RAIN DELAY
Preparing 100-year-old Hoy Field for a 100-year Storm

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ABSTRACT

On its 100th birthday, Cornell University's Hoy Field will receive an extreme makeover. Home to the Cornell Big Red baseball team for a century, the area will be rededicated to the College of Computing and Information Science (CIS) in 2022.

Outdated stormwater drainage infrastructure connects this area to Cascadilla Gorge. Currently, stormwater from campus flows through this site and empties into the gorge untreated. Key issues facing this site are unsustainable drainage rates causing gorge erosion, flood damage, and runoff contributing nutrients to algal blooms. Increased runoff due to climate change will exacerbate these concerns.

We chose this site because it includes the final opportunity to treat stormwater on campus as well as the flash point for discharge before reaching Cascadilla Gorge and Cayuga Lake. As the CIS building's construction is part of the Cornell Master Plan, our design offers a tangible response to ecological challenges facing the community.

We relied on experts in planning, architecture, watershed engineering, facilities, ecological compliance, and botanical gardens to create this vision for Cornell University's future.

Our solution uses green infrastructure, including rain gardens, bioswales, native grasses, a green roof, permeable pavers, and a retention pond, to decrease runoff and nutrient loads. We also provide a network of pedestrian paths leading to collaboration spaces, natural features, and key access points. The design demonstrates utility, beauty, and ecological education.

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***Figure** 1.* *Hoy Field in 2021 before construction on the CIS Building taken from the west looking eastward. Gates Hall is the silver building above the right field line (top of photo).*

Figure 2. *Architectural consultant's rendition of the future CIS building on Hoy Field. Courtesy of Leers Weinzapfel Associates. View is from west looking eastward. Gates Hall on left of tan-colored angled CIS building in center.*

History & Overview

In 2022, Cornell University will begin construction on a new building connected to Bill & Melinda Gates Hall. The new building, part of the Cornell Bowers College of Computing and Information Science (CIS), is depicted in Figure 2. It will occupy the area where Hoy Field, shown in Figure 1, has been for the last 100 years. This space has also served as the home of the Cornell Big Red Baseball team since 1922. The baseball field will be moved to a different location on Cornell University land.

Our project site is an 8.5-acre corridor from Hoy Field to Cascadilla Creek that includes what is currently the baseball field, a wooded hillside and tennis courts. Cascadilla Creek is approximately 60 feet below the field's surface. Runoff from Gates Hall, the artificial surface of the field, roadways, and an adjacent parking garage collects under Hoy Field, discharging directly into Cascadilla Creek, untreated.

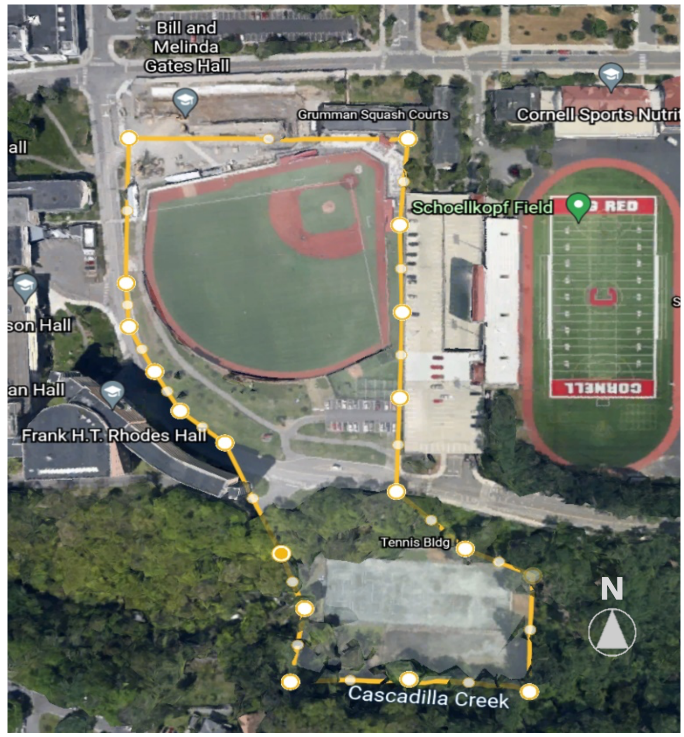

Figure 3. *Satellite view of 8.5-acre site. Bound on the north by Bill & Melinda Gates Hall, to the east by the Schoellkopf parking garage, to the south by Cascadilla Creek, and the west by Hoy Road. Top of photo is north. Hoy Field (Figure 1) is the baseball field in the image.*

Site Selection

Due to its proximity to the Cascadilla Creek, the Hoy Field site offers an opportunity to address stormwater management issues on Cornell University campus that will meet university objectives and broader regional and state water quality goals. As outlined in the Cornell University Campus Master Plan, protection and enhancement of Ithaca's iconic gorges and creek systems is a priority. Key initiatives in the Cornell Master Plan include collecting and reusing stormwater on campus, implementing stormwater management strategies to mitigate legacy stormwater impacts, and including stormwater management in landscape features. Similarly, the City of Ithaca has established stormwater management goals to educate and involve the public, manage construction activities, and encourage municipal stormwater pollution prevention measures. This design aims to meet campus-wide ecological initiatives, as well as local, regional, and state stormwater management guidelines through consideration of the following problems.

