COMMONWEALTH of VIRGINIA

Office of the Governor

L. Preston Bryant, Jr.
Secretary of Natural Resources

P.O. Box 1475
Richmond, Virginia 23218

Marilyn B. Tavenner
Secretary of Health and Human Resources

December 22, 2008

TO: The Honorable Timothy M. Kaine
Governor, Commonwealth of Virginia

and

Members, Virginia General Assembly

FROM: L. Preston Bryant, Jr., Secretary of Natural Resources
Marilyn B. Tavenner, Secretary of Health and Human Resources

SUBJECT: Biosolids Expert Panel Report (HJ694 – 2007 Session)

We are pleased to present to you the final report of the panel of experts convened pursuant to HJR 694 (2007).

The Secretary of Natural Resources and the Secretary of Health and Human Resources were tasked with assembling a panel of experts to discuss several broad questions regarding the land application of biosolids and provide recommendations where possible. The questions for discussion posed within HJR 694 included:

1. Are citizen-reported health symptoms associated with the land application of biosolids?
2. Do odors from biosolids impact human health and well-being and property values?
3. To what degree do biosolids-associated contaminants accumulate in food (plant crops and livestock)?
4. To what degree do biosolids-associated contaminants affect water quality?
5. What are the effects of an accumulation of biosolids-associated contaminants in wildlife?

In addition, HJR 694 directed the expert Panel in conducting its study to (i) perform a detailed analysis of the chemical and biological composition of biosolids; (ii) evaluate the toxic potential of biosolid constituents derived from land application to humans, agricultural products,

Patrick Henry Building • 1111 East Broad Street • Richmond, Virginia 23219 • (804) 786-0044 • TTY (800) 818-1120
Fax (804) 371-8333 • Web: www.naturalresources.virginia.gov

soil organisms, and wildlife; (iii) evaluate the capacity of alternative technologies to facilitate the beneficial use of biosolids and their disposal; (iv) determine the availability, costs, and feasibility of technological alternatives to Class B land application; (v) investigate the availability, capital and operations costs, feasibility, environmental and human health impact, and public acceptance of alternative technologies for the beneficial use of biosolids; and (vi) identify and recommend institutional and financial mechanisms for assisting localities in implementing alternative technologies at the state, local, and regional levels.

The Secretary of Natural Resources and the Secretary of Health and Human Resources appointed individuals to the expert Panel based upon their training, education, experience, and knowledge regarding the land application of biosolids. The Panel met twelve times over the course of its deliberations. We wish to thank the Panel members for their commitment and significant effort toward this issue. In addition, several staff members of the Department of Environmental Quality provided an exceptional level of effort regarding staffing the Panel and ensuring that the final report was finalized in time for your review. Their exemplary work has not gone unnoticed.

We must emphasize that the Panel intentionally included a broad range of participants selected for their wide variety of expertise and viewpoints. This diverse Panel membership endeavored to explore a broad range of perceptions, benefits, concerns, and recommendations regarding biosolids land application. This report is the result of those lengthy conversations and reflects the Panel's efforts to consider both the available peer-reviewed scientific literature and the diverse personal and professional opinions and perspectives of the Panelists.

This report is intended to provide you not only with a document responsive to HJR 694 but also one that captures the diverse viewpoints of Panel members who invested valuable time, energy, and resources to inform this process with their opinions. This report should be read with an understanding of that approach and intent. Although numerous scientific studies are referenced or summarized in this report, the report as a whole is not intended to represent an impartial scientific review of the HJR 694 issues. This report in its numerous statements and even in its "Panel Recommendations" reflects varying degrees of agreement or disagreement on individual points. Accordingly, the report contents should not be ascribed to individual Panelists, except where expressly noted as reflecting the viewpoints of a named individual.

We trust that you will find this report helpful for any future biosolids issues you may encounter.

Please let either of us know if you have any questions.

HJR 694 Biosolids Expert Panel
Final Report

December 22, 2008

HJR 694 Biosolids Expert Panel
Final Report

Executive Summary

December 22, 2008

Executive Summary

Legislative Directive
In accordance with House Joint Resolution No. 694, the Secretary of Natural Resources and Secretary of Health and Human Resources convened a Panel of experts in 2007 to study the impact of land application of biosolids on human health and the environment. The General Assembly posed specific questions to the Panel and requested that they consider the typical contaminant concentrations and application rates of biosolids in their responses.

Panel Logistics
The Panel included stakeholders from a broad range of disciplines including medicine, higher education, forestry, agronomy, environmental science, ecology, veterinary medicine and law. Secretary of Natural Resources L. Preston Bryant, Jr., and Secretary of Health and Human Resources Marilyn Tavenner served as co-chairs of the Panel. The Panel met a total of 12 times between September 18, 2007 and November 19, 2008. An informational website with pertinent information regarding its meetings, communications and resources was maintained at www.deq.state.va.us/info/biosolidspanel.html.

Report Content and Intended Use
This report is intended to provide the Virginia General Assembly with a document responsive to HJR 694, but also one that also captures the diverse viewpoints of Panel members who invested valuable time, energy and resources to inform this process with their opinions. This report should be read with an understanding of that approach and intent. Although numerous scientific studies are referenced or summarized in this report, the report as a whole is not intended to represent an impartial scientific review of the HJR 694 issues. This report in its numerous statements and even in its "Panel Recommendations" reflects varying degrees of agreement or disagreement on individual points. Accordingly, the report contents should not be ascribed to individual Panelists except where expressly noted as reflecting the viewpoints of a named individual.

Transfer of Regulatory Oversight from VDH to DEQ
Regulatory oversight of all land application of biosolids from the Virginia Department of Health (VDH) to the Virginia Department of Environmental Quality (DEQ) occurred on January 1, 2008. DEQ provided the Panel with information regarding the new regulatory structure, including compliance and enforcement procedures, and new statutory requirements for biosolids operations and permitting. In the first ten months of the program, DEQ conducted over 1000 inspections and issued six warning letters relating to compliance.

DEQ has formed a Technical Advisory Committee (TAC) to review DEQ regulations pertaining to the land application of biosolids. The Panel recommends that the TAC consider all of the issues and recommendations in the Report that are within the purview of the current DEQ regulatory action.

Summary of responses to the questions raised in HJR 694

1. Are citizen-reported health symptoms associated with the land application of biosolids?

In early discussions, the Panel agreed that addressing the questions surrounding citizen-reported health symptoms should be its highest priority. In the past 18 months, the Panel uncovered no evidence or literature verifying a causal link between biosolids and illness, recognizing current gaps in the science and knowledge surrounding this issue. These gaps could be reduced through highly controlled epidemiological studies relating to health effects of land applied biosolids, and additional efforts to reduce the limitations in quantifying all the chemical and biological constituents in biosolids. While the current scientific evidence does not establish a specific chemical or biological agent cause-effect link between citizen health complaints and the land application of biosolids, the Panel does recognize that some individuals residing in close proximity to biosolids land application sites have reported varied adverse health impacts.

In response to its findings related to this question, the Panel recommends:

a. DEQ formalize a process that clearly defines the roles and responsibilities of agencies in addressing concerns to land applications on the basis of individual health.
b. Additional research should be conducted on the potential relationship between human health and exposure to biosolids.
c. An incident response protocol should be used to systematically collect data regarding citizen complaints.
d. A communication plan should be used to improve communication among all parties involved in or potentially affected by biosolids land application, especially those who believe that their health has been or may be affected by biosolids land application.

2. Do odors from biosolids impact human health and well-being and property values?

Panel members agreed that there is a perceived relationship between odor and health issues and that reducing odor issues will likely reduce concerns about health impacts. The Panel recognizes that odors from biosolids could potentially impact human health, well being and property values, but could not confirm such an impact or the extent of such an impact based on the current body of scientific literature and information presented directly to this Panel.

In response to its findings related to this question, the Panel recommends:

a. The TAC should examine the DEQ regulations pertaining to odor, including considering that municipal biosolids generators be required to have odor control plans.
b. Municipal wastewater treatment facilities should voluntarily implement an Environmental Management System to address quality control issues such as odor.

3. To what degree do biosolids-associated contaminants accumulate in food (plant crops and livestock)?

The response to this question is closely aligned with the additional directive that the Panel "**evaluate the toxic potential of biosolid constituents derived from land application to**

humans, agricultural products, soil organisms, and wildlife." The Panel responses are summarized here simultaneously.

As long as biosolids are applied in conformance with all state and federal law and regulations, there is no scientific evidence of any toxic effect to soil organisms, plants grown in treated soils, or to humans (via acute effects or bio-accumulation pathways) from inorganic trace elements (including heavy metals) found at the current concentrations in biosolids.

Whether there are longer term chronic effects from bioaccumulation of pharmaceutical and personal care products and other persistent organic compounds that might be applied in biosolids is more difficult to measure, and has not been rigorously studied to date. There are gaps in the research to characterize the composition, fate, and effects of these constituents in biosolids, as well as in other products, materials and the environment. Furthermore, the relative importance and risk of these constituents, which have not been fully assessed, and their potential for bioaccumulation in plant crops and livestock are the subject of ongoing research.

In response to its findings related to these questions, the Panel recommends regular review of the research that pertains to biosolids and its fate and transport to livestock and plant crops, with summaries developed that would document any significant new findings.

4. To what degree do biosolids-associated contaminants affect water quality?

The effect of biosolids land application on water quality depends on the rate, timing and location of application and can be minimized or eliminated if applications are made using practices that are in conformance with all state and federal laws and regulations.

A certain amount of nutrient loss, whether through surface runoff or groundwater leaching, is inevitable in farming systems, including those that use biosolids. Nutrient management planning has developed as a means of minimizing potential nutrient losses while maintaining an economically viable farming operation. Virginia biosolids regulations require the use of a nutrient management plan (NMP) to determine the nitrogen (N) and phosphorus (P) applications. Some sites are considered more "environmentally sensitive" to N losses than other sites and have even more stringent timing requirements.

Much of the research to date has been focused on nutrients, pH, and metals, thus much is known regarding how to control the associated water quality effects. However, there is very little research to date on other constituents, their transport mechanisms, and how they might affect water quality. While certain contaminants have been found in land applied biosolids, mere presence will not in itself cause water quality impacts without a means to reach ground and surface waters. Additionally, presence does not indicate danger without a toxic concentration. Transport mechanisms of inorganic nutrients have been studied extensively, but transport of other constituents have not.

In response to its findings related to this question, the Panel recommends:

a. The TAC should examine the DEQ regulations regarding environmentally sensitive sites, mined and disturbed land reclamation, and the methods used to determine the phosphorus application rate.
b. Review and consolidation of recent information on water quality impacts other than those from nutrients. The Panel notes there is ongoing research on this topic.

5. What are the effects of an accumulation of biosolids-associated contaminants in wildlife?

The evidence concerning the impact of biosolids on wildlife is mixed, with some studies indicating a positive effect on wildlife populations as a result of the use of biosolids to restore wildlife habitat, as well as minimal impact on forest small mammal populations due to heavy metal contamination from the application of biosolids for silvicultural purposes. However, other studies have suggested potential long-term negative health, reproductive, behavioral and population viability impacts from the exposure to compounds and contaminants that are ubiquitous in multiple environmental media including biosolids. There are few studies or field trials that have investigated the above listed impacts of these contaminants on wildlife from biosolids land application.

In response to its findings related to this question, the Panel recommends research to investigate potential acute and chronic health impacts of biosolids on wildlife. Additionally, research should be regularly reviewed that pertains to biosolids and its effects on wildlife, with summaries developed that would document any significant new findings.

HJR 694 also directed the Panel to take the following additional steps in conducting their study:

Perform a detailed analysis of the chemical and biological composition of biosolids.
The Panel was limited in the performance of this task considering no funding was available to conduct new analyses. The vast number of constituents in biosolids combined with the specialized analytical methodologies to detect and quantify these constituents involves significant cost. Thus the Panel relied on existing data.

In an effort to gather information on the biosolids material being land applied in Virginia, the expert Panel sent a request to wastewater treatment plants that generate biosolids land applied in Virginia. The results of this survey demonstrate that an extensive history of the compliance regarding levels of regulated parameters is available. Information on non-regulated parameters is limited, although it was noted that in the small data set obtained by the Panel, the levels of most of these other parameters were non-detectable based on the sensitivity of the analytical methodology.

The complete results of the latest US EPA limited biosolids survey are expected to be released by the end of calendar year 2008. This survey will report on the concentrations of 145 chemical constituents in biosolids.

To support research being conducted in response to questions regarding biosolids effects on human health, wildlife, or water quality, the Panel suggests that DEQ inspectors could be utilized to gather samples.

Alternative Technology

HJR 694 also directed the Panel to investigate the capacity of alternative technologies to facilitate the beneficial use of biosolids and their disposal. The Panel discussed many different technologies and the benefits and detractors of each. The Panel noted that adoption of alternative technologies is often hindered by cost and lack of performance history.

The Virginia Biosolids Council held a Biosolids Technology Forum in September, 2008 to explore new technology. The notes from that forum are attached as an attachment to this report.

The Panel recommends that additional research and engineering analyses of alternative technologies is needed to fully evaluate the risk-benefit and cost-benefit. The institutional and financial mechanisms that should be considered when implementing or investigating alternative technologies include federal government agencies, state financial incentives in cooperation with local governments, partnering with private companies, and research foundations. Incentives for conducting pilot studies of alternative technology also should be investigated. Public-private partnerships and development of a state or regional project should be explored.

Additional Panel Considerations

The Panel recommends that the fees collected from municipal wastewater treatment plants to fund the biosolids permitting, compliance and enforcement program should be continued in order to provide assurance that the regulations that protect human health and the environment are followed.

HJR 694 Biosolids Expert Panel
Final Report

INTRODUCTION

Legislative Directive

In accordance with House Joint Resolution No. 694, the Secretary of Natural Resources and Secretary of Health and Human Resources convened a Panel of experts in 2007 to study the impact of land application of biosolids on human health and the environment. The General Assembly posed specific questions to the Panel and requested that they consider the typical contaminant concentrations and application rates of biosolids in their response to the following questions:

1. Are citizen-reported health symptoms associated with the land application of biosolids?
2. Do odors from biosolids impact human health and well-being and property values?
3. To what degree do biosolids-associated contaminants accumulate in food (plant crops and livestock)?
4. To what degree do biosolids-associated contaminants affect water quality?
5. What are the effects of an accumulation of biosolids-associated contaminants in wildlife?

The Panel also was asked to (i) perform a detailed analysis of the chemical and biological composition of biosolids; (ii) evaluate the toxic potential of biosolids constituents derived from land application to humans, agricultural products, soil organisms, and wildlife; (iii) evaluate the capacity of alternative technologies to facilitate the beneficial use of biosolids and their disposal; (iv) determine the availability, costs, and feasibility of technological alternatives to Class B land application; (v) investigate the availability, capital and operations costs, feasibility, environmental and human health impact, and public acceptance of alternative technologies for the beneficial use of biosolids; and (vi) identify and recommend institutional and financial mechanisms for assisting localities in implementing alternative technologies at the state, local, and regional levels.

