21st Century Sustainable Schoolyard
IEPA IGIG Grant

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PRE-CONSTRUCTION CONDITIONS

Goethe Elementary School is located between Rockwell St and Talman Ave near Lyndale St. The total site area within Goethe School property is 96,215 square feet, with the project area consisting of 55,650 square feet on the north side of the property. The site is bordered on all sides by low-rise apartment buildings, city streets, businesses and surface parking. A map of the pre-construction area is shown in Figure 1.

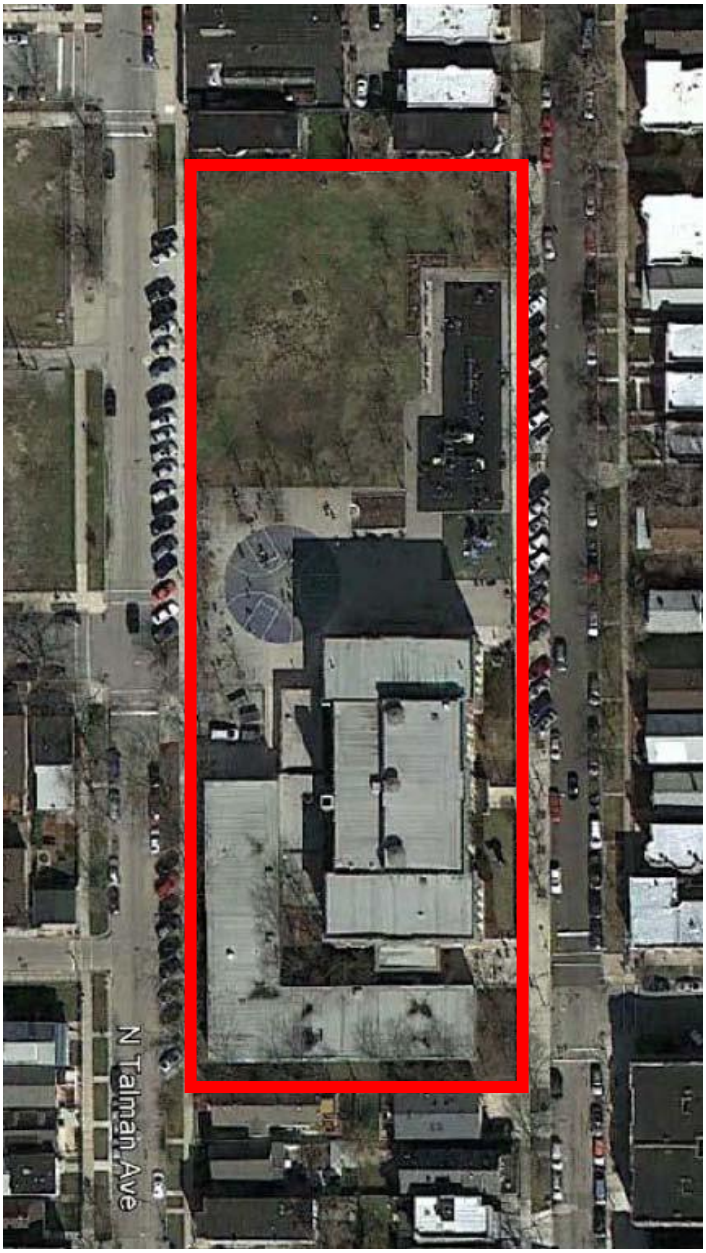

FIGURE 1. MAP OF GOETHE ELEMENTARY SCHOOL

The 21st Century Sustainable Schoolyard project was initially proposed by the Friends of Goethe School (FOGS); a school based community group. The project addresses the impairment of waterways from urban runoff, the dangers of standing water in a children's sports field, Combined Sewer Overflow (CSO) events, and flooding in local homes and businesses. The

objective of the 21st Century Sustainable Schoolyard project is to use green infrastructure BMPs to:

In the short term:

1. Reduce stormwater runoff quantity and improve runoff quality by using BMPs.
2. Prevent CSO events by retaining roof and surface runoff.
3. Maximize the impact of existing green infrastructure projects, like green alleys, in the neighboring 35th Ward.

