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Goddard Space Flight Center

Sustainability Status Report

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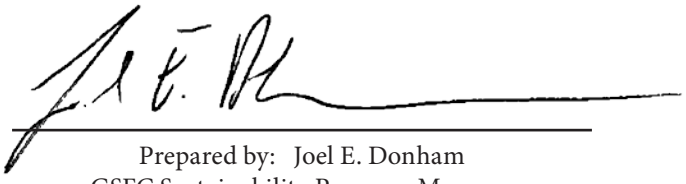

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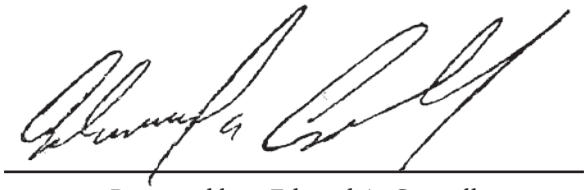

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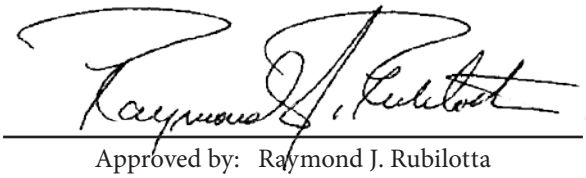

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Executive Summary

Purpose

This report presents the current performance and activities of the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center (Goddard) relevant to the sustainability initiatives presented in the 2012 NASA Strategic Sustainability Performance Plan (SSPP), Climate Adaptation Science Investigators (CASI) research program, and other internal sustainability goals. The report also outlines potential future activities that will continue to advance sustainability practices at Goddard. The SSPP incorporates goals from the 2007 Energy Independence and Security Act (EISA), Executive Orders 13423 and 13514, and other requirements related to sustainability in the Federal Government. This report will focus on the performance of Goddard's principle facilities at Greenbelt in Maryland (Greenbelt) and the Wallops Flight Facility in Virginia (Wallops). Information relevant to each facility is identified in section headings by the symbols '**G**' for Greenbelt and '**W**' for Wallops.

Sustainability at Goddard

Goddard views sustainability as a way to approach our work with consideration for the impacts our activities may have on the environment and natural resources. We acknowledge that Goddard's activities affect natural systems, resources, and local communities. At all levels, the Center is developing strategies to minimize these effects.

The pursuit of sustainability at Goddard will:

- Ensure that NASA's missions are not adversely affected by changes to the climate, environment, natural resources, or energy supplies.
- Mitigate the impact of Center operations on the natural environment.
- Enhance the efficiency of Goddard operations by reducing the demand for non-renewable energy sources.

Current Performance Overview

Goddard is presently balancing efforts to support increasing mission activities while pursuing its sustainability goals. Current initiatives include using renewable energy, alternatively fueled vehicles, and reducing paper consumption, as well as pursuing Leadership in Energy and Environmental Design (LEED) certification for new, renovated, and existing buildings. These activities demonstrate that Goddard is striving to reduce its resource consumption and environmental impact.

While indicative of the strength of Goddard as a whole, the overall growth in mission activities at the Center has increased resource consumption in some areas despite numerous initiatives to improve efficiency and reduce waste. Specifically, Goddard has not achieved SSPP-goal proportional interim targets for total greenhouse gas emissions (GHGs) and waste diversion rate (recycling) despite completing numerous energy efficiency projects and implementing a single-stream recycling program.

Recent Initiatives

W G ***CASI Research:*** CASI workgroups at Greenbelt and Wallops are pursuing research objectives that will inform institutional decision making in the interest of averting impacts associated with climate change on Goddard's assets and activities. Examples include preparing a hydrologic analysis of Greenbelt, evaluating relationships between urban heat island effects, land cover and stormwater management practices, and modeling sea level rise and storm surge impacts on Wallops assets, operations, and ecosystems. These research efforts will provide the data needed to develop sustainable facilities resilient to climate change.

G ***Bikes Around Goddard:*** Greenbelt recently initiated the "Bikes Around Goddard" bicycle-sharing program. The program reduces pollution and promotes healthy transportation by encouraging employees to navigate the campus without fueled vehicles.

G ***Stormwater BMPs:*** Recognizing advances in stormwater management methods, Greenbelt has begun implementing Best Management Practices (BMPs) for stormwater. The rain garden (installed 2010) and bioretention area (installed 2008) manage stormwater runoff from Building 32 and its parking lots. These BMPs limit erosion damage to creeks and remove contaminants from storm runoff. The new Flight Projects Building site currently under construction also incorporates similar BMPs. These projects are the initial efforts of a more comprehensive, Greenbelt-wide implementation of BMPs that will begin when Greenbelt receives its revised Municipal Separate Storm Sewer System (MS4) permit from the Maryland Department of the Environment (MDE). This new permit is expected to require extensive implementation of stormwater BMPs beginning in calendar year 2014.

W ***Storm Surge Protection:*** Wallops has taken the first steps towards protecting the island's launch facilities from severe storm surges similar to those observed during Hurricane Irene in 2011 and Superstorm Sandy in 2012. These events are anticipated to increase as a result of climate change. A sand and stone seawall, constructed in the interim between the two storms was effective in preventing the $3.8 million in damage to NASA facilities experienced during Irene from reoccurring during Sandy.

W ***HVAC Retrofits:*** Wallops is in the final stages of retrofitting the original, centralized fuel-oil heating system with a distributed liquefied-petroleum-gas (LPG) and geothermal system. As of Phase 1 (LPG boilers), this retrofit has reduced GHGs by 26 percent, energy intensity by 35 percent, and water usage intensity by 8 percent. Goddard received the 2012 Virginia Governor's Environmental Excellence Award in recognition of this innovative approach to reducing natural resource consumption.

These initiatives serve as examples of the ongoing sustainability activities at Goddard and provide insight into the breadth of approaches being used to reduce the Center's impacts on the environment.

Proposed Initiatives

G ***Combined Heat and Power:*** NASA Headquarters, in association with the Environmental Protection Agency's (EPA) Combined Heat and Power (CHP) Partnership, commissioned a Level 1 feasibility analysis for implementing CHP at Greenbelt. The preferred alternative identified in the study would retrofit the existing heating plant boiler in Building 24 with a 20 MW turbine that would produce steam for both building heat and generating electricity at Greenbelt. The analysis estimated that the system would provide 94 percent of the electrical demand and all steam heat required at Greenbelt.

Because Greenbelt currently uses landfill gas (LFG), a carbon-neutral fuel, as its primary heating fuel, the CHP system would contribute to NASA's renewable energy generation directives and reduce Greenbelt's GHGs by approximately 21 percent through reduced use of grid-sourced electricity generated from fossil fuel combustion. Unfortunately, LFG production at the current source (Sandy Hill Landfill in Bowie, MD; closed since 2000) is projected to decline, falling below Greenbelt's level of demand by 2020. Greenbelt is exploring numerous alternative energy sources to continue to improve energy performance after the Sandy Hill LFG runs out. Until an alternative heating fuel can be identified, the CHP system would transition to using pure natural gas. However, even operating entirely on natural gas the CHP system would still emit 16 percent less GHG as compared to separately purchased electricity and natural gas boiler fuel.

As an additional benefit, because the CHP system would produce electricity on site, Greenbelt would be less vulnerable to local electrical supply disruptions, reducing risk to missions, and potentially reducing the need for emergency backup generators and associated environmental impacts. Based on the favorable results of the Level 1 feasibility analysis, Greenbelt is currently pursuing a Level 2 analysis to more fully evaluate the concept.

G ***Comprehensive IT Planning:*** To advance the development of innovative information technology (IT) management strategies that started with the Greenbelt cloud-container project in 2010, the IT and Science and Exploration Directorates are exploring opportunities to further implement best practices to increase IT performance, efficiency, and security by consolidating data centers and evaluating advanced heat management strategies. Many of the benefits of advanced IT management strategies depend on consolidating data and applications on fewer pieces of hardware in more centralized locations. IT consolidation at Greenbelt is complicated due to the dispersed management of IT equipment around the Center. Incorporating all IT projects and users into a comprehensive IT plan, however, would greatly extend capability to consolidate IT functions, and hence extend the benefits of advanced management practices. To support IT consolidation, new buildings at Greenbelt are no longer built to accommodate distributed server rooms.

These project concepts serve as examples of opportunities to address sustainability objectives at Goddard. The full Goddard Space Flight Center 2014 Sustainability Status Report details additional projects that could be investigated or pursued to further reduce the Center's costs, impact on the environment, and risk to missions.

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Introduction

As one of the premier Earth science research organizations in the world, NASA's Goddard Space Flight Center (Goddard) is acutely aware of the impact of its activities on the Earth's systems and the changes that humanity as a whole is bringing to the Earth. In light of this awareness, Goddard's scientists, engineers, and management are constantly striving to understand and address our impacts on local and global environments, and strengthen the sustainability of Goddard's operations considering changing climate conditions. To demonstrate Goddard's efforts to address sustainability, this document summarizes Goddard's performance relative to Federal, Agency, state, and internal sustainability goals, presents concept initiatives being evaluated by the Center to further enhance sustainable operations at Goddard, and highlights the scientific research being pursued to characterize vulnerabilities of future activities related to climate change impacts in order to promote educated management decision making in a changing climate. Moving forward, this document will be used to support planning to address sustainability at Goddard (Table 1).

Many of Goddard's sustainability goals are provided in NASA's 2012 Strategic Sustainability Performance Plan (SSPP), which incorporates guidance from Executive Orders 13423 and 13514, the 2007 Energy Independence and Security Act, and other legislation (Appendix A). Many of these goals include interim targets to help the Agency gauge progress relative to long-term goals. Throughout this document, the performance of Goddard's principle facilities at Greenbelt in Maryland, (Greenbelt) and Wallops Flight Facility in Virginia (Wallops), as well as Goddard as a whole are documented relative to SSPP interim and final goal targets using the four-color system below:

Red		Not achieving interim target
Yellow		Achieving interim target, but not yet achieving the final goal target
Green		Achieving final goal target
Grey		Not applicable to the given facility

Although the performance of Goddard, Greenbelt and Wallops, is compared to SSPP goals in this document for reference purposes, the Office of Management and Budget (OMB) tracks the attainment of these goals at the Agency level only. Therefore, Goddard is not required to meet proportional reduction targets for specific goal categories individually. Some NASA Centers are more strategically positioned than others to contribute to attainment of certain goals. Attainment of goals as an agency will occur most efficiently by capitalizing on the best opportunities to contribute to meeting the various goals at each Center.

Table 1: 2012 SSPP Sustainability Planning Goal

	Goddard's Contribution to Agency Goal
Goal 2.3.e: Integrate methods and practices necessary to achieve the goals of this plan [2012 SSPP] into the Agency's master planning documents (i.e., high-performance, sustainable building goals, pollution prevention and waste reduction goals, water use reduction goals, sustainable acquisition goals, electronic stewardship and data center consolidation, etc.).	This sustainability report will be made available to Center and Agency management to support future planning efforts.

While institutional managers implement most sustainability actions at Goddard, the science community also promotes and supports science-based management as implemented through the Climate Adaptation Science Investigators (CASI) program. CASI is a partnership between earth scientists and institutional stewards at each facility. CASI conducts local workshops to introduce and improve planning for climate change, provides analysis of climate data and predictions tailored to each facility, develops climate impact and adaptation toolsets, and pursues facility-specific research and engagement in climate issues. Throughout this document, relevant projects being pursued by CASI groups at Greenbelt and Wallops are discussed in blue callout boxes.

Goal 1: Limit GHG Emissions from Goddard Operations

Greenhouse gas emissions (GHGs) are grouped into three categories (scopes) according to the owner or operator of the equipment that is the source of the emissions. At Goddard, Scope 1 includes emissions from NASA-owned and operated equipment, Scope 2 includes emissions from equipment owned by electrical utilities, and Scope 3 includes emissions from equipment owned by employees, transportation companies, water utilities, and other third parties. Scope 1 and 2 emissions comprise roughly 90 percent of all GHGs resulting from Goddard operations. Scope 1 and 2 emissions are discussed together because they are the result of equipment and activities directly controlled by Goddard, and because emissions from some interchangeable processes can fall under either of these two scopes depending on the specific equipment used. Addressing Scope 1 and 2 emissions as a group ensures the total climate impact is reduced, irrespective of equipment selection.

At Goddard, Scope 1 GHGs primarily result from fuel burned to heat buildings and domestic water. In 2012 at Greenbelt, Scope 1 emissions resulting from natural gas combustion comprised 13 percent of combined Scope 1 and 2 GHGs. In 2012 at Wallops, approximately 20 percent of Scope 1 and 2 emissions were the result of fuel oil and liquefied petroleum gas (LPG) combustion for heat.

Scope 2 comprises approximately 84 and 73 percent of Scope 1 and 2 emissions at Greenbelt and Wallops, respectively. This electrical energy is used to operate equipment such as computers, servers, clean rooms, and fabrication equipment, and to light, heat, cool, and ventilate buildings. The remaining Scope 1 and 2 GHG emissions at each facility are attributable to fleet vehicle operations.

Greenbelt has reduced the net GHGs from its energy usage by using landfill gas (LFG, a carbon-neutral fuel) for a significant portion of its energy needs (Figure 1), and by purchasing renewable energy to meet Goal 2.1.b.i (Table 4). Unfortunately, these initiatives have not been sufficient to offset growth in Scope 1 and 2 GHGs resulting from increased mission activities at Greenbelt over the past few years.

Wallops has recently addressed Scope 1 and 2 GHGs by modernizing aging infrastructure through the replacement of a large fuel-oil-fired heating system with a network of LPG-fired heaters and geothermal heat systems (page 17). This is a major contributor to the recent decreases in Scope 1 and 2 emissions at Wallops. SSPP Scope 1 and 2 GHG reduction goals can be found in Table 2.

When accounting for GHGs, and other sustainability metrics relevant to the SSPP goals, NASA excludes certain buildings that are intrinsically energy intensive, or are unique in some specific way that complicates contributing to the goals. Excluded buildings include those that house equipment, labs, and shops that are intrinsically energy intensive. Performance relative to SSPP goals presented in this document is hence termed 'Goal Subject' to demonstrate that the data **does not** include excluded facilities.

1.0 Goddard's Status

Table 2: 2012 SSPP Scope 1 and 2 GHG Reduction Goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 1.1.a: Reduce Scope 1 and 2 GHGs by 18.3% by FY 2020, from an FY 2008 baseline.[1]	New facility construction has increased GHGs beyond the 2008 baseline. Greenbelt was 11% above the 2012 interim target.	Replacing fuel oil boilers with LPG boilers has greatly reduced GHGs. Wallops was 13% below the 2020 final goal target.	Combined GHGs from Wallops and Greenbelt was 2% above the 2012 interim target level.
Goal 2.1.a: Reduce energy consumption per gross square foot (GSF) of building area by 3% annually from FY 2003 baseline for FY 2006 – FY 2015 (30% total) (EO 13423) following the per fiscal year reductions mandated in EISA 2007.[1, 2]	2012 energy intensity was 2% below the 2015 final goal target (Figure 2).[2]	2012 energy intensity was 9% below the 2012 interim target, but has not yet met the 2015 final goal target.	GSF-weighted energy intensity from Wallops and Greenbelt was 1% below the 2015 final goal target.[2]
1 GHG reduction goals are intended to be met at an agency-wide level. Individual Centers are not accountable for proportional reductions, although for the purposes of this report, GHG trends are tracked against reductions goals proportional to the agency-wide goals. 2 In 2011, Greenbelt revised its method for calculating energy intensity. This change created a discontinuity in the energy intensity trend that is not the result of improved facility performance (Figure 2).			

The bulk of recent GHG increases at Greenbelt (Figure 1) resulted from the increase in electrical demand to run additional equipment and cool the additional occupied space associated with recent mission growth and construction. This increased electrical demand is associated with standard buildings and equipment. Unique facilities designated as intrinsically energy intensive, such as high performance computing facilities or specialized labs, are excluded from GHG targets.

NASA's sustainable buildings program (page 14) is intended, in part, to reduce Scope 1 and 2 GHGs associated with building design and operation by requiring that new construction attain Leadership in Energy and Environmental Design (LEED) certification, which promotes energy efficiency initiatives. Because Scope 1 and 2 GHGs are related to heating and electrical energy consumption in buildings, the effectiveness of the sustainable buildings program in addressing Scope 1 and 2 GHGs can be determined by tracking energy intensity [British Thermal Units (BTUs)/gross square footage (GSF)] (Figure 2)—i.e. energy intensity is an objective measure of the performance or efficiency of a building, independent of building size.

Figure 1: Goal Subject Scope 1 and 2 GHGs

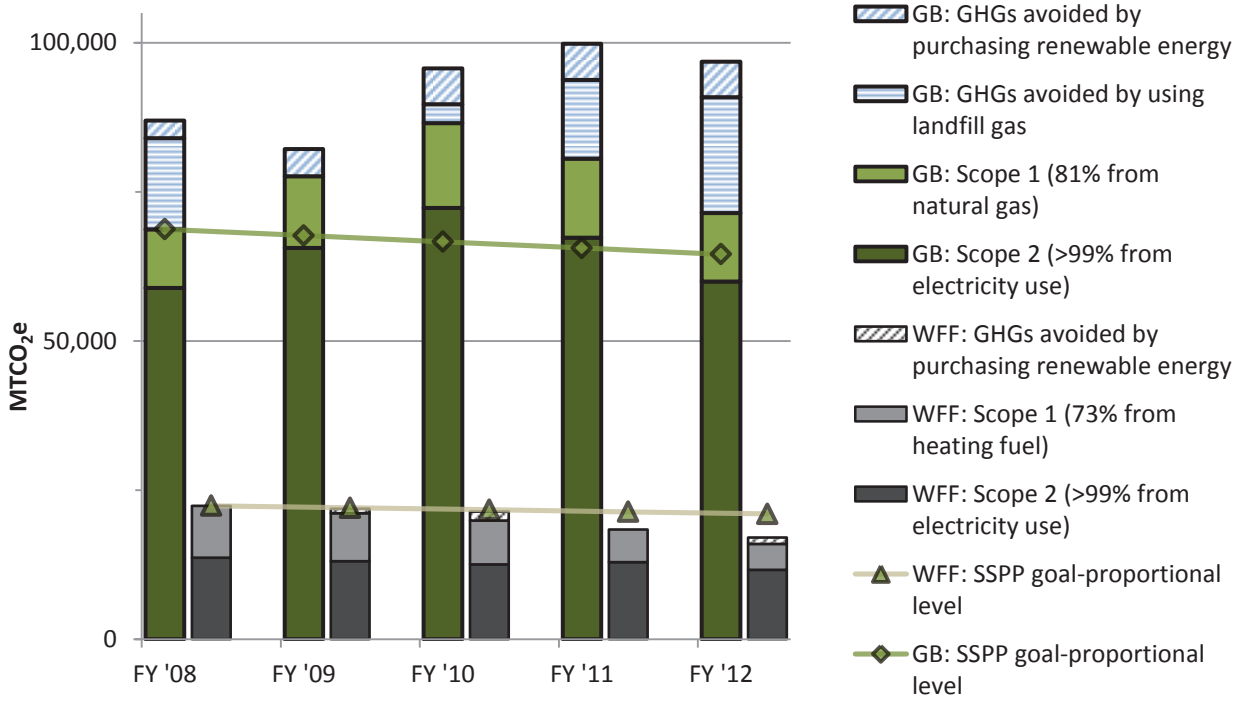
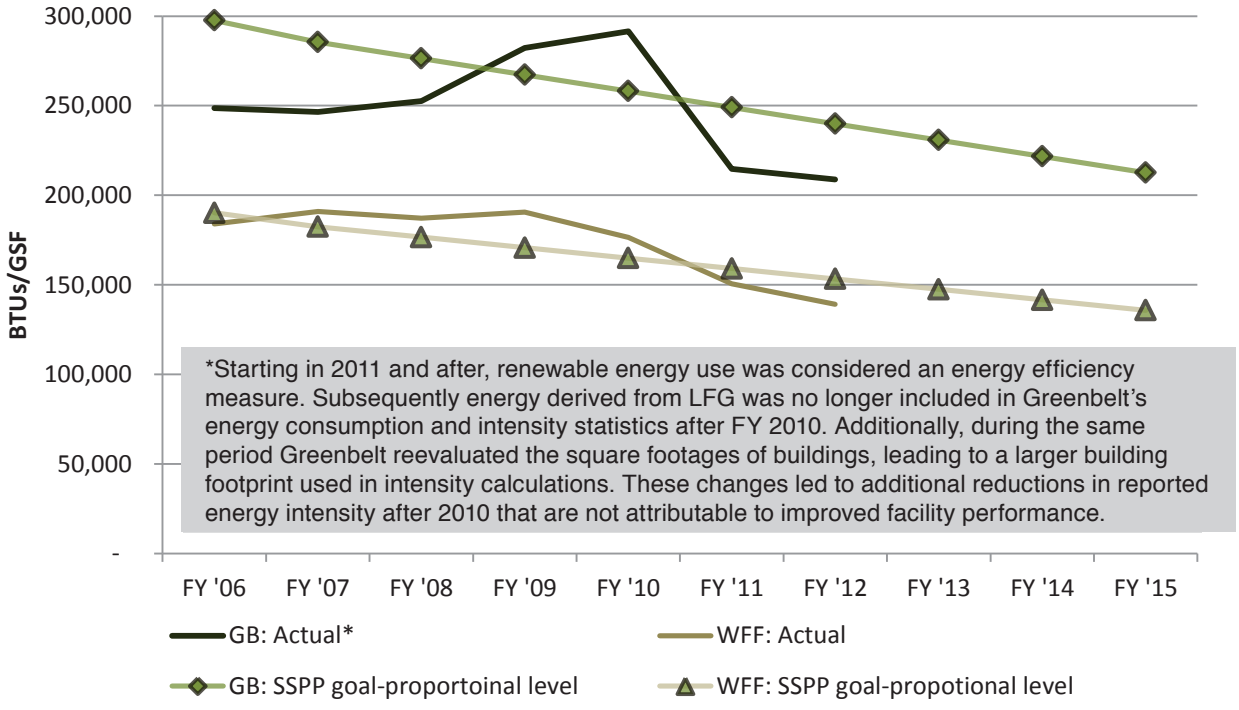


Figure 2: Goal Subject Energy Intensity



Despite numerous energy efficiency and conservation initiatives at Greenbelt, GHGs have still increased beyond the SSPP goal-proportional reduction. Additionally, noted epistemic uncertainty in the Greenbelt energy intensity data makes it challenging to make quantitative conclusions regarding the effectiveness of recent GHG and energy efficiency initiatives on the performance of Greenbelt solely based on energy intensity.

