



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

OFFICE OF  
RESEARCH AND DEVELOPMENT

Gary S. Saylor, Ph.D.  
Chair, Board of Scientific Counselors  
Center for Environmental Biotechnology  
The University of Tennessee  
676 Dabney Hall  
Knoxville, Tennessee 37996

Dear Gary:

On April 25-26, 2007, the Science and Technology for Sustainability (STS) Program Subcommittee of the Board of Scientific Counselors (BOSC) met in Cincinnati, Ohio to evaluate the Office of Research and Development's (ORD) Sustainability Program. Following that review, the Subcommittee presented a report of its findings and recommendations to the Executive Committee of the BOSC on September 17, 2007, and the Executive Committee, in turn, provided a final BOSC report to the ORD on April 22, 2008. With this letter, I am pleased to enclose the Agency's response to the final BOSC report on its review of the STS Program.

The program benefited a great deal from the insight and advice offered by the Subcommittee, and the recommendations were greatly appreciated. The attached narrative presents an overview of the recommendations made by the BOSC and provides a brief comment in response that indicates how the STS program has taken the findings into consideration. A table that summarizes each recommendation, the action to be taken, and a schedule for completion of the action is also attached.

As you are aware, ORD conducts periodic evaluations of progress for each of its research programs at intervals of four to five years. The purpose of these reviews is to determine progress with regard to relevance, quality, performance, and scientific leadership. The reviews also focus on identifying how the scientific community and programmatic clients utilize ORD's scientific outputs to protect human health and the environment. In addition to these formal reviews, ORD evaluates program progress midway through the review cycle. These mid-cycle reviews provide critical feedback to the program concerning its progress since the last review and the extent to which recommendations from that review are being met.

The date for the mid-cycle review of the STS program will be March 12, 2009, and we look forward to demonstrating our progress at that time. In the meantime, if you or other members of the BOSC have any questions about the enclosed response, please contact Alan Hecht, through Greg Susanke the appropriate DFO of course. Thank you again.

Sincerely,

A handwritten signature in black ink, appearing to read "Kevin Y. Teichman".

Kevin Y. Teichman, Ph.D.  
Deputy Assistant Administrator for Science

Enclosure



**Office of Research and Development's (ORD) Response to the  
Board of Scientific Counselors (BOSC) Report on the Review of ORD's  
Science and Technology for Sustainability (STS) Research Program  
(final report received April 2008)**

December 2008

**BOSC Technology for Sustainability Subcommittee**

Dr. John Giesy (Chair)

Dr. Martin Abraham

Dr. Earl Beaver

Dr. Concepción Jiménez-González

Dr. Wayne Landis

Dr. Ted Tomasi

Dr. Peter Corcoran

**December 2008 Office of Research and Development's (ORD) Response to the Board of Scientific Counselors (BOSC) Report on the Review of ORD's Science and Technology for Sustainability Research Program (final report received April 2008)**

The following is a narrative response to the comments and recommendations of the review by the Board of Scientific Counselors (BOSC) of ORD's Science and Technology for Sustainability Research Program (STS), which took place in April 2007 in Cincinnati, Ohio. We thank the members of the BOSC Science and Technology for Sustainability Research Subcommittee for their comprehensive review of the Research Program's multi-year plan (MYP). Based on the Subcommittee's comments and recommendations, ORD has already initiated efforts to modify the STS Program and looks forward to the mid-year review scheduled for March 2009 for further discussion and feedback on the Program's evolution and achievements.

For the April 2007 review, which is considered to be part of a series of consultative reviews, the BOSC Subcommittee focused on the STS's strategic goals; its program relevance, quality, and structure; its scientific leadership, coordination, and communication with stakeholders; and the degree to which research outputs are being used by stakeholders, e.g., outcomes. The panel addressed a number of charge questions intended to focus on each of these themes. It rated many parts of the STS Research Program favorably and found that the Program was meeting expectations. The Subcommittee recognized the high caliber of excellent researchers who are achieving high-quality research with relatively limited resources. The Subcommittee recognized that the current structure of the Program was well suited for the development of decision support tools that promote environmental stewardship and sustainable management practices. The BOSC also acknowledged that the Program as planned would be able to develop, apply, and demonstrate innovative technologies that solve environmental problems and provide sustainable outcomes. At the same time, the BOSC offered numerous suggestions to improve the program. The insights provided by the BOSC Subcommittee are helping ORD to better focus its planned STS research.

In preparing this narrative response, ORD grouped the Subcommittee's many detailed comments into seven overarching strategic issues related to the charge questions. Under each issue, relevant Subcommittee comments are printed in italics and ORD's response follows in regular type. Attached to this document is a summary table that provides a more comprehensive list of BOSC comments and ORD responses.

**Strategic Issue #1: Better define, communicate, and coordinate metrics research and its outputs and better explain their relationship with other components of the STS.**

*The use of rigorous metrics is critically important in the development of decision-making tools and also should drive research needs in both internal and external programs. A key component of the development and testing of appropriate metrics is a clear conceptual definition of what is to be measured with a particular set of metrics. Thus, clear definitions of the sustainability concepts being addressed and the component elements of these concepts are required*

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*before a specific metric can be assessed and its applicability in real-world situations evaluated. Additional attention needs to be given in this element to the process of development and evaluation of sustainability metrics. Testing of specific metrics in real-world situations also is appropriate, but one needs to propose and develop the metrics first. Then, the testing protocols should be established to determine if the metrics are measuring the intended functions, if they are consistent in their evaluation, if they are sufficiently independent, and if they can be effectively used to determine if specific actions are driving society to become more sustainable.*

*A clear definition of sustainability and a framework for its application is required to fund appropriate extramural research programs and to determine the efficacy of specific metric or decision tools.*

*The metrics developed under the P2NT Research Program have not pervaded other programs.*

