The Chesapeake Bay and Agricultural Pollution:

The Problem, Possible Solutions, and the Need for Verification

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Introduction

Forty years ago, the Chesapeake Bay shifted to a degraded state unprecedented in the estuary's history. Population growth in the 1960s and '70s, combined with post-war agricultural practices, led to an excess of nitrogen and phosphorus — two essential nutrients for life — in the Bay's waterways. This "eutrophication," or over-fertilization, has clouded Bay waters with algae, killing vital habitats and creating "dead zones" deprived of oxygen. Many parts of the Chesapeake Bay continue to be hazardous not only to the environment but also to human health.

To solve this immense pollution problem, government officials and scientists have identified the key sources of excess nitrogen and phosphorus. The Chesapeake Bay watershed originates in Cooperstown, New York, and covers 64,000 square miles across six states and the District of Columbia. The state of Maryland — the focus of this Abell report — is estimated to contribute roughly 20 percent of pollution to the Bay.[1] In Maryland, 36 percent of the nitrogen and 53 percent of phosphorus in the Bay come from agriculture, 21 percent of both come from urban and suburban stormwater runoff, and about 23 percent of both come from sewage treatment plants. Agriculture is responsible for more than half the sediment running into state waterways as well. [2]

Efforts to clean up the Chesapeake Bay began in earnest in 1983, when the principal jurisdictions of the watershed, including Maryland, signed an historic agreement with the federal government, led by the U.S. Environmental Protection Agency (EPA), to develop coordinated plans to restore the Bay's health. In 1987, these jurisdictions, joined by the Chesapeake Bay Commission, signed an Agreement that set forth goals to improve the Bay's living resources, habitat, and water quality, including the specific goal of a 40 percent reduction of nitrogen and phosphorus by 2000. Subsequent Agreements in 1992 and 2000 refined the commitments. In 2006, Maryland adopted its Tributary Strategies, which assigned responsibility for pollution reductions from urban and suburban sources as well as agriculture. Yet despite all that effort and money, the Chesapeake remains seriously impaired today.

In 2010, the failure to meet water quality goals triggered a more regulatory approach that required measurable, verifiable results. The EPA instituted the Total Maximum Daily Load (TMDL), or "pollution diet." Through the TMDL, the EPA has mandated that the Chesapeake Bay watershed reduce millions of pounds of pollution from nitrogen, phosphorus, and sediment by 2025. The ramped-up pace of the cleanup, combined with signs of slowing progress overall, raises questions of cost-effectiveness and fairness among the major sectors.

The Abell Foundation has a mission to focus on poverty in Baltimore. So why is it interested in agricultural pollution? The reason is that the city of Baltimore is now — appropriately — being held accountable by the Maryland Department of the Environment (MDE) and the EPA for both its stormwater and sewage pollution. City residents of all income levels are paying taxes and fees to enable the city to fix its pollution problem. Yet farmers — whose collective contribution to Bay pollution is the largest of any single sector — are not being required to fix their pollution problem; they are simply being asked to do so voluntarily. Why the difference in approach?

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Where we spend Maryland's effort and money to clean up the Bay between now and 2025 will be as important as how much we spend. We have already picked the low-hanging fruit: We have spent billions of dollars on cutting nitrogen and phosphorus from sewage discharges, automobiles, and smokestacks. Tightly controlled urban systems, like sewage treatment plants, are easier to regulate than the more amorphous "non-point source" farm pollution. Engineers can make adjustments at a central location and achieve water quality benefits system-wide. Cities, with help from federal and state governments as well as ratepayers, have spent millions of dollars to improve sewage treatment.

Cities and suburbs are also now mandated by government to better manage their polluted stormwater runoff, through greening and other practices, so less surface pollution gets swept into streams and rivers after a heavy rain. In many cases, they do so through a fee charged to urban and suburban residents.

Meanwhile, on the Eastern Shore and in other rural areas, farmers continue to spread untreated manure — rich in nitrogen and phosphorus — on the ground, and because only a certain amount of nitrogen and phosphorus can be absorbed by the land, much of the excess seeps into the groundwater and ends up polluting the Chesapeake Bay.

Just as urban and suburban jurisdictions receive federal and state funds to clean up their sewage and stormwater pollution, farmers receive public funds to implement "best management practices" (BMPs, or practices to clean up pollution) on their land. Agricultural BMPs are typically far less expensive to implement per unit of pollution than stormwater or sewage BMPs, but Maryland spends only one-fourteenth of the state's Chesapeake restoration money on agricultural cleanup.

That is not to say that we should spend less on urban and suburban sources. One does not want to imagine what Baltimore's Inner Harbor would look like with less effort. Current efforts to make the Harbor fishable and swimmable are hoping to replicate the success stories of cities like Boston. But if we do not adequately address agriculture, we will not clean up the Chesapeake Bay. And though all states must do their part — Delaware, Pennsylvania, and Virginia have large agricultural industries — Maryland has historically led the way on environmental initiatives and should do so again now.

What can we do? First, we can learn the history of the Chesapeake Bay cleanup effort, and try not to repeat our mistakes between now and 2025. Second, we can look to other states for solutions. And finally, we should establish a strong, independent inspection and verification process to ensure that farmers — and cities and suburbs — are in fact putting the practices in place for which they are receiving public funds, and that these practices are achieving the expected water quality improvements. Without understanding where we've been, learning from success stories elsewhere, and verifying what we do going forward, we will just be treading water or, even worse, backsliding on our efforts to have a clean Chesapeake Bay.

Agriculture and the Chesapeake Bay: A Complicated History

By Tom Horton and Tom Simpson

The Chesapeake Bay watershed includes six states, 64,000 square miles, 17 million people, and large-scale crop and animal agriculture to feed a growing population. Once a pristine waterway teeming with crabs, oysters, and rockfish, the nation's largest estuary began its slow and long slide into a degraded state in the 1960s. It continues to suffer from pollution today, despite billions of dollars invested in its cleanup and tough new regulations aimed at cleaning it up.

Nitrogen, phosphorus, and sediment flow into the Chesapeake Bay and its tributaries. They come from land application of fertilizer, particularly manure; sewage treatment plant discharges; stormwater; septic systems; and urban and suburban development practices. These pollutants cloud bay waters with algae, block light that sea grasses need to grow, and deprive the waters of oxygen that benthic organisms such as worms and small shrimp need to survive. The pollution creates harmful conditions up and down the food chain: Oysters covered in sediment cannot thrive; crabs often die in watermens' pots because of a lack of oxygen; striped bass are losing their habitat.

What have we done about this problem? In 1983, the principal jurisdictions of the watershed, including Maryland, signed an historic Chesapeake restoration plan with the federal government, led by the U.S. Environmental Protection Agency (EPA). Later iterations agreed only ambitious cuts in pollution on the order of 50 percent could return the Bay to the health it enjoyed as recently as the 1960s. The federal and state partners have already spent billions of dollars to dramatically reduce nitrogen and phosphorus from sewage discharges, automobiles, and smokestacks. Maryland's greatest success to date, sewage treatment, is increasingly nearing technological and cost constraints. The latest upgrades to the District of Columbia's giant Blue Plains facility, which serves suburban Maryland counties, removed about a tenth as much pollution as 1990s upgrades, at roughly 10 times the cost.[3] In other words, it is folly to keep spending billions to get minor reductions.

Stormwater work is necessary, but expensive. There, remediation can be up to $100,000 an acre, and $150-$400 a foot for restoring urban streams. Median costs of stormwater nutrient reductions ran about three times as much when compared to reductions from farmland for nitrogen, and about 10 times as much for phosphorus in a 2012 Chesapeake Bay Commission assessment. An earlier Bay Commission study of the six most cost-effective ways to help the Bay targeted agriculture in all but one (sewage treatment).[4] But stormwater reductions are projected to require about half of the $14 billion Maryland estimates it needs to meet 2025 Bay water quality goals. Agriculture is budgeted for slightly less than $1 billion — about one-fourteenth of the money for nearly half the nutrient problem. Upgrading septic tanks, a significantly smaller nutrient source than agriculture, is projected to cost $4 billion.[5]

With that strategy, Maryland is spending a relatively small amount of money on its largest problem. Agriculture is the biggest source of nitrogen and phosphorus to the Bay, yet it is the one source least subject to the accountability and verification that has

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worked for sewage and cleaner air. In Maryland, farming covers more of the land, about a third, than anything but forests (40 percent); and on Maryland's Eastern Shore, it involves the manure from about a third of a billion chickens annually. Maryland also has about 300,000 cows located mainly west and north of Baltimore. Given farming's scope and intensity, it is not surprising it contributes close to 40 percent of Maryland's nitrogen to the Bay and more than 50 percent of its phosphorus.

There is strong evidence that pollution reductions from agriculture would be substantially cheaper than from metropolitan stormwater solutions. This does not mean backing away from pollution controls in the cities and suburbs, or putting disproportionate costs on the farming industry. But a greater focus on agriculture makes sense. There is little documentation that the industry has put runoff from farmlands on a strict enough "pollution diet," as the EPA calls it, to meet 2025 restoration goals — particularly in manure-rich areas like the lower Eastern Shore, and to a lesser degree the dairy farming counties along Maryland's border with Pennsylvania.

A greater focus on agricultural pollution reduction must avoid setting up an urban-rural "war" that pits farming against the larger public. Maryland's farmers and agribusinesses are players in a national and global food system that inadvertently promotes water pollution by pursuing cheap and abundant food, intensive cropping, highly concentrated animal/manure complexes — even fuel.