In contrast, Wallops has exceeded the SSPP goals for both GHGs and energy intensity years ahead of the goal deadlines. This is largely due to the LPG boiler retrofit, which reduced heating energy consumption at Wallops by 55 percent (page 17).

SUB-GOAL 1.1 – SUSTAINABLE BUILDINGS

NASA has numerous goals relating to building management that Goddard is actively pursuing in order to meet building energy and GHG goals (Table 3). NASA-promoted sustainable building initiatives involve large-scale facility planning activities to ensure the most efficient use of buildings as well as technical initiatives to improve building performance. The Agency pursues such technical initiatives using the Guiding Principles for Federal High Performance and Sustainable Buildings (Guiding Principles; Appendix B) and certification by the U.S. Green Building Council's LEED rating system.

Table 3: 2012 SSPP Sustainable Buildings Goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 2.1.c: Reduce per capita energy consumption through space management.	Server and supercomputer consolidation will improve space management prospects (page 27).	New and renovated buildings are using the Guiding Principles and LEED concepts to reduce energy use where applicable.	
Goal 2.2.b: Comply with the Guiding Principles in all new construction, major renovation, or repair and alteration of federal buildings.	All new construction and major renovation projects are pursued following the Guiding Principles and LEED concepts where applicable.		
Goal 2.2.c: Assess and demonstrate that at least 15% of agency's existing government-owned and leased buildings greater than 5,000 GSF meet Guiding Principles by FY 2015.	Currently 13% of buildings and 21% of goal subject GSF are LEED certified on track to 24% of buildings and 34% of GSF when B35 and B36 are certified (Figure 3). Conformity with Guiding Principles has not yet been documented for these projects.	Currently no Wallops buildings are LEED-certified, on track to 8% and 24% of buildings and goal subject GSF respectively upon certification of building E109 in FY 2014. Conformity with Guiding Principles has not yet been documented for these projects.	Currently 7% of buildings and 18% of goal subject GSF are LEED-certified, on track to 17% of buildings and 32% of GSF in FY 2015. Conformity with Guiding Principles has not yet been documented for these projects.
Goal 2.2.d: Demonstrate annual progress toward 100% conformance with Guiding Principles for entire building inventory by 2015 and thereafter.			

Continued on page 15

Goal 2.2.g: **Operate and maintain, and conduct all minor repairs and alterations for existing building systems to reduce energy, water and materials consumption in a manner that achieves a net reduction in agency-deferred maintenance costs.**	Building 25 Geothermal retrofit (page 16) was performed to avoid chilled water and steam distribution network maintenance.	LPG boiler retrofit drastically reduced emissions and water use and geothermal projects (page 17) will extend these benefits.	Addressed at the facility level.
Goal 2.2.h: **Optimize performance of the agency's real property portfolio—dispose and consolidate excess and underutilized property, co-locate field offices, and consolidate across metropolitan and regional locations.**	Recent and planned demolition of obsolete buildings improves performance of building portfolio.		
Goal 2.2.k: **Align agency space actions (new leases, new construction, consolidation) with Agency Scope 1 & 2 and Scope 3 GHG reduction targets.**	New construction is designed to meet the Guiding Principles and LEED standards to reduce Scope 1 & 2 GHGs.		
Goal 2.2.j: **Conserve, rehabilitate, and reuse historic federal properties, using current best practices and technology.**	Ongoing building rehab program, including B26 upgrade in FY 2013.	Ongoing building rehab program, including E109 upgrade in FY 2013.	Addressed at the facility level.
NOTE: Goals are intended to be met by the agency as a whole. Individual Centers are not expected to meet proportional reductions, although for the purposes of this report, performance is tracked against goals proportional to the agency-wide goals.			

1.1.a Current Building Management Initiatives

Four projects, as identified below, were part of an energy savings performance contract (ESPC) with Ameresco, Inc. The contract was initiated March 2, 2010, and completed March 2, 2012. Total energy savings from these projects is estimated at 34,686 million BTUs (MMBtu) per year in energy, or 4.9 percent of 2011 (calendar year) of total annual SSPP Goal Subject energy use at Greenbelt. Savings from projects not identified as part of the ESPC are in addition to the 4.9 percent from the Ameresco projects.

G *Buildings 6, 22, and 33 Recommissioning*

Buildings 6, 22, and 33 were recommissioned (aka retrocommissioned) by Ameresco by employing a third-party building engineer to inspect HVAC systems and ensure that all settings and equipment were coordinated and functioning properly. Recommissioning provides some of the most cost effective building energy efficiency gains, especially in older buildings that may have been reconfigured or may be in need of minor repairs or modifications. Recommissioning typically increases the heating and cooling efficiency of a building by 5 percent, with limited capital expenditure, while significantly improving occupant comfort. The recommissioning projects in Buildings 6, 22, and 33 at Greenbelt had an expected simple payback period of 4.6 years.

G *Buildings 10 and 15 Lighting Retrofit*

Lighting fixtures in the Building 10 high bay were replaced by Ameresco with high-efficiency T5 fluorescent units. A controller was installed in Building 15 to automatically turn the lights on and off. This retrofit is expected to reduce lighting energy demand by more than 58 percent in the project areas.

G *Water-Side Economizer in the Building 24 Chiller Plant*

Ameresco was also involved in installing an economizer in the Building 24 chiller plant. Typically, the chilled water system uses a compressor to consolidate heat, which is then dispersed through a cooling tower. When outside temperatures are sufficiently low, the economizer allows the chilled water system to bypass the compressor, reducing energy demand. This facilitates significant increases in cooling efficiency during cooler temperatures. A similar device has been in use in the Building 31 chiller plant for several years.

G *Replace Building 8 Entryway Doors and Windows*

Ameresco replaced the aluminum-framed single-pane glass wall, and four swinging glass doors at the main entrance to Building 8 with an insulated glass and aluminum wall, and automatic sliding glass doors. The new windows and doors provide better insulation than the previous installation and serve to increase the heating and cooling efficiency of the building. These types of improvements have been demonstrated to reduce building energy consumption by 7 to 12 percent.

G *CASI-Greenbelt Research: Climate Change Impacts on Building Energy*

Goddard currently pursues building energy projects based on a favorable lifecycle cost-benefit analysis wherever possible. These costs and benefits are evaluated using energy market projections, historical climate data and associated heating and cooling needs based on industry standards. Climate change, however, is expected to alter the climatic conditions these buildings are operating in, leading to higher cooling energy demand; leading to undervaluation of the benefits of energy projects evaluated based on historic data. Additionally, due to the unique equipment and activities at Goddard, it is unclear how well industry standards reflect actual energy consumption. To better inform energy investment decisions that could be affected by climate change, CASI-Greenbelt is developing models of how energy is used in buildings, and the effect of foreseeable climate change on building energy consumption patterns in the Greenbelt buildings.

The RETScreen building energy modeling tool is being used to model Buildings 28, 32, and 33 at Greenbelt. The building energy models will allow a detailed analysis of how the buildings are using energy now, under predicted climate change scenarios, and after potential energy efficiency upgrades to the buildings. Specifically, the RETScreen tool performs:

1. Energy Modeling—energy consumption under climate change and expected benefits of efficiency upgrades
2. Cost Analysis—incremental costs and benefits of energy projects
3. Emissions Analysis—potential GHG reductions resulting from efficiency improvements
4. Financial Analysis—cash flow, incentives, and environmental credits payable to a contractor to offset contract costs
5. Sensitivity and Risk Analysis—Monte Carlo simulation to determine validity of analyses based on confidence in model input values.

The building-specific information from the RETScreen tool will allow the Facilities Management Division (FMD) to evaluate proposed approaches to reduce energy use with appreciation for expected climate change impacts. The Greenbelt Energy Manager will need this information to plan new work, meet Federal reporting requirements, and justify new projects. Information gathered from the RETScreen models will also be used to update design parameters in Goddard's Standard Reference Document for Facilities to ensure climate change considerations are included in all facilities decision-making going forward.

G *Building 25 Geothermal Retrofit*

A geothermal heat pump was installed in Building 25 to avoid the replacement costs to update the obsolete steam and chilled water lines. This project demonstrates the potential to retrofit a medium-sized building with geothermal technology with minimal disruption to the building operations.

The system began initial operations on May 30, 2012, and can provide Building 25 with up to 2.6 MBtuh of heating and 3.4 MBtuh of cooling, saving a total of approximately 200 MMBtu of energy annually, equivalent to 1 percent of Greenbelt's annual natural gas consumption.

G *Burning LFG for Building Heat*

Since 2003, Greenbelt has used landfill gas (LFG) to offset traditional natural gas used in the boilers to heat buildings at the Center. LFG is a natural byproduct of the decomposition of waste in landfills. Historically, LFG was burned off in flare stacks at landfills until this beneficial use was identified. Using this alternative fuel reduced 2011 Scope 2 GHG emissions by more than 19,000 MTCO2e, or roughly 20 percent of total Greenbelt Scope 1 and 2 emissions that would have been emitted using natural gas alone.

Through FY 2012, the use of LFG at Greenbelt had saved $18.8 million. While annual LFG consumption has remained relatively constant over time, natural gas prices associated with the current boom in natural gas production have decreased. Therefore, the annual cost avoidance from using LFG as compared to natural gas has fallen from around $2 million per year in 2003 to approximately $0.5 million per year.

W G *Replacing inefficient buildings*

Building 2 at Greenbelt and Building E-108 at Wallops were designed and constructed more than 50 years ago based on contemporary mission needs and design standards. Subsequently, due to their maintenance needs, poor efficiency, and limited utility for modern mission needs, these buildings were identified as 'repair by replacement' candidates. Repair by replacement is a management strategy that identifies buildings that, based on their advanced age, are more expensive to repair, maintain, operate, and modernize than it would be to take them down and build new structures.

Building E-108 was deconstructed in 2008 and Building 2 was deconstructed in January of 2012 to free up operations and maintenance resources to support constructing new buildings that are better aligned with current mission needs, and more efficient to operate and maintain. The term "deconstruction" is used because most of the building hardware and materials were salvaged for use in other buildings or sold to recyclers, rather than being landfilled.

W G *Sustainable Buildings*

Goddard is pursuing two types of sustainable building certification: LEED for building design and construction (BD+C, formerly NC) certification for new and substantially renovated existing buildings, and LEED for operations and maintenance of existing buildings (EB: O+M, formerly EB). Both types of projects receive a rating of 'certified', 'silver', 'gold', or 'platinum' depending on the number of recommended environmental practices they incorporate, as outlined in the relevant LEED handbook, and ultimate environmental performance. BD+C projects receive a one-time certification after completion of construction or renovation. O+M buildings must be recertified every five years to demonstrate continued conformance with LEED standards.

Building 34, the Exploration Sciences Building, was Greenbelt's first LEED BD+C certified building, attaining a gold rating in 2010. Current LEED building projects at Greenbelt include recent LEED BD+C gold certification for the Building 26 renovation, silver BD+C certification for the Logistics Facility (Building 35), and gold BD+C for the Flight Projects Building (Building 36). Wallops expects to certify its first LEED O+M project, Building E-109, in FY 2014 followed by two LEED BD+C certifications for the Mission Launch Control Center and Island Firehouse, projected for FY 2016 and FY 2018, respectively. The portion of the building portfolio that is LEED certified at each facility separately and the Center as a whole is shown in Figure 3. It is important to note that while LEED certification is NASA policy for new buildings, the SSPP goals use conformance with the Guiding Principles to demonstrate building sustainability.

G *Reducing Mowed Area*

Greenbelt has several "no-mow" areas on campus that are being allowed to revert to natural vegetation and has sponsored numerous tree-planting projects. Reduced mowing reduces air emissions and fuel consumption associated with mowing activities while tree planting, and allowing grass to grow increases vegetative carbon sequestration and improves stormwater management (GOAL 3 – Strengthen Water Management and Climate Change Adaptation). Tree plantings can be observed in the lawn area near the parking lot between Buildings 16 and 23, as well as to the north and east of Buildings 8 and 31. No-mow areas are located around the ponds at the Parkway and North gates. This type of landscaping initiative is promoted in SSPP Goal 2.2.f (page 43).

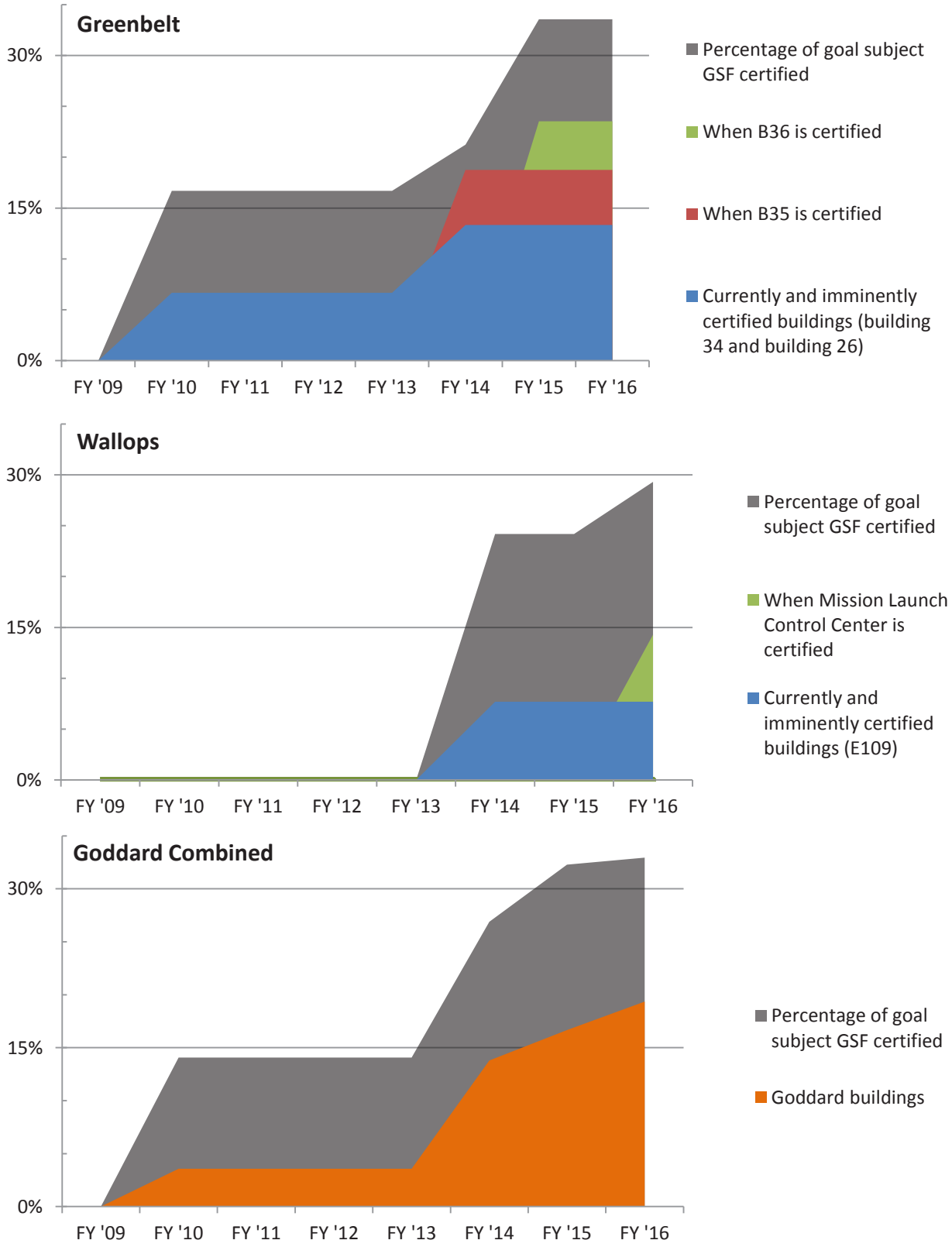
W *Boiler and Lighting Retrofits*

Wallops replaced fuel-oil-fired boilers with high-energy-efficiency LPG-fired boilers; upgraded heating, ventilation, and air conditioning (HVAC) systems in 13 buildings; and upgraded more than 10,000 lighting fixtures in Buildings E132, E134, E002, A001, A041, B129, and E007. In total, these retrofits had a profound impact on energy and GHGs at Wallops. Combined, the projects reduced site averaged energy intensity by 35 percent and Scope 1 and 2 GHGs by 26 percent. These projects, as well as the Wallops geothermal project below, were also funded through ESPCs.

W *Geothermal Project*

Wallops is converting additional HVAC systems to geothermal ground-source heat pumps in facilities on Wallops Island that support rocket launch activities. The geothermal project will involve 20 buildings around the facility, drastically reducing heating and cooling energy demand in those buildings and saving approximately $20 million over the life of the systems.

Figure 3: Planned LEED building certification at Goddard - Greenbelt and Wallops



G *CASI-Greenbelt Research: Urban Heat Island Effect*

The urban heat island (UHI) effect is observed when shading vegetation and moisture-bearing natural ground cover are replaced with buildings and pavement on a large scale during urban development and expansion, as has occurred in the development of the Greenbelt campus. According to the U.S. EPA State and Local Climate and Energy Program, UHIs occur because urban land cover provides little shade, which increases ground level irradiative heating relative to natural cover, and sheds water quickly after storms, which decreases evaporative cooling. These effects can lead to temperature increases from 2˚F to 5˚F in the microclimate around buildings, and subsequent increases in required cooling energy by as much 5 to 10 percent (Figure 4), compared to a similar building set in an otherwise natural area. Additionally, these elevated temperatures can increase the incidence of uncomfortable and potentially unhealthy outdoor conditions for humans.

