DOWNTOWN DALLAS

SEPTEMBER 2022

PARKS ANALYSIS

CIVIC GARDEN 2012

PACIFIC PLAZA 2019

WEST END SQUARE 2021

CARPENTER PARK 2022

HARWOOD PARK 2023 ant.

CAPPA COLLEGE OF ARCHITECTURE, PLANNING AND PUBLIC AFFAIRS
THE UNIVERSITY OF TEXAS AT ARLINGTON

DILLON CENTER FOR TEXAS ARCHITECTURE

UTA ENGINEERING

PARKS FOR DOWNTOWN DALLAS

ToC

DOWNTOWN DALLAS PARKS | PUBLIC SPACE DOWNTOWN

Public Space Downtown

Public space, and especially green public space, has always been a rare commodity in downtown Dallas. When Dallas County built its fifth county courthouse in 1890, known today affectionately as "Old Red," it set a pattern that would take more than 75 years to change. The new courthouse was built all the way to the edges of its lot, eliminating the small, fenced courthouse lawn that had surrounded earlier courthouses on the same spot. That decision, to eliminate that small hint of a courthouse square for the city of Dallas, meant that the young downtown was left without any official public space.

Dallas's city halls, like the 1890 courthouse, had no public commons. Other American cities like New York and New Orleans linked a grassy open plaza to their civic buildings but Dallas had no public space connected with its municipal buildings. Public parks were also scarce. The closest park to downtown Dallas was City Park, opened in 1886 and located south of the city's commercial core in the residential neighborhood. Dallas's city cemetery provided open green space at the southwest corner, hemmed in by railroad tracks and an ice factory and cold storage warehouse. Nearby, Ferris Plaza, a small square with a fountain, opened in 1918 to provide open space in front of the city's train terminal, Union Station.

Dallas developed across its first 100 years as a city focused on commerce, manufacturing, and connections to freight and transport, emphasizing private, commercial development of land rather than civic space. Sanborn Maps of Dallas from 1921 show a downtown core of industrial buildings (shown in red representing their masonry construction) surrounded by railroad tracks and wood-frame housing (shown in yellow) in Figure i.1.

"In general appearance Dallas confirms its business activities." –George E. Kessler, A City Plan for Dallas (1911)

While there were early calls to transform Dallas through parks, parkways, and a connection to the Trinity River from consultants like St. Louis based planner George E. Kessler, there was no serious commitment to the creation of public space in downtown Dallas until the 1960s. The Goals for Dallas program led by Mayor Erik Jonsson led directly to the creation of a new city hall designed by I. M. Pei, with a large public civic plaza whose design was managed by local landscape architecture firm Myrick, Newberg, & Dahlberg. While this was a serious commitment to public space, the plaza's potential was curtailed by its isolated location and its vast, unforgiving hardscape surfaces. Other initiatives sparked by the Goals for Dallas program also undermined public space for people and emphasized remaking downtown as a place that facilitated fast travel by car and created a tunnel system that drew people away from outdoor spaces into underground passages between buildings.

By the 1980s, Dallas, like most American cities, had pivoted to new strategies to revive flagging downtowns eviscerated by postwar white flight and rapid suburban growth. An early initiative focused on the revitalization of Main Street, and led to the creation of Pegasus Plaza, which opened in 1994. Redevelopment of office buildings and warehouses into lofts began, and the downtown population began to grow slowly. In 2009, Main Street Garden added to the growing list of small public spaces in downtown.

"In general appearance, Dallas confirms its business activities."

George E. Kessler
A City Plan for Dallas (1911)

Figure i.1 Sanborn Map of Downtown Dallas - 1921

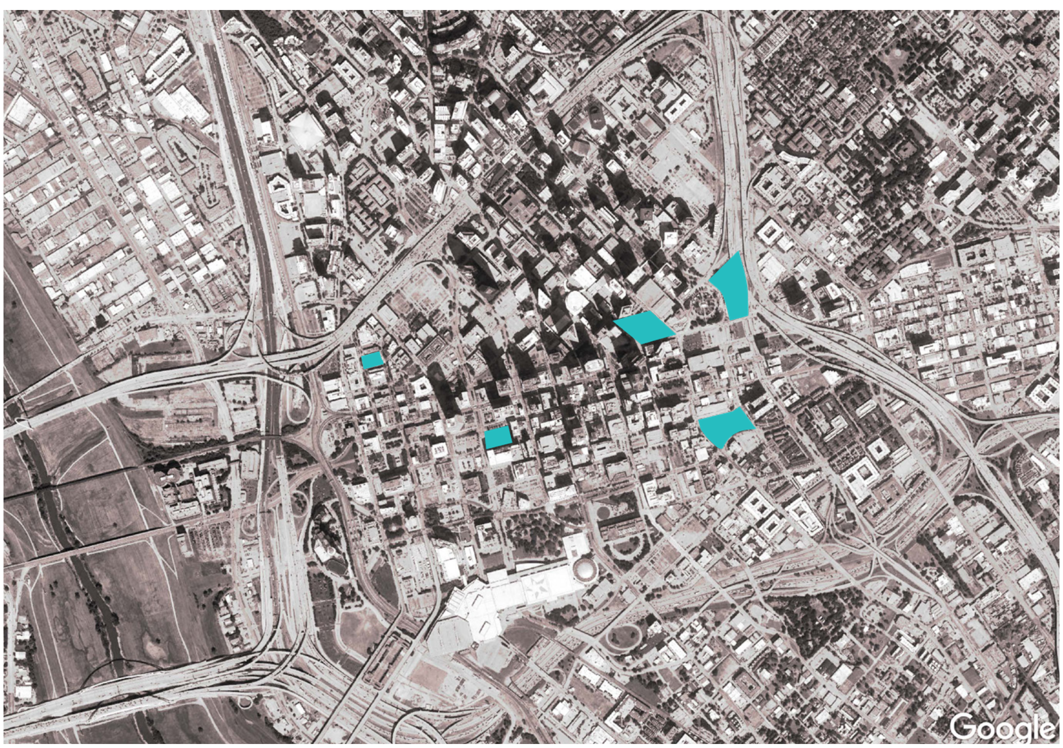

Figure i.2 Map of Downtown Dallas - 2022

"Downtown Dallas still needs big ideas, but it also needs greening and softening and more connective tissue to pull its fragments together." –David Dillon, "Quick Fix Syndrome," Dallas Morning News (2002)