We think of farmers as salt-of-the-earth operators who grow our food, and neither we nor they like to view themselves as polluters. But the fact is that the agriculture of the past is not the agriculture we see now. Where independent farmers once raised food for consumption, today's growers raise feed for livestock and chickens, as well as ethanol as an additive for gasoline. They do it with large federal subsidies that encourage plowing and planting more of the land but don't have many, if any, safeguards for water quality. Here in Maryland, much of the corn we see goes to feed; in the Midwest, it is ethanol, which takes nearly as much energy as it gives and has already offset claimed farm pollution reductions as more lands are plowed up.[6]

If focusing on agriculture is the answer, why haven't we put more eggs in that basket? Simply put, agriculture has been much harder to regulate. The powerful farm industry lobbied to be exempt from the Clean Air Act and the Clean Water Act. The EPA can only regulate farms if they meet the definition of a Concentrated Animal Feeding Operation. Most in the watershed do not. There are 87,000 individual farms across the 64,000-square-mile drainage. Complicating the problem is that the pollutants — mostly from manure — often travel from a regulated source where a farmer grows chickens to an unregulated one, where a farmer has no animals but many acres of row crops on which he spreads manure.

To be sure, partnerships across the country have worked to address farm pollution. Large landscape initiatives such as the Cooperative Sagebrush Initiative and the Blackfoot Challenge brought together government, industry, and nonprofit groups to solve the problem. In the Chesapeake Bay and the Midwest, groups like the Nature Conservancy are helping to secure funding for drainage projects that will reduce nitrogen and phosphorus, and to research resources to monitor their progress. And yet, we seem to be not making nearly enough headway, and not getting there nearly fast enough. To find solutions, it helps to explain how we arrived at this juncture.

Manure: A history

So how did we get here? Agriculture's fertilizer problems throughout its 10,000-year history were more related to scarcity of nutrients needed to grow crops than to overabundance. As cheap nitrogen and phosphorus fertilizer became available after World War II, government and university scientists encouraged farmers to increase fertilizer use. By the 1980s, this had reached a point where crops were absorbing less from each additional pound of fertilizer nutrients applied, and more of it was leaking to the Bay. Farmers had also quit counting the nutrient value of manure, often spreading it on fields just to dispose of it.

Scientists and regulators recognized that excess nutrients were degrading water quality as early as the 1960s, but it was largely confined to freshwater and phosphorus, the main culprit in freshwater algal blooms. Nitrogen was not officially recognized as a pollutant in mixed, salt-freshwater systems like the Chesapeake until a federal lawsuit forced the issue around 1980, and then it was largely viewed in the context of sewage in a single river, the Patuxent.[7]

Phosphorus, too, was mostly a concern of sewage treatment plants. Only in the 1980s was research beginning to question the widely accepted science that said phosphorus stuck tightly to soil in farm fields, and could not pose a water quality problem so long as a farmer practiced tried and true erosion control. That old science was largely true until we started over-applying phosphorus, particularly found in manure.[8]

But research — some of it conducted at the University of Maryland's Wye Agricultural Research Center — has been building evidence over the last two decades as to how inherently "leaky" of nutrients are row crops like corn and soybeans, grown across so much of Maryland's farmland. Researchers Russ Brinsfield and Ken Staver at Wye showed how even carefully fertilized corn plants cannot absorb nearly all the nitrogen applied. The leftover fertilizer moves off through shallow groundwater to streams, rivers, and ultimately to the Bay. This happens even with soybeans, which fix their own nitrogen from the air and need none from the farmer. When their roots decay, they release substantial nitrogen into the groundwater.

Phosphorus, unlike water-soluble nitrogen, sticks to soil only up to a point, researchers found. But if it builds to levels found commonly on Eastern Shore fields, especially in manure-rich areas, phosphorus then moves with rainwater into waterways at levels several times higher than ideal for the Bay's troubled seagrasses, research at Wye showed.[9]

When chicken manure is the fertilizer, a dilemma results. All manure, or "litter," is phosphorus-rich. In putting enough on the crop to meet nitrogen requirements for a good yield, a farmer can't avoid over-applying phosphorus as he could if he bought the nutrients separately at a farm supply store. This leads to phosphorus-saturated soils.

Staver also has observed farmers applying up to 300 pounds of nitrogen per acre in manure, more than twice what they would do with store-bought liquid nitrogen fertilizer. The reason is not all manure nitrogen is available for the crop as it is in commercial fertilizer. Farmers are advised by university and farm experts to recognize this, and to "take credit" for the slowly released manure nitrogen, meaning they would need to apply less manure in subsequent years. But in practice, using manure ends up putting extra nitrogen into groundwater and the Bay.

So why would farmers even use manure? Because in animal-growing regions like the Eastern Shore and north-central Maryland, it is cheaply available — indeed it may present a disposal problem to farmers with many animals and few acres of cropland. And manure's high organic content is excellent for growing crops and building soil health. It is a great fertilizer so long as water quality is not a consideration. But in places like the Delmarva Peninsula, the volumes of manure and the proximity of farms to sensitive and polluted tidal waters make it the worst of fertilizers.

And that is not the end of leakiness. Whether fertilized with manure or purchased fertilizer, modern corn uses most of the nitrogen it needs in less than 60 days. Soybeans stop using nitrogen after about 75 days. Both are bred to be short-lived "annual" crops that ripen and dry in the field for fall harvest. This means they stop using fertilizer months before decomposing roots and other organic material in soil stop releasing nitrogen as winter sets in. Unlike forests or other perennial, natural vegetation, corn and soybeans can't absorb any of this continued nitrogen production before it moves off in groundwater; and after dying, they release nitrogen from their own decomposing roots and leaves. Finally, if drought occurs during the growing season, unirrigated farm crops grow poorly and use less fertilizer than the farmer planned, translating into more runoff.

Farmers respond

Farmers frequently point to a list of Bay-friendly changes they have made in response to water quality concerns. They now store manure until spring and quickly plow it into soils to retard runoff. They spread it in quantities estimated at a third of a couple decades ago. Poultry giant Perdue requires dead chickens be composted rather than buried where they can pollute the groundwater; the company also hauls around eight percent of Delmarva's chicken manure to a recycling plant that makes it into soil conditioners. Farmers also participate in manure exchanges that send it from those who have too much to others who have fields that can accept it.

Maryland farmers have also begun planting winter "cover crops," cereal grains grown solely to extract nitrogen from groundwater before it can move into waterways. This now extends to several hundred thousand acres.[10] The bulk of Maryland farmers also now have nutrient management plans designed to promote more efficient use of fertilizers.

Poultry feed now contains phytase, an enzyme that allows the birds to retain more phosphorus, thus lowering the amount in manure. Tractors increasingly employ GPS and other techniques to let farmers who are using purchased fertilizer match nutrient applications more precisely to crop needs.

All of the above represent progress, with cover crops perhaps the most outstanding example. It is basis enough for Chuck Fry, the Maryland Farm Bureau president, to earnestly proclaim in *The Baltimore Sun* that farmers are "ahead of schedule on the plan to clean up the [Bay]."[11] And Joseph Bartenfelder, Maryland's Secretary of Agriculture, can accurately report in *The Sun* that the latest EPA progress reports show agriculture has already "achieved its 2017 target goal for phosphorus."[12]

No one's being dishonest here. But there is a striking disjunct between what the agricultural community is hearing, and what the Bay's water quality is saying. In part, this stems from the historical role of agricultural bureaucrats and scientists to protect and promote farming.

Indeed, agricultural scientists at the University of Maryland and other state universities have been timid about communicating honestly to farmers and legislators the emerging science on farm runoff and water quality. As recently as 2015, email communications show that the EPA was in a pitched battle with panels of agricultural experts from around the watershed who were lobbying hard to get more credit for what farmers were doing without adequate verification.

The model, the measurement, and the message

This disjunct has been exacerbated by what remains a widespread lack of measurement, Like all computer models, the EPA's model is only as good as the data it gets — the old "garbage in, garbage out" caution applies. And data from the watershed states on agriculture are too often low quality or unverifiable.

monitoring, independent verification, and transparency as to what is actually happening on farmlands draining to the Chesapeake. More than in any other sector of Bay pollution, clean water progress in agriculture is still based on assumptions and estimates. Matters can be further complicated by "lag times," the months to years it may take for more nutrients — or nutrient reductions — to translate from a farm's soils, through runoff and groundwater, into rivers and the Bay. Such lags make it even more critical to know how much pollution is being reduced now, at the level of the farm field.

The complex computer model that the EPA uses to track progress and measure work is further contributing to the disjunct. Overall, the model works as well as comparable large landscape models elsewhere; but for agriculture's impact on the Bay, it has yet to catch up to reality. Like all computer models, the EPA's model is only as good as the data it gets — the old "garbage in, garbage out" caution applies. And data from the watershed states on agriculture are too often low quality or unverifiable.

For example, the model credits farmers with pollution reductions if they have filed state-required Nutrient Management Plans. These plans are supposed to optimize fertilizer use to reduce runoff. They don't take land out of production like other farm pollution solutions. But inspections in Maryland show only about two-thirds of plans being followed, and there is widespread debate as to how well they are being implemented and how well they are working, with not enough independent verification to resolve the issue. Watershed-wide, a U.S. Department of Agriculture (USDA) survey found less than 10 percent of farms were fully meeting the USDA-Natural Resource Conservation Service definition of nutrient management.[13]

The EPA's computer model may continue giving the same cleanup "credit" for a dairy farm's manure management, although the farmer has doubled his herd and his manure. The model also does not recognize a lot of the excessive phosphorus that the EPA knows is stored in historically manured soils on the Eastern Shore and in Western Maryland. And it still gives nutrient reduction credit to farmers for "conservation tillage." This does save energy and cuts soil erosion by seeding with minimal plowing — but it can also increase nutrients soaking into soils and leaking to the Bay.