There are numerous proposed methods to mitigate UHIs. These methods attempt to reduce the absorbance of incident solar energy by using white surface coatings, shading, or pressure-washing pavement to increase reflectivity. Alternatively, retaining water onsite through stormwater best management practices (BMPs) to recreate natural, evaporative cooling has been proposed to mitigate UHI. Retaining water onsite also reduces stormwater impacts identified in GOAL 3 – Strengthen Water Management and Climate Change Adaptation.

Studying UHI at Greenbelt provides a unique opportunity to gauge UHI's effect on air temperatures and humidity, which cannot be measured directly using satellite data. Compared to previous UHI study sites in dense urban public areas, the Greenbelt campus allows a high level of control over the environment, preventing interference from the public. Additionally, the large expanses of specific land cover types at Greenbelt (e.g. pavement, mowed lawn, forest, building rooftops, etc.) allow for highly independent measurements of temperature and humidity associated with each land cover type that are difficult to obtain with the fine-granularity of land cover types found in dense urban spaces. Additionally, Greenbelt provides a unique opportunity to evaluate presumed UHI mitigation effects associated with stormwater BMPs.

Based on these strengths, CASI-Greenbelt is collaborating with faculty at Columbia University in New York City, to investigate UHI effects on campus relative to specific types of land cover and BMPs. Investigators will characterize the extent of the UHI at Greenbelt and quantify the UHI mitigation benefits of BMPs. With a better understanding of demonstrable UHI effects at Greenbelt, and empirical evidence as to the effectiveness of UHI mitigation strategies, the stormwater BMP program (page 47) will be modified to maximize energy, outdoor human comfort, and stormwater benefits, potentially realizing an energy savings of up to 10 percent based on EPA estimates. Starting in fall 2013, the study began monitoring temperature and humidity in various locations over the course of a year to support the research.

Figure 4: Energy impacts of UHI effect

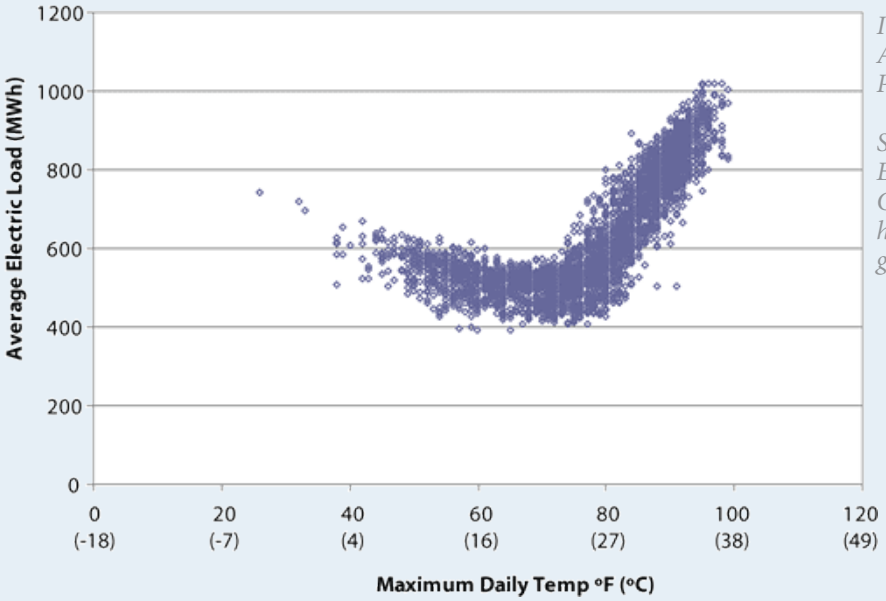


Image Credit: The U.S. Environmental Protection Agency, State and Local Climate and Energy Program, reprinted with permission.

Source: "Heat Island Impacts" by The U.S. Environmental Protection Agency, State and Local Climate and Energy Program. Retrieved online from http://www.epa.gov/hiri/images/electricdemand-sm.gif September 13, 2013.

W G *Sustainability under the National Environmental Policy Act*

As a Federal Agency, NASA must meet the requirements of the National Environmental Policy Act (NEPA) for any action it pursues. NEPA mandates that federal agencies evaluate the environmental impacts of their proposed actions and potential alternatives before proceeding. Additionally, NEPA emphasizes public involvement in government decisions affecting the environment by requiring that the benefits and risks associated with proposed actions be assessed and publicly disclosed. Specific impact areas must be evaluated, including air quality, hazardous wastes and materials, health and safety, water resources, land use, land resources, vegetation, and wildlife. This high level of review supports critical evaluation of NASA's actions and early identification and mitigation of unsustainable actions and practices.

1.1.b Potential Building Management Initiatives

G *Reallocated Area Due to IT Containerization*

In addition to numerous other benefits, the server and supercomputer containerization initiatives (page 27) provide energy benefits for buildings by relocating energy-intensive IT equipment to separate facilities that provide greater heating and cooling efficiency. Additionally, the vacated floor area can then be repurposed, which reduces the need for new construction or off-site space leases. Consolidating computers in dedicated containers and people in dedicated buildings increases the Center's efficiency in both computing and human services, such as food service or transportation. This type of strategic space management is promoted in SSPP Goal 2.1.c.

G *Combined Heat and Power*

Combined heat and power generation (CHP or cogeneration) occurs when electricity and building heat are generated from a single fuel source. A simplified example of CHP is a system that uses a natural gas fired turbine electrical generator to produce electrical energy, and uses the heat from the turbine exhaust for building heat. Such systems demonstrate considerably higher efficiency compared with a combination of grid-supplied electricity and conventional boiler heat—approximately 50 percent improvement in efficiency and 30 percent reduction in GHGs (Figure 5).

CHP that utilizes LFG, a renewable fuel, supplied to Greenbelt would contribute to Greenbelt's renewable energy portfolio requirement (SSPP Goal 2.1.b.i, page 23), giving the facility—and the Agency as a whole—a significant boost in achieving the sustainability goals. Furthermore, because CHP produces electrical power on site, CHP would reduce the potential risk to missions presented by disruptions in energy supply due to utility outages.

Figure 5: Energy diagram of CHP

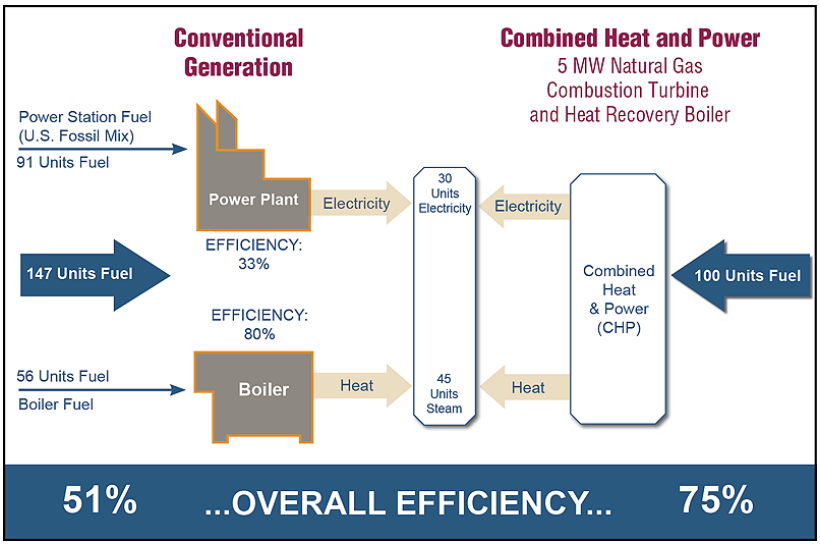


Image Credit: U.S. EPA Combined Heat and Power Partnership, reprinted with permission.

Source: "(CHP) Efficiency Benefits" by The U.S. Environmental Protection Agency Combined Heat and Power Program. Retrieved online from http://www.epa.gov/chp/basic/efficiency.html September 13, 2013.

In support of CHP at Greenbelt, NASA Headquarters collaborated with the U.S. Environmental Protection Agency's CHP Partnership Program to prepare a preliminary (Level 1) feasibility analysis of CHP at the facility. This analysis estimated that a CHP system could be installed at Greenbelt that would provide more than 90 percent of Greenbelt's electrical energy and all of its heating energy for roughly $30 million, with a simple payback period of 5.5 years. These estimates are preliminary and the actual costs and benefits would likely vary, but they demonstrate a strong case for additional study regarding the potential for CHP at Greenbelt.

Based on this analysis, the Facilities Management Division at Greenbelt is pursuing a more detailed Level 2 analysis.

Regarding SSPP goals, the evaluated LFG-powered CHP system would supply nearly 50 percent of energy demand at Greenbelt with renewable energy (based on 2012 LFG supply rates) greatly surpassing the 7.5 percent renewable energy goal in the SSPP. The system would also reduce Greenbelt's Scope 1 and 2 GHGs by 21 percent through reduced grid-sourced electricity purchases and associated reduced losses in electricity transmission and distribution through the regional grid (T&D Losses). Additionally, because CHP reduces the risk of electrical supply failure, implementing CHP could strengthen Greenbelt's competitiveness for project funding by reducing overhead costs associated with backup electricity generators—often purchased through mission project budgets, thus increasing operational overhead costs on missions. Reducing the number of generators at Greenbelt would also reduce environmental and regulatory costs related to the maintenance and operation of generators, and fuel tanks.

Beyond conventional CHP, a facility power plant can achieve even greater levels of efficiency by incorporating absorption cooling. Absorption cooling is an established technology that uses thermal energy to drive heat transfer to chill water for building cooling. For example, a private technology firm in California has developed a CHP system for their San Diego facility using this type of "trigeneration" (electricity, heat, and cooling). Their CHP system has a total capacity of 6.9 MW of electricity generation and 1,400 tons of cooling capacity. For comparison, Greenbelt uses 20 MW of energy, on average, during the summer months. The company has reported $0.5 million in annual savings from this project and estimated a four-year payback for CHP projects they have implemented.

Ultimately, there are numerous benefits and opportunities for CHP at Greenbelt. Implementing CHP at Greenbelt would drastically reduce energy costs, energy-based risks to the mission, and environmental impacts.

G *Improved Energy Metering*

The building specific energy metering systems at Greenbelt have been installed over a long period of time and thus have varying capabilities. Subsequently, the resulting meter data is hosted on several different data management systems. Also, there are a few buildings that lack one or more meters for specific energy sources. These shortcomings in the metering system make it challenging to fully analyze energy data to identify strategic energy conservation measures or perform the energy benchmarking necessary to satisfy the Guiding Principles for Sustainable Buildings. Options to address gaps in the metering systems, and integrate all metering data into a modern energy management system are being explored.

W G *Guiding Principles for Sustainable Buildings*

While NASA has pursued LEED certification as an indicator of sustainable building design and operation, the SSPP indicates that conformance with the Guiding Principles put forth by the "Federal High Performance and Sustainable Buildings—Memorandum of Understanding" (Guiding Principles; Appendix B) is the federal standard for sustainable buildings, not LEED. While LEED buildings certified before October 1, 2008, are grandfathered into the Guiding Principles, LEED projects certified since then do not necessarily meet the Guiding Principles. Ultimately, LEED projects are more likely than traditional buildings to meet the Guiding Principles criteria, however, Goddard should evaluate these projects relative to the Guiding Principles to evaluate its performance on sustainable buildings goals and determine the need for additional action.

W G *Additional Recommissioning*

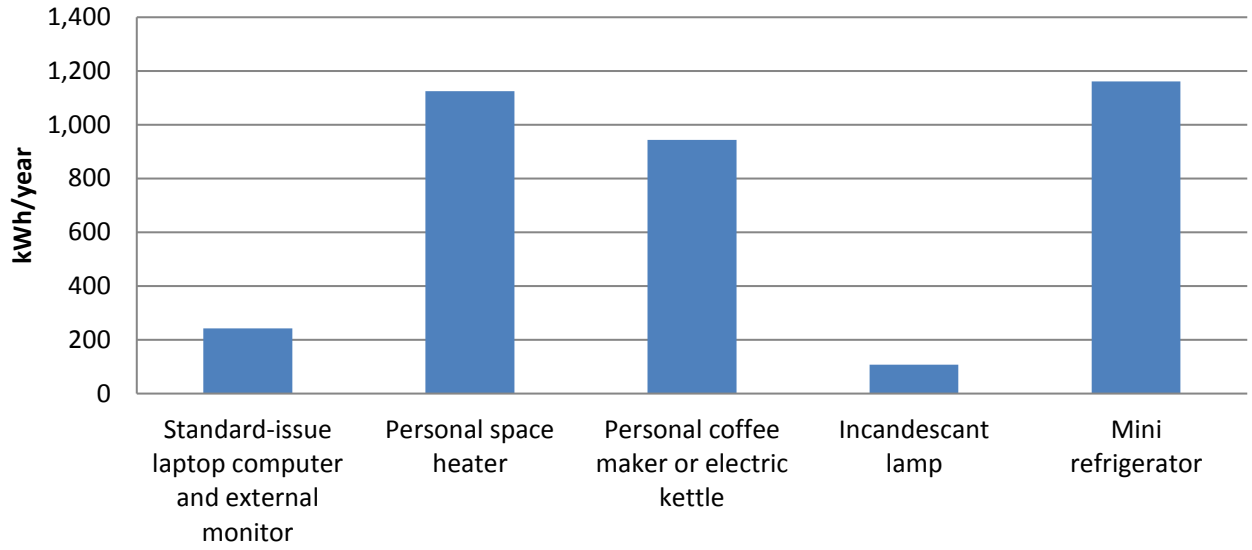
Recommissioning has been pursued at Goddard in a limited number of buildings with good results (e.g. Greenbelt: Buildings 6, 22, and 33 recommissioning, page 15). Such projects have been demonstrated to provide immediate efficiency gains of five percent with payback in four to five years. This type of project presents some of the simplest Scope 1 and 2 GHG reduction opportunities. Wallops has begun to address this concern by developing an in-house commissioning team consisting of NASA personnel.

LEED v2009 gives up to six points for implementing an ongoing commissioning program. Such a program requires recommissioning every two years. Compliance with the Guiding Principles requires commissioning every four years. Developing a streamlined recommissioning program at Goddard would greatly facilitate LEED and Guiding Principles certification; save significant money, energy and GHGs; and improve employee comfort by ensuring HVAC systems are working properly.

W G *Individual Plug Load Management*

Individual employees can have a significant impact on energy usage, even in a basic office workstation. Preliminary estimates indicate that there may be 1,200 to 1,400 personal space heaters in seasonal use at Greenbelt, costing roughly $1 million per year in electricity. Figure 6 shows how common personal office equipment compares with the power usage of a standard issue laptop and monitor.

Figure 6: Plug loads of typical office items



Alternatives for addressing employee-level plug loads include managing the extent of energy-intensive office equipment (e.g. space heaters) at Goddard; providing individual, workspace-level electricity meters (roughly $20 retail) to help employees manage their own energy use; or installing individual, workspace-level occupancy sensors to turn off electrical outlets (except those powering computers) when employees are not present, as implemented in the new North Propellants LEED Building at NASA's Kennedy Space Center.

W G *Lighting Audit*

Isolated lighting projects have been pursued in various facilities, such as the lighting retrofit in Greenbelt Buildings 10 and 15 (page 15). Given continuing advances in lighting equipment markets and technologies, however, there may still be cost effective opportunities for additional retrofits at Goddard or additional savings garnered by upgrading previous retrofit projects with newer technologies, such as LED lighting. Given that lighting currently consumes approximately 20 percent of commercial electricity usage, it is likely that significant additional energy savings can be realized by continuing to reevaluate lighting technology employed at Goddard. This could be accomplished through a Center-wide audit of lighting systems.

Such an audit would allow easy identification of traditional retrofit projects as well as upgrade-through-replacement projects that could be performed when less efficient lighting equipment needs to be replaced. Having readily available lighting equipment data from a comprehensive lighting audit would support numerous projects, which could be readily pursued using expiring end-of-year funding sources.

W G *Energy Benchmarking*

Energy benchmarking is required in Section 543, 8A of the EISA of 2007. While the Center does benchmark energy use in buildings based on historical consumption, Goddard may have additional opportunities to utilize benchmarking to its fullest capacity.

Benchmarking tools, such as the EPA's, online ENERGY STAR Portfolio Manager, provide an objective comparison of how much energy and water a building should be using as compared to how much it is actually using based on its age, size, use, and other

features. This level of analysis allows facility managers to compare a building's performance to its theoretical potential rather than its historical performance. This level of analysis makes it possible to identify buildings that are underperforming regardless of age or changes to the building use. When considering the age of the buildings at Goddard, and frequent space reallocations, this kind of diagnostic tool would greatly enhance facility managers' abilities strategically to address energy consumption.

Additionally, the ENERGY STAR program sponsors a performance based rating system for buildings based on their performance in the Portfolio Manager benchmarking application. Buildings performing at or above the 75th percentile for their size and use are eligible for ENERGY STAR certification, which documents superior energy performance (Figure 7).

Figure 7: ENERGY STAR Building Certification

Source: www.energystar.gov

Finally, some LEED rating programs and the Guiding Principles can integrate benchmarking performance scores into their certification criteria. LEED EB: O+M v2009, for example, grants up to 8 points (roughly 25 percent of the points required for gold certification) based on the building's energy performance rating in Portfolio Manager or another benchmarking program.

SUBGOAL 1.2 – RENEWABLE ELECTRICITY

NASA promotes the use of renewable energy to reduce GHGs associated with conventional electricity generation, and to support the growing alternative energy industry. Specific NASA goals relating to the adoption of renewable energy are shown in Table 4. NASA specifically promotes the development of on-site capabilities for generating renewable energy at its facilities; however, Goddard does not currently host or operate any generation projects for renewable electrical energy. Goddard does purchase grid-sourced renewable energy to receive renewable energy credits (RECs) for selecting renewable energy providers.

Table 4: 2012 SSPP Renewable Energy Goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 2.1.b.i: Increase percentage of total electricity from renewable sources (3% FY 2007 to FY 2009; 5%, FY 2010 to FY 2012; 7.5% FY 2013 on).	Greenbelt obtained 5.0% of its goal subject electricity from RECs in FY 2012.	Wallops obtained 4.8% of its goal subject electricity from RECs in FY 2012.	Goddard obtained 5.0% of its goal subject electricity from RECs in FY 2012.
Goal 2.1.b.ii: Strive for at least half of the renewable energy from new renewable sources (placed into service after January 1, 1999).	All purchased renewable energy is from new sources.		

1.2.a Current Renewable Energy Initiative

Over the last decade, renewable electricity generation initiatives—including wind, solar, and CHP using LFG—have been reviewed for potential application at Goddard. Other than recent research into LFG-CHP at Greenbelt, these technologies have not previously proved viable based on technical, financial, or environmental constraints; however, markets and technologies are rapidly evolving and creating new opportunities for on-site renewables.

W G *Renewable Energy Credits*

Because Goddard does not currently operate or host any renewable electricity generation, the Center purchases RECs to contribute to SSPP Goal 2.1.b.i. In 2012, Greenbelt and Wallops purchased RECs to source 5.0 percent and 4.8 percent of their electrical energy, respectively, from renewable sources.

1.2.b Potential Renewable Energy Initiatives

W G *Energy Efficiency*

A low-tech approach for increasing the portion of Goddard's energy sourced from renewables is to reduce the total electricity demand of the Center. For example, if the facility is purchasing 7.5 percent of electrical energy as renewable energy credits, a 5 percent reduction in electricity use at the Center would increase the renewable energy share from 7.5 percent to 7.9 percent without increasing renewable energy purchases. Potential areas for increased electricity efficiency are discussed in Section 1.1.b, Potential Building Management Initiatives (page 20).

W G *Solar Energy*

Goddard does not currently host any solar energy production. While solar is becoming increasingly viable in the private market, one barrier to implementing renewable energy projects at Goddard, as compared to private companies, is the comparatively low electricity rates Goddard pays owing to its tax free status. This lower effective energy rate reduces the cost avoidance benefits of both renewable energy and energy efficiency projects and makes it challenging to justify such initiatives solely using financial arguments.

W G *Wind Energy*

Wind energy is a promising sustainable energy solution on the national scale. Local prospects for wind energy, however, are highly dependent on local wind conditions. Unfortunately, Greenbelt, Maryland, has inadequate wind conditions for cost-effective energy production (Figure 8). For this reason wind energy is not likely to be a promising renewable technology at Greenbelt.