Over the long term:

1. Create a sustainable play and educational space for Goethe students and community members that addresses stormwater retention and infiltration.
2. Maximize the benefits of neighboring Milwaukee Ave. Green Corridor Development Sub-granting Project in the 35th Ward.
3. Foster a culture of awareness and community involvement for green infrastructure projects on school grounds and throughout the city.

The proposed improvements will reduce the burden on the combined sewers as well as provide phosphorous, nitrogen, and Total Suspended Solids (TSS) reductions. The permeable concrete, pervious playground areas, and enhanced natural turf area, rain gardens, and cistern provide a variety of beneficial sustainable BMP's for this site, along with meeting the Chicago Stormwater Ordinance for detention requirements. The improvements are detailed in Table 1 below.

Table 1.Original Projected Environmental Benefits

BMP	Amount/ Area	Flow reduction gallon/yr**	Phosphorus Reduction lbs/yr	Nitrogen reduction lbs/yr	TSS reduction lbs/yr
Cisterns	3,000 gallons	44,128			
Downspout disconnect-ions	Seven	Est. 500,000			
Permeable surfaces	53,650 SF	491,084	1	12	1462
Permeable pavement	24,150 SF	383,750 (includes play area and running track)	1	5	658
Play area	9,000 SF		0	2	245
Running track	4,900 SF		0	1	133
Synthetic field***	15,600 SF	107,334	0	3	428
Rain gardens	2,000 SF	46,544	0	0	45
Stormwater reuse systems	Allowance	Est. 2,000			
Trees		34,478			
Totals		**1,118,234**	**1**	**12**	**1507**

Shaded cells are subcategories of permeable surfaces, included in total of permeable surfaces.
*Pollutant load reduction totals are from the EPA Region 5 Load Reduction worksheet. Synthetic field, running track, and play surfaces are based on porous pavement calculation within that worksheet.
**Flow reduction calculations are from the Center for Neighborhood Technology's Green Values National Stormwater Management Calculator.
***Synthetic field includes surface, infill, drainage system, aggregate detention system. Artificial turf fields with aggregate detention storage are a BMP, according to the City of Chicago Stormwater Ordinance and, therefore, a BMP followed by CPS.

The 21st Century Sustainable Schoolyard is a public space used by thousands of people every week. FOGS volunteers see the schoolyard project as a model for green infrastructure as a foundation for healthy public spaces that will be visited by architects and educators. All BMPs were designed as iconic elements incorporating student/community artwork, and will be integrated into educational experiences, functioning as outdoor classrooms with educational signage identifying sustainable practices. Thousands of students will play in this space for at least a generation. A recently established partnership with nearby Chicago Park District Haas Park will also promote visibility of this cause and use of the space. The project, as previously

mentioned, will bolster the green alley and green corridor projects running along Milwaukee Avenue 500 feet west of school grounds.

POST-CONSTRUCTION CONDITIONS

With the construction of the site improvements, the stormwater runoff will be significantly reduced, as will the impervious area of the site. The water quality leaving the site will also improve because of the filtering through the permeable concrete and CA-7 stone in the detention areas and the rain gardens. The underground detention facility detains 1.16 million gallons of water per year and releases it into the combined sewer system during each rain event at a controlled rate. The existing pre-project site conditions allowed this water to flow directly off-site into the combined sewer system causing an over burden on these sewers and in some instances flooding local residences. The construction of this facility will greatly reduce these instances. The construction of the cistern also was able to remove approximately 10,000 SF of roof area from direct discharge into the combined sewer and utilize it as a harvest water source to irrigate the enhanced natural turf area. This also created a highly visible BMP for teaching purposes.

The construction of the green infrastructure has been recently completed. A recent aerial image of the site during construction is shown in Figure 2

FIGURE 2.CONSTRUCTION PROGRESS AS OF OCTOBER 31, 2013

The bioinfiltration basin (Enhanced Natural Turf area with Aggregate Detention Area) was completed in the fall of 2014. Figure 3 below shows the Enhanced Natural Turf area with turf grass established as of Summer 2014.

FIGURE 3.ENHANCED NATURAL TURF AREA – TURF GRASS ESTABLISHED, SHOWN HERE AUGUST 6, 2014

PROJECT COMPONENTS

Five BMPs were designed for the 21st Century Sustainable Schoolyard. They include: Porous Concrete, Rain Garden, Bioinfiltration Basin (Enhanced Natural Turf Area), Cistern, and Other (Trees & Engineered Wood Fiber). These BMPs will maximize stormwater retention, as well as reduce runoff quantity while simultaneously increasing runoff quality.