So although Secretary Bartenfelder can claim farmers are meeting their goals, the EPA is essentially saying that's accurate according to the current computer model but is likely to change as it "add[s] better data in the next couple years."

There is a vast gap between the tiny amounts of data from actual runoff measurements on farms and estimates used in computer models. One place where good measurement exists is the Green Run watershed feeding the lower Eastern Shore's Pocomoke River, astraddle the Maryland-Delaware state boundary. Some 15 years ago, Maryland's environmental agencies, in conjunction with agribusiness groups, agreed to a side-by-side comparison. One branch of Green Run that drained a few square miles in Delaware would continue farming "business as usual" while the Maryland branch would employ a range of techniques to reduce nutrient runoff, including replacing poultry manure with chemical fertilizers.[14]

Agricultural and environmental interests have signed onto new regulations that will more realistically limit how much phosphorus is applied to farm fields (known technically as the PMT, or phosphorus management tool).

Nitrogen leaving the Maryland branch of Green Run plummeted quickly by 30 percent. That required substantially larger cuts in fertilizer applications — about 50 percent — than are on the drawing boards today for most of the Bay watershed.

As for phosphorus, Staver's recent re-evaluation of the Maryland branch of Green Run found that farmers' efforts there between 1999 and 2010 had only succeeded in slowing, by about half, the rate of increase in soil phosphorus. On Delaware's portion of Green Run, where no changes were made, farmers apparently remain in compliance with water quality goals for agriculture in that state.

A broader look at the reality on the ground is the Choptank River, the Eastern Shore's major drainage. Nutrient levels have been rising even as many farmers have made sincere efforts to be more Bay friendly. Tom Fisher, an ecologist at the University of Maryland's Horn Point laboratory on the Choptank, has shown that agriculture was already dominant on the Choptank 150 years ago, but water quality was far better.[15]

The intensity of farming has changed, Fisher says, such that farmers are growing more crops per acre, and using more fertilizers. Today's landscape puts from two to 15 times as much nitrogen and phosphorus in the water. Sewage plays a role in that, but farming is driving the river's worsening water quality.

Fisher says lag times of up to several years in nutrients (or nutrient reductions) moving from field to river "are real. . . but I don't think we're headed down. I don't see evidence of the progress we'd need at any of our monitoring stations."

Farmers along the river are cooperating with Fisher these days to install innovative Best Management Practices to reduce nutrient runoff. They will be accompanied with the kind of long-term measurement and evaluation that has been largely absent from BMPs to date.

A larger-scale, measured (versus computer modeled) look at the problem comes from improved data analysis of nutrients flowing down nine major Bay rivers, principally from Maryland, Virginia, and Pennsylvania. Since 1985, this U.S. Geological Survey's (USGS) monitoring has shown generally encouraging declines in nutrients, though not close to what's needed for a restored Bay.

But recent USGS analysis that looks only at the most recent decade of water quality monitoring shows progress in most places has slowed or reversed. Because we know pollution from sewage and the air is still declining, this implicates runoff from farmland and to some extent stormwater. The EPA says farm fertilizer sales are also rising in the Bay watershed. Again, paper progress appears inconsistent with direct measurement.[16]

The USGS also has found the Eastern Shore, while it's only seven percent of the Bay's watershed, to be delivering far higher than average pollution loads to the Bay: 40 percent more nitrogen per acre and 50 percent more phosphorus. The bulk is from row cropping and poultry. Even a 40 percent decrease in fertilizer use wouldn't likely meet Bay restoration goals on some Shore rivers by the 2025 deadline.

The phosphorus diet: A slow way forward

Recently, a promising consensus has emerged that could put agriculture in Maryland on a diet healthier for the Bay. Agricultural and environmental interests have signed onto new regulations that will more realistically limit how much phosphorus is applied to farm fields (known technically as the PMT, or phosphorus management tool). It is a significant platform for progress, but full implementation is by no means a given, and if it gets implemented without change, that will not be complete until sometime between 2022 and 2024, depending on the availability of alternative uses for the manure. The new rule has the potential to eliminate manure on many farm fields, but Maryland does not have enough alternatives in place for the excess manure.

What else can Maryland do? State energy officials recently bungled the building of a power plant to convert manure to energy, but other companies are waiting in the wings to have their chance, and the next part of this report explains how they would do it. Shipping manure elsewhere could also be a solution, but as the next section of this report shows, it needs a robust market-driven undergirding to work properly. Certainly, the state should look at expanding drainage controls. The Midwest has developed many, and they're showing great promise here. Finally, the state needs enforcement to ensure farmers are doing what they promise, and verification to show that those promises deliver. That model is discussed in the third part of this report.

Maryland and its fellow watershed states have a long way to go in sustaining agriculture while also minimizing water pollution. If they can't do their part to minimize water pollution, the Bay restoration simply can't succeed.

Solving Maryland's Manure Problem: How Other States Keep Phosphorus Out of Waterways, and What We Can Learn From Their Efforts

By Rona Kobell

The Chesapeake Bay is choking from pollution. As in many states, agriculture is a major cause of that pollution. But compounding that problem is the chicken industry on the Delmarva Peninsula.

Farmers on the Maryland portion of the Eastern Shore raise close to 300 million chickens a year. Farmers apply much of the chickens' waste to the ground on the Shore to raise corn that becomes feed for those same chickens. Every few weeks, chicken farmers clean out their chicken houses and haul away the manure, and then the cycle begins again. While much of that manure finds a home on farm fields, about 200,000 tons of it is excess manure. It needs to be stored, hauled away, turned into energy, or otherwise addressed. Farmers can't apply the manure in most cases because the phosphorus levels on their fields are already too high.[17] Nitrogen, too, is a major agriculture pollutant found in manure, fertilizer, and emissions from chicken houses in the form of ammonia. And while chickens are the largest source of manure in Maryland, they are not the only source. The dairy industry west and north of Baltimore also contributes significantly to the pollution load.

The cycle of too much pollution from manure continues because demand for inexpensive poultry continues to rise. In 2013, at least 35 percent of the cash income from Maryland farms came from meat chickens. The state ranked eighth nationwide for production, with 1,617,600 pounds that year.[18] Raising larger amounts of animals on ever-smaller tracts of land is a nationwide trend likely to increase. During the past 10 years, the number of cattle, pigs, and poultry on farms increased, while the number of farms on which they were reared decreased. Maryland is no exception. In Somerset County alone in recent years, county officials have permitted for 50 new chicken houses, some of which can hold close to 200,000 birds per year on small lots. More than 60 applications are pending.[19]

The byproducts of the state's $565 million chicken industry can be dire for both human health and marine life. Poultry manure contains both nitrogen and phosphorus. Farmers who use chicken manure as fertilizer apply it to their fields for their nitrogen needs, and the phosphorus comes along for the ride. The result is fields with so much phosphorus they need no more to grow the crops and should accept no more for environmental reasons. When that happens, the phosphorus runs off the field during storms, and seeps into groundwater through sub-surface paths.

What can we do about this problem? Though Marylanders often lead the way on environmental solutions, we can learn from many innovations in other states. This report will discuss an export solution in Arkansas, a drainage solution in Indiana, and the move toward manure-to-energy in our own region.

The Arkansas example: A court-mandated manure solution

From the air, Northwest Arkansas is a swirl of blue lakes and lush greenery. Then suddenly, long, silver structures emerge, seven or eight

While much of that manure finds a home on farm fields, about 200,000 tons of it is excess manure. It needs to be stored, hauled away, turned into energy, or otherwise addressed.

in a cluster. This is Chicken Country, home of Tyson Foods. Arkansas has the nation's second-largest poultry industry, after Georgia.

Arkansas produces about two billion chickens a year, bringing in $3 billion.[20] Many buildings at the University of Arkansas bear the names of former poultry executives; only Wal-Mart carries more clout in this part of the state.[21]

And yet in one watershed, farmers have reduced the amount of manure they apply to land by almost 90 percent.[22] They store almost no manure, and they have developed a robust private market for selling and shipping it out of state. They file nutrient management plans with the state to control their phosphorus and then follow the plans; a few have voluntarily signed up for monitoring of nutrient runoff.[23]

It happened because, a decade ago, a judge required the farmers in one distinct watershed to reduce their phosphorus run-off. Those farmers have complied, but so have many others nearby. They want to reduce their nutrient runoff, increase their profitability, and safeguard the health of their birds.

"I think we have a unique setup in Arkansas in that we have a very strong conservation partnership," said Mike Sullivan, state conservationist for the Natural Resources Conservation Service, the environmental arm of the U.S. Department of Agriculture. "Producers really want to know how their system is operating. I have seen a change in the culture."

It all began in the Eucha-Spavinaw watershed. Lake Eucha and Lake Spavinaw are man-made lakes in Oklahoma. Together, they supply the water for fast-growing Tulsa, which has half a million people. The watershed spans 229,807 acres of land, including 1,600 poultry houses that produce 70,000 tons of chicken litter annually. Farmers would spread the manure on pastureland for beef cattle. [24]

Oklahoma and Arkansas have fought for decades over who was responsible for maintaining a clean water supply to those lakes as well as others fed by the Arkansas and Illinois rivers. In 1992, the legal wrangling led to a Supreme Court ruling that upstream states must meet the water quality demands of downstream states.[25]

By 2001, the lakes were becoming increasingly fouled. Tulsa leaders did not want ratepayers to foot the bill for phosphorus from Arkansas. So the Tulsa Metropolitan Water Authority sued the city of Decatur, Arkansas, and six poultry companies, accusing them of polluting Tulsa's drinking water supply.[26]

After two years of court hearings and negotiations, the water authority and the poultry companies settled.[27] Decatur would upgrade its sewage treatment plant, which serves about 1,600 homes in addition to a poultry plant. Much of the money came from various stimulus packages, and the upgrade reduced phosphorus by close to 80 percent.[28] That contribution seemed to soften the blow of rate increases that have bedeviled other small towns, such as those in the Shenandoah Valley.

