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The Montessori School
Stormwater Management and Landscape Master Plan

Community Planning + Visualization Lab | Rowan University

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FUNDED BY
THE MONTESSORI SCHOOL AND THE PARTNERSHIP FOR THE DELAWARE ESTUARY, THROUGH A GRANT FROM PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL PROTECTION'S GROWING GREENER PROGRAM

Executive Summary

The Montessori School of Dresher, Pennsylvania is highly regarded as a creative and individualized school for children of a wide range of ages to cultivate knowledge in creative and dynamic ways. The 6.4-acre school property is located within the Sandy Run Watershed, which has been identified through William Penn Foundation's *Delaware River Watershed Initiative* as a priority for watershed restoration and improved stormwater control. Having a relationship with the environment is promoted throughout the Montessori curriculum and this plan recommends ways to improve the site to ensure this principle is achieved. Challenges facing the school include stormwater management, as well as a lack of play areas on site, making it difficult for students to immerse themselves in the space. The site has eroded areas, impervious concrete, and points of unhealthy plant life, as well as few gardens and recreational features. In order for the school to follow their ethos, this master plan proposes green stormwater management practices, as well as outdoor educational and play areas.

Students, staff, and stakeholders of The Montessori School were engaged in this planning process for a year and participated in several formal and informal meetings to discuss current challenges and brainstorm about the best solutions available to amend them. Several recurring themes were clear in this planning process, such as the desire for additional gardens, porous surfaces, reduced slopes on site, recreational areas, and reduction of erosion.

The project team—headed by environmental planners, stormwater management specialists, and landscape designers—proposes a restorative approach throughout this master plan that aims to maintain the natural beauty of the school's location. The team recommends incorporating green infrastructure practices that reduce water pollution, increase potential habitats for local ecosystems, and provide educational opportunities for the local community. Such methods include the construction of bioswales, a rain garden, a constructed wetland, a trench drain, porous pavement, flow-through planters, a vegetable garden, a wildflower garden, a native pollinator garden, a slide play element, and rain barrels. These strategies seek to reduce water runoff and should be installed in phases to comply with time and financial capabilities. The proposed stormwater features would capture 41,817.16 gallons per 1" of rainfall and 1,881,772 gallons annually, and manage 67,082.4 square-feet or 1.54 acres of drainage area.

The project team incorporated outdoor recreational opportunities that combine education and play in the design in response to the school's child-centered educational focus. Such design elements include a peace garden, climbing tower/observation deck, wood chip path, log balance beam, terraced seating area, digging pit, and a rock climb and slide area.

It is imperative that the school adopts the strategies included in this plan to preserve the longevity of the site, as well as care for the students' safety and enjoyment. The proposed green stormwater control features are estimated to cost $192,257, and the recreational features are expected to cost $56,492. The series of stormwater treatment features across the front of the campus should be completed working upslope, installing the lowest feature first. The planting of the stormwater features and gardens should serve as an excellent opportunity to engage The Montessori School students, staff, and families in understanding the benefits of stormwater management and importance of clean water.

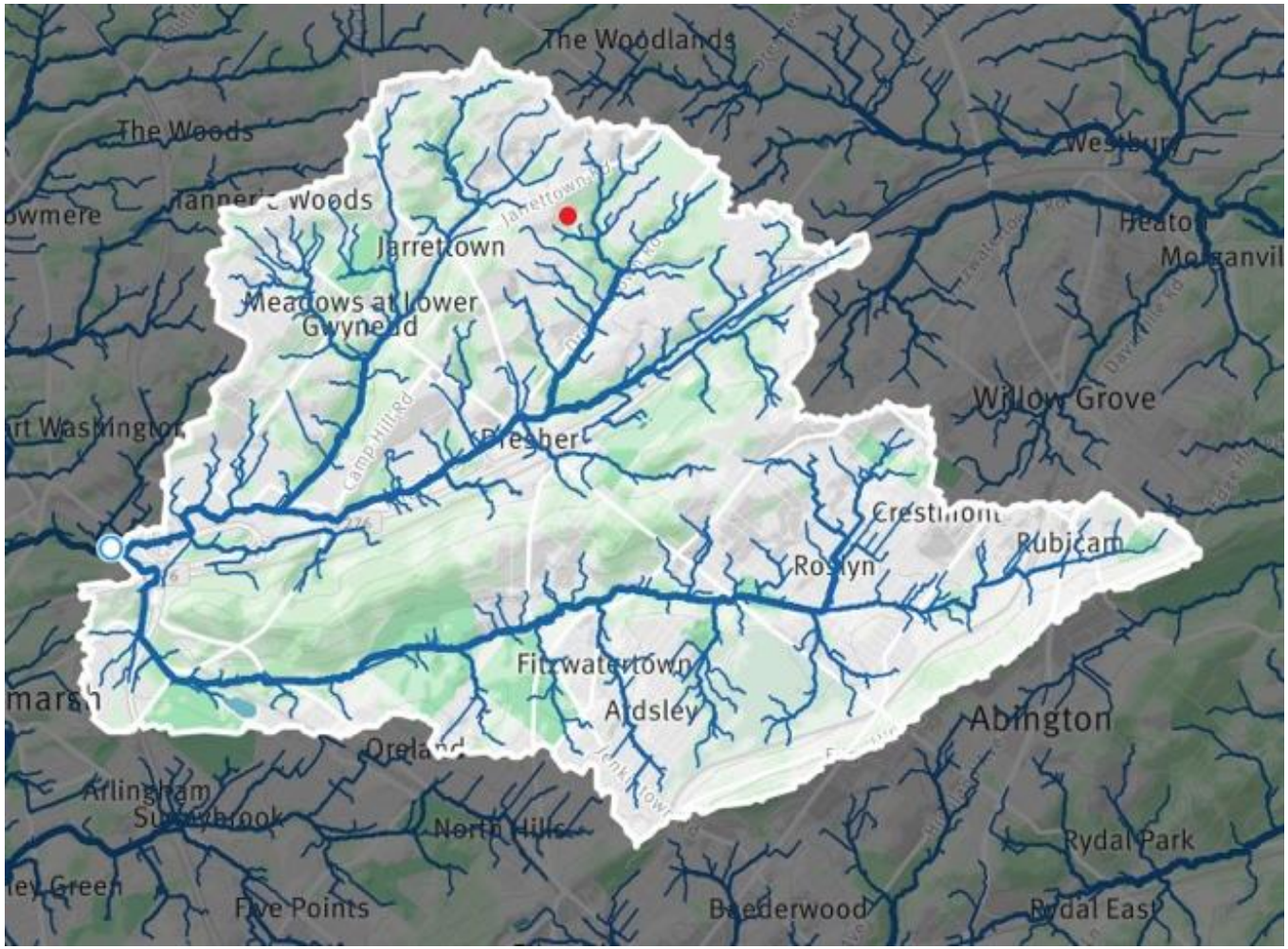
Introduction

This report presents a conceptual stormwater management and landscape master plan for the Montessori School of Dresher, Upper Dublin Township, Pennsylvania. The school exists as an accredited school through the Pennsylvania Association of Independent Schools and the American Montessori Society, as well as a 501(c)(3) non-profit organization. One hundred and fifty students are enrolled, ranging from 18 months up until sixth grade. The school boasts a low student-teacher ratio, providing a specialized focus for each student.

The property is a 6.4-acre campus that is within the Sandy Run Watershed, which has been identified through William Penn Foundation's Delaware River Watershed Initiative as a priority for watershed restoration and improved stormwater control. The site was designed over the course of 1969 and 1970 and had previously been owned by the Phil-Mont Christian Academy from 1960 until 2006. When the Montessori School purchased the property in 2006 landscape architects from SED Design installed the log feature in the back center of the site, along with some grasses. Recent renovations of the campus and school occurred in 2015, though more extensive work must be met to update the school's ambitions.

This project was funded by the Partnership for the Delaware Estuary through a grant from Pennsylvania Department of Environmental Protection's Growing Greener program, and the Montessori School. The project team members included landscape designers, environmental planners, and stormwater management specialists from Cerulean, LLC, Rowan University, and Temple University. The overall goal of this project was to outline a sustainable plan for the campus, as well as offer recommendations to ensure the success of the plan. More specifically, the project team intended to develop recommendations to revitalize the school property and create a sensory-rich campus that would allow students to further their education, as well as create a landscape that would unite students and provide opportunities for multi-age interactions.

This master plan identifies opportunities to incorporate green stormwater management and outdoor educational features throughout the property. The plan focuses on green stormwater management projects, including bioswales, rain gardens, and porous surfaces to create a more sustainable campus. Through the use of green stormwater management, underused areas should become revitalized, allowing students to improve



Location of The Montessori School (identified as red circle) within Sandy Run Watershed

their sensory-motor learning capabilities by interacting with the property's features.

Montessori's mission to create a child-centered education that considers the emotional, intellectual, physical, and social development of the whole child has influenced the master plan. Students, designers, and Montessori school stakeholders provided additional input on ways to achieve these principles throughout the physical property of the school. The current site conditions have been built up to stimulate active learning and play by implementing natural materials and non-programmed spaces. The steps to re-activate outdoor spaces would provide learning stimuli; assist in green stormwater management and safety management; and delay soil erosion. This holistic approach to planning and landscape design process should promote a welcoming and meaningful institution. The design approaches seen within the plan (e.g., climbing structure and influx of gardens) would encourage children's curiosity and promote conceptual learning and development throughout the school day.

The following four sections outline existing geographic and historic site conditions of the school campus, the participatory design process initiated by the project team, a narrative of design components and mini-projects included in the final master plan and drawings, as well as a strategic implementation plan.

The Montessori School and surrounding neighborhood are located within the Pine Run Creek tributary of the Sandy Run watershed

Existing Site Conditions

This section provides insight into the current state of the campus through an environmental and geographic standpoint. This assessment was based on multiple field observations during all four seasons, discussions with school authorities and stakeholders, and geographic information systems (GIS) analysis.