Below is a detailed description of each BMP, including the reason for selecting the BMP, advantages and disadvantages, location, design considerations, maintenance, installation, materials and cost for each.

POROUS CONCRETE

REASON FOR SELECTING BMP

Porous concrete has not been previously used on CPS projects, but FOGS and CPS wanted to incorporate new green technologies into the site improvements. These paved areas will prevent pollution at the source, allowing runoff to infiltrate through the voids of the permeable surface which will filter and attenuate stormwater runoff flows. Porous concrete was chosen over porous asphalt due to the LEED benefit for reducing heat island effect.

Advantages/Disadvantages

Some of the advantages of Porous Concrete include pollutant removal and better skid resistance. Additionally, curb and storm sewers costs are reduced over traditional pavement. Poured rubber playgrounds were included in this section because they have similar principles as the porous concrete. Poured rubber is very pervious, which will allow rainwater to freely flow through to an aggregate layer & perforated pipes to be collected and stored in the detention area. It is also an advantage since it is safer than other playground materials to play on. The primary disadvantage associated with permeable concrete areas is an increase in maintenance costs.

Location

There will be approximately 7,300 square feet of permeable concrete in the center of the schoolyard and 4,000 square feet of poured rubber playground surfacing in and around playgrounds. Both materials act under the same principle of being permeable to freely infiltrate water into underlying aggregate bases to collect water and convey to an underground aggregate detention system.

Design

Porous concrete has been designed with a thick aggregate base and perforated under-drains. During rain events, water will quickly flow through the porous concrete, through the aggregate voids and into the underdrains where it will flow to the detention facility. This design element will allow for play to occur on this surface immediately after the event.

Installation & Construction

Installation of the porous concrete will be in accordance with the manufacturers' specifications.

Materials

The porous concrete areas consist of five (5) inch thick porous concrete, two (2) inches of CA-16 aggregate bedding, and six (6) inches of CA-7 aggregate.

Cost Effectiveness

The porous concrete area is 7,300 square feet plus 4,000 square feet of poured rubber playground surfacing for a total cost of $255,416.98, or $22.60 per square foot. This cost includes earthwork, perforated PVC underdrain, porous concrete, aggregate bedding, and aggregate base.

Cistern

Reason for selecting BMP

The proposed cistern will be used as the first step in the water conservation efforts on the Goethe School project site. The cistern is classified as a rainwater harvesting system. Rooftop runoff will be captured and stored for later reuse in watering landscaped areas, which will reduce runoff volume from the site. A cistern was selected as part of the proposed improvements due to the potential cost savings as a result of the re-use of rainwater for irrigation for the enhanced natural turf field. In addition, the cistern will be a highly visible element on the site, which provides an education opportunity for Goethe School to lead by example to students, neighbors, and employees.

ADVANTAGES/DISADVANTAGES

The advantages include a decrease in water use and cost savings to the school. A disadvantage of a cistern is that it was not cost effective to collect the entire roof area within the project budget. Additionally, watering of landscaping will be monitored more closely through the use of a cistern. Regular maintenance of the cistern will be required.

LOCATION

The cistern is located near the building's northwest corner.

DESIGN

The water re-use system will collect stormwater runoff from the roof of Goethe Elementary School which will fill the 14,700 gallon cistern. The collected rainwater will be re-used for irrigation of the landscaping on the site. In addition, the cistern will contain controls to utilize potable pressurized water in case of drought. A pump will be provided to ensure there is sufficient pressure for the irrigation system under the enhanced turf area.

INSTALLATION & CONSTRUCTION

Installation of the cistern will be installed in accordance with the manufacturer's and designer's specifications.

MATERIALS

The rainwater re-use system consists of: 14,700 gallon corrugated steel storage tank with a internal rubber liner (cistern), booster pump, check valves, strainer, irrigation system and all other appurtenances for a complete system.

COST EFFECTIVENESS

The total cost of the cistern is $95,631.65. The cost breakdown of the cistern is show below in Table 2.