Under the settlement, the poultry companies would pay $7.5 million. That would help establish a litter bank so that farmers in other states that wanted the Arkansas manure could get it.

After reviewing evidence from University of Arkansas phosphorus scientists as well as other experts, the judge settled on a phosphorus limit of 300 parts per million. If a soil test indicated more than that, the farmer could spread no more phosphorus.

Jeff Marley's Northwest Arkansas farm includes 10 chicken houses that grow 240,000 birds a year. Marley stores no manure on his farm and sells most of the litter his chickens produce to out-of-state farmers, who use it on their pastures.

Credit: Rona Kobell

Immediately, farmers exported 15 percent of the manure. Soon, the judge halved the phosphorus limit again, to 150 parts per million. Every year, the percentage of exported manure rose, and the amount of manure applied to fields dropped.[29]

In 2015, more than 90 percent of the litter leaves the Eucha-Spavinaw watershed for Kansas, Missouri, and even Oklahoma. Only 10 percent is spread on the land, though even that is "too much for some people," according to Andrew Sharpley, a leading soil scientist at the University of Arkansas.

The upside of the new phosphorous limits was that many farmers in the region that did not fall under the Eucha-Spavinaw court order suddenly had a market for their manure. That is because the judge appointed Sheri Herron, a longtime poultry industry employee, to run the manure exchange, called Litter Link. Herron had $1.5 million to jump-start the company, called BMP's Inc. About half the money came from the poultry companies, and the rest from state and federal grants. [30]

Herron is paid on commission and said the market has been "phenomenal," with more buyers (400) than product. Customers are paying about $15 a ton for the manure. With 150 tons per house, a chicken farmer can make about $17,000 a year with eight houses. Though they do need to buy commercial fertilizer, many of these farmers are raising animals in pastures. They do not have the intensive fertilizer needs of a row-crop farmer. It is different from the Maryland Eastern Shore model, where the Department of Agriculture runs the manure transport program, and much of the manure moves within the Delmarva Peninsula.

The threat of lawsuits is a major motivator for participation in Litter Link.

Jeff Marley, who grows 240,000 birds a year for Tyson in 10 well-kept chicken houses along a busy state road, said he never keeps manure piled up, either uncovered or covered, and neither do other chicken farmers. Once they clean out their houses, he said, the buyer is ready to come and take it away.

"That is one of the most positive offshoots of the Spavinaw lawsuit. They threw us all in the same bucket. We were supposed to come out dirty. But we are not," said Marley, who farms in the White River watershed. "I spend more time managing my litter than I do my chickens. There is no comparison in terms of what we did and what we do today. We used to pile the litter. We didn't care where we piled it. We would never consider doing that today." [31]

The piles are also frowned upon because, should it rain, the pile becomes liquid manure and falls under a different EPA regulation, said Karl VanDevender, a University of Arkansas extension agent. And an environmental group could turn a pile of manure into a mountain of legal trouble. That happened in the Chesapeake Bay in 2009, when the Assateague Coastkeeper and the Waterkeeper

Curtis Moore's family has been raising chickens in Arkansas for more than 50 years. Recently, the family put in practices to reduce runoff from the chicken litter as it is handled and transferred out of state. One such practice: pads in front of the chicken houses.

Credit: Rona Kobell

Alliance filed a lawsuit against Berlin farmer Alan Hudson for polluting the Pocomoke River. The piles that attracted the riverkeepers' attention turned out to be biosolids, not manure, and the environmental groups lost the case. Still, the farmer spent several years and lots of money defending himself in court.[32] The case further increased friction between environmentalists and farmers at a time when the two sides, at least on a local level, were striving to work together.

The Hudson lawsuit offered a trove of information on the lax enforcement of nutrient management plans, as Hudson admitted in court that he did not have such a plan from 2002 to 2008. He could not say for sure which of his fields were too high in phosphorus to accept any more. The case also revealed that the Maryland Department of the Environment had lax standards for storing biosolids, a situation the department addressed following the Hudson case. In the end, Hudson did have to move his pile, and the public got a glimpse into the lack of government enforcement and oversight.[33]

That has led some environmentalists to question Maryland's enforcement system. In Maryland, the Department of Agriculture's mission is both to regulate farms and promote them. It inspects about 8 percent of the farms every year for nutrient management compliance. In Virginia, a separate agency regulates the best management practices of farms. In Pennsylvania, it is an agency that is a hybrid of officials from the departments of environment and agriculture. Yet both states, despite the independent agencies, have their own enforcement challenges — in part because their agriculture industries are larger than Maryland's. A separate agency regulating agriculture is not a panacea.

The Arkansas model has downsides. Despite huge reductions in the amount of manure applied, the amount of phosphorus in the soils is not coming down as much as scientists had hoped, in part because phosphorus moves slowly. The water quality has improved, but upgrading the Decatur plant accounted for some of that. Also, Arkansas farmers need nutrient management plans, but the farmers accepting their manure do not, leading some to believe Arkansas is exporting its problem. Maryland may well be, too, as some of the areas receiving the manure may not have plans and probably should. And at 1.8 million acres, the Eastern Shore drainage is about eight times the size of Eucha-Spavinaw's.

Despite those drawbacks, the decisive action in the Eucha-Spavinaw case has gotten other states' attention, as has the fact that poultry companies, not water ratepayers, had to finance the bulk of the improvements.

In 2013, environmental groups in Washington

State sued Cow Palace, an 11,000-head industrial dairy, claiming that its manure lagoons were polluting the water supply of the Yakima Valley. In January 2015, a federal judge ruled that Cow Palace's manure was the source, and posed an "imminent and substantial endangerment."[34] Two months after the Cow Palace decision, the Des Moines Water Works sued three rural Iowa counties, alleging that their inadequate drainage tiles were leaching nitrates into the rivers that feed the Des Moines and Raccoon rivers. Iowa occupies only 5 percent of the Mississippi River Drainage Basin, but it is responsible for 25 percent of the nitrate that the Mississippi River delivers to the Gulf of Mexico. The utility built a $4.1 million facility to extract nitrate from its finished water, but concentrations still exceed allowable levels about a quarter of the time.[35]

Cedar Rapids, which is three hours east of Des Moines, is hoping to avoid that situation. As nitrate levels climb, the city on the Cedar River has established a partnership with the farms north of it to install drainage practices that will capture runoff before it reaches groundwater and flows into the river. The city depends on the farmers; they grow the corn and soybeans that Cedar Rapids companies process into cereal and foodstuffs that will travel around the country. Cedar Rapids officials say they're doing everything possible to avoid an expensive nitrate treatment facility and litigation.[36]

EPA officials are closely watching the Des Moines case. So are Arkansas farmers. In 2005, two years after the Eucha-Spavinaw settlement, the Oklahoma attorney general sued eight poultry companies in Arkansas, accusing them of polluting the watershed. That case has not been resolved yet.[37]

In Arkansas, farmers and scientists are trying to protect their waterways and themselves. They are installing swales between chicken houses, water catchment areas to absorb runoff, and pads in front of chicken houses to absorb manure. Marley is one of eight operators participating in Discovery Farms through the University of Arkansas, a program that helps monitor the practices to see if they work and then provides farmers real-time data so they can make adjustments. Another farmer, Curtis Moore, is in his 20s, and says he likes to receive the information as soon as possible so he can tweak his operations.

After so many decades of growing chickens, Moore's fields are too high in phosphorus for more manure. And though he must pay high prices for fertilizer for his pasture, the young farmer said he understands.

"You don't want to over-apply anything," he said. "It does not benefit you in the long run."

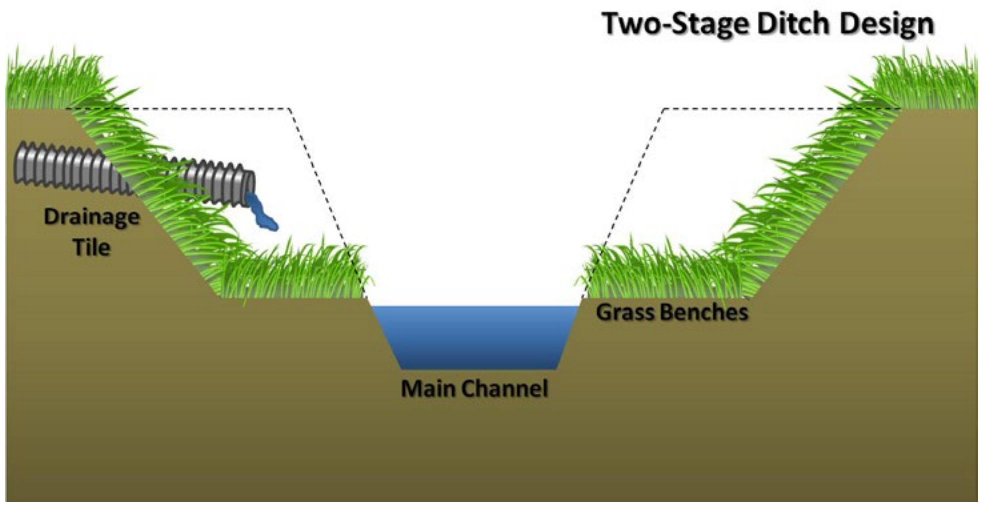
Indiana: A Ditch to Save the Farm

A decade ago, Jamie Scott looked across his 2,000 acres of corn, soybeans, and wheat in Northern Indiana and wondered if there was a better way to grow food.

