with at least the following information:

- tons of litter,
- name and location of poultry operation that generated the litter,
- specific locations of farm fields that would have received the litter if it had not been diverted to the baling operation (see additional detail on this item below), and
- date.

The third bullet above represents a key question in terms of verifying the generation of credits. It is recognized that a single poultry operation may distribute its litter to multiple farms and fields, including its own operation, neighboring operations, or other farms and fields located some distance away. As described above in Section 2.4, the credit project boundary includes the fields now receiving litter that, after implementation of the baling operation, will no longer receive that litter because the litter is now transported to the baling operation. Therefore, it is important that, when the baling operation is operating, this documentation is created.

This may be a difficult question to answer because the litter supplier is asked to document something that has not occurred: what ***would have happened*** to the litter. If specific destinations are not known, then the documentation could include the destination county. Another option would be to document the destination of litter generated in the previous year or years, with the assumption that the litter generated in the current year would be sent to similar locations.

In addition to the documentation of litter sent to the baling operation, it will be very important for the operation to document the destination of each bale in order to calculate the percentage of bales exported from the watershed. This should be relatively easy to accomplish because the baling operation will know where its bales are being sold. If feasible, attaching unique bar codes to each bale would facilitate a complete tracking system from the time that bales are created, through their storage and distribution. Tracking information is important because the more bales are exported, the greater the water quality benefit for the Bay watershed.

In addition, periodic nutrient testing of the litter that is transported to the baling operation, and of the litter that is baled, will help provide confidence in the success of the operation in diverting N and P from the watershed. If there is significant variation between the weight of different bales, then the total weight of each bale may need to be found; however, if the weight of bales is relatively constant, it may be sufficient to weight only representative bales.

It is envisioned that the revised NPDES permit and/or contract between credit purchaser and generator would require that this monitoring information be generated and submitted each year to WVDEP. It would then be up to the agency to take appropriate actions if on-the-ground actions are inconsistent with the specifications of the Chesapeake Bay Watershed Model run upon which the number of credits was based.

4. CONCLUSIONS AND RECOMMENDATIONS

This report describes the benefits of a poultry litter baling operation in the Eastern Panhandle of West Virginia, and lays out a step-by-step process for quantifying the reduction of nutrients delivered to the Chesapeake Bay and capturing the economic benefits of these reductions by selling nutrient credits. These credits would be quantified using the Chesapeake Bay Watershed Model so that they are consistent with the TMDL and approvable by the agencies that oversee water quality trading in the watershed.

4.1 Conclusions

There are several reasons for optimism regarding the possibility of generating and selling credits to help finance the poultry litter baling operation. Reasons for optimism include:

- Compared with other agricultural BMPs, a baling operation makes it easy to generate verifiable credits. The primary reason for this is that bales are unitized items that can be easily tracked. Even compared with a traditional composting operation, in which litter is composted in open-air windrows and sold in bulk, a baling operation would have an advantage in this regard.
- If the weight of bales is relatively consistent, then rather than having to track the weight of transporting a bulk material out of the watershed, exported litter can be calculated simply by multiplying the number of bales exported times their average weight. Periodic nutrient testing of the baled litter will also provide confidence in the amount of N and P that is actually exported.
- Nutrient losses are minimized in a baling operation; N and P in the litter at the time of baling will be the same as the N and P when the bales are opened and applied to land. Compared with open-air composting, in which N continues to be lost to the atmosphere, and in which N and P can be lost to water, bales are airtight.
- In its business plan proposal (17), Delta has identified markets that they believe would be sufficient to justify establishing and sustaining a baling operation.

However, there are several challenges to overcome in order for a baling operation to generate credits, find a trading partner, and gain regulatory approval. Challenges include:

- Although Delta's business plan proposal (17) is a major step, it will still take a significant organizational effort and financial investment in order for poultry growers to organize a cooperative and establish a baling operation.
- Quantifying the number of credits generated by the operation requires the use of the Chesapeake Bay Watershed Model, because this is the only method likely to gain regulatory approval at the current time. This model can only be run by specialists at the Chesapeake Bay Program, and there is a many-month waiting period for model runs.
- In the future, it is possible that new rules will preclude the generation of nutrient credits through the transport of manure from the Bay watershed. In particular, there appears to be a shift occurring in the neighboring Bay states of Pennsylvania and Maryland.

4.2 Recommendations

Moving forward, we offer recommendations for steps necessary before the poultry litter baling operation is financed and built:

- Finalize the estimate of the value of nutrient credits generated by the baling operation. This will require following through with the Chesapeake Bay Watershed Model run and then combining the results with the analysis presented in this report. Key players include the Chesapeake Bay Program (who will run the model) and WVDEP and WVDA (agencies with oversight and expert knowledge on water quality trading in West Virginia).
- Integrate the results into the planning process for the new facility. Should the value of the nutrient reduction credits prove to be substantial, this could significantly impact the financial viability of a new baling operation.

