THE MORTON ARBORETUM'S "GREEN" PARKING LOT

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ABSTRACT

In the late 1990's, The Morton Arboretum, a 1700+ acre outdoor museum of woody plants, decided to undergo a large scale redevelopment of their visitor center, main entrance, and main parking lot. A "low impact" type of design was highly desirable. Simultaneously with this redevelopment, a complete renovation of Meadow Lake, which lies adjacent to the visitor center and main parking lot, was made possible by a grant from the EPA Clean Lakes Program. Consequently, constructing a 5 acre impervious parking lot immediately adjacent to the lake, utilizing the standard asphalt, curb and gutter approach, was not looked upon favorably.

To solve this problem, the designers for The Morton Arboretum decided to construct a "green" parking lot, incorporating numerous BMP's that filter and infiltrate stormwater prior to entering the lake and ultimately the East Branch of the DuPage River. The new parking lot incorporates BMP's such as permeable pavement, bio-swale medians, perforated storm sewer, underground compensatory storage, level spreaders, and created wetlands. This project represents the most expansive use of these types of BMP's, especially permeable pavement, in the mid-western United States to date.

As a part of the EPA grant requirements, a free outreach seminar was held to educate the public on the types of BMP's used in the project, and how they can be applied to urban applications. In addition, the designers will be monitoring water quality and run-off volumes, to compare the run-off from the "green" parking lot to that from an immediately adjacent asphalt parking lot. By July, 2005, the desire is to have 6 months of data. This data will provide the first hard evidence of the effect of these BMP's in an urban environment on storm water run-off in the mid-western United States.

It is anticipated that this project, and the subsequent research, will provide realistic performance data for "green" parking lot BMP's that have, to date, rarely been implemented in northern climates.

INTRODUCTION

The Morton Arboretum is located in unincorporated DuPage County, Illinois, immediately adjacent to the Village of Lisle. It has been located there since the 1920's and has a long, proud history of preserving and enhancing the environment, and in educating the general public with its knowledge of trees, shrubs, and other plantings. Traditionally, it was viewed as primarily a research facility with attendance mostly by those who already knew it well. The only exception to this was significant attendance by the general public during the Fall color season. In the 1990's, the Arboretum Board of Directors wished to increase visitation by the general public in an effort to bring their message to more of the mainstream populace. They underwent a large scale planning process and developed a 20-year master plan for the build out of a new core area, with additional gardens and visitor stations throughout the grounds. As a part of this master plan, a large, new visitor center was proposed. The new visitor center would be immediately adjacent to several new gardens, including a maze garden and an extensive children's garden. These new gardens and the visitor center, it is hoped, will bring a much larger year-round visitation to the Arboretum.

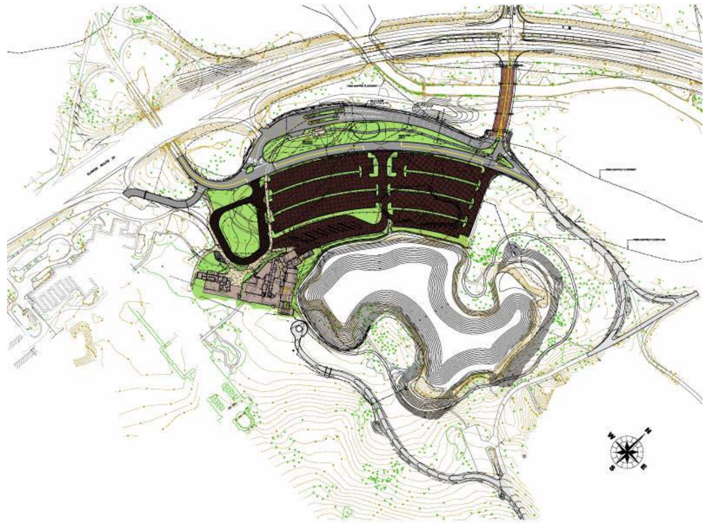

Figure 1 – The Morton Arboretum Core Area Site Plan

A new parking facility would need to be constructed for the anticipated increase in visitation. It needed to handle approximately 500 cars, or roughly three times the capacity of the existing parking facility. This parking lot posed a challenge, as the visitor center was located immediately adjacent to Meadow Lake and the East Branch of the DuPage River. The parking facility would be situated between these two bodies of water. Meadow Lake was simultaneously undergoing a clean up and restoration project, partially funded by a grant from the Illinois EPA Clean Lakes program. The idea of constructing a 5-acre asphalt parking lot immediately adjacent to Meadow Lake, and in the floodplain of the East Branch of the DuPage River, did not seem to uphold the goals of the Clean Lakes program. Such a parking lot would produce a significant concentration of pollutants, which would immediately drain into Meadow Lake, and subsequently the River. In addition, the asphalt parking lot would heat the water, thereby degrading the biodiversity and ecosystem in the downstream water courses. Given these factors, the Arboretum decided that a "green" parking lot would be the best solution to this problem.

To facilitate the construction of a "green" parking lot, the Arboretum submitted for and received a 319 Grant from the IEPA, to be used for the construction of best management practices (BMP's) within the parking facility. The grant was a 60/40 matching grant, for which the Arboretum could receive up to approximately $1.2 million for the design and construction of the parking lot. The grant application was general in nature, and listed several BMP's that could potentially be incorporated into a parking lot. Thus, upon receipt of the grant, the design team was charged with the task of weighing the different BMP's and deciding which ones were most appropriate for this project.