Scott and his father, Jim, were spending thousands of dollars a year on pest control, spraying large quantities of atrazine to rid the farm of weeds. Atrazine, an endocrine disrupter, can turn male frogs into females and contaminate well water. The Scotts were also running into problems they couldn't control while tilling their land. Rainwater pooled in the fields, destroying crops and contributing to flooding. Banks would become destabilized, with sediment eroding into the streams.

Scott looked and did not like the turbidity in the Shatto Ditch, a canal-like structure that ran through his farm. He knew the ditch was taking his farm's sediment and fertilizer runoff and sending it down to the Tippecanoe River, which would then deposit the pollution into the Wabash River. From there, it would enter the Ohio, then the Mississippi, and then the Gulf of Mexico, which suffers from dead zones of oxygen-depleted waters every summer.

"We could look at it and say, 'boy that's dirty water. It can't be from us.' But the truth is, we always feel like we're responsible," said Scott, president of the Koscuisko County Conservation District. "We know that the Chesapeake Bay has a problem, Lake Erie has a problem, the Gulf of Mexico has a problem.



The two-stage ditch has benches on either side to absorb runoff. It does the job well, according to Notre Dame researchers who have been monitoring the work for several years in the Midwest.

Credit: Notre Dame

As farmers, we say, 'we're part of the problem. We got to help solve it.'"

Scott and his neighbors essentially turned their vast acreage into a giant nutrient sponge. Sixty-seven percent of the farmers in the 3,000-acre Shatto Ditch watershed have overhauled their farming practices. They have installed acres of cover crops and buffer strips and instituted the practice of no-till farming. They spray infrequently for pests, allowing earthworms and other natural features of healthy soil to do the job for them.[38]

The centerpiece of the approach is called a two-stage ditch. A regular ditch is trapezoidal in cross-section. Water comes over the side and falls to the bottom, where it flows along to the stream. A two-stage ditch is more like a split-level staircase. The water flows down the sides gradually and collects in a bench on each side of the deeper trench. The bench is filled with vegetation slowing the flow of water. That means nutrients in the runoff enrich plant life in the bench instead of polluting the waterway. The two-stage ditch also traps sediment, blunts storm surges, and collects nitrate. In essence, the two-stage ditch creates a natural floodplain. It returns channelized streams to the contours of how they once flowed, before agriculture systems altered them.

Jennifer Tank, director of the Notre Dame Environmental Change Initiative, introduced the two-stage ditch to Scott and his neighbors, and has been monitoring their project since 2007. Her research has found a 31 percent reduction in nitrate in the ditch's water compared to the conventional ditch and a 50 percent decline in phosphorus. In addition, 12 percent less water ran off the landscape. Tank and her colleagues will monitor the system and share the data with farmers and the public. The program is a partnership between Notre Dame, the farmers, the Nature Conservancy, and the soil conservation districts.[39]

Tank said the system functions as "a wastewater treatment plant" for the farm. But doing it right is not just about the ditch, which Scott said is like a "diaper," or a back-up plan, for everything that isn't captured. To reduce the phosphorus, nitrogen, and sediment coming off farm fields, Scott said, farmers can't try an a la carte approach. They need the crops, the buffers, the no-till approach, and the ditch.

Every year in the Chesapeake Bay, a record number of farmers sign up for cover crops. Many install buffers. No-till farming is popular. But few farmers have installed ditch structures, according to John Rhoderick, special projects and research coordinator with the resource conservation office at the Maryland Department of Agriculture. Talbot County is experimenting with several ditch projects in conjunction with the Nature Conservancy and the Chesapeake Bay Foundation, which helped to secure about $500,000 in funding.

The county opted not to borrow several million dollars to spread out a two-stage project over a larger area, citing financial concerns. Many of the projects under consideration are smaller and use wood chips to “digest” pollution or management structures to control runoff. [40]

Talbot County’s only two-stage ditch on a working farm is on John Swaine’s 1,800-acre row-crop farm in Royal Oak, a couple of miles from where the Oxford-Bellevue ferry crosses the Tred-Avon River. (The others are on county-owned land.) Swaine, who volunteered his land as a demonstration project, admits his is not a true two-stage ditch. The designers could install only one berm because of a roadway on the other side. Swaine said after watching the summer rainstorms that more runoff is coming from the roadside than from the farm.

Two-stage ditches cost between $6 and $10 per linear foot. A farmer will pay $13,000 for a half-mile ditch, then still have to combine it with the other practices. Land is also an obstacle. Maryland has 101 tax ditch associations that run drainage ditches. Farmers pay taxes to an association and jointly manage the maintenance issues. Getting 200 feet of land to build the bench is difficult, Rhoderick said, because it requires the buy-in of several owners. Swaine was able to make his own decision for the land that has been in his family for close to 100 years.[41]

Since the two-stage ditch was born in Ohio 13 years ago, it has been gaining traction in the Midwest because of Lake Erie’s phosphorus problems. The excess phosphorus coming from fields in the Maumee watershed became so acute that Toledo residents could not drink their water for two days in 2014. Through federal and state programs, the two-stage ditch has spread across the Great Lakes watersheds. Indiana has 52 projects in 21 counties, for a total of 23 miles of ditch.[42]

But as is the case for many projects, the federal and state government programs only provide money to install the practice. They do not provide money to monitor it, make sure it’s maintained, and prove its continued effectiveness.

Tom Fisher, a nutrient input professor at the University of Maryland Center for Environmental Science, was working on a Caroline County farm when he stumbled on a promising ditch-management structure. Fisher convinced the U.S. Department of Agriculture to fund some monitoring. Results were encouraging, but Fisher was able to monitor the site for only a year. Nevertheless, the government declared the practice a success and will offer farmers money to implement it.[43]

Scott wants to know the nitrogen and phosphorus numbers as soon as they’re available. With the facts, he said, he can convince more farmers to invest in the two-stage system and decrease their collective contribution to water pollution.

“I’m out here pushing conservation every day,” he said. “Now, there’s data backing me up that says, hey, scientifically he’s right.”

Manure to Energy in Pennsylvania: Two Birds, One Stone?

Along a busy road in Gettysburg, Patrick Thompson is doing something many believed could not be done. He and his colleagues at Energy Works are turning the manure from five million egg-laying hens into power. The nitrogen becomes the fuel that operates his plant; the phosphorus, a potassium-rich ash. Without the conversion, Thompson said, the pollutants would leave the Hillandale Farms egg facility and be spread on farm fields throughout Maryland, West Virginia, and Pennsylvania.

Such projects not only make an alternative fuel but also reduce pollution destined for farm fields and waterways. Farmers turn an environmental liability into an asset. They can become energy independent while using the byproducts — steam heat, waste heat — to fuel their operations and save more money. They can also profit from the solids that come out of the process. Dairy farmers can make even more money by adding rotten produce from places like Wal-Mart to the digester. Out the other end come natural gas and more cash.

Des Moines Water Works Lab Manager Jeff Mitchell collects a water sample from the Raccoon River in Des Moines in March. The water works company is suing rural counties for polluting the city's water supply.

Photo credit: Clay Masters

But turning manure into energy has drawbacks. Combustion processes typically lead to elevated air emissions. Environmentalists also note that manure-to-energy plants are often proposed in poor, disenfranchised neighborhoods.

The Environmental Integrity Project is working with Thompson's Energy Works to bring the emissions down. It solved part of the problem by lowering the temperature and operating at a lower capacity.[44] Energy Works needs revenue to install more controls so it can operate at design capacity, and it can't get the revenue due to delays in the state's nutrient program, which isn't set up yet to buy Thompson's credits. It is, in a manner of speaking, a chicken-and-egg problem.

Energy Works is not the only company facing challenges. In Benson, Minnesota, the state air pollution agency fined Fibrowatt $65,000 for air-quality violations shortly after its turkey manure-to-energy plant was built. But after a couple of years, city officials had only praise for the plant. Fibrowatt no longer builds combustion plants, having switched to the more environmentally friendly anaerobic digester models that will make natural gas. These do not get rid of the nitrogen and phosphorus, but their conversion process does not create odors and is more akin to composting.

Another challenge has been to find markets for the byproducts. Thompson's Energy Works sells bags of ash as a fertilizer, as a liming agent, and for remediation of acidic soils from mine operations. The ash is lighter and does not have the same water-quality drawbacks as manure. Thompson is still waiting for the Food and Drug Administration to certify it as a feed additive so it can have even more commercial appeal.

Perhaps the biggest drawback for manure-to-energy is the difficulty in extracting the energy from the manure. Dairy manure contains moisture that helps convert the nitrogen and phosphorus to fuel through tiny digesting bacteria. Chicken manure, by contrast, is dry. Adding moisture is too expensive to justify the output. For newer technologies, like gasification, dry manure is a benefit. But that technology is more complicated and costly.

In 2013, Maryland contracted with a California company to construct a manure-to-energy power plant on the Eastern Shore. It never materialized.[45] Perdue and AgEnergyUSA, Fibrowatt's parent company, have proposed a $100 million anaerobic digester that would turn manure into a nitrogen-rich fertilizer and a phosphorus-rich peat moss.[46] An Irish company, BHSL, has another solution: individual farm units that combust the poultry manure in a furnace in the chicken house, then turn it back into a fuel that heats the house as well as solid ash for sale.

