LANDSCAPE PERFORMANCE SERIES
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# Methods Document:
# Owensboro Health Regional Hospital
West Virginia University

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**Overview of CSI:** This investigation was conducted as part of the Landscape Architecture Foundation's 2017 *Case Study Investigation* (CSI) program. CSI matches faculty-student research teams with design practitioners to document the benefits of exemplary high-performing landscape projects. Teams develop methods to quantify environmental, economic and social benefits and produce Case Study Briefs for LAF's Landscape Performance Series.

The full case study can be found at:
https://landscapeperformance.org/case-study-briefs/owensboro-hospital

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Diagram 1: Owensboro Health Regional Hospital Site Plan (Image Source: HGA Architects and Engineers)

# Environmental Benefits

An extensive stormwater management plan has been put in place at Owensboro Health Regional Hospital, as outlined in its Natural Resource Management Plan. Stormwater runoff from all parking lots and roadways are collected in either curbless parking lot islands that serve as rain gardens or guttered roadside drains and diverted into a 15-acre system of retention ponds. From roadside drains, the water travels through an underground stormwater system before being discharged down a concrete culvert. Between the end of the concrete waterway and the pond waterline is a strip of native grass and other vegetation that will go in and out of the water's edge as water levels rise and fall. These plants serve as a water break and filter before allowing the water into the ponds. All building runoff is drained into the "Healing Pond" immediately behind the hospital. This pond also serves as an irrigation reservoir to reduce the consumption of potable water.

The system of ponds is made up of 8 retention ponds that vary in size. All of the retention ponds are interconnected through a system of pipes that allows the water levels to rise and fall together as the weather and seasons change. On the southeast corner of the site a detention area has been built to catch overflow from the retention ponds in the case of a flash flood. The detention pond also serves as a settling area for sediment that is suspended in the water to prevent downstream contamination.

Slopes and banks along all water bodies are grassy with the majority of them being planted with tall native grass. The grass helps to not only to filter the water but will hold pond and creek banks intact, preventing erosion. Additionally, the native/naturalized areas slow water runoff and prevent much of the stormwater runoff from entering a storm drain. When runoff does enter drains, it will then be directed into one of the onsite retention ponds.

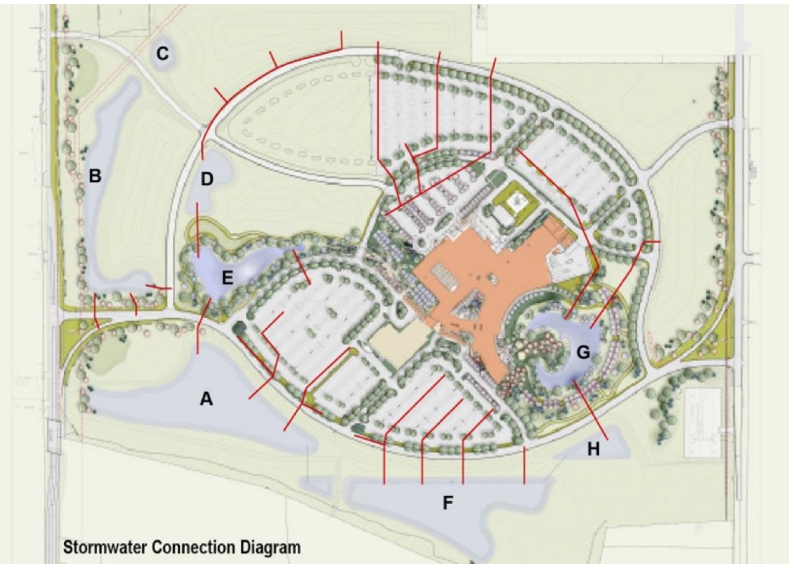


Diagram 2: Owensboro Health Regional Hospital Stormwater Connection Diagram (HGA Architects and Engineers)

● **Manages 83% of stormwater onsite annually, or 177,016,500 gallons, equivalent to 268 Olympic-sized swimming pools.**

Reduces the site runoff by approximately 33% for a 50-year storm event as compared to a conventional scenario. Reduces annual runoff by 25.59 inches, reduces days per year with runoff by 54 days, and retains 75 more wet days as compared to a conventional scenario. The various LIDs onsite also reduce annual stormwater runoff by 48% as compared to a conventional scenario. The maximum rainfall retained by the current scenario is 3.7 inches more than a conventional scenario.

**Method:**

Using EPA's National Stormwater Calculator (1.2.0.0 Beta MSI version), two site development scenarios are estimated. The current scenario is based on the current site design with LID practices, including retention ponds, a rain garden, street planters and infiltration islands on the parking lot, courtyards and gardens, and a green roof. The conventional scenario is a site design with 70% impervious materials and 30% green spaces. Parameters needed for the calculations are listed in the following tables.

Current Scenario - Land Cover

| **Land Cover** | | **Percentage (%)** |
|---|---|---|
| Building | | 3 |
| Vehicle Use | | 20 |
| Other Paving | | 10 |
| **Total Impervious Areas** | | **33** |
| Wetland/Infiltration Basin | | 10 |
| Other landscaped Area | Street Planter | 2.9 |
| | Green Roof | 0.1 |
| | Rain Garden | 1.4 |
| | Meadow | 36 |
| | Lawn | 16.6 |
| **Total Pervious Areas** | | **67** |
| **Site Total** | | **100** |

As for the parameters for the calculator:

| **Land Cover** | **Percentage (%)** |
|---|---|
| Meadow | 10 |
| Lawn | 57 |
| Desert | 0 |
| Impervious | 33 |

Current Scenario - LID Controls

| **LID Practice** | **What % of your site's impervious area will be treated by the following LID practices? (%)** | **Capture Ratio of the LID Practice (%)** |
|---|---|---|
| 1. Rain Garden | 12 | 35 |
| 1. Green Roof | 5 | N/A |
| 2. Street Planters | 12 | 72.5 |
| 3. Retention Ponds | 71 | 14 |

1. Around 50% of the building areas will be treated by the green roofs. Therefore, 0.5*3/33 = 5% of the site will be treated by the green roofs.

2. Around 20% of the vehicle use areas will be treated by the rain garden. Therefore, 0.2*20/33 = 12% of the site will be treated by the rain garden. Capture Ratio of the Rain Garden = Area of the LID/Treated Impervious Areas = 1.4/(0.2*20) = 35%

3. Around 20% of the vehicle use areas will be treated by the street planters. Therefore, 0.2*20/33 = 12% of the site will be treated by street planters. Capture Ratio of the Street Planter = Area of the LID/Treated Impervious Areas = 2.9/(0.2*20) = 72.5%

4. The retention ponds will treat the rest of the impervious areas: 100%-12%-5 -12% = 71%. Capture Ratio of the Retention Ponds = Area of the LID/Treated Impervious Areas = 10/71 = 14%.

The baseline scenario is estimated according to a conventional site development with 70% of the land covered with impervious materials:

Baseline Scenario – Land Cover

| **Land Cover** | **Percentage (%)** |
|---|---|
| Total Impervious Areas | 70 |
| Total Pervious Areas (Meadow) | 30 |
| Site Total | 100 |

Calculation results are illustrated with charts and analyzed as following:

| Statistic | Current Scenario | Baseline Scenario |
|---|---|---|
| Average Annual Rainfall (inches) | 47.88 | 47.88 |
| Average Annual Runoff (inches) | 8.21 | 31.11 |
| Days per Year With Rainfall | 75.96 | 75.86 |
| Days per Year with Runoff | 13.09 | 59.07 |
| Percent of Wet Days Retained | 82.76 | 22.13 |
| Smallest Rainfall w/ Runoff (inches) | 0.37 | 0.11 |
| Largest Rainfall w/o Runoff (inches) | 1.30 | 0.27 |
| Max. Rainfall Retained (inches) | 2.39 | 0.97 |

Table 4: Stormwater Performance Comparison between Current and Baseline Scenario

Amount of annual rainfall managed on site in gallons = (Average annual rainfall – Average annual runoff) * Area of the site * Conversions

