



Office of Audits  
Office of Inspector General  
U.S. General Services Administration

# Audit of the Public Buildings Service's Green Roof Maintenance and Safety Practices

Report Number A180085/P/4/R20008  
July 23, 2020

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## ***Executive Summary***

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### **Audit of the Public Buildings Service's Green Roof Maintenance and Safety Practices**

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#### **Why We Performed This Audit**

GSA's Public Buildings Service (PBS) manages nearly 2 million square feet of green roofs on federally owned buildings throughout the nation. While more expensive to both install and maintain than traditional roofs, green roofs can provide economic, environmental, and societal benefits that offset their added costs. However, failure to maintain green roofs will result in lost benefits, thereby negating the justification to install this premium roof type. Accordingly, PBS has a responsibility to ensure its green roofs are maintained in accordance with internal guidance and industry standards. In doing so, PBS must also protect individuals accessing these roofs by providing required fall protection. We performed this audit to assess how PBS is fulfilling these responsibilities.

Our audit objectives were to determine whether PBS: (1) has a maintenance strategy in place to protect its green roof inventory investment and (2) provides fall protection in accordance with internal guidance and federal regulations.

#### **What We Found**

PBS does not have a comprehensive maintenance strategy in place to protect its investment in green roofs. We found that PBS does not ensure that all of its green roofs are maintained in accordance with internal guidance and industry standards. We reviewed maintenance approaches at 14 sites representing 43 percent of PBS's total managed green roof square footage and found that in most cases PBS did not properly maintain the green roofs. We also found that PBS does not educate staff on maintenance requirements for green roofs and that PBS does not consider green roof maintenance costs when planning to install a green roof. PBS's failure to maintain its green roof inventory has led to lost environmental benefits, wholesale green roof failures, and wasted taxpayer dollars.

Additionally, we found that PBS has not put safeguards in place to protect contractors and employees against fall hazards for half of the green roofs we tested. In these instances, individuals were exposed to fall hazards or the roofs were not maintained.

## What We Recommend

We recommend that the PBS Commissioner develop a comprehensive strategy to ensure that PBS:

1. Maintains its green roof inventory in accordance with internal guidance and industry standards.
2. Provides regular training on the unique requirements of green roof maintenance to PBS staff with responsibility for green roofs.
3. Uses life-cycle costing during green roof design as required by PBS P100, *Facilities Standards for the Public Buildings Service*.
4. Protects individuals accessing green roofs from fall hazards by enforcing contract terms and adhering to federal regulations and internal guidance.
5. Mitigates fall hazards when installing green roofs.
6. Discontinues installation of future green roofs until recommendations 1 through 5 are implemented.

The PBS Commissioner agreed with our recommendations. PBS's written comments are included in their entirety in **Appendix D**.

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## Introduction

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We performed an audit of the GSA Public Buildings Service's (PBS's) management of its green roof inventory.

### Purpose

PBS manages nearly 2 million square feet of green roofs on federally owned buildings throughout the nation. While more expensive to both install and maintain than traditional roofs, green roofs can provide economic, environmental, and societal benefits that offset their added costs. However, failure to maintain green roofs will result in lost benefits, thereby negating the justification to install this premium roof type. PBS has a responsibility to ensure its green roofs are maintained in accordance with internal guidance and industry standards. PBS must also protect individuals accessing these roofs by providing required fall protection. We performed this audit to assess how PBS is fulfilling these responsibilities.

### Objectives

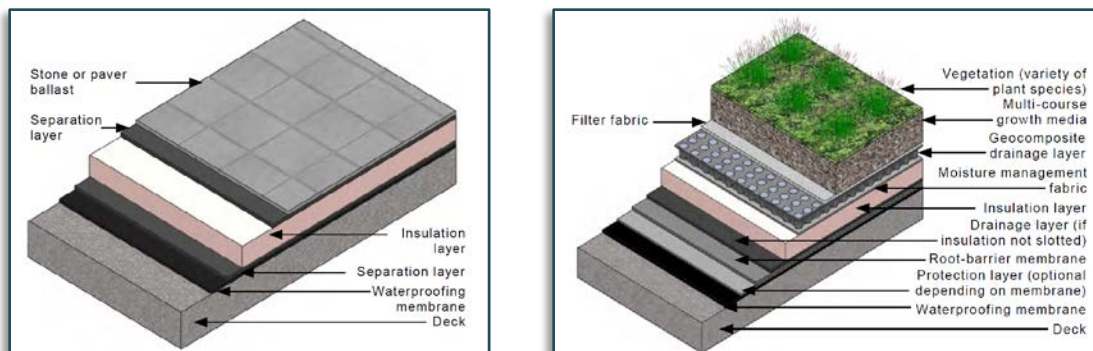
Our audit objectives were to determine whether PBS: (1) has a maintenance strategy in place to protect its green roof inventory investment and (2) provides fall protection in accordance with internal guidance and federal regulations.

See **Appendix A** – Scope and Methodology for additional details.

### Background

Green roofs are built atop a traditional roof deck using several elements, or layers, including a waterproofing membrane, insulation, growth media, and vegetation. These roofs are designed to capture and retain storm water to reduce the burden on local sewer systems; reduce energy consumption; and improve acoustics, air quality, aesthetics, and biodiversity and habitat. *Figure 1* illustrates the functional elements of a traditional roof assembly compared with those of a green roof.

**Figure 1 – Roof Elements (Traditional and Green)**



There are two main types of green roofs: extensive and intensive. Extensive roofs feature plants that can be sustained in 6 inches or less of growing medium and typically consist of non-woody, drought-tolerant herbs, grass, moss, and succulents. Intensive roofs have a deeper growing medium, sometimes several feet, which can support a more diverse plant selection, including trees. Both types generally consist of the same green roof elements shown in *Figure 1*.

### **PBS's Green Roof Inventory and Office Responsibilities**

PBS currently manages nearly 2 million square feet of green roofs on federally owned buildings in GSA's 11 regions. According to estimates from a 2011 GSA study, these roofs were installed at a cost of at least \$48 million. Two offices located in GSA's headquarters in Washington, D.C., provide national oversight of PBS's green roof projects and inventory: the Office of Design and Construction (ODC) and the Office of Facilities Management (OFM).