"It has been a difficult and imperfect project, and one that is far from complete, but downtown Dallas is gradually becoming a more hospitable and humane place. The latest sign of that progressive reinvention is the opening, on May 3, of Carpenter Park..." –Mark Lamster, "Downtown Dallas has a Glowing, $20.1 Million New Park with a Landmark Work of Sculpture," Dallas Morning News (2022)

The ambitious program begun by Parks for Downtown Dallas in 2015 to create four new public parks in downtown Dallas is transformative, moving the city more rapidly toward a sustainable downtown that has the capacity to nurture civic life in public space. Guided by the City of Dallas's 2013 Downtown Parks Master Plan, and built with a combination of private and public funds, Pacific Plaza (2019), West End Square (2021), Carpenter Park (2022), and Harwood Park (2023), along with Civic Garden (2012, created by the Foundation's predecessor organization) create more of the "connective tissue" that architecture critic David Dillon identified as missing in his writing about Dallas twenty years ago.

In the following pages, our project team shares our analysis of a variety of benefits brought to Dallas by the Parks for Downtown Dallas program. While details of each analysis can be found in the next pages, we list a few key takeaways here:

The five parks created by Parks for Downtown Dallas contribute to a more sustainable city by diverting excess stormwater runoff, contributing to carbon sequestration, and providing spaces that downtown residents and workers value for relaxation, exercise, and rejuvenation.

Areas for Potential Growth

- Carbon sequestration and air quality can be improved through future maintenance that adds additional trees, with attention paid to species and size
- Stormwater diversion can be increased through future maintenance that considers the possibility of bioswales and green infrastructure
- Future changes to paving and hardscape materials can be guided by evolving standards and criteria for materials with low embodied energy and high recycled content
- Awareness of the parks can be increased through inclusion in tour programs like Urban Armadillos and other means to link these new green spaces to each other and other public spaces downtown

Figure i.3 Downtown Dallas Park Map

"Downtown Dallas still needs big ideas, but it also needs greening and softening and more connective tissue to pull its fragments together."

David Dillion
"Quick Fix Syndrome,"Dallas Morning News (2002)

"It has been a difficult and imperfect project, and one that is far from complete, but downtown Dallas is gradually becoming a more hospitable and humane place. The latest sign of that progressive reinvention is the opening, on May 3, of Carpenter Park..."

Mark Lamster
"Downtown Dallas has a Glowing, $20.1 Million New Park with a Landmark Work of Sculpture," Dallas Morning News (2022)

5
parks
designed & built

1 CIVIC GARDEN
2 PACIFIC PLAZA
3 WEST END SQUARE
4 CARPENTER PARK
5 HARWOOD PARK

DOWNTOWN DALLAS PARKS | ABOUT THE TEAM

Parks for Downtown Dallas
Parks for Downtown Dallas (PfDD) sought to quantify the benefits of four new urban parks, in addition to a previously constructed park, that were recently designed and built in the heart of the City of Dallas. This study identifying the benefits of new green infrastructure will support the foundation's efforts to secure future funding to support park maintenance and development.

Research Team | University of Texas at Arlington
The University of Texas at Arlington (UTA) project team generated a set of prioritized areas of study and proposed methodologies comprising the contents of this report. Faculty members Professor Melanie Sattler (Civil Engineering), Assistant Professor Letora Anderson (Landscape Architecture), and Adjunct Assistant Professor Amanda Aman (Architecture) conducted the research for this study and assembled this report. Two University of Texas at Arlington courses were engaged in the study, involving students from landscape architecture and from civil engineering in data collection and analysis. Professor Kathryn Holliday (Architecture) assisted with continued coordination and communication with Parks for Downtown Dallas. PhD candidate Sally Ayuk conducted GIS spatial analysis, MLA student Patricia Cerda analyzed survey data, and MARCH graduate Cindy Nguyen collected temperature data.

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DOWNTOWN DALLAS PARKS SPECIAL THANKS

Special Thanks
The project team would like to thank the following for their generous assistance during the course of this study.

Parks for Downtown Dallas
Downtown Dallas, Inc.
Hargreaves Jones
SWA Dallas
James Corner Field Operations
Ten Eyck Landscape Architects

1

CIVIC GARDEN

CIVIC GARDEN | CARBON SEQUESTRATION | TREES

Carbon Sequestration | Trees
Carbon sequestration and stormwater runoff avoidance were calculated for the trees on site using i-Tree Eco v6. i-Tree Eco v6 is a software application within a suite of tools that utilizes data to estimate ecosystem services and structural characteristics of rural and urban forests. The application provides sampling and data collection protocols, automated processing, and final reports illustrating carbon sequestration in pounds, carbon storage in pounds, and avoided runoff in cubic feet.

i-Tree's database assigns values for each tree species and size types. The calculation used to determine CO^2 sequestered per tree (kg) = tree mass (kg of fresh biomass) x 65% (dry mass) x 50% (carbon %) x 3.67 x 120%. Avoided runoff is estimated based on local weather data from the nearest weather station.

Civic Garden's **114** trees sequester **0.7 metric tons** of atmospheric carbon and intercept approximately **4,619 gallons** of stormwater runoff annually. Carbon sequestered here equates to approximately **1,689 miles** driven by an average passenger vehicle annually.