SELECTION OF BEST MANAGEMENT PRACTICES (BMP's)

Once the 319 Grant had been awarded, the Arboretum's design team began the task of selecting the appropriate best management practices (BMP's) for this project. The goals were simple: reduction in overall stormwater runoff and improvement in downstream water quality. The idea was to produce a parking lot with the exact opposite result of the standard asphalt parking lot, which will typically increase stormwater runoff and degrade downstream water quality. In order for the design team to make educated decisions on which BMP's would function the best on this particular site, many site conditions needed to be analyzed. Site constraints such as soils, existing drainage, floodplain, and wetlands all needed to be analyzed prior to the site planning process. Once all the site parameters were defined, a site plan could be put together that would produce the desired amount of parking, with enough room left over for whatever BMP's were selected.

Soils were analyzed through the use of geotechnical borings, which were scattered throughout the proposed area of the parking lot. In general, it appeared as though the site was previously used for the distribution of overburden from the excavation of Meadow Lake. Meadow Lake had been a borrow site for the construction for Illinois Route 53, some 50 years prior. Apparently, soils that were not suitable for roadway embankment has been cast aside in the general area of the proposed parking lot. Most of the borings showed approximately 3-4 feet of unsuitable material lying on top of in-situ clayey sands and gravels. The design team determined that once the overburden had been removed, the existing clayey sands and gravels would be permeable enough to infiltrate significant amounts of stormwater runoff.

An analysis of the groundwater in this area had already been performed as a part of the Meadow Lake project. The data generally showed a groundwater elevation of approximately 665.0 ft (feet above mean sea level, NAD 27), with significant fluctuations, which did not generally rise higher than elevation 666.0 ft. The groundwater in this area is heavily tied to the water surface elevation in the East Branch of the DuPage River, and generally flows in the same direction as the river, from northeast to southwest.

The base flood elevation (BFE) was plotted on the existing topographic survey. It was fairly clear that the majority of the parking lot would need to be within the floodplain of the East Branch of the DuPage River. This posed a design challenge in that local ordinance requires no more than 12 inches of water over any parking lot surface during the 100-year flood event. This set the minimum elevation for the parking surface at 672.1 ft, exactly one foot below the BFE of 673.1 ft. Thus, in order to minimize the amount of floodplain fill and hence, minimize the amount of compensatory storage required for the project, the parking lot must be installed at a relatively flat slope. In addition to which, because of the 3 or 4 feet of existing unsuitable soil located in the area of the proposed parking lot, a sizeable amount of structural fill would be required to raise the lot to elevation 672.1 ft.

Once all of the existing conditions were investigated, and to the extent possible plotted on the existing topography, the site planning process began. The goal was to provide the maximum amount of parking within the space provided, with maximum space left over for BMP's. The Arboretum planning staff developed a plan with long, linear medians separating each parking bay from the next. These medians generally stretched from southwest to northeast. The minimum median width was 9 feet, from back of curb to back of curb (B-B) with the maximum width being approximately 15-20 feet. A 30-foot buffer was provided between the parking lot and the edge of the proposed Meadow Lake. As expected, about three-fourths of the parking lot would be within the BFE of the East Branch of the DuPage River. Once the site plan had been established, the design team analyzed several BMP's for use with the project. These included but were not limited to permeable pavement, bio-swales, level spreaders, created wetlands, vegetated channels, grass filter strips, and vortex-type oil traps.

The first BMP selected were bio-swales. The long linear medians, and the permeable existing soils, made bio-swales an obvious choice. The bio-swale's function is to absorb stormwater and filter it, using plants and permeable soils to trap heavy metals and other pollutants prior to their entering the groundwater. The project was tailor made for bio-swales. The 9-foot medians, being long and linear, gave the team a great opportunity to drain the parking lot into the medians. Considering the parking lot needed to be built on a minimum of 3-4 feet of fill, structural, permeable fill could be used in lieu of clay to allow stormwater to run through the soil and into the existing subgrade, thereby reducing total stormwater runoff. The bottom of the unsuitable soil that needed to be removed from this site was at approximately elevation 668.0 ft. This was an important elevation because with the groundwater at roughly elevation 665.0 to 666.0 ft, the design would provide the minimum 2 feet of separation required by the Illinois EPA for groundwater protection. This separation helps ensure that any impurities or contaminants are filtered by the soil prior to entering the groundwater.