ODC supports regional projects by coordinating policies, procedures, initiatives, and customer programs, and by sharing knowledge about the Agency's best practices. ODC developed the PBS P100, *Facilities Standards for the Public Buildings Service (P100)*, which references green roof installation, maintenance, and safety standards. ODC officials told us they also developed the specifications for all American Reinvestment and Recovery Act of 2009 (Recovery Act) funded roofing projects, which required installation of energy-saving roofs, including green roofs. These specifications required green roof installation contractors to provide periodic maintenance during the 2-year plant warranty period. While Recovery Act specifications are no longer applicable, an ODC official identified the 2-year maintenance period as an industry best practice.

According to ODC officials, green roofs are installed primarily to meet Section 438 of the Energy Independence and Security Act of 2007 (EISA), *Storm Water Runoff Requirements for Federal Development Projects*.<sup>1</sup> EISA requires that federal agencies reduce storm water runoff from any development or redevelopment project with a footprint that exceeds 5,000 square feet. Green roofs are one of a variety of "green infrastructure" practices that PBS can implement for Section 438 compliance.

OFM is responsible for providing safe, reliable, productive, and sustainable workplace environments that support the business of the federal government. OFM produced the 2012 and subsequent 2018 revision of the PBS *Preventative Maintenance Guide*, which includes green roof maintenance standards. This guide includes a requirement of quarterly green roof maintenance for both extensive and intensive roof types.

PBS's 11 regional offices also have significant responsibilities for the installation and maintenance of green roofs. For example, regional ODC staff must ensure that green roofs are designed and installed in accordance with P100 requirements and the Department of Labor's Occupational Safety and Health Administration (OSHA) regulations. Following installation,

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<sup>1</sup> 42 USC 17094.

regional OFM offices are responsible for green roof maintenance and for ensuring the safety of individuals accessing these roofs. Additionally, regional contracting officers procure the design and installation of green roofs for ODC and ongoing maintenance for OFM.

### 2011 GSA Study

As a requirement of GSA's Fiscal Year 2009 appropriation, Congress mandated that GSA conduct a study of the measurable benefits and challenges associated with the use of green roofs in its owned and leased inventory.<sup>2</sup> An official from GSA's Office of Federal High-Performance Buildings informed us that they collaborated with ODC to complete *The Benefits and Challenges of Green Roofs on Public and Commercial Buildings* (2011 GSA Study). GSA's study found:

- Green roofs offer economic, environmental, and societal benefits for the individual building and the wider urban environment. A green roof's soil and vegetative layers provide significant protection to its base waterproofing membrane layer (see illustration in *Figure 1* on page 1 of this report), which is almost identical to that of a black (traditional) or white (cool) roof.<sup>3</sup> Soil and vegetation minimize the negative effects of exposure to sun, wind, water, and mechanical damage. This study puts the average life expectancy of a green roof at 40 years versus 17 years for a black roof.
- Green roofs are more expensive to both install and maintain than traditional roofs. Nationally, installation costs for extensive green roofs, which are less expensive than intensive green roofs, were estimated at \$24.50 per square foot (\$15.51 per square foot more than traditional roofs) and annual maintenance costs were estimated at \$0.27 per square foot (\$0.21 per square foot more than traditional roofs). Although the added maintenance costs of a green roof as compared with a traditional roof are significant, these added costs are more than made up for over the roof's lifetime by its increased longevity.
- The maintenance of a green roof includes weeding, harvesting cuttings and distributing them in bare spots to improve coverage, checking for loss of growth medium, and inspecting for other potential problems. The first years of a green roof's existence are considered its establishment period, in which maintenance is critical to the roof's long-term success and maintenance requirements are greatest. A minimum of three maintenance visits per year is recommended for an extensive green roof during the establishment period. After the green roof is established, the number of maintenance visits is reduced to two annual visits for the remaining life of the extensive roof. Intensive roofs require additional

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<sup>2</sup> Financial Services and General Government Appropriations Bill, 2009, H.R. 7323, 110<sup>th</sup> Cong. 2 (2008).

<sup>3</sup> According to the 2011 GSA Study, black or traditional roofs are typically constructed of petroleum-based products. Due to their color and construction, these roofs absorb solar energy, which can lead to increased energy consumption. White or cool roofs are typically constructed with reflective white or light-colored material. These roofs are designed to reduce building energy consumption by reflecting rather than absorbing solar energy.

maintenance needs and should receive a minimum of four annual visits for their full life-cycles.

The 2011 GSA Study identified challenges to green roof construction which, if not properly reviewed or addressed, could increase costs and deter potential clients from installing such roofs. Maintenance and safety challenges were included in this section of the study and are described below.

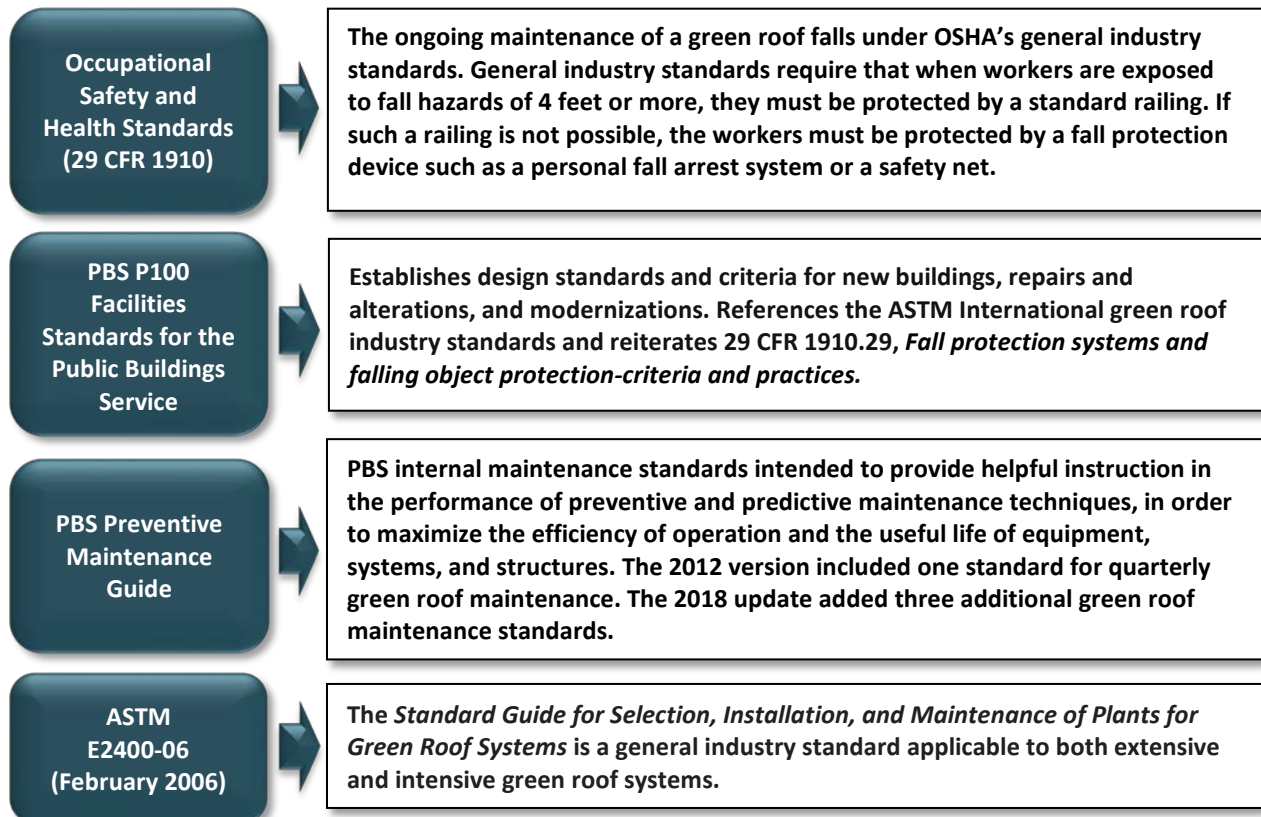
**Maintenance** may prevent wholesale failure of a green roof, which is defined as the inability of the roof to perform at the level for which it was designed.