114
trees
planted on site

4,619
gallons/year
stormwater runoff intercepted

0.7
metric tons/year
carbon sequestered

=

1,689
miles/year
driven by a passenger vehicle

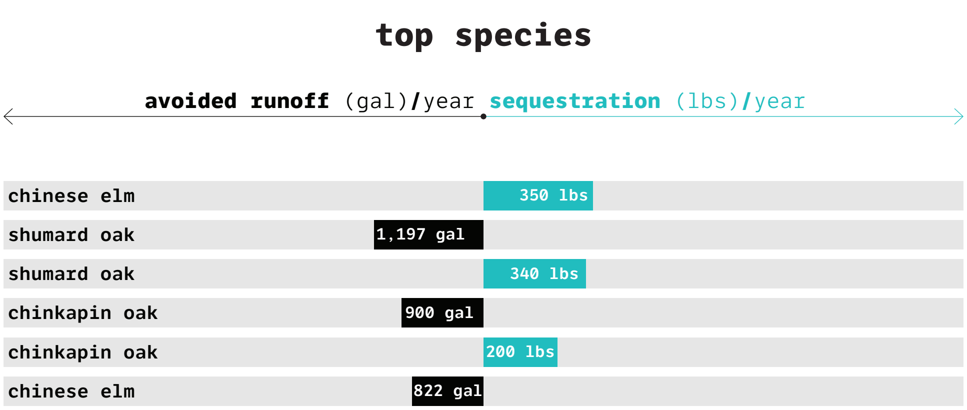


Figure 1.1 Top Species for Avoided Runoff and Sequestration

CIVIC GARDEN STORMWATER RUNOFF

Stormwater Runoff

Stormwater runoff was calculated for the park for both pre- and post-development conditions. The total amount of stormwater runoff was calculated by utilizing the Rational Equation Method (***Q=CiA***) which equates peak discharge (runoff) of a drainage field (park) during a specific rain event.

***Q** (cfs)*: Peak Discharge
C: Runoff Coefficient, unique to pervious and impervious ground conditions
***i** (inches/hour):* Rainfall Intensity
***A** (acre):* Drainage Area

Civic Garden prevents approximately **612,134 gallons** of stormwater from entering the city stormwater system annually, primarily due to a **1,029% increase** in pervious cover when compared to pre-development site conditions.

1,029% ↑
pervious cover

612,134
gallons/year
stormwater runoff avoided

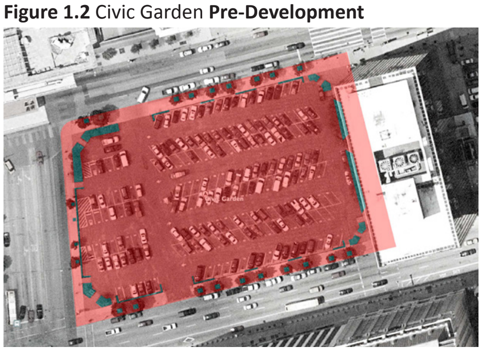


Figure 1.2 Civic Garden **Pre-Development**

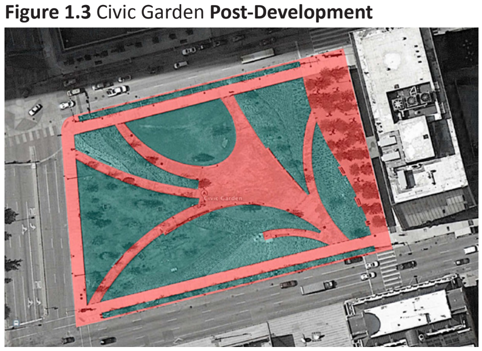


Figure 1.3 Civic Garden **Post-Development**

CIVIC GARDEN (2012)							
Stormwater Runoff Pre-Development							
Description	Area (sf)	**A** (area in acres)	**i** (inches/hour)	**C** (coefficient)	**Q** (Q=CiA) in cfs	Total Volume (cf/year)	**Total Volume** (gal/year)
Pervious	4,120.00	0.0946	0.0041	0.05	0.00001939	611.46	4,574.06
Impervious	77,762.00	1.7852	0.0041	0.70	0.00512344	161,572.73	1,208,647.85
Total	81,882.00					162,184.19	1,213,221.91

Stormwater Runoff Post-Development							
Description	Area (sf)	**A** (area in acres)	**i** (inches/hour)	**C** (coefficient)	**Q** (Q=CiA) in cfs	Total Volume (cf/year)	**Total Volume** (gal/year)
Pervious	46,533.00	1.0683	0.0041	0.05	0.00021899	6,906.11	51,661.31
Impervious	35,349.00	0.8115	0.0041	0.70	0.00232901	73,447.63	549,426.36
Total	81,882.00					80,353.74	601,087.67

Total Difference	**612,134.24**
% Pervious Cover Increase	**1029.44%**

Figure 1.4 Stormwater Runoff Pre- and Post-Development Calculations

CIVIC GARDEN HEAT ISLAND EFFECT

13.1°F ↓
average AM air temp

6.6°F ↓
average PM air temp

Heat Island Effect

In order to determine the cooling effect of the vegetation and tree canopy, the air temperature of the park was compared to the air temperature of an adjacent site with similar hardscape materials, but no vegetation or tree canopy. Multiple locations on each site were measured and averaged, and all temperature readings were taken during the same time periods on the same days. An ambient thermometer with 3 data loggers (with an accuracy of ±1°F) was used to take readings approximately 12-15 inches above the ground.

The average air temperature in Civic Garden on a typical summer day was **reduced** by an average of **13.1°F in the morning** and **6.6°F in the afternoon** through the presence of canopy coverage and vegetation.