Once it was decided to include bio-swales in the design of the parking lot, a lengthy discussion, held over several weeks time, was conducted regarding the benefits of permeable pavement. During this time, all members of the design team pursued a quest for information on the various types of permeable pavement and the investigation of how these pavements would function given the requirements of the Arboretum. The Arboretum desired a parking lot that could be in use year-round. This, of course, meant that the pavement surface would need to be durable and plowable. In addition to this, the location of the bus parking area and visitor center truck dock required that a significant portion of the parking lot be structurally designed to withstand heavy truck and over-the-road bus loading. These factors seemed to rule out products that were primarily substructure support with grass or gravel placed on top, as they would not be plowable and did not seem to have the structural integrity to withstand the heavy truck and bus loading. Thus, the design team focused on permeable concrete paver units. Porous asphalt and concrete pavers were initially investigated, but the majority of the research studied indicated that they tend to clog within 3-5 years of installation and are quite difficult to clean once they have become clogged. In addition, some of the research indicated that in freezing climates, black ice could form as droplets of water are retained at the surface of the pavement, creating small, icy domes. This could create a situation that could either become dangerous or require the Arboretum to excessively apply de-icing materials, which as a policy they try to minimize. Thus, based on the research investigated at the time, the product of choice became the interlocking, permeable concrete paver.

Interlocking concrete pavers are extremely durable and very high strength. Their interlocking nature gives them the ability to withstand heavy traffic loading, and the high strength concrete from which they're made (8,000 – 11,000 psi) gives them durability and the ability to withstand heavy point loading. The pavers themselves are L-shaped, with notches in strategic locations that, when the pavers are pieced together, form openings approximately 1-inch square. These openings are filled with uniformly graded washed stone, which allows stormwater to flow through the voids and into the base coarse and sub-base of the pavement. Research indicates that this type of pavement acts as an excellent filter to trap heavy metals and other pollutants from the initial runoff in the majority of rainstorms. Coupled with the fact that the project site had a highly permeable in-situ sub base, permeable pavement seemed like an obvious choice.

It was determined early in the design process that even though much of the pavement would need to be heavy duty, and would be more expensive than typical parking lot pavement, the installation of the pavers would initially be much more expensive than asphalt. The Arboretum's 319 Grant, however, would cover 60% of the cost of the pavers and the entire pavement section because permeable pavement is a BMP. Asphalt pavement is not a BMP and therefore would not necessarily be covered by the grant. Nevertheless, the initial cost of the paver installation was so significant that it had to be seriously considered in the decision to select permeable pavement for use on this project.

The Arboretum is a facility that will own and maintain its parking lot for many years into the future. Thus, the lifecycle cost of permeable pavers versus asphalt was a significant consideration in the decision to install the pavers. The sub-base installation would be required in either case, due to the significant depth of the existing unsuitable soil, so it was removed from the lifecycle cost analysis. The pavement structure included in the analysis was the wearing course and gravel base. Initial installation cost for asphalt averaged at about $17/sq. yd., including both heavy duty and light duty pavements. The initial installation costs for the permeable pavement system was approximately $42/sq. yd., or roughly 2½ times the cost of the asphalt system. However, based on actual installations and research performed throughout Europe and Australia, the lifespan of the concrete paver system is expected to be at least 50 years. Thus, a 50-year lifecycle cost analysis was performed.

Obviously, asphalt parking lots do not last 50 years, especially in freeze-thaw climates. Frequent crack filling and overlaying, and at least one reconstruction will be required within a 50-year span. Conversely, the maintenance required on a permeable concrete paver system is minimal, limited generally to restriping and the occasional cleaning of the aggregate within the 1-inch holes. The latter of these items will only need to performed on a case-by-case basis, depending on how the pavement is performing. In the case of the Arboretum, it was anticipated that this may need to be done approximately every three years, and would probably cost around $1,000 per application. The cost of restriping was considered the same in both the asphalt and the paver system, but was included in the analysis, as it is a significant part of the minimal maintenance required for the permeable pavement system.

After factoring in the initial cost and anticipated maintenance, the total 50-year cost (given in 2002 dollars) for asphalt was approximately $80/sq. yd., whereas the total 50-year cost for the permeable paver system only went up to $45/sq. yd. Thus, because the Arboretum will own the parking lot and will need to maintain the parking lot for many years, the paver system was a much better long-term choice. Based on this analysis, it was decided to install the permeable paver system as a BMP within this project.

After the decision had been made to include both the bio-swales and the permeable pavement system, the remainder of the drainage system could be further analyzed and additional BMP's selected. Because the bio-swales and the permeable pavement both function well as infiltration systems, the fill that was used as a sub-base for the parking lot should be permeable as well. Thus, the design for the entire sub-base of the parking lot is a uniformly graded, washed, granular base. This provides significant stormwater storage and the ability for infiltration into the in-situ soils. It was decided to use perforated storm sewers along the length of each bio-swale so that any stormwater run-off entering the storm sewer system would still have an opportunity to irrigate back into the sub-base and infiltrate into the ground. To assist in this process, a control structure would be installed at the downstream end of the system to help restrict the flow of water, and allow it more time to infiltrate into the ground. In the event that this sub-base became overly saturated, and needed to be drained, the control structure would be designed to allow for easy access and removal of the restriction so that the perforated storm sewers would no longer irrigate the sub-base, but help to drain it. This would help ensure that the Arboretum would have not only an excellent BMP in its pavement system, but also a fully functional heavy duty pavement system with the ability to provide an extremely well-drained base course when necessary.

The sewer system still needed to be designed to meet the local ordinance requirements, because at the time there were no credits given in run-off coefficients for the installation of a permeable pavement. Thus, a relatively large (30-inch diameter) storm sewer drained the parking lot into Meadow Lake. It was not desirable to install a typical flared end section and lined rip-rap apron at the end of this system, as it seemed in conflict with the green parking lot concept. Thus, a created wetland/level spreading pool system was designed at the downstream end of the storm sewer system. This system would provide a final polishing pool, created wetlands to help filter out impurities, and would act as a level spreader to help eliminate point discharge into the lake.