Wholesale failures include leaks, plant loss, inadequate drainage conditions, soil erosion due to wind and water, and slope instability.

**Safety** training and precautions are required by law for all roof types. During maintenance, any worker exposed to a fall distance greater than 4 feet must be protected by a guardrail system, safety net system, or personal fall arrest system.

In addition to the 2011 GSA Study, federal regulations, industry standards, and PBS internal guidance documents prescribe green roof maintenance and safety requirements, as shown in *Figure 2*.

**Figure 2 – Green Roof Maintenance and Safety Criteria**





In order to perform as intended, green roofs should be preventatively maintained by a knowledgeable individual. ASTM E2400-06 establishes, “It is important to consult with a professional horticulturist, green roof consultant, or work with similar professionals that are knowledgeable, experienced, and acquainted with green roof technology and plants.” The 2011 GSA Study noted that individuals responsible for maintenance should be adequately educated on green roof types and plant selections. Below are two examples of PBS green roofs that have received preventative maintenance in accordance with the criteria in *Figure 2*. In both examples, maintenance was conducted or overseen by a knowledgeable green roofing professional.

**U.S. Custom House.** Completed in 2012, this Region 3 extensive green roof covers 22,000 square feet of this building in Philadelphia, Pennsylvania. PBS Region 3 contracts for ongoing maintenance with the building’s operations and maintenance (O&M) contractor who then subcontracts the work to a knowledgeable green roofing contractor. The roof receives six maintenance visits during the growing season (March through November) at an annual cost of \$6,634.92 (\$0.30 per square foot). The maintenance contractor provides inspection reports to the PBS building manager following each visit noting the health of the green roof, maintenance activities that were conducted, and potential issues requiring PBS’s attention. During our December 2018 site visit, we found that the green roof exhibited full plant coverage, was free of debris and trash, and drains were free of weed growth. The images in *Figure 3* show the U.S. Custom House green roof at different times of the year.

**Figure 3 – U.S. Custom House Green Roof Seasonal Photographs**



**Douglas A. Munro Coast Guard Headquarters Building.** Completed in 2013, this Region 11 green roof is the largest in PBS’s inventory. It consists of 557,000 square feet of extensive and intensive roofs covering multiple buildings at the St. Elizabeths Campus (see *Figure 4* on the following page) in Washington, D.C. Maintenance of the roofs is conducted by a landscaping contractor at an annual cost of \$198,300 (\$0.36 per square foot). In accordance with contract terms, these green roofs are weeded at least four times per year, soil is tested, fertilization is applied in response to test results, and dead plants are replaced. A PBS Region 11 horticulturist oversees the maintenance.

During our July 2018 site visit, we witnessed landscapers weeding the parking deck green roofs. Also during this visit and a subsequent December visit, we noted full plant coverage, roofs free of debris and trash, and drains that were free of weed growth (see *Figure 5*).

**Figure 4 – Douglas A. Munro  
Coast Guard Headquarters Building**



**Figure 5 – Douglas A. Munro  
Coast Guard Headquarters Building**



The examples above show well-maintained green roofs. Unfortunately, they are among the few exceptions in our audit sample. As we describe further below, failure to maintain green roofs can result in lost benefits, thereby negating the justification to install this premium roof type. PBS spent more than \$48 million in taxpayer dollars for its green roof inventory, and accordingly, has a responsibility to ensure they are maintained in accordance with internal guidance and industry standards.

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## Results

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PBS does not have a comprehensive maintenance strategy in place to protect its investment in green roofs. We found that PBS does not ensure that all of its green roofs are maintained in accordance with internal guidance and industry standards. We reviewed maintenance approaches at 14 sites, representing 43 percent of PBS's total managed green roof square footage, and found that in most cases PBS did not properly maintain the green roofs. We also found that PBS does not educate staff on maintenance requirements for green roofs and that PBS does not consider maintenance costs when planning to install a green roof. PBS's failure to maintain its green roof inventory has led to lost environmental benefits, wholesale green roof failures, and wasted taxpayer dollars.

Additionally, we found that PBS has not put safeguards in place to protect contractors and employees against fall hazards for half of the green roofs we tested. In these instances, individuals were exposed to fall hazards or the roofs were not maintained.

**Finding 1 – PBS does not consistently ensure its green roofs are properly maintained, resulting in lost environmental benefits, wholesale green roof failures, and wasted taxpayer dollars.**

We found that PBS does not ensure that all of its green roofs are maintained in accordance with internal guidance and industry standards. Specifically, we found that PBS did not properly maintain 8 of the 14 green roofs in our sample, educate staff on maintenance requirements, or consider the cost of long-term maintenance. As a result, these roofs may require costly repairs or replacement due to plant loss, soil erosion, and weed infestation.