Temperature Data [°F]
Civic Garden

Day 1: August 06, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover	**10a**	87.1	100.8	**13.7**
	4p	100.6	107.8	**7.2**
Site 2: Canopy/impervious cover	**10a**	87.6	100.8	**13.2**
	4p	101.6	107.8	**6.2**

Day 2: August 07, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover	**10a**	86.8	100.8	**14.0**
	4p	101.2	107.8	**6.6**
Site 2: Canopy/impervious cover	**10a**	89.2	100.8	**11.6**
	4p	101.4	107.8	**6.4**

Figure 1.5 Temperature Measurement Locations

2

PACIFIC PLAZA | CARBON SEQUESTRATION | TREES

Carbon Sequestration | Trees
Carbon sequestration and stormwater runoff avoidance were calculated for the trees on site using i-Tree Eco v6. i-Tree Eco v6 is a software application within a suite of tools that utilizes data to estimate ecosystem services and structural characteristics of rural and urban forests. The application provides sampling and data collection protocols, automated processing, and final reports illustrating carbon sequestration in pounds, carbon storage in pounds, and avoided runoff in cubic feet.

i-Tree's database assigns values for each tree species and size types. The calculation used to determine CO^2 sequestered per tree (kg) = tree mass (kg of fresh biomass) x 65% (dry mass) x 50% (carbon %) x 3.67 x 120%. Avoided runoff is estimated based on local weather data from the nearest weather station.

Pacific Plaza's **175** trees sequester **1.6 metric tons** of atmospheric carbon and intercept approximately **13,748 gallons** of stormwater runoff annually. Carbon sequestered here equates to approximately **4,044 miles** driven by an average passenger vehicle annually.

175
trees
planted on site

13,748
gallons/year
stormwater runoff intercepted

1.6
metric tons/year
carbon sequestered

=

4,044
miles/year
driven by a passenger vehicle

top species

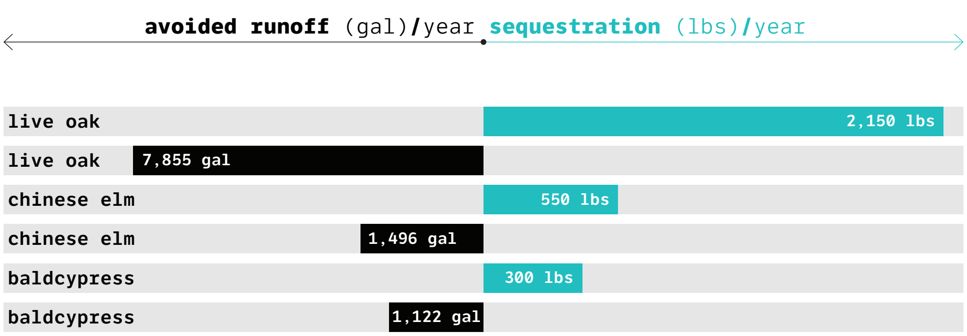


Figure 2.1 Top Species for Avoided Runoff and Sequestration

PACIFIC PLAZA STORMWATER RUNOFF

Stormwater Runoff

Stormwater runoff was calculated for the park for both pre- and post-development conditions. The total amount of stormwater runoff was calculated by utilizing the Rational Equation Method (***Q=CiA***) which equates peak discharge (runoff) of a drainage field (park) during a specific rain event.

***Q** (cfs)*: Peak Discharge
C: Runoff Coefficient, unique to pervious and impervious ground conditions
***i** (inches/hour):* Rainfall Intensity
***A** (acre):* Drainage Area

Pacific Plaza prevents approximately **882,531 gallons** of stormwater from entering the city stormwater system annually, primarily due to a **287% increase** in pervious cover when compared to pre-development site conditions.

287% ↑
pervious cover

882,531
gallons/year
stormwater runoff avoided

Figure 2.2 Pacific Plaza **Pre-Development**

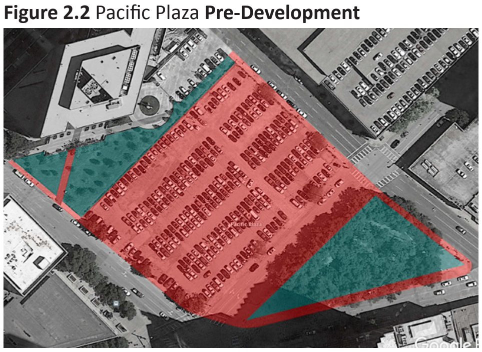


Figure 2.3 Pacific Plaza **Post-Development**

PACIFIC PLAZA (2019)

Stormwater Runoff Pre-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	21,300.00	0.4890	0.0041	0.05	0.00010024	3,161.20	23,647.43
Impervious	140,360.00	3.2222	0.0041	0.70	0.00924778	291,637.92	2,181,603.00
Total	161,660.00					294,799.12	2,205,250.43

Stormwater Runoff Post-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	82,448.00	1.8927	0.0041	0.05	0.00038801	12,236.37	91,534.42
Impervious	79,212.00	1.8185	0.0041	0.70	0.00521897	164,585.52	1,231,185.07
Total	161,660.00					176,821.89	1,322,719.50

Total Difference	882,530.93
% Pervious Cover Increase	287.08%

Figure 2.4 Stormwater Runoff Pre- and Post-Development Calculations

PACIFIC PLAZA HEAT ISLAND EFFECT

Heat Island Effect

In order to determine the cooling effect of the vegetation and tree canopy, the air temperature of the park was compared to the air temperature of an adjacent site with similar hardscape materials, but no vegetation or tree canopy. Multiple locations on each site were measured and averaged, and all temperature readings were taken during the same time periods on the same days. An ambient thermometer with 3 data loggers (with an accuracy of ±1°F) was used to take readings approximately 12-15 inches above the ground.

The average air temperature in Pacific Plaza on a typical summer day was **reduced** by an average of **10.3°F in the morning** and **8.1°F in the afternoon** through the presence of canopy coverage and vegetation.