Wallops, however, has average wind speeds nearly double that of Greenbelt (Figure 9). Wallops has explored wind power projects but has met strong opposition from environmental groups due to potential impacts on wildlife due to bird and bat strikes. While these concerns have prevented a proposed large-scale wind project, a small-scale wind turbine has been procured for installation at the Wallops main base.

Considering the potential for large-scale wind energy production at Wallops, it would be worthwhile to continue to investigate opportunities to implement large scale wind production that would be compatible with local wildlife. Recent wildlife-sensitive planning and design guidance from the U.S. Fish and Wildlife Service may provide information and strategies to reduce potential wildlife impacts created by large-scale wind generation at Wallops. Additionally, Goddard manages numerous small sites around the world where wind power may be feasible.

Figure 8: Maryland wind energy resources map

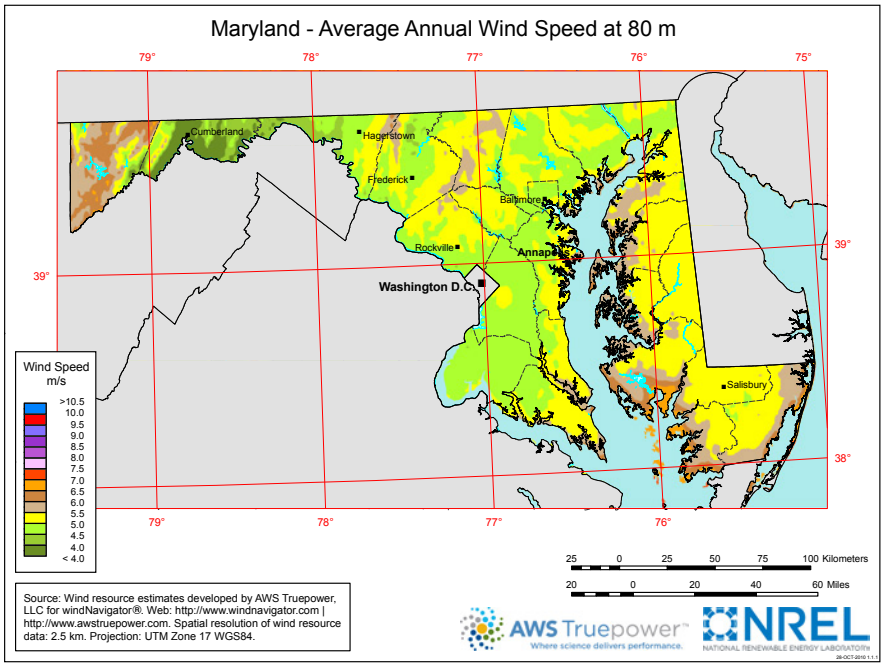


Image Credit: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, reprinted as public domain content.

Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. 80-Meter Land-Based Utility-Scale Wind Resource Maps: Maryland. Retrieved September 16, 2013 from http://www.windpoweringamerica.gov/images/windmaps/md_80m.jpg.

Figure 9: Virginia wind energy resources map

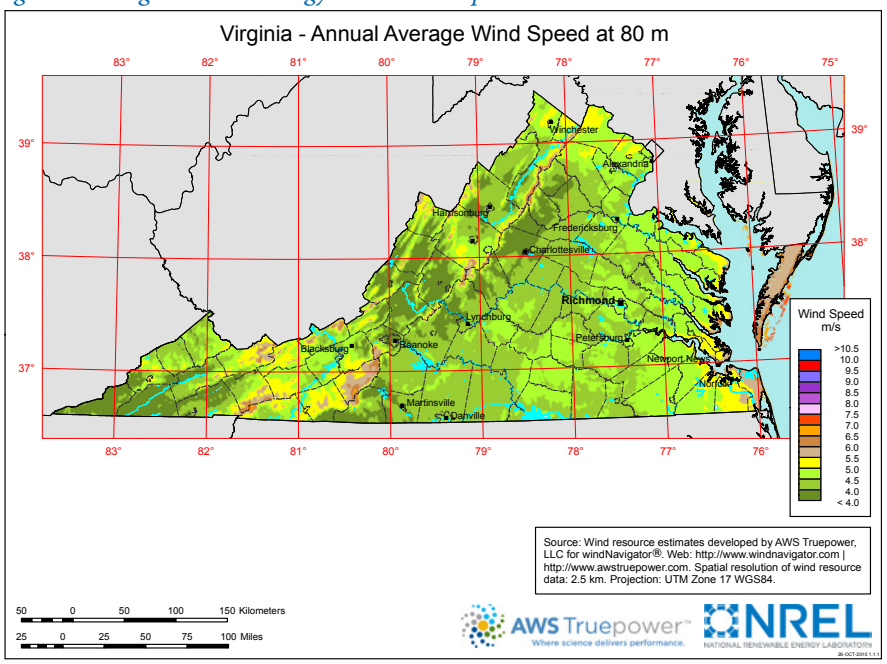


Image Credit: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, reprinted as public domain content.

Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. 80-Meter Land-Based Utility-Scale Wind Resource Maps: Virginia. Retrieved September 16, 2013 from http://www.windpoweringamerica.gov/images/windmaps/va_80m.jpg.

SUBGOAL 1.3 – INFORMATION TECHNOLOGY MANAGEMENT

Due to the data-intensive nature of the work done at Goddard, computing (information technology, or 'IT') equipment contributes significantly to energy use and associated GHGs. Greenbelt has a long history of extensive IT deployment and currently hosts hundreds of servers as well as the Center for Climate Simulation's Discover supercomputer (Figure 10). Likewise, Wallops maintains a considerable IT portfolio to manage the launch range. This scale of IT deployment at Goddard consumes a considerable amount of energy, and numerous emerging efficiency strategies are being investigated to address energy demand from IT at Goddard. Advances

such as high-temperature, direct, and fresh-air cooling; server virtualization; containerized housings; and cloud computing are just some of the cutting-edge concepts Goddard is currently looking at to increase the efficiency and performance of its IT. Given the scale of IT at Goddard, there are considerable opportunities to realize the benefits of new IT concepts, but significant organization, management, and planning are required to realize these benefits.

Additionally, the 2012 SSPP proposed numerous strategies to reduce the impacts of IT equipment (Table 5). Goddard has also pursued many of these initiatives.

Figure 10: Goddard computer room circa 1961 and the current Discover supercomputer

Photo credits: NASA/Goddard; NASA/Goddard/Izzo, 2012.

Table 5: 2012 SSPP IT Management Goals

	Goddard's Contribution to Agency Goal
Goal 2.2.i: **Reduce need for new building and field office space by utilizing technologies to increase telework opportunities and expand delivery of services (over the internet or electronically).**	The Goddard teleworking program is projected to save more than 35,000 commuting trips at Greenbelt, Wallops, and The Goddard Independent Validation and Verification Facility in West Virginia in CY 2013.
Goal 5.e: **Reduce printing paper use.**	Printing paper use has shown no net change since 2008.
Goal 7.a: **Ensure acquisition of EPEAT-registered, Energy Star-qualified, and FEMP-designated electronic office products when procuring electronics in eligible product categories.**	All electronics procured meet required certifications where feasible.
Goal 7.b: **Establish and implement policy and guidance to ensure use of power management, duplex printing, and other energy efficient or environmentally preferred options and features on all eligible agency electronic products.**	Duplex printing had been the default setting, but was reset to single-sided printing due to employee complaints. Goddard is currently participating in a computer power management pilot initiative spearheaded by NASA's Langley Research Center and implemented under the Agency Consolidated End-user Services (ACES) contract. If successful, policy will be developed to ensure use of power management options wherever feasible.

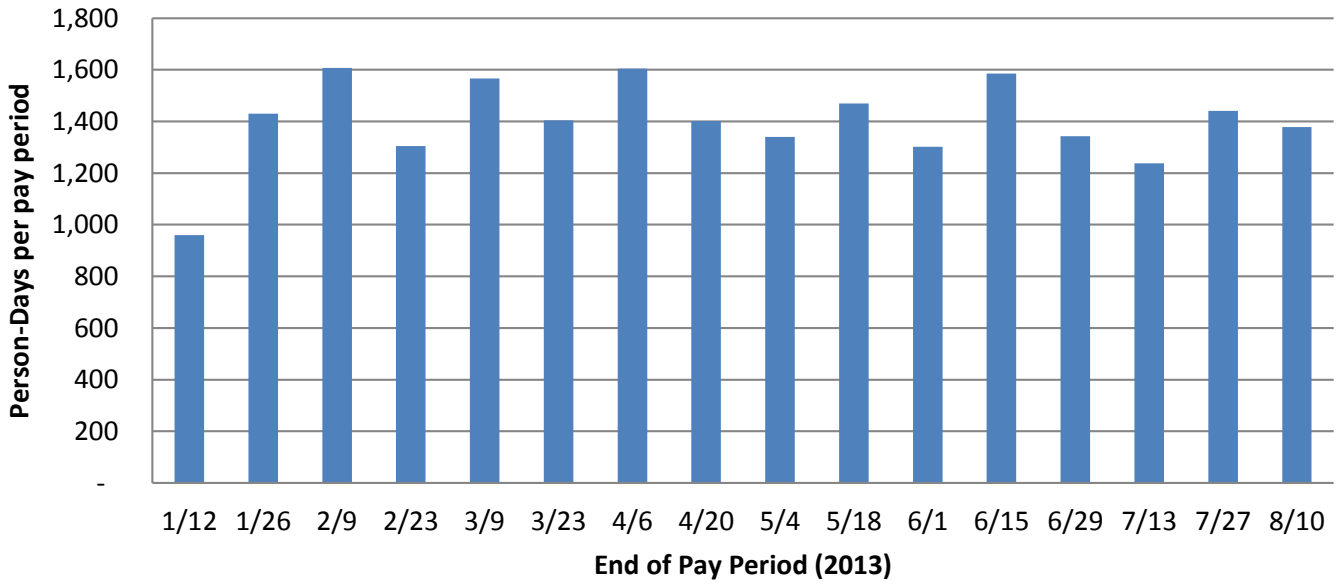
1.3.a Current IT Management Initiatives

W G *Telecommuting and Mobile Video Conferencing*

Telecommuting at NASA helps reduce Scope 3 GHGs associated with commuting and operating buildings while also facilitating the continuity of operations when the Center must close for inclement weather or other events. The Office of Human Capital Management is actively researching and promoting telecommuting or "work from anywhere" practices at all Goddard facilities to enhance these benefits.

A new data collection system was implemented in early CY 2013 to monitor telework rates (Figure 11). At these rates, the Goddard telework program is projected to save more than 35,000 round-trip employee commutes and 37 MWh of Goddard provided electricity per year—the equivalent of roughly 140 full-time workers eliminating their GHGs from commuting and electricity used at Goddard entirely or approximately 0.1 percent of total Goal Subject GHGs.

Figure 11: Telework days at Greenbelt, Wallops, and Goddard's IV&V facility in West Virginia



One challenge for teleworking is that it reduces opportunities for communication and collaboration due to the physical separation of employees. In an effort to address these barriers to enhance mobile work capabilities, NASA is piloting Desktop Mobile Video Conferencing through the Enterprise Service Desk. This service will allow employees to host and log into video teleconferences remotely using laptops or mobile internet devices. This addition to NASA's telecommunications services will greatly enhance the capabilities of the telework program.

G *IT Equipment Containerization, Cloud Computing, and Server Virtualization*

Containerization is an IT management strategy that involves physically housing servers in dedicated container housings instead of inside buildings. Cloud computing is an IT management strategy wherein commonly used applications are hosted on remote servers and made available to users over a network or the internet, reducing the equipment requirements of individual desktop machines while providing access to shared hi-spec cloud IT equipment. Server virtualization involves moving from a traditional management philosophy of hosting one application on one server to consolidating numerous server applications on a fewer number of servers to reduce hardware needs. In all, these strategies increase efficiency and can reduce capital and operating costs because of the more efficient use of IT hardware and improved thermal properties of purpose-built container housings.

Both the Information Technology and Communications Directorate (ITCD) and the Computational and Information Sciences and Technology Division (ISTD) are beginning to explore these strategies and all three are implemented at the NASA Cloud Services container near Building 28 at Greenbelt (Figure 12). The NASA Cloud Services container at Greenbelt began operation in October 2012 and ITCD estimates there is enough server demand to justify a total of three server containers at full build-out.

Figure 12: NASA Cloud Services Server Container at Greenbelt

Photo credit: NASA/Goddard, 2013

Containerized IT is more efficient because containers can be insulated more effectively than human-occupied buildings, and can be maintained at higher temperatures more suitable for IT than human occupants. These thermal benefits can reduce data center energy use by more than 75 percent compared to conventional data centers. ITCD estimates a savings of $0.5 million to $0.8 million per year in energy savings per container. At a purchase price of approximately $3.2 million for a server container, servers, and HVAC system, a server container has a simple payback period of 4 years, with the majority of capital expenditure coming from IT equipment budgets. Additionally, because some containers utilize self-contained cooling systems, transitioning to containerized housing could reduce stress and demand on the chilled water generation and distribution system at Greenbelt.

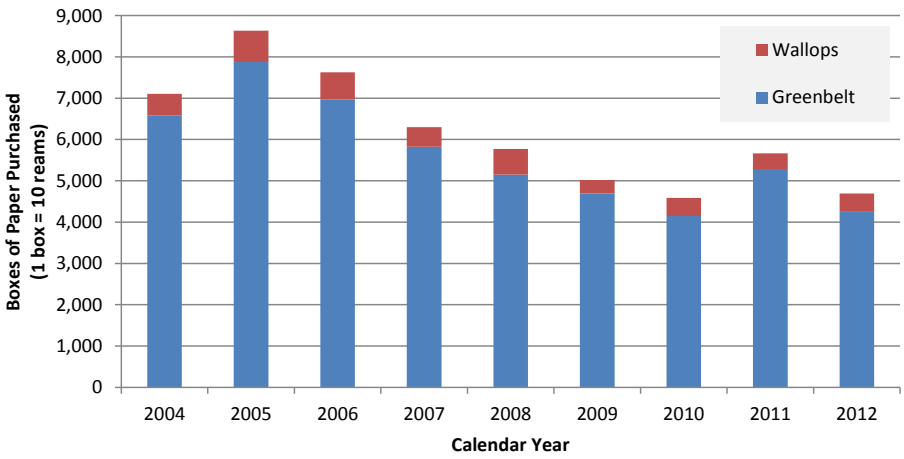
Cloud hosted applications and virtualized servers improve efficiency by reducing hardware requirements and maximizing the use of the required hardware. Also, consolidating equipment and applications through these techniques can simplify data backups and service redundancy, reducing the threat to missions posed by server failure and data losses.

One potential barrier to maximizing the benefits of these management concepts is the decentralized management of IT at Goddard. Independent technical groups at Goddard have a long tradition of managing their own hardware. Many of the benefits of the three emerging management techniques discussed in this section, however, are maximized through centralized management of IT. In order to maximize the benefits of these strategies while preserving the independence of Goddard staff, Greenbelt has created a data Center consolidation working group that includes representatives involved with IT management from around the Center to determine the best application of these strategies for Goddard.

WG *Printing Paper Conservation*

Reducing the amount of paper used for printing is encouraged in 2012 SSPP Goal 5.e. The Center has experimented with setting the default print option to duplex (double-sided printing); but based on employee complaints, reverted to the traditional single-side default. Nevertheless, printing paper use has dropped by 34 percent since 2004 (Figure 13). This may be due to employees electing to print double-sided documents, using computers and portable electronics (e.g. iPads) to read documents in lieu of printing, or changes to operational procedures. Paper use, however, has plateaued since 2008 with no consistent reductions since.

Figure 13: Printing paper consumption at Goddard



1.3.b Potential IT Management Initiatives

G *Waste Heat Reuse*

In addition to being more efficient, consolidating IT equipment creates an opportunity to utilize waste heat for a productive purpose. Waste heat is generated as IT is air-cooled, producing hot air that must be re-cooled by the building cooling system. If this heat could be redirected to heat occupied space in winter months, it could offset the use of natural gas or LFG for building heat instead of fighting the building air conditioning system. Unfortunately, it is energy intensive to move hot air large distances to building spaces in need of heat.

In high-performance supercomputers, as opposed to servers, enough heat is produced to justify direct cooling, whereby fluid is pumped through the IT circuit boards to mitigate heat buildup, instead of simply blowing chilled air over the equipment. This state-of-the-art cooling approach generates high-temperature liquid, reaching 50˚C (122˚F), which can be pumped to a remote building space more efficiently than the hot air generated by traditional IT systems (Figure 14). ISTD is researching the potential to use IT waste heat from the Discovery supercomputer in the building heat system on campus at Greenbelt. The roughly 20,000 MMBtu per year of heat produced by the supercomputer alone has the potential to reduce Scope 1 and 2 GHGs by two percent due to reduced natural gas demand (used to make up deficiencies in LFG supplies).

To visualize the prospects for supercomputer waste heat utilization, a preliminary estimate indicates that the energy generated by the Discovery supercomputer could provide heating energy for more than 700,000 square feet (assuming heating energy of 7 kWh/square feet per year). For comparison, the combined occupied area of buildings 32 and 33, on the southeast corner of the Greenbelt Campus is 250,000 square feet. This preliminary analysis indicates entire sections of the campus could potentially be heated using only waste heat from the supercomputer.

Figure 14: Diagram of IT waste heat reuse

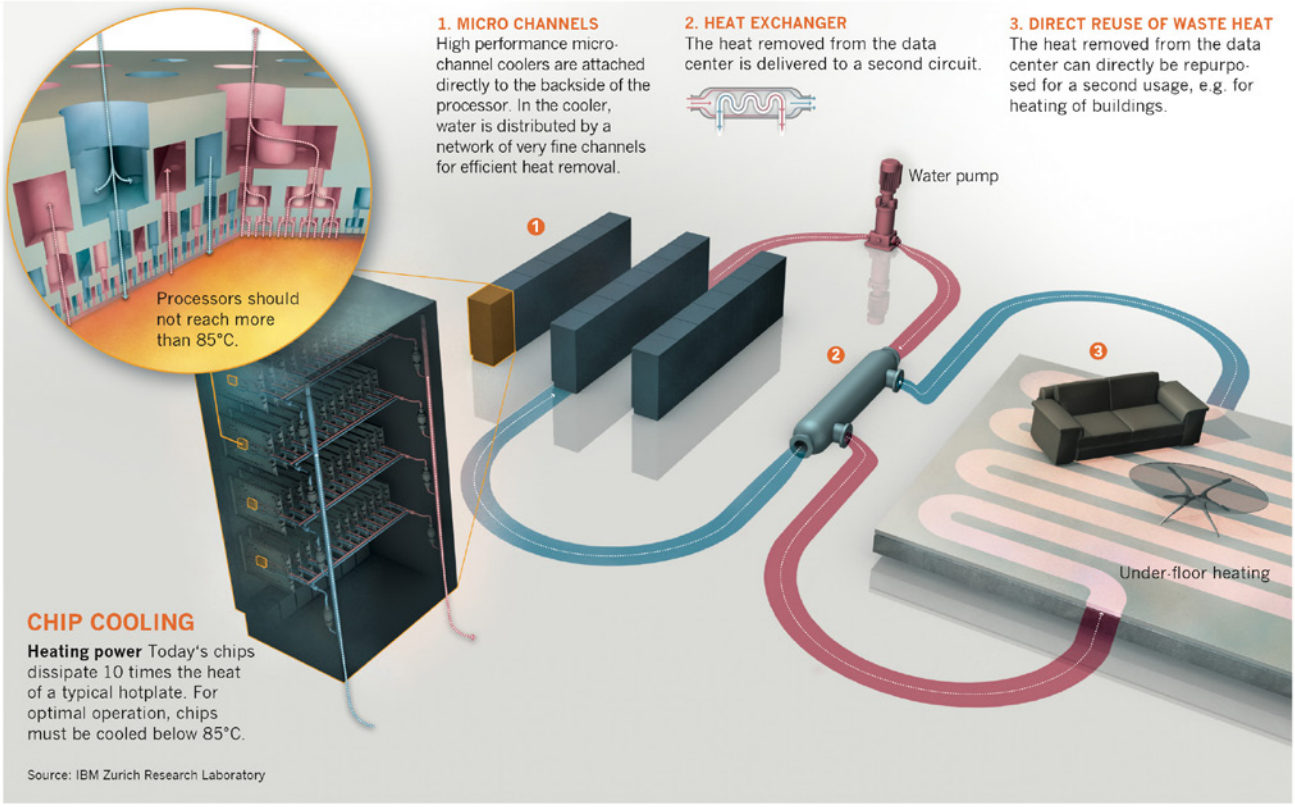


Image Credit: IBM Research - Zurich, reprinted with permission.