In addition to all of the BMP's incorporated into the parking lot design, another storm sewer system which drained an adjacent traditional asphalt parking lot and some other parts of the core area also discharged into Meadow Lake. With all of the BMP's designed as part of the main parking lot, it did not seem appropriate to install a typical flared end section at the end of this storm sewer system. Thus, a level spreader system was designed to help to dissipate energy and minimize erosion at the downstream end of the system.

DESIGN DETAILS

Bio-swales

A typical bio-swale cross section was developed, using the 9 foot back to back (B – B) median width. The concept of the bio-swale is to collect stormwater and allow it to be infiltrated into the constructed soil where it is either utilized by plantings or percolated through the soil prior to overflowing into a storm sewer system. The desired depth of ponding is no more than 0.5 ft. Therefore, the rims of the catch basins along the storm sewer system are set at an elevation 0.5 ft above the bottom of the bio-swale.

The initial concept was to provide a concrete pavement edge, without a curb, to allow the stormwater runoff to sheet flow into the bio-swales, thereby minimizing any concentrated flows and the resulting erosion. However, this would require the installation of wheel stops at every parking stall along the bio-swales. Due to the large number of parking stalls, and the maintenance associated with wheel stops, this was not desirable for the Arboretum. Therefore, a barrier curb was incorporated into the design. This proposed a challenge to the design team to provide the barrier curb but minimize the amount of concentrated flow into the bio-swales. The final design incorporated 3 foot gaps in the barrier curb, located along parking lot stripes to avoid the potential of small vehicles or motorcycles driving into the bio-swales. These gaps are spaced no more than 3 stalls (27 feet) on center (O.C.). This distance was a good compromise between having too many gaps, effectively eliminating the curb, and having too long a distance for stormwater to travel and concentrate. The curb line along the bio-swales was primarily level due to the floodplain restrictions, so the slope required to direct stormwater along the gutter line to these gaps was entirely provided within the curb structure itself. The top of curb and the edge of pavement remain level, while the gutter pitches from the middle of the solid curb section to each gap at a slope of approximately .5%. Special grading details had to be provided to ensure that the contractor would construct this correctly, as this is not a standard curb installation.

Once stormwater enters the bio-swale, it collects in the bottom and ponds to a depth of 0.5 ft, prior to overflowing into the storm sewer. The side slopes of the bio-swale are graded at a 3:1 slope, from the edge of the curb gaps down to the swale bottom, which is approximately 1 foot below the edge of pavement. This allows for a 3-foot wide flat bottom down the center of each bio-swale. A special soil mix was designed for the bio-swale to allow for an adequate growing medium and the appropriate amount of infiltration.

The soil mantle was created using a constructed sandy loam soil mix with approximately 5% coarse organic matter content. Specific criteria for many soil properties were prepared based on site criteria, available soil mix components, and mantle thickness. Several key chemical and physical characteristics were necessary for the soil mantle to function as a chemical as well as a physical filter. The organic matter needed to be uniform, coarse and fully mature. Organic matter maturity was tested using a Solveta compost maturity test. The in-situ pH of the final soil product needed to be between 5.5 and 7.5. This was difficult to achieve in northeastern Illinois where the sands are typically alkaline with a pH between 7.5 and 8.0. The amount of fine particle alkalinity was reduced by using washed medium grained sand that has the fines removed. This was sufficient to create a sand pH in the upper end of the acceptable range. The soil was mixed off-site at a batch plant and backfilled with moderate compaction. Filter fabric was not utilized to avoid two conditions: blinding and the creation of a perched water table. Minimal settling into the stone was observed.

The plantings designed for the bio-swales were specifically selected to handle both inundation and drought conditions. This was a difficult challenge that took many months of discussion by the design team. The ultimate design also incorporated an irrigation system to allow the plants to be watered in times of drought.

Lighting and storm sewers also needed to incorporated into the cross section. For obvious reasons, it was not desirable for light pole bases to conflict with the storm sewer, so the storm sewer and catch basins were placed on the opposite side of the bio-swale from the light pole bases. This obviously impacted and directed the appropriate locations for any trees within the bio-swales, which needed to be located so as not to conflict with surface drainage, storm sewers, or lighting. All of this was accomplished within the 9 foot section allowed by the plan. The final bio-swale cross section can be seen in Figure 2.