Therefore,

Reduced annual stormwater runoff in gallons = (47.88 inches – 8.21 inches) * 0.083 in/ft * 165 acres * 43,560 sf/acre * 7.48 liquid gallon/cu.ft. = 177,016,482.3 gallons

An Olympic-size pool measures 50 meters long and 25 meters wide, and minimum 2 meters deep. Therefore, an Olympic-size pool holds 660,430 gallons of water. Therefore,

177,016,482.3 gallons / 660,430 gallons = 268 Olympic-size pools

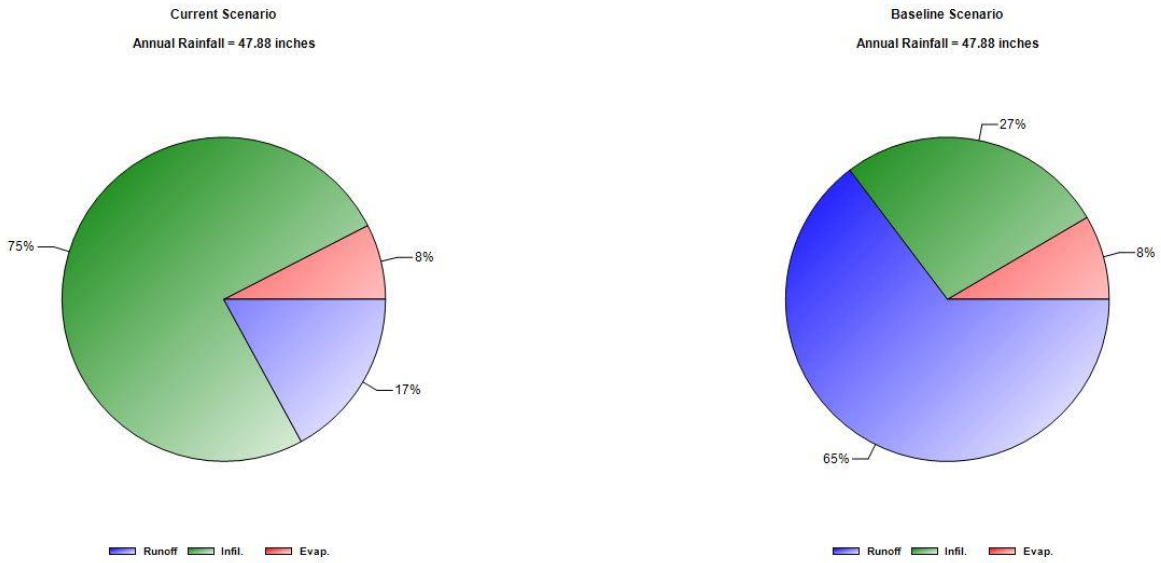


Chart 1: Stormwater Performance Comparison between Current and Baseline Scenario

Managed stormwater runoff annually onsite in the current scenario is: 75% (infiltration) + 8% (evaporation) = 83%

Managed stormwater runoff annually onsite in a conventional scenario is: 27% (infiltration) + 8% (evaporation) = 35%

Reduced stormwater runoff annually compared to a conventional scenario = 83% -35% = 48%

**Extreme Events:**

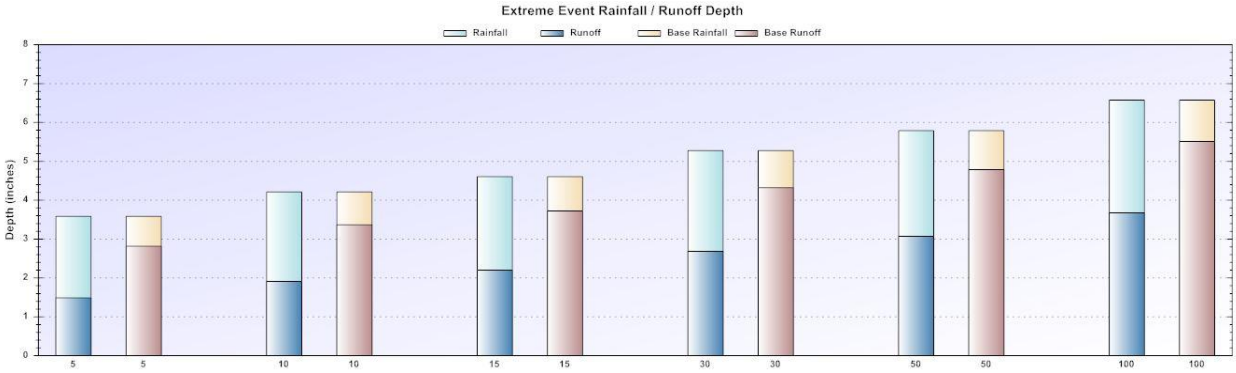


Diagram 3: Extreme Storm Event and the Comparison between Current and the Baseline Scenario

For a 50-year return period, the max daily rainfall depth for both the current scenario and baseline scenario is 5.8 inches. For the current scenario, the stormwater runoff depth is 3.1 inches max per day. For the baseline scenario, the stormwater runoff depth is 4.6 inches max per day. Therefore,

(4.6 inches – 3.1 inches)/4.6 inches = 33%

**Limitations:**

To conduct calculations using EPA National Stormwater Calculator the proportions of the landcover types on the site are necessary. Because of information limitations, the areas of various landcovers were traced and measured using AutoCAD based on the construction documents provided by the design firm, hence, human errors were inevitable, which presents a limitation to this part of the calculations. Another limitation is that the Land Cover menu at EPA National Stormwater Calculator does not include a section for water areas/ponds, which could not reflect the most precise landcover portions.

● **Provides habitat for 33 bird species and 11 mammal species as observed by natural environment management experts. 25 of these were not observed when the site was an agricultural field.**

**Methods:**

This information was provided by HGA Architects and Engineers. The newly observed wildlife species are documented as following:


Diagram 4: Owensboro Site Wildlife Species

**● Sequesters approximately 35,260 lbs of atmospheric carbon annually in over 35,000 newly-planted trees. The tree canopies also intercept 376,000 gallons of stormwater runoff annually.**

**Methods:**

Calculations of stormwater intercepted and atmospheric carbon sequestered in the newly planted tree canopy for major landscape areas were conducted using i-Tree Design v6.01, based on the Plant Materials Schedule provided by HGA Architects and Engineers, as demonstrated in the following tables:

**L101 AREA 1 Tree Benefits**

| Common Name | Botanical Name | DBH (inches) | Quantity of Trees | Intercepted Stormwater Yearly (gallons) | Total Intercepted Stormwater Yearly (gallons) | Reduced Atmospheric Carbon Dioxide Yearly (CO2) (pounds) | Total Reduced CO2 Yearly (pounds) |
|---|---|---|---|---|---|---|---|
| **Large Deciduous Overstory** | | | | | | | |
| Red Maple | *Acer rubrum* | 6 | 7 | 958 | 6706 | 133 | 931 |
| Sugar Maple | *Acer saccharum* | 6 | 5 | 1193 | 5965 | 66 | 330 |
| Bur Oak | *Quercus macrocarpa* | 6 | 6 | 1125 | 6750 | 49 | 294 |
| Red Oak | *Quercus rubra* | 6 | 5 | 1125 | 5625 | 94 | 470 |
| Basswood | *Tilia americana* | 6 | 5 | 668 | 3340 | 57 | 285 |
| Hackberry | *Celtis* | 6 | 5 | 1237 | 6185 | 29 | 145 |
| Honeylocust | *Gleditsia triacanthos* | 6 | 5 | 1177 | 5885 | 134 | 670 |
| **Medium Deciduous Overstory** | | | | | | | |
| River Birch | *Betula nigra* | 4 | 7 | 401 | 2807 | 82 | 574 |
| Linden | *Tilia* | 4 | 7 | 346 | 2422 | 34 | 238 |
| Amur Maple | *Acer ginnala* | 4 | 7 | 472 | 3304 | 62 | 434 |
| **Deciduous Ornamental Shrub** | | | | | | | |
| Flowering Pear | *Pyrus* | 4 | 67 | 397 | 26599 | 57 | 3819 |
| Magnolia | *Magnolia* | 4 | 22 | 497 | 10934 | 60 | 1320 |
| Kwanzan Cherry | *Prunus serrulata* | 4 | 18 | 497 | 8946 | 32 | 576 |
| Crabapple | *Malus* | 4 | 30 | 340 | 10200 | 57 | 1710 |
| **Coniferous Tree** | | | | | | | |
| Pine | *Pinus* | 4 | 16 | 636 | 10176 | 16 | 256 |
| **Coniferous Shrubs** | | | | | | | |
| Gold Lace Juniper | | 4 | 19 | 289 | 5491 | 15 | 285 |
| **Total** | | | | | **121,335** | | **12,337** |