*Given their limited numbers, the team leaders are having an appropriate impact on the development of scientifically based sustainability metrics. A team that was better integrated throughout EPA could draw on additional resources that could enhance its effectiveness.*

*The development of sustainability metrics is a critical component of the overall effort, because these are the measures on which the success of all activities needs to be evaluated. It is unclear, however, precisely how the metrics to be developed within this element will be used in other LTGs, and it also is unclear how the metrics to be developed will be informed by activities in the other LTGs.*

While the P2NT Research Program was not specifically designed for or focused on metrics development, ORD agrees with the BOSC perspective that development of metrics is an important area and that we must work diligently to ensure they are widely used within and outside the Agency to guide decisions on sustainable alternatives. The STS is only one of many programs across the Agency that will address sustainability. We concur that the Agency needs to further develop definitions of sustainability concepts and define how sustainability can be made operational. However, resolution of this issue transcends the STS and must be addressed across the Agency. Over the next year, ORD will coordinate a series of workshops to facilitate a discussion on this issue. These workshops will be designed to engage key Agency officials in Program Offices and Regions to obtain their perspectives. Ultimately, the decisions regarding an Agency sustainability framework, including appropriate definitions, will be the responsibility of these officials. Any metrics resulting from these discussions will need to incorporate clear conceptual definitions of what is to be measured. In general, development of sustainability concepts and metrics will be produced to address specific problems of national importance consistent with the following recommendations of the Environmental Engineering Committee of EPA's external Science Advisory Board:

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The Committee supports application of sustainability principles to address and resolve specific, multi-faceted environmental problems.

The Agency should be prepared to undertake some "higher risk– higher payoff" projects, i.e., projects that because of complexity, data requirements, methodological novelty, and interdisciplinary focus, may be challenging, but would have a large impact if they are indeed developed successfully. The project portfolio should also balance targeted Agency needs and geography.

In a few key areas, including urban development and biofuels, ORD is already working on developing sustainability metrics that be used as the foundation for discussions at the workshops mentioned above. ORD is using its new work on biofuels as a model of how we might work across EPA to address such other key issues as materials management and ecosystem protection. ORD is now working with other federal agencies to define a set of criteria and indicators for sustainable biofuel production. The work requires clearly identifying the critical elements of biofuel production and identifying relevant indicators to measure progress toward sustainability. Information contained in the *EPA Biofuels Strategy* can help to guide STS activities in the biofuels area. In addition to the biofuels work, ORD is also developing a set of system metrics that represent the most fundamental properties and processes that must be preserved to ensure the sustainability of a particular geographical system or region. These metrics will be used to ascertain whether the region is moving towards or away from sustainability over time and to promote adaptive environmental management for sustainability.

We think the above examples address the BOSC concern about defining sustainability and "testing of specific metrics in real-world situations also is appropriate." In the first case, ORD is testing the model in the growing biofuel sector. In the second example, ORD is developing and evaluating the application of metrics in specific geographic region of importance. Also, the Collaborative Science and Technology Network for Sustainability (CNS) has funded 23 projects across the country that are developing coupled decision-making tools and metrics and applying them for real-world sustainability decision-making in diverse settings. While we cannot adjust these projects, ORD will sponsor a webinar series followed by a workshop to bring together internal and external investigators to identify any lessons learned from the CNS program and determine if there are any specific outputs from the ongoing projects that could be used to enhance internal research efforts.

Also, ORD will expand the existing metrics team to include other parts of the Agency. For example, an internal EPA team focused on sustainable biofuel production has been organized and is already discussing issues related to metrics.

In the revised MYP, the general approach for the development of sustainability metrics will be described including criteria to assess their utility. Finally, as part of the STS revisions, ORD will add language to the MYP to ensure that appropriate linkages are

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made between the metrics LTG and the balance of the Program. The revisions will factor in the role of metrics and other driving forces.

**Strategic Issue #2: Relevance of the Green Technology Program (GTP) is unclear in light of activities in industry and other federal agencies.**

*The Green Technology Program is less relevant and there is a less clear connection to Program goals. It was not clear what activities were underway that could not be accomplished in the public or academic sectors in the absence of the EPA program; thus, the public benefits were not evident.*

*The Green Technology Program as currently configured might be perceived to be largely irrelevant. Consideration should be given to redirecting the Program or replacing it with an extramural grants program.*

*The relevance and impact of the Green Technology Program is less apparent and this program needs to be assessed internally to determine if it is serving a function that is not being met already by the private sector and academia.*

*Results derived from the Green Technology Program have not been effectively communicated to larger industrial enterprises.*

The original goal of the GTP was to perform research that could be broadly applied to many processes in industry. The research results from the Program's many projects have been the subject of numerous presentations at national professional meetings attended by representatives of nearly all major chemical producers. In the ten year period from 1996 to 2006, the Green Chemistry program published 384 peer reviewed papers, 34% of which are listed among the top 10% of all cited papers in their field. This work was coupled with successful decision support tools such as PARIS (Program for Assisting the Replacement of Industrial Solvents) and SAGE (Solvent Alternatives Guide) that have assisted industry to identify cleaner products and processes. However, as the need for metrics and decision support tools has increased, as well as the green technology efforts of industry and others, ORD has eliminated in-house research to investigate new green technologies and chemistries.

The extramural portion of the Program has continued its partnership with the National Science Foundation (NSF) to identify research needs in areas such as green chemistry and green engineering in rapidly growing (or changing) sectors (including energy and nanotechnology); green building; advanced life cycle assessment, material flow analysis, and related systems analyses; and environmental sensors and information systems. The partnership is currently focusing on Green Building.