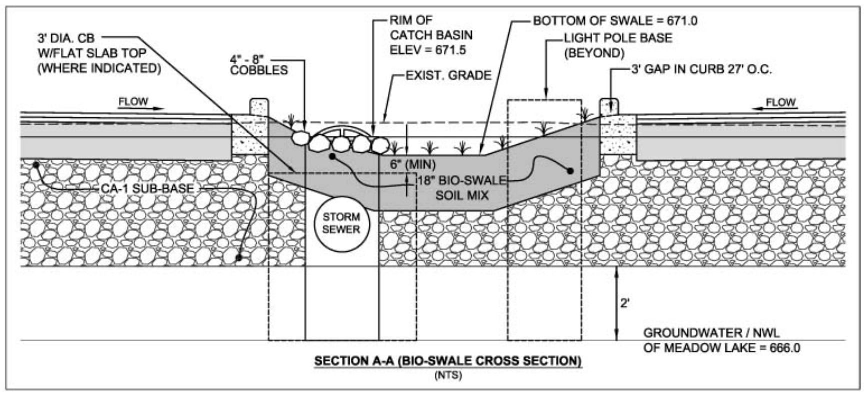

Figure 2 – Bio-swale Cross Section

Permeable Pavement

Much forethought and discussion went into the design of the permeable pavement cross section. As this type of pavement is not yet commonly used in the Midwestern United States, and there are no standards regarding permeable pavement and/or interlocking concrete pavers in the Illinois Department of Transportation (IDOT) Standard Specifications for Road and Bridge Construction (SSRBC), the design team had to select sub-base, base, setting bed, and filler aggregates for the pavement section. The aggregate under the pavement needed to serve two purposes: It needed to replace the unsuitable soils that existed beneath the proposed parking lot section, and it needed to provide adequate permeability to facilitate the infiltration of stormwater into the in-situ sub-grade. In order to meet the IEPA regulations with regard to groundwater protection, a minimum 2-feet of separation between the groundwater and the bottom of the excavation/fill was required. Thus, using the conservative elevation of 666.0 for the groundwater table, the bottom elevation for the excavation was set at 668.0. In reviewing the soil boring data, this was determined to be adequate to remove all of the existing, unsuitable soil. Thus, the parking lot base elevation, or bottom of subgrade, was set at elevation 668.0.

From the subgrade elevation up to the bottom of the base course for the pavement, a uniformly graded, crushed aggregate with no fines was desired. The coarse aggregate #1 (CA1) designation in the SSRBC was selected. This material is angular, crushed stone with no fines, ranging from approximately 1½ to 3 inches in size. This material was used as fill from elevation 668.0 to the subgrade elevation immediately beneath the pavement base course. Then, utilizing the LockPave® Pro Software for the structural design of interlocking concrete pavements, developed by Dr. Brian Shackel, the design team proceeded to design the remainder of the pavement section. Due to the strong interlocking nature of the pavers, and the significant amount of aggregate sub-base being provided, a minimal base course was needed. The material selected is SSRBC designation CA7, which is basically a uniformly graded, crushed aggregate approximately ¾" in size, with no fines. The design team anticipated that this material may be difficult to construct with any level of accuracy, because of its lack of fines. However, after discussions with various contractors in the area, it was determined that it would be possible to construct a thin layer of CA7 to an acceptable level of accuracy. The minimum thickness that was desired by most of the contractors consulted was 6 inches. A lift less than 6 inches in depth would be difficult to grade to the appropriate elevation, but a lift of more than 6 inches may be difficult, because equipment tires may have more of a tendency to sink. Thus, a 6-inch base course of CA7 was selected for the pavement base course.

An experienced concrete paver installer was consulted regarding the design of the setting bed and pavers. The optimal setting bed was a 1½" lift of 3/8" crushed aggregate with no fines. This most closely related to the SSRBC CA16 designation. It was discussed that this material would also be suitable for the filler material in the holes created by the pavers. However, for aesthetic reasons, the Arboretum desired a filler material that more closely matched the paver color. The Arboretum chose a crushed granite, mined in Wisconsin. The final cross section of the pavement can be seen in Figure 3.

