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Report to the Governor and the General Assembly of Virginia

Land Application of Biosolids and Industrial Residuals

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JLARC
JOINT LEGISLATIVE AUDIT AND REVIEW COMMISSION

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WHAT WE FOUND

Regulations generally protect human health and water quality

Land application of biosolids and industrial residuals poses some risk to human health and water quality, but the risk is low under current state regulations. This conclusion is based on the best available scientific evidence, but more research could reduce uncertainty.

Even though risk is low, risk is sometimes slightly elevated during land application for nearby residents, who could inhale aerosolized contaminants. During land application, small particles of material become airborne. This material can be inhaled, potentially causing gastrointestinal illness or the common cold.

The state's regulatory requirements may not adequately mitigate this risk for nearby residents, but only under conditions that are optimal for exposure: when Class B biosolids (which contain pathogens) are applied and nearby residents are downwind and outside for an extended period during application. These conditions present greater risk at a small number of sites that receive far more land applications than other sites.

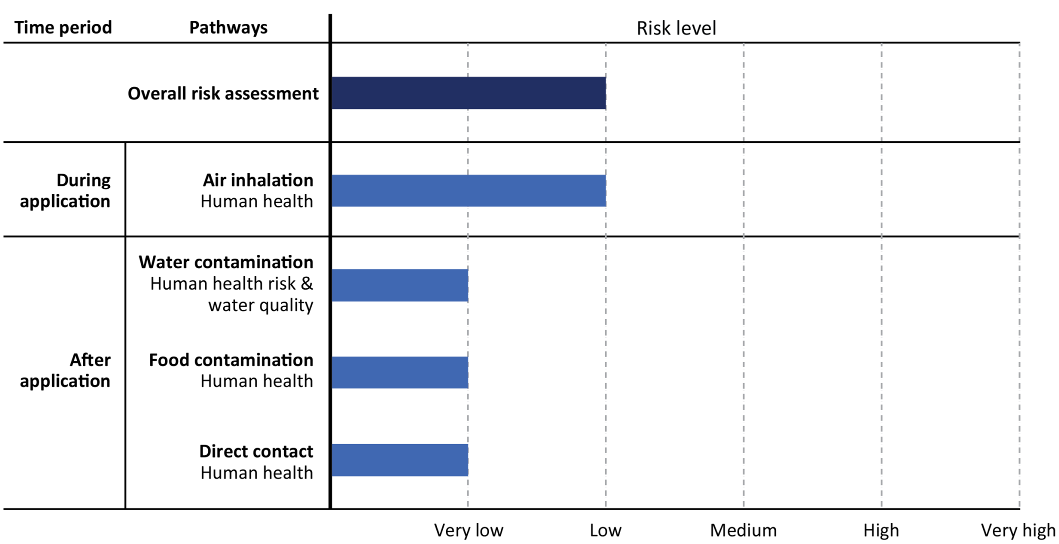
WHY WE DID THIS STUDY

In 2016, the General Assembly directed JLARC to study land application of biosolids and industrial residuals in Virginia. The mandate specifically called for staff to analyze the scientific research literature on potential effects on human health and the environment.

ABOUT BIOSOLIDS AND INDUSTRIAL RESIDUALS

Biosolids and industrial residuals are nutrient-rich materials left over at the end of sewage treatment or a manufacturing process. If they meet regulatory standards, these materials are can be applied to farm and forest land as agricultural fertilizers. Biosolids and industrial residuals contain pathogens and chemical compounds and elements that may pose risks to human health and the environment. To minimize these risks, they are subject to federal and state regulations.

Overall risk from land application is low under current state regulations



SOURCE: JLARC review of more than 150 scientific research papers and interviews with biosolids researchers.

Regulatory compliance programs are generally effective

The Department of Environmental Quality and the Department of Agriculture and Consumer Services (DEQ and VDACS) each operate compliance programs that are generally effective. Both agencies' processes ensure regulatory compliance. DEQ's process to review and approve land application permit requests is reasonable and appropriately involves the public. VDACS's process to initially certify products as safe and beneficial is also reasonable.

DEQ's process to inspect land application sites and correct violations is effective. Although the agency now inspects a lower percentage of land applications than in prior years, it still was able to inspect 31 percent of application sites in 2016.

VDACS has an annual process for registering biosolids and industrial residuals, but its ongoing product verification process is not sufficient in all cases. VDACS does not verify, after its initial certification, that products continue to have acceptably low levels of potentially harmful chemical compounds and elements.

WHAT WE RECOMMEND

Legislative action

- Appropriate funding for the Virginia Department of Health to (a) conduct a pilot epidemiological study of whether land application of biosolids causes human health problems and (b) test Virginia biosolids for pathogens.

Executive action

- Assess whether regulations should be modified to reduce risks of infection for residents living near land application sites (a) when aerosolization of pathogens is more likely and (b) where applications are made more frequently.
- Require producers of industrial residuals to submit current chemical analyses as part of the annual registration process.

The complete list of recommendations is available on page iii.

Recommendations: Land Application of Biosolids and Industrial Residuals

RECOMMENDATION 1
The General Assembly may wish to consider directing the Virginia Department of Health (VDH) to design and conduct a pilot epidemiological study of the human health effects of land application of biosolids. The General Assembly may wish to consider appropriating $50,000 to fund the study. In designing and conducting the pilot study, VDH should contract with third parties, such as researchers at Virginia institutions of higher education, as needed. VDH should be assisted by the Virginia Department of Environmental Quality as needed. Following completion of the pilot study, VDH should submit its findings and a proposed design for a full-scale epidemiological study, if needed, to the Senate Finance, and Agriculture, Conservation, and Natural Resources Committees; and House Appropriations, and Agriculture, Chesapeake, and Natural Resources Committees. (Chapter 2)

RECOMMENDATION 2
The Virginia Department of Health should assess the risk of aerosol infection to the public by reviewing the most current research literature and determine whether regulatory setbacks for protecting human health should be expanded. (Chapter 2)

RECOMMENDATION 3
The Virginia Department of Health should assess whether the risk of aerosol infection to the public is elevated near sites that receive frequent applications and whether restrictions on land application frequency or larger setback areas are needed to ensure that residents are sufficiently protected. (Chapter 2)

RECOMMENDATION 4
The General Assembly may wish to consider directing the Virginia Department of Health (VDH) to perform sample testing of Class B biosolids that are land applied in Virginia to determine their pathogen content. The General Assembly may wish to consider appropriating $50,000 to fund sample testing over the course of one year. VDH should use test results to inform its epidemiological pilot study and assessment of aerosol infection risks (Recommendations 1, 2, and 3). (Chapter 2)

RECOMMENDATION 5
The State Health Commissioner should submit a written report to the State Water Control Board and the director of the Department of Environmental Quality on the findings of the Virginia Department of Health's epidemiological pilot study, assessments of aerosol infection risks, and pathogen tests (Recommendations 1, 2, 3, and 4). The report should include, as necessary, recommendations for amending biosolids regulations to further protect human health and water quality. The report should be submitted no later than July 1, 2019. (Chapter 2)

RECOMMENDATION 6

The Department of Environmental Quality should report annually to the State Water Control Board on the effectiveness of its land application inspection program. The report should provide (i) the percentage of land application sites and events inspected, (ii) the number and type of violations and citizen complaints, (iii) the five-year trend in violations and citizen complaints, (iv) a recommendation on the number of inspections needed in the coming year, and (v) an assessment of whether changes to the program, program funding, or other actions are needed to maintain regulatory compliance. (Chapter 3)

RECOMMENDATION 7

The Virginia Department of Agriculture and Consumer Services (VDACS) should require producers of biosolids and industrial residuals products to submit chemical analyses of their products as part of the annual registration process. VDACS should review these analyses to ensure that products continue to have acceptably low levels of trace chemicals. (Chapter 3)

1 Application, Benefits, Risks, and Regulation of Biosolids and Industrial Residuals

SUMMARY Biosolids and industrial residuals are organic matter produced by wastewater treatment facilities and industrial manufacturing processes. They can be used as an agricultural fertilizer because they contain nutrients such as nitrogen and phosphorus. Most land application in Virginia occurs in rural localities. More biosolids are applied than industrial residuals, and most biosolids are applied to crops that are not consumed by humans. They are often provided to landowners for free. Pathogens and chemical elements and compounds in these materials can pose risks to human health and water quality, and citizens have expressed concerns about the safety of the practice. State regulations aim to minimize risk through permitting land application sites, limiting the contaminant concentrations in materials, and restricting where and when application can take place.

In 2016, the General Assembly directed JLARC to study land application of biosolids and industrial residuals in Virginia. The mandate specifically called for staff to analyze the scientific research literature on potential effects on human health and water quality. The mandate also directs JLARC to evaluate state regulations and determine whether changes are needed to regulations or to how biosolids are generated. (See Appendix A for study mandate.)

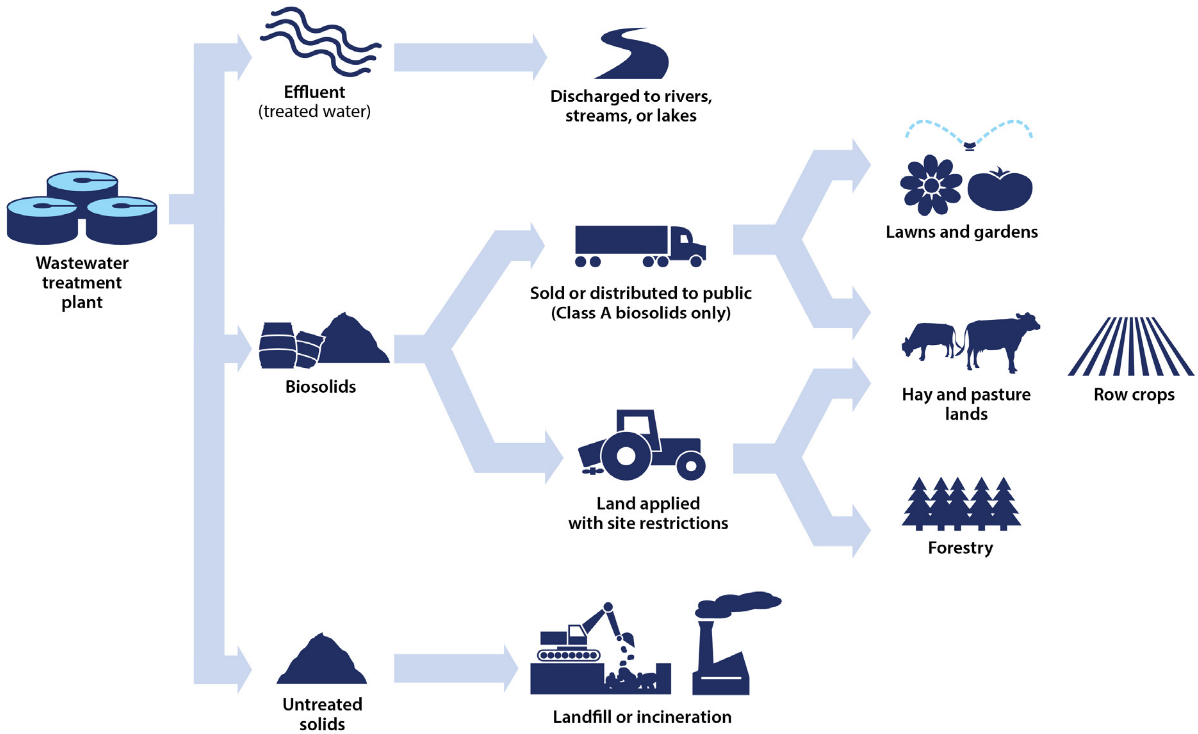
To address the mandate, JLARC staff reviewed more than 150 scientific research papers about the risks biosolids and industrial residuals pose to human health and water quality. JLARC staff interviewed scientific researchers; staff at the Virginia Department of Environmental Quality (DEQ), the Virginia Department of Agriculture and Consumer Services (VDACS), and the Virginia Department of Health (VDH); wastewater treatment facility managers; land appliers; and concerned citizens. In addition, JLARC staff analyzed data provided by DEQ, VDACS, and land appliers. (See Appendix B for more detail on the research methods used in this study.)

Biosolids are treated sewage sludge. Raw sewage enters wastewater treatment plants and is separated into liquids and solids. Most liquid is cleaned and filtered until it can be returned to surface waters. The solids, or untreated sewage sludge, are either landfilled, incinerated, or further treated for land application.

Biosolids and industrial residuals are applied as agricultural fertilizer to a small percentage of farmland across the state

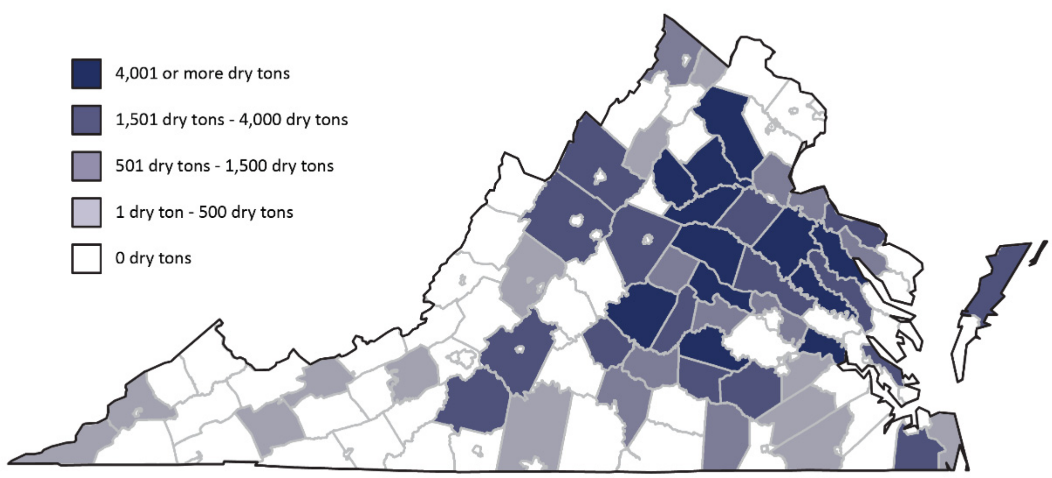
Biosolids are organic matter resulting from the treatment of sewage at municipal wastewater treatment plants (Figure 1-1). Industrial residuals are manufacturing byproducts, such as sludge from paper mills and ash from wood-fired electric plants. Biosolids and industrial residuals contain nutrients, including phosphorus and nitrogen, that are beneficial to plant growth. Because of their nutrient content, biosolids and industrial residuals can be applied to farms and forest land as fertilizer.

FIGURE 1-1
Treatment plants produce biosolids that are sent to be land applied



SOURCE: Academic research literature, DEQ, and VDACS.

FIGURE 1-2
Land application occurred in at least 53 of Virginia's 133 localities (2016)



SOURCE: JLARC analysis of data from DEQ.
NOTE: DEQ and VDACS both regulate biosolids and industrial residuals. Map only includes materials land applied under DEQ site restrictions. Neither DEQ nor VDACS tracks where other materials are applied.

Biosolids and industrial residuals are applied to land throughout the state. In 2016, land application occurred in at least 53 different localities (Figure 1-2), but only to about 1.5 percent of Virginia's 8.2 million acres of farmland. Most land application occurred in rural counties. In 2016, Amelia, Buckingham, Caroline, Culpeper, and Madison counties had the most material applied.

Majority of land application involves biosolids being applied to crops that are not consumed by humans

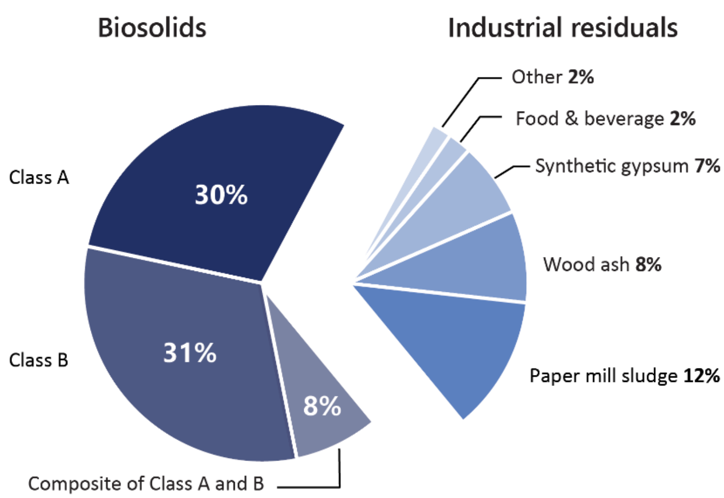
Biosolids are categorized as either **Class A or Class B** based on the treatment used and level of pathogens in the material. Class B material has a higher pathogen content.

In 2016, the majority of materials applied to land were biosolids (69 percent). Thirty percent of land-applied materials were Class A biosolids and 31 percent were Class B biosolids (Figure 1-3). Eight percent of land-applied materials were composite biosolids from storage facilities, a mix of Class A and B materials. The most common land-applied industrial residuals were paper mill sludge, wood ash, and synthetic gypsum.

About two-thirds of biosolids applied under DEQ site restrictions are applied to crops that are not consumed by humans. The majority of land application is to hay and pasture fields (55 percent) and pine tree farms (14 percent). The remainder is applied to fields that grow corn (27 percent) or other row crops, such as soybeans or wheat (four percent). Corn and other row crops are used for animal feed or as ingredients in processed food products that may be consumed by humans. Biosolids applied under DEQ site restrictions, including all Class B and most Class A biosolids, are not used on fresh produce crops.

Biosolids from other states are applied to land in Virginia. Twenty-four percent came from wastewater treatment plants in Maryland. An additional 10 percent comes from other states, including West Virginia and Wisconsin. Twenty-four percent comes from the Blue Plains treatment plant located in Washington, DC, which processes sewage from parts of Northern Virginia, DC, and Maryland.

FIGURE 1-3
Biosolids constitute a majority of land-applied materials (FY16)



SOURCE: JLARC analysis of data from DEQ and VDACS.
NOTE: Total dry tonnage of biosolids and industrial residuals applied in FY16 was 233,025. Composite biosolids are from a storage facility where Class A and B materials may have been mixed. Synthetic gypsum is a by-product of emissions "scrubbing" at coal plants to remove sulfur dioxide and is chemically identical to naturally occurring gypsum.

Recent shift toward Class A has reduced amount of biosolids applied

Switching from Class B to Class A treatment can reduce the amount of biosolids generated. The amount can be reduced because additional digestion occurs during some Class A treatments. Plants that switch from a Class B lime-treatment method to a Class A method where lime is no longer being added can experience especially large decreases in biosolids output. Blue Plains reduced the amount of biosolids it generates by half.

The amount of biosolids applied in Virginia has declined in recent years. Between 2008 and 2016, the total tonnage of biosolids applied to land in Virginia, under DEQ site restrictions, declined by 44 percent (from 260,000 to 146,000 dry tons). The main reason for the decline is that the largest producer of biosolids, the Blue Plains wastewater treatment plant in Washington, DC, switched from producing Class B to Class A biosolids. When Blue Plains switched its treatment process, the amount of material generated by the plant was reduced by half. Blue Plains is the largest source of biosolids used in Virginia, so the reduction resulted in a net decrease in the overall amount applied.

Other large wastewater treatment plants are planning to convert to Class A biosolids treatment. Similar to Blue Plains, they indicated that the amounts of biosolids they produce will likely be reduced over the short term.

Although the amounts of biosolids generated may decline in the short term, amounts should increase over the long term as population increases. Additionally, some wastewater treatment plants that currently landfill or incinerate sludge may switch to biosolids production. A larger share of future biosolids will be Class A as more wastewater plants convert to or begin Class A treatment.

Land application benefits several parties

Biosolids and industrial residuals are valuable fertilizers because they contain essential plant nutrients like nitrogen and phosphorus and other important micronutrients like iron, copper, and zinc. Biosolids and industrial residuals also contain organic matter that helps soils absorb water, which can improve plant health and reduce runoff and erosion.

Disposal alternatives, such as landfilling and incineration of sewage sludge, may pose environmental risks. Landfills in Virginia have had recent issues with buildup of leachate (water carrying leached constituents), contaminants leaking into waterways, or escape of other materials during storms. Incinerators create air pollution, although recent federal regulations are designed to limit pollutants.

Applying biosolids and industrial residuals as fertilizers benefits several parties. Wastewater treatment plants and manufacturers of industrial residuals benefit because it gives them a reliable and cost-effective way to dispose of waste materials. Farmers and other landowners, who receive these materials at no cost, also benefit, as do a small number of companies that are hired to apply the materials.