**Strategic Issue #3: Use sustainability criteria to evaluate proposals (SBIR and P3).**

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*The solicitation/judging criteria for the P3 Program should be improved to require a clear statement by students as to effects articulated via sustainability metrics or decision tools. More emphasis should be placed on measurement. This will force students to more clearly articulate how their projects relate to sustainability. The ETV Program should encourage an increased role in supporting emerging markets in trades/mitigation/offsets, such as mercury/greenhouse gases, etc. An analysis should be conducted to determine if there are emerging markets in the trade/offset areas that have barriers to verification. Then, research could focus on how to solve or minimize these impediments to verification and subsequent use. The SBIR Program should increase the use of sustainability metrics in the selection criteria. It also should increase the linkages between Program outcomes and sustainability metrics.*

*The Program could benefit from a more systematic evaluation of the program outcomes, such as tracking of careers of recipients to obtain information that can be used to measure impact as outcome. Thus, a detailed analysis of the impacts on the P3 Program on the student participants is desirable.*

ORD understands the BOSC desire to ensure any proposal funded with ORD STS resources include measurement of progress towards sustainability. Many of the ongoing research projects already consider metrics and measurement in their design and implementation. For example, the P3 Program requires student teams to quantitatively and/or qualitatively articulate the benefits of their project in the social, environmental, and economic dimensions, both at the proposal stage and at the final report stage. For the Small Business Innovation Research (SBIR) program, the strongest opportunity to focus on sustainability is in the identification of solicitation topics. Though SBIR is structured to address environmental technology priorities beyond sustainability across the agency, many of these priorities have been sustainability-related in recent years. SBIR does release "success story" reports that quantify environmental benefits. EPA's scientific expertise in this area, particularly related to metrics, can directly support future efforts to more overtly consider sustainability criteria and concepts in the SBIR and P3 Programs.

Regarding the Environmental Technology Verification (ETV) Program, several of the existing centers have or are currently verifying technologies in some emerging market areas. For example, in the area of climate change, ETV has verified several combined heat and power units designed to reduce CO<sub>2</sub> and other pollutants.

Although the P3 Program is a relatively young program (it was started in 2003), NCER is working with ORD/ORMA to assess the effectiveness of the program relative to its role in (1) stimulating sustainability in academic institutions; (2) providing students with an opportunity to work on a real-world problems and thereby learn the value of teamwork and diversity; and (3) develop technologies, tools and processes that promote sustainability.

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**Strategic Issue #4: Better program integration is needed as the P2NT transitions to the STS.**

*In general, the Program structure appears to be adequate but it should be assured that there is integration and continuity among the elements during the plan for transition. The existing Program elements and the structure proposed for STS research in the future are organized around the development of scientifically based sustainability metrics. The current structure of the Program and the proposed structure are well-suited for the development of decision support tools that promote environmental stewardship and sustainable management practices.*

*There needs to be significant interaction between this LTG and, in particular, LTG 2, which are intimately tied together.*

*Economics and other social dimensions should be incorporated as part of feedback loops of process or output evaluated decision-making.*

*The Subcommittee recommends integrating an implementation plan as part of the STS MYP. Some concepts in the APGs of the STS MYP need to be defined (e.g., 'sustainable land use,' 'sustainable water use,' 'local level') to ensure clear understanding by stakeholders and to ensure that all the aspects of sustainability are incorporated. Strengthen and expand communication aspects of tools as part of the MYP including: (1) guidance regarding scope (e.g., what LCA does and does not do), outreach, and influence (how LTG 1, LTG 2, and LTG 3 tie together in the path to sustainability); and (2) interrelations of different aspects of sustainability. Ecological aspects should be incorporated into the tools for decision analysis. Additional expertise might be needed to cover ecological systems so it would be wise to strengthen collaborations with the ORD Ecology Research Program. Geographic and landscape orientation should be incorporated for local implementation.*

The STS MYP was designed to describe an integrated program that explains how each of the LTG outcomes/products link to provide a holistic perspective on sustainable solutions. In order to clarify these linkages, ORD will incorporate changes that will better explain how ORD and its partners will integrate the various research components described in the STS MYP. While we agree that economic and social dimensions should be integrated into the tools produced, these topics are primarily being addressed by others in the Agency, e.g., the National Center for Environmental Economics. ORD will remain abreast of what others in the Agency are doing and attempt, where feasible, to incorporate the results.

An example of how this integration is already happening is in the biofuels area where unlike other programs, research is starting with potential metrics as a way to influence and inform research. ORD's Ecology Program, through the Future Midwest Study, is also evaluating location-specific sustainability issues related to changes in land use. In

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addition, as part of the revision of the STS MYP, ORD will also include any additional appropriate language to better describe the planned research. However, the MYP will not include specific implementation details on every research activity that ORD plans to perform over the next five years. ORD Laboratories and Centers typically develop these implementation details consistent with the MYP goals. ORD also recognizes that sustainability will occur at various geographic scales.

Different sustainability metrics and indicator efforts that relate to LTG 1 in the STS MYP are also related to each other. At the sub-national scale, ORD is developing place-based local and regional scale metrics and indicators. For example, the STS Program is deriving a suite of science-based sustainability metrics to assess and track system condition, including dynamic order (Fisher information), ecological footprint, energy content, and net regional product. Also, informed by collaborative processes, the CNS Program is developing a series of case studies with sets of sustainability indicators and desired outcomes to inform regional decision-making. Both the more theoretical metrics and the more practical indicators rely on similar data sets. Over time, we will blend the two efforts so that the scientific indicators become more accessible and more decision-relevant, and the practical indicators become more scientifically sound. Sub-national sustainability metrics based on resource use, principally focused on supporting the decisions of industry, may relate to manufacturing and other activities at numerous locations. For example, the ETV Program is supporting the development of sustainability metrics to inform technology verification, and the CNS Program supports some industrial metrics and indicators based on resource use.