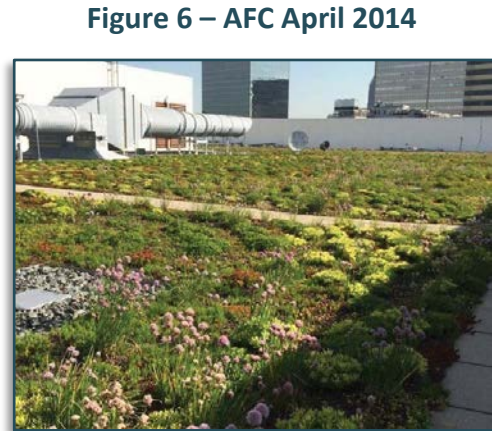
### **PBS Does Not Ensure Required Maintenance is Performed**

PBS does not ensure that all of its green roofs are maintained in accordance with internal guidance and industry standards. The P100 references minimum green roof standards, including ASTM International industry standards, which require regular maintenance of extensive and intensive roofs. Additionally, the 2012 and 2018 editions of the PBS *Preventative Maintenance Guide* each include a standard for quarterly green roof maintenance, including inspection and weeding.

However, we found that PBS is not adhering to green roof maintenance activities prescribed in industry standards and internal guidance. During our fieldwork, we asked for copies of the ASTM standards, but PBS officials stated that they did not have them. Additionally, GSA employees did not mention the PBS *Preventative Maintenance Guide* during our interviews with GSA Central Office officials or PBS staff in the six sample regions. We found these documents independently while conducting audit research.

In lieu of following the standards and guidance, PBS regional staff have employed a variety of green roof maintenance approaches with results ranging from healthy, regularly maintained green roofs (examples in *Background*) to those meeting the 2011 GSA Study definition of wholesale failure (examples below).

**Sam Nunn Atlanta Federal Center.** Located in Atlanta, Georgia, this Region 4 extensive green roof covers 63,188 square feet on two buildings at the Sam Nunn Atlanta Federal Center (AFC). PBS used \$2.7 million in Recovery Act funding for the design and construction of these roofs, which were completed in 2011. The roofs received 3 years of establishment period maintenance by a knowledgeable green roofing contractor. *Figure 6* shows the AFC green roof in April 2014, following establishment.



During a June 2018 interview, PBS Region 4 staff told us that they believed the roof was self-sustainable. For this reason, after establishment, they did not perform maintenance of the roof. *Figure 7* shows the roof after more than 4 years of neglected maintenance.



According to the establishment period maintenance contractor, annual assessments were provided from 2015 to 2017 to update PBS on the roof's diminishing health. The environmental horticulturist who completed the 2017 assessment identified the following issues resulting from neglected maintenance:

- Eighty percent of the original installed plant community had been choked out by weeds and lack of regular maintenance. The remaining intended plants will not thrive because available nutrients in the growing media are being used by the weed community.
- The lack of maintenance in the form of weed removal for several years has created a landscape condition referred to as “a long term four season weed seed bank.”<sup>4</sup> Unchecked, these roofs will be inundated with weeds for the balance of the serviceable life of the roof.

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<sup>4</sup> A weed seed bank is the reserve of viable weed seeds present on the soil surface and scattered throughout the layers of the soil, which contribute to weed growth.

- With the current lack of original vegetation, only 70 percent of the original storm water retention benefit is being realized. If left unchecked, the original calculated cost savings and environmental benefit associated with the justification to implement vegetated green roof technology will continue to be compromised and unrealized.
- Drains, drain fields, and vegetation-free zones are filled with debris, plants, and weeds. During large rain events, water is backing up into the surrounding growing media. Prolonged wet growing media is harmful to the intended plants while fueling the propagation of weed seeds.
- The degree of the stated problem conditions is considered by this inspector to be “harmful and critical.” Immediate action should be taken to remove all weeds and debris in order to eliminate any possible fire hazard. Beyond this immediate action, a long-term effort is required if it is the desire of GSA to reap the cost savings and environmental benefits intended from the original design of these roofs.

The 2017 assessment included a quote for over \$120,000 for “a future replanting and maintenance effort to regain a minimum 80% plant density coverage.” It also included a \$19,775 quote for an immediate weeding effort to address the fire hazard. Instead, PBS awarded a \$22,916 contract to the building’s O&M contractor to address only the immediate weeding effort.

The O&M contractor informed us that it subcontracted the work to a landscape contractor. While conducting the weeding effort, the subcontractor removed large sections of soil, exposing the green roof elements below (*Figure 8 inset*). The subcontractor also failed to clear drains of debris and plant life, potentially causing further damage to the green roof.

**Figure 8 – AFC February 2019**



Upon completion, PBS staff approved the work and paid the O&M contractor the full contract amount. The February 2019 photo in *Figure 8* shows the results of the weeding effort. The O&M contractor told us that it had only expended \$1,990 to subcontract work to landscapers; resulting in a \$20,926 markup. In September 2019, we conducted a follow-up visit to assess the roof’s current state. *Figure 9* shows the roof now re-covered in weeds.

**Figure 9 – AFC September 2019**



**Lafayette Building.** Located in Washington, D.C., this Region 11 green roof covers 20,575 square feet on three separate levels of the Lafayette Building. These roofs were completed in 2016. Green roof maintenance requirements for this location are written into a Region 11 landscaping contract. Contract terms state that the roof should be weeded at least three times per year, soil should be tested, and fertilizer applied in response to test results.

During our December 2018 site visit, we noted areas of bare soil, debris, plant growth outside of intended areas, and plant growth near drain areas. *Figure 10* shows two sections of the 12th floor green roof exhibiting plant loss. This roof meets the 2011 GSA Study definition of wholesale failure and will require re-plantings and restoration efforts in order to perform at the level for which it was designed. PBS staff told us that they use a maintenance log to track when maintenance was performed; however, they did not respond to our request to provide this documentation.

**Figure 10 – Lafayette Building  
December 2018**



**Figure 11 – Peace Arch Land Port of Entry  
November 2018**



**Peace Arch Land Port of Entry.** Located in Blaine, Washington, this 22,000 square foot extensive roof in Region 10 was installed in 2009 for an estimated \$642,400. In 2012, the roof was replaced for an additional \$299,704. We visited the roof in November 2018 and observed areas of bare soil and plants that appeared wilted and yellow as shown in *Figure 11*. PBS Region 10 staff attributed this to an infestation of fly larvae that feed on the roots of the roof's vegetation. In order to eradicate this infestation, a chemical insecticide was used on the green roof. However, ASTM 2400-06 states that insecticides should be used sparingly because they could potentially hasten degradation of the roof membrane.

PBS staff said the roof receives monthly maintenance under a grounds landscaping contract, adding that maintenance is also tracked by PBS on a shared internal spreadsheet. We made multiple requests for contract documents and the tracking spreadsheet; however, PBS failed to respond.