Land application is a reliable and cost-effective disposal method

Wastewater treatment plants treat and apply sewage sludge because it can be a more reliable and cost-effective method of disposal than incineration or landfilling. The disposal methods available to a plant depend on the plant's size, location, and existing infrastructure. Approximately half of the sewage sludge generated in Virginia is treated to meet biosolids standards and land applied, while the remainder is sent to landfills or incinerated.

The state does not have adequate landfill capacity to dispose of the large amount of sludge produced by its wastewater treatment plants. Landfills need to mix the sludge they receive with other materials, to keep the landfill from becoming unstable. This operational requirement limits the amount of sludge a landfill can accept on a given day. Landfills may also be unable to accept any sludge on days when there is rain or snow. These limitations make landfilling an unreliable disposal alternative for many treatment plants.

Virginia's incinerators have limited capacity to accept additional treated and untreated sewage sludge. There are only six incinerators in the state that are permitted to handle sewage sludge. These incinerators, which are operated by wastewater treatment plants or local governments, are sufficient for disposing of sludge from their own plants, but their capacity to dispose of sludge from other plants is very limited. Other types of incinerators—such as municipal solid waste incinerators—would need modifications to burn sludge.

Land application can be less expensive for wastewater treatment plants than landfilling and incineration. Staff of two large treatment plants interviewed for this study reported that their disposal costs would double if they landfilled sewage sludge instead of treating it and applying it to land. Their costs would be greater because they would have to pay more to transport sludge to the landfill and pay landfill fees. Incineration can also be more expensive because of the substantial up-front costs for incinerator construction and permitting, and ongoing costs, such as incinerator maintenance and emissions monitoring.

Other technologies, such as gasification and pyrolysis, which convert biosolids to renewable fuel, show long-term potential as alternatives to land application. However, these technologies are not widely used for biosolids in the U.S. or other countries and have not been proven on a large scale. Like incinerators, these alternatives require large capital investments.

Gasification and pyrolysis treat sludge with extreme heat but do not use combustion. These processes break the sludge down into simpler molecules that can be converted to gas and biochar. The gas can be used as an energy source, and biochar has been used as a soil amendment and as a fuel alternative for cement kilns.

Like wastewater treatment plants, manufacturers of industrial residuals benefit from being able to land apply their materials. Land application offers manufacturers a less expensive disposal method than alternatives, such as using commercial landfills or constructing and permitting their own landfills. Some industrial residuals can be marketed and sold as a fertilizer or soil amendment, which generates revenue for the manufacturer.

Land application benefits landowners and several companies

Landowners, primarily farmers, benefit from land application because biosolids and many industrial residuals are provided as a free-of-charge fertilizer. According to one estimate, the annual nutrient value of biosolids provided to Virginia farmers is $25,000 per farm, on average. Access to free fertilizer reduces farmers' production costs. One study found that a farmer raising a corn crop could generate a net profit of $350 per acre using free biosolids compared to $90 per acre after paying for a commercial chemical fertilizer. This estimate was based on reduced fertilizer costs and a higher crop yield from biosolids, compared to the chemical fertilizer.

Landowners can also benefit by using biosolids on land they otherwise would not fertilize. Forest and pasture land, for example, is often not fertilized because the cost is not worth the financial return. According to research conducted by Virginia Tech, applying biosolids to pine plantations increases timber yield and reduces harvest times, which increases profitability. Applying biosolids to hay and pasture lands also allows farmers to raise more livestock, which improves their profitability.

The demand for biosolids and industrial residuals from landowners is high and generally exceeds supply, and materials are applied to land as they become available. However, some biosolids are landfilled or temporarily stored in storage facilities when weather conditions do not allow for land application.

A small number of companies rely on land application as their primary line of business. These companies contract with wastewater treatment plants and manufacturers to haul and apply materials to farms and timberland. The private land application industry in Virginia comprises three large land appliers and five smaller companies. These eight companies were paid at least $32-$35 million by treatment plants in 2016 and employed over 80 full-time workers, according to a JLARC staff estimate. (Estimate only includes revenues from biosolids land application occurring under DEQ site restrictions and excludes employment from sub-contracted operations, such as trucking.)

Contaminants in biosolids and industrial residuals have caused concern in Virginia

Biosolids and industrial residuals contain pathogens and chemicals that may pose risks to human health and water quality. Pathogens include bacteria, viruses, and parasites that can cause illness. Chemicals include metals such as lead and mercury, and trace amounts of organic compounds, such as pesticides, disinfectants, pharmaceuticals, and endocrine-disrupting compounds. These contaminants can have harmful health effects if sufficient amounts are inhaled, ingested, or otherwise come into direct contact with people. The nutrients found in biosolids and industrial residuals can also pollute rivers and groundwater if not absorbed by plants.

Biosolids today contain far fewer industrial chemicals than in the 1970s and 1980s. Chemicals from manufacturing processes flowing into public sewer systems have decreased due to the implementation of industrial wastewater pretreatment regulations and a general decline in U.S. manufacturing. Most of the biosolids applied in Virginia are from domestic sewage.

Because of the potential effects on human health and water quality, citizens have expressed a range of concerns about land application of biosolids and industrial residuals. Some people who live near land application sites are concerned that biosolids or residuals cause health problems. Some citizens are concerned about the unpleasant odor of biosolids. Other common concerns are the effects of land application on water quality, nearby property values, and quality of life. Several rural communities have formed citizen groups to oppose land application.

Most land application faces relatively little citizen opposition, but the practice has been controversial in some areas. For example, a recently approved request to land apply biosolids in Nelson County was strongly opposed by several citizens in that community. Even though there is strong opposition to land application in some areas, DEQ receives relatively few citizen complaints statewide. DEQ received one call for approximately every 35 land applications in the state from 2014 to 2016. (See Appendix C for more information about citizen concerns and complaints.)

Ongoing citizen concerns and complaints have prompted multiple reviews in Virginia over the years, including

- VDH reviews of the scientific research literature in 2007 and 2014, which found some evidence of risk but "no immediate public health concerns regarding the production and land application of biosolids"; and
- an expert panel convened in 2008, which "uncovered no evidence or literature verifying a causal link between biosolids and illness."

In a **2005 review of biosolids, JLARC concluded** that localities were wary of biosolids and that oversight and enforcement of regulations (which at the time were conducted by the Virginia Department of Health) were weak.

Each of the reviews acknowledged gaps in the scientific research on risks to human health and water quality, including a lack of health studies and limited understanding of the effects of some contaminants found in biosolids. (See Appendix D for a timeline of Virginia studies and regulatory changes.)

There have been few studies of the risks from industrial residuals in Virginia. Staff with state regulatory agencies indicated that the types of industrial residuals land applied in Virginia generally pose less of a risk than biosolids because they typically do not contain human pathogens and usually contain fewer chemicals of concern.

State regulation and monitoring aim to protect human health and water quality

To minimize human health and water quality risks, Virginia regulates and monitors the production and use of biosolids and industrial residuals. State regulations set minimum standards for biosolids treatment and land application. Some Virginia regulations, such as biosolids treatment requirements, conform to federal regulations. Others, such as requirements for additional setback distances from land application sites, are more restrictive than federal regulations. State agencies are responsible for ensuring compliance with Virginia regulations.

The **Environmental Protection Agency (EPA) sets federal regulations** for land application of biosolids. Neither EPA regulations nor federal laws specifically address land application of industrial residuals, although they limit the application of "solid waste" near food-chain crops.

State regulations for biosolids and industrial residuals conform to or are more restrictive than federal standards

Virginia regulations, established under the State Water Control Law (§ 62.1-44), set the requirements for disposing of biosolids and industrial residuals. Under state regulations, biosolids can only be land applied if they meet certain standards. The state identifies nine heavy metals that must be tested for and sets limits on the concentrations that biosolids can contain. The rules require biosolids to be treated to reduce their pathogen levels and attractiveness to pests (Figure 1-4). State standards for biosolids conform to the federal standards that were established by the Environmental Protection Agency under federal regulations (40 CFR Part 503).

FIGURE 1-4
State regulations require biosolids to meet metals and treatment standards

Metal concentration limits

The nine metals that the state sets concentration limits for are Arsenic, Cadmium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, and Zinc.

Pathogen reduction

Ways to reduce pathogens include treating biosolids with heat, lime, and microbial digestion processes.

Biosolids generators can also meet the pathogen reduction requirement by testing for indicator species like fecal coliform.

Vector attraction reduction

Ways to reduce "vector attraction" (attractiveness to pests) include adding alkaline materials to raise the pH, reducing the moisture content of the biosolids, incorporating the biosolids into the soil during land application, and injecting the biosolids beneath the surface during application.

SOURCE: Virginia regulations 9VAC25-31.
NOTE: The state regulations highlighted here are identical to federal regulations set forth in 40 CFR Part 503.

Wastewater treatment facilities produce biosolids using several different methods, including heat, lime, and microbial digestion (aerobic or anaerobic). Based on the level of treatment to reduce pathogens, state regulations classify biosolids as either Class A or Class B (Table 1-1).

TABLE 1-1
Class B biosolids contain higher pathogen levels than Class A

	Pathogen treatment	Use restrictions
Class A	Treated to reduce pathogens to very low or undetectable levels	Can be land applied in bulk under site restrictions or sold to the public in bags like other fertilizers
Class B	Must meet certain standards for pathogen treatment, but can contain higher pathogen levels than Class A	Must be land applied in bulk under site restrictions

SOURCE: Federal regulations (40 CFR Part 503) and Virginia regulations (9VAC25-31).

Virginia regulations establish several additional site restrictions that must be followed when Class B biosolids are being used, some of which are not required under federal regulations:

- The amount of materials that can be applied to a site is limited by the requirements set in site-specific nutrient management plans; these plans prescribe how often and how much land application can occur, based on the soil at the site and the nutrient needs of the crop.
- Setbacks are required between land application sites and residences, property lines, and surface and ground water features.
- Materials cannot be applied when groundwater tables or bedrock are within 18 inches of the surface.
- Crops cannot be harvested until 30 days to 38 months after land application, depending on the crop.
- Animal and human access to the land application site is restricted for 30 days, and up to one year, after application.

Virginia's Fertilizer Law and Agriculture Liming Materials Law (Chapters 36 and 37 of Title 3.2, Code of Virginia) allow for industrial residuals and Class A biosolids to be sold and distributed without site restrictions. Currently, most Class A materials in Virginia are distributed in bulk and land applied with site restrictions like Class B biosolids. However, DEQ is considering allowing most of these materials to be applied with limited oversight. Industrial residuals are regulated the same as either Class A or Class B biosolids, depending on the individual residual. (See Appendix E for more information on regulatory requirements for different types of biosolids and industrial residuals.)

State agencies enforce Virginia regulations, and localities can supplement enforcement

In Virginia, two state agencies are responsible for regulating biosolids and industrial residuals. DEQ, the main agency responsible for biosolids regulations and compliance under the State Water Control Law, oversees all Class A and B biosolids and some industrial residuals. Materials under DEQ authority can be applied only after obtaining a permit. Most materials are bulk applied under site restrictions, but DEQ permits some Class A biosolids to be sold and distributed under VDACS certification. DEQ has implemented a compliance program to ensure that state regulations are followed when land applying biosolids and industrial residuals.

DEQ assesses a fee when biosolids are applied to land under site restrictions. The fee is $7.50 per dry ton of Class B material, and $3.75 per dry ton of Class A material. These fees are paid by wastewater treatment plants, and are used to fund DEQ's compliance program. These fees do not apply to materials that are sold or distributed under VDACS certification.

VDACS is responsible for regulating industrial residuals and a subset of Class A biosolids that can be sold or distributed to the public under Virginia's fertilizer and liming material laws. VDACS requires that manufacturers and wastewater treatment plants that want to sell or distribute their materials have their products certified and registered. If a product is certified as safe and beneficial, it can be used without further oversight. (As noted above, Class A biosolids must also be permitted for sale and distribution by DEQ.)

In Virginia, localities are authorized to adopt ordinances for inspection and monitoring of land applications that take place under DEQ site restrictions. However, they cannot enact ordinances that are stricter than the state's regulations. Localities that choose to adopt land application ordinances have the option to hire local monitors to provide additional oversight. Localities are eligible for state reimbursement to assist with the cost of local monitoring programs. In 2016, four counties—Culpeper, Westmoreland, Nottoway, and Clarke—requested state reimbursement. At least two others—Goochland and Nelson—conducted some form of monitoring but did not request reimbursement.

2 Risks to Human Health and Water Quality

SUMMARY Land application of biosolids and industrial residuals poses some risk to human health and water quality, but the risk is low if state regulations are followed. Additional research, however, would reduce uncertainty about health risks, especially for chronic, long-term illness. Although state regulations generally protect human health and water quality, they may not prevent nearby residents from exposure to a common virus under certain conditions. Class B biosolids contain higher levels of pathogens, and if residents are downwind and outside for an extended period during a land application, they could be at a slightly elevated risk of catching a mild to moderate illness. Under its responsibilities to ensure public health, VDH should determine whether current setback requirements are sufficient and if limits should be placed on how frequently biosolids can be applied to a site. VDH should also sample test biosolids to determine if their pathogen content poses a risk.

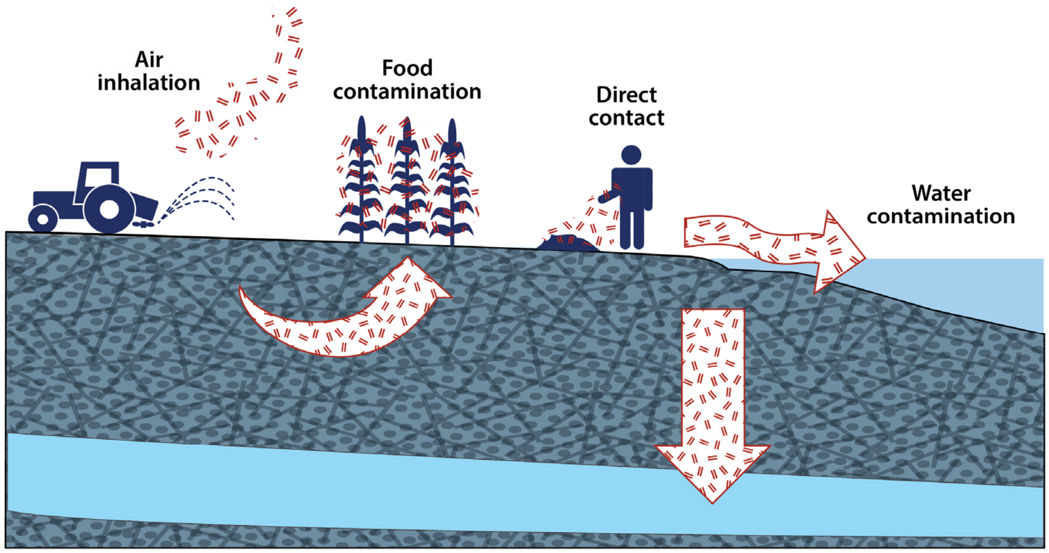
If not properly regulated, biosolids and industrial residuals could pose a risk to human health and water quality. Biosolids contain contaminants (pathogens and chemical elements and compounds) that can cause illness and pollute waters. Industrial residuals can contain some potentially harmful chemicals but typically do not contain pathogens. There are a number of possible pathways through which people can be exposed to contaminants in the two materials (Figure 2-1). These pathways include inhaling aerosolized contaminants, ingesting contaminated ground- or surface water, consuming food that has been contaminated, or coming into direct contact with materials after they have been applied.

Virginia has regulations that are intended to mitigate the risks from land application of biosolids and industrial residuals. All land applications of Class B biosolids, and currently most Class A biosolids, are subject to specific site restrictions—such as setback requirements, harvesting restrictions, and access restrictions—and are monitored by DEQ. However, some Class A biosolids (and most industrial residuals) are not subject to site restrictions or DEQ monitoring.

Land application poses some risk to human health and water quality, but the risk is low

Biosolids and industrial residuals contain pathogen and chemical contaminants that pose inherent risks to human health and water quality. Exposure to a small quantity of biosolids could result in a short-term illness, such as a common viral infection, and chemicals found in biosolids and some industrial residuals have been linked to a

FIGURE 2-1
People could be exposed to contaminants through several pathways



SOURCE: JLARC review of scientific research literature and interviews with biosolids researchers.

number of chronic illnesses. Land application of these materials is regulated to mitigate these risks. State regulations are generally effective at reducing the risk that people will be exposed to contaminants or that contaminants will pollute waters. Even though regulations address the risks that have so far been identified, scientists emphasize that the risks from some contaminants are not yet fully understood.

Biosolids and industrial residuals contain harmful contaminants that can cause illness and pollute waters

Land application of biosolids and industrial residuals poses a risk to human health because these materials contain harmful contaminants, but the risks are low as long as exposure to contaminants is minimized. There are two types of human health risks from exposure to these materials: acute and chronic illnesses. Acute illnesses develop suddenly and last a short time. These include illnesses such as the common cold and the gastrointestinal "stomach flu." Chronic illnesses develop slowly, over months or years. These include ailments such as lead poisoning and cancer.

Scientific research has found that biosolids can cause acute illnesses if inhaled or ingested. The risk of acute illness comes mostly from Class B biosolids because they contain more pathogens than Class A materials. The pathogens found in biosolids are mostly common viruses and bacteria that can cause mild to moderate illness in a healthy person, such as the common cold or a "stomach flu." Illness could be more severe in persons with weakened immune systems, such as the elderly or chronically ill. Pathogens that can cause severe illnesses such as Legionnaire's disease are sometimes, but not frequently, found in biosolids, with the exception of some parasites. (See Appendix F for more information on the frequency of pathogens in biosolids.)

After inhaling or ingesting enough biosolids or industrial residuals material, a person could have an acute reaction to metals or other chemicals that are present. However, studies suggest that metal and other chemical inhalation risks are very low (Paez Rubio 2006 and 2007; Ziemba 2013). The risks of toxic metal or other chemical poisoning from ingesting biosolids are similar to, or in some cases much lower than, the risks from ingesting common household and agricultural products, such as cleaners and pesticides.

There has been little research examining whether exposure to biosolids and industrial residuals can lead to chronic illnesses, but the risks appear low as long as exposure to these materials is minimized. Biosolids and industrial residuals contain trace amounts of chemicals, such as lead, that are known to cause chronic illness. However, a person would likely have to be exposed to a relatively large amount of material at once or small amounts of material repeatedly for these chemicals to accumulate in the body. For example, the federal Environmental Protection Agency (EPA) sets the maximum contaminant level threshold for lead in drinking water at 0.015 parts per million. An individual would have to accidentally ingest 1/10 to 1½ teaspoons of biosolids each day to stay above this threshold, depending on the lead content of the material. Other trace chemicals found in biosolids may be harmful in extremely low quantities. For example, phthalate chemicals found in plastics and household products are suspected carcinogens and endocrine disruptors, and the EPA sets very low limits on ingestion. However, these chemicals are found in extremely low concentrations in biosolids, so an individual would likely need to accidentally ingest material over a long time period to have a chronic health effect.

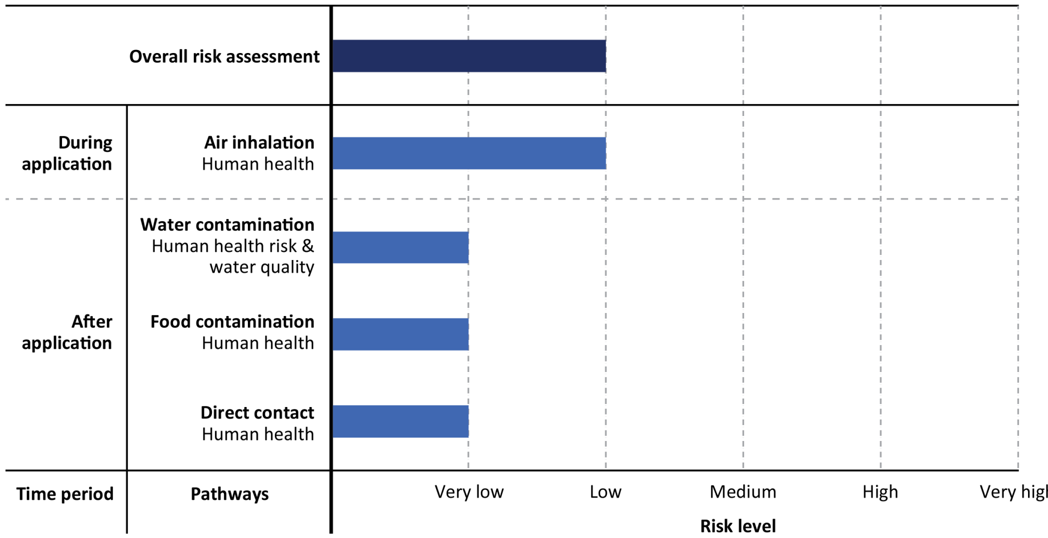
Human health and water quality **risks were assessed** through a JLARC review of state regulations, interviews with researchers, and a review of more than 150 scientific research papers. Risks identified in the research were then compared to risks that would be likely to occur under state regulations. Appendix B lists the researchers interviewed and Appendix G lists the research papers that were reviewed.