Site Problems

Figure 4. *Site Map.*

According to the Fourth National Climate Assessment, heavy precipitation events in the United States have increased in intensity and frequency since 1901, with the largest increases occurring in the northeastern United States. In New York State, precipitation volume is expected to continue to increase, with more frequent storm events and heavier downpours. Currently, stormwater overwhelms outdated infrastructure, which runs through the Hoy Field site and releases untreated stormwater directly into the Cascadilla Gorge. As shown in Figure 6, a stormwater discharge on the site flows directly into the Cascadilla Gorge from surrounding areas on campus.

The increased peak stormwater volume overwhelms a stormwater system built for a prior climate. During storm events, water also pools around walkways on the site and nearby roadways, as depicted in Figure 5. As a result, excess nutrients such as phosphorus and nitrogen, road salt, and other pollutants end up in the Cascadilla Gorge and Cayuga Lake. The southern end of Cayuga Lake has been identified as an impaired water body by the New York State Department of Environmental Conservation (NYS DEC) due to phosphorus loads that exceed state Total Maximum Daily Load (TMDL) levels. Cornell University's Lake Source Cooling program (LSC), demonstrated in Figure 7, has contributed to this problem. The lake source cooling facility draws water from Cayuga Lake and uses it to cool campus buildings. The water is then discharged back into Cayuga Lake. Although the system operates as a "closed loop" system, the discharge from the cooling facility contains phosphorus that was in the water when originally withdrawn from Cayuga Lake. The phosphorus that was in the water when withdrawn from the lake is then released at a higher level in Cayuga Lake, where it is exposed to sunlight. This process is suspected to contribute to harmful algal

Figure 5. *Pooling on walkways near Hoy Field.*

Figure 6. *Stormwater discharge into Cascadilla Gorge in the south portion of our site.*

blooms. In April 2021, the NYS DEC proposed a 30% reduction of phosphorus loads to protect Cayuga Lake water quality.

To continue using this method of cooling buildings on campus, Cornell University is responsible for mitigating phosphorus levels in other areas of campus as directed by the NYS DEC and EPA.

Stormwater runoff into Cascadilla Creek, poor drainage, newly added impervious surfaces, and university incentives to earn phosphorus credits are some of the key motivations for our site redesign.

Methodology & Interviews

Our site intervention is guided by the maximum stormwater runoff we predicted for the 100-year return period: 108,523 cubic feet of water. We take this number to be the "worst case scenario." This model is sensitive to increased rainfall loads due to climate change. Therefore, we planned our interventions to handle an event of this magnitude. To learn more about the stormwater problems, solutions, and current management strategies on Cornell's campus, we relied on several case studies and interviews with subject experts. Their testimony guided our analysis and decision-making regarding what interventions to apply.

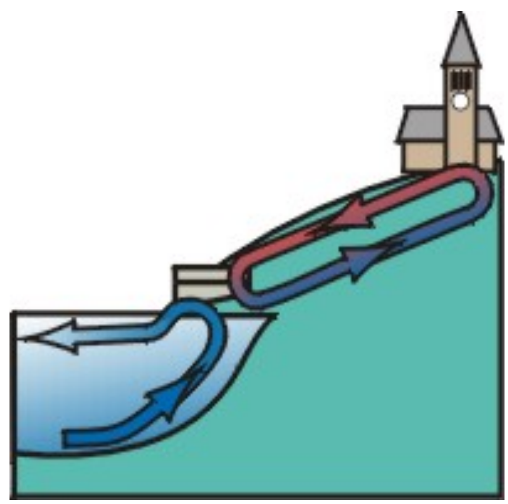

Figure 7. *Simplified graphic of Cornell's Lake Source Cooling system.*

First, we consulted with the University Architect and Campus Planning staff. From this interview, we learned about Cornell's plans for the future and identified areas with problematic stormwater infrastructure. Hoy Field's rededication to a CIS building and proximity to Cascadilla Gorge made it a prime candidate for this project. Review of the Master Plan for campus precincts solidified our decision to redesign this site.

Then, we looked at several case studies to understand how Cornell has implemented stormwater infrastructure in the past. We looked at the rain gardens and bioswales at Cornell Botanic Gardens' Nevin Welcome Center, talked with the Gardens' director of natural areas to learn what local flora effectively treat stormwater, and interviewed soil scientists to understand the drainage capabilities of the subsoil in this region. This information helped us to choose sensible, proven, and harmonious intervention strategies.

