CREATING A MODEL OF SUSTAINABILITY THROUGH THE DESIGN, CONSTRUCTION, AND OPERATIONS OF A NEW HIGH SCHOOL

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INTRODUCTION

The new Glen Allen High School was built in 2010 by Henrico County Public Schools (HCPS) to serve the growing student population in the Glen Allen area of Henrico County, Virginia. As a suburban area northwest of the City of Richmond, Glen Allen's population doubled between 1980 and 2000, and grew an additional 18% between 2000 and 2010. The new high school is one of nine in the county and can accommodate approximately 1,800 students and 150 staff. The school facility is located on a 95-acre parcel of land that was previously wooded and undeveloped. The facility consists of the 256,000 square-foot main school building, a field house building, concessions stand, and ticket booth to support the athletic complex. Major spaces in the school include an auditorium, gymnasium, auxiliary gymnasium, kitchen, two commons areas, media center, and a two-story academic wing.

The project design began in 2007, and was kicked off with a collaborative design charrette between representatives of HCPS, Moseley Architects, and Timmons Group (Civil Engineers). During the charrette, the programming needs of the building were discussed, the site plan was evaluated, and participants experimented with space adjacencies that helped begin the development of a floor plan. From the priorities discussed in the charrette, the group developed this project vision statement: We will design a new high school that provides our community with a safe, innovative, adaptable, state-of-the-art facility that will create a functional and efficient learning environment, embodying responsible environmental values.

The project design team consisted of Moseley Architects (Architecture, Interior Design, and Mechanical, Electrical, and Plumbing Engineering), Timmons Group (Civil Engineering), Stewart Acoustical (Acoustical Consultants), Facility Dynamics (Commissioning Agent), and Foodservice Consultants Studio (Food Service). For construction, KBS (General Contractor) and Rappahannock Construction Company, Inc. (Site Contractor) were added to the team, along with many subcontractors.

KEYWORDS

LEED for Schools, air barrier, enthalpy wheel, acoustics, cistern, certified wood, green housekeeping, integrated pest management, light pollution

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FIGURE 1. Main Building Entrance.

PURSUIT OF LEED CERTIFICATION

During the schematic design phase, Moseley Architects did a preliminary evaluation of the project to determine the feasibility of Leadership in Energy and Environmental Design (LEED®) certification. The LEED green building rating system is a comprehensive approach that measures achievements across five major categories: Sustainable Sites, Water Use Reduction, Energy & Atmosphere, Materials & Resources, and Indoor Environmental Quality. LEED is administered by the U.S. Green Building Council (USGBC) and applications are third-party verified by the Green Building Certification Institute.

The project vision statement had provided a solid foundation for environmental stewardship. Therefore, certain sustainable design principles were already in place, such as energy conserving measures (ECMs) in the mechanical and electrical design, daylighting of regularly occupied spaces, and roof coverings with a high solar reflectance. However, the USGBC had just released the new LEED for Schools 2007 rating system, which contained several new, unpiloted prerequisites and credits. When evaluated using the LEED for Schools checklist, it became evident that LEED certification was not going to be achieved easily. While HCPS opted not to formally commit to LEED certification at this point, the project team continued to consider high performance building strategies whenever appropriate.

Moseley Architects also continued to educate HCPS, and many other clients, on what "green building" is, and specifically about how to use the LEED rating system as a framework for evaluating and implementing green building strategies. A major consideration for HCPS was the project budget, and the potential increased cost of the innovative systems and materials needed to achieve LEED certification. As a municipal project, the project was to be publicly bid. In 2007, the bidding market was not favorable toward owners. The market began to change in early 2008 and became a more favorable bidding environment, although at that time no one knew that it was a precursor to the recession on the horizon.