Biosolids and industrial residuals can also pose a risk to water quality. Chemicals, especially nitrogen and phosphorous, can run off into surface waters or leach into groundwater if they are applied in large quantities. Nitrogen and phosphorous pollution is one of the state's leading water quality concerns. Chemical fertilizers and animal wastes, not biosolids, are the main agricultural sources of nitrogen and phosphorous. Animal wastes are also a major source of water-borne pathogens, especially parasites that cause gastrointestinal illness.

Overall, land application of biosolids and industrial residuals, in accordance with state regulations, poses low risk

Land application of biosolids and industrial residuals poses a low overall risk to human health and water quality under current state regulations. State regulations minimize exposure to the contaminants in these materials in several ways. Regulations limit the amounts of material that can be applied to a site, which prevents materials from being concentrated on a few sites where pathogens or chemicals could accumulate to high levels. The regulations also create setback areas between land application sites and nearby residences, and restrict access to sites, further reducing the risk of exposure.

FIGURE 2-2
Overall risk is low under state regulations, but risk is sometimes slightly elevated during land application process



SOURCE: JLARC review of scientific research literature, interviews with biosolids researchers, and JLARC assessment of risks under current state regulations.
NOTE: Human health risks from industrial residuals are lower than the risks from biosolids. Industrial residuals applied in Virginia are unlikely to contain pathogens and have lower concentrations of chemicals than biosolids.

The most likely pathway of exposure for members of the public is through inhaling aerosolized contaminants during application of biosolids (Figure 2-2). Even the health risk from this pathway is low overall, because certain conditions are needed for aerosolization to occur and state-required setbacks help minimize public exposure. After application, risks are very low through the other possible exposure pathways (water contamination, food contamination, and direct contact). Risks are very low because state regulations, such as application limits and harvesting restrictions, mitigate exposure.

In Alabama, biosolids were accidentally contaminated by industrial chemicals in 2007. High levels of perfluorinated compounds, which had been discharged into a municipal sewage system, were found in biosolids applied to 5,000 acres of farmland. Some of the chemicals leached into nearby well water, creating a health risk for a small number of residents close to the application site.

Although regulations are generally protective, an accidental spill that results in high levels of chemicals being released into a sewage system could greatly increase the risk from biosolids applied to a given site. Accidents involving biosolids have happened in other states (sidebar), but not in Virginia.

Accidents are unlikely if wastewater plants have properly implemented their industrial pretreatment programs. Pretreatment programs require industrial facilities that send wastewater to municipal sewage systems to screen out harmful chemicals. Wastewater treatment plants place limits on chemicals, based on the type of industrial facility, and monitor facility discharges to ensure compliance. Pretreatment programs are required under state and federal regulations but are designed and implemented by municipal utilities.

Epidemiological research is needed to fully understand risks to human health

The human health risks posed by land application of biosolids and industrial residuals appear low as long as exposure to these materials is minimized, but the scientific community has not reached consensus. Some researchers interviewed for this review said the risks are negligible for the public, and others said the risks raise safety concerns. The difference in opinions exists because there is insufficient evidence to definitively rule out human health risks even at minimal levels of exposure, especially from biosolids. Researchers are generally less concerned about the risks from industrial residuals because these materials do not typically contain pathogens and have far fewer chemicals of concern.

According to researchers, the risks from land application of biosolids are not fully understood. Biosolids contain hundreds of different pathogens and chemicals in low levels, and exposure is possible through multiple pathways. The potential health effects of some of the many organic chemical compounds found in biosolids are also not fully understood. Some of these compounds can persist in the environment or degrade into more persistent forms. Persistent compounds can accumulate and pose a greater risk over time. Organic compounds may also move through the environment or interact with each other in unforeseen ways.

Epidemiology is the study and analysis of the patterns, causes, and effects of illness and disease in human populations. It is one of the main tools of public health. State epidemiology offices, such as the one at VDH, are tasked with identifying, investigating, and monitoring environmental factors that present a potential human health hazard.

The most significant gap in the scientific research literature is the absence of authoritative epidemiological research to definitively conclude whether human illness is linked to land application. The most comprehensive study to date found there was no difference in the risk of illness found in individuals residing near biosolids sites and a control group (Dorn 1985). The methods used in this study were sound, but the study is more than 30 years old and had a relatively small sample size. A more recent study used surveys to assess health risks and found a relationship between biosolids applications and elevated incidents of illness (Khuder 2007). The study is credible, but its reliance on self-reporting and its low response rate limit confidence in its findings. Other studies surveyed individuals residing near application sites and found health concerns (Lewis 2002, Lowman 2013). Findings from these studies are not reliable for assessing risk because they did not use control groups to establish a baseline for comparison, among other methodological limitations. (See Appendix H for more information on studies linking land application of biosolids to health outcomes.)

To help fill the gap in the scientific research and provide more certainty about the safety of biosolids, the General Assembly may wish to consider directing the Virginia Department of Health (VDH) to design and pilot an epidemiological study, with the goal of better understanding whether and how land application of biosolids affects human health. Following completion of the pilot study, VDH would determine the cost and resources needed to conduct a full-scale study.

RECOMMENDATION 1

The General Assembly may wish to consider directing the Virginia Department of Health (VDH) to design and conduct a pilot epidemiological study of the human health effects of land application of biosolids. The General Assembly may wish to consider appropriating $50,000 to fund the study. In designing and conducting the pilot study, VDH should contract with third parties, such as researchers at Virginia institutions of higher education, as needed. VDH should be assisted by the Virginia Department of Environmental Quality as needed. Following completion of the pilot study, VDH should submit its findings and a proposed design for a full-scale epidemiological study, if needed, to the Senate Finance, and Agriculture, Conservation, and Natural Resources Committees; and House Appropriations, and Agriculture, Chesapeake, and Natural Resources Committees.

JLARC staff use a **cash reserve benchmark** for internal service funds. The benchmark is for funds to have 60 days of operating expenses on hand in the event of unexpected revenue losses or expense increases.

The pilot study could be paid for from DEQ's sludge management fund but doing so would affect DEQ's ability to use the fund to cover future operating losses. The fund, which DEQ uses to fund its compliance program, has a positive cash balance. The cash balance has been declining the last few years because DEQ has been using the cash balance to offset annual losses. The losses have been due to a decline in fund revenue caused by wastewater treatment plant operators switching to Class A biosolids, which are assessed a lower fee than Class B. Using part of the fund's cash balance to fund this and other report recommendations would result in the balance falling below the recommended cash reserve benchmark about one year earlier than it would otherwise (FY23 rather than FY24). (See Appendix I for more information on the sludge management fund.)

Following submission of the pilot study's findings, the General Assembly could decide whether to fund a full-scale study. Because epidemiological studies are complex, the cost of conducting a full-scale study could range from $250,000 to $1,000,000.

There are several options for an epidemiological study:

- A lower-cost option would be to retrospectively review existing health records, such as state Medicaid records, to see if there are links between documented illnesses and land application.
- A higher-cost option would be to prospectively monitor health outcomes in a sample population.
- Another option would be to review records or monitor health in a higher-risk group, such as employees of land appliers or persons residing near sites that receive frequent applications.

Risk of a common viral infection is low, but sometimes slightly elevated, for nearby residents during application

Although overall risk is low, there is sometimes a slightly elevated risk of viral infection to nearby residents during land application. During land application, small particles of material, including microorganisms in biosolids, can become airborne. This material can then be inhaled by people who are downwind of the application site. If there are pathogens in this material, a person who inhales the aerosolized material could become infected. The most likely infections from this kind of exposure are common viral illnesses, such as the common cold and the "stomach flu." This risk of infection is low for nearby residents because several conditions have to be met for exposure to occur, and state regulations help minimize exposure.

Other aerosolization risks may exist, but they are very low. Risks from aerosolized metals and other chemicals are minimal because the trace amounts that are found in biosolids are not sufficient enough to be toxic if inhaled (Paez-Rubio 2006, Paez-Rubio 2007, Ziemba 2013). Industrial residuals that are used in Virginia pose a very low aerosolization risk because they are unlikely to contain pathogens and contain fewer chemicals than biosolids.

After application, the risk of aerosol infection is very low. After material has been applied, it can only be aerosolized by tractor activity or wind.

Wind aerosolization appears unlikely. One study found that the concentration of biosolids material aerosolized from "high-wind events" was 250 to 10,000 times lower than concentrations found during application (Baertsch 2007). The potential for wind aerosolization is even lower under normal wind conditions.

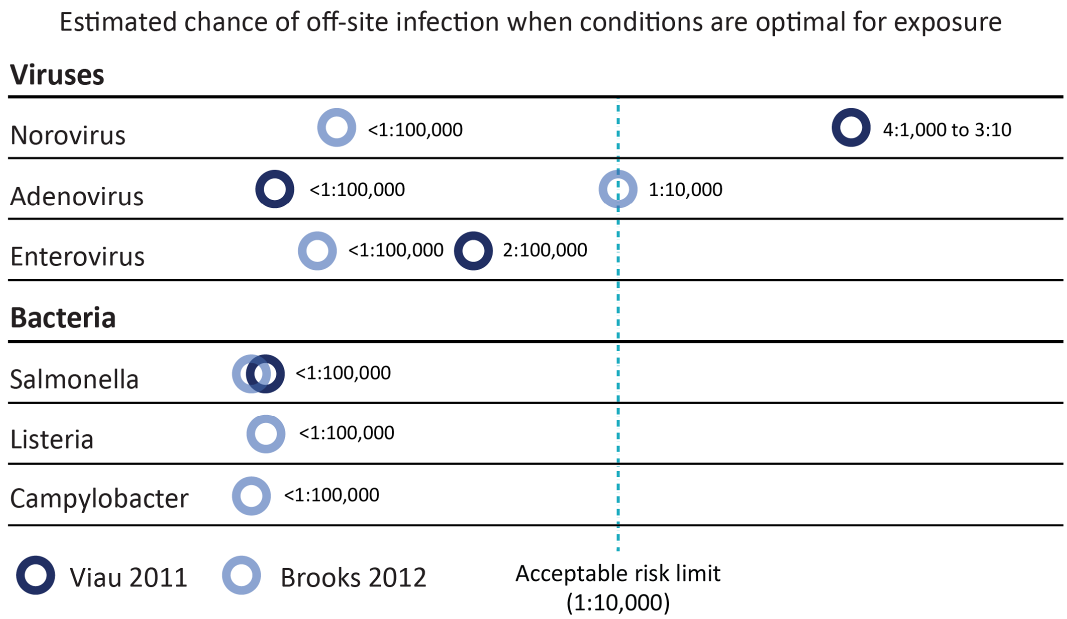
Risk of aerosol infection is very low for Class A biosolids but higher for Class B biosolids when conditions are optimal for exposure

The risk of aerosol infection is low for nearby residents because several conditions have to be met for exposure to occur. These conditions are (1) Class B biosolids are being applied, (2) wind is blowing towards the residence during application, and (3) residents are at home and outdoors during application. If these conditions are not met, people near application sites may not be exposed at all during application. Even when all the conditions are met, the likelihood of infection varies greatly depending on the amount of time that an individual is exposed.

The aerosol infection risk from land application is very low when Class A biosolids are applied, and about half of the biosolids applied in Virginia are Class A. Application of Class A biosolids presents a very low risk because the materials have very low pathogen levels. Class A pathogen levels are about 100 to 1,000 times lower than untreated sewage sludge, and the aerosol infection risk is 100 to 100,000 times lower (Viau 2009, Viau 2011). By comparison, Class B treatment reduces pathogens to levels that are only 10 times lower than untreated sludge.

Class B application presents a low risk of aerosol infection under most conditions, but the risk could be higher when conditions for exposure are optimal. Two recent scientific studies assessed the risk of aerosol infection to individuals who were nearby during land application of Class B biosolids (Viau 2011, Brooks 2012). The studies concurred that

FIGURE 2-3
Aerosolization poses a very low risk of infection for most pathogens that are commonly found in biosolids



SOURCE: DEQ biosolids regulations, Viau 2011, Brooks 2012.
NOTE: Viau 2011 assumed individual outside and downwind of 3.4 mph wind at a distance of 65 meters (213 feet) over course of 39 hours of application and 3 hours of soil incorporation (or about 4-6 days of application). Infection risk for norovirus varied depending on assumptions of how the virus occurs in biosolids. Brooks 2012 assumed individual outside and downwind of 0.7-5.5 mph winds at a distance of 100 meters (328 feet) for one hour per day over course of six days of application.

there was very low risk of aerosol infection by most of the pathogens that are commonly found in biosolids, including several types of viruses and bacteria (Figure 2-3). However, one study found a moderate risk of aerosol infection with norovirus under optimal conditions for exposure (that is, when a person is regularly outside and downwind of land application over about 4-6 days). The other study found that adenovirus presented some risk under similar conditions.

An **infection risk limit** of 1:10,000 was established by the EPA as the acceptable risk of microbial infection from drinking water.

This limit is used as a proxy benchmark in several research studies of aerosol infection risk from biosolids.

The aerosol infection risk from a typical land application is likely to be lower than study estimates because actual conditions vary during application. The majority of land-applied materials are Class A or industrial residuals, so many land applications do not pose an aerosol or infection risk. Nearby residents are also at little to no risk of infection if they are upwind of an application or if there is no wind on the day of application. Risk is also lower when residents are not present or are indoors during application. The duration of exposure is also likely to be lower in most cases. Land application sites in Virginia receive an average of two days of application per year, compared to the 4-6 day assumptions used in the two studies.

Regulations may not adequately mitigate Class B aerosol infection risk when conditions are optimal for exposure

State regulations generally alleviate the risk of aerosol infection, but may not adequately mitigate the risk when conditions are optimal for exposure and there are frequent land applications nearby. The state requires setback areas between land application sites and nearby residences which may not adequately mitigate aerosol infection risk. Under its responsibilities to ensure public health, VDH should undertake a targeted review of current regulations. VDH should determine whether the state's current regulatory setbacks are sufficient and if limits should be set on how frequently biosolids can be applied to a site. VDH should also sample test biosolids to determine if their pathogen content poses a risk. At the conclusion of these reviews, and after completing a pilot epidemiological study, the State Health Commissioner should report to the director of DEQ on whether and why the state regulations should be changed.

The state's standard setback between the edge of a land application and a residence is 200 feet. The two recent risk assessment studies found that these setbacks mitigate infection risks from most pathogens. However, the studies also found that a person residing outside this setback area could be at an elevated risk of infection from a common virus when wind conditions are optimal for exposure and the person is exposed for several days. One of the studies found some risk even for a person residing outside the 400-foot extended setback that DEQ grants to citizens with health conditions.

More broadly, the state's current setbacks for residences are not based on the most recent research on pathogen aerosolization. The current setbacks, which were approved in 2011, were established on the basis of assessments made by VDH at least a decade ago. Now that more recent research is available, VDH should assess whether changes to the setbacks are needed to better protect public health. In making this assessment, VDH should consider each study's risk model and key assumptions.

RECOMMENDATION 2

The Virginia Department of Health should assess the risk of aerosol infection to the public by reviewing the most current research literature and determine whether regulatory setbacks for protecting human health should be expanded.

The state also does not limit how often biosolids can be applied in a geographic area, and more frequent applications may elevate the risk of infection. From 2014 to 2016, 21 sites in Virginia had more than 14 days of application per year, including three that had more than 30 days of application. There were approximately 560 addresses (residences, businesses, public spaces, other) within 1,000 feet of these sites. Many of the sites were so large that it is unlikely all adjacent residents were exposed during every application. For example, if biosolids were applied to fields on one side of a 500-acre farm, residents who are half a mile away on the other side of the farm are unlikely to be exposed. Still, residents who are near frequent application sites may have a higher likelihood of exposure to aerosolized biosolids.

VDH should assess whether changes to current regulations are needed to address risks at the small number of sites where applications occur more frequently. Changes could include placing a limit on the number of application days per year for sites where residences are within a certain distance or requiring larger setback areas around these sites. In making this assessment, VDH should consider how greater exposure affects the risk of infection under the models used in the two recent studies.

RECOMMENDATION 3

The Virginia Department of Health should assess whether the risk of aerosol infection to the public is elevated near sites that receive frequent applications and whether restrictions on land application frequency or larger setback areas are needed to ensure that residents are sufficiently protected.

The state does not require testing for pathogens in Class B biosolids, which could make it difficult for VDH to determine whether current residential setbacks are adequate. Biosolids with higher concentrations of viral pathogens pose a greater risk of aerosol infection and could require larger setback areas under certain circumstances.

VDH should sample and test biosolids that are land applied in Virginia as part of a one-time effort to better understand their pathogen content. Using the test results, VDH could compare the specific pathogen content in Virginia biosolids to the assumptions used by recent studies. Test results could also be used to inform the pilot epidemiological study. Sampling could focus on the pathogens that VDH determines pose the most significant public health risk. VDH could partner with DEQ to collect samples and contract with a commercial laboratory to test for pathogens. Testing could be paid for from DEQ's sludge management fund but doing so would affect DEQ's ability to use the fund to cover future operating losses. (See Appendix I for more information on the sludge management fund.)

RECOMMENDATION 4

The General Assembly may wish to consider directing the Virginia Department of Health (VDH) to perform sample testing of Class B biosolids that are land applied in Virginia to determine their pathogen content. The General Assembly may wish to consider appropriating $50,000 to fund sample testing over the course of one year. VDH should use test results to inform its epidemiological pilot study and assessment of aerosol infection risks (Recommendations 1, 2, and 3).

RECOMMENDATION 5

The State Health Commissioner should submit a written report to the State Water Control Board and the director of the Department of Environmental Quality on the findings of the Virginia Department of Health's epidemiological pilot study, assessments of aerosol infection risks, and pathogen tests (Recommendations 1, 2, 3, and 4). The report should include, as necessary, recommendations for amending biosolids regulations to further protect human health and water quality. The report should be submitted no later than July 1, 2019.

State regulations mitigate, but do not eliminate, odors

Although not as harmful as illness, the odor of biosolids and industrial residuals can be strong and offensive and can cause health symptoms for people near application sites. Some biosolids have a chemical odor from ammonia and some have a fecal odor from sulfur and other compounds. Industrial residuals such as paper mill sludge can have similar odors. Odors are most prevalent during and shortly after application. In addition to being unpleasant, strong odors can cause eye and throat irritation, shortness of breath, headaches, and nausea. Prolonged exposure to offensive odors can affect mental health and well-being.

Current state regulations attempt to address odor concerns, but do not prevent use of materials that have a strong and offensive smell. Regulations require wastewater treatment plants and land appliers to have odor control plans. These plans are intended to prevent the application of biosolids with an odor that is atypical for that material. In certain circumstances, DEQ can require materials to be tilled into the earth to reduce or eliminate the odor. However, state regulations do not prevent use of biosolids or industrial residuals—or other substances like animal manure—just because the odor is offensive.

DEQ staff indicated that biosolids from uncovered, in-ground storage facilities have historically had occasional odor problems. DEQ regulations do not allow these types of facilities to be built anymore, but two pre-existing facilities are still in use in Virginia. A third such facility in Maryland also sends biosolids to Virginia. Facility operators indicated they have updated their odor management plans and implemented new management practices in an attempt to address odor concerns from materials stored at these facilities.

Risks of water and food contamination, and direct public exposure to land-applied materials are very low

State regulations effectively address the risks of biosolids and industrial residuals after they have been applied to land. Pathogens and chemicals in the materials have the potential to leach into groundwater, run off into surface waters, or be transferred to crops. Contaminated water or food could then be ingested by people. People could also come into direct contact with contaminants if passing through a recently-treated area. If state regulations are followed, the risks from these three pathways of exposure are very low. Industrial residuals have even fewer chemicals and pathogens that could cause concern for health and water quality.

