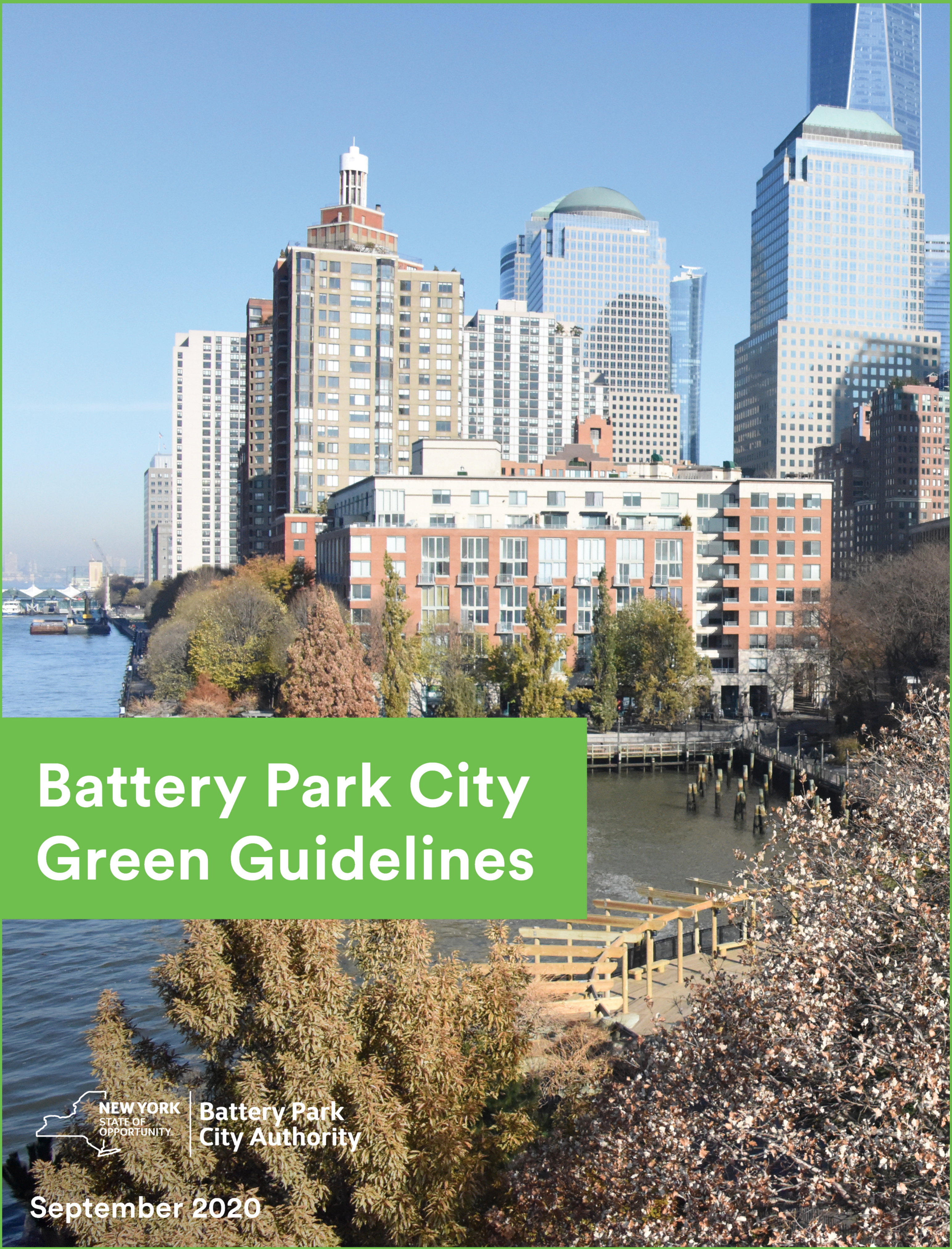

Battery Park City Green Guidelines

NEW YORK STATE OF OPPORTUNITY
Battery Park City Authority

September 2020

NEW YORK STATE OF OPPORTUNITY™ | Battery Park City Authority

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Contents

Executive Summary

Introduction

The Battery Park City Green Guidelines support the Targets and Strategies outlined in the Battery Park City Sustainability Plan of 2020. While achieving carbon neutrality by 2050 is an important aspiration for Battery Park City (BPC), it is equally important to do so while preserving and improving the neighborhood's environmental quality for its residents and visitors alike.

As such, these guidelines embrace the core values of the plan and provide technical guidance, relevant references, and a menu of Interventions and best practices for BPC property owners, building managers, and Battery Park City Authority (BPCA).

These guidelines are applicable for site-scale upgrades, retrofits and renovations of existing buildings, ongoing building and grounds operations, as well as new construction projects. They set forth guidance to enhance the performance of current assets while minimizing the impact on natural resources. Although primarily focused on building performance, these guidelines highlight synergies between recommendations and public health and wellbeing.

> "We envision a Battery Park City that will serve as an innovative model for urban climate action, where all of us who live, work, and spend time here mobilize to create a sustainable future."
>
> –Battery Park City Sustainability Plan

It should be noted that these guidelines address environmental sustainability factors only. Other criteria or guidelines, including, but not limited to, design reviews and financial considerations, will apply to any new construction or building retrofit project as well.

Guidelines for Existing Buildings & Landscape

This document provides technical guidance on physical Interventions and ongoing operations for existing buildings, landscape, and site elements, but does not categorically mandate any of the Interventions described herein. Each property and/or individual project should select the design and implementation strategies based on need, aspirations, or obligation to satisfy legal or regulatory requirements as well as any existing or future contractual agreements.

Guidelines for New Construction

For all new construction projects, a set of mandatory requirements are defined that align with BPC's overarching sustainability goals.

Codes and Regulation Compliance

Where applicable, industry standards, protocols, and procedures such as the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) standards have been referenced in this document. In the absence of such a standard, an overview of the key elements and considerations, based on industry best practices, has been provided for guidance in individual sections.

Although it is the intent of all recommendations provided in this document to achieve the highest standard of performance, they do not supersede the requirement to meet all applicable local, regional, and federal regulatory requirements.

Durable Guidelines

The Green Guidelines are intended to be a resource for the BPC community over a period of ten years, and perhaps beyond. To ensure the applicability of these guidelines, the most current version of a source referenced is the applicable one at any given time. This will prevent this document from becoming obsolete as resources and references evolve.

Should new pertinent directives, programs, legislation or standards develop over the next 10 years, mandatory or voluntary, that align with the aspirations of BPC and BPCA, they can be included or used to replace references or sources in this document, as determined at the discretion of BPCA.

Note that there are several opportunities for interactive navigation within this PDF.

Bookmarks (denoted by a symbol in the Adobe Acrobat interface) provide an ever-present list of links to the sections within this document.

Cross-references are underlined, clickable pieces of text that navigate to figures, tables, and sections within this document.

Endnotes are superscript, clickable numbers ([1]) that navigate to information sources compiled in the "Endnotes" sections.

After clicking a bookmark, cross-reference, or endnote in Adobe Acrobat, you can hold **Alt + Left Arrow** to navigate back to your original location.

How to Use This Document

The primary user groups for the Green Guidelines are the Battery Park City Authority (BPCA), Building Owners and Managers, and Condo Boards. These guidelines are designed to be a resource for multiple applications at different stages of planning, design, construction, or operations.

As an example, a Condo Board may use the Green Guidelines to inform simple upgrades in their building they can accomplish either internally or via external expertise or, property managers may utilize them as part of a design approval process with BPCA. To cater to such diverse purposes, the Green Guidelines are structured to disseminate technical information in an easy-to-use way.

The Green Guidelines are aligned with the Battery Park City Sustainability Plan and the Sustainability Implementation Plan, both of which should be reviewed for context. Where Interventions are supported by helpful implementation resources such as policies, programs, partnerships, tools, and funding mechanisms, references to the Sustainability Implementation Plan are provided.

Document Content & Structure

Since most Green Guidelines content pertains to existing assets, the bulk of the document provides detailed guidance for existing buildings and landscapes, with the content structured as shown in Figure 1. All requirements for new construction are presented at the end of the document with the content structured as shown in Figure 2.

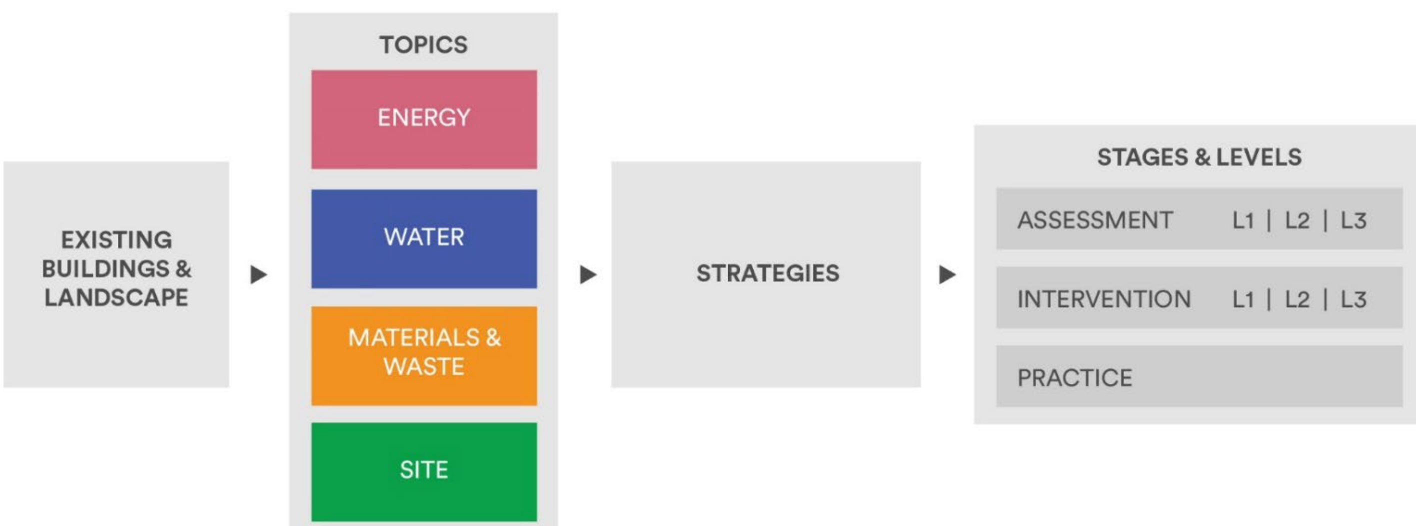


Figure 1: Existing Buildings and Landscape Organization Diagram

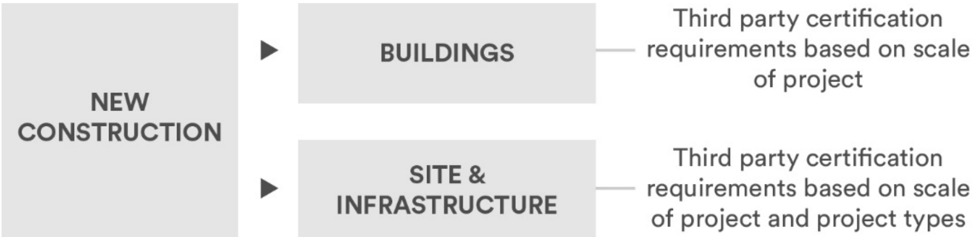


Figure 2: New Construction Organization Diagram

In alignment with the Sustainability Plan, the guidelines for existing buildings and landscape are grouped into four primary Topics: Energy, Water, Materials & Waste, and Site. Overall there are 10 Strategies from the Sustainability Plan covered in the guidelines, as shown in Figure 3 in color. It should be noted that certain strategies defined in the Sustainability Plan do not require technical guidance and, as a result, are omitted from these guidelines, as shown in Figure 3 in grey text.

See Appendix C – Synergies for opportunities to capture benefits across multiple strategies.

Figure 3: Topic and Strategy Alignment Between Green Guidelines and Sustainability Plan

As shown in Figure 4, each of the strategies has three stages: Assessment, Intervention, and Practice. The Assessment stage describes methods to assess existing conditions and establish a baseline. The Intervention stage provides a host of potential physical improvements to enhance performance and achieve the goals of the Strategy. Interventions are categorized into three Levels based on anticipated complexity, disruption, and cost impact. The Practice stage outlines ongoing best practices. It should be noted that not all of the specific steps below are required for each type of Intervention.

Approach

The approach for determining appropriate Interventions is as follows:

1. Determine the current level of performance and resource demand,
2. Deploy simple, inexpensive Interventions (Level 1) to improve performance, if applicable,
3. Reassess and plan for more involved Interventions (Levels 2-3), and
4. Ensure ongoing performance is maintained through M&V and O&M.

While Levels 1, 2, and 3 represent Interventions of varying cost and complexity, they also broadly outline the sequencing in which they should be implemented. Starting with the simpler and less costly Interventions will preserve resources, which can be then be used to determine which more expensive measures or packages of measures, such as new HVAC equipment or water recycling capacity, may be needed.

Assessment

Defines any preliminary work involved with evaluating and benchmarking existing conditions. This is essential before establishing what interventions (if any) need to be implemented.

Audit

- Gather existing performance data
- Assess opportunities

Benchmarking

- Compare against wider industry dataset

Feasibility Study

- Determine viability of a specific intervention

Intervention

Defines recommended steps to achieving measurable improvement in resource efficiency. The Green Guideline Interventions are ranked as Level 1, Level 2, and Level 3 which are qualitatively distinguished by their levels of cost and complexity to implement.

Menu of Intervention Options

- **Level 1:** Interventions that can be done easily by property's on-site facilities team to improve resource efficiency. These interventions are low-hanging fruit.
- **Level 2:** Interventions that require replacement or installment of certain components that are not dependent on other systems/components. The Assessment scope should be carried out to identify applicable interventions in this category. These interventions may require feasibility studies and external expertise.
- **Level 3:** Interventions that require replacement or installation of a full system and possibly the components that support it. The Assessment scope should be carried out to identify applicable interventions in this category. These interventions may require feasibility studies and external expertise.

Practice

Provides guidance for ongoing best practices for operational efficiency and the monitoring of progress.

Measurement & Verification (M&V)

- Measure key performance indicators (KPIs) to verify actual performance against predicted values

Operations & Maintenance (O&M)

- Ongoing practices for operations and maintenance to ensure better performance

Figure 4: Assessment, Intervention, Practice Description

Shown in Figure 5 is an excerpt from the Green Guidelines illustrating the terminology and content structure. Each Intervention has an Applicability Group identified below the Intervention ID. Refer to Appendix A – Applicability Groups for additional information and Strategy specific Applicability Tables.

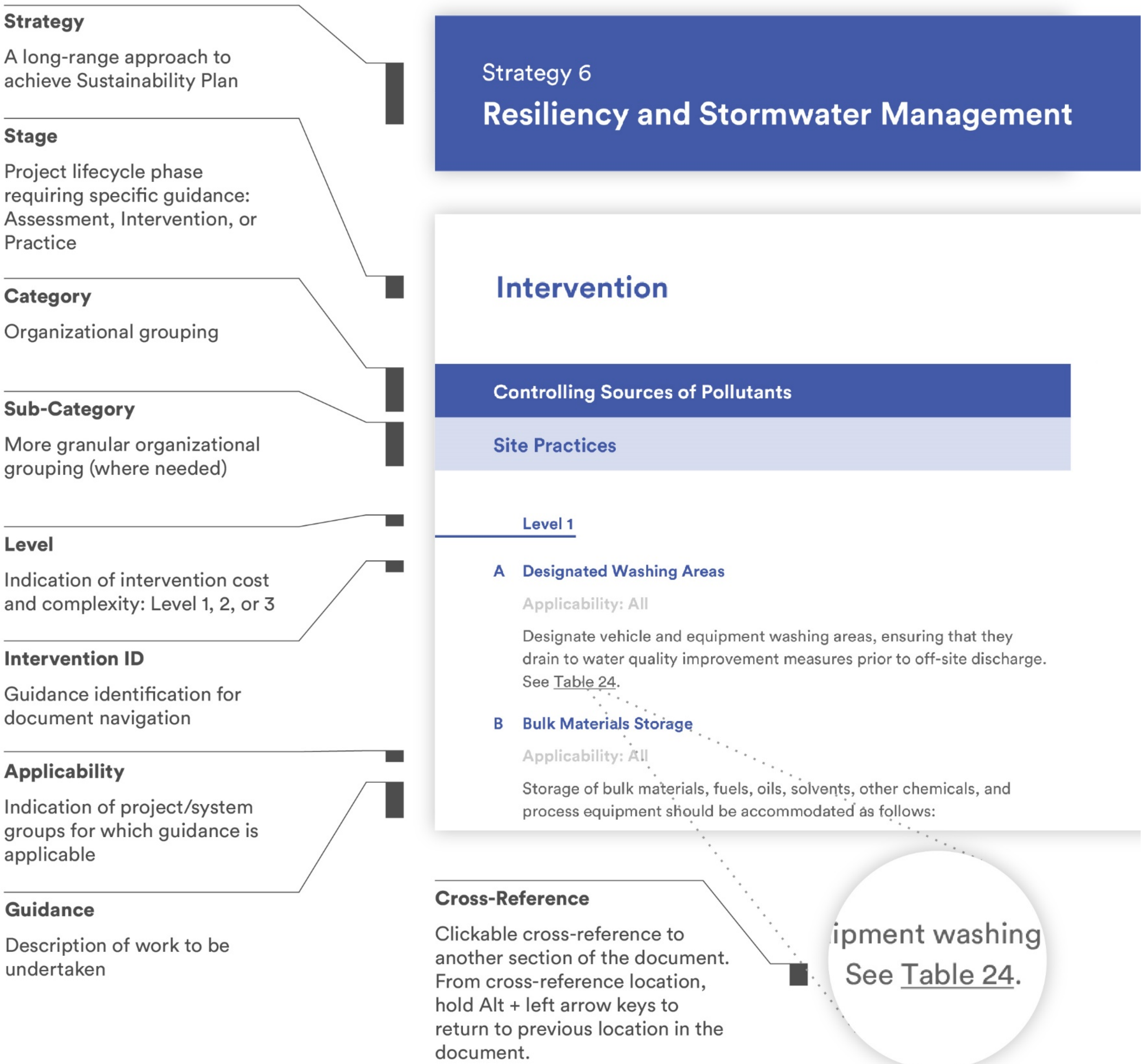


Figure 5: Example of Terminology Identification Within Document

Project Type Scenarios

To assist BPC user groups, Figure 6 shows a few potential scenarios for project types where these guidelines can be applied. Each of the project type scenarios provides a likely path through document Topics, Strategies, Interventions, and Levels. These scenarios are suggestive examples and should be used as a point of reference only.

PROJECT TYPES	CONTRUCTION TYPE	TOPIC
WATER-RELATED SITE PROJECTS	EXISTING BUILDINGS & LANDSCAPE	WATER
BUILDING REPAIRS (IN-HOUSE)	EXISTING BUILDINGS & LANDSCAPE	ALL TOPICS (LEVEL 1 ONLY)
BUILDING RENOVATIONS REPLACEMENT ITEMS BUILDING REPAIRS (3RD PARTY)	EXISTING BUILDINGS & LANDSCAPE	ALL TOPICS
ONGOING MAINTENANCE	EXISTING BUILDINGS & LANDSCAPE	ALL TOPICS (PRACTICE ONLY)
FAÇADE OR STOREFRONT REPLACEMENT	EXISTING BUILDINGS & LANDSCAPE	ENERGY MATERIALS & WASTE
OUTDOOR SPACE IMPROVEMENTS (E.G. PAVING, GARDENS, FENCES, WATER FEATURES)	EXISTING BUILDINGS & LANDSCAPE	WATER MATERIALS & WASTE SITE
STREET FURNITURE AND TEMPORARY STRUCTURES (E.G. OUTDOOR BAR, SEATING, PLANTERS)	EXISTING BUILDINGS & LANDSCAPE	MATERIALS & WASTE
SITE ENHANCEMENTS (E.G. PAVING, PLANTINGS)	EXISTING BUILDINGS & LANDSCAPE	MATERIALS & WASTE SITE
NEW BUILDING CONSTRUCTION	NEW CONSTRUCTION	BUILDING
NEW SITE CONSTRUCTION External Repairs Resiliency Public Open Spaces Infrastructure District-Wide Contracts	NEW CONSTRUCTION	SITE & INFRASTRUCTURE

Figure 6: Project Type Scenarios

Existing Buildings & Landscape

Introduction

The existing building stock in Battery Park City will play a crucial role in any collective carbon emissions reduction goals. It is, therefore, imperative to address energy conservation strategies and goals in existing buildings and sites with a sense of urgency. Existing buildings also need to ensure compliance with carbon emission targets in 2024 and 2030 as established by Local Law 97 (LL97) of New York City (and as part of NYC Climate Mobilization Act).[1] As a result, the Energy Topic comprises a significant portion of the Green Guidelines.

Furthermore, it should be noted that water and waste recommendations also have inherent energy and carbon impacts and will contribute to Battery Park City's overarching sustainability vision.

General Descriptions

Throughout the Green Guidelines, certain terminologies and concepts have been used repeatedly and consistently. Here, we define and describe what these terms imply in the context of these guidelines.

Audits are processes designed to gather information in the form of data and visuals from buildings and their processes, generally to assess current performance and identify applicable interventions to improve resource utilization, e.g., energy efficiency or waste reduction. We often rely on internationally recognized protocols, such as *ASHRAE Energy Audits,* that formalize the procedure for conducting an audit.

Generally, the more granular the data the better, but good insights can be made from even high-level data. The simplest and least expensive audits might involve the review of easily accessible data in the form of energy/water bills. These might not provide much insight into how or where consumption occurs but could give insights such as seasonal variations and peak consumption. Increasingly granular data can be gathered in walk throughs or review of as-built/design/retro-commissioning documentation. Through these assessment activities, building owners and operators can determine which interventions make sense to pursue to achieve reduced resource consumption and greenhouse gas emissions.

Feasibility Studies are used to determine whether a particular intervention would be appropriate for the project's specific context. This could include geographic factors such as annual temperature fluctuations or precipitation, local contextual factors such as neighboring buildings or infrastructure, and existing project conditions such as HVAC or stormwater systems, as well as return on investment aspects. These guidelines include guidance for the technical aspects to be covered as part of a feasibility study.

Benchmarking is a way of gauging the resource efficiency of one set of data against a wider sample of similar datasets. Depending on the metric, comparisons can be made at a local, regional, national, or international level, with a host of public datasets available. ENERGY STAR Portfolio Manager[2] is an online tool to track and report energy and water consumption as well as greenhouse gas emissions and waste generation. New York City also has a dataset of energy and water use, as implemented for Local Law 84. This comparative analysis can provide insight into the potential for performance improvement.

Measurement & Verification (M&V) is necessary once interventions have been implemented. A formal, regular, and ongoing review of key relevant metrics should be undertaken to determine whether upgrades are having the intended impact, or if further troubleshooting is required. If an intervention doesn't achieve the desired impact, be it resource efficiency or increased comfort, etc., the reason for these discrepancies can then be investigated. The methods for measurement and verification can be qualitative, quantitative, or both, and can range from individual room sensors or meters to building-scale submeters or user surveys.

A robust **Operations & Maintenance (O&M)** protocol will ensure that systems using various resources are operating in an optimized way. O&M plans should be developed to establish the procedures to keep various systems and components performing as desired. An inventory of all maintained elements should be updated regularly and include useful information i.e. their location, size, manufacturers' information, etc. The plans should describe required tasks including condition indicators, the frequency of each task, task schedule, the party responsible for performing the task and the party responsible for authorizing the task, task documentation procedure, plan monitoring procedures, and procedures for evaluation and feedback. Where an industry standard exists such as *ASHRAE 180 Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems* these have been referenced, otherwise, key O&M aspects are highlighted.

Health & Wellbeing is an important key performance indicator (KPI) for the Battery Park City community. Specific interventions that have health and wellbeing benefits have been identified throughout the document with a ♥ symbol. See Appendix B – Health and Wellbeing Summary for an overview of the interventions that benefit occupant health and comfort.

Lifecycle Costing as a Decision-Making Tool

While assessing proposed building upgrades to enhance performance, it is essential to look beyond just the capital cost investments and utilize Lifecycle Costing (LCC) to understand the financial impact of a project through the lifespan of an asset. It should be noted that LCC is also sometimes referred to as Total Cost to Ownership (TCO).

In 2008, the Empire State Building (ESB) began a process of investing in comprehensive building performance upgrades, incorporated as a package of interventions that balanced CO_2 reductions and financial returns. The interventions projected a 38% reduction in energy use in their operations, which have been achieved and even surpassed.[2]

By coordinating energy saving building retrofits with anticipated capital improvements, such as a chiller replacement, it is possible to benefit from energy savings that will help to offset the investment. Additionally, by first implementing simple and inexpensive measures that reduce energy demand, the required system upgrades will require smaller capacity.

Figure 7 shows how ESB reduced its capital cost by retrofitting the chillers rather than replacing them. This was only possible due to the reduced cooling demand from other previous interventions. In addition to the lower capital costs, the ongoing energy savings from the various interventions meant that the simple payback for this upgrade was reduced to three years.

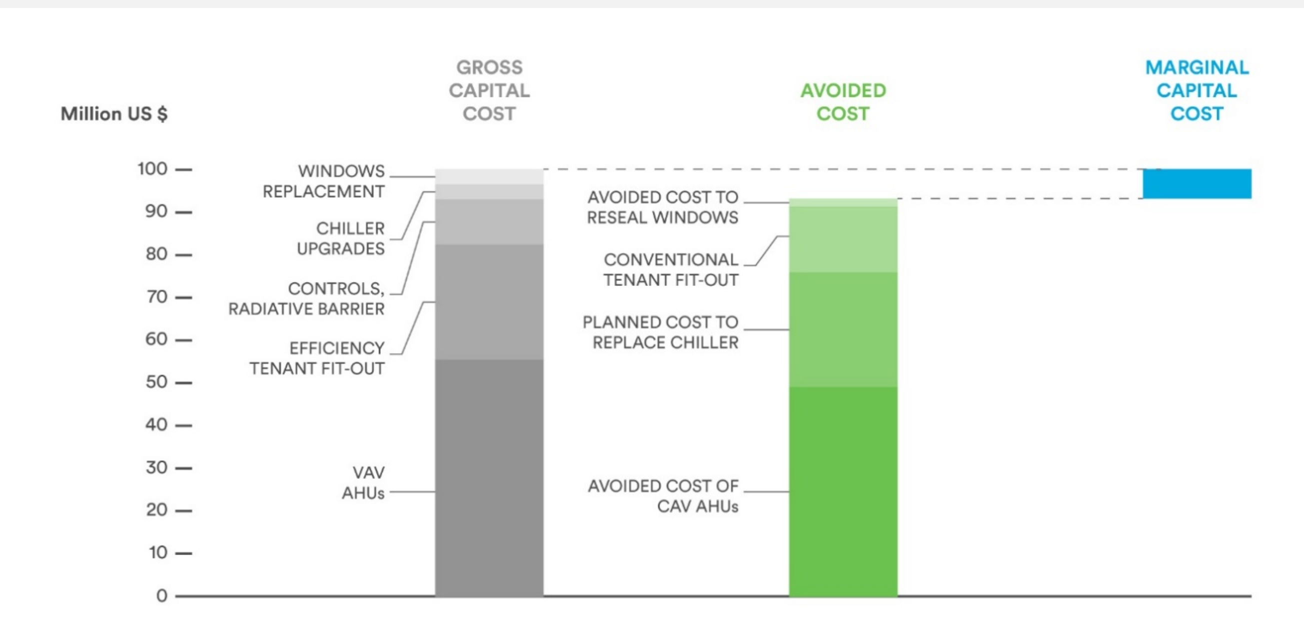


Figure 7: Empire State Building Gross and Avoided Costs[3]

Multifamily residential buildings make-up the majority of the BPC building stock. Figure 8 illustrates indicative cost vs. energy savings for a set of interventions for these typologies. Generally, more expensive, complex, and intrusive interventions, such as systems replacement (Level 3) will result in more significant consumption reductions. For the rest of the interventions, and although the range will vary on a building by building basis, savings are not always proportional to cost. For example, lighting upgrades demonstrate higher energy reduction potential per dollar spent as compared to the installation of variable frequency drives (VFD). Understanding the relationship between cost and impact will be instrumental to optimal decision making. The interventions that require higher capital investment should be carefully planned for and often make the most sense when considered together with other major building works such as end-of-life equipment replacement or building envelope or roof upgrades.

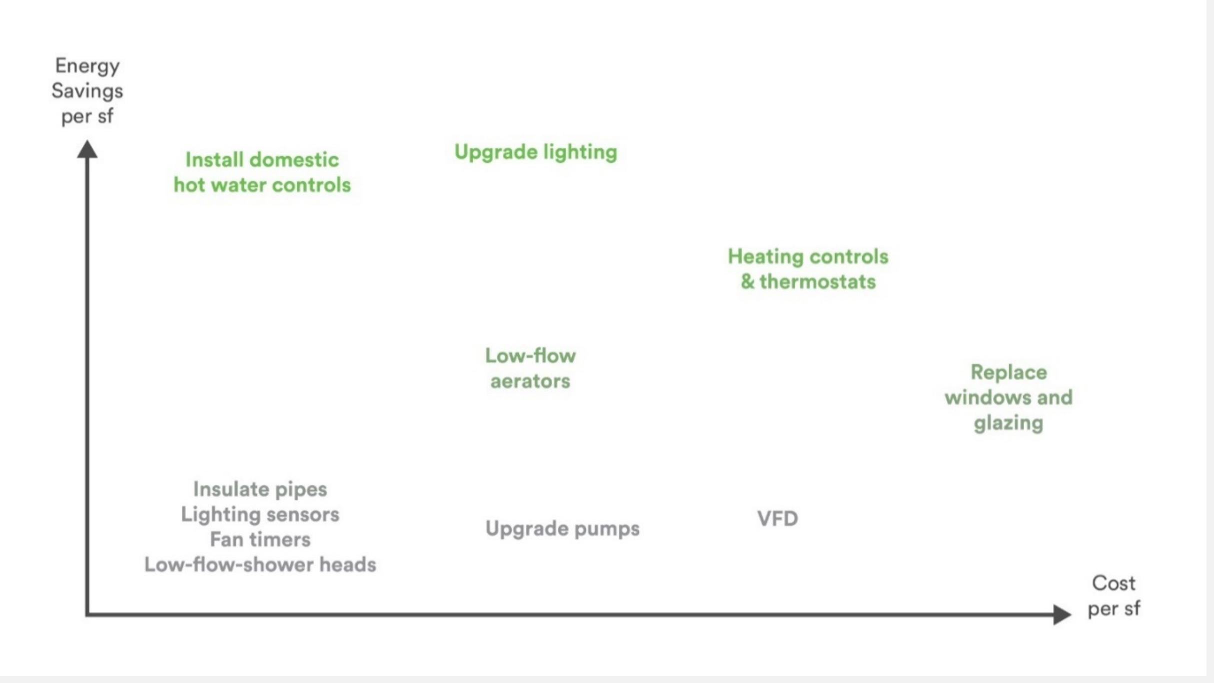


Figure 8: Indicative Cost vs. Energy Savings for Post-1980 Gas High-Rise Buildings in NYC[4]

It is important to note that in the current NYC regulatory environment, in addition to energy cost savings, buildings considering retrofits will also benefit from fine avoidance pertaining to carbon emission limits prescribed by Local Law 97. Both the avoided fines and energy cost savings should be included in the LCC analysis.

Existing Building Certification Programs

An analysis of BPC building consumption data revealed no clear correlation between building age or design certification level and performance. This gap in performance is most likely attributable to ongoing building operations and maintenance. We can infer that there is much potential for operational improvement and related resource optimization.

The following programs are voluntary, best practice frameworks that offer certification options for building operations and should be encouraged when possible:

- **LEED for Operations and Maintenance (O+M):**[5] This program provides a framework for existing buildings to pay close attention to building operations. The program applies to whole buildings and interior spaces that have been fully operational and occupied for at least one year. Projects need to provide data annually and must recertify every three years
- **LEED Zero:**[6] This program applies to buildings that have previously achieved LEED certification during design and complements it by verifying the achievement of net-zero goals during operations. These include:
  - **Energy:** Achieve a source energy use balance of zero over 12 months
  - **Water:** Achieve a potable water use balance of zero over 12 months
  - **Waste:** Achieve GBCI's TRUE Zero Waste certification at the Platinum level[7]
- **True Zero Waste Certification:**[8] This program provides a framework for facilities to define, pursue and achieve zero waste goals and enhance resource efficiency.

For buildings undergoing major retrofits the following certification programs can be pursued during the design phase to ensure a holistic, integrated approach:

- **Living Building Certification**:[9] Applicable to renovations that alter either the envelope or the major systems of a building. This program provides a streamlined approach focused on eliminating the demand for external sources of water and energy while maximizing positive impacts specific to the project and its community
- **EnerPHit**:[10] The EnerPHit Quality Approved Energy Retrofit with Passive House Components Certificate applies to renovations that alter either the envelope or the major systems of a building. This standard is focused primarily on energy related issues

Endnotes

[1] The Climate Mobilization Act Overview, https://be-exchange.org/insight/the-climate-mobilization-act-int-1253/

[2] Empire State of Green, https://www.washingtonpost.com/graphics/2020/climate-solutions/empire-state-building-emissions/

[3] Guide to Building the Case for Deep Energy Retrofits, https://rmi.org/wp-content/uploads/2017/04/Pathways-to-Zero_Bldg-Case-for-Deep-Retrofits_Report_2012.pdf

[4] Building Energy Exchange, "Turning Data Into Action" Report, https://be-exchange.org/wp-content/uploads/2018/08/Turning-Data-into-Action-Tearsheets_Final-1.pdf

[5] LEED Operations and Maintenance Version 4.1, https://www.usgbc.org/leed/rating-systems/existing-buildings

[6] LEED Zero, https://www.usgbc.org/programs/leed-zero

[7] TRUE Zero Waste, https://true.gbci.org/

[8] TRUE Zero Waste, https://true.gbci.org/

[9] ILFI Living Building Challenge Version 4, https://living-future.org/lbc/

[10] EnerPHit Standard, https://passiv.de/en/03_certification/02_certification_buildings/04_enerphit/04_enerphit.htm

Energy

Overview

Energy consumption and greenhouse gas (GHG) emissions attributable to the built environment have a direct and significant impact on our climate. The reduction of these impacts is an important goal for Battery Park City. In 2017 alone, Battery Park City buildings were responsible for producing approximately 159,000 tons carbon dioxide equivalent (tCO2e) of GHG emissions or 87% of BPC's total GHG emissions.

Space heating, cooling, lighting and other equipment loads central to our daily lives drive demand for energy. The breakdown of energy consumption varies from building type to building type, but oftentimes there are major energy savings that can be achieved by addressing inefficiencies and losses.

Energy demands are met by various energy sources – either located on or off-site. On-site energy generation includes combustion processes, such as natural gas burned to heat water, or renewable energy systems, such as rooftop solar photovoltaics or solar thermal systems. Off-site energy generation is primarily sourced for electricity and comes from a mix of regional energy sources, including renewables and non-renewables, all of which feed into the electricity grid. The energy sources that feed into Battery Park City have a large impact on the GHG emissions in the community as fossil fuels like coal or natural gas are major contributors to climate change. Battery Park City has set goals to transition to renewable energy sources in order to reduce GHG emissions.

Local Context

New York State power generation utilizes a combination of natural gas, nuclear, and hydropower energy sources that make it one of the cleaner grids in the United States. Locally in NYC, electricity generation facilities primarily depend on fossil fuels. The recently enacted New York State Climate Leadership and Community Protection Act (CLCPA) requires utilities to source 70% of state-wide electricity from renewable sources by 2030, pushing the region towards decarbonization. New York City has also set new renewable energy targets, including a goal to achieve 1,000 Megawatts (MW) of solar capacity by 2030 and 100 MWh of energy storage by 2020.[11] Further, with NYC's Local Law 97 (LL97) the City's buildings will need to quickly transition to lower operational GHG emissions to meet limits set by the law. To avoid steep fines buildings will need to make a variety of improvements to envelope, heating, ventilation, and/or air conditioning systems.

Path to GHG Reduction of BPC Buildings

With BPC's goal to become carbon neutral by 2050, there is an imperative to replace fossil fuel-based energy sources with a renewable energy supply. This energy transition in Battery Park City relies on three primary strategies identified in the BPC Sustainability Plan: 1) deep energy retrofits, 2) building electrification, and 3) renewable energy supply and storage. Technical guidance for achieving these strategies is provided in this section.

Strategy 1: Deep Energy Retrofits

Reducing Energy Demand

Reducing energy consumption can be as simple as choosing a less energy-intensive light bulb or regulating temperature setpoints, or more involved like replacing a boiler system with a heat pump system. The best approach for reducing building energy demand is to address simple, low-cost interventions first so that larger interventions can be sized for a reduced building energy load, thus minimizing capital costs.

Tracking Progress Towards Energy and GHG Reduction Goals

A better understanding of the energy consumption in Battery Park City is necessary to inform retrofit interventions and to improve energy-related operation and maintenance practices. Smart meters and building management systems gather data to help raise awareness of energy consumption and allow for more efficient management of systems and equipment.

Strategy 2: Building Electrification

In anticipation of a cleaner energy grid in the future, another way to achieve GHG emission reduction is through building electrification, or the transition from fossil fuel-dependent building systems (i.e., gas-fired boilers and cooking stoves) to electrically-powered systems. Buildings in Battery Park City primarily rely on a combination of natural gas boilers and district steam for heating, domestic hot water, and cooking, representing 38% of the total energy consumed by BPC buildings.[12] The impact of electrification on GHG emission is dependent on the Northeast region increasing the amount of renewable energy fed into the grid. As such, of the transition towards electrification should be considered in parallel with decarbonization of the grid as well as local policies like LL97.

Strategy 3: Renewable Energy Supply & Storage

The third Strategy for reducing GHG emissions from energy is to prioritize renewable energy generation. Options for on-site generation should be considered for their multiple benefits such as lower energy costs, resiliency against power outages and disruptions, tariff fluctuations, reducing climate impact, as well as compliance with Local Law 97 requirements. However, renewable energy sources are often variable, depending on weather patterns and other factors. With energy storage, renewable energy generation can be utilized consistently, year-round. Beyond being an enabler of renewable technologies, energy storage resources can serve as demand management opportunities to reduce costs and relieve demand on the local grid.

Strategy 1:
Deep Energy Retrofits

Priorities

The Deep Energy Retrofit Strategy offers energy conservation opportunities to upgrade building components and systems to enhance a building's performance while at the same time ensuring better indoor environmental quality.

The interventions included in this section are focused on the following priorities:

- **Reducing Energy Demand:** A variety of interventions, from simple sealing or caulking of windows to upgrading to high-efficiency equipment and appliances, can help reduce energy use in a building
- **Tracking Progress Towards Energy and GHG Reduction Goals:** Tracking the impact of interventions will not only raise awareness but also provide data necessary to measure progress in achieving targets

Assessment

Audits

General

Level 1

A Energy Audit – Level 1

Conduct a building energy audit in accordance with 'Level I Energy Audit' as described in the most current version of ASHRAE Standard 211.[13] Review utility bills, engage with and interview facility staff, and conduct a walkthrough analysis as outlined in the ASHRAE guideline. This audit intends to help identify significant gaps in efficiencies and low-cost upgrades as well as set the stage for additional detailed assessments.

B Occupant Survey

Conduct an Occupant Survey, such as the Center for the Built Environment's Occupant Indoor Environmental Quality (IEQ) Survey, to assess satisfaction with regard to comfort and indoor environment issues.[14] The survey should cover the following topics, at a minimum:

- Acoustics
- Thermal comfort (include activity levels, typical clothing, humidity, airflow/drafts, temperature and space heater/blanket use – capture seasonal fluctuations for all parameters)
- Furnishings
- Lighting levels and quality
- Odors, stuffiness, etc.
- Cleanliness and maintenance
- Layout

Level 2

C Energy Audit – Level 2

Conduct a building energy audit in accordance with the Level II Energy Audit as described in the most current version of ASHRAE Standard 211.[15] Engage in specific analysis and diagnostic testing as appropriate for the specific building. The findings of the audit can be used to create a plan for appropriate interventions as well as more capital-intensive projects.

D Soft Landings

Ensure the key consultants responsible for a project's design are on board from the early stages to help set goals and manage expectations to ensure successful project delivery. Key aspects of Soft Landings include but are not limited to:

- Setting and maintaining client and design aspirations, and managing them through the whole project delivery process and into operations
- Incorporating important activities into the design and construction process i.e. ensuring accessibility review of plant and equipment
- Providing support to end-users, troubleshooting, undertaking fine-tuning
- Feeding knowledge back into the industry and closing the feedback loop

See BSRIA Soft Landings for further guidance on Soft Landings.[16]

E Indoor Air Quality (IAQ) Testing – Level 2

Refer to the Materials & Waste, Sustainable Building Materials, Assessment, Audit, IAQ Testing – Level 2 for guidance.

Level 3

F Energy Audit – Level 3

Facilitate a building energy audit in accordance with 'Level III Energy Audit' as described in the most current version of ASHRAE Standard 211.[17] Engage in specific analysis, diagnostic testing, and long-term studies as appropriate for the specific building. The findings of the audit can be used to create a plan for appropriate interventions as well as ongoing operations and maintenance strategies.

G Indoor Air Quality (IAQ) Testing – Level 3

Refer to the Materials & Waste, Sustainable Building Materials, Assessment, Audit, IAQ Testing – Level 3 for guidance.

Envelope

Level 1

A Visual Inspections

Conduct energy related to façade inspections. Inspections should include:

- Sealant and caulk joints for cracking, delamination, and other degradation

- Masonry joint pointing at brick and/or stone cladding
- Signs of water infiltration and air leakage, including staining, spalling, and efflorescence
- Roofing for cuts, delaminated seams, gaps at equipment, and other deficiencies
- Interior finish materials at exterior walls & ceilings for signs of damage caused by air and water infiltration

Level 2

B Investigative Probes

Perform probes to inspect hidden envelope components, not visible in walkthroughs:

- In typical wall assemblies
- In wall assemblies where degradation is expected to occur, such as at copings, flashings, and windowsill flashings
- In unique assemblies, details, and cavities behind façades or above exterior soffits

C Thermal Bridging

Identify and locate thermal bridging components and sections in the building envelope assemblies that contribute to conductive energy loss. This can be done through:

- Examining and assessing of as-built detail drawings of the building envelope
- Analyzing infrared (IR) scans (external or internal) or thermal variances. Refer to practices described in ASTM E1187 - Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems.

D Mold and Moisture Testing

Conduct mold and moisture tests of exterior masonry materials to identify moisture or water infiltration issues and inform intervention strategies.

Level 3

E Air Leakage Testing

Perform building envelope air leakage detection testing, without pressurization, on-site using industry accepted testing standards such as American Society for Testing & Materials (ASTM) listed below and as appropriate and needed for each building:

- Use practices described in ASTM E1186 - Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems to locate leakage sites in envelope systems, especially at joints between systems, and around common areas of leakage such as soffits, roof-to-wall joints, expansion joints, parapet flashing, and roof penetrations[18]

- Use practices described in ASTM E783 - Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors determine airtightness of door and window assemblies[19]

F Air Leakage Testing (Pressurized)

Perform building envelope pressurized air leakage detection testing on-site using industry accepted testing standards such as American Society for Testing & Materials (ASTM) listed below and as appropriate and needed for each building. These tests are typically used in buildings configured to a single zone.

- Use practices described in ASTM 779 - Standard Test Method for Determining Air Leakage Rate by Fan Pressurization to measure air leakage rates through the building envelope under controlled pressurization and depressurization[20]
- Use practices described in ASTM 1827 - Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door to measure air leakage rates through building envelope by inducing pressure[21]

G Digital Simulations

Based on as-built documentation and other relevant envelope information available, create a digital simulation to assess potential deficiencies in envelope detailing including but not limited to the following:

- Thermal simulation of building envelope assemblies to determine effective U-values
- Thermal simulation of building envelope details to quantify thermal bridges. Compare with IR scans of the envelope if available
- Hygrothermal analysis of exterior masonry materials

HVAC

Level 1

A Maintenance Logs

Check that there are organized maintenance records of all major equipment and water quality control/treatment systems. Check for non-performance of contracted and typically required tasks.

B Air Filters, Water Filters, and Strainers

Check that filters meant to protect systems and equipment are installed and are regularly maintained. Clogged filters can impede system performance, missing filters and strainers can damage equipment.

C Steam Systems

Check the delay between steam valves opening/boilers firing and steam reaching critical branches. Check condensate temperatures, particularly toward the end of the steam cycle. Check for evidence of moisture carryover/boiling over as steam systems switch on and reach operating pressure. Check for correct pitch and clogged strainers wherever there is a water hammer.

Level 2

D Ventilation System Airflow

Check for airflows at the top, middle, and bottom of each ventilation riser as an initial spot check.

E Equipment Performance

Spot check operation of equipment based on Key Performance Indicators (KPIs) such as COP that may be noted in or determined from information that appears in energy-related regulatory filings. This is to check that equipment performance has not significantly changed from reporting and analysis previously performed. For example, checking chiller efficiency might reveal that a chiller condenser needs to be cleaned.

F Automatic Equipment Operation

Check for equipment that is not operating automatically. Interview building operators to determine any equipment frequently requiring adjustment to the automatic operation or setpoint to achieve desired operation or comfortable conditions. Check for overridden points in Building Management System (BMS).

G Equipment Sizing

Determine whether equipment is right-sized for the current and anticipated loads. Check for evidence of short cycling—frequent cycling on and off—and hunting—unstable damper/valve/actuator position under relatively constant loads. This behavior may appear during partial or near peak loads. Note that interventions suggested in this document may reduce or significantly reduce loads on existing equipment. Right-sizing of existing-to-remain equipment in any project must be checked.

H Thermal Comfort

Review occupant survey data including occupant satisfaction, typical activity levels, clothing preferences, demographics, thermal conditions, airflows and design information. Collected information can be compared against thermal comfort requirements described in the most current version of ANSI/ASHRAE Standard 55.[22] This assessment can lead to adjustments in controls or systems to address occupant comfort.