In March 2008, the Henrico County Board of Supervisors decided to pursue LEED Silver certification for all new construction in the county. Therefore, the project was already well into the Construction Documents phase when it was registered for LEED. The design team began immediately to assess what elements of the project needed to be modified in order to meet LEED requirements. Fortunately, there were many things that were already being done in an environmentally friendly and sustainable manner, in accordance with the project vision statement. However, as our preliminary LEED evaluation had shown, there were many more things that had to be re-evaluated, and quickly.

The original project schedule called for the project to be finished with design and advertised for bids in June 2008, and for construction to begin in August 2008. Substantial completion was set for June 2010 since the school was to be opened to students for the 2010–2011 school year. Although the school's opening date could not be delayed, the team did find a way to buy a little more time to refine the design in light of the new LEED certification requirement. In order to keep the construction process on schedule while the design schedule was extended, an early site package was released in May 2008 so that site clearing and grading could begin on time. The building package was advertised for bids in August 2008, and building construction started in October 2008. Although the Civil Engineers still had a very aggressive schedule to meet, the building design team got an additional two months to decide which LEED strategies could be pursued easily, which ones required re-design, and which were not possible at all. All LEED-inspired redesign was completed in that additional two-month window.

According to Al Ciarochi, Director of Operations with HCPS, "I would suggest to other projects taking on this challenge that you start as early in the design of the project as possible, and arm yourself with an experienced team. We were fortunate to have an experienced team guide us through this process."

SOMETIMES IT COMES NATURALLY

Design

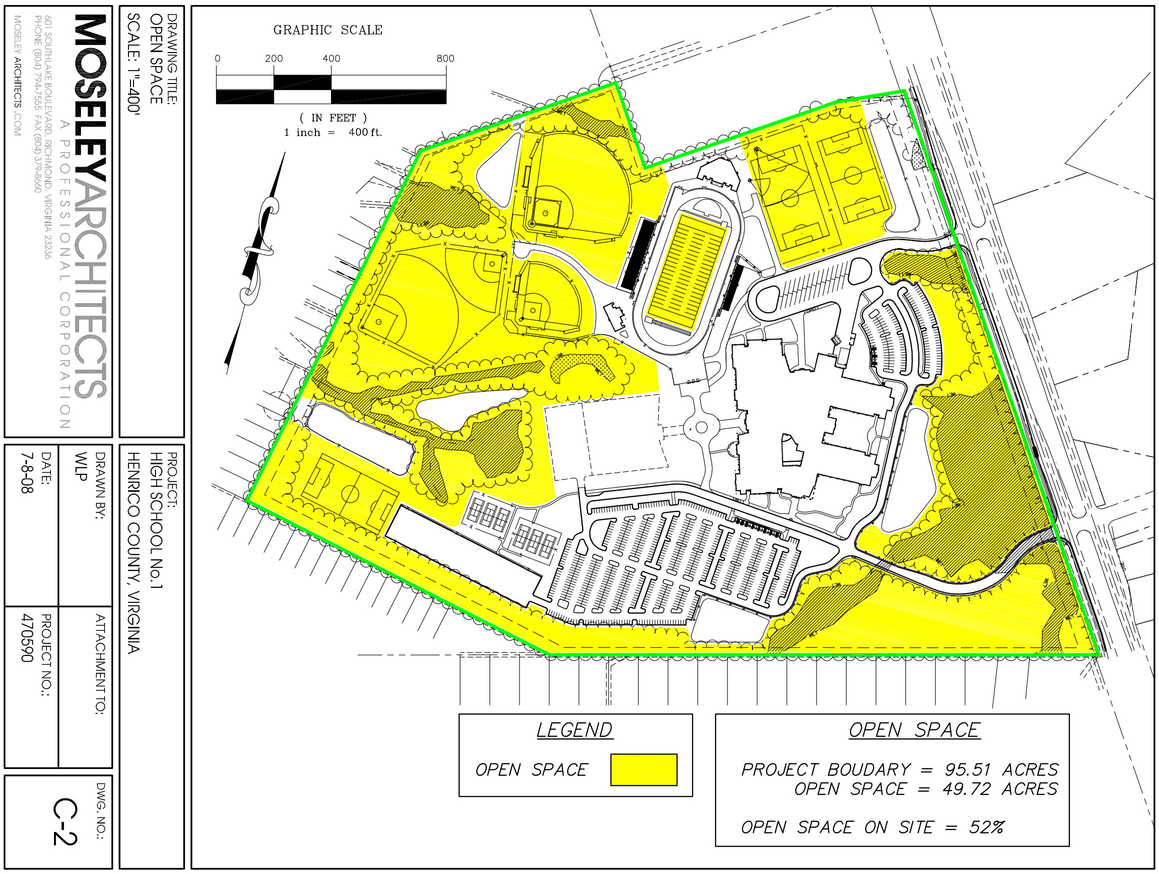
Certain sustainability strategies had already been incorporated into the design, either because those strategies were considered best practices in keeping with the project vision statement, or simply because they are features inherent to schools. Many of these aligned easily with LEED prerequisites and credits, or could be aligned with minor modifications.