Water contamination risk is very low when biosolids are applied in compliance with state regulations

The risk of water contamination from biosolids applications is generally very low, both for groundwater and surface water. Groundwater contamination could occur if pathogens and chemicals leach through the soil. Surface water contamination could occur through run-off during heavy rain events. People who ingest contaminated water from either source could be at risk of illness or disease. State regulations, when properly followed, mitigate the risks of water contamination and the associated risks to human health.

Groundwater contamination risk is very low under state regulations

Residents of rural areas often rely on wells for drinking water. These wells draw on deep or shallow groundwater. Deep groundwater is found below the water table and is the source of drinking water for most community wells and many private wells. Shallow groundwater is found close to the surface and is also used for private wells.

Deep groundwater is at very low risk of contamination from land application of biosolids because it has been filtered through tens to hundreds of feet of soil. Some wells, especially those in eastern Virginia, draw water from a confined aquifer. These aquifers' confining layers filter water for tens, hundreds, or thousands of years.

USGS researchers interviewed by JLARC staff indicated that **chemicals found in biosolids are largely immobile**. Most of the metals and organic chemical compounds found in biosolids are hydrophobic and do not easily migrate out of the soil column. They noted that most organic chemical compounds degrade over time. A 2002 review by the National Research Council made similar observations.

Even groundwater drawn from shallow wells is at very low risk of contamination from biosolids. Shallow groundwater could be contaminated by pathogens leaching from biosolids and through the soil, but state regulations mitigate this risk. The state requires at least 18 inches of soil between the surface and the water table or bedrock, reducing the risk that pathogens could leach through. Two recent studies found soil barriers effectively prevent the contamination of shallow groundwater by microorganisms (Eisenberg 2008, Wagner 2014). Pathogens are much more likely to contaminate groundwater if there is a direct route, such as a faulty well or sinkhole, but state regulations restrict the application of biosolids near wells and sinkholes.

Shallow groundwater could be contaminated by chemicals in biosolids, but studies suggest the risk is very low. Two recent studies by the U.S. Geological Survey (USGS) examined the risk of groundwater leaching for a combined 150 chemicals of concern (Yager 2013, Wagner 2014). (See Appendix J for a complete list of these chemicals.) These chemicals included metals and organic compounds such as pesticides, disinfectants, pharmaceuticals, and endocrine-disrupting compounds. The studies found that very few chemicals leached into shallow groundwater at detectable levels. One of the studies found that only three chemicals of concern (nickel and two pesticides) were present in groundwater near biosolids application sites, and their concentrations were only slightly above those found at non-biosolids sites. The other study found one chemical, uranium, in several groundwater samples at levels that posed a human health concern. However, this study did not have a control, so it is not clear if biosolids were the source.

Nitrogen from biosolids could leach into shallow groundwater and pose a human health risk, according to the USGS studies, but the risk is very low under Virginia regulations. State regulations restrict biosolids from being applied above the rate at which crops can absorb nitrogen or soil can absorb phosphorus. These restrictions greatly reduce the leaching risk, which is already low compared to many chemical fertilizers, because biosolids release nitrogen gradually.

The groundwater contamination risks from land application are likely lower than risks from other sources. Septic systems can release human pathogens and chemicals directly into shallow groundwater and are a main source of groundwater pollution in rural areas. Animal wastes from manure applications and livestock operations are also widely present in rural areas. Animal wastes are often untreated and contain significantly higher concentrations of non-viral pathogens, including bacteria and parasites, that are common causes of waterborne illness (EPA 2015, Oun 2014, Brooks 2012, CDC 2009, GAO 2008, Goss 2008, Burkeholder 2007, Gerba 2005, Houda 2000).

Surface water contamination risk is very low under state regulations

Virginia's surface waters include thousands of streams, rivers, ponds, lakes, and reservoirs. Surface waters are a major source of public drinking water and are widely used for recreation by swimmers, boaters, and others.

Although biosolids run-off can transport pathogens into surface waters, the risks of human exposure through this pathway are very low. Surface waters that are used as public drinking water supplies are treated to remove pathogens. Swimmers, boaters, and others who use surface waters for recreation could accidentally ingest contaminated water, but the likelihood of infection from accidental ingestion is much lower than consuming contaminated drinking water.

Animal waste includes cow manure, hog waste, and poultry litter that is used as a fertilizer or otherwise released into the environment.

Metals and trace organic compounds in biosolids can also run-off into surface waters, but studies found that the concentrations were relatively low and were likely to be diluted (Yager 2013, Wagner 2014).

The water quality risks from biosolids nutrient run-off are no greater than risks from other agricultural sources. Biosolids, animal waste, and chemical fertilizers all contain nutrients, most notably nitrogen and phosphorous, that can pollute waterways. During heavy rain events, these nutrients can wash into rivers and streams. Of the three sources, biosolids account for only about five percent of the potential nutrient load.

State regulations place greater restrictions on Class B biosolids than other fertilizers, further reducing the risks to water quality. Regulations require that farms permitted for Class B biosolids must have nutrient management plans limiting how much nitrogen and phosphorous are applied. Regulations also require setbacks between biosolids application sites and surface waters. Currently, most Class A biosolids are subject to these same site restrictions. No comparable regulations apply to chemical fertilizers or most manures.

Risks of food contamination and direct public exposure are very low when biosolids are applied in compliance with regulations

The risk of illness from food grown in soil fertilized with biosolids is very low. The risk of direct exposure to members of the public is also very low. State regulations, when properly followed, sufficiently mitigate these health risks.

Food contamination risk is very low under state regulations

Pathogens from Class B biosolids could adhere to a crop's surface, but pathogens are unlikely to contaminate food products because of the waiting periods required in regulations. State regulations require a 30-day to 38-month period between when land application of Class B biosolids occurs and when crops can be harvested. These waiting periods allow for pathogens to die off. The longer waiting periods effectively keep farmers from using Class B biosolids to grow fresh produce, such as vegetables. These crops would be more likely to transmit pathogens because they are often consumed raw. The same restrictions are currently in place for most, but not all, applications of Class A biosolids. The risk of pathogen contamination from these materials is much lower due to their lower pathogen content.

Chemicals from either class of biosolids could be taken up by crops, but the health risk to consumers is very low. Several recent studies evaluated up-take of chemicals by plants and found that the chemical concentrations that accumulate in plant tissue are not harmful (Yager 2013, Mathews 2014, Meng 2014, Prosser 2015, Shargil 2015, Wu 2015, Verslycke 2016). Past studies have reached the same conclusions (VDH 2007, VDH 2014).

The risk of crop contamination in Virginia is even lower because the majority of biosolids are not used on food crops. Most biosolids are currently applied under site restrictions. Only one-third of those biosolids are applied to food crops, and these crops are usually processed instead of eaten fresh. The rest of these biosolids are applied to hay, pasture, or forest land. Chemicals can potentially accumulate in livestock that graze on hay or pasture land that has been fertilized with biosolids, but a recent study suggest this risk is low (Meng 2014). Another study, which found that livestock might be negatively affected by grazing on biosolids-treated fields, did not examine the potential human health risks (Lea 2016).

Direct public exposure risk is very low under state regulations

Exposure to the contaminants in biosolids is possible through direct contact with materials after land application. For example, if a member of the public walks through a recently-treated area, small amounts of biosolids material can be transferred to shoes, hands, or clothing. This material could accidentally be ingested and cause an infection (Eisenberg 2008, Viau 2011, Brooks 2012). Members of the public generally do not come in direct contact with biosolids because almost all land application occurs on private property.

State regulations address the risk of direct contact by the public in several ways. The state requires warning signs to be posted before land application of Class B biosolids occurs to keep members of the public from entering land application sites. Warning signs are required to stay in place for 30 days following application. Some pathogens can survive for several months after application, so regulations require that public access to sites that have received Class B biosolids must be restricted for one year. Regulations also require setbacks between biosolids sites and property lines, publically accessible areas, and roadways. The same restrictions are currently in place for most, but not all, applications of Class A biosolids.

Changing regulations to prohibit Class B biosolids not necessary or feasible at this time

There is not a compelling case to prohibit Class B biosolids and require wastewater treatment plants to upgrade to Class A treatment. Several large plants have voluntarily switched to Class A treatment already, and several more are planning to follow suit. Once these additional treatment plants have completed their upgrades, approximately two-thirds of biosolids applied to land in Virginia will be Class A.

Converting to Class A may be cost-prohibitive for some wastewater treatment plants. Simple Class A treatment methods used by mid-sized plants cost from $9.5 million (pre-pasteurization method) to $17 million (composting) to implement. More advanced thermal hydrolysis methods used by larger treatment plants cost $40–470 million to implement. Plant managers indicated that they plan to recoup these up-front investments through lower long-term operating costs. For example, switching to Class A allowed some treatment plants to reduce the amounts of biosolids generated and their associated disposal costs. However, smaller treatment plants may not have the capital to make such large up-front investments or the economies of scale to recoup them. Additionally, some Class A treatment methods may be more expensive to operate annually than Class B methods.

Wastewater treatment plants may be unable to switch to Class A treatment for other reasons. Many plants lack the physical space for less expensive options like composting and sand bed-drying. Treatment plants could contract with private companies to compost their biosolids to Class A standards, but private capacity is limited. The costs to transport materials to private composting facilities could also be prohibitive.

3 State Compliance Programs

SUMMARY The state's programs to ensure that biosolids and industrial residuals are in compliance with regulatory requirements are generally effective. DEQ's permitting program effectively ensures that land application requirements are clear and provides appropriate opportunities for public input. Permit processing times can be lengthy, but DEQ is implementing changes that it believes will address this. DEQ's inspections effectively ensure requirements are being followed even though the agency is not performing as many inspections as it used to. Given the decrease in inspections, DEQ should annually review its inspection program to ensure it remains effective. VDACS's compliance program is also generally effective at certifying that products sold and distributed to the public are safe. However, VDACS could better verify safety, after products have been approved, by annually collecting and reviewing chemical analyses.

State regulations are intended to protect human health and water quality from the risks posed by biosolids and industrial residuals. Two state agencies—the Department of Environmental Quality (DEQ) and the Virginia Department of Agriculture and Consumer Services (VDACS)—administer programs to ensure that the regulations for using these materials are followed (Table 3-1). Localities have the authority to establish monitoring programs that supplement DEQ oversight. (See Appendix K for more information on local monitoring programs.)

TABLE 3-1
DEQ and VDACS oversee use of biosolids and industrial residuals

	Materials overseen	Main duties	Number of staff
DEQ	Class A and B biosolids *100% of what is applied* Industrial residuals *≈10% of what is applied*	Ensure compliance with land application regulations through permitting and inspections	12
VDACS	Class A biosolids *≈20% of what is applied (partial authority)* Industrial residuals *≈90% of what is applied*	Protect consumers from unsafe or unreliable materials through product certification and registration	3

SOURCE: DEQ; VDACS; JLARC review of the Code of Virginia and Virginia Administrative Code.
NOTE: DEQ has authority over all Class A biosolids but permits some of these materials to be sold and marketed under VDACS certification. VDACS does not monitor use of the products it has approved.

DEQ's compliance program is generally effective

Land applier companies perform most land application in the state. These specialized companies contract with wastewater treatment plants and manufacturers of industrial residuals. Plants and manufacturers can also apply their own materials. In each case, the party that is acting as the land applier is required to obtain a permit from DEQ.

DEQ regulations are intended to ensure that land application of biosolids and industrial residuals does not harm human health and water quality. To ensure that regulations are followed, DEQ administers a compliance program that consists of issuing permits and conducting unannounced inspections at land application sites across the state each year. DEQ also monitors compliance by requiring land appliers to submit a variety of information about their activities.

DEQ's program is generally effective (Table 3-2). The permitting process is effective and provides appropriate opportunities for public input, but the agency is unable to approve some permits in a timely manner. DEQ's inspections are effective when conducted but are occurring less often than in prior years. DEQ also collects appropriate information through its monitoring activities, further ensuring compliance.

TABLE 3-2
DEQ's compliance program is generally effective

	Criteria used to evaluate program	Assessment
Permitting	Process for reviewing permit requests and issuing permits, including site-specific conditions, is reasonable	●
	Public is appropriately involved	●
	Permits are processed in timely manner	◑
Inspections	Process for inspecting sites and correcting violations is effective	●
	Sufficient number of inspections are conducted	●
Monitoring	Process for monitoring statewide land application activity is reasonable	●

KEY: ● = meets criteria ◑ = needs improvement

SOURCE: JLARC review of DEQ documents and data; DEQ interviews; JLARC site visits.

Sizes of land application sites vary substantially. In 2016, biosolids were applied to one site that was 762 acres and to another that was less than four acres. Most sites do not receive biosolids every year, and large sites may not receive full coverage every year. For example, the 762-acre site received biosolids on only 45 acres in 2016.

Permit process is effective, and appropriately involves the public, but is lengthy for some permits

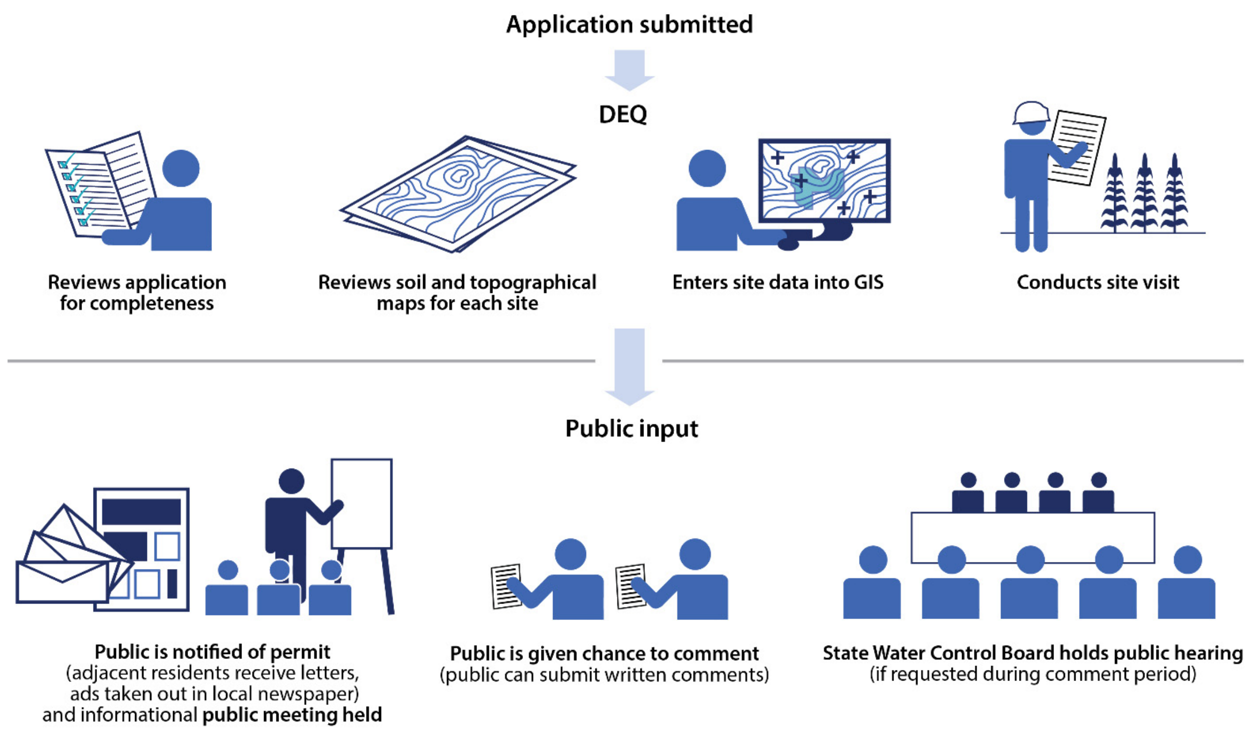
Issuing permits to land appliers is a key component of DEQ's compliance program. Land appliers are required to obtain a separate permit from DEQ for each locality where they operate. For example, one land applier has permits for 18 different counties. Each permit specifies the sites within the locality where biosolids and industrial residuals can be applied. A formal permit modification is required any time new land is added to a permit. Permits specify the requirements that each land applier must follow at each site. Permits are typically granted for a 10-year period.

Review and approval process is effective

The process used by DEQ and the State Water Control Board (SWCB) to review and approve permits is effective. The SWCB is responsible for issuing permits but has delegated administration of the permit program to DEQ staff. DEQ staff conduct thorough examinations of permit requests, including document and site reviews, to ensure the accuracy of information provided by permittees (Figure 3-1). Each permit includes site-specific conditions, such as setback areas and limits on the amount of material that can be applied to a particular field. Site-specific conditions are set out in detailed site books and nutrient management plans that are considered an enforceable part of the permit.

The criteria for evaluating and approving permits are clear. The SWCB has the authority to approve or deny new permits and changes to existing permits. The SWCB delegates approval authority to DEQ staff in most cases, but makes decisions on permits that have been contentious enough to require a public hearing. Permit requests can be denied if they do not comply with regulations or if the proposed application is otherwise found to threaten human health or water quality. DEQ can add specific conditions to permits, such as odor control requirements, if it determines additional restrictions are needed.

FIGURE 3-1
DEQ reviews permit requests and collects public input



SOURCE: DEQ permit process descriptions and documentation, JLARC site visits.
NOTE: A public meeting is not held for a permit modification that cumulatively adds less than 50 percent of the acreage included in original permit.

Opportunities for public input are appropriate

The permit process provides several opportunities for public input. DEQ holds a public meeting after a permit request is complete to provide information to residents about the permit. Citizens can also submit written comments to DEQ, and the SWCB holds a public hearing if it receives 25 or more hearing requests. Although some permits have been strongly opposed by the public, most are approved with little opposition. For example, only three of the 13 permit requests in 2016 generated enough opposition to trigger a public hearing.

Public input can result in changes to the permit that is being requested. For example, the public input process gives citizens the opportunity to request extended setbacks around an application site, and DEQ may change the permit to accommodate these setbacks. (Citizen requests for extended setbacks are routinely granted when the individual presents a note from a doctor.) Public opposition has also led land appliers and landowners to withdraw or change their permit requests, as illustrated in the examples on the following page.

Opponents of land application assert that public input has little or no effect on permit decisions because neither DEQ nor the SWCB has ever denied a permit request. However, DEQ and the board do not have the authority to deny a permit if it (1) meets regulatory requirements, and (2) there is no evidence that land application under the permit will harm human health or water quality. DEQ staff work through the permit process with applicants to ensure compliance with regulatory requirements, which is why permit requests have been withdrawn or delayed but not denied.

Review and approval process can be lengthy

Permit processing times can range from a few months to several years. For the 42 permits that were approved in 2016 and 2017, the average processing time from receipt of the application to final approval was 1.6 years. Many of these permits were reviewed and approved within a few months. However, nine permits took more than two years to process, including two permits that took more than seven years.

There are **no statutory or regulatory requirements for permit processing times**. DEQ has not set a goal for completing its administrative review. DEQ has an internal goal to complete the public input process and make a permit decision within 120 days.

Delays are due in part to an increasing workload and limited staffing. DEQ's workload has been higher in recent years because DEQ has been updating old permits to comply with the new regulations that went into effect in 2013. For example, the permits that took more than two years to process were old permits issued by the Virginia Department of Health that needed to be updated and converted to DEQ permits. Workload challenges have been compounded by staffing reductions, which were implemented in response to a decline in program revenues. DEQ's decentralized structure for the compliance program also had some inefficiencies that created backlogs.

Some permits have been delayed by the public input process. Permit requests that are strongly opposed usually take longer to approve. DEQ must organize public hearings and the SWCB must convene to approve or deny the permit. Citizen requests for extended setbacks, when approved, must be incorporated into the permit. These additional steps can add months or years to the permit process.

EXAMPLES
Public input has led to changes in recent permits

Locality: Lunenburg County (2014)

Proposed permit action
Land applier requested adding 4,400 acres to an existing biosolids permit.

Public input
480 residents signed a petition opposing the permit change. Petition argued that new sites were too close to water sources, homes, and public spaces such as churches.

Outcome
Permit request was withdrawn by land applier due to public opposition.

Locality: Multiple counties (2014)

Proposed permit action
Land applier requested a new permit allowing industrial residuals to be applied to 16,174 acres in seven counties. (This is the only case in which DEQ issued one permit for multiple counties.)

Public input
Over 100 public comments were submitted in opposition to the permit, including opposition from the Boards of Supervisors for several counties. A public hearing was also held.