Lastly, we consulted with Cornell University's Environmental Engineering & Compliance Department. Notably, they let us know what is feasible on our site. They also guided us toward a design aligned with Cornell's phosphorus credit and reduction goals. Using the New York State Stormwater Design Manual, we then designed a plan that integrates runoff calculations, green infrastructure, and acceptable stormwater management practices (SMPs).

Goals

Using this information, we identified six goals to achieve with this site design.

Goal #1: Reduce Peak Stormwater Discharge into Cascadilla Gorge

Cascadilla Creek's headwaters are located ten miles southeast of Cornell's campus. It drains through the site and leads to the dramatic Cascadilla Gorge before running through the city of Ithaca and emptying into Cayuga Lake. This gorge forms the southern boundary between Cornell's central campus and adjacent College town.

Currently, stormwater drains directly into the gorge without treatment or protective riprap to prevent erosion in the creek. Outdated stormwater infrastructure collects stormwater runoff into a discharge pipe (figure 6), which discharges the water from a height of approximately 20 feet above Cascadilla Gorge.

We relied heavily on the New York State Stormwater Management Design Manual to implement proven and legal green infrastructure interventions. By slowing water down and holding onto it or allowing it to infiltrate into the ground, we can reduce peak flows and mitigate flooding potential.

Site Soil

The inherent soil types of the site are Hudson and Rhinebeck silt loam and silty clay loam. These soil series are classified as hydrologic group C. Hudson and Rhinebeck soils developed from lake (lacustriane) sediments that were laid down when the proto–Cayuga Lake covered this site approximately 12,000 years ago. After the site transformation, the site is estimated to be 55% grassed open space, 35% forested, and 10% impervious. Table 1 shows the effect of this land use on run-off calculations.

Table 1. Post-project land cover and soil type summary.

	C Soils (Acres)	Curve Number	% of Total
Impervious	0.8	98	10
Open Space	4.7	75	55
Forest	3.0	76	35
TOTALS	**8.5**	**78**	**100**

Runoff Calculation

Runoff calculations for the site utilize data from the Northeast Regional Climate Center (NRCC) and the curve number approach for estimating runoff volume. NRCC values for 1, 2, 10 and 100-year, 24-hour rainfall events for Ithaca, NY, were used to estimate runoff for this site. The NRCC has developed a robust approach of estimating return periods for NYS that account for the effects of climate change, which is increasing the frequency and magnitude of large precipitation events. Then the curve number method was applied, which uses curve number values to estimate the amount of water that the site can absorb. The final design for the site was intended to accommodate runoff generated from the 100-year, 24-hour event (Table 2).

Table 2. Estimates of runoff from the site for different return periods.

Return Period (yr)	NRCC - 24 hr (in)	Runoff Depth (in)	Runoff Volume (ft3)	Runoff Volume (gal)
1	2.01	0.48	15,120	113,102
2	2.34	0.69	21,171	158,371
10	3.43	1.44	44,567	333,381
100	5.93	3.52	108,523	811,799

Permeable Pavers

The access road leading to the service court area to the east of the CIS building and the small parking lot are not throughways, so they are an attractive option for permeable pavers. Runoff from the CIS building is directed to this area which connects directly to the main stormwater pipe bounding the site's east side. Surface runoff can permeate the paving surface and into the ground and other treatment conduits such as bioswales and rain gardens.

The parking lot, service area and walkways occupy 15,324 square feet. These permeable pavers can retain 3,193 cubic feet of rainwater. Water retention calculations are based on 10 inches of permeable pavement with a porosity of 25%.

Green Roof

A 16,800 sq. ft. extensive green roof atop the new CIS Building will mitigate heat island effects on campus and reduce building energy use. Following the EPA's Green Roof Implementation guidelines, a roofing membrane will separate the building from the soil. Between the soil and the building, a drainage, water storage and root barrier will ensure proper runoff. Species such as *Sedum album* (White Stonecrop), *Sedum*

Spurium (White Two-Row Stonecrop), *Sedum Spurium* (John Creech Two-Row Stonecrop), and *Sedum Ternatum* (Wild Stonecrop) will be planted on the roof because they have minimal maintenance and are self-propagating plants.

A green roof of this size can retain 2,224 cubic feet of stormwater. Calculations were based on a green roof design that had a 3-inch soil media layer on top of a 2-inch drainage layer.

Rain Gardens

An educational rain garden is the centerpiece of the open area between Gates Hall and the CIS building. Runoff from these buildings will be directed into the rain garden. At the deepest part of the gardens, woody shrubs and water-loving plants, like *Aronia melanocarpa* (Black and Red Chokeberry), *Cephalanthus occidentalis* (Buttonbush), *Ilex verticillate* (Common Winterberry), and *Linder benzoin* (Spicebush) anchor the environment. Smaller plants, like *Chelone glabra* (White Turtlehead), will adorn the edges of the rain gardens. Eutrochium maculatum (Spotted Joe-Pye Weed), *Iris versicolor* (Blue Flag Iris), and *Labelia cardinalis* (Cardinal Flower) are additional peripheral plants effective in this climate for use in rain gardens.