W G *Comprehensive IT Equipment Planning and Management*

So far, advanced IT management strategies have only been pursued in isolated pilot projects for a small portion of servers and other high-capacity, non-desktop IT at Goddard. Leveraging these pilot projects to create advanced IT management standards applicable to all non-desktop IT has the potential to greatly extend the cost, security, and energy benefits of these concepts. Greenbelt has created a data center consolidation working group that is well positioned to develop such standards. In order to realize the greatest possible benefits of advanced IT management strategies, Goddard should continue to support the data center consolidation working group, and work with the group to develop standards for advanced management of all non-desktop IT at Goddard.

W G *Coordinated Telework*

The Center could enhance the benefits of telecommuting by coordinating telework schedules in specific areas of buildings, e.g. floor- or wing-wide teleworking programs. This strategy would allow facility managers to set lighting and HVAC systems in standby mode for portions of buildings when all workers in those areas have agreed to telework. Increasing building standby time in this way would reduce Scope 1 and 2 GHGs that result from lighting, heating, and cooling. Currently, there are no office-wide telework programs at Goddard. This type of work model may not be suitable for all work disciplines at Goddard, and would require significant coordination and management, but the GHG benefits could be substantial.

SUB-GOAL 1.4 – FLEET MANAGEMENT

Fleet vehicle operations at Goddard contributed 2 percent of Scope 1 and 2 GHGs in 2012. In the interest of reducing fleet fuel costs and vehicle emissions, and to support evolving alternative fuels markets, NASA has adopted several goals in the SSPP relating to the environmental performance of NASA's vehicle fleets (Table 6).

Table 6: 2011 SSPP fleet management goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 3.1: Reduce petroleum use 2% annually from the FY 2005 baseline between FY 2005 and FY 2020 (30% total).	Petroleum fuel consumption was 1.7% below the FY 2012 interim target.	Petroleum fuel consumption was 15.8% above the FY 2012 interim target.	Petroleum fuel consumption was 7.1% above the FY 2012 interim target.
Goal 3.2: Increase use of alternative fuels in alternative fuel vehicles (AFVs) and flex-fuel vehicles. Increase alternative fuel use by 10% annually from 2005 baseline between FY 2005 and FY 2015.	Alternative fuel consumption was 10% above the FY 2012 interim target.	Has implemented alternative fueling, but has not maintained continuous 10% annual growth.	Alternative fuel consumption was 25% above the FY 2012 interim target.
Goal 3.3: Optimize the use of vehicles and right-size the fleet.	Annual motor vehicle utilization reviews are performed to ensure appropriate composition of vehicle fleet.		
Goal 3.4: Increase the use of low emission and high fuel-economy vehicles.	Added an average of 6.6 AFVs per year since FY 2005.	Added an average of 5.7 AFVs per year since FY 2005.	Added an average of 12.3 AFVs per year since FY 2005.

The vehicle fleets at Goddard are used to move employees around the facilities for maintenance duties and mission activities as well as to transport civil servants and contractors on official business in the local area. Goddard's Logistics and Transportation Management Branch (LTMB) has addressed agency fleet objectives for transitioning from petroleum to alternative fuels over the past several years using the thoughtful application of alternative transportation strategies and evaluation of vehicle functional roles . The benefits of these initiatives can be seen in the increased use of AFVs and alternative fuel, and reduced use of petroleum fuel at both Goddard facilities. (Figures 15 and 16).

Figure 15: Percentage of AFVs in Goddard's vehicle fleet

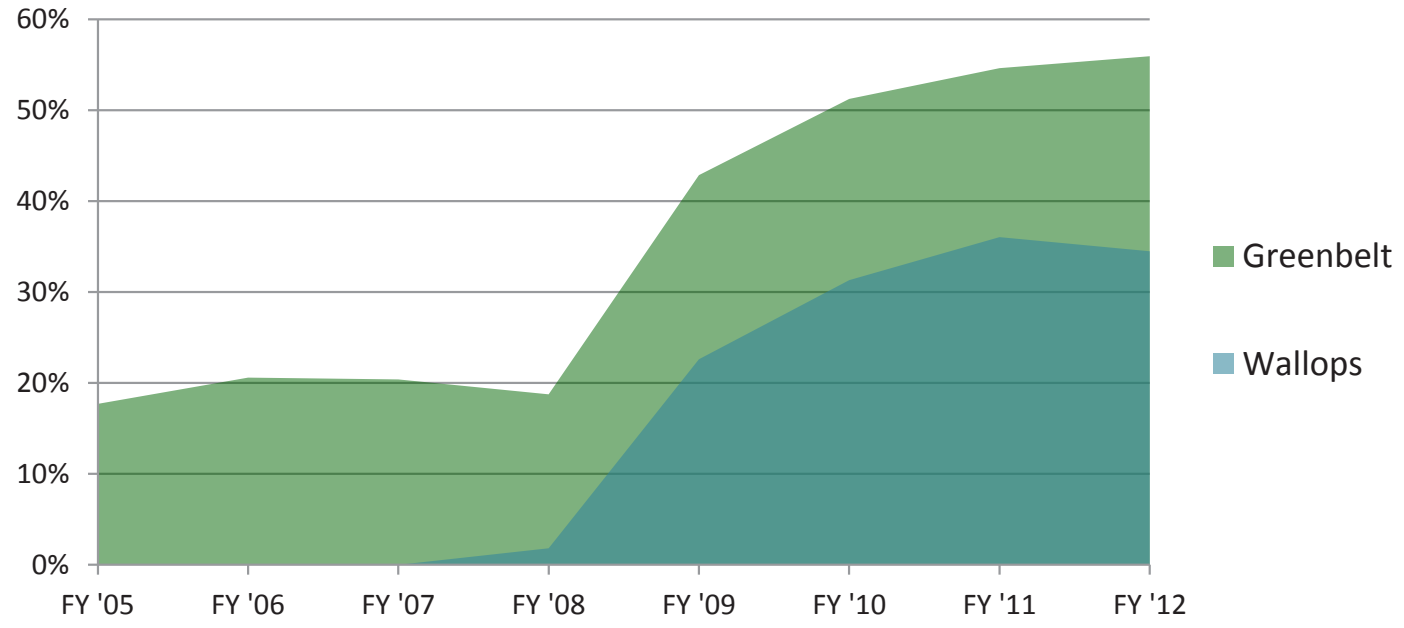
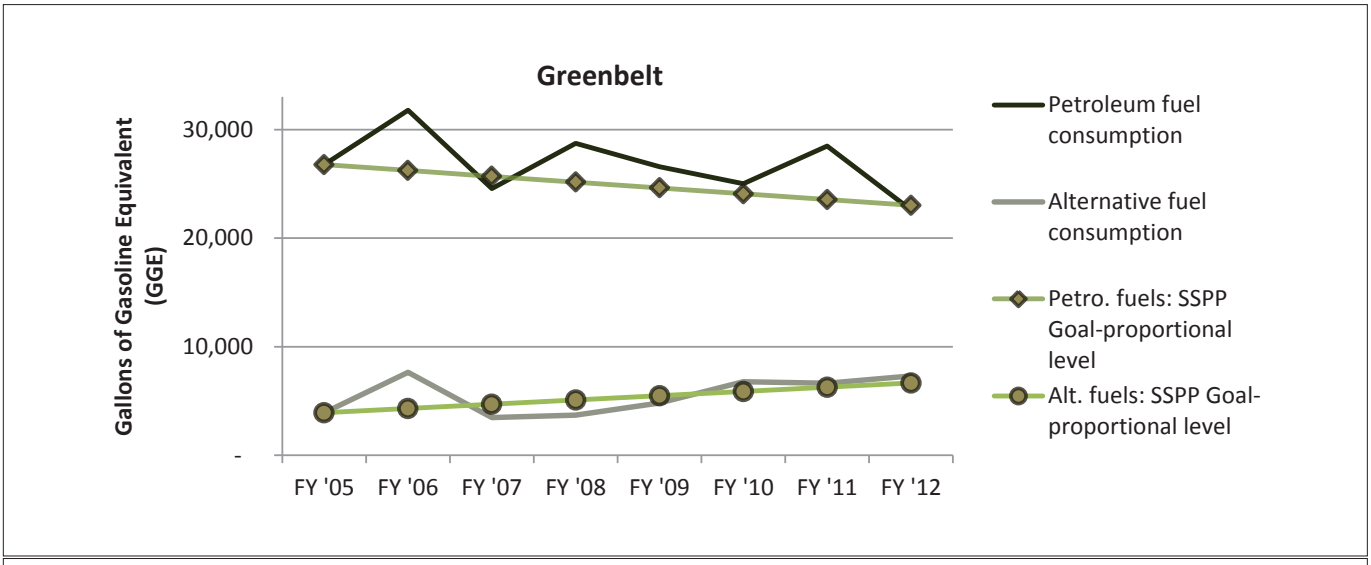
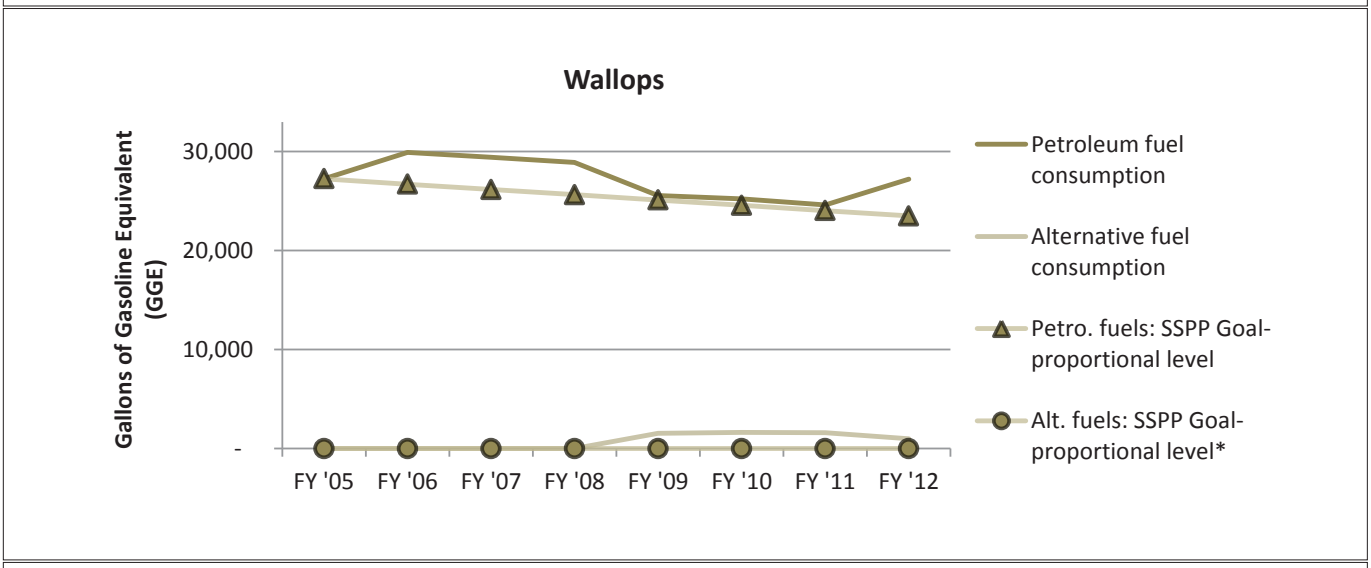
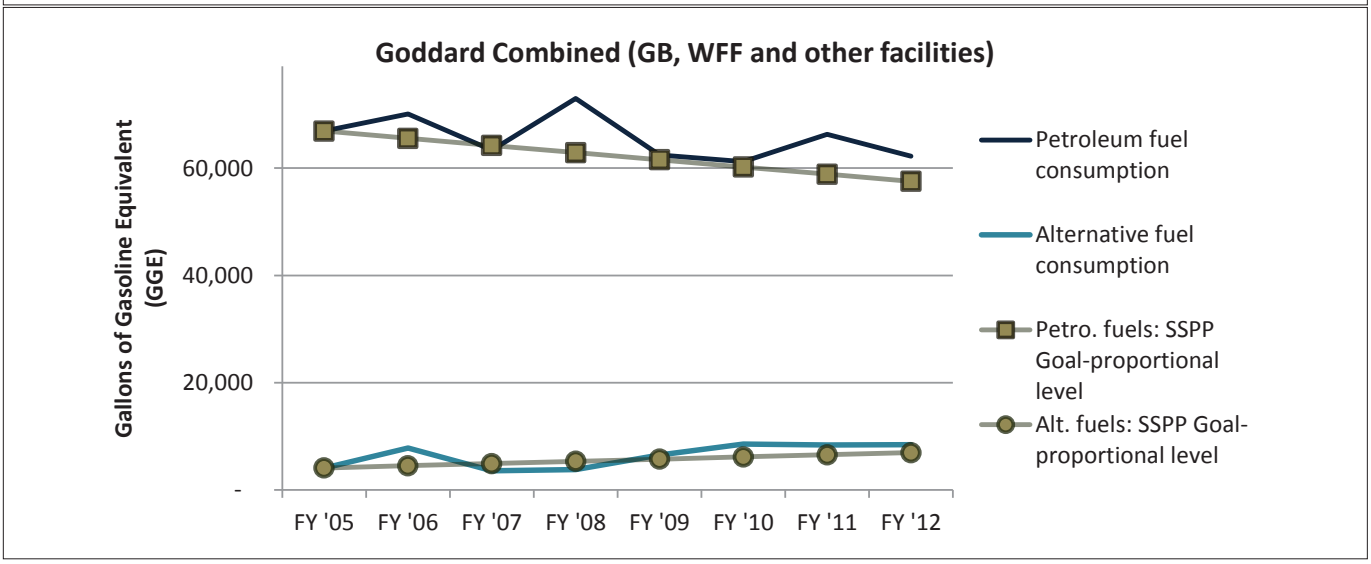


Figure 16: Fleet fuel consumption at Goddard







**Wallops used no alternative fuel in the SSPP Goal 3.2 base-year, making the SSPP proportional goal undefined for subsequent years.*

1.4.a Current Sustainable Fleet Management Initiatives

G *Bikes Around Goddard*

In an effort to reduce vehicle activity on the Greenbelt campus and support commuting by public transportation, a Goddard team from the Agency-wide FIRST Leadership training program initiated Bikes Around Goddard, a facility-wide bike-sharing program to be managed by LTMB. Thirty yellow bikes (Figure 17) are available for any user on Center to ride to meetings or other areas within the campus security gates. After arriving at a destination, the bikes are left unlocked in designated bike rack areas. Riders can use a tag on the bike to reserve it for their return trip or leave the bikes to be available for another user. If the initial 30-bike program proves successful, the bike share program will be expanded at Greenbelt and potentially extended to Wallops. The program was approved by Center management last December and launched on Earth Day, April 22, 2013.

Figure 17: Bikes Around Goddard bicycle

Photo credit: NASA/Goddard, 2013

W G *Annual Motor Vehicle Utilization Reviews*

The entire Goddard fleet is reviewed annually to ensure that the most appropriate vehicles are deployed for thier specific functional role. This includes right-sizing vehicles to ensure that the most suitable and efficient vehicle is provided for each task. Alternative fuel and hybrid vehicles are also deployed, where appropriate, to support emerging sustainable vehicle technologies. For example, LTMB exchanged a mix of 22 gasoline hybrid vehicles from Greenbelt, for 22 E85 SUVs previously deployed at Wallops. This exchange capitalized on the availability of E85 at Greenbelt and subsequent ability to maximize the use of this alternative fuel.

1.4.b Potential Sustainable Fleet Management Initiative

G *Identifying a Low-Emission Goddard Taxi Vehicle*

The Goddard Taxi is a service provided by the Center to transport personnel around Greenbelt. This service reduces emissions associated with personal vehicle startup and helps employees that commute by public transportation to navigate the large campus. The current vehicle used for the Goddard Taxi is a highway-capable, nine-passenger shuttle bus (Ford E-350 platform) that is estimated to return between 8 and 10 mpg.

Given that the Center speed limit is 25 mph and the taxi is rarely filled to capacity, it may be possible to meet the needs of the Greenbelt community with a downscaled vehicle that would use less fuel, reduce Greenbelt's capital asset portfolio, and demonstrate Goddard's commitment to environmental sustainability to its employees and guests.

For example, a neighborhood electric vehicle could serve as the Goddard Taxi. The Electro Transit Buddy (Figure 18) retails for $30,295, can travel at 25 mph, is wheelchair accessible, has capacity for 15 passengers, and could be equipped with rooftop solar panels to extend the range of the vehicle. The solar panels available from this manufacturer could supply approximately 10 percent of the full-throttle power of this vehicle—or 100 percent of the power of the vehicle, assuming it is runs at full throttle for 10 percent of the time.

Figure 18: Potential alternative for the Goddard Taxi

Photo credit: Moto Electric Vehicles and More, LLC, Reproduced with permission.

Source: Moto Electric Vehicles and More, LLC, Electro Transit Buddy 15 Passenger Hard Door ADA Shuttle. Retrieved September 18, 2013 from http://www.motoelectricvehicles.com/store/CitEcar-Electro-Transit-Buddy-15-Passenger-Hard-Door-ADA-Shuttle-p1686.html.

GOAL 2: Limit GHG Emissions Induced by Goddard

Scope 3 GHGs result from NASA's requirements for services and personnel. Examples of Scope 3 emissions include GHGs resulting from employee commuting, employee business travel, contracted wastewater treatment, electrical energy lost by transmission and distribution through the grid (T&D losses), and solid waste disposal. Table 7 demonstrates NASA's Agency-wide goals for Scope 3 GHGs.

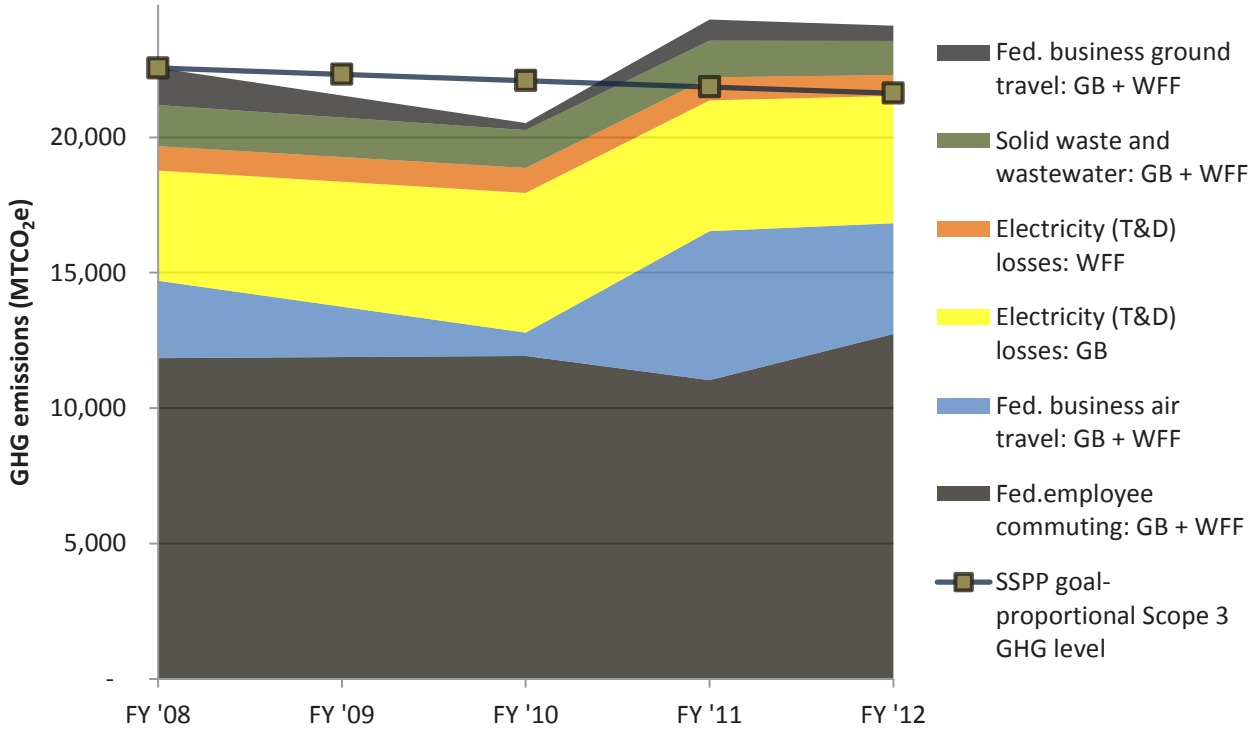
Table 7: 2012 SSPP Scope 3 GHC goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 1.2.a: Reduce Scope 3 GHGs by 12.6% by 2020.	Goddard's Scope 3 GHGs have increased by 7% since 2008.		
Goal 1.2.b: Reduce Scope 3 GHGs associated with contracted waste disposal by 23.1% by 2015, excluding waste generated from construction and demolition activities (C&D waste).	Greenbelt's waste disposal GHGs have increased by 2% since 2008.	Wallops' waste disposal GHGs have decreased by 40% since 2008.	Goddard's waste disposal GHGs have decreased by 18% since 2008.
Goal 1.2.c: Reduce Scope 3 GHGs associated with T&D losses from purchased energy by 15.1% by 2020.	Greenbelt's GHGs from T&D losses have increased by 16% since 2008.	Wallops' GHGs from T&D losses have decreased by 14% since 2008.	Goddard's GHGs from T&D losses have increased by 3% since 2008.