The Montessori School campus and features

Parking, Outdoor Landscape, and the School Building

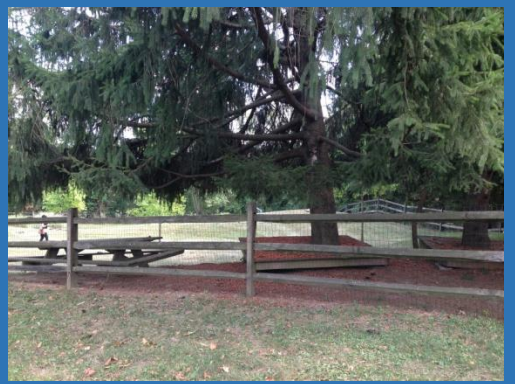
Directly in the front of the school is a 15-spot parking lot, three of which are designated accessible parking spots. East of the school there is a larger parking lot used by visitors of the Pine Run Park. There are two points of entry from Jarrettown Road to the Montessori school and the athletic fields. The main driveway, designed in a circular layout, has one entrance from Jarrettown Road. Access from the driveway at Jarrettown Road is at grade with the school property line, and slopes downward ranging from 5% to 25%. These ranges do not comply with Americans with Disabilities Act (ADA) standards for handicap accessible paths. Jarrettown Road has a speed limit of 35 mph; however, the Montessori School is within a 15 mph school zone. There is a sidewalk along Jarrettown Road that ends at the driveway to the school.

There is a peace garden in the front of the school in the northernmost corner of the property. Near the garden is a small patch of grass with two trees and a small sign displaying the name of the school, contact information, and the Montessori blue "M" emblem. Jarrettown Road is directly north of the garden, entrance to the Pine Run Park parking lot is east of the garden, and the exit from the school's driveway is west of the garden.

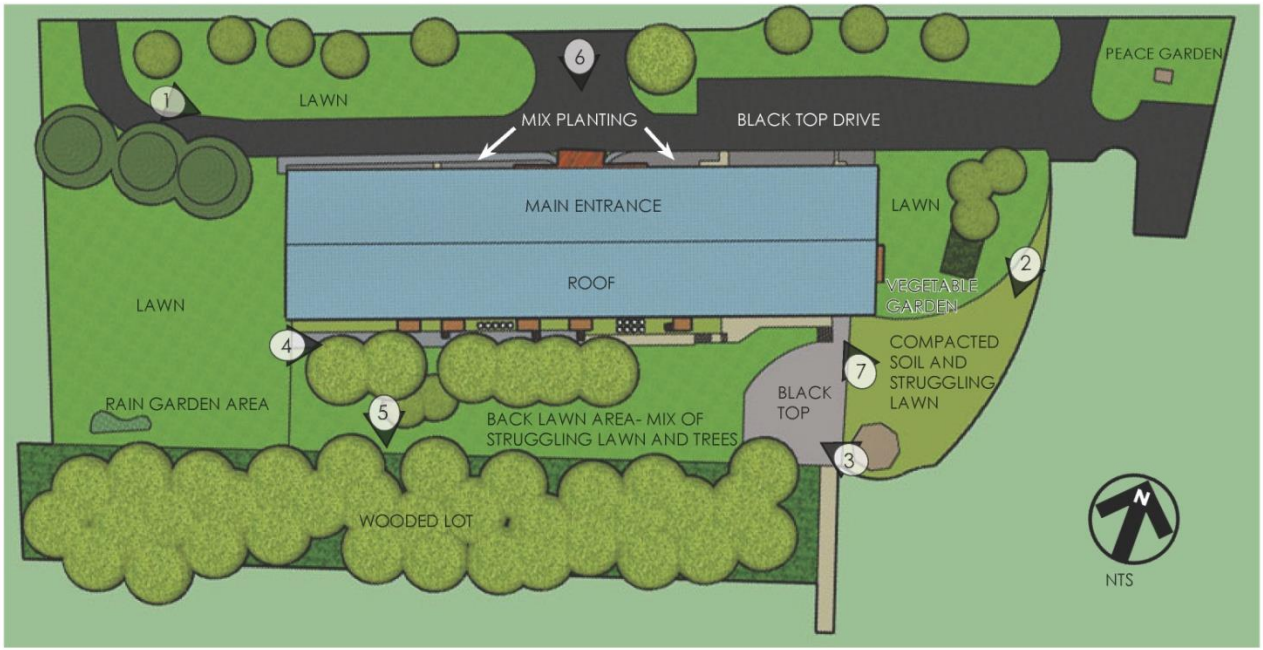
There is a small plot of grass fitted with a vegetable garden east of the school. Southeast of the garden is a larger lawn with a gaga pit and tetherball court that has compacted soil and grass struggling to grow. West of this lawn is a section of black top with a basketball court equipped with two hoops. Next to the court are large red oak trees that litter the court with acorns during late summer and fall.

A 12-foot non-ADA compliant concrete stairway from the basketball court leads to the Pine Run Park where there is a larger plot of grass with two soccer fields. A wooded lot, mostly consisting of locust trees and invasive woody plants, act as a barrier between the property line of the park and school. It is a common occurrence to find lost balls and toys from students in this section of the property.

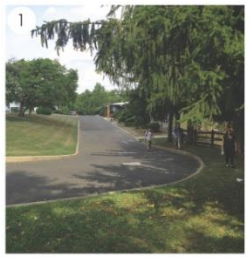
Outdoor recreational features include a slide, fenced-in play area, and an outdoor seating area.



Map of Surface Area



Surface Materials



The area in front of the building is mostly lawn and black top. There is a mix of vegetation in the front of the building consisting mostly of Ilex, Azalea and Taxus with a mix of some perennials. There are some struggling trees along Jerrettown Road.

This area contains the Gaga pit and tether ball court. The lawn is struggling and filled with debris from the stone path running through it. The soil is compacted, probably from vehicle use.

The back lawn consists of big red oaks and lawn. There is an old black-top patch for basketball. During late summer/fall, the lawn becomes littered with falling acorns from the trees.

The walkway along the back of the building is old, and failing black-top. There is a bumpout where belgian block is used as a border.

The back part of the site is wooded, mostly consisting of locust trees and invasive woody plants. The unkept lot is home to many lost balls, toys, and some miscellaneous debris.

Structure Materials

The main entrance makes use of horizontal solid wood slats. It is the only place where this type of material is used making it distinguishable from the rest of the building.

The rest of the building facade is a mix of colors and exposed aggregate in panels. The blue panels only exist on the right and left of the main entrance. The orange doors only exist on each side of the building. The stone panels are not on the back.

In the back there is a mural that adds much needed color to the area and against the concrete walls.

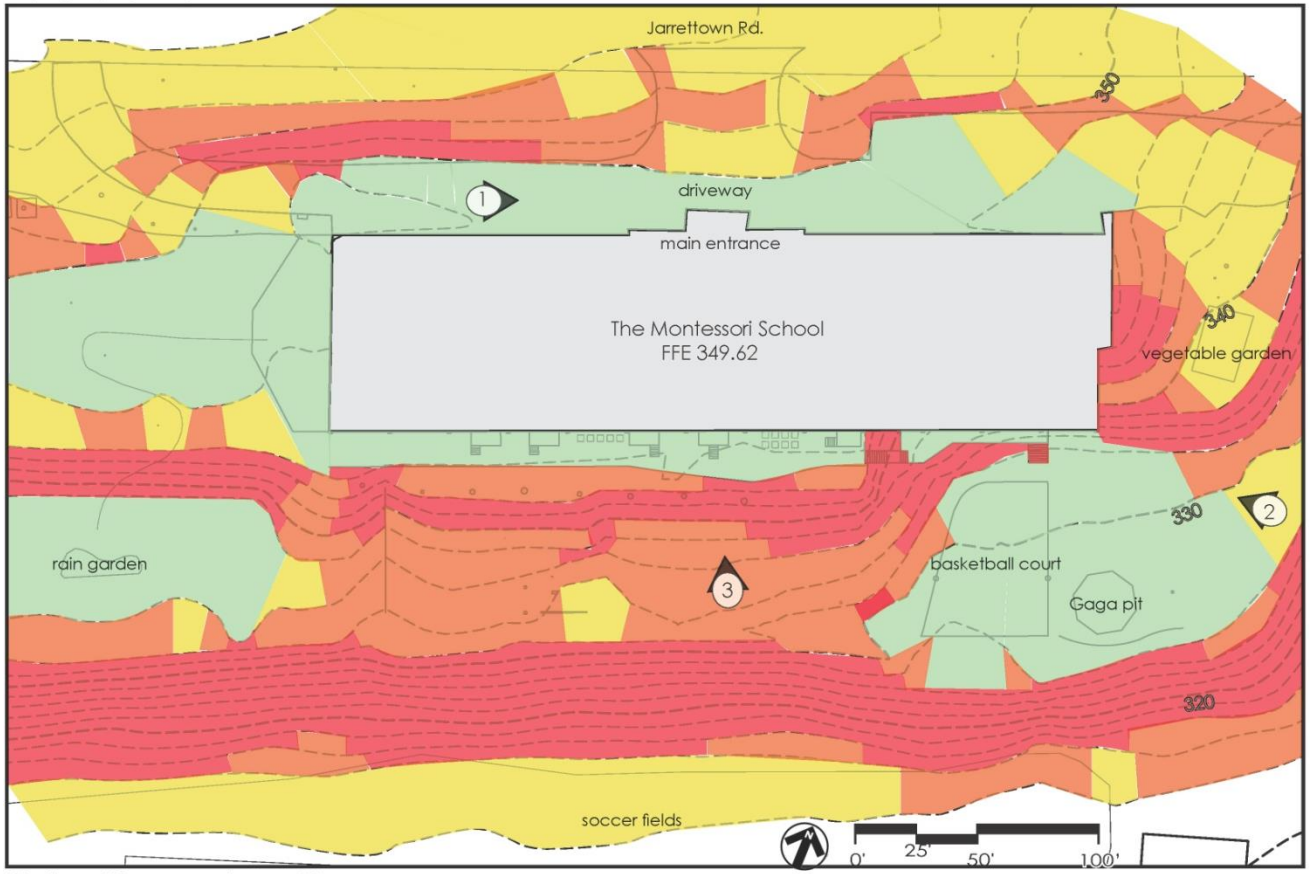
The decks along the back are a mix of wood and composite decking. The handrails are alumunium and plastic.