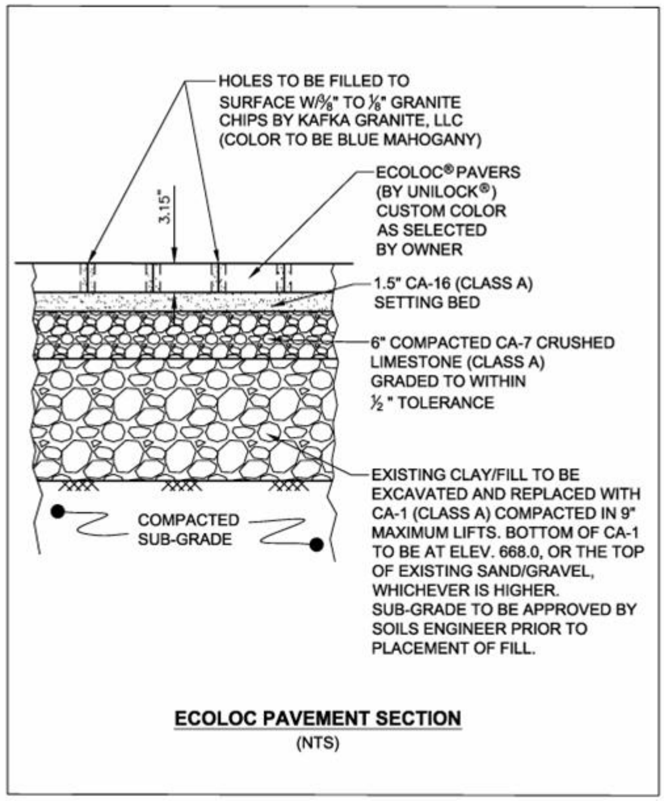

Figure 3 – Permeable Pavement Cross Section

There were no guidelines in the local ordinances that would allow for a reduction in storm sewer or stormwater detention sizing based on the use of the permeable pavement system. However, the design team realized that there was an extensive amount of stormwater storage located within the voids of the aggregate material beneath the pavement section. Detention storage for the entire project had already been provided in a separate facility. Storm sewers were already being designed to handle runoff in accordance with local ordinance requirements. However, because the majority of the project was within the floodplain of the East Branch of the DuPage River, floodplain compensatory storage was needed. A separate facility was being designed in a downstream location to handle compensatory storage for the majority of the core area of projects. However, because of the extent of the parking lot project, additional stormwater storage between the 10 and 100 year floodplain elevations was needed. The storage provided within the voids of the aggregate sub-base was calculated, using a conservative ratio of 0.35. This provided a significant amount of the compensatory storage needed beneath the pavement section. This storage could be accessed several different ways via the perforated storm sewer, the bio-swales, or the pavement section itself. Therefore, the DuPage County Department of Environmental Concerns was satisfied that this storage would be accessed in a flood event greater than the 10 year storm. Therefore, it was classified as compensatory storage within the 10 – 100 year floodplain elevations, providing an enormous secondary benefit to the project.

Perforated Sewers/Water Level Control Structure

Perforated High Density Poly Ethylene (HDPE) storm sewers were selected for several reasons. They could be installed on a slight radius to follow the bio-swales, and they would infiltrate/exfiltrate stormwater. A structure needed to be designed at the downstream end of the system that would restrict the flow of water out of the storm sewer system to allow it additional time to infiltrate into the sub-base. Additionally, however, it needed to be easily maintained and the restriction easily removable. This would ensure that, in the event the sub-base was not draining quickly enough, it could be drained more rapidly to maintain the pavement integrity. Thus a water level control structure was designed utilizing a simple concrete baffle with slots cast into it, where 2” x 6” stop logs could be inserted. The stop logs help to restrict the flow of water but are not water tight, so as to allow the eventual draining of the system. In the event that the system needs to drained quickly, the structure is not very shallow and the stop logs can be removed easily by hand. A detail of this structure can be seen in Figure 4.

The storm sewers were designed in the customary fashion to handle a 10-year storm event at the “pipe flowing full” condition. It was not anticipated that these storm sewers would actually need to function in this manner, but again, local ordinance requirements dictated as such. The storm sewers are pitched toward the water level control structure just as they would be in a standard design. This allows for them to be cleaned with traditional, readily available jetting equipment from any downstream structure. Catch basins are located within the bio-swales, to allow for the easy removal of sedimentation should any get trapped in the system.

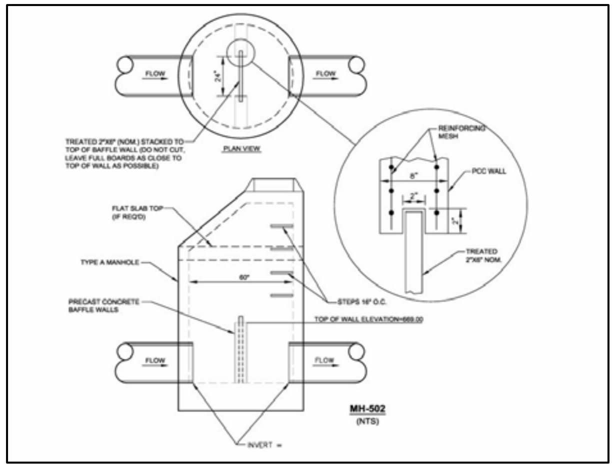

Figure 4 – Water Level Control Structure

Created Wetland/Level Spreading Pool

The downstream created wetland was provided for several reasons. It acts as a final polishing pool or sediment trap, as well as very large level spreader, which helps to reduce the erosive effect of any significant flow. Wetland plants were selected for both the upper “level spreading” pool, and the lower created wetland along the fringe of the newly-constructed Meadow Lake. A cross section of the created wetland/level spreading pool can be seen in Figure 5. The length of the “level spreading” pool is approximately 200 feet, which allows for significant energy dissipation of any flow entering Meadow Lake at this location. The required plantings for this area were incorporated into the Meadow Lake project to allow for a seamless installation of plantings along the newly-constructed shoreline.