2.0 Goddard's Status

It is difficult to determine the performance of individual Goddard facilities since most data related to Scope 3 GHGs is collected for Goddard as a whole (Figure 19). Goddard is not currently on track to contribute to the Agency's attainment of the 2012 SSPP goals, 1.2.a, or 1.2.c relating to Scope 3 GHGs, however, data available for Wallops alone indicates it is currently meeting SSPP goal 1.2.b and is on track to meet SSPP goal 1.2.c (Table 7). The largest contributors to Scope 3 GHGs are employee commuting, T&D losses, and air travel; these areas comprise 11 percent, 5 percent, and 4 percent, respectively, of the total (all scopes) Goal Subject GHGs.

Figure 19: Goddard's Scope 3 GHGs



2.a Current Scope 3 GHG Initiatives

W G *Teleworking and Desktop Mobile Video Conferencing*

Telecommuting (page 27) serves to reduce employee commuting GHGs, and T&D losses from electricity used on Center. At current participation levels, telework at Goddard results in a nearly 0.5 percent decrease in Scope 3 commuting emissions compared to conventional five-day per week commuting schedules. Additional teleworking capabilities are under development, such as desktop and mobile video conferencing, which will increase the attractiveness, effectiveness, and environmental benefits of telework.

W G *Energy Efficiency*

GHGs from T&D losses are proportional to grid-supplied electricity usage. Energy efficiency and renewable energy projects identified in Section 1: Scope 1 and 2 GHGs (page 11) are helping to reduce energy demand and subsequently address Scope 3 T&D GHGs.

G *Bikes Around Goddard*

Bikes Around Goddard, the Greenbelt bike-sharing program (page 33), helps employees travel around the campus without using fueled vehicles. The program also facilitates public transit access to the Center by reducing the need for employees to drive personal vehicles to move around the campus.

W G *Ridesharing, Transit, and Cycling Benefits*

NASA, local governments and the Federal Government promote low GHG commuting alternatives. The transit benefit program, operated by the Logistics and Transportation Management Branch, and ridesharing program, operated by the Metropolitan Washington Council of Governments, provide financial and organizational assistance for using public transportation and participating in ridesharing programs. Additionally, Federal employees who bicycle to work primarily during all or portions of the year may be eligible for $20 per month benefit for bicycle commuting expenses under the U.S. Department of Transportation's 2010 Bicycle Benefit Policy. The Goddard Cycling Wiki (http://goddardcyclists.wikispaces.com/) provides information about bike commuting and recreational biking for the Greenbelt Community.

2.b Potential Scope 3 GHG Initiatives

W G *Facilitate Electric Vehicle Charging for Employees*

As electric vehicles (EVs) and plug-in electrics continue to develop, many Goddard employees are expressing an interest in utilizing vehicle charging capabilities at Goddard to mitigate concerns about the limited range of these evolving vehicles. Providing electricity to employees to support personal EV commuting presents cost, electrical infrastructure, and legal issues regarding the use of government resources (electricity and car charging infrastructure) for personal use. Subsequently, EV-charging stations are not currently provided for employee's personal vehicles at Goddard. It may be possible to avoid these concerns by implementing EV charging through GEWA or WEMA using the same contractual arrangement that allows food service providers to operate on Goddard property.

W G *On-Site Renewables and Energy Efficiency*

Goddard can further reduce Scope 3 T&D emissions by continuing to increase electrical efficiency and producing energy on site (page 24).

W G *Involvement with Regional Bicycle and Public Transportation Planning*

Greenbelt and Wallops are located in low-density suburban and rural areas, which provide a narrow range of local housing options for employees and limited access to public transportation. For most employees, this leaves driving as the preferred means to get to work. There are numerous initiatives in the Greenbelt area to promote regional transit and bicycle commuting (Figure 20) that could improve non-motorized access to Greenbelt.

Likewise, Star Transit operates bus routes in the Wallops area (Figure 21), however service does not extend into Maryland. There are also no established bike routes in the Wallops area. To help improve public transportation and bicycle access to both facilities, Goddard should take an active role in planning and advocacy for bicycle routes and public transportation. Beyond environmental benefits, human resources experts indicate that having a diversity of commuting options can be a significant employee recruiting and retention tool in light of foreseeable gas price increases and changing worker lifestyle preferences.

Figure 20: Excerpt from Prince George's County bikeway plan

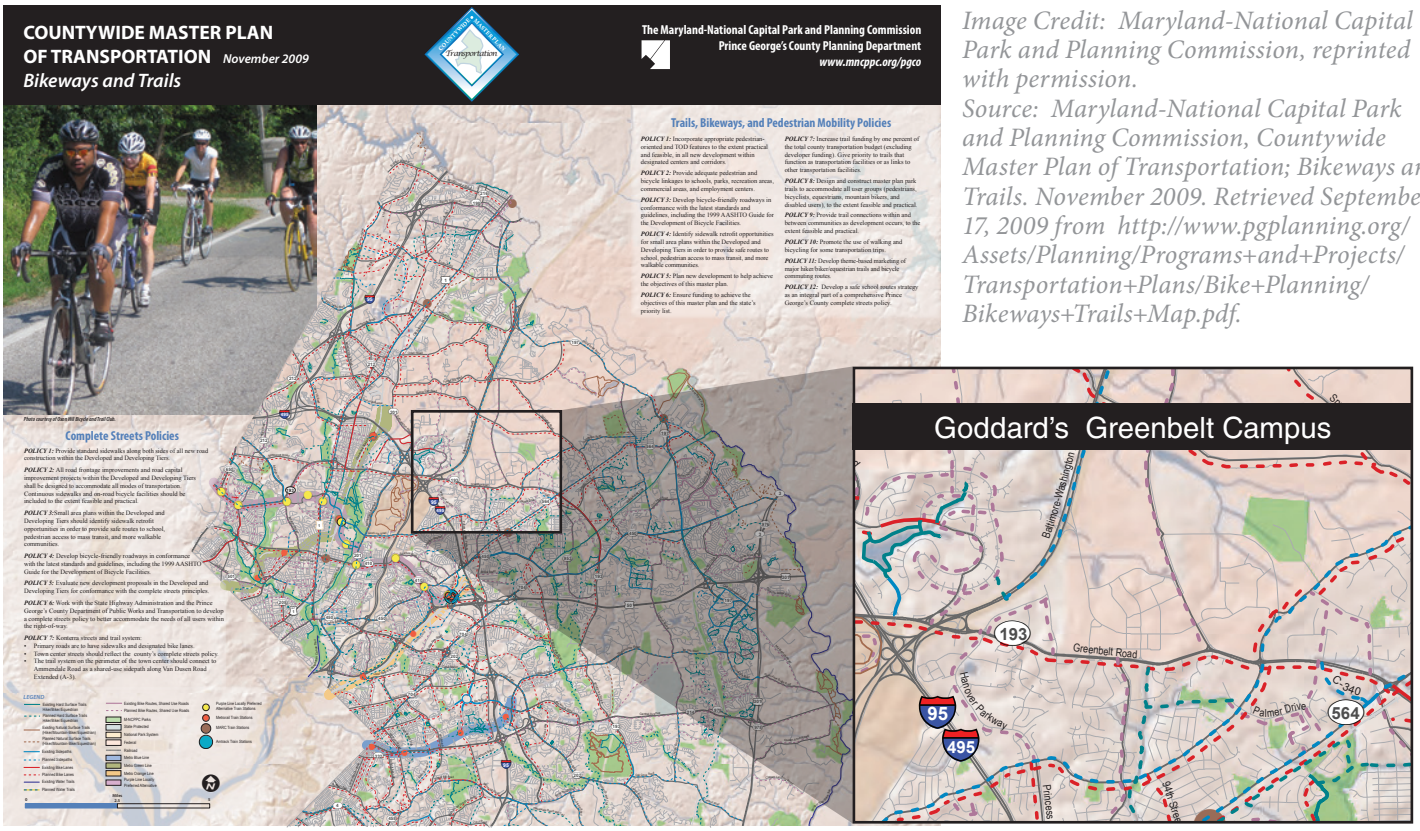


Image Credit: Maryland-National Capital Park and Planning Commission, reprinted with permission.
Source: Maryland-National Capital Park and Planning Commission, Countywide Master Plan of Transportation; Bikeways and Trails. November 2009. Retrieved September 17, 2009 from http://www.pgplanning.org/Assets/Planning/Programs+and+Projects/Transportation+Plans/Bike+Planning/Bikeways+Trails+Map.pdf.

Figure 21: Virginia's Eastern Shore transit map

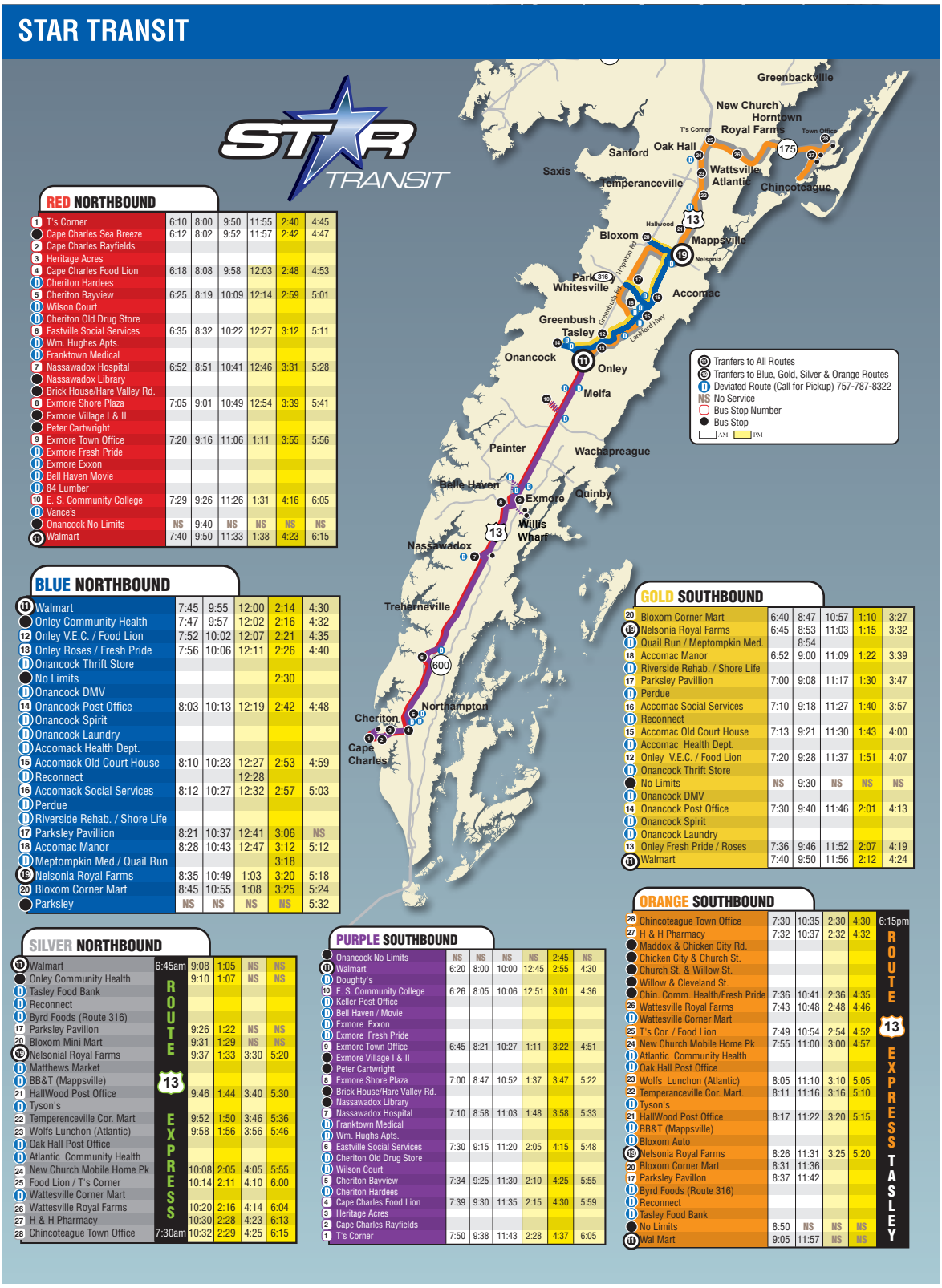


Image Credit: Star Transit, Reproduced with permission.

G *Rail or Bus Travel for Regional Business*

GHGs associated with airplane and single occupant vehicle (car) transportation are significantly higher than rail and regional bus transportation (Figure 22). Promoting the use of rail and bus transport instead of air travel where possible could significantly reduce Scope 3 emissions.

Figure 22: GHG emissions of rail, road and air transportation

Transportation Type	GHGs (kg per passenger mile)
Bus	**0.06**
Rail	**0.16**
Air	**0.24**
Car	**0.37**

Source: American Bus Association Website. Retrieved January 23, 2014 from http://www.buses.org/files/ComparativeEnergy.pdf

As an additional benefit, rail and intercity bus transportation significantly reduce transportation requirements to and from airports at either end of a journey. Because bus and train stations are generally in more urbanized areas, personal vehicles are often unnecessary thereby reducing parking, car rental, taxi, and shuttle costs and emissions.

GOAL 3: Strengthen Water Management and Climate Change Adaptation

Stormwater runoff from impervious surfaces, including pavement and rooftops, contributes to erosion and pollution in regional waters such as the Chesapeake Bay (Figure 23) and sensitive ecosystems on Wallops Island. The severity of these types of impacts prompted Executive Orders 13508 and 13547 that direct Federal agencies to lead efforts to address impacts to marine environments and prompted the, EPA, NASA, and MDE to advocate strongly for stormwater best management practices (BMPs) to reduce runoff impacts, as well as the legacy requirements for stormwater management in the 1972 Clean Water Act. For example, MDE has indicated that Greenbelt's next National Pollutant Discharge Elimination System Municipal Separate Storm Sewer System (MS4) permit will contain a quantitative requirement to restore 20 percent of the Center's impervious surface area using BMPs. Additionally, EPA's Stormwater Guidance for Federal Facilities (Appendix C) incorporated in the SSPP, and 2012 NASA Facilities Design Guide requires similar efforts to mitigate stormwater impacts from development and redevelopment sites greater than 5,000 square feet. To address environmental impacts and increasingly stringent state and Federal requirements, Goddard must begin to move from the traditional curb and gutter stormwater management practices towards BMPs.

Figure 23: Runoff sediment pollution in the Chesapeake Bay

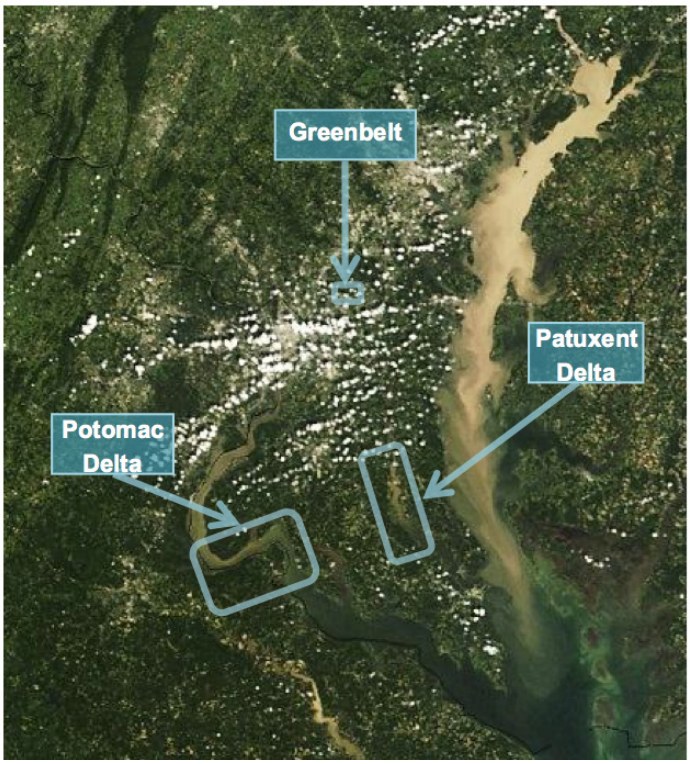


Photo Credit: NASA/Goddard 2011 (base image)

Traditional stormwater management systems were designed to rapidly drain water from impervious surfaces through curbs, gutters, and drain pipes. These types of systems cause water to flow quickly over surfaces, picking up pollutants, and enter receiving waters at very high flow rates causing erosion. Current BMPs address these impacts in numerous ways including slowing runoff flow rates, reducing their capacity

to entrain pollutants and cause erosion; filtering runoff through engineered biological filter media reducing pollution; and preventing water from directly entering receiving waters allowing for infiltration into the ground. Because of the large area needed to slow down and infiltrate runoff, BMPs often occupy more surface area than conventional stormwater management features. For this reason, they are often implemented as secondary functions to many landscaping features (Figure 24).

Figure 24: Stormwater management best practices

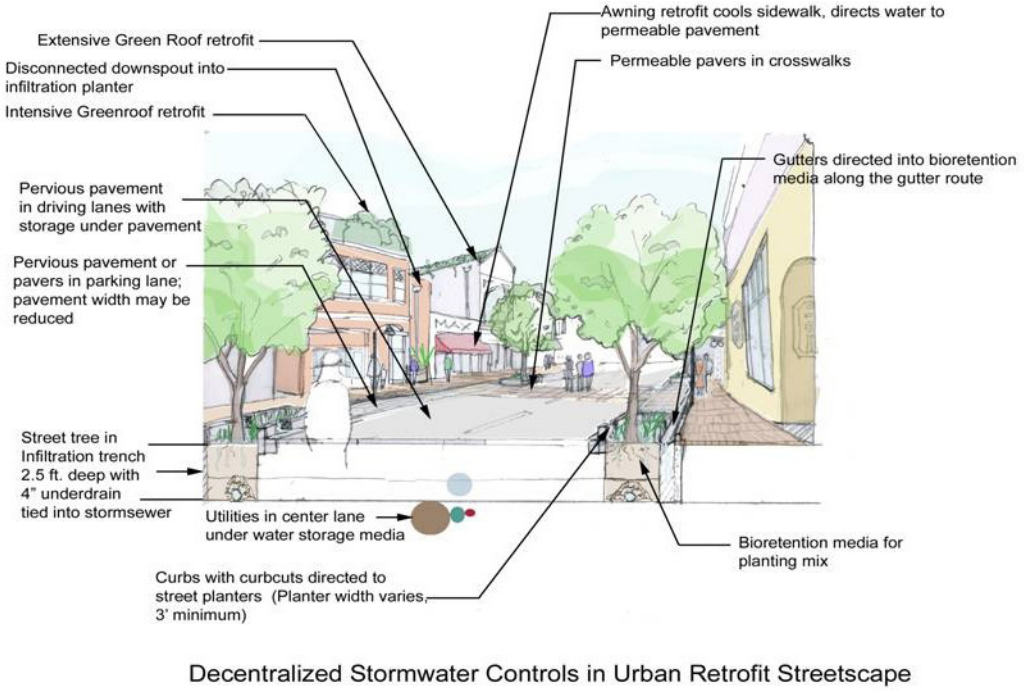


Image Credit: Water Environment Research Foundation, reprinted with permission.
Source: Water Environment Research Foundation. Retrieved September 10, 2013 from http://www.werf.org/liveablecommunities/images/concepts2.jpg.