Table 1: Owensboro Health Regional Hospital Tree Benefits Calculation I

**L102 AREA 2 Tree Benefits**

| Common Name | Botanical Name | DBH (inches) | Quantity of Trees | Intercepted Stormwater Yearly (gallons) | Total Intercepted Stormwater Yearly (gallons) | Reduced Atmospheric Carbon Dioxide Yearly (CO2) (pounds) | Total Reduced CO2 Yearly (pounds) |
|---|---|---|---|---|---|---|---|
| **Large Deciduous Overstory** | | | | | | | |
| Red Maple | *Acer rubrum* | 6 | 5 | 958 | 11910 | 133 | 665 |
| Sugar Maple | *Acer saccharum* | 6 | 5 | 1193 | 5965 | 66 | 330 |
| Bur Oak | *Quercus macrocarpa* | 6 | 3 | 1125 | 3375 | 49 | 147 |
| Red Oak | *Quercus rubra* | 6 | 3 | 1125 | 3375 | 94 | 282 |
| Basswood | *Tilia americana* | 6 | 5 | 668 | 3340 | 57 | 285 |
| Hackberry | *Celtis* | 6 | 5 | 1237 | 6185 | 29 | 145 |
| Honeylocust | *Gleditsia triacanthos* | 6 | 6 | 1177 | 7062 | 134 | 804 |
| **Medium Deciduous Overstory** | | | | | | | |
| River Birch | *Betula nigra* | 4 | 8 | 401 | 3208 | 82 | 656 |
| Linden | *Tilia* | 4 | 8 | 346 | 2768 | 34 | 272 |
| Amur Maple | *Acer ginnala* | 4 | 6 | 472 | 2832 | 62 | 372 |
| **Small/Medium Deciduous Ornamental** | | | | | | | |
| Clevland Select Pear | *Pyrus calleryana* | 4 | 30 | 397 | 11910 | 57 | 1710 |
| Chanticleer Pear | *Pyrus calleryana* | 4 | 35 | 397 | 13895 | 57 | 1995 |
| Donald Wyman Crabapple | *Malus* | 4 | 20 | 340 | 6800 | 57 | 1140 |
| Autmn Brilliance Serviceberry | *Amelanchier x grandiflora* | 4 | 10 | 497 | 4970 | 17 | 170 |
| Eastern Redbud | *Cercis canadensis* | 4 | 10 | 497 | 4970 | 0 | 0 |
| Daybreak Yoshino Cherry | *Prunus x yedoensis 'Akebono'* | 4 | 10 | 401 | 4010 | 87 | 870 |
| Royal Raindrops Crabapple | *Malus 'JFS-KW5'* | 4 | 8 | 340 | 2720 | 57 | 456 |
| **Coniferous Tree** | | | | | | | |
| Pine | *Pinus* | 4 | 10 | 636 | 6360 | 16 | 160 |
| **Deciduous Ornamental Shrub** | | | | | | | |
| Pussy Willow | *Salix Ddiscolor* | 4 | 10 | 346 | 3460 | 52 | 520 |
| Miss Kim Lilac | *Syringa patula 'miss kim'* | 4 | 15 | 497 | 7455 | 30 | 450 |
| Summersweet Clethra | *Clethra alnifolia* | 4 | 15 | 497 | 7455 | 18 | 270 |
| Sibirica Redtwig Dogwood | *Cornus alba 'sibirica'* | 4 | 24 | 497 | 11928 | 46 | 1104 |
| **Total** | | | | | **135,953** | | **12,803** |

Table 2: Owensboro Health Regional Hospital Tree Benefits Calculation II

**L103 AREA 3 Tree Benefits**

| Common Name | Botanical Name | DBH (inches) | Quantity of Trees | Intercepted Stormwater Yearly (gallons) | Total Intercepted Stormwater Yearly (gallons) | Reduced Atmospheric Carbon Dioxide Yearly (CO2) (pounds) | Total Reduced CO2 Yearly (pounds) |
|---|---|---|---|---|---|---|---|
| **Large Deciduous Overstory** | | | | | | | |
| Red Maple | *Acer rubrum* | 6 | 10 | 958 | 9580 | 133 | 1330 |
| Sugar Maple | *Acer saccharum* | 6 | 11 | 1193 | 13123 | 66 | 726 |
| Bur Oak | *Quercus macrocarpa* | 6 | 4 | 1125 | 4500 | 49 | 196 |
| Red Oak | *Quercus rubra* | 6 | 3 | 1125 | 3375 | 94 | 282 |
| Basswood | *Tilia americana* | 6 | 5 | 668 | 3340 | 57 | 285 |
| Hackberry | *Celtis* | 6 | 5 | 1237 | 6185 | 29 | 145 |
| Honeylocust | *Gleditsia triacanthos* | 6 | 6 | 1177 | 7062 | 134 | 804 |
| **Medium Deciduous Overstory** | | | | | | | |
| River Birch | *Betula nigra* | 4 | 12 | 401 | 4812 | 82 | 984 |
| Linden | *Tilia* | 4 | 15 | 346 | 5190 | 34 | 510 |
| Amur Maple | *Acer ginnala* | 4 | 6 | 472 | 2832 | 62 | 372 |
| **Coniferous Tree** | | | | | | | |
| Virginia Pine | *Pinus virginiana* | 4 | 10 | 636 | 6360 | 38 | 380 |
| Bald Cypress | *Taxomium distichum* | 4 | 14 | 411 | 5754 | 41 | 574 |
| Pyramidal Arborvitae | *Thuja occidentalis 'Pyramidalis'* | 4 | 7 | 411 | 2877 | 41 | 287 |
| Shalimar Cedar | *Cedrus deodra 'Shalimar'* | 4 | 12 | 411 | 4932 | 12 | 144 |
| Eastern White Pine | *Pinus Strobus* | 4 | 6 | 636 | 3816 | 36 | 216 |
| **Deciduous Ornamental Shrub** | | | | | | | |
| Pussy Willow | *Salix Ddiscolor* | 4 | 15 | 346 | 5190 | 52 | 780 |
| Miss Kim Lilac | *Syringa patula 'miss kim'* | 4 | 15 | 497 | 7455 | 30 | 450 |
| Summersweet Clethra | *Clethra alnifolia* | 4 | 15 | 497 | 7455 | 18 | 270 |
| Sibirica Redtwig Dogwood | *Cornus alba 'sibirica'* | 4 | 30 | 497 | 14910 | 46 | 1380 |
| **Total** | | | | | **118,748** | | **10,115** |

Table 3: Owensboro Health Regional Hospital Tree Benefits Calculation III

Total yearly intercepted stormwater runoff by newly planted tree canopies in the above three areas are:

121,335 gallons + 135,953 gallons + 118,748 gallons = 376,036 gallons

Total yearly reduced CO2 by newly planted trees in the above three areas is:

12,337 lbs + 12,803 lbs + 10,115 lbs = 35,255 lbs

**● Reduces atmospheric carbon by 9,060 lbs annually due to sequestration and avoidance provided by the green roofs.**

**Methods:**

*Direct Sequestration of Atmospheric CO2:*

Formula:

total area of practice (SF) *
average annual amount of $CO_2$ sequestered (lbs C/sf)
= annual amount of $CO_2$ sequestered (lbs C)

- The sum of areas of practice for rooftop gardens is 8,700 sf
- The recommended range of grams of $CO_2$ sequestered per square meter from

aboveground biomass, as determined by the averages of the two Michigan State University studies, is 162 g C/$m^2$ to 168 g C/$m^2$ (Getter et al. 2009).