The existing MYP attempts to describe the interaction and dependence of LTG 1 (metrics) and LTG 2 (decision support tools), which are meant to be coupled to provide integrated solutions to complex environmental problems. In many cases, these metrics couple with tools developed under Goal 2. The research supported in the STS MYP provides tools and related underlying models [including life cycle assessment (LCA), material flow analysis (MFA), Future Scenarios, and Geographic Information Systems (GIS)] that support planning and decision-making for government (APG 2.1), companies (APG 2.2), and communities (APG 2.3). The key programs include LCA, Environmental Impact Assessment (EIA), and the Collaborative Science and Technology Network for Sustainability (CNS).

Since it also transcends the STS MYP, the sustainability concept needs to be reflected in other MYPs. ORD will work with the rest of the Agency to determine how sustainability concepts can be integrated into the design and execution of other programs. Those carrying out the STS MYP, particularly the ORD Sustainability Director, will continue to suggest to ORD National Program Directors (NPDs) how they can use STS research results and sustainability concepts to evaluate their proposed research agendas. However, in order for sustainability concepts to become an Agency priority, senior Agency officials, such as the members of the Science Policy Council, will need to promote the concept.

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**Strategic Issue #5: ORD STS Program should be more strategic and focus on a limited number of areas where it can make unique contributions and impacts.**

*Currently, much of the work being conducted by the STS Research Program is eclipsed by the magnitude and pace of advancements of industrial and academic communities. Thus, in developing the plan, the Program must make strategic decisions on where it can make an impact on the overall field.*

*Some Program elements are small components and lack a critical mass of personnel.*

*The potential impact of STS programs is limited by lack of a critical mass and resources. In developing the STS Research Program, ORD must make better use of capabilities across ORD.*

*The ETV Program should encourage an increased role in supporting emerging markets in trades/mitigation/offsets, such as mercury/greenhouse gases, etc. An analysis should be conducted to determine if there are emerging markets in this trade/offset area that have a barrier surrounding verification issues.*

*Development of streamlined methods is needed as part of the expansion of LCA tools (e.g., make them user-friendly) as well as integration of material flow analysis (e.g., industrial ecology concepts).*

*System-based methods are indispensable for moving towards sustainability. These are integrated in the STS MYP, but need to be integrated into tools.*

*Carefully examine the rationale for the selection of target areas/technologies to better address market failures and tie outcome measures to sustainable measures and metrics.*

*The Program should incorporate additional decision-making tools, such as probabilistic risk assessment, Bayesian networks, causal pathways, and Multi-Criteria Decision Analysis (Igor Linkov and others) in the research program.*

This recommendation is consistent with guidance from the June 2007 Science Advisory Board (SAB) Advisory on ORD's Sustainability Research Strategy and the Science and Technology for Sustainability Multi-year Plan), which "acknowledges that the judicious selection of research projects within the Plan will help to facilitate the diffusion and adoption of the sustainability paradigm both within and outside the Agency." In concert with its internal and external partners, ORD will work to focus the STS Program on a select number of issues in which its expertise and resources can provide unique outputs that will meet client needs and advance sustainability solutions. Smaller and less relevant components of the Green Technology Program will be eliminated and the associated resources will be redirected to address higher-priority research. Based on BOSC

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recommendations, ORD has already made some strategic adjustments by starting to focus on issue of the sustainability of various biofuel production options. This emphasis on national environmental problems will ensure the Program will have a significant impact now and into the future.

With respect to the Environmental Technology Verification (ETV) Program, while we agree with this recommendation, we note that ORD has already engaged in market analysis research to identify where verification will be most useful. For example, in the area of climate change, ETV has verified several combined heat and power units designed to reduce CO<sub>2</sub> and other pollutants. Consistent with the self-sustaining concept of the ETV program, should the private sector provide the resources, ETV will perform additional verifications.

One area where ORD is already making a unique contribution is the development of integrated tools using a systems-based approach. For example, several efforts are underway to produce tools that will holistically examine the environmental impacts of the production, utilization and disposal of biofuels.

In addition, the revised STS MYP will more clearly delineate the strategic choices and the criteria for selection of programs and projects. New outreach activities across EPA programs and regions are underway to help inform the strategic choices. As these strategic choices are made, ORD will make better use of ORD-wide capabilities by strengthening existing partnerships with other Agency programs such as continuing linkages with Ecosystems Research Program and strengthening partnerships with the Drinking Water and Global Change Research Programs. ORD collaborates extensively with other federal agencies to minimize duplication of effort and ensure involvement of academia in high-priority research areas. This collaboration includes efforts to influence NSF and other federal agencies that provide funding to the outside academic community for fundamental research.

Already at the forefront of developing LCA methodology, ORD will ensure that the revised MYP accurately reflects the need for streamlined LCA approaches. Several projects supported by CNS employ MFA methodologies. ORD is also cosponsoring with NSF a special issue of the *Journal of Industrial Ecology* on applications of MFA. The MYP will also be revised to ensure we explain the range of decision-making tools available.

**Strategic Issue #6: ORD needs to collaborate more extensively with outside partners to avoid duplication and enhance research impact.**

*Currently, it does not appear as if extramural collaborations are planned on techniques to better relate process outputs to environmental impacts.*

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*It is not clear if the coordination has been successful in reaching a wider set of stakeholders, such as NGOs, state agencies, etc. If possible, these efforts should be encouraged.*

*Many of the results of the research under LTG 3 have not reached the user community. Some outside partners appear dedicated to obtaining grant support and/or license fees as opposed to utilization of the technology. Also, there is a need to better understand what has been done by academia and industry. While it is clear that ORD has collaborated with and obtained input from others on research objectives, especially to avoid duplication of effort, the Subcommittee members thought that this is so critical to the acceptance and use of the technologies developed that the Program should seek input from a number of extramural groups to assist EPA. In fact, such communications could result in partnerships and greater leveraging of the limited Program resources. Some of the work is a duplication of previous or current work being done by others outside of EPA. Larger industrial and manufacturing firms are underrepresented in setting objectives and avoiding duplication. Hurdles should be lowered and/or obstacles removed to insure that "those who really know" participate. It appears that the U.S. Department of Energy (DOE) and others may be acting without knowledge of the P2NT efforts. While not a complete replication, the projects and programs seem to be uncoordinated with those of other agencies.*