As these examples demonstrate, PBS does not ensure that all of its green roofs are maintained according to industry standards and internal guidance. Failure to maintain these roofs has resulted in wasted taxpayer dollars, wholesale green roof failures, and lost environmental benefits, specifically the green roofs' ability to reduce storm water runoff.

### **PBS Has Not Trained Staff on Green Roof Maintenance Requirements**

PBS has not provided staff with training on green roof maintenance requirements. Building managers from all six regions in our sample stated that they had not been trained on green roof maintenance requirements. GSA reported to Congress in its 2011 GSA Study that:

A client should be adequately educated on the type of green roof system and its purpose, and on the type of plants that are used in the green roof. This can also help the client understand the maintenance requirements for the green roof.

During our audit, an ODC official emphasized the importance of identifying green roofs as either extensive or intensive in order to understand the level of maintenance required for individual roofs. However, when asked to categorize PBS green roofs as extensive or intensive, another ODC official responded that they do not have expertise in the regions (outside of Region 11) to make this determination.

ASTM 2400-06 provides that "It is important to consult with a professional horticulturist, green roof consultant, or work with similar professionals that are knowledgeable, experienced, and acquainted with green roof technology and plants." Region 11 is the only region that employs a team of full-time horticulturists. Staff from the other five regions in our sample stated that they do not consult with a knowledgeable green roofing professional regarding green roof maintenance.

A Region 11 horticulturist told us there is a common misconception within the industry that green roofs require no maintenance. This misconception was evident in Regions 4 and 10, where staff told us that they believed their green roofs were self-sustaining. As a result, they did not maintain the roofs. Additionally, this misconception was written into a Region 9 green roof report, which stated that extensive roofs require "little to no" maintenance following the establishment period.<sup>5</sup>

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<sup>5</sup> GSA White Paper: *Living Architecture: Green Roofs for Public Buildings*, January 12, 2013.

As described in the examples below, PBS's failure to educate staff on maintenance requirements has resulted in inadequate and inconsistent maintenance practices that significantly degraded the performance of green roofs.

**Peachtree Summit Federal Building.**

Figure 12 shows the Peachtree Summit Federal Building's 2,800 square foot extensive green roof. Located in Atlanta, Georgia, this Region 4 green roof was completed in 2011 with \$235,000 of Recovery Act funding. PBS Region 4 staff stated that they were unaware that the green roof required maintenance or of any maintenance activities ever being conducted on this roof. Years of neglected maintenance has resulted in areas of bare soil, lost intended plant life, and weed growth.

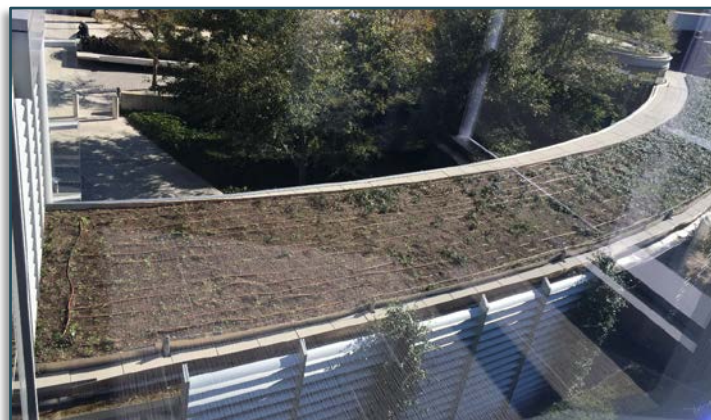
**Figure 12 – Peachtree Summit Federal Building  
June 2018**



**G.T. Leland Federal Building.** Located in Region 7, this 2,236 square foot extensive green roof was completed in 2015 at the G.T. Leland Federal Building in Houston, Texas. PBS Region 7 staff, who had received no green roof training, stated that the building's O&M contractor is responsible for maintenance of the roof. When asked what type of maintenance activities the contractor performed, PBS staff responded that the contractor was only expected to address problem areas after they were identified. We reviewed the O&M contract and found no specifications or requirements related to green roof maintenance.

According to PBS staff, the O&M contractor damaged the roof's irrigation system while performing maintenance on the green roof in 2017, resulting in the death of the green roof. The O&M contractor then replanted the roof in Spring/Summer 2018 at its own expense of approximately \$20,000. PBS staff concluded that the roof now leaks because the contractor did not know what it was doing. Figure 13 shows that the green roof continued to exhibit plant loss in December 2018, after the replanting.

**Figure 13 – G.T. Leland Federal Building  
December 2018**





**Hipolito F. Garcia U.S. Courthouse.** In 2012, this 15,312 square foot extensive green roof in Region 7 was completed at the Hipolito F. Garcia U.S. Courthouse in San Antonio, Texas, using \$1.3 million of Recovery Act funding. According to PBS Region 7 staff, who had received no green roof training, maintenance for the green roof is occurring under the current O&M contract; however, the contractor has no specific knowledge of green roofs. The O&M contract does not specify green roof requirements or frequency of maintenance. Instead, maintenance is conducted on an “as-needed” basis. PBS provided documentation supporting that maintenance occurs only after issues are observed.

**Figure 14 – Hipolito F. Garcia U.S. Courthouse  
December 2018**



Six months after installation, leaks were discovered on the 1st floor of the building and have been pervasive ever since. In order to determine the root cause of these leaks, PBS Region 7 ordered two studies, one in 2016 and one in 2018, totaling more than \$46,000.

Although maintenance was not identified as the sole cause of the leaks, certain findings in the two studies support that proper maintenance could have prevented further damage. For example, the 2018 study found that drainage channels under the green roof trays were filled with growing medium, which prevented water flow to the drains. This issue should have been identified sooner had preventative maintenance been conducted in accordance with the 2012 PBS *Preventative Maintenance Guide* and industry standards.

Region 7 has decided to permanently remove all green roof elements above the waterproofing membrane in order to inspect, identify, and repair existing leaks. *Figure 14* shows the roof in December 2018.

**Seattle Federal Center South.** This 2,800 square foot extensive roof in Region 10 was completed in 2012 at the Seattle Federal Center South in Seattle, Washington. PBS Region 10 staff told us they believed the roof was self-sustaining. Therefore, they had not maintained the roof since establishment. They added that the green roof had dried out, consisted of dead weeds, and had failed. *Figure 15* shows the green roof during our November 2018 site visit.

**Figure 15 – Seattle Federal Center South  
November 2018**



The 2011 GSA Study noted that clients should be educated on green roof requirements; however, PBS has made no such efforts to educate its own staff. Failure to educate staff has resulted in inadequate and inconsistent maintenance practices throughout the nation, and ultimately, failed green roofs.