10.3°F ↓
average AM air temp

8.1°F ↓
average PM air temp

Temperature Data [°F]
Pacific Plaza

Day 1: August 09, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover	**10a**	92.9	102.1	**9.2**
	4p	97.6	108.5	**10.9**
Site 2: Canopy/impervious cover	**10a**	94.9	102.1	**7.2**
	4p	102.1	108.5	**6.4**

Day 2: August 11, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover	**10a**	88.6	102.1	**13.5**
	4p	99.7	108.5	**8.8**
Site 2: Canopy/impervious cover	**10a**	90.7	102.1	**11.4**
	4p	102.2	108.5	**6.3**

Figure 2.5 Temperature Measurement Locations

3

WEST END SQUARE

WEST END SQUARE | CARBON SEQUESTRATION | TREES

Carbon Sequestration | Trees

Carbon sequestration and stormwater runoff avoidance were calculated for the trees on site using i-Tree Eco v6. i-Tree Eco v6 is a software application within a suite of tools that utilizes data to estimate ecosystem services and structural characteristics of rural and urban forests. The application provides sampling and data collection protocols, automated processing, and final reports illustrating carbon sequestration in pounds, carbon storage in pounds, and avoided runoff in cubic feet.

i-Tree's database assigns values for each tree species and size types. The calculation used to determine CO^2 sequestered per tree (kg) = tree mass (kg of fresh biomass) x 65% (dry mass) x 50% (carbon %) x 3.67 x 120%. Avoided runoff is estimated based on local weather data from the nearest weather station.

West End Square's **44** trees sequester **0.2 metric tons** of atmospheric carbon and intercept approximately **1,462 gallons** of stormwater runoff annually. Carbon sequestered here equates to approximately **399 miles** driven by an average passenger vehicle annually.

44
trees
planted on site

1,462
gallons/year
stormwater runoff intercepted

0.2
metric tons/year
carbon sequestered

=

399
miles/year
driven by a passenger vehicle

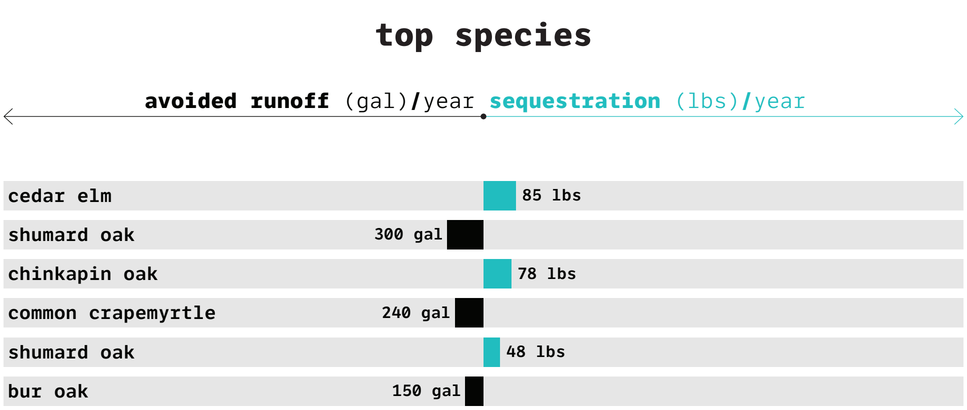


Figure 3.1 Top Species for Avoided Runoff and Sequestration

WEST END SQUARE STORMWATER RUNOFF

Stormwater Runoff

Stormwater runoff was calculated for the park for both pre- and post-development conditions. The total amount of stormwater runoff was calculated by utilizing the Rational Equation Method (***Q=CiA***) which equates peak discharge (runoff) of a drainage field (park) during a specific rain event.

***Q** (cfs)*: Peak Discharge
C: Runoff Coefficient, unique to pervious and impervious ground conditions
***i** (inches/hour):* Rainfall Intensity
***A** (acre):* Drainage Area

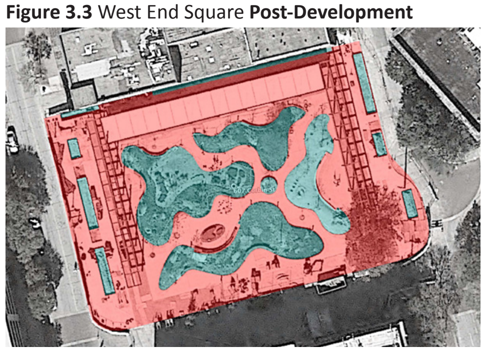
West End Square prevents approximately **166,409 gallons** of stormwater from entering the city stormwater system annually, primarily due to a **751% increase** in pervious cover when compared to pre-development site conditions.

751% ↑
pervious cover

166,409
gallons/year
stormwater runoff avoided

Figure 3.2 West End Square **Pre-Development**

Figure 3.3 West End Square **Post-Development**



WEST END SQUARE (2021)							
Stormwater Runoff Pre-Development							
Description	Area (sf)	**A** (area in acres)	**i** (inches/hour)	**C** (coefficient)	**Q** (Q=CiA) in cfs	Total Volume (cf/year)	**Total Volume** (gal/year)
Pervious	1,535.00	0.0352	0.0041	0.05	0.00000722	227.81	1,704.17
Impervious	41,716.00	0.9577	0.0041	0.70	0.00274851	86,676.88	648,388.08
Total	43,251.00					86,904.70	650,092.25

Stormwater Runoff Post-Development							
Description	Area (sf)	**A** (area in acres)	**i** (inches/hour)	**C** (coefficient)	**Q** (Q=CiA) in cfs	Total Volume (cf/year)	**Total Volume** (gal/year)
Pervious	13,065.00	0.2999	0.0041	0.05	0.00006149	1,939.02	14,504.87
Impervious	30,186.00	0.6930	0.0041	0.70	0.00198884	62,720.02	469,178.31
Total	43,251.00					64,659.04	483,683.18

Total Difference	**166,409.07**
% Pervious Cover Increase	**751.14%**

Figure 3.4 Stormwater Runoff Pre- and Post-Development Calculations

WEST END SQUARE HEAT ISLAND EFFECT

Heat Island Effect

In order to determine the cooling effect of the vegetation and tree canopy, the air temperature of the park was compared to the air temperature of an adjacent site with similar hardscape materials, but no vegetation or tree canopy. Multiple locations on each site were measured and averaged, and all temperature readings were taken during the same time periods on the same days. An ambient thermometer with 3 data loggers (with an accuracy of ±1°F) was used to take readings approximately 12-15 inches above the ground.