Panel Membership

The Panel included stakeholders from a broad range of disciplines including medicine, higher education, forestry, agronomy, environmental science, ecology, veterinary medicine and law. The individuals selected to serve on the expert Panel are as follows:

- Ralph O. Allen, Ph.D., Professor, Director, Office of Environmental Health and Safety, University of Virginia School of Medicine
- Russell W. Baxter, Deputy Director, Virginia Department of Conservation and Recreation
- Robert Call, M.D., Medical practitioner, Allergy Specialist
- Jerre Creighton, Research Program Manager, Virginia Department of Forestry
- W. Lee Daniels, Ph.D., Professor, Department of Crop and Soil Environmental Sciences, Virginia Tech

- Barry Dunkley, P.E., Director of Utilities, City of Danville
- Greg Evanylo, Ph.D., Professor, Department of Crop and Soil Environmental Sciences, Virginia Tech
- Susan Fischer Davis, M.D., Deputy Director, Office of Epidemiology, Virginia Department of Health
- Tom Fox, Ph.D., Associate Professor, Department of Forestry, Virginia Tech
- Rima B. Franklin, Ph.D., Assistant Professor, Department of Biology, Virginia Commonwealth University
- James J. Golden, Deputy Director for Program Development, Virginia Department of Environmental Quality
- Robert Hale, Ph.D., Professor, School of Marine Science, Virginia Institute of Marine Science
- Scott P. Johnson, M.P.A., Commissioner's Office, Virginia Department of Agriculture and Consumer Services
- Howard Kator, Ph.D., Associate Professor, Chair, Department of Environmental and Aquatic Animal health, Virginia Institute of Marine Science
- Mark Levine, M.D., MPH, Director, Henrico County Health Department, Virginia Department of Health
- Karen Pallansch, CEO, Alexandria Sanitation Authority
- Christopher Peot, P.E., Manager, Biosolids Management Division, DC Water and Sewer Authority
- Alan B. Rubin, Ph.D., Consultant (Principal, Envirostrategies, LLC)
- Jonathan Sleeman, VetMB, Dipl. ACZM, MRCVS, Wildlife Veterinarian, Virginia Department of Game and Inland Fisheries
- Henry Staudinger, JD, Citizen representative
- R. Leonard Vance, Ph.D., JD, Associate Professor, Department of Epidemiology and Community Health, Virginia Commonwealth University School of Medicine

Secretary of Natural Resources L. Preston Bryant, Jr. and Secretary of Health and Human Resources Marilyn Tavenner served as co-chairs of the Panel.

Additional experts provided the Panel with information on specific topics with presentations and interaction with the Panel at several meetings. These persons and the topic of their presentations are listed below:

- Robert K. Bastian, US Environmental Protection Agency: Development of the federal biosolids regulations and risk assessment
- Thomas Maestri, Director of Business Development, Synagro Technologies, Inc.: Overview of Class A, Thermal, and Developing Technologies for Biosolids Treatment
- Mike Newman, Virginia Institute of Marine Science: Ecological Risk Assessment
- Russ Perkinson, Assistant Director, Division of Soil and Water Conservation, Department of Conservation and Recreation: Virginia's Nutrient Management Program
- Steve Wing, Associate Professor, University of North Carolina School of Public Health, Complaint Response Protocol

Panel Guidance
During the first meeting of the Panel on September 18, 2007, Secretary of Natural Resources Bryant observed that there already exists much scientific peer-reviewed literature and research. The Secretary directed the Panel to focus only on that which is most applicable to biosolids land application in Virginia. He noted that there is great interest in biosolids from both a health and environmental perspective. Secretary of Health and Human Resources Tavenner noted that the Resolution is about perceived, as well as real, health issues related to the use of biosolids. The Panel's recommendations were prepared in accordance with the Secretaries' guidance.

Panel Meetings
After the initial meeting on September 18, 2007, the Panel decided to split into two workgroups, one focusing on health issues and the other focusing on environmental issues. Several Panel members elected to serve on both workgroups. As the Panel's work progressed, the workgroup sessions were discontinued and after the January 23, 2008 individual workgroup meetings, all subsequent meetings of the Panel were full Panel sessions. There were a total of seven meetings of the full Panel, three meetings of the environment workgroup, and two meetings of the health workgroup. The final meeting of the Panel was held on November 19, 2008.

On September 24, 2008, the Panel participated in a field trip to the Henrico County Water Reclamation Facility. During the trip, the Panel had the opportunity to tour the various components of a wastewater treatment facility as well as observe a demonstration of biosolids land application at a nearby farm.

Panel Communication
The Panel offered an opportunity at the end of each meeting for the public to provide comment. On several occasions, citizens presented prepared comments or responses to the discussions of the Panel heard that day. A total of 28 citizens provided oral comment over the course of the Panel meetings. The comments included both support and criticism of the practice of biosolids land application.

Public notice for Panel meetings was posted on the Virginia Town Hall website. In addition, a website dedicated to the work of the Panel was developed. This website was located within DEQ's website, at www.deq.state.va.us/info/biosolidspanel.html. The website included meeting minutes, correspondence from Panel members, correspondence from the public, and links to related technical information.

The website served as a means for Panel members to share technical information. Members provided various documents related to biosolids regarding safety, metals, wildlife, health concerns, nutrients, unregulated compounds, pathogens, and other topics and issues. Correspondence between Panel members also was posted in certain instances to enhance communication.

The website also allowed the public an opportunity to express their views regarding biosolids as well as the ongoing work of the Panel. Due to the sensitive nature of personal health information that was provided by the public, guidelines were developed to control the posting of such correspondence, requiring permission from persons that submitted personal information.

Report Development and Intended Use

The Panel intentionally included a broad range of participants selected for their wide variety of expertise and viewpoints. This diverse Panel membership endeavored to explore a broad range of perceptions, benefits, concerns, and recommendations regarding biosolids land application. This report is the result of those lengthy conversations and reflects the Panel's efforts to consider both the available peer-reviewed scientific literature and the diverse personal and professional opinions and perspectives of the Panelists.

This report is intended to provide the General Assembly with a document responsive to House Joint Resolution 694, but one that also captures the diverse viewpoints of Panel members who invested valuable time, energy and resources to inform this process with their opinions. This report should be read with an understanding of that approach and intent. Although numerous scientific studies are referenced or summarized in this report, the report as a whole is not intended to represent an impartial scientific review of the HJR 694 issues. This report in its numerous statements and even in its "Panel Recommendations" reflects varying degrees of agreement or disagreement on individual points. Accordingly, the report contents should not be ascribed to individual Panelists except where expressly noted as reflecting the viewpoints of a named individual.

Lastly and most importantly, the Panel would like to take this opportunity to publicly recognize the hard work of DEQ staff in facilitating Panel meetings and in developing this report. The dedication of these DEQ employees, most notably Neil Zahradka, Angela Neilan, and Christina Wood, cannot be overstated.

BIOSOLIDS PROGRAM UPDATE

Statute and Regulation

House Bill 2802 and Senate Bill 1339 were passed in the 2007 session of the Virginia General Assembly. These bills transferred regulatory oversight of all biosolids land application from the Virginia Department of Health (VDH) to the Virginia Department of Environmental Quality (DEQ).

At its September 25, 2007 meeting, the State Water Control Board (SWCB) adopted a "final exempt" regulatory action to transfer VDH Biosolids Use Regulations to DEQ's Virginia Pollution Abatement (VPA) (9VAC25-32), Virginia Pollutant Discharge Elimination System (VPDES) (9VAC25-31), Sewage Collection and Treatment (9VAC25-790), and Fee regulations (9VAC25-20) currently administered by the SWCB. In this same regulatory action, new statutory requirements passed by the 2007 General Assembly also were incorporated into DEQ regulation. At its July 29, 2008 meeting, the SWCB voted to repeal the Biosolids Use Regulations at 12 VAC 5-585, as these regulations were superseded by the adoption of the amendments to the SWCB regulations.

While enactment clause number 4 of HB 2802 and SB 1339 allowed existing VDH land application permits to remain in effect, the VPA regulations required all current holders of VDH permits to follow the operational requirements found in the VPA regulations.

DEQ has formed a Technical Advisory Committee (TAC) to review DEQ regulations pertaining to the land application of biosolids. The TAC held its first meeting on October 3, 2008 to begin the participatory process to consider further changes to the regulations. The Panel recommends that the TAC consider all of the issues and recommendations in the Report that are within the purview of the current DEQ regulatory action.

Regulatory Oversight

Beginning January 1, 2008, DEQ assumed regulatory oversight of all land application of biosolids in the Commonwealth. As of October 25, 2008, DEQ had filled 18 full time positions dedicated to the proper management of biosolids. The majority of these positions are located in the seven regional office locations throughout the Commonwealth and filled by biosolids inspectors who focus on monitoring and enforcing biosolids regulations, as well as responding to concerns from the public.

Unannounced inspections of land application sites, as mandated by statute, began on January 7, 2008. In the first ten months of the program, 1089 inspections had been conducted. The inspections occurred before, during and after application of biosolids, with particular emphasis on being present as many times as possible when biosolids spreading was in progress. In this same time period, DEQ staff inspected 58 percent of the fields and 84 percent of the farms where biosolids were spread in Virginia, with 81% of the farm inspections occurring during biosolids applications. An inspection report was prepared for each visit to a land application site. Six warning letters were issued for problems identified by inspectors including inadequate adherence to buffer provisions and failure to comply with nutrient management plan requirements. Compliance with the regulatory requirements was achieved in these cases without formal enforcement action.

DEQ staff evaluates the biosolids inspection program in an effort to achieve continual improvement. Guidance development and inspector training are used to ensure evaluation of permitted activities is consistent statewide. Regulatory interpretations are a particular focus since DEQ did not develop most of the existing biosolids permits and regulations.

Operational Requirements

Biosolids application timing, amounts, buffers, and other field operational parameters must meet the DEQ regulatory standards as well as those of the Virginia Department of Conservation and Recreation (DCR). Nutrient management plans (NMPs) are now required for all land receiving biosolids, and must be prepared prior to land application. Virginia law requires that NMPs must be written by a person certified by DCR (§ 62.1-44.19:3.C.8 of the *Code of Virginia*). DEQ coordinates with DCR regarding compliance issues associated with nutrient management planning.

Virginia law requires that all persons land applying Class B biosolids must be a certified land applier (§ 62.1-44.19:3.1 of the *Code of Virginia*). Initiated by VDH in 2007, DEQ continued

this training and certification program that emphasizes regulatory compliance. As of the date of this report, 114 persons had been certified as biosolids land appliers in Virginia.

DEQ collects fees from the permit holder land applying the material in the amount of $7.50 per dry ton of biosolids land applied. The permit holder collects this fee from the producer of the biosolids. Land application of biosolids that meet the requirements to be classified as "exceptional quality biosolids", including biosolids meeting Class A disinfection limits, are exempt. The fee helps fund the biosolids regulatory functions of DEQ and DCR, as well as local government monitoring programs. DEQ collected over $1,250,000 in fees in the first ten months of the program.

Permitting
New land application sites must be acquired through the issuance or modification of a DEQ VPA or VPDES permit. The permitting process includes all of the new statutory provisions regarding public notice. These requirements include public meetings for new permits, adjacent resident notification for addition of sites to an existing permit, as well as existing VPA and VPDES requirements for public notice of draft permits and opportunities to request public hearings.

Local monitor program
In the past, some localities chose to employ a local monitor to inspect biosolids activities in a manner very similar to that of a DEQ inspector. According to statutory provisions, DEQ reimburses these localities for this work. As of October 31, 2008, DEQ had reimbursed 14 counties for local monitor expenses. Current projections estimate that approximately $90,000 of the fees collected from biosolids land application will be reimbursed to local monitors for activities occurring in calendar year 2008. Local monitors have participated in training sessions offered by DEQ, including inspection procedures, nutrient management planning for biosolids, and odor science.

Coordination with VDH
DEQ currently relies upon the medical expertise at VDH regarding response to health complaints and concerns. VDH local district health directors are involved with investigation of specific complaints and evaluation of site specific permit conditions related to biosolids land application.

DEQ staff evaluates the procedures related to response to health complaints in an effort to achieve continual improvement.

RESPONSE TO THE QUESTIONS RAISED IN HJR 694

1. Are citizen-reported health symptoms associated with the land application of biosolids?

Panel Discussion
In early discussions, the Panel agreed that addressing the questions surrounding citizen-reported health symptoms should be its highest priority. In the past 18 months, the Panel uncovered no evidence or literature verifying a causal link between biosolids and illness, recognizing current gaps in the science and knowledge surrounding this issue. These gaps could be reduced through

highly controlled epidemiological studies relating to health effects of land applied biosolids, and additional efforts to reduce the limitations in quantifying all the chemical and biological constituents in biosolids. While the current scientific evidence does not establish a specific chemical or biological agent cause-effect link between citizen health complaints and the land application of biosolids, the Panel does recognize that some individuals residing in close proximity to biosolids land application sites have reported varied adverse health impacts.

The Panel was presented with comments from Virginia residents in regard to their concerns about biosolids and the alleged negative impact on their health. These comments were presented in person as well as through written or videotaped submissions. Some commenters included statements from their personal physicians recommending no exposure to biosolids. While the physician statements were professional opinions, they provided no scientific cause and effect evidence that health symptoms were related to biosolids. The Panel considered all concerns and discussed them at length.

The Panel also received comments, both in person and by mail, from farmers who manage and live adjacent to fields that have received biosolids, some for many years. These farmers reported no ill effects to themselves, their families or their livestock.

While the Panel received comments reporting both negative and neutral impact, they could not determine whether the number of commenters accurately represented the universe of affected stakeholders. To better evaluate comments regarding biosolids, Panel member Dr. Ralph Allen proposed conducting a survey by medical doctors enrolled in one of his classes. The survey would have targeted persons who claimed negative effects as well as those who claimed no effect. There was disagreement among Panel members as to how much information should be collected from survey respondents. In order to include the medical information some Panel members felt was necessary, the project would have required approval from the university medical board. The survey was not conducted due to the approvals necessary and the limited time the medical students would be available.

Reports of health symptoms originated from individuals who believe that they were exposed to biosolids constituents and the related odors, via an airborne route as a result of residing in close proximity to biosolids land application sites. Reported health symptoms included an exacerbation of pre-existing health conditions, new symptoms or a decreased overall feeling of well being. The Panel discussed that citizens seem to be more concerned about exposure through airborne transmission, often characterized by odor, rather than transport through soil or water. Some did, however, express concern about contamination of old or poorly constructed wells through runoff. The Panel found that the reports tend to focus on a select group of individuals, conditions, or circumstances.

The Panel also received the VDH report *Health Effects of Biosolids Applied to Land: Available Scientific Evidence* (Jenkins et al., 2007) that represents a review of the current scientific literature about biosolids and human health and draws, among others, the following conclusion:

> *Although much still needs to be learned about the content, bioavailability and fate of chemicals and pathogens in biosolids and their health effects, there does not*

seem to be strong evidence of serious health risks when biosolids are managed and monitored appropriately. Human health allegations associated with biosolids usually lack evidence of biological absorption, medically determined human health effects, and/or do not meet the biological plausibility test. (p. 25)

The scientific evidence of which the Panel is aware (much of which is listed on the Panel's website at www.deq.virginia.gov/info/biosolidspanel.html) does not document a specific chemical or biological agent link between citizen health complaints and the land application of biosolids. The Panel reviewed a number of scientific reports and studies from across the country that relate to this question and discussed the issue in considerable detail. The following are selected summaries from the research:

- A group of scientists reviewed the most recent study to be released on the health impacts of biosolids. In their summary, "A Review of a Health Survey of Residents Living Near Farm Fields Permitted to Receive Biosolids," this group of scientists wrote: "While there have not been any scientifically-documented cases of illnesses caused by biosolids, there have been a number of scientific studies that demonstrate the difficulty of transmitting biosolids-related diseases or illnesses through the air." In this summary the scientists note specifically research by Rusin et al.(2003), Brooks, et al. (2005), and Dowd et al. (2000).