#### **PBS Does Not Consider Green Roof Maintenance Costs in Investment Decision**

Long-term maintenance costs are not included in PBS's decision to install green roofs. Industry standards indicate that failure to consider funding for long-term green roof maintenance could result in a serious weed problem. Further, according to an Environmental Protection Agency report, for green infrastructure projects to capture and infiltrate storm water onsite to the maximum extent, consideration should be given to whether sufficient funds are in place to cover O&M activities.<sup>6</sup>

ODC Central Office considers green roofs as a design choice primarily to meet EISA Section 438 storm water management requirements. P100 requires PBS to use life-cycle costing when selecting a system from several alternative systems or components for a project. When we asked ODC officials if they considered long-term maintenance costs when deciding to install a green roof, they replied that factors such as roof accessibility played a role in decision-making but no numbers were considered for long-term green roof maintenance.

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<sup>6</sup> Environmental Protection Agency, Office of Water, *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure: A Review of Green Infrastructure O&M Practices in ARRA Clean Water State Revolving Fund Projects*, PA-832-R-12-007, March 2013.

However, as shown in *Figure 16*, the 2011 GSA Study clearly showed that extensive green roof maintenance costs are significantly higher than those for traditional roofs.

**Figure 16 – Extensive Green Roof Maintenance Cost Estimates**

Roof Type	Cost Per Square Foot	PBS Annual Maintenance Costs (Total Inventory Square Feet)	Inventory Maintenance Cost Over 50 Years**
Extensive Green*	\$0.27	\$526,166	\$26,308,300
Traditional	\$0.06	\$116,926	\$5,846,300

\* Actual amounts are higher because PBS’s inventory also includes intensive roofs, which are more expensive to maintain (e.g., annual maintenance costs for Douglas A. Munro Coast Guard Headquarters Building are \$0.36 per square foot).

\*\* The 2011 GSA Study estimates were based on a 50-year time period in order to capture the entire lifetime of both roof types.

Prior to the 2011 GSA Study, government and academic studies also estimated higher maintenance costs for green roofs. Based on these estimates, ODC should have foreseen the increased maintenance costs associated with the green roofs prior to project approval to ensure the long-term viability of the investment. ODC’s failure to consider these costs has resulted in an unexpected financial burden for regional budgets. For example, PBS Region 4 officials, who are responsible for managing 9 percent of GSA’s total green roof inventory, stated they do not have any available budget for green roof maintenance. The lack of funding for maintenance costs places PBS’s green roof inventory at risk of degraded performance or wholesale failure.

In summary, we found that PBS does not properly maintain all of its green roof inventory, educate staff on maintenance requirements, or consider long-term maintenance costs. As a result, PBS has wasted taxpayer dollars and lost intended benefits. To address these deficiencies, PBS should implement controls to ensure that all green roofs are maintained according to industry standards and internal guidance.

**Finding 2 – PBS’s green roofs lack safeguards to protect against fall hazards, which has resulted in contractors being exposed to fall hazards and prevented proper maintenance.**

While maintenance of green roofs is critically important, their location brings about the potential for fall hazards. To mitigate this risk, PBS must adhere to federal regulations including OSHA’s general industry standards. OSHA identifies green roofs in its list of green job hazards, providing that:

Maintenance work on green roofs is generally considered to fall under OSHA’s general industry standards. General industry standards require that when workers are exposed to fall hazards of 4 feet or more, they must be protected by a standard railing. If such a railing is not possible then the workers must be protected by a fall protection device such as a personal fall arrest system or a safety net.

OSHA's guidance also states:

The potential for a fall is very likely while installing and maintaining green roofs, when workers are not provided with fall protection. Falling from a roof can result in death or a serious injury. As green roof workers can get too close to the edge of the roof and may fall, trip on an uneven surface and fall, or fall through a hole or other openings, it is crucial that employers provide necessary protective equipment such as a fall arrest system to protect workers from such hazards.

In addition to OSHA's general industry standards, P100 requires that flat roofs designed for access include a parapet or perimeter railing at least 42 inches high. The design must anticipate facility O&M and ensure it can be performed in compliance with, and must not subject building occupants to conditions in violation of, OSHA's general industry standards.

However, of the 14 sites in our sample, 7 lacked adequate fall protection in accordance with these requirements. As discussed in the examples below, this exposed individuals to fall hazards or resulted in neglected green roof maintenance.

**Exposure to Fall Hazards.** In 2012, 55,000 square feet of green roofs were completed on five wings of the Stewart Lee Udall Department of the Interior Building in Washington, D.C. A 2013 green roof safety assessment identified safety-related conditions on all five wings due to inadequate fall protection. The assessment also recommended the installation of OSHA-compliant guardrails but none have been added as of December 2018.

Despite the reported fall hazards, maintenance is conducted by a Region 11 landscape contractor whose employees access the roofs at least three times per year. PBS Region 11 staff told us that it was the responsibility of the contractor to meet fall protection requirements according to the terms of its PBS Region 11 landscaping contract. According to the contract:

The landscape contractor will ensure their workers are in compliance with OSHA's "Duty to Have Fall Protection" (29 CFR 1926.501) when service/maintenance work is required in any area with an unprotected side of edge which is 6 feet or more above a lower level shall be protected from falling by the use of guardrail systems, safety net systems, or personal fall arrest systems.<sup>7</sup> [sic]

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<sup>7</sup> We determined that the PBS Region 11 landscaping contract language incorrectly references OSHA's construction standard (29 CFR 1926) rather than the general industry standard (29 CFR 1910).

During our July 2018 site visit, while accompanied by PBS Region 11 staff, we witnessed green roof maintenance workers near the edge of the 7-story building protected only by an 18-inch parapet (*Figure 17*). Despite witnessing the contractor in non-compliance, PBS made no effort to enforce its contract clause and maintenance workers were exposed to fall hazards.

**Figure 17 – Stewart Lee Udall Department of the Interior Building July 2018**



**Lack of Proper Maintenance.** In 2011, Region 10 completed a 12,150 square foot green roof at the 911 Federal Building in Portland, Oregon. As shown in *Figure 18*, the roof does not have a guardrail installed. According to PBS Region 10 staff, a maintenance contractor viewed the green roof in 2015 and stated it would not perform maintenance on the roof unless fall protection was provided.

**Figure 18 – 911 Federal Building November 2018**



PBS staff told us that they have plans to install a fall protection system on the roof and will commence green roof maintenance once installed. However, due to the prolonged period of neglected maintenance, the roof currently meets the 2011 GSA Study definition of a wholesale failure. *Figure 18* shows the roof in November 2018.

PBS's failure to provide fall protection or enforce safety requirements included in its maintenance contracts has resulted in unsafe working conditions and failed green roofs. Accordingly, PBS should take necessary steps to protect individuals from fall hazards and include fall hazard mitigation when installing green roofs.

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## Conclusion

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PBS does not ensure that all of its green roofs are maintained in accordance with internal guidance and industry standards. We reviewed maintenance approaches at 14 sites, representing 43 percent of PBS's total managed green roof square footage, and found that PBS does not ensure required maintenance is performed, educate its staff on maintenance requirements, or consider the cost of maintenance when planning green roofs. Neglected maintenance has resulted in lost intended benefits, wholesale green roof failures, and wasted taxpayer dollars.

Additionally, we found that PBS has not put safeguards in place to protect contractors against fall hazards for half of the green roofs we tested. In these instances, individuals were exposed to fall hazards or the roofs were not maintained.

To address these deficiencies, PBS should implement a comprehensive strategy to ensure that green roofs are appropriately maintained and individuals are protected from fall hazards in accordance with industry standards and internal guidance.

## Recommendations

We recommend that the PBS Commissioner develop a comprehensive strategy to ensure that PBS:

1. Maintains its green roof inventory in accordance with internal guidance and industry standards.
2. Provides regular training on the unique requirements of green roof maintenance to PBS staff with responsibility for green roofs.
3. Uses life-cycle costing during green roof design as required by PBS P100, *Facilities Standards for the Public Buildings Service*.
4. Protects individuals accessing green roofs from fall hazards by enforcing contract terms and adhering to federal regulations and internal guidance.
5. Mitigates fall hazards when installing green roofs.
6. Discontinues installation of future green roofs until recommendations 1 through 5 are implemented.

## GSA Comments

The PBS Commissioner agreed with our recommendations. PBS's written comments are included in their entirety in **Appendix D**.

## **Audit Team**

This audit was managed out of the Southeast Sunbelt Region Audit Office and conducted by the individuals listed below:

Nicholas Painter	Regional Inspector General for Auditing
Arthur Edgar	Audit Manager
Lucas Mann	Auditor-In-Charge
Gina Gainer	Auditor

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## Appendix A – Scope and Methodology

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This audit assessed PBS’s management of its green roof inventory. We examined PBS’s responsibilities related to the maintenance of its green roofs and safety for individuals accessing green roofs.

To accomplish our objectives, we:

- Researched and reviewed industry practices for green roof management, including green roof studies conducted by federal agencies, ASTM International standards, and the International Code Council’s building codes;
- Reviewed legislation and regulations related to high-performance and sustainable federal buildings, including EISA 2007;
- Researched and reviewed safety regulations and standards specific to green roof job hazards, including 29 CFR 1910 and 29 CFR 1926;
- Examined PBS internal guidance, including the P100 and the PBS *Preventive Maintenance Guide*;
- Interviewed personnel from GSA’s Office of Government-wide Policy and PBS’s Office of Design and Construction and Office of Facilities Management;
- Requested and reviewed documentation related to PBS’s green roof inventory, including 63 unique sites containing over 2 million square feet of green roofs nationwide;
- Selected a judgmental audit sample of 14 sites in six regions:
  - 2 sites from the Mid-Atlantic Region (Region 3);
  - 3 sites from the Southeast Sunbelt Region (Region 4);
  - 2 sites from the Greater Southwest Region (Region 7);
  - 1 site from the Pacific Rim Region (Region 9);
  - 3 sites from the Northwest Arctic Region (Region 10); and
  - 3 sites from the National Capital Region (Region 11);
- Conducted site visits and interviewed PBS building managers and personnel at each of the 14 sites selected;
- Requested and reviewed documentation for each site related to the design, installation, and maintenance of green roofs;
- Reviewed safety documentation, including Consolidated Risk Management Surveys, the Inventory Reporting Information System, and other site-specific safety reports; and
- Obtained information from regional directors of PBS’s Office of Facilities Management and Office of Acquisition Management.

We conducted the audit between June 2018 and July 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.



## **Internal Controls**

Our assessment of internal controls was limited to those necessary to address the objectives of the audit.

## Appendix B – Audit Sample

This appendix lists the six regions and 14 sites included in our audit sample. The sample represents 43 percent of PBS’s total managed green roof square footage.

Region	Building Number	Building Name	Location	Installation Date	Square Feet
3	PA0144	U.S. Custom House	Philadelphia, PA	2012	22,000
3	PA0277	Byrne-Green Complex	Philadelphia, PA	2011	21,000
4	KY0086	Romano Mazzoli Federal Building	Louisville, KY	2013	20,000
4	GA0087	Peachtree Summit Federal Building	Atlanta, GA	2011	2,800
4	GA1007	Sam Nunn Atlanta Federal Center	Atlanta, GA	2011	63,188
7	TX0298	G.T. Leland Federal Building	Houston, TX	2015	2,236
7	TX0164	Hipolito F. Garcia U.S. Courthouse	San Antonio, TX	2012	15,312
9	CA0093	50 United Nations Plaza	San Francisco, CA	2013	14,000
10	OR0033	911 Federal Building	Portland, OR	2011	12,150
10	WA0961	Seattle Federal Center South	Seattle, WA	2012	2,800
10	WA0132	Peace Arch Land Port of Entry	Blaine, WA	2009/2012*	22,000
11	DC0020	Stewart Lee Udall Department of the Interior Building	Washington, D.C.	2012	55,000
11	DC0026	Lafayette Building	Washington, D.C.	2016	20,575
11	DC1473	Douglas A. Munro Coast Guard Headquarters Building	Washington, D.C.	2013	557,000
<b>Total Sample</b>					<b>830,061</b>
<b>Total PBS Managed</b>					<b>1,948,764</b>

\* The green roof at this facility was originally installed in 2009. It was removed and a new roof was installed in 2012.

## Appendix C – Audit Sample Findings

This appendix identifies the deficiencies observed at each of the sites listed in our audit sample.

Note	Building Number	Building Name	Findings (Note 1)
N/A	PA0144	U.S. Custom House	N/A
N/A	PA0277	Byrne-Green Complex	N/A
2	KY0086	Romano Mazzoli Federal Building	2
3	GA0087	Peachtree Summit Federal Building	1, 2
4	GA1007	Sam Nunn Atlanta Federal Center	1, 2
5	TX0298	G.T. Leland Federal Building	1
6	TX0164	Hipolito F. Garcia U.S. Courthouse	1
N/A	CA0093	50 United Nations Plaza	N/A
7	OR0033	911 Federal Building	1, 2
8	WA0961	Seattle Federal Center South	1, 2
9	WA0132	Peace Arch Land Port of Entry	1
10	DC0020	Stewart Lee Udall Department of the Interior Building	2
11	DC0026	Lafayette Building	1, 2
N/A	DC1473	Douglas A. Munro Coast Guard Headquarters Building	N/A

### Notes:

1. This column identifies the finding related to green roof(s) at the building as follows:
  - a. Finding 1 – PBS does not consistently ensure its green roofs are properly maintained, resulting in lost environmental benefits, wholesale green roof failures, and wasted taxpayer dollars.
  - b. Finding 2 – PBS’s green roofs lack safeguards to protect against fall hazards, which has resulted in contractors being exposed to fall hazards and prevented proper maintenance.
  - c. N/A – Not applicable or no findings for this report.
2. Romano Mazzoli Federal Building: The green roof lacks fall protection. Despite the fall hazards present, maintenance is being conducted by an O&M contractor. Contract language requires that the contractor ensure fall protection equipment is provided to their employees. However, PBS does not ensure that this requirement is met.
3. Peachtree Summit Federal Building: PBS does not ensure that required green roof maintenance is being performed. Of the two green roofs evaluated at this site, only one is accessible and neither provides fall protection.
4. Sam Nunn Atlanta Federal Center: With the exception of a one-time weeding effort in 2018 to correct a reported fire hazard, PBS does not ensure that required green roof maintenance is being performed. Additionally, two sections of the green roof lack fall protection.

5. G.T. Leland Federal Building: PBS Region 7 staff stated that the building's O&M contractor is responsible for maintenance of the green roof; however, the O&M contract has no specifications or requirements related to green roof maintenance. Maintenance is conducted only after problems are identified.
6. Hipolito F. Garcia U.S. Courthouse: According to PBS Region 7 staff, who had received no green roof training, maintenance for the green roof is occurring under the current O&M contract; however, the contractor has no specific knowledge of green roofs. The O&M contract has no specifications or requirements related to green roof maintenance. Maintenance is conducted only after problems are identified.
7. 911 Federal Building: PBS does not ensure that required green roof maintenance is being performed. The green roof has no fall protection mechanism in place. According to PBS staff, the green roof has not received maintenance since it was installed because of the lack of fall protection.
8. Seattle Federal Center South: PBS does not ensure that required green roof maintenance is being performed. No fall protection is in place.
9. Peace Arch Land Port of Entry: PBS staff said the green roof receives monthly maintenance under a grounds landscaping contract. PBS staff also said they track maintenance on a shared internal spreadsheet. We made multiple requests for contract documents and the tracking spreadsheet; however, PBS failed to respond. Visual inspection did not support the occurrence of maintenance.
10. Stewart Lee Udall Department of the Interior Building: The green roof lacks fall protection. Despite the fall hazards present, maintenance is being conducted by a landscape contractor. Contract language requires that the contractor ensure fall protection equipment is provided to their employees. However, PBS does not ensure that this requirement is met.
11. Lafayette Building: PBS staff said the green roof receives regular maintenance under a landscaping contract. PBS staff also said that maintenance is tracked on maintenance logs. We made multiple requests for the maintenance logs; however, PBS failed to respond. Visual inspection did not support the occurrence of maintenance. Additionally, fall protection has not been provided for all sections of the green roof.

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## Appendix D – GSA Comments

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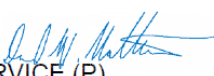
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Public Buildings Service

June 19, 2020

MEMORANDUM FOR NICHOLAS PAINTER  
REGIONAL INSPECTOR GENERAL FOR AUDITING  
SOUTHEAST SUNBELT REGION AUDIT OFFICE (JA-4)

FROM: DANIEL W. MATHEWS  
COMMISSIONER   
PUBLIC BUILDINGS SERVICE (P)

SUBJECT: Response to the Office of Inspector General (OIG) draft  
report entitled *Audit of the Public Buildings Service's Green  
Roof Maintenance and Safety Practices (A180085)*

The Public Buildings Service (PBS) appreciates the opportunity to review and comment on the subject draft report. As described by several examples in this report, PBS sees the direct economic, environmental, and societal benefits of establishing and properly maintaining green roofs that offset their added costs over the roof's lifetime. PBS also values the protection of individuals accessing these roofs by providing required fall protection.

The OIG recommends that the PBS Commissioner develop a comprehensive strategy to ensure that PBS:

- (1) Maintains its green roof inventory in accordance with internal guidance and industry standards.
- (2) Provides regular training on the unique requirements of green roof maintenance to PBS staff with responsibility for green roofs.
- (3) Uses life-cycle costing during green roof design as required by PBS-P100, *Facilities Standards for the Public Buildings Service*.
- (4) Protects individuals accessing green roofs from fall hazards by enforcing contract terms and adhering to federal regulations and internal guidance.
- (5) Mitigates fall hazards when installing green roofs.
- (6) Discontinues installation of future green roofs until recommendations 1 through 5 are implemented.

PBS agrees with the recommendations and is committed to ensuring that green roofs will comply with items under Recommendations 1 through 4. Recommendation 5 will be incorporated on all new roofs being installed. Recommendation 6 will be included for all future roofs as they enter the design process. Additionally, in order to ensure compliance, PBS will include green roofs designed and installed after the publication of this report in the building's commissioning process.

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Commissioning will ensure a more effective hand-off from project delivery to facility management and maintenance, and will incorporate the maintenance standards, training, life-cycle costing, and fall mitigation elements identified in this report. These recommendations will immediately be implemented to address these issues on green roofs as our national strategies are developed.

Thank you for the opportunity to provide a response to the draft report. If you have any questions, please contact Chuck Hardy, (312) 886-0205.

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## ***Appendix E – Report Distribution***

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GSA Administrator (A)

GSA Deputy Administrator (AD)

Commissioner (P)

Deputy Commissioner (PD)

Chief of Staff (PB)

Deputy Chief of Staff (PB)

Acting Chief Architect (PCA)

Assistant Commissioner (PM)

Regional Commissioner (3P, 4P, 7P, 9P, 10P, WP)

Chief Administrative Services Officer (H)

Audit Management Division (H1EB)

Assistant Inspector General for Auditing (JA)

Director, Audit Planning, Policy, and Operations Staff (JAO)