Outcome
Permit was approved but 1,000 acres were withdrawn by landowners in response to citizen concerns.

Locality: Nelson County (2017)

Proposed permit action
Land applier requested adding 1,930 acres to an existing biosolids permit.

Public input
53 public comments were submitted in opposition to the permit and a public hearing was held.

Outcome
Permit was approved, but all sites on one farm were withdrawn in response to citizen concerns.

NOTE: Permits are issued to land appliers, but landowners must agree to have their property permitted for land application.

DEQ has recently attempted to improve the permit process and reduce processing times. DEQ has centralized the compliance program, which DEQ staff said allows them to better balance workloads. Centralization also has allowed staff to specialize in specific parts of the permitting process. The program manager has implemented weekly calls to discuss the status of each permit, and staff indicated this helps keep them on target. DEQ staff said they are also working to improve the permit application form.

Inspections are effective even though DEQ now conducts fewer than in past years

DEQ routinely conducts unannounced site inspections and responds to citizen calls and complaints. Inspections are vital because they are the primary way that DEQ ensures land appliers are complying with regulations.

DEQ inspections find land appliers are generally in compliance with state regulations. Most of the violations DEQ finds are minor and can be addressed without formal corrective action. Since 2008, less than one percent of over 12,000 DEQ inspections found a major violation that resulted in a corrective action. The number of major violations found by DEQ has generally declined since 2008 as the compliance program and new regulations have become well established. DEQ issued only one corrective action in 2016.

DEQ inspects storage facilities for biosolids and industrial residuals. Storage facilities are used by land appliers to temporarily house materials when weather conditions do not allow application. These facilities are subject to a number of requirements to prevent leaching and runoff.

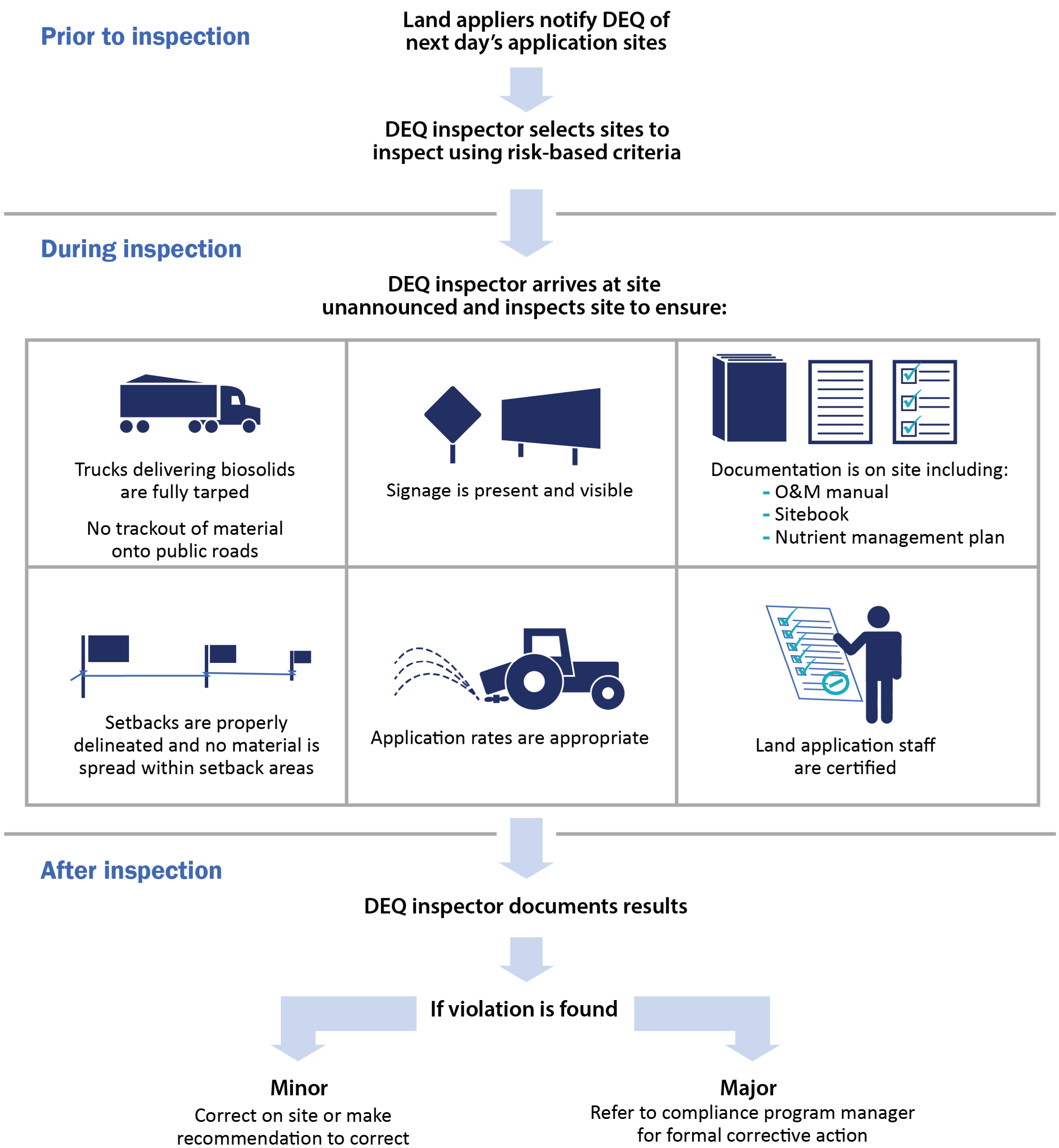
Inspection process is effective and well defined

DEQ's inspection process is designed to ensure compliance with land application regulations. DEQ selects inspection sites based on risk, in order to maximize the value of each inspection. For example, DEQ gives higher priority to sites where Class B biosolids are applied, or to sites where extra caution may be needed, such as those near public areas. Inspections are unannounced, so land appliers do not know if DEQ will arrive to inspect their work on any given day. These unannounced inspections incentivize land appliers to consistently follow regulations or risk being subject to a corrective action.

Once on site, inspectors use a well-defined process to check that regulations are being followed (Figure 3-2). Inspectors have a standard checklist of items to look for, which includes all relevant aspects of the regulations, such as truck activity, signage, required documentation, setbacks, application rates, and staff certifications. Inspection results are documented on site.

DEQ inspectors have authority to address violations found during inspections. When inspectors find minor violations, they can have the land applier make immediate corrections. Major or repeated violations can be referred to the compliance program manager for formal corrective action. Corrective actions range from warning letters to civil penalties. Corrective actions are seldom taken (only one to 12 per year) because land appliers are generally found to be in compliance with state regulations.

FIGURE 3-2
DEQ activities prior to, during, and after inspections are well defined



SOURCE: DEQ inspection process descriptions and documentation; JLARC site visits.

DEQ has appropriate procedures to respond to citizen calls and complaints about land application activities. Citizens can call DEQ to ask questions about a nearby application, lodge a complaint, or report a violation. DEQ also requires land appliers and local governments to forward calls they receive to DEQ. In most cases, DEQ sends an inspector to the application site to check for violations. All calls and the actions taken to resolve them are documented.

DEQ rarely finds regulatory violations when responding to citizen calls. Only two violations were found in response to the 132 citizen complaints investigated by DEQ from 2014 to 2016.

DEQ inspections are effective even though the percentage of sites inspected has declined

In 2016, DEQ inspected 31 percent of sites where biosolids were applied. In 2008, when the compliance program began, DEQ inspected 75 percent of sites. DEQ inspected nearly all sites from 2010 to 2014 as new regulations were implemented. The number of sites inspected decreased in 2015, followed by a more substantial drop in 2016.

DEQ performs fewer inspections because it has fewer inspectors. DEQ had eight full- and part-time inspectors in 2013 and now has only five. Staffing levels were reduced when fee revenues declined, primarily because one large wastewater treatment plant (Blue Plains in Washington, DC) pays lower fees after converting from Class B to Class A biosolids and generates half as much material. Revenue may continue to decline as other wastewater treatment plants convert to Class A biosolids.

Land appliers undergo certification training, as required by DEQ. Training improves compliance by ensuring that land appliers are familiar with regulations and share a common understanding of the rules.

Although the number of inspections has decreased, DEQ still appears able to provide adequate oversight. DEQ inspects one out of every three land application sites (and about one in every 10 land application events). Inspections are unannounced and site selection is risk-based. Fewer inspections are needed if these approaches are used and few violations are found.

Many wastewater treatment plants and local governments conduct their own inspections; this minimizes the impact of declining DEQ inspections. Several large treatment plants send their own inspectors to monitor sites where their biosolids are being applied. According to plant managers, these additional inspections are conducted to verify that their materials are properly disposed. Further, at least five localities employ monitors who actively inspect sites within their localities.

DEQ does not need to increase the number of inspections at this time. There is currently no minimum threshold (based on best practices or established by other states, for example) for the percentage of total land applications that should be inspected each year. However, DEQ should routinely assess whether its inspection program is effective and provide the SWCB with a short status report each year. The status report should include several key indicators of the program's effectiveness (such as percentage of sites inspected, percentage of land application events inspected, number and severity of any violations found), and indicate whether changes are needed. The report would also likely need to address the annual losses in the sludge management fund that DEQ uses to operate its compliance program.

RECOMMENDATION 6
The Department of Environmental Quality should report annually to the State Water Control Board on the effectiveness of its land application inspection program. The report should provide (i) the percentage of land application sites and events inspected, (ii) the number and type of violations and citizen complaints, (iii) the five-year trend in violations and citizen complaints, (iv) a recommendation on the number of inspections needed in the coming year, and (v) an assessment of whether changes to the program, program funding, or other actions are needed to maintain regulatory compliance.

Monitoring of land application activity is appropriate

DEQ monitors land application activity throughout the state to support and enforce compliance. Land appliers are required to notify DEQ in advance of land applications so that DEQ can determine which sites to inspect. Land appliers are required to submit monthly reports on each land application, and DEQ uses the report data to verify compliance with regulations. For example, DEQ verifies that the proper amount of material was applied to each site and that the metal concentrations of those materials were below regulatory limits. If a load of biosolids did not meet regulatory requirements, DEQ could identify where and how much material was applied and take remedial action as necessary. If biosolids from a plant were found to have been contaminated by high levels of an industrial chemical, DEQ could identify where those materials were applied.

DEQ compiles land appliers' reports in a database that details every land application in Virginia since 2008. DEQ also maintains older paper records from when the program was administered by the Virginia Department of Health.

VDACS's product safety certification is effective, but ongoing verification does not fully address risks

VDACS regulations are intended to ensure that biosolids and industrial residuals products that are sold or distributed to the public are safe to use and beneficial to soil or crops. To ensure that regulations are followed, VDACS administers a compliance program that certifies and registers products. However, VDACS does not monitor where or how products are used. The biosolids and industrial residuals compliance program is one part of VDACS's broader consumer protection program.

VDACS's compliance program for biosolids and industrial residuals is less rigorous than the DEQ program. The lower level of oversight is appropriate because the products VDACS regulates pose a lower risk to human health. The industrial residuals certified by VDACS, such as wood ash and paper mill sludge, are not likely to contain

VDACS's consumer protection program is broadly responsible for ensuring that products sold to Virginia consumers are safe and meet the product's stated specifications, such as the nutrient content that is stated on fertilizers.

The industrial residuals and biosolids compliance program is managed by the feed, fertilizer, and seed group. This group is one of several under the VDACS Division of Consumer Protection.

pathogens. These products also contain fewer organic chemical compounds and have lower levels of metals than biosolids. Similarly, the Class A biosolids that VDACS oversees are either pelletized or composted, and these forms have the lowest concentrations of pathogens, especially viruses, of all Class A materials (Viau 2009).

The VDACS compliance program is generally effective but the registration process could be improved (Table 3-3). VDACS has implemented a reasonable process for certifying that products are safe and beneficial. After the initial certification, an annual registration process confirms that the products continue to contain the beneficial ingredients that are being claimed on the product label. However, VDACS does not verify that products continue to have acceptably low levels of potentially harmful trace chemicals.

TABLE 3-3
VDACS's compliance program is generally effective, but registration process could be improved

	Criteria used to evaluate program	Assessment
Initial product certification	Process for certifying products as safe and beneficial is reasonable	●
Annual product registration	Process for verifying that products continue to meet safety and benefit standards is reasonable	◑

KEY: ● = meets criteria ◑ = needs improvement

SOURCE: JLARC review of VDACS documents and data, VDACS interviews, and JLARC site visits.

VDACS adequately certifies product safety and benefits, but some documentation is missing

VDACS's certification process is effective for ensuring that products are safe and beneficial. VDACS has developed clear criteria for the types of industrial residual and biosolids products that must be certified and requires producers to self-report products for review. These requirements are more stringent than requirements for other fertilizers and soil amendment products, which do not need to be reviewed by VDACS before they are sold.

When certifying products, VDACS consults with researchers with the Virginia Cooperative Extension at Virginia Tech. Producers, which include manufacturers and wastewater treatment plants, are first required to submit a chemical analysis of their product to VDACS (Figure 3-3). This analysis shows the concentrations of nutrients, metals, and other chemicals present in the material. The results of the chemical analysis are reviewed by research staff at Virginia Tech, who recommend whether to approve or deny certification, or further test the product. Further testing includes greenhouse and field grow tests that demonstrate how the product affects crops and soils. The producer pays for all analysis and testing.

FIGURE 3-3
VDACS certification uses chemical analysis and grow tests

Chemical analysis
Chemical analysis performed by state-certified lab.

Greenhouse grow test
Product is tested on greenhouse-grown plants.

Field grow test
Product is tested on plants grown in field.

SOURCE: VDACS program descriptions and documentation.

VDACS responds to complaints about water pollution involving the storage or land application of Class A biosolids and industrial residuals through its Agricultural Stewardship Act Program.

Calls and complaints rarely find violations. Over the last 10 years, VDACS received only two complaints and neither one led to the discovery of a violation.

VDACS generally maintains records of completed product reviews, but did not have records for two of the 16 industrial residual products that were sold or distributed in FY15 or FY16. One of the missing documents was for a synthetic gypsum product that accounted for seven percent of all industrial residuals and biosolids applied in Virginia (measured in dry tons). VDACS should have a documented review for this product because synthetic gypsum can have high levels of mercury (Briggs 2014, Chen 2014, Watts 2014).

VDACS did not have product reviews for five of the 13 Class A biosolids products that were sold or distributed in FY15 or FY16. The missing review documents are a minor issue because DEQ annually collects and reviews chemical analyses for these five products.

Registration process partially verifies product safety

VDACS randomly tests fertilizer products to verify that label claims, such as nutrient content, are accurate. Concentrations of potentially harmful trace chemicals are not usually tested.

Most industrial residual and biosolids products are not subject to random testing; they go directly from producers to the farmers or other landowners who use them. Only industrial residuals and biosolids products that are sold in stores are subject to this random testing program.

VDACS requires producers of industrial residuals and biosolids to annually register their products but does not require updated chemical analyses to verify the products remain safe. To register, a producer must submit a registration form and the current product label. Labels provide information on the product's main beneficial ingredients, such as nitrogen content or pH value, but do not include information on concentrations of chemicals that could pose a health risk.

Regular verification is important after certification because the concentrations of trace chemicals could change over time. VDACS partially addresses this risk by requiring producers to re-certify products when there is a change to their label or manufacturing process. However, concentrations of trace chemicals could change over time even if there is no change to the label or manufacturing process. For example, the concentrations of metals found in wood ash can change depending on natural variations in wood (Omil 2007). Some VDACS-certified products were last reviewed over 10 years ago, and trace chemical concentrations could have changed due to the cumulative effect of gradual, minor changes to inputs or processes.

VDACS should expand its annual registration requirements so that producers submit a recent chemical analysis of their products. VDACS should review theses analyses to ensure that all products sold or distributed in the state continue to have acceptably low levels of heavy metals and other chemicals of concern. Such a requirement would also address previously noted concerns about missing documents. The chemical analysis required for each product should be consistent with the analysis that was performed when the product was initially certified and with testing requirements recommended by researchers at Virginia Tech.

Requiring chemical analyses to be submitted annually would create little or no burden on producers. Producers of biosolids products already provide this information annually to DEQ as part of its compliance program. Producers could provide copies to VDACS or DEQ could share the copies it collects with VDACS. Some manufacturers already perform routine chemical analyses for their own internal purposes. Costs to other manufacturers are likely to be low. Most products would only need to be tested for metals content, and these tests range from about $250 to $2,500, depending on the material and number of tests performed.

RECOMMENDATION 7

The Virginia Department of Agriculture and Consumer Services (VDACS) should require producers of biosolids and industrial residuals products to submit chemical analyses of their products as part of the annual registration process. VDACS should review these analyses to ensure that products continue to have acceptably low levels of trace chemicals.

Appendix A: Study mandate

2016 Session

HOUSE JOINT RESOLUTION NO. 120

AMENDMENT IN THE NATURE OF A SUBSTITUTE

Directing the Joint Legislative Audit and Review Commission to study biosolids and industrial residuals in Virginia. Report.

Agreed to by the House of Delegates, February 11, 2016

Agreed to by the Senate, February 23, 2016

WHEREAS, prior to 1994, the Department of Environmental Quality (DEQ) regulated all land application of treated sewage sludge, commonly known as biosolids, when biosolids were applied to agricultural lands; and

WHEREAS, in 1994 the General Assembly directed the Virginia Department of Health (VDH) to adopt regulations to ensure that (i) sewage sludge permitted for land application, marketing, or distribution is properly treated or stabilized; (ii) land application, marketing, and distribution of sewage sludge is performed in a manner that will protect public health and the environment; and (iii) the escape, flow, or discharge of sewage sludge into state waters in a manner that would cause pollution of state waters, as those terms are defined in § 62.1-44.3 of the Code of Virginia, will be prevented; and

WHEREAS, in 2007, the General Assembly authorized the transfer of all regulatory oversight of biosolids from VDH to DEQ; and

WHEREAS, since 2008, biosolids have been land applied in at least 68 localities in the Commonwealth, with at least 54 of those localities receiving biosolids annually; and

WHEREAS, between 2008 and 2013, an average of 221,000 dry tons of biosolids have been beneficially recycled over an average of 63,000 acres annually; and

WHEREAS, this acreage represents less than one percent of the available crop land, pasture land, and forest land in the Commonwealth; and

WHEREAS, the National Academy of Sciences reviewed current practices, public health concerns, and regulatory standards and concluded that the use of biosolids in the production of crops for human consumption, when practiced in accordance with existing federal guidelines and regulations, presents negligible risk to the consumer, to crop production, or to the environment; and

WHEREAS, in accordance with House Joint Resolution No. 694 of the 2007 Session of the General Assembly, the Secretary of Natural Resources and Secretary of Health and Human Resources convened a panel of experts to study the impact of land application of biosolids on human health and the environment; and

WHEREAS, the General Assembly posed specific questions to the panel and requested that it consider the typical contaminant concentrations and application rates of biosolids in its study; and

WHEREAS, the panel included stakeholders from a broad range of disciplines, including medicine, higher education, forestry, agronomy, environmental science, ecology, veterinary medicine, and law; and

WHEREAS, the Secretary of Natural Resources and Secretary of Health and Human Resources published the final report of the panel in 2008 (House Document 27); and

WHEREAS, the panel uncovered no evidence or literature verifying a causal link between biosolids and illness but recognized gaps in the science and knowledge surrounding this issue; and

WHEREAS, the panel stated that these gaps could be reduced through highly controlled epidemiological studies relating to health effects of land-applied biosolids and through additional efforts to reduce the limitations in quantifying all the chemical and biological constituents in biosolids; and

WHEREAS, the panel stated that there are gaps in the research that characterizes the composition, fate, and effects of pharmaceutical and personal care products and other persistent organic compounds in biosolids, as well as in other products, materials, and the environment; and

WHEREAS, House Joint Resolution No. 694 of the 2007 Session of the General Assembly also directed the panel to perform a detailed analysis of the chemical and biological composition of biosolids; and

WHEREAS, detailed analysis of the vast number of constituents of biosolids, combined with the specialized analytical methods employed to detect and quantify these constituents, involves significant cost; and

WHEREAS, because no funding was available to conduct new analyses, the panel was limited in performing a detailed analysis of the chemical and biological constituents of biosolids; and

WHEREAS, under § 405(d)(2)(C) of the federal Clean Water Act, the U.S. Environmental Protection Agency is required to conduct a review of the standards set out in 40 C.F.R. Part 503 not less than every two years for purposes of regulating new pollutants where sufficient data exist; and

WHEREAS, § 62.1-44.3 of the Code of Virginia defines industrial wastes as "liquid or other wastes resulting from any process of industry, manufacture, trade, or business or from the development of any natural resources"; and

WHEREAS, the land application in Virginia of industrial wastes, including industrial residuals, is regulated by the Virginia Department of Agriculture and Consumer Services (VDACS) and DEQ; and

WHEREAS, VDACS regulates certain industrial residuals as "industrial co-products" in accordance with the regulations applicable to agricultural liming materials and fertilizer, providing for the marketing and distribution of industrial wastes; and

WHEREAS, the land application of industrial residuals that is not regulated by VDACS is regulated by the State Water Control Board and DEQ; and

WHEREAS, industrial residuals from more than 35 facilities are land applied in Virginia pursuant to the terms of a Virginia Pollution Abatement or Virginia Pollutant Discharge Elimination System Permit issued by DEQ; and

WHEREAS, since taking over the regulatory program from VDH, DEQ has conducted over 10,000 inspections of biosolids and industrial residual land application sites; and

WHEREAS, biosolids and industrial residuals are beneficially land applied on less than one percent of the cropland, pastureland, and forestland on Virginia farms; and

WHEREAS, on average, less than 10,000 dry tons of industrial wastes are land applied annually in Virginia, an amount representing less than five percent of the annual amounts of biosolids land applied in Virginia; and

WHEREAS, the permits issued by DEQ include authorization for land application of industrial wastes from a variety of facilities, including poultry hatching plants, breweries, rendering plants, chicken and pork processing and packaging plants, plants for the processing of apples, fish, meat, tomatoes, and wood, plants for the manufacturing of concentrated and dried soup stock, confections, beverages, and snack cakes, farmers' markets, and municipal potable water treatment plants; and

WHEREAS, the Department of Environmental Quality's permit application requires the applicant to submit details regarding the design of the industrial wastes treatment works, including the storage facility and land area determination, as well as characterization of the industrial wastes that includes analyses of heavy metals and other constituents; and

WHEREAS, DEQ examines the specific processes used at the facility generating the industrial wastes to determine whether any waste constituents may represent a threat to human health and the environment; and

WHEREAS, DEQ requires the permit applicant to provide analyses to determine the capacity of the land application site to assimilate nutrients, metals, and any other pollutants of concern, in order to demonstrate that the activity may be performed safely and protect the environment; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Joint Legislative Audit and Review Commission be directed to study biosolids and industrial residuals in Virginia.

