

## From Pigasties

In the continuing transformation of U.S. agriculture, North Carolina finds itself on the leading edge of change. Between 1989 and 1998, the number of hogs in the state's pork industry soared from about 2 million to nearly 11 million, according to the state health director's office. In 1997, public concerns over concentrated hog populations and their environmental consequences brought about a moratorium on new hog farms. The industry consolidated into fewer large operations with high animal densities, which critics label "hog factories."

In some places, large waste lagoons at these facilities—some covering more than an acre—bring complaints of sickening odors and groundwater risks [see *EHP* 107:A154–A157 (1999)]. The lagoons and the spraying of liquid effluent on crop fields have been standard methods for disposing of pig excrement. Now the state has engaged private and public resources in a rapid search for better ways to handle hog waste.

The process for testing new technologies emerged after Hurricane Floyd struck in September 1999. Flooding caused by Floyd created widespread concerns over threats to public health from overloaded waste lagoons in eastern North Carolina. In the hurricane's wake, then-state attorney general Mike Easley approached the pork industry for help in solving the problem of hog waste. In July 2000, the state reached an agreement with Smithfield Foods, the state's largest pork producer. According to Easley, the agreement balances the interests of economic health and environmental concerns. "We do not have to choose between a clean environment and a healthy economy," Easley said of the

agreement at the time. "We must have both, and this agreement proves that we can have both."

The agreement has the effect of a legal contract. It requires Smithfield Foods and its subsidiaries (representing about 70% of the state's hog industry) to pay \$15 million to fund research and testing of what the agreement calls "environmentally superior technologies." The agreement stipulates a schedule of two years for research and verification, with a report containing recommendations due in July 2002. Smithfield-affiliated farmers then have three years to convert their facilities to the recommended technologies. In addition, the agreement requires Smithfield to pay \$50 million for environmental improvements such as mapping and closing abandoned waste lagoons in the eastern half of the state. The company will also identify wetlands and plan for their protection, and play a leading role in a plan for improving water quality in the region.

The agreement with Smithfield Foods spells out the role of a technology review panel, composed of a wide range of stakeholders,

# to Hog Heaven?

to advise the technology selection process. The process of technology identification and testing is being coordinated by Mike Williams, director of the Animal and Poultry Waste Management Center at North Carolina State University in Raleigh. Williams assembled a panel that, in addition to industry representatives and environmental groups, includes animal waste management experts, officials from the North Carolina Department of Environment and Natural Resources (DENR), a business consultant from the University of North Carolina at Chapel Hill, and an official representative from one of the counties affected by the hog industry.

In response to requests for proposals, Williams received 97 proposals for new technologies. A first round of five technologies got the green light for on-farm testing in February 2001. Most of the technologies are already being studied at the Animal and Poultry Waste Management Center. North Carolina State University has a Web site these technology evaluations at [http://www.cals.ncsu.edu/waste\\_mgt/apwmc/te.html](http://www.cals.ncsu.edu/waste_mgt/apwmc/te.html).

The panel conducted its review of the final proposals after a first-round screening guided by a more conventional anonymous peer review. The panelists approached their work from a range of different perspectives. "We don't always have consensus—we have very diverse stakeholders involved, after all," Williams observes, "but that was the idea." Yet all the panel members agree that there have been few strong disagreements. Joe Rudek, a panel member and a

senior scientist with the Raleigh, North Carolina, office of the public interest group Environmental Defense, notes that the two-layer review went beyond the standard procedure, notwithstanding a challenging schedule. "The time line is very quick," Rudek says. "Mike Williams has worked very hard to get things together."

## Environmentally Superior?

The state agreement stipulates that for a technology to meet the definition of "environmentally superior" it must be technically, operationally, and economically feasible. The environmental criteria include elimination of animal waste discharge to surface water and groundwater. They also include substantial reduction of three elements: atmospheric emissions of ammonia and odorants beyond farm boundaries, release of disease vectors and airborne pathogens,

and soil and groundwater contamination from nutrients and heavy metals.

Measuring some of these factors presents scientific challenges. Methods for measuring odor emissions are controversial because the science of measuring odorants is still in the early stages. Techniques for tracking pathogens in the environment are advancing quickly but have not been standardized. "Pathogens are a relatively new concern with respect to animal waste," says Kim Colson, one of two panelists from the DENR. Colson, supervisor of nondischarge permitting in the DENR's Division of



**Blue lagoons?** Waste lagoons have been a source for contaminants as well as cause for consternation for hog producers and those living near farms.

Water Quality, adds that tracking movement of pathogens in swine waste involves a different set of parameters than for human waste. “The evaluation of the different technologies will be a challenge, be it pathogen emissions, ammonia, or odor,” he says.