Converting to lbs C/sf from metric units, the range can be defined: 0.0332 lbs C/sf to 0.0344 lbs C/sf

Lower bound: 0.0332 lbs C/SF * 8,700 sf = 288.84 lbs of $CO_2$ per year
Upper bound: 0.0344 lbs C/SF * 8,700 sf = 299.28 lbs of $CO_2$ per year

The 8,700-sf extensive green roof sequester between about 288.84 and 299.28 lbs of $CO_2$ annually, or an average of *294.06 lbs* of $CO_2$ per year

*Total Annual Indirect Benefit*

Benefit from kWh of Electricity Saved

Formula:

total annual electricity saved (kWh) * lbs CO2 / kWh
= lbs annual avoided CO2 emission from practice's electricity savings

- Reduced energy from reduced water treatment

The table below shows how much energy (kWh) is consumed per millions of gallons of water treated by 6 different treatment plant sizes using four different types of treatment methods:

| | Unit Electricity Consumption \| kWh/million gallons | | | |
|---|---|---|---|---|
| Treatment Plant Size million gallons/day | Trickling Filter | Activated Sludge | Advanced Wastewater Treatment | Advanced Wastewater Treatment Nitrification |
| 1 MM gal/day | 1,811 | 2,236 | 2,596 | 2,951 |
| 5 MM gal/day | 978 | 1,369 | 1,573 | 1,926 |
| 10 MM gal/day | 852 | 1,203 | 1,408 | 1,791 |
| 20 MM gal/day | 750 | 1,114 | 1,303 | 1,676 |
| 50 MM gal/day | 687 | 1,051 | 1,216 | 1,588 |
| 100 MM gal/day | 673 | 1,028 | 1,188 | 1,558 |

Table 5: Unit Electricity Energy Consumption per kWh/ million gallons (EPRI 2002)

As calculated in the previous sections, 185,513 gallons of runoff is reduced annually = 0.1855 million gal saved. Because of a lack of information, to achieve a conservative estimation, the 100 MM gal/day treatment plant size for advanced wastewater treatment nitrification was adopted in this calculation. Therefore,

0.1855 million gal * 1,558 kWh/million gal = 289.01 kWh

Thus, the 8,700-sf green roof contributes to an annual electricity savings from reduced water treatment needs of 289.01 kWh.

- Annual building electricity savings is 5381.1 kWh, as calculated by Green Roof Energy Calculator (see Cost Comparison section for details).

Total electricity savings from a 8,700 SF green roof = 5381.1 kWh in building electricity savings + 289.01 kWh in water treatment electricity savings = *5,670.11* kWh annually

Using the U.S. average of 1.33 lbs $CO_2$/kWh, the reduced electricity savings would provide the following indirect climate benefit:

5,670.11 kWh * 1.33 lbs $CO_2$/kWh = 7,541.25 lbs avoided $CO_2$ emissions from reduced electricity annually

Benefit from Btu of Natural Gas Saved

Formula:

total heating natural gas saved (Million Btu) *
lbs $CO_2$ /Million Btu
= lbs of avoided CO2 emissions annually from heating natural gas savings

Note that the previous equation relies on the $CO_2$ emissions factor of 116.89 lbs $CO_2$/Million Btu of natural gas (i.e. the number of lbs of $CO_2$ released per million Btu) (US EPA 2009).

- Reduced gas use of the rooftop garden is 37.5 Therms as calculated by Green Roof Energy Calculator, therefore 3,749,105 Btu per 8,700 sf area, which equals 3.749105 million Btu

Using the CO2 emissions factor above of 116.89 lbs CO2/Million Btu, the reduced natural gas savings would provide the following indirect climate benefit:

3.749105 Million Btu * 116.89 lbs CO2/Million Btu = *438.23* lbs avoided CO2 emissions from reduced natural gas annually

Total Benefit from Electricity and Heating Natural Savings

Formula:

lbs avoided $CO_2$ emissions from electricity savings
+ lbs avoided $CO_2$ emissions from heating natural gas savings
= total lbs avoided $CO_2$ emissions from electricity and heating natural gas savings annually

Therefore,

7,541.25 lbs CO2 + 438.23 lbs CO2 = *7,979.48* lbs avoided CO2 emissions from reduced building cooling and heating and reduced water treatment energy use annually

*Annual Direct Carbon Sequestration Benefit in CO2 Equivalent*

As previously calculated the green roof sequestered between 288.84 and 299.28 lbs of $CO_2$ annually. An average of 294.06 lbs of $CO_2$ is used in the following calculation.

To convert lbs of $CO_2$ sequestered into lbs of $CO_2$ equivalent, a formula will be used:

total lbs $CO_2$ sequestered (lbs C) * 3.67 lbs $CO_2$/lb C
= total annual equivalent sequestration benefit (lbs $CO_2$)

Therefore,

294.06 lbs * 3.67 lbs $CO_2$/lb C = *1,079.20* lbs $CO_2$ in total annual sequestration benefit

*Total annual climate benefit (Direct + Indirect)*

This green roof had the indirect benefit of avoiding *7,979.48* lbs of $CO_2$ emissions from reduced energy use.

To obtain total annual climate benefit, formula will be used:

Sum of total equivalent sequestration benefit (lbs $CO_2$) +
total avoided $CO_2$ emissions (lbs $CO_2$)
= total annual climate benefit (lbs $CO_2$)

Therefore,

1,079.20 lbs $CO_2$ + 7,979.48 lbs $CO_2$ = 9,058.68 lbs CO2 in total annual climate benefits

**Limitations:**

Climate benefits were estimated in a conservative manner because of insufficient information and a lack of up-to-date parameters for above calculations.

# Social Benefits

**● Increases visual engagement with nature and wildlife from patient room windows in an estimated 90% of the patient population as reported by interviewed nurses.**

**● Increases staff satisfaction and sense of pride about their job and work environment in 100% of interviewed staff members, who described the campus environment as "peaceful" and "beautiful".**

Additional Social Benefits:

● Provides opportunities for staff to take a break in a garden, which could help reduce their work-related stress and improve their mood status, as reported by focus group participants.

● Provides rehabilitation opportunities for patients as described by interviewed nurses, as well as exercise opportunities for visitors, hospital employees, and local community residents through the wellness trail system and exercise equipment on campus as reported by the majority of the focus group participants.

● Facilitates social cohesion for local communities through wellness programs and design features on campus, as agreed upon by all interviewed participants.

**Methods:**

Two focus group interviews were conducted onsite to study the participants' usage, opinions and attitudes about the design of the landscapes. The focus group discussion was structured following a list of predetermined questions, as attached in the Appendix. In total 11 participants attended two focus group studies. The demographic information of participants are demonstrated in Table 10. Social benefits results of the Owensboro Hospital gardens were obtained through thematic analysis of: 1) narrative data collected through two hospital staff focus group interviews and 2) notes collected by behavioral mapping analysis of three most used hospital gardens.

| Age Group | Number |
|---|---|
| 18-29 years old | 1 |
| 30-49 years old | 1 |
| 50-64 years old | 6 |
| Above 65 years old | 3 |

| Age Group | Number |
|---|---|
| Female | 7 |
| Male | 4 |

| Professional Background | Number |
|---|---|
| Nurse | 1 |
| Physical Therapist | 1 |
| Courier | 1 |
| Hospital Volunteer | 2 |
| Administrator/Manager | 1 |
| Social Worker | 1 |
| Human Resource | 1 |
| Ground Keeper | 2 |
| Mechanical Maintenance | 1 |

Table 10: Demographic information of focus group participants at Owensboro Health Regional Hospital

Through content analysis of the focus group transcript, a total of 399 codes were identified that fall into 4 types of topics, including (1) general descriptive topics, (2) overall usage preference and attitude, (3) user behaviors and activities, and (4) domains of garden restorativeness and design features. Each topic covers several sub-topics. Details and frequencies of discussion are listed in Table 11 and Diagram 5.