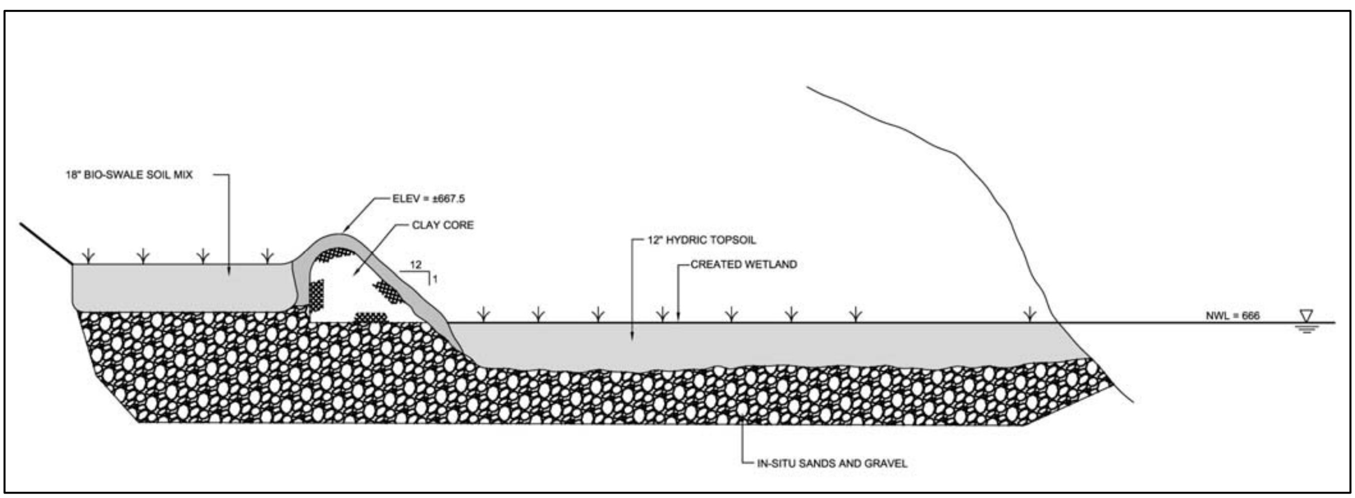

Figure 5 – Created Wetland/Level Spreading Pool Cross Section

Level Spreader

A level spreader was designed for the outlet of the traditional storm sewer system, which drains an adjacent asphalt parking lot. A 12" diameter level spreader was designed to handle the more frequent storm events. At a higher elevation, an overflow storm sewer with a traditional flared end section was provided, so that if the capacity of the level spreader is exceeded, the storm sewer system still drains adequately. The storm sewer was designed based on a downstream tail water elevation slightly above the elevation of the level spreader, to ensure that stormwater will not surcharge any of the rim elevations in the upstream system. The level spreader design consists of approximately 80 feet of slotted 12" HDPE pipe. The slot is laid level from one end to the other, which allows for a more uniform sheet flow and minimizes the potential of channelization and erosion. Downstream of the level spreader, from the slotted pipe to the water's edge, an apron of aggregate/soil mix (at a 2:1 ratio) was provided and native plantings were incorporated into the planting plan for the Meadow Lake construction in this area. As a part of the Meadow Lake construction project, the shoreline was additionally reinforced with turf reinforcement mat (NAG C350). A cross section of the level spreader detail can be seen in Figure 6.

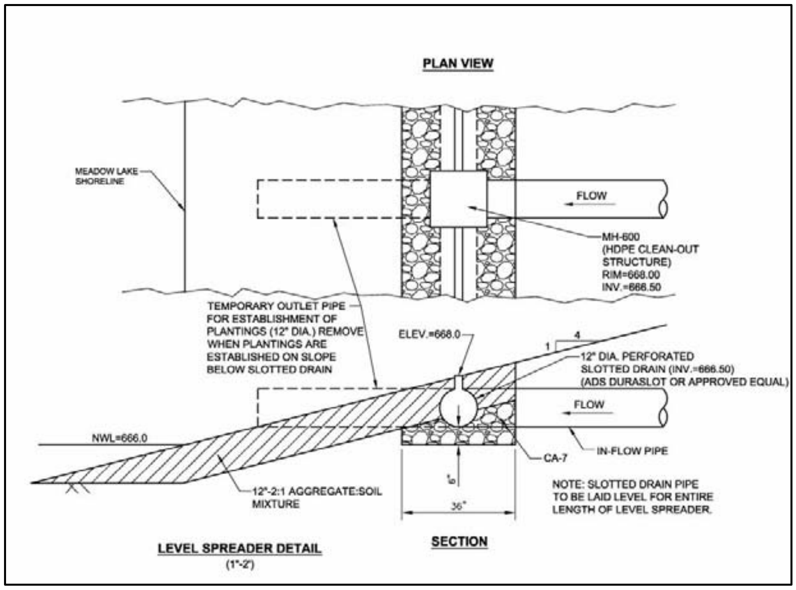

Figure 6 – Level Spreader Detail/Cross Section

CONSTRUCTION

The construction effort for this project went very smoothly. The combination of an excellent construction manager, a conscientious contractor, and solid design plans provided a basis for very few change orders and contractor requests for information. As with any project that is not designed entirely using standard practices and procedures, there were a few lessons learned.

This parking lot was entirely constructed within the CA1 fill above the existing soils, which forced the contractor to put careful thought into the scheduling and sequence of construction. Storm sewers, for instance, were laid on the existing subgrade in the open and covered with CA1, prior to the installation of the remainder of the CA1 sub-base. Light pole bases needed to be extended, making them a total depth of approximately 10 feet, so that 5 feet of the base was in the in-situ soils prior to the backfilling of the CA1 sub-base. This item was one of the few change orders on the project.

One of the considerations whenever constructing cast-in-place concrete curb and gutter is the immediate backfilling of the curbs, to prevent them from moving, settling, or rolling backwards. Because the curbs were constructed far in advance of the bio-swale soil mix being placed, there was some concern that the curbs would roll backwards upon the placement of the pavers. The curbs were monitored closely, however, and the contractor extended the CA1 sub-base an additional foot beyond the back of curb to help prevent this from happening. Through careful construction practices, no curb settled or rolled backwards prior to the placement of the bio-swale soil mix.