- Writing for the American Society of Agronomy, Crop Science of America, and Soil Science of America (Pepper et al., 2008), stated the following: "The conclusion we have reached, based on all of our land application studies over the past two decades and an in-depth review of other relevant land application studies, is that land application of Class B biosolids is sustainable. Specifically, the risks to human health posed by microbiological entities within biosolids have been shown to be low if current USEPA regulatory guidelines are followed. In addition, risks from indirect exposures, such as aerosolized pathogens or contaminated groundwater appear to be particularly low."

- A study by Tanner et al, published in the November 2008 *Journal of Environmental* Quality concluded that the risks to land application workers from aerosolized microorganisms from biosolids is extremely small, even less than those of workers in wastewater treatment plants, whose health has been shown to be comparable to the general population. The findings are significant, since land application workers are typically exposed to biosolids on a daily basis, compared to rural populations, which typically are exposed to aerosolized constituents, if at all, for only a few hours every few years.

  The authors (Tanner et al., 2008) conclude that the potential for transport of aerosolized microorganisms is slight: "It has been well-documented that microorganisms subjected to any substantial transport through air, such as would be required to reach a population center, undergo rapid inactivation due to environmental factors such as ultraviolet light and desiccation" (Brooks et al., 2005; Peccia et al., 2001; Teltsch et al., 1980).

Other members of the scientific community, without substantial scientific data related to biosolids, hypothesize about the plausibility of airborne transmission by borrowing from other research fields.

An example of such a contrasting viewpoint is that the virus that causes Foot and Mouth Disease (FMD) in livestock can be carried by wind-borne aerosols for up to 60 km overland under the correct environmental conditions (United States Animal Health Association, 2008). While the Panel found no studies documenting the presence of the FMD virus in biosolids, the argument presented is that the aerosol route might be a possible means of pathogen transport.

The Panel conducted a literature review of epidemiological studies related to biosolids (www.deq.virginia.gov/info/biosolidspanel.html) and found that the limited studies available reflected a low probability of risk. However, the Panel recognized that there are significant limitations to the studies and conflicting scientific research associated with biosolids and alleged health effects.

An example of research that speaks to potential causes of health symptoms comes from Duke University researcher Susan Schiffman, who has identified three mechanisms by which odors may produce health symptoms: (1) reaction to the odor may simply be a learned or innate (genetically coded) aversion, (2) there may be an actual irritant present and the odor just serves as a marker and (3) there is a copollutant (such as an endotoxin) that is a part of the mixture. (Schiffman and Williams, 2005). While research into the psychology of odors appears to be limited, there are studies indicating that odors can provoke symptoms of illness in some individuals who associate those odors with illness or with environmental threats.

The Panel agrees that the evaluation of reported health symptoms believed to be associated with exposure to biosolids may require the involvement of medical professionals. Part of a medical assessment should include physician recommendations about limiting exposure to biosolids if there is a basis for associating such exposure with an individual's health complaint or problem. Some Panel members proposed the possibility that biosolids could trigger respiratory symptoms in a similar manner to mold and other asthma triggers; however, there are currently no epidemiological studies addressing exposure to land applied biosolids as a trigger for respiratory symptoms. Assessment of health complaints by medical professionals may help define the scope of perceived or real health issues related to exposure to biosolids among Virginia citizens.

The Panel recommends establishing procedures for the Virginia biosolids program and industry to respond to concerns from individuals who report illness they believe is related to exposure to biosolids. The Panel recommends that DEQ, VDH, the municipal biosolids generators, the land application contractors, the receiving farmers and farmers' neighbors should work together in a cooperative and consultative manner to seek reasonable accommodations to the concerns of neighbors, and develop these procedures and responses while balancing the legitimate interests of all parties and ensuring the orderly and efficient management of the program.

The Panel makes the following recommendations based on the discussion above:

Panel recommends: In the past 18 months, the Panel uncovered no evidence or literature verifying a causal link between biosolids and illness, recognizing current gaps in the science and knowledge on this issue. The Panel recognizes that persons who report a chronic or acute illness may have more concern about a proposed land application. The Panel therefore recommends that DEQ formalize a process that clearly defines the roles and responsibilities of agencies in addressing concerns to land applications on the basis of individual health. Included in this consideration should be evidence provided by private practice physicians who are treating patients living adjacent to a proposed land application site, including patient medical history, diagnosis and treatment, and other clinical experience and medical literature relevant to the patient's individual situation.

With the expectation of a reasonable outcome for all involved, DEQ should develop and provide the tools for implementing this recommendation, relying on the TAC for detailed regulatory guidance.

The Panel did not reach consensus on specific recommendations, but discussed the following potential tools to address reported health concerns:

- Buffers
- Temporary relocation during application
- Injection or incorporation
- Other appropriate measures

Panel Recommends: Research to study the potential relationship between human health and exposure to biosolids, such as a well designed, highly controlled epidemiological study to determine if there is a statistically significant link between biosolids exposure and health symptoms. The study also should attempt to:

1. determine current and emerging constituents and irritants in biosolids
2. identify the exposure mechanism
3. identify the exposure pathway
4. determine the duration of the exposure needed to impact human health
5. identify the exposure response

Panel Recommends: The Virginia biosolids program should implement an "Incident Response Protocol" for systematically collecting data relating to citizen complaints and maintaining a record for each case. Professor Steve Wing, from the University of North Carolina, addressed the Panel regarding his involvement in developing such a protocol and detailed the benefits and limitations it could provide.

Implementing a protocol can not be undertaken without a significant amount of funding dedicated to the project. A recent research project sponsored by WERF included an award of $400,000 to develop an incident response protocol. This award included money for lab analyses, staff hiring, interim and final reports, and several other items that would not be necessary if

implemented with existing staff and for data collection purposes. WERF officials estimate that to implement a finalized protocol with existing staff would cost approximately $25,000 to $50,000.

The protocol should collect data that may be used to:

1. track and categorize heath complaints and document the health of complainants over several years
2. show statistical trends in quantity and type of complaints
3. provide areas of focus for further study
4. distinguish between complaints alleging health impacts and those expressing other concerns
5. distinguish between complaints that occur before and after application
6. provide additional information to corroborate a complaint, such as reports from multiple individuals, weather conditions or other factors influencing objectivity.

The biosolids program should make use of the existing WERF protocol development work in establishing a procedure for use in Virginia. Health expertise will be needed to assist in this program, either from VDH, or private or academic medical professionals.

Panel Recommends: The Virginia biosolids program should include a communication plan to improve communication among all parties involved in or potentially affected by biosolids land application, especially those who believe that their health has been or may be affected by biosolids land application. A solid communication plan also will facilitate the collection of data which may help answer the question "Are reported health symptoms associated with the land application of biosolids?"

At a minimum, the communication plan should include the following entities and define their roles in biosolids management:

a. DEQ
b. VDH
c. DCR
d. Local Monitors
e. Local Governments
f. Municipal biosolids generators
g. Land Application Contractors
h. Citizens
i. Farmers
j. Virginia Cooperative Extension
k. Virginia Department of Agriculture and Consumer Services: for "exceptional quality" biosolids
l. Virginia Department of Mines, Minerals and Energy: for mined land reclamation
m. Virginia Department of Forestry: for silviculture applications

The plan should address issues associated with operational communication including improved, proactive public notification and response to public comment during permit development, and notification of neighbors prior to application, including adequate signage. The communication plan should require that adequate advanced notice of a planned biosolids land application project be provided so that those who have specific health concerns have adequate time for review by the regional Health Department. A protocol for effective, timely communication between involved agencies and the public should be included.

The roles that DEQ, VDH, or other entities play in regard to complaints should be defined. For example, analysis of a health complaint needs to involve a medical professional, while an environmental complaint should involve DEQ. A Standard Operating Procedure for communicating with a health expert or medical professional is important when a health complaint is received. Odor or nuisance complaints may involve multiple agencies. The communication plan should clearly define the authority of each agency and what possible tools the agency could use to address the complaint, including which agencies have the authority to stop an application.

This plan should provide for clear procedures that citizens can use to voice their concerns or complaints and a defined period for consideration of such information in order to ensure an efficient and effective permitting process. Predictability of the complaint process is important for citizens as well as the municipalities and business associated with biosolids land application. Providing one central phone number for citizen complaints may serve to simplify this process.

Panel Recommends: DEQ and VDH should regularly review biosolids research and provide a summary to the Secretary of Natural Resources and the Secretary of Health and Human Resources. A formal relationship between the state agencies and Virginia universities may help facilitate acquisition and technical review of relevant new research. Biosolids land appliers and generators also should be encouraged to submit new findings relevant to protection of health and the environment. These reports would document any significant new findings and include strategies to communicate current knowledge about biosolids and health to the public.

2. Do odors from biosolids impact human health and well-being and property values?

Panel Discussion

Panel members agreed that there is a perceived relationship between odor and health issues and that reducing odor issues will likely reduce concerns about health impacts. The Panel recognizes that odors from biosolids could potentially impact human health, well being and property values, but could not confirm such an impact or the extent of such an impact based on the current body of scientific literature and information presented directly to this Panel.

The Panel received comments from individuals relating to health effects and biosolids odors. The most commonly reported complaint about biosolids is related to odor, as documented by the VDH and DEQ. An informal review of the complaint record maintained by the VDH from 2004 through 2007 indicated that odor complaints averaged about 26 per year. DEQ received 29 complaints about odor during the first ten months of 2008, out of a total of 79 documented

complaints. Many of these complaints were received prior to an actual land application of biosolids in anticipation of malodors. An informal review of the resolution of these complaints indicated that in most cases VDH inspectors and/or the local biosolids monitors reported that the odors they observed were considered typical for properly treated biosolids, and were not particularly malodorous. In investigating odor complaints during 2008, DEQ inspectors found no instances of permit non-compliance related to the land application procedures that would have caused odor problems, and no formal or informal compliance actions have been initiated to address the regulatory requirement that biosolids shall not have nuisance odors. The Panel did not explore the DEQ regulatory standards for odor.

Odors from volatilized ammonia and reduced sulfur compounds are the most noticeable irritants from land-applied biosolids and are usually most noticeable during actual application. These odors generally dilute with distance and dissipate over time.

Not all biosolids have malodor, i.e. offensive odors. Well managed biosolids production and land application can prevent and mitigate odor problems. Poorly managed biosolids production and land application can create malodors. Malodors also may occur during handling, transporting and storage of biosolids.

Biosolids generators serving Virginia and their land application contractors have implemented quality control procedures and best management practices in an effort to prevent malodorous biosolids from being transported to the field and from being applied if they do arrive. Malodorous loads may be rejected and transported back to the generator for additional processing or to a landfill for disposal. Malodors can be an indicator that regulatory requirements for the treatment of biosolids have not been met. DEQ field inspectors and the local biosolids monitors are authorized to halt any land application that does not meet state regulations regarding treatment.

Wastewater treatment plants and land application contractors should use current technology and best management practices to reduce odors from land application of biosolids. As the Panel learned during its visit to the Henrico Water Reclamation Facility and the nearby biosolids land application demonstration, there have been significant advances in technology and processes to reduce odor and its migration off site.

The issue of a perceived impact of biosolids on an individual's quality of life is more difficult to assess, since the "quality of life" is subjective and self-defined. The Panel believes there are common sense and practical approaches to such quality of life issues, which are addressed in the recommendations.

The Panel determined that it did not have the resources to undertake a valid study of the impact of biosolids on property values. Two Panel members volunteered to investigate the property value issue to determine if such an association existed. These two members worked with the Virginia Association of Realtors to conduct an on-line survey, which produced results that the Panel considered inconclusive based on sample selection and validity of the questions asked. The Panel could not make any determination as to whether or not biosolids odors had any impact on property values.

Panel members discussed the possibility of initiating a new general permit for municipal biosolids generators that would include a substantive outreach program with the hosting community to deal with malodorous biosolids and how this material would be managed on site. The general permit could require an odor control plan and site inspections. The odor control plan should ensure that the generator is looking at critical control points to minimize odors, and has a communication plan in place to minimize impact on persons who might smell the odors. A voluntary Environmental Management System (EMS) program also could be developed by DEQ, similar to the current Virginia Environmental Excellence Program (VEEP). Municipal biosolids generators participating in the EMS would improve the biosolids product, resulting in less odor.

The Panel makes the following recommendations based on the discussion above:

Panel Recommends: The following concepts should be considered by the TAC in making their recommendations regarding changes to DEQ biosolids regulations:

1. Currently DEQ has the statutory authority to apply site-specific conditions to land application permits at the time of issuance (§62.1-44.19:3.E of the *Code of Virginia*). This allows DEQ to accommodate neighbors of farmland permitted to receive biosolids by expanding, if appropriate, the standard buffers from property lines and occupied dwellings. DEQ staff should consider odor issues and concerns when permitting sites and regulating the application at permitted sites. The TAC should examine the DEQ regulations pertaining to this issue.

2. Odor issues and concerns should be considered in the development of buffer distances. The TAC should examine the DEQ regulations pertaining to this issue.

3. DEQ is required to have procedures in place for receiving and responding to public comments on permit applications or amendments (§62.1-44.19:3.C.10 of the *Code of Virginia*). The TAC should examine the DEQ regulations pertaining to this issue.

4. The Panel notes that DEQ has the statutory authority to establish site-specific permit conditions, including expanded buffers, to minimize the impact on odor-sensitive receptors (§62.1-44.19:3.O. of the *Code of Virginia*). The statute also states that incorporation of the biosolids into the soil may be required when practicable and compatible with a soil conservation plan (§62.1-44.19:3.N. of the *Code of Virginia*). The TAC should examine the DEQ regulations pertaining to this issue.

6. By regulation, DEQ could require any generators of biosolids who land apply in the state to have odor control plans. These plans would include elements to both minimize odors through wastewater plant processes and to minimize application of odorous biosolids in the field through appropriate communications. DEQ could preclude application of biosolids from any generator who does not have odor control plans. The TAC should examine the DEQ regulations pertaining to this issue.

Panel Recommends: That treatment facilities voluntarily use an EMS to address such quality considerations such as odor. An EMS encourages a participant, the generator in this case, to document its environmental performance, surpass minimum regulatory requirements and strive for continual improvement. The VEEP provides wastewater agencies with incentives for actions that go beyond regulatory requirements. DEQ should investigate ways that self-improvement protocols for biosolids production and recycling can be incorporated into Virginia's existing VEEP. Incorporating elements of a biosolids EMS within VEEP would provide Virginia's wastewater treatment agencies with meaningful incentives to effectively manage biosolids production to mitigate malodors.

3. To what degree do biosolids-associated contaminants accumulate in food (plant crops and livestock)?

Panel Discussion

As long as biosolids are applied in conformance with all state and federal law and regulations, (e.g., within contaminant limits, loading rate constraints, application site criteria, site access restrictions), there is no scientific evidence of any toxic effect to soil organisms, plants grown in treated soils, or to humans via bio-accumulation pathways from inorganic trace elements (including heavy metals) found at the current concentrations in biosolids.