During their deliberations, panel members held differing priorities among those criteria. For Rudek, key public health issues included odor, respiratory problems, and airborne pathogens. “Work in North Carolina indicates that the odor is not only a nuisance but that it can also cause health problems,” Rudek says, citing research published in the Spring 1998 issue of the *Journal of Animal Science* by Susan Schiffman, a psychiatrist at Duke University Medical Center, who found that odorants in hog waste can cause psychological stress and irritate nasal passages. On the other hand, odor was not the biggest concern for panel member Don Butler, director of government relations/public affairs for Murphy-Brown LLC, a company that manages production facilities for Smithfield Foods in Warsaw, North Carolina. Says Butler, “When odor complaints are registered, they come to me, and they are almost nonexistent.”

Groundwater and surface water contamination formed perhaps a more central part of the panel’s assessment. After Hurricane Floyd, floodwaters overran hundreds of hog farms, inundating at least 46 waste lagoons in the state’s eastern coastal plain and threatening drinking water and aquatic ecosystems. Compounding this problem was the flooding of several wastewater treatment plants and their sewer systems, which dumped raw sewage into streams.

In the weeks after the hurricane, local health departments in the affected counties monitored water quality. In Duplin County, about 30 of 310 private wells tested at the time contained significant fecal coliform bacteria, a percentage significantly higher than average for eastern North Carolina. Studies by researchers at the University of North Carolina School of Public Health, including one by Otto Simmons presented at the annual meeting of the American Society for Microbiology in May 2000, suggested that fecal coliform levels caused by hurricane-related flooding could pose risks to drinking water supplies in the eastern coastal plain. However, when the Division of Environmental Health of the DENR conducted follow-up tests across the state, it found no significant threats to drinking water quality, according to Malcolm Blalock, the division’s deputy director.

As for threats to ecosystems, post-Floyd studies led by the U.S. Environmental Protection Agency showed that ammonia concentrations in the Neuse River were generally two orders of magnitude higher than at the same places the year before. High nutrient concentrations from farm runoff have been found to cause shifts in behavior of the toxic dinoflagellate *Pfiesteria piscicida*, believed responsible for major fish kills and diseases in North Carolina’s coastal estuaries. Industry officials note, however, that elevated nutrient concentrations in shallow wells can be due to factors other than hog waste, including fertilizer runoff, improperly operating septic tanks, and waste from other types of livestock farming.

Delilah Blanks, a public health expert on the panel who is also a Bladen County commissioner, acknowledges that water quality is perhaps the factor in hog waste treatment that raises the most public concern. “You can see fish kills,” Blanks says. “You can see water discoloration.” Still, Blanks notes that air and water effects are interrelated, and that for a sound scientific assessment of the health effects of hog facilities, more research is needed.

### The Technologies

The technologies selected for testing address these environmental concerns in several ways, adapting practices from other applications for testing in hog facility conditions. “They’ve all been used in other settings,” Colson observes, “but they’re all innovative in this situation.”

With the panel’s input, Williams has selected options designed to give pork producers alternatives suited for a variety of situations. Some of the technologies are centralized systems; for areas with a high concentration of hog farm facilities, these could offer incentives for energy production and favorable economies of scale (that is, it may be more feasible for larger farms

or groups of farms to buy large equipment such as the centralized systems rather than many small pieces of equipment). For areas with scattered hog facilities, decentralized systems need to be relatively easy to operate and adaptable to variable peaks and no-flow phases of waste flow.

The first round of five technologies includes an aerobic biofilter system, a thermophilic anaerobic digester, constructed wetlands, a sequencing batch reactor, and an in-ground digester. Several of the technologies separate waste solids from liquids and use the treated liquid for on-farm functions. According to Butler, none of the new technologies will completely eliminate the need to store some amount of liquid. “It’s not a closed loop,” he says. Some are batch processes, for example, that necessitate storing liquid waste at least temporarily.

**Aerobic biofilter.** One of the more developed technologies in the group is a biofilter that separates solids from liquid waste and then flushes the liquid manure up through two reactor towers, each about 15 ft tall. The towers contain layers of porous plastic that trap the solid waste, whereupon bacteria break down smelly compounds and convert ammonia to nitrates. A second-stage anaerobic polisher then converts the nitrates to nitrogen gas. The system, made by the Cary, North Carolina-based company Ekokan, will be tested on a farm in Bladenboro. There it will replace one of the farm’s two waste lagoons. Compared to the lagoon’s surface of 650 ft × 350 ft, the biofilter uses just 1.6% of the space (60 ft × 60 ft). The treated water will be used to clean the hog houses. A disadvantage is the expected cost: The biofilter is one of the two most



## Suggested Reading

- Agreement on pork problems. *Environ Health Perspect* 106(5):A226–A227 (1998).
- Cochran K, Rudek J, Whittle D. Dollars and sense: an economic analysis of alternative hog waste management technologies. Washington, DC:Environmental Defense, 2000.
- Schiffman SS. Livestock odors: implications for human health and well-being. *J Anim Sci* 76(5):1343–1355 (1998).
- Simmons OD, Meschke JS, Lovelace GL, Wu MJ, Sobsey MD. Fecal contamination of eastern North Carolina ground and surface water following hurricane-associated flooding. In: *ESE Research Notes* (Department of Environmental Sciences and Engineering, School of Public Health, University of North Carolina at Chapel Hill), volume 1, issue 1, 2001.

expensive technologies in the first round, according to preliminary analysis.