Visual analysis of surface and structure materials by Robert Gladfelter, Landscape Architecture Studio LARC 3145, 2016, Temple University

Elevation, Slope, and Soil

The highest point of elevation is 356 feet in the northwest corner of the site, and the lowest point of elevation is 328 feet. This range results in a total change in elevation across the property at around 28 feet. There is a limited capability of comfortable usage of the open space behind the school due to the range of slope, 10% to 25%, and in some spots greater than 25%.

Topography Map of the Site



Legend

0-5% SLOPE- The angle shown above is 3%. Positive slopes are needed for water flow. 0-2% will show very little erosion. Puddling may occur in in low areas.

5-10% SLOPE- The angle shown above is 8%. ADA (Americans with Disabilities Act) requires slopes below 8.33%.

10-25% SLOPE- The angle shown above represents 18%. At these slopes, erosion becomes a big issue from heavier storm events.

25%+ -The angle shown above represents 33% . Mowers cannot mow a hill beyond this slope. Erosion becomes a larger issue and methods of slowing down flow should be implemented.

Photos of Topography on Site

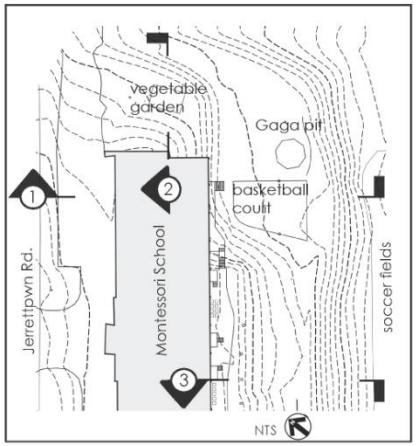
This photograph shows the various slopes in the front of the building. The pitch also varies, but everything is pitched away from the main entrance.

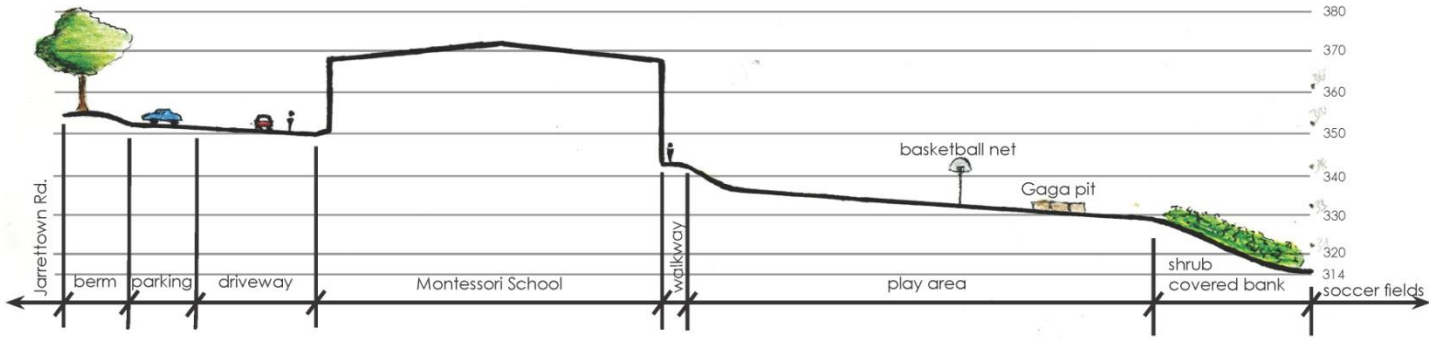
There are many hill sides along the back. The various slopes create an interesting landscape, but consideration of erosion is needed.

Concentrated water on steeper slopes can cause considerable amounts of erosion like behind the school.

The sections provided show some of the diversity of topography on the site.

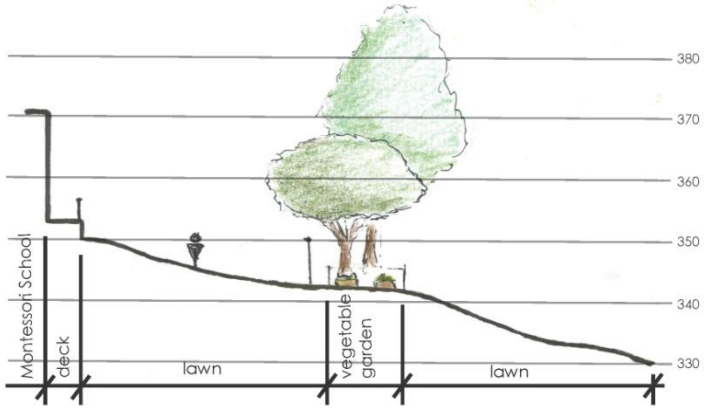
Section Location





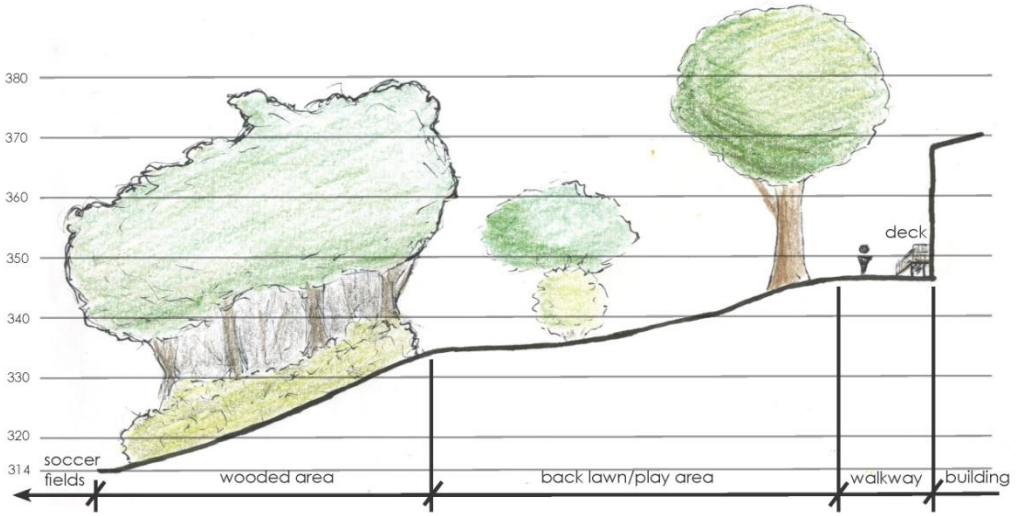
1 Section from Jarrettown Road to the soccer fields

SCALE 1"=30'



2 Section on the vegetable garden side of the building

SCALE 1"=20'



3 Section of back lawn area

SCALE 1"=20'

The school grounds are composed of three soil compositions, with soil health varying throughout the property. Croton silt loam (CrA) occupies the wooded area of Pine Run Park. This fertile soil supports plant life, though it has trouble retaining water and can easily become compact. This soil consists of deep, poorly drained soils on uplands with slopes at 0% to 3%. Runoff is low and drainage is poor, which causes the area to become occasionally ponded. The fields behind the school, a portion of the wooded lot behind the school, as well as the eastern portion of the campus, are primarily composed of Lansdale loam (LaC). This soil is well drained and has slopes of 8% to 15%. The campus itself is considered Urban land-Udorthents, with a mixture of shale and sandstone complex. This area of land (UusD) has slopes of 8% to 25%.

Montgomery County, Pennsylvania (PA091)			
Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
CrA	Croton silt loam, occasionally ponded, 0 to 3 percent slopes	2.0	17.6%
LaC	Lansdale loam, 8 to 15 percent slopes	6.0	51.8%
PIB	Penn-Lansdale complex, 3 to 8 percent slopes	0.1	0.5%
UusD	Urban land-Udorthents, shale and sandstone complex, 8 to 25 percent slopes	3.5	30.1%
Totals for Area of Interest		11.6	100.0%

Water Drainage

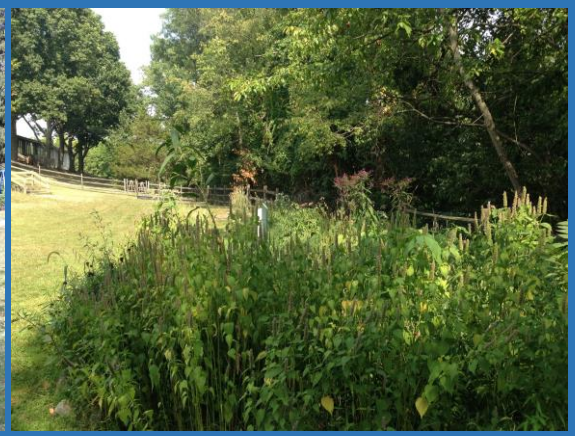
The school itself is on top of a hill, which occasionally creates a challenge for proper water drainage, especially during times of heavy rainfall. The coverage of non-permeable surfaces, including the black-top driveway, walkways, and lawn further contribute to drainage challenges. All the water on site flows toward the Pine Run Creek.

There are fifteen downspouts on the roof of the school, eight in the front of the building and seven in the back; however, the location of the discharge is unknown. The Montessori School was unable to locate any records illustrating locations or specifications of drainage features. A topographic and existing features survey, including subsurface utilities, is recommended as part of the design phase of proposed stormwater features. The survey will be able to determine discharge from the rooftop downspouts. The cost of this survey is included in the estimated project budget.

There is one stormwater grate on site, on the west side of the front drive, leading to the drainage ditch in the back of the property that runs along the west side of the soccer fields.

(Left) Runoff from the front entranceway flows towards the creek via the driveway and adjacent swale. (Right) Evidence of erosion was observed on the backside of the school.