Whether there are longer term chronic effects from bioaccumulation of pharmaceutical and personal care products (PPCPs) and other persistent organic compounds that might be applied in biosolids is more difficult to measure, and thus has not been rigorously studied to date. There are gaps in the research to characterize the composition, fate, and effects of these constituents in biosolids, as well as in other products, materials and the environment. Furthermore, the relative importance and risk of these constituents, which have not been fully assessed, and their potential for bioaccumulation in plant crops and livestock are the subject of ongoing research.

The Panel makes the following recommendations based on the discussion above:

Panel Recommends: DEQ should regularly review research that pertains to biosolids and its fate and transport to livestock and plant crops. DEQ, in consultation with the Virginia Department of Agriculture and Consumer Services, should provide a summary to the Secretary of Natural Resources and the Secretary of Agriculture and Forestry that would document any significant new findings. A formal relationship between the state agencies and Virginia universities may help facilitate acquisition and technical review of relevant new research. Biosolids land appliers and generators also should be encouraged to submit new findings relevant to protection of health and the environment.

4. To what degree do biosolids-associated contaminants affect water quality?

Panel Discussion

The effect of biosolids land application on water quality depends on the rate, timing and location of application and can be minimized or eliminated if applications are made using practices that are in conformance with all state and federal laws and regulations. These include the United States Environmental Protection Agency 40 CFR 503 regulations, State Water Control Law

(Section 62.1-44.19. of the *Code of Virginia*), and regulations promulgated by the State Water Control Board (VPA, VPDES and Sewage Collection and Treatment regulations). These rules include contaminant limits, loading rate constraints, application site criteria, site access restrictions, and other criteria designed to limit contaminant loss to the environment. Regarding contaminant limits, the levels of regulated inorganic trace elements (including heavy metals) found at the current concentrations in biosolids are often an order of magnitude lower than the risk-based limits in the regulations. This was confirmed in the data submitted to the Panel by 15 wastewater treatment plants.

Nutrients

Nutrients (primarily nitrogen and phosphorous) are a primary concern for water quality. Life in lakes, rivers, and other water bodies depends upon nutrients from terrestrial sources. However, excess nutrients, primarily nitrogen (N) and phosphorous (P), can cause excessive algal growth, a process known as eutrophication. As the algae dies, biological processes consume the dissolved oxygen (DO) from the water column and as a result the ecosystem is no longer hospitable to fish and most other aquatic life. This has been the case in the Chesapeake Bay and its tidal tributaries, where many water bodies and the bay main stem are degraded with respect to DO concentrations and other effects of high nutrient levels.

Nitrogen also can have an adverse effect on groundwater. The standard for drinking water, set by the EPA, is 10 ppm (mg/L) NO_3^--N (nitrate-N) which is a chemical form of nitrogen. Adverse health effects can occur if higher levels of nitrate in groundwater are consumed by humans. Many Virginians get their drinking water from groundwater sources.

Nutrient Management Plans

A certain amount of nutrient loss, whether through surface runoff or groundwater leaching, is inevitable in farming systems, including those that use biosolids. Nutrient management planning has developed as a means of minimizing potential nutrient losses while maintaining an economically viable farming operation. Virginia biosolids regulations require the use of a nutrient management plan (NMP) to determine the N and P applications. NMPs are designed to manage the amount, placement, timing, and application of manure, fertilizer, biosolids, or other materials containing plant nutrients in order to reduce nutrient loss to the environment and to produce crops. This plan must be prepared by a Virginia certified nutrient management planner. The NMP addresses two of the major environmental concerns associated with these activities, which are the loss of N and the loss of P from the soil-plant system. NMPs for biosolids must include the requirements set forth in 9VAC 25-32-600A.

Nitrogen applications are limited to those that will meet the projected agronomic needs of the current season's crop. Previous applications of organic N are factored in as well, because some fraction of past applications will become available to plants in subsequent years. These residuals are then deducted from the amount of presumed plant-available N that can be applied. Also, due to the mobility of certain forms of N, the timing of the applications, based on the growth stage of the crop, is considered.

Some sites are considered more "environmentally sensitive" to N losses than other sites and have even more stringent timing requirements. These sites are defined as any field which is

particularly susceptible to nutrient loss to ground water or surface water since it contains or drains to areas which contain sinkholes; or where at least 33% of the area in a specific field contains soils with high potential for leaching, shallow soils lying over fractured or limestone bedrock, subsurface tile drained soils, soils with high potential for subsurface lateral flow, floodplains, or lands with slopes greater than 15%. There was discussion among Panel members as to whether or not the existing criteria for determining what is an environmentally sensitive site should be expanded (for example, increasing limitations based on slope), and whether the application of biosolids should be prohibited or simply limited in certain areas. Two examples of sensitive sites that were the subject of Panel discussion included sloping land and karst topography (landscape that includes landforms such as shafts, tunnels, caves and sinkholes that can accelerate ground water movement). Following these discussions, the Panel did not reach consensus regarding the appropriate application restrictions on these sites, but made a recommendation that the TAC consider this issue.

Phosphorus (P) is not as mobile as N under typical agricultural situations and, therefore, the timing of nutrient source application requirements are not as limiting. However, continued applications of P in excess of what the crop can remove will cause it to build up in, or saturate, the soils. Fields that have high P saturation levels are more susceptible to losses to the environment. The NMP specifies that any one of three methods that can be used to apply organic sources of P: routine agronomic soil test, environmental threshold soil test, or P-index model.

The most conservative method, preferred by DCR, is the **soil test method**, which recommends P application rates based on routine soil test results to achieve optimum growth. These application rates have been established by plot work research on soils based on crop response, and allow no P to be applied once soils have sufficient P, such that no crop benefit is expected if more were added. The use of the soil test method is primarily used when commercial fertilizers are applied, as commercial fertilizer is costly to the farmer and can be blended to achieve more precise recommendations. The ratio of N to P in biosolids is determined by the nature of the source of the organic materials, not by the fertilizer distributor, making it more difficult to follow a specific soil test recommendation for both N and P. This method may be the most limiting for P application and is the simplest to implement.

Applications of organic sources of P also may be based on two other methods. The **environmental threshold method** also uses a soil test, but applications using this method are based upon environmental indices of soil P (i.e. P saturation of soil). At less than 20% saturation, applications can be made based upon the available N content of the organic material. Applications to fields with less than 35% saturation are limited to what the crops in the rotation can remove from the soil within the lifetime of the NMP. If the field is above 35% saturation, then no P applications may be made using this method.

One limitation of the soil test and environmental threshold methods is that they limit applications to soils based on soil P levels regardless of whether or not a given site is at actual risk for P losses. For example, on certain sites (e.g., a well-drained Coastal Plain soil with a 1% slope at a substantial distance from a surface stream and in conservation tillage) there is a relatively low risk of significant P movement to ground or surface water.

A third method, **the phosphorus index** was developed by agronomists, engineers, and other scientists at Virginia Tech and is similar to methods used in other Chesapeake Bay states. The index may allow applications up to 65 percent saturation. However, this method is a risk-based method, and in some cases may restrict P application altogether if there is sufficient evidence that P could be lost from the field through runoff, erosion, or subsurface flow. These factors are considered by the index, which based upon the relative risk may allow applications at rates based upon one of the following:

1. Low Risk: No P limitations: available N content of the organic material,
2. Medium Risk: P removal of the crops in the rotation over the life of the plan
3. High Risk: 1.5 times the crop P removal rate or
4. Very High Risk: No P shall be applied.

The P-index is the option that in nearly all cases allows for the most P to be applied, and is used often when landowners or land applicators are willing to acquire the data necessary for calculations. However, long-term accumulation of P must be considered even on sites where risk of loss is low, as the P-index will eventually preclude application of P if the soil reaches 65 percent saturation. Furthermore, the P-index assumes that the agricultural practices specified in the input process will remain consistent over the modeled period. For this reason, it is important that some mechanism be established that ensures that the control practices contained in the NMP are implemented not only in the year biosolids are applied, but also over the lifetime of the NMP (usually three years). Also, the P-index may significantly understate losses if a former agricultural field is subjected to land disturbance and associated short-term sediment losses after years of application of materials that contain P.

It also is important to note that other soil contaminants that may interact with P applications are not accounted for in any of these methods. Arsenic in soil, for example, will react in one of two ways when P is applied. Depending upon soil texture, arsenic may leach from the soil, or accumulate more readily in plant tissue (Bellows, 2005). This effect may be of significance where historical land use included significant application rates of arsenic, as would be the case in some fruit orchards. This phenomenon should be evaluated by the TAC as part of the evaluation of sensitive sites.

Some Panel members discussed the potential for limiting the method of P application rate determination to the soil test method. Regulations establishing the three options for managing phosphorus were promulgated by the Department of Conservation and Recreation in December 2005. The regulations and accompanying guidance apply equally to users of both animal manures and biosolids. The VPA regulation states that the amount of P to be applied shall be in accordance with a NMP written according to DCR regulations (9VAC25-32-560.A.1). However, the current VPA regulation also states that, “(t)he applied nitrogen and phosphorus content of biosolids shall be limited to amounts established to support crop growth” (9VAC25-32-600.A). Some Panel members interpret the latter regulatory provision to call for the exclusive use of the soil test method for biosolids application. The Panel did not reach consensus regarding a preferred P application rate method nor did they determine whether any changes to the VPA regulations are needed. Therefore, the Panel recommends that this matter be referred to the TAC for consideration.

Other Issues Related to Water Quality

The Panel also discussed the need for further clarification in the regulations for mined land or disturbed land reclamation. One-time application of biosolids at higher than agronomic rates to mined lands has been shown to be quite beneficial for soil reconstruction purposes. In these applications, the benefit of soil stabilization and environmental remediation should be weighed against the nutrient loss potential. Regulations that allow for the reclamation of mined land or disturbed lands in a manner that is beneficial to the soil and not harmful to the environment should be considered by DEQ.

Much of the research to date has been focused on nutrients, pH, and metals, thus much is known regarding how to control the associated water quality effects. However, there is very little research to date on other constituents, their transport mechanisms, and how they might affect water quality. While certain contaminants have been found in land applied biosolids, mere presence will not in itself cause water quality impacts without a means to reach ground and surface waters. Additionally, presence does not indicate danger without a toxic concentration. Transport mechanisms of inorganic nutrients have been studied extensively, but transport of other constituents have not. Thus, there is a need for additional research regarding:

- Interactive effects (additive or antagonistic) within the complex mixture of biosolids (contaminants present may act differently when combined than separately);

- Antibiotics, endotoxins, endocrine disruptors, brominated flame retardants, pharmaceuticals and personal care products (PPCPs), other persistent organic compounds and micro-contaminants, including mobility to ground and surface waters and at what concentrations these substances might be harmful; and

- Whether indicator bacteria regrowth potential in biosolids dewatered in centrifuges has the potential to lead to impacts on receiving waters.

Buffers are based on reducing or eliminating transport of nutrients to adjacent surface waters, and no study has shown that N and P act as surrogates for organic microcontaminants and microorganisms. Research is needed to investigate what buffers are appropriate to protect public health and the environment for these other biosolids constituents.

There has been no evidence thus far that exposure to organic micro-constituents in land applied biosolids pose any greater risk to humans than exposure to these chemicals through other routes (e.g., in treated wastewater discharge). However, long-term effects on the environment, including the biota, and the potential for biomagnifications within food webs, are more difficult to assess and thus have not been researched extensively. In summary, the relative importance of the unknown characteristics of these micro-contaminants with respect to currently regulated parameters and water quality has not been studied sufficiently to reach a conclusion.

The Panel notes that there are two currently active research projects by the USDA and the University of Maryland (sponsored by the District of Columbia Water and Sewer Authority; DCWASA) examining fate and transport of PBDE's and antimicrobials (triclosan and triclocarban) from land-applied biosolids. There also is a joint research project between the

University of North Carolina (School of Public Health) and the Virginia Institute of Marine Science (VIMS) (funded by the National Institute of Environmental Health Science) aimed at examining composition of biosolids and potential for atmospheric transport and subsequent human exposure. In addition, there is a collaborative research project evaluating the fate of PBDEs in agricultural soil and potential uptake in corn between the Metropolitan Water Reclamation District of Greater Chicago and VIMS.

The Panel makes the following recommendations based on the discussion above:

Panel recommends: The TAC should examine the DEQ regulations regarding identification of environmentally sensitive sites, as well as the management practices unique to these sites. Special considerations should be given to the methods used to address circumstances such as slopes greater than 7 percent and restrictions applicable to karst topography, or soils with high runoff potential.

Panel recommends: The TAC should examine the DEQ regulations addressing the land application of biosolids on mined land and disturbed land reclamation sites.

Panel recommends: Funding should be provided to university researchers to produce a "white paper" to review and consolidate recent information on water quality impacts other than those from nutrients in order to identify effects and prioritize research needs.

Panel recommends: The TAC should examine the DEQ regulations addressing the method used to determine P application rate.

5. What are the effects of an accumulation of biosolids-associated contaminants in wildlife?

Panel Discussion

The evidence concerning the impact of biosolids on wildlife is mixed, with some studies indicating a positive effect on wildlife populations as a result of the use of biosolids to restore wildlife habitat, as well as minimal impact on forest small mammal populations due to heavy metal contamination from the application of biosolids for silvicultural purposes. However, other studies have suggested potential long-term negative health, reproductive, behavioral and population viability impacts from the exposure to compounds and contaminants that are ubiquitous in multiple environmental media including biosolids. There are few studies or field trials that have investigated the above listed impacts of these contaminants on wildlife from biosolids land application.

Given these gaps in our knowledge the Panel is recommending the establishment of research and monitoring efforts that will gather the necessary data to assist in determining any potential negative or positive impacts on wildlife populations from applied biosolids.

The Panel makes the following recommendations based on the discussion above:

Panel Recommends: Research to investigate potential acute and chronic health impacts of biosolids on wildlife. The goal of this recommendation is to determine if health impacts on wildlife directly related to biosolids land application exist. Monitoring of wildlife for potential health effects has an added advantage in that they can act as sentinels or predictors of potential human health effects, due to greater sensitivity and exposure to certain compounds and contaminants.

At minimum, the studies would include:

a. Monitoring of wildlife for potential acute or immediate toxicological effects of land applied biosolids in order to augment existing DEQ and Department of Game and Inland Fisheries monitoring programs. Monitoring could include routine monitoring associated with land application, as well as incident monitoring of any unusual incidents, such as a fish kill.

b. Monitoring of wildlife for potential effects of land applied biosolids in order to investigate the potential long-term health and population impacts, including bioaccumulation of the potentially harmful constituents in biosolids, which could include heavy metals, organochlorine compounds and pesticides, flame retardants, pharmaceuticals, and pathogens.

Panel Recommends: DEQ, together with the Department of Game and Inland Fisheries, should regularly review research that pertains to biosolids and its fate and transport to wildlife, and provide a summary to the Secretary of Natural Resources and the Board of the Department of Game and Inland Fisheries that would document any significant new findings. A formal relationship between the state agencies and Virginia universities may help facilitate acquisition and technical review of relevant new research. Biosolids land appliers and generators also should be encouraged to submit new findings relevant to protection of health and the environment.

When conducting the study, the Panel will also take the following steps:

(i) Perform a detailed analysis of the chemical and biological composition of biosolids

Panel Discussion
The Panel was limited in the performance of this task considering no funding was available to conduct new analyses. The vast number of constituents in biosolids combined with the specialized analytical methodologies to detect and quantify these constituents involves significant cost. Thus the Panel relied on existing data.

The complete results of the latest US EPA limited biosolids survey are expected to be released by the end of calendar year 2008. This survey will report on the concentrations of 145 chemical constituents in biosolids through the United States. It will not characterize all of the chemical and microbiological constituents in biosolids.