When the bio-swale soil mix was placed, the contractor had concern that the soil would migrate into the CA1 sub-base. This was handled by adding a layer of base course (CA 7) and then compacting the stone to lock the void space thereby producing the smallest voids possible. Soil was backfilled in lifts so that the interface voids would fill with soil. This method has been used successfully in other constructed soils and eliminates the problems encountered with filter fabrics.

Finally, a discussion was held after the installation of the pavement base course (CA 7 layer). The general contractor was able to construct the base course as designed to the tolerances required. This took some effort but was achievable. The paver subcontractor had a somewhat difficult time moving equipment around on the CA7 base course and requested that the base course be thinner on the next project. However, through conversations with both the general contractor and the paver subcontractor, it was determined that the 6 inch lift was optimal, as the general contractor confirmed the original decision that any lift thinner than 6 inches would be difficult to construct to the required tolerances.

The owner, as of the writing of this paper, has been utilizing the parking facility for a little over a year. Generally speaking, they are extremely happy with the parking facility. They continually monitor the plantings that were selected, and because they are a facility that focuses on trees and plants, they are able to monitor the progress of each species, and eventually replace them if they feel they are unsuitable for the bio-swales. Overall however, the majority of the plantings originally selected appear to be doing well. One practical issue that has been raised occurs where two curb gaps are aligned on either side of a bio-swale. When this situation occurs close to the Visitor Center, it seems that visitors use the opportunity to walk through the bio-swale, as if the gaps were aligned for this purpose. Thus, on future projects, it is desirable to make sure curb gaps are offset from one another to prevent this. This is not a major concern for the Arboretum, as they feel that proper plantings will deter visitors from walking through the bio-swales in these areas.

RESEARCH

Subsequent to the construction of the main parking lot, a joint effort between the Arboretum, Unilock of Chicago, and Christopher Burke Engineering has been undertaken to research the effects of this parking lot and the combination of the BMP's utilized. The research has two main goals: First, to calculate the reduction in stormwater runoff being realized by the downstream receiving system, as a result of each individual best management practice. Second, an increase in water quality is expected and will be monitored throughout the research.

Several data logging transducers were installed at various locations around the parking lot to monitor the flow of water from different portions of the design. They were placed at curb inlets and in bio-swales, and one was placed in the immediately adjacent asphalt parking lot to act as a base line. The sensors have been calibrated, and take readings every 5 minutes, which will produce huge amounts of data, but will help ensure that no storm event, no matter how small, is missed. A photo of one of the sensor installations can be seen in Figure 8. The sensor lies within the PVC housing and measures depth of flow. This must be converted to a flow rate utilizing formulae created ahead of time.

Staff members from the Morton Arboretum will read the sensors once or twice a month and submit the data to Christopher Burke Engineering for analysis. Additionally, Arboretum staff members will collect runoff samples from both the asphalt parking lot and the main parking lot as a basis for comparison. Tests will be run on the stormwater to determine levels of various pollutants, such as total suspended and dissolved solids, phosphorous, zinc, copper, and cadmium. The anticipated result of this research is a reduction in stormwater runoff and an increase in water quality to the downstream receiving system. Research began in December, 2004. At this time, it is anticipated that a 2-year study will be undertaken, with final results being released in early Spring of 2007.

Figure 7 – Water Level Sensor in PVC Housing

SUMMARY

The Morton Arboretum's main parking lot project was exemplary from start to finish. The cooperative design process between the owner, engineers, landscape architects, regulators, and contractors facilitated an end product that is not only good for the environment, but very functional for the Arboretum. The grant from the EPA largely facilitated this project, and through its public outreach and education requirements will help to ensure that this project will be noted by the general public and hopefully used as a pilot project for others to model. It is our hope that the successful implementation of the BMP's on this project will help to facilitate additional local research, and increase the confidence of local regulators and public officials to significantly increase the use of such applications on a widespread basis.

ACKNOWLEDGEMENTS

Christopher Burke Engineering would like to acknowledge all of the following parties for their support of this project:

The Morton Arboretum
Unilock of Chicago
Uni-Group Inc.
Hanscomb, Faithful & Gould
V3 Construction Corporation
LPS Pavement
Dr. Brian Shackle
Mr. Dan Ahern
Conservation Design Forum
The Conservation Foundation

DuPage County
Illinois Environmental Protection Agency
Illinois Department of Natural Resources
U.S. Army Corps of Engineers
Testing Service Corporation

REFERENCES

- *LockPave® Pro* by Dr. Brian Shackel, presented by Uni-group U.S.A. ©1998 – 2005 F. von Langsdorff Lic. Ltd.

- *Uni Eco-Stone® Guide and Research Summary*, ©2002 Uni-group U.S.A.

- *Design Considerations for the Uni Eco-Stone® Concrete Paver*, by Raymond S. Rollings, Ph.D., P.E., and Marian P. Rollings, Ph.D., P.E., for Uni-group, U.S.A., ©1999 Uni-group U.S.A.

- *Design and Construction of Interlocking Concrete Block Pavements*, by Dr. Brian Shackel, Elsevier Applied Science, London, ©1990.

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