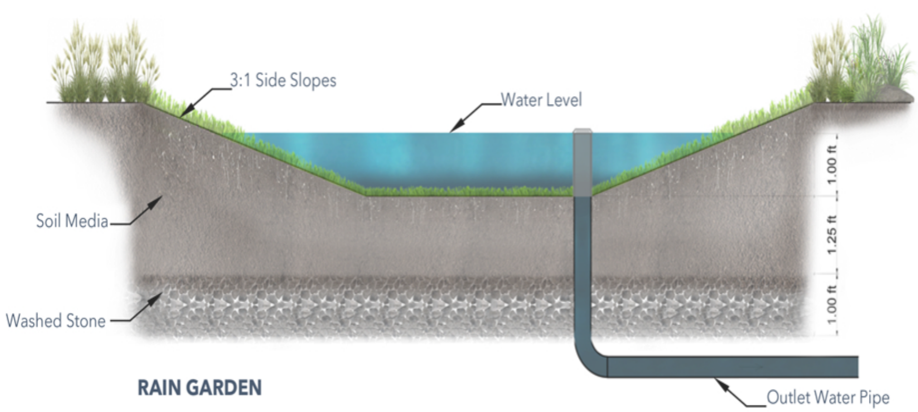

Figure 8. *Cross section of proposed rain garden design.*

The rain gardens were designed with 1.25 feet of native soil on top of 1 foot of washed 1 inch aggregate. These media have porosities of 40% and 45% respectively. The rain garden will have a concave shape to accommodate 1 foot of ponding. A few inches of mulch serve as the rain garden's surface to absorb the impact of rain droplets. The two rain gardens at the site will be 3,596 and 3,210 square feet for a total area of 6,806 square feet. They offset 13,272 cubic feet of stormwater.

Bioswales

Bioswales 10 ft wide and 1.3 ft deep outline the "Diamond," an outdoor-seating area that evokes Hoy Field's infield. Each side of the diamond is 90 ft for a total of 360 ft of swale. We chose plants used at the Nevin Welcome Center at Cornell's Botanical Gardens for their ability to treat stormwater and demonstrated resilience to Ithaca's climate.

The vegetated open swale model slows rain runoff, collects it, and releases it into the larger stormwater management system. Native grasses and forbs such as *Juncus effsus* (Soft Rush), *Panicum virgatum* (Switchgrass), *Helianthus divaricatus* (Woodland Sunflower), and *Hypericum prolificum* (Shrubby St. John's Wort) will be planted along and within the swales to promote infiltration and nutrient removal. The bioswales on our site adjoin walkways, roadways, and other pedestrian areas. Bioswales connect to the central rain garden. Measuring 582 ft in length and 10 ft in width, they can manage 11,826 cubic feet of water.

Retention/Detention Pond

A retention/detention pond at the south end of the abandoned faculty tennis courts is the final stop for stormwater before being released into the creek. The dilapidated and unused state of these two tennis courts makes this an attractive area for repurpose. This area is isolated from foot traffic with immediate proximity to Cascadilla Gorge. These factors make it safe and accessible for returning the treated stormwater into the gorge. It will reduce the erosion in the gorge currently caused by the elevated runoff pipe (Figure 6). Additionally, it provides a new habitat for amphibious animals and native plant species. Specialized plants will be planted around the retention/detention pond to filter out excess nutrients. Specifically, Northern Bayberry will be planted near the retention/detention pond as it is tolerant to road salt, attracts birds and butterflies, and prevents erosion. Other planting choices near or in the retention/detention pond include *Scirpus atrovirens* (Green Bulrush) and *Itea virginica* (Virginia Sweetspire). Water from the stormwater pipe that currently deposits water into the gorge will be rerouted to empty into the retention/detention pond.