More chicken farmers are interested, but they have to change the current system. Farmers are buying their propane from the companies for whom they grow, and they need to be able to save that money and use their own fuel — and maybe sell electricity back to the grid — for this system to benefit them.[47] At the moment, the price of propane is bundled into the contract, offering no mechanism to seek a different source.

In manure-to-energy, the technology is expensive, and the disappointments have been many: pilot programs that do not last, digesters that become mothballed when subsidies run out, technology that either pollutes or doesn't live up to its promise, and bureaucratic hassles. Yet, it remains tantalizing. As Chesapeake Bay Commission Executive Director Ann Swanson noted, manure is the only renewable fuel that guards against climate change while simultaneously solving a major water-pollution problem.

Verification: How We Know That Controls Work, and Where to Give Credit When Credit is Due

By Robert Summers, Ph.D.

For decades, federal and state governments have used two primary tools to clean up water pollution in the Chesapeake Bay and beyond. The Clean Water Act protected the waters of the United States from pollution that spewed into creeks and rivers from sewage treatment plants and factories discharging industrial waste. The Clean Air Act, meanwhile, forced power plants, manufacturing facilities, and smokestacks to reduce their emissions and lessen the mercury and other pollutants that came down in the air and settled into the water.

These laws are powerful tools when dealing with pollution that is mostly from sewage and industrial sources. Enforcing them resulted not only in cleaner air and water, but also accountability, as those who violated the laws faced fines and even prison time.

But this is not enough, because much of the pollution is coming from the way we drive our cars, grow our food, and live on the land. These diffuse sources of pollution, called non-point sources, are more expensive to control — and the controls are more difficult to verify. But control and verify we must: The U.S. Geological Survey's water quality monitoring data show that the Bay watershed states have made significant progress reducing nitrogen and phosphorus levels since 1985, but that progress is slowing and is even getting worse in some areas.[48]

Crippling progress is an unhealthy blame game that pits one sector against another as they compete for dollars to address the cleanup and fend off more regulation. Because the Susquehanna River delivers nearly half the freshwater and pollution to the Bay, some counties have contended the Bay Program must control pollution at the Conowingo Dam before asking others to clean up their parts of the Chesapeake. But if close to half the pollution is from the Susquehanna, then more than half is not from it. If we are going to restore the Bay and all its tributaries, we cannot just address one source of pollution, we need to address them all.

The public has a huge investment and stake in the success of the restoration of the Bay and its tributaries. Many are making lifestyle and financial sacrifices and expect assurances that their actions and expenditures are not in vain. The verification and audit process described here is essential to giving all of us the confidence that the Bay restoration effort is on the right track and is working as intended.

The TMDL - Leveling the Hammer

In 2000, after 17 years of "voluntary" actions, it was clear that pollution control efforts were not meeting expectations. Already under a court order to either meet the nutrient reduction goals by 2010 or put in place a legally binding Total Maximum Daily Load (TMDL), required by the federal Clean Water Act, all the jurisdictions signed a new agreement to either meet the goals or work with the EPA to develop the TMDL. The goals were not met and the TMDL was developed by the Bay Program and approved by the EPA in December 2010.[49]

The TMDL has been called the "Blueprint" for the restoration. It estimates the levels of nitrogen, phosphorus, and sediment that the Bay can accommodate and still meet water quality standards. The Chesapeake

The verification and audit process described here is essential to giving all of us the confidence that the Bay restoration effort is on the right track and is working as intended.

Bay TMDL sets an overall limit on nitrogen, phosphorus, and sediment loading to the Bay and its tidal tributaries, and divides the responsibility for meeting those limits among the Bay's 92 tributaries, seven jurisdictions, and six "source sectors" — agriculture, urban/suburban stormwater, wastewater, forest, nontidal atmospheric deposition, and on-site septic.

Each of the jurisdictions and the federal agencies with property in the watershed were required to develop detailed Watershed Implementation Plans, called "WIPs," that describe the pollution control actions that each would take to reduce nutrient and sediment pollution to meet their TMDL allocations for each source sector. The WIPs document the actions that will be taken and the timeframe over which those actions will be taken. The deadline is 2025, but in addition, to ensure that the restoration stays on track to achieve that goal, the WIPs must also set "Milestone" goals every two years. The EPA evaluates progress toward the Milestones and publicly reports it so that all can see the progress.

How do we measure progress?

Chesapeake Bay pollution comes from everywhere: agriculture, forestry, urban and suburban stormwater runoff, municipal and industrial wastewater, rural onsite sewage (septic) systems, and air emissions from everything from power plants to cars and trucks.

The public and private sectors spend millions of dollars to design and put pollution controls (Best Management Practices, BMPs) into action for many of these sources throughout the watershed.

- How do we know whether the planned pollution controls are sufficient to meet water quality goals in the watershed and Chesapeake Bay?
- How do we measure progress in the restoration to make sure the restoration stays on track?

Any watershed, but particularly one the size of the Bay's, has many places where nutrients and sediments can accumulate — in groundwater, floodplains, riverbeds, and reservoirs — only to release over long periods of time as groundwater slowly moves or catastrophically when major storms cause streams and rivers to flood and scour stored sediments. Because of the tendency for watersheds to release their stored nutrients and sediments over long periods of time and because of the impact of variable rainfall and large storms, pollutant loading from streams and rivers is highly variable and progress is slow. A drought (1999–2002), or large storm event (Tropical Storm Lee in 2011), can exaggerate or obscure any progress that has been achieved by our pollution control actions.

As a result, the Chesapeake Bay Program [CBP] must rely on both monitoring and computer modeling to set restoration goals and measure progress in the restoration. Monitoring tells us the specific condition of a part of the Bay, river, or stream at a particular point in time, but even with sophisticated, modern equipment, it is not possible to monitor every stream and river all the time. In addition, depending on whether it has been a wet year with many storms causing flooding and stirring things up, or a dry year when it is generally calm and the water clears up, water quality conditions vary considerably, making it impossible to directly measure what occurred due to our pollution control actions separate from what is simply the result of changing weather conditions.

Because we can't realistically monitor every place all the time and we can't separate the human impacts from changing weather by monitoring alone, computer models give us the ability to separate the effects of weather and humans and fill in the gaps in our monitoring data. Models also give us the ability to test different future combinations of pollution control measures to predict what is needed to meet water quality standards and predict the result of our pollution control actions (or lack of action) to determine whether the restoration is on track to meet future TMDL goals. Models are not perfect (otherwise, they wouldn't be models, they would be the real thing), but they must have enough detail to reasonably represent the real world.

The Bay Program's watershed model represents the entire watershed and its streams and rivers. When rain falls on the forests, farms, and towns, it soaks into the ground and runs off the land surface. As it travels it picks up nutrients and sediments that flow with the water down the streams, rivers, and reservoirs, eventually making it to the Bay. The model represents all of these processes and provides an estimate of river flow and pollutant concentrations at key points in the watershed where the model is calibrated to match monitoring data. Calibration is the process of adjusting the model inputs and internal processes to match real world data.

But once it is calibrated, the model can do what we can't do in the real world. With the model, we can estimate pollution loading from streams and rivers where it is not possible to accurately monitor or there is no monitoring data. We can add agricultural and urban runoff controls, sewage treatment upgrades, and other pollution control measures to sources in the calibrated model and predict what will happen to water quality in all the rivers and streams throughout the entire watershed, and in different parts of the watershed, in a wet, dry, or average year. And with accurate data on what types and where pollution control measures are in place, we can estimate pollution loading changes that are the result of our management actions and not just the effect of a drought or a flood.

But models are only as good as the data on which they are based. Good data on the pollution control measures being implemented is essential for accurately tracking our progress in meeting the requirements of the TMDL. Accurate BMP data is also essential for interpretation of monitoring data to see what works and doesn't work so that adaptive management decisions can be made to improve the pollution reduction effort.

Many pollution sources — sewage plants, industrial discharges, stormwater systems, concentrated animal feeding operations (CAFOs) — are regulated by the federal, state, and local governments and are subject to regular inspections, monitoring, and enforcement when they are not meeting legally mandated requirements.

Other pollution control measures, mostly in agricultural or less densely populated suburban areas, are not mandated, but are often built with public funding and are also critical to achieving water quality goals. These practices must also be inspected and monitored to ensure that they are achieving the expected water quality benefits. But government agencies often do not have the money, staff, or technical resources to make sure the pollution control practices are properly installed and working as intended.

In May 2011, after an intensive review of the Bay Program requested by the Chesapeake Executive Council, the National Academy of Sciences (NAS) released its report, "Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay: An Evaluation of Program Strategies and Implementation." The NAS Panel looked carefully at the Bay Program's nutrient reduction program, with a focus on the tracking of BMP implementation across all the jurisdictions. In the report summary, the review panel's key conclusions relating to accounting for progress included:

The Bay Program's BMP Verification Framework represents a major step forward in defining a process for determining the reliability and accuracy of the BMP data.

- *"Accurate tracking of BMPs is of paramount importance because the CBP relies upon the resulting data to estimate current and future nutrient and sediment loads to the Bay."*
- *"The current accounting of BMPs is not consistent across the Bay jurisdictions. Additionally, given that some source-sector BMPs are not tracked in all jurisdictions, the current accounting cannot on the whole be viewed as accurate."*
- *"The committee was unable to determine the reliability and accuracy of the BMP data reported by the Bay jurisdictions. Independent (third-party) auditing of the tracking and accounting at state and local levels would be necessary to ensure the reliability and accuracy of the data reported."*
- *"Targeted monitoring programs in representative urban and agricultural watersheds and subwatersheds would provide valuable data to refine BMP efficiency estimates, particularly at the watershed scale, and thereby improve Watershed Model predictions."*[50]

In short, accurate BMP data is needed to make sure all sectors are doing the right practices in the right places, and that the practices are working and will continue to work.