The average air temperature in West End Square on a typical summer day was **reduced** by an average of **11.0°F in the morning** and **8.1°F in the afternoon** through the presence of canopy coverage and vegetation.

11.0°F ↓
average AM air temp

8.1°F ↓
average PM air temp

Temperature Data [°F]
West End Square

Day 1: September 18, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover				
	10a	87.8	100.1	**12.3**
	4p	96.6	105.7	**9.1**
Site 2: Canopy/impervious cover				
	10a	90.4	100.1	**9.7**
	4p	98.6	105.7	**7.1**

Figure 3.5 Temperature Measurement Locations

4

CARPENTER PARK

CARPENTER PARK | CARBON SEQUESTRATION | TREES

Carbon Sequestration | Trees

Carbon sequestration and stormwater runoff avoidance were calculated for the trees on site using i-Tree Eco v6. i-Tree Eco v6 is a software application within a suite of tools that utilizes data to estimate ecosystem services and structural characteristics of rural and urban forests. The application provides sampling and data collection protocols, automated processing, and final reports illustrating carbon sequestration in pounds, carbon storage in pounds, and avoided runoff in cubic feet.

i-Tree's database assigns values for each tree species and size types. The calculation used to determine CO^2 sequestered per tree (kg) = tree mass (kg of fresh biomass) x 65% (dry mass) x 50% (carbon %) x 3.67 x 120%. Avoided runoff is estimated based on local weather data from the nearest weather station.

Carpenter Park's **146** trees sequester **0.9 metric tons** of atmospheric carbon and intercept approximately **7,727 gallons** of stormwater runoff annually. Carbon sequestered here equates to approximately **2,333** miles driven by an average passenger vehicle annually.

146
trees
planted on site

7,727
gallons/year
stormwater runoff intercepted

0.9
metric tons/year
carbon sequestered

=

2,333
miles/year
driven by a passenger vehicle

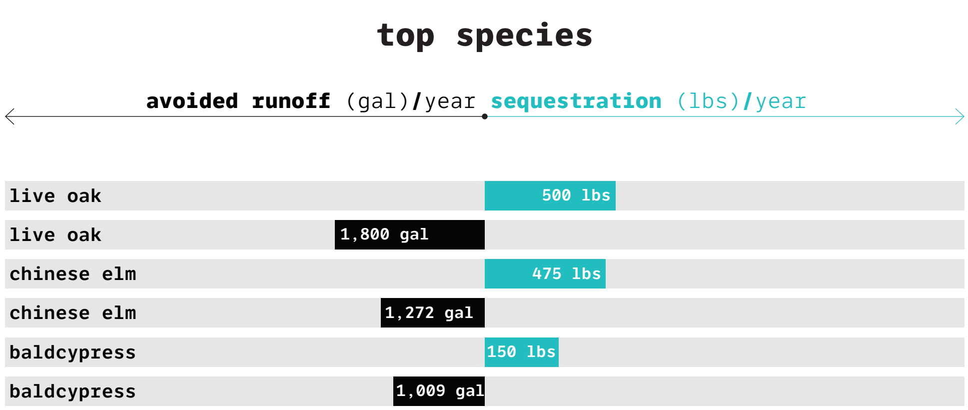


Figure 4.1 Top Species for Avoided Runoff and Sequestration

4.2 Downtown Dallas Parks Analysis → Carpenter Park

CARPENTER PARK STORMWATER RUNOFF

Stormwater Runoff

Stormwater runoff was calculated for the park for both pre- and post-development conditions. The total amount of stormwater runoff was calculated by utilizing the Rational Equation Method (***Q=CiA***) which equates peak discharge (runoff) of a drainage field (park) during a specific rain event.

***Q** (cfs)*: Peak Discharge
C: Runoff Coefficient, unique to pervious and impervious ground conditions
***i** (inches/hour):* Rainfall Intensity
***A** (acre):* Drainage Area

Carpenter Park prevents approximately -**575,518 gallons** of stormwater from entering the city stormwater system annually, primarily due to a **-22% increase** in pervious cover when compared to pre-development site conditions. **The negative metrics here are the result of an intentional increase in hardscape due to the park's nature of serving the public as more of a plaza in addition to the freeway adjacency.**