Level 3

N/A

Lighting

Level 1

A Illuminance Study

Using light meters or similar devices measure illuminance levels in different spaces and assess if they are aligned with those recommended in the most current version of Illuminating Engineering Society (IES) Lighting Handbook as shown in Table 1.[23] Best practice and guidance on testing standards and locations can be found in the Light chapter of The WELL Performance Verification Guidebook.[24]

B Lighting Power Density

Using as-built documentation, other available building information, or field condition assessment calculate the lighting power density (LPD) using the building area method as described in the most current version of ASHRAE 90.1 standard. Table 1 provides LPD values from ASHRAE 90.1 for reference only.[25]

C Envelope Transparency

Determine (through as-built documents or otherwise) the following parameters for transparent envelope glazing with a visible light transmittance (VLT) greater than 40%:

- The ratio of transparent envelope glazing area to the floor area
- Percentage of floor area within 20 feet of transparent envelope glazing

Level 2

D Spatial Daylight Autonomy

Undertake a Spatial Daylight Autonomy (sDA) simulated analysis for existing conditions in all regularly occupied spaces to assess available natural light. This simulation can be used further to implement changes to improve daylight availability within occupied spaces.

E Circadian Rhythm

Determine the Equivalent Melanopic Lux (EML) or Melanopic equivalent daylight D65 for regularly occupied spaces to estimate the biological impact of lighting on occupants. Best practice and guidance on testing standards and locations can be found in the Light chapter of The WELL Performance Verification Guidebook.[26]

F Glare Assessment

Undertake a typical commercial floor glare assessment to determine the major sources of glare in the project.

G Annual Sunlight Exposure

Determine the Annual Sunlight Exposure (ASE) achieved in regularly occupied spaces.

H Fixtures

Undertake a review of existing fixtures (through as-built drawings or fixture inspection) for the following parameters:

- Unified glare rating - Determine the unified glare rating (UGR) and their height of installation and shielding angles
- Color – Determine the Color Rendering Index (CRI), R9, or IES TM-30-18
- Frequency and flicker – Determine the frequency at all 10% light output intervals from 10% to 100% and the risk of flicker

I Lighting Controls

Determine the existing lighting control systems, the extent of localized control, the parameters controllable, and that it is energy code compliant.

Level 3

N/A

Table 1: IES Lighting Handbook 10th Edition and ASHRAE 90.1 (2019) Performance Criteria for Lighting Parameters

Space Type	Horizontal Illuminance Levels[27] (lux)	Lighting Power Density[28] (W/ft^2)
Lecture/Training	300	0.71
Enclosed Office <250 ft^2	300	0.74
Open Plan Office	300	0.061
Lobby, Typical	100	0.84
Lobby, Elevator	50	0.65
Lobby, Movie Theater	150	0.23
Atrium (>40 ft height)	100	0.6
Conference /Meeting /Multipurpose	300	0.97

Audience Seating, Movie Theater	50	0.27
Copy /Print Room	100	0.31
Lounge /Breakroom	40	0.59
Dining Area, family dining	100	0.6
Food Preparation Area	500	1.09
Gymnasium /Fitness Center	150	0.9
Locker Room	50	0.52
Corridor /Transition	50	0.41
Stairway, stairwell	100	0.49
Restrooms	200	0.63
Electrical/Mechanical	200	0.43
Storage <50 ft^2	100	0.51
Loading Dock, Interior	100	0.88
Parking area, Interior	500	0.15
Outdoor Walkways	10	0.2
Landscape	N/A	0.04
All Other Outdoor Space	N/A	0.2

Appliances and Plug Loads

Level 1

A Appliances

Create a thorough appliance inventory listing installation date, input fuels and connection sizes, and whether it is ENERGY STAR certified.

B IT Equipment

Check whether the equipment is capable of scheduled power-on and wake-on-LAN. Check for lightly loaded servers that could be merged with virtualization.

Level 2

N/A

Level 3

N/A

Vertical Transportation

Level 1

A Elevator Use

Assess to determine the vertical transportation's usage profile (time and number of users) and whether reducing service during off peak times (i.e. shutting off one or more elevators at particular times/days) is feasible for the safe and functional operation of the building.

B Elevators (Variable Frequency Drives)

For traction elevators with variable frequency drives carry out a study to assess the feasibility of retrofitting a regenerative braking system to improve the energy efficiency of the system.

Level 2

C Vertical Transportation Condition

Undertake assessments to identify issues affecting the vertical transportation's energy performance as outlined in the most current version of the American Society of Mechanical Engineers (ASME) Handbook on Safety Code for Elevators and Escalators.[29] Aspects requiring attention include, but are not limited to:

- Alignment of the guide rails
- Car and counterweight counterbalance of the guides
- Lubrication
- Inching

Level 3

N/A

Building Management System & Submetering

A Building Management System (BMS) comprises the following categories:

- Front End System (Operating software system, graphics, and peripherals)
- Unitary Controls (Hardware equipment comprised of specific controllers and application controllers)
- End Devices (control damper actuators, control valves, duct and well sensors, flow meters, pressure sensors, relays)

Level 1

A Front End System

Assess the building management front end system – determine the current version of the front end, the current state of unitary controllers and end devices, gather the specific capabilities or measurements available to the BMS for the different type of control systems as follow:

- Cooling Plant
  - Cooling Towers
  - Chillers
  - Heat Exchangers
  - Pumps
  - Chilled beams
- Heating Plant
  - Boilers
  - Heat Exchangers
  - Pumps
  - Unit Heaters
- Ventilation Systems
  - Air Handling Unit (AHU)
  - Remote Terminal Unit (RTU)
  - Fan Coils

    - AC units
    - Variable Refrigerant Flow (VRF) Systems
    - Computer Room Air Conditioning (CRAC) Units
- Integrated Systems
    - Generators
    - Fuel Oil Pump System
    - Lighting controls
    - Access controls
    - Chillers
    - Boilers
    - Elevators

The objective is to determine if the following control strategies are in place:

- Scheduling Strategies
- Setpoint Settings
- Alarms Settings
- Trending Settings
- Ventilation Control Strategies
- Temperature and Pressure Control Reset Strategies
- Lockouts Strategies
- Energy Demand Control

Assess opportunities for the following:

- Adjustments to the programming to enhance performance
- Upgrades to the front end for better controllability
- Upgrades to unitary controls for better controllability
- Replacement of control end devices due to wear and tear
- Upgrades of any pneumatic control system to electronic controls

B Field Survey

- Check operation of system's end devices and unitary controllers
- Sample point checks for accurate performance
- Sample point commanding techniques for proper operation
- Disable system modules on a selective basis to review problem annunciation and system behavior

- Perform a system wide function test to verify complete and accurate operation
- Examine and analyzing standard log reports
- Review service history, and the performance of temperature control
- Review energy management applications

C Controls Audit

Assess the following:

- Audit sequences of operation. Code running on controllers frequently is different than the written sequences of operation. The sequences should be written to accurately reflect the actual operation of the code in the first instance
- Rewrite/debug code or controller outputs that have been bypassed by building operators due to unclear function or undesirable function
- To the extent possible with existing equipment, conform sequences of operation to contemporary recommended practices and guidance of ASHRAE 90.1 and 189.1
- Validate that sensors are calibrated and measuring the parameters they're supposed to. Check for proper air sealing behind thermostats and induct and AHU sensor probes. Check for a thermally conductive compound in sensor wells. Check for adequate insulation and thermally conductive compound on pipe surface temperature sensors. Check calibration and lifespan of humidity and Carbon Dioxide (CO_2) sensors. Check proper installation of flow meters

Benchmarking

A Benchmarking Data

Use gathered data to benchmark current (baseline) performance against buildings of the same typology using the most current data set of New York City's LL84.[30] Use Table 2 as a reference for energy use intensity data compiled by building types in Battery Park City.

Table 2: New York City's LL84 (2014, 2015) Performance Criteria for Energy Use Intensity[31]

Property Type	Median NYC Weather Normalized Source Energy Use Intensity (kBtu/ft^2.year)
Multifamily	125
Senior Community	248
Hotel	237
Office	186
Retail	203
K-12 School	112
Museum	No Data

Intervention

Envelope

General

Level 1

N/A

Level 2

A Airtight Smoke Vents

Applicability: All

Provide airtight dampers at all smoke vents. Where permitted by current codes, remove and seal smoke vents that are no longer required or provide breakable glass where permitted in lieu of open vents.

Level 3

N/A

Windows & Doors

Level 1

A Air Infiltration Prevention

Applicability: All

Apply any or all of the preventive measures below to minimize air infiltration and associated energy loss through envelope components.

- Replace worn out weather stripping at operable doors and windows to minimize air infiltration. Select appropriate weather stripping in coordination with adjacent materials and conditions

- Spot seal any gaps in sealant or caulk around windows, door frames, infill panels, mullions, and in the frames themselves
- Calibrate automatic doors and controls to ensure minimal air loss
- Use air sealing tapes or membranes to air seal from the interior where caulk and sealant has failed

Level 2

B Entrance Vestibule

Applicability: All

Add/replace entry vestibules and/or revolving doors at building entrances separating conditioned and unconditioned spaces to ensure compliance with the most current version of New York City Energy Conservation Code.[32]

C Re-Caulking & Re-Sealing

Applicability: Punched Opening

Remove existing and re-caulk and re-seal around all window and door frames from both interior and exterior sides. Ensure the new sealing system is appropriately specified and installed for each condition to minimize air infiltration through gaps. Where needed insulate the gap between window frames and rough openings.

D Window Performance Enhancement – Punched Openings ❤

Applicability: Punched Opening

Use one or all interventions listed below to enhance the thermal and visual performance of existing windows on site to enhance energy performance as well as comfort for building occupants.

- Install interior storm windows (insert windows) at all window locations
- Install architectural window film based with varying performance properties including:
  - Solar energy rejection film at windows to prevent excessive solar heat gain
  - Low-emissivity film on the interior of glass to reflect interior heat energy back to occupied spaces

E Window Performance Enhancement – Window Wall and Curtain Wall ❤

Applicability: Window Wall and Curtain Wall

Use one or all interventions listed below to enhance the thermal and visual performance of existing windows on site to enhance energy performance as well as comfort for building occupants.

- Inspect, remove and re-gasket and re-seal all exterior joints
- Install an additional layer of interior glazing (single or double pane) between or behind curtain wall mullions

Level 3

F Solar Control Devices

Applicability: All

Refer to the Energy, Intervention, Lighting, Sun Glare Control for guidance.

G Glazing Replacement

Applicability: All

Remove and replace existing glazing components of the building envelope to enhance performance and reduce energy consumption while improving indoor thermal comfort. Ensure all fenestration prescriptive requirements are at 10% better than listed in 'Building Envelope Fenestration Maximum U-Factor and SHGC Requirements' in the most current version of the New York City Energy Conservation Code (NYCECC).[33]

H Re-Cladding/ Over-Cladding

Applicability: All

Remove and re-clad or over-clad poorly performing façades with higher performance assemblies.

- Remove and re-clad or over-clad existing building envelope systems to enhance performance and reduce energy consumption while improving indoor thermal comfort. Regardless of code compliance path undertaken, ensure all new building envelope components listed below exceed prescriptive requirements in the most current version of New York City Energy Conservation Code (NYCECC) by 10%:[34]
    - Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method (Refer to Table C402.1.4 in Chapter C4 of NYC 2020 Energy Conservation Code)
    - Building Envelope Fenestration Maximum U-Factor and SHGC Requirements (Refer to Table C402.4 in Chapter C4 of NYC 2020 Energy Conservation Code)
- Ensure that all new envelope design and construction incorporates the following:
    - Continuous thermal, air, vapor, and water barrier
    - Airtight details at all connections and penetrations
    - Airtightness inspection and testing measures during installation of the air barrier and related components
    - Thermally isolated attachments through envelope insulation
- Confirm through thermal and hygrothermal analysis that the new cladding assemblies will not harm existing building assemblies, especially in terms of vapor diffusion, condensation and freeze/thaw cycles
- Coordinate window replacements to ensure continuity

- Perform Building Enclosure Commissioning (BECx) to ensure appropriate envelope design detailing and that the construction quality and performance aligns with proposed design

Opaque Walls

Level 1

A Localized Air Leakage Repairs

Applicability: All

Perform localized envelope air leakage repairs:

- Seal any obvious punctures through cladding and air barriers such as electrical conduits, pipes, louvers and ducts
- Reapply paints or coatings
- Patch/replace deteriorated sealant or caulking
- Patch large holes with solid materials appropriate to adjacent construction

B Duct Insulation

Applicability: All

Install additional insulation for ducts connected to exterior louvers for a minimum of 5 feet distance from the interior face of the exterior wall. Louver plenum, outside air intake, and energy recovery unit exhaust discharge duct insulation values should be increased to match or exceed the exterior wall insulation value.

Level 2

C Re-Caulking & Re-Sealing

Applicability: Punched Opening

Refer to the Energy, Deep Energy Retrofits, Intervention, Windows & Doors, Re-Caulking & Re-Sealing section for guidance.

D Wall Insulation

Applicability: Punched Opening

Add inboard insulation. Institute an incremental interior insulation retrofit plan based on opportunities and limitations of specific program types:

- **Tenant by tenant:** As tenants of buildings move out and new tenants retrofit spaces, insulation can be added at perimeter walls
- **Zoned:** Where spaces are occupied, retrofits can occur in discrete zones such as in rooms or by column bays to minimize the area and duration of the disruption
- **Seasonal:** In schools or other spaces with seasonal use, retrofits can be undertaken in the summer or other off-season times

Use envelope expert consultation and/or analysis to ensure additional insulation does not result in condensation and mold in interior spaces.

E Slab Edge and Spandrel Insulation

Applicability: All

Increase or add insulation at slab edges and opaque spandrel panels to increase insulation and reduce conductive transfers thus reducing energy use.

F Radiator Wall Insulation

Applicability: All

At all existing radiator locations, install insulation with a radiant barrier behind such radiators to reflect heat back to the interior.

Level 3

G Re-Cladding/Over-Cladding

Applicability: All

Refer to the Energy, Deep Energy Retrofits, Intervention, Windows & Doors, Re-Cladding/ Over-Cladding section for guidance.

Improving a building envelope's thermal performance, such as by air sealing room air conditioners, can improve occupants' audio and thermal comfort in addition to saving energy.

Slabs, Soffits, and Roof

Level 1

A Localized Air Leakage Repairs – Level 1

Applicability: All

Perform localized envelope air leakage repairs to minimize energy losses from infiltration.

- Repair and seal any obvious punctures through the air barrier such as electrical conduits, pipe, and ducts, paying specific attention to areas where exterior soffits abut interior ceiling cavities
- Patch/replace deteriorated sealant or caulking
- Patch large holes with solid materials appropriate to adjacent construction
- Reapply paints or coatings

B Exposed Slab Insulation

Applicability: All

Add insulation under exposed slabs over unconditioned spaces, such as at cantilevers, balconies, and parking garages.

Level 2

C Localized Air Leakage Repairs – Level 2

Applicability: All

Repair air leakage at typically weak roof joints, connections, and penetrations such as roof-to-wall joints, expansion joints, parapets, and duct penetrations.

D Roof Penetration Repair & Replacement

Applicability: All

Implement repairs and replacement as needed to minimize thermal bridging and air infiltration at roof including:

- Thermally isolate all penetrations and equipment through roofs and soffits, such as for HVAC equipment, structural dunnage, posts for maintenance and fall protection
- Remove and replace roof penetration systems for roof hatches, smoke vents, and exhausts to minimize air infiltration

E Roof Solar Reflectance

Applicability: All

Minimize solar radiation absorption by applying high 'Solar Reflectance Index' (SRI) value roof coatings, membranes, pavers, or other finishes. Comply with the requirements outlined in New York City Local Law 94 (LL94) for solar reflectance and SRI values.

F In-Board Roof Insulation

Applicability: All

Add in board insulation to the interior side of the roof to help increase overall roof insulation value.

G Soffit Insulation

Applicability: All

Increase or add insulation and repair air, vapor barriers in soffits and adjacent areas typically hidden including the following:

- Hung soffits
- Visually hidden areas above soffits, such as undersides of slabs and walls above storefronts
- Visually hidden gaps above soffits between the façade and slab, or other conditions

Ensure all new insulation exceeds the prescriptive requirements listed in the 'Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method' in the most current version of NYC 2020 Energy Conservation Code' by at least 10%.[35]

Level 3

H Soffit Replacement

Applicability: All

Remove and replace entire soffits that do not have adequate insulation or air & vapor barriers and are detrimental to the performance of overall building envelope. Ensure all new insulation exceeds the prescriptive requirements listed in the 'Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method' in the most current version of NYC 2020 Energy Conservation Code' by at least 10%.[36]

I Roofing Replacement ❤

Applicability: All

Remove and replace entire roofing including any at bulkheads with high-performance roofing system.

- Ensure all new roofing assembly exceeds the prescriptive requirements listed in the 'Opaque Thermal Envelope Assembly Maximum Requirements, U-Factor Method' in the most current version of NYC 2020 Energy Conservation Code' by at least 10%.[37]

- Minimize solar radiation absorption by applying high ‘Solar Reflectance Index’ (SRI) value roof coatings, membranes, pavers, or other finishes. Comply with the requirements outlined in New York City Local Law 94 (LL94) for solar reflectance and SRI values.
- Design and install vegetated (green) roof system over high-performance roofing assemblies in accordance with New York City Local Law 92 and 94.

Refer to Water, Resiliency and Stormwater Management, Intervention, Stormwater Capture, Green Infrastructure, Green or Blue Roofs ♥ section for additional guidance.

- Design and install solar photovoltaic panel arrays over roof assemblies in accordance with New York City Local Law 82 and 94.

Refer to the Renewable Energy Supply and Storage, Intervention, Renewable Energy Systems, Roof Solar PV System section for additional guidance.

HVAC

Air Systems

Level 1

A Ventilation Dampers

Applicability: Non-Residential

Replace poor quality or failed outside air, exhaust, and mixing dampers with Air Movement and Control Association (AMCA) Class 1A low-leakage type with robust, low-hysteresis linkages for positive shutoff during off and preoccupancy modes.

B Kitchen and Dryer Exhaust

Applicability: Residential

Verify and provide adequate turndown of ducted residential kitchen and dryer exhaust systems under conditions of zero or low- load. Provide upgraded fan motors with lower minimum rotational speed than standard motor design if required or provide a barometric bypass at the fan. Control barometric bypass to reduce riser negative pressure when fan speed reaches its minimum, but riser negative pressure is above set point. It is common for these systems to have excessive design fan capacity and inadequate fan motor turn down. Verify sensors measure the difference between building and duct pressure and are not measuring outdoor air pressures.

C Low-Delta T Mitigation

Applicability: Non-Residential

Install temperature sensors on return water pipes from AHU coils to allow localized detection/prevention of low-delta T operation of cooling coils.

D System Balancing

Applicability: All

Verify proper air balancing in areas and systems with air quality or temperature complaints

E System Balancing During Construction

Applicability: All

Test and balance all newly installed and altered mechanical ventilation systems in accordance with ASHRAE 111

F Air Filtration ❤

Applicability: All

Use appropriate filtration media to protect equipment and occupants. Do not use excessive filtration levels where not warranted. Media filters to filter outdoor air supplies should be at a minimum MERV 11.

G Local Fan Filter Units ❤

Applicability: All

Consider local, higher filtration levels separate from main HVAC equipment for people with allergies and/or respiratory issues or other localized requirements exist.

H Thermostat Strategy ❤

Applicability: All

For all thermostats, pursue one of the following strategies:

- Adjust settings to only display setpoint. Precisely displaying the current temperature may unduly influence perceptions of comfort or discomfort
- Adjust settings to remove setpoint and current temperature display from all commercial thermostats. Use buttons as hot vote/cold vote rather than permanent setpoint change. Precisely displaying the current temperature and setpoint may unduly influence perceptions of comfort or discomfort

I Automatic Balancing Dampers for Toilet Ventilation

Applicability: Residential

Replace manual volume dampers in exhaust systems with pressure independent flow regulators/automatic balancing dampers. Set airflow rates to no more than 4 Air Changes per Hour (ACH) for residential bathrooms and no less than 20 Cubic Feet per Minute (CFM) per bathroom.

J Automatic Balancing Dampers for Kitchen Ventilation

Applicability: Residential

Replace manual volume dampers in kitchen area exhausts and reduce airflow rates to 25 (CFM) for electric stoves but retain up to 100 CFM per kitchen for gas stoves.

Level 2

K Exposed Duct Fitting Improvements

Applicability: All

Improve poorly designed exposed fittings and all dampers:

- Replace all exposed sharp throat elbows with mitered elbows with turning vanes where design velocities exceed 700 Feet Per Minute (FPM)
- Provide a 6” bellmouth or 8” 45° chamfered bevel on all exposed louver plenum connections where existing connections are hard 90° taps, including within air handler casings
- Install splitter vanes in all exposed short radius elbows (inside radius < 0.75 times duct dimension in the plane of the turn)
- Install splitter vanes in all exposed radiused elbows (even long radius) less than 3x duct width (in the plane of the turn) upstream of the next fitting/takeoff
- Install bellmouth, transition, or wye type takeoffs for all exposed VAV box inlet ductwork connected to mains with hard taps
- Inspect fire smoke and control dampers for blades more than 5° off parallel to airflow at a full open position. Repair and adjust linkages so that blades positively close when commanded and blades are parallel to airstream when open with minimum hysteresis
- Inspect fire dampers to verify dampers are held open properly

L Duct Design Improvement

Applicability: All

For systems with critical branches with disproportionate pressure requirements, install booster fans on minor critical branches to reduce main fan pressure requirements. Systems will need to be rebalanced, but systems with poorly designed ductwork will no longer need to over pressurize the majority of the airflow to meet the pressure demands of a poorly designed minor branch.

M Vented Dryer Elimination

Applicability: Residential

Eliminate vented clothes dryers in dwelling units and eliminate multi-story dryer exhaust systems. Replace with heat pump condensing type dryers. Install dryers in closets with manufacturer recommended cooling openings or install signage to open the closet door during dryer operation. Dryers are used infrequently (~1-3% of hours) and the background exhaust wastes cooling and heating energy 99-97% of the time. Condensing dryers, when operated properly, reduce building heating loads during the heating season. The additional cooling load during the cooling season is easily offset by the elimination of background ventilation. In buildings without sufficient fresh air ductwork infrastructure, abandoned duct risers can be cleaned and repurposed for ventilation.

N Ventilation Rate Codes

Applicability: All

Perform calculations to establish required ventilation rates for all spaces under the current NYC Mechanical Code or ASHRAE 62.1 and re-balance air systems accordingly. Many spaces will have been over-ventilated compared to these standards. Provide pressure independent airflow controls to maintain required outside airflow rates under varying supply airflows.

O Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability.[38]

Level 3

P Energy Recovery Ventilation Systems

Applicability: All

Install energy recovery systems to recover energy from exhaust systems to preheat/precool outside air intakes. This may involve rerouting exhaust and intake ducts to pass through enthalpy wheels, adjusting fan speeds, replacing fan motors or adding booster fans where necessary, or installation of glycol runaround loops where duct rerouting is not feasible or exhaust streams do not permit the use of enthalpy wheels.

Where retrofits to central ventilation systems are impossible, provide unitary through wall ERVs for classrooms, dwelling/sleeping units, and smaller offices as new mechanical codes will facilitate the application of these devices. Transitioning away from vertically distributed ventilation systems and sealing openings in horizontal assemblies can reduce stack driven infiltration. Smaller ventilation systems can also more easily be operated according to the individual classroom, dwelling unit, or tenant needs reducing energy demand for heating, cooling, and air movement.

Q Concealed Duct Fitting Improvements

Applicability: All

Improve poorly designed concealed fittings based on as-built and sheet metal shop drawings:

- Replace all sharp throat elbows with mitered elbows with turning vanes where design velocities exceed 700 FPM
- Provide a 6” bellmouth or 8” 45° chamfered bevel on all louver plenum connections where existing connections are hard 90° taps including within air handler casings
- Install splitter vanes in all exposed short radius elbows (inside radius < 0.75 times duct dimension in the plane of the turn)
- Install splitter vanes in all radiused elbows (even long radius) less than 3x duct width (in the plane of the turn) upstream of the next fitting/takeoff
- Install bellmouth, transition or wye type takeoffs for all VAV box inlet ductwork connected to mains with hard taps

R Adsorbent/Desiccant Air-Cleaners

Applicability: Non-Residential

Install adsorbent type air cleaners to reduce outside air intake and relief air flowrates. Desiccant/adsorbent type air cleaners adsorb common gaseous contaminants including CO_2, ammonia, and VOCs from return air reducing the amount of outside air needed to maintain acceptable indoor air quality compared to traditional dilution only systems. These systems continuously or periodically regenerate desiccants discharging collected contaminants into the exhaust air. By using the ASHRAE standard 62.1 IAQ method together with proven air cleaning devices ventilation rates can typically be reduced.[39]

This will also pair well with IAQ verification and monitoring interventions. Refer to Table 16 for guidance.

Automatic Controls – Air Systems

Level 1

A Filter Monitoring

Applicability: All

Monitor pressure drop of major equipment filters through the controls system.

B Unoccupied Setpoints

Applicability: All

Consider unoccupied/temporary unoccupied setback temperature enforcement except for critical spaces (people at home during the day, people with disabilities, spaces with capacity or orientation issues limiting temperature recovery speed e.g. daytime cooling setbacks for west facing living rooms).

C HVAC Vacancy Response

Applicability: Non-Residential

Program HVAC zones to provide zero airflow under zero load conditions when during normal opening hours zero occupancy is detected in offices, conference rooms, and similar spaces on a space by space basis. CO_2 sensors may not be used since they do not positively detect zero occupancy. Vacancy detection can be shared with lighting systems, however, line voltage lighting vacancy systems may present challenges as rooms may be occupied even when lights are not switched on and should be ventilated during those conditions. Vacancy detection systems can also temporarily relax HVAC system setpoints, but this should be balanced with the ability of systems to bring the space back to the desired temperature. Consider occupancy responsive thermostats with automatic set back when spaces become unoccupied. These thermostats can also signal ventilation systems to reduce their output when they detect vacancy.

D Pressure Independent Ventilation Control

Applicability: Non-Residential

Install pressure independent control of outside air intake and exhaust airflow to guard against over ventilation and improper building pressurization particularly during supply air economizer modes. Depending on air handler configuration, this may include piezometer rings on fans or airflow stations

E Pneumatic Controls

Applicability: All

Replace pneumatic actuators and controls with electronic actuators and direct digital controls.

F Fan Variable Frequency Drives

Applicability: Non-Residential

Remove inlet guide vanes, discharge dampers, and other technologies for using constant speed fans in variable volume applications and retrofit variable frequency drives to Variable Air Volume (VAV) and other pressure and volume-controlled systems.

G Static Pressure Reset

Applicability: Non-Residential

Implement static pressure reset based on the VAV box damper position.

H Supply Air Temperature Reset

Applicability: Non-Residential

Implement supply air temperature reset when space or outdoor dewpoint and temperature allows. This is particularly beneficial in equipment with a supply air economizer as it will expand the footprint of non-mechanical cooling. In systems with water economizer, this may allow warmer distribution temperatures in the shoulder season allowing improvements in chiller efficiency and an expansion of the operating footprint of water economizers. This will be most effective when temperature optimization routines take into account terminal fan energy as well as central plan energy efficiency.

I Variable Speed Pumping

Applicability: All

Install pressure, flow, or temperature based variable speed controls on pumps as appropriate to system and piping distribution. In constant volume pumping systems that cannot be converted to variable speed due to equipment limitations, three way valves, or missing valves but which have pump balancing valves set to throttle more than 10% of the head at the operating point, replace the pump with a variable speed pump or trim the impeller so the balancing valve can be fully opened or removed. Installing VFDs even if the system may remain constant volume for some time, will still be an economically viable retrofit. It will also facilitate progressive conversion to variable flow in the system.

Level 2

J Building Pressurization Control

Applicability: All

In tall buildings, some ventilation systems may benefit from increased airflow or pressure settings in proportion to outside temperatures falling below 60°F. In apartments this may be accomplished by proportionally balancing more airflow to lower floor corridors and gradually increasing fan speeds (where equipment has available capacity) as temperatures decrease. In office buildings, this can be accomplished by reducing relief airflows from lower floors or increasing the difference between the amount of outside air introduced and the amount of exhaust taken out of lower floors as temperatures decrease. This can reduce stack driven infiltration at lobbies.

K Demand-Controlled Ventilation ♥

Applicability: Non-Residential

Install demand-controlled ventilation systems. Requires occupancy detection in non-dense spaces and CO_2 sensors in densely occupied spaces. Sensors must be installed in all occupied spaces to be provided with DCV. Using return air-based CO_2 by itself has no support in cognizant technical standards or codes and is unlikely to deliver required IAQ due to independent variations in occupancy rates between different spaces served by a single air handler. For example, a conference room might be full of people for a lunch meeting while a large open office area might nearly vacant. Sensing only the return air in this scenario would cause significant IAQ issues for the conference room.

L Automatic Fault Detection and Diagnosis

Applicability: All

Install automatic fault detection and diagnosis routines. These routines compare system behavior to a heuristic model to find potential problems. For example, an economizer Fault Detection and Diagnosis (FDD), which detects an increase in chilled water flow when switching from normal to economizer mode, would register a fault with the economizer.

Level 3

N/A

Piping: General

Level 1

A Valve Balancing

Applicability: All

Install balancing valves, pressure independent balancing devices, or pressure independent control valves in systems where balancing devices are missing.

B Water Chemistry and Quality

Applicability: All

Install filtration of open and closed systems. Fouling and corrosion can reduce equipment efficiency. Provide side stream high-efficiency sand filters for open systems and bypass high-efficiency cartridge or bag filters for closed systems.

Level 2

C 3-Way Valves

Applicability: All

Remove 3-way valves and replace them with 2-way valves. If a small number are installed to limit end of run stagnation, install a dedicated 2-way valve for this purpose controlled on pipe temperature. If the end of run 3-way valves is also for minimum circulating thermal mass and minimum central plant equipment flow, ensure bypass legs have their own balancing valves, but leave as is.

Level 3

N/A

Piping: Cooling

Level 1

N/A

Level 2

A Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability. Higher efficiency and variable speed chillers can easily be paired with a refrigerant change.[40]

Level 3

B Low Global Warming Potential (GWP) Refrigerants ❤

Applicability: Chilled Water Systems

Retrofit or replace high-GWP and high-Ozone Depletion Potential (ODP) refrigerant equipment to less harmful refrigerants. Refrigerants should have an ODP of zero and a GWP of less than 50.[41] This upgrade is more straightforward if this is pursued as part of energy efficiency upgrades to central plants or planned chiller replacement.

A study of New York State multifamily building retrofits showed that average reductions in energy consumption were 23%, comprised of a 17% and 28% reduction in electricity and heating fuel (gas, oil, district steam) respectively.[42]

Automatic Controls - Piping: Cooling

Level 1

A Chiller Plant Btu/Flow Meters

Applicability: Chilled Water Systems

Install flow meters on chilled water and condenser water connections to chillers and economizer heat exchangers for more accurate control of water flows.

B Chilled Water Supply Temperature Reset

Applicability: Chilled Water Systems

Install building humidity sensors and weather stations with outside air humidity to allow chilled water supply temperature optimization based on outside air temperature, outside air dewpoint, indoor humidity, and load.

Level 2

C Chiller Plant Optimization

Applicability: Chilled Water Systems

Install chilled water plant optimization software that optimizes plant performance based on performance parameters of all plant equipment, load, weather, air handler dehumidification requirements (based on outdoor humidity levels, indoor humidity levels, or both), and cooling demands, and fan and pump energy from cooling towers right through to air handler fans.

Level 3

N/A

Piping: Heat Rejection

Level 1

A Passive Heat Recovery for Domestic Hot Water

Applicability: Residential

Install heat exchangers to preheat domestic hot water using waste heat from a heat pump loop or condenser water loop during cooling and shoulder modes.

Level 2

B Remote Sumps for Basin Heating

Applicability: All

Install remote sump systems or automated drain down vessels in lieu of operating high-capacity basin heaters during freezing conditions when no heat rejection is required.

C Storage for Passive Heat Recovery

Applicability: Residential

Install storage tanks to diurnally store heated domestic hot water or HVAC system water at temperatures suitable for preheating. To reduce legionella risks, do not configure systems to store domestic water between 70°F and 140°F. Storage within that temperature range should remain on the non-potable side of a domestic water heat exchanger which meets instantaneous preheating demands to limit legionella risk.

D Active Heat Recovery Water Heating

Applicability: Residential

Install heat pumps to recover waste heat from condenser water or chilled water systems for domestic water heating loads. Ideally, size domestic hot water storage tanks for such systems to allow heat recovery systems to continuously extract heat from condenser water systems 24 hours a day. This is beneficial because the domestic hot water peak typically occurs for an hour or two about 12 to 14 hours after the heat rejection peak load.

E Heat Recovery for Simultaneous Loads

Applicability: Non-Residential

Install dedicated heat recovery chillers to recover heat for dehumidification reheat during the summer and simultaneous heating and cooling loads during the shoulder season and winter months.

F Condenser Water Flow Control

Applicability: All

Install water regulating valves/control valves where they are missing on unitary equipment and provide modulating condenser water valves on chillers to meet varying flow and head pressure requirements under varying loads and condenser water temperatures.

G Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability.[43]

Level 3

N/A

Automatic Controls - Piping: Heat Rejection

Level 1

A Wet-Bulb Reset Controls-Heat Pumps

Applicability: Heat Pump Loops

Rewrite temperature controls to detect heating dominated, shoulder season/swing day, and cooling dominated modes of operation.

- Cooling dominated mode resets water temperature based on outside air wet-bulb temperature. This will optimize condenser water temperature for peak cooling efficiency during the peak cooling season.
- Shoulder mode will allow swing day cooling loads to increase loop temperatures to up to about the maximum supply temperature for heat pumps to operate in heating mode before rejecting heat through the cooling tower and will allow the loop supply temperature to get as low as 10°F above the outdoor dewpoint with a minimum of 55°F. This will maximize the transfer of heat from cooling loads to heating loads within the building and maximize the diurnal storage of thermal energy in the building loop while mitigating a condensation risk on the surface of uninsulated pipes
- Heating mode will increase the minimum supply water temperature from shoulder mode to a value better suited to efficient operation of heat pumps. Passive condenser water heat recovery systems might be disabled if the loads they are preconditioning use the same fuel. For example, steam fired domestic hot water system using the heat pump loop for preheat, should have its preheat inactive while

steam is also being used to support heat pump loop temperature. But where an air to water heat pump is the heat source, such systems would continue to operate

- Verify the proper functioning of wet-bulb reset programming and associated humidity sensors. Consider using National Oceanic and Atmospheric Administration (NOAA) humidity data if local sensors are unreliable. Ensure programming does not try to achieve an approach that continuously runs cooling tower fans at maximum speed regardless of load

Level 2

B Cooling Tower Fan VFDs

Applicability: All

Install VFDs on tower fans to maintain cold water basin setpoint rather than cycling fans.

C Cell by Cell Turndown

Applicability: All

Install flow meters or configure pump VFDs to approximate system flow and provide hot deck, cold basin, and equalizer valves on each cell to provide an appropriate system turn down under reduced loads.

Level 3

N/A

Piping: Heating

Level 1

A Distribution Temperatures

Applicability: Hot Water Systems 115-140°F, Hot Water Systems > 140°F

Identify opportunities to lower supply water temperatures and reduce water flow rates to existing equipment due to issues such as oversizing of existing terminal equipment. Typically, existing equipment will be capable of satisfying loads at reduced hot water temperatures without interventions or with potentially very limited interventions to a small subset of equipment or areas.

Level 2

B Conversion of Cooling Coils to Dual Temperature Operation

Applicability: Chilled Water Systems

Change AHU and fan coil cooling coils to dual temperature coils and remove AHU heating coils. This will allow AHUs to have the same heating duty with lower water flow rates, higher water temperature drops and/or lower supply water temperatures. Aligned water chemistry programs and parameters in hot and chilled water systems so they are not incompatible. Removing heating coils will reduce air handler pressure drops and generate scrap metal value. The lower temperature requirements will make it easier to use air to water heat pumps required in electrification interventions.

C Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability.[44]

Level 3

N/A

Automatic Controls - Piping: Heating

Level 1

A Outside Air Reset

Applicability: All

Install outside air reset controls for hot water perimeter and outside air heating systems including hydronic Packaged Terminal Air Conditioners (PTACs), and, critically, any systems not presently fitted with terminal control valves. For systems that cannot produce different temperatures for different load types, consider reconfiguring pumping to allow for higher temperature distribution to loads which more consistently require higher temperatures.

Level 2

B Perimeter Heating Valves, Cooling Interlock

Applicability: All

Install control valves at all radiators/finned tube systems. Interlock controls with air conditioning to prevent valves from being open when the space temperature is less than 5°F below space cooling setpoint. All construction within the last 15 years should already be compliant since this has been a long-standing mandatory requirement of energy code.

Level 3

N/A

Unitary Equipment

Level 1

A Through Wall AC Infiltration

Applicability: PTAC, Through Wall

Inspect for and repair air leakage at through wall equipment chassis/sleeve seals. This applies typically to PTACs, Packaged Terminal Heat Pumps (PTHPs), and especially to through wall AC units where tenants are expected to provide their own AC units to match existing, proprietary wall sleeves.

B Terminal Equipment GWP Reduction ❤

Applicability: Water Loop Heat Pumps, PTAC, Through Wall

Install replacement equipment that uses low-GWP refrigerants.

Level 2

C Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability.[45]

Level 3

D PTAC Replacement with PTHP

Applicability: PTAC, Through Wall

Replace cooling only chassis in hydronic/steam PTACs with heat pump chassis programmed to switch to heating sources at a preprogrammed low-outside air temperature based on carbon efficiency of heat pump operation compared to existing fossil fuel systems. At the time of replacement, only low-GWP refrigerants should be used.

Automatic Controls – Unitary Equipment

Level 1

A Programmable Thermostats

Applicability: Water Loop Heat Pumps, PTAC

Install 7-day programmable thermostats to replace mechanical and non-programmable thermostats.

Level 2

B Communicating Thermostats and Demand Response

Applicability: All

Install communicating controls on terminal equipment for demand limiting and weather responsive controls. For example, an air source heat pump system could temporarily maintain a higher setpoint during milder weather preceding a colder period when setpoints would be progressively lowered. This would allow the building thermal mass to store heat produced more efficiently. This could also be used to lock out cooling when natural ventilation would suffice.

Level 3

N/A

Steam Systems

Level 1

A Distribution Pressure Reduction for Radiators

Applicability: All

Audit peripheral and main air venting performance to reduce steam supply pressure to radiators to 0.5-2 Pounds per Square Inch, Gauge (PSIG) if possible. Adding steam traps or vents at the ends of risers or long horizontal runs that are taking a long time to heat will allow lower operating pressures. In two-pipe steam, providing steam traps to route air back to the main vent in the boiler room is generally preferable to providing air vents on piping since traps will more effectively and quietly pass air into the condensate system on startup.

B Modulating Burners

Applicability: Two-Pipe Steam

Install modulating burners on boilers for two-pipe steam systems to reduce burner cycling. With each burner cycle, cold air is introduced into the boiler and vent stack as part of the end of combustion and start of combustion safeties. This cools the boiler down significantly. A modulating burner reduces this wasted energy by reducing burner output when the full output is not required. Modulating burners can also reduce moisture carryover by throttling output during cold starts as pressure builds in the system. One-pipe systems are usually much smaller than two-pipe systems making modulating burner retrofits less cost effective and are generally designed to cycle regularly since control of individual radiators requires complicated valve trim and cannot be accomplished with manual valves. Because of their size and the types of buildings, they are applied to one-pipe systems are usually straightforward candidates for removal and replacement with split heat pumps like VRF.

C Orifice Plates

Applicability: Two-Pipe Steam

Install orifice plates on small steam coils with manual or two position valves. This should be pursued where overheating and steam trap maintenance are issues. This need not be combined with thermostatic radiator valve interventions.

Level 2

D Recovering Flash Steam

Applicability: District Steam

Pipe flash tanks to feed low-pressure systems or use heat exchangers to cool condensate ahead of flash tanks. Minimize venting and losses of flash steam.

Level 3

E Steam System Removal

Applicability: All

Have a plan to remove steam systems within 10 years. Steam systems cannot be efficiently decarbonized from the central plant. Heating will need to be provided by air source heat pumps instead. Steam piping systems generally cannot be reused for hydronic duty due to their smaller size and lower pressure rating.

Automatic Controls – Steam Systems

Level 1

A Steam Cycle Controls for Perimeter Heat

Applicability: All

Install outside air reset steam cycle controls on perimeter heating systems. Provide zoning by orientation or even per riser. Carefully tune steam cycle controls for perimeter heating systems without widely deployed terminal thermostatic controls to avoid overheating by reducing cycle times for overheated spaces and increasing cycle times for cold areas. Audit end of line air vents and traps to avoid overheating most spaces to satisfy cold rooms at the end of poorly vented lines.

B Radiator Valves

Applicability: All

Install appropriately sized (low flow rate) thermostatic radiator control valves on perimeter heating systems where no air conditioning is installed or separate unitary air conditioning systems such as through wall or window air conditioning units are installed. For one-pipe systems install thermostatic radiator valves and vacuum breakers between the radiator and the air vent.

C Cooling Interlocks

Applicability: All

Install electronic control valves interlocked with zone cooling on perimeter heating systems where HVAC systems are permanently installed.

Level 2

D Condensate Temperature Monitoring

Applicability: Two-Pipe Steam

Install condensate riser temperature sensors to identify steam leaks by riser.

Level 3

N/A

Lighting

Lighting Levels

Level 1

A Illuminance Levels

Applicability: All

Ensure that room illuminance values are aligned with those recommended in the most current version of Illuminating Engineering Society (IES) Lighting Handbook as shown in Table 1 through modifying/adding/removing/replacing existing fixtures.[46] Best practice and guidance on testing standards and locations can be found in the Light chapter of The WELL Performance Verification Guidebook.[47]

B Lighting Power Density

Applicability: All

Ensure that fixture lighting power density (LPD) values are at least 20% better than those in the most current version of ASHRAE 90.1, as shown in Table 1. [48]

C Light Emitting Diode (LED) Lamps

Applicability: All

LED lamps to be specified for all new fixtures and lamp retrofits.

D Sun Glare Control

Applicability: All

Undertake one or more of the following sun glare control measures:

- Interior Glare Control Strategies: Install internal shading for all exterior envelope glazing. Atria or lobbies may be excluded. The shading is controllable by the occupants or set to automatically prevent glare. If shading is controlled by occupants, all shades are raised or retracted either manually or automatically at least twice per week
- Exterior Glare Control Strategies: Add exterior window shading to reduce cooling loads and/or add light shelves to reduce the use of artificial lighting. Confirm the structural stability of glazing frames to support exterior window shading elements and light shelves
- Glare Control Analysis: Perform a daylighting and energy analysis to determine the optimal location, size, shape, length, distance, and depth of shading elements or light shelves for visual comfort and energy load reduction. Target the following values:
    - Target over 75% Spatial Daylight Autonomy to provide ample daylight in regularly occupied spaces
    - Target a maximum of 20% Annual Sunlight Exposure to limit potential glare in regularly occupied spaces
    - Design shading elements and light shelves to avert excessive cooling loads but allow useful heat into the building
    - Shading elements and light shelves should not overly obstruct visual connection to the exterior

E Magnetic Ballasts

Applicability: All

Inspect lighting ballasts and remove any magnetic ballasts. Refer to the Materials & Waste, Intervention, Healthy Materials, Red List Material Compliance for additional guidance.

Level 2

F Access to Daylight – Non-Residential

Applicability: Non-Residential

Ensure one of the following is met as per the most current version of the WELL standard[49]:

- Spatial Daylight Autonomy of $sDA_{200/40\%}$ is achieved for at least 30% of regularly occupied space
- 30% of all workstations are within 20 ft of transparent envelope glazing. Visible light transmittance (VLT) of transparent glazing is greater than 40%

G Access to Daylight - Residential

Applicability: Residential

Ensure that Spatial Daylight Autonomy of $sDA_{200/40\%}$ is achieved for at least 30% of the space as per the most current version of the WELL standard.[50]

H Fixture Color Rendering

Applicability: All

Electric lighting except those in circulation areas meets one of the following (excluding decorative, emergency, and other special purpose lighting) as per the most current version of the WELL standard [50]:

- CRI>90
- CRI >80 with R9>50
- IES $R_f \geq 78$, IES $R_g \geq 100$, $-1\% \leq$ IES $R_{cs,h1} \leq 15\%$

I Circadian Lighting Design

Applicability: All

Light levels of at least 150 EML [136 melanopic equivalent daylight D65] OR 120 EML with light fixtures measured on the vertical plane at eye level at least between 9 AM-1 PM as per the most current version of the WELL standard.[51] Best practice and guidance on testing standards and locations can be found in the Light chapter of The WELL Performance Verification Guidebook.[52]

J Fixture Flicker

Applicability: All

As per the most current version of the WELL standard, all electric lights (except decorative lights, emergency lights, and other special purpose lighting) used in regularly occupied spaces either[53]:

- Have a minimum frequency of 90 Hz at all 10% light output intervals from 10% to 100% light output
- Are LED products with a low-risk level of flicker (light modulation) of less than 5%, especially below 90 Hz operation as defined by the Institute of Electrical and Electronics Engineers (IEEE) standard 1789-2015 LED

K Electric Lighting Glare Control

Applicability: All

If possible, download and import fixture photometry IES file from the manufacturer's website into AGI32[54] to ensure each luminaire (excluding wall wash fixtures aimed at walls and decorative fixtures) meets one of the following for regularly occupied spaces as per the most current version of the WELL standard [55]:

- 100% of light is emitted above the horizontal plane
- Unified Glare Rating (UGR) values are met as per the below conditions:

- Luminaires installed at a height of 16 ft or lower meet UGR of 19 or lower
- Luminaires installed at a height greater than 16 ft meet UGR of 22 or lower

- Fixtures have a luminance of less than 10,000 cd/m² between 45 and 90 degrees from nadir, and/or an intensity of less than 1,000 candela between 45 and 90 degrees from nadir
- Shielding angles are as described in Table 3

L Balanced Lighting ❤

Applicability: All

Meet at least four of the following in all regularly occupied spaces as per the most current version of the WELL standard[56]:

- Main rooms do not exhibit 10 times greater or lesser luminance than an ancillary space. This is to avoid substantial changes in light levels as occupants move from one space to another
- Surfaces do not exhibit 3 times greater or lesser luminance than an adjacent surface. This is to avoid substantial changes in light levels as occupants look around their immediate area
- Surfaces do not exhibit 10 times greater or lesser luminance than another remote surface in the same room. This is to avoid substantial changes in light levels as occupants look around the room
- Changes in light levels to 1.5 times higher or lower than initial light levels are carried out for at least 30 minutes in steps or with a smooth transition. Timing considerations in the rate of change of light levels or spectrum diminish abrupt or disruptive lighting transitions
- Uniformity of at least 0.4 is achieved on work planes. Exclude supplemental lighting from calculations
- One section of the ceiling does not exhibit 10 times greater or lesser luminance than another section of the ceiling in the same room. Distribution of light across ceilings in a given room that maintains lighting variety but avoids both dark spots and bright spots

M Light Pollution ❤

Applicability: All

See Dark-Sky Association for recommendations on mitigating the impact of artificial light at night (light pollution) and consider the specification of Dark Sky Approved fixtures.[57] All outdoor lighting should be installed in conformance with the provisions of the Model Lighting Ordinance (MLO) Requirements for Lighting Zone 2.[58]

Indoor lighting (considering both fixture design and controls) should be designed to limit trespass of light out of the façade. All lighting should be designed to limit trespass of light outside of project boundary.