In an effort to gather information on the biosolids material being land applied in Virginia, the expert Panel sent a request to 43 wastewater treatment plants that generate biosolids land applied in Virginia. The request asked generators land applying in Virginia to submit testing analyses conducted on biosolids produced over the past five years. Much of these data would have been previously submitted in order to satisfy state and federal regulatory requirements, particularly metals and priority pollutants required by NPDES permits. The Panel also requested any additional pathogen and any other analysis results beyond the existing regulatory requirements.

In response to the request, 15 facilities submitted data. These facilities and test parameters are summarized in an attachment to this report. Data included details on the parameters required by Virginia and EPA regulations, and showed compliance with those requirements. Further, several facilities included data on other results including fecal coliform, *Escherichia coli*, salmonella, helminth ova, and percent volatile solids reduction. Two facilities, the District of Columbia Water and Sewer Authority (DCWASA) Blue Plains plant and the city of Milwaukee (manufacturer of Milorganite®) submitted additional data on other potential contaminants.

The results of this survey demonstrate that an extensive history of the compliance regarding levels of regulated parameters is available. Information on non-regulated parameters is limited, although it was noted that in the small data set obtained by the Panel, the levels of most of these other parameters were non-detectable based on the sensitivity of the analytical methodology.

Some Panel members noted that increased field sampling by DEQ inspectors could be used to further verify compliance with the regulated parameters, particularly with respect to nutrients as well as when there have been reports of illnesses associated with a particular application. Other Panelists believed the work associated with additional field sampling was unnecessary due to the history of compliance associated with land application. The Panel noted that a field sample collected during land application would be a grab sample, the results of which would not be directly interchangeable with the results of composite samples taken at the wastewater treatment facility. For this reason, the significance of non-compliance with a field grab sample would have to be clearly defined as part of a protocol defined in the regulatory requirements. In addition, any defined protocol should address who would bear the cost of additional field sampling.

The Panel was unable to make a consensus recommendation regarding the need for additional parameters to be regulated. The presence (identification and quantification) of any current or new constituent in biosolids does not necessarily mean the public is exposed to these constituents nor does it necessarily translate to a negative health impact.

The Panel also discussed the importance of effective industrial pre-treatment programs to the successful operation and compliance of wastewater treatment plants, including novel and emerging programs that may address some of the newer constituents of concern. Pre-treatment is an effective means of minimizing some potentially harmful contaminants from reaching wastewater plants in the first place, thus ensuring select contaminants are excluded from biosolids as well as the treated liquid effluent discharged to receiving water bodies.

The Panel makes the following recommendation based on the discussion above:

Panel Recommends: To support research being conducted in response to questions regarding biosolids effects on human health, wildlife, or water quality, the Panel suggests that DEQ inspectors are ideally suited to be neutral parties that could obtain sample materials for such studies. Collecting additional samples for parameters beyond those required by the regulation would benefit researchers at Virginia universities. A protocol for requesting such material through DEQ should be devised that includes chain of custody procedures and a communication plan that includes generators and researchers, ensuring that generators from whom biosolids are obtained are informed regarding the results of the study.

(ii) Evaluate the toxic potential of biosolid constituents derived from land application to humans, agricultural products, soil organisms, and wildlife

Panel Discussion
As long as biosolids are applied in conformance with all state and federal law and regulations, (e.g., within contaminant limits, loading rate constraints, application site criteria, site access restrictions), there is no published scientific evidence of any acute toxic effect to soil organisms, plants grown in treated soils, or to humans from inorganic trace elements (including heavy metals) found at the current concentrations in biosolids.

Whether there are longer term chronic effects of pharmaceutical and personal care products (PPCPs) and other persistent organic compounds that might be applied in biosolids is more difficult to measure, and thus has not been rigorously assessed to date. There are gaps in the research to characterize the composition, fate, and effects of these constituents in biosolids, as well as in other products, materials and the environment. Furthermore, the relative importance and risk of these constituents, which have not been fully assessed, and their potential for toxic effect is the subject of ongoing research.

Panel Recommends: DEQ should regularly review research that pertains to biosolids and its fate and transport to livestock and plant crops. DEQ, in consultation with the Virginia Department of Agriculture and Consumer Services, should provide a summary to the Secretary of Natural Resources, the Secretary of Agriculture and Forestry, and the Secretary of Health and Human Resources that would document any significant new findings. A formal relationship between the state agencies and Virginia universities may help facilitate acquisition and technical review of relevant new research. Biosolids land appliers and generators also should be encouraged to submit new findings relevant to protection of health and the environment.

(iii) Evaluate the capacity of alternative technologies to facilitate the beneficial use of biosolids and their disposal

(iv) Determine the availability, costs, and feasibility of technological alternatives to Class B land application

(v) Investigate the availability, capital and operations costs, feasibility, environmental and human health impact, and public acceptance of alternative technologies for the beneficial use of biosolids

(vi) Identify and recommend institutional and financial mechanisms for assisting localities in implementing alternative technologies at the state, local and regional levels

Panel Discussion

Biosolids are a necessary product of wastewater treatment and its management is a challenge that is met in many different ways. It is important that biosolids be viewed as a resource rather than a waste that uses landfill space, while minimizing health and environmental risk. The Panel heard testimony about the benefits of biosolids, whether they are used as a soil amendment and fertilizer replacement on Virginia's farms or in an emerging role as a potential source of renewable energy. Many Virginia's farmers depend on biosolids to provide nutrients and organic matter that enhance soil and crop production, while reducing their fertilizer costs and ensuring the sustainability of their farming operations. Identifying alternatives to landfilling biosolids not only extends the life of landfill facilities, but with today's economic issues and the high cost of fossil fuels and fertilizer, it is sensible to take advantage of the benefits of a product that is ever present and must be managed.

Some other alternative technologies using biosolids rely on proven technologies, such as digestion and drying. These technologies reduce the volume of product and in some cases can reduce odor. Digestion based technologies have an added benefit - the production of methane gas that can be used for heating or power generation.

Some of the emerging technologies focus on converting biosolids more directly into energy, but these technologies are relatively unproven and have not been widely used. Emerging technology may make it possible to derive energy from biosolids in the form of synthetic gas, ethanol or electricity.

The Panel noted that the stringent regulations governing effluent discharge from Virginia's wastewater operations require operators to approach new technology with caution when considering costs vs. benefits. The biosolids management technology used must be dependable, otherwise the effluent quality may be compromised. In addition, such new technology is very expensive at present to implement and pursuing it on an individual plant basis could impose major burdens on the plants' ratepayers.

There are trade-offs to be considered with the various technologies. Improved digester-based technologies reduce the volume of biosolids to be managed by reducing the organic matter in them and, therefore, the volume to be managed. However, the resulting biosolids may be of less value to the farmer due to decreased organic matter and nutrient content. As innovative technologies take hold and are more widely implemented, fewer biosolids may be available for farm land application, resulting in higher fertilizer costs for some farmers.

Some Panel members said that the first step in addressing this problem is to investigate the alternative technologies that are already in place (in Virginia, U.S. and Europe) and to conduct

engineering assessments of existing and functional technologies. Taking a step toward that assessment, the Virginia Biosolids Council, in cooperation with the Chesapeake Bay Foundation, held a Biosolids Technology Forum in September, 2008 to explore new technology. The notes from that forum are included as an attachment to this report.

The Panel makes the following recommendations based on the discussion above:

Panel Recommends: The institutional and financial mechanisms that should be considered when implementing or investigating alternative technologies include:

1. Federal sources such as the Environmental Protection Agency or Department of Agriculture
2. State funded financial incentives to promote and develop alternative technologies in cooperation with local governments and authorities
3. Partnering with private companies interested in promoting their technologies
4. Research foundations such as WERF

Panel Recommends: An engineering assessment be conducted of the technology currently available for the management of biosolids, ensuring that cost-benefit evaluation and environmental impacts are included. It is important that representatives of the wastewater community are actively involved in this process to ensure existing public infrastructure and related operations are not unduly affected. In addition to the technical and economic evaluation of the process, pilot studies of alternative technologies should evaluate aesthetic impacts on the host community and the prospects for public acceptance.

Panel Recommends: Research of alternative technologies. For each technology, the research should consider the whole environmental footprint, including risk-benefit and cost-benefit analyses. The analyses should include the potential to:

1. generate renewable energy
2. impact human health
3. complement existing wastewater treatment technology
4. impact existing operations
5. impact public ratepayers
6. impact local community aesthetics
7. create regulatory permitting challenges.

Panel Recommends: Sponsorship of funding and incentives for (a) conducting pilot studies of alternative technology for the management of biosolids, (b) encouraging the development of these alternative technologies by private business, and (c) developing a state or regional project that would include the participation of interested wastewater treatment plant owners (localities and authorities), Virginia universities and members of Virginia's conservation community.

In addition to the technical evaluation of the equipment, the pilot studies of alternative technologies also should include the evaluation of aesthetic impact on the host community and public acceptance. Public education and outreach should also be a major constituent of any pilot project.

Additional Panel Considerations

Compliance and Enforcement

The panel discussed many issues in regard to program management, including compliance and enforcement, which are relevant but do not answer the questions posed by the General Assembly.

Compliance assurance and appropriate enforcement measures are not only necessary to protect public health and the environment, but also for the credibility of the biosolids program as an effective program to recycle biosolids in a responsible manner. The Panel felt that a rigorous compliance and enforcement program was essential to reaching the conclusions stated in this report. At the outset of the Panel meetings, several Panelists felt that compliance should be assumed in the preparation of the responses. Other Panelists felt strongly that since alleged non-compliance was often a factor in historical complaints, it could not be assumed. The inspection activities of the DEQ in the first ten months of the program have not revealed widespread compliance issues.

There was Panel discussion regarding what the specific enforcement actions should be if persistent violations of the laws or regulations do occur, including restricting the biosolids generator or land applier from applying biosolids in Virginia, and restricting the farm operator from further receipt of biosolids material. No consensus was reached regarding what actions should ultimately be taken for non-compliance. Under existing DEQ enforcement procedures, the agency has the ability to undertake a range of enforcement responses up to and including the revocation of a permit in the case of chronic noncompliance.

There was also further discussion regarding whether compliance issues should be assigned priority that includes risk of environmental harm as a factor in determining enforcement action, or whether for non-compliance with biosolids regulations, that all violations should be weighted equally. In addition, there was discussion about the authority of other state or local government agencies to enforce the biosolids regulations. The Panel makes no consensus recommendation regarding these concepts.

Panel Recommends: The fees collected from municipal wastewater treatment plants to fund the biosolids permitting, compliance and enforcement program should be continued in order to provide assurance that the regulations that protect human health and the environment are followed.

Biosolids Program Health Resources

DEQ currently relies upon VDH to carry out its important mandate to protect public health when biosolids are land applied.

Since the transfer, DEQ has attempted to comply with this mandate by asking VDH to provide needed technical expertise on health impacts from land applied biosolids. Some citizens report continued dissatisfaction with the manner in which their health complaints are being investigated and addressed. If VDH is not adequately funded to provide this resource, sufficient funding and resources must be available to DEQ to carry out this function.

Access to Current Research

Although focused research could address specific concerns raised throughout this document, it is uncertain given the current economic situation that research support will be forthcoming in the very near future. In the meantime, a thorough technical review of the current literature could aid in identifying and prioritizing the most important research needs. This review should include recent technical literature submitted to the Panel. While the cost of literature review is far less than that of applied research, funding sources would still need to be identified for the collection and dissemination of this information.

Panel Recommends: Production of a series of white papers by objective researchers providing a review and analysis of the most recent literature focused on health effects, constituents of concern, fate and transport, effects of biosolids on the environment and plants and animals. This activity would augment the white paper produced by the Department of Health. At the very least the white papers should address:

- Biosolids and human health (in order to update VDH review)
- Biosolids and receiving water quality
- Biosolids and animal including wildlife health
- Toxicity of biosolids constituents (biological and chemical)
- Biosolids constituent characterization
- Biosolids constituents and food crops/livestock
- Methods to detect biosolids constituents under various conditions
- Biosolids and its value as a sustainable alternative fuel to Virginia
- Benefits of biosolids (economic and environmental) on reclamation of mined sites and disturbed lands

Results should be easily accessible to all interested parties through DEQ's biosolids program website.

Biosolids Expert Panel Report Bibliography*

*****Panel members provided the following information for Panel consideration

---

Professional Journal Articles, Books, and Other References

Ames, B. N. and L.S. Gold. "Environmental Pollution, Pesticides and the Prevention of Cancer: Misconceptions," Federation of American Societies for Experimental Biology Journal 11:1041-1052, December, 1997.

Arnold, Ken, et al. "Safety and Benefits of Biosolids," University of Missouri Extension, Bulletin WQ0427.

Baertsch, Carolina, et al. "Source Tracking Aerosols Released from Land-Applied Class B Biosolids During High-Wind Events," Applied and Environmental Microbiology, 73(14):4522-5431, July, 2007.

Basta, N. T., et al. "Trace Element Chemistry in Residual-Treated Soil:
Key Concepts and Metal Bioavailability," Journal of Environmental Quality, 34:49–63, January-February, 2005.

Basta, Nicholas, et al. "A Review of a Health Survey of Residents Living Near Farm Fields Permitted to Receive Biosolids," Ohio State University and Ohio Water Environment Association, July 29, 2008.

Bellows, Barbara. "Arsenic in Poultry Litter: Organic Regulations," The National Sustainable Agriculture Information Service. Publication #IP266/269, 2005.

"Bioenergy from Wastewater Treatment-A Clean, Affordable Energy Source," Water Environment Federation, Alexandria, VA, 2004.

Brooks, J. P., et al. "Estimation of Bioaerosol Risk on Infection to Residents Adjacent to a Land Applied Biosolids Site Using an Empirically Derived Transport Model," Journal of Applied Microbiology, 98(2):397-405, 2005.

Brown, Sally, et al. "Heavy Metals in the Environment: Effect of Biosolids Processing on Lead Bioavailability in an Urban Soil," Journal of Environmental Quality, 32:100-108, January-February, 2003.

Brown, Sally. "Biosolids and Wildlife," University of Washington.

Burtscher, Carola and Stefan Wuertz. "Evaluation of the Use of PCR and Reverse Transcriptase PCR for Detection of Pathogenic Bacteria in Biosolids from Anaerobic Digestors and Aerobic Composters, Applied and Environmental Microbiology, 69(8):4618-4627, August 2003.

Cheng, C., J.P. Kimmins and T.P. Sullivan. "Forest Fertilization with Biosolids: Impact on Small Mammal Population Dynamics" Northwest Science. 70: 252-261, 1996.

Collins, F. M. "Relative Susceptibility of Acid-Fast and Non-Acid-Fast Bacteria to Ultraviolet Light," Applied Microbiology, 21:411-413, 1971

"CSC's Sampling and Analysis Report for the 2006-2007 Targeted National Sewage Sludge Survey," USEPA Report under GSA Task Order GS-10F-0135K, September 30, 2007

Dowd, S.E., et al. "Bioaerosol Transport Modeling and Risk Assessment in Relation to Biosolid Placement," Journal of Environmental Quality, 29:343-348, 2000.

Dudley, D. J. et al. "Enumeration of Potentially Pathogenic Bacteria from Sewage Sludges," Applied and Environmental Microbiology, 39(1):118-126, January, 1980.