Table 1. Cistern Cost Summary

Description	Unit Type	Amount	Cost Per Unit	Total
Catch Basin, 4' dia	Number	2	$3,000.00	$6,000.00
Catch Basin, 2' dia	Number	1	$2,500.00	$2,500.00
Concrete Pad w/foundation walls & CA-6	Yard (cubic)	18	$1,200.00	$21,600.00
Cistern, Corgal, 12' dia	Number	1	$22,000.00	$22,000.00
Downspouts (2 types + removal)	Feet (linear)	470	$24.00	$11,285.00
Earthwork	Yard (cubic)	310	$23.82	$7,383.70
Manhold, 4' dia	Number	1	$3,300.00	$3,300.00
Misc for cistern*	Number	1	various	$8,150.00
Demo**	Lump Sum	1	various	$7,250.00
Misc***	Lump Sum	1	various	$6,412.95
			TOTAL	$95,631.65

Shading indicates an average cost per unit

*Misc. appurtenances for cistern; booster pump with hot box, controls, UV purifier; Elec connection to pump, include 20A; backwater valve w/extension in MH

**Demo existing irrigation pump & controls, remove 2" cold water pipes & environmental abatement, wall penetration for 2" water service

***PVC 6", cleanout, ESVCP 6", 2" Type K Water w/ insulation mounted to cistern, CA-7

The alternative to the cistern would be to use the public water supply, which is purchased from the City of Chicago. The cost of this water is approximately $3.31per 1,000 gallons – this information is summarized below in Table 13.

Table 3. Cistern Water Cost Summary

Cistern Capacity	14,700	gallons
Annual Rainwater needed for Irrigation	137,200	gallons
Cost to use solely Public Water	$454,132	per year
Cistern Cost Savings	$359,132	

FIGURE 4.CISTERN AND POROUS CONCRETE

Rain Garden

Reason for selecting BMP

The rain garden was selected to aid in water retention on the Goethe Elementary School Project Site.

Advantages/Disadvantages

The Rain Garden is a low-cost contributor to the underground aggregate detention system. This cost effective element is also a low maintenance addition to the project site. The vegetation slows the flow of stormwater and allows for infiltration, thereby recharging groundwater and reducing detention needs. A disadvantage includes its relatively one-dimensional use in comparison with other BMPs.

Location

The Rain Garden is located on the east side of the site, on either side of the main entrance of the school.

Design

The rain garden was designed to be approximately 2,150 square feet in area. The rain garden contains a very permeable soil/sand mixture with underlying aggregate base with perforated underdrains to convey water to an underground aggregate detention system.

Installation & Construction

Installation will be in accordance with contract specifications.

Materials

The materials for the rain garden include the underlying aggregate base, the permeable soil/sand mixture, perforated underdrains and the foliage planted on the surface.

Cost Effectiveness

The rain garden has a total cost of $77,080.04.

FIGURE 5.RAIN GARDEN AT GOETHE ELEMENTARY SCHOOL MAIN ENTRANCE

BIOINFILTRATION BASIN

REASON FOR SELECTING BMP

This detention, for documentation purposes, has been classified as an infiltration basin, due to the fact it will be detaining water until it infiltrates. The Bioinfiltration Basin in this case functions as an Enhanced Natural Turf Area. The Enhanced Natural Turf Area is ideal for an elementary school as it provided an open space for playing and use by students, teachers, and the community. This area contains the bulk of the provided & required detention for the site. The enhanced turf field will also contain an irrigation system to water this area on a regular basis. The water used is the harvest roof water collected, stored & pumped from the cistern.

ADVANTAGES/DISADVANTAGES

The advantages of the Bioinfiltration Basin include the removal of pollutants including phosphorous, nitrogen, and total suspended solids through settling and filtration. As with rain gardens, the vegetation slows the flow of stormwater and allows for infiltration, thereby recharging groundwater and reducing detention needs. The primary disadvantage of enhanced natural turf areas is the increased maintenance over the first year to allow the vegetation to become established.

Location

The Bioinfiltration Basin is located at the north end of the project site.

Design

The enhanced turf field has an average of 3.2 feet of aggregate detention underneath approximately 7,500 square feet of turf.

Installation & Construction

Installation will be in accordance with contract specifications.

Materials

The enhanced natural turf area will have one (1) foot thick growing soil, four (4) inches of pea gravel, various depths of CA-7 and/or CA-1 aggregate and perforated underdrains.