If CPGAV moves forward with creating a cooperative and establishing a poultry litter baling operation, we recommend that the operation:

- Establish systems to bale poultry litter as soon as possible after litter is removed from poultry houses, in order to minimize pre-baling losses. Creating bales at poultry farms where the litter is generated—instead of at a centralized location—would minimize nutrient losses even further. The more that pre-baling losses are minimized, the greater the environmental benefit of the facility (whether or not the additional benefit is actually captured by the credit calculations in the Chesapeake Bay Watershed Model).
- Consider labeling each bale to allow for easy tracking. The better that bales can be tracked from the time that they are created to the time that they are applied, the more accurately nutrient credit trades can be monitored and verified.
- Establish systems that generate public trust. Water quality trading is a potentially controversial solution to implementing the TMDL and returning the Bay to health. Basing the nutrient credit generation and sales on transparent and scientifically defensible systems will be essential toward generating and keeping the trust of the public.

Through this project, we have drawn together scientific information about nutrient generation and losses and policy research regarding the TMDL, permits, and water quality trading. Relevant scientific knowledge is increasing every year. Even in the recent past, researchers are continuing to learn more about nutrient generation and losses in the context of agricultural practices and water quality. This research will certainly continue into the future and will help refine the Chesapeake Bay Watershed Model and better quantify the generation of nutrient credits. Today, however, we are required to use one particular model to quantify credits in West Virginia. Meanwhile, policies such as those that regulate the use of water quality trading to implement the TMDL and improve water quality will also continue to evolve.

Due to this changing landscape, we cannot state with certainty that credits that have a value today will continue to have a value in the future. However, by completing the model run and calculating the value of the baling operation's credits at the current time—base on current scientific knowledge, models, and rules—it may be possible to capture some value for the reductions in delivered loads to the Chesapeake Bay.

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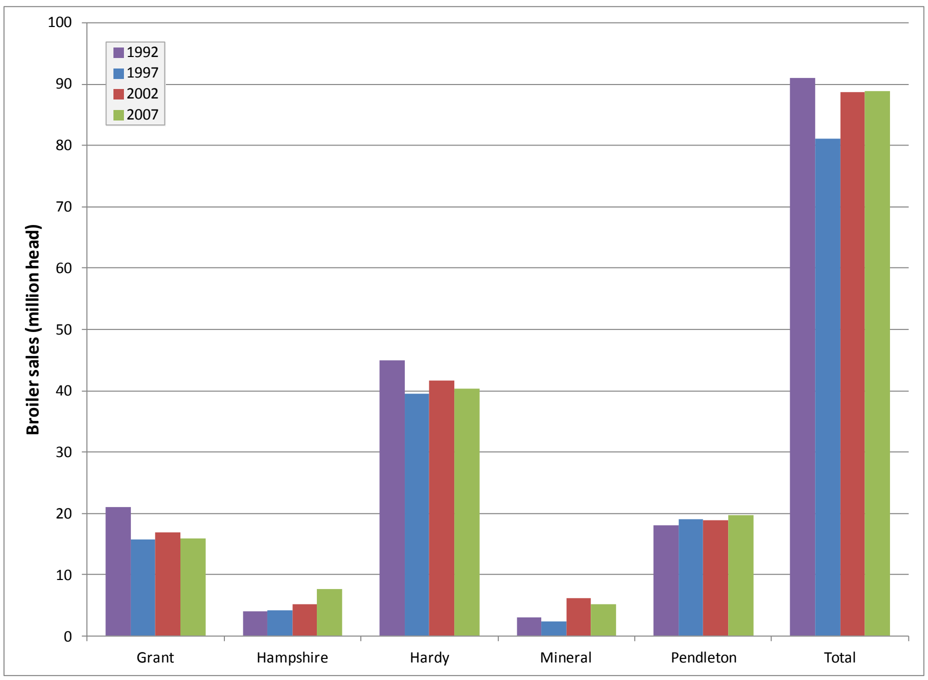
APPENDIX A: CARRYING CAPACITY UPDATE

In 1999, Downstream Strategies released a report, *Poultry Litter in the Potomac Headwaters: How Can We Reach a Long-term Balance?* (8) For the five counties of interest in West Virginia, this report calculated nutrient generation by poultry and nutrient uptake on agricultural land. It then compared these values to determine the number of birds that each county could sustain while maintaining a nutrient balance.

The model used in the 1999 report was based on then-recent data regarding poultry populations and agricultural production. This appendix shows trends in key agricultural statistics that would impact the nutrient balance calculations: poultry sales, field crop production, and land in pasture.