**Thermophilic anaerobic digester.** The second technology approved for testing, the thermophilic anaerobic digester, uses an enclosed anaerobic digester to convert waste to methane and carbon dioxide.



The digester, developed by Jason Shih, a professor of biotechnology at the North Carolina State University College of Agriculture and Life Sciences, has already been tested in Taiwan and China. It is one of the few technologies that can eliminate pathogens in wastes, according to one technical review. The gas produced through the decomposition process could then be used to heat greenhouses for growing crops or burned to generate energy, according to outside reviewers. "It's fair to say that I'm skeptical about that one," says Butler, "but I'll keep an open mind."

**Constructed wetlands.** A third option, constructed wetlands, adapts a technique that has been used to treat wastewater in small municipal systems. In constructed wetlands, man-made structures use



the natural filtration processes of wetland vegetation, soils, and microbial interactions to treat effluent. This proven passive treatment system will be tested on a farm in Onslow County. Whereas some of the other candidate technologies may be feasible only for larger facilities, the significantly less expensive constructed wetlands approach may be technically feasible only for smaller facilities; it may not be powerful enough to eliminate pathogens at larger operations. "The footprint gets too big to use in really big applications, where you have a lot of flow," Colson explains.

**Sequencing batch reactor.** Similar to a sludge treatment system, the sequencing batch reactor holds waste in a reaction basin, by turns mixing and aerating it, allowing the solid waste to settle and drain-



ing off the liquid. An outside review notes that the proposal's plan to aerate large amounts of waste in a single tank can be difficult, and pathogen concentrations

measured in a demonstration suggest no improvements over a standard waste lagoon.

**In-ground digester.** The in-ground digester adds the innovation of a waste gas-powered greenhouse to a conventional covered lagoon. Outside reviewers note that this is the most cost-effective method for animal waste treatment already widely in use.



A second round of candidates had been whittled down to 16 finalists by May. Of those, at least five are expected to be approved. According to Williams, the second round of technologies for testing will include further applications for solids separation and anaerobic digestion, as well as nitrification and denitrification, ultrasonic plasma resonance, microturbine technology for recovering energy, belt systems for manure collection (as opposed to flush systems), and ozonation. Among the likely candidates is a separator system created by Super Soil Systems USA that removes 97% of solids so that the liquid can be recycled for use in cleaning the facility or irrigating crops. The solid is made into fertilizer and soil amendment products. Another separator is a screw press that uses gasification to produce two salable products, energy and ash.

### Technologies for Diversification

Economic feasibility for the various processes won't be known until the tests proceed, but a number of them yield one or more by-products (including energy, compost, ash, and fertilizer) that can help defray the added expense of installing the technology. The panel has generally viewed these by-products as promising, but industry representatives and environmentalists agree that questions remain about markets for these products. For example, there are currently no incentives to encourage farmers to generate on-farm energy. "There is no developed market for by-products at this point, and that is a key missing ingredient," says Butler. For example, he says, there is not a big market for compost, and it has little value. "These markets need to be developed," he says.

Rudek suggests that the state may need to implement policies that foster such markets—for example, mandating the state Department of Transportation to purchase compost for roadside landscaping from hog producers. He adds, "There is still the issue of how we get these technologies onto the land and close down the old systems. Right now, no state agency

has the authority or resources to put those pieces together."

Environmentalists and industry members also agree that the verification process, with its July 2002 target for recommendations, faces an ambitious time line. "It's a very, very, very aggressive schedule that's been laid out," says Butler. Given that seasonal variation could affect a number of the technologies, Butler insists that a reasonable assessment can take place only after a full year of operations.

Williams says he will work hard to meet that deadline, but cautions that the reality is that most of the projects are "major construction projects" involving complex approval processes for every step, from design to construction to field operation. Furthermore, each technology involves an array of university, private-sector, and government actors.

"There's a lot at stake," Williams says. "I just want to get the best out of the investment." For him, a process transparent to stakeholder scrutiny is crucial. With that aim, he says he hopes to update the technology evaluation Web site quarterly, perhaps more often.

For Commissioner Blanks, this search for new technologies is a first step in reckoning with the changes in agriculture. Driving to a panel meeting this spring, she was struck anew by the nearby hog facilities. "It's like a small town of nothing but hog houses," she says. "It's not agriculture as we used to know it. We've got to look at it for what it is now."

Although hog farming is still classified as agriculture, it works on a scale that is more industrial, according to Blanks. Blanks explains that North Carolina's laws have historically favored agriculture over industry; as waste flows have increased, that historical situation has made pork producers exempt from environmental standards that they would not meet if pork production were classified as heavy industry.

Now localities face a new set of parameters in development issues. "On one side you have people talking about *health* promotion," Blanks says, "and on the other side you have people talking about *wealth* promotion."

Most panel members agree that testing technical alternatives is just the start of a broader review process that is needed. Once the verification tests are done, it will be up to the people of North Carolina to complete the work of deciding the new face of the state's agricultural sector.

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