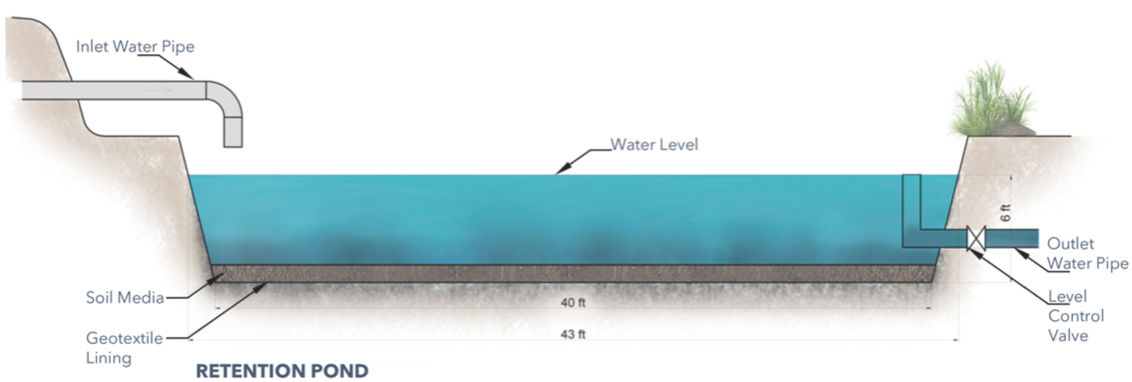

Figure 9. *Cross section of proposed retention/detention pond.*

The pond, 270 ft x 50 ft x 6 ft, will retain as much as 78,570 cubic feet of stormwater. Six inches of clay will line the bottom of the pond to ensure that water leaves the pond slowly. This area is the lowest part of the site, and the other interventions will slow and infiltrate water before it arrives at the pond. An overflow pipe will remove water in the event of an unusually large storm.

As shown in Table 3, our green infrastructure interventions will have a total offset of 109,085 cubic feet or 101% of the 100-year return period event.

Table 3. Stormwater discharge reductions because of green infrastructure.

Intervention	Stormwater Offset (ft. ^{3})	% of 100-year event
Permeable Pavers	3,193	2.9%
Green Roof	2,224	2.0%
Rain Gardens	13,272	12.2%
Bioswales	11,826	10.8%
Retention/Detention Pond	78,570	72.4%
TOTALS	**109,085**	**101%**

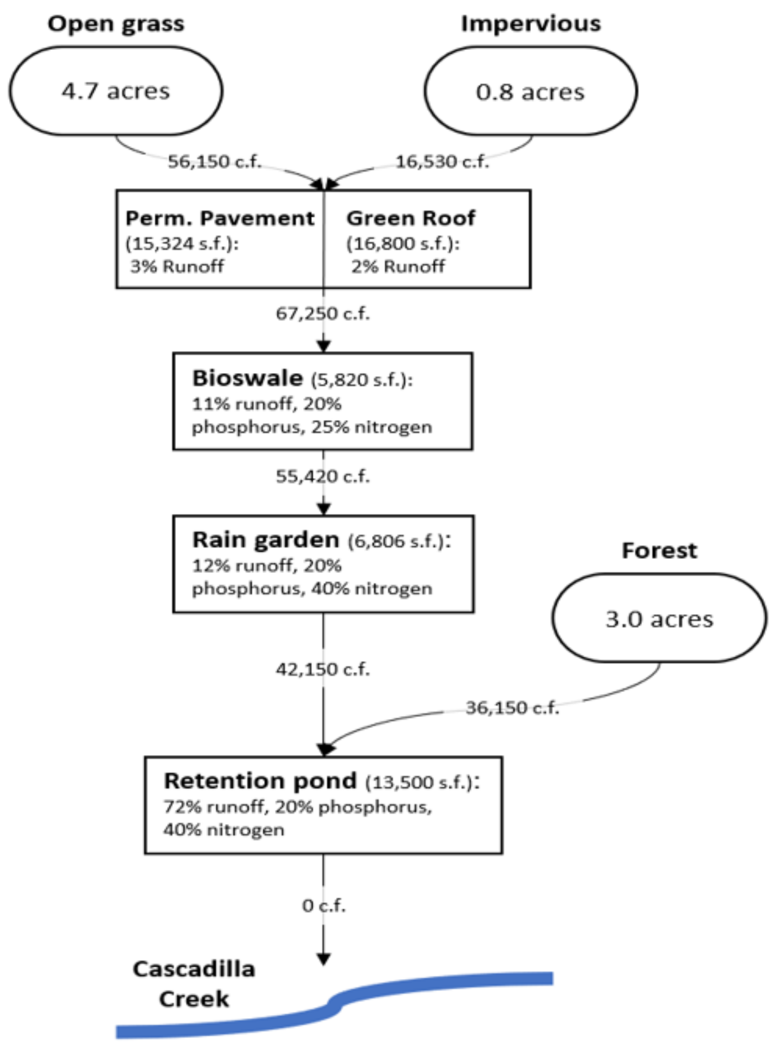

Figure 10. *Flowchart illustrating the conceptual order of green infrastructure elements in the site with corresponding offset percentages.*

Goal #2: Contribute to campus-wide phosphorus reduction initiative

Algal blooms in Cayuga Lake have become more common and more severe in recent years. This increase is partly due to increases in nutrient loads caused by Cornell's Lake Source Cooling infrastructure. The University has launched an initiative to offset their contribution to the algal blooms by managing phosphorus in other parts of the campus. Earning "phosphorus credits" with interventions at the Hoy Field site enables Cornell to meet campus and state-wide ecological objectives.

Bioswales, rain gardens, the retention pond, and native grasses can all filter water biologically, and we use natural flora to use and cycle phosphorous, nitrogen, and other nutrients. The annual reduction in pollutant load by the proposed BMPs is given in Table 4. These values were calculated using EPA's Spreadsheet Tool for Estimating Pollutant Loads (STEPL).