Evanylo, Greg, et al. "Bioavailability of Heavy Metals in Biosolids-Amended Soil," Communications in Soil Science and Plant Analysis, Volume 37: 2156-2170, June 2006.

Evanylo, Greg. "Effects of Biosolids Application Timing and Soil Texture on Nitrogen Availability for Corn," Communications in Soil Science and Plant Analysis, Volume 34: 123-143, March, 2003.

Evanylo, Greg, et al. "Herbaceous Vegetation Productivity, Persistence, and Metals Uptake on a Biosolids-Amended Mine Soil," Journal of Environmental Quality, Volume 34:1811-1819, September 8, 2005

Farfel, Mark R., et al. "Biosolids Compost Amendment for Reducing Soil Lead Hazards: a Pilot Study of OrgroR Amendment and Grass Seeding in Urban Yards," Science of the Total Environment 340:81– 95, 2005.

Foreign Animal Diseases, 7th Edition, United States Animal Health Association, 2008.

"Guidelines for the Land Application and Surface Disposal of Biosolids, Water Pollution Control Division," Tennessee Department of Environment and Conservation.

Hale, Robert C., et al. "Persistent pollutants in land-applied sludges," Nature, Volume 412, July 12, 2001.

Harrison, Ellen Z. "Land Application of Sewage Sludges (aka Biosolids): The Case for Caution," Presentation to the National Research Council Panel on Sewage Biosolids March 14, 2001.

Harrison, Ellen Z. and Summer Rayne Oakes. "Investigation of Alleged Health Incidents Associated with Land Application of Sewage Sludges," New Solutions, Volume 12(4):387-408, 2002.

Harrison, Ellen Z., et al. "Organic chemicals in sewage sludges," Science of the Total Environment 367:481-497, 2006.

Heidelberg, J. F., et al. "Effect of Aerosolization of Culturability and Viability of Gram-Negative Bacteria," Applied Environmental Microbiology, 63:3585-3588, 1997.

Jenkins, Suzanne R., et al. "Health Effects of Biosolids Applied to Land: Available Scientific Evidence," Virginia Department of Health, November, 2007.

Jones, Keith J. Brief of Amicus Curiae the National Association of Clean Water Agencies in Support of Appellees, City of Los Angeles vs. County of Kern, #07-56564.

Khuder, Sadik, et al. "Health Survey of Residents Living Near Farm Fields Permitted to Receive Biosolids," Environmental and Occupational Health, Volume 62(1), 2007.

Kinney, Chad A., et al. "Survey of Organic Wastewater Contaminants in Biosolids Destined for Land Application," Environmental Science and Technology, Volume 40(23):7207-7215, 2006.

La Guardia, Mark J., et al. "Alkylphenol Ethoxylate Degradation Products in Land Applied Sewage Sludge (Biosolids)," Environmental Science and Technology, Volume 35(24), 4798-4804, 2001.

Lewis, David L. and David K. Gattie. Comment on "Evidence for the Absence of Staphylococcus aureus in the Land Applied Biosolids" Environmental Science and Technology, Volume 37(24):5835, 2003.

"Livestock Legacy," Environmental Health Perspectives, 103(12), December, 1995.

Markman, Shai, et al. "Pollutants Increase Song Complexity and the Volume of the Brain Area HVC in a Songbird," PLoS One Volume 3(2), 2008.

McGinley, Susan. "Biosolids Safe for Land Application," University of Arizona Agricultural Experiment Station Research Report, 2003.

Paez-Rubio, Tania, et al. "Emission Rates and Characterization of Aerosols Produced During the Spreading of Dewatered Class B Biosolids," Environmental Science and Technology, 41(10):3537-3544, 2007.

Paul, Catriona, et al. "Cellular and Hormonal Disruption of Fetal Testis Development in Sheep Reared on Pasture Treated with Sewage Sludge," Environmental Health Perspectives, Volume 113(11):1580-1587, November, 2005.

Peccia, J., et al. “Effects of Relative Humidity on the Ultraviolet Induced Inactivation of Airborne Bacteria”, Aerosol Science and Technology 35:728-740, 2001.

Peccia, Jordan, et al. “Quantification of Airborne Biological Contaminants Associated with Land Applied Biosolids,” Water Environment Research Foundation, 2006.

Pepper, Ian, et al. “Sustainability of Land Application of Class B Biosolids,” Journal of Environmental Quality, 37:58-67, September, 2008.

Reich, M. R. “Environmental Politics and Science: The Case of PBB Contamination in Michigan,” American Journal of Public Health, 73(3): 302-313, March, 1983.

Roberts, P., et al. “Behaviour of the Endocrine Disrupting Chemical Nonylphenol in Soil: Assessing the Risk Associated with Spreading Contaminated Waster to Land,” Soil and Biochemistry, Volume 38, Issue7, pages 1812-1822, July 2006.

Rusin, Patricia A., et al. “Evidence for the Absence of Staphylococcus Aureus in Land Applied Biosolids,” Environmental Science and Technology 37(18):4027-4030, July 26, 2003.

Rusin, Patricia A., et al. “Response to Comment on ‘Evidence for the Absence of Staphylococcus Aureus in Land Applied Biosolids,’” Environmental Science and Technology, 37:5836, October, 2003.

Schwab, Paul, et al. “Development of a Metals Toxicity Protocol for Biosolids,” Purdue University Report for Water Environment Research Foundation, 2006.

Spargo, John T., et al. “Repeated Compost Application Effects on Phosphorus Runoff in the Virginia Piedmont,” Journal of Environmental Quality, Volume 35:2342-2351, October 27, 2006.

Sukkariyah, Beshr, et al. “Cadmium, Copper, Nickel, and Zinc Availability in a Biosolids-Amended Piedmont Soil Years after Application,” Journal of Environmental Quality, Volume 34:2255-2262, November 7, 2005.

Sukkariya, Beshr, et al. “Distribution of Copper, Zinc, and Phosphorus in Coastal Plain Soils Receiving Repeated Liquid Biosolids Applications” Journal of Environmental Quality, 36:1618-1626, November 1, 2007.

Sukkariyah, Beshr, et al. “Recovery and Distribution of Biosolids-Derived Trace Metals in a Clay Loam Soil,” Journal of Environmental Quality, Volume 34:1843-1850, September 8, 2005.

Sullivan, Constance, et al. “Induction of CYP1A and DNA Damage in the Fathead Minnow (Pimephales promelas) Following Exposure to Biosolids,” Science of the Total Environment, 384:221-228, 2007.

on reducing environmental impacts. The Biosolids Expert Panel is charged with reporting to DEQ before the end of the year.

- Every year there are several pieces of legislation at the state level that deal with biosolids, except last year, when the legislature created the Biosolids Expert Panel to address biosolids issues. Most of the bills have a few vocal, educated constituents. The question not being asked, however, is "If not land application, then what?"
- There used to be three ways to get rid of solids: burn, bury, or land apply. There is a need to look at alternative technologies that have the capacity for beneficial biosolids use, exploring whether they are available, what the capital and operation costs are, the relative environmental and human health impacts, their public acceptability, and what institutional and financial alternatives there are.
- Interest from legislators means there is potential for money to implement some of these. Costs are critical! Can we put these on the ground in Virginia? Public acceptability is a key consideration.

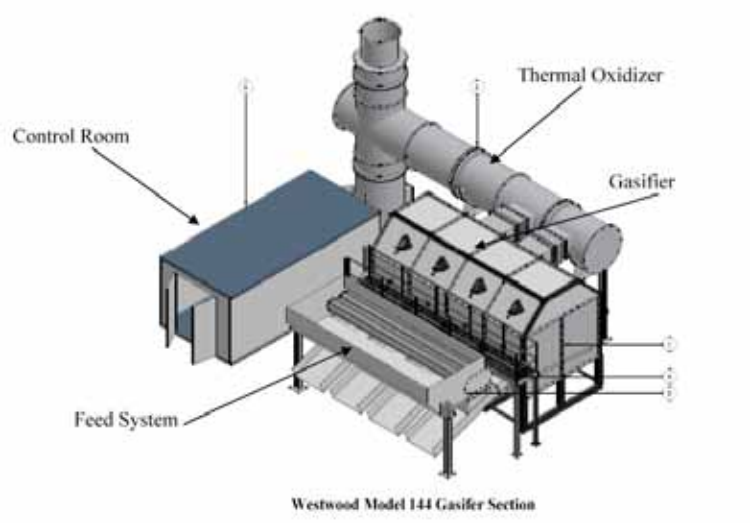
Afternoon Session 1: Innovative Technology

MaxWest Environmental Systems Inc. Biosolids Management and Energy Generation Through Gasification, Richard Heien, President (rheien@MaxWestEnergy.com). MaxWest designs, builds, owns, and operates waste-to-energy gasification facilities. Houston, TX, www.maxwestenergy.com

- Gasification converts energy contained in biomass or biosolids into a combustible gas in an oxygen-starved environment. It is a modern adaptation of a technology that is more than 200 years old. It provides renewable "green" energy systems for wastewater treatment industry outputs, wood wastes, agriculture (animal wastes, crop residue), municipal solid waste, industrial wastes.

- Gasification produces renewable green "Syngas" (CO, H2, CH4) energy, and inert, inorganic residual ash. It produces minimal air emissions and little water, which can be returned to

- Economic benefits include reduced cost of management and minimized cost volatility.
- Process flow: Waste is delivered to the gasifier via hydraulic rams, one per cell. Ceramic-lined primary gasification chambers (1–4) handle up to 28 x10^6 Btu/hr and produce syngas. Hot exhaust gases are fed into a heat recovery steam generator to produce steam that can be used to generate electricity and provide thermal heat
- The system can handle 400 tons per day with 3 MW power. Ash is 2% inert. May be used like mulch, with nutrient value. Typical cost per unit: $12M cash on cash. Typically needs to go to 60-65% moisture. Belt press isn't enough, so need dryer. Could blend with other materials so no drier may be needed.

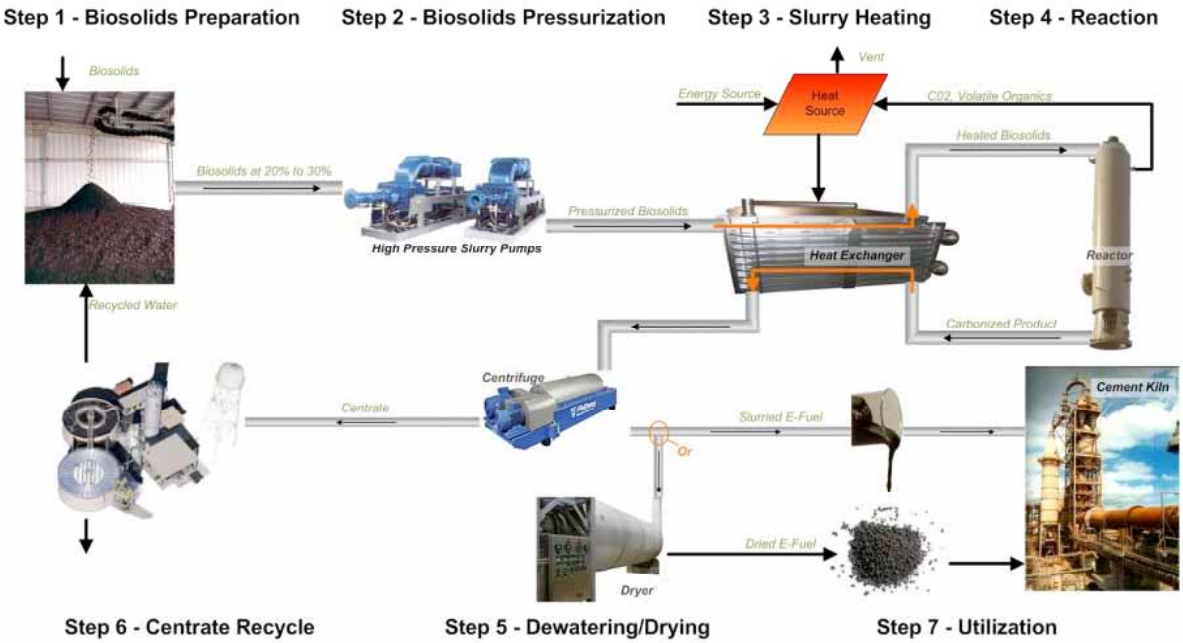


Westwood Model 144 Gasifier Section

- MaxWest will finance, build, own and operate (BOO) the gasification system, with no "upfront" capital costs; assume responsibility for design, permitting, financing, construction and operation; contract to receive a waste stream for a 15-year period for a fixed price per ton; lease land for the facilities from the customer for installing the gasification facilities; and deliver electric power and/or other commodities to the host or a third-party via PPA.
- 3rd-generation commercial gasifier installations completed: Six wood-fired systems in Canada and one chicken litter system is in West Virginia. Four wastewater sludge operations are scheduled for Florida in the next year. Several are under discussion in MA, NC, MD, DC, MN, and CA. Systems using biosolids from animal waste also are being discussed.

EnerTech Environmental Inc. *The SlurryCarb Process Energy Efficiently Converts Biosolids to a Renewable Fuel;* Raymond J. Kearney, PE, BCEE, Vice President. EnerTech is a renewable energy company that develops and commercializes clean combustion technologies for biosolids and other organic wastes. Atlanta, GA, www.enertech.com

- The SlurryCarb™ process is a net energy producer, generating 98% more thermal energy than it consumes. Traditional drying requires 160 million Btus to produce 20% solids from 100 wet tons. SlurryCarb requires 64 million Btus to produce the same percent solids, with lower CO_2 emissions. It also captures 64 tons of water that might otherwise evaporate. The resulting E-fuel has 5,800 to 8,000 Btus/lb in dry form, and can be used in multiple coal applications. It is certified as a renewable fuel in California.



- Process flow: High-pressure slurry pumps avoid losing heat and keep the solids moist. Solids go into a heat exchanger, then into a reactor (a large pipe), which maintains the biosolids at the same temperature and pressure. The resulting high BoD centrate is dewatered / dried so it can be turned into fuel. Discharge water recirculates for treatment.

- In 2009, the Rialto Regional Biosolids Processing Facility will be processing 683 wtpd of biosolids from Orange County, Los Angeles County, and the cities of Rialto, Riverside, and San Bernardino in CA. It will produce 167 tpd of e-fuel for a cement kiln.

- The site has a 30-year lease and the customer contracts are for 25 years (the length of the bonds). The price for each agency differs. Excess capacity is being sold for $72 per wet ton (not fixed), there are escalators for CPI and O&M, and indexes for natural gas and electricity pricing.

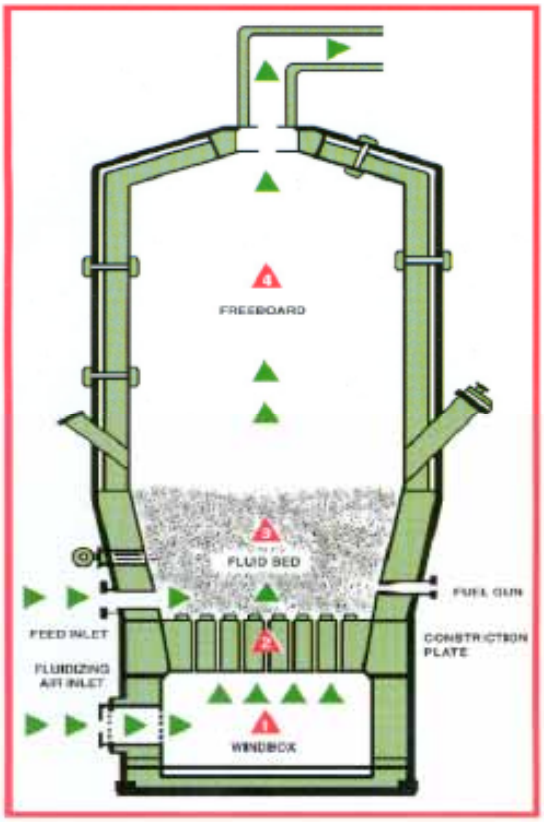
- Of note: The Rialto project did not require capital funding from the clients and had local community support. The process had no trouble getting permitted since it is not combusting anything except natural gas.