Bay Program's BMP Verification Framework

The EPA had long assumed that the states have provided accurate information and will continue to do so, even without a framework for verification. The Bay Program formed a subcommittee to address the NAS's issues, and over the course of the next three years, hundreds of staff from all of the jurisdictions worked together to develop a basinwide verification framework and documentation published in October 2014. The framework lays out a detailed plan for federal, state, and local agencies to follow in setting up their BMP accounting and verification systems. This process is described in extensive documentation (527 pages, including appendices).[51]

The Bay Program's BMP Verification Framework represents a major step forward in defining a process for determining the reliability and accuracy of the BMP data. It must be successfully implemented if anyone is to have confidence that the pollution control actions are being equitably applied in all jurisdictions, by all source sectors, throughout the watershed. Only then can we be sure that others are doing their share and their failure to act is not undermining our own efforts.

Verification of BMPs throughout the 64,000-square-mile Chesapeake Bay watershed is a huge undertaking. The Bay Program defines more than 200 BMPs that jurisdictions can get nutrient reduction credit for in the Watershed Model.[52] The Verification Framework includes specific guidance (Appendix B) defining the verification process for each of six technical sectors: agriculture, forestry, urban stormwater, wastewater, wetlands, and streams. [53] Each of these sectors has different types of BMPs that require different verification approaches.

Agriculture

Agriculture is particularly difficult because it has the largest number of best management practices of any sector.

The agricultural BMP verification guidance divides agricultural BMPs into three categories: 1) BMPs that inspectors can see only for a limited time and must be verified and reported on an annual basis (e.g., within a growing season); 2) BMPs that inspectors can see for more than a single year when properly maintained; and 3) BMPs that inspectors cannot see and must be verified by inspection of records (e.g., nutrient management plans). These categories are further subdivided into four groups, based on the source of funding for the BMP and whether regulations require it.

The methods of verification for BMPs that fall into each of these categories can vary considerably, including farm inventories, review of office/farm records, inspection of a statistical sampling of BMPs, agency-sponsored surveys of a statistical sampling of farms, and remote sensing with aerial photography or satellite imagery. The guidance document includes 26 pages of tables summarizing the considerations recommended for verification of agricultural BMPs.[54] In general, the guidance recommends that jurisdictions verify 100 percent of the initial identification of BMPs by trained and certified technical field staff or engineers with supporting documentation that the BMP meets the governmental and/or Bay Program practice standards. Follow-up annual inspections should be made for a minimum of 10 percent of multi-year BMPs that collectively account for 5 percent or more of a jurisdiction's agricultural sector pollutant load reduction as estimated in the most recent Bay Program progress assessment. Jurisdictions can propose alternative statistical sampling. BMP verification priority should be given to those practices that provide the largest proportion of a given jurisdiction's nutrient and sediment loading reductions.

A particularly challenging aspect of verifying agricultural BMPs is the legal restriction in the 2008 Farm Bill, Section 1619, that prohibits the disclosure of *"(A) information provided by an agricultural producer or owner of agricultural land concerning the agricultural operation, farming or conservation practices, or the land itself, in order to participate in programs of the Department; or (B) geospatial information otherwise maintained by the Secretary about agricultural land or operations for which information described in subparagraph (A) is provided."* [55] Many of the agricultural BMPs that are being implemented in the Bay watershed are funded by USDA programs, and specific information needed to verify their implementation and continued maintenance and operation is not available to most of the Bay Program jurisdiction agencies or stakeholders who are interested in tracking the progress of agricultural BMP implementation for the TMDL.

Instead, the Bay Program must rely on a provision of Section 1619 that authorizes the USDA to release the information to a "1619 Conservation Cooperator," who has signed an agreement with the USDA to only release the data in aggregated form so that farmer privacy is protected. A number of the Bay jurisdictions' agricultural agencies have executed such agreements with the USDA. In addition, the U.S. Geological Survey has signed an agreement and is able to provide agricultural BMP data aggregated by sub-watershed for use in estimating progress in meeting agricultural TMDL requirements.[56] The aggregated BMP data are provided by the USDA authorized agencies to the Bay Program for use in the Watershed model for progress accounting purposes. This allows for progress accounting but does not permit anyone other than 1619 Conservation Cooperators to verify the installation of the BMP and continued operation and maintenance of the BMPs over their expected life span. So how can environmental regulators — or anyone else — verify that a practice is working if they can't see it?

Another challenging aspect of agricultural BMP verification is accounting for BMPs funded by the private sector. These BMPs, referred to as "resource improvement (RI) practices," may or may not be constructed to the same standards as BMPs that are constructed with public cost share funds. The Bay Program's Agriculture Workgroup has provided additional guidance for jurisdictions to determine whether or not privately funded BMPs are providing similar annual environmental benefits as BMPs constructed to cost-share standards.[57] The guidance provides protocols and checklists for a visual inspection (VI) that can be conducted by *"any trained and/or certified technical field staff person that has the required knowledge and skills to determine if the practice meets the applicable RI definition and VIs may conduct the RI practice review."* [58]

Forestry

The forestry BMP verification guidance covers five different BMPs: 1) agricultural riparian forest buffers; 2) agricultural tree planting; 3) expanded tree canopy; 4) urban riparian forest buffers; and 5) forest harvesting BMPs. As in the case of the agricultural BMP verification, the forestry BMP guidance recommends that jurisdictions focus verification efforts on the practices that give them the most significant loading reductions. A particular challenge in verification of forest BMPs is determining the net gain in forested area given the loss of forest to urban/suburban development and conversion of forested areas to cropland.[59]

Verification of forest BMPs on agricultural land has the same 2008 Farm Bill restrictions on disclosure of farm-specific data as other agricultural BMPs and requires the data to be aggregated within a watershed of sufficient size that the identity of an individual farmer is protected. This is a severe limitation on the Bay Program jurisdictions and interested stakeholders' ability to verify that practices are installed and maintained.

The forestry BMP guidance recommends that jurisdictions use both ground-level inspections and remote sensing tools to document urban tree canopy and conduct an assessment of overall canopy every five years to verify that there has not been a loss of tree canopy in other areas due to disease or new development. Similarly, the guidance recommends that riparian forest buffers be verified with a combination of ground surveys and remote sensing. Maintenance of newly planted riparian buffers is particularly important due to the impact of invasive weeds and dehydration. The guidance recommends spot-checking of buffers using statistical sampling.

In addition, much of the watershed is already forested and forest harvesting is a common practice throughout the watershed. Forest harvesting BMPs are designed to protect streams and wetlands through the use of buffer zones, stream crossing BMPs, and erosion controls for roads and timber loading areas. Some Bay Program jurisdictions control harvesting on both public and private land, others only on public land. The guidance recommends that jurisdictions track total acres of forest harvested using BMPs on both public and private land and conduct site visits within six months after site preparation for harvest to ensure proper installation. Recommended statistical sampling methods are designed to meet a confidence level of 80 percent.[60]

Urban Stormwater

The urban stormwater guidance divides BMPs into four categories: 1) traditional stormwater BMPs (e.g., stormwater retention ponds) installed under a local plan review process to meet state requirements; 2) new runoff reduction BMPs (e.g., rain gardens, infiltration basins, etc.) designed to meet state stormwater performance standards; 3) operational BMPs (e.g., street sweeping, urban nutrient management); and 4) restoration BMPs used to treat existing impervious areas (e.g., stormwater retrofits and stream restoration). BMPs can be installed in regulated areas that fall under a Municipal Separate Storm Sewer System (MS4) Permit, in areas outside of MS4 jurisdiction that are regulated by a state construction stormwater general permit (one acre or larger), or in areas that are unregulated.[61] Inspection and verification procedures vary depending on the resources available to the local government and state overseeing the programs, with the highest

Many acres of wetland creation, restoration, and enhancement are funded each year by federal programs administered by the USDA and state cost-share programs in Maryland and Virginia.

degree of oversight in the MS4 permitted areas and at construction sites larger than one acre in size that are regulated under the construction general permits.

The guidance recommends that jurisdictions' urban BMP verification should be founded on the existing MS4 inspection and maintenance framework. Initial inspections of all BMPs to verify proper installation should be done by the MS4 permit holder with periodic review by state stormwater program staff. The guidance recommends that local inspectors conduct follow-up visual inspections and maintenance of BMPs at least once every other MS4 permit cycle to ensure that pollutant removal performance is maintained. Because a permit cycle is five years, this would mean 10 percent of installed practices would need to be re-inspected each year. If a re-inspected BMP is not performing adequately, corrective maintenance would be required within one year or the BMP would be removed from the jurisdiction's inventory of BMPs, and nutrient and sediment reduction credits would be lost. MS4 permits require annual reports and inspection documents, which are available for review by interested members of the public. State stormwater program staff are responsible for reviewing local programs' reports annually and for periodically conducting more in-depth reviews.

Communities that are not covered under MS4 permits typically do not have the resources to inspect, report, and verify their BMPs. In these situations the guidance recommends that the state, local government, or third-party performs the inspection and verification of a sub-sample of BMPs using statistical sampling methods. If inspection and verification is not done, the EPA will not allow credit for the BMP.

Wastewater Treatment

The guidance provides recommendations for inspection and verification of municipal sewage treatment facilities, industrial wastewater treatment facilities, combined sewer overflow (CSO) areas, and onsite wastewater treatment (septic) systems. All wastewater facilities that discharge to surface waters are under federal Clean Water Act permits administered by the jurisdictions and are required to submit Discharge Monitoring Reports (DMRs), which are reviewed by the state regulatory agencies. In addition, all significant facilities are to be inspected annually and 20 percent of nonsignificant facilities are to be inspected each year.