In conducting its study, the Joint Legislative Audit and Review Commission (JLARC) shall (i) analyze the current scientific literature regarding the long-term effects of biosolids and industrial residuals on health, including potential impacts on well, surface, and ground water; (ii) evaluate the regulatory requirements for land application and storage; (iii) evaluate the differences between biosolids and industrial residuals rated as "Class A" materials and "Class B" materials; (iv) evaluate the feasibility, especially for local governments, and including an economic impact on citizens of the Commonwealth, of requiring municipal utilities currently permitted to generate, as a byproduct of the municipal wastewater treatment process, "Class B" material to upgrade those facilities to generate "Class A" material; (v) evaluate the effectiveness of the local monitoring component of the programs, while also analyzing the potential for private contractors to serve in a monitoring capacity; (vi) evaluate both the potential outcomes and the probable costs from additional testing requirements for these products; (vii) analyze potential alternatives for waste materials that are currently processed and treated to be land applied, and any potential costs that could be associated with such alternatives; (viii) evaluate the contractual relationships among Virginia localities and the impacts of local agreements and decisions that could affect wastewater treatment and land application, including septic tank pump out requirements; and (ix) where applicable, analyze the potential impacts of Virginia's biosolids and industrial residuals regulations on agricultural interests and future economic development in the Commonwealth.

Technical assistance shall be provided to the Joint Legislative Audit and Review Commission by the Department of Environmental Quality, the Virginia Department of Agriculture and Consumer Services, the Virginia Department of Health, the United States Geological Survey, and the members of the W3170, a multi-state workgroup composed of representatives of the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, universities, and municipal governments from across the United States that is conducting research on understanding the potential hazards and value of constituents in biosolids and other residuals. All agencies and academic institutions of the Commonwealth, local governments, and other interested parties as necessary shall provide assistance to the Commission for this study, upon request.

The Joint Legislative Audit and Review Commission shall complete its meetings for the first year by November 30, 2016, and for the second year by November 30, 2017, and the chairman shall submit to the Division of Legislative Automated Systems an executive summary of its findings and recommendations no later than the first day of the next Regular Session of the General Assembly for each year. Each executive summary shall state whether the Commission intends to submit to the General Assembly and the Governor a report of its findings and recommendations for publication as a House or Senate document. The executive summaries and reports shall be submitted as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents and reports and shall be posted on the General Assembly's website.

Appendix B: Research activities and methods

JLARC staff conducted the following primary research activities:

- structured interviews with staff at the Department of Environmental Quality (DEQ), Virginia Department of Agriculture and Consumer Services (VDACS), Department of Conservation and Recreation (DCR), and Virginia Department of Health (VDH); staff from several wastewater treatment plants and an industrial residuals generator; land appliers; national biosolids experts, including university researchers from across the country and staff from Virginia Tech's Virginia Cooperative Extension office; localities with local monitoring programs; concerned citizens; and special interest groups;
- site visits to two land application sites, one storage site, and one wastewater treatment plant;
- review of research literature and other documents;
- review of other states' biosolids programs; and
- quantitative analysis of tonnage data, data on land application sites and frequency, data on the size of the land application industry, call and complaint data, and metal and nutrient content data.

Structured interviews

Structured interviews were a key research method that JLARC staff used to review the state's biosolids and industrial residuals program. JLARC staff conducted more than 50 interviews throughout its review, including interviews with state agency staff, local wastewater treatment plant staff, land appliers, national biosolids experts, local governments, concerned citizens, and special interest groups.

State agency staff

JLARC staff conducted interviews with staff from four state agencies: DEQ, VDACS, DCR, and VDH. The purpose of these interviews was to understand the state's regulatory and oversight responsibilities for biosolids and industrial residuals, obtain data for the study, and help understand the health and environmental risks from land application.

JLARC staff conducted eight interviews with staff from DEQ's biosolids program to obtain information on topics such as the regulatory framework for biosolids and industrial residuals, DEQ's permitting process, the compliance and enforcement program, and the availability of land application and other data. JLARC staff also conducted interviews with staff from DEQ's Division of Land Protection and Revitalization to discuss the feasibility of using landfills as an alternative to land application and DEQ's Office of Air Permit Programs to discuss the feasibility of using incinerators as an alternative.

Interviews were also conducted with VDACS staff to understand their biosolids and industrial residuals program. Four interviews were conducted with VDACS staff; topics included the certification and registration process for biosolids and industrial residuals, compliance requirements, and the availability of various types of data.

JLARC staff interviewed DCR staff to discuss the risks of nutrient pollution and how state requirements for DCR-approved nutrient management plans address that risk.

Interviews were conducted with VDH staff to discuss health risks associated with biosolids and industrial residuals and past literature reviews conducted by VDH staff. JLARC staff also consulted with VDH on potential options for further evaluating state regulations for land application.

Wastewater treatment plants and industrial residuals generator

Staff conducted structured interviews with eight wastewater treatment plants. Plants were selected for interviews based on size, geographic location, disposal method used, and class of biosolids generated. The eight treatment plants interviewed were:

- Alexandria Renew Enterprises,
- Arlington County Water Pollution Control Plant,
- Blue Plains Advanced Wastewater Treatment Plant (DC Water),
- Halifax County Service Authority,
- Hampton Roads Sanitation District,
- Henrico County Water Reclamation Facility,
- Hopewell Regional Wastewater Treatment Facility, and
- Western Virginia Water Authority.

Six of the treatment plants interviewed use land application as their primary disposal method. Topics for these interviews included their biosolids treatment process and land application activities; benefits of land application; costs of land application and other disposal methods used, if applicable; testing, reporting, and other regulatory requirements; opinions of DEQ's compliance program; and rationale and cost estimates for upgrading to Class A biosolids, if applicable. Staff also received a tour of the Henrico County facility to observe how biosolids are generated.

Two of the treatment plants interviewed use landfilling or incineration as their primary disposal method (Halifax and Hopewell). Interview topics for these plants included the costs, advantages, disadvantages, and regulatory requirements of these disposal methods.

JLARC staff interviewed one manufacturer that generates industrial residuals. Other manufacturers were contacted but did not respond to requests for an interview. Interview topics were similar to the topics for wastewater treatment plants and included benefits of land application; testing, reporting, and other regulatory requirements; and opinions on DEQ's compliance program.

Land appliers

JLARC staff interviewed representatives from three land application companies to discuss their land application activity in Virginia, the benefits of land application, DEQ's regulations and compliance and enforcement program (including the permitting process) and how it compares to other states, VDACS regulations, local monitoring, and testing and reporting requirements. The land appliers interviewed included both large and small companies.

National experts

Staff conducted phone interviews with a number of national biosolids experts who have recently researched biosolids issues, to discuss the potential health and environmental risks from land application:

Edward Furlong, PhD, Research Chemist
National Water Quality Laboratory
US Geological Survey

Rolf Halden, PhD, Director
Biodesign Center for Environmental Health Engineering
Arizona State University

Robert C. Hale, PhD
Professor of Marine Science
Virginia Institute of Marine Science

Linda S. Lee, PhD
Professor of Agronomy
Purdue University

Murray McBride, PhD, Professor
College of Agriculture and Life Sciences
Cornell University

Jordan Peccia, PhD
Professor of Chemical and Environmental Engineering
Yale University

Ian L. Pepper, PhD, Co-director
Water & Energy Sustainable Technology Center
University of Arizona

Chad Wagner, Associate Director
South Atlantic Water Science Center
US Geological Survey

JLARC staff also interviewed Mark Bennett, Director of the United States Geological Survey's Virginia and West Virginia Water Science Center. These interviews focused on the potential risks associated with the contaminants in biosolids and industrial residuals; potential exposure methods; how well federal and state regulations protect human health and the environment; and the relative risks of biosolids compared to other fertilizers, such as animal manures and chemical fertilizers.

Staff also interviewed three experts at Virginia Tech's Cooperative Extension Office: Dr. Greg Evanylo, Dr. W. Lee Daniels, and Dr. Tom Fox. These staff have researched the benefits of land applying biosolids and industrial residuals. They also conduct product testing of industrial residuals and Class A biosolids for VDACS.

Staff interviewed two nationally prominent opponents of land application: Dr. David Lewis and Dr. Caroline Snyder.

Local governments

Interviews were conducted with three local governments that have local biosolids monitoring programs. Other local governments were contacted but did not respond to our requests for an interview. Interview topics included the rationale for having a local monitoring program; the value a program provides; responsibilities of the local monitor; costs associated with the program; the adequacy of state reimbursement; adequacy of support provided by DEQ; and opinions of DEQ's land application compliance program.

Concerned citizens

JLARC staff interviewed 10 Virginia residents who are concerned about land application of biosolids and industrial residuals (including individual interviews and a group interview). The interviews focused on their specific concerns, their opinions of the adequacy of state regulations, suggestions for improving the land application program, and potential alternatives to land application. Staff also attended public meetings related to two land application permit requests. These research activities were part of a larger effort to assess citizen concerns, which also included document reviews and quantitative analysis.

Special interest groups

JLARC staff conducted interviews with six interest groups that represent various stakeholders, including wastewater treatment plants, land appliers, manufacturers, and farmers. The purpose of these interviews was to understand their constituents' perspectives on the land application of biosolids, the benefits of land application, and their thoughts on DEQ's compliance program. Groups interviewed include:

- Virginia Agribusiness Council,
- Virginia Association of Municipal Wastewater Agencies,
- Virginia Biosolids Council,
- Virginia Farm Bureau,
- Virginia Manufacturers Association, and
- National Association of Clean Water Agencies.

Site visits

JLARC staff conducted two day-long site visits to observe biosolids land applications. One of the main goals of the site visits was to observe DEQ's inspection process and talk with inspectors. Staff were also able to view and smell different types of biosolids from several sources. Staff also visited a biosolids storage facility.

Review of research literature and documents

JLARC staff conducted an extensive review of the research literature on the health and environment effects of biosolids and industrial residuals. JLARC staff also reviewed several other documents related to land application of biosolids and industrial residuals program.

Literature review

JLARC staff reviewed more than 150 scientific research papers about the risks biosolids and industrial residuals pose to human health and the environment and over 100 other papers and reports on the risks and benefits of land applying these and other materials.

For risks from biosolids, most of the literature reviewed consisted of peer-reviewed articles published in scientific journals. Staff identified the studies through searches of several online sources, including Proquest, PubMed, and Google Scholar. Staff also searched four journals individually: *Environmental Health Perspectives*, *Journal of Exposure Science and Environmental Epidemiology*, *International Journal of Hygiene and Environmental Health*, and *Journal of Environmental Quality*. Using these sources, staff searched for terms such as "biosolids," "sewage sludge," "human health," and "public health" individually and in combination. Staff also focused the search on studies published from 2014 to the present because most relevant studies prior to 2014 were expected to be captured in 2014 and 2007 VDH literature reviews. Approximately 50 percent of studies selected for review by JLARC staff were published since 2014; the rest were published before 2014 and were included because they were recommended by stakeholders or were related to key topics where there was limited recent research, such as risks from aerosol exposure to pathogens. In addition to published articles, the review included government reports, research presentations, opinion articles, student dissertations, and other pertinent literature.

For risks from industrial residuals, a majority of the literature reviewed consisted of peer-reviewed articles published in scientific journals. The review also included government reports and VDACS product reviews that were published by researchers with the Virginia Cooperative Extension at Virginia Tech. Literature was identified through online searches and discussions with VDACS.

JLARC staff reviewed literature on the health and environmental risks from other sources, such as animal wastes and chemical fertilizers. JLARC staff also reviewed literature on the benefits of biosolids and industrial residuals. In both cases, the literature reviewed consisted mainly of peer-reviewed articles and government reports that were identified through online searches or discussions with researchers and other stakeholders.

See Appendix G for a bibliography of the articles, reports, and other research included in the literature review.

Document review

Numerous documents related to biosolids and industrial residuals were reviewed by JLARC staff during the course of the study.

JLARC staff reviewed several notable summary evaluations and books, including:

- Review of Land Application of Biosolids in Virginia (2005 JLARC report);
- *Science for Sale*, by David L. Lewis, PhD; and
- Virginia Biosolids Expert Panel Report pursuant to HJR 694 (2007).

JLARC staff reviewed federal and state regulatory documents, including:

- Federal CFR 40 Part 503 Biosolids Rule;
- Code of Virginia, including the State Water Control Law (§ 62.1-44), Virginia Fertilizer Law (§ 3.2-36) and the Virginia Agricultural Liming Materials Law (§ 3.2-37);
- Virginia Administrative Code, including sections for the State Water Control Board (9VAC25) and the Department of Agriculture and Consumer Services (2VAC5);
- documents related to the development of current biosolids regulations (under 9VAC25);
- DEQ inspection reports, land application permits, and letters and notices for corrective actions;
- land applier daily notification and monthly reports to DEQ; and
- wastewater treatment plant reports to EPA and DEQ on biosolids, including annual biosolids reports, routine metals test reports, biosolids leachate test reports, pretreatment program plans, and odor control plans.

JLARC staff reviewed documents to help capture citizen concerns, including:

- citizen submissions to JLARC regarding risks associated with biosolids and industrial residuals and other concerns,
- State Water Control Board meeting materials that include summaries of citizen concerns, and
- news articles and citizen blogs.

Review of other states

JLARC staff researched land application programs in several states:

California
Maryland
Michigan
New Hampshire
North Carolina
Ohio
Pennsylvania

States were selected based on their proximity to Virginia or their use of practices that are different than Virginia. Maryland, North Carolina, and Pennsylvania are close to Virginia and relatively similar agriculturally. California and New Hampshire were selected because they are among states with the strictest biosolids regulations in the country. Michigan and Ohio were selected because they both receive delegation from the Environmental Protection Agency to enforce federal regulations.

For each state, JLARC staff collected information on the types of testing required, application and notification requirements, permitting programs, and inspection programs. Information was collected from state agency websites, reports, and phone interviews. Staff conducted phone interviews with state agency employees in two of the states—Pennsylvania and Ohio—to obtain additional information about their biosolids programs.

Quantitative analysis

JLARC staff analyzed data from DEQ and VDACS to calculate the amount and use of biosolids and industrial residuals that are land applied in Virginia; assess and categorize citizen calls and complaints about biosolids; and analyze permitting timeframes. JLARC staff worked with staff at the Virginia Geographic Information Network (VGIN) to analyze data on the frequency of land application at specific sites.

Analysis of tonnage data

JLARC staff analyzed data from DEQ and VDACS on the total amount (in tons) of biosolids and industrial residuals that were land applied in Virginia in recent years. Staff compiled the data by type of material to show how much was land applied in Virginia in fiscal year 2016 and which type of materials were land applied most frequently. Fiscal year was used because VDACS collects tonnage data on a fiscal year basis, whereas DEQ data is detailed enough to be grouped by either fiscal or calendar year.

JLARC staff analyzed several other data sets related to biosolids and industrial residuals, including:

- amounts of sewage sludge disposed of through alternatives (incineration and landfilling);
- amounts of biosolids from in- and out-of-state sources;
- trends in biosolids land application over time, including historical changes in amounts applied and projection of future Class A biosolids use; and
- percentage of Virginia farmland receiving biosolids and industrial residuals, as determined using cropland data from the US Department of Agriculture's National Agricultural Statistics Survey and data on private pine plantations from the US Forest Service's Forest Inventory & Analysis database.

Mapping of land application sites and frequency

JLARC staff collected data on each land application event from 2014 to 2016 that occurred under DEQ site restrictions. This data included date, county, permit number, field identification, material source, material treatment type, and tonnage. JLARC staff analyzed this data to understand where land application occurred and how frequently. The total tonnage and days of application were calculated per county and per field.

To better understand where land application occurred, particularly where land application occurred more frequently, JLARC staff grouped fields into farms (6,050 fields were grouped into 1,357 farms). Groupings were made based on permit number and field identification naming conventions. Staff calculated the number of days of land application for each farm. JLARC staff noted farms receiving over 14 days of land application per year.

Staff from VGIN analyzed geographic information system (GIS) data provided by DEQ. Staff matched the GIS data for farms with frequent land application to Address Point and Building Footprint datasets to estimate the number of residences and businesses within 500 and 1,000 feet of the land application sites. VGIN staff also reported census-block-level population and population density estimates for areas where the farms were located.

Size of land application industry

JLARC staff estimated the size of the land application industry in terms of employment and revenues generated. JLARC staff worked with the Virginia Biosolids Council to obtain employment information from the land appliers. Five of the eight private land applier companies in Virginia provided information through the council. JLARC staff extrapolated the data for the remaining three companies to estimate total direct employment. Employment estimates did not account for employment by subcontractors, such as employment at the trucking companies that are often hired to haul biosolids from wastewater treatment plants to application sites.

JLARC staff also estimated the annual revenues for the land application industry in Virginia. Revenues were estimated by multiplying the dry tons of biosolids land applied from each wastewater treatment plant by the estimated fees paid, per ton, by plants to private land appliers. Fees estimates were based on the price per ton paid by eight treatment plants interviewed by JLARC staff. Fees paid by these plants were used as a proxy for other plants. Revenue estimates did not account for any revenues that land appliers receive from land applying industrial residuals, VDACS-certified Class A biosolids, or other fertilizers and soil amendments.

Call and complaint data

JLARC staff collected and analyzed data on all biosolids calls and complaints made to DEQ from March 2014 to December 2016. Staff reviewed calls and complaints to better understand the concerns of citizens near land application sites. Staff categorized the data by citizens' area of concern as well as by DEQ's response. For example, in some cases DEQ provided information to concerned citizens, and in some cases they inspected or investigated potential violations reported by citizens.

Additional research

The scope of research for this report was largely defined by the items in the study mandate. However, one study mandate item was not pursued in detail and is not discussed in the report or its appendixes. This item directed JLARC to "evaluate the contractual relationships among Virginia localities and the impacts of local agreements and decisions that could affect wastewater treatment and land application, including septic tank pump out requirements."