Infilco Degremont Inc. *Fluidized Bed Thermal Oxidation: A Sustainable Approach To Wastewater Biosolids Disposal*; Richard Ubaldi, Vice President. Infilco is a full-service water and wastewater treatment equipment and system provider. It is a member of the Degremont Group, part of SUEZ Environment, an international multi-utility provider of drinking water, wastewater, and sludge treatment services. Richmond, VA, www.infilcodegremont.com

- Although land application is a cost-effective and beneficial use of biosolids, it poses challenges (land availability, nutrient loading, and transportation).

- Fluid bed incineration is becoming widely accepted for sludge and biosolids disposal. In a fluid bed incinerator, water is evaporated and organic materials are combusted, eliminating odors and reducing the sludge to a much smaller quantity of inert ash (as low as 7% by weight). Typical reduction of sludge volume is 93%. Land requirements and air pollution are reduced, protecting the environment.

- Process flow:
  - Wastewater treatment produces sludge, which goes into the high-temperature fluid bed (HTFB) incinerator. The resultant exhaust gas leaves the fluid bed and enters the heat recovery and air pollution control systems, and the energy can be put to use.
  - The incinerator contains sand, and the term "fluid bed" refers to the violent boiling action of the sand bed, which occurs when air is blown through from below and fine solids are transformed into a fluid like state. To ensure that the air passes evenly through the sand, it must first pass through the windbox and a refractory arch distributor.
  - Dewatered sludge and auxiliary fuel (if required) are introduced directly into the bed, where they are instantly combusted at 1250°F. In the next stage, combustion gas and evaporated water flow upward into the teardrop-shaped freeboard, where the bed material is disengaged. Operating at 1550°F, the freeboard provides sufficient residence time to polish the gas and to complete the combustion.



- Depending on sludge characteristics, the heat recovery system can be composed of heat exchangers to preheat the combustion and the plume suppression air, or a waste heat boiler for steam generation. Both methods of heat recovery reuse energy for maximum cost savings.

- Uniform bed temperature, the result of steady turbulence, simplifies PLC / PC automation and logic control systems. Data gathering for compliance reports becomes much easier. Gaseous and particulate emissions, and heavy metals comply with all regulatory requirements; the highest emission characteristics are during startup and shutdown

- In a 200-tpd dry solids case, 2.5 MW of electricity are produced, 1.15 MW are used, with a green energy net of 1.35 MW. Two trains can handle 200 dtpd. Steady-state operating temperature: 650 degrees. Will self-sustain reaction indefinitely.

- By co-locating waste to energy (WTE) with biosolids HTFB, upfront capital cost can be avoided, footprint is reduced, NIMBY issues are eliminated, lime stabilization and long-haul transport is minimized; economies of scale and are possible, shared equipment between HTFB and WTE are possible, and energy recovery offsets tip fees.

- Infilco experience:

Pfizer, CT – 18 dry TPD 1995
Bayshore, NJ – 27 dry TPD 1995
Morton International, MS – 76 dry TPD 1996
Greensboro, NC – 60 dry TPD 1996
Camden County, NJ – 10 dry TPD 1996

Northwest Bergen, NJ – 27 dry TPD 1999
Little Miami, OH – 72 dry TPD 2000
District d'Elbeuf, France – 11 dry TPD 2003
Valence, France – 14 dry TPD 2003
Puerto Nuovo, PR – 64 dry TPD 2004
Ypsilanti, MI – 76 dry TPD 2005
Lakeview I, ON – 110 dry TPD 2006
Cobb County I and II, GA – 53 dry TPD, each 2007
Lakeview II, III, IV, ON – 110 dry TPD, each 2008
Tripoli, Lebanon I and II – 31 dry TPD, each 2008
Le Havre, FR – 30 dry TPD 2010
Mill Creek, I, II, III, OH – 96 dry TPD, each 2010
Duffin Creek, I and II, ON – 115 dry TPD, each 2010

- New incinerators have been difficult to build so past strategies have been to upgrade existing facilities, but since the US EPA has designated HTFIs as a "green technology," there have been several inquiries from agencies in CA.

New Planet Energy/INEOS Bio. *Back to the Future: Converting Carbon to Ethanol*, Ray Crabbs. NPE Florida works with INEOS Bio, a division of INEOS Technologies, to convert carbonaceous feedstock into bioethanol. Los Angeles CA (NPE); Lisle, IL, www.ineosbio.com

- "We believe very strongly in the magic of heat."
- The INEOS Bio Ethanol technology efficiently converts a wide range of low-cost, organic materials, including household and commercial wastes, into bioethanol for use as a renewable road transport fuel or petrochemical intermediate.
- INEOS uses a thermal gasification process to "crack" complex carbon molecules and re-form them into simple carbon monoxide and carbon dioxide. The bioreactor looks like a huge blender on high. Patented bacteria used to catalyze the process are in an aqueous solution, and take a two-minute trip through reactor, where they consume 85% of CO and 45% of H, giving off ethanol. The waste is ash, which can be land-applied. There is nothing in the technology that isn't off the shelf. The only thing new is the colony of bacteria in bioreactor.
- Process flow: The INEOS Bio process is a combined thermochemical and biochemical processes in the following steps:

  1. Flexible feed handling, where organic materials are economically dried using heat from the process before being fed into the gasifier. The process is fully compatible with high recycling rates.

  2. Organic material gasification, with oxygen at high temperature under controlled conditions to produce synthesis gas, or syngas, a mixture of principally carbon monoxide and hydrogen. Syngas has valuable chemical energy.

  3. Energy recovery, where the hot syngas is cooled and cleaned before being introduced to the fermenter. The heat recovered from the hot syngas is used to generate renewable power for use in the process.

  4. Fermentation: The cool, clean syngas is introduced to patented active bacteria, which ingest it and convert it quickly and selectively to ethanol. The bacteria biocatalyst is far more effective than all known conventional catalysts for syngas conversion to fuels.

  5. Bacteria: The naturally occurring bacteria are at the heart of the process. They are found in nature where they have evolved to efficiently convert carbon monoxide and hydrogen to

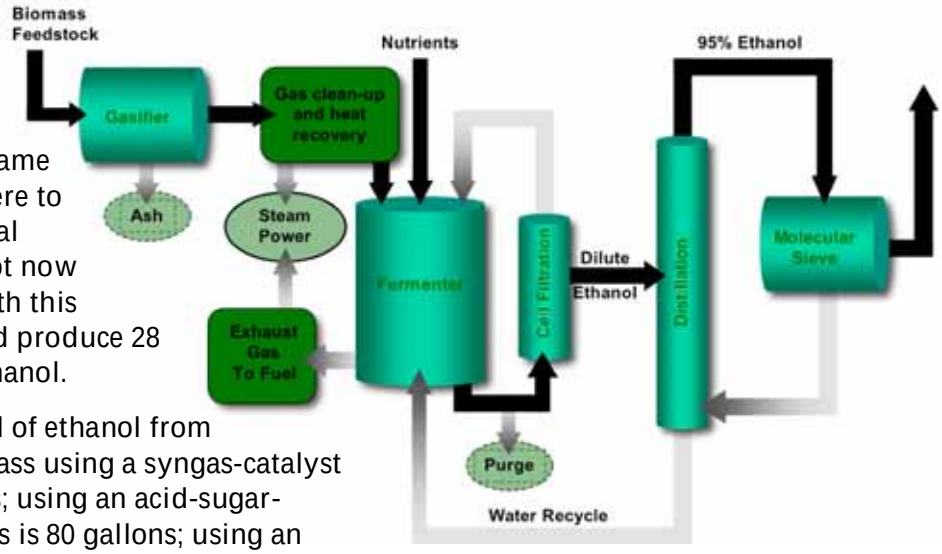
ethanol. They are maintained in a healthy state with the help of small amounts of essential nutrients to achieve a high yield of ethanol. At processing temperatures of 2,300 degrees, these bacteria have no natural predators in this environment.

6. Ethanol purification: Most of the water is removed from the ethanol to produce hydrous ethanol, which is around 96% ethanol in 4% water. The water is returned to the fermenter.

7. Ethanol drying: Finally, the ethanol product is refined to produce anhydrous ethanol (>99.7% ethanol), which can be used as a clean, green transport fuel or as a renewable chemical intermediate for the production of a variety of plastics.

8. INEOS bioethanol use: The INEOS bioethanol delivers 90% greenhouse gas savings compared with burning petrol (gasoline) in a car and it is potentially cheaper than petrol. The INEOS bioethanol process can convert wastes generated locally into clean, renewable, cost-competitive transport fuel for use locally.

- Gas fire doesn't care where carbon comes from. For example, autofill -- all parts of a car, like the chassis, dashboard, seats, etc., that are left when metal is removed – has the same Btu as coal. If we were to take all the municipal solid waste that's not now being converted, with this technology we could produce 28 billion gallons of ethanol.



- The theoretical yield of ethanol from one dry ton of biomass using a syngas-catalyst process is 77 gallons; using an acid-sugar-fermentation process is 80 gallons; using an enzyme-sugar-fermentation process is 85 gallons; and using a syngas-biocatalyst (INEOS) process is 145 gallons.
- Byproducts: Solids from ash for the gasifier are handled by a landfill; liquids from the cell purge are recycled to the gasifier; liquid from the gas scrubber is handled by wastewater treatment; gas form the fermenter and exhaust are combusted for energy.
- Key points: Different feedstocks can be blended; the process handles up to 30% moisture content; dry feedstock (tires & plastics) can be blended with wet feedstock to achieve the 30% moisture limit; the process is odorless; it can alternatively produce hydrogen.
- Plans are modular. A single plant module will process 50,000 tons of carbon and biomass annually, produce 4,000,000 gallons of bioethanol annually, and generate 1.5 MW of excess electricity for sale to the grid. Processing time is about two hours on the plant; corn ethanol takes 48 to 55 hours to produce.
- One plant has been operational since 2000 with a full gasifier in place. It uses steam-blown gasification (moisture with feedstock used to release water). The other portion is O-blown,

90%, which promotes additional CO. Bacteria will consume twice the CO as H and create CO_2 and ethanol.

- New Planet Energy soon will have the first commercial site on the coast of FL, a brownfields site that was a citrus juice farm. It shares a common boundary with landfill. It is expected to produce 8 million gallons of ethanol / yr, costing about $47 million to produce, at less than 60 cents / gallon. New Planet Energy will get the wholesale price plus a hosting fee and in return will pay the company for not landfilling.
- New Planet Energy has submitted a proposal to Roanoke VA (pop. 100K), which treats 8 mgd, enough for five bioreactors that can process a total of 750 tons per day, producing 20 million gallons of ethanol per year. Feedstock can include coal, for clean coal technology, and municipal solid waste.
- We've shorted universities of R&D money to help keep this country on the cutting edge. We cannot rest on the laurels of the past.

Biological Systems Engineering, Virginia Tech. *Thermal Depolymerization That Converts Organic Matter to Oil*, Dr. Foster A. Agblevor (fagblevo@vt.edu). Presented by Kristen Hughes, Staff Scientist for the Chesapeake Bay Foundation. The Department of Biological Systems Engineering develops and disseminates engineering knowledge and practices that protect natural resources and improve sustainable production, processing, and utilization of biological materials. Blacksburg, VA, www.cals.vt.edu / departments / bse.html

- The Waste Solutions Forum, held April 28 & 29, 2005, in Roanoke, VA, hosted 80 stakeholders from Virginia and across the nation to develop a waste solutions strategy (a detailed action plan) for identifying, researching, and implementing economically and environmentally viable solutions for manure and litter management in the Shenandoah Valley of Virginia. 40% of Virginia's dairy industry and 76% of Virginia's poultry industry is in the Shenandoah Valley.
- As a result of this initiative, Virginia Tech, with support from the Virginia Poultry Federation, Chesapeake Bay Foundation, Shenandoah RC & Council, and the National Fish and Wildlife Federation, developed a portable pyrolysis unit for turning poultry litter into bio-fuel and synthetic gas for energy, and ash into a slow-release fertilizer. This is the first unit of its kind, and is being tested and analyzed in the Harrisonburg, VA area (Shenandoah Valley). It uses a modified traditional boiler to run bio-oil for a radiant heating system in the floor of a poultry shed.
- Pyrolysis is an endothermic reaction (i.e., you must add heat) in the absence of oxidizing agents (oxygen) that converts organic matter into gas. Pyrolysis always occurs before any combustion process. In gasification, the end product usually is synthetic gas, but it can produce bio-oil.
- Process flow: The feedstock is air-dried poultry litter from neighboring farms, put through a fluidized-bed pyrolysis reactor where it is heated to 450 to 500^{o}C. It then goes through a hot filtration cyclone filter system and a pyrolysis oil condensation system that produces raw oil. Nitrogen or other gas that is produced goes to the re-heat burner, and excess gas can be used to heat the dryer. The feed rate is 200 gallons per hour.
- Traditionally, poultry litter is used in land application and as cattle feed. Disposal of poultry litter in the US is becoming a major problem because it can create excess nutrients in the soil

from land application, contaminated drinking water, eutrophication (excess plant growth because of too many nutrients) in surface waters, ammonia emissions from poultry houses, oil acidification through nitrification and leaching, and biosecurity concerns. Biosecurity concerns drove development of this system because instead of taking chicken litter to a central facility, it can be processed onsite, then moved to the next one.

- One advantage of this system is that many members of the thriving Mennonite community in Virginia are not on the power grid, so they face large costs to heat and cool poultry houses with diesel-run generators. Bio-oil can be used in a boiler instead.
- Pyrolysis is brand new for VA so regulators don't know how to regulate it. The question: Is it an incinerator? But nothing burns. It has no category.
- Right now, it costs several hundred thousand dollars because it is a pilot unit, and Virginia Tech is looking for companies that can manufacture it, perhaps in a public/private partnership.

Afternoon Session 2: Alternative Management Options

Environmental Solutions Inc. *Changing Conditions for Compost Manufacturing*, Brenda Robinson, President (Brenda.Robinson@envirsol.com). ESI develops innovative, patented green products derived from wastes and has been composting for municipalities since 1995. Richmond, VA, www.envirsol.com

- Composting is facing a changing landscape. It is focused more on the manufacturer and less on the seller, there are larger facilities involved, it faces higher production rates because of population growth, there is a greater emphasis on product quality – it must meet higher regulatory standards and public expectations, and there are competing alternative management options.
- Windrow composting is low-tech but can have hidden operating costs and odor management challenges. Aerated static pile (ASP) systems have upfront investment requirements and a higher learning curve, but they provide better management practices if the right approach is used. Composting partnerships with biosolids generators can produce some of the best benefits when used with AST systems. Modern indoor facilities that meet permit requirements can be better financed and can maintain manufacturing integrity.