The LEED for Schools rating system included a new prerequisite requiring a Phase I Environmental Site Assessment. An assessment had been performed when the property was purchased by the school system; it simply had to be updated to comply with the most recent standards in accordance with the LEED requirements.

One strategy that is usually a natural fit for schools is the preservation of vegetated open space. Some areas of the site were left wooded and undisturbed since they contained wetlands or streams and were therefore considered resource-protection areas. Additionally, numerous grassy athletic fields were planned for the school, including baseball, softball, football, and soccer fields. With no modifications to the site layout, the project achieved 52% vegetated open space area, which not only earned the LEED credit but also an exemplary performance credit for doubling the 20% requirement.

By meeting the state and local stormwater management requirements, this project also satisfied the LEED requirements for stormwater discharge quantity (rate and volume reduction) and quality (total suspended solids removal). A stormwater management plan was implemented to protect receiving stream channels from excessive erosion using quantity control strategies. These strategies included seven extended detention basins which slow the rate of release while promoting infiltration, and an underground 50,000-gallon cistern which collects roof runoff for reuse. The stormwater management strategies were calculated to reduce the

FIGURE 2. Open Space Exhibit.



one-year 24-hour rate of runoff from a pre-development value of 26.77 cubic feet per second (cfs) to a post-development value of 9.97 cfs (a 63% reduction). The two-year 24-hour rate of runoff was reduced from 40.24 cfs to 17.65 cfs (a 56% reduction). Each facility is intended to promote infiltration and groundwater recharge and therefore reduce flows prior to discharging into sensitive wetland areas. In addition, all receiving channels for this project were analyzed to document sufficient capacity and non-excessive velocity to prevent erosion. The Virginia Erosion and Sediment Control Minimum Standard 19 (MS-19) was used to determine if the existing channel would serve as an adequate outfall for the proposed development. The MS-19 standard was used to determine the "critical values" for receiving streams and requires an existing outfall channel to have adequate capacity to contain the peak runoff for the two-year storm without exceeding erosive velocities. The calculations demonstrated that post-development conditions were below the critical values that would cause excessive stream velocities and erosion in the receiving waterways.

The extended detention basins were designed to detain stormwater for an extended period to allow for infiltration and settling of total suspended solids, thereby improving the quality of the stormwater discharge to receiving waterways. The basins capture and treat just over 90% of the total stormwater volume that falls on the site. Each basin includes sediment forebays at each inflow point, which slow the incoming stormwater and allow greater time for settling of solids. Each basin has also been provided with a low-flow infiltration trench consisting of a perforated under-drain in a gravel trench to allow the basin to completely dry between large storm events. This trench will also provide water-quality filtration for smaller storm events. Since the basins were oversized to treat twice the required water quality volumes, and include numerous enhancements, including longer detention time, large forebays at each inflow point, and low-flow water quality infiltration trenches, each basin is anticipated to achieve a minimum of 80% total suspended solids removal.

FIGURE 3. Extended Detention Basin.