JLARC found that local contractual relationships do not have a substantial impact on the wastewater treatment processes used by a plant or subsequent land application activities. There are two types of local contractual relationships. First, a locality may pipe sewage to a neighboring locality's wastewater treatment facility under a contractual relationship. For example, Goochland County sends sewage to Henrico County's treatment plant and a portion of the City of Alexandria's sewage is treated by the Blue Plains plant in Washington, DC. Second, septage from one locality may be deposited at a treatment plant in another locality. Septage is typically pumped and hauled by private companies. These companies have certifications or agreements with one or more treatment plants that allow them to deposit septage in the plant's headworks. This septage often comes from locations outside of the plant's service area, such as rural areas in neighboring counties. The source of the material does not impact the treatment process used by the plant or where biosolids resulting from treatment are applied.

Appendix C: Citizen concerns about biosolids and industrial residuals land application

Citizens have expressed a range of concerns about land application of biosolids and industrial residuals. The most prominent concern raised by citizens is the potential health impacts of land application on nearby residents. Other common concerns are odors, the effects of land application on water quality, nearby property values, quality of life, and whether it is justifiable to dispose of urban waste in rural communities. Several rural communities have created citizen groups to oppose land application.

Citizens opposed to land application cited health concerns about the practice and how it is regulated

JLARC staff interviewed 10 citizens who are concerned about the land application of biosolids and reviewed documentation that they submitted. Most of these citizens were concerned about the health effects of biosolids on citizens living near land application sites. Many believe there is evidence that biosolids are harmful to human health and that the state is either ignoring or discounting this evidence. Several citizens said they have gotten sick from biosolids or know people in their community who have gotten sick. Others expressed concerns that the state has no process to collect or analyze data on citizen health problems caused by biosolids.

Citizens questioned aspects of DEQ's regulatory program. For example, some citizens said there is no scientific basis for the current setbacks in the regulations. Others felt the state's process for notifying residents of nearby land applications was flawed because it does not give people enough time to request extended setbacks. For example, if a person buys a house near a biosolids site that has already been permitted, they may not know that biosolids are applied nearby until signs are posted five days before an application takes place.

Citizens indicated that the state is unresponsive to their concerns and they feel patronized by the public hearing process. Citizens spend time preparing comments and compiling research for the public hearings, but say that their remarks are summarized by DEQ instead of being provided in their entirety to the State Water Control Board. Others stated that the rights of rural citizens are being ignored, and several questioned whether the practice was even legal.

Citizens also questioned the effectiveness of DEQ's oversight, noting that DEQ staff have little incentive to question or limit land application because the DEQ compliance program is funded by land application fees; some believed this to be a conflict of interest. Citizens felt that DEQ oversight is insufficient to address the risks posed by land application and that the level of oversight has gone down due to recent staff reductions within the compliance program. Some citizens felt that oversight is inadequate because there is no post-application monitoring, such as routine testing of soil and water. Others noted that additional and repeated testing of biosolids, soil, and water is needed to adequately protect public health.

Land application generates few calls or complaints statewide

Most land applications occur under a site-specific DEQ permit. (See Chapter 3.) After a permit has been approved, citizens can call DEQ or local monitors to report violations and voice concerns. The vast majority of land applications occur without complaint. From 2014 to 2016, DEQ received 132 calls, or approximately one call for every 35 land applications that occurred.

The issue most frequently raised is odor. One-third of callers were concerned about offensive odors from nearby applications. Offensive odors are commonly associated with biosolids, but are not against federal or state regulations. In responding to these calls, DEQ inspectors typically found that the odor was typical for the material, but in a few cases the smell was deemed "malodorous." In a few cases, inspectors found that animal manure was the likely cause of the odor complaint.

Fourteen percent of complaints were from people who were against the practice of land applying biosolids in general. Most of these calls were made in response to notification signs being posted regarding an upcoming biosolids land application. Citizens wanted to either share that they were opposed to the practice or ask more about the effect that biosolids and industrial residuals may have on nearby residents. In most cases, DEQ staff shared information on the state regulations that were in place to protect human health.

Another fourteen percent of calls pertained to water quality. Examples of water quality concerns include citizens citing the potential for nutrient runoff into surface water and leaching into groundwater and wells.

Thirteen percent of calls were reports of potential regulatory violations, such as improper storage or application practices. Examples include calls from citizens who believed materials were over-applied to a field, applied to frozen ground, applied too close to property lines, or stored or stockpiled for too long.

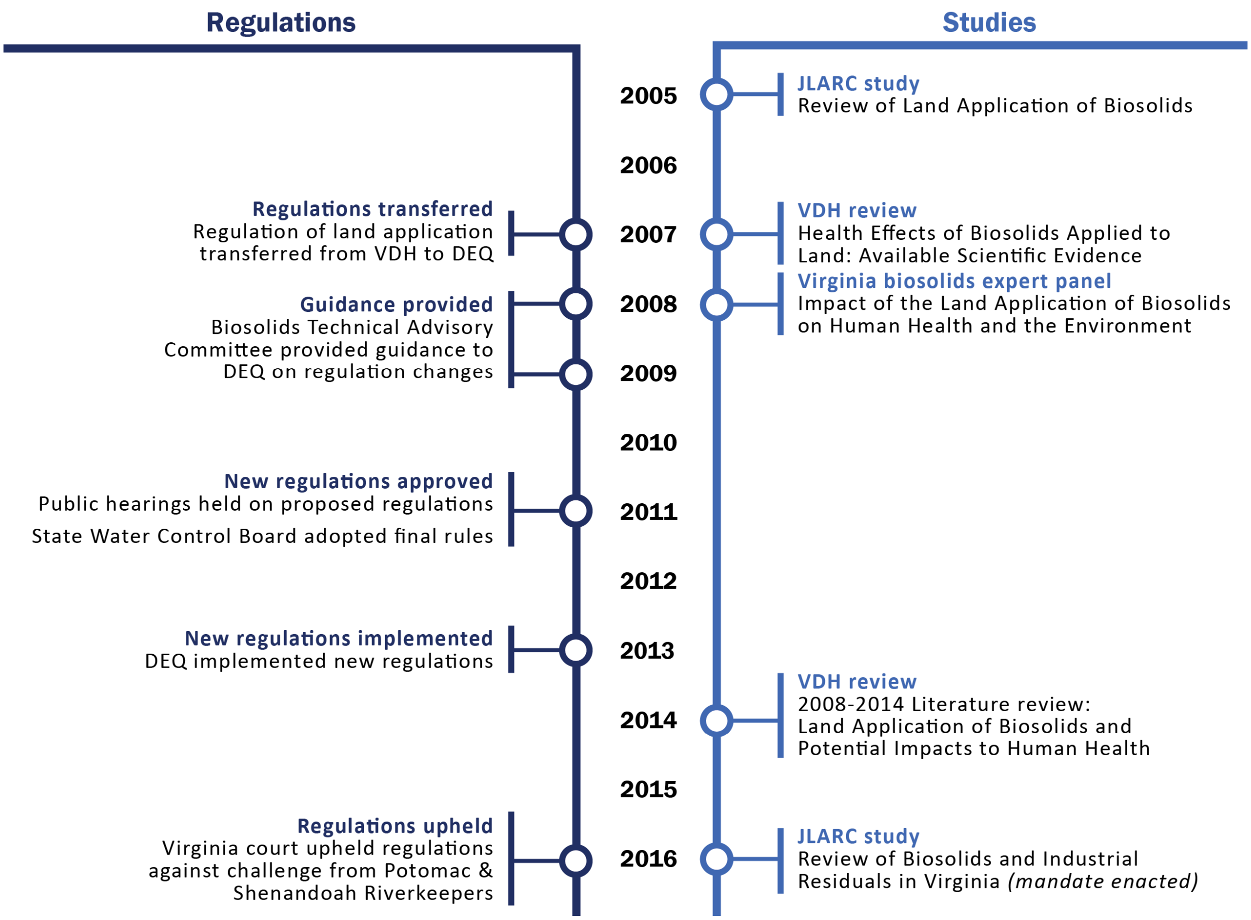
Eight percent of callers reported either truck spills or traffic accidents involving trucks delivering biosolids and industrial residuals. DEQ inspectors or local authorities worked with land appliers to ensure roads were cleaned and treated with lime when necessary. An additional seven percent of callers reported track-out, which is when material is tracked onto public roads by truck tires. According to state regulations, land appliers have until the end of the work day to remove track-out from roadways.

The remaining calls pertained to various concerns including complaints about the timing of land application or the notification process. For eight percent of calls, no land application had taken place or was scheduled to take place nearby.

Calls and complaints rarely uncovered violations. Only two calls resulted in inspectors finding a violation of state regulations that was corrected by DEQ. However, in eight other instances the farmer or the land applier took some action to try and address the citizen's concern. For example, one individual called to express concern about the potential for runoff from biosolids into a stream on her property, and in response the neighboring farmer agreed to increase the setback from her property.

Appendix D: Timeline of Virginia's major regulatory changes and prior studies

FIGURE D-1
Virginia has a history of regulatory changes and studies of biosolids



SOURCE: Past Virginia biosolids studies and State Water Control Board meeting minutes.

Appendix E: Summary of key regulatory requirements for biosolids and industrial residuals

The regulatory requirements for biosolids and industrial residuals can differ depending on the class and type of material. Table E-1 provides information on the key requirements for each type of material: Class B biosolids, Class A biosolids, and industrial residuals.

TABLE E-1
Regulatory requirements for biosolids and industrial residuals

	Type of material	Regulatory agency	Applied under site restrictions	NMP required	Product quality verified
Class B biosolids	Cake, liquid	DEQ	Yes	Yes	Yes
Class A biosolids	Cake	DEQ	Yes [a]	Yes	Yes
	Pelletized, composted	DEQ/VDACS	No	No	Yes
Industrial residuals	Paper mill sludge, food & beverage, other	DEQ	Yes	Yes	Yes
	Paper mill sludge, wood ash, synthetic gypsum, food & beverage, other	VDACS	No	No	Yes

SOURCE: Virginia regulations and information provided by DEQ and VDACS.
NOTE: NMP = nutrient management plan
[a] Currently, most Class A cake material is applied in bulk and follows Class B site restrictions, even though this is not explicitly required in the regulations. Site restrictions may not apply to some Class A cake biosolids in the near future. DEQ is currently working with one large generator of Class A cake biosolids to reduce some site restrictions through the issuance of a distribution and marketing permit for the material, which would also include VDACS regulation of the product. Reduced site restrictions may be applicable to other Class A cake generators in the future.

Appendix F: Frequency of pathogens in biosolids

TABLE F-1
Type and frequency of pathogens found in biosolids

Type	Pathogen	Related illness	Frequency
Bacteria	Campylobacter jejuni	Food poisoning	Rarely
	Clostridium difficile	Gastrointestinal illness	Sometimes
	Clostridium perfingens	Food poisoning	Frequently
	E. coli 0157:H7	Gastrointestinal illness	Rarely
	Legionella	Lung infection	Sometimes
	Listeria monocytogens	Fever, gastrointestinal illness	Rarely
	Salmonella	Food poisoning	Sometimes
	Shigella	Gastrointestinal illness	Rarely
	Staphylococcus aureus	Skin or lung infection	Rarely
	Yersinia enterocolitica	Gastrointestinal illness	Sometimes
Parasite	Ascaris	Round worm	Rarely
	Cryptosporidium	Gastrointestinal illness	Frequently
	Giardia	Gastrointestinal illness	Frequently
Virus	Adenovirus	Common cold, pink eye	Frequently
	Aichi virus	Gastrointestinal illness	Rarely
	Astrovirus	Gastrointestinal illness	Frequently
	Bocavirus	Gastrointestinal illness	Frequently
	Coronavirus	Common cold	Sometimes
	Cosavirus	Gastrointestinal illness	Rarely
	Coxsackievirus	Respiratory illness, rash	Rarely
	Enterovirus	Gastrointestinal illness	Sometimes
	Hepatitis A	Gastrointestinal illness	Rarely
	Hepatitis C	Liver infection	Sometimes
	Hepatitis E	Liver infection	Sometimes
	Herpesvirus	Sores	Frequently
	HIV	Immunodeficiency	Sometimes
	HPV	Warts, cancer	Frequently
	Klassevirus	Gastrointestinal illness	Frequently
	Norovirus	Gastrointestinal illness	Frequently
	Parechovirus	Fever, rash	Sometimes
	Parvovirus	Fever, rash	Rarely
	Rhinovirus	Common cold	Sometimes
	Rotavirus	Gastrointestinal illness	Frequently
	Rubella virus	Fever, rash	Sometimes
	Sapovirus	Gastrointestinal illness	Sometimes
	T-lymph virus	Muscle weakness, motor changes	Rarely
	TTV	Liver infection	Frequently

SOURCE: Barbier 1990, Bibby 2013, Chapron 2000, Chauret 1999, Dahab 2002, Gantzer 2001, Garrec 2009, Hu 1996, Jones 2001, Parmar 2001, Pepper 2010, Rimhanen-Finne 2004, Rhodes 2015, Russin 2003, Sahlstrom 2004, Schwartzbrod 2005, Sidhu 2009, Simmons 2011, Straub 1994, Van den Berg 2005, Viau 2009, Wong 2010, and Yanko 1988.
NOTE: Pathogens that were found in 0%-25% of biosolids samples are listed as rarely, pathogens found in 26%-75% of samples are listed as sometimes, and pathogens found in 76%-100% of samples are listed as frequently.

Appendix G: Literature review bibliography

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Appendix H: Studies linking health outcomes to land application of biosolids

Study	Key findings	Methods	Limitations
Municipal Sewage Sludge Application on Ohio Farms (Dorn 1985)	There was no difference in the risk of respiratory and gastrointestinal illness or symptoms found in farmers and family members residing near biosolids sites and a control group.	Three-year prospective epidemiological study of 47 farms receiving annual biosolids applications and 46 control farms. Participants completed monthly questionnaires about their health, received quarterly blood sampling for serological tests, and received annual tuberculin testing.	Study sample size was small (Biosolids n=164; control n=130) which affects reliability. Biosolids sites used in the study had low rates of application so may not be representative of areas which have more frequent applications.
Health Survey of Residents Living Near Farm Fields Permitted to Receive Biosolids (Khuder 2007)	Residents living near farms where biosolids are applied reported statistically higher instances of respiratory and gastrointestinal illnesses and may be at increased risk of contracting these illnesses, among others.	One-time retrospective survey of 607 households, including households that were exposed to biosolids and a control group. Participants were mailed a health questionnaire to complete and return.	Study relied on self-reporting of symptoms and had a low response rate (below 50%). These factors combined could bias results towards persons who experienced illness. Study may not adequately adjust for clustering of respondents within the same households, resulting in over-reporting from some households.
Interactions of pathogens and irritant chemicals in land-applied sewage sludges (biosolids) (Lewis 2002)	Residents living near land application sites complained of irritation (e.g., skin rashes and burning of eyes, throat, and lungs) after exposure to winds blowing from treated fields, which was likely attributable to *Staphylococcus aureus* infections.	One-time retrospective survey of 48 residents near 10 land application sites in several states. Participants were either questioned by an interviewer or were sent health questionnaires to complete and return (the exact method used isn't clear). Participants were tested for *Staphylococcus aureus* infections.	Study did not have an unexposed control group that could be used as a baseline for comparison and assessing risk. Study sample size was very small (n=48), the basis for selecting the sample is unclear, and the response rate is not given. These sampling limitations and unknowns affect reliability for assessing risk.
Land Application of Treated Sewage Sludge: Community Health and Environmental Justice (Lowman 2013)	Residents living near biosolids sites reported health symptoms and quality of life concerns from biosolids exposure.	One-time retrospective survey of 34 residents near land application sites in three states, including Virginia. Participants were questioned by an interviewer.	Study did not have an unexposed control group that could be used as a baseline for comparison and assessing risk. Study sample size was very small (n=34) and the basis for selecting participants appears biased toward selecting persons who believe they have experienced negative health outcomes from biosolids applications. These sampling limitations and unknowns affect reliability for assessing risk.

Appendix I: DEQ sludge management fund

The DEQ sludge management fund is used to pay the costs of DEQ's compliance program. The fund has carried a cash balance since DEQ inherited the program from VDH in 2008. The fund's cash balance has been declining in recent years because revenues have fallen and the fund has begun incurring annual operating losses (Table I-1). Fund revenues come from fees that are charged for each ton of biosolids applied in Virginia, and fewer biosolids are being applied since the Blue Plains wastewater plant in Washington, DC, converted to Class A treatment.

TABLE I-1
DEQ sludge management fund balance declined due to lower revenue and operating losses

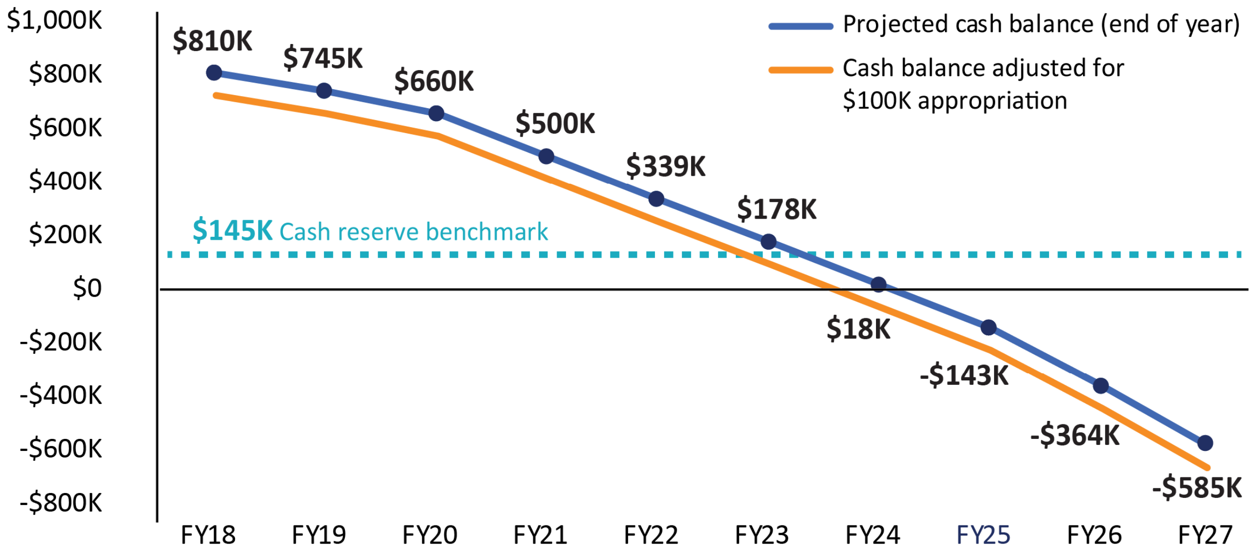
	FY13	FY14	FY15	FY16	FY17
Starting cash balance	$1,292,577	$1,467,126	$1,167,620	$900,855	$871,725
Revenues	1,776,972	1,396,088	1,360,088	1,074,372	794,963
Expenditures & transfers	−1,602,423	−1,695,593	−1,626,853	−1,103,502	−856,223
Net gain or loss	174,549	−299,505	−266,765	−29,130	−61,260
Ending cash balance	$1,467,126	$1,167,620	$900,855	$871,725	$810,463

SOURCE: DEQ financial statements.
NOTE: Expenditures and transfers includes a cash transfer to the Department of Conservation and Recreation to pay for one position that is responsible for reviewing and approving nutrient management plans for biosolids and industrial residuals land application sites.

Revenues for the fund will likely decline in the near future as other large plants convert to Class A treatment, resulting in continued operating losses and a further declining fund balance. JLARC staff identified three large utilities that are planning to convert to Class A treatment. After accounting for their planned conversions, JLARC staff project that the fund balance could fall below the cash reserve benchmark sometime during FY24 (Figure I-1). (JLARC staff use a cash reserve benchmark for assessing the financial well-being of the state's internal service funds; the benchmark is for funds to have 60 days of operating expenses on hand in the event of unexpected revenue losses or expense increases.) The fund balance could be drawn down sooner if other large plants convert to Class A treatment between now and then.

If DEQ sludge management funds were appropriated to implement the recommendations made in this report, JLARC staff project the fund would fall below the recommended cash reserve benchmark about one year earlier than it would otherwise (FY23 rather than FY24).

FIGURE I-1
DEQ sludge management fund cash balance will likely continue to decline



SOURCE: JLARC analysis of DEQ financial statements and wastewater treatment plant capital plans.
NOTE: The three wastewater utilities converting to Class A; tentative conversion dates: Hampton Roads Sanitation District (2020); Washington Suburban Sanitary Commission (2021); and Arlington Water Pollution Control Plant (2026).