-22% ↑
pervious cover

-575,518
gallons/year
stormwater runoff avoided

Figure 4.2 Carpenter Park **Pre-Development**

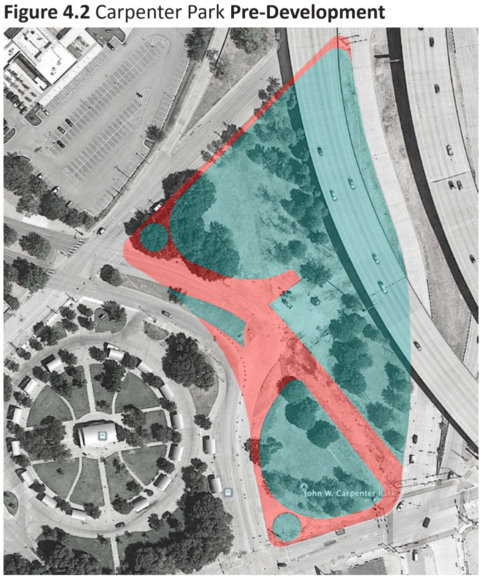
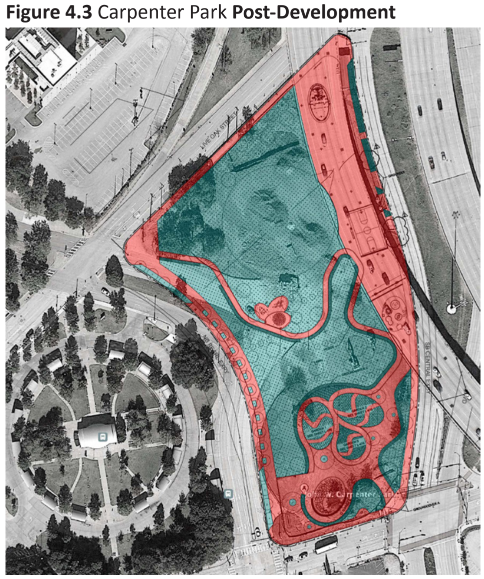


Figure 4.3 Carpenter Park **Post-Development**



CARPENTER PARK (2022)

Stormwater Runoff Pre-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	182,455.00	4.1886	0.0041	0.05	0.00085866	27,078.73	202,562.99
Impervious	67,213.00	1.5430	0.0041	0.70	0.00442840	139,654.17	1,044,685.68
Total	249,668.00					166,732.91	1,247,248.67

Stormwater Runoff Post-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	142,579.00	3.2732	0.0041	0.05	0.00067100	21,160.61	158,292.34
Impervious	107,089.00	2.4584	0.0041	0.70	0.00705568	222,507.93	1,664,474.81
Total	249,668.00					243,668.54	1,822,767.14

Total Difference	-575,518.47
% Pervious Cover Increase	-21.86%

Figure 4.4 Stormwater Runoff Pre- and Post-Development Calculations

CARPENTER PARK HEAT ISLAND EFFECT

Heat Island Effect

In order to determine the cooling effect of the vegetation and tree canopy, the air temperature of the park was compared to the air temperature of an adjacent site with similar hardscape materials, but no vegetation or tree canopy. Multiple locations on each site were measured and averaged, and all temperature readings were taken during the same time periods on the same days. An ambient thermometer with 3 data loggers (with an accuracy of ±1°F) was used to take readings approximately 12-15 inches above the ground.

The average air temperature in Carpenter Park on a typical summer day was **reduced** by an average of **8.3°F in the morning** and **10.4°F in the afternoon** through the presence of canopy coverage and vegetation.

8.3°F ↓
average AM air temp

10.4°F ↓
average PM air temp

Temperature Data [°F]
Carpenter Park

Day 1: August 12, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover				
	10a	90.4	99.9	**9.5**
	4p	97.7	110.7	**13.0**
Site 2: Canopy/impervious cover				
	10a	94.0	99.9	**5.9**
	4p	102.8	110.7	**7.9**

Day 2: September 20, 2022

Location	Time	Site Temp	Comp Site Temp	Difference
Site 1: Canopy/pervious cover				
	10a	90.3	100.0	**9.7**
	4p	96.4	107.2	**10.8**
Site 2: Canopy/impervious cover				
	10a	92.1	100.0	**7.9**
	4p	97.5	107.2	**9.7**

Figure 4.5 Temperature Measurement Locations

5

HARWOOD PARK

HARWOOD PARK | CARBON SEQUESTRATION | TREES

Carbon Sequestration | Trees

Carbon sequestration and stormwater runoff avoidance were calculated for the trees on site using i-Tree Eco v6. i-Tree Eco v6 is a software application within a suite of tools that utilizes data to estimate ecosystem services and structural characteristics of rural and urban forests. The application provides sampling and data collection protocols, automated processing, and final reports illustrating carbon sequestration in pounds, carbon storage in pounds, and avoided runoff in cubic feet.

i-Tree's database assigns values for each tree species and size types. The calculation used to determine CO^2 sequestered per tree (kg) = tree mass (kg of fresh biomass) x 65% (dry mass) x 50% (carbon %) x 3.67 x 120%. Avoided runoff is estimated based on local weather data from the nearest weather station.

Harwood Park's **248** trees sequester **1.2 metric tons** of atmospheric carbon and intercept approximately **8,340 gallons** of stormwater runoff annually. Carbon sequestered here equates to approximately **2,979 miles** driven by an average passenger vehicle annually.

248
trees
planted on site

8,340
gallons/year
stormwater runoff intercepted

1.2
metric tons/year
carbon sequestered

=

2,979
miles/year
driven by a passenger vehicle

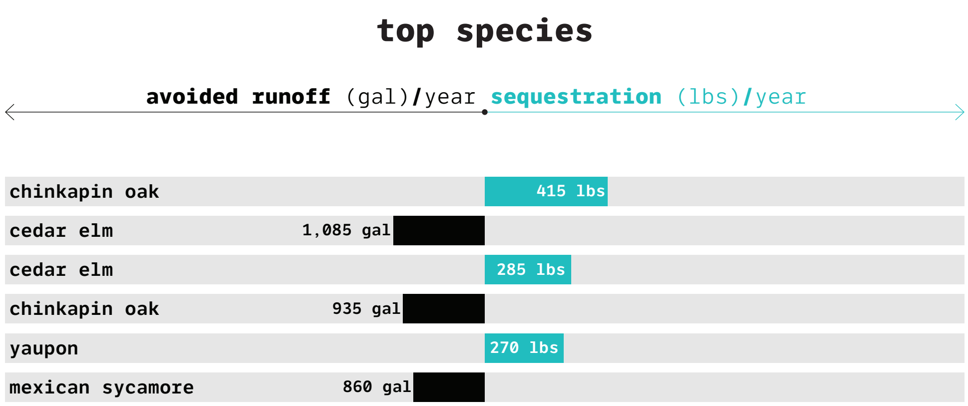


Figure 5.1 Top Species for Avoided Runoff and Sequestration

HARWOOD PARK STORMWATER RUNOFF

Stormwater Runoff

Stormwater runoff was calculated for the park for both pre- and post-development conditions. The total amount of stormwater runoff was calculated by utilizing the Rational Equation Method (***Q=CiA***) which equates peak discharge (runoff) of a drainage field (park) during a specific rain event.