The swale and rain garden are currently the only stormwater control practices managing runoff from the property. The swale is located to west of the school building - starting from the toddler area leading to the rain garden, allowing for some water collection.



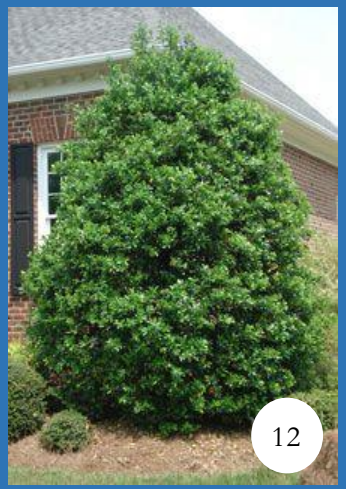
Tree Inventory

Along Jarrettown Road, on the left side facing the road there are two *Tsuga canadensis* (Hemlock), one of which is dying. There is also a *Lagerstroemia* (Crepe Myrtle), a *Cornus florida* (Flowering dogwood), and a grouping of *Ilex compacta* (Japanese Holly shrub). There is a small perennial bed that surrounds the sign.

On the opposite side, there is a *Betula platyphylla* 'Japonica' (White Birch) surrounded by *Ilex compacta* and Creeping juniper varieties. Additionally, there is a group of weak *Styrax japonica* (Japanese Snowbell). By the Peace Pole are two *Acur rubra* (Red Maple). Most of the existing trees are not native. Some of the native trees such as the hemlock and creeping junipers are struggling.

1. *Tsuga canadensis* (Hemlock)
2. *Lagerstroemia* (Crepe Myrtle)
3. *Cornus florida* (Flowering Dogwood)
4. *Ilex compacta* (Japanese Holly shrub)
5. *Betula platyphylla* 'Japonica' (White Birch)
6. Creeping juniper
7. *Styrax japonica* (Japanese Snowbell)
8. *Acur rubra* (Red Maple)

The front foundation planting consists of Taxus varieties, Azalea varieties, *Ilex compacta*, a *Juniperus virginiana* (Red Cedar), and three large *Ilex opaca* (American Holly) trees that are too big for space. There are some perennials in the open spaces, but they are not densely planted, which requires mulch and allows for weeds to grow. By the garden, there is two *Styrax japonica* (Japanese Snowbell) and a *Liriodendron tulipifera* (Tulip Poplar). The Styrex is not native and stressed due to long periods of sun exposure.



9. Taxus
10. Azalea
11. *Juniperus virginiana* (Eastern Red Cedar)
12. *Ilex opaca* (American Holly)
13. *Styrax japonica* (Japanese Snowbell)
14. *Liriodendron tulipifera* (Tulip Poplar)

A row of *Picea abies* (Norway Spruce) surrounds two sides of the fenced-in children's play area. Inside the play area, three *Liriodendron tulipifera* (Tulip Poplar) and one *Quercus rubra* (Red Oak) were recently planted. There also is a Magnolia variety and a Viburnum variety that exist with some invasive Buddleia (Butterfly Bush). There is a small children's garden with some perennials and two Lagerstroemia and a young *Cornus florida*. There are some groupings of Taxus that grow next to the stairway leading to the bottom of the play area. At the base of the play area, there is a recently planted rain garden that contains a variety of native perennials.

15. *Picea abies* (Norway Spruce)
16. *Quercus rubra* (Red Oak)
17. Magnolia
18. Virurnum
19. *Buddleia* (Butterfly Bush)
20. Lagerstroemia

Along the back of the building are six mature *Quercus rubra* (Red Oaks) that should remain intact if possible. There are also two large native *Juniperus virginiana* that benefit the local ecology and should be preserved. Along the back of the schoolyard and the soccer fields is a wooded area consisting mostly of *Gleditsia triacanthos* (Honey Locust), Maple varieties (including the invasive *Acer platanoides*, Norway maple), *Juglans nigra* (Black Walnut), and the invasive *Pyrus calleryana* (Callery Pear). The undergrowth is mostly non-native invasive plants including *Lonicera maackii* (Amur Honeysuckle) and *Rosa multiflora*.

A lot of the plants in this area are struggling due to the overgrowth of aggressive vines. Upon observation, there is a need for plant knowledge by the groundskeeper. Some invasive plants are being cultivated and cared for that should be removed.

21. *Quercus rubra* (Red Oak)
22. *Juniperus virginiana*
23. *Gleditsia triacanthos* (Honey Locust)
24. *Acer platanoides* (Norway Maple)
25. *Juglans nigra* (Black Walnut)
26. *Pyrus calleryana* (Callery Pear)
27. *Lonicera maackii* (Amur Honeysuckle)
28. *Rosa multiflora*

Participatory Design Process

Montessori students, teachers, and stakeholders, as well as Landscape Architecture students from Temple University participated in the multi-step participatory design process. The project team facilitated activities and design charrettes held from June through August 2016. Current lower and upper elementary students participated in the start of the process. The students participated in a physical map activity as well as a facilitated discussion of their ideas for the master plan. A community design charrette occurred two months after the initial student charrette and included stakeholders, teachers, and administrators from Montessori. The attendees participated in an interactive design activity as well as small-group discussions. Temple students from the Landscape Architecture Design Studio led a brainstorming activity by way of presenting their conceptual designs for the property. After extended discussions, the project team held a voting and comment period where stakeholders and teachers choose their favorite conceptual plans. Participation from community members allowed the project team to understand what features were necessary for the master plan.

Upper and Lower Elementary Student Design Charrette

On June 2, 2016, students from the two lower elementary houses and the one upper elementary house participated in an interactive mapping exercise. Students completed an outdoor scavenger hunt to become better familiarized with aspects of the campus landscape. Students found the listed items and placed color-coded stickers on their group's map. Facilitators led the students in a discussion where children split up into small groups and held productive conversations about the future of the campus.

Map Activity: Students from the upper elementary school and lower elementary school engaged in an outdoor scavenger hunt and small group discussions led by a facilitator. The participants searched for streams, tall trees, vegetable, peace, and rain gardens, eroding earth, sites of water drainage, roof downspouts, and porous surface materials. This activity helped students get their bearings of the campus and a better understanding of what the school has and lacks. Once the students found the items listed in the scavenger hunt, they placed a color-coded sticker on a map of the area. When students had a completed map, they reconnected inside and had small group-discussions regarding their favorite parts of the campus and desires they had for the future of the school's landscape.

Small Group Discussions: After the interactive outdoor scavenger hunt and mapping exercise students reconvened indoors to share their insights and desires for the Montessori School. Both upper and lower elementary students expressed a desire for a greater ease of access to the outdoors and ability to explore and relax in the area in unique ways including hammocks, log seating, tree houses, and seating on slopes. Students expressed interest in having spaces where they could make art, have lessons, relax, and play.

Their solutions to reducing erosion included installing stormwater controls, such as rain barrels and downspout plants, to absorb water. Students conveyed an interest in design features that involved interaction with the natural environment: a slide built into the hillside, natural climbing opportunities, a bridge, and outdoor seating areas with logs underneath shade-providing trees. The school currently has one vegetable garden, and the children vocalized ways they could expand it, including planting an orchard and berries.

Most responses alluded to the students' enjoyment of the outdoors and desire of fostering a community at school. Students gave feedback on the current recreational activities offered at the school, noting that the gaga pit is rarely used; soccer is the majority's favorite activity; the basketball court needs to be improved, and the area near the tetherball court should be converted to a more naturalized surface. Student responses varied from the imaginative, "I wish we had a city in the trees," to the practical, "add more native plants near the stream." Those who participated gave insight on how they interact with the property as well as their favorite places on site.

"What I love about my school, what I want to add to my school"

"Vegetable garden – I like harvesting plants. Plant trees by toddler area and soccer field. I would add more flowers and plants to the peace garden. I sometimes like to sit under the trees in the field. We spend the least amount of time in the parking lot. We usually play soccer. We should have platforms on the trees with a bungee bridge."

- Upper elementary student

"I liked the idea of the outdoor classroom. I want an actual playground. My favorite place is the fields by the oak tree. Expand the vegetable garden. Vegetables will become big part of outside learning. I want a dove on the peace garden."

- Lower elementary student

"Rain garden: because it's mostly plants and flowers. I like the trees by the backside of the school because they throw the most shade. There should be more trees at the front of the school building. You should add more non-vegetable plants by the peace garden. I like sitting on the steps by the field. To protect the stream you could plant more native plants. I think the school should have a cloister. I also think there should be a giant tree house. I like the shady spot by the back of the school near the ditch. I don't spend much time by the tetherball area. I talk on the steps and play soccer on the field."

- Upper elementary student

"More shade *[arrow drawn to steps near mural]*. So much trees, thousands. More shade on play area. More shade on soccer field. Peace garden, we need lots of plants. Trash can on our playground. Add patio to roof, so we could hang up on there."

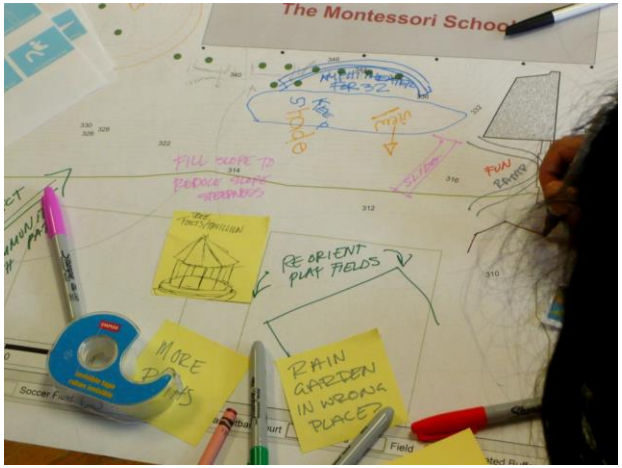
- Upper elementary student

Community Design Charrette

On August 31, 2016, the project team organized a community design charrette at the school. Thirty-four people attended, including Montessori School teachers, administrators, and Board members; faculty and students from the Temple University Landscape Architecture department; and representatives from the Partnership for the Delaware Estuary, Upper Dublin Township, and Wissahickon Valley Watershed Association.