Appendix J: Chemical test results from recent USGS studies

TABLE J-1
Metals and organic chemical compounds tested in recent USGS studies of biosolids

Compound	Type	Groundwater (Wagner 2014)	Groundwater (Yager 2013)	Surface water (Wagner 2014)
1,4-Dichlorobenzene	Pesticide	Below detection	Below detection	All samples above control, but average level small
1,7-Dimethylxanthine (p-Xanthine)	Pharmaceutical	Below detection	-	Below detection
17-alpha-Estradiol	Hormone*	Below detection	-	Below detection
17-alpha-Ethynyl estradiol	Hormone*	Below detection	-	Below detection
17-beta-Estradiol	Hormone*	Below detection	-	Below detection
1-Methylnaphthalene	Polycyclic aromatic hydrocarbon (PAH)	Below detection	Below detection	Below detection
2,2′,4,4′-Tetrabromodiphenylether (PBDE 47)	Fire retardant	Below detection	-	-
2,6-Dimethylnaphthalene	Polycyclic aromatic hydrocarbon (PAH)	Below detection	Below detection	Below detection
2-Methylnaphthalene	Polycyclic aromatic hydrocarbon (PAH)	Below detection	Below detection	Below detection
3,4-Dichlorophenyl isocyanate	Chemical intermediate	Below detection	-	Below detection
3-beta-Coprostanol	Sterol	Below detection	Below detection	Mostly below detection, but some samples above
3-Methyl-1H-indole (skatole)	Fragrance	Below detection	Below detection	Below detection
3-tert-Butyl-4-hydroxy-anisole	Antioxidant*	Below detection	Below detection	Below detection
4-Androstene-3,17-dione	Hormone	Below detection	-	Below detection
4-Cumylphenol	Detergent degradate*	Below detection	Below detection	Below detection
4-Epichlorotetracycline	Pharmaceutical	Below detection	-	Below detection
4-Epioxytetracycline	Pharmaceutical	Below detection	-	Below detection
4-Epitetracycline	Pharmaceutical	Below detection	-	Below detection
4-n-Octylphenol	Detergent degradate*	Below detection	Below detection	Below detection
4-Nonylphenol	Detergent degradate*	Below detection	Below detection	Below detection
4-Nonylphenol diethoxylate	Detergent degradate*	Below detection	Below detection	Below detection
4-Nonylphenol monoethoxylate	Detergent degradate*	Below detection	-	Below detection
4-tert-Octylphenol	Detergent degradate*	Below detection	Below detection	Below detection

4-tert-Octylphenol diethoxylate	Detergent degradate*	Below detection	Below detection	Below detection
4-tert-Octylphenol monoethoxylate	Detergent degradate*	Below detection	Below detection	Below detection
5-Methyl-1H-benzotriazole	Corrosion inhibitor	Below detection	Below detection	Below detection
9,10-Anthraquinone (anthraquinone)	Polycyclic aromatic hydrocarbon (PAH)	Below detection	Below detection	Below detection
Acetaminophen	Pharmaceutical	Below detection	-	Below detection
Acetophenone	Fragrance	Below detection	Below reporting level	Below detection
Acetylhexamethyltetra-hydronaphthalene	Fragrance*	Below detection	Below detection	Below detection
Aluminum	Metal	-	No health standard	-
Anhydroerthromycin	Antibiotic	Below detection	-	Below detection
Anthracene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	Below detection	Below detection
Antimony	Metal	-	Below health standard	-
Arsenic	Metal*	Below detection	Mostly below detection, few samples slightly above	Below detection
Atrazine	Pesticide	Slightly above detection, close to control level	-	Below detection
Azithromycin	Antibiotic	Below detection	-	One sample at several times detection limit, average still low
Barium	Metal*	-	Below health standard	-
Benzo[a]pyrene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	Below detection, but health standard also below detection level	Below detection
Benzophenone	Photo initiator*	Below detection	Below reporting level	Below detection
Beryllium	Metal	-	Below health standard	-
Beta-Sitosterol	Sterol*	Below detection	Below detection	Below detection
Beta-Stigmastanol	Sterol	Below detection	Below detection	Below detection
Bis(2-Ethylhexyl) phthalate	Phthalate acid ester (PAE)*	Below detection	-	One sample above detection
Bisphenol A	Plastic*	Below detection	-	Below detection
Boron	Metal	-	No health standard	-
Bromacil	Pesticide*	Below detection	Below detection	Below detection
Bromoform (Tribromomethane)	Fire retardant	Below detection	Below detection	Below detection
Cadmium	Metal*	Below detection	Below detection	Below detection
Caffeine	Pharmaceutical*	Below detection	Below reporting level	Below detection
Camphor	Fragrance	Below detection	Below reporting level	One sample above control level
Carbamazepine	Pharmaceutical	Below detection	-	Below detection
Carbaryl	Pesticide*	Below detection	Below detection	Below detection
Carbazole	Pesticide	Below detection	Below detection	Below detection

Chloramphenicol	Antibiotic	Below detection	-	Below detection
Chlorpyrifos	Pesticide	Below detection	Below detection	Below detection
Chlortetracycline	Pharmaceutical	Below detection	-	Below detection
Cholesterol	Sterol	Below detection	Below detection	Below control level
Chromium	Metal*	Below detection	Below detection	Below detection
Ciprofloxacin	Pharmaceutical	Below detection	-	Below detection
Cis-Androsterone	Hormone	Below detection	-	One sample above control level
Cobalt	Metal	-	No health standard	-
Codeine	Pharmaceutical	Below detection	-	Below detection
Copper	Metal	Below detection	No health standard	Below detection
Cotinine	Pharmaceutical	Below detection	Below detection	Below detection
Dehydronifedipine	Pharmaceutical	Below detection	-	Below detection
Diazinon	Pesticide*	Below detection	Below detection	Below detection
Dichlorvos	Pesticide	Below detection	-	Below detection
Diethyl phthalate	Phthalate acid esters (PAE)*	Below detection	-	Below detection
Dihydrotestosterone	Hormone	Below detection	-	Below detection
Diltiazem	Pharmaceutical	Below detection	-	Below detection
Diphenhydramine	Pharmaceutical	Below detection	-	Below detection
d-Limonene	Fragrance	Below detection	Below detection	Below detection
Doxycycline	Pharmaceutical	Below detection	-	Below detection
Enrofloxacin	Pharmaceutical	Below detection	-	Below detection
Epitestosterone	Hormone	Below detection	-	Below detection
Equilenin	Hormone*	Below detection	-	Below detection
Equilin	Hormone*	Below detection	-	Below detection
Erythromycin	Antibiotic	Below detection	-	Below detection
Estriol	Hormone*	Below detection	-	Below detection
Estrone	Hormone	Below detection	-	Below detection
Fluoranthene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	-	Below detection
Hexahydrohexamethyl-cyclopentabenzopyran	Fragrance	Below detection	-	Below detection
Ibuprofen	Pharmaceutical	Below detection	-	Below detection
Indole	Fragrance*	Below detection	Below detection	Below control level
Iron	Metal	-	No health standard	-
Isoborneol	Fragrance	Below detection	Below detection	Below detection
Isochlortetracycline	Pharmaceutical	Below detection	-	-
Isoepichlorotetracycline	Pharmaceutical	Below detection	-	-
Isophorone	Solvent	Below detection	Below reporting level	Below control level
Isopropylbenzene	Solvent	Below detection	Below detection	Below detection
Isoquinoline	Flavor*	Below detection	Below detection	Below detection
Lead	Metal*	Below detection	Below health standard	Below detection
Lincomycin	Pharmaceutical	Below detection	-	Below detection

Lomefloxacin	Pharmaceutical	Below detection	-	Below detection
Magnesium	Metal	-	No health standard	-
Manganese	Metal*	-	No health standard	-
Menthol	Flavor	Below detection	Below detection	Below detection
Mercury	Metal*	Below detection	Below detection	Below detection
Mestranol	Hormone*	Below detection	-	Below detection
Metalaxyl	Pesticide	Below detection	Below detection	Below detection
Methyl salicylate	Counterirritant*	Below detection	Below reporting level	At or below control level
Metolachlor	Pesticide*	Below detection	Below detection	Below detection
Molybdenum	Metal	Below detection	Below health standard	Below detection
N,N-diethyl-meta-toluamide (DEET)	Pesticide	Below detection	Below reporting level	Below detection
Naphthalene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	Below reporting level	Below detection
Nickel	Metal	2 of 3 wells slightly above detection	-	Below detection
Norethindrone	Hormone	Below detection	-	One sample above detection
Norfloxacin	Pharmaceutical	Below detection	-	Below detection
Ofloxacin	Pharmaceutical	Below detection	-	Below detection
Ormetoprim	Pharmaceutical	Below detection	-	Below detection
Oxytetracycline	Pharmaceutical	Below detection	-	Below detection
p-Cresol	Chemical intermediate*	Below detection	Below detection	Average above control level
Pentachlorophenol	Pesticide	Below detection	-	Below detection
Phenanthrene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	Below reporting level	One sample above detection, but still low
Phenol	Disinfectant*	Below detection	Below reporting level	One sample above control level
Potassium	Metal	-	No health standard	-
Progesterone	Hormone*	Below detection	-	Below detection
Prometon	Pesticide	1 of 3 wells slightly above detection	Below detection	-
Pyrene	Polycyclic aromatic hydrocarbon (PAH)*	Below detection	Below detection	Below detection
Roxithromycin	Pharmaceutical	Below detection	-	Below detection
Salbutamol (albuterol)	Pharmaceutical	Below detection	-	Below detection
Sarafloxacin	Pharmaceutical	Below detection	-	Below detection
Selenium	Metal	Below detection	Few samples above health standard	Below detection
Silver	Metal*	-	Below health standard	-
Strontium	Metal	-	No health standard	-
Sulfachlorpyridazine	Pharmaceutical	Below detection	-	Below detection
Sulfadiazine	Pharmaceutical	Below detection	-	Below detection
Sulfadimethoxine	Pharmaceutical	Below detection	-	Below detection

Sulfamethazine	Pharmaceutical*	Below detection	-	Below detection
Sulfamethoxazole	Pharmaceutical	Below detection	-	Below detection
Sulfathiazole	Pharmaceutical	Below detection	-	Below detection
Testosterone	Hormone	Below detection	-	Below detection
Tetrachloroethylene	Chemical intermediate	Below detection	Below detection	Below detection
Tetracycline	Pharmaceutical	Below detection	-	Below detection
Thiabendazole	Pharmaceutical	Below detection	-	Below detection
Trans-Diethylstilbestrol6	Hormone*	Below detection	-	Below detection
Tributyl phosphate	Fire retardant*	Below detection	Below detection	Below detection
Triclosan	Disinfectant*	Below detection	Below detection	One sample above detection, but still low
Triethyl citrate	Flavor	Below detection	Below detection	Below detection
Trimethoprim	Antibiotic	Below detection	-	Below detection
Triphenyl phosphate	Plastic*	Below detection	Below detection	One sample above detection, but still low
Tris(2-butoxyethyl) phosphate	Fire retardant*	Below detection	Below reporting level	One sample above detection, but still low
Tris(2-chloroethyl) phosphate	Fire retardant	Below detection	Below detection	Below detection
Tris(dichloroisophrpyl) phosphate	Fire retardant	Below detection	Below detection	Below detection
Tungsten	Metal	-	Below detection	-
Tylosin	Pharmaceutical	Below detection	-	Below detection
Uranium	Metal	-	Half of samples above health standard	-
Virginiamycin	Pharmaceutical	Below detection	-	Below detection
Warfarin	Pharmaceutical	Below detection	-	Below detection
Zinc	Metal*	Below detection	No health standard	Below detection

SOURCE: Wagner et al. 2014, and Yager et al. 2013.
NOTE: Wagner et al. 2014 sampled soil from land applied fields, shallow groundwater monitoring wells at the edge of land applied fields, and a surface-water monitoring site on a creek down-stream of land applied fields in North Carolina. Control samples of soil and groundwater were collected from a nearby field that had never received land-applied biosolids and control samples of surface water were collected from the creek up-stream of application. Samples were collected over a two-year time period. Yager et al. 2013 sampled bedrock and alluvial groundwater monitoring wells on land applied fields. Control samples of groundwater were collected from a site where biosolids were not applied. Samples were collected over a six-year time period. Some values were found to be above detection, but below the minimum reporting level. These values are reported in the table as "below reporting level."
*Chemical element or compound is a suspected endocrine disrupting compound.

Appendix K: Local monitoring programs

Local governments have the authority to establish their own land application monitoring programs. Under these programs, they can hire local monitors to enforce DEQ regulations. Local monitors can be local government employees, or localities can hire private contractors to serve in a local monitoring capacity. For example, until recently, five localities employed a contractor to serve as a regional monitor. Localities do not have the authority to enact local requirements that are more restrictive than state regulations. Localities can request reimbursement from DEQ for a portion of their program's expenses.

At least five localities have active local monitoring programs. Local monitors inspect land application sites within their locality and respond to citizen concerns. Local inspections are similar in scope to those performed by DEQ inspectors. Local monitors also have the authority to conduct additional testing of biosolids, soils, and water. One local monitor interviewed for this study reported conducting periodic tests of citizens' well water, but the others reported that they do not conduct additional testing.

Localities indicated that their monitoring programs are valuable to them because they allow them to be responsive to constituents and add an extra level of assurance. Local monitors can promptly respond to calls, meet with residents, and provide information about nearby land applications. Localities report that having a local employee handle these activities often puts residents more at ease. The locality that conducts well water tests indicated that the testing helps to ease citizen concerns. Monitors can also inspect application sites, which promotes compliance with state regulations.

Most localities do not have local monitoring programs. Some localities do not want to be involved with land application because it is a state program and they have little control over it. Some localities feel local programs are unnecessary because the state conducts inspections.

At least six localities have discontinued their programs within the past two years, including five that shared a regional monitor. Localities are discontinuing their programs for two main reasons. First, localities may see less of a need for inspections because a larger portion of the biosolids being applied are lower-risk Class A material. Second, the shift towards Class A biosolids has reduced the amount of material applied in many localities, along with the amount of reimbursement they can request from the state.

Appendix L: Agency responses

As part of an extensive validation process, the state agencies and other entities that are subject to a JLARC assessment are given the opportunity to comment on an exposure draft of the report. JLARC staff sent an exposure draft of this report to the Department of Environmental Quality, Virginia Department of Agriculture and Consumer Services, and Virginia Department of Health. The Virginia Secretaries of Agriculture and Forestry, Health and Human Resources, and Natural Resources were also sent a draft of this report.

Corrections resulting from technical and substantive comments are incorporated, as appropriate, in this version of the report. This appendix includes response letters from the following:

- Department of Environmental Quality,
- Virginia Department of Agriculture and Consumer Services, and
- Virginia Department of Health.

COMMONWEALTH of VIRGINIA

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Molly Joseph Ward
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
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October 2, 2017

Hal E. Greer
Joint Legislative Audit and Review Commission
919 East Main Street, Suite 2101
Richmond, VA 23219

RE: JLARC Report, *Land Application of Biosolids and Industrial Residuals*

Dear Mr. Greer:

Thank you for the opportunity to review the draft of the JLARC Report, *Land Application of Biosolids and Industrial Residuals*. We have reviewed the draft and look forward to publication of the final report following input from our agency and others that provided input.

Overall, the report is very well balanced. It acknowledges the potential risk posed by the constituents in biosolids and industrial residuals when improperly land applied, and it also recognizes the success of the comprehensive regulatory oversight provided by both the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Agriculture and Consumer Services (VDACS). This oversight has resulted in management of these materials such that the overall risk to human health and the environment is low or very low. The concerted efforts of DEQ and the Virginia Department of Health (VDH), along with the decades of research by the United States Environmental Protection Agency (EPA), have combined to make Virginia's regulatory programs for these materials successful in meeting the statutory mandate to protect human health and the environment.

Regarding the recommendations for VDH to perform a focused assessment of recent research and examine specific human health risks, DEQ remains supportive of the collaboration between our agencies that serves to promulgate and maintain science-based regulations. Through such ongoing review, we can ensure that the regulations remain protective.

As efforts are made to identify funding for VDH to perform pathogen testing and/or design of an epidemiological study, it should be noted that the biosolids fee fund currently operates at an annual loss due to recent reductions in Class B biosolids production. As the report acknowledges, revenues are likely to continue declining as the trend to increase Class A production continues. DEQ responded to the initial reduction in revenues by reducing the number of staff assigned to the biosolids program, but this has resulted in decreased inspection frequencies and has made addressing protracted timelines for biosolids permit processing more challenging. While there is currently a cash balance in the fund, any significant depletions in this balance may have adverse implications for DEQ's ability to effectively permit and oversee land application activities.

In light of all these factors, please extend my compliments to your staff in the thoroughness of this examination, particularly their efforts to gather data from a broad range of sources. The Appendixes to the report represent wide-ranging viewpoints on the practice of land applying biosolids and industrial residuals, and the report captures well those various perspectives.

Sincerely,

David K. Paylor

DKP:ewf
cc: Molly Joseph Ward, Secretary of Natural Resources

Sandra J. Adams
Commissioner

COMMONWEALTH of VIRGINIA

Department of Agriculture and Consumer Services

P.O. Box 1163, Richmond, Virginia 23218
Phone: 804/786-3501 ● Fax: 804/371-2945● Hearing Impaired: 800/828-1120
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September 27, 2017

Hal E. Greer
Director
Joint Legislative Audit and Review Commission
919 East Main Street
Suite 2101
Richmond, VA 23219

Dear Director Greer:

Thank you for the opportunity to review and comment on the exposure draft entitled *Land Application of Biosolids and Industrial Residuals*. Staff at the Virginia Department of Agriculture and Consumer Services (VDACS) reviewed this draft and agrees with your recommendation that this agency (i) require producers to submit chemical analyses of their products as part of the annual registration process and (ii) review these analyses to ensure that products continue to have acceptably low levels of trace chemicals. VDACS will work to implement this recommendation as part of future registrations by this agency of industrial residuals and biosolids. VDACS staff identified technical corrections and communicated these to Mark Gribbin of your staff by email on September 27, 2017.

Thank you again for the opportunity to participate in the research and interview stages of this report development and for the chance to review this exposure draft. Please feel free to contact me should VDACS be able to provide any additional information or assistance.

Sincerely,

Sandra J. Adams
Commissioner

COMMONWEALTH of VIRGINIA

Department of Health
P O BOX 2448
RICHMOND, VA 23218

Marissa J. Levine, MD, MPH, FAAFP
State Health Commissioner

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September 29, 2017

Hal E. Greer
Director, Joint Legislative Audit and Review Commission (JLARC)
919 East Main Street, Suite 2101
Richmond, Virginia 23219

Dear Mr. Greer:

This is in follow-up to the recent meeting between JLARC staff and representatives of the Virginia Department of Health (VDH) regarding the JLARC report, *Land Application of Biosolids and Industrial Residuals.* Based on that meeting, as well as our subsequent correspondence, it is VDH's understanding that the final report presented at the JLARC meeting on October 10 will reflect the following changes as compared to the exposure draft:

- With respect to Recommendation 1, an alternative recommendation to the effect that the General Assembly may wish to consider language in the Appropriation Act directing and providing $50,000 to VDH in order to contract with university familiar with biosolids research in order to conduct a pilot study of whether land application of biosolids causes human health problems. VDH would submit the results of the pilot study to the General Assembly.

- With respect to Recommendation 2, recognition of the fact that laboratory testing of Class B biolsolids for pathogens would have a fiscal impact, as well as recognition of communication that VDH has had with staff at the Division of Consolidated Laboratory Services (DCLS), to the effect that DCLS does not currently have capacity or established protocols to perform laboratory testing of biosolids for pathogens.

- With respect to Recommendations 3 and 4, recognition that VDH does not have regulatory authority concerning biosolids application and buffers, and can only make recommendations to the State Water Control Board and the Department of Environmental Quality (DEQ).

- With respect to Recommendation 5, a recommended deadline of July 1, 2019 for VDH to submit the required report to DEQ.

Thank you again for your willingness to thoughtfully consider the comments and suggestions of VDH. I greatly appreciate the professionalism and courtesy displayed by JLARC staff throughout the study process. Please let me know if you require anything further. You can reach me at (804) 864-7009 or Marissa.Levine@vdh.virginia.gov.

Sincerely,

Marissa J. Levine, MD, MPH, FAAFP
State Health Commissioner

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