*SBIR: Increase meeting of stakeholder needs. If the Program can better address the internal Agency needs from the STS MYP, it will provide a valuable service and be recognized more favorably. The goal of moving to a 100 percent cost share basis needs to be carefully evaluated. Although this will better leverage funds, it might miss important opportunities. This might be a future goal, but it needs to be determined if this would result in missed opportunities for small businesses. This could occur if they: (1) could not afford the assessment; and (2) are not being funded for this purpose through the SBIR Program. Additional SBIR opportunities in the broader set of sustainability concerns, such as land and water uses, need to be explored. One example might be the design of storm water handling systems in new developments. Certainly there are other opportunities as well.*

ORD is keenly aware of sustainability activities across the government and internationally. ORD has always worked with outside organizations on aspects of tools development. ORD also benefits from having a strong academic effort in this area and is pursuing partnerships with other federal agencies that are poised to fund this research. For example, the STS is conducting a demonstration project with the direct support of a variety of local governments, including the regional metropolitan sewer district, which is facing an EPA consent decree to solve the community's stormwater problem.

Coordinated strategic plans are currently being developed for certain high priority sustainability areas such as biofuels. Both the extramural and intramural portions of the

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Program are currently developing relationships with our federal partners (and others investing in research) to positively influence their research and identify any gaps/niches for future ORD investment. Over the next year, the Program will better characterize activities underway, nationally and internationally, in the areas of metrics and decision support tools to ensure our research is adding incremental value. We will capitalize on the successful approach used to engage stakeholders in the ETV Program to gather this information.

The SBIR program encourages but does not require cost sharing as part of the commercialization focus of the program. An SBIR Phase II program review completed this year showed that 73% of SBIR projects secure additional investment beyond their SBIR awards. SBIR is structured to address technology priorities across EPA through the Environmental Technology Council (ETC) and other mechanisms. Storm water management technology has been among the sustainability-related topics addressed by SBIR in recent years.

**Strategic Issue #7: Develop annual goals that are better defined and quantifiable so that impact can be determined.**

*The APGs should be provided in more quantifiable forms, generally in the form of SMART (specific, measurable, achievable, relevant, and timely) goals. The goals are written very generically, without sufficient measurable targets against which one can evaluate performance.*

*ETV: The current outcomes analysis does not measure the effect of the ETV Program, because it does not attempt to identify outcomes in the absence of the ETV Program. Outcome measures stated in terms of numbers of verifications are probably better, even if considered less relevant. These metrics are better linked to the question of number of decision-makers/impacts. The metrics were deemed to be well-defined, but not well-quantified.*

ORD will make adjustments to the existing APG language and structure in order to ensure that goals are more quantifiable and to better define the anticipated outcomes.

ETV is a critical component of the overall technology continuum, which has been strongly endorsed by NACEPT. Over the years, ETV has produced many protocols that are widely used across many industries to evaluate technologies and their environmental implications. ETV offers independent and unbiased data which decision-makers feel comfortable using for implementation of regulations and/or voluntary programs. The ETV program tracks its verifications and protocols and can provide the BOSC annual figures.

The Appendix consists of a table that provides more details on how we plan to respond to each of the BOSC recommendations, including a timeline showing completions dates for

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each action. We look forward to meeting with the BOSC in 2009 and reporting on the activities described in this response.

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**Appendix. Table of Recommendations and Response/Actions**

Issue #	Recommendations	Response/Actions	Time Line
1	A clear definition of sustainability and a framework for its application are required to fund appropriate extramural research programs and to determine the efficacy of specific metric or decision tools.	While the STS programs adopts the general definition of sustainability given in E.O. 13423, more specific goals and metrics must be defined for each media or cross media element, as in the case of sustainable production of biofuels. ORD will coordinate a series of workshops to facilitate discussions that will further identify sustainability outcomes and metrics in key areas such as sustainable urban development, green building design and sustainable agriculture, as for example. These workshops will be designed to engage key Agency officials in Program Offices and Regions to obtain their perspectives.	Sept 09
1	Definitions are needed for some terms to improve clarity of Program elements and responsibilities.	See response above.	Sept 09
1	Develop an outline for how metrics for sustainability will be developed. This should include criteria for assessing the utility and predictability of metrics.	In the revised MYP, the general approach for the development of sustainability metrics will be described including criteria to assess their utility.	Feb 09
		ORD is working with other federal agencies to define a set of criteria and indicators for sustainable biofuel production. This work will be a model for application and development of metrics in other areas.	Nov 08
1	Coordinate metric development with other LTGs.	ORD will add language to the MYP to ensure that appropriate linkages are made between the metrics LTG and the balance of the program. The revisions will factor in the role of metrics and other driving forces.	Feb 09
1	Determine a strategy of how metrics will be used.	ORD will coordinate a series of workshops to facilitate a discussion to further develop definitions of sustainability concepts, including metrics.	Sept 09