Table 4. Annual Reductions in Pollutant Loads due to best management practices.

Pollutant	Annual Load Reduced
Total Nitrogen (lbs)	37.7
Total Phosphorus (lbs)	6.0
Biochemical Oxygen Demand (lbs)	124.6
Sediment Load (t)	1.2

Goal #3: Improve the aesthetic, natural, and social environment

In addition to improving stormwater runoff management and water quality, our process was guided by three design tenets: Utility, Beauty, and Ecological Harmony. Each green infrastructure application uses or mimics nature to provide ecosystem services. Natural solutions are proven to treat and manage stormwater effectively.

We also pay tribute to Hoy Field's 100-year history occupying this site. In homage, "The Diamond" adjacent to the CIS building recognizes the shape of the playing field while offering students a new outdoor collaboration space. With COVID-19 indoor restrictions in place, Cornell has set-up tents with tables and chairs for outdoor meetings. The Diamond is a permanently tented outdoor area inspired by the temporary outdoor structures. Bioswales surrounding the space create the effect of a secluded island. Two "fowl poles" will give refuge to birds and repurpose pieces of the old ballfield. The two birdhouses will provide protected space for Blue Jays, Orioles, and Cardinals (among other species) to build their nests each spring. A scoreboard in what was the outfield tracks the work of the stormwater applications.

Beautiful rain gardens, stepped terraces, and walkways cutting through native grassland plantings make the site aesthetically pleasing and inviting. We hope to create a functional, nature-focused environment juxtaposing the high-tech computer science facilities nearby.

Plant Selections

A variety of plant species were chosen based on biophysical traits, plant wetness factor, nutrient uptake capabilities, aesthetic value, and other specific functions. Plants were also selected based on local availability from The Plantsmen Nursery and White Oak Nursery as suggested by Cornell Botanic Gardens. Our site design incorporates species highlighted in the New York State Stormwater Management Design Manual including *Ilex verticillate* (Common Winterberry), *Eutrochium maculatum* (Spotted Joe-Pye Weed), and *Panicum virgatum* (Switchgrass). Maintenance needs, light requirements, and cost were also considered.

Table 5. Site plant species with common and scientific names.

Common Name	Scientific Name	Common Name	Scientific Name
River Birch	*Betula nigra*	**Cardinal Flower**	*Lobelia cardinalis*
American Larch	*Larix laricina*	**Common Monkey Flower**	*Mimulus ringens*
Black & Red Chokeberry	*Aronia melanocarpa*	**Lizard's Tail**	*Saururus cernuus*
Buttonbush	*Cephalanthus occidentalis*	**Spotted Joe-Pye Weed**	*Eutrochium maculatum*
Spicebush	*Lindera benzoin*	**Soft Rush**	*Juncus effusus*
Virginia Sweetspire	*Itea virginica*	**Green Bulrush**	*Scirpus atrovirens*
Northern Bayberry	*Morella pensylvanica*	**Big Bluestem**	*Andropogon gerardii*
Common Winterberry	*Ilex verticillata*	**Switchgrass**	*Panicum virgatum*
White Turtlehead	*Chelone glabra*	**White Stonecrop**	*Sedum Album*
Woodland Sunflower	*Helianthus divaricatus*	**White Two-Row Stonecrop**	*Sedum Spurium*
Shrubby St. John's Wort	*Hypericum prolificum*	**John Creech Two-Row Stonecrop**	*Sedum Spurium*
Blue Flag Iris	*Iris versicolor*	**Wild Stonecrop**	*Sedum Ternatum*

Goal #4: Educate community on green infrastructure

We want the use of green infrastructure to become "business as usual". As a transition space between campus and the natural area of Cascadilla Gorge, this site offers opportunities for green infrastructure education. Our design includes several educative aspects highlighting how the interventions contribute to treating stormwater and how the built environment can improve regional water quality.

Inside the Diamond, the centerpiece features a plaque that explains how plants are a natural solution for infiltrating and treating contaminated stormwater.

Also, educational digital resources accessible by scanning a QR code on an entryway plaque will provide a historical and future virtual experience. Pedestrians can also learn about the positive benefits of native grasses and creating an ecologically responsible social space on the interface. As part of the education initiative, the site includes a scoreboard to inform Cornell's community of the annual pollutant load reduced with designed interventions.

Lastly, the rain garden between Gates Hall and the new CIS building will showcase the benefits of green infrastructure. Expected to be a high-traffic area, many pedestrians pass the rain gardens each day. Easily accessible and interesting to look at, the rain gardens add to the educational qualities of our site design.

Goal #5: Set sustainable example for future campus development projects

As Cornell continues to expand and redesign parts of its aging Ithaca campus, we want this site design to serve as an example of how simple solutions can be beautiful, functional, and integrated into the regional environment. We also wish to demonstrate how local action with a recognition of a broader consciousness can make a sizeable and positive difference.