***Q** (cfs)*: Peak Discharge
C: Runoff Coefficient, unique to pervious and impervious ground conditions
***i** (inches/hour):* Rainfall Intensity
***A** (acre):* Drainage Area

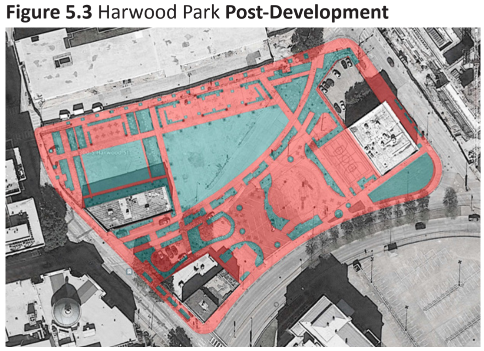
Harwood Park prevents approximately **805,720 gallons** of stormwater from entering the city stormwater system annually, primarily due to a **1,075% increase** in pervious cover when compared to pre-development site conditions.

1,075% ↑
pervious cover

805,720
gallons/year
stormwater runoff avoided

Figure 5.2 Harwood Park **Pre-Development**

Figure 5.3 Harwood Park **Post-Development**



HARWOOD PARK (2023 ant.)

Stormwater Runoff Pre-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	5,194.00	0.1192	0.0041	0.05	0.00002444	770.86	5,766.42
Impervious	145,976.00	3.3511	0.0041	0.70	0.00961779	303,306.76	2,268,891.99
Total	151,170.00					304,077.62	2,274,658.41

Stormwater Runoff Post-Development

Description	Area (sf)	A (area in acres)	i (inches/hour)	C (coefficient)	Q (Q=CiA) in cfs	Total Volume (cf/year)	Total Volume (gal/year)
Pervious	61,020.00	1.4008	0.0041	0.05	0.00028717	9,056.17	67,744.89
Impervious	90,150.00	2.0696	0.0041	0.70	0.00593963	187,312.33	1,401,193.44
Total	151,170.00					196,368.50	1,468,938.32

Total Difference	805,720.09
% Pervious Cover Increase	1074.82%

Figure 5.4 Stormwater Runoff Pre- and Post-Development Calculations

HARWOOD PARK HEAT ISLAND EFFECT

DATA PENDING

Heat Island Effect

This data is recommended to be collected during the summer when air and surface temperatures are at their highest once the park is completed.

In order to determine the cooling effect of the vegetation and tree canopy, the air temperature of the park should be compared to the air temperature of an adjacent site with similar hardscape materials, but no vegetation or tree canopy. Multiple locations on each site should be measured and averaged, and all temperature readings should be taken during the same time periods on the same day. An ambient thermometer with 3 data loggers (with an accuracy of ±1°F) should be used to take readings approximately 12-15 inches above the ground.

Figure 5.5 Temperature Measurement Locations

a

APPENDIX

DOWNTOWN DALLAS PARKS ADDITIONAL INFORMATION

1 Carbon Sequestration
Only trees were included in this analysis.

2 Stormwater Runoff
No additional information.

3 Heat Island Effect
No additional information.

DOWNTOWN DALLAS PARKS SOURCES & LIMITATIONS

i Park Introductions & Background

Sources:
Individual area Sanborn maps: Perry-Castañeda Library Map Collection, UT Austin

1 Carbon Sequestration

Sources:

EPA Greenhouse Gas Equivalencies Calculator. Accessed February 28, 2022. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

i-Tree Eco v6. Accessed February 8, 2022. https://www.itreetools.org/eco/index.php

Tree schedules were provided by the Landscape Architects:
Civic Garden: Hargreaves Jones
Pacific Plaza: SWA Dallas
West End Square: James Corner Field Operations
Carpenter Park: Hargreaves Jones
Harwood Park: Ten Eyck Landscape Architects

Limitations:

1. The tree species and breakdowns used for these calculations were based off of the original construction documents provided by the landscape architect. These calculations do not account for changes in the field during construction or ongoing maintenance, replacement, or repair.

2. iTree does not take into account groundcover and while shrubs can be taken into account, they were not included in this analysis. The benefits discussed above will increase over time.

2 Stormwater Runoff

Sources:

Rational Equation Method. Accessed February 13, 2022. https://www.lmnoeng.com/Hydrology/rational.php

Material, plant/tree schedules, and irrigation data were provided by the Landscape Architects:

Civic Garden: Hargreaves Jones
Pacific Plaza: SWA Dallas
West End Square: James Corner Field Operations
Carpenter Park: Hargreaves Jones
Harwood Park: Ten Eyck Landscape Architects

Limitations:

1. Precision: There may be small errors caused by manual tracing of aerial imagery.

2. Image quality: While the quality of the pre-development images is very high, there are portions that are pixelated and/or covered in shadow from adjacent buildings. Areas were estimated to the best of the team's capability.

3. The equation Q=CiA, when scaled out to represent the total hourly rainfall during any given hour throughout the year, doesn't take into account large rainfall events, where total discharge may be greater than average.

3 Heat Island Effect

Sources:

This data was collected on site by the research team from August 6-14, 2022.

Limitations:

1. The research team relied on the ambient thermometer and data loggers for data collection. Though this equipment was tested for accuracy, there still exists the potential for slight error and inaccuracy. The range for these data loggers was 300 feet, therefore the adjacent park site chosen had to be within that range for this comparison.