| Topic Type | Sub-Topic | Number of Codes | Frequency of Discussion | Frequency of Discussion Sum |
|---|---|---|---|---|
| General Descriptive | Site and Location | 39 | 10% | 10% |
| | Users | 48 | 12% | 12% |
| Overall Usage Preference and Attitude | Positive Perception/Attitude | 36 | 9% | 16% |
| | Negative Perception/Attitude | 26 | 7% | |

| | | | | |
|---|---|---|---|---|
| User Behaviors and Activities | Existing Behaviors/Activities | 22 | 6% | 9% |
| | Desired Behaviors/Activities | 12 | 3% | |
| Domains of Garden Restorativeness and Design Features | Access and Visibility | 31 | 8% | 53% |
| | Nature Engagement | 93 | 23% | |
| | Path and Paving | 13 | 3% | |
| | Places to Rest | 12 | 3% | |
| | Sense of "Being Away" | 8 | 2% | |
| | Aesthetics and Maintenance | 49 | 12% | |
| | Other Desired Features | 8 | 2% | |
| | Sustainable Design | 2 | 0% | |

Table 11: Focus Group Transcript Content Analysis: Frequency Analysis

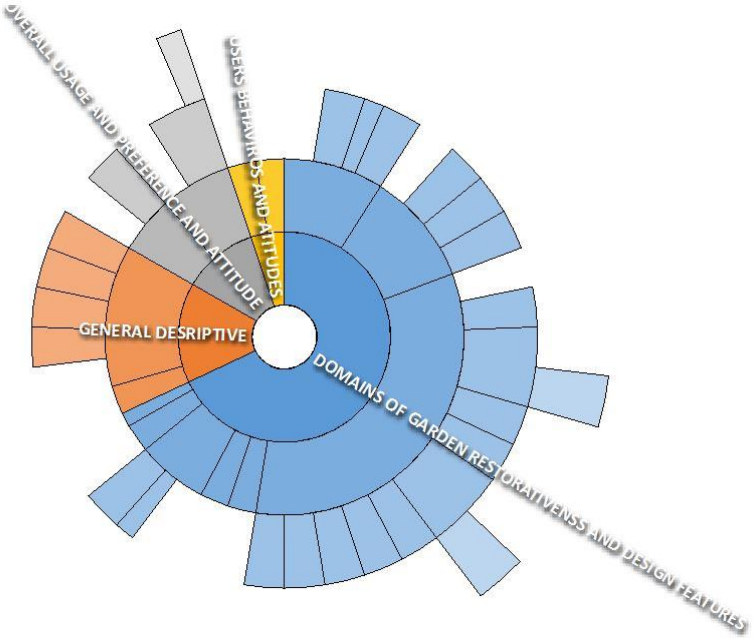


Diagram 5: Focus Group Transcript Content Analysis: Data Visualization

*Visual and Experiential Quality*

The most prevailing topic was the extraordinary visual and experiential quality of the overall landscape design on campus by various users. The landscape environments increase staff job satisfaction, and all interviewed participants expressed a sense of pride working in this facility because of all the appraisals they frequently receive from patients, families and visitors:

> "I hear so many compliments about how pretty this facility is, how lucky we are and how beautiful the grounds are. So you know, for me it is the sense of pride working in it. I think that helps you to be a better employee."

Participants described that having opportunities to temporarily get away and take a break in a garden space could help reduce their work-related stress and improve their mood status:

> "It is the space to get away, peaceful, it is calming you know, it is beautiful... I think that helps definitely to recharge and go back to the situation where you were. And hopefully if you deal with patients, your situation is much easier, after you have that experience."

Approximately 90% of the patients enjoy looking at nature from windows in patient rooms as reported by the focus group. Patients enjoy the extraordinary views, watching the wildlife from their rooms and from the outside seating areas. The feeling of comfort and peace for the patients is often provided by engagement in those activities, by watching and enjoying outdoor scenery:

> "It is just, you know, they feel private in this hospital, and sense of peace when they go outside and look out the windows. Sense of comfort for our patients. And I would say probably at least 90% of them have had comments about what they see from their window. Some of the patients ask to sit by the window so they can watch this whole drama playing out with the geese, and the ducks and the babies."

*Native Plants and Wildlife*

Another significant discussion topic is the great variety of flora and fauna and wildlife species that thrive on this site. Owensboro Hospital landscape was designed to create around 85 acres of prairie and grassland habitat. Themes of the variety of animal species on the site are mentioned in total 25 times through interviews, with 9% transcript coverage of focus group 1 and 14% coverage of focus group 2. The conversations focused on bird-watching and geese that nest on campus (specifically around the pedestrian bridge at the Dry River Garden) during the reproductive season.

Regarding sustainability and low maintenance design topics, we identified wildly varying attitudes about the appearances of native plant palettes on site. Some participants highly praised the native grassland and wildflowers, and the overall sense of "escaping" and peace those plant materials created on site.

However, there also exists a portion of the local population that prefers "the golf course" appearance, and these attitudes resulted in different maintenance strategies against the initial design intents at certain areas. The majority of the focus group participants stressed that the public needs education about sustainable design.

> "I am not sure everybody understands our grassland exterior. So lots of times they think that they are just letting the grass become overgrown. And that is not the situation. So I would know is there a way to, you know, like to put up the sign... I know you cannot just put all the details or something for somebody who drives by. But I hear that comment: Why are they letting the grass

grow? That is not, it's not what is happened, because it is grassland area and you do not want anything to be there…"

*Wellness Programs and Design Features*

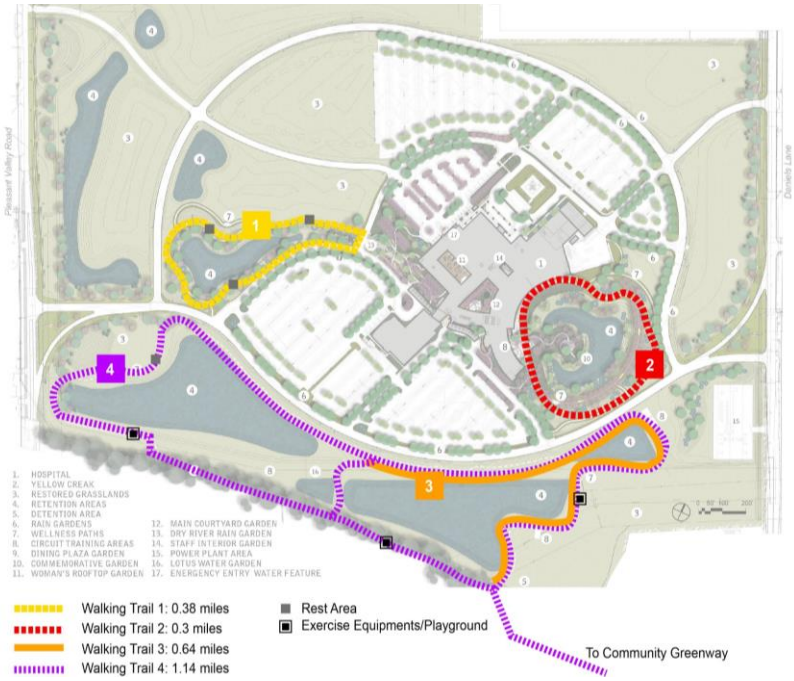


Diagram 6: Wellness Walking Trail System at Owensboro Health Regional Hospital

Based on the content analysis and frequency analysis of discussion topics, the hospital staff uses various gardens and walking trails the most, mentioned 20 total times during the focus group discussions. The 1.82-mile trail system is an essential wellness program onsite that promotes green exercises among staff members and local community residents, as shown on Diagram 6. Site observations and behavior mapping reflected similar results. Staff members usually use their break time to stretch their legs, walking up and down the small trails (Walking Trail 1 in Dry River Garden) which is the closest to the hospital, considering the limited break time. The ground maintenance employees confirmed this based on their everyday observations:

> "I think it is a good thing, you can see lots of staff outside. As soon as the weather is good everybody is outside. They all want to be there."

> "I see a lot the same staff members who walk on the farthest part of large walking trail, they sit on those benches by themselves, they would take their lunch break out, just quiet, and they walk back in. It is almost every day when the weather is good."

Many staff members found that having places not only to look at from interiors, and to sit and rest outside, but also areas that they can use to improve their wellness is the most beneficial part of the campus design:

> "The wellness element that is not only for visitors, for patients that they can get out, but for employees too. I just love that peace of it, there is like pieces of exercise equipment, there are on some of the trails, and that to me is such a gift for employees. When I come up for meetings, I have been recharged."