The charrette began with a visioning and design workshop presentation to promote creativity. Attendees answered two questionnaires, one preceding the group design exercise and another following the activity. Before the group activity, the project team asked participants what their vision for the Montessori schoolyard is, and what they would like to add to the schoolyard. After participants shared their proposed elements for the future grounds, those in attendance split into five groups. The groups engaged in design exercises to visually depict their group's design elements on a large-scale map of the focus area. Temple University Landscape Architecture students (Design Studio III, taught by Professor Rob Kuper) assisted the groups by taking notes and giving helpful suggestions on how to place specific elements on maps.

The charrette allowed participants to voice their ideas and concerns and generate a collective vision for the Montessori School, influencing the master plan. Participants noted that the exercise opened their eyes to new creative options. After the group design exercise, the questionnaire asked the participants to reflect by asking if their vision changed based on the group design experience, which design was their favorite, and which elements they liked best from each group design.



Conceptual Design Presentations

On October 24, 2016, students of Temple University Landscape Architecture Design Studio III presented their conceptual design ideas for the study area at the Montessori School. There were thirteen proposals in total: “Where We Grow Our Roots,” “Habitats Abroad,” “Mountaintop View,” “Waves with Nature,” “Pure Imagination,” “Overlook,” “Tranquil Adventures,” “The Outlook,” “Nature's Gift”, “Ancient Story Time,” “Sprout Terrace,” “Splash of Color,” and “Wild Watering Holes.”

Designs reflected comments and ideas from the two previous charrettes held at the Montessori School and were guided by Professor Kuper. Students presented their inspiration, objective, and program, along with their physical drawing. The program described elements of their design that remedied problems raised at the student and community charrettes. Some of these solutions included: create a shaded lawn play area underneath oaks by regrading, add climbing rocks to retain soil on steep topography, and increase garden areas.

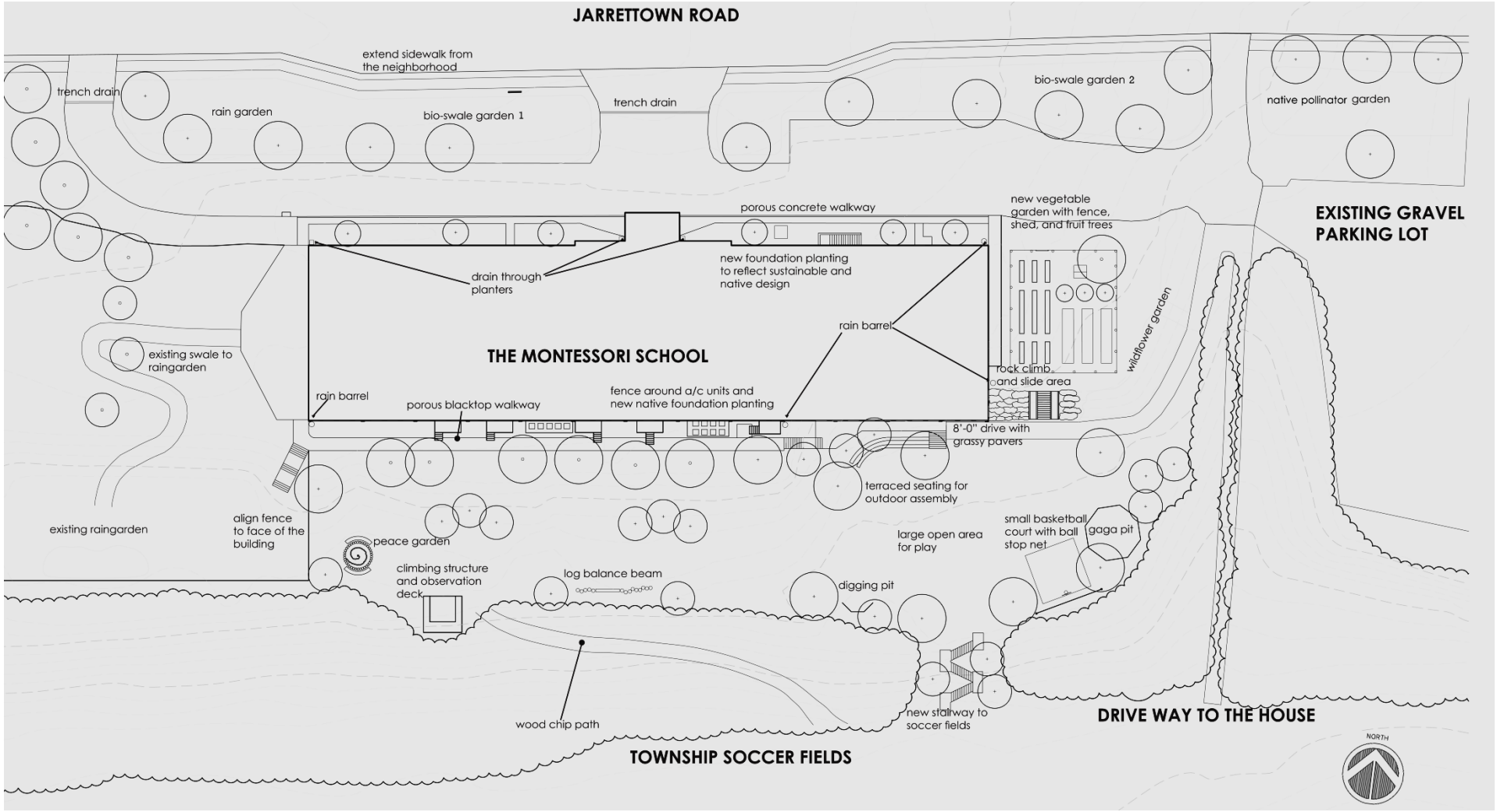
Following the presentations, school representatives and stakeholders offered feedback regarding the designs’ plausibility, creativity, and necessity.

Reoccuring Themes / Design Elements

Layout of the School	Outdoor Recreation/ Gardens	Water Drainage/ Erosion	Slope/Elevation	Education
Bright colors were brought up in several students' designs, though the general consensus of the stakeholders was to stick to a natural color palette, avoiding an overabundance of visual stimulation while still appealing to multiple ages and genders.	Though digging and building areas interested participants, teachers made it clear that play areas could not be secluded - adults need all play areas to be in sight at all times and cannot be encumbered by tall trees or plants as they can obscure supervision.	Additional rain gardens appealed to stakeholders as a way to improve stormwater management.	Adding slides to the hillside on campus allows for positive interaction with the environment.	Attendees reacted positively to the construction of an amphitheater outdoor classroom where classes could be easily held and organized
Stakeholders responded warmly to adding larger gardens out front as a way to buffer the school from Jarrettown road.	Participants disliked adding a pond on-site as it is a potential safety hazard and may attract mosquitoes.	Incorporation of porous surfaces to reduce standing water was an important element.	Participants felt that additional work needs to be done to the hillside in the back of the site, either by leveling the hill, incorporating a hillside slide, or adding a ramp with a more gradually sloped hillside.	Having places for students to rest and engage in silent observation is a beneficial addition.
Attendees agreed it would be beneficial to move the peace garden from the front of the building to a safer and quieter area.	Those in attendance felt building a labyrinth would be a positive addition to the school and would invite students to practice meditation, self control, and a sense of discovery.	Additional stormwater management tools need to be incorporated into the plan as reducing erosion is a top priority.	Participants mentioned the need for flat spaces on campus for sports.	Having a space where children could dig and build is important for building their sensory-motor skills.
Participants felt strongly that decks should not be removed.	Expanding the vegetable garden and adding a pumpkin vine area or orchard is an important addition.	Erosion along the side of the campus needs to be extensively controlled.	Building a tree house, climbing structure, or observation deck would help break up the topography of the site and give students access to higher elevation.	Each design element should tie into the Montessori philosophy of education.

Master Plan Components

The proposed master plan is based on the reoccurring themes and the thirteen original concepts described in the previous section. The process began with a meeting with Partnership for the Delaware Estuary representative, Montessori School representatives, and project team members to discuss the comments and ideas generated from the previous design initiatives. Following the meeting, the project team finalized the program and prioritized two main design categories: stormwater management and outdoor education/play areas. Stormwater management is prioritized throughout the plan, and many of the elements seen in the design assist in retaining water on site. Several outdoor education/play areas also assist in stormwater management. Since the small children's play area had been recently designed and installed prior to this project, it was omitted from the final design. The following section describes the stormwater management and outdoor education/play areas in further detail.

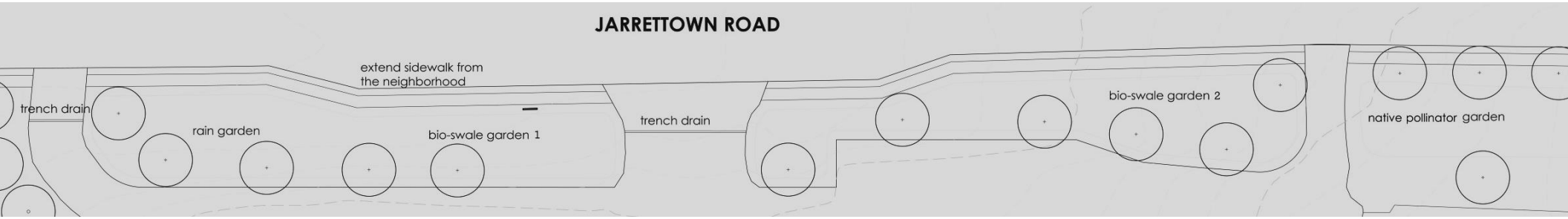


Stormwater Management

The plan recommends that the two lawn areas between the school and Jarrettown Road become a treatment series of large ***bioswales*** (or ***vegetated swales***) with a small ***rain garden*** on the top piece of lawn. ***Trench drains*** placed in the driveway could capture water run-off from Jarrettown Road and direct it to these areas. A deep rooted native plant palette able to withstand flood and drought conditions would allow for better water infiltration into the soil. Water that may dispose from these swales would lose much of the impurities and velocity as it is filtered through the plantings.