The solutions proposed here are easily replicable, relatively cheap, and simply maintained. They address problems laid out in the NY State Stormwater Management Design Manual and work towards campus-wide phosphorus reduction initiatives. Increasingly threatening storm events necessitate revisiting insufficient infrastructure, some of which was built over a century ago. To maintain a safe, sustainable learning environment, Cornell and other institutions need to address these challenges in innovative ways. We hope our solutions here inspire similarly nature-based solutions to common stormwater challenges experienced across diverse geographies.

Goal #6: Provide easily and economically maintained infrastructure

Outlined in the "Maintenance" section, the interventions we chose require little regular maintenance. Relying on tall grasses, ponds, and nature-mimicking solutions means that the site will not be expensive or difficult to maintain.

Figure 11: Tall Grass, Small Gas. Native grasses offset greenhouse gases and are easily maintained

In the rain gardens, perennials and woody shrubs are easily maintained throughout the years, with minimal herbicides and pruning necessary. Tall grasses in the open areas only require annual mowing. Permeable pavers do not require special maintenance compared to traditional paved walkways. Snow can be placed into low bioswale areas on the edges of walkways. The retention/detention pond requires only seasonal maintenance to ensure that excessive growth does not extend beyond the pond's immediate edges. The ease of maintenance is also an attractive feature for other campus projects or individuals wanting to use green infrastructure in other scenarios.

Maintenance

The green infrastructure solutions proposed in this report require minimal maintenance. As mentioned, plant species were meticulously chosen based on maintenance requirements. Woody plants, perennial and annual herbaceous plants, and native grasses incorporated into the planting design are all considered low maintenance species.

Retention/Detention Pond

Excessive vegetation on the pond's edges requires removal on a seasonal basis. Clogging of the drainage outlet may occur but can be removed easily if noticed during regular inspections. Otherwise, the pond is sequestered to a low-traffic area, so debris should not accumulate.

Green Roof

Sedum plants were chosen for the extensive green roof based on low maintenance and ability to self-propagate. However, in the first 12-15 months after planting, maintenance of the green roof will include fertilization, watering, and weeding for plant survival. Inspections are required to check for leaks, blocked drainage, dead/overgrown vegetation, debris, and issues with irrigation. Inspections should be conducted annually.

Snow Removal

Snow can be placed into bioswales that eventually connect through the treatment train into the detention pond and, eventually, Cascadilla Creek.

Bioswales & Rain Gardens

Mulching should occur in the fall before extensive winter frost. Biannually, weeding, minimal herbicide, and debris removal should occur. The swales should be mowed during the spring and summer months. Perennial flowers will minimize maintenance and replanting. Bioswales and rain gardens at Cornell Botanical Gardens' Nevin Welcome Center provides a maintenance model for these two interventions.

Permeable Pavers

Regular vacuuming using a vacuum-powered street sweeper is recommended for maintaining permeable pavers. Inspection for repairs is also necessary to ensure safety on walkways. Individual pavers are advantageous because they can be simply replaced.

Tall Grasses

In line with Cornell's initiative to implement low-maintenance grasses in non-walkable areas around campus (such as Libe Slope), the tall grasses do not require a consistent maintenance schedule.

Project Phasing

April-August 2022
Pavement | Dig Ponds | Connect Utilities

→

September-November 2022
Ground covering | Install Green Roof

→

April-August 2023
Construct the Diamond | Plant Perennials in Rain Gardens and Bioswales

As the CIS building construction is scheduled to begin in 2022, implementation will start after the removal of Hoy Field's artificial surface. RAIN DELAY's portion of the project will begin the summer of 2022, as shown by the phasing model. The project can be completed in one year.

Costs & Budgeting

The RAIN DELAY design will cost $391,244 to install, and $35,111 to maintain annually. The initial planting will cost approximately $27,029 with an annual maintenance cost of $7,113.

Table 6. Green Infrastructure Solution Cost Analysis.

	Measurement	Initial Cost	Annual Maintenance Cost	Life Cycle Cost*
Green Roof	16,800 ft^2	$114,524.00	$12,600.00	$445,068.00
Rain Gardens	6,806 ft^2	$41,312.00	$2,790.46	$95,306.00
Bioswales	582 ft^2	$10,232.00	$151.32	$18,633.00
Permeable Pavers	15,324 ft^2	$133,012.00	$306.48	$192,047.00
Retention Pond	78,570 ft^3	$65,135.00	$12,150.00	$308,135.00
Native Vegetation	142,260 ft^2	$27,029.00	$7,113.00	$240,419.00
TOTALS		**$391,244.00**	**$35,111.26**	**$1,299,608.00**

Sources: CNT (2020), Environmental Finance Center (2019)

*Life Cycle Cost assumes a 3.1% discount rate over a 30-year life cycle.