In contrast to other hospitals observed in this study, the medical team at Owensboro uses different areas of the grounds for patients' rehabilitation activities whenever the weather allows, and nursing staff is always open to new suggestions on how to improve and accelerate recovery process for patients by using the exterior areas. The hospital landscape provides many areas for walking with different types of physical challenges: ramps, stairs, concrete, gravel, etc. Care providers believe that the patients need "real" outside conditions in order to recuperate after the operation or injury. Furthermore, for disabled patients, exterior of the hospital represents a "safe environment," a neutral zone where they can work with their therapist and prepare for the life outside the hospital:

> "And once they cannot walk you are in the sense of pressure, you have community sidewalk, and if they are going to be in wheelchair they are going to have to use that. So that is an opportunity to practice in a safe environment with a therapist. It gives them an opportunity to gain confidence even the fact that they count on another people who are not patients, I think is good, because they... many times people, when they have a stroke, for some reason they feel embarrassed."

The community members are also using the trails for different types of activities on an everyday basis: walking, biking, running, walking with babies, and so on. The hospital provides convenient and free parking spaces to the local community, and the campus will be strategically linked to the local green belt project as part of a larger greenway system. The "big trails" (Walking Trails 3 and 4) are equipped with exercise and seating equipment. As interview participants commented, those trails would be better used by hospital residents if properly signed, for more people to know of their existence. The hospital also organizes multiple community activities on their grounds, such as 5k runs, wellness days, Easter Egg Hunt, farmers' market, rehab picnics, and so on. All interviewed participants stated that the wellness programs and design features on campus facilitate social binding for local communities.

> "I am on the ground out there, so I see things… I see lots of people using the trail, on a schedule. So there are lots of people that are living close here that come with the vehicle and park on the parking lot and they would come here every day and ride the bikes, walk the dogs, let the kids play in the playground."

Overall, 100% of interviewed participants expressed positive attitudes about the campus landscape design, one quote expressed:

> "I would say the area that you look at it right there is my favorite spot with a wild grass and wild flowers and the ducks and the geese and lakes and... Just coming in...You know, everybody that comes in this hospital, with that view, especially the people who are not from this area, they are coming in from (some) county, southern Indiana, talk about how beautiful landscape here is and

how beautiful the hospital is. That is the thing that I hear more than anything: this is a really beautiful campus."

*Location Matters*

For all garden areas on campus, the majority of participants agree that they are aesthetically pleasurable places. However, beyond being used for viewing purposes, those gardens are not much used physically except for having lunch, which is a short period of time (about 2-3 hours around noon) during the day. Behavioral mapping that we conducted confirms that. There are complicated reasons behind this, such as safety and administrative regulations for patients and short break times for staff to travel long distances to the exterior. We found that the location of the garden matters the overall usage (see Diagram 7-9). Among the four garden spaces studied at Owensboro Health Regional Hospital, the dining garden is the mostly used for comparatively longer period (e.g., for a lunch outside) by staff and visitors. The Dry River Garden is frequently used by patients or visitors who arrive and depart the facility and wait there for being picked up for a short period of time. The central courtyard is only used occasionally by a small group of people for a meal because it's a fairly small space and can easily get crowded. One participant in the focus group described a "fishbowl" feeling when she sat in the garden and felt like being stared by people inside the building. The rooftop garden is only used for providing views and natural light to patient rooms but has no physical access because of safety considerations.

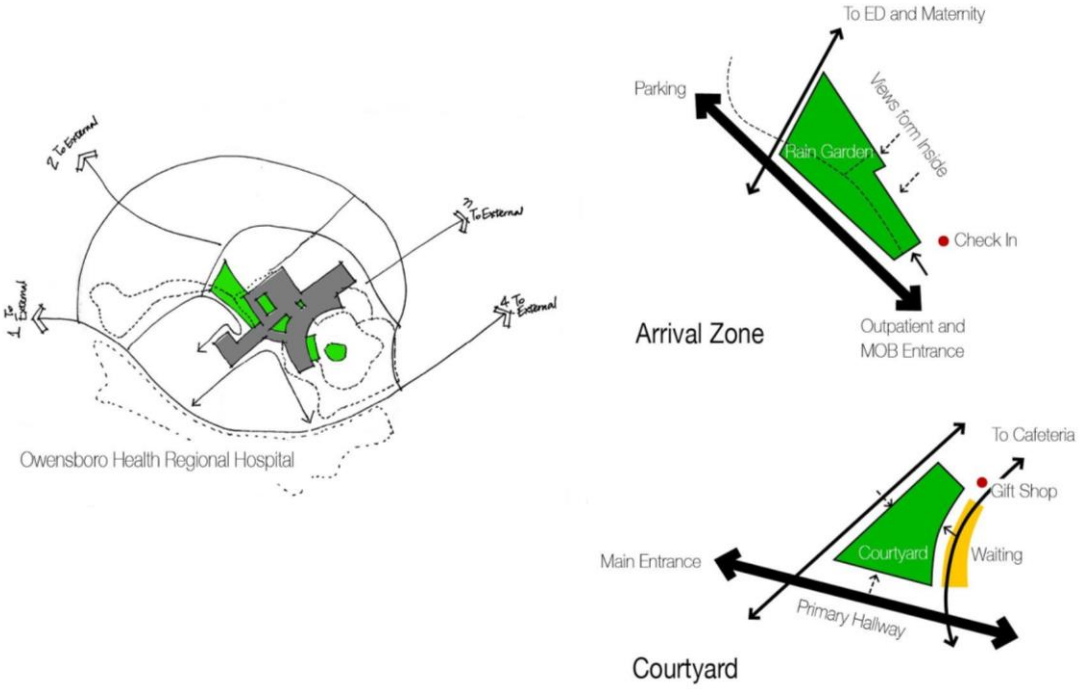


Diagram 7: Owensboro Health Regional Hospital Garden Location Analysis I

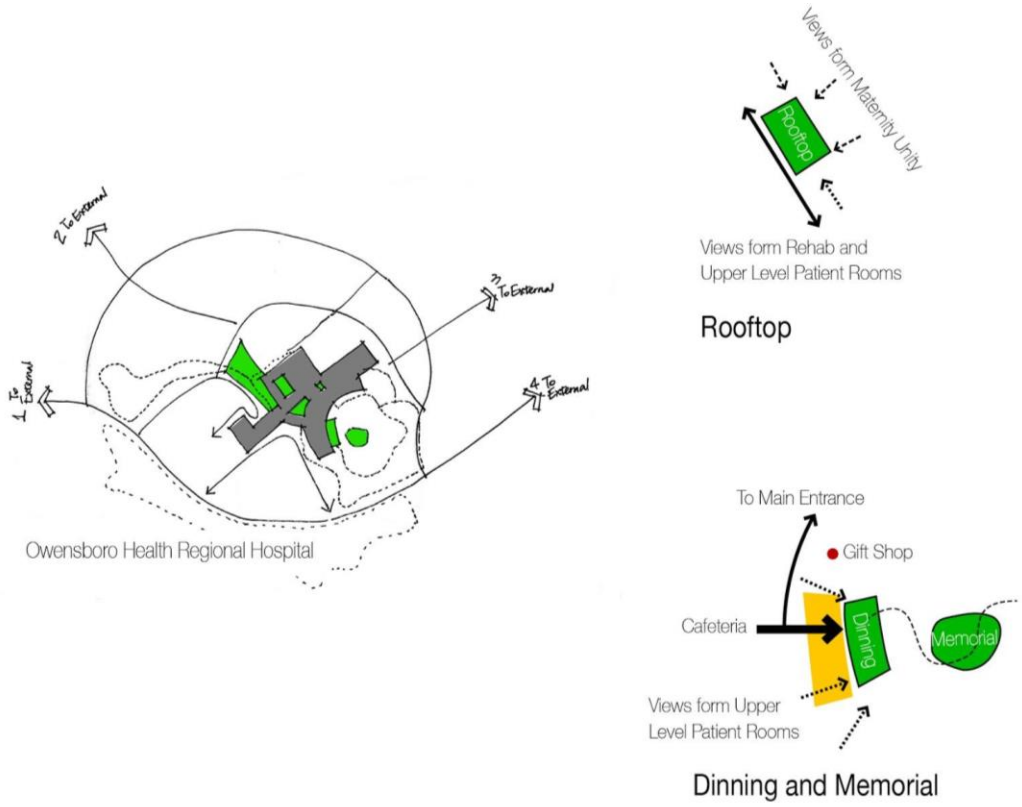


Diagram 8: Owensboro Health Regional Hospital Garden Location Analysis II

**● Provides a significant level of restorativeness for hospital patients and staff, achieving a GATE rating of 7.3 for the Dining Plaza and Commemorative Garden, 8.3 for the Main Courtyard, and 7.3 for the Dry River Rain Garden, based on a 1-10 scale.**