In addition to the need to help reduce stormwater pollution, Greenbelt is currently experiencing minor periodic flooding associated with the degradation of the existing curb and gutter stormwater system. Also, climate change is expected result in to increased high-intensity rainfall events potentially exacerbating flooding and runoff issues over time. Ultimately, the need to mitigate runoff pollution, flooding impacts, stormwater infrastructure maintenance issues, and the projected increases in rainfall intensity create an imperative for the Center to critically evaluate and improve its stormwater management practices.

Finally, given the potential impacts of Goddard's demand for potable water on regional supplies and the energy impacts associated with drinking water treatment, the Energy Independence and Security Act of 2007 (EISA) and the 2012 SSPP have put in place ambitious water efficiency goals to reduce consumption that Goddard has addressed in a variety of ways (Table 8).

Table 8: Water Management and Climate Change Adaptation Goals

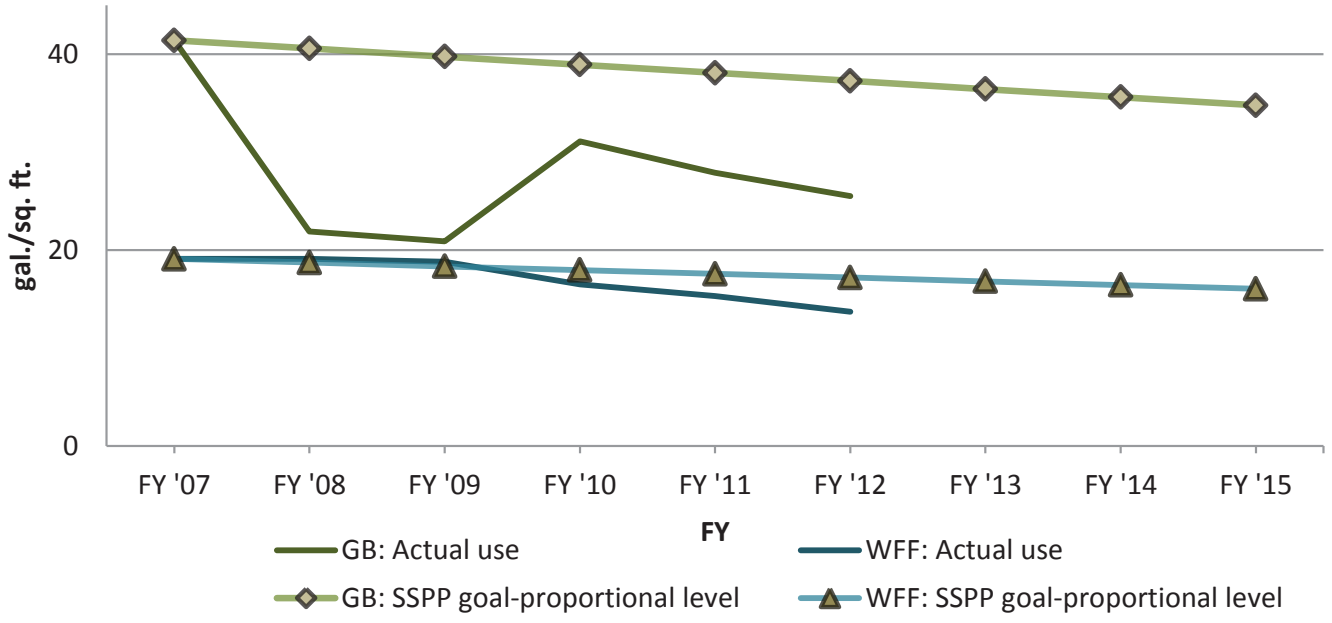
	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
State of Maryland MS4 permit requirement: Restore 20% of the facility's impervious surface.	Greenbelt has implemented two BMP retrofit projects at B32 and the new B36 incorporates BMPs sufficient to restore the entire site area.	Not applicable to facilities outside Maryland.	
SSPP Goal 2.2.: Align agency policies and actions to increase the effectiveness of regional measures that enhance integrity of local ecosystems and watersheds.	Member of The Baltimore Washington Partners of Forest Stewardship, however, Greenbelt does not have an ecosystem management plan in accordance with the partnership's mission.	Has collaborated with the Marine Sciences Consortium at Millersville University, The Nature Conservancy, Chincoteague National Wildlife Refuge, and the U.S. Fish and Wildlife Refuge to protect and enhance the sensitive ecosystems at Wallops Island and the Eastern Shore of Virginia.	Addressed at facility level.
SSPP Goal 4.a: Reduce potable water use intensity by at least 26% by FY 2020 [from FY 2007 base year].	Reduced water use by 38%, as of FY 2012	Reduced water use by 28%, as of FY 2012	Reduced water use by 35%, as of FY 2012
SSPP Goal 2.2.f: Demonstrate use of cost-effective, innovative building and sustainable landscape strategies to minimize energy, water, and materials consumption.	Certain previously mowed areas are being allowed to revert to unmowed meadows to reduce mowing impacts.	Innovative HVAC decentralization saves 1 million gallons of industrial water in addition to noted energy savings.	Addressed at facility level.
SSPP Goal 4.b: Reduce industrial, landscaping, and agricultural water use by at least 20% by FY 2020 [from FY 2010 base year].	Uses no irrigation water. B25 geothermal system reduces industrial water consumption.		
SSPP Goal 4.c: Identify and implement water reuse strategies.	Goddard does not currently have any water reuse programs.		
SSPP Goal 4.d: Achieve objectives established by EPA in Stormwater Guidance for Federal Facilities.	Goddard has consistently pursued objectives established in the EPA's Stormwater Guidance for Federal Facilities where applicable.		
SSPP Goal 4.e: Incorporate appropriate reduction strategies for non-potable water use into agency policy and planning.	The B25 Geothermal System (page 16) saves 560,000 gal. of well water per year (almost 1% of total well use) through reduced boiler plant demand.	Does not have a non-potable water system.	Addressed at facility level.

3.0 Goddard's Status

Water Conservation

Goddard has implemented several initiatives to reduce water usage on Center, and the Center is currently surpassing SSPP proportional goals for water-use reduction at both primary facilities (Figure 25).

Figure 25: Goddard's water use intensity



Stormwater Management

Greenbelt has completed two stormwater BMP pilot projects, and has incorporated BMPs in the design of Building 36 projected for completion in FY 2015.

Coastal Climate Adaptation

A major component of NASA's sustainability policy is to plan for adaptation to foreseeable changes in climate and hydrology by incorporating climate change risks and projections into NASA's asset planning and management processes. One of the most severe potential climate change impacts faced by Goddard is coastal storm surge damage at Wallops. Wallops has begun to address these concerns by protecting flood-prone areas of the facility and collaborating with CASI-Wallops to identify strategic locations to site new projects, protect existing infrastructure from storm surge inundation, or relocate sensitive infrastructure to higher elevations.

3.a Current Water Management and Climate Change Adaptation Initiatives

W *Storm Surge Protection*

Wallops has taken the first steps towards protecting the island launch facilities from anticipated increasingly severe storm surges similar to those observed with Hurricane Irene in 2011 and Superstorm Sandy in 2012. A beach restoration project including a sand and stone seawall constructed between the two storms (Figure 26) prevented the $3.8 million in damage to NASA facilities experienced during Irene from repeating as a result of Sandy.

Figure 26: Wallops Island beach restoration

Photo credit: NASA/Wallops 2012.

CASI-Wallops Research: Inundation Risk under Climate Change

Research has been carried out to understand the variability of tidal changes in the Chesapeake Bay in order to support the development of NASA's Surface Water Ocean Topography Project. The results of this research demonstrated that the majority of the variability in the Bay was controlled primarily by tidal and wind forcing processes. This work demonstrated it is possible to obtain valid and detailed observations on the dominant physical processes that drive tidal variability using point-source level gauge observations. Analyses of tidal variability from historical time series can be used to create probability distribution functions for processes such as tides, local wind-forcing, and larger storm- and hurricane-forcing events. These distribution functions were then made available for use with Wallops' Facility Planning GIS tools to characterize the present risk levels associated with the observed sea level variability (Figure 27). This risk assessment will serve as a baseline measure of the present-day risk levels for each asset on Wallops Island by linking the risk to known elevations of each asset with a Monte Carlo approach to estimating inundation risk.

In order to understand the increased risk of flooding from the anticipated mean-sea-level rise due to climate change, we will use various estimates of sea-level rise obtained from the Intergovernmental Panel on Climate Change predictions and Goddard Institute for Space Studies (GISS), as well as CASI-supported work by Dr. Robert Nerem at the University of Colorado.

These sea level rise estimates, and a 100-foot resolution bare-earth Digital Elevation Model of the Virginia region will be entered into the NOAA Sea, Lake and Overland Surges from Hurricanes (SLOSH) model. The SLOSH model will generate additional predictions using a probabilistic approach that links future hurricane probability to expected and observed frequencies of tidal- and storm surge-induced sea level variability. The model will also generate flood risk estimates for adjacent coastal regions relevant to a variety of local partners, such as the Nature Conservancy; the U.S. Fish and Wildlife Service; the U.S. National Park Service; the Town of Chincoteague, Virginia; etc.. These risk assessment efforts directly link to the Center's Master Plan, provide an up-to-date Digital Elevation Model for Wallops Island, and generate risk assessments for regional partners.

Finally, additional risk assessments will evaluate how the loss of wetlands, coastal beaches, and the sea wall and beach expansion affect inundation threats. With the recent addition of the sea wall and beach expansion on Wallops Island, NASA has made a significant investment in protecting the facility assets from storm surge. The CASI-Wallops team and partners plan to conduct investigations using the SLOSH model to investigate how inundation risks change if the beach protection system is improperly maintained or damaged. All risk assessments will be carried out in coordination with the CASI team in partnership with the Wallops GIS support group.

Figure 27: GIS map of the WFF boundary and the +0.5 m water level.

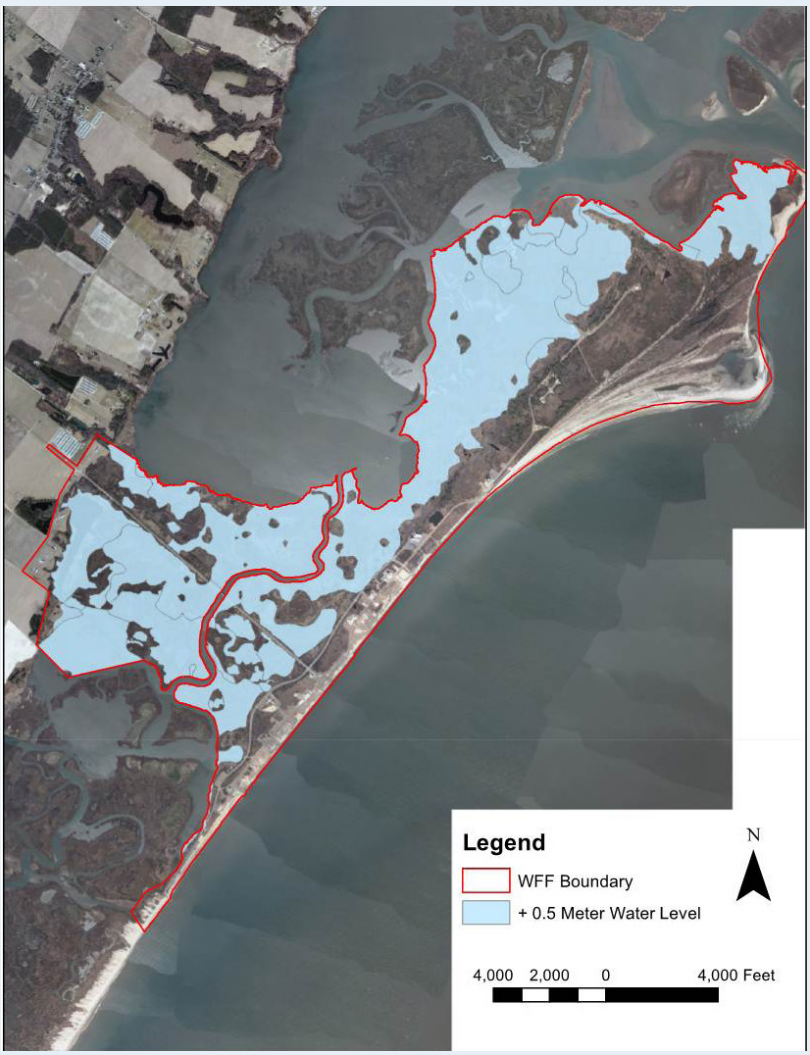


Photo credit: NASA/T. Moisan, J. Mitchell, 2012.

W *Mid-Atlantic Coastal Resilience Institute (MACRI)*

In early 2014, GSFC entered into an agreement with eight other Federal agencies, universities, and research institutions to establish MACRI. The core research partners include NASA's Goddard Space Flight Center: Wallops, Greenbelt, and Goddard Institute of Space Studies (GISS); US Fish and Wildlife Service; US Geologic Survey; The Chincoteague Bay Field Station of the Marine Science Consortium; College of William and Mary, Virginia Institute of Marine Science; University of Virginia, Virginia Coast Reserve Long-Term Ecological Research Program; University of Maryland, College Park; University of Delaware, College of Earth, Ocean, and Environment; and the Nature Conservancy.

The combined assets, competencies, and 65 miles of coastal land holdings of MACRI partners will facilitate research to address coastal resilience in the context of sea level rise, extreme weather events, and coastal ecosystem degradation in the Mid-Atlantic. The

vision for the MACRI collaboration is the Mid-Atlantic will be the best understood coastline in the United States and a destination for coastal science research and public policy integration for coastal resilience worldwide. MACRI will use the complementary competencies and assets of the partners to integrate, expand, and validate a framework for local and regional climate change data modeling. The purpose of the agreement is for MACRI to be the platform to combine and leverage the capabilities of the participating institutions to provide an unprecedented integration of science and its applications to support local, state, and regional policy that promotes resilience for both human and natural coastal communities during climate change. As MACRI matures, collaboration with these partners will greatly expand the capabilities and scope of the current CASI research programs at Goddard.

G *On-Site Well Water for Non-Potable Use*

Greenbelt has two groundwater wells that provide makeup water for evaporative losses in the HVAC boilers and cooling towers. The benefit of using locally sourced water is the ability to avoid using energy to treat water to a potable standard and pump it through a municipal drinking water distribution system. In 2011, Greenbelt used an average of 186,032 gallons per day of well-sourced makeup water.

G *Low-Flow Toilets and Automatic Faucets*

Facilities Management Division replaced approximately 700 three–gallon-per-minute (gpm) faucets at Greenbelt with 1.5–gpm sensor-operated faucets. Each faucet saves $105 per year and the entire faucet replacement project has a simple payback period of 5.6 years. Toilets and urinals on Center were also retrofitted with low-flow devices, which resulted in similar savings.

G *Stormwater BMPs*

Greenbelt has begun to employ stormwater BMPs in two pilot projects: a rain garden and a bioretention area (Figure 28) installed adjacent to the parking lot at Building 32. Both serve to slow, filter, and infiltrate stormwater, reducing runoff volume and pollution. Additionally, to address Federal requirements for stormwater management in new construction, the new Flight Projects Building (Building 36), projected for completion in FY 2015, was designed to manage all runoff from the site using BMPs.

To ensure early adopters of BMPs get credit for their early action, MDE plans to set 2002 as the expected baseline year for the restoration requirements under the new MS4 permit. Therefore, Greenbelt is likely to get credit for these initiatives under the 20 percent restoration requirement in the new permit.

Figure 28: Building 32 bioretention area with diagram

Diagram from Figure 28 on previous page

Bioretention areas are shallow landscaped depressions that use soil, plants, and microbes to filter pollutants from stormwater before it is discharged. Many typical pollutants from parking lot runoff, such as metals, oil, and nutrients are removed from the water before it flows into stormwater ponds, rivers, and, eventually, the Chesapeake Bay. The basins also reduce the velocity of runoff and allow the water to be taken up by plants and percolate through the soil into groundwater.

Photo Credit: NASA/Goddard Medical and Environmental Management Division, 2012.

Greenbelt has also designated several "no mow" areas on campus and is planting native trees where possible. The deeper rooting vegetation that flourishes in unmowed areas promotes stormwater infiltration and slows runoff into local surface waters. These areas can be observed in the lawn area near the parking lot between Buildings 16 and 23, to the north and east of Building 8 and near Building 31. In addition to stormwater management, on-site infiltration increases evaporative cooling to reduce possible urban heat island effects at the Center (page 19).

W G *Heating System Retrofits Result in Water Savings*

In addition to saving energy, Greenbelt's Building 25 geothermal heating and cooling system saves 560,000 gallons of well water per year. This savings is realized through a decrease in evaporative losses due to reduced demand on the cooling towers and boilers as well as a decrease in leakage losses due to reduced demand on the steam and chilled water distribution network. Likewise, the Wallops LPG heater retrofit (page 17) saves roughly 1,000,000 gallons of water per year by replacing the old, leaky boiler core.

W G *Achieve Objectives Established by EPA's Stormwater Guidance*

The SSPP requires compliance with EPA's Stormwater Guidance for Federal Facilities for any development or redevelopment project involving a federal facility that disturbs more than 5,000 square feet of ground area. The Stormwater Guidance requires agencies to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to temperature, rate, volume, and duration of runoff flow. This guidance has been incorporated into the 2012 NASA Facilities Design Guide and is met for all new construction, including Building 36, projected for completion in FY 2015.

The guidance clearly defines how restoration is demonstrated, and what metrics should be used to determine technical infeasibility that would justify an exception to the restoration requirement. In some cases, especially those involving redevelopment of an existing building site, this guidance is more stringent than state regulations, which are often the design standard. Goddard requires contractors involved with projects that disturb more than 5,000 feet to meet these criteria in addition to any other relevant requirements.

G *CASI-Greenbelt Research: Hydrological Modeling*

Climate change will likely intensify the water cycle, making rainfall events more intense and variable. Rainfall increases, combined with state and Federal mandates to retain even more water on site could complicate managing current minor flooding issues at Greenbelt. Unfortunately, there is not currently a good understanding of how water moves through the Greenbelt site to support strategically addressing the combined interests of runoff pollution prevention, flood mitigation, and climate change adaptation.

Currently, the monitoring of stormwater outflow from Federal facilities is not correlated with meteorological information. Therefore, it is difficult for institutional managers to extricate the effects of groundwater flows and rainfall, or evaluate potential future impacts of a changing climate, future site development, or efforts to reduce runoff rates. In order to manage all interests in water management at Greenbelt, the facility needs a better understanding of how water moves through the site.

CASI-Greenbelt plans to develop a high (10m) resolution hydrologic model, using an established model methodology such as the GISHydro, at a pilot scale of two drainage basins within the Greenbelt site. The goal is to characterize the actual flows in the basins to better understand how they will react to increased flow during intense rain events. CASI-Greenbelt will provide appropriate modeling that can link satellite observations with decision making to enable the exploration of the effects of rainfall and land-cover changes on stormwater at Greenbelt. This policy-relevant hydrological model will provide the mechanism to explore the impact of future rainfall regimes predicted in climate models. The goal is to implement the hydrological model to provide environmental compliance and facilities management personnel at Greenbelt with a tool for developing a strategic vision for stormwater management for the Center.