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Issue #	Recommendations	Response/Actions	Time Line
		<p>These workshops will be designed to engage key Agency officials in Program Offices and Regions to obtain their perspectives. During these discussions, ORD will address how metrics will be used to support the sustainability concepts identified and determine their applicability to key Agency programs. Biofuel work is a good case study. Here the intent of using metrics is to define a "dashboard" of key environmental, social and economic measures for all agencies to monitor. Where trends are going in the wrong direction, collaborative federal action would be initiated.</p>	
1	<p>The metrics developed under the P2NT Research Program have not pervaded other programs.</p>	<p>While P2 is an important consideration in other Agency programs, the P2NT Research Program was not specifically designed for or focused on metrics development for other programs.</p>	N/A
1	<p>Going forward, an extramural program based on the Technology for a Sustainable Environment (TSE) Program could be crafted to emphasize metrics and how technologies move toward improving the measures.</p>	<p>The STS program is pursuing partnerships with NSF and other extramural research agencies on topics such as Green Building. In addition, current projects funded under the extramural CNS program are using decision-making tools to move towards identified sustainability outcomes at a regional scale. Many of the projects have a strong focus on metrics and some are also incorporating technologies. Beginning in October 2008, ORD will initiate a monthly webinar accessible to all of EPA on these projects. In addition, ORD will sponsor a workshop in the spring of 2010 to bring together internal and external investigators to identify lessons learned from the CNS program and identify any specific outputs from the ongoing projects that could be used to enhance research efforts related to metrics and decision support.</p>	Oct. 08
1	<p>Testing protocols [in real world applications] should be established to determine if the metrics are measuring the intended functions, if they are</p>	<p>We agree metrics should be evaluated to ensure they are moving society to a more sustainable future. There is some work underway to develop and test a set</p>	Feb 09

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	<p>consistent in their evaluation, if they are sufficiently independent, and if they can be effectively used to determine if specific actions are driving society to become more sustainable.</p>	<p>of system metrics that represent the most fundamental properties and processes that must be preserved to ensure the sustainability of a particular geographical system or region (e.g., the San Luis Valley community).</p> <p>However, since these studies are data-intensive and often resource-intensive, the extent to which EPA alone can fund and manage such activities is limited. Therefore, at the present time, our efforts are limited to geographic-specific studies like the one above and a new effort in the area of biofuels. The revised MYP will reflect our current plans in these areas.</p>	
1	<p>The predictability of the models should be evaluated and sensitivity analyses conducted.</p>	<p>See response above.</p>	<p>Feb 09</p>
1	<p>Sustainability targets need to be identified so that appropriate metrics can be designed and tested.</p>	<p>ORD will coordinate a series of workshops to facilitate a discussion on further developing definitions of sustainability concepts, including metrics and how to make them operational. These workshops will be designed to engage key Agency officials in Program Offices and Regions to obtain their perspectives. During these discussions, ORD will address metrics and their applicability to key Agency programs.</p>	<p>Sept 09</p>
1	<p>Critical experiments should be designed that allow testing of hypotheses within the realm of defined metrics.</p>	<p>We agree that the intent of metrics is to ensure they are moving society to a more sustainable future. There is some work underway to develop and test a set of system metrics that represent the most fundamental properties and processes that must be preserved to ensure the sustainability of a particular geographical system or region (e.g., San Luis Valley community).</p> <p>However, since these studies are often resource intensive and are data intensive, the extent to which EPA alone can fund and manage such activities is limited. Therefore, at the present time, our efforts are limited to geographic-</p>	<p>Feb 09</p>

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		specific studies like the one above and a new effort in the area of biofuels. The revised MYP will reflect our current plans in these areas.	
1	Evaluation of the metrics should be done systematically and quantitatively.	Our new work on biofuels is setting a model of how we might proceed to addressing critical national issues. ORD will use the biofuel example as a model of how to work across EPA and the rest of government to establish and implement metrics that are systematic and quantitative.	Nov 08
1	A team that was better integrated throughout EPA could draw on additional resources that could enhance their effectiveness.	ORD will expand the existing metrics team to include other parts of the Agency. For example, an internal EPA team focused on sustainable biofuel production has been organized and is already discussing issues related to metrics.	Jun 09
2	The relevance and impact of the Green Technology Program (GTP) is less apparent and this program needs to be assessed internally to determine if it is serving a function that is not being met already by the private sector and academia.	ORD will deemphasize in-house Green Technology research (LTG 3) and modify the MYP to reflect increased emphasis on metrics (LTG 1) and decision support tools (LTG 2). The MYP will also be modified to indicate that extramural GTP efforts will be focused on partnerships with other funding agencies to help identify important priorities.	Feb 09
2	All of the program elements and the Green Technology Program in particular are in need of refinement to better address sustainability issues and to demonstrate and articulate the role that they play in contributing to sustainable outcomes.	See response above.	Feb 09
2	Consideration should be given to redirecting the Green Technology Program or replacing it with an extramural grants program.	See response above.	Feb 09
2	<i>Green Technology:</i> Carefully examine the rationale for the selection of target	See response above.	Feb 09

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	areas/technologies to better address market failures and tie outcome measures to sustainable measures and metrics.		
2	Results derived from the Green Technology Program have not been effectively communicated to larger industrial enterprises.	The research results from the Program's many projects have been the subject of numerous presentations at national professional meetings attended by representatives of nearly all major chemical producers. In the ten year period from 1996 to 2006, the Green Chemistry program published 384 peer reviewed papers, 34% of which are listed among the top 10% of all cited papers in their field. Staff was elected as the Second Vice-Chair of the American Institute of Chemical Engineers' Environmental Division, thus an additional opportunity to highlight ORD sponsored Green Chemistry research.	N/A
3	The P3 Program should improve the solicitation/judging criteria to require a clear statement by students as to the effects articulated via sustainability metrics or decision tools. A clear tie-in with the goals of LTG 1 and LTG 2 could be developed.	The MYP will be revised to indicate that the P3 program already requires student teams to quantitatively and/or qualitatively articulate the benefits of their project in the social, environmental, and economic dimensions, both at the proposal stage and at the final report stage. Results from ORD's STS research program will be used to enhance the sustainability criteria used in future P3 solicitations.	N/A
3	The SBIR Program should increase its use of sustainability metrics in selection criteria and increase the linkage of program outcomes to sustainability metrics.	The MYP will also be modified to indicate that this is an excellent opportunity to focus on sustainability in the Small Business Innovation Research (SBIR) program. Like other extramural programs, SBIR is in the stage of identifying solicitation topics. SBIR already releases "success story" reports that quantify environmental benefits. SBIR is structured to address technology priorities across the Agency, many of which have been sustainability-related in recent years. In addition, the law that authorizes SBIR requires that potential for commercialization be a strong	N/A