The bioswale should terminate at the second island and discharge to a swale along the driveway toward the farmhouse, as this is the natural flow path and the most suitable location to discharge these features. The island in front of the gravel lot—currently containing the Peace Pole—can be converted to a ***native pollinator garden***.

Native pollinator garden

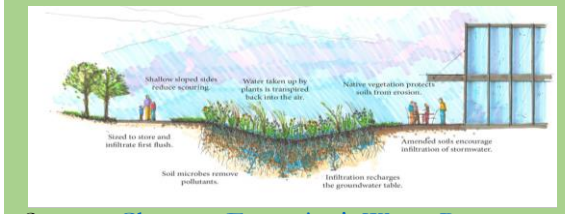


BIOSWALES

Bioswales are usually linear systems, designed to manage runoff from a large impervious area, such as a parking lot or roadway. Bioswales often require use of engineered soils and are deeper than rain gardens, because they need to accommodate greater quantities of stormwater. Bioswales can effectively manage stormwater by reducing flow velocity and filtering stormwater. They are vegetated with plants that can withstand both heavy watering and drought.

Two bioswales for a housing development. Foreground - under construction; background - established (Source: Wiki Commons)

Bioswale in Portland (Source: Clemson Extension's Water Resources Program)



Source: Clemson Extension's Water Resources Program Team

RAIN GARDENS

Rain gardens are smaller systems with a slight depression to help collect storm water. They are vegetated with plants that can withstand both heavy watering and drought. The existing soil is often used in rain gardens if it provides adequate water infiltration rates, although native soils can be amended with some sand or compost if needed.

Source: Friends of Bolin Creek

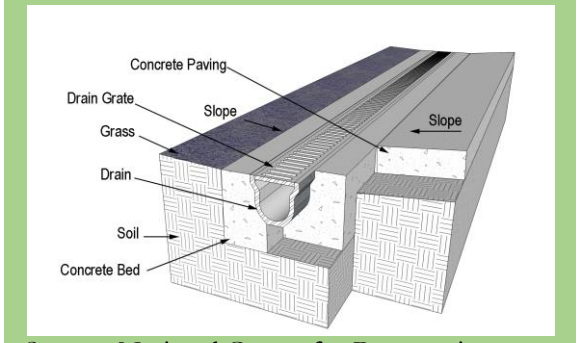
Source: Friends of Bolin Creek

Source: Washington State University Extension

TRENCH DRAIN

A trench drain is a cast-in-place or preformed concrete trench usually covered with a grate that serves as both a drain and a collection point for storm water runoff.

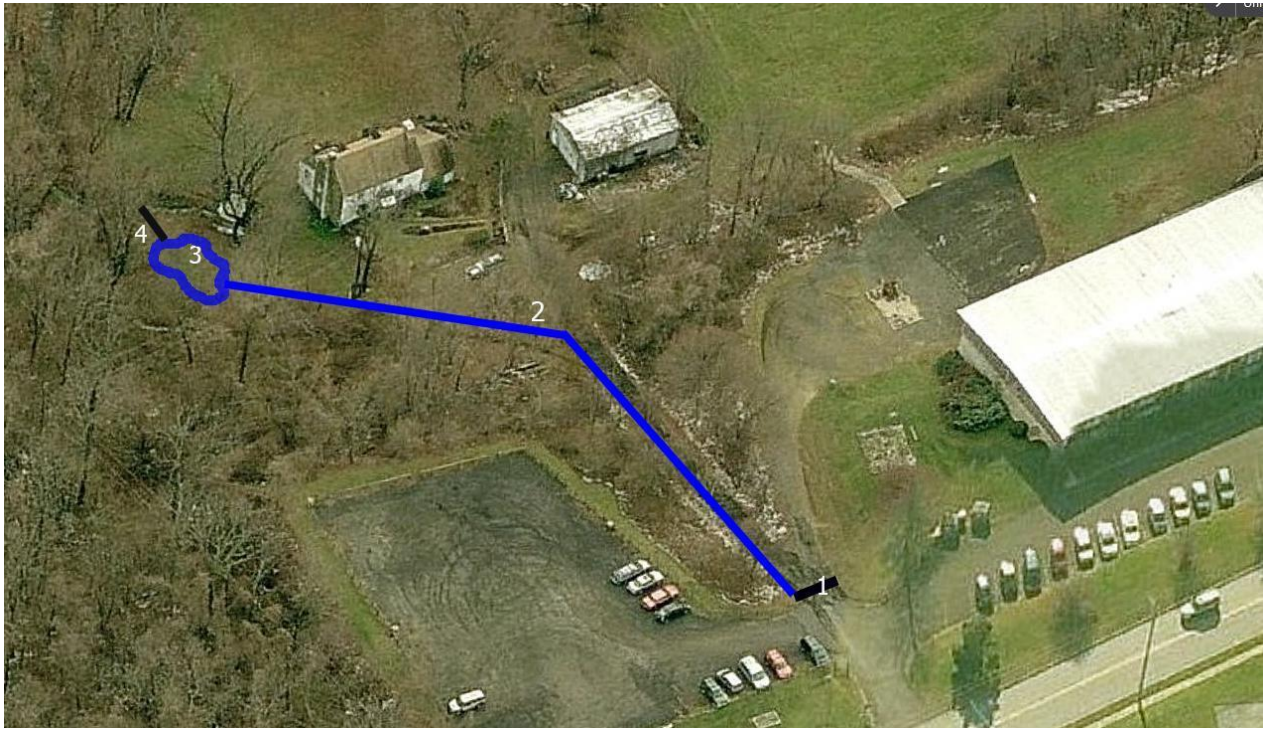
Source: Trench Drain Blog



Source: National Center for Preservation Technology and Training. Image Credit LDHP Cynthia J Steward.

Runoff from the Montessori School flows on and along the driveway to the farmhouse. A portion of the drainage flows through a natural swale that runs parallel with the school's driveway. In order to better promote drainage, the existing swale could be more defined and shaped to provide additional capacity to convey flows. A stabilized ***bioswale*** could reduce velocity of the runoff while safely conveying flows to the creek. The swale could also provide a suitable discharge location for any stormwater features installed at the front of the school.

A ***trench drain*** should be installed at the top of the driveway to intercept and direct flows toward the swale. There is space available to install a stormwater feature at the termination of the swale prior to its discharge to the creek. A ***rain garden*** or ***constructed wetland*** at this location would provide opportunity to reduce the volume of stormwater and pollutants discharging to the creek. A report of August 7, 2017 site observations can be found in **Appendix A**.

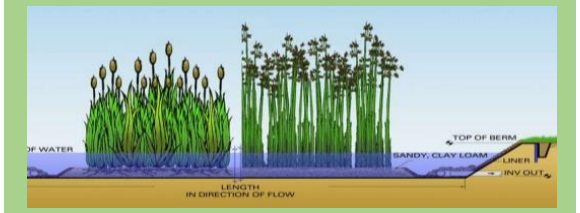


This is an aerial view of recommended option for conveying stormwater runoff. Numerical references identify proposed locations for: 1. Trench drain; 2. Bioswale; 3. Stormwater feature (a rain garden or constructed wetland); and 4. Discharge to creek.

CONSTRUCTED WETLAND

A constructed wetland is an artificial wetland created for the purpose of treating stormwater runoff. The system uses natural processes involving wetland vegetation, filter bed- consisting usually of a combination of sand and gravel, soils, and their associated microbial assemblages to improve water quality. Some constructed wetlands may also serve as a habitat for native and migratory wildlife.

Source: Natural Building Blog



Source: Natural Systems International

POROUS PAVEMENT

Porous (or pervious) pavement (e.g., concrete, blacktop surfaces) is a special type of pavement with a high porosity allowing for stormwater runoff and groundwater recharge.

Porous Concrete (Source: Secement.org)

Porous Asphalt (top) vs. traditional asphalt (bottom) (Source: vaasphalt.org)

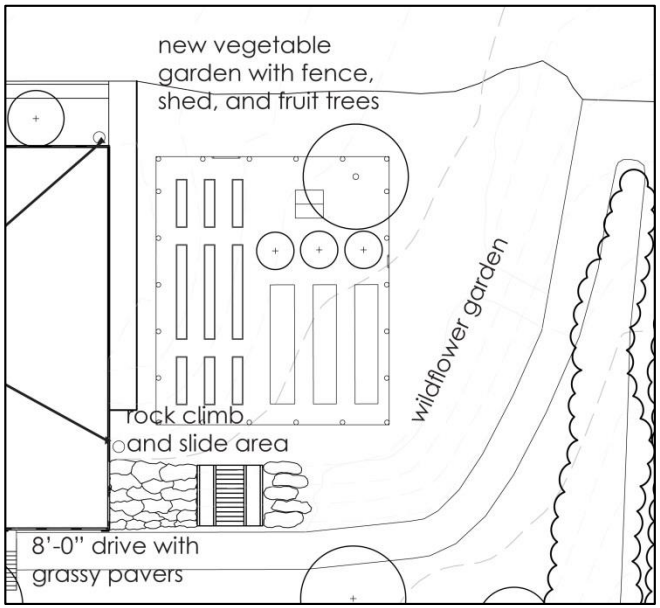
FLOW-THROUGH PLANTER

Flow-through planters can be used next to buildings where soil moisture is a potential concern. They are designed to treat and detain stormwater runoff--via downspouts leading from the roofs--without allowing seepage into the underlying soil. Source: Welsh wildlife

A sidewalk should be included to allow for safe passage along the school property from the surrounding neighborhoods. This sidewalk should be constructed of ***porous pavement*** (porous concrete). A grass border along the beds would give a manicured appearance to the entranceways of the schools, and offer a potential space for interpretive signage regarding the benefits of green stormwater management. It is recommended that large trees be planted along the edges toward the school to supply shade to the blacktop driveway and to the school in late afternoon. This would help with thermal impacts of drainage that flows off of the blacktop and should also help with cooling costs during the hot summer months.