**● Encourages users' engagement with nature, achieving a GATE rating of 9.5 for the Dining Plaza and Commemorative Garden, 9.3 for the Main Courtyard, and 9.0 for the Dry River Garden, based on a 1-10 scale.**

**● Creates a sense of "being away" in the main garden spaces, achieving a GATE score of 8.5 for the Dining Plaza and Commemorative Garden, and 8.5 for the Main Courtyard, based on a 1-10 scale.**

**Methods:**

Three landscape areas were evaluated using the Garden Assessment Tool for Evaluators (GATE) (Sachs, Cooper Marcus & Barnes, 2016), including (1) Dining Plaza and Commemorative Garden, (2) Main Courtyard, and (3) Dry River Garden. There are five domains that measures the level of restorativeness of

the given space, including (1) Access and Visibility, (2) Sense of "Being Away", (3) Nature Engagement, (4) Walking and Activities, and (5) Places to Rest.

Two evaluators conducted evaluations on-site using an individual scale for each of the mentioned gardens. Mean scores for each domain were calculated. Background information for the evaluation activities, as well as evaluators, is shown in Table 6. Within each domain there are sub-domains that cover multiple design variables. Scoring details of the sub-domains are demonstrated in the following tables. The overall restorativeness score for each of the areas was calculated, as indicated by the "Actual GATE Score".

| **Name of Facility and Location** | **Type of Facility or Patients Served** | | **Evaluated Gardens in the Facility** | **Evaluation Date** | **Weather** |
|---|---|---|---|---|---|
| Owensboro Health Regional Hospital, Owensboro KY | General Acute Care | | (1) Dining Plaza and Commemorative Garden<br>(2) Main Courtyard<br>(3) Dry River Garden | 06/22/2017 | Cloudy to Light Rain |
| **Name of Garden** | **Location and Type of Garden** | **Evaluator** | **Role of Evaluator** | **Evaluation Time** | **Temperature (F)** |
| (1) Dining Plaza and Commemorative Garden | By Cafeteria | A | Researcher | 4:50 PM | 73 |
| | | B | Architect and PhD Student | 4:10 PM | 73 |
| (2) Main Courtyard | Courtyard near MOB Entrance | A | Researcher | 8:45 AM | 77 |
| | | B | Architect and PhD Student | 4:40 PM | 73 |
| (3) Dry River Garden | MOB Front Entrance | A | Researcher | 4:27 PM | 73 |
| | | B | Architect and PhD Student | 5:15 PM | 73 |

Table 6: Site Background and Evaluator Information

Complete evaluation scores using Garden Assessment Tool for Evaluators (GATE) toolkit for all garden areas are listed as below.

## Garden Assessment Tool for Evaluators (GATE) Results

Owensboro Health Regional Hospital, Owensboro, KY – Dining Plaza and Commemorative Garden
Total Max: 344  Total Actual: 250.5  Percentile: 73%
Intuitive Restorativeness Score:  9
Actual GATE score (converted to a 1-10 scale): 7.3

| Domain 1 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Access & Visibility | Visual Access to the Garden | 36 | 26.5 | 74% | 51.5 | 72% |
| | Physical Access to the Garden | 36 | 25 | 69% | | |

| Domain 2 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Sense of "Being Away" | Sense of "Being Away" | 20 | 16.5 | 82.5% | 41 | 69% |
| | Aesthetics & Maintenance | 28 | 24.5 | 87.5% | | |

| Domain 3 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Nature Engagement | Plantings | 40 | 37 | 92.5% | 64.5 | 95% |
| | Other Natural Features (e.g., water features) | 28 | 27.5 | 98% | | |

| Domain 4 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Walking & Activities | Primary Walkway (Path or Paved Thoroughfare) | 24 | 19 | 79% | 65 | 86% |
| | All Paved Areas | 16 | 15.5 | 97% | | |
| | Lighting, Wayfinding, & Amenities | 20 | 17 | 85% | | |
| | Variety & Activities | 16 | 13.5 | 84% | | |

| Domain 5 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Places to Rest | Seating Availability & Type | 20 | 19.5 | 97.5% | 76.5 | 96% |
| | Private or Social | 20 | 20 | 100% | | |
| | Aesthetics & Sun | 20 | 17 | 85% | | |
| | Tables | 20 | 20 | 100% | | |

Table 7: GATE Score of Dining Plaza and Commemorative Garden

## Garden Assessment Tool for Evaluators (GATE) Results

Owensboro Health Regional Hospital, Owensboro, KY – Main Courtyard
Total Max: 344 Total Actual: 284 Percentile: 83%
Intuitive Restorativeness Score: 9.5
Actual GATE score (converted to a 1-10 scale): 8.3

| Domain 1 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Access & Visibility | Visual Access to the Garden | 36 | 26.5 | 74% | 48 | 67% |
| | Physical Access to the Garden | 36 | 21.5 | 60% | | |

| Domain 2 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Sense of "Being Away" | Sense of "Being Away" | 20 | 13 | 65% | 41 | 85% |
| | Aesthetics & Maintenance | 28 | 28 | 100% | | |

| Domain 3 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Nature Engagement | Plantings | 40 | 37 | 92.5% | 63.5 | 93% |
| | Other Natural Features (e.g., water features) | 28 | 26.5 | 95% | | |

| Domain 4 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Walking & Activities | Primary Walkway (Path or Paved Thoroughfare) | 24 | 19 | 79% | 57.5 | 76% |
| | All Paved Areas | 16 | 14.5 | 91% | | |
| | Lighting, Wayfinding, & Amenities | 20 | 15.5 | 77.5% | | |
| | Variety & Activities | 16 | 8.5 | 53% | | |

| Domain 5 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Places to Rest | Seating Availability & Type | 20 | 18.5 | 92.5% | 74 | 92.5% |
| | Private or Social | 20 | 17 | 85% | | |
| | Aesthetics & Sun | 20 | 18.5 | 92.5% | | |
| | Tables | 20 | 20 | 100% | | |

Table 8: GATE Score of Main Courtyard

## Garden Assessment Tool for Evaluators (GATE) Results

Owensboro Health Regional Hospital, Owensboro, KY – MOB Entry Rain Garden
Total Max: 344 Total Actual: 250.5 Percentile: 73%
Intuitive Restorativeness Score: 8.5
**Actual GATE score (converted to a 1-10 scale): 7.3**

| Domain 1 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Access & Visibility | Visual Access to the Garden | 36 | 26.5 | 74% | 57.5 | 80% |
| | Physical Access to the Garden | 36 | 31 | 86% | | |

| Domain 2 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Sense of "Being Away" | Sense of "Being Away" | 20 | 12 | 60% | 33 | 48% |
| | Aesthetics & Maintenance | 28 | 21 | 75% | | |

| Domain 3 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Nature Engagement | Plantings | 40 | 36 | 90% | 61.5 | 90% |
| | Other Natural Features (e.g., water features) | 28 | 25.5 | 91% | | |

| Domain 4 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Walking & Activities | Primary Walkway (Path or Paved Thoroughfare) | 24 | 16 | 67% | 58.5 | 77% |
| | All Paved Areas | 16 | 14 | 87.5% | | |
| | Lighting, Wayfinding, & Amenities | 20 | 16.5 | 82.5% | | |
| | Variety & Activities | 16 | 12 | 75% | | |

| Domain 5 | | Max Total | Mean Score | Percentile | Sum | Percentile |
|---|---|---|---|---|---|---|
| Places to Rest | Seating Availability & Type | 20 | 9 | 45% | 40 | 50% |
| | Private or Social | 20 | 14.5 | 72.5% | | |
| | Aesthetics & Sun | 20 | 15.5 | 77.5% | | |
| | Tables | 20 | 1 | 5% | | |

Table 9: GATE Score of Dry River Garden

# Economic Benefits

- Created 10 full-time jobs directly associated with the maintenance of the hospital's exterior, landscape, and grounds. Approximately 1,000 jobs were associated with the whole project construction, 38 of which were directly associated with landscape construction.