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		criterion for funding. Results from ORD's STS research program will be used to enhance the sustainability criteria used in future SBIR solicitations.	
3	The [P3] Program could benefit from a more systematic evaluation of the program outcomes, such as tracking of careers of recipients to obtain information that can be used to measure impact as outcome. Thus, a detailed analysis of the impacts on the P3 Program on the student participants is desirable.	Although the P3 Program is a relatively young program (it was started in 2003), NCER is working with ORD/ORMA to assess the effectiveness of the program relative to its role in (1) stimulating sustainability in academic institutions, (2) providing students with an opportunity to work on a real-world problems and thereby learn the value of teamwork and diversity, and (3) develop technologies, tools and processes that promote sustainability.	2010
4	The Subcommittee recommends integrating an implementation plan as part of the STS MYP.	As part of the revision of the STS MYP, ORD will include additional appropriate language to better describe the planned research. However, the MYP is not intended to include specific implementation details about the research activities that ORD plans to perform over the next 5 years. ORD Laboratories and Centers typically develop these implementation details consistently with the MYP goals.	Feb 09
4	The two Annual Performance Goals (APGs) do not seem to flow well into a logical research plan with quantifiable goals and objectives.	ORD will make adjustments to the existing APG language and structure to ensure that goals are more quantifiable and to better define the anticipated outcomes.	Feb 09
4	There needs to be significant interaction between this LTG [1] and, in particular, LTG 2, which are intimately tied together. It should be assured that there is integration and continuity among the elements during the plan for transition.	ORD will incorporate changes into the MYP that will better explain how ORD and its partners will integrate the various research components described in the STS MYP.	Feb 09
4	LTG 1 metrics should be used to inform LTG 3 activities.	Language will be added to the MYP to address this recommendation.	Feb 09

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4	Geographic and landscape orientation should be incorporated for local implementation.	ORD also recognizes that sustainability will occur at various geographic scales. Some efforts within STS and in other programs already have activities that address geographic-specific sustainability issues. The MYP will be modified to more clearly reference these efforts.	Feb 09
4	Economics and other social dimensions should be incorporated as part of feedback loops of process or output evaluated decision-making.	Others in the Agency are components of this work. ORD will remain abreast of these activities and attempt, where feasible, to incorporate results into our decision tools.	N/A
4	The life cycle assessment (LCA) programs, metrics, and procedures developed under the Pollution Prevention and New Technologies (P2NT) Research Program are relevant and important to the goals of EPA, stakeholders, and the international community. The STS Research Program is positioned to move these initiatives forward and is encouraged to build on this strength.	Agree.	N/A
4	Ecological aspects should be incorporated into the decision analysis tools. Additional expertise might be needed to cover ecological systems so it would be wise to strengthen collaborations with the ORD Ecology Research Program.	Aspects of this recommendation are already being incorporated into ORD's Eco research program, and efforts to coordinate the two programs will continue.	N/A
5	Some program elements are small components and lack a critical mass of personnel. Currently, much of the work being conducted by the STS Research Program is eclipsed by the magnitude and pace of advancements of industrial and academic communities. Thus, in developing the plan, the Program must make strategic decisions on where it can make an impact on the overall field.	The MYP will be modified to reflect integration or elimination of smaller components. ORD has advanced academic sustainability concepts by funding the Technology for a Sustainable Environment (TSE) and Collaborative Science and Technology Network for Sustainability (CNS) programs. Based on these recommendations and those of the Science Advisory Board, ORD has already made some strategic adjustments, to ensure high impact, including focusing on the key emerging issue of the sustainability of various	Feb 09

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		biofuel production options and these will be reflected in the revised MYP.	
5	The potential impact of STS programs is limited by lack of a critical mass and resources. In developing the STS Research Program, ORD must make better use of capabilities across ORD.	The revised STS will more clearly delineate the strategic program choices made and the criteria for selection. The ORD sustainability lead will conduct new outreach activities across EPA programs and regions to help inform the strategic choices.	Feb 09
5	... is important to keep abreast of and continue to lead the development of LCA methodologies.	ORD is already at the forefront of LCA methodology development.	N/A
5	Development of streamlined methods is needed as part of the expansion of LCA tools (e.g., make them user-friendly) as well as integration of material flow analysis (e.g., industrial ecology concepts).	The MYP will be modified to ensure that it reflects streamlined LCA approaches. Several supported CNS projects employ material flow analysis (MFA) methodologies. ORD is also cosponsoring with NSF a special issue of the <i>Journal of Industrial Ecology</i> on applications of MFA.	Feb 09
5	System-based methods are indispensable for moving towards sustainability. These are integrated in the STS MYP, but need to be integrated into tools.	ORD is already taking a systems-based approach as it develops its integrated tools. For example, several efforts are underway to produce tools that will holistically examine the environmental impacts of biofuels. However, we will make this more explicit in the revised MYP.	Feb 09
5	Carefully examine the rationale for the selection of target areas/technologies to better address market failures and tie outcome measures to sustainable measures and metrics.	This is a very ambitious goal. Some STS elements attempt to provide technologies that promote sustainable choices, particularly the environmental implications of the production and utilization and disposal of biofuels.	Feb 09
5	The ETV Program should encourage an increased role in supporting emerging markets in trades/mitigation/offsets, such as mercury/greenhouse gases, etc.	Several of the existing ETV centers have or are currently verifying technologies in emerging market areas. For example, in the area of climate change, ETV has verified several combined heat and power units designed to reduce CO <sub>2</sub> and other pollutants.	N/A