In front of the school the blacktop walkway should be removed and replaced with ***porous pavement*** to allow for water infiltration. The planting bed along the foundation could include some small understory trees and a native plant palette that, once established, would require less maintenance and water. If planted, the small trees would give partial shade to the front of the building in the afternoon, reducing energy usage for cooling. There are three ***flow-through planters*** that were donated by Pennsylvania Horticulture Society (PHS). It is suggested that two be placed on either side of the main entrance and one by the entrance to the kindergarten room. Considerations should be made to sealing the basement wall before completing the planting on that side, as there are problems with water getting in.

The existing ***vegetable garden*** located along the east side of the building should be increased in response to student and faculty requests. The garden boxes may be terraced to allow for better water infiltration and a reduction in water run-off from the hillside. The garden could have a fence around it to keep deer from entering. On the hillside below the garden, students can plant a ***wildflower garden*** which would provide ground cover, allow for better infiltration of stormwater, and reduce water velocity. To the bottom of this hill it is suggested that a ***slide play element*** be built to assist in stabilization of eroded areas.



On the back of the building, the blacktop walkway should be replaced with ***porous pavement***. If replaced, the cobblestones would have to be removed and soil would be brought in so that the eroded hillside could be repaired and turned into a lawn area. This would allow water to sheet flow toward the woodland area in the back of the property. If the area becomes restored, it would allow for even more infiltration and evapotranspiration. Along the building foundation additional planting beds with native plant palette to assist in water infiltration should be installed.

Three ***rain barrels*** have been donated to the school by PHS to be used for plant watering purposes. These should be placed by the kindergarten room, along the back, and by the garden side. In the future they may be replaced with a cistern, which not only would hold more water for the gardens, but would reduce the amount of water going down the drains. It is recommended that the overflow from the rain barrels be tied back into the downspouts.

There is a need for occasional vehicular access to the bottom gym and basement doors and a 8'-0" wide pathway with ***grassy pavers*** is a suggested design element. The grassy pavers would give structure so that a vehicle could drive across the lawn without compacting the soil, and still allow grass to grow.

The plan recommends a substantial reduction of the lawn area and the large perennial beds with trees and shrubs, which would greatly reduce the amount of runoff from this area. This would also relieve the stress from the only drain located in the front of the building and reduce the volume and velocity of water that enters Pine Run through the drain ditch.

By implementing these green stormwater elements the volume of water that makes it to Pine Run Creek would be reduced and the water that reaches the creek would be better filtered. Using a native plant palette that could handle different conditions and functions would reduce the amount of watering and mowing needed, making the site more sustainable. The first two years of plant care is the most important to ensure that the plants become established.

GRASSY PAVERS

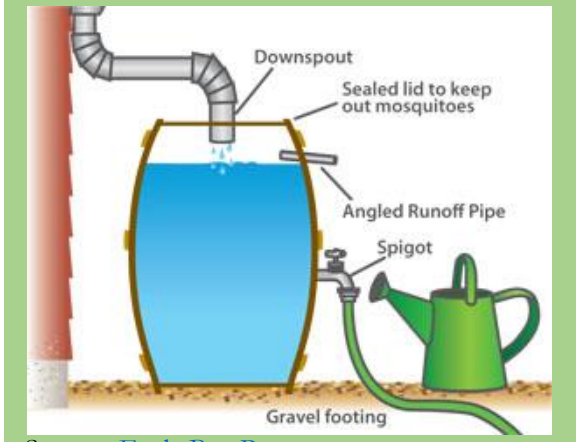
Grassy Pavers are the environmentally-friendly alternative to solid paving. With the strength of pavement and the natural beauty of grass, these pavers eliminate soil compaction, reduce reflective heat, and allow for all-weather accessibility, while allowing stormwater to naturally penetrate into the subsoil.

Sources: ptkevrodor.ru (left) and des.state.nh.us (right)

RAIN BARRELS

A rain barrel is a storage container connected to a downspout that captures stormwater runoff from the roof. Once the barrel is full, excess water will flow back into the downspout. The stored water can be used for plants or outdoor cleaning.

Source: Phillywatersheds.org



Source: Eagle Bay Pavers

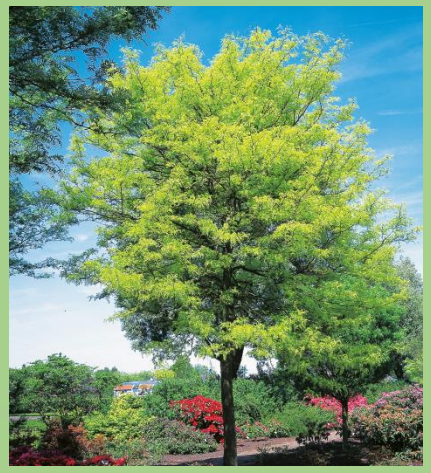
Plant Pallette

This section proposes a conceptual set of suggestions design professionals may use in planning landscapes across the campus. A beautiful and responsible planting design that includes ecological principles promotes healthy and sustainable landscapes connecting students, faculty, and visitors to a natural-state environment and its functions within the urban setting. The plant palette should utilize native and adaptive plants using a right-plant-in-right-place concept based on growth habits and required habitat for longevity and plant health. Through the use of native plants and plant communities, a resilient and adaptable landscape system would develop. Management of natural plantings should be with the understanding that these are dynamic ecologies and are subject to change as biomass increases.

The Montessori School lies in the Piedmont ecology zone defined by mostly oak and chestnut dominated forests. The 3school is likely located in a bottomland oak/hardwood forest, induding oaks, hickory, honey locust, sycamore, and red maple. This plant community should be used when restoring the woodland edge.

Red Oak

Hickory



Honey Locust

Sycamore

Red Maple

The bioswales and rain gardens should use a plant palette that is salt tolerant and able to handle occasional flooding. They should consist of a mix of warm and cold season grasses with some flowering perennials.

Rain Garden Plants

Liatris spicata, dense blazing star
Blooms July and August
FAC native plant reaching 3'-4' tall

Asclepias tuberosa, milkweed variety
Blooms May – September
FAC native plant reaching 1'-3' tall

Rudbeckia speciose, black eyed susan
Blooms August- September
OBL native plant reaching 2'-3' tall

Symphyotrichum novi-belgii, New York Aster
Blooms July – October
FACW native plant reaching 2'-3' tall

Baptisia australis, Blue Wild Indigo
Blooms April – July
FAC native plant reaching 3'-5' tall

The wildflower gardens should be a combination of perennials to attract pollinators to the vegetable garden. Using a mix of sedums and stonecrops around the climbing rocks would help cover any exposed soils and reduce any erosion. Creating these types of different plant communities would help build plant diversity as well as create learning opportunities for the school and the surrounding communities. To reduce the amount of mulch used there should be a completely covered ground layer. Partial shade tolerant plants should be considered in the foundation beds. To reduce the whitetail deer population from damaging the restoration area fences should be strategically placed around the plant community.

Wildflower Garden

Sedum

Stonecrop

Local Examples of Native Plant Community

Native grasses at Morris Arboretum

Native foundation planting at University of Pennsylvania

Native pollinator garden at Jenkins Arboretum

Native pollinator garden at Morris Arboretum

Woodland edge at Jenkins Arboretum

Woodlands at Robbins Park

Environmental Benefits of Stormwater Management

The Wissahickon Creek Watershed is identified as impaired on the Pennsylvania Integrated Water Quality Report for Siltation, Suspended Solids (list 4a), Nutrients (list 4a), and Pathogens (list 5). Upper Dublin Township is working on strategies to address these impairments and reduce the pollutant loads to the Wissahickon. Implementation of these projects would provide opportunities to reduce Total Phosphorus and Total Suspended Solids.

The following charts outline the potential pollutant reductions based on the Department of Environmental Protection's guidance document on BMP (stormwater best management practices) Effectiveness Values.

The proposed stormwater features will collectively manage 67,082.4 square-feet or 1.54 acres of drainage area. On average in Montgomery County, there is 45" of rainfall annually. The United States Geological Survey (USGS) calculations derive that 1" of rainfall on 1 acre of impervious area produces 27,154 gallons of runoff. The project team used this calculation to determine that the proposed stormwater features would capture 41,817.16 gallons per 1" of rainfall and 1,881,772 gallons annually.

The drainage area delineation and pollutant reduction estimates for bioswale 1 includes the associated rain garden in the entrance island. The drainage area delineation and pollutant reduction estimates for the rain garden at the farmhouse includes the capture areas for bioswales 1 and 2.

Load Reduction

Project Type	% Efficiency Value	P Reduction with BMP lbs/yr	TSS reduction with BMP lbs/yr
Bioswale 1	75% TP, 80% TSS	0.231	113.96
Bioswale 2	75% TP, 80% TSS	0.269	175.52
Rain garden – farmhouse	45% TP, 55% TSS	1.03	882.45
Porous Pavement & Pavers	20% TP, 55% TSS	0.018	40.46
Filtering practices	54% TP, 56% TSS	0.035	11.57
Tree Planting	15% TP, 20% TSS	0.012	5.3
Total Pollutant Reduction =		**1.595**	**1229.26**

Pollutant Load Determination

Project Type	Capture Area (acres)	Impervious capture area (acres)	Pervious Capture are (acres)	Impervious existing P load lbs/yr (2.28 x acres)	Pervious existing P load lbs/yr (.84 x acres)	Total P Load lbs/yr	Impervious existing TSS (1839 lbs/acre/yr)	Pervious existing TSS (264.96 lbs/acre/yr)	Total TSS Load lbs/yr
Bioswale 1 (includes rain garden DA)	0.3	0.04	0.26	0.09	0.218	0.308	73.56	68.89	142.45
Bioswale 2	0.26	0.1	0.16	0.228	0.134	0.359	183.9	35.5	219.4
Rain Garden farmhouse	1.32	0.82	0.5	1.87	0.42	2.29	1507.48	132.48	1604.46
Porous Pavement & Pavers	0.04	0.04		0.091		0.091	73.56		73.56
Filtering Practices	0.078		0.078		0.065	0.065		20.66	20.66
Tree Planting	0.1		0.1		0.084	0.084		26.5	26.5
				Total existing P load = 3.197			**Total Existing TSS load = 2087.03**		

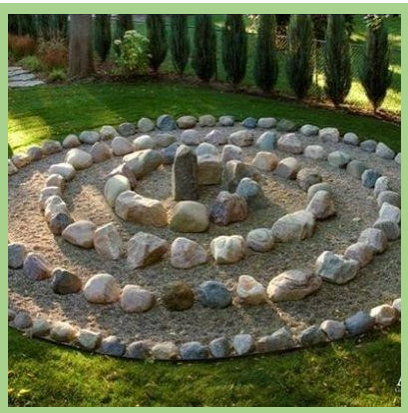
Outdoor Education/ Play Areas

The master plan includes many different play and educational elements that reflect the principles of the Montessori School education. Many elements allow for discovery play, while others allow for more traditional play. Comments from the children and teachers of the school inspired these designs. As stormwater management is an important part of the design, play elements included some ability to reduce runoff velocity and water infiltration when applicable.