Broiler and turkey sales have remained relatively stable since the 1992, as illustrated by Figure 9 and Figure 10. These trends suggest that N and P production by poultry has likely also remained relatively stable in the five counties of interest.

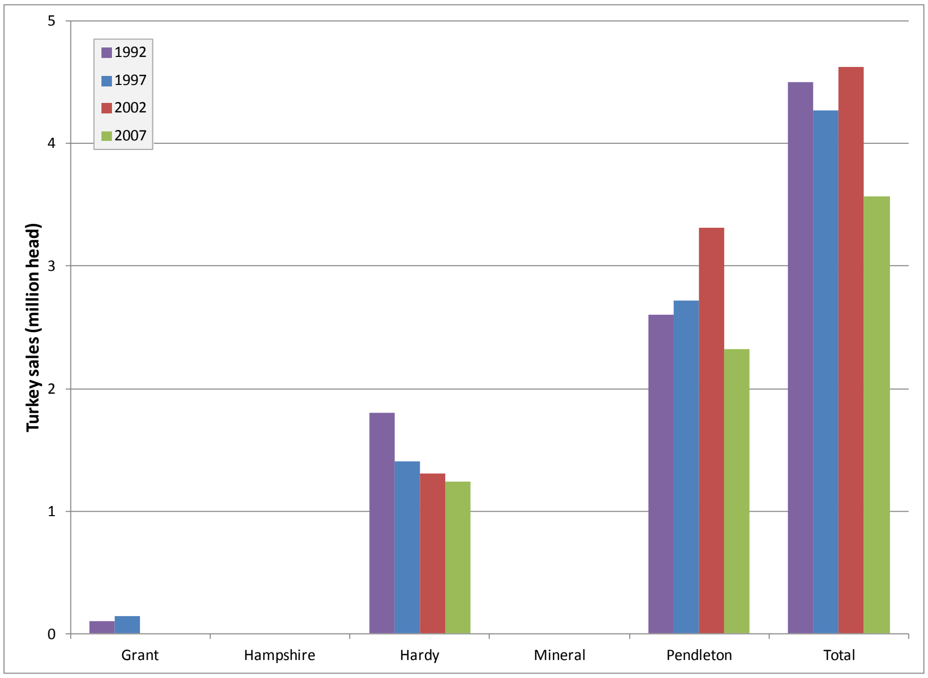
Figure 9: Broiler sales, 1992-2007



Source: 1992 data from (8) Table A-6. 1997, 2002, and 2007 acreage from (18).

Table 14 reproduces the field crop production estimates from 1995-1996 that were published in the 1999 report, and Table 15 provides updated figures from 2007. Field crop production has stayed relatively consistent. Corn and hay remain the most important field crops in the region. Based on this comparison, nutrient uptake by field crops would not be expected to have changed drastically since the late 1990s.

Figure 10: Turkey sales, 1992-2007



Source: 1992 data from (8) Table A-6. 1997, 2002, and 2007 acreage from (18).

Table 14: Field crop production, 1995-1996 average (thousand)

County	Hay: alfalfa (tons, dry)	Hay: other (tons, dry)	Corn: grain (bushels)	Corn: silage (tons, green)	Wheat (bushels)	Oats (bushels)	Barley (bushels)	Rye (bushels)	Soy-beans (bushels)
Grant	3	25	49	9	1[c]	4[c]	D	D	D
Hampshire	2[b]	53[b]	101	9	18	16a	4[c]	<1[c]	D
Hardy	3	35	386	38	20[c]	6[c]	14[c]	6[c]	17[c]
Mineral	2	22	76	4	3[c]	8[c]	2[c]	D	D
Pendleton	4	35	63	24	18[a]	D	D	D	D
Total	14	171	675	84	61	34	20[c]	6[c]	17[c]

Source (8) Table A-2. Notes: Data are 1995-96 averages except: "a" based on 1995 only (1996 data unavailable), "b" based on 1996 only (1995 data unavailable), and "c" based on 1992 data from U.S. Department of Commerce, 1994 (1995 and 1996 data unavailable). D: Production data not published in 1996, 1995, or 1992.

Table 15: Field crop production, 2007 (thousand)

County	Hay: alfalfa (tons, dry)	Hay: other (tons, dry)	Corn: grain (bushels)	Corn: silage (tons, green)	Wheat (bushels)	Oats (bushels)	Barley (bushels)	Rye (bushels)	Soy-beans (bushels)
Grant	1	27	8	6	D	D	0	0	0
Hampshire	2	38	39	12	3	1	3	0	D
Hardy	2	32	547	39	D	D	19	11	24
Mineral	2	18	38	2	0	2	1	D	0
Pendleton	4	29	269	18	0	0	D	0	6
Total	11	145	901	78	3	3	23	11	30

Source: (18). Note: D: Production data not published.

Table 16 illustrates recent changes in pasture acreage in the five-county area. Since 1997, pasture acreage by county has remained relatively constant or has declined somewhat. Acreages for 1992 were calculated using a different methodology and may not be directly comparable to the other years. These data suggest that nutrient uptake on pastures would not be expected to have changed drastically since the late 1990s.

Table 16: Pasture acreage (thousand acres)

County	1992	1997	2002	2007
Grant	41	69	62	58
Hampshire	37	55	55	48
Hardy	48	71	61	59
Mineral	23	31	30	30
Pendleton	66	98	94	98
Total	215	323	301	292

Source: 1992 acreage from (8) Table A-4. 1997, 2002, and 2007 acreage from (18). Pasture in 1992 is the sum of two categories: “cropland used only for pasture or grazing” and “pastureland and rangeland other than cropland and woodland pastured.” Pasture in other years is reported directly by the Census of Agriculture as total pastureland.

APPENDIX B: TRADING DETAILS FROM "APPENDIX A, WEST VIRGINIA POTOMAC RIVER BASIN WATER QUALITY NUTRIENT TRADING PROGRAM"

Even though the 2009 "APPENDIX A, West Virginia Potomac River Basin Water Quality Nutrient Trading Program" document has not been formally adopted by WVDEP, this document was produced by West Virginia stakeholders and represents a significant amount of effort. In addition, it helps to identify certain issues that might have to be addressed should a formal water quality trading program move forward in West Virginia. Further, it helps clarify issues related to a possible water quality trade involving a poultry litter baling operation.

The program contemplated in this document would allow trades to occur for P, N, and sediment credits. Credits are the unit of compliance and include three categories:

- nutrient load reduction,
- instream nutrient load removal, or
- unused nutrient permit allocation. (42)

Each credit represents one pound of nutrients delivered to the Bay in one year. According to this program, credits generated in one year would have to be used in that same year. Trades could occur among point sources, nonpoint sources, and aggregators/brokers (42).

Credits would only be generated for pollution reductions that go beyond the baseline. For agriculture, the baseline is the more restrictive of:

- "any existing regulatory requirements or effluent limits related to nutrient management; or
- implementation of a whole-farm Nutrient Management Plan and an average per-acre nutrient load for the field or livestock production area where credits are being generated based on the 2005 average Edge of Segment…nutrient load for the specific agricultural land use (cropland, hay, pasture and manure)." (42 p. 7)

Table 17 summarizes these baselines contemplated for P. These per-acre loads were calculated using a computer tool, NutrientNet, and were based on farm-specific inputs such as land use, fertilizer application rates, and conservation practices. (42)

Table 17: Agricultural land use baselines for phosphorus

Land use	Total phosphorus (pounds/acre)
Hay	0.7
Cropland	2.9
Manure	39
Pasture	0.8

Source: (42 p. 8).

This document contemplates providing some flexibility in generating tradable nutrient reduction credits: "For non-point sources, nutrient reduction proposals must contain Department-recognized methods for demonstrating nutrient reductions occurring from activities that reduce nutrient application, increase nutrient uptake and retention, or result in net export of nutrients/sediments from the watershed." (42 p. 10) Of particular importance is that this guidance explicitly contemplates that credits could be generated by exporting nutrients from the watershed, which is the fundamental benefit of a poultry litter baling operation.

Further flexibility is expressed as follows: “Where Department-recognized methods for a nutrient reduction activity do not exist, methods may be proposed for Department review and approval.” (42 p. 10)

This document recognizes that nutrient reductions on a different parcels of land do not necessarily result in the same reductions of delivered loads to the Bay. It therefore proposes the use of delivery factors to account for this variation. (42)

To calculate nonpoint source agricultural credits, this document contemplates that activities must result in average per-acre loads below the stipulated baseline. Recall that Table 17 provides P baselines for four different agricultural land uses. A computer tool, NutrientNet, would be used to calculate the per-acre loads and to apply the relevant delivery factors to calculate the amount of pollution that actually reaches the Bay. However, the document recognizes that other approaches may be necessary: “The Department may consider other calculation approaches for practices not included in the NutrientNet program.” (42 p. 14)

Another consideration is the application of trading ratios. This document describes three types of ratios: reserve ratios, uncertainty ratios, and special concerns ratios. For credits generated from nonpoint source agriculture, a reserve ratio of 0.2 would be applied, and an additional uncertainty ratio may also be applied on a case-by-case basis. Therefore, the total trading ratio will be 1.2:1 or higher. This means that a credit purchaser—such as a wastewater treatment plant—would need to purchase 1.2 credits or more for each credit that it needs for compliance.