Onsite wastewater treatment (septic) systems are not subject to national regulations and existing state regulations vary considerably among the Bay Program jurisdictions. The guidance states that verification of onsite wastewater systems is only required for nitrogen reducing systems that a jurisdiction is reporting for load reduction credit. Only Delaware, Maryland, and Virginia have regulations in place and are intending to obtain nitrogen credits. Jurisdictions are required to verify proper installation, operation, and maintenance using state, local, or certified design professionals. Maintenance and inspection will be conducted and reported annually.

Wetlands

When new wetlands are created or restored, they reduce nutrient and sediment pollution, and generate credits for the jurisdictions' TMDL limits. Many acres of wetland creation, restoration, and enhancement are funded each year by federal programs administered by the USDA and state cost-share programs in Maryland and Virginia.

The guidance recommends field assessments be conducted by the funding agency using a checklist provided in the guidance manual. The documentation should be submitted to the appropriate state agency for reporting to the Bay Program. Performance of the wetland should be verified by a second inspection within three years following construction. Wetland projects can be done as part of agricultural, urban, or stream restoration BMPs. Depending on which area the wetland is located, specific verification guidance for that sector should be consulted.[62]

As with all USDA funded agricultural BMPs, data on the specific location and descriptions of wetland projects funded by the USDA must be aggregated to the watershed scale to ensure privacy of the participating farmers before it can be released to the public or many of the Bay Program participating agencies.

Stream Restoration

Removal of sediment accumulations in stream channels and floodplain areas, referred to as legacy sediments, can be a very effective way of reducing nutrient and sediment loads from watersheds. The stream channel can then be restored using natural channel and flood plain design to maintain its stability in a range of flow levels, further reducing sediment and nutrient losses from stream banks and floodplains. Stream and flood plain restoration projects are carefully regulated and require permits issued by the U.S. Army Corps of Engineers and state agencies. Often, stream restoration projects include wetland restoration as an integral component of the design. Each stream restoration project is unique and must be carefully designed with consideration of the hydrology of the watershed and the hydraulics of the channel configuration to ensure that the restoration does not cause flooding or other unintended problems for upstream and downstream property owners.

The process for verification of stream restoration projects must be tailored to the specific project, and a number of different acceptable protocols are discussed in the guidance document. The project's initial verification will typically be provided by the regulatory agency review process to ensure that the project is properly designed and constructed. Detailed protocols for field inspections that have been developed for different types of stream restoration projects are referenced in the guidance document.[63]

Because a stream is subject to periodic catastrophic flooding, ongoing inspection and maintenance is critical to long-term success of the BMP. The guidance calls for the jurisdictions' verification protocols to define the frequency of field inspections and the process for reducing and ultimately removing the stream restoration credits if the maintenance is not performed. The agency responsible for the stream restoration project should conduct inspections within two years of construction and at least once every five years thereafter to ensure that the project is continuing to function as designed. Projects should also be inspected after a catastrophic flood, as defined by the jurisdictions. If the inspection finds that the project is not functioning, the project sponsor should be allowed one year to make corrections or the pollution reduction credit would be eliminated.

Next steps in strengthening the verification process

The Bay Program's published schedule calls for the jurisdictions' verification protocols to be completed, fully documented, and approved by the EPA by January 2016, with two years after approval to implement them.[64]

Initial drafts of the jurisdictions' verification protocols, called Quality Assurance Project Plans (QAPPs), were published by the jurisdictions in early July 2015, and have been reviewed by an expert panel (Verification Review Panel), which is advising the Bay Program jurisdictions regarding changes needed to bring their programs into conformance with the agreed framework. The Bay Program's BMP Verification Review

Panel has been involved in the review and development of the Verification Framework and has provided extensive guidance for the jurisdictions to use in preparing their verification protocols.[65] The Panel issued its final public report in September 2015.[66]

The case for strong verification protocols and independent, third-party audits

In order to know whether the Bay Restoration is working and on schedule, we must have a full understanding of the verification procedures that will be used by the CBP, participating jurisdictions, and agencies. Any effective verification system will need to be able to document actions taken at four key points: 1) initial field inspections to determine whether the pollution control system in place is working; 2) follow-up inspections to ensure that the pollution control system is being maintained and is continuing to function; 3) review of documentation and data bases to ensure the field data is accurately recorded; and 4) review of the accounting model to ensure the data is being accurately represented and credited for pollution reduction.

Additionally, as is the case with any major government program or business, independent third-party audits (similar to Maryland legislative audits of Administration programs) are essential to maintaining the integrity of the verification process. A third-party auditing process for the Bay Program will need to: 1) verify that the jurisdictions' and agencies' reporting and verification procedures are being followed; 2) ensure that there is transparent and accurate accounting of BMP implementation and progress in meeting the requirements of the Bay Watershed Implementation Plans; 3) regularly report the findings of the audit to the public; and 4) confirm that the restoration is effective and is being carried out in a manner that makes best use of available resources.

Again, it's worth noting that the public has a huge stake in Bay restoration, and residents need to know that both their expenditures and their efforts to reduce pollution are not in vain. This verification and audit process provides that reassurance.

Recommended Next Steps

1. The Bay Program jurisdictions must continue to diligently follow through on ensuring that their verification protocols meet the requirements of the Verification Framework.

2. Anyone who is interested in the integrity of the Bay Program progress accounting needs to work to ensure that Bay Program jurisdictions develop a strong BMP verification process that follows the recommendations of the Independent Verification Review Panel.

3. A viable, third-party auditing system needs to be designed and funded to complement the jurisdictions' verification protocols. The individuals conducting the audit must have the expertise to understand the technical aspects of the BMPs and Bay Program accounting process, and must be credibly independent.

4. The third-party audit must also include a review of the installation and continued operation and maintenance of agricultural BMPs over their expected life span. Due to the legal restrictions in the 2008 Farm Bill, Section 1619, that prohibits the disclosure of information about a specific farm, this will require either a revision to the law or the cooperation of the USDA to authorize the auditor to review the farm specific data as a "1619 Conservation Cooperator."

5. Coupling of the verified BMP information with water quality monitoring data collected on a small watershed scale is essential to verifying the performance of BMP systems and understanding where adaptive management adjustments would be beneficial, particularly in agriculturally dominated areas where Farm Bill privacy restrictions require the aggregation of BMP data to the small watershed scale.

Conclusion

The Chesapeake Bay is a critical economic and recreational engine for Maryland, and lawmakers have worked hard to protect it from harm. And yet, it remains a place with frequent fish kills, huge "dead zones," harmful algae blooms, and imperiled habitats. Agriculture is the source of half of the pollution from Maryland that is killing the Chesapeake Bay, but the state's relationship with the agriculture industry has complicated its curbs on farm pollution. Farmers have tried to reduce pollution through voluntary programs that have underperformed, are not monitored, or appear to be only paper exercises. In contrast, urban pollution sources are tightly regulated with permits, inspections, and fees. State officials must verify that the practices for which farmers receive taxpayer money are actually controlling pollution; if they're not, inspectors need to figure out why.

If farmers do not control agricultural pollution and states do not require farmers to do so, the EPA has said that under the authority of the Clean Water Act, its only alternative will be to require more regulations on the sources it can control: sewage plants, industries, and urban/suburban stormwater programs. Because it is far less expensive to prevent nutrient pollution from a farm, the failure to act aggressively to control agricultural pollution now will cost all of us far more in the long run.

Maryland is certainly not the only state contributing to the loads of pollution in the Chesapeake Bay. Nor is agriculture the only culprit. But Maryland has traditionally been at the forefront of legislation and regulation to improve the Chesapeake's health, and agriculture has thus far been held to a different accountability standard than other sectors.

Maryland must learn from its history and give farmers the best information and the most resources it can muster to tackle these problems. It must also enforce the regulations it has; the voluntary approach, here and across the country, has not been adequate to tackle the pollution problem. But state farmers should look into large landscape partnerships that let them leverage resources, combine money, and work together. With an economy of scales, they can accomplish more in a time of dwindling federal funds.

Maryland must invest in a robust manure exchange that connects those who want manure with those who need to dispose of it. The state must also put money into technologies to keep pollutants out of the ditches in the first place. Maryland should also invest in non-emitting manure-to-energy technology, and that includes developing markets for safe manure-to-energy products. The $3 million in the Maryland Department of Agriculture's Animal Waste Technology Fund is a small start, but as budgets tighten and priorities change, the state must make sure those funds reach the best engineers.

Finally, Maryland should trust but verify. It needs to ramp up inspections. Currently, the Maryland Department of Agriculture is only inspecting eight percent of the state's farms yearly. Inspectors must verify that farmers are following their nutrient management plans, and must also ensure that the plans are resulting in the promised reductions of phosphorus. The state must further verify all other best management practices. Maryland also needs an independent audit program to ensure the integrity of the state's verification process and ensure that taxpayer money is actually being invested in practices that are effectively combating pollution. Agriculture in particular needs to be subject to the same level of verification and auditing as other sources, despite the privacy provisions in the 2008 farm bill. We need and must expect all farmers to be full partners in the restoration of Chesapeake Bay and its tributaries.

After 30 years and billions of dollars in investments, the Chesapeake Bay is still impaired. Agriculture practices are a major reason why. They don't have to be. If we are smart about finding solutions to our nutrient problem, everyone can benefit — farmers, ratepayers, citizens, and the Chesapeake Bay itself.

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