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5	An analysis should be conducted to determine if there are emerging markets in this trade/offset area that have a barrier surrounding verification issues.	ORD's NRMRL has already engaged in market analysis research to identify where verification will be most useful.	N/A
5	...industrial sectors [need] to have tools for streamlining LCAs that allow for rapid evaluation of environmental burdens.	The MYP will be modified to ensure that it reflects streamlining LCA approaches.	Feb 09
5	The Program should incorporate additional decision-making tools, such as probabilistic risk assessment, Bayesian networks, causal pathways, and Multi-Criteria Decision Analysis (Igor Linkov and others) in the research program.	The MYP will be revised to explain the range of decision-making tools being applied.	Feb 09
6	Because the STS Research Program is sparsely populated and not coordinated with outside efforts, a strategic plan that includes an awareness of what is being done outside of the Agency, including that of organizations outside of the United States, and how ORD can make a significant impact on the science should be developed.	Language will be added to the MYP to explain how areas in the STS are coordinated with international research and other outside efforts. ORD cannot commit to developing a separate strategic plan to describe these relationships. Since the sustainability concept transcends the STS, integration must occur with other ORD MYPs. ORD will lead a dialogue among its National Program Directors (NPDs) and others to determine how sustainability concepts can be integrated into the design and execution of all of its research programs. However, in order for sustainability concepts to become a priority, senior Agency officials such as members of the Science Policy Council will need to participate and support this effort.	Feb 09
6	LTG 2 could be improved through targeted extramural collaborations on the development of new tools or cooperation on the advancement of existing tools or tools being developed in the private sector.	A number of tools have been developed or enhanced through the CNS program. An example is the Energy & Materials Flow & Cost Tracker (EMFACT), a free materials management tool designed for small business manufacturers. ORD has worked extensively with outside organizations to advance the implementation of new tools. For	N/A

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		<p>example, to help implement TRACI (Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts), ORD has worked with numerous organizations and programs including the NSF International/American National Standards institute and the Leadership in Energy and Environmental Design (LEED) green building rating system of the U.S. Green Building Council.</p>	
6	<p>Efforts should be made to reach a wider set of stakeholders, such as nongovernmental organizations (NGOs), state agencies, etc.</p>	<p>The revised MYP will identify specific efforts ORD will conduct to better characterize activities underway, nationally and internationally, in the areas of metrics and decision support tools to ensure our research is adding incremental value.</p>	Feb 09
6	<p>One example of a program with many successful elements is the ETV Program ... The Subcommittee would like to recognize two program elements that it considered to be of excellence. These include: (1) the public outreach component which brings early public use; and (2) the clear team spirit of the Program members. To find a balance of speed and a team sense of "over-accomplishment" is rare. ORD can be rightly proud of this program element and the impact that it has had. The Subcommittee recommends this program element for an ORD citation if this has not been done already.</p>	<p>The ETV program was nominated by ORD for and won an Agency Bronze Medal in 2004 for its work to verify homeland security technologies from 2002 through 2004. ORD agrees with the BOSC and will consider submitting a package recognizing these and other components of the ETV program.</p>	N/A
6	<p><i>SBIR</i>: Increase meeting of stakeholder needs. If the Program can better address the internal Agency needs from the STS MYP, it will provide a valuable service and be recognized more favorably. The goal of moving to a 100 percent cost share basis needs to be carefully evaluated. Although this will better leverage funds, it might miss important opportunities. This might be a future goal, but it needs to be determined if this would result in</p>	<p>The SBIR program encourages but does not require cost sharing as part of the commercialization focus of the program. An SBIR Phase II program review completed this year showed that 73% of SBIR projects secure additional investment beyond their SBIR awards. SBIR is structured to address technology priorities across EPA through the Environmental Technology Council (ETC) and other mechanisms. Storm water management technology has been</p>	N/A

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	<p>missed opportunities for small businesses. This could occur if they: (1) could not afford the assessment; and (2) are not being funded for this purpose through the SBIR Program. Additional SBIR opportunities in the broader set of sustainability concerns, such as land and water uses, need to be explored. One example might be the design of storm water handling systems in new developments. Certainly there are other opportunities as well.</p>	<p>among the sustainability-related topics addressed by SBIR in recent years.</p>	
7	<p>The APGs should be provided in more quantifiable forms, generally in the form of SMART (specific, measurable, achievable, relevant, and timely) goals. The goals are written very generically, without sufficient measurable targets against which one can evaluate performance. APM 1, 2008 is well-defined, but 2009 is nebulous and could be refined.</p>	<p>ORD will make adjustments to the existing APG language and structure to ensure that goals are more quantifiable and better define the outcomes anticipated.</p>	Feb 09
7	<p>The actual outputs and outcomes could be more clearly defined and communicated to targeted sectors.</p>	<p>See response above.</p>	Feb 09
7	<p>The two Annual Performance Goals (APGs) do not seem to flow well into a logical research plan, with quantifiable goals and objectives.</p>	<p>See response above.</p>	Feb 09
7	<p><i>ETV</i>: The current outcomes analysis does not measure the effect of the ETV Program, because it does not attempt to identify outcomes in the absence of the ETV Program. Outcome measures stated in terms of numbers of verifications are probably better, even if considered less relevant. These metrics are better linked to the question of number of decision-makers/impacts. The metrics were deemed to be well-defined, but not well-quantified.</p>	<p>Over the years, ETV has produced many protocols that are widely used across many industries to evaluate technologies and their environmental implications. ETV offers independent and unbiased data which decision-makers feel comfortable using for implementation of regulations and/or voluntary programs. The ETV program tracks its verifications and protocols and can provide the BOSC annual figures. On February 2, 2009, the ETV Program will be hosting a kick-off meeting for the "Advanced ETV European Effort to Support International</p>	Feb 09

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		<p>Environmental Technology Verifications.” This meeting will be held in conjunction with the 4<sup>th</sup> Annual International ETV Working Group Meeting, bringing together representatives from verification programs in the United States, Canada, and the European Union.</p>	