The first element is a ***peace garden***. The existing Peace Pole sits in the patch of lawn between Jarrettown Road and the parking lot for Pine Run Park. It is recommended that it be moved to the back of the school near the small children's enclosed play area where there is minimal slope. In order to make it an aesthetically inviting area, it could have a circle of large rocks with smaller stones to fill in. Two benches matching the arc of the circle on either side of the garden should be placed for people to comfortably sit. There should be a small rake located by this element to allow children to move the stones to different patterns, allowing them creative exploration. Planting a large canopy tree by the garden would keep the area shaded during the hotter parts of the day.

A ***climbing tower/observation deck*** is proposed for the back of the property. It is designed to get children closer to the top of the trees on the hillside. There should be two layers to this deck. One should be large enough to allow for room for relaxation or observation. The taller deck should include climbing elements that would give children different ways to get to the top, such as a pole, rope and wall climb. At the top there should be a low strength telescope to allow children to observe and discover the environment around them. This structure should be built using natural materials to allow it to blend into the environment.

An entrance to the ***wood chip path*** should lay next to the climbing structure. This path would move along the contours of the hillside to allow the children a more scenic and easier grade to get to the soccer fields below. Using wood chips allows for a more natural path that would reduce soil compaction along the path. This also would be a great area to use any fallen woody debris to keep on the site.



Examples of peace gardens

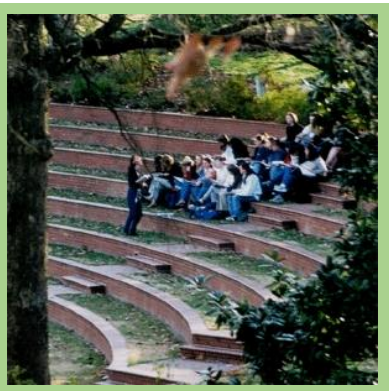
Examples of climbing tower/ observation decks

Examples of wood chip paths

A ***log balance beam*** is recommended to give children a natural material to walk across or sit. As it is a natural element, it would be easy to replace or repair. Allowing the logs not to be fixed could give children the ability to set up their own challenges. The area below is currently an existing man made swale that should be filled in so that water cannot channel in it. This would allow water to sheet flow into the woods that border the property.

The plan proposes an outdoor ***terraced seating area*** with two levels endosed by the large flat play area within the steeper slope of the back. A garden should be planted on the top level with substory trees. The two levels would give children a shady space to sit and relax, or be used as an outdoor classroom. The terraced seating area would reduce water runoff and runoff velocity. The terrace seating should be done with concrete wall blocks and caps. Each wall should be no higher than 1'-6". The cap should be at least 2'-0" in order to create a comfortable seating area. The flat lawn area in between should be 2'-0".



Examples of log balance beams and terraced seating areas


Examples of terraced seating areas

This master plan proposes modifications to a number of existing outdoor play features, including the open play area, basketball court, gaga pit, and concrete stairway to the soccer fields. A larger ***open play area*** was requested often from students and faculty. This area is currently composed of highly compacted soil mixed with stone, and was likely used as a parking area at one point. To make this area function as requested, the soil would have to be amended to allow for water infiltration and healthy lawn growth. The large broken ***basketball court*** should be replaced with a much smaller half court play area. It is suggested to use porous pavement (e.g., porous blacktop) as the playing surface. A ball stop net should be added to this feature to keep balls from entering the wooded area. The ***gaga pit*** is proposed to be moved to the edge of the large playing area. Larger canopy trees should be planted to add shade during hot days. An ADA-compliant new ***stairway*** to the soccer field should be added.

A ***digging pit*** can be placed along the edge of the large playing area. The pit should have a small wooden wall along three sides to assure that soil be contained and not quickly eroded away. There should be a small space approximately 6" on the south facing wall to allow any water build up to drain without adding to any erosion.

A ***rock climb and slide area*** is recommended to be installed on the hillside below the vegetable garden. The two proposed slides should be built into the contours of the hill between two rock climbing walls with stairs in the center. The rock walls would help reduce water runoff velocity and give the children a more challenging obstacle to get to the top. This type of play feature was highly requested by the children.

If implemented, the additional elements and increased play area would give students many more options for free play. By adding more trees the play areas would have more shade during the hot months, and would increase water infiltration and evapotranspiration. This area would be enjoyed by children for years to come.

Examples of digging pits

Examples of rock climb / slide areas

Implementation Plan

The project team developed an estimated budget for implementation of the master plan for each component included in the plan. All of the estimates were based on completed projects within the last 12 months, product research, or by acquiring quotes directly from manufacturers.

Stormwater & Landscaping Features		Recreational Features	
Feature	**Cost**	**Feature**	**Cost**
Rain Garden at island	$22,500	Outdoor Benches	$760
Bioswale 1	$12,440	Climbing structure	$11,334
Bioswale 2	$31,915	Log balance beam	$1248
Driveway swale	$5,040	Hillside climb and slide feature	$4,999
Constructed wetland - farmhouse	$40,060	Digging pit	$1,999
Native Pollinator Garden	$1,910	Boulder wall	$1500
Wildflower Gardens	$900	Vegetable Garden - fencing, shed, and terraced planters	$6,329
Porous Surfaces	$11,443	Peace Garden	$2,277
Trees	$2,500	Hillside steps and path	$7,304
Trench Drains	$28,000	AC Fence kits	$368
Rooftop capture features	$1,350	Invasive control	$1500
Survey & Engineering	$34,200	Shipping and installation	$16,884
Total for Stormwater Features = $192,257		**Total for Recreational Features = $56,492**	

The series of stormwater treatment features across the front of the campus should be completed working upslope installing the lowest feature first. Before designing the stormwater features a survey that includes all existing and topographic features should be completed to prepare a detailed base plan of the area. It is recommended to complete infiltration testing to accurately quantify storage capacity, soil conditions, depth of amended soils and outlet structure sizing of the bioswale and rain garden features.

For the purpose of estimating, assumptions were made as to the dimensions space could accommodate and a typical depth of feature. Estimates were made based on the cost of acquiring construction materials and contractor installation of features. The budget estimations assumed a 20' long trench drain into a 1200 ft^2 rain garden which flows into a 140' x 10' meandering bioswale with 3:1 side slopes. Drainage from the upslope rain garden and bioswale feature would overflow into a 52' long trench drain across the main entranceway. The trench drain would convey overflow as well as intercept runoff from Jarrettown Road and direct flows towards a second bioswale which is approximately 230' x 15'. The entire front stormwater system could be safely conveyed to the creek through a vegetated swale along the driveway to the farmhouse.

Priority consideration of the stormwater features would be given to 1) address current drainage issues and 2) maximize the ability to capture larger drainage areas. The proposed feature at the farmhouse would manage the majority of the impervious surfaces from the front of the building, while also reducing high-velocity discharges to the Pine Run Creek. Given the natural flow path to this location, less excavation is necessary than at other areas of the property. Providing a stabilized method to convey runoff safely would reduce sediment loss from erosion and minimize ponding on the school's impervious areas. The features at the front of the school provide high visibility but require extensive grading due to the current condition.

Students, staff, and Montessori School families should have the opportunity to get involved in the planting of the stormwater features and gardens. For this reason, the project team recommends that these features be planted utilizing volunteers. Participants would have the chance to learn about the benefits of stormwater management and the importance of clean water. The event could include educational exhibits and demonstrations by partners including the Wissahickon Valley Watershed Association and the Partnership for the Delaware Estuary.

Cost estimates for recreational features include both materials and professional installation. In **Appendix B** there is a more detailed budget and quantity estimates. Two sources were considered for researching options for the playground features: 1) Bear Playgrounds of Lima, New York; and 2) Play & Park Structures of Douglassville, PA. Bear playgrounds equipment was more aligned with the vision for the Montessori School. Their mission is "to create fantastic, nature inspired playgrounds and other products which enhance children's environments." A proposal from Bear Playgrounds is included in **Appendix C** to this master plan. Recreational features such as the peace garden and vegetable garden expansion could be completed as a service project or parent/staff coordinated activity. These features were estimated based on material cost only.

Feature	Grants and Resource Opportunities (links embedded in text)
Rain gardens, bioswale, Porous pavement, native wildflower gardens	DCED Watershed Restoration and Protection DEP Growing Greener DEP Environmental Education National Fish and Wildlife Foundation - Delaware River Restoration Fund Innovation grant Philadelphia Water Department Retrofit Guidance Manual Creating Meadows in Southeast Pennsylvania
Tree Planting	TreeVitalize Fruit Tree Planting Foundation Pennsylvania Native Plant List Native Plant Brochure
Vegetable Gardens	America in Bloom Annie's grants for gardens Kids Gardening PA Farm to School mini-grants
Recreational Features	Pennsylvania Recreation and Park Society
Fence and building materials	Home Depot Community Impact Grants Lowes Charitable and Educational Foundation

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