Level 3

N Access to Daylight – Non-Residential ❤

Applicability: Non-Residential

Ensure one of the following is met as per the most current version of the WELL standard[59]:

- $sDA_{300,50\%}$ is achieved for 55% of regularly occupied floor area (industry best practice is 75%)
- 70% of all workstations are within 25 ft of transparent envelope glazing or atria. Visible light transmittance (VLT) of transparent glazing is greater than 40%
- The window area is no less than 10% of the floor area. Visible light transmittance (VLT) of transparent glazing is greater than 40%.

O Access to Daylight - Residential ❤

Applicability: Residential

Ensure one of the following is met as per the most current version of the WELL standard[60]:

- $sDA_{300,50\%}$ is achieved for 55% of regularly occupied floor area in each dwelling (industry best practice is 75%)
- The window area is no less than 10% of the floor area. Visible light transmittance (VLT) of transparent glazing is greater than 40%

P Circadian Lighting Design ❤

Applicability: All

Light levels of at least 240 EML [136 melanopic equivalent daylight D65] OR 180 EML with light fixtures measured on the vertical plane at eye level at least between 9 AM-1 PM as per the most current version of the WELL standard.[61]

Q Quality Views ❤

Applicability: All

Transparent envelope glazing provides access to views for at least 50% of regular building occupants. Views meet at least two of the following as per the most current version of the WELL standard.[62]

- If at ground floor, distance from fenestration to the roadway is at least 25 ft from the exterior of the glazing
- View factor of 3 or greater[63]
- Views with a vertical view angle of at least 30 degrees from occupant facing forward or sideways provide a direct line of sight to the ground or sky

R Annual Sunlight Exposure ❤

Applicability: All

Ensure Annual sunlight exposure of $ASE_{1000,250}$ is achieved for no more than 10% of regularly occupied space as per the most current version of the WELL standard.[64]

Table 3: WELL Version 2 (2020) Shielding Angles[65]

Luminance	Shielding angle (α = 90 - cutoff angle)
< 20,000 cd/m² (including reflected sources)	No shielding required
20,000 cd/m² to 50,000 cd/m²	15°
50,000 cd/m² to 500,000 cd/m²	20°
> 500,000 cd/m²	30°

Lighting accounts for 17% of the electricity use in NYC commercial buildings. Lighting upgrades are the most frequently recommended energy conservation measures, in both multifamily and office buildings.[66]

Automatic Controls – Lighting

Level 1

A Outdoor Lighting

Applicability: All

Install sensor controlled light fixtures for entrances, outside parking areas, loading bays, etc.

See Dark-Sky Association for recommendations on mitigating the impact of artificial light at night (light pollution) and consider the specification of Dark Sky Approved fixtures.[67]

B Smart Lighting ❤

Applicability: Residential

Install sensor-controlled LED smart lighting to provide time and dimming control for occupied spaces.

C Daylight Harvesting

Applicability: Non-Residential

Daylight harvesting controls (either dimming or switching) to be incorporated in areas where daylight is present in sufficient quantities to serve as the primary source of lights for a space or area.

Level 2

D Motion Sensors and Time Controls

Applicability: All

Motion sensors and/ or time control should be incorporated in the following low-occupancy space types, where appropriate:

- Corridors
- Common Stairs
- Storage rooms
- Bathrooms

E Occupant Control ❤

Applicability: All

Ambient lighting systems in regularly occupied spaces meet the following:

- Light systems are tunable and automated to meet the circadian and visual requirements of the occupants
- Occupants have control of light levels, color temperature, and color of electric light in their immediate environment and can override automated settings for at least 30% of operating hours

F Lighting Schedule

Applicability: Non-Residential

Establish a lighting control schedule that involves a significant reduction in light pollution through dimming or turning off lights.

Level 3

N/A

Appliances and Plug Loads

Level 1

A ENERGY STAR Rating

Applicability: All

All new and replacement appliances must have an ENERGY STAR rating.

B Refrigerator Placement

Applicability: All

Place the refrigerator away from the stove, dishwasher, or heat vents or exposed to direct sunlight. Ensure that airflow and clearances around refrigerators meet or exceed manufacturer's required clearances.

C Plug-In Heaters

Applicability: All

Locate and discard all space heaters. Provide comfort air balancing and local conditions reviews to ensure occupant comfort is maintained.

D Advanced Power Strips

Applicability: All

Install tier 1 or 2 advanced power strips to reduce vampire loads by automatically turning the power off when appliances (including laptops etc.) are not being used.[68]

Level 2

E Automatic Receptacles

Applicability: All

Install occupancy controls on at least 50% of receptacles. Instruct tenants to use controlled receptacles for phone chargers, laptop computers, monitors, printers, plug-in lighting, and other devices which do not need power when people aren't around.

F Receptacle and Lighting Master Switch

Applicability: All

Provide a master switch or control to switch off all automatically controlled receptacles, switched receptacles, and non-emergency lighting within a space. Where required, this function may be secured physically or by software during business hours.

G IT Power Saving Settings

Applicability: Non-Residential

Work with IT departments to configure equipment to enter power off-suspend states when not in active use. Configure wake on LAN or scheduled power-on settings so that powered off equipment can update the software after hours. Set software alarms for high personal computer uptime.

H Set Top Boxes

Applicability: Residential

Require that set top boxes meet power consumption standards. Avoid top boxes, including DVRs, requiring more than 10kWh per year or with more than 1W standby consumption.

Level 3

N/A

Domestic Hot Water

Domestic Hot Water Systems

Level 1

A Recirculation System Balancing

Applicability: Central Systems

Balance domestic hot water temperature maintenance systems (recirculation systems). Some risers may have insufficient recirculation flow causing a delay in the arrival of water of adequate temperature.

Level 2

B Heat Recovery from HVAC Systems

Applicability: Central Systems

See Energy, Deep Energy Retrofits, Intervention, HVAC, Piping: Heat Rejection, Passive Heat Recovery for Domestic Hot Water, Storage for Passive Heat Recovery, and Heat Recovery for Simultaneous Loads interventions for opportunities to recover waste heat from HVAC systems.

C Lavatory Pipe Sizes and Heaters

Applicability: Distributed Systems

Lavatories that have been retrofit with 0.5 Gallons Per Minute (GPM) aerators generally result in existing piping being oversized and too far from a heater or recirculation system for the new, reduced flows. Install appropriately sized piping—which may be as small as 3/8”—to reduce lag time for hot water delivery. Consider relocating heaters closer to lavatories or installing instantaneous heaters under the counter at banks of lavatories.

D Replacement Equipment Efficiency

Applicability: All

Ensure new and replaced equipment demonstrate a 20% efficiency improvement upon NYCECC dependent on market availability.[69]

Level 3

E Sewage Heat Recovery Heat Pumps

Applicability: Central Systems

Install heat pump type water heaters that use sewage as a heat source to provide domestic water heating in lieu of gas or electric resistance type heaters. These systems will typically require providing wastewater storage and increased domestic hot water storage.

Automatic Controls – Domestic Hot Water

Level 1

A Recirculation System Temperature and Time of Day Controls

Applicability: Central Systems

Install controls that turn off recirculation systems at hours when they are not required or when adequate temperature has been reached in the system. Controls should also bring the entire system to adequate temperature often enough and for long enough to reduce the risk of legionella growth.

B Electric Hot Water Heater Time of Day Controls

Applicability: Distributed Systems

Shut off distributed electric hot water heaters outside of business hours. Configure controls to heat water hot enough, long enough, and often enough to mitigate microbial growth when otherwise out of use.

Level 2

C Riser Recirculation Controls

Applicability: Central Systems

Install controls at the top of each domestic hot water riser to manage recirculation demands on a per riser basis. This will result in reduce running time of recirculation pumps since the sensor that activates the pump is closer to the last load. It will also reduce standby losses from recirculation return piping since the system only seeks to maintain the temperature at the fixture. This eliminates the need to balance each riser since a small pump will be dedicated to each riser or a small cluster of risers.

Level 3

N/A

Vertical Transportation

Vertical Transportation Systems

Level 1

A Access to Stairways

Applicability: All

Designate at least one stairway that allows building users to travel between floors. Codes or key cards can be used to address safety concerns.

B Stairway Use Encouragement

Applicability: All

Encourage the use of stairways through the use of active design elements:

- Install signage to encourage stair use, both inside and outside of stairways. Signage outside of stairways should direct building users toward stairways, particularly in elevator lobbies, and at corridor junctions that lead to either stairways or other types of vertical transportation (i.e. elevators or escalators). See the Center for Active Design for further guidance on promoting health through design.[70]
- Install glazing, fire-rated where applicable, at eye level between 5'7" and 6'5", in all accessible stairway doors, to increase the visibility of stairways and the sense of safety while using them. The glazing should encompass at least half of the door area for ground floor doors and a third of the door area for all other floors
- Install magnetic strips to hold doors open to increase the visibility of stairways and the sense of safety while using them. Doors shall be capable of being released if smoke is detected
- Make stairways aesthetically inviting through at least two of the following per floor as per the most current version of the WELL standard[71]:
    - Music
    - Artwork
    - Light levels of at least 215 lux when in use
    - Views of an interior atrium, courtyard or daylight via windows or skylights
    - Natural design elements (e.g., plants, water features, images of nature)
    - Gamification

C Elevator Cab Energy Improvements

Applicability: Hydraulic Elevators, Traction Elevators

Ensure new and replaced in-cab elements (i.e. lighting and ventilation) demonstrate a 20% efficiency improvement upon the most current version of the NYCECC dependent on market availability.[72] See Table 4 for reference.

Level 2

D Motor Replacement

Applicability: All

Where possible, motors should be replaced with gearless, Permanent Magnet (PM) synchronous motors with solid-state electronic inverters. These should employ regenerative line side converters that supply electrical energy to the building electrical system.

E Hoistway Smoke Vent Performance

Applicability: Hydraulic Elevators, Traction Elevators

Provide air sealing and proper insulation of elevator bulkheads, particularly around machine room doors access doors and parapets. Provide AMCA Class 1A low leakage dampers at hoistway smoke vents. Provide with local manual controls in accordance with the "hinged openable damper" language of the elevator code or interface with fire alarm system. Provide two or more dampers in series for hoistways taller than 180 feet. Do not use barometric or back draft dampers. Do not leave open "smoke holes". If future codes permit removal of hoistway smoke vents, make building alterations to allow for removal and complete sealing of existing hoistway smoke vents.[73]

F Escalator and Moving Walkway Drive Replacement

Applicability: Escalators & Moving Walkways

When replacing escalator and moving walkway drive, they should meet the requirements in the NYCECC[74]:

- Install either automatic controls configured to reduce speed to a minimum when not in use, or a variable voltage drive system that reduces operating voltage in response to light loading conditions.
- Escalators designed either for one-way down operation only or for reversible operation should have a variable frequency regenerative drive that supplies electrical energy to the building electrical system when the escalator is loaded with passengers whose combined weight exceeds 750 pounds.

Level 3

G Hydraulic Elevator Phase-Out

Applicability: Hydraulic Elevators

Where feasible, look to phase-out hydraulic elevators in favor of traction elevators. Otherwise, focus on cab energy improvements such as lighting, ventilation, and door-operating motors.

Table 4: NYCECC (2020) Performance Criteria for Elevator Equipment and Cabs[75]

Equipment	Performance Criteria
Luminaires	35 lumens/W
Ventilation Fans	0.33 W/CFM

Automatic Controls – Vertical Transportation

Level 1

A Elevator Software Controls – Level 1

Applicability: Hydraulic Elevators, Traction Elevators

Controls shall be provided that will de-energize ventilation fans and lighting systems when the elevator is stopped, unoccupied and with its doors closed for over 15 minutes.

Level 2

B Elevator Software Controls – Level 2

Applicability: Hydraulic Elevators, Traction Elevators

Employ control strategies to manage elevator groups such as destination dispatch, real-time wait-duration control, standby strategies, and grid response. These strategies should use measured or anticipated usage patterns to optimize elevator usage.

C Elevator Sequential Standby Modes

Applicability: Hydraulic Elevators, Traction Elevators

Employ sequential standby modes that selectively switch off (or put in low energy mode) equipment when not in use, dependent on the duration of inactivity.[76] The first standby mode should turn off equipment with a near-instant restart time such as lighting, ventilation, car displays (i.e. floor indicator), and landing displays. The second mode should turn off equipment with longer restart times such as the drive unit, door operators, car electronics, and light curtains/door detectors.

Level 3

N/A

Building Management System & Sub-Metering

Level 1

A Automatic Fault Detection and Diagnosis

Applicability: All

Install automatic fault detection and diagnosis routines. These routines compare system behavior to a heuristic model to find potential problems. For example, an economizer Fault Detection and Diagnosis (FDD) which detects an increase in chilled water flow when switching from normal to economizer mode would register a fault with the economizer.

Level 2

B Real Time Energy Management – Building Level

Applicability: All

Install Real Time Energy Management (RTEM) systems for live optimization routines. Document the expected behavior of these routines and include expected inputs, outputs, and behavior in graphics so operators do not bypass them and can assist in debugging where behavior becomes counterproductive. Optimization routines should balance tradeoffs between, for example, higher chilled water temperature improving chiller Coefficient of Performance (COP) while increasing AHU fan energy.

Also consider the demand management opportunities of RTEM, in alignment with Feasibility Studies found in: Energy, Building Electrification, Assessment, Building Electrification Feasibility Study and the Energy, Renewable Energy Supply and Storage, Assessment, On-Site Renewable Energy Generation & Storage Feasibility Study.[77]

See NYSERDA's Real Time Energy Management Program for further guidance.[78]

C Data Storage – Building Level

Applicability: All

Install sufficient data storage capacity to retain at least 3 years of data on 10-minute intervals and the last 30 days of data at 30-second intervals.

D Meters

Applicability: All

Install meters while ensuring the following:

- Meters should be permanently installed, record at intervals of one hour or less, and transmit data to a remote location
- Electricity meters should record both consumption and demand. Whole building electricity meters should record the power factor, if appropriate
- The data collection system should use a local area network, building automation system, wireless network, or comparable communication infrastructure
- All meters should be integrated with the automated building system
- The system should be capable of storing all meter data for at least 18 months and the data should be remotely accessible
- All meters in the system should be capable of reporting hourly, daily, monthly, and annual energy use
- Meters should be installed to monitor the energy use of the following equipment:
    - Chillers (each chiller) – energy input and energy extracted
    - Boilers for heating and domestic hot water (each boiler) – energy input and energy extracted
    - Heat pumps – electricity input and heat extracted/supplied
    - Pumps – electricity input
    - Fans with variable speed drive or carbon monoxide sensors – electricity input
    - Thermostats – temperature settings
    - Heat recovery – energy recovered
    - Corridor and stair lighting – electricity use
    - Renewable energy systems – energy produced
    - Energy storage systems – energy stored
    - Water systems - refer to the Water, Water Conservation, Intervention, Metering section for metering of water metering information.
- Ensure the following is incorporated:

- Tracking of building level (core building services) and system level energy use (tenant)
- Electricity meters that record both consumption and demand. Whole building electricity meters that record the power factor
- Meters that feature BACNET or MODBUS protocols
- Integration of Elevator System into BMS

Note that for some of the end-use metering, certain configurations can be grouped i.e. identical corridors across sequential floors.

See Sustainability Implementation Plan for additional resources.

E Sub-Meters

Applicability: All

Install electric/gas/heating hot water/chilled water/domestic hot water sub-meters.

- All logged sub-meter information should be verified to record accurate energy and flow information with a demonstration of data logging and data retrieval capability
- All HVAC and sub-meter data should be recorded for a minimum of 3 years, capable of reporting hourly, daily, monthly, and annual energy use

Refer to the Water, Water Conservation, Intervention, Metering section for metering of water metering information

See Sustainability Implementation Plan for additional resources.

Level 3

F IAQ Monitoring ❤

Applicability: All

Refer to the Materials & Waste, Sustainable Building Materials, Intervention, Healthy Materials, IAQ Monitoring ❤ section for guidance.

Practice

Measurement & Verification

A Data Gathering

Monthly, gather the most granular data available for energy consumption (by end use if possible) in the following units: kBtu/ft^2 , kBtu/resident or kBtu/employee, kBtu/residential unit.

B Ongoing M&V

Perform ongoing measurement and verification using available points on the BMS. Install additional points/sensors where a small number of additional sensors would allow significantly more robust M&V.

If an M&V plan in in place, comply with the current International Performance Measurement and Verification Protocol (IPMVP) Guidelines to ensure that the systems are monitored as intended. This includes verification of energy consumption by end use, production of renewable energy, and monitoring of energy levels for battery energy storage.

Regularly assess whether assumptions made during the energy audit to verify if they are still accurate and that the interventions made have had the anticipated reduction effect. A reassessment might be required if any major changes to the building are made such as those affecting building occupancy schedules.

C Occupant Survey

Conduct a yearly Occupant Survey to identify comfort issues relative to building enclosure or HVAC systems.

Refer to the Energy, Deep Energy Retrofits, Assessment, Audits, Occupant Survey section for guidance.

D Periodic IAQ Data Review

Refer to the Materials & Waste, Sustainable Building Materials, Practice, Measurement & Verification, Periodic IAQ Data Review section for guidance.

Operations & Maintenance

General

A O&M Plan

Develop an O&M plan to outline scheduling, tasks, and procedures for the following systems:

- Envelope
- HVAC
- Lighting
- Appliances
- Domestic Hot Water
- Vertical Transportation
- Building Management System & Sub-Metering

The O&M Plan should include the following at a minimum:

- Descriptions, details, and schedules of installed building services, plants, systems, and controls
- Specific manuals and additional manufacturer's literature, model numbers, methods of operation, and maintenance practices (including preventative maintenance) for installed building equipment, plants, systems, and controls
- Details on the various metering systems and mechanisms that collectively enable energy consumption to be monitored and controlled
- Best practices for maintenance
- Up to date information on newly installed systems

B Soft Landings

Retain consultants responsible for a project's design to advise on operations for the first two years following completion of any project. Soft Landings should begin during initial project stages but after project hand-over, the consultants should provide post occupancy evaluation (POE), technical support, identify opportunities for retro-commissioning, undertake fine-tuning, and engage in longer-term monitoring and review. See BSRIA Soft Landings for further guidance on Soft Landings.[79]

C Ongoing Retro-Commissioning

Retain in-house engineering staff or consultants to provide retro-commissioning, operational intent and recommended practice feedback and support periodically with higher frequency than what is required by NYC Local Law 87 (LL87).

Envelope

A Envelope Maintenance Program

Develop and track a scheduled envelope maintenance program focused on energy efficiency:

- Include visual inspections, audits, and analyses listed in the Energy, Deep Energy Retrofits, Assessment, Audits, Envelope section

- Utilize warranty related inspections
- Use inspection results to plan for repairs and budget for end-of-life replacements and upgrades
- Consider timing inspections with façade Inspection Safety Program (Local Law 11) inspections to utilize scaffolding for shared purposes or other potential economic synergies
- Perform regular envelope maintenance:
    - General: re-caulking, cleaning weep holes, repairing flashing and coping, replacing damaged components
    - Brick with Mixed Glazing: repointing, replacing brick with evidence of staining, spalling, or efflorescence
    - Granite with Mixed Glazing: spot checking anchors
    - Cast-In-Place Concrete with Storefront Glazing: patching cracked concrete
    - Additional maintenance per inspections

B Dirt Prevention ❤

All regularly used entrances to the building with pedestrian traffic to the exterior use an entryway system composed of grilles, grates, slots or rollout mats that are at least the width of the entrance and 10 feet long in the primary direction of travel (sum of indoor and outdoor length). These are cleaned as per below:

- Walk-off mats, indoor and outdoor, are wet-cleaned at least once every two days and fully dry before use
- Underside of entry mats are cleaned at least once a day
- Entry mats are vacuumed using a vacuum with a beater bar in both directions at least once a day

HVAC

A Maintenance Schedule and Practice

Set HVAC maintenance schedules with building staff and external vendors to conform to the most current version of ASHRAE Standard 180.[80]

B Adaptive Maintenance Schedule

Perform inspections and record observations at two to four times higher frequency than required by ASHRAE Standard 180 to establish site and season specific maintenance trends.[81] Modify maintenance frequencies listed in ASHRAE Standard 180 based on observations.

C Thermal Comfort ♥

Review occupant survey data including activity levels, clothing preferences/requirements, demographics, space temperatures, airflows and design information to check thermal comfort performance per ASHRAE standard 55. Adjust dress codes, airflows, and temperatures to resolve comfort issues.

D Filter Maintenance Cycle

Establish an appropriate maintenance cycle for terminal equipment filters by close monitoring for an initial period followed by occasional audits. Reset maintenance cycles at changes in tenancies and occupancies. Check for seasonal variation in filter loading.

E Heat Exchanger Monitoring

Verify the performance of filtration systems by configuring controls to continuously check in-situ heat exchanger approach temperatures. Determine mechanical cleaning requirements and adequacy of the filtration program based on the impact of approach temperature trends. Provide higher levels of filtration efficiency as required to return heat exchanger performance to as designed levels. Consider automatic heat exchanger cleaning systems for chillers.

F Steam Trap Maintenance

Implement programs to regularly audit and repair steam traps and air vents to avoid steam in condensate lines and to ensure rapid distribution of steam to the ends of the system through efficient air venting. Clean strainers on Hartford loops and other low-condensate returns.

G Water Chemistry/Quality

Check corrosion rates at coupon racks annually. Verify performance of chemical treatment systems and programs monthly. If vendor information is not comprehensible, hire a consulting chemical engineer or alternate treatment vendor to audit the program.

H Check Equipment Efficiency

Check heat exchanger approach temperatures, and, where sensor packages allow, check equipment efficiency on a monthly basis. Where checking by the BMS is not possible, check equipment efficiency in situ in the equipment's peak operating season on an annual basis. Reduced efficiency may be indicative of failed controls, fouled heat exchangers, or other failed parts.

Lighting

A Maintenance Schedule and Practice

Set maintenance frequencies with building staff and external vendors to conform to IES/NALMCO Recommended Practice for Lighting Maintenance.[82]

B Degradation of Lamps

Ensure that lamps that have reach end-of-life or failed are replaced. See the Illuminating Engineering Society (IES) Lighting Handbook for life expectancy metrics of different light sources.[83]

C Fixture Lenses

Periodically clean fixtures of dirt and/or insect penetration to maintain/improve the performance of the lighting system.

D Lighting Control and Sensor Settings

Periodically review the settings on lighting controls and sensors based on occupant feedback and preference but ensure that any alterations do not unduly compromise intended energy saving measures

Appliances and Plug Loads

A Plug Load Champion

Applicability: All

Train a member of building staff to help residents or commercial tenants identify and manage wasteful plug loads and provide strategies to enable hard power off.

B IT Energy Champion

Applicability: All

Provide a consultant or trained member of staff who can guide tenant IT organizations to implementation of power saving IT equipment settings.

C Plug-In Heaters

Applicability: All

Discard any plug-in heater found in use except for staff located at building entrances.

Vertical Transportation

A Maintenance Schedule and Practice

Set maintenance and frequencies with building staff and external vendors to conform to the most current version of the American Society of Mechanical Engineers (ASME) Handbook on Safety Code for Elevators and Escalators.[84]

Building Management System & Sub-Metering

A Maintenance Schedule and Practice

The following tasks should be performed twice annually to verify integrity and performance of the BMS:

- Check operation of thermostats and make recommendations as required
- Do spot checks for accurate performance
- Do spot checks for commanding techniques for proper operation
- Disable system modules on a selective basis to review potential problems and system behavior
- Perform a system wide function test to verify complete and accurate operation
- Examine and analyze standard log reports
- Review and discuss system and service history, and the performance of temperature control and energy management applications
- Recommend necessary modifications, replacements, upgrades or repairs as a result of the annual review
- Replace components that are suspect of being faulty in advance to prevent system failure

Case Study 1A

Ken Soble Tower – Ontario, Canada, 2020[85]

One of the largest EnerPHit certified projects in the world, the Ken Soble Tower has 146 affordable seniors' housing units, 18 stories, and is approximately 80,000 ft^2.

At project completion, energy consumption was reduced by 70% and greenhouse gas emissions by 94% from existing levels. At peak times, the total energy needed to heat or cool each unit will be equivalent to running 3 incandescent light bulbs. Beyond updating the MEP systems, the existing brick exterior envelope will be updated to High-Performance with R38 insulation, increased air tightness, and triple glazed fiberglass Passive House Certified windows. One notable change to the existing building structure was that concrete balconies, which were a large contributor to thermal bridging, were replaced with thermally isolated Juliette balconies.

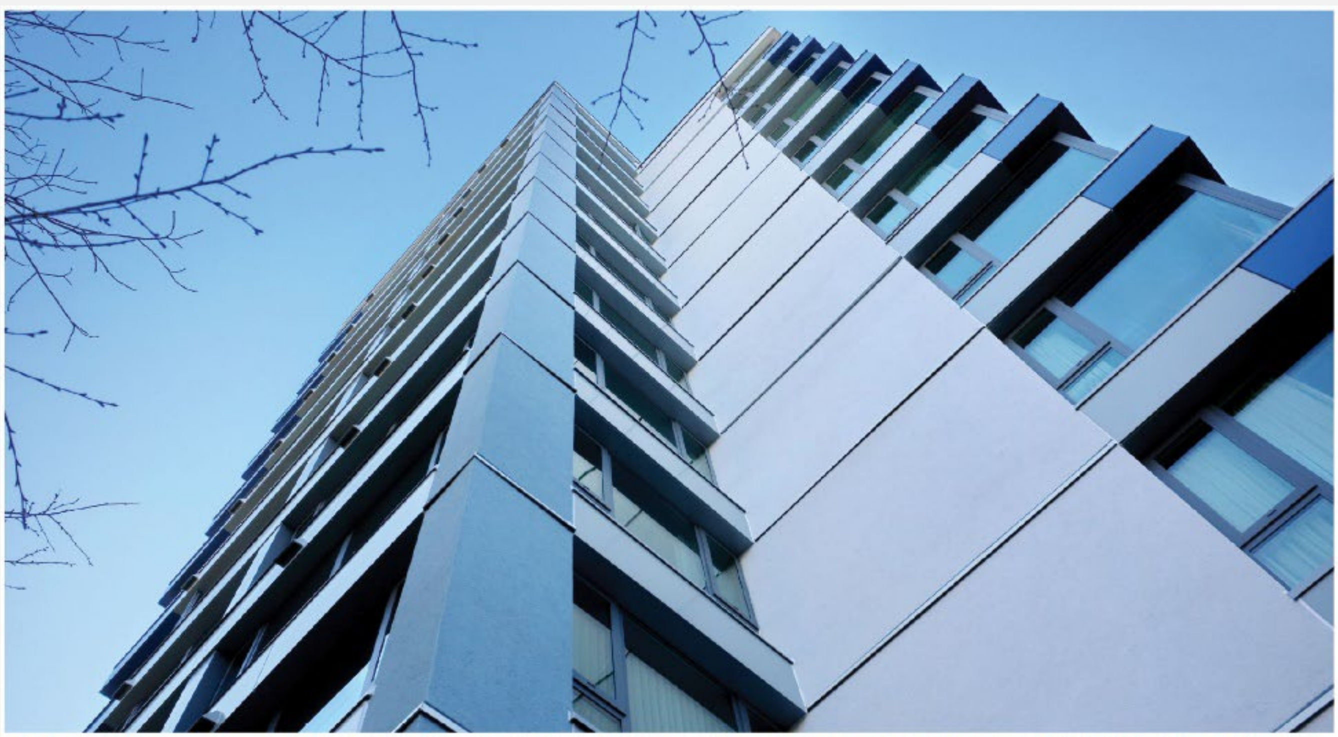


Figure 9: Ken Soble Tower – Ontario, Canada, 2020 [86]

Case Study 1B

Empire State Building - New York City, NY, 2015[87]

Retrofit planning for the Empire State Building began in 2008. The emphasis of the retrofit was on the right steps in the right order - reducing lighting, heating, and cooling loads before looking at equipment efficiency.

The resulting retrofit was projected to save 38% of the building's energy and $4.4 million annually with a post-retrofit Energy Use Intensity (EUI) target of 60 kBth/ ft^2/yr and ENERGY STAR target of 90. The project identified eight improvements that could be achieved with the building occupied. The economic analysis helped to identify the combination of interventions that would have the most synergy reinforcing one another to maximize benefit.

Rather than a costly full replacement, a retrofit of all 6,514 windows with high-performance thin film glazing was performed. Radiant barrier insulation was installed behind radiators to reflect heat back into the space. Pneumatic controls were replaced with digital ones, and the constant volume system was replaced with variable air volume system. A new building management system was installed as well as building wide energy metering and a web-based tenant energy dashboard to enable ongoing live monitoring of energy consumption patterns. These measures led to a cooling load reduction that enabled the chillers to be retrofitted rather than a full replacement which avoided a significant capital cost.

Figure 10: Empire State Building - New York, USA, 2015[88]

Strategy 2: **Building Electrification**

Priorities

Building Electrification Strategy offers intervention opportunities to upgrade building components and systems to reduce the use of fossil fuels, while at the same ensuring better indoor environmental quality. While energy efficiency measures will reduce energy demand and associated GHG emissions, transitioning to electrically-powered building systems enables additional GHG reductions from the ongoing decarbonization of the electricity grid.

The interventions included in this section are focused on the following priorities:

- **Reduce GHG and Reliance on Fossil Fuels:** Recognizing the carbon intensity of different energy sources and the decarbonization of the electricity grid, these interventions enable the transition towards fully electric systems and a carbon neutral BPC
- **Improve Local Air Quality:** In addition to the reduced GHG emissions, the elimination of combustion in BPC will result in improved indoor and outdoor air quality.

Assessment

Feasibility Study

A Building Electrification Feasibility Study

Undertake a building electrification study to estimate the opportunities to switch from fossil fuel dependent equipment/systems to electrical ones based on the non-exhaustive list of technologies below. The study should cover at a minimum:

- List of Possible Systems or Upgrades
  - PTAC Cooling Chassis
  - VRF/Mini-Splits
  - Air to Water Heat Pump, Without Cascade
  - Air to Water Heat Pumps, with Cascade or Advanced Refrigeration Systems
  - Sewage Source Heat Pumps
  - Heating with Chilled Water Systems
  - Electric Resistance Heating
  - Air and Ground Source Heat Pumps
  - Electric Stoves
  - In-unit Dryers
  - Vented Electric Dryers
  - Gas Vented Dryers
- Technical Feasibility
  - Undertake a Demand Management Study
    - Examine power needs based on the building(s) current annual and peak electrical and energy consumption pattern at hourly, daily, monthly and annual intervals - seasonal fluctuations should be identified. This can be done through energy bills or measurement with a BMS/watt meter. If hourly or daily patterns cannot be readily assessed, useful consumption information (i.e. occupancy, lighting, HVAC) can be estimated using the "Example Operating And Occupancy Schedules" Tables in the most current version of the ASHRAE 90.1 User's Manual.[89] See Energy, Deep Energy Retrofits, Assessment, Audits
    - for further guidance.

    - Assess capacity and fuel sources of current building mechanical and water heating system
    - Assess current building electrical distribution capacity

- Undertake an Electrification Impact Study
    - Assess implications on annual electrical grid demand and both magnitude and timing of peak(s)
    - Assess impact on current building electrical distribution sizing requirements of replacement of existing fossil fuel equipment

See Sustainability Implementation Plan for additional resources.

Intervention

Heating System Electrification

See Energy, Deep Energy Retrofits, Intervention, HVAC section for more general system specifications and efficiencies

Level 1

A PTAC Cooling Chassis

Applicability: PTAC, Through Wall

Replace cooling only PTAC chassis and through wall AC with heat pump versions. Where reverse cycle operation will not satisfy the peak heating load, configure the emergency/auxiliary heat signal to activate existing fossil fuel systems such as steam or hydronic coils in PTACs or radiators in the case of through wall systems. The legacy systems should be activated when the heat pump cannot satisfy a peak load or at an outdoor temperature at which it has been determined that the legacy systems remain more carbon efficient based on the electrical grid footprint.

Level 2

B VRF/Mini-Splits

Applicability: All

Install VRF or mini-split heat pumps to replace existing fossil fuel-based heating systems. Apply systems in accordance with manufacturer's recommendations and important safety requirements such as Chapter 11 of the New York City Mechanical Code.

C Heat Pump Loop Heat Injection

Applicability: Heat Pump Loops

Install air to water heat pumps to replace fossil fuel boilers and steam heat injection systems for boiler-tower heat pump loop systems.

D Air to Water Heat Pump, without Cascade

Applicability: Hot water <115°F

Install air to water heat pumps to replace boilers.

E Air to Water Heat Pump, without Cascade

Applicability: Hot water 115-140°F

Install air to water heat pumps to replace or supplement boiler operation. Review hydronic terminal operation for opportunities to minimize supply temperature requirements to minimize boiler operation. Operate boilers only in peak conditions when water supply temperature requirements are too high for heat pumps to meet. Ideally, reduce water supply temperature requirements so that boilers can be removed.

Level 3

F Air to Water Heat Pumps, with Cascade or Advanced Refrigeration Systems

Applicability: Hot Water >140°F

This intervention builds on the basic air to water heat pump intervention. To adapt air to water heat pumps to higher temperature loads, advanced technology heat pumps using newer technologies such as transcritical CO_2 refrigeration or utilizing two refrigeration circuits operating in a cascade will be required. The cascade systems may be less efficient and will require doubled electrical infrastructure and installation. The second stage of refrigeration can be a separate dedicated heat recovery chiller or a customization of the main air to water heat pump. Due to the complexity of this option, it should be carefully weighed against upgrades to the terminal components of the heating system to reduce temperature requirements.

G Sewage Source Heat Pumps

Applicability: All

These systems are similar to geothermal water to water heat pumps but use building sewage as a heat source or sink. A sewage detention tank holds a volume of sewage to create a daily thermal buffer and a filtration system pumps filtered sewage through a heat exchanger where a separate fluid transfers heat to or from a heat pump. Sewage returns to the tank. When the tank is full excess sewage naturally flows to the city sewer. While these systems are thermally efficient, the tank and filtration system require attention and maintenance. These systems are best applied to residential buildings and other buildings with consistent sewage flow throughout the week.

H Heating with Chilled Water Systems

Applicability: Chilled Water Systems

Install air to water heat pumps to inject heat into chilled water systems during heating dominant operation. Install water to air heat pumps or water to water heat pumps to provide heating using chilled water as a heat source.

Domestic Hot Water (DHW) System Electrification

See Energy, Deep Energy Retrofits, Intervention, Domestic Hot Water for more general system efficiencies.

Level 1

A Domestic Hot Water Load Reduction

Applicability: Central Systems

Pursue heat recovery and demand reduction interventions in the Deep Energy Retrofits section to reduce the capacity required from other domestic hot water decarbonization schemes.

B Electric Resistance-Only Heating

Applicability: Distributed Systems

Provide point of use instantaneous electric hot water heating for light loads such as hand washing in office buildings. Pursue fixture efficiency measures first. This is not recommended for high demand end uses like residences, gyms or restaurants.

Level 2

C Indoor Air Source Heat Pump

Applicability: Distributed Systems

Provide point of use heat pump type heaters. Install heaters in areas with cooling demand such as ceiling plenums or air handler rooms that act as return air plenums. Do not install in unventilated closets or areas without heating supply or cooling demand.

D Outdoor Air Source Heat Pump with Electric Resistance

Applicability: Central Systems

Provide central air to water heat pumps to provide most of the domestic water heating load up to about 120°F supply temperature. Provide storage tanks with small electric resistance heaters sized to raise the stored water temperature to 140°F overnight or during other periods of near zero demand.

Level 3

E Full Heat Pump System

Applicability: Central Systems

Install air or ground source heat pumps designed to provide the full domestic hot water load at safe temperatures without electric resistances. Heated water may be produced and stored below 140°F on the non-potable side of a heat exchanger with domestic water produced instantaneously and indirectly.

It is estimated that to achieve the city of New York's 80x50 target, over 90% of NYC building stock will need to electrify their domestic hot water.[90]

Electric Cooking Systems

Level 1

N/A

Level 2

A Electric Cooking

Applicability: All

Replace all gas cooking appliances with electric cooking appliances.

Level 3

B Electric Commercial Cooking

Applicability: Non-Residential

Replace exhaust systems with UL710B type recirculating systems for commercial electric cooking wherever possible to reduce exhaust rates.

Induction cooking is often considered one of the most efficient cooking technologies. With this technology, up to 90% of the energy consumed is transferred to the food, compared to about 74% for traditional electric systems and 40% for gas.[91] In addition, induction cooking provides indoor air quality benefits as a result of eliminating combustion from inside the household.

Clothes Drying Electrification

Level 1

A In-Unit Dryer

Applicability: Residential

Remove all in-unit dryers. Provide or retain a small number of dryers for common use for loads that cannot be effectively line dried such as large comforters. Provide permanent or portable line drying capacity within dwelling units adequate to line dry at least a full load of laundry.

A large proportion of households outside the US use washing machines and do not have access to clothes dryers. We do not need them either.

Level 2

B Condensing Electric Dryer in Lieu of Vented Electric Dryer

Applicability: Residential

Replacing existing electric dryers with condensing dryers. Abandon and cap or repurpose common venting systems to eliminate exhaust airflow through these systems which are unproductive for 97-99% of hours each week in each apartment.

Carefully clean ventilation risers previously used for dryer exhaust. Repurpose these for ventilation supply to address building airflow imbalances and pressurization issues.

Do not install condensing dryers behind solid doors or provide clear signage that the dryer must be operated with the closet door open. Install in conformance with manufacturer's instructions regarding room and air circulation configuration.

Refer to the Energy, Deep Energy Retrofits, Intervention, Energy Recovery Ventilation Systems section for guidance.

Level 3

C Condensing Electric Dryer in Lieu of Vented Gas Dryer

Applicability: Residential

Remove vented gas dryers and replace them with condensing electric dryers. Provide any electrical infrastructure upgrades as required. See electric vented dryer removal for further details.

Practice

Measurement & Verification

Refer to Energy, Deep Energy Retrofits, Practice, Measurement & Verification section.

Operations & Maintenance

Refer to Energy, Deep Energy Retrofits, Practice, Operations & Maintenance section.

Case Study 2

The Stansbury Condominiums – Salt Lake City, UT, 2019[92]

The Stansbury Condominium, a 75-unit market rate owner occupied property, had a very old and inefficient central boiler and chiller system. To reduce the high repairs and utility costs of these systems, the tenants decided to convert to a decentralized system with 75 cold climate heat pumps. This approach also enabled the transfer of the heating and cooling utility costs to the individual owners which incentivizes further savings through behavioral changes. These improvements led to an annual energy saving of approximately 300,000 kWh, $35,950, and 275 tons of carbon.

Figure 11: The Stansbury Condominiums – Salt Lake City, UT, 2019[93]

Strategy 3: **Renewable Energy Supply & Storage**

Priorities

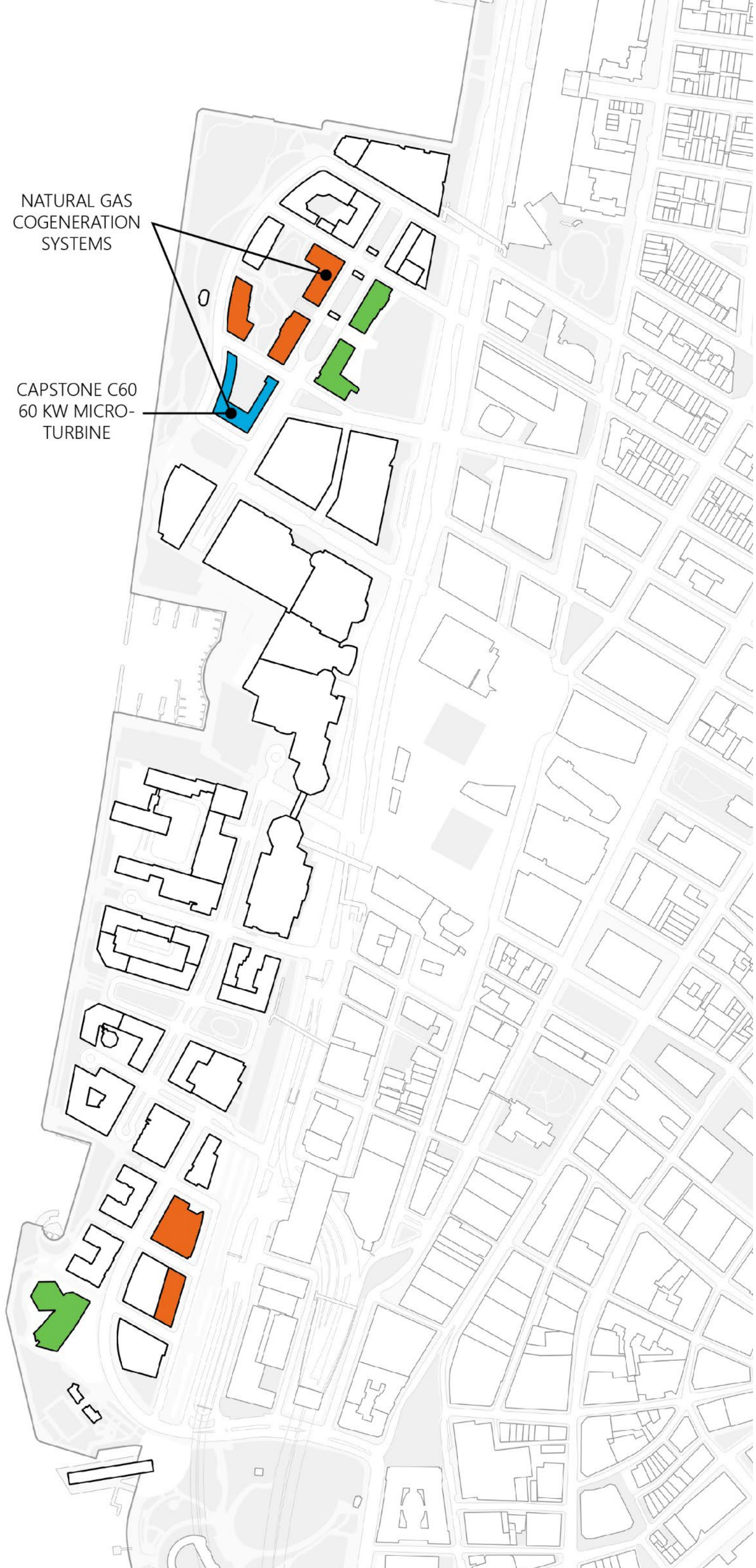
Renewable Energy Supply and Storage Strategy offers intervention opportunities to integrate renewable energy systems to reduce demand on fossil fuels, while at the same time ensuring energy resilience through on-site energy storage. Energy storage also presents opportunities to reduce the peak electricity demand and should be considered alongside building electrification interventions.

The interventions included in this section are focused on the following priorities:

- **On-Site Renewable Energy Generation:** While New York State transitions to a cleaner electricity grid, on-site renewable energy generation will help accelerate BPC towards its goal to become carbon neutral by 2050
- **On-Site Energy Storage and Resilience:** Energy storage provides many benefits including the ability to shift peak loads and use power when electricity demand chargers are lower, saving energy costs. Providing on-site energy storage will also improve the resilience of Battery Park City by protecting buildings from power outages and other emergencies.

Figure 12: Existing Solar PV Systems on Battery Park City Buildings, 2020

- Rooftop PV
- Building Integrated Photovoltaics (BIPV)
- Rooftop PV / BIPV



Assessment

Feasibility Study

A On-Site Renewable Energy Generation & Storage Feasibility Study

Undertake an on-site generation and storage study to estimate the on-site and near-site generation potential of the project, as well as energy storage applicability, based on the non-exhaustive list of technologies below. The study should cover at a minimum:

- List of technologies
    - Photovoltaic (rooftop or building integrated, ie: façade) Note that all building orientations should be considered
    - Solar thermal
    - Wind
    - Heat pumps (Refer to the Energy, Strategy 2: Building Electrification section for guidance)
    - Battery, fuel cell, and thermal storage
    - Biofuels are excluded
- Technical Feasibility
    - Undertake a Demand Management Study as outlined in the Energy, Deep Energy Retrofits, Building Electrification, Assessment, Building Electrification Feasibility Study section.
    - Undertake a Renewables & Storage Impact Study
        - Assess opportunities for load shedding and/or load shifting from renewables integration: review implications on annual electrical grid demand and to what extent peak electricity consumption can be reduced or shifted by renewables and/or storage
        - Assess impact on current building electrical distribution sizing requirements
        - Determine ability to provide energy for critical loads
    - Determine whether the implementation of Direct Current (DC) is practical for PV installations for improved efficiency
    - Feasibility of exporting heat or electricity from the system into local BPC community systems, considering if the building is connected to an existing source of waste heat or power

See Sustainability Implementation Plan for more resources.

B Electric Vehicle Charging Infrastructure Feasibility Study

Undertake a technical feasibility study for installing Electric Vehicle (EV) charging infrastructure in the project. The study should cover at a minimum:

- Electric Vehicle demand for current and future anticipated vehicle fleet size, including passenger, bus, and facilities vehicles. This is to include both owned vehicles and transient vehicles visiting the site. Include the average annual and daily hours each vehicle is anticipated to be on-site, and any additional information needed to assess charging schedule scenarios
- Viability of Level 1 (110/120V), Level 2 (220/240V) and Level 3 (commercial grade 208/440/480 VAC) charging stations, and additionally relevant charging station technologies, against existing on-site electrical infrastructure capacity, including any upgrades required
- IT integration for software and reservation system options, including, but not limited to, pay at the point of use, advance scheduling, and membership models. WiFi internet connected (smart) stations vs dumb stations
- Submetering required to adequately partition and track energy use associated with EV charging stations
- The requirements and potential to power EV charging stations via on-site renewable energy generation source, include an assessment of any additional needed EV infrastructure
- Annual greenhouse gas reduction potential for each EV charging scenario being considered
- Local planning criteria, including land use, noise, applicable codes, regulations, and restrictions
- Structural implications and load requirements of installing EV charging systems on grounds or in buildings
- The integration of EV charging infrastructure with existing or proposed on-site renewable energy and storage solutions

See Sustainability Implementation Plan for more resources.

In New York City, over 30% of a building's energy consumption is used to provide space heating and hot water. This demand is largely met by fuel oil and natural gas-powered boilers. Solar thermal technology provides a renewable, emissions-free, and cost-efficient alternative to fossil fuel based space and water heating.[94]

Intervention

Renewable Energy Systems

Level 1

N/A

Level 2

A Solar Street and Site Lighting

Applicability: Site

Incorporate local solar powered lighting fixtures in public outdoor spaces.

Refer to the Energy, Deep Energy Retrofits, Intervention, Lighting, Light Pollution ♥ section for guidance on light pollution mitigation, and the Lighting Power Density section for guidance on energy efficiency.

Level 3

B Roof Solar PV System

Applicability: Residential, Non-Residential

Install rooftop solar photovoltaic panels/modules. If a PV system is to be installed on more than one building or linked to a broader on-site installation, as part of the same project, ensure proper assessment of and connection to main electrical systems.

C Building Integrated PV

Applicability: Residential, Non-Residential

Install non-roof building integrated photovoltaic panels/modules – these can be integrated into shading devices, glazing elements, and opaque façades. The air gap behind the panels in the latter can serve to both cool the PV panels and to improve the building envelope's thermal performance.[95]

D Solar PV Arrays

Applicability: Site

Incorporate local ground-mounted solar PV arrays into public spaces such as shading elements and playgrounds. These panels can be installed with tracking capabilities to better harness the power of the sun.

E Roof Solar Thermal System

Applicability: Residential

Install rooftop solar thermal systems to help offset Domestic Hot Water loads.

F Demonstration Technologies

Applicability: Residential, Non-Residential, Site

Incorporate demonstration technologies to help showcase alternative renewable energy solutions. These could include:

- River Turbines
- Vertical Axis Wind Turbines
- Kinetic Energy Walkways

In addition to providing on-site renewable energy, PV panels shade roofs, reducing the temperature of the exposed roof surface, and extending the useful life of the roof. Also, note that NYC's Sustainable Roof Laws (LL92 & LL94) require all new or major roof renovation projects to install green roofs or solar panels.

On-Site Energy Storage

Level 1

N/A

Level 2

A EV Charging Infrastructure

Applicability: Residential, Non-Residential, Site

Incorporate existing or planned EV charging infrastructure into building/site's power storage strategy

Level 3

B Battery Storage

Applicability: Residential, Non-Residential

Install a battery storage system in accordance with the total building energy consumption profile and the renewable production profile.

- Look for opportunities to connect to a larger microgrid infrastructure project
- Establish a maintenance contract with solar panel and battery storage installers to have consistent monitoring of battery capacity

C Fuel Cells

Applicability: Residential, Non-Residential, Site

Install fuel cells and hydrogen storage to be used as a renewable, low-cost back-up power source.

D Thermal Energy Storage

Applicability: Residential, Non-Residential

Install a thermal energy storage system. Coordinate with the HVAC system improvements as outlined in the Energy, Deep Energy Retrofits and Strategy 2: Building Electrification sections.

Combining solar energy generation and storage, known as 'resilient solar', offers many benefits. Besides generating electricity and reducing peak demand charges, the combination can provide power during extended grid outages, avoid the risk of running out of fuel for generators.[96]

Practice

Measurement & Verification

Refer to Energy, Deep Energy Retrofits, Practice, Measurement & Verification section.

Operations & Maintenance

Refer to Energy, Deep Energy Retrofits, Practice, Operations & Maintenance section.

Case Study 3

11 Madison Avenue – New York City, USA[97]

Built in 1932, 11 Madison Avenue is a 30 story office building in Manhattan, and is currently the national headquarters for Credit Suisse. As the building's existing chiller plant was reaching the end of its lifecycle, high performance replacements were investigated. The selected approach was the installation of a thermal storage system in the form of three 800-ton high efficiency centrifugal chillers, which used a lower GWP refrigerant (HCFC-123), 64 ice storage tanks, heat exchangers. The system uses one of its chillers to make ice at night when grid demand is lower and electricity is cleaner – using natural gas power plants rather than oil-fired ones. 11 Madison Avenue was able to capitalize on substantial subsidy incentives from NYSERDA due to its energy efficiency (or use of cleaner fuels - whichever is more accurate). The result of this project was a shift of nearly 1 megawatt of peak electric demand and reduced annual peak energy use by more than 2.15 million kWh.

Figure 13: 11 Madison Avenue – New York, USA[98]

Resources

Advancing Elevator Energy Efficiency

https://www.aceee.org/sites/default/files/publications/researchreports/a1501.pdf

ENERGY STAR Action Workbook for Small Business

https://www.energystar.gov/sites/default/files/tools/ENERGYSTAR_Small_Business_AWB_Main_508_November_2019.pdf

Geothermal Systems and their Application in New York City

http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf

GridOptimal Buildings Initiative

https://newbuildings.org/resource/gridoptimal/

Going Electric – Retrofitting NYC's Multifamily Buildings, Urban Green

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High Performance Technology Primers, Building Energy Exchange

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Lighting the Way – Upgrading lighting systems for commercial offices

https://be-exchange.org/wp-content/uploads/2017/11/20170519LightingtheWay_Web-1.pdf

New York City's Energy and Water Use 2014 and 2015 Report

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New York Solar Guidebook

https://www.nyserda.ny.gov/-/media/NYSun/files/Solar-Basics.pdf

New York Solar Study

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NYC Green Codes Task Force Full Proposals

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Premium Efficiency Motor Selection and Application Guide

https://www.energy.gov/sites/prod/files/2014/04/f15/amo_motors_handbook_web.pdf

Pursuing Passive – Strategies for a High-Comfort, Low-Energy Retrofit in NYC, Building Energy Exchange

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State of the New York City Grid

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Abbreviations & Definitions

ACH	Air Changes per Hour (ach/hr, ft^3/s)
AHU	Air Handling Unit
AMCA	Air Movement and Control Association
ASHRAE	The American Society of Heating, Refrigerating and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
BACNET	Building Automation and Control networks.
BMS	Building Management System
BTU	British Thermal Unit
CFM	Cubic Feet per Minute
CO_2	Carbon Dioxide
COP	Coefficient of Performance
CRAC	Computer Room Air Conditioning Unit
CRI	Color Rendering Index
DC	Direct Current
DHW	Domestic Hot Water
EML	Equivalent Melanopic Lux
EUI	Energy Use Intensity (kBtu/ft^2.year)

EV	Electric Vehicle
FDD	Fault Detection and Diagnosis
FPM	Feet Per Minute
GHG	Greenhouse Gas
GPM	Gallons Per Minute
GWP	Global Warming Potential
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IEEE	Institute of Electrical and Electronics Engineers
IES	Illuminating Engineering Society
IPMVP	International Performance Measurement and Verification Protocol
KPI	Key Performance Indicator
LED	Light Emitting Diode
LPD	Lighting Power Density (Watts per ft^2)
MEP	Mechanical, Electrical, and Plumbing
MLO	Model Lighting Ordinance
MW	Megawatt
NOAA	National Oceanic and Atmospheric Administration
NYCECC	New York City Energy Conservation Code

ODP	Ozone Depletion Potential
PCB	Polychlorinated Biphenyl
PSIG	Pounds per Square Inch, Gauge
PTAC	Packaged Terminal Air Conditioner
PTHP	Packaged Terminal Heat Pump
PV	Photovoltaic
RTEM	Real Time Energy Management
RTU	Remote Terminal Unit
sDA	Spatial Daylight Autonomy
SHGC	Solar Heat Gain Coefficient
SRI	Solar Reflectance Index
VAV	Variable Air Volume
VFD	Variable Frequency Drives
VLT	Visible Light Transmission
VOC	Volatile Organic Compound
VRF	Variable Flow Refrigerant

Circadian Rhythm	A human's internal clock that regulates the sleep wake cycle and repeats every 24-hours. It can be influenced by artificial lighting colors and schedules.
Cladding	A non-loadbearing skin or layer attached to the outside of a building to help protect the building from the weather in addition to aesthetic considerations.
Curtain Wall System	A thin, usually aluminum framed wall, containing infills of glass, metal panels, or thin stone. The framing is attached to the building structure and does not carry the floor or roof loads of the building.
Daylight Harvesting	An automatic lighting control strategy where electric lighting is either dimmed or switched off when sufficient daylight is present in a room or area.
Deep Energy Retrofit	An improvement in the building energy performance by implementing energy conservation measures in existing building designs.
Delta T	Reference to change in temperature in the HVAC industry.
Diurnal	Throughout the day.
Elevator Groups	Multiple elevators serving the same floors in a building.
Energy Recovery	Recovering energy from exhaust air or waste heat in cooling systems to precondition ventilation air or deliver heat to heating loads. Involved both heat and humidity recovery.
EnerPHit	A high-performance building retrofit certification standard developed by the Passive House Institute.
Envelope	All components that separate the interior from the exterior of a building. To maintain comfortable indoor conditions in low-energy buildings, the envelope should be well-insulated and prevent/reduce air leakages.
Fuel Cell	An electrochemical device that operates through a chemical reaction rather than combustion to produce electricity, heat, and water.
Glare	A visual sensation caused by excessive and uncontrolled brightness – can be uncomfortable or even disabling.

Greenhouse Gas A gas that absorbs infrared radiation, thereby contributing to the greenhouse gas effect. The leading greenhouse gases in the atmosphere are CO_2 (Carbon dioxide), CH_4 (Methane), and NO_x (Nitrogen oxides), and SO_x (Sulfur oxides).

Heat Pump A device that uses electricity and refrigerant to move heat from one location or medium to another.

Heat Recovery Used in reference to water systems, recovering heat that would otherwise be released and lost, i.e. black water drainage systems, and using it as a preheat to reduce required heating energy

Hydronic Systems that transport heat by circulating water.

Infiltration The leakage of outside air into a building, typically through cracks in the building envelope and through the use of doors/windows.

Legionella Bacteria that flourish in central heating units and air conditioners and will cause Legionnaires' disease.

Luminance The intensity of light per unit area.

MODBUS A data communications protocol used to connect a plant/system supervisory computer with a remote terminal unit.

Phantom Loads Electrical power being drawn by appliances or electronics while not in use or in standby mode.

Photovoltaics Semiconducting materials, that when exposed to light, will convert it into an electric current.

Piezometer An instrument used to measure the pressure, and associated pressure properties, of a gas or liquid.

PM10 Atmospheric particulate matter that has a diameter of less than 10 micrometers (12% the diameter of a human hair).

PM2.5 Atmospheric particulate matter that has a diameter of less than 2.5 micrometers (3% the diameter of a human hair).

Resilient Solar

Solar energy generation that is coupled with storage technology that allows it to continue to provide power during grid outages.

Thermal Bridge

A localized area of the building envelope where heat flow is higher in comparison with adjacent areas. This leads to reduced thermal performance of the envelope and poorer building energy efficiency.

U-Value

The thermal transmittance of materials/constructions.

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Water

Overview

Water is a valuable resource and water conservation is a critical first step in preserving a finite supply. By identifying wasteful practices, leaks, and ways to conserve, Battery Park City can reduce its need for potable water and reduce the strain on local watersheds. Additionally, water requires energy to be moved and heated, and it requires chemically based treatment, aggravating impact on climate and environmental quality.

Local Context

The New York City Department of Environmental Protection (DEP) operates one of the most complex water and wastewater systems in the world. It manages a network of 19 reservoirs and three controlled lakes that cover approximately 2,000 square miles of watershed land resulting in the largest unfiltered water supply in the world.

NYC is served by both separated and combined stormwater and sewer systems. Separated systems collect and convey stormwater runoff through a dedicated network of pipes, whereas combined systems mix any stormwater runoff with sanitary sewage collected from streets and buildings, respectively. This combined flow is typically transported to a sewage treatment plant. However, in the case of a large rain event or heavy snowmelt, the system capacity can be exceeded in which case outfalls, called Combined Sewer Overflows (CSOs), are discharged directly into a nearby water body. This is a major pollution concern for New York City.

Path to Potable Water Reduction at BPC

Multifamily residential properties are among the most water-intensive building typologies in Battery Park City with domestic uses for clothes washing, dishwashing, cooking, and showers. Retail spaces and schools can also have higher water needs from commercial size kitchens and demands for cleaning and washing. In office buildings, water consumption is predominantly associated with water-based cooling systems.

In the Green Guidelines, sustainable water systems will be achieved through technical guidance that supports the following strategies from the BPC Sustainability Plan: 1) water conservation, 2) water recycling systems, and 3) resiliency and stormwater management.

Strategy 4: Water Conservation

The quickest, easiest way to reduce water demand is through water-efficient fixtures and equipment. The replacement of water intensive fixtures and the addition of aerators in faucets can go a long way towards reducing potable water consumption.

Strategy 5: Water Recycling Systems

For improved sustainability, the focus needs to shift beyond conservation to recycling water and identifying alternative sources. Through this transition, it is important to match water sources and water quality needs with the appropriate end use. For example, water recycling systems can recover water from rainfall, greywater, or blackwater for treatment and reuse. Treated or recycled water can be used to offset non-potable water demands in cooling systems, irrigation systems, and flushing toilets and urinals, or if treated fully, for potable water demands.

The infrastructure required for water recycling systems includes four components:

- Collection - Rain cisterns or water storage tanks
- Treatment - Essential to ensure adequate water quality levels for reuse
- Distribution - The use of non-potable water in buildings often requires a separate plumbing system (called dual plumbing). This is the most cost effective to install during new construction, but it is possible to retrofit buildings to accommodate it
- Storage - Non-potable system demands change throughout the day, water storage should be provided for times when demand is low

Although recycled water infrastructure can be expensive and disruptive it can yield a large volume of treated water and savings.

Expanding current water recycling systems at Battery Park City into a site wide network that can integrate storage, and include rainwater, greywater, and blackwater systems to meet more of the non-potable demands of buildings, parks, and the site should be properly considered and assessed given the high-potential for potable water savings. This would also help to reduce the water demand on the aging New York infrastructure.

Strategy 6: Resiliency and Stormwater Management

Climate change is escalating the magnitude and frequency of intense storms and making precipitation rates more unpredictable. Inadequately managed stormwater can lead to erosion, increased flooding, and increased concentration of pollutants reaching surface waters. Robust stormwater management systems that incorporate green infrastructure help maximize future resiliency.

A critical concern for Battery Park City is large storms and the potential for flooding. Through ongoing resiliency projects, BPC is working on becoming a more resilient neighbourhood. There are a number of actions that are important for preparing for future storms and climate hazards such as improving stormwater collection and detention infrastructure and providing permeable, green spaces, and separated stormwater and sewer infrastructure.

Battery Park City has four CSOs, all of which drain into the Hudson River. The separated stormwater system in BPC, more officially known as a Municipal Separate Storm Sewer System (MS4), extends south of Liberty Street to the northern edge of Wagner Park. It has two outfalls into the Hudson, which are used during heavy storms, but otherwise drains through a force main to the Newtown Creek Wastewater Treatment Plant in Brooklyn, along with the outflow from the combined sewer system.

In certain areas of Battery Park City stormwater runoff is captured by large below grade detention tanks and treated for re-use. This happens at Teardrop Park North, where a storage tank located under the west side of the park supplies water for the rock wall water feature and irrigation through a purple pipe and, and at Teardrop Park South, where detention tanks located in the basement of the Icon parking garage supply the water features. Thirteen buildings within the neighborhood provide rainfall capture and attenuation through various strategies including green roofs.

Interventions such as these are typically carried out as part of larger projects, but contributions from individual projects can occur separately, providing they are integrated with the overall stormwater management strategy.

Strategy 4: **Water Conservation**

Priorities

The Water Conservation Strategy offers intervention opportunities to upgrade building water systems and fixtures to enhance building water performance and identify opportunities for water reuse and recycling, while at the same reducing energy needs for water heating and pumping.

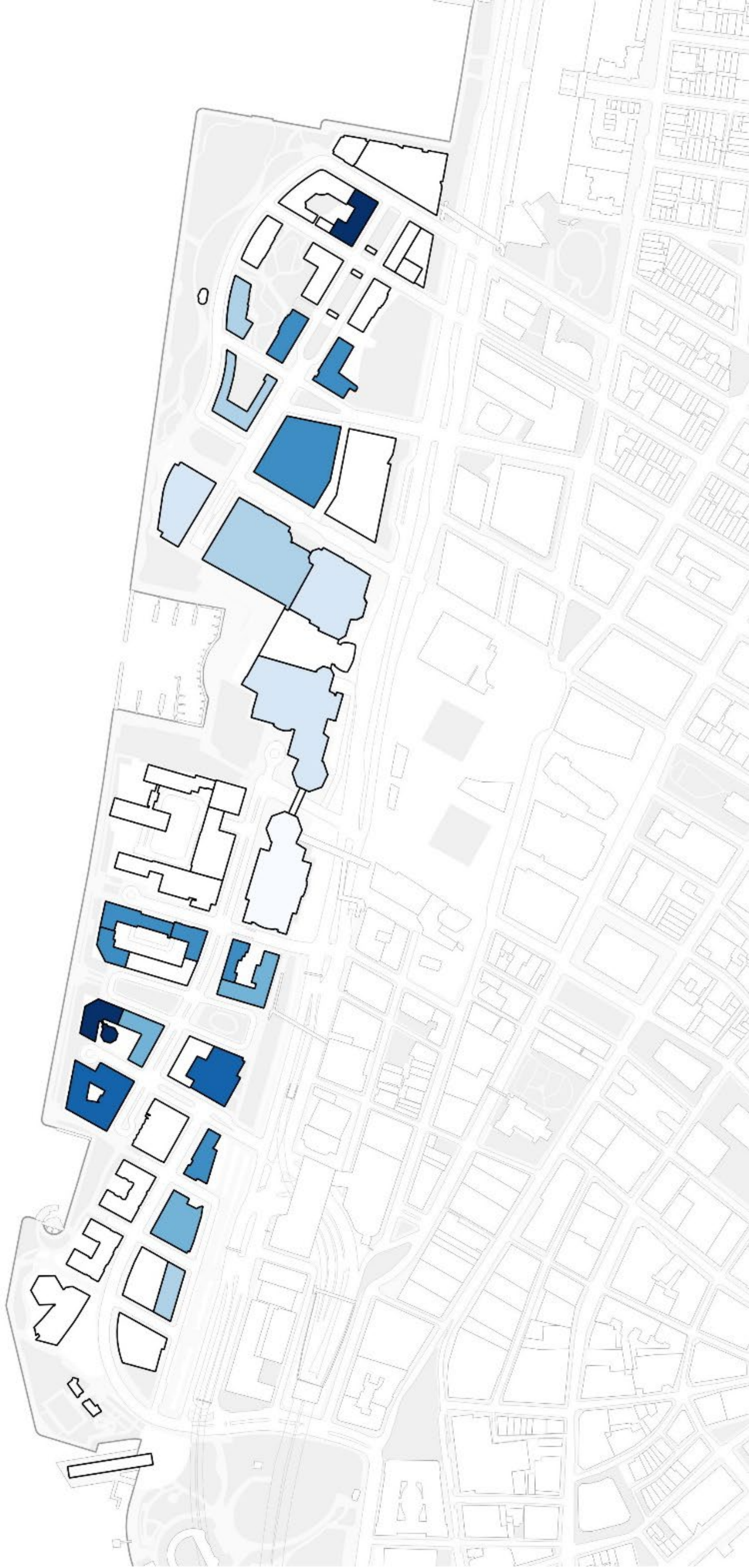
This section focuses on interventions to support the following priorities:

- **Raise Awareness of Water Consumption:** Before implementing any intervention geared toward reducing potable water consumption, it is essential to assess current water use, analyze trends, share findings with building staff and occupants, and compare data to similar buildings in BPC or New York City
- **Reduce Total Water Use:** A variety of interventions can be applied to reduce water use in a building. From simple fixes of leaks to upgrading of high-efficiency fixtures and appliances can help reduce water use in a building. While fixture upgrades might be more suitable for multifamily residential buildings, others (like those associated with upgrading Heating, Ventilation, and Air Conditioning (HVAC) systems) may make sense for commercial properties

Figure 14: Water Use Intensity at Battery Park City, 2017[99]

Water Use Intensity (gal/ft²)

- Less than 10
- 10–20
- 20–30
- 30–40
- 40–50
- 50–60
- 60 or Greater



Assessment

Audits

Level 1

N/A

Level 2

A Water Consumption Audit

Undertake a building water audit to establish a baseline.[100] Carry out the following, as applicable:

- Calculate a baseline annual water use for a specific year or an average water use over several years. If monthly data is available, plot the monthly use over time and identify trends (e.g., water use increasing, decreasing, or remaining steady over time)
- If indoor and outdoor water is supplied separately, determine distinct baselines for each one
- Attempt to ascertain the cause of major trends. For instance, seasonal increases in the summer months often are the result of irrigation or cooling water demand during warm weather
- Conduct a walk-through survey of the building to:
    - Measure water flow rates
    - Note equipment condition and visual leaks
    - Record equipment information such as model number and manufacturer
    - Identify efficiency opportunities such as low and no cost measures or retrofit and replacement options
- Gather building use information:
    - Gather building use and equipment information to enable calculation of usage data metrics and trends. The following information can be useful:
        - Number of building occupants
        - Estimated gender split (this may be more applicable in commercial buildings)
        - Typical floorplans
        - Hours of operation (this may be more applicable in commercial buildings)
        - List of major water use intensive equipment such as commercial kitchen, cooling tower, irrigation equipment, etc

- Use the gathered data to determine water use intensity in the following units:
  - Gal/ft^2
  - Gal/person

B Water Quality Audit – Level 2

Perform a water quality test to measure the values of Level 2 contaminants listed in Table 5 to establish a baseline and check against reference data for acceptable ranges. Best practice and guidance on testing standards and locations can be found in the Air chapter of The WELL Performance Verification Guidebook.[101]

Level 3

C Water Quality Audit – Level 3

Perform a water quality test to measure the values of Level 3 contaminants listed in Table 5 to establish a baseline and check against reference data for acceptable ranges. Best practice and guidance on testing standards and locations can be found in the Air chapter of The WELL Performance Verification Guidebook.[102]

Table 5: WELL Version 2 (2020) Performance Criteria for Water Quality Thresholds[103]

Contaminant	Level 2 Thresholds	Level 3 Thresholds
Sediment	Turbidity less than or equal to 1.0 Nephelometric Turbidity Unit (NTU)	Turbidity less than or equal to 1.0 Nephelometric Turbidity Unit (NTU)
Microorganisms	Total coliforms (including E. coli) less than or equal to 0 Colony-Forming Unit (CFU) /100 mL	Total coliforms (including E. coli) less than or equal to 0 Colony-Forming Unit (CFU) /100 mL
Dissolved metal	Arsenic less than 0.01 mg/l	Arsenic less than 0.01 mg/l Lead less than 0.01 mg/l Antimony less than 0.006 mg/l Mercury less than 0.002 mg/l Nickel less than 0.07 mg/l Copper less than 1.0 mg/l Cadmium less than 0.005 mg/l Chromium (total) less than 0.1 mg/l

Organic pollutants		Styrene less than 0.02 mg/l Benzene less than 0.005 mg/l Ethylbenzene less than 0.3 mg/l Vinyl chloride less than 0.002 mg/l Toluene less than 0.7 mg/l Xylenes (total: m, p, and o) less than 0.5 mg/l Tetrachloroethylene less than 0.005 mg/l
Disinfectant byproducts		Total trihalomethanes (sum of dibromochloromethane, bromodichloromethane, chloroform, and bromoform) less than 0.08 mg/l Total haloacetic acids (sum of chloroacetic, dichloracetic, trichloracetic, bromoacetic and dibromoacetic acids) less than 0.06 mg/l
Herbicides and pesticides		Atrazine less than 0.003 mg/l Simazine less than 0.002 mg/l 2,4-Dichlorophenoxyacetic acid less than 0.07 mg/l
Fertilizers	Nitrate less than 50 mg/l (11 mg/l as nitrogen)	Nitrate less than 50 mg/l (11 mg/l as nitrogen)
Public water additives	Fluoride less than 4 mg/l	Fluoride less than 4 mg/l Total chlorine less than 4 mg/l Chloramine less than 4 mg/l

Benchmarking

A Benchmarking Data

Use data gathered in the audit to benchmark current baseline performance against buildings of the same typology using the most current data set of New York City's Local Law LL84.[104] Use Table 6 as a reference for water use intensity data compiled by building types in Battery Park City.

Table 6: NYC Local Law 84 (2015): BPC Water Use Intensity, 2015[105]

Property Type	BPC 2015 Water Use Intensity (gal/ft^2)
Multifamily	751
Senior Community	206
Hotel	161
Retail	68
Office	48
Museum	43
K-12 School	31

Intervention

Fixtures

Level 1

A Leaks and Drips

Applicability: All

Repair leaks and drips identified during a water audit to remove background water loss throughout the building plumbing system.

B Existing Fixtures

Applicability: All

Establish Water Use Intensity (WUI) goals. Based on the assessment results, create a plan to repair existing fixtures to achieve WUI goals.

Add the following to existing fixtures, as applicable:

- Flow restrictors
- Aerators
- Thermostatic Mixing Valve (TMV) - with separate temperature and flow controls
- Flush Volume Reducer

C Fixture Replacement

Applicability: All

When replacement of existing fixtures is required, install those that are at least 20% better those in the most current version of the International Green Construction Code (IgCC) 2018, as shown in Table 7, dependent on market availability.[106]

D Controls

Applicability: All

All new lavatory faucets (non-residential) should have one of the following control devices installed:

- Time controller
- Programmed time controller

- Volume controller
- Presence detector and controller
- Central control unit

Level 2

E Water Quality and Filtration – Level 2 ❤

Applicability: All

Install filtration media as required to ensure the water delivered for human consumption, handwashing, showers, baths, etc. should meet the Level 2 Thresholds outlined in the "Fundamental Water Quality" Precondition as per the most current version of the WELL standard.[107] Use Table 5 as a reference.

Level 3

F Water Quality and Filtration – Level 3 ❤

Applicability: All

Install filtration media as required to ensure the water delivered for human consumption, handwashing, showers, baths, etc. should meet the Level 3 Thresholds outlined in the "Enhanced Water Quality" Optimization as per the most current version of the WELL standard.[108] Use Table 5 as a reference.

Table 7: IgCC (2018) Performance Criteria for Fixture Efficiency[109]

Plumbing Fixture	Performance Criteria
Water closets (toilets)—flushometer single-flush valve type	Single-flush volume of 1.28 gal
Water closets (toilets)—flushometer dual-flush valve type	Full-flush volume of 1.28 gal
Water closets (toilets)—single-flush tank-type	Single-flush volume of 1.28 gal
Water closets (toilets)—dual-flush tank-type	Full-flush volume of 1.28 gal
Urinals	Flush volume 0.15 gal*
Public lavatory faucets	Flow rate—0.5 gpm
Public metering self-closing faucet	0.25 gal per metering cycle
Residential bathroom lavatory sink faucets	Flow rate—1.5 gpm
Residential kitchen faucets	Flow rate – 1.8 gpm
Showerheads	Flow rate – 1.8 gpm

*** Reduced from IgCC based on industry best practice**

Appliances

Level 1

A Appliance Efficiency - Residential

Applicability: Residential

When replacement of existing appliances is required, follow the most stringent recommendations for the minimum performance required, noted in the most current version of International Green Construction Code (IgCC) 2018.[110] Use Table 8 as a reference.

B Appliance Efficiency – Non-Residential

Applicability: Non-Residential

When replacement of existing appliances is required, follow the most stringent recommendations for the minimum performance required, noted in the most current version of International Green Construction Code (IgCC) 2018.[111] Use Table 9 as a reference.

Level 2

N/A

Level 3

N/A

Table 8: IgCC (2018) Performance Criteria for Residential Appliance Efficiency[112]

Appliance	Recommended Performance
Residential clothes washers	Maximum water factor (WF) of 5.4 gal/ft^3 of drum capacity and meet all ENERGY STAR requirements for Clothes Washers
Residential dishwashers	Standard size max. WF of 3.8 gal/cycle Compact size max. WF of 3.5 gal/cycle Meet all ENERGY STAR requirements for Dishwashers

Table 9: IgCC (2018) Performance Criteria for Commercial Appliance Efficiency[113]

Appliance	Recommended Efficiency
Commercial clothes washers	Maximum WF of 4.0 gal/ft^3
Commercial dishwashers	Meet all ENERGY STAR requirements for Commercial Dishwashers
Pre-rinse spray valves	Valves that function at 1.3 gpm or less and comply with a 26-second performance requirement when tested in accordance with American Society for Testing Materials ASTM F2324

Dishwashers	Meet all ENERGY STAR requirements for Commercial Dishwashers
Food steamers	Boiler less/connectionless that consume no more than 2.0 gal/hr in the full operational mode
Combination ovens	Consume no more than 10 gal/hr in the full operational mode
Air-cooled ice machines	Meet all ENERGY STAR requirements for Commercial Ice Machines
Faucet controllers	Hands-free (foot controllers, sensor activated, or other) for all faucet fittings within the food preparation area of the kitchen and the dish room, including pot sinks and washing sinks

Cooling Towers

Level 1

A Float Valves

Applicability: All

Set float valves and monitor water levels in the cooling tower reservoir to prevent overflow. Check fill valve settings and operation. Clean level sensing probes regularly. Replace mechanical makeup water controls with electronic controls or install pulse counters on makeup water meters to monitor water makeup in real time.

B Overflow Alarm

Applicability: All

Install an overflow alarm to alert the operator in case of sump overflow.

C Drift Eliminators

Applicability: All

Install efficient drift eliminators to minimize or eliminate water droplets being entrained in and discharged with cooling tower airflow (drift). Water lost to drift does not contribute to the thermal performance of the cooling tower and can carry infectious particles from the cooling tower. Drift eliminators should reduce drift to a maximum of 0.002% of the recirculated water volume for counterflow towers and 0.005% of the recirculated water flow for crossflow towers.

D Make-Up Water Reduction

Applicability: All

Target cooling tower blowdown and water treatment systems to maintain ten cycles of concentration or more while maintaining water quality parameters within equipment operating limits. NYC tap water has low-mineral content compared to most areas of the world, so this should be straightforward to achieve by applying automatic treatment chemical dosing systems with the assistance of competent water chemistry service providers. Use turbidity sensors, chemical monitors, automatic bleed systems, side stream filtration, and other methods to maintain acceptable water quality levels in towers. Calibration and monitoring of the water quality in the system is critical since cooling tower blow down can be a significant source of make-up water demand.

Level 2

E Alternative Make-Up Water Source

Applicability: All

Consider alternative make-up water sources such as recycled water sources. See Water, Strategy 5: Water Recycling Systems section for guidance.

F Once-Through Cooling Loops

Applicability: All

Replace/remove once-through cooling loops using potable water.

G Automatic Controls

Applicability: All

Use existing building management system technology to control tower operations, including automatically shutting the tower down when possible without impacting occupant comfort. This should include automatic chemical feed systems and blow down systems.

See Energy, Deep Energy Retrofits, Interventions, Building Management System & Sub-Metering, Automatic Fault Detection and Diagnosis section for guidance.

H Sensors

Applicability: All

Cooling towers and evaporative coolers should be equipped with make-up and blowdown meters, conductivity controllers, and overflow alarms in accordance with the thresholds in the most current version of IgCC.[114] Use Table 10 as a reference.

Level 3

N/A

Table 10: IgCC (2018) Performance Criteria for Sub-System Water Measurement Thresholds[115]

Sub-System	Sub-Metering Threshold
Cooling towers (meter on make-up water and blowdown)	Cooling tower flow through tower > 500 gpm
Evaporative coolers	Make-up water > 0.6 gpm
Steam and hot water boilers	> 500,000 Btu/hr input
Total irrigated landscape area with controllers	> 25,000 ft
Separate campus or project buildings	Consumption > 1000 gal/day
Separately leased or rental space	Consumption > 1000 gal/day
Any large water using process	Consumption > 1000 gal/day

Most cooling towers operate at two to four cycles of concentration, but ten cycles or more may be possible in New York City. Increasing cycles from just three to six may reduce cooling tower make-up water by 20% and cooling tower blowdown by 50%.[116]

Irrigation

Level 1

A Low-Water Species Landscape Selection

Applicability: All

Preferentially select planting species that require low-water consumption.

B Turf Grass

Applicability: All

Utilize turf grass sparingly due to its high-water requirements and limited permeability, particularly strip grass due to its difficult maintenance.

C Mulch

Applicability: All

Add mulch to plant beds to decrease water loss from soil through evaporation and help reduce weed growth.

D Hydrozoning

Applicability: All

Design the landscape so that plants with similar water needs are grouped together, enabling more efficient irrigation.

E Low-Flow Irrigation

Applicability: All

Use drip irrigation over traditional sprinklers or underground systems and high-efficiency sprinkler heads for turf and other areas that require spray irrigation.

F Ornamental Water Features

Applicability: All

Avoid incorporating ornamental water features in design or supply with recycled water where possible.

Level 2

G Irrigation Controls

Applicability: All

Use demand-based irrigation controls i.e. weather or sensor-based controls.

Level 3

N/A

Drip irrigation systems can result in water savings of 20-50% compared with conventional irrigation systems.[117]

Metering

Level 1

N/A

Level 2

A Major Water Systems Sub-Metering

Applicability: All

Sub-meter major water systems servicing the buildings and grounds based on the largest demands. Connect sub-meters with central building management system for regular access to data. Sub-metering should include the following water systems (as applicable):

- Irrigation
- Pools
- Laundry Facilities
- Gymnasium and Locker Rooms
- Food and Beverage Retail Zones

- Replacement Water for Cooling Towers

See Energy, Deep Energy Retrofits, Intervention, Building Management System & Sub-Metering, Meters and Sub-Meters sections for additional guidance.

B Indoor Water Systems Sub-Metering

Applicability: All

Sub-meter major water systems servicing the building by end use. Connect sub-meters with central building management system for regular access to data. Sub-metering should include the following water systems (as applicable):

- Indoor plumbing fixtures
- Domestic hot water
- Process water for humidification systems, dishwashers, clothes washers, and others

See Energy, Deep Energy Retrofits, Intervention, Building Management System & Sub-Metering, Meters and Sub-Meters sections for additional guidance.

C Automated Water Monitoring

Applicability: All

Install automatic water monitoring equipment such as flow monitoring and leak detection, with automatic alerts in case water consumption patterns change. Connect sub-meters with central building management system for regular access to data. Evaluate and analyze data to implement leak prevention, water quality and efficiency improvements, and overall conservation of water.

See Energy, Deep Energy Retrofits, Intervention, Building Management System & Sub-Metering, Meters and Sub-Meters sections for additional guidance.

D Smart Metering

Applicability: All

Install smart meters able to log real-time water consumption patterns. Connect sub-meters with central building management system for regular access to data.

See Energy, Deep Energy Retrofits, Intervention, Building Management System & Sub-Metering, Meters and Sub-Meters sections for additional guidance.

Level 3

N/A

Practice

Measurement & Verification

A Data Gathering

Monthly, gather the most granular data available for potable water consumption by end use in the following units: gal/ ft^2, gal/pp, gal/unit.

B Ongoing M&V

Perform ongoing measurement and verification using available points on the Building Management System (BMS). Install additional points/sensors where a small number of additional sensors would allow significantly more robust M&V.

If an M&V plan in in place, comply with the current International Performance Measurement and Verification Protocol (IPMVP) Guidelines to ensure that the systems are monitored as intended. This includes verification of water consumption by end use and generation of recycled water.

Regularly assess whether assumptions made during the water audit to verify if they are still accurate and that the interventions made have had the anticipated reduction effect. A reassessment might be required if any major changes to the building are made such as those affecting building occupancy schedules or cooling requirements.

C Water Quality

Water delivered for human consumption, handwashing, showers, baths, etc. should be measured at least once per year and should meet at a minimum the Level 2 Thresholds, or ideally Level 3, as per the most current version of the WELL standard.[118] Use Table 5 as a reference.

Ideally, measurements should be taken quarterly for Lead, Copper, Turbidity, and Coliforms and should meet the thresholds outlined in the most current version of the WELL Standard.[119] Use Table 5 as a reference.

Operations & Maintenance

A Plumbing

Develop a maintenance schedule in compliance with the American Society of Plumbing Engineers

Plumbing Engineering Design Handbook for ongoing operations and maintenance of plumbing systems including[120]:

- Monitor equipment maintenance frequency
- Ensure waste receptacles are maintained and cleaned out regularly to prevent overflow

- Comply with the guidance given in the Pressure Management
- Manage pressure in the system to ensure that optimal levels are maintained. High-pressure causes wear and tear on the system causing new leaks and increasing loss rates.

B Ongoing Fixture Performance

Perform periodic testing to confirm that low-flow rates match rated performance – particularly for significant end-uses, and that replacement fixtures are not requiring increased maintenance.

C Appliances

Perform ongoing monitoring of appliances to identify significant consumers of water. Pre-failure replacement of very old and inefficient appliances should be considered.

D Ongoing Underground Leak Detection

Use leak detection devices, such as acoustic or sound based technology, to identify leaks for repair in underground distribution systems. Water escaping from pipes creates a distinct sound that moves through the piping material. Different pipe materials transmit different frequencies at differing lengths, creating distinct sounds. There are a variety of acoustic technologies for different pipe types.

E Cooling Towers

Establish a protocol for water chemistry and quality maintenance programs and filtration of open and closed systems. Fouling and corrosion can reduce equipment efficiency.

The NY Department of Environmental Protection estimates that a single faucet with a steady drip could waste 180 gallons of water per day, costing approximately $842 annually.[121]

Case Study 4

Pacific Beacon - San Diego, CA[122]

Pacific Beacon is a high-end residence for sailors at the Naval Base San Diego and consists of 941 dual master suites in three 18-story buildings. The project commissioned a series of water efficiency upgrades, including the replacement of 1,882 aerators in lavatories, 941 kitchen aerators, 1,882 showerheads, and the inspection and repair of all toilets in the residence and common areas. The water conservation measures implemented at Pacific Beacon resulted in over 6,244 kgal of water savings per year. The average simple payback of implementing these measures was 0.5 years which saves Pacific Beacon approximately $132,172 a year in utility costs, with the total project cost being reduced by 38% through various utility rebates and incentives.

Figure 15: Pacific Beacon - San Diego, CA, USA [123]

Strategy 5: **Water Recycling Systems**

Priorities

The Water Recycling Systems Strategy offers Intervention opportunities to incorporate recycled water systems to reduce potable water consumption and to enhance building water performance. When planning for water recycling systems, it is important to consider the water quality that should be aligned with the requirements of a given application or end-use, whether it be non-potable or potable demand.

This section focuses on interventions to support the following priorities:

- **Reduce Potable Water Consumption:** Reducing potable water consumption is becoming ever more important as new and existing water resources as well as utility infrastructure become increasingly strained. There are other benefits as well such as a reduction in the energy required to move and heat water and lower water and sewer costs
- **Meet Non-Potable Demands with Recycled Water:** It is important to understand a buildings non-potable versus potable water demand. Non-potable water demands often include cooling needs, process equipment, washing of cars or sidewalks, toilet flushing, and more. These demands can be met with treated and recycled water to significantly reduce the amount of potable water needed in BPC.

Figure 16: Location of MS4 Outfalls at Battery Park City[124]

Assessment

Feasibility Study

A On-Site Water Recycling Systems Feasibility Study

Undertake an on-site water recycling system study to estimate the potential of the project, as well as water storage and reuse applicability, based on the non-exhaustive list of options below. This study could use input from a water audit as mentioned in the Water, Water Conservation, Assessment section. The study should cover at a minimum:

- List of Possible Water Sources:
    - Condensate
    - Cooling tower blowdown
    - Foundation drainage
    - Rainwater
    - Stormwater
    - Greywater
    - Blackwater
- List of Possible End Uses:
    - Drip Irrigation
    - Cooling Towers
    - Toilet Flushing, Surface/Building Washing[125]
- Technical Feasibility
    - Complete a preliminary water balance study to assess the following:
        - Total annual water consumption gal/pp
        - Recycled water generation opportunity in gal/yr, calculated per month or per season for the applicable water sources as noted above
        - Calculate reuse opportunities for non-potable end uses, total gal/yr and gal/pp (i.e. flushing, irrigation, cooling tower make-up, water features, equipment/sidewalk washing, laundry). Best practice reuse strategy against the usage shown in Table 11.
    - Identify key opportunities for recycled water system types, focusing on significant water consumers with simple plumbing systems
    - Identify appropriate water treatment system dependent on the intended end use, as shown in the WJW Foundation On-site Non-Potable Water Reuse Guide.[126] Use Table 12 as a reference.

Note that water quality must be maintained at al least the thresholds in the most current version of the NYC Construction Codes.[127] Use Table 13 for reference.

- Identify locations for the treatment and storage systems for recycled water including structural, spatial, and distribution requirements

See Sustainability Implementation Plan for more resources.

Table 11: Baseline vs. Best Practice Water Reuse Strategies

Typology	End Uses	Best Practice Water Quality
Residential	Sinks, Showers, Kitchen	Potable
	Toilets, Clothes washing	Non-potable
Non-Residential	Sinks, Showers, Kitchen	Potable
	Toilets, Urinals	Non-potable
Site	Water features, Water Fountains	Potable
	Irrigation, Cleaning	Non-potable

Table 12: Typical 3-Step Water Treatment Processes Required for Differing End Uses[128]

Water Source Type	Primary		Secondary	Tertiary		
	Screen	Flow Equalization	Bio Treatment or Chem Oxidation	Filter	Disinfect	Reverse Osmosis
Condensate				✓	?	
Rainwater (roof)	✓	✓		✓	?	
Stormwater (ground)	✓	✓		✓	✓	
Foundation Drainage	?		?	✓	✓	
Cooling Tower Blowdown	✓	✓	?	✓	✓	
Greywater	✓	✓	?	✓	✓	?
Blackwater	✓	✓	✓	✓	✓	?

"✓" represents Typically Required, "?" represents Dependent on Project Specific Requirements

Table 13: NYC Construction Codes (2014) Performance Criteria for Minimum Water Quality Standards of Non-Potable Uses[129]

Pollution	Definition	Quantity Limit
Biological Oxygen Demand (BOD)	Amount of dissolved oxygen needed by an aerobic organism to break down organic material in water	< 10 mg/l *
Total Suspended Solids (TSS)	Measurement of total solid material suspended in the water	< 10 mg/l
Total Coliform	Indicator organisms for microbial contamination	< 100 per 100 ml
E. Coli	Indicator organisms for microbial contamination	< 2.2 colonies per 100 ml
Potential of Hydrogen (pH)	Measure of the acidic or basic nature of a solution	6.5 – 8.5
Turbidity	Measure of water clarity	< 2.0 NTU **

* Effluent from rainwater and condensate collected in separate tanks or compartments from wastewater should not be required to meet the BOD limitations indicated below.

** The wastewater facility effluent should meet the performance standards of <2.0 NTU for turbidity for 95% of the measurements. At no time can the turbidity result be above 5 NTU.

The non-potable water demands in U.S. multifamily residential and commercial buildings can be up to 50% and 95% of total water usage in buildings, respectively.[130]

Intervention

Collection Sources

Level 1

N/A

Level 2

A Rainwater and Stormwater

Applicability: Site, Building

At building-scale, implement a rainwater or stormwater treatment and reuse system. The water may be contaminated with clay, oils, or grease. Additionally, stormwater usually requires additional screening to remove trash after collection. Yield: inconsistent, throughout the year

At site-scale, rain cisterns could be installed to collect and capture stormwater runoff. The main components of a rain cistern include a watertight storage container, a coarse inlet filter with a clean-out valve, an overflow pipe, a drain, and an extraction system (tap or pump).

The size of the cistern is based on the water demand from its intended use.[131]

If the stormwater runoff volume is not high enough for its intended use, a supplementary water source may be needed to augment the system. Most of the rain cisterns currently in use in BPC can also pull from the city water supply if necessary. Cisterns that are intended to be used year-round should incorporate additional insulation to protect them from freezing during the winter months.

See Water, Strategy 6: Resiliency and Stormwater Management section for guidance in stormwater retention.

B Foundation Drainage

Applicability: Building

Implement a foundation drainage treatment and reuse system. The water could require little additional treatment depending on local soil conditions. Foundation drainage could have higher levels of dissolved salts, organics, or other pollutants that may require special biological and filtration systems. Yield: consistent year-round.

C Condensate

Applicability: Building

Install systems for collecting condensate from air conditioning units to recover for reuse. The water usually requires very little treatment though it could be slightly acidic and may require buffering. Yield: consistent during the cooling season.

D Cooling Tower Blowdown

Applicability: Building

Install a cooling tower blowdown treatment and reuse system. The water has a high-salt build-up due to evaporation. Yield: consistent during the cooling season.

Level 3

E Greywater

Applicability: Site, Building

Install a greywater treatment and reuse system. The water requires a dedicated treatment system. Yield: consistent year-round.

F Blackwater

Applicability: Site, Building

Implement a blackwater treatment and reuse system. The water requires more treatment than for any other water source due to its high-biological content. Yield: consistent year-round.

Possible Uses

Level 1

A Irrigation

Applicability: Site, Building

Utilize recycled water for landscape drip or hose irrigation. Drip irrigation is preferable, as it is a more efficient system for delivering water directly to the plants and is less prone to water loss through evaporation.

See Water, Water Conservation, Intervention, Irrigation section for guidance.

B Washing

Applicability: Site, Building

Utilize recycled water for the washing of sidewalks, streets, or buildings.

Level 2

C Cooling Tower Make-Up

Applicability: Building

Utilize recycled water for cooling tower make-up. Manufacturer requirements for reclaimed water quality should be considered.

Level 3

D Flushing and Laundry

Applicability: Building

Utilize recycled water for toilet, urinal flushing, or laundry. Manufacturer requirements for reclaimed water quality should be considered. Additional plumbing required.

Metering

Level 1

A Metering

Applicability: All

Meter reclaimed water, regardless of rate. A reclaimed water system with a make-up water connection should also be metered so that the total reclaimed water volume can be determined.

Level 2

N/A

Level 3

N/A

Practice

Measurement & Verification

A Recycled Water Quality

Develop a quality testing protocol that establishes the following:

- NYC requirements for the system to ensure all water is safe for reuse. See Table 13 for city water quality requirements and Water, Water Conservation, Practice, Measurement & Verification, Water Quality for improved water quality
- Frequency for testing
- Laboratories for testing

B Recycled Water Consumption

Track consumption of recycled water in systems, including the following (as applicable):

- Volumes of recycled water available and potable water top-up required
- Patterns of variation in recycled water availability and non-potable water demand

See Energy, Deep Energy Retrofits, Intervention, Building Management System & Sub-Metering section for additional guidance.

Operations & Maintenance

A Maintenance Plan

An ongoing maintenance plan should include the following aspects[132]:

- Inspections
    - Operators to perform a daily walk through inspection of system components, checking for leaks, noises, or other system abnormalities
- Service instrumentation
    - Water reuse systems typically have a variety of online instrumentation. These components need to be calibrated and serviced at predetermined intervals to assure accuracy. Frequency to be based on regulation and system guidelines
- Replenish products

  - Chemicals such as chlorine used in the disinfection process need to be continually replenished. Other products such as cartridge filters may also need to be regularly replaced
- Preventative maintenance
  - Mechanical components of the treatment process such as pumps, valves, or blowers may require preventative maintenance, such as changing oil, to maintain long, reliable service life. Microfilter and ultrafilter membranes require regular clean-in-place procedures to maintain performance. Ultraviolet (UV) bulbs need to be cleaned and replaced at regularly scheduled intervals. Membrane bioreactors should be periodically cleaned by physical (backflushing) and/or chemical means to recover permeability of the system
- Emergency maintenance
  - Preventative maintenance and mitigation of risk factors in the system design (e.g., duty/standby pumps) can reduce but not eliminate the need for emergency maintenance due to the failure of mechanical components or biological upsets. Most water reuse systems have online control systems that respond automatically to emergency conditions, preventing the reuse of noncompliant water. These systems can quickly alert operators to address problems and restart reuse, while diverting source water to the sewer and switching over to city supplied mains water
- Waste removal
  - Fats, Oils, and Grease (FOG) that is screened and skimmed from the influent prior to entry into the treatment process is typically dewatered and disposed of in landfills or sent to a secondary facility for stabilization and reuse as a soil amendment. Sludge, consisting of settled solids from the primary and secondary treatment processes, is often reused within the system for bacteria stabilization. Depending on the system, sludge may need to be periodically removed by a septage service, discharged to municipal treatment, or transported to a secondary facility for dewatering and stabilization for disposal or reuse as for FOGs

Case Study 5

WaterHub at Emory University - Atlanta, GA[133]

The WaterHub is an on-site water recycling system on the Emory University campus capable of recycling 400,000 gallons per day (almost 40% of the university's demand). The WaterHub is a reciprocating wetland that mimics natural biological decomposition with low-energy treatment. The treated water is used as make-up water in their steam and chiller plants and for toilet flushing. The system also reserves 50,000 gallons of emergency water to enable chiller plant functionality for an average of seven hours in case of water supply disruption.

Figure 17: WaterHub at Emory University - Atlanta, USA[134]

Strategy 6:
Resiliency & Stormwater Management

Priorities

The Resiliency and Stormwater Management Strategy offers intervention opportunities to incorporate stormwater management strategies that can improve BPC's stormwater detention capacity, add vegetated features slow down and filter stormwater runoff, and provide a source for recycled water. Most importantly, stormwater management practices, and resilience efforts can reduce the impact of major storms and weather events, protecting infrastructure and the BPC community.

This section focuses on interventions that support the following priorities:

- **Capture Stormwater to Reduce Flooding:** Reducing the volume of runoff will alleviate the risk of flooding, enhance the resilience and accessibility of the open spaces at BPC during storm events, offer the opportunity for rainwater capture for treatment and reuse, and reduce stormwater runoff into the combined sewer system and the Hudson River
    - **Green Infrastructure:** Green infrastructure such as rain gardens, bioswales, and green roofs can offer many benefits and represents an approach to stormwater management that uses small-scale hydrological control measures to mimic the predevelopment conditions in the watershed. Traditional stormwater infrastructure has focused on the use of a system of piped drainage and water treatment systems to move urban stormwater off-site as quickly as possible, whereas green infrastructure instead aims to make space for water on-site and encourage natural filtration
    - **Increase Ground Permeability:** This is the most basic aspect of stormwater management. A permeable surface, such as grass or other green space, will absorb water from a rain event and retain it on site, while filtering out contaminants. An impervious surface will not allow infiltration and will either cause water to pond in that area or flow elsewhere
- **Treat Runoff Before Discharge:** Controlling pollutants before they enter the runoff stream will help prevent contamination of downstream water bodies and reduce the requirements for water quality improvement measures within green infrastructure measures. At the highest level, care should be taken to avoid practices and products that can contaminate runoff on a site-level. Additionally, treating stormwater before discharge can help to minimize pollution in the local waterways.

Assessment

Audits

Audits – Green Infrastructure

Level 1

A Surface Finishes

Review surface finishes with the following considerations when upgrading external spaces and features:

- Review planting strategies to improve water infiltration in existing green areas
- Assess percentage permeability of open space i.e. area of hardscape vs. softscape

Level 2

B Geotechnical Survey

Conduct a limited geotechnical investigation at the site to assess the potential for green infrastructure interventions. The survey should be performed by a New York State licensed Geotechnical Engineer. The investigation should at minimum determine the following:

- Subsurface soil characteristics and texture
- Groundwater table
- Depth to bedrock
- Any hydraulically limiting layer(s) that would potentially inhibit vertical infiltration
- Hydraulic conductivity using permeability tests
- Follow the procedure for conducting a limited geotechnical investigation outlined in Appendix F of the NYC Green Infrastructure On-Site Design Manual[135]
- If contamination is discovered during testing, abandon the site immediately and notify NYC DEP and Battery Park City Authority

Level 3

C On-Site Survey

Conduct a limited on-site survey. The survey should be performed by a New York State licensed Professional Land Surveyor. The survey should include enough information to create a comprehensive base for project design. This includes surface and subsurface features, as well as topographic and drainage information. The survey limits should extend to the limits of construction and the Tributary Drainage Area (TDA) of the proposed installation. The TDA is the amount of surface area that drains into the green infrastructure practice and may extend beyond the limits of construction. This survey may occur concurrently with the Limited Geotechnical Investigation. Below are the basic elements that should be included in each aspect of the survey[136]:

- Surface Features
- Utility castings and overhead lines (manholes, fire hydrants, catch basins, etc.)
- Existing site furniture (benches, tables, signs, light poles, etc.)
- Trees and stumps, including diameter and drip line
- Tree pit extents
- Site accessibility features (driveways, curb cuts, crosswalks, ramps, and stairwells)
- Curb material, condition, and reveal (top and bottom curb elevations)
- Existing buildings and structures
- Building egress
- Sidewalk and roadway surface materials
- Pavement markings

If the green infrastructure practice is designed to capture street runoff, the following should also be included:

- Legal Right-of-Way (ROW) width of street
- Roadway width (curb to curb)
- Distances to intersections
- Elevations and street grades
- Bus stops, bus stop shelters, and signs
- Subway entrances
- ROW green infrastructure, if present
- Subsurface Features
- Vertical alignment, horizontal alignment, dimensions, type, and cover for utilities

If a green infrastructure practice is sited within 10 feet of a protruding basement or utility vault, a vault investigation should be performed. This is a visual inspection that includes the following:

- Basement information (width, depth of slab below street or sidewalk grade, extension into sidewalk beyond building line, etc.)
- Visual signs of existing water damage
- Presence and location of sump pump
- Location of service lines entrance or exit from the building
- Topographic Information
- All existing elevations are necessary to characterize the topography of the site, including high and low-points. Elevations should be shown in feet and referenced to the NAVD88 vertical datum
- Contour lines at 0.5-foot intervals
- Drainage Information. Details of drainage structures should include:
    - Size
    - Material
    - Type
    - Rim/grate elevation
    - Invert elevations

If manholes, catch basins, or pipes are filled with sediment they should be cleaned before measuring elevations.

D Hydrologic Analysis

Perform a Hydrologic Analysis using the finalized Tributary Drainage Area (TDA). This method targets both the quantity and quality of the stormwater on site to ensure that selected green infrastructure can be optimized to treat the impervious area and avoid impacts to the downstream collection system. The procedure for this analysis is outlined in the steps below.[137]

- Determine the pre-development stormwater flow rate on site to establish a baseline for water quantity. Then, using the proposed site plan, determine the initial post-development flow
- Implement and size green infrastructure practices to reduce the post-development flow to 20% less than the pre-development flow. Instructions for sizing and design of each green infrastructure practice can be found in their respective Intervention sections below
- Determine the Water Quality Volume (WQ_v) on site to establish a baseline for stormwater quality. The WQ_v is the volume of runoff generated by the entire 90th percentile rain event, or 90% of all 24-hour rain events. Doing so targets the small, frequent storm events that usually contain higher pollutant levels
- Design and size green infrastructure practices to treat 100% of the WQ_v. Instructions for sizing and design of each green infrastructure practice can be found in their respective Intervention sections below

Between 2010 and 2018 the NYC Department of Environmental Protection implemented 591 Total Equivalent Greened Acres citywide – contributing to the reduction of Combined Sewage Overflow (CSO) by 507 million gallons a year (MGY). (One Greened Acre is equivalent to one inch of managed stormwater from one acre of drainage area or 27,158 gallons of managed stormwater.)[138]

Audits – Watershed Context

Level 1

A Watershed Context

Assess Battery Park City's watershed context to identify potential issues related to freshwater, stormwater, and wastewater. Particular attention should include other resiliency projects currently being evaluated in the Lower Manhattan region. For instance, refer to the 2019 Lower Manhattan Climate Resilience Study (NYCEDC), which outlines the response to sea level rise and climate change for lower Manhattan, post-Hurricane Sandy.[139]

- Examples include watershed plans, regional water, and wastewater utility plans, climate change reports, etc.
- Documentation should include location, type, quantity, rate of recharge, and quality of water resources in the watershed
- Identification of the source and impacts of wastewater used and the destination and impacts of wastewater

Level 2

N/A

Level 3

N/A

Audits – Surface Water Buffer

Level 1

A Stormwater Networks

Identify all receiving water bodies and associated stormwater networks within BPC.

B Buffer Zones

Identify the appropriate type and width of buffer zones for the protection of the identified surface waters.

- Calculate the proposed buffer type
- Document the considered site conditions, including soil type, slope, land use, and vegetation mix
- Document that the proposed buffer width and type are sufficient to address pesticide retention, bank stabilization, sediment control, nutrient retention, litter and debris, water temperature, terrestrial wildlife, and aquatic wildlife

Level 2

N/A

Level 3

N/A

Audits – Groundwater Quality

Level 1

A Groundwater Survey

Perform a survey to determine potential impacts to surface water or groundwater quality, including temperature, during operational activities. Document should include location and potential hazards associated with equipment, facilities, polluting substances/materials, and current best management practices (BMP) for the preservation of groundwater quality

B Contaminant Sources

Identify work and storage locations such as shipping areas and vehicle maintenance yards that that are likely to provide significant sources of contaminants during rainfall events, like grease, oil, heavy metals, and process fluids

Level 2

N/A

Level 3

N/A

Benchmarking

Level 1

A Watershed

Use collected watershed context data to establish the baseline benchmark of current conditions in Battery Park City.

B Surface Water

Use collected wetland and surface water buffer data as baseline benchmark and develop a plan to implement appropriate type and width of buffer zones for wetland and surface water protection. Battery Park City is located in the National Wetland Inventory (NWI) Estuarine and Marine Deepwater area.[140]

C Groundwater Quality

Test existing levels of surface water and groundwater contamination. Use collected information on current groundwater quality to establish the baseline benchmark of current conditions at BPC.

D Construction Activities

Determine potential impacts to surface water and groundwater during construction activities. See Materials & Waste, Strategy 9: Construction and Demolition Activities section for guidance on construction impact mitigation.

Level 2

E Stormwater Infrastructure Performance

For sites with existing stormwater management or green infrastructure systems, establish the performance of the features against the latest design criteria.

Level 3

N/A

Intervention

Stormwater Capture

Green Infrastructure

Level 1

N/A

Level 2

A Stormwater Gardens

Applicability: Site

Stormwater gardens are smaller than rain gardens and can be optimally located in the following areas:

- Adjacent to large sections of impervious ground cover, such as streets or parking lots
- At the base of a slope in a lawn

When planning a stormwater garden, the following criteria should be observed:

- Place in areas with well-draining soil (infiltration rate of at least 0.5 inches per hour)
- If proper soil drainage cannot be achieved, use an underdrain pipe or similar structure
- Place at least ten feet away from building foundations or provide a method to waterproof foundations
- The garden should drain within 12-48 hours after a rain event
- Use a mix of upland and wetland plants with well-developed roots
- Use native plants to minimize the need for fertilizer and prevent the spread of invasive species
- Provide a means of overflow for large storm events such as a broad weir, riser pipe, or spillway
- Achieve necessary separation between drainage infrastructure and existing utility corridors

Considerations for sizing a stormwater garden[141]:

- The ideal drainage area to bioretention area ratio is 5:1
- Side slopes should be less than 3:1. Slopes of 2:1 may be used only with a fence or retaining structures
- Provide a soil base of at least two feet using 50% sand, 20-30% topsoil with less than 5% clay, and 20-30% leaf compost

- Provide an underlying layer of clean open graded gravel 6-10" deep for storage and infiltration

B Rain Gardens

Applicability: Site

Rain gardens are larger than stormwater gardens and can be optimally located in the following areas:

- Adjacent to large sections of impervious ground cover, such as streets or parking lots
- At the base of a slope in a lawn
- Close to the source of the runoff to mimic natural drainage patterns

The following drainage criteria should be observed:

- Soil should have an infiltration rate of at least 0.5 inches per hour
- If proper soil drainage cannot be achieved, use an underdrain pipe or similar structure
- Place at least ten feet away from building foundations or provide a method to waterproof foundations
- The garden should drain within 12-48 hours after a rain event
- Use a mix of upland and wetland plants with well-developed roots
- Use native plants to minimize the need for fertilizer and prevent the spread of invasive species
- Provide a means of overflow for large storm events such as a broad weir, riser pipe, or spillway

Sizing criteria:

- The ideal drainage area to bioretention area ratio is 5:1
- Side slopes should be less than 3:1. Slopes of 2:1 may be used only with a fence or retaining wall
- Provide a soil base of at least two feet using 50% sand, 20-30% topsoil with less than 5% clay, and 20-30% leaf compost
- Provide an underlying layer of clean open graded gravel 6-10" deep for storage and infiltration

See the NYC Department of Parks and Recreation's High-Performance Landscape Guidelines Section W.5 for detailed sizing and design calculations.

C Rock-Lined Drainage Swale or Dry Creek Beds

Applicability: Site

A drainage swale is best used as a means of conveying stormwater at grade from an inlet to an outlet. Its progress through the swale slows, filters, and disperses it to reduce the impact on the receiving system. These swales can be placed at the outlet of any runoff collection system from an impervious surface such as a roof drain, street drain, or parking lot catch basin, and can be used to enhance a landscaped area, as they are designed to look like the bottom of a riverbed.

- Although these can have a meandering or straight alignment. If possible, a meandering one is preferred, as it maximizes the retention time of water in the swale

- The recommended slope of a swale from inlet to outlet is 3%
- The rocks used to line the swale should be a minimum of 6 inches in diameter and create a layer roughly one foot thick. This should be underlain by a layer of gravel or filter fabric 3 inches deep
- The depth of the swale should be between 10 and 15 inches and the width between 4 and 6 feet

D Vegetated Bioswales

Applicability: Site

Vegetated bioswales can be optimally located with the following considerations:

- In street right-of-ways and on developed sites convey and treat stormwater runoff from nearby impervious surfaces
- In areas that have a high-percentage of impervious surfaces such as adjacent to plaza or parking areas

When designing a bioswale, the following installation and sizing criteria should be observed:

- Areas should have a drainage area of less than five acres and a peak flow less than three cubic feet per second
- The length of the drainage course should ideally be 100 feet and have a slope between 0.5% and 4%
- The width of the bottom of the swale should be between two and six feet, and the slope of the sides should be no greater than 3:1
- It should be sized to retain the treatment volume for 10 minutes if receiving discharge from an inlet, or five minutes if receiving from sheet flow or multiple discharge points
- The vegetation height should reach approximately 4-6 inches and consist of native plant
- Informational signage can be placed to bring awareness to the public

See the NYS Stormwater Design Manual Chapter 5.3.3 for detailed sizing and design calculations.

E Detention Basins

Applicability: Site

Detention basins are designed to provide stormwater quantity control through slow infiltration. They fill during heavy rain events and should dry within 72 hours. They require substantial open space but can be used for parkland or recreational purposes between storm events

When designing a detention basin, the following criteria should be observed:

- The detention basin should be placed in an area where the soil is permeable and the groundwater table is not too high to provide adequate infiltration
- The main components of a detention basin are the sediment forebay, vegetation, a micro-pool, and an outflow structure:
    - The sediment forebay is a pool and settling basin constructed at the inlet of the detention basin to provide retention for the first flush of stormwater runoff. This is generally the runoff with the

highest level of pollutants, so it is necessary to provide an area where the sediment can settle out before it reaches the larger detention basin

- The sides of the basin should be vegetated to provide erosion control and sediment entrapment. Vegetation should be a mix of turf and low-lying shrubs and should all be native species
- A micro-pool is a shallow, permanently inundated pool that concentrates the finer sediment and reduces re-suspension. This helps the detention basin maximize its water quality performance. The pool is typically planted with wetland vegetation such as cattails
- The outflow structure controls the flow of excess runoff from the basin. Its size is determined by the soil capacity below the basin and it is typically located at the lowest point of the structure. A grate or mesh should be installed over the entrance to prevent clogging

Considerations for sizing:

- Maximum water depth of 10 feet
- Minimum width of 10 feet
- Minimum length to width ratio of 2:1
- Vegetated embankments are recommended to be 3 feet in height and should never exceed 15 feet. The slope of the embankments should be 3:1 (horizontal to vertical)
- The lowest basin elevation should be a minimum of 2 feet above the seasonal high-water table

Level 3

F Green or Blue Roofs

Applicability: Building

When designing a green roof, the following should be considered:

- A green roof can be extensive or intensive. Extensive roofs have a thin layer of soil which is lighter, less expensive and requires less maintenance. An intensive one includes pedestrian access and a deeper layer of soil with more plant diversity
- An extensive roof can be installed on a flat surface or ones sloped up to 30%. Intensive roofs require flat surfaces but can be tiered
- The choice of roof type is determined by the strength of the building, its usage, and the preference of the owner
- An extensive green roof uses a mixture of soil, sand, and gravel to form a base three to six inches deep. This increases the roof load by 16 to 50 pounds per square foot when fully saturated. Plant species used in this environment should be low and hardy
- An intensive green roof uses a less sandy soil with a depth of six to 24 inches. This will support a diverse mixture of trees, shrubs, and groundcover. The saturated roof loading is 50 – 200 pounds per square foot

Refer to the New York State Stormwater Design Manual, Chapter 5.3.8, for detailed sizing and design calculations.[142]

Rain garden vegetation and soils remove pollutants and nutrients from stormwater runoff through biological and physical processes such as plant uptake and sorption to soil particles. Infiltrating stormwater through rain gardens reduces peak flows and loadings of both pollutants and nutrients.[143]

Ground Permeability

Level 1

A Runoff Reduction – Level 1

Applicability: Site

Infiltrate, evapotranspirate and/or reuse 100% of the 85th percentile local 24-hour event. If infiltration, evapotranspiration, or reuse are not permitted or impracticable detail and treat 150% of 85th percentile 24-hour event.

Level 2

B Runoff Reduction – Level 2

Applicability: Site

Infiltrate, evapotranspirate and/or reuse 100% of the 90th percentile local 24-hour event. If infiltration, evapotranspiration, or reuse are not permitted or impracticable detail and treat 150% of 90th percentile 24-hour event.

C Permeable Pavement

Applicability: Site

Where feasible, replace non-permanent pavement with more permeable options. When incorporating permeable pavement, the following criteria should be observed:

- Best located in low-traffic hardscapes such as sidewalks, driveways, parking lots, and courtyards
- Best used for the treatment of small, frequent rainfall events
- Permeable pavement has three main components: surface, storage, and outflow
    - Within the surface category, there are two major types: porous pavement and permeable pavers. Porous pavement is permeable asphalt or concrete that uses larger aggregate to create void spaces for infiltration. This allows stormwater to quickly infiltrate to an underlying reservoir. Permeable pavers can include interlocking concrete pavers, bricks, or reinforced turf that allow infiltration through the cracks between the pavers
    - The storage component of permeable pavement is generally a layer of coarse aggregate that can store stormwater in the voids and help distribute mechanical loads. A layer of geotextile fabric is placed between the bottom of the surface layer and the top of the aggregate to prevent sand and soil from entering the storage space. A layer of fine aggregate can also be placed above the textile to provide additional filtration. The storage bed can be designed to hold only runoff from the permeable pavement surface or to store additional runoff from nearby areas as well
    - The outflow component can either be percolation directly into the underlying soil or through a perforated pipe system out of the stone reservoir. The system should be designed based on the capacity of the underlying soil

See the NYS Stormwater Design Manual Chapter 5.3.11 for detailed sizing and design calculations.[144]

Level 3

D Runoff Reduction – Level 3

Applicability: Site

Infiltrate, evapotranspirate and/or reuse 100% of the 95th percentile local 24-hour event, OR If infiltration, evapotranspiration, or reuse are not permitted or impracticable detail and treat 150% of 95th percentile 24-hour event.

E Lower Manhattan Watershed ❤

Applicability: Site

Coordinate a net-positive improvement to the broader Lower Manhattan Watershed. Improvements may include:

- Improved water quality
- Improved hydrologic connectivity

- Increased water storage and availability

F Buffer Naturalization

Applicability: Site

Return previously developed or disturbed sites within the buffer zone to a natural state.

- Include maps and plans of developed areas of BPC that will be returned to a natural state within the protective buffer zones
- Developed areas include manmade surfaces (e.g., pavement) and/or structures (e.g., facilities)

Controlling Sources of Pollutants

Site Practices

Level 1

A Designated Washing Areas

Applicability: All

Designate vehicle and equipment washing areas, ensuring that they drain to water quality improvement measures before off-site discharge.

B Bulk Materials Storage

Applicability: All

Storage of bulk materials, fuels, oils, solvents, other chemicals, and process equipment should be accommodated as follows:

- On an impervious surface covered with a roof to prevent contamination of stormwater runoff
- In designated locations that should not allow stormwater runoff to pass through such as shipping areas, vehicle maintenance yards, and other workplaces. These typically utilize contaminants like grease, oil, heavy metals, and process fluids

C Waste Storage

Applicability: All

Areas designated for trash storage should be covered to protect containers from contaminating stormwater runoff.

D Polluting Substances ❤

Applicability: All

Significantly reduce or eliminate hazardous and/or potentially polluting substances from operational activities such as oils/lubricants, substances containing heavy metals, pesticides/herbicides, etc.

E Signage

Applicability: All

Add signage next to trash bins and work areas to educate the public and maintenance staff on where the runoff flows to.

Level 2

N/A

Level 3

N/A

Treatment

Level 1

N/A

Level 2

A Pre-Treatment

Applicability: Site

Ensure all stormwater is routed through water quality improvement measures before discharge to surface waters. Potential solutions for trafficked areas with higher concentrations of hydrocarbons or increased sediment loading could include the following:

- Install petrol and/or grit interceptors before discharge to stormwater management systems
- Use part of the green infrastructure overall area to capture grit/sediment and trash e.g. cigarette butts that get washed off hardscape areas

B Treatment

Applicability: Site

Ensure all stormwater is routed through water quality improvement measures before discharge to surface waters. Potential solutions for inlets that discharge directly to the waterways include the following:

- Infiltration
- Detention and settling
- Biofiltration
- Filtration
- Flow Through Separation

C Natural Buffers

Applicability: Site

Provide vegetated or natural buffer zone around at least 90% of wetland and surface waters. These should slow surface runoff, and trap sediments, pesticides, and other pollutants. Buffer zones maintain the integrity of receiving water bodies while playing an important role in the following:

- Protect wildlife habitats, provide connected habitat corridors, and maintain biodiversity—Many wetland and aquatic dependent species also require access to riparian or upland habitats for feeding, nesting, breeding, and hibernation
- Regulate water temperature—Shade from vegetation in buffer areas maintains water temperatures. Increased water temperatures can harm aquatic life
- Maintain water quality—Buffer areas provide erosion control and filter excess nutrients and pollutants from runoff
- Protect hydrology—Buffer areas regulate the flow of stormwater runoff and help preserve surface water and groundwater levels and flows
- Protect against human disturbance—Providing a buffer helps protect wetlands and surface waters from impacts in nearby areas, including destroying vegetation, compacting soils, debris, noise, and light
- Incorporate educational elements within the children’s playgrounds to promote water quality awareness
- Incorporate signage and stenciling for catch basins and trash receptacles to inform the public about where stormwater drains to and the importance of properly discarding waste
- Relocate equipment and facilities containing potentially polluting substances away from sensitive environments
- Prepare Spill and Leak Prevention and Response Plan to handle all operational activity incidents

Level 3

N/A

Practice

Measurement & Verification

A Stormwater Runoff Quality

Ensure acceptable ongoing greywater quality by doing the following:

- Test water quality to assess the presence of chemicals of concern: sodium, chloride, and boron
- Review distribution of trash and grit throughout stormwater management measures to identify whether interception measures are correctly capturing coarse contaminants
- Collect samples of stormwater runoff and compare against EPA standards before discharge into surface waters twice a year

Operations & Maintenance

A Operational Practices Review

Review and update operational practices, spill control measure policies, and equipment protocols to prevent pollutants from coming into contact with storm or wash water runoff and identify the adequacy of work and storage areas that contain contaminants at ensuring they are not affecting stormwater runoff quality.

B Spill and Leak Prevention and Response Plan

Annually, evaluate Spill and Leak Prevention and Response Plan to determine that they continue to cover all current operational activities.

C Waste Signage

Annually evaluate signage and stenciling on catch basins and around waste receptacles.

D Maintenance Schedule

Develop a maintenance schedule for stormwater capture infrastructure including:

- Employee training
- Operations schedule
- Maintenance frequency
- Routine service schedule

- Vegetation management, including cutting overgrown vegetation and re-planting lost vegetation

E Eco-Friendly Products

Utilize eco-friendly maintenance materials (i.e. ice melt, fertilizer, pesticides, cleaning agents, etc.)

Case Study 6

Long-Term Control Plan Modification for Green Infrastructure – Washington, D.C. [145]

The DC Water and Sewer Authority has been working on a project since 2002, called the Long-Term Control Plan, that redirects Combined Sewer Overflows (CSO) to a nearby wastewater treatment plant through a series of large concrete underground tunnels. The plan also includes green infrastructure measures, such as rain gardens, porous pavement, green roofs, and rain barrels. Their purpose is to promote rainwater detention and infiltration into the soil, to divert water away from the CSO system. This will help to reduce the amount of polluted runoff that enters the DC watershed while also providing many environmental, social, and economic benefits to the community.

This method of replacing grey infrastructure with green helps to alleviate pressure on the CSO system and reduces the amount of pollution entering the surrounding watershed. Replacing impervious ground cover with green space cools and cleans the surrounding air, helping to reduce heat island effect. Including green infrastructure practices in projects creates local green jobs, and the skills learned will continue to benefit the community even after the project has been completed. The addition of greener public and private spaces increases property values and improves the quality of life for the surrounding community.

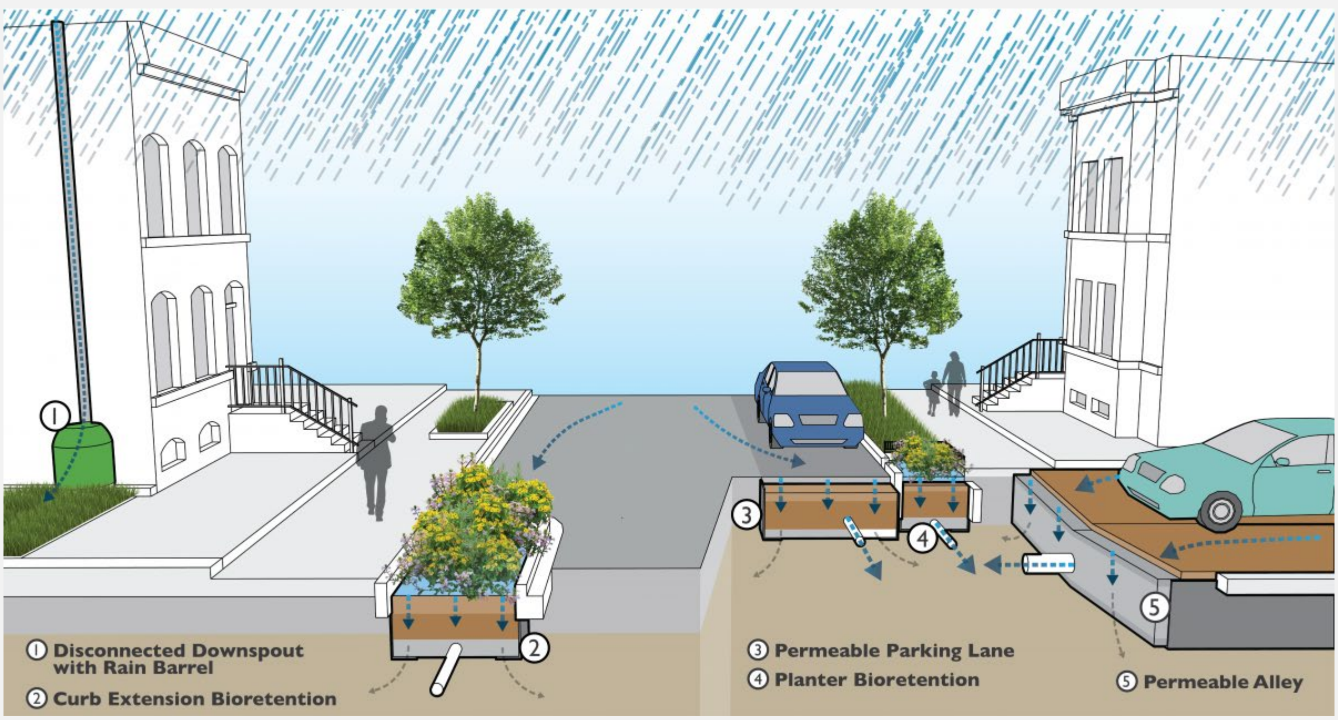


Figure 18: Long-Term Control Plan Modification for Green Infrastructure - Washington D.C, USA[146]

Resources

American Society of Plumbing Engineers (ASPE) Handbook

https://www.aspe.org/publications-news/aspe-plumbing-engineering-design-handbooks/

Best Management #4: Water Efficient Landscaping

https://www.energy.gov/eere/femp/best-management-practice-4-water-efficient-landscaping

Evapotranspiration Rates

http://www.nrcc.cornell.edu/wxstation/pet/pet.html

Guidelines for the Design and Construction of Stormwater Management Systems. NJDEP. July 2012

www1.nyc.gov/assets/dep/downloads/pdf/water/stormwater/stormwater-design-construction-guidelines-2012-final.pdf

Institute for Sustainable Infrastructure

https://sustainableinfrastructure.org/envision/

Mate Institute for Sustainable Infrastructure

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NYC DEP

www1.nyc.gov/site/dep/water/stormwater-management.page

NYC Economic Development Corporation. Lower Manhattan Climate Resilience Study. (March 2019)

https://edc.nyc/sites/default/files/filemanager/Projects/LMCR/Final_Image/Lower_Manhattan_Climate_Resilience_March_2019.pdf

NYC Mayor's Office of Sustainability. Water Management.

https://www1.nyc.gov/site/sustainability/initiatives/water-management.page

NYC Parks High-Performance Landscape Guidelines

www.nycgovparks.org/sub_about/sustainable_parks/design_guidelines.pdf

NYC Plumbing Code (2014)

https://www1.nyc.gov/site/buildings/codes/2014-construction-codes.page#plumb

NYC Water Conservation/Reuse Grant Guide

www1.nyc.gov/assets/dep/downloads/pdf/water/drinking-water/water-conservation-reuse-grant-faqs.pdf

NYS DEC Environmental Resource Mapper

https://gisservices.dec.ny.gov/gis/erm/

NYS DEC. New York State Stormwater Management Design Manual. Chapter 5, Green Infrastructure Practices

https://www.dec.ny.gov/docs/water_pdf/swdm2010chptr5.pdf

NYS Stormwater Management Design Manual

www.dec.ny.gov/docs/water_pdf/swdm2015entire.pdf

On-site Non-Potable Water Reuse

https://static1.squarespace.com/static/582a1176893fc0eadc79722d/t/5a622d0b71c10b9a450435ab/1516383505843/WaterReuseGuide_2018.pdf

WaterSense Mechanical System Maintenance

www.epa.gov/sites/production/files/2017-12/documents/ws-commercialbuildings-waterscore-mechanical-systems-guide.pdf

WaterSense Residential Kitchen and Laundry Guide

www.epa.gov/sites/production/files/2017-10/documents/ws-commercialbuildings-waterscore-residential-kitchen-laundry-guide.pdf

Abbreviations & Definitions

ASTM	American Society of Testing Materials
BMPs	Best Management Practices
BOD	Biological Oxygen Demand
BPC	Battery Park City
BMS	Building Management System
CFU	Colony Forming Unit
CSO	Combined Sewage Overflow
DEC	NYS Department of Environmental Conservation
DEP	NYC Department of Environmental Protection
EPA	Environmental Protection Agency
FOG	Fats, Oils, and Greases
GAL/ft^2	Gallons per Square Foot
GAL/PP	Gallons per Person
GPF	Gallons per Flush
GPM	Gallons per Minute
GPY	Gallons per Year
GWTS	Greywater Treatment Systems

HVAC	Heating, Ventilation, and Air Conditioning
IgCC	The International Green Construction Code
KGAL	One Thousand Gallons
LL	NYC Local Law
MGD	Million Gallons per Day
MGY	Million Gallons per Year
MS4	Municipal Separate Storm Sewer System
NTU	Nephelometric Turbidity Unit
NWI	National Wetland Inventory
pH	Potential of Hydrogen (used to measure acidity levels)
PM	Permanent Magnet
PSI	Pounds per Square Inch
SPCC	Spill Prevention, Control, and Countermeasure Rule (US EPA)
TDA	Tributary Drainage Area
TMV	Thermostatic Mixing Value
TSS	Total Suspended Solids
UV	Ultraviolet
WF	Water Factor
WJW	William J. Worthen

WUI	Water Use Intensity

Biofiltration	Using a bioreactor that contains organisms that capture and degrade influent wastewater pollutants.
Bioswale	A vegetated swale incorporates a garden of native plants to provide additional filtration, intended to handle the first flush of pollutants during a rain event.
Black Water Treatment System	Black water treatment systems are more complex and energy intensive per gallon than grey water treatment systems, but they can be applied to existing sanitary systems without modification of building piping risers. The recycled water can be piped to non-potable uses such as toilet flushing, irrigation, and cooling tower make-up. Treated water can also be a heat source for domestic water preheating or heating by a heat pump.
Blackwater	Recovered from plumbing fixtures such as water closets and urinals and cooling tower water which contains chemicals in its treatment.
Buffer Zones	Area of protection surrounding surface water and/or wetland.
Clean-in-Place	Method of cleaning closed systems without disassembly and removal.
Coliform	Bacteria present in the digestive tract of mammals, and their wastes. A common example of the rod-shaped bacteria includes E. coli.
Detention Basin	Shallow artificial pond designed to infiltrate stormwater through permeable soils into the groundwater aquifer. It remains dry most of the time and only fills during heavy rain events. It does not release water to any nearby water bodies – only through infiltration, evaporation, or emergency overflow during floods. They require substantial open space but can be used for parkland or recreational purposes between storm events.
Green Roof	Vegetation and soil installed on a rooftop that absorbs and filters rainwater, eventually releasing it via evaporation. It can be extensive, with a thin layer of soil which is lighter, less expensive and requires less maintenance, or intensive, with pedestrian access and a deeper layer of soil with more plant material.

Greywater Treatment System	Treatment system used to recycle and filter greywater from residential and commercial buildings and reused for garden irrigation.
Greywater	Wastewater including all sources except kitchen and sewage.
Hydrology	A branch of science that studies the properties and movement of earth's water with respect to land.
Percolation	The movement of fluids through a porous medium, an example includes the passage of water through a filter material.
Performance Gap	The well-documented disparity between design and as-built building performance (i.e. energy models vs. metered consumption). This arises for many reasons, from design, construction, and operations.[147]
Permeable Pavement	A pervious type of pavement with an underlying stone reservoir that allows water to infiltrate through the surface and slowly drain into the soil or discharge via a drainpipe. Permeable pavement can trap pollutants both physically and chemically and requires regular maintenance to keep pores free of sediment.
Rain Cistern	Large container for storing stormwater runoff so it may be used in future activities. It can be located above ground to capture runoff from a roof or other elevated area, or below ground to capture stormwater from parks or open spaces.
Rain Garden	A small garden of native plants designed to temporarily hold and absorb rainwater runoff from nearby impervious surfaces.
Rainwater	Precipitation which is collected in cisterns for use in non-potable uses with little or no treatment
Recycled Water Risers	Installing grey water risers is disruptive but can yield a large volume of easily treated water that can be applied to non-potable uses such as toilet flushing, irrigation, and cooling tower make-up. Treated water can also be a heat source for domestic water preheating or heating by a heat pump.
Recycled Water	Refers to clean water treated to remove bacteria, heavy metals, and organic material.

Spill and Leak Prevention and Response Plan	A documented plan, which identifies all areas of hazardous chemicals, potential leakages, and other pollutants that have the potential to enter surface water and groundwater areas. The plan should identify measures to prevent and/or mitigate the contamination.
Stormwater Garden	A small rain garden of native plants designed to temporarily hold and absorb rainwater runoff from nearby impervious surfaces.
Swale	Can be either vegetated or rock-lined. The swale itself is a depressed, turf-lined pathway through a landscaped area along which runoff can travel. A rock-lined swale is the simpler of the two and will slow the flow of water and spread it out into the surrounding soil.
Tributary Drainage Area	The area where precipitation falls into tributary areas (e.g., creeks, streams, rivers, lakes, and reservoirs).
Water Balance Study	A water balance equation can be used to describe the flow of water in and out of a system.
WaterSense Products	Products bearing this label have met the environmental protection agencies' specifications for water efficiency and performance.

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Materials & Waste

Overview

The current supply chain economy is primarily a linear one: raw natural resources are taken from nature, used to make products, the products are used and disposed of. This model cannot work in a world of finite resources. In contrast, a circular economy offers a different model, one that is restorative by intent and design. It replaces the concept of waste with one of restoration and requires a holistic approach and substantial transition that values lifecycle impact.

To operate a sustainable neighborhood, the first step is to be conscious of what materials and goods come into the neighborhood.

Local Context

In 2020, an estimated 85% of Battery Park City waste ended up in landfills while only 15% was composted or recycled. Battery Park City has incorporated various initiatives to reduce volumes of waste sent to landfill, including adding drop-off locations for organic waste and on-site composting equipment.

Path to Sustainable Material Sourcing and Waste Management at BPC

As consumers, those who live in, work in, or visit BPC are active participants in the waste system. Through behavior change and education, as well as new infrastructure, Battery Park City can strive to both reducing the volume generated and the volume sent to landfill.

In this section of the Green Guidelines, technical guidance is provided to support the successful achievement of the following strategies from the BPC Sustainability Plan: 1) sustainable building materials, 2) waste diversion, and 3) construction and demolition activities.

Strategy 7: Sustainable Building Materials

New projects offer opportunities for reuse of existing building components, careful material selection, consideration of end-of-life applications, and designing for future disassembly to reduce embodied carbon. This applies to all project types including maintenance and upkeep, major renovations, and new construction. Beyond global environmental impacts, materials have a significant influence on the indoor environmental quality, directly affecting occupant health and wellbeing. This is significant when we consider that people spend the vast majority of their time (approximately ninety percent) indoors.[148]

Strategy 8: Waste Diversion

The methods used to dispose of our waste, be it landfill or recycling, contribute to GHG emissions, as does the transportation required to move the waste from its source to its final destination.

BPCA operates a successful, small-scale composting program that can be expanded to the larger community to maximize the proper disposal and treatment of organic waste. Additionally, expanding education and awareness around recycling and reuse programs available to the community can make an impact on proper disposal rates which can be monitored and further informed by waste audits.

Strategy 9: Construction and Demolition Activities

Construction and demolition activities can produce large volumes of waste in a short amount of time. The waste generation impact should be seriously considered and mitigated.

The main origins of waste derived from construction projects include[149]:

- Over-ordering through inaccurate materials quantities and the surplus ordering of low-cost materials leading to chronic over-ordering
- Damage of materials either during delivery or during storage on-site (handling errors, inadequate storage, poor coordination with other trades)
- Off-cuts of materials resulting from inefficient design and construction practices
- Design changes leading to reworking and wasted materials
- Temporary works materials (e.g. formworks, hoarding, etc.)
- Packaging

Construction and demolition activities can also have an impact on environmental quality, which can be mitigated through proper planning to address issues of not only waste, but also air quality, noise pollution, erosion control, ecology, and water pollution.

Strategy 7:
Sustainable Building Materials

Priorities

Key considerations of the Sustainable Building Materials Strategy are the environmental impacts from extraction, manufacturing, transport, use, replacement, and demolition of materials and products that end up in our buildings.

This section provides interventions focused on the following priorities:

- **Longevity and Circular Economy**
    - Assessment of environmental impact: Assessing the lifecycle impact of building and construction materials is a crucial step to understand and reduce the environmental impact of projects
    - Selection of environmentally preferable materials: A detailed quantitative analysis of a material's environmental impact is not required to reduce environmental harm. Putting simple procedures in place, such as prioritizing the use of recycled and/or refurbished materials, or locally harvested or manufactured materials, can drastically reduce the environmental impact of materials and, ultimately, projects
    - Optimized design: Design decisions that support dematerialization, disassembly, and modular layouts can be made to help ensure material efficiency during purchasing, construction, useful life and at the end-of-life
- **Healthy Materials**
    - Material selection: Select interior materials to ensure good indoor air quality for occupants. Disclosure of material ingredients can help teams make informed choices and influence market transformation
    - Ongoing monitoring: Testing and monitoring of indoor air quality should be done after construction and during occupancy to ensure healthy indoor air quality levels

Assessment

Audits

Longevity and Circular Economy

Level 1

A Product as a Service

Identify providers of recycled/refurbished procurement and/or Product as a Service (PaaS) for all building material categories identified in the most current version of the International Living Future Institute's Embodied Carbon Guidance.[150] Use Table 14 as a reference. See UKGBC's Light as a Service How-To Guide for PaaS for an example on the process for procuring Light as a Service.[151] Other PaaS services may include carpeting, office equipment, and on-site energy generation technologies.

B High-Impact Areas

Identify areas that are prone to damage, such as:

- High-traffic zones (i.e. corridors, stairs, doors, etc.)
- Areas within proximity of the building entrances
- Public and common areas
- Roof, exterior paved areas and street furniture

Identify protection measures currently in place in those areas to ensure durability.

Level 2

C Existing Asset Recoverability

Summarize the recoverability of existing physical assets, rating them from easy to recover, like furniture, mechanical equipment, and fixtures, to challenging to recover, such as those shown in Table 15.

- Assets can be organized by the material categories from the most current version of the International Living Future Institute's Embodied Carbon Guidance.[152] Use Table 14 as a reference
- The assessment should include the asset's current condition, expected lifespan, and a projected cost and process analysis for its reuse or refurbishment

Level 3

D Materials Inventory

Create a full materials inventory for existing buildings or sites. Capture all physical assets, issues, and pathways for reuse, as outlined in Queensland's Maintenance Management Framework.[153] Also, refer to the UKGBC's Reuse How-To-Guide.[154] The assessment should include the asset's current condition, expected lifespan, and a projected cost and process analysis for its reuse or refurbishment

Table 14: International Living Future Institute's Embodied Carbon Guidance, Performance Criteria for Building Material Categories [155]

Assembly	Category	Components
Primary Material Assemblies	Foundation	Footings Retaining Walls
	Structure	Framing Reinforcement Slabs + Decking
	Enclosure	Cladding Fenestration Insulation Roofing
Interior Material Assemblies	Finishes	Ceilings Floors Walls + Partitions
	Partitions	Fenestration Framing Insulation
Additional Assemblies	Interior Furnishings	Equipment Fixtures Furniture

	Building Systems	Electrical Mechanical Plumbing + Fire Protection
	Site Work	Excavation Exterior Paving Shoring + Formwork

Table 15: Examples of Possible Demolition Waste Difficulties[156]

Product	Recovery Issues
Brick slips/brick tile system	Bonded to composite insulation panels, so difficult to separate
Closed panel timber frame: phenolic foam applied in a factory	Time consuming to separate, mineral wool and phenolic foams generally end up in landfill
Concrete with macro fibers (steel fibers, plastic fibers)	Not known whether this material can be recycled back into aggregates
Floor cassettes (composite)	Difficult to segregate materials on site
Insulated plasterboard	Difficult to segregate on site
Insulating concrete formwork	Difficult to segregate on site, risking contamination of recyclable material
Phase change materials	It is not currently known how PCMs would affect recycling
Roof cassettes	Slow to dismantle and segregate materials

Carpets represent 60% of the U.S. flooring market and only 5% is recycled. Carpet is often difficult to recycle due to a complex material make-up which includes toxic chemicals. Aside from difficulty in recycling, chemical make-up also results in poor indoor air quality, leading to carpets often ending up as landfill waste.[157]

Healthy Materials

Level 1

N/A

Level 2

A IAQ Testing – Level 2

Test occupied spaces to determine whether Level 2 thresholds are met in the most current version of the WELL standard.[158] Use Table 16 as a reference. Take indoor air measurements in representative areas of all occupied spaces, within the breathing zone (3-6 feet above the floor) during normal occupied hours, under typical minimum ventilation conditions. Laboratory-based test methods are recommended. Best practice and guidance on testing standards and locations can be found in the Air chapter of The WELL Performance Verification Guidebook.[159]

B Construction Related IAQ

See Materials & Waste, Strategy 9: Construction and Demolition Activities section for guidance in indoor air quality measures during and after construction.

Level 3

C Occupant Survey

See Energy, Deep Energy Retrofits, Assessment, General section for guidance.

D IAQ Testing – Level 3

Test occupied spaces to determine whether Level 3 thresholds are met in the most current version of the WELL standard.[160] Use Table 16 as a reference. Take indoor air measurements in representative areas of all occupied spaces, within the breathing zone (3-6 feet above the floor) during normal occupied hours, under typical minimum ventilation conditions. Laboratory-based test methods are recommended. Best practice and guidance on testing standards and locations can be found in the Air chapter of The WELL Performance Verification Guidebook.[161]

E Volatile Organic Compound (VOC) Testing

Test to ensure that individual component VOC thresholds are met in the most current version of the WELL standard.[162] Use Table 17 as a reference for all spaces except commercial kitchen spaces. Take indoor air measurements in representative areas of all occupied spaces, within the breathing zone (3-6 feet above the floor) during normal occupied hours, under typical minimum ventilation conditions. Laboratory-based test methods are recommended. Best practice and guidance on testing standards and locations can be found in The WELL Performance Verification Guidebook.[163]

Table 16: WELL Standard Version 2, Performance Criteria for IAQ Thresholds [164]

Contaminant	Level 2 Threshold Concentration (Commercial Kitchens in parentheses)	Level 3 Threshold Concentration
PM2.5	15 µg/m³ (35 µg/m³)	10 µg/m³
PM10	50 µg/m³	20 µg/m³
Formaldehyde	27 ppb (81 ppb)	13.4 ppb
Carbon monoxide	9 ppm (30 ppm)	6 ppm
Ozone	51 ppb	25 ppb
Nitrogen dioxide		21 ppb
Benzene		3 µg/m³

Table 17: WELL Standard Version 2, Performance Criteria for VOC Thresholds [165]

Compound Name	CAS Number[166]	Allowable Concentration (μg/m³)
Benzene	71-43-2	30
Carbon disulfide	75-15-0	400
Carbon tetrachloride	56-23-5	20
Chlorobenzene	108-90-7	500
Chloroform	67-66-3	150
Dichlorobenzene (1,4-)	106-46-7	400
Dichloroethylene (1,1)	75-35-4	35
Ethylbenzene	100-41-4	1000
Hexane (n-)	110-54-3	3500
Isopropyl alcohol	67-63-0	3500
Methyl chloroform	71-55-6	500
Methylene chloride	75-09-2	200
Methyl tert-butyl ether	1634-04-4	4000
Styrene	100-42-5	450
Tetrachloroethene	127-18-4	17.5
Toluene	108-88-3	150
Trichloroethylene	79-01-6	300
Vinyl acetate	108-05-4	100
Xylene (m, o, p combined)	108-38-3 + 95-47-6 + 106-42-3, 179601-23-1 + 95-47-6,	350

If the project has a regularly occupied, natural ventilated space at or below grade, the radon level is less than 0.15 Bq/L [4 pCi/L], as tested by a professional demonstrated not to have a conflict of interest. One test is conducted per 25,000 ft of the lowest regularly occupied space at or below grade.

Benchmarking

Level 1

N/A

Level 2

N/A

Level 3

N/A

Lightweight gypsum board (25-30% lighter) requires less water during the manufacturing process which results in lower drying energy and lower carbon emissions. Use the minimum thickness needed to reduce the amount of material being used. This will also significantly reduce carbon emissions from transportation.[167]

Intervention

Longevity and Circular Economy

Level 1

A Reused Building Elements – Level 1

Applicability: Building, Tenant Improvements

Reuse or salvage 50% of the surface area of non-structural elements.

B Reused Furniture – Level 1

Applicability: Tenant Improvements

Reuse or salvage 20% of the total furniture and furnishings by cost.

C Material Declarations

Applicability: Site, Building, Tenant Improvements

Ensure that at least 50% of the total value of permanently installed products in the project have a third-party certification (such as the International EPD System, Cradle to Cradle) that demonstrate impact reduction in at least three of the following categories[168,169]:

- Global Warming Potential (CO_2e)
- Depletion of the stratospheric ozone layer (kg CFC-11)
- Acidification of land and water sources (moles H+ or kg SO_2)
- Eutrophication (kg nitrogen or kg phosphate)
- Formation of tropospheric ozone (kg NO_x or kg ethene)
- Depletion of non-renewable energy resources (MJ)

D Responsible Sourcing

Applicability: Site, Building, Tenant Improvements,

Procure materials and products that meet the following:

- Procure materials/products with sustainable extraction and manufacturing standards that are developed and enforced by the third-party rather than by the industry, such as Natural Stone Council (NSC) 373 Standard

- Ensure that 80% of wood within the project is either Forest Stewardship Council (FSC) certified or salvaged.[170] The remainder should be from low-risk sources as determined by The Nature, Economy and People Connected tool, or equivalent[171]
- Avoid the use of hardwoods such as oak or mahogany where possible in favor of faster growing alternatives such as bamboo or recycled composites

E Recycled Content

Applicability: Site, Building, Tenant Improvements

Ensure that at a minimum the recycled content levels shown in

Table 19 are achieved for new products/materials.

F Regional Materials

Applicability: Site, Building, Tenant Improvements

Source materials/products using the following criteria referenced from the Living Economy Sourcing Imperative in the Living Building Challenge standard[172]:

- 20% or more of the materials construction budget should come from within 300 miles of the construction site
- An additional 30% of the total materials construction budget should come from within 600 miles of the construction site or closer
- An additional 25% of the materials construction budget should come from within 3000 miles of the construction site

G Product as a Service

Applicability: Site, Building, Tenant Improvements

Pursue Product as a Service (Paas) opportunities based on performance i.e. a lighting system with a certain lighting level regardless of fixtures, or leasing for when replacements are needed. If a PaaS is unavailable, prioritize products and equipment that have take-back agreements with manufacturers.[173]

H Modular Flooring

Applicability: Building, Tenant Improvements

Use modular flooring products for 95% (by surface area) of the finished floor.

I Design Standardization

Applicability: Site, Building, Tenant Improvements

Use standardized design elements to reduce on-site waste, increase material efficiency, and ease of future replacement and reuse based on standard material sizing.

J Design for Durability

Applicability: Site, Building, Tenant Improvements

Include measures into the project that aim to reduce damage from accidental or malicious activity. Areas at particular risk are:

- High-traffic zones (i.e. corridors, stairs, doors, etc.)
- Areas within proximity of the building entrances
- Public and common areas

Protection measures can include:

- Door stoppers to prevent door handles damaging walls
- Hard wearing and easily washable floor and wall finishes in heavily used circulation areas (i.e. main entrance, corridors, public areas, etc.)
- Bollards, barriers or raised curbs to delivery and vehicle drop-off areas
- Robust external wall construction, up to 6 feet high
- Protection rails at corridor walls
- Kick plates or impact protection on doors
- Incorporate adequate lighting and transparent elements where feasible to increase visibility and dissuade malicious or reckless activity

Select materials for exterior applications, such as roof and paving materials, as well as street furniture, that can withstand the elements.

K Design for Material Disassembly and Reuse

Applicability: Site, Building, Tenant Improvements

Incorporate thresholds for reuse and disassembly into the design process.

- Ensure the design enables ease of access for assembly/disassembly and assess the future life of products and how they can be reused or repurposed
- Ensure the use of reversible fasteners to allow for future element reuse, avoiding permanent fixing, i.e. glue and cement mortar, wherever possible. Ensure these fasteners are durable so that they will not degrade with ongoing element replacement
- Ensure layer independence (see Figure 19) to enable replacement of only those elements reaching end-of-life, to achieve the building disassembly rates shown in Table 18[174]

L Low-Carbon Products

Applicability: Building, Tenant Improvements

Identify the top five materials by volume in the most current version of the International Living Future Institute's Embodied Carbon Guidance.[175] Use Table 14 as a reference. Specify alternative materials or products that have a lower kg CO_2/yd^3 than the average values from the most current version of the Carbon Leadership Forum's (CLF) baseline data using the EC3 tool or mindfulMaterials database.[176,177,178]

- For structural renovations, this likely means studying concrete, insulation, and glazing (note steel, timber have limited opportunity)
- For non-structural renovations, this likely means metal studs, insulation, glazing, gypsum board and fireproofing

Level 2

M Modular Design Approach

Applicability: Site, Building, Tenant Improvements

Pursue modular design approaches, such as factory-made elements, where appropriate, to improve material efficiency and reduce on-site waste, reduce construction duration, and facilitate refurbishment/replacement.

N Reused Building Elements – Level 2

Applicability: Building, Tenant Improvements

Reuse or salvage 75% of the surface area of non-structural elements.

O Reused Furniture – Level 2

Applicability: Tenant Improvements

Reuse or salvage 30% of the total furniture and furnishings cost.

P Material Declarations

Applicability: Site, Building, Tenant Improvements

Ensure that at least 60% of the total value of permanently installed products in the project have a third-party certification (such as the International EPD System, Cradle to Cradle) that demonstrate impact reduction in at least three of the following categories[179,180]:

- Global Warming Potential (CO_2e)
- Depletion of the stratospheric ozone layer (kg CFC-11)
- Acidification of land and water sources (moles H+ or kg SO_2)
- Eutrophication (kg nitrogen or kg phosphate)
- Formation of tropospheric ozone (kg NO_x or kg ethene)
- Depletion of non-renewable energy resources (MJ)

Q Demolition Reuse Plan

Applicability: Site, Building, Tenant Improvements

Develop an Abatement and Demolition Reuse Plan to improve material reuse. This plan should, at a minimum, include the following:

- Inventory of reusable materials
- Plans to ensure the safe disassembly and storage of items for reuse
- Requirements for testing of recovered structural elements
- Create a database of recovered materials that can be linked with a Building Information Modeling (BIM) model for future reference
- Contractor to be onboard early in the process to ensure materials are reused in applications that retain their value

R Embodied Impact Reduction – Level 2, Buildings

Applicability: Building, Tenant Improvements

Quantify embodied carbon in terms of Global Warming Potential (GWP) for lifecycle phases A1-A3 according to the Carbon Leadership Forum's (CLF) LCA Practice Guide.[181] First, identify all relevant material categories based on the International Living Future Institute's Embodied Carbon Guidance and the bullets below.[182] Then refer to the Carbon Leadership Forum's (CLF) baseline data to calculate a baseline building embodied carbon by multiplying the project quantity of each material by the CLF's average baseline value for each material type. Next, work to reduce material quantities or specify products that contribute to an overall 10% reduction in embodied carbon from the baseline building.[183,184]

- For renovations, focus on Primary and Interior Material Assemblies and use the EC3 tool or mindfulMaterials database[185,186]
- For tenant improvements, focus on Interior Material Assemblies and use the EC3 tool or mindfulMaterials database[187,188] Note that although Interior Furnishings and Building Systems do not feature in the CLF baseline data, efforts should be made to reduce the impacts of these categories

S Embodied Impact Reduction – Level 2, Site

Applicability: Site

Identify the key project materials from the International Living Future Institute's Embodied Carbon Guidance as shown in Table 14.[189] Focus on Sitework components and use the ClimatePositiveDesign Calculator to quantify the impacts the project as designed.[190] Then, work within the tool to reduce emissions by 10% by altering the site or landscape design components.

Level 3

T New Materials Inventory

Applicability: Site, Building, Tenant Improvements

At the end of the design phase of a project, create a materials inventory from Revit or similar, for all elements including their location, anticipated lifespans, constituent materials, structural loadings (if applicable), and the ability for each aspect to be reused/recycled. This should be kept up to date as maintenance and replacement occurs.

U Embodied Impact Reduction – Level 3, Buildings

Applicability: Building, Tenant Improvements

Quantify environmental impacts for all lifecycle phases using a full building LCA tool such as Tally[191], One-Click LCA[192], or Athena[193]. Next, identify all relevant material categories based on the International Living Future Institute's Embodied Carbon Guidance and the bullets below.[194] Then refer to the Carbon Leadership Forum's (CLF) baseline data to calculate a baseline building embodied carbon by multiplying the quantity of each material by the CLF's average baseline value for each material type. Finally, work to reduce material quantities or specify products that contribute to an overall 25% reduction in embodied carbon from the baseline building.[195,196] Monitor the other impact categories to ensure no other category is adversely affected by the reduction measures (i.e. no other category should increase by more than 10%).

- For renovations, focus on Primary and Interior Material Assemblies
- For tenant improvements, focus on Interior Material Assemblies. Note that although Interior Furnishings and Building Systems do not feature in the CLF baseline data, efforts should be made to reduce the impacts of these categories

V Embodied Impact Reduction – Level 3, Site

Applicability: Site

Identify the key project materials from the International Living Future Institute's Embodied Carbon Guidance as shown in Table 14.[197] Focus on Sitework components and use the ClimatePositiveDesign Calculator to quantify the impacts the project as designed.[198] Then, work within the tool to reduce emissions by 25% by altering the site or landscape design components. If possible, work with a contractor to estimate GHG emissions from construction processes including excavation, hauling, trucking and crushing processes and implement plans to reduce/eliminate these emissions.

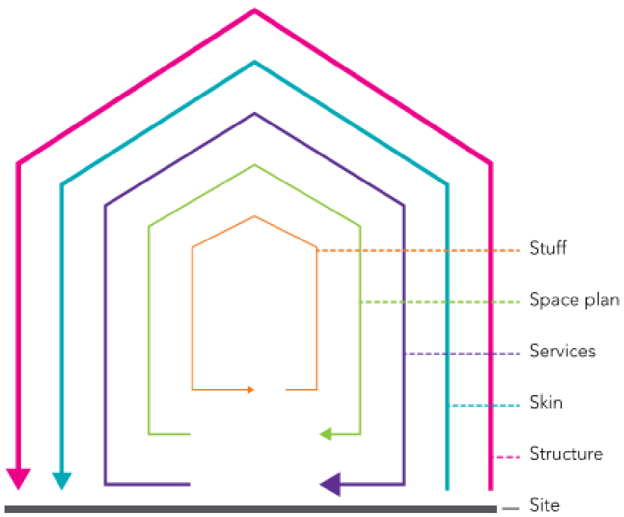

Figure 19: Layers of Building Design[199]

Table 18: Building Disassembly Rates [200]

Building Category/Component	Percentage Disassembly by Surface Area
Structure	50%
Façade	75%
Roof	90%

Table 19: Minimum Recycled Content Values

Category	Product/Material	Recommended Minimum Total Recycled Content
Concrete	Concrete (Cement-Fly Ash)	40%
	Concrete (Cement- Silica Fume)	10%
	Concrete (Cement-Slag)	45%

	Concrete (Aggregate)	20%
	Concrete (Ready-Mixed)	30%
	Concrete (Cast-In-Place)	25%
Masonry	Concrete (CMU - Fly-Ash, Silica, Fume, Slag)	10%
	Brick	25%
Metals	Aluminum Fabrications	10%
	Aluminum Storefront, Curtain Wall Extrusions	10%
	Aluminum Panels, Decorative Louvers	20%
	Aluminum Roofing	10%
	Steel (Pipes, Hollow Structural)	60%
	Steel (Decorative)	60%
	Steel (Rolled Shapes and Plates, Channels, Angles)	70%
	Steel (Cold Formed, Interior Framing)	25%
	Steel (Gratings)	25%
	Steel (Fabrications)	25%
	Steel (Joists)	80%
	Steel (Metal Deck)	25%
	Steel (Structural)	90%
	Steel (Reinforcing Bars)	20%
	Stainless Steel	25%
	Steel (Stairs)	25%

	Metals (Ornamental, Fabrication, Railings)	50%
	Metal (Composite, Curtain Wall)	75%
	Metal (Lockers)	60%
Woods, Plastics, Composites	Substrates for Casework and Millwork	25%
	Roofing (Plastic, Rubber Composites)	100%
	Tile (Plastic)	95%
	Wood (Composite)	95%
	Wood (Laminate Veneer)	95%
Thermal and Moisture Protection	Cellulose Insulation	75%
	Fiberglass Insulation	25%
	Plastic, Non-Woven Batt	100%
	Fiberglass Batt, Semi-Rigid Insulation	30%
	Mineral Wool Insulation	35%
	Polystyrene - Expanded	10%
	Polystyrene - Extruded	10%
	Plastic Rigid (Foam-in-Place)	5%
	Plastic Rigid (Glass Fiber Reinforced)	5%
	Plastic Rigid (Phenolic Rigid Foam)	5%
	Thermoplastic Polyolefin	25%
	Metal Flashing and Trim Roofing	60%
Doors and Windows	Doors (Access-Steel)	60%

	Doors and Frames (Hollow Metal)	25%
	Doors (Solid Wood-Cores)	25%
	Doors (Fire-Rated, Metal)	25%
	Glazing (Interior)	25%
	Glazing (Exterior)	25%
	Unit, Metal Framed Skylights	25%
Finishes	Ceiling (Acoustical - Metal Supports)	40%
	Ceiling (Acoustical – Mineral Fiber)	40%
	Ceiling (Acoustical – Metal Pan)	25%
	Ceiling (Acoustical – Ceiling Tile)	45%
	Ceramic Tile Flooring	60%
	Resilient Flooring and Terrazzo Flooring	25%
	Rubber Flooring and Base	60%
	Linoleum	40%
	Synthetic Gypsum Board	95%
	Structural Fiberboard	40%
	Floor Tiles (Rubber)	90%
	Carpet	25%
	Carpet (Padding)	40%
	Carpet Cushion (Jute)	40%
	Carpet Cushion (Synthetic Fibers)	100%
	Carpet Cushion (Rubber)	85%

Specialties	Toilet Partitions (Metal)	60%
	Toilet Partitions (Plastic)	25%
Exterior Improvements	Asphaltic Concrete	30%
	Landscape Concrete Paving, Decorative Paving (Fly Ash, Silica Fume, Slag)	25%

Recycled content percentages above refer to % of material weight. Total recycled content % reflects the sum of post-consumer (PO) recycled content + ½ pre-consumer (PR) recycled content

Healthy Materials

Level 1

A IAQ Pollution Sources

Applicability: Building, Tenant Improvements

Using IAQ testing results from the Sustainable Building Materials, Assessment, IAQ Testing – Level 2 section, Transparency's Precautionary List and the ILFI Red List as a guide, identify materials that are harmful to indoor air quality. Either remove or replace all such materials and finishes during refurbishment/renovation to enhance IAQ.[201] [202]

B Low-Emitting Materials

Applicability: Building, Tenant Improvements

Select products that comply 100% with the criteria outlined in the most current version of Enterprise Green Communities as shown in Table 20.[203] See the Optional and Recommendations columns in the Enterprise Green Communities Manual for further guidance and recommendations.[204]

C Healthy Products Declaration – Level 1

Applicability: Building, Tenant Improvements

Specify a minimum of one product per 2,000 square feet of the project area (up to a maximum of 10) that have one of the following third-party Healthy Material certifications indicated in the LEED Building Design and Construction credit Building Product Disclosure and Optimization - Material Ingredients Advanced Inventory and Assessment: Manufacturer Inventory or Health Product Declaration.[205,206] The product should demonstrate a chemical inventory to at least 0.01% by weight (100 ppm) with no GreenScreen LT-1 hazards or GHS Category 1 hazards. The HPD or

Manufacturer Inventory should be third-party verified. See Sustainable Minds and Mindful Materials for further guidance.[207, 208]

- Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 75% by weight of product is assessed using GreenScreen Benchmark assessment. The remaining 25% by weight of product has been inventoried. The GreenScreen assessment should be publicly available. The HPD or Manufacturer Inventory should be third-party verified
- Declare labels designated as Red List Free that are third-party verified
- Cradle to Cradle. Product has a Material Health Certificate or is Cradle to Cradle Certified with a Material Health achievement level at the Silver level or higher [209]

Level 2

D IAQ Monitoring

Applicability: Building, Tenant Improvements

Install Grade B RESET Accredited monitors to measure at least three of the following within a regularly occupied or common space as recommended in the A08 Air Quality Monitoring and Awareness point in the WELL standard[210, 211]:

- $PM_{2.5}$ or PM_{10} (accuracy 2 μg/m³ + 15% of reading at values between 0 and 150 μg/m³)
- Carbon dioxide (accuracy 50 ppm + 3% of reading at values between 400 and 2000 ppm)
- Carbon monoxide (accuracy 1 ppm at values between 0 and 10 ppm)
- Ozone (accuracy 10 ppb at values between 0 and 100 ppb)
- Nitrogen dioxide (accuracy 20 ppb at values between 0 and 100 ppb)
- Total VOCs (accuracy 20 μg/m³ + 20% of reading at values between 150 and 2000 μg/m³)
- Formaldehyde (accuracy 20 ppb at values between 0 and 100 ppb)[212]

Monitor density should be at a minimum one per floor or one every 3,500 feet, whichever is more stringent. Monitors are sited at locations compliant with the following requirements:

- 3.6-5.6 feet above the finished floor at locations where occupants would typically be seated or standing
- Sampling points should be at least 3.3 feet away from doors, windows, and air supply/exhaust outlets

Measurements should be taken at intervals of no longer than 10 minutes for particulate matter and carbon dioxide and no longer than one hour for other pollutants. Monitors are recalibrated or replaced annually.

See Sustainability Implementation Plan for additional resources.

E Healthy Products Declaration – Level 2

Applicability: Building, Tenant Improvements

Specify a minimum of one product per 2,000 square feet of the project area (up to a maximum of 25) that have one of the following third-party Healthy Material certifications indicated in the LEED Building Design and Construction credit Building Product Disclosure and Optimization - Material Ingredients Advanced Inventory and Assessment[213]:

- Manufacturer Inventory or Health Product Declaration: The product has demonstrated a chemical inventory to at least 0.01% by weight (100 ppm) with no GreenScreen LT-1 hazards or GHS Category 1 hazards. The HPD or Manufacturer Inventory should be third-party verified
- Manufacturer Inventory or HPD: The product has demonstrated a chemical inventory to at least 0.01% by weight (100ppm) and at least 75% by weight of product is assessed using GreenScreen Benchmark assessment. The remaining 25% by weight of product has been inventoried. The GreenScreen assessment should be publicly available. The HPD or Manufacturer Inventory should be third-party verified
- Declare labels designated as Red List Free that are third-party verified
- Cradle to Cradle. Product has Material Health Certificate or is Cradle to Cradle Certified with a Material Health achievement level at the Silver level or higher[214]

Level 3

F Red List Material Compliance

Applicability: Site, Building, Tenant Improvements

For all new materials and finishes, analyze material ingredients to ensure that none from the ILFI Red List are present.[215]

Americans spend an average of 90% of their time indoors, where low-air circulation can result in pollutant concentration two to five times higher than in outdoor air. A major source of indoor pollution is volatile organic compounds (VOCs), which are emitted from building materials, fabrics, furniture, cleaning materials, vinyl wall coverings, and office equipment.[216]

Table 20: Enterprise Green Communities (2020), Performance Criteria for Healthy Material Specifications[217]

Product Category	Specification
Interior paints, coatings, primers, and wallpaper	VOC content less than or equal to the thresholds provided by the South Coast Air Quality Management District (SCAQMD) 1113 available at the time of product specification for all interior paints, coatings, and primers.[218] Volatile Organic Compounds (VOC) emissions verified as compliant with the California Department of Public Health (CDPH) Standard Method for all wall finish paints. All wallpaper, phthalate-free.
Interior adhesives and sealants	VOC content less than or equal to the thresholds provided by the SCAQMD 1168 available at the time of product specification for all interior adhesives and sealants.[219]
Flooring	All flooring products (whether carpet or hard surface) should comply with CDPH emission requirements. No flexible Polyvinyl Chloride (PVC) with phthalates may be installed, whether the phthalates were intentionally added or added via recycled content. No carpet in the project may be installed in building entryways, laundry rooms, bathrooms, kitchens/kitchenettes, or utility rooms. Fluid applied finish floors may only be installed in non-occupied spaces, such as mechanical rooms.
Insulation	If fiberglass or mineral wool batts are used, these should be formaldehyde-free
Composite wood	For plywood, particleboard, MDF, and these materials within other products like cabinets and doors or other wood elements used in interior spaces, these should be No Added Urea Formaldehyde (NAUF) (have no added urea formaldehyde).

Practice

Measurement & Verification

Longevity and Circular Economy

A Preferable Materials and Products

Undertake the following actions to incorporate preferable materials into the ongoing operations of the project:

- Gather preferable material and products resources collected during an upgrade or renovation that can help to improve future procurement needs
- Identify building elements that present ongoing challenges, such as the regular need for repair/replacement or difficulty in disposal due to hazard or volume. Identify opportunities for alternatives such as more durable options or modified operations
- Use the tools identified in the Materials & Waste, Sustainable Building Materials, Intervention, Longevity and Circular Economy, Embodied Impact Reduction – Level 2, Buildings and Embodied Impact Reduction – Level 2, Site section, to inform material choices based on embodied impacts

B Recoverability

Assess on an ongoing basis whether the disposal of physical assets is aligned with the assessment undertaken in Materials & Waste, Sustainable Building Materials, Assessment, Audits, Existing Asset Recoverability section. If they are not, determine the reason for the misalignment and identify opportunities to improve asset recoverability through ongoing practices and/or partnerships.

Insulation materials such as wood, straw, clay-straw, hemp, cork, and sheep's wool naturally sequester carbon and store it over their useful life. Using these materials can reduce the carbon footprint of our buildings.

Healthy Materials

A Periodic IAQ Data Review

Prepare an IAQ testing plan and periodically conduct IAQ data reviews to ensure that indoor air quality standards are maintained

Refer to the Materials & Waste, Sustainable Building Materials, Assessment, Audit, IAQ Testing – Level 2 section for additional guidance.

Operations & Maintenance

Longevity and Circular Economy

A Repairs

Establish the capacity to maintain and repair materials and products rather than replace them. This capacity could be in-house or through third-parties.

B Replacement Materials and Product Sourcing

Ensure that standards outlined in the Materials & Waste, Sustainable Building Materials, Intervention section, such as Responsible Sourcing and Recycled Content, are maintained for ongoing maintenance and replacement of materials and products.

See Sustainability Implementation Plan for additional resources.

C Product as a Service

Upkeep PaaS relationships with procured product providers to ensure proper maintenance and longevity.

D Ongoing Procurement and Disposal Partnerships

Establish and maintain partnerships for sourcing recycled/refurbished materials or products when needed and for non-landfill, end-of-life destinations for materials or products such as old or damaged furniture and electronics.

See Sustainability Implementation Plan for additional resources.

E Durability

Monitor areas identified as high-impact areas, to ensure that protection measures are working effectively and monitor whether similar measures are required in other places previously unidentified as being at risk.

F Disassembly

Avoid using any permanent fixing i.e. glue wherever possible during ongoing maintenance to enable easier non-destructive replacement in the future.

G Materials Inventory

Ensure that the inventory recommended in the Materials & Waste, Sustainable Building Materials, Intervention, section is kept updated with ongoing maintenance and replacement including products' information such as anticipated lifespans, constituent materials, etc.

Healthy Materials

A IAQ Monitor Equipment Maintenance

Establish a schedule for ensuring that installed air monitoring equipment is properly maintained according to manufacturer instructions for sensor performance. This is likely to include:

- Calibration with pollutant standards
- Cleaning of internal and external surfaces and components
- Replacement of filters and products
- Replacing rechargeable batteries
- Ongoing review of sensor placement for significant changes in surroundings i.e. tree growth, space use type, etc.

B Maintenance and Cleaning Practices

Develop maintenance and cleaning practices that do not unduly affect indoor air quality such as those outlined in the Green Cleaning Policy Prerequisite and Green Cleaning Credits from the most current version of LEED Operations and Maintenance.[220]

Case Study 7

Hucktree – London, UK[221]

Commissioned to design the new ‘shared workspace’ of Huckletree, Grigorio Interiors used a company that salvages materials and furniture from TV and film production companies. This large database of materials was used to inform much of the new design to drastically reduce the use of raw materials for the fit out. Benches were produced from old scaffolding planks and poles, ladders were used as screens and shelving, partitions were made from reclaimed glass, etc. Timber finishes used no volatile organic compounds (VOCs), both to avoid negative indoor air quality impacts and to maximize opportunities for future reuse or disposal. Much of the furniture was designed to be disassembled, enabling it to be replaced or repurposed in the future.

Figure 20: Hucktree – London, UK[222]

Strategy 8: **Waste Diversion**

Priorities

The Waste Diversion Strategy offers intervention opportunities to incorporate measures that help reduce the volume of waste from buildings and outdoor areas going to landfill. This Strategy does not include construction and demolition waste, this is addressed in the Construction and Demolition Activities Strategy.

This section focuses on interventions to support the following priorities:

- **Education and Behavior Change**: A key aspect in influencing behavior change is to convey the context and impact of interventions. Some relevant interventions include audits and benchmarking as well as signage. Awareness of the current baseline of waste generation and disposal rates can help identify opportunities for improvement and signage educates on best waste sorting practices.
- **Waste Management:** Key interventions to reduce the volume of waste that ends up in landfills include expanding on-site composting, ensuring adequate storage and bin capacity for different waste streams, providing compacting and bailing equipment, and providing access to recycling programs.

Figure 21: Estimated Waste Generation Rates of Buildings in Battery Park City, 2017[223]

Estimated Annual Building Waste Generation (lbs/yr)

- Less than 250,000
- 250,000–500,000
- 500,000–1,000,000
- 1,000,000–2,000,000
- 2,000,000–5,000,000
- 5,000,000 or Greater

Assessment

Audits

Level 1

A Waste Calculation

Perform an annual estimate of waste generation using the AIA Zero Waste Design Guidelines Waste Calculator.[224]

B Waste Audit – Level 1

Perform a one-time waste audit:

- Establish a leader of the audit and a team to assist
- Label each collected bag with where in the project it came from
- Set up an audit area which is well-ventilated and lay tarpaulin out to keep the trash on
- Sort through and collect data for each bag including but not limited to:
    - A list of every material type found
    - The volume of each material
    - Weights and percentage of all material types
    - Weight and percentage of contaminated material (ie: food waste in recyclables bin)
    - Weights and percentage of recoverable materials (i.e. recyclables and reusables in compost or landfill bin)
    - Separate the materials into the twelve master categories of commodities/discards used by the TRUE rating system[225]
- Log findings in tables similar to those in the RubiconMethod Waste Audit Guide[226]

See Sustainability Implementation Plan for additional resources.

C Waste Audit Report

Prepare Waste Audit Report with audit results above, along with audit methodology. The report should also identify the main sources of waste generation (catering, deliveries) and review policies affecting waste (purchasing, collection agreements, etc.) Gather the following baseline data for input into the Waste Audit Report:

- Weigh the total contents of the waste and recycling bins after a typical day, to get an estimate of the total daily waste generation. (lbs/day)

- Estimate the total annual waste generation by multiplying results above by the number of operation days per year, use 260 days per year for offices, 365 days per year for residential (lbs/yr)
- Total annual waste generation by waste stream: organics, recyclables, landfill/other (%) and (lbs/yr)
- Total annual diverted waste (%) and (lbs/yr). Include recyclables and composted waste, if applicable

D Waste Infrastructure Audit

Carry out a waste infrastructure assessment including the type of bins used, ongoing issues in management and transportation of waste through the building, how waste hauler trucks access the site, waste storage rooms, sizes, and distribution, etc.

Additionally, categorize building waste infrastructure and typology (per American Institute of Architects (AIA) Zero Waste Design Guidelines) which impacts various factors influencing the collection and separation of waste (space required, labor required, convenience, cost, and maintenance).[227]

Level 2

E Waste Audit – Level 2

Perform four waste audits (one per season to capture seasonal waste trends) and gather the most granular data possible to get an estimate of the annual waste generation.

Refer to the Materials & Waste, Waste Diversion, Assessment, Audit, Waste Audit section for additional guidance.

Level 3

N/A

7.5% of New York City's waste stream consists of plastic film such as supermarket bags.[228]

Benchmarking

Level 1

A Waste Sorting

Use data from waste audit to benchmark current (baseline) waste sorting against New York City averages in Table 21 - Table 25. Estimate the total annual waste by the waste stream (organics, recyclables, landfill + other) by applying the following diversion rates (NYC averages for commercial and residential buildings).[229]

B Waste Infrastructure

Benchmark the existing waste storage areas and bin volumes with recommended building level materials and waste storage area given by the AIA Zero Waste Design Guidelines Calculator.[230]

Level 2

N/A

Level 3

N/A

Table 21: Estimated Waste Composition[231]

Waste Composition	Residential	Commercial
Landfill	32%	11%
Metal, Glass, and Plastics (MGP)	17%	17%
Paper	17%	37%
Organics	34%	35%

Table 22: Estimated Waste Generation

Property Type	Waste Generation
Residential[232]	1,979 lbs/household/yr
Commercial (Office)[233]	676 lbs/employee/yr

Table 23: Residential Recycling Accuracy[234]

Waste Stream	Recycling Accuracy
Metal, Glass, and Plastics (MGP)	45%
Paper	52%
Organics	0%

The data in this table is from a 2017 study that was conducted while NYC was rolling out an organics collection program. At the time, the vast majority of organic materials were still being discarded in landfill

Table 24: Estimated Waste Diversion[235]

Property Type	Landfilled Waste (%)	Recycled/Diverted Waste (%)
Residential	81	19
Commercial	74	26

Intervention

Disposal and Storage

Level 1

A Bin Provision

Applicability: Residential, Non-Residential, Site

Buildings that have single stream recycling should provide instructional signage to describe the approach and provide 2 bins, one for landfill waste and one for single-stream recycling, which should be adequately sized to collect paper, cardboard, glass, metal, and plastics.

Buildings that do not have single stream recycling should provide at least three bins to separate waste (paper/cardboard, MGP: metal, glass, and plastic, and landfill) of appropriate volume to the space's anticipated generation rates arising from daily or weekly operational activities and occupancy rates.

Provide additional bins to accommodate streams specific to a location i.e. organics for residential/commercial/restaurants/schools, textile bins for centralized laundry rooms, clothes hangers for high-end residential buildings, packaging in residential buildings, cooking oil in kitchens, etc.

Refer to the Materials & Waste, Waste Diversion, Assessment, Audit, Waste Audit section and The AIA Zero-Waste Design Guidelines Calculator for an estimate of the storage requirements.[236]

B Waste Collection Rooms

Applicability: Residential, Non-Residential, Site

Waste collection rooms should be kept clean, organized, well-ventilated, adequately lit, and be a pleasant and sanitary place to dispose of waste in. Harmful products should be stored in dedicated bins and adequate ventilation provided.[237]

C Waste Collection Room Sinks ❤

Applicability: Residential, Non-Residential, Site

Provide sink in waste collection rooms where organic waste bins are being centrally stored, or to rinse containers before recycling to prevent contamination.

D Equal Convenience Disposal

Applicability: Residential, Non-Residential, Site

Ensure equal convenience disposal by not making one waste stream (namely landfill) more convenient than other streams (i.e. organics); except where waste generated will be largely one stream i.e. organics in a kitchen.

E Disposal Signage

Applicability: Residential, Non-Residential, Site

Provide adequate signage for sorting at all bins (including centralized waste collection rooms).[238]

- Bins should be clearly labeled with visual cues of acceptable items and internationally accepted color coding for each stream
- Adequate signage should be provided for harmful products disposal
- Signs should be consistent throughout the building
- Avoid keeping trash bags on the street for collection. Suitably robust containers should be provided where centralized storage/compacting is not feasible
- The route to dispose of waste by both occupants and operation staff should be carefully planned for convenience, and all waste streams should be located in the same space, if feasible[239]

F Bin Map

Applicability: Residential, Non-Residential, Site

Prepare a map identifying the disposal locations for various waste streams throughout the space.

G Trash Chutes

Applicability: Residential

Ensure that any garbage chutes that accept organics are assembled and maintained properly to ensure that they don't cause bags to rip on their way down.

H Food Donations

Applicability: Residential, Non-Residential, Site

Establish infrastructure to enable the donation of unwanted food items, either through virtual platforms, physical (refrigerated and dry) storage, and/or partnership with local charities.[240]

See Sustainability Implementation Plan for additional resources.

I Shared Equipment and Services

Applicability: Residential

Provide communal access to equipment and services to reduce the need for personal equipment such as weights, toys, barbecue grills on roof terraces, cleaning, and plumbing/repairs.

J Water Fountains ❤

Applicability: Non-Residential, Site

Provide water fountains and bottle fillers to refill bottles to reduce disposable plastic bottled water.

Level 2

K Baling and Compaction

Applicability: Residential, Non-Residential, Site

Compact or bale waste (either in the building or centrally within Battery Park City) to reduce the volume of waste to be taken away and frequency of pick-ups and increase the storage capacity.

L On-Site Composting

Applicability: Residential, Non-Residential, Site

Use either indoor (through Bokashi or worm bins) or outdoor composting to avoid the need for hauling and provide compost for local gardening. Guidance for handling food waste at a commercial-scale can be found in Food Waste, A Q&A Guide For New York State Businesses, Municipalities, and Communities.[241]

M SMART Waste Infrastructure

Applicability: Site

Install technologically enabled bins and waste management platforms that include automatic compacting, data collection, live tracking, and operational insights.

N Waste Feedback Loops

Applicability: Residential, Non-Residential, Site

Deploy means of providing feedback to users about waste stream contamination rates such as printed or virtual results of recent waste audits. This could include scales for weighing organics in restaurants.

Level 3

Organic Waste Pre-Treatment

Applicability: Non-Residential, Site

Install on-site organic pre-treatment such as aerobic and anaerobic digesters, dewaterers, etc.

Diesel trucks drive 7.8 million miles every year to transport Manhattan's garbage. That's the equivalent of driving more than 312 times around the earth.[242]

Practice

Measurement & Verification

A Data Gathering

Establish a protocol for ongoing data gathering, tracking, and reporting of waste generation.

- Perform quarterly waste audit
- Track costs and savings of waste diversion interventions

Refer to the Materials & Waste, Sustainable Building Materials, Assessment, Audits, Waste Audit section for additional guidance.

See Sustainability Implementation Plan for additional resources.

B Annual Waste Reporting

Use the ENERGY STAR Portfolio Manager to submit baseline and annual waste generation report.

Annual waste report options:

- Prepare annual waste audit report with audit results along with audit methodology and a list of opportunities for reducing waste generation
- Generate a waste report using U.S. EPA WARM model to track and report greenhouse gas (GHG) emissions reductions, energy savings and economic impacts from six different waste management practices including source reduction, recycling, composting and landfilling[243]

See Sustainability Implementation Plan for additional resources.

C Bin Capacity Monitoring

Identify areas that experience continued issues with waste such as an overflow of cardboard in storage rooms from delivery packages. Identify alterations in operations or infrastructure that would mitigate the issue such as those noted in the Materials & Waste, Waste Diversion, Intervention section.

D Ongoing Diversion Opportunities

Identify elements that present ongoing waste diversion challenges such as regular disposal of single-use or difficulty in disposal due to hazard or volume. Determine opportunities for alternatives such as multi-use options or modified operations.

Operations & Maintenance

A Bin Operations

Ensure that bins (both distributed bins and centralized storage facilities) are emptied often enough to avoid overflow and that they are kept sanitary so as not to discourage people from disposing of waste properly, particularly anywhere that organics are stored.

B Bin Map Update

Update bin location map to reflect adjustments needed for volumes, program, or space changes.

C Diversion Partnerships

Establish and maintain partnerships with organizations that collect items such as food, old/damaged furniture, and electronics that have not reached their end-of-life.

See Sustainability Implementation Plan for additional resources.

Case Study 8

Ljubljana Waste Management - Ljubljana, Slovenia[244]

Snaga is the local, public waste management company for Ljubljana that covers 11 municipalities and 395,000 people. In 2006, Snaga began to expand curbside trash collection in Ljubljana to include separated organics (kitchen and garden waste). The company further expanded its collection to include paper and plastic collection, and reduced the frequency of the municipal solid waste pickup while keeping the organics and recyclables pickup schedule the same. This process successfully encouraged households to separate their waste streams to keep their residual waste volumes at a minimum.

Snaga also manages eight collection centers where residents may drop off waste that cannot be picked up curbside. It is then sorted at these locations into different streams including hazardous waste, electronics, construction waste, clothes and textiles, and more.

Another success of the zero-waste initiative in Ljubljana is around reuse. In 2013, a reuse center was established, and 70 percent of residents actively engage in reuse schemes for their products when they are no longer needed (such as clothing or furniture) where they are sorted, cleaned and resold. At the reuse center, nearly 200 items are sold every day.

Over the course of 14 years, the City decreased the amount waste generated by 15 percent and waste sent to landfills by 95 percent.

Figure 22: Ljubljana Waste Management - Ljubljana, Slovenia[245]

Strategy 9:
Construction & Demolition Activities

Priorities

Construction and Demolition (C&D) activities have impacts on the natural environment that include waste generation, air quality, noise, water pollution, and damage to vegetation and habitat loss. The key to managing impacts is to carefully plan for demolition and construction activities.

This section focuses on interventions that support the following priorities:

- **Minimize C&D Waste Generation:** Comprehensive C&D waste reduction strategies require addressing multiple aspects, including sustainable construction waste management practices, procuring materials with no or little packaging waste, providing adequate storage for sorting of waste streams, and identifying partners who will reuse or recycling C&D waste.
- **Mitigate Other Impacts through Sequencing and Coordination:** By identifying other planned construction projects in BPC and working alongside BPCA, construction project teams can identify resources that can be shared between projects and materials that can be reused or recycled in other projects. For example, by sharing heavy machinery and equipment, construction projects can limit the amount of heavy traffic and, therefore, emissions, reducing the negative impact on air quality in BPC. Additionally, considerations such as noise pollution, erosion and sedimentation control, ecology and water pollution should also be planned for, and their impacts mitigated.

Assessment

Audits

Level 1

N/A

Level 2

A Pre-Construction

Assess potential localized environmental impacts as a result of the project. The following topics should be considered:

- Waste and Hazardous Materials
- Transportation
- Indoor/Outdoor Air Quality
- Noise
- Ecology and Water Pollution

At a minimum, consider the following actions:

- Where applicable, establish the environmental baseline (current conditions of the site). If relevant, consult with relevant local stakeholders/organizations to gather pertinent information
- Estimate environmental impacts and their significance. Consider both the sensitivity of any environmental features, people or property which could be affected, and the potential magnitude of the impacts. These impacts should also be considered in-tandem with other concurrent nearby projects and the potential for interactions (i.e. construction noise occurring at the same time as dust from demolition across multiple sites might produce a more significant effect overall)
- Plan for measures which will reduce the significance of environmental impacts
- Highlight any significant residual impacts which will remain even after mitigation measures have been implemented, these can be positive as well as negative

See Sustainability Implementation Plan for additional resources.

B Waste and Salvage

Conduct a pre-demolition and renovation waste and salvage assessment which, in addition to appraising the material breakdown and volume of waste, should identify opportunities to maintain and reuse building elements to reduce the waste generated.

This should include a detailed inventory of both materials and elements using the Construction and Demolition Debris definition of salvageable materials.[246] The inventory should also identify appropriate dismantling and demolition practices to maximize the re-use of materials.[247]

Refer to the Materials & Waste, Sustainable Building Materials, Materials Inventory section for additional guidance.

Level 3

N/A

Benchmarking

A Benchmarking C&D Waste Diversion

Reference NYC industry data on recyclability of various C&D materials to inform requirements for diversion in the Construction & Demolition Waste Management Plan. Use Table 25 as a reference for anticipated NYC C&D waste streams and potential end uses which shows that 95% is anticipated to be recyclable.

Table 25: NYC Construction and Demolition Diversion Opportunities[248]

Material Category	Percentage of Stream (By Weight)	Material	End Use
Rock, brick, concrete, tile	22%	Rock & concrete	Aggregate – approved DOT road-base
		Red brick	Landscaping, baseball field clay
		White brick, tile & porcelain	Aggregate – not approved road-base
Wood	25%	Clean dimensional lumber (CDL)	Mulch, landscape
		CDL + glued wood	Biomass / alternative fuel
		Non-leaded painted wood	RDF
Plastic	3%	Low-density polyethylene (LDPE) / Film	LDPE / film
		High-density polyethylene (HDPE) / Rigid	Paint buckets, garbage cans, auto parts
		Polypropylene (PP)	Auto parts, tool cases, industrial plastic
		Polyvinyl chloride (PVC) & vinyl	Not recyclable – landfill
Paper & Cardboard	2%	Paper and cardboard boxes	Paper and cardboard boxes
Metal	8%	Ferrous	Re-used as scrap metal
		Non-ferrous	Re-used as scrap metal
Screenings	35%	Alternative daily cover	Alternative daily cover
Landfill	5%	Treated wood, PVC, nylon tarps, roofing material, insulation	N/A

Intervention

Construction & Demolition Waste Management Plan

Level 1

A C&D Waste Management Plan

Applicability: All

Create a Construction & Demolition Waste Management Plan (CDWMP) that describes how work will be undertaken to reduce the amount of waste being sent to landfills and to maximize the value of those materials/products being diverted from landfills. This plan should include guidance on the following[249]:

- How different materials will be separated and kept from being contaminated
- Distinguish between streams requiring different treatment options i.e. cleaning for reuse (i.e. soil) and recycling in the same application vs. another application (i.e. glass vs. aggregates)
- Demolition waste separation: deconstruction, separation of fixation materials, and structural or mechanical demolition
- On-site processing and reuse of demolition materials where possible
- Decontamination from hazardous waste material
- On-site operations
- Packaging waste disposal
- Waste logistics
- Quality management
- Waste targets:
    - Individual Material Targets are shown in the most current version of the Living Building Challenge.[250] Use Table 26 as a reference . Note that though Demolition Waste is distinct from the other materials, efforts should still be made to separate this into its individual components where possible – namely concrete, brick, asphalt, wood, steel/metal, dry wall, and cardboard
    - New Construction and Major Renovations should not generate more than 7.5 pounds of construction waste per square foot of construction[251]
    - Existing Buildings/Retrofits should not generate more than 2.5 pounds of construction waste per square foot of construction[252]

B Waste Minimization by Design

Applicability: All

Identify opportunities to minimize waste through sourcing and planning in the design phase.

Refer to the Materials & Waste, Sustainable Building Materials, Intervention, Design Standardization section for additional guidance.

C Waste Monitoring

Applicability: All

Use a monitoring tool, such as the LEED C&D Waste Calculator, to regularly track and report volume/tonnage of C&D waste, final destination, and hauling company and receipts.[253]

Level 2

D Clustering

Applicability: All

When multiple demolition or construction projects are occurring in one area, there is an opportunity to share resources and reduce environmental impacts from demolition activities through clustering. Where possible, align scheduling across multiple projects. Benefits can include increased recycling rates, reduced traffic/pollution/noise associated with material and waste transport, lower development costs, etc.

E Waste Champion

Applicability: All

Train a dedicated team on aspects essential to sustainable C&D waste practices including:

- General waste information within the construction site induction
- Specific training for on-site environmental issues for key staff
- Promote feedback with relevant incentives

Level 3

N/A

Table 26: Living Building Challenge Version 4, Performance Criteria for Construction and Demolition Waste Diversion Targets[254]

Material	Individual Material Targets
Metal	99%
Paper and cardboard	99%
Soil and biomass	100%
Rigid foam, carpet, and insulation	95%
All others – combined weighted average	90%
Demolition Waste (Excluding Hazardous Materials)	80%
All Materials	90% diversion total excluding Alternative Daily Cover (ADC)

Packaging Waste

Level 1

A Manufacturer Responsibility

Applicability: All

Engage with supply chain vendors to minimize the amount of waste coming to the site as much as possible i.e. through bulk deliveries and take back agreements.

B Residual Packaging

Applicability: All

Packaging waste left on-site i.e. paint cans, cardboard, plastics, etc. should be cleaned, if necessary, and sorted for recycling.

Level 2

N/A

Level 3

N/A

Approximately half of all waste (by weight) generated in NYC is construction and demolition debris. Studies estimate a possible 40% recycling rate for non-fill C&D materials and between 60-100% for fill materials.[255]

Materials & Waste Storage

Level 1

A Waste Collection Areas

Applicability: All

Provide conveniently located areas designated for the collection and storage of the various waste streams anticipated on the site identified within the CDWMP in addition to the various hazardous materials as identified by the EPA.[256]

- Provide containers to segregate waste streams, use compactors and balers
- Ensure material and waste storage areas are secure and weatherproof (where required)
- Ensure clear labels and signage for appropriate material disposal methods and separation
- Handle materials carefully to avoid damaging and generating excessive waste

B Handling

Applicability: All

Careful cutting and transport processes should be employed to minimize material waste through damage or incorrect processing.

C Scraps

Applicability: All

Use scraps in lieu of cutting full new materials through collecting and keeping scraps at cutting and fabricating locations.

D Just-in-Time Delivery

Applicability: All

Aim for just-in-time delivery to receive goods at the time they are needed for the project. This can improve project efficiency by requiring less storage space and avoiding materials getting inadvertently damaged or degraded in storage.[257]

Level 2

N/A

Level 3

N/A

Construction Indoor Air Quality

Level 1

A Indoor Air Quality Management Plan ❤

Applicability: Building, Tenant Improvements

Develop an Indoor Air Quality (IAQ) Management Plan for the construction and pre-occupancy phases of the building that meets or exceeds the recommended Design Approaches of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) and those from the most current version of the WELL standard, Precondition “Construction Pollution Management”.[258, 259] The plan should include the following:

- Duct Sealing - Ducts should be sealed and protected from possible contamination during construction or cleaned before installing registers, grills, and diffusers
- MERV Filtration - If the permanently installed ventilation system is operating during construction, media filters with a minimum efficiency reporting value (MERV) of 8 should be used to filter return air. All filters should be replaced before occupancy

- Absorptive Materials - Carpets, acoustical ceiling panels, fabric wall coverings, insulation, upholstery and furnishings, and other absorptive materials should be stored in a separate designated area protected from moisture damage
- Area Isolation - All active areas of work should be isolated from other spaces by sealed doorways or windows or through the use of temporary barriers
- Walk-Off Mats - Temporary walk-off mats should be used to reduce the transfer of dirt and pollutants
- Dust Generating Equipment - Saws and other tools should use dust guards or collectors to capture generated dust
- External Pollution Sources - All equipment, vehicles, and loading/unloading zones should be located at least 25 feet away from air intakes and operable openings of adjacent buildings when possible
- Flush-Out Before Occupancy - Upon completion of construction (including installation of woodwork, doors, acoustic tiles, paints, carpets, movable furnishings, and other interior finishes), a building air flush is performed while maintaining an indoor temperature of at least 59°F and relative humidity below 60%, at one of the below volumes:
    - A total air volume of 14,000 ft^3 of outdoor air per square foot of floor area before occupancy.
    - A total air volume of 3,500 ft^3 of outdoor air per square foot of floor area before occupancy, followed by a second flush of 10,500 ft^3 of outdoor air per square foot of floor area post-occupancy. While the post-occupancy flush is taking place, the ventilation system should provide at least 0.3 cubic feet per minute (CFM) of outdoor air per square foot of floor area at all times.
- Air Contamination - Ensure operable windows and air intakes that are inside or within 35 feet of the construction area are closed or have interventions to limit the contaminant entry

Construction Outdoor Air Quality

Level 1

A Soil Transport

Applicability: Site

Undertake measures to limit soil transport:

- Minimize vegetation clearance, clearing in stages, stabilization of cleared areas and soil stockpiles by regular light watering or use of matting/coarse material
- Minimize the lifting height of the loader bucket when transferring soil or rubble from front-end loaders to trucks and controlling its unloading speed

- Limit the movement of soil and earth and use of high-speed abrasive disc saws and sanders during windy periods
- Use a water spray when transferring soil or rubble from earthmoving equipment to trucks
- Prevent soil from leaving the site via traffic movement
- Minimize wheel generated dust by watering roadways or preparing roadways with coarse gravel or other road coverings

B Construction and Delivery Vehicle Idling ❤

Applicability: Site, Building, Tenant Improvements

Construction and delivery related vehicles should not idle on the construction site for more than five minutes in any 60-minute period, except where necessary to perform their construction related function.

Level 2

N/A

Level 3

N/A

Noise Pollution

A Timing Constraints ❤

Applicability: All

Limit any particularly noisy activity (i.e. masonry sawing or jack hammering) to between 9 AM and 6 PM.

B Equipment Noise ❤

Applicability: All

Undertake measures to limit equipment noise pollution including:

- Locate especially loud equipment (i.e. masonry saws or cement mixers) and processes to minimize disturbance, such as through distancing, sound barriers, or off-site work
- Shut or throttle down equipment (i.e. generators, bobcats, cranes) when not in use
- Ensure that noise reduction devices (i.e. mufflers) are fitted and operating effectively
- Install temporary barriers/enclosures around noisy equipment

- Ensure equipment is properly maintained to prevent reduce/eliminate its noise levels

See the Laborers' Health & Safety Fund of North America Guide to Controlling Noise on Construction Sites for further guidance.[260]

Erosion and Sedimentation Control Plan

Level 1

A Erosion and Sedimentation Control (ESC) Plan ❤

Applicability: Site

Develop and implement an Erosion and Sedimentation Control (ESC) plan for all exterior construction activities, regardless of size, as outlined in the "Construction Activity Pollution Prevention" prerequisite in in the most current version of LEED Building Design and Construction.[261] The ESC plan should conform to the erosion and sedimentation control requirements of the US EPA National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Construction Activities, or local erosion and sedimentation control standards and codes, whichever is more stringent.[262]

Level 2

N/A

Level 3

N/A

Ecology & Water Pollution

Level 1

B Invasive Plant Control and Management

Applicability: Site

Manage known invasive plants found on site before construction:

- Refer to NYS DEC Nuisance and Invasive Species webpage to identify plants and animals considered as a nuisance and invasive species in the region. Refer to NYS DEC Invasive Species Comprehensive Management Plan to identify appropriate management measures[263,264]
- Ensure removal of invasive species are discarded/treated through appropriate procedures that hinder further propagation including maintenance controls (treating individuals) versus extirpation (full removal and soil replacement)
- Ensure that all soils and other landscape materials imported to the site are free of noxious weeds and noxious weed seeds

Refer to the Site, Biodiversity and Habitats, Intervention, Terrestrial Habitat, Native Plants section for additional guidance.

C Healthy Soils and Appropriate Vegetation

Applicability: Site

Conserve healthy soils and plants that are appropriate for site conditions and climate:

- Identify high-value vegetated areas or individual plans (such as trees) based on plant maturity, biodiversity, biomass density, and climate readiness (salt tolerance, hardiness zone)
- Refer to the NYC Parks Tree Valuation Method to conduct tree appraisal for on-site trees; conserve and protect trees and root zone to the extent possible. Use tree appraised value as a guide for tree replacement if necessary (number of replacement trees)[265]
- Protect existing ecosystem services by conserving identified high-value vegetated areas or individual plants during the construction process
    - This includes protection from construction activities such as compaction and physical damage resulting from construction access, staging, and stockpiling activities, as well as protection from pollutants and damaging runoff (including, for example, thermal pollution, concrete wash, fuels, solvents, hazardous chemical runoff, high or low-pH discharges, and pavement sealants)
    - Employ strategies such as temporary and permanent seeding, mulching, earth dikes, sediment traps, sediment basins, filter socks, compost berms and blankets, secondary containment, spill control equipment, hazardous waste manifest, and overfill alarms

Refer to the NYC Parks Tree Valuation Method to conduct tree appraisal for on-site trees; conserve and protect trees and root zone to the extent possible. Use tree appraised value as guide for tree replacement if necessary (number of replacement trees)[266]

Refer to the Site, Biodiversity and Habitats, Assessment, Soil Health section to assess soil health

Refer to the Site, Biodiversity and Habitats, Assessment, Terrestrial Habitat section to identify climate and site appropriate vegetation

Refer to the Site, Biodiversity and Habitats, Intervention, Terrestrial Habitat, Biodiverse and Species Rich Planting section for additional guidance.

D Soils Disturbed During Construction

Applicability: Site

Restore all soils on site that have been disturbed by current construction activities and that will serve as the final vegetated area:

- Identify reference soils to guide soil performance criteria based on program and functionality
- Where possible, remove and stockpile existing topsoil on site to be reused in site restoration activities
- Restore soils to the appropriate depth (minimum 12" for the planted area, increase for tree planting to accommodate root zone for a mature tree)
- For detailed soil restoration criteria and recommended strategies, refer to SITES Version 2 Section 7.3.[267] These criteria include:
    - Organic matter
    - Compaction or Infiltration
    - Chemical characteristics
    - Biological function

See Site, Biodiversity and Habitats, Intervention, Soil Health, Soil Health Monitoring Technology section for additional guidance.

E Salvaged Plant Materials

Applicability: Site

Divert waste from landfill by salvaging appropriate plant material found on site.

- Reuse appropriate plant materials (verify that salvaged plants are disease-free and show no signs of stress before moving)
- Identify native plant societies who may rescue plants before construction and can also be a resource for conserving plants off-site until the installation
- Recycle excess vegetation generated during land clearing to produce compost, mulch, erosion control protection measures, etc.
- Divert reusable vegetation, rocks, and soils that exceed the amount that can be used on site to local outlets as soil blenders and mulch and compost producers
- Utilize NYC Clean Soil Bank to source and/or export excess clean soils resulting from construction activities

F Construction Pollutant Impact on Adjacent Waterways

Applicability: Site

Protect the adjacent Hudson River by preventing and minimizing the discharge of site pollutants into areas that drain directly into the river. See Site, Biodiversity and Habitat, Intervention, Aquatic Habitat for guidance. Prevent runoff and infiltration of site pollutants (including, for example, thermal pollution, concrete wash, fuels, solvents, hazardous chemical runoff, high or low-pH discharges, and pavement sealants), and ensure proper disposal.

Level 2

G Ecology Assessment

Applicability: Site

Prior to initiating a major site project require a review by a professional ecologist to assess potential impacts to local habitats and seasonal or other sensitivities for local species.

Level 3

N/A

Practice

The temporary nature of Construction and Demolition Activities means that there are no ongoing Practice recommendations as a part of the Green Guidelines.

Case Study 9

101 Prince of Wales Drive - Battersea, London, UK[268]

As part of a neighborhood rehabilitation of a former industrial area, 101 Prince of Wales Drive plans to provide over 800 homes alongside commercial, financial, and education spaces across 12 buildings. The site is complex, located within a high-risk flood zone with multiple railway lines and the River Thames nearby. An Environmental Impact Assessment (EIA) was conducted for the full planning application of the project and considered impacts on traffic/transportation, noise and vibration, air quality, water resources, and flood risk, ecology, waste, ground conditions, wind/microclimate, daylight/overshadowing, and socioeconomics.

To address noise pollution a few steps were taken, including selecting quieter mechanical plant equipment, locating the equipment as far from noise sensitive receptors as practical, and incorporating noise barriers and other acoustic screening.

To reduce the impacts of dust on sensitive typologies (ie: residential buildings and schools) a number of strategies were incorporated, including covering material stockpiles and chutes to prevent airborne dust exposure, implementing a speed limit of 10mph on unpaved roads, and avoiding the dry sweeping of large areas, with water assisted sweeping used on local access roads as needed, instead.

Strategies for managing ecological impacts were also included for best practice. This involved timing the clearing vegetation in sensitive habitat areas to happen at preferable times of the year, specifically, outside of the bird breeding season.

Figure 23: 101 Prince of Wales Drive Battersea, London, UK[269]

Resources

Building Revolutions – Applying the circular economy to the Built Environment, David Cheshire

https://www.designingbuildings.co.uk/wiki/Building_Revolutions_-_review

Circular Economy Guidance for Construction Clients: How to practically apply circular economy principles at the project brief stage, UKGBC

https://www.ukgbc.org/wp-content/uploads/2019/04/Circular-Economy-Report.pdf

Circular Economy Implementation Packs for Reuse and Products as a Service

https://www.ukgbc.org/ukgbc-work/circular-economy-implementation-packs/

Circular Economy in the Built Environment, Arup

https://www.arup.com/perspectives/publications/research/section/circular-economy-in-the-built-environment

Circularity in the Built Environment: Case Studies, Ellen MacArthur Foundation

https://www.ellenmacarthurfoundation.org/assets/downloads/Built-Env-Co.Project.pdf

Cluster Guide

www.claire.co.uk

Department of Sanitation of NY (DSNY) Waste Characterization Studies

https://www1.nyc.gov/assets/dsny/site/resources/reports/waste-characterization

ENERGY STAR Portfolio Manager

https://www.energystar.gov/buildings/owners_and_managers/existing_buildings/use_portfolio_manager/track_waste_materials

EPA Waste Reduction Model (WARM)

https://www.epa.gov/warm

Food Waste, A Q&A Guide for New York State Businesses, Municipalities, and Communities

https://www.rit.edu/affiliate/nysp2i/sites/rit.edu.affiliate.nysp2i/files/docs/resources/A_Food_Waste_Q%26A_Guide_for_NYS_Businesses_Municipalities_and_Communities.pdf

Lean Construction

https://www.leanconstruction.org/

NYC Master Composter Manual

https://materials.bwprronline.org/system/tdf/MCM-Nov2018-0219-FINAL.pdf

AIA Zero Waste Design Guidelines

https://www.zerowastedesign.org/

Abbreviations & Definitions

ADC	Alternative Daily Cover
AIA	American Institute of Architects
BIM	Building Information Modeling
C&D	Construction and Demolition Waste
CARB	California Air Resources Board
CDL	Clean dimensional lumber
CDPH	California Department of Public Health
CDWMP	Construction and Demolition Waste Management Plan
CFM	Cubic Feet per Minute
CLF	Carbon Leadership Forum
DEC	Department of Environmental Conservation
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ESC	Erosion and Sedimentation Control Plan
FSC	Forest Stewardship Council
GHG	Greenhouse Gas Emissions
GWP	Global Warming Potential

HDPE	High-Density Polyethylene
HPD	Health Protection Declaration
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
Lb/ft^2	Pounds per Square Foot (commercial)
Lb/pp	Pounds per Person (residential/hotel/school)
LEED	Leadership in Energy and Environmental Design
LDPE	Low-Density Polyethylene
MERV	Minimum Efficiency Reporting Value
MGP	Metal, Glass, and Plastics
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NPDES	National Pollutant Discharge Elimination System
NSC	Natural Stone Council
PM	Particulate Matter
PP	Polypropylene
PVC	Polyvinyl Chloride
SCAQMD	South Coast Air Quality Management District
SD	Severe Duty

TPY	Tons per Year
TRUE	Total Resource Use and Efficiency (Zero Waste Certification Program)
UKGBC	United Kingdom Green Building Council
VOC	Volatile Organic Compound

Alternative Daily Cover	Material placed on top of municipal solid waste landfills to prevent scavenging, fires, and odors.
Bokashi	A Japanese method of composting, involving fermentation through addition of beneficial microbes. Input can include meat, dairy, fish, napkins and organic waste but not large bones and shells.
Circular Economy	A global economic model that aims to decouple economic growth and development from the consumption of finite resources. To go beyond the current take-make-waste extractive linear industrial model and focus on designing out waste and pollution, keeping products and materials in use for longer, and regenerating natural systems.
Closed Loop Cycles	A processes in which nearly all materials remain within the system and are recovered and used by other organisms or processes rather than being lost as waste.
Comingled	Method of collecting recycling in which a mixture of several recyclable materials are in one container rather than separated.
Compost	Decayed organic material, whether it be garden waste, food scraps, or manure, that can then be used as plant fertilizer.
Global Warming Potential	A measure of the impacts of different greenhouse gases by assessing their heat trapped in the atmosphere relative to the emissions of Carbon dioxide.
Hauler	A waste collection company that provides complete waste removal services. Many will also collect recyclables. It can include both private and public entities.

Hazardous Waste	Waste streams that can prove dangerous for human health that can include some paints, solvents, pesticides, and other materials/products containing volatile chemicals that catch fire or are corrosive or toxic.
Incinerator	A furnace for burning solid waste under controlled conditions.
Landfill Waste	Items that are not reused, recycled or composted.
Leakage	Cases in which residential recyclables are collected outside of a municipal collection system. As a result, these materials are often undetected during normal data collection efforts.
Material Passports	A process of providing information on the value of materials and products, their reusable or toxic content, and the ease with which they can be disassembled. Information is collected in a database to facilitate the recovery, recycling, and/or re-use of materials.
Municipal Solid Waste	Waste consisting of household items that are thrown out by the public.
Product as a Service	A model where a service, such as lighting or furniture, is offered instead of the sale of a product e.g. light bulbs or carpets. Ownership rests with the provider and performance-based contracts are often used to ensure the provider delivers an agreed level of service.
SITES	A rating system that focusses on the sustainability of ecosystems and the urban realm.
Volatile Organic Compound	Several compounds of carbon that can be harmful for human health and are mostly released indoors from the use of certain products and materials.
WELL	A rating system that focusses on improving the human health and wellbeing of buildings and the urban realm.
Zero Waste	An approach that prioritizes the reuse of all materials and products. This includes maximizing recycling, minimizing waste, reducing consumption, and designing for reuse, repair and recycling.

Endnotes

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[157] Eliminating Toxics in Carpet, https://healthybuilding.net/blog/227-eliminating-toxics-in-carpet-lessons-for-the-future-of-recycling

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[165] WELL Standard Version 2, https://v2.wellcertified.com/v/en/overview

[166] Substance Details, Volatile Organic Compounds https://ofmpub.epa.gov/sor_internet/registry/substreg/substance/details.do?displayPopup=&id=83723

[167] Gypsum Board, https://materialspalette.org/gypsum-board/

[168] The International EPD System, https://www.environdec.com/

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[170] FSC Certification, https://us.fsc.org/en-us/certification

[171] Timber Risk Score, https://www.nepcon.org/sourcinghub/timber

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Site

Overview

For many, the Battery Park City experience is defined by experiences in the public realm – in the streets and sidewalks, the parks, the Esplanade, and other open spaces. To enhance the sustainability of the neighborhood, BPC will leverage these spaces through thoughtful design and maintenance so that natural systems and constructed open spaces contribute to sustainability efforts. Ecosystem services and the sustainable design and operation of public and private open spaces have a direct and significant impact on the neighborhood's GHG emissions and environmental impact.

Local Context

Urban ecological systems can provide multiple environmental benefits including increased resilience to climate change, reduced heat island effect, improved air quality, reduced stormwater runoff, as well as offer opportunities for public education and enjoyment. Climate resilient and climate-ready landscapes are critical infrastructure for a neighborhood as they can mitigate the effects of climate change and reduce the risk of injury, illness, or death related to extreme weather events such as heat waves and severe storms. In addition, connection and exposure to nature have been shown to have a positive impact on health and wellbeing and are especially important in a dense urban environment like Lower Manhattan.[270]

In addition to benefits provided by BPC's parks and open spaces, private courtyards offer further opportunities for increasing biodiversity, enhancing ecosystem services, and improving residents' quality of life. While smaller in size, courtyards and private gardens often offer environments that are less exposed to strong winds and salt spray, thus able to support more vulnerable plant and wildlife species.

Path to Rich Biodiversity and Thriving Habitats at BPC

As an urban waterfront neighborhood with 36 acres of parks and open spaces, Battery Park City is well situated to make a significant impact on environmental sustainability and climate resilience through the design and management of its landscape. A range of approximately 1,132 plant species and cultivars provides a unique immersive experience that varies throughout the seasons.

While all plantings have the potential to host various taxa or organism groups throughout their lifecycle, the use of native plant material with complex vegetative structures (groundcover, understory, and canopy) will maximize this potential. However, it is important to note that the changing climate is also leading to a change in plants' ability to survive and thrive in different zones, as outlined by the USDA's Plant Hardiness Zones, see Figure 24.[271] For this reason, plants identified as being within Zones 6 and 7 in Figure 25 may need to eventually be phased out.

The landscape performance at Battery Park City is directly tied to the invaluable component of soil and soil health. As an integral part of the urban park infrastructure, soils have the capacity to support diverse microbial and fungal communities, sustain plant health, capture and clean water, break down pollutants, regulate nutrient cycling and store carbon. Battery Park City should build on its successful ongoing practices and maintain its community specific soils as an asset and find opportunities to amplify its capacity to perform.

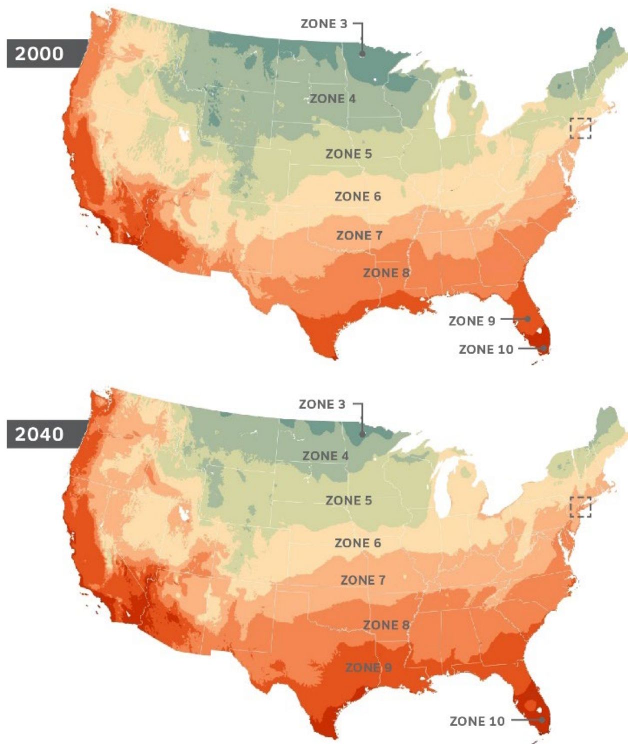

Figure 24: UDSA's Plant Hardiness Zones[272]

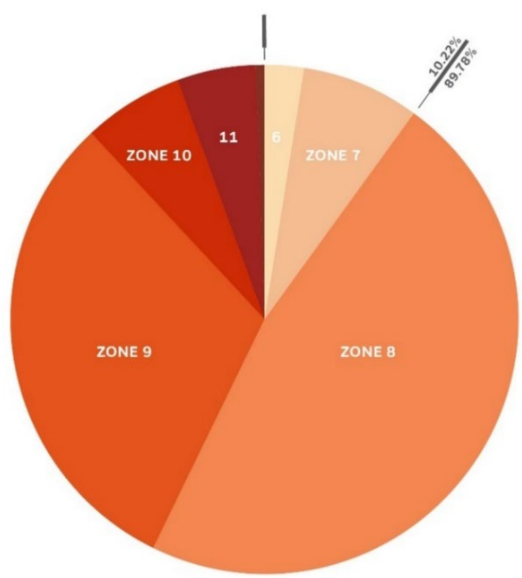

Figure 25: Battery Park City Plant Hardiness Breakdown, 2016[273]

A robust range of wildlife species are integral to ecosystem health and allow it to thrive. These include microbial and fungal communities, beneficial insects and pollinators, mammals and reptiles, as well as native and migratory birds. In addition to the terrestrial environment, developing a more diverse range of conditions at the water's edge and encouraging habitat connectivity across the land/water interface can help enhance subtidal and intertidal habitat function, support biodiversity in the NY Harbor, and advance BPC's and the City's long-term resilience.

In addition to sea level rise and increased frequency and intensity of storms, extreme heat is one of the most significant hazards facing New York City, as identified by the NYC Office of Emergency Management.[274] According to the NYS Department of Environmental Conservation, the annual average temperature in New York State has risen about 2.4 degrees since 1970.[275] Battery Park City's street trees and vegetated park and roof spaces perform a critical role in alleviating Urban Heat Island Effect while providing continuous ecological corridors supporting urban wildlife species. Refer to the Water, Resiliency and Stormwater Management, Intervention section for guidance on hazard mitigation and heat related strategies that employ stormwater management tools.

The Site section of the Green Guidelines provides technical guidance in support of the Biodiversity and Habitats Strategy from the BPC Sustainability Plan.

Strategy 10:
Biodiversity & Habitats

Priorities

Enhancing the biodiversity of the natural environment and habitats at Battery Park City is a continuous effort requiring dedication and discipline. Success hinges upon a holistic and interconnected approach.

This section focuses on interventions that support the following priorities:

- **Terrestrial Habitat:** Terrestrial habitats consist of robust and diverse plant communities and provide a range of living environments for native and migratory species
- **Soil Health:** Critical to a healthy ecosystem, managing soil health is the first step to a sustainable landscape
- **Aquatic Habitat:** Although not immediately accessible in BPC today, an improved aquatic habitat can play a key role in increasing resilience and climate adaptation
- **Urban Forest:** BPC's tree cover provides ecological corridors for birds, pollinators, and other species, supports stormwater management, while also contributing to the mitigation of Urban Heat Island Effect through shade and evapotranspiration
- **Shading:** Shading helps mitigate Urban Heat Island Effect
- **Hardscape:** Hardscape materials and design can help mitigate Urban Heat Island Effect
- **Emergency Landscape Preparedness:** Considering sustainability and resilience of the landscape as well as the people who enjoy it, interventions are outlined to prepare for extreme events in a manner that aims to reduce injury and minimize damage to site and property ensure plants and habitats in BPC are resilient to major storms, extreme heat, and other climate impacts

Figure 26: Battery Park City Existing Tree Canopy, 2020[276]

■ Tree Canopy

Assessment

Audits

Terrestrial Habitat

Level 1

A Plant Survey

Develop a protocol for and conduct a baseline Plant Survey (including quantities) to update the BPCA Plant Survey document including both additions and subtractions. Include institutional knowledge of Horticulture Department staff to identify and document historical modifications to the original plant palette. Where information is available, document reasoning for modifications to original plant palette (for example: climate adaptability, sun/shade, soil performance, salt tolerance, wildlife recruitment potential, etc.) Building owners and/or managers with associated planted spaces are encouraged to conduct their own Plant Survey using the protocol developed by BPCA and share survey results with BPCA for a more comprehensive picture of all plant communities and habitats throughout BPC.

As part of the survey:

- Map and quantify the area and condition of distinct plant communities and habitats (woodland, meadow, grasses, etc.) as it compares to use for recreational and other programmatic activities and purposes. Identify habitat types that should be expanded to provide enhanced ecological function, with a limited impact on high-use areas. The reference guide Ecological Communities of New York State edited by Edinger, et al and published by the NYS Department of Environmental Conservation should be used to help define existing plant community types and associations within the park. The NYC Department of Parks and Recreation Native Species Planting Guide for New York City (3rd Edition) should be used to help guide decisions for expanding and replanting within identified plant communities
- Map and quantify NYS designated invasive plant species by area and type (conduct early springtime) to identify recurring issues or problematic locations. Determine areas of high priority for management. The NYC Department of Parks and Recreation Native Species Planning Guide for New York City provides a list of invasive and problematic plant species regulated by New York State that should be used as a guide for the BPC audit.[277,278] Distinguishing between invasive plants which are clonal (reproduce vegetatively) and non-clonal will help determine the appropriate maintenance approach: treating individual plants or extirpation (full removal and soil replacement)[279]
- Identify harmful opportunistic weed species that pose the greatest threat specifically to biodiversity within BPC. BPCA Horticultural Staff may already have significant institutional knowledge of the specific threats. That said, the NYC Department of Parks and Recreation Native Species Planning Guide for New York City provides a list of invasive and problematic plant species that are regulated by New York State, which may be referenced for additional confirmation

- Identify climate thresholds for existing biological communities within the park referring to the United States Department of Agriculture (USDA) Plant Hardiness Zones[280]
- Estimate biomass density of existing plant communities and identify areas that can support increased biomass density (and thus have increased carbon storage capacity)
- Identify climate thresholds for existing biological communities within the park referring to the USDA Plant Hardiness Zones[281]
- Estimate biomass density of existing plant communities and identify areas that can support increased biomass density (and thus have increased carbon storage capacity)
- Identify climate thresholds for existing biological communities within the park referring to the USDA Plant Hardiness Zones[282]
- Estimate biomass density of existing plant communities and identify areas that can support increased biomass density (and thus have increased carbon storage capacity)
- Identify climate thresholds for existing biological communities within the park referring to the USDA Plant Hardiness Zones
- Estimate biomass density of existing plant communities and identify areas that can support increased biomass density (and thus have increased carbon storage capacity)
- Identify additional native plants to be introduced into BPC open spaces that are adapted to specific site microclimate and other conditions (wind and salt exposure, shallow soil volumes on top of the structure, occasional inundation within flood zones as identified by Federal Emergency Management Agency (FEMA) flood hazard maps).[283] Building on the institutional knowledge of various microclimate areas within BPC, the reference guide Ecological Communities of New York State edited by Edinger, et al can be used to help define existing plant community types and associations within the park and the NYC Department of Parks and Recreation Native Species Planting Guide for New York City (3rd Edition) should be used to help guide decisions for expanding and replanting within identified plant communities[284,285]
- Document bloom periods of existing plants in a Bloom Calendar (as shown in Figure 27) to identify seasons or periods with reduced bloom, where habitat opportunities could be expanded through the planting of species that bloom earlier or later in the season

See Sustainability Implementation Plan for additional resources.

Level 2

N/A

Level 3

N/A

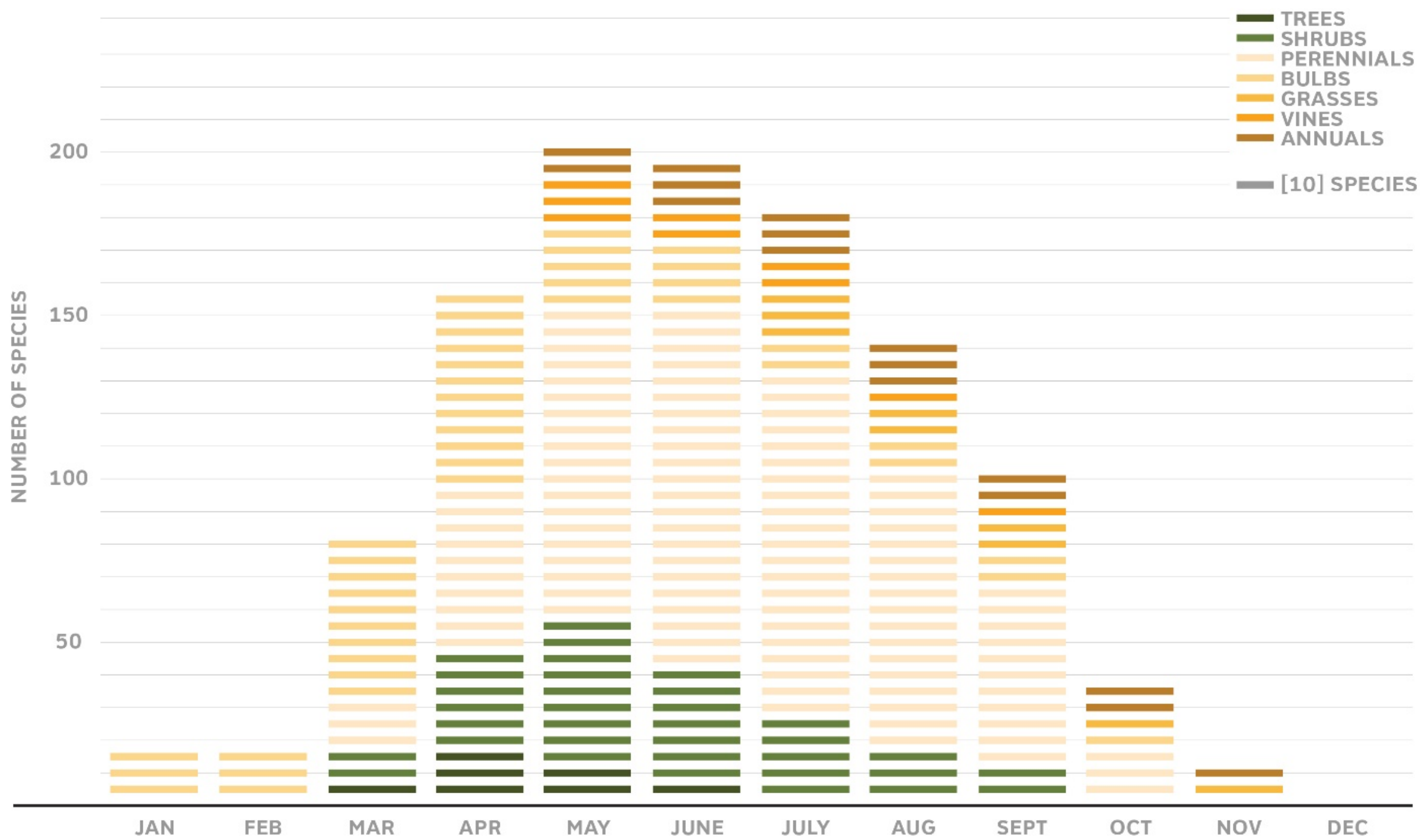

Figure 27: Battery Park City Bloom Calendar of Plant Palette 2016[286]

Wildlife Census

Level 1

A Wildlife Census

Review and expand upon existing Wildlife Census protocol, conduct survey recording repeated/decreasing sightings and respective habitat including:

- Develop community programming and/or partner with researchers to conduct a comprehensive survey of existing wildlife species throughout BPC (BioBlitz), including the specific habitat conditions they are documented in. Assess populations seasonally to understand wintering, migrating, and breeding patterns
- Identify wildlife species commonly found in similar regional contexts but not found in BPC, and target habitat enhancing or food web enhancing species for recruitment. Target threatened and endangered

species to the extent possible. Refer to The New York Natural Heritage Program for animal conservations guides on native species descriptions and local habitat associations[287]

- Partner with researchers to map regional wildlife and habitat network. The New York Natural Heritage Program spatial data should be used as a reference for regional and local species, habitat, and landscape ecology[288]

See Sustainability Implementation Plan for additional resources.

Level 2

N/A

Level 3

N/A

NYC provides a stopover habitat for many migratory birds, fishes, and butterflies, as well as for numerous plant and animal species of conservation concern. The way the City's green spaces are conserved and managed for biodiversity will affect the health of these species far into the future.[289]

Soil Health

Level 1

A Soils Assessment Report

Create a comprehensive Soils Assessment Report mapping out soil types and compositions across BPC. According to the USDA Natural Resources Conservation Service Soil Quality Indicator Sheets for Physical, Chemical, and Biological Properties.[290] See Table 27 for reference.

B Soil Performance Comparison

Compare soil type performance across different locations/plant types and communities.

Level 2

N/A

Level 3

N/A

Table 27: Relationship Between Soil Chemical Indicators and Soil Quality Function[291]

Soil Quality Indicators	Soil Function				
	Sustain biological diversity, activity, and productivity	Regulate and partition water and solute flow	Filter, degrade, detoxify, organic and inorganic materials	Store and cycle nutrients and carbon	Physical stability and support for plants and structures associated with human habitation
			Biological Soil Quality Indicators		
Earth Worms	High		High	High	High
Particulate Organic Matter	High	High	High	High	High
Potentially Mineralizable Nitrogen	High			High	
Soil Enzymes	High			High	
Soil Respiration	High		Low	High	High
			Chemical Soil Quality Indicators		
Phosphorus	Low	Low			
Reactive Carbon	Medium	Low	High	Medium	Medium
Soil Electrical Conductivity		High			
Soil Nitrate	Low	Low			
Soil pH	Medium	High	High	High	

Aquatic Habitat and Land/Water Threshold

Level 1

A Aquatic Habitat Conditions – Level 1

Assess and develop a protocol for existing aquatic habitat conditions including:

- Water quality (salinity, turbidity, nutrient levels, pollutant levels)
- Exposure to special conditions such as intense or repetitive wave action

B Aquatic Species Identification

Identify aquatic and water reliant species native to the Lower Hudson Estuary to be targeted by habitat enhancements. Refer to the Army Corps of Engineers' Comprehensive Restoration Plan for the Hudson Raritan Estuary for Target Ecosystem characteristics.[292]

Level 2

C Aquatic Habitat Conditions – Level 2

Include in the Aquatic Habitat Conditions assessment the following additional considerations:

- Available substrates
- Sediment characteristics including grain size, TOC (Total Organic Content), and contamination (presence of toxins and other contaminants resulting from previous industrial activities or harmful spills in existing sediment)

D Water Edge Biological Survey

Develop a protocol for and survey BPC's water edge (biological survey) to identify any existing aquatic species including sessile communities, benthic macroinvertebrates (including, for example, abundance, composition, richness, biomass, and population density), fish, as well as water birds spotted in the area.

Level 3

N/A

Urban Heat Island

Level 1

A Street Tree Lifespan

Assess the average street tree lifespan.

B Tree Canopy Expansion

Identify areas for expanding Tree Canopy and existing tree pits along streets and in open spaces.

C Exposed Areas Identification

Identify exposed areas where pedestrians may spend extended periods of time such as bus stops and plazas that could benefit from providing additional shade.

D Paved Area Planting

Identify paved areas that could feature additional planting or be converted to fully planted areas.

E Solar Reflective Index

Assess the solar reflectance index (SRI) across various plazas and streetscapes. Identify areas where surface materials have high-heat absorption and storage (low-albedo) and could be replaced with higher albedo materials.

F Hardscape

Identify hardscape areas in need of crack filling, resurfacing, and repairs to maintain existing assets to maximize the life of the pavement and avoid entire resurfacing projects which are energy intensive.

Level 2

G Urban Heat Island Effect

Assess Urban Heat Island effect across BPC using a combination of remote data and the measurement and documentation of Heat Index on site.

H Site Carbon Capture and Storage

Assess carbon capture and storage capacity by soil and plant material across BPC using USDA Forest Service tools and collaboration.[293]

I Night-Time Temperature

Measure night-time temperature variation in the summer months. This is most easily done with a sensor, and frequency can be easily adjusted as needed. Frequency should be hourly during heat waves.

J Existing Tree Canopy Condition

Assess the extent and condition of existing tree canopy including, for example: species, Diameter at Breast Height (DBH), height, crown spread, structure and health of trunk, structure, and health of roots, branching structure, and foliage and/or buds. Refer to the USDA Forest Service's Forest Inventory and Analysis (FIA) program.[294]

Level 3

N/A

Landscape Emergency Preparedness

Level

A Open Space Vulnerability

Identify areas within BPC's open spaces that are vulnerable to:

- Coastal Inundation
- Stormwater Inundation
- Wave Impact
- Extreme Wind
- Extreme Heat

See Sustainability Implementation Plan for additional resources.

B Unsafe Areas Categorization

Identify and categorize areas where access was restricted due to unsafe conditions during and immediately after recent climate emergencies such as Hurricane Sandy. Assess the duration of closure (closed for clean-up vs. closed for long-term repair work).

See Sustainability Implementation Plan for additional resources.

C Landscape Features

Plan for the repair of landscape features in the aftermath of recent climate emergencies including major storms and heatwaves (plant loss, furniture, fixtures, surface repair, etc.).

D Climate Emergency Impact Assessment

Compile information on landscape impacts during and following recent climate emergencies such as Hurricane Sandy, including:

- Number of downed trees and major tree limbs
- The severity of impact on planting, planting recovery time
- Quantity of waste collected

Level 2

E Reconstruction and Repair

Compile information on costs of reconstruction and repair of landscape features in the aftermath of recent climate emergencies including major storms and heatwaves (plant loss, furniture, fixtures, surface repair, etc.)

Level 3

N/A

Benchmarking

Biodiversity

Level 1

A Plant Palette

Use data collected from the plant survey to benchmark the current plant palette against the data summarized in Table 28, Figure 28, and Figure 29 to assess change and trends in recent years.

- Species diversity: To preserve and promote the diversity of plantings within BPC, management efforts should work to achieve a plant palette weighing heavily toward native plants and reintroduce threatened or extirpated plant species to the greatest extent possible, while respecting the original design intent of the different open spaces. This will support the greatest diversity of ecological interactions and maintain robust native habitat value that will be resilient to outside stresses[295]

- Tree species mortality rate: set average tree survivorship of 50% after 35 years[296,297]
- Biomass density increases should be based on the Biomass Density Index (BDI) benchmarks shown in the most current version of SITES.[298] Use
- Table 29 as a reference

B Soil Organic Carbon Storage

Quantify soil organic carbon storage within existing soil profiles, benchmark against a total maximum of 10%, as appropriate for specific plant communities.

Level 2

N/A

Level 3

N/A

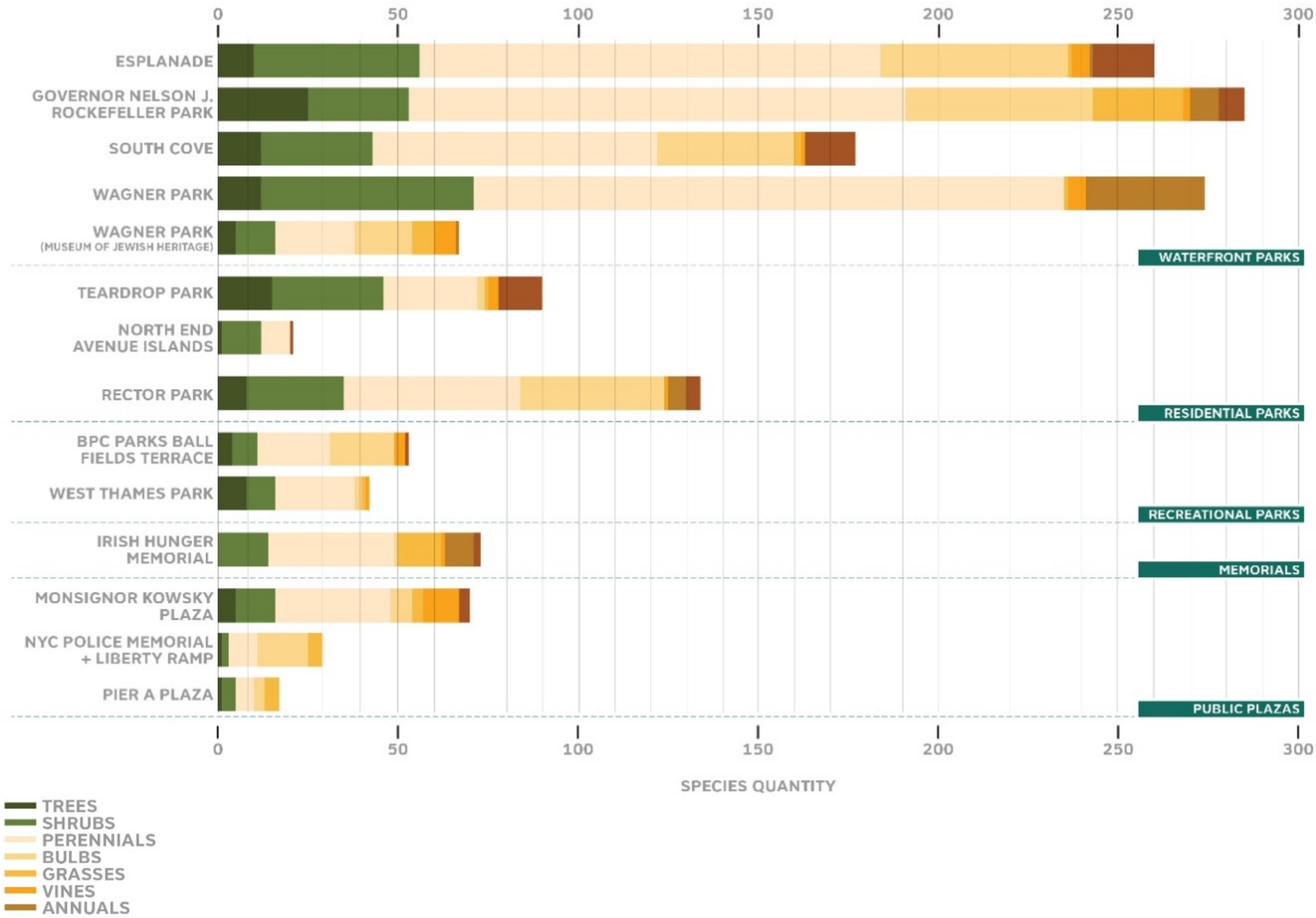

Figure 28: Plant Species per Open Space, 2016[299]

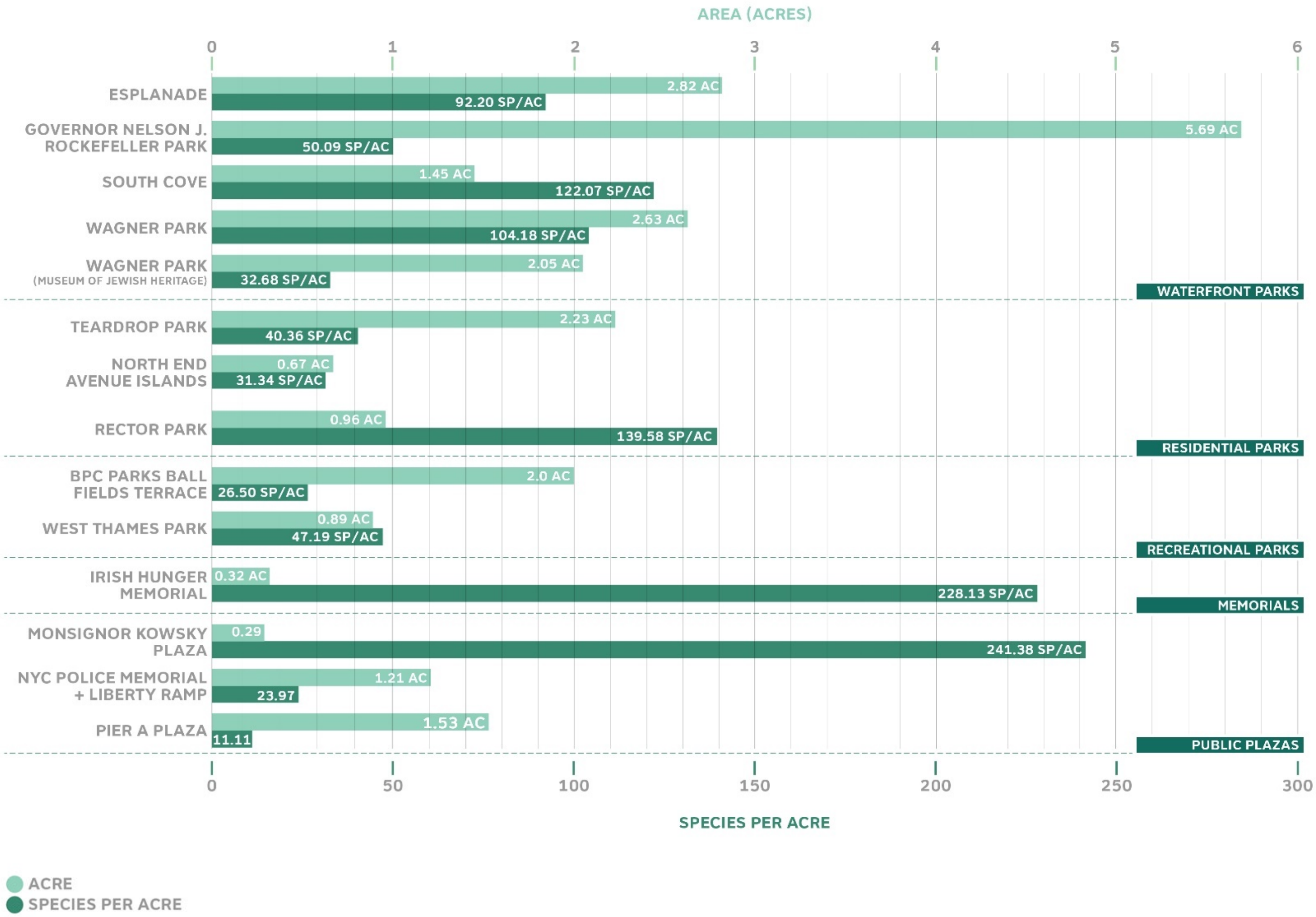

Figure 29: Open Space Area and Species per Acre Comparison, 2016[300]

Table 28: Battery Park City Plant List (2016)[301]

Species Type	Number of Species
Trees	70
Shrubs	201
Perennials	484
Bulbs	211
Grasses	49
Vines	26
Annuals	54
Ferns	37

Table 29: SITES Version 2, Performance Criteria for Biomass Density Index[302]

Land Cover Type	Biomass Density Index (BDI)
Trees with understory	6
Trees without understory	4
Shrubs	3
Perennials	2
Annual Plantings	1.5
Managed turf >3" (includes emergent wetland)	3
Managed turf <3" (includes emergent wetland)	2
Prairie/pasture	1.5
Wetlands	6

Urban Heat Island

Level 1

A Tree Species Mortality Rate

Tree species mortality rate: a benchmark to average tree survivorship of 50% after 35 years.[303,304]

Level 2

B Tree Canopy Expansion

Based on tree assessment, identify strategies to achieve a minimum 40% tree canopy cover along streetscapes and in open spaces.[305]

C Summer Temperature Variation

Use measured temperature variation in summer months to benchmark against NYC average of 7°F increase as assed by Columbia University Center for Climate Systems Research.[306]

D Surface Material

Benchmark surface material ratings across BPC against recommendations of an aged solar reflectance value of at least 0.3 and quantity of open grid pavement for at least 30% of the site's non-roof impervious surfaces, including parking lots, plazas, etc.[307]

Level 3

N/A

Emergency Landscape Preparedness

Level 1

N/A

Level 2

A Collaboration and Sharing of Data

Collaborate with similar recently constructed landscapes in NYC to gather data on the performance during and following climate emergencies such as Hurricane Sandy (e.g. Brooklyn Bridge Park, Hudson River Park, Long Island City's Hunters Point South Park); use collected data to compare BPC's performance. Specifically, compare:

- Duration that access to public spaces was restricted
- Costs of necessary repairs or replacements
- Number of downed trees and major tree limbs
- Severity of impact on planting, planting recovery time
- Quantity of waste collected

Level 3

N/A

Intervention

Terrestrial Habitat

Level 1

A Native Plants

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards

Conserve and use native plants throughout parks, plazas, and streetscapes. Encourage native species to migrate to new areas by mimicking the conditions of successfully established habitat nearby. Expand the use of native plants that are adapted to microsite conditions while adhering to original design intent wherever possible.

B Plant Community Hardiness

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards

Transition plant communities according to established climate thresholds and phase out plants with low-survival rates or species that are projected to become incompatible with the local climate in the immediate term in USDA Hardiness Zones 6 and 7. Further develop working relationships with local nurseries to establish source and timeline for plant availability and use BPC's purchasing power to contract grow opportunities and encourage nurseries to carry native and resilient plant species.

C Multi-Tiered/Layered Planting ❤

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards

Expand multi-tiered and multi-layered plantings by increasing the combined use of grasses, shrubs, and smaller understory trees as well as larger canopy trees where possible.

D Salt Tolerant Species

Applicability: Esplanade/Waterfront

Expand the quantity and range of salt tolerant species (spray and/or inundation) planted along the promenade and in areas exposed to salt air. Expand the quantity and range of plants that can withstand occasional inundation within flood zones as identified by FEMA flood hazard maps.[308] Refer to Design and Planning for Flood Resiliency Guidelines for NYC Parks and the Greenbelt Native Plant Center Salt Tolerant Species List for appropriate plant species.[309,310]

E Biodiverse and Species Rich Planting

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards

Expand areas of biodiverse and species rich planting proven to provide significant wildlife habitat:

- Select plants to expand Bloom Calendar to extend seasonal habitat opportunities for pollinators and other wildlife species throughout the seasons
- As a starting point, plant species should recruit arthropods and nematodes being supported by the root structure and planting media
- As the plant communities mature, they should attract more complex biological associations including both non-migratory and neotropical migratory songbirds. These birds would be attracted to vegetative seed/fruit sources as well as smaller organisms. Expanded planting of grasses will be able to support birds that are likely to be found in proximity to the district such as mourning doves and field sparrow. Woodland communities and fruit or berry bearing shrubs can present a more suitable opportunity for warblers and thrushes

Level 2

N/A

Level 3

F Park and Natural Area Linkages ❤

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront

Create linkages among individual parks and natural areas that enhance larger-scale ecological functioning. Establish connected habitat corridors to adjacent parks (Battery, Hudson River Park) as well as physical connections throughout the district itself. These can be accomplished through streetscape design (tree pits as well as longer and more continuous planting strips), green roofs, and new planted open spaces.

G Regionally Specific Habitats

Applicability: Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards

Based on the Wildlife Census, create or expand regionally significant habitats for species of interest in different habitat categories such as coastal shrub and grassland. Characteristic wildlife species associated with these habitat types may include birds such as passerines and raptors, terrestrial invertebrates, herpetofauna, and mammals such as bats and rodents.

Community gardens can be quite diverse floristically, with counts ranging from 50 to over 180 species of plants per ¼ acre. Food crops growing in the City's community gardens also attract insect pests and associated beneficial arthropods that assist in biological control of these pests.[311]

Soil Health

Level 1

A Engineered/Structural Soils

Applicability: All

Use engineered/structural soils to meet critical programming needs for plant health and to sustain recreational use or heavier loads where relevant, with reference to the practices described in the NYC Parks Department High-Performance Landscape Guidelines Part IV S-6.[312]

Level 2

B Soil Health Monitoring Technology

Applicability: All

Introduce technology that continuously monitors soil health and performance and provides alerts when nutrient level or other metrics require intervention. Some common examples of continuous soil monitoring instrumentation include:

- Pore pressure instruments
  - Observation wells
  - Piezometers
- Deformation instruments
  - Vertical pipe settlement gages

    - Remote Settlement Gages
- Soil moisture instruments
    - Weighing Lysimeter
    - Tensiometers
    - Electrical resistance blocks
    - Time domain reflectometry
- Soil temperature instruments

C Soil Organic Carbon Storage

Applicability: All

Increase soil organic carbon storage within existing soil profiles by 2-4% up to a total maximum of 10%, as appropriate for specific plant communities. The increase of soil carbon content could be achieved through directly amending the soil media with woodchips or biochar as well as through long-term management practices such as increasing plant biomass density by planting species known to have robust root systems and maintaining any plant clippings or debris on location.

Level 3

N/A

Aquatic Habitat

Level 1

N/A

Level 2

A Aquatic Habitat Expansion

Applicability: Esplanade/Waterfront

Based on a survey of existing aquatic and intertidal species and regional ecosystem priorities, identify opportunities to create or expand habitat for aquatic species of interest.

- Include habitat categories such as constructed wetlands and rocky subtidal and intertidal habitats

- Characteristic wildlife species associated with these habitat types may include birds such as waterfowl, shorebirds, gulls, wading birds, and passerines, amphidromous, anadromous, catadromous, estuarine fish, microbenthic invertebrates, and mammals such as bats

B Diverse Bulkhead Ecosystem

Applicability: Esplanade/Waterfront

Along existing bulkhead where bulkhead removal is not feasible, use materials and technologies that provide a bio enhancing substrate and increase rugosity (surface complexity) for subtidal and intertidal organisms to attach to and grow a more diverse ecosystem.

- Use materials such as bio-enhanced concrete, stone, and rock gabions, and oyster shells or other organic materials to help support estuarine species, gradually developing habitat for rich riverine and harbor ecology
- Install additional oyster restoration stations in collaboration with the Billion Oyster Project program and/or other similar oyster or fish nursery features to increase the presence of oyster larvae in the water column and encourage spat settlement on shells and other appropriate substrates

Level 3

C Water Edge Softening ❤

Applicability: Esplanade/Waterfront

Where possible and where space allows, remove the existing bulkhead and re-grade shorelines to have shallow slopes, and introduce substrates and vegetation to enhance the shoreline's potential to support biodiversity and dissipate wave energy. Refer to NYC DEC Tidal Wetlands Guidance Document (Living Shorelines Techniques in the Marine District of New York State) for proper siting and other considerations.[313]

- Create a diverse matrix of intertidal and subtidal habitat using rocks, bio-enhanced concrete, woody debris, and other habitat enhancing materials, to recruit organisms that typically inhabit rocky shorelines. Examples of species of interest for this habitat type include American Oyster, invertebrate community, juvenile fish, American herring gull, bay anchovy, striped bass, Easter oyster, ribbed mussel, Polychaete worm, green algae
- Create brackish constructed wetlands to further expand biodiversity along the water's edge. Wetlands should have a range of elevations to allow for different inundation periods which would allow a wider variety of species to thrive. Examples of species of interest for this habitat type include Terns, Saltmarsh sparrow, red winged blackbird, mud crab, Eastern mud snail

Urban Forest

Level 1

A Street Tree Diversity

Applicability: Streetscapes

Increase street tree diversity. Refer to NYC Parks approved street tree list and identify appropriate shade tree species to be incorporated into BPC's tree palette, to expand the variety and provide increased resistance to disease and pests as well as environmental stressors.[314] Feature trees resistant to limb drop and toppling and suitable to wind conditions along streets exposed to high-winds.

B New Park/Plaza Trees ♥

Applicability: Parks, Plazas, Esplanade/Waterfront, Courtyards

Introduce new trees in existing parks and plazas and increase park tree diversity. Feature trees resistant to limb drop and toppling and suitable to wind conditions along the esplanade and waterfront.

Level 2

C Existing Street Tree Pits

Applicability: Streetscapes

Existing tree pits should be retrofitted to expand their size and increase the root zone. Tree pits should be connected where possible, providing additional space for root growth and lateral water flow (especially important on landfill and in high-water table areas like BPC).[315]

D New Street Tree Pits

Applicability: Streetscapes

Introduce new street trees with ample root space, structural soil, and/or supported with systems that perform structural and stormwater management services. Optimal tree pit size should be 5 ft x 20 ft with 3 foot depth, although a larger size is preferable.

E Planting Strips ♥

Applicability: Streetscapes

Introduce planting strips along sidewalks and in medians and provide planted medians in extensive areas currently marked by road striping. Cluster plants in these areas to create low-maintenance, self-sustaining plantings. By mimicking natural habitat, clustered planting protects each other from environmental stressors such as strong winds and sun scorch and allows for the development of better root systems.

Level 3

N/A

Urban Heat Island Effect

Shading

Level 1

A Street Shading Structures ❤

Applicability: Streetscapes

Provide shade structures along streets, especially in areas where pedestrians may spend extended periods of time such as bus stops and plazas.

B Park Shading ❤

Applicability: Parks, Plazas, Esplanade/Waterfront, Courtyards

Provide shading at parks and open spaces, especially at playgrounds and adjacent caretaker seating areas.

Level 2

N/A

Level 3

N/A

Hardscape

Level 1

A Hardscape Solar Reflective Index ❤

Applicability: All

In areas with high-sun exposure and high-measured Urban Heat Island effect, replace existing low-albedo surface materials with light colored /high-albedo materials (maximum Solar Reflectance Index (SRI) value of 29) and/or open grid pavement for at least 30% of the site's non-roof impervious surfaces. Where possible prioritize natural materials (such as crushed stone) or materials with high-recycled content (such as crushed concrete or glass aggregate).

B Paved Area Vegetation ❤

Applicability: All

Introduce additional vegetation in paved areas with substantial sun exposure to reduce Heat Index through shading and evapotranspiration

Level 2

N/A

Level 3

N/A

Emergency Landscape Preparedness

Level 1

A High-Risk Areas

Applicability: All

Identify and designate areas of the neighborhood that should be closed off during extreme/severe weather events in order to avoid risks such as wave impact, impact from falling tree limbs, etc.

B Emergency Conditions

Applicability: All

Protect human safety in open areas by planning for emergency conditions which includes effective wayfinding and operations both prior to and following events considering the most vulnerable communities, such as those with impaired mobility.

Level 2

C Recovery Cost Reduction

Applicability: All

Use data collected from recovery after previous storms, adjusted for storm impact, strength and duration, and target a 15% reduction in the cost of repairs after major storm events including costs of waste collection and removal, hardscape, furniture, and fixture repair, and planting restoration and recovery. This can be done by preemptive work such as pruning trees so dead limbs don't cause damage to landscape or streetscape elements.

D Emergency Landscape Preparedness Plan

Applicability: All

Develop and implement an emergency preparedness landscape plan with clearly defined mission and goals including:

- Identify and protect vulnerable vegetation before extreme frost or extended heatwave events and adjust irrigation pre-emptively to assist plants in surviving extreme conditions
- Identify and prune trees in areas prone to strong winds or wave impact to reduce risk of limb breakage
- Limit public access to vulnerable areas before and immediately after severe storms (including areas with multiple trees or areas vulnerable to wave impact)
- Consider accessibility challenges and plan for the most vulnerable community members including those with impaired mobility. Identify areas that are prone to paving or other surface failures, protect these areas in advance of extreme events if possible, and assess in the aftermath to expedite any necessary repair work
- Map vulnerable assets within the floodplain and develop strategies for securing these assets before a storm. Familiarize site management and maintenance personnel with these strategies
- Develop a strategy for outreach and education designed to communicate climate related risks specific to BPC to community residents and workers. Provide residents with information about local community resources as well as state or federal resources available during and after emergencies

Level 3

N/A

Practice

Measurement & Verification

Biodiversity and Habitat

A Soil Data Review

Review soil monitoring data on an annual basis to assess soil performance trends, trajectories, or additional monitoring needs that may be addressed at the district-scale.

B Citizen Science Platforms

Promote citizen science platforms such as eBird[316] and iNaturalist[317] among residents and visitors to BPC to encourage the crowd sourcing of species occurrences as a supplement to traditional research/survey efforts and participation in BPC BioBlitz surveys.[318]

See Sustainability Implementation Plan for additional resources.

C Plant Survey

Utilize plant survey protocol to conduct a comprehensive plant survey every 5 years.

D Wildlife Census

Utilize Wildlife Census protocol to conduct seasonal wildlife surveys. Include information collected through citizen science platforms as well as scientific observations. Conduct during wintering, migrating, and breeding seasons.

Urban Heat Island

A Tree Canopy Update

Update assessment of the condition of tree canopy every 3-5 years, including, for example: DBH, height, crown spread, structure and health of trunk, structure and health of roots, branching structure, and foliage and/or buds. Refer to the USDA Forest Service's Forest Inventory and Analysis (FIA) program and establish targeted maintenance protocols for trees whose performance decreases within distinct ranges.[319]

B USDA Forest Service

Collaborate with the USDA Forest Service to measure carbon capture and storage across BPC every 3-5 years.

See Sustainability Implementation Plan for additional resources.

Operations & Maintenance

Terrestrial Habitat

A Partnerships

- Partner with agencies and organizations conducting ongoing ecosystem conservation and restoration projects in the Lower Hudson – Raritan Estuary to develop collaborations and contribute to the overall restoration of the estuary and harbor ecosystem
- Reach out to and establish a collaboration with major botanical institutions, neighboring parks, and NYC Parks to share information and exchange knowledge about observed changes to plant performance

See Sustainability Implementation Plan for additional resources.

B Invasive Species Management

Manage Invasive Species per the New York State Invasive Species Comprehensive Management Plan to address harmful opportunistic weed species rather than strictly non-native species including initial treatment, follow-up treatments, long-term control.

- Include monitoring and methods of invasive plant material disposal to prevent the spread
- Reduce invasive plant cover and identify management practices based on invasive species audits. Management activities should work toward a maintenance control of < 5% cover per planting area over a period of three years[320]

Soil Health

A Nutrient Cycling

Promote on-site nutrient cycling through the retention of landscape debris on-site and reintegration of raw woodchips and clipping into the soil profile. Maintain beneficial microbial and fungal communities through direct inoculation and applying other soil inputs based on microbial community needs.

B Sustainable Soil Practices

Establish sustainable management practices for specific soil characteristics associated with each plant community type within BPC (adapted from USDA Soil Quality Indicators).[321] See Table 27 for reference.

Aquatic Habitat

A Coastal Monitoring and Maintenance Protocol

Develop and implement monitoring and maintenance protocol for coastal interventions, including inspection as well as additional inspection after major storm events. Refer to NYS DEC Tidal Wetlands Guidance Document as well as the Hudson River Sustainable Shorelines for maintenance and monitoring priorities and protocols. The protocol should include the following[322, 323]:

- Plant Establishment - Ongoing assessment of any plants established (species and number of plants, plant survival rates) as appropriate.
- Invasive Species – Presence of any invasive species as well as any action taken for removal
- Storm Damage - Any storm damage or adjacent site activity
- Target Species - Response of target species as appropriate. Expert ecologist opinion recommended
- Bulkhead Structural Integrity - The structural integrity of any elements installed on or adjacent to bulkhead structure, or any structural habitat, including any settlement. Expert engineer opinion required
- Sediment Monitoring - Monitoring of any sediment erosion or deposition. Sediment sampling required

Urban Heat Island

A Materials Lifecycle

See Materials & Waste, Sustainable Building Materials, Intervention, Longevity and Circular Economy section for guidance on reducing embodied impacts of building materials.

B Pavement Maintenance

Maximize the life of pavement with preventative maintenance including crack filling, resurfacing, and repairs.

C Low-Albedo Asphalt

Promote innovative ways to increase the low-albedo of asphalt in maintenance and renovation projects such as incorporating:

- Recycled aggregates to reduce the amount of virgin aggregate and asphalt binder
- Light color aggregates which can be rolled into the top course to lighten the asphalt
- Thinner pavement sections by considering anticipated traffic volume and vehicle weights
- Shot blasting existing asphalt to remove black asphalt surface and expose the lighter aggregate
- Lower asphalt installation temperatures

Case Study 10A

Brooklyn Bridge Park - New York City, NY[324]

Brooklyn Bridge Park extends for 1.3 miles along the East River shore from Jay Street to Atlantic Avenue. Previously a cargo shipping and storage complex, the site has been transformed into an 85-acre civic landscape. Today the park offers a range of passive and active recreation opportunities and flexible open space for community activities.

The park introduces a range of aquatic and terrestrial plant communities and habitats, including eight different planting typologies. These include two different meadow communities as well as freshwater wetlands and salt marshes. As a result, 119 species of birds have been observed on site, including both nesting and migratory species.

Each area within the park has a unique managed successional maintenance plan. These areas provide annual benefits including 4,370 lbs of gross carbon sequestration, 2,246 ft^3 of annual avoided runoff, and 966 lbs of pollutant removal. They also demonstrate an increase in the Floristic Quality Index from 0.0 to 23.1 relative to existing site conditions and a traditional waterfront park landscape. Similarly, the Biomass Density Index is nearly three times greater than that of nearby traditionally designed waterfronts.

Throughout the landscape design, an emphasis was placed on the reuse of material. Wherever possible, structures and material from the existing site were reused. One example is the yellow pine beam and columns from an existing building that were reconstructed as site furnishing. The park's distinctive landforms were created from 90,000 cubic yards of fill material from the Long Island Railroad East Side.

Figure 30: Brooklyn Bridge Park - New York, USA[325]

Case Study 10B

Cambridge Urban Forest Master Plan - Cambridge, MA[326]

The City of Cambridge has recently invested in protecting and promoting a healthy and sustainable urban forest and will release an Urban Forest Master Plan in 2020. The plan's goal is to evaluate, maintain, and expand the urban forest canopy while increasing climate change resiliency, reducing the urban heat island effect, mitigating stormwater runoff, reducing nutrient runoff, and contributing to community wellbeing.

The plan presents a multi-pronged approach to best respond to canopy loss including planning (understanding the implications of trees), policy (regulations created by the city), practice (measures to support the life of trees), and advocacy (community engagement).

After a rigorous existing conditions study, the preliminary report identified the current state of the urban forest and priority areas of where to best focus city efforts. These areas are defined as those with canopy deficiency, vulnerable populations, heat island hotspots, and community infrastructure. Based on the current state of the urban forest, the report suggests multiple response strategies. It studies how to best improve both existing and proposed conditions.

For existing conditions, a series of precedent studies were selected based on common street tree conditions and an appropriate response strategy. The strategies range from removing two-way traffic to allow for a wider curb/planting zone, creating continuous panting strips with expanded soil volumes in pervious paving, and transforming parking spaces into green spaces for trees. The plan emphasizes the importance of protecting mature trees.

For proposed conditions, the plan sets forth best practices for tree planting in the urban realm. The plan suggests a list of species that will best survive in street conditions and climate change.

To best secure the health of both existing and proposed trees, the plan establishes several policies including ideal planting conditions and management practices. The maintenance efforts include pruning and removals, pest/disease treatment, inventory tracking, watering, mulching, sidewalk de-icing, and soils management. Recently, the City has implemented several new pilots for brewing liquid biological compost and installing porous pavement over tree pits in high-pedestrian traffic areas. Each individual tree is viewed as important and a piece of a larger forest system.

Figure 31: Cambridge Urban Forest Master Plan - Cambridge, USA[327]

Resources

Comprehensive Restoration Plan for the Hudson-Raritan Estuary

https://www.nan.usace.army.mil/Missions/Environmental/Comprehensive-Restoration-Plan-for-the-Hudson-Raritan-Estuary/

Design and Planning for Flood Resiliency: Guidelines for NYC Parks

https://www.nycgovparks.org/pagefiles/128/NYCP-Design-and-Planning-Flood-Zone__5b0f0f5da8144.pdf

Ecological Communities of New York State (2nd Edition)

https://www.dec.ny.gov/docs/wildlife_pdf/ecocomm2014.pdf

FEMA Region II Coastal Analysis and Mapping

http://www.region2coastal.com/view-flood-maps-data/what-is-my-bfe-address-lookup-tool/

Greenbelt Native Plant Center – Salt Tolerant Species List

https://www.nycgovparks.org/sub_about/parks_divisions/gnpc/pdf/salt_tolerant_species_list.pdf

Hudson River Sustainable Shorelines: Assessing Ecological and Physical Performance

https://www.hrnerr.org/hudson-river-sustainable-shorelines/assessing-ecological-physical-performance

Native Species Planting Guide for New York City (3rd Edition)

https://www.nycgovparks.org/pagefiles/142/Native-Plant-Guide-2019-FINAL__5d4c302e1755f.pdf

New York Natural Heritage Program – Rare Plant and Animal Status Lists

https://www.dec.ny.gov/animals/29338.html

New York State Department of Environmental Conservation Tidal Wetlands Guidance Document: Living Shoreline Techniques in the Marine District of New York State

http://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf

New York State Invasive Species Comprehensive Management Plan

https://www.dec.ny.gov/docs/lands_forests_pdf/iscmpfinal.pdf

NYC DOT Street Design Manual

https://www1.nyc.gov/html/dot/downloads/pdf/nycdot-streetdesignmanual-interior-lores.pdf

NYC Parks & Recreation – High-Performance Landscape Guidelines – Engineered/Structural Soil

https://www.nycgovparks.org/sub_about/sustainable_parks/design_guidelines.pdf

Plants of Battery Park City (2016)

https://bpca.ny.gov/wp-content/uploads/2018/06/Plant-List-2016.pdf

Soil Quality Indicator Sheets

https://www.dec.ny.gov/docs/wildlife_pdf/ecocomm2014.pdf
https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1269817&ext=pdf
https://www.nrcs.usda.gov/wps/PA_NRCSConsumption/download?cid=stelprdb1269818&ext=pdf

USDA Forest Service - Carbon Estimation Tools

https://www.fs.usda.gov/ccrc/topics/forests-carbon

USDA Plant Hardiness Zone Map

https://planthardiness.ars.usda.gov/PHZMWeb/#

Abbreviations & Definitions

ASTM	American Society for Testing Materials
BDI	Biomass Density Index
DBH	Diameter at Breast Height
FEMA	Federal Emergency Management Agency
FIA	Forest Inventory Analysis
LEED	Leadership in Energy and Environmental Design
NRCS	Natural Resources Conservation Service
NYC DOT	NYC Department of Transportation
SRI	Solar Reflectance Index
TOC	Total Organic Content
USDA	United States Department of Agriculture

Albedo	The quantity of incident radiation that is reflected by a surface. It varies from 0 and 1 where 0 corresponds to the absorption of all incident radiation and 1 reflects all radiation
Bike Lane	A portion of the roadway is designated, by striping, signing, and pavement markings, for the preferential or exclusive use of bicycles.

Bike or Bicycle Route	A designated bikeway with appropriate direction and route marker. In New York City, bike routes categorized as, Class 1 (bridge, park, or separated on-street path, Bicycle Lane, Class 2 (on-street striped route); and Bicycle Route, Class 3 (on-street signed route).
Bike Path	A path physically separated from motorized vehicle traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way and is intended for the use of bicycles.
Biodiversity	The variety of life found in a place. Biodiversity is measured as an attribute that has two components, richness (the number of groups of genetically or functionally related individuals) and evenness (proportions of species or functional groups present on site)
Biomass Density	The total amount of aboveground living organic matter in trees expressed as dry weight per unit area
Brackish	A mixture of fresh and seawater, such as that found in estuaries
Citizen Science	A method of engaging the general public in collaborative scientific research through crowd sourced data gathering.
Climate Threshold	An established range which if exceeded, can lead to negative repercussions to the performance and health of the plant community.
Curb Extension	An extension of the curb line into the lane of the roadway adjacent to the curb for a portion of a block either at a corner or mid-block.
Diadromous	Fish that migrate between fresh and saltwater as part of its lifecycle including anadromous and catadromous.
Ecosystem Services	Direct and indirect benefits of the natural resources to human wellbeing.
Endangered Species	An animal or plan that is considered at risk of extinction.
Engineered Soils	Soils that are design and manufactured from soil and soil components – sand, silt, clay, and organic matter/compost – to achieve a prescribed ratio of ingredients, suitable for a specific application.
Evapotranspiration	The process of transferring land water into the atmosphere through the transpiration of plants and the evaporation from surfaces.

Extirpation	A situation in which a species or population no longer exists within a certain geographical location.
Impact Threshold	The relationship between the invasive plant abundance (biomass and spatial extent) and natural assets, affecting species richness or ecosystem properties.
Inoculation	The introduction of a pathogen or antigen into a living organism to stimulate the production of antibodies.
Intersection	The area contained within the grid created by extending the curb lines of two or more streets at the point at which they cross each other.
Intertidal	An area where the ocean meets the land between high and low-tides. Four physical divisions, each with distinct characteristics and ecological differences divide the intertidal zone (Spray, High, Middle, and Low).
Invasive Species	An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.
Microclimate	The climate of a small geographic area, especially when it may be different from its larger surroundings.
Nutrient Cycling	Movement and exchange of organic and inorganic matter.
Plant Hardiness Zone	A standard developed by the United States Department of Agriculture (USDA), by which gardeners and growers can determine which plants are most likely to thrive at a location. The map is based on the average annual minimum winter temperature, divided into 10°F zones.
Plaza	An area located fully within the roadway that is designated by the Department of Transportation for use by pedestrians.
Raised Speed Reducer	A raised area of a roadway that deflects both the wheels and frame of a traversing vehicle to reduce vehicle speeds.
Salt Tolerance	Salt tolerance is the degree to which living organisms can withstand moderate-high concentrations of salt in the soil, air, or water without significant negative effects.

Sidewalk	That portion of a street, whether paved or unpaved, between the curb lines or the lateral lines of a roadway and the adjacent property lines intended for the use of pedestrians. They are located on both sides of all streets that are 22 feet or wider.
Soil Organic Carbon Storage	Total quantity of organic carbon matter stored in the soil, consisting of plant or animal tissue in various stages of breakdown (decomposition).
Solar Reflectance Index (SRI)	A measure of solar reflectance and emissivity of a surface, as shown by a small temperature rise. It is defined so that a standard black surface (reflectance 0.05, emittance 0.90) is 0 and a standard white surface (reflectance 0.80, emittance 0.90) is 100.
Structured Soils	A mixture of crushed gravel and soil that is designed to be compacted while permitting root growth.
Subtidal	Area lying below the low-tide mark. The word is often used as a general descriptive term for a subaqueous but shallow marine depositional environment.
Taxa	Any unit used in the science of biological classification to group one or more populations of an organism or organisms. Taxa are arranged in a hierarchy from kingdom to subspecies.
Terrestrial	Of, pertaining to, or corresponding to land, as opposed to water and air.
Threatened Species	Any species which is likely to become an endangered species within the foreseeable future throughout all, or a significant portion of its range.
Urban Heat Island Effect	Urban and metropolitan areas are hotter than their surroundings due to development density and materiality.

Endnotes

[270] Spending at Least 120 Minutes a Week in Nature is Associated with Good Health and Wellbeing, https://www.nature.com/articles/s41598-019-44097-3

[271] USDA Plant Hardiness Zone Map, https://planthardiness.ars.usda.gov/PHZMWeb/

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New Construction

Introduction

All new projects at building or site-scale are opportunities to incorporate best design practices for environmental sustainability in keeping with Battery Park City's green legacy, as well as to meet the goals outlined in the BPC Sustainability Plan. Given advancements in technology and the growing urgency presented by climate change, all new projects will be designed to more stringent regulatory requirements than existing buildings.

All new construction for building, site, and infrastructure projects within Battery Park City will be required to comply with the requirements in the New Construction section. For new buildings, requirements to comply with third-party certification systems have been defined based on project size. The Buildings section uses an evidence-based approach and applies to all building typologies. Similarly, the Site and Infrastructure section requirements have been aligned with third-party certification systems based on the type of projects and viability within the context of Battery Park City.

While the guidelines for new construction projects are mandatory, in the case that a project has unique circumstances and may not be suitable for the guidelines, the project may be exempt from certain aspects of these guidelines upon written approval from BPCA. Additionally, the guidelines for new construction will be distinct from, and in addition to, other design guidelines/requirements or legal obligations associated with such new construction.

Buildings

New Building Projects

Minimum Project Criteria

- Must be a new, permanent building.
- Minimum floor area: 1,000 ft^2 for whole buildings including 250 ft^2 of occupied space.
- Minimum occupancy rates: 1 FTE (full time equivalent).

In addition to the minimum criteria outlined above, additional requirements are based on the project area. See below.

Projects below 20,000 ft^2 gross

Must comply with the following requirements:

- Achieve Living Building Challenge 4.0 (LBC 4.0) Certification as provided by International Living Future Institute, or BPCA approved comparable certification.[328]
- Ensure that the project achieves the following:
  - 10% less CO_2e emissions as compared to current NYC LL97 requirements,[329] and
  - Transparency by providing whole building energy and water use data on an annual basis to BPCA. Method of tracking and reporting to be coordinated with BPCA.

Projects between 20,000 ft^2 and 30,000 ft^2 gross

Must comply with the following requirements:

- Achieve Zero Energy Certification as provided by International Living Future Institute, or BPCA approved comparable certification.[330]
- Achieve Core Green Building Certification as provided by International Living Future Institute, or BPCA approved comparable certification.[331]
- Ensure that the project achieves the following:

- 10% less CO_2 emissions as compared to current NYC LL97 requirements,[332] and
- Transparency by providing whole building energy and water use data on an annual basis to BPCA. Method of tracking and reporting to be coordinated with BPCA.

Projects above 30,000 ft^2 gross

Must comply with the following requirements:

- Achieve Zero Carbon Certification as provided by the International Living Future Institute, or BPCA approved comparable certification.[333]
- Achieve Core Green Building Certification as provided by International Living Future Institute, or BPCA approved comparable certification.[334]
- Ensure that the project achieves the following:
    - 10% less CO_2 emissions as compared to current NYC LL97 requirements,[335] and
    - Transparency by providing whole building energy and water use data on an annual basis to BPCA. Method of tracking and reporting to be coordinated with BPCA.

Endnotes

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[335] New York City Local Law 97, https://www1.nyc.gov/assets/buildings/local_laws/ll97of2019.pdf

Site & Infrastructure

New Site & Infrastructure Projects

Minimum Project Criteria

- Minimum area*: 2,000 ft^2
- The project should contain a vegetated, open space, streetscape, plaza, or stormwater management element.

*Project area is defined as the total disturbed area for the proposed improvements.

In addition to the minimum criteria outlined above, additional requirements are based on the project area. See below.

Parks, Plazas, and Courtyards

Between 2,000 and 10,000 ft^2 gross

Must comply with one of the following two requirements:

- Design to meet SITES Silver Level equivalent (no certification), as provided by the Sustainable SITES Initiative.[336]
    - Comply with requirements for 30 points in the Materials Selection and Construction sections (combined).
- Design to meet Envision Gold Level equivalent (no certification), as provided by the Institute for Sustainable Infrastructure.[337]
    - Comply with requirements to achieve 40% of the total applicable Envision points within the five categories; Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Resilience.

The project applicant should submit the following to BPCA:

- A plan on how the project plans to comply with either of the above requirements, during the Schematic Phase of design.
- Documentation or presentation on the specific strategies incorporated to meet either of the above requirement, at the start of the Construction Documents phase of the design.

Over 10,000 ft² gross

Must comply with one of the following two requirements:

- Achieve SITES Silver Level Certification (>85 points), as provided by the Sustainable SITES Initiative.[338]
    - Submit copy of certificate to BPCA.
- Achieve Envision Gold Level Certification (>40% of points), or equivalent points without certification, as provided by the Institute for Sustainable Infrastructure.[339]
    - If pursuing certification, the project applicant should obtain a certificate from the Institute for Sustainable Infrastructure and submit to BPCA. Or,
    - If not pursuing certification, submit a review of all documents to ensure compliance with the above requirement, performed by an Envision Sustainability Professional (ENV SP).

The project applicant should submit the following to BPCA:

- Stormwater Pollution Prevention Plan (SWPPP) and associated Erosion and Sediment Control (ESC) Plan.

Projects that are located along the waterfront should meet the following requirement:

- Achieve WEDG Verification (>115 points).[340]
    - Submit copy of certificate to BPCA.

Streetscape projects

Over 2,000 ft² gross

Must comply with one of the following two requirements:

- Design to meet SITES Silver Level equivalent (no certification), as provided by the Sustainable SITES Initiative.[341]
    - Comply with requirements for 30 points in the Materials Selection and Construction sections (combined).
- Design to meet Envision Gold Level equivalent (no certification), as provided by the Institute for Sustainable Infrastructure.[342]
    - Comply with requirements to achieve 40% of the total applicable Envision points within the five categories; Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Resilience.
- The project applicant should submit the following to BPCA:

- A plan on how the project plans to comply with the above requirement, during the Schematic Phase of design.
- Documentation or presentation on the specific strategies incorporated to meet the above requirement, at the start of the Construction Documents phase of the design.

Endnotes

[336] SITES Version 2, http://www.sustainablesites.org/resources

[337] Sustainable Infrastructure Envision Rating System, https://sustainableinfrastructure.org/envision/use-envision/

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Appendices

Appendix A: Applicability Groups

Applicability Groups are meant to assist the user in locating content applicable to their assets and system types based on the specific project type or Interventions they are seeking. The applicability groups are as illustrated in Table 30.

Table 30: Applicability Group Summary

Category	Applicability	Applicability	Applicability	Applicability	Applicability	Applicability
Project Type	Site*	Building**	Tenant Improvements***	N/A	N/A	N/A
Typology	Residential	Non-Residential	N/A	N/A	N/A	N/A
Envelope Type	Punched Openings	Window Walls	Curtain Wall	N/A	N/A	N/A
Cooling/Heat Rejection Systems	Chilled Water Systems	Heat Pump Loops	N/A	N/A	N/A	N/A
Heating System Type	Hot Water <115°F	Hot Water 115-140°F	Hot Water >140°F	Heat Pump Loops	Two-Pipe Steam	District Steam
Unitary Equipment	Water Loop Heat Pumps	Through Wall	PTAC	N/A	N/A	N/A
Domestic Hot Water System Type	Central Systems	Distributed Systems	N/A	N/A	N/A	N/A
Vertical Transportation	Hydraulic Elevators	Traction Elevators	Escalators & Moving Walkways	N/A	N/A	N/A
Biodiversity & Habitat	Parks	Plazas	Streetscapes	Esplanade/ Waterfront	Courtyards	N/A

*Refers to site projects, including landscape, infrastructure, outdoor space improvements and temporary structures.

**Refers to building-scale upgrades or renovations.

***Refers to single-tenant upgrades or renovations.

Applicability Tables

Deep Energy Retrofits

Table 31: Deep Energy Retrofits Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Envelope	General	All
	Windows & Doors	Punched Openings, Window Wall, Curtain Wall
	Opaque Walls	All
	Slabs, Soffits, and Roof	All
HVAC	Air Systems	Residential, Non-Residential
	Automatic Controls - Air Systems	Residential, Non-Residential
	Piping: General	All
	Piping: Cooling	Chilled Water Systems
	Automatic Controls - Piping: Cooling	Chilled Water Systems
	Piping: Heat Rejection	Residential, Non-Residential
	Automatic Controls - Piping: Heat Rejection	Heat Pump Loops, Condenser Water Systems
	Piping: Heating	Hot Water Systems 115-140°F, Hot Water Systems >140°F, Chilled Water Systems
	Automatic Controls - Piping: Heating	All
	Unitary Equipment	Water Loop Heat Pumps, Through Wall, PTAC

	Automatic Controls - Unitary Equipment	Water Loop Heat Pumps, Through Wall, PTAC
	Steam Systems	Two-Pipe Steam, District Steam
	Automatic Controls - Steam Systems	Two-Pipe Steam, District Steam
Lighting	Lighting Levels	Residential, Non-Residential
	Automatic Controls - Lighting	Residential, Non-Residential
Appliances and Plug Loads	N/A	Residential, Non-Residential
Domestic Hot Water	Domestic Hot Water Systems	Central Systems, Distributed Systems
	Automatic Controls - Domestic Hot Water	Central Systems, Distributed Systems
Vertical Transportation	Vertical Transportation Systems	Hydraulic Elevators, Traction Elevators, Escalators & Moving Walkways
	Automatic Controls - Vertical Transportation	Hydraulic Elevators, Traction Elevators
Building Management System & Sub-Metering	N/A	All

Building Electrification

Table 32: Building Electrification Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Heating System Electrification	N/A	Hot Water <115°F, Hot Water 115-140°F, Hot Water >140°F, PTAC, Heat Pump Loops, Through Wall Chilled Water Systems
Domestic Hot Water (DHW) System Electrification	N/A	Central Systems, Distributed Systems
Cooking Electrification	N/A	Residential, Non-Residential
Clothes Drying Electrification	N/A	Residential

Renewable Energy Supply & Storage

Table 33: Renewable Energy Supply & Storage Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Renewable Energy Systems	N/A	Site, Residential, Non-Residential
On-Site Energy Storage	N/A	Site, Residential, Non-Residential

Water Conservation

Table 34: Water Conservation Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Fixtures	N/A	None
Appliances	N/A	Residential, Non-Residential
Cooling Towers	N/A	All
Irrigation	N/A	All
Metering	N/A	All

Water Recycling Systems

Table 35: Water Recycling Systems Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Collection Sources	N/A	Site, Building
Possible Uses	N/A	Site, Building
Metering	N/A	All

Resiliency and Stormwater Management

Table 36: Resiliency and Stormwater Management Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Stormwater Capture	Green Infrastructure	Site, Building
	Ground Permeability	Site, Building
Controlling Sources of Pollutants	Site Practices	All
	Treatment	Site

Sustainable Building Materials

Table 37: Sustainable Building Materials Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Longevity & Circular Economy	N/A	Site, Building, Tenant Improvements
Healthy Materials	N/A	Building, Tenant Improvements

Waste Diversion

Table 38: Waste Diversion Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Disposal and Storage	N/A	Site, Residential, Non-Residential

Construction and Demolition Activities

Table 39: Construction and Demolition Activities Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Construction & Demolition Waste Management Plan	N/A	All
Packaging Waste	N/A	All
Materials & Waste Storage	N/A	All
Construction Indoor Air Quality	N/A	Building, Tenant Improvements
Construction Outdoor Air Quality	N/A	Site, Building, Tenant Improvements
Noise Pollution	N/A	All
Erosion and Sedimentation Control Plan	N/A	Site
Ecology & Water Pollution	N/A	Site

Biodiversity and Habitats

Table 40: Biodiversity and Habitats Intervention Applicability Groups

Category	Sub-Category	Applicability Groups
Terrestrial Habitat	N/A	Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards
Soil Health	N/A	All
Aquatic Habitat	N/A	Esplanade/Waterfront
Urban Forest	N/A	Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards
Urban Heat Island Effect	Shading	Parks, Plazas, Streetscapes, Esplanade/Waterfront, Courtyards
	Hardscape	All
Emergency Landscape Preparedness	N/A	All

Appendix B: Health & Wellbeing Summary

Table 41: Summary of Health and Wellbeing Impacts of the Green Guidelines

Wellbeing Area	Strategy	Interventions
Thermal Comfort	Strategy 1: Deep Energy Retrofits	Window Performance Enhancement – Punched Openings ❤ Roofing Replacement ❤ Thermostat Strategy ❤ Thermal Comfort ❤
	Strategy 10: Biodiversity & Habitats	Street Shading Structures ❤ Park Shading ❤ Hardscape Solar Reflective Index ❤ Paved Area Vegetation ❤
Respiratory Health	Strategy 1: Deep Energy Retrofits:	Air Filtration ❤ Local Fan Filter Units ❤ Demand-Controlled Ventilation ❤ Dirt Prevention ❤
	Strategy 7: Sustainable Building Materials:	IAQ Pollution Sources ❤ Low-Emitting Materials ❤ Healthy Products Declaration – Level 1 ❤ IAQ Monitoring ❤ Red List Material Compliance ❤
	Strategy 9: Construction & Demolition Activities:	Indoor Air Quality Management Plan ❤ Soil Transport ❤ Construction and Delivery Vehicle Idling ❤

	Strategy 10: Biodiversity and Habitats	Multi-Tiered/Layered Planting ❤ Soil Organic Carbon Storage ❤ New Park/Plaza Trees ❤ Planting Strips ❤ Paved Area Vegetation ❤
Visual Comfort	**Strategy 1: Deep Energy Retrofits**	Illuminance Levels ❤ Sun Glare Control ❤ Access to Daylight – Non-Residential ❤ Electric Lighting Glare Control ❤ Balanced Lighting ❤ Fixture Color Rendering ❤ Circadian Lighting Design ❤ Fixture Flicker ❤ Light Pollution ❤ Quality Views ❤ Annual Sunlight Exposure ❤ Smart Lighting ❤ Occupant Control ❤
Physical Health	**Strategy 1: Deep Energy Retrofits**	Access to Stairways ❤ Stairway Use Encouragement ❤ Low Global Warming Potential (GWP) Refrigerants ❤ Terminal Equipment GWP Reduction ❤ PTAC Replacement with PTHP ❤
	Strategy 4: Water Conservation	Water Quality and Filtration – Level 2 ❤ Water Quality ❤

	Strategy 5: Water Recycling Systems	Recycled Water Quality ❤
	Strategy 6: Resiliency and Stormwater Management	Polluting Substances ❤ Eco-Friendly Products ❤
	Strategy 8: Waste Diversion	Waste Collection Room Sinks ❤ Water Fountains ❤
Mental Health	Strategy 1: Deep Energy Retrofits	Roofing Replacement ❤
	Strategy 6: Resiliency and Stormwater Management	Stormwater Gardens ❤ Rain Gardens ❤ Rock-Lined Drainage Swale or Dry Creek Beds ❤ Vegetated Bioswales ❤ Detention Basins ❤ Lower Manhattan Watershed ❤ Buffer Naturalization ❤ Natural Buffers ❤ Green or Blue Roofs ❤ Stormwater Runoff Quality ❤
	Strategy 9: Construction & Demolition Activities	Timing Constraints ❤ Equipment Noise ❤ Erosion and Sedimentation Control (ESC) Plan ❤
	Strategy 10: Biodiversity and Habitats	Park and Natural Area Linkages ❤ Water Edge Softening ❤ New Park/Plaza Trees ❤ Planting Strips ❤

Appendix C: Synergies

Table 42: Green Guidelines Synergies Detail

Synergies	Strategies									
A. Peak Electrical Demand Reduction: Reducing building electricity demand can lead to smaller peak electrical loads which make building electrification and renewables more viable	1	2	3							
B. Water Demand Reduction: Improving building water efficiency can lead to lower non-potable water demand, reducing the required capacity for water recycling systems and making them more viable.				4	5					
C. Material Efficiency: Designing projects to prioritize material efficiency can lead to a reduction in embodied impacts from extraction and manufacturing, on-site delivery of materials, and C&D waste generation							7		9	
D. Ecosystem Protection: Planning of C&D activities can mitigate or eliminate negative impacts on onsite and surrounding ecosystems									9	10
E. Indoor Air Quality Improvement: Addressing Indoor Air Quality can be done through both healthy materials selection and ventilation system design	1						7			
F. Ground Permeability: Landscape design can help increase site permeability and stormwater retention capacity while improving biodiversity, access to nature, and reducing urban heat island effect						6				10
G. Domestic Hot Water Demand Reduction: Improved building water efficiency can lead to a reduction in the energy required for water pumping and domestic hot water heating	1			4						
H. Project Resource Efficiency: Improve the circular economy by optimizing project resource efficiency, leading to downsizing of plant capacity and less equipment being required	1				5		7			
I. Roof Design: A green roof, blue roof, a PV array, or a combination of these can help improve biodiversity, stormwater retention and/or electrical grid demand, depending on project priorities			3			6				10

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