Cost Effectiveness

The Bioinfiltration Basin is the most costly BMP on the Goethe project site. The total cost was $295,550.09. This cost includes earthwork, the underground irrigation system, and vegetation. Please see Figure 2 and Figure 3 for an understanding of the bioinfiltration basin and the now-established enhanced natural turf area.

Other (Trees & Engineered Wood Fiber)

Reason for selecting BMP

Trees and Engineered Wood Fiber were selected for their versatility and the seamless application of these BMPs into the project site at Goethe School. Trees are the perfect addition to a play area for shade and a calming atmosphere. The engineered wood fiber easily fit with the rest of the design.

Advantages/Disadvantages

The advantages of trees and engineered wood fiber relate quite closely to other advantages for this project. The trees provide shade, reduce the heat island effect and also provide oxygen rejuvenation. The engineered wood fiber has the added bonus of being a porous material that allows for water infiltration, much in the same way as the porous concrete. Once established, trees are low maintenance. There were no disadvantages incorporating trees into the project from a cost or maintenance objective. The disadvantage with the engineered wood fiber is the cost to periodically replenish the beds.

Location

The trees and engineered wood fiber are distributed throughout the play area specifically, with additional trees throughout the project site.

Design

Tree locations were selected to ultimately maximize provided shade. Engineered wood fiber was incorporated into the play area design.

Installation & Construction

The saplings were planted and carefully cultivated over their first year to ensure they are established. The engineered wood fiber was installed with drainage as recommended by the manufacturer. This is done to increase the life of the engineered wood fiber by reducing mold and fungus issues and to help with cold resistence.

MATERIALS

Saplings were planted and engineered wood fiber was purchased in 12 foot lengths. Three-inch deep mulch was placed at the base of the trees. Topsoil was also used in the planting.

COST EFFECTIVENESS

The trees are a cost-effective investment as after they are established, they require very minimal maintenance. The only maintenance required would be to the mulch at the base of the trees. Engineered wood fiber is also a cost-effective selection but requires maintenance.

Table 4.Tree and Engineered Wood Fiber Costs

Description	Unit Type	Amount	Cost Per Unit	Total
Mulch	Yard (cubic)	11	$40.00	$440.00
Shade Trees, 4" Caliper	Number	14	$950.00	$13,300.00
Earthwork, Re-use onsite soils	Yard (cubic)	230	$20.00	$4,600.00
Topsoil, 6' depth	Yard (cubic)	100	$30.00	$3,000.00
Engineered Wood Fiber, 12'	Feet (square)	2081	$8.00	$16,648.00
CA-7	Yard (cubic)	40	$46.00	$1,840.00
			Total	**$39,828.00**

POLLUTANT REMOVAL EFFICIENCY

In order to determine pollutant reduction from the proposed improvements, the Illinois EPA's Estimating Pollutant Load Reductions for Nonpoint Source Pollution Control BMPs workbook was used. The annual pollutant load reductions are summarized in Table 5.

Table 5. Pollutant Reductions

BMP	Cistern	Infiltration Basin	Porous Pavement	Vegetated Filter Strips	Extended Wet Detention	**Total (lbs/yr)**
BOD				1	8	**9**
COD		36	62	6		**104**
TSS		170	286	48	250	**754**
Lead						
Copper						
Zinc						
TDS						
TN		1	2		1	**4**
TKN						
DP						
TP						
Cadmium						

This treatment train process will maximize stormwater infiltration and pollutant removal by treating stormwater runoff by several different BMPs prior to discharging downstream. The wetland basins have the highest pollutant removal of all the BMPs on the site as shown in the above table. This is partially due to the duration the runoff will be in the basins, allowing suspended solids to settle while also utilizing the native vegetation and soil to remove pollutants. All stormwater runoff that is not infiltrated or evaporated will be treated by a minimum of two BMP, one of which is the wetland basins.

The cistern was not analyzed for pollutant removal efficiency, though there is a filtration system for the cistern that will remove some pollutants. The reclaimed water from the cistern will be used for irrigation of the enhanced natural turf area. The filtration system will remove large particles that could block valves and sprinkler heads as well as remove pollutants from the roof that could be harmful to vegetation.