**Methods:**

The 10 full-time jobs have been verified by Owensboro Health Regional Hospital administrators.

For the whole project construction jobs, the Regional Industrial Multiplier System II (RIMS II) economic input-output model was used. RIMS II was developed by the Bureau of Economic Analysis (BEA) to estimate the number of jobs associated with the project construction and more specifically, the site and landscape construction.

Construction is a final good, so final demand for the site construction equals the actual construction cost for this portion. The Employment Multiplier is the number of jobs created per million dollars of real final demand, using Kentucky as the final demand region, the multiplier is 10.5 (BEA RIMS II multiplier). Multipliers are based on the 2007 Benchmark Input-Output Table for the Nation and 2015 regional data.

Construction cost for landscape installation of Owensboro Health Regional Hospital was 1.85 million (in 2013 dollars). As reported by Bureau of Labor Statistics, the Consumer Price Indexes for 2007 is 2.8 and for 2013 is 1.45 (Bureau of Labor Statistics Data).

Equation:

$$\text{Total employment} = \text{construction cost as final demand} \div 1{,}000{,}000 \times \text{CPI2007/CPI2013} \times \text{employment multiplier}$$

Therefore,

Total number of jobs associated with the landscape construction = 1.85 * 2.8/1.45 * 10.5 = 37.5

The total jobs created by the whole project construction were estimated by HGA Architects & Engineers.

**Limitations:**

Using the bill-of-goods method is the best approach for estimating impacts because RIMS II multipliers for the construction industry are based on national averages across a wide variety of construction projects. Type I multipliers were employed in the calculation for a conservative estimation because of a lack of detailed information. The estimation is for both the building and the site construction. Knowing the cost for the site and landscape construction would allow a more exact estimation.

# Cost Comparison

**● Irrigation for the sustainable planting palette costs about $34,200 annually, which is about 2/3 less expensive than a conventional design which would cost $102,600.**

According to the EPA, hospitals are typically one of the most significant water consumers in their communities. Owensboro hospital site has been designed in a way that promotes water conservation through xeriscaping and appropriate irrigation management strategies. In this project, approximately 85 acres of the site is covered with grass materials where 2/3 of the turf areas have been planted with drought-tolerant species that require limited or no irrigation (see Diagram 10). Areas close to the building and interior gardens are maintained areas. The healing pond serves as a reservoir and the retained stormwater is saved to irrigate exterior landscapes if required. Drip-line irrigation has been installed in around the building and for interior irrigation. For safety consideration, potable water is used for all interior garden irrigation due to possible patient exposure to these features.


Diagram 10: Owensboro Health Regional Hospital Landscape Maintenance Map

Without the above strategies, the whole site could have been designed in a conventional way that ornamental grass species are planted, such as tall fescue, *Festuca arundinacea*, which is the turfgrass currently planted along all roadsides and in high visibility areas near and around the hospital building. Then, irrigation water demands are compared between the conventional strategy and the sustainable design using the SLIDE (Simplified Landscape Irrigation Demand Estimation) equation as following:

$$\text{Irrigation Demand in Gallons} = ETo * PF * LA * 0.623$$

where,

· *ETo* is inches of historical average or real-time reference evapotranspiration data in inches for the period of interest.
· *PF* is the Plant Factor.
· *LA* is the landscape area, in square feet.
· 0.623 is the factor to convert inches of water to gallons; omit this factor if the estimated water demand is desired in inches.

In Louisville KY area, the estimated yearly total evapotranspiration values according to weather data is 30 inches. Plant factor for tall fescue is 0.8. Then, annual irrigation water demand if the site were designed conventionally is:

30 inches * 0.8 * (85 * 43560 sf) * 0.623 = 55,361,275 gallons

And, annual irrigation water demand using the site's sustainable design strategy is:

55,361,275 gallons * 1/3 = 18,453,758 gallons

According to Owensboro Municipal Utilities, the potable water fee for the site is about $1.39 per 100 cubic feet. The annual cost of irrigation water for conventional design is:

55,361,275 gallons / 7.5 gallons/cu. ft = 7,381,503 cu. ft
7,381,503 cu. ft / 100 * $1.39/cu. ft = $102,602.89

The annual cost of irrigation water for sustainable design is:

18,453,758 gallons / 7.5 gallons/cu. ft = 2,460,501cu. ft
2,460,501cu. ft / 100 * $1.39/cu. ft = $34,200.96

**● The site's green roof saves $430.91 in annual energy costs as compared to a conventional dark roof.**

**Method:**

Green Roof Energy Calculator by Urban Climate Research Center – Arizona State University was adopted for the calculation. The calculation output is as following:

**Annual Energy Savings compared to a Dark Roof (albedo = 0.15)**

| | |
|---|---|
| Electrical Savings: | 5381.1 kWh |
| Gas Savings: | 37.5 Therms |
| Total Energy Cost Savings(1): | $430.91 |

Table 11: Green Roof Energy Saving

Calculator output: You specified an Old Office Building in Louisville, KY with a total roof area of 8700 ft2. The Green Roof you specified for this building has a Growing Media Depth of 5 inches, a Leaf Area Index of 2, covers approximately 93% of the total roof area (the rest being a dark roof), and is irrigated. For reference, the annual whole building electricity consumption for the specified green roof was 472609 kWh and the annual gas consumption of this green roof was 1828 Therms.

Green areas of the rooftop are all covered with ground materials/turfgrass. Due to equipment inadequacy, the team was not able to measure LAI directly onsite. As a result, the value 2 was adopted in the calculation for a conservative estimation.

**Primary References:**

Natural Resource Management Plan Owensboro Regional Health Hospital, provided by HGA Architects and Engineers

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ArchGIS World Evapotranspiration Web Viewer:
http://www.arcgis.com/apps/OnePane/main/index.html?appid=b1a0c03f04994a36b93271b0c39e6c0f

Owensboro Municipal Utilities: https://omu.org/water-rates/

## Appendix

### Owensboro Health Regional Hospital Focus Group Interview Predetermined Questions

**Part 1: Demographic Information**

1. What is your age?
2. What is your gender?
3. What is your role/professional background (nurse, medical officer, etc.)?
4. How many years of experience have you had in this current job?
5. How many years have you worked in this health facility?

**Part 2: Usage of General Green Spaces of the Hospital**

1. Which part of the green spaces on campus and what specific gardens/courtyards do you use the most during staying in the facility, and how do you use them?
2. What are the feelings or emotional status when and after you use the green spaces, try to use some adjectives to describe the feelings?
3. Regarding visibility and accessibility aspects, how do you perceive the green spaces from major indoor areas such as major corridors, waiting areas, dining areas, and patient wards?
4. How do you usually interact with design features in the green spaces, including planting, seats, paving, water feature, sculpture, etc., and have you found any facilitators/barriers to the use of the space?
5. For hospital employee: how do you think the having various green spaces on campus could impact your work performance and satisfaction about the physical environments of your workplace.
6. For family members and hospital visitors: how do you think having various green spaces on campus could impact your satisfaction about the hospitalization environment?
7. Do you have any additional comments about the green spaces on campus?

**Part 3: Usage of Specific Areas**

1. Have you ever noticed or assisted any patients to use any of the green spaces for rehabilitative activities?
2. Are you aware of any environmental benefits of having the Healing Pond on site?
3. Landscape designers adopted native plant palette to lower maintenance needs, which may inevitably result in a wild look of the planting areas. May I know your opinions about the aesthetic aspects of the design?