3.b Potential Water Management and Climate Change Adaptation Initiatives

G *Develop a Forest Management Plan*

To further the interests of the Baltimore–Washington Partnership for Forest Stewardship and capitalize on the ecosystem services provided by Goodard's forests in Greenbelt, the Greenbelt campus plans to develop a forest management plan. This plan will identify specific projects and practices to protect and strengthen the natural stormwater, climate, and wildlife processes inherent in its forest holdings and ensure that the forests do not pose a risk to NASA's efforts by disrupting utilities or infrastructure, or fostering nuisance plants and wildlife. Ecosystem services provided by managed forests include stormwater management, urban heat island mitigation, and carbon sequestration as well as aesthetic benefits.

W G *CASI-Greenbelt and CASI-Wallops Research: Climate Change Sensitive Design Standards*

Stormwater management systems at NASA buildings and sites traditionally have been designed based on historical local rainfall records. Climate scientists at NASA predict that rainfall patterns will change significantly over the coming decades. These expected changes discredit stormwater standards based on historic data that traditionally serve as the basis for stormwater management designs. In light of this situation, the CASI-Greenbelt workgroup, the SSPP, and the NASA Office of Strategic Infrastructure advocate developing design standards for infrastructure that are based on foreseeable meteorological conditions under climate change at the specific site. Both Goddard CASI workgroups can provide guidance to develop appropriate design standards.

W G *Reclaim Wash Water for Toilet Flushing*

An industry study estimates that 40 percent of all potable domestic water is used to flush toilets. Offsetting some of that potable water consumption with locally available grey water, such as handwashing water, would significantly reduce the potable water being used in toilets. Numerous plumbing fixture manufacturers are developing systems to reclaim and partially treat water that drains in bathroom sinks to be used to flush toilets. This water reuse strategy could significantly reduce water consumption at Goddard. Sink water reuse systems are designed to revert to the conventional sink drain and toilet water supply if the volume of sink water is greater or less than the volume required to flush toilets, so users would not experience any changes in operation or reliability. Many systems are compatible with existing toilets and sinks, drastically reducing capital costs. Maintenance is reported to be minimal.

G *Harvest Rainwater for Boiler and Chiller Makeup Water*

Capturing and using rainwater in the campus boilers and chillers has the unique potential to address three sustainability impact areas at Greenbelt:

- Capturing stormwater would prevent it from causing erosion and transporting surface pollutants from the Greenbelt campus into local waterways, likely contributing to the impending surface restoration requirement under the new MS4 permit
- Using captured rain water for industrial purposes would benefit water conservation efforts by reducing demand for well

or municipal water

- Offsetting well water with rainwater in the boilers and chillers could reduce mineral scaling and increase efficiency in industrial equipment. While using well water does reduce the demand on municipal water sources, well water generally has high mineral content (hardness) which can lead to mineral scaling in boilers. Industry research has shown that 66 percent of all boilers experience an average 3.1 percent efficiency loss due to just 1/32 in of boiler scale. Boilers at Greenbelt may be on the high end of that average given the use of mineral-rich well water. This 3.1 percent loss directly translates to 3.1 percent of the fuel cost of operating the boilers and nearly 3.1 percent of Scope 1 GHG emissions. The use of rainwater with lower mineral content could reduce the accumulation of boiler scale, thus improving efficiency and reducing boiler maintenance requirements.

Given the ample land area at Greenbelt, it might be possible to collect a significant volume of rainwater. For reference, in an average rain year, 2.5 million square feet of area would be sufficient to provide all the required makeup water currently sourced from on-site wells. The total roof area at Greenbelt is 1.7 million square feet with significantly more paved parking served by an existing stormwater system that could potentially be adapted to collect rainwater for industrial use. Collecting runoff from these impervious areas for industrial uses would reduce stormwater impacts, reduce energy demands for pumping well water, and increase boiler efficiency. Treatment required prior to using rainwater in industrial equipment depends on the specific surface it is collected from, however, it is likely that settling or rapid filtration would be sufficient for use in boilers and cooling towers.

One potential implementation of this concept may involve collecting water from building roof downspouts and connecting it in to the cool return water at each building site to avoid the need for potential centralized large scale water storage or transportation.

G *BMP Retrofits Required by Revised MS4 Permit*

The Center will be expanding the BMP program in light of impending changes to its MDE MS4 permit. The 20 percent restoration requirement in the MS4 permit is expected to require the following:

- Assessment of the Center's current impervious surface area
- Inventory of existing and potential new BMPs or retrofits
- Restoration maintenance plan development
- Incorporation of restoration into master plans
- Submission of regulatory reports including maintenance and inspection records, restoration plans, implementation schedules, and inventories

Despite the comparatively low cost of BMP installation compared to traditional curb and gutter systems, the cost of maintaining required BMPs may present annual recurring costs not experienced with curb and gutter stormwater management. Many BMPs employ the use of vegetative and expendable filter media to achieve hydrology and filtration benefits. The Center may have to maintain such features that by caring for vegetation and replacing filtration media (generally soil and mulch) to ensure BMP features function as designed in order to receive credit towards restoration. MDE will expect maintenance and inspection records to be submitted as part of the regulatory reporting.

As a final note, pavers can be used to create porous pavements, contributing to restoration requirements while providing an attractive design element in paved areas. Some pavers can incorporate additional environmental benefits by incorporating titanium dioxide (TiO_2) photocatalysts. When struck by sunlight, these pavers degrade hazardous nitrogen oxide gases produced in particularly high quantities during cold vehicle startup. Using such methods to treat nitrogen oxide reduces smog as well as acid rain, which is particularly prevalent in the Mid-Atlantic U.S.

W: *Using Seawater for Fire and Sound Suppression Deluge Systems*

Currently, thousands of gallons of potable water are used at Wallops to reduce rocket liftoff noise and protect launch structures from the heat of launches and tests using deluge systems integrated in launch structures. It would be valuable to determine if seawater (readily available at all coastal NASA launch facilities) could be used in fire and sound suppression deluge protection systems instead of potable water supplies. Using seawater could present significant complications due to mineral scaling upon evaporation, but such issues could possibly be addressed by cycling more sea water through the system to dissolve mineral scale buildup.

Although this capability is not critical to Wallops' operations due to the ample supply of drinking water in the Mid-Atlantic region, the capacity to offset potable water use with seawater could be invaluable at launch facilities located in regions where fresh water is scarce.

GOAL 4: Waste Management and Recycling

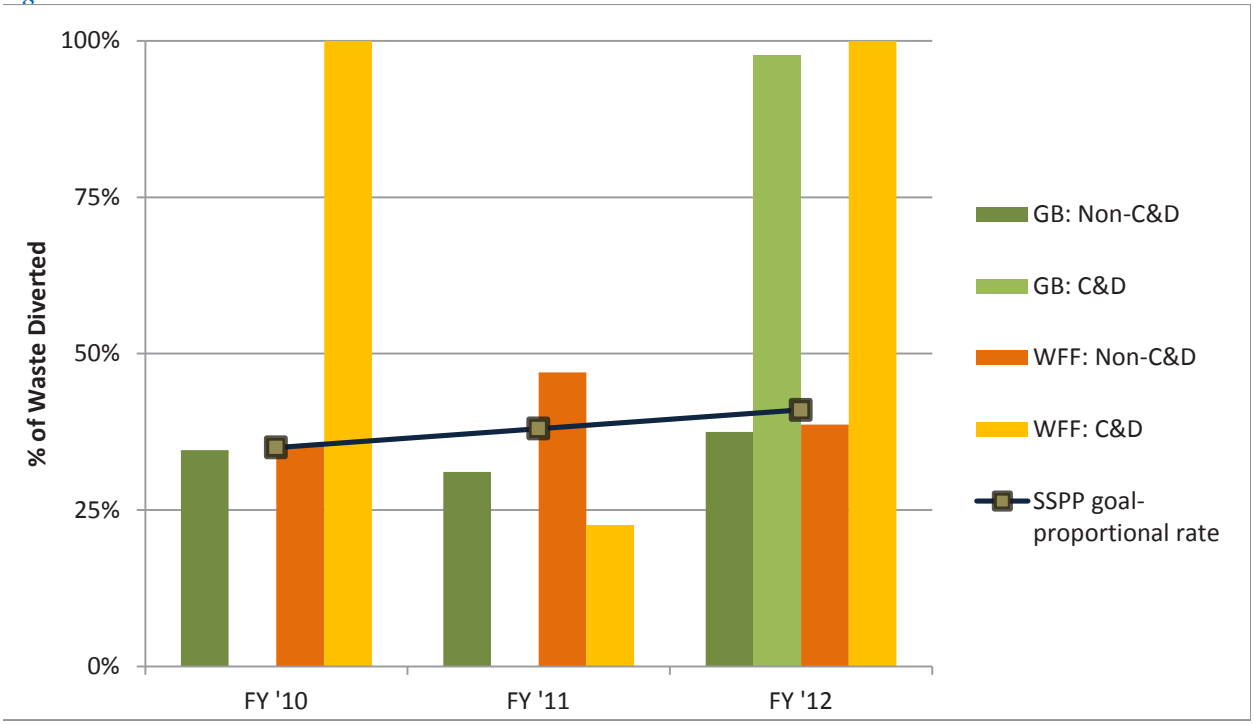
Goddard disposes of a several tons of material every day. A large portion of the material disposed, however, still could have a beneficial use—whether as compost to be used for agricultural fertilizer or re-purposed furniture used in a different location on Center. Goddard actively pursues several opportunities to increase the portion of no longer needed materials that find a beneficial use either through recycling, compost, or reuse. By actively managing the Center's waste streams, Goddard reduces space occupied in solid waste landfills, minimizes the possibility of hazardous materials impacts, and supports recycled materials markets. The 2012 SSPP contains numerous goals regarding recycling and waste management (Table 9).

Table 9: 2012 SSPP Waste Management and Recycling Goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 5.a: Increase source reduction of pollutants and waste.	The Hazardous Materials Management System (HMMS) reduces need to stockpile hazardous material and facilitates identifying less hazardous alternative products.	Beginning HMMS implementation.	Addressed at facility level.
Goal 5.b: Divert at least 50% of non-hazardous solid waste by FY 2015, excluding C&D debris.	Diverted 37% of waste not associated with construction and demolition activities (non-C&D waste) in FY 2012 (Figure 29).	Diverted 39% of non-C&D waste in FY 2012 (Figure 29).	Diverted 38% of non-C&D waste in FY 2012.
Goal 5.c: Reduce municipal solid waste sent to landfills to assist the agency in achieving FY 2020 GHG reduction targets [See Goal 2] and discuss agency strategies and implementation.	Increased waste sent to landfills by 24% from 2010 to 2012.	Reduced waste sent to landfills by 27% from 2010 to 2012.	Increased waste sent to landfills by 17% from 2010 to 2012.
Goal 5.d: Divert at least 50% C&D materials and debris by FY 2015, and discuss methods used to monitor and track progress.	Diverted 98% of C&D waste in FY 2012.	Diverted 100% of C&D waste in FY 2012.	Diverted 99% of C&D waste in FY 2012.
Goal 5.h: Increase diversion of compostable and organic materials from the waste stream.	Composted 418,000 lbs. of shipping pallets as mulch in 2012. Contributed 1,865 lbs. of cafeteria kitchen waste to a USDA composting program in 2010. The USDA program has since stopped. There is currently no food waste composting program.	Has no composting program.	Addressed at facility level.

4.0 Goddard's Status

Figure 29: Goddard's Waste Diversion Rates



4.a Current Waste Management and Recycling Initiatives

W G *Single-Stream Recycling*

Goddard implemented single-stream recycling in September 2011 to increase recycling at Wallops and Greenbelt. The single-stream system is intended to facilitate recycling efforts by reducing the need for employees to sort recyclables and decrease on-site management costs associated with collecting multiple streams of recyclables.

Goddard has yet to realize a significant increase in recycling rates since the single-stream program started. Goddard's Medical and Environmental Management Division (MEMD) and Facilities Management Division are currently evaluating the possibility of collecting building-specific data regarding recycling behavior to help identify specific activities that lead to low recycling rates.

W G *Freecycle@NASA*

Freecycle@NASA began at Goodard and was expanded to all other NASA Centers. This online forum helps employees exchange surplus office supplies. Employees post notices for surplus office items to the Freecycle website to make them available for use by other employees. So far, more than one ton of supplies have been re-used through the Freecycle@NASA system instead of entering landfills. Information about Freecycle at Goddard can be found at http://freecycle.gsfc.nasa.gov/index.html.

W G *Hazardous Materials Substitution*

The Hazardous Materials Substitution initiative (page 56) serves to improve waste management at Goddard by reducing the quantity of hazardous materials used and disposed of on Center.

W G *Outreach*

MEMD manages an outreach website (http://recycle.gsfc.nasa.gov) that provides recycling information to help employees responsibly dispose of waste, both at home and at work. Periodically, content from the site has been reposted to the main Goddard internal webpage to raise awareness about recycling opportunities at the Center.

4.b Potential Waste Management and Recycling Initiative

W G *Waste Audit*

MEMD at Goddard has insufficient data on the composition of waste leaving the Center to strategically develop intervention strategies to increase recycling rates. Typically, large-scale solid-waste generators perform waste audits to help identify opportunities for waste minimization and recycling. Waste audits are also eligible for credit under many LEED rating systems. The last time Greenbelt performed a waste audit was in 1997 as part of the Recycling at NASA's Goddard Space Flight Center report prepared by Great Forest Inc.; no such information is available for Wallops. Since the 1997 audit, there have been significant changes in the types of waste generated at Greenbelt. Commissioning an up-to-date audit at Greenbelt and performing a baseline audit at Wallops would provide vital information regarding the current waste stream at Goddard, which would help environmental managers develop strategies to capitalize on the benefits of single-stream recycling and minimize waste.

GOAL 5: Affirmative Procurement

While Goddard is striving to reduce the environmental impact of its activities directly, there are significant but less visible environmental impacts associated with products Goddard uses to carry out its missions. These impacts may stem from any stage of a product's life cycle: from obtaining raw materials, manufacturing, transportation, use, or disposal. Additionally, these impacts range from ecological impacts from harvesting materials to human health impacts from improper use or disposal. Goddard promotes the 'Affirmative Procurement' concept to reduce potential impacts related to the products it consumes by requiring procurement of products designed and manufactured to minimize negative environmental impacts in contracts wherever feasible. The 2012 SSPP contains numerous goals regarding Affirmative Procurement (Table 10).

Table 10: 2012 SSPP Affirmative Procurement Goals

	Greenbelt's Contribution to Agency Goal	Wallops' Contribution to Agency Goal	Goddard's Contribution to Agency Goal
Goal 5.g: Reduce and minimize the acquisition, use, and disposal of hazardous chemicals and materials, and discuss how implementation will assist the agency in achieving FY 2020 GHG reduction targets.	The HMMS documents use of hazmat and helps EMD manage waste by treating on-site prior to disposal, and identifying less hazardous alternative products.	Beginning HMMS implementation at Wallops.	Addressed at facility level.
Goal 5.j: Increase agency use of acceptable alternative chemicals and processes.			
Goal 5.i: Implement integrated pest management and landscape management practices to reduce and eliminate the use of toxic and hazardous chemicals and materials.	Herbicides and pesticides are used sporadically and only when necessary, in keeping with integrated landscape management practices.		
Goal 6.a: Ensure 95% of new contract actions, including Task and Delivery orders under new contracts and existing contracts, require the supply or use of products and services that are energy efficient (Energy Star or FEMP-designated), water efficient, bio-based, environmentally preferable (excluding EPEAT-registered products), non-ozone depleting, with recycled content, or are non-toxic or less toxic alternatives.	All contract actions currently require the use of designated alternative products where available.		

5.0 Goddard's Status

The Procurement Operations Division at Goddard ensures that contracts contain requirements for procuring environmentally preferable products wherever possible. The attainment of this goal is confirmed through biannual audits performed by NASA Headquarters' Procurement Management Review Team.

5.a Current Affirmative Procurement Initiatives

W G *Hazardous Materials Substitution*

The Hazardous Materials Management System (HMMS), yellow-tag hazardous materials (hazmat) labeling system, and streamlined acquisition systems for hazmat serve to manage and reduce the quantities of hazmat stored and disposed of by Goddard. Prior to the HMMS, hazmat users tended to stockpile chemicals to avoid long reordering timelines and ensure uninterrupted supply. This behavior led to the storage of large quantities of hazmat on site, creating the potential for large-scale hazmat spills, wastage of unused chemicals, and considerable fees for disposing of heritage unidentifiable waste.

The revised acquisition system allows hazmat users to order smaller quantities of required hazardous chemicals with the assurance of being able to obtain resupplies more quickly and easily than the previous acquisition process. The HMMS database catalogues all hazmat on Center and allows managers to analyze hazmat usage trends, develop targeted interventions to ensure proper hazmat management, and identify safer and more environmentally benign alternatives for hazmat used on Center. The yellow-tag hazmat labeling system identifies all regulated hazmat on Center facilitating safe handling, and avoiding fees for the disposal of unidentifiable materials.

This effort was initiated in 2010 and the HMMS system was fully populated at Greenbelt in October 2012, with Wallops slated for implementation in FY 2014.

G *Sustainable Cafeterias*

As of 2012, all cafeterias at the Greenbelt facility have implemented the General Services Administration's Health and Sustainability Guidelines for Federal Concessions and Vending Operations. The guidelines promote best practices for improving nutrition and reducing impacts on the environment. Example guidelines include offering locally grown meats, fruits, and vegetables that are low in fat, sugar, and sodium and also high in fiber, as well as using bio-based and environmentally friendly cutlery, plates, bowls, and cleaning products.

G *Farmers Market*

The Twin Springs Fruit Farm, based in Southern Pennsylvania, sells fresh fruits and vegetables on Thursdays from 9:00 a.m. until 2:00 p.m., year-round, in the parking lot across from Building 8. This service provides Greenbelt employees and contractors with access to fresh, local fruit and avoids emissions associated with produce shipped from overseas or across the continent.

G *Green Cleaning Products*

The HMMS also allows the Goddard Medical and Environmental Management Division (MEMD) to easily review hazardous cleaning products used at Goddard and propose potential alternatives. At Greenbelt, for example, a potentially hazardous solvent used in parts washers across the Center was substituted for a safer aqueous cleaner after identification in HMMS.

5.b Potential Affirmative Procurement Initiative

W G *Full accounting for Building Product Procurements*

For procurements related to constructing and operating buildings, requirements in LEED and the Guiding Principles may justify centralized accounting for building product procurements similar to HMMS. LEED and the Guiding Principles both stress the use of sustainable materials in construction, maintenance, and building operation. Both certification programs require detailed documentation to demonstrate that materials meet sustainability requirements. Documenting materials used in sustainable buildings in an HMMS-like database could greatly streamline compliance with LEED and the Guiding Principles and enhance Goddard's ability to leverage its purchasing power to promote sustainable products.

CONCLUSION

After more than 50 years of cutting-edge earth and space research, Goddard Space Flight Center continues to grow and evolve. A core of research at Goddard shows that the growth of human activity is overwhelming the water, climate, energy, and material systems that support it; that advances in human activity can irrevocably harm our planet and way of life…unless we change the way we interact with our environment.

This report has demonstrated how Goddard is changing its relationship with the environment by reconsidering approaches to operations, management, and development to prevent our mission growth from exceeding the capacity of the environment to support our activity. Projects such as the decentralized heating system at Wallops, the Hazardous Materials Management System (HMMS), and the Bikes Around Goddard program demonstrate Goddard's commitment to reevaluate traditional ways of doing business to find solutions that reduce energy consumption, waste, and the environmental impacts of work on Center.

The more we reduce the collateral impacts of our work as a Center, agency, and species, the more growth and prosperity we can enjoy without disrupting the natural systems we rely on for survival. Goddard's unrelenting pursuit of sustainability is evidenced by its onging evaluation of combined heat and power at Greenbelt, storm surge inundation prevention and risk analysis work at Wallops, and strategic efforts to manage IT energy use while improving service and performance.

Ultimately, while our sententiae may be focused on the stars, at Goddard, our corpora are on the Earth. This is why we ask all members of the Goddard community to consider the goods they use and dispose of in their lives, and appreciate that the environment is the ultimate supplier of resources and recipient of our wastes.

Figure 30: Historic "Blue Marble" photo of Earth taken from Apollo 17

"If there ever was a fragile-appearing piece of blue in space, it's the Earth right now,"

— Harrison Schmitt
Apollo 17 Astronaut