- Market shifts include greater acceptance of compost (it is more mainstream), "green" environmental movements that are looking for recycling opportunities, nutrient management concerns that can open markets to quality compost, expanding markets, and new and more credible product certifications.

- Challenges for municipalities include lack of integral support by government officials to manage permitting programs, reduced public outreach resources to address vocal local activists who can drown out messages about the benefits of compost to the community, and justifying upfront costs of building indoor AST systems that may be superior and cost-beneficial technologies in the long-run.

- In sum, composting is a viable, sustainable option for municipalities. Modern AST processing provides benefits to product quality, odor management, permitting challenges. What is needed is assistance from government to ensure composting is seen as a viable management option. There is proven desire for the product among citizens.

Brown and Caldwell. *Anaerobic Digestion*, Perry L. Schafer, PE, BCEE. Brown and Caldwell is a full-service environmental engineering and consulting firm with 45 offices and 1,500+ professionals across the country. Walnut Creek, CA, www.brownandcaldwell.com

- Anaerobic digestion is a naturally occurring biological process in which large numbers of anaerobic bacteria convert organic matter into methane and carbon dioxide (a mixture called biogas) in the absence of air. It is a widely used biological process for treating wastewater solids.

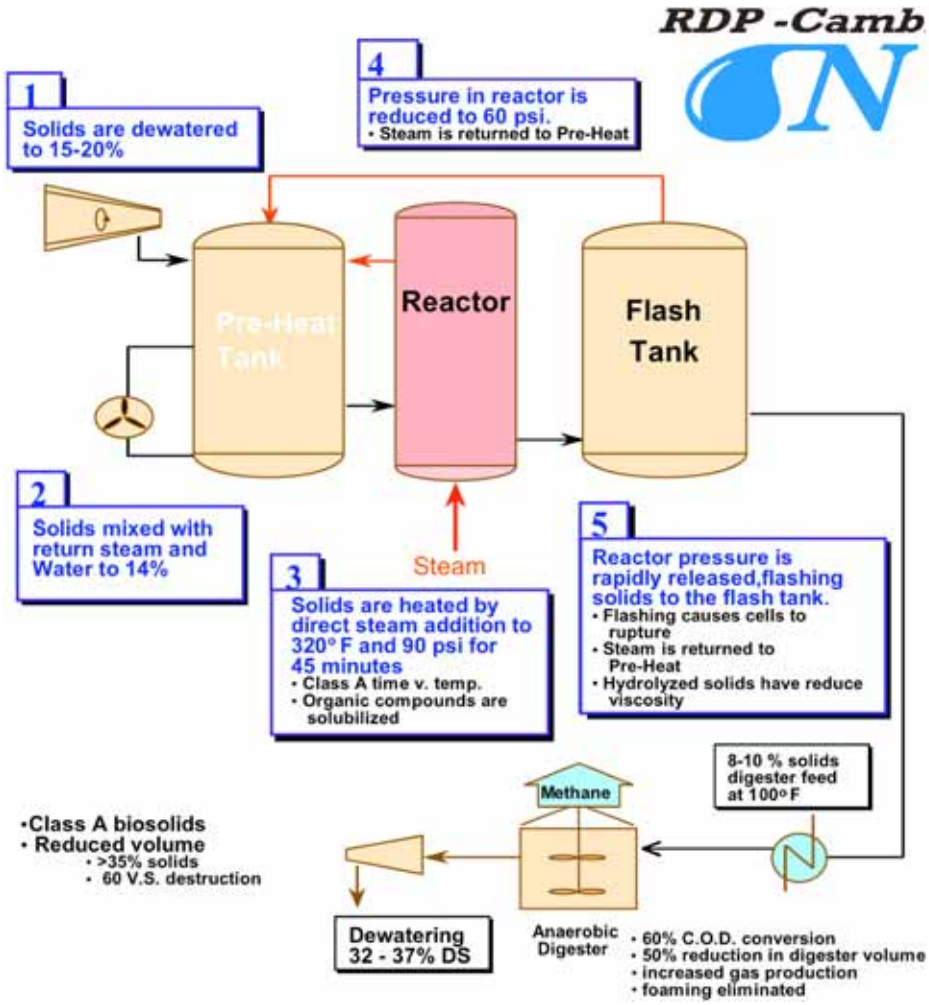
- This process stabilizes organic matter in wastewater solids, reduces pathogens and odors, and reduces the total solids/sludge quantity by converting part of the volatile solids (VS) fraction to biogas. Anaerobic digestion results in a product that contains stabilized solids, as well as some available forms of nutrients such as ammonia-nitrogen. In short, anaerobic digestion destroys solids, produces methane (biogas), destroys pathogens (Class A/B), stabilizes sludge, and provides a product suitable for beneficial use.

- (The next two paragraphs were adopted by the editor of this summary from the EPA document, *Biosolids Technology Fact Sheet, Multi-Stage Anaerobic Digestion* (www.epa.gov/owm/mtb/multi-stage.pdf))

- Process flow: Anaerobic digestion can take three separate steps, each of which is performed by a different group of microorganisms: 1) hydrolysis, during which proteins, cellulose, lipids, and other complex organics are broken down into smaller molecules and become soluble by using water to split the chemical bonds of the substances; 2) volatile acid fermentation, during which the products of hydrolysis are converted into organic acids through the biochemical processes; and 3) methane formation, during which the organic acids produced during fermentation are converted to methane and carbon dioxide.

- The standard multi-stage anaerobic digestion system is a two-stage acid/gas (AG)-phased system, in which the acid-forming steps (hydrolysis and volatile acid fermentation) are physically separated from the gas-forming step (methane formation) by being conducted in separate digestion tanks. An alternative method is to separate the stages over time by adding different levels of heating at different times in the process by a process called temperature-phased anaerobic digestion, or TPAD.

- A renaissance is occurring in anaerobic digestion driven by improved performance requirements (volatile solids reduction, biogas production, Class A needs, product stability, odor management), reduced costs (systems are more efficient and require less tankage), and desire for renewable energy and reduced carbon footprints. Research on impacts by chemicals such as ammonia has created process innovations and has quantified benefits, such as beneficial nutrient recycling outcomes. Digestion-related R&D is expected to continue.
- Digestion processes have evolved from use of lagoons and tanks and psychrophilic/mesophilic digestion in the early 1900s, to industrial waste digestion 60 years ago, to sector-specific digestion just ten years ago. Major digestion advances include thermophilic digestion, 2/3 phase, Class A, the Cambi process, co-digestion enhancements, and biogas use options.
- There are five basic causes of digestion instability/failure that must be monitored and controlled: hydraulic overload, organic overload, temperature stress, toxic overload, foaming situations
- Digesters come in many shapes and sizes, from cylindrical shapes with fixed, floating, or submerged covers, to single-component piece egg-shaped digesters that don't need covers.
- Process modifications and enhancements include physical, chemical or biological sludge disintegration to destroy volatile solids; pre-pasteurization; pre-digestion thermal hydrolysis systems; batch digestion at pressure and elevated temperatures; flow-through vs. batch thermophilic tanks; heat recovery systems; methane gas recovery systems; and co-digestion that allows two different waste streams to be processed simultaneously.



- There is a growing body of data on ROIs, life-cycle analysis, energy efficiency and recovery, greenhouse gas reduction, fertilizer and other end-use benefits, costs, etc. that are providing

utilities with decisionmaking tools as they improve and upgrade their systems.

Department of Crop and Soil Environmental Sciences (CSES), Virginia Tech. *Biosolids Utilization for Disturbed Land Rehabilitation*, Dr. W. Lee Daniels (with other scientists, support staff, and graduate students). CSES's combined research, teaching, and outreach programs focus on development of new techniques and strategies for rehabilitating drastically disturbed soils and landscapes. Blacksburg, VA, www.cses.vt.edu/revegetation

- The research program originally focused on coal-mined land reclamation and associated water quality issues, and has been continuously supported by the Powell River Project since 1979. In addition, researchers worked cooperatively with Iluka Resources on mineral sands mining reclamation since 1989.
- Over the past decade, they have significantly expanded their research base into wetland creation and restoration, acid sulfate soil remediation, roadside revegetation, dredge spoil use, manufactured soil production, by-product screening, and an array of related programs based in environmental soil science. The combined research program employs six to nine scientists, support staff and graduate students and maintains two support laboratories and two greenhouse facilities at Virginia Tech that offer complete physical and chemical analytical capability for soils, sediments, and mine spoils. It also offers greenhouse experimental and bioassay support.
- Biosolids have been used at higher-than-agronomic rates on coal-surface mined lands in the Appalachians since the 1970s. To test the effects of this practice, Penn State University and Virginia Tech launched a controlled overburden placement (COP) experiment in 1982, which ultimately confirmed the benefits of this practice and indicated a general lack of ground and surface-water impacts.
- The pictures above show the course of a typical study, this one of an Appalachian haul-back contour mine in Virginia. Over a five-year period, a 300 acre application of 65 T/ac of

Left: During this surface treatment experiment begun in April 1982, biosolids were applied at 10, 25, 50 and 100 T/ac vs. topsoil and sawdust plots *Center:* COP in early June, 1982, after seeding and rainfall. *Right:* COP Plot (50 T/Ac) in 2005. Red oak in foreground; fescue etc. in background. These are the oldest continuously monitored mine soil research plots in the world.

biosolids + woodchips (C:N = 30) had no effect on ground water NO_3 levels. In fact, NO_3 levels were highest before application due to the use of NH_4NO_3 explosives used in the mine.

- In 1995, the State of Virginia Department of Mines, Minerals, and Energy developed guidelines for the application of biosolids on coal-mined lands. These guidelines capped loading rates at 35 T/ac (dry) for biosolids cake and at 50 T/ac when the C:N ratio of the applied product was 25:1 or greater. However, use and application of these rates on non-coal mined lands in eastern Virginia was questioned by DCR and a number of follow-up studies ensued.

Tailings revegetation species trial with/without biosolids. Both areas received conventional lime/fertilizer/seeding. Not much more to say?

- Conclusions: Application of biosolids at higher than agronomic loading rates is an important and very effective disturbed land reclamation alternative. Benefits of this application include establishment of long-term organic matter and nutrient pools, improved water holding capacity, and long-term mine soil resilience and quality. Higher-than-agronomic rates are used on a one-time basis only with appropriate setbacks, buffers, water table separation etc.

ERCO Inc. *The Use of Biosolids to Grow Forest Crops: A Private-Public Success Story,* Eric Flamino, ERCO Inc. (eflamino@erco-inc.com) (with Jonathan Kays and Gary Felton of Maryland Cooperative Extension). ERCO owns a tree farm and specializes in growing sustainable crops at reclamation sites and other locations using biosolids. Glen Burnie, MD.

- ERCO Inc. has operated a 120-acre tree farm on a sand gravel mine reclamation site in southern Maryland since 1983. The company uses deep-row trenching to incorporate biosolids for fertilizer. This involves one-time application of biosolids in a wide and shallow trench that is covered with overburden and planted with hybrid poplar cuttings that use the nutrients over a seven-to-nine year rotation.

- Environmental benefits: Reduces or eliminates energy used to generate nitrogen (compared with ethanol production from corn, hybrid poplar production using fertigation); high rate reduces energy use per ton for application (compared with land application for crops); maintains and increases green space, even in suburban settings in close proximity to housing; produces wildlife habitat; gives the landowner a reason to keep the land rather than sell it for development; carbon sequestration; increased infiltration/decreased storm runoff impact; extended life of landfills.

- The biomass from the forestry operation can be used for energy and fertilizer production along with imported biosolids. Fore example, at least one on-site wastewater treatment

plant is necessary to get the effluent (water) that makes the trees survive (income source). It could process biomass and biosolids to create Class A compost.

- Compost can be sold, and biomass from the forestry operation can be used to created useful products like paper, dimensional products, and biofuel energy via cellulosic ethanol feedstock or palletizing.
- The system can adapt to the markets and to biosolids input availability, which is likely to increase. Once started, a forestry crop goes on without additional biosolids input. However, additional biosolids can be surface-applied. Biofuels from hybrid poplar and switchgrass can use spent sand and gravel mine spoils and marginal agricultural land without negatively affecting Maryland's agricultural land base.
- Energy values for various biomass crops: Acre corn = 233 gal. gasoline; acre switchgrass = 530 gal. fuel oil; Acre 6-year old hybrid poplars = 1,023 gal. fuel oil.
- If corn ethanol were used to replace gasoline as E85 (as in Brazil) it would require more farmland than exists in the US. Biomass energy can be a component of a system with flexibility, but in the current state of science and technology, it is not a practical replacement for transport fuels. The energy gain is small, the water requirement is 4-5 gal/gal ethanol, the energy content = 2/3 gasoline energy content (therefore reduced mileage), one gallon of gasoline equivalent costs $3.99 for E85.
- Research: ERCO has been working with the University of Maryland, the Washington Suburban Sanitary Commission, and DC-WASA to analyze groundwater samples to study the fate and transport of nitrogen and other nutrients in the deep-row trenching-tree planting system. The researchers also have been studying the impact on tree growth of different fertilizer and spacing rates and the overall economics of the system.
- It also has launched several projects to explore the use of biosolids and poultry litter to grow hybrid poplars without contributing to water pollution. One of the projects was to be conducted by Dr. Gary Felton at the Beltsville Agricultural Research Center and another at the university's Wye research farm on the Eastern Shore. In both cases, the trees are planted conventionally and biosolids or other soil amendments are surface-applied.
- In addition, trials of using different hybrid poplar clones are helping select clones best adapted to different sites.

ERCO deep-row biosolids trenching hybrid poplar farm.

College of Natural Resources, Virginia Tech. *Land Application of Biosolids to Forests*, Dr. Thomas R. Fox, Associate Professor of Forestry (trfox@vt.edu). As part of the program at Va Tech, researchers are studying the impact of biosolids application on forested sites to water quality and tree growth. Blacksburg, VA.

- The growth of most pine plantations in the south is limited, but following are the effects of biosolids on two-year growth of young loblolly pine in Florida (showing treatment, height, and growth in feet): Check -- 4.8a – 0.6a; N+P fertilizer – 5.6b – 0.9b; biosolids – 6.0b – 1.1b.
- Researches wanted to answer the following questions: Do trees grow faster after application of biosolids? What are the effects of biosolids on nutrient dynamics in forest soils? What is the potential for offsite movement of nutrients following biosolids application in forest ecosystems? Are there differences among the various types of biosolids?
- They launched two studies: 1) Soil Nutrient Dynamics and Growth Response of Loblolly Pine Following Biosolids Application; 2) SMZ Effectiveness and Water Quality Following Biosolids Application (where biosolids were applied to paired stream segments with 50 ft SMZs)
- At the first study site in Amelia County, VA, they applied different levels of biosolids to a loblolly pine plantation and measured the flux of nutrients leaving the site in ground and surface water. The project was designed to identify the maximum level of biosolids amendment that would benefit the trees without compromising water quality. Nitrogen availability increased after biosolids and conventional fertilizer applications. Results from this study indicate that biosolids, applied at low rates, may be a good alternative as a source of nutrients. Biosolids and conventional fertilization increase nitrogen availability. With allowed 215 kg/ha PAN there is no sign of nitrogen leaching.
- The second study evaluated forestry best management practices (BMPs) at streamside management zones (SMZs) to maintain water quality. It is indicating that water quality shows no significant declines when SMZs are retained adjacent to biosolids-applied forestland. Forestland soils applied with biosolids have elevated N & P availability.