Potential Funding Sources

The construction of the CIS building will be funded by a $10 million donation from Cornell alumni Niraj Shah and Steve Conine. Additionally, a $100 million gift from alumna Ann S. Bowers will fund the creation of the new College of Computing and Information Science that will occupy this site. These funding sources could potentially support this sustainable Hoy Field design as the future home of CIS.

Other possible funding sources are the New York State Green Innovation Grant Program, New York State Water Quality Improvement Project (WQIP) Program, and the Cornell University Atkinson Center Rapid Response Fund. The Green Innovation Grant Program supports projects across New York State that employ EPA-designated green stormwater infrastructure design and create cutting-edge green technologies. The WQIP Program funds projects that address documented water quality impairments or protect a drinking water source. Further research and studies related to our site design could be financed by the Cornell University Atkinson Center Rapid Response Fund which supports activities within a broad range of sustainability initiatives.

Conclusion

RAIN DELAY Preparing 100-year-old Hoy Field for a 100-year Storm will slow and treat stormwater runoff from the future CIS building site. Bioswales, rain gardens, permeable pavers, a retention pond, and native plants will manage all precipitation that falls on the site during a 100-year event. Additionally, the design will contribute to the campus-wide phosphorus reduction initiative. The interventions are beautiful, useful, safe, and easily maintained. The project design serves as an educational example for individuals and future development on Cornell University's campus.

We hope to make a tangible and lasting difference with this site design.

Acknowledgements

We extend our sincerest gratitude for the support of the following people:

Todd Bittner, Director of Natural Areas, Cornell Botanic Gardens

Kara Bugis, Environmental Engineering & Compliance Specialist

David Cutter, University Landscape Architect

Emily Detrick, The Elizabeth Weaver Director of Horticulture, Cornell Botanic Gardens

Michael Tomlan, Professor, Director of Historic Preservation, City and Regional Planning

Todd Walter, Professor, Department of Biological and Environmental Engineering

References

Clermont Soil & Water Conservation District. (2015). *Maintaining Your Detention Basin*. Area IV Urban Tech Team

Cline, M.G. & A.L. Bloom. (1965). *Soil survey of Cornell University property and adjacent areas*. New York State College of Agriculture

Cornell University. (2021). *Core Campus: Zone C03 Hoy Green* (Landscape Design Guidelines and Precinct Plans). [Cornell Master Plan].

Environmental Finance Center. (2019, July). *Estimating Benefits and Costs of Stormwater Management* (Part I: Methods and Challenges). https://www.efc.csus.edu/reports/efc-cost-project-part-1.pdf

EPA. (2013). *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure*.

EPA. (2021). *Operation and Maintenance Considerations for Green Infrastructure*. https://www.epa.gov/G3/operation-and-maintenance-considerations-green-infrastructure

EPA. (2021). *Spreadsheet Tool for Estimating Pollutant Loads (STEPL) and Region 5 model reference documents*. https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl-and-region- 5-model-reference-documents

Green Values. (2020). *Stormwater Management Calculator*. https://greenvalues.cnt.org/index.php?s=7164 .

Northeast Regional Climate Center. (2021). *Extreme Precipitation in New York & New England: An Interactive Web Tool for Extreme Precipitation Analysis.* http://precip.eas.cornell.edu/

Northeast Regional Climate Center. (2021). *Monthly and annual climatological normals for Ithaca, NY*. The Ithaca Climate Page. https://www.nrcc.cornell.edu/wxstation/ithaca/normal.html

NY State Department of Environmental Conservation. (2013). *Cornell Lake Source Cooling*. https://www.dec.ny.gov/lands/101040.html

NY State Department of Environmental Conservation. (2014). *Impacts of Climate Change in New York*. https://www.dec.ny.gov/energy/94702.html

NY State Department of Environmental Conservation. (2015). *New York State Stormwater Management Design Manual*. Center for Watershed Protection.

NY State Department of Environmental Conservation. (2021). *DEC Proposes New Phosphorus Limits to Protect Cayuga Lake Water Quality*. https://www.dec.ny.gov/press/122736.html

Palmer, M.A. (2014). *Methodology for Landscape Performance Benefits: Cornell University Brian C. Nevin Welcome Center*. Cornell University.

Reidmiller, D. R., C. W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Stewart, & B.C. Stewart (Eds.). (2018). *Executive Summary: Impacts, Risks, and Adaptation in the United States*. U.S. Global Change Research Program.

Soil Survey Staff. (2021). *Web Soil Survey*. https://websoilsurvey.sc.egov.usda.gov/

The Philadelphia Water Department. (2014). *Green City, Clean Waters Green Infrastructure Maintenance Manual: City of Philadelphia Combined Sewer Overflow Long Term Control Plan Update*.

USDA-NRCS. (1986). Urban Hydrology for Small Watersheds. TR-55. Conservation Engineering Division. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf