# A Neighborhood-Specific Framework for Understanding Green Roof Feasibility in Easton, PA

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Types of green roofs: Intensive (shown left), and extensie (shown right).

**Intensive: Intended for Human Interaction**

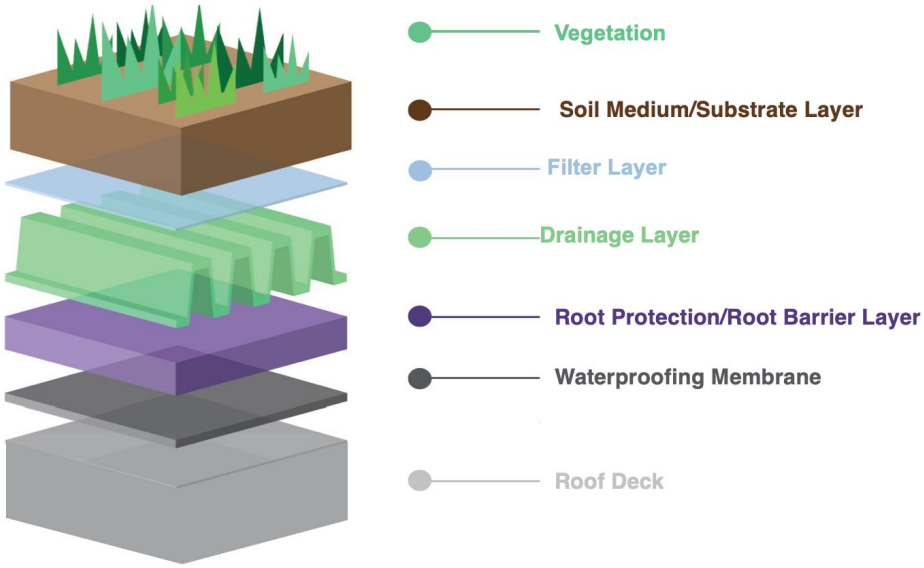
- More in the form of a garden with pathways and thus are often times a source of food
- Serve as space for people to gather, similar to a park
- Must be designed to sustain the additional weight from
    - Human foot traffic
    - Plants & Trees
- Almost exclusively installed on
    - Concrete roof frames
    - Flat roofs
- High maintenance requirements
    - Watering the plants
    - Cutting the shrubs
    - Harvesting the crops
- High weight: 102 and 410 pounds per square foot
- Thick substrate layer: typically at least 12 inches thick

**Extensive: Intended for environmental benefit**

- Self-maintained system
    - Do not include plants that require maintenance
    - Do include drought resistant and self-sufficient plants
        - Sedums, moss, and perennials
- More versatile than intensive green roofs
- Can be installed on roofs with slopes in addition to flat roofs
- Low weight: 15 and 37 pounds per square foot
    - More feasible to retrofit on an existing building
- Little to no maintenance required
- Thin of a substrate: between 2 and 6 inches

**Note**: Information and images compiled in this framework is drawn from the sources referenced in the full Green Roof Feasibility Assessment, found here.

**Green Roof Components:**




- Vegetation Layer
  - Most variable
    - Dependent on :
      - Measures of hardiness, wind resistance, and drought tolerance
      - Weight data
      - Availability and price data
      - Evapotranspiration rates
      - Data on thermal effects of evapotranspiration
      - Leaf area indices
      - Foliage heights
  - Commonly used plants for extensive roofs - sedums, moss, perennials
  - Commonly used plants for intensive roofs - shrubs, trees, lawn
  - Determining factor for all other aspects of roof
- Growing Medium/Substrate Layer
  - Supports vegetation and its roots, and provides water for vegetation
  - Main source of stormwater retention/detention
    - The thickness of this layer has a direct correlation with the amount of stormwater a green roof can retain
  - Inorganic material
    - May be mixed with a slow-release fertilizer to sustain vegetation

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    - Specific materials within the substrate layer vary frequently based on the necessary minerals for intended vegetation
    - General guidelines
        - Begins with roughly a 4:1 mixture of a mineral (such as clay) and a lighter substance (such as pearlite)
            - roughly 20% aerated pore space, 40% water holding capacity, and 40% solid mineral mixture
- Filter Layer
    - Prevents drainage layer from getting clogged by trapping particles from substrate layer
    - The most commonly used fabric is Polypropylene Fabric:
        - Water permeable
        - Decay resistant
        - Tough
    - Can be combined with the drainage layer in order to make the installation process easier

- Drainage Layer
    - Allows water to flow away from the green roof system and toward the roof's drainage system
        - Important on completely flat roofs because if drainage doesn't happen properly, water could pool on the roof causing potential structural damage, as well as drowning the roots of the vegetation.
    - Prevents plants from being consistently saturated with water, which may cause them to drown, and dampens their ability to absorb latent heat and mitigate the urban heat island effect.
    - Two types for different environmental benefits:
        - Granular material made of plastic (similar shape to pebbles, but lighter)
            - Releases water slowly, but does not have stormwater retention, and does not hold water in instances of drought.
            - Best suited for intensive green roofs - ability to include irrigation for higher maintenance plants
        - Mat of spongy, webbed material
            - Heavier because it holds water
            - Stormwater retention
            - Can provide plants with water during drought
            - Not well suited for irrigation
            - Better suited for Extensive green roofs
- Protective Layer
    - Provides a barrier between plants' roots and the waterproofing membrane beneath.

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    - Invaluable to a successful green roof
        - Failure at this layer could cause severe water damage to the existing building.
    - Two types of protective layers
        - A physical barrier typically consists of strong metal or plastic trays welded together and elevated from the waterproofing membrane.
        - A chemical root inhibitor stops the growth of roots once they've reached it.
- Existing roof membrane and drainage system
    - Implemented to withstand consistent standing water
        - Green roofs can be most readily implemented on buildings whose roofs are already waterproofed and flat.
    - Two main types:
        - Polyurethane-based liquid applied treatments
        - Asphalt-based sheets.

**Additional Resources for green roof design and implementation may be found in the appendix.**

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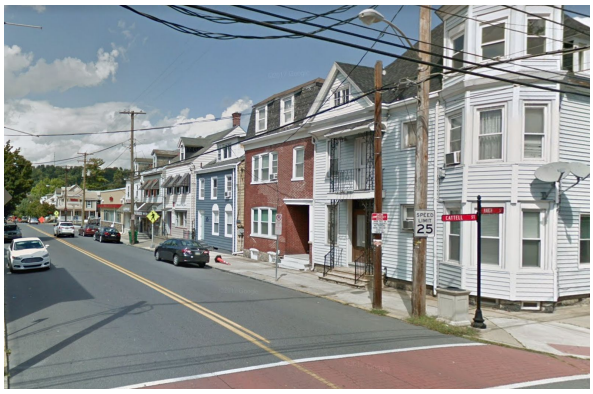
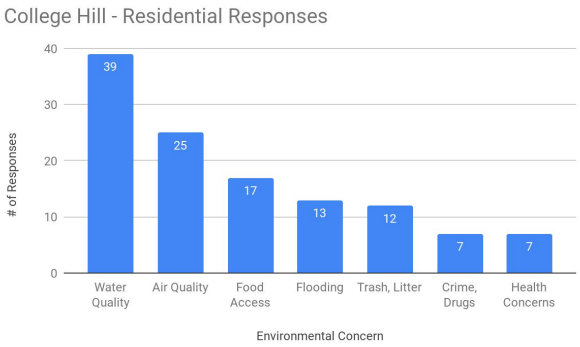
# Neighborhood: College Hill






**Main Identified Concerns (88 responses)**
**(Source - Easton Matters Report)**

1. Water Quality (44%)
2. Air Quality (28%)
3. Food Access (19%)

**Other factors**:
**(Source - Vulnerability Assessment)**

- Presence of Lafayette College
- Relatively few impervious surfaces
- Relatively high tree canopy cover
- Relatively high socioeconomic-status
- High prevalence of parcels at possible risk of flooding

**Assessment:** A green roof best suited to solve College Hill's environmental issues could either be extensive or intensive, depending on the community members' prioritization of concerns. An extensive green roof works to solve air and water quality, while a intensive green roof works to improve food access, in addition to improving air and water quality. However, since the intensive green roof provides the additional access to food, it does come at a higher cost. Generally speaking, an intensive green roof costs $20-$40 per square foot and an extensive green roof costs $10-$20 per square foot. The higher general socioeconomic status of the residents of College Hill increases the likelihood of private implementation of green roofs, either on residential homes or on the Lafayette College campus. We speculate that green roofs will be a viable tool to help College Hill solve their environmental issues, given the wide range of implementation options and ample financial resources.

**Note**: Information and images compiled in this framework is drawn from the sources referenced in the full Green Roof Feasibility Assessment, found here.

**If College Hill were to decide to implement a green roof, our design recommendations for the roof are as follows:**

Vegetation
- Shrubs to improve air and water quality if community decides to do an extensive green roof
- Fruit and vegetable crops for food access if community decides to do an intensive green roof

Substrate Layer
- Dependant on intensive or extensive

Extensive - Ideally growing medium with high proportion of sand for sedum growth, can also grow in mediums with high prevalence of loam and clay

Intensive - Slow releasing fertilized growing medium to promote produce growth, with high proportion of loam and organic material

Filter Layer - Polypropylene fabric (most common)

Holds nutrients in the system and prevents substrate from going into the drainage layer

Drainage Layer - Granular material made of plastic (as flooding and stormwater management are not major concerns)

Releases water slowly

Does not store very much stormwater

Tends to be the lighter of the two drainage layer options

More versatile for different buildings.

Protective Layer - Physical protective layer (as water quality is a main concern)

Mitigate the possibility of the chemical root inhibitor polluting stormwater/ watershed

Roof Membrane - Cannot make a sufficient recommendation - dependent on the uplift resistance of included soils and the expected roof life.

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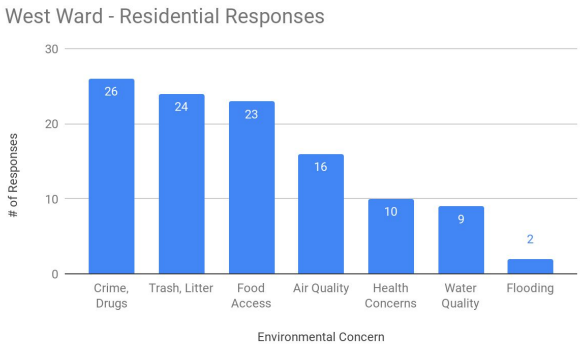
# Neighborhood: West Ward

**Main Identified Concerns (95 responses)**
**(Source - Easton Matters Report)**

1. Crime, Drugs (27%)
2. Trash, Litter (25%)
3. Food Access (24%)




**Other factors**:
**(Source - Vulnerability Assessment)**

- Relatively high prevalence of impervious surfaces
- Relatively low tree canopy cover
- Relatively high percentage of household in poverty
- Low prevalence of parcels at possible risk of flooding

**Assessment:** Green roof implementation which successfully alleviates the environmental issues of the West Ward consists of a highly interactive intensive green roof, costing around $20-$40 per square foot, likely on the upper range of $30-$40 per square foot. While the West Ward has a high percentage population with low household income, policy could help the neighborhood subsidize green roofs high initial costs. Additionally, the main issues identified by community members and city officials differed, so government assistance and policy may help to align concerns. Ultimately, we are skeptical that green roofs are a viable solution to the West Ward's environmental issues, given their main identified concerns and financial constraints.

**Note**: Information and images compiled in this framework is drawn from the sources referenced in the full Green Roof Feasibility Assessment, found here.

**If West Ward were to decide to implement a green roof, our design recommendations for the roof are as follows:**

Vegetation - Trees and grasses, fruit and vegetable crops
- Provide space for community gathering
- Fruit and vegetable crops help to improve food access

Substrate Layer - Growing medium with slow-release fertilizer, higher content of organic material
- Loam, clay will promote growth of produce and other delicate vegetation
- Soil may be tended to and fortified with consistent maintenance

Filter Layer - Polypropylene fabric (most common)
- Holds nutrients in the system and prevents substrate from going into the drainage layer

Drainage Layer - Granular material made of plastic (as flooding and stormwater management are not major concerns)
- Releases water slowly
- Does not store very much stormwater
- Tends to be the lighter of the two drainage layer options
    - More versatile for different buildings.

Protective Layer - Physical barrier
- Less expensive (more manageable for areas with lower socioeconomic status)

Roof Membrane - Cannot make a sufficient recommendation because it is dependent on the uplift resistance of included soils and the expected roof life.

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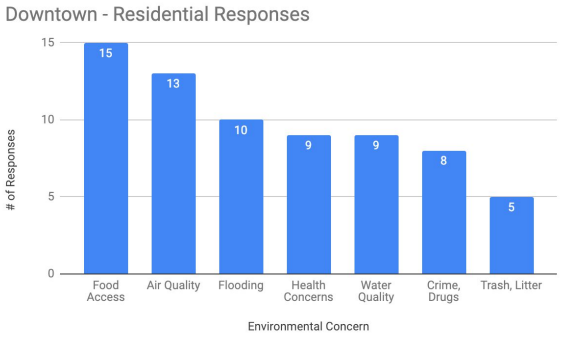
# Neighborhood: Downtown




**Main Identified Concerns (68 responses)**
**(Source - Easton Matters Report)**

1. Food Access (22%)
2. Air Quality (19%)
3. Flooding (15%)

**Other factors**:
**(Source - Vulnerability Assessment)**

- High prevalence of parcels in 100 year, 500 year flood plain
- High impervious surface coverage - majority of impervious surfaces are structures
- Low tree canopy cover
- Relatively high percentage of household in poverty
- High prevalence of parcels at possible risk of flooding

**Assessment:** Downtown has a high prevalence of impervious surfaces and lies in a flood plain. It has a relatively low socioeconomic status, but with proper policy in place, intensive green roofs could be a feasible solution to their environmental concerns. Intensive green roofs provide food access to the urban area and mitigate issues with air quality and flooding in the area. Therefore, intensive green roofs are a viable solution to address the concerns raised by the citizens of Downtown Easton.

**Note**: Information and images compiled in this framework is drawn from the sources referenced in the full Green Roof Feasibility Assessment, found here.

**If Downtown were to decide to implement a green roof, our design recommendations for the roof are as follows:**

Vegetation
- Shrubs to improve air and water quality
- Fruit and vegetable crops for food access
- Plants with high water retention capabilities (e.g. succulents) to help with stormwater management.

Substrate Layer - Growing medium with slow-release fertilizer, higher content of organic material

Loam, clay will promote growth of produce and other delicate vegetation
Soil may be tended to and fortified with consistent maintenance
High proportion of sand for sedum and succulent growth

Filter Layer - Polypropylene fabric (most common)

Holds nutrients in the system and prevents substrate from going into the drainage layer

Drainage Layer - Granular material that is made of plastic

Allows for installation of an irrigation system
Lighter of the two drainage layer options
More versatile for buildings with different weight capacities and
Allows more flexibility in vegetation options.

Protective Layer - Physical protective layer (as water quality is a main concern)

Mitigate the possibility of the chemical root inhibitor polluting stormwater/watershed

Roof Membrane - Cannot make a sufficient recommendation because it is dependent on the uplift resistance of included soils and the expected roof life.

**Assessment:** Downtown has a high prevalence of impervious surfaces and lies in a flood plain. It has a relatively low socioeconomic status, but with proper policy in place, intensive green roofs could be a feasible solution to their environmental concerns. Intensive green roofs provide food access to the urban area and mitigate issues with air quality and flooding in the area. Therefore, intensive green roofs are a viable solution to address the concerns raised by the citizens of Downtown Easton.

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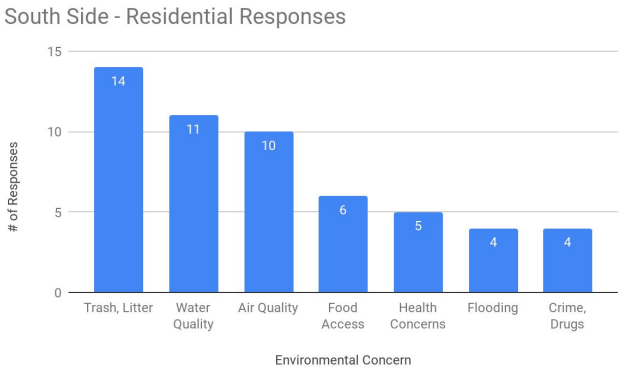
# Neighborhood: South Side


**Main Identified Concerns (60 responses)**
**(Source - Easton Matters Report)**

1. Trash, Litter (23%)
2. Water Quality (18%)
3. Air Quality (17%)




**Other factors**:
**(Source - Vulnerability Assessment)**

- Relatively few impervious surfaces
- Moderate amount of tree canopy
- Low prevalence of parcels at possible risk of flooding
- Relatively low percentage of households in poverty (<$30,000)

**Assessment:** South Side has a generally low prevalence of impervious surfaces, with generally high tree canopy cover and relatively low percentage of households in poverty. An extensive green roof implemented would help solve the environmental issues identified by the South Side. Relatively high household income increases the feasibility of private implementation of green roofs. Ultimately, we believe green roof implementation in South Side helps to solve the environmental issues identified by community members.

**Note**: Information and images compiled in this framework is drawn from the sources referenced in the full Green Roof Feasibility Assessment, found here.

**If South Side were to decide to implement a green roof, our design recommendations for the roof are as follows:**

Vegetation - Grasses, shrubs, and sedums for an extensive green roof
Species from different taxonomic groups increases biodiversity and survivability

Substrate Layer - Higher ratio of inorganic material for an extensive green roof
Slow-release fertilizer may be necessary depending on specific plant needs - not necessarily required.

Filter Layer - Polypropylene fabric (most common)
Holds nutrients in the system and prevents substrate from going into the drainage layer

Drainage Layer - Spongy, webbed material is best suited for extensive green roof
Retain stormwater during instances of high precipitation
Retaining water for plants to use in instances of drought
Mitigates any need for outside irrigation to maintain vegetation

Protective Layer - Physical protective layer (common and less expensive option)
Prevents chemicals (and pollutants from trash and litter) from entering water supply
Mitigate the possibility of the chemical root inhibitor polluting stormwater/watershed

Roof Membrane - Cannot make a sufficient recommendation because it is dependent on the uplift resistance of included soils and the expected roof life.

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