Ensuring that the school facilities are available for joint use by community organizations was a new LEED for Schools strategy that was already standard practice in Henrico County, and is actually documented in their school policies and procedures. Sharing the playing fields, gymnasium, auditorium, and meeting rooms with community organizations and recreation leagues was planned from the beginning. The shared areas were provided with separate entrances and available restroom facilities. The design was easily modified to meet the LEED requirements that the academic wings be securable from the shared areas.

Attention had been paid to the design of the building envelope to maximize thermal performance as a best practice. Moseley Architects had already begun to transition to using air barriers on all new projects to tighten up the envelope and prevent air leakage between the interior conditioned space and the outside. This not only improves the thermal efficiency of the building, but also protects from moisture damage and outside air pollutants (e.g. vehicle exhaust, mold, or pollen). For this building, the architect specified a continuous spray-applied polyurethane foam building insulation and an air/vapor barrier system.

The roof covering was designed as a best practice to reduce the urban heat island effect, which is a localized rise in temperature around developed areas caused by dark pavement and roof surfaces. In addition to exacerbating the heat island effect, dark roof surfaces also cause

FIGURE 4. Air Barrier on Field House.

FIGURE 5. Reflective Roofing.

unwanted heat gain to the building, which is a detriment in this climate (EPA Climate Zone 4). A white thermoplastic polyolefin (TPO) membrane was specified for the low-sloped roof surfaces and standing-seam metal panels for the steep-sloped surfaces. The bright white surface of the TPO and the light gray color selected for the metal panels both had a sufficiently high solar reflectance index (SRI) to meet the LEED requirements.

The owner and the architect both desired interior spaces that are bright, open, and welcoming, with plenty of natural daylight; however, with many windows come challenges such as thermal transfer, solar heat gain, and glare. To minimize thermal transfer, insulating glass units were specified as a best practice, with a low-emissivity coating to reduce solar heat gain. Measures taken to reduce glare include a gray tint to the glass, strategic use of translucent glass, and window shades in offices and classrooms.

The heating, ventilation, and air conditioning (HVAC) system is a variable-air volume (VAV) system that provides individual-zone temperature control of classrooms. Rooftop units serving the classrooms provide air to a mixture of fan-powered and non-fan-powered VAV terminal units and include enthalpy wheels. Enthalpy wheels are devices consisting of a rotating heat exchanger that transfers temperature and humidity from the building exhaust airstream to the incoming outdoor airstream, in order to recover thermal energy from the exhaust air.

FIGURE 6. Enthalpy Wheel.

Single-zone spaces, such as the auditorium or commons, are served by dedicated air-handling units with dehumidification and/or demand-controlled ventilation controls where appropriate. Hot water and chilled water are generated by central plant equipment. The central chiller plant includes two centrifugal chillers, two cooling towers with variablespeed fans, constant-flow condenser pumps, and variable-flow chilled water pumps. The central boiler plant includes four efficient condensing boilers and variable-flow hot water pumps. Both the hot and chilled water systems operate with variable-primary pumping strategies, which reduce the number of pumps required and improve the operating efficiency of pumping. A comprehensive direct digital control building automation system incorporates efficient control methods, including economizer operation, optimal start/stop, and demand-controlled ventilation.

The system had already been designed with energy-efficiency in mind; therefore, no significant changes were necessary in order to meet the LEED energy use reduction requirements. The Mechanical Engineers performed whole-building energy modeling to determine that the proposed design is estimated to use 30.5% less energy than the ASHRAE baseline model, with an energy cost reduction of 28.4%. The LEED requirements dictate a default process energy cost of 25% of the baseline building energy cost, unless a lower percentage can be substantiated for a project. After reviewing the 2003 Commercial Buildings Energy Consumption Survey (CBECS) data for educational facilities, the mechanical engineers decided that a lowered process load was appropriate for this project. The CBECS data indicated that equipment and process loads for educational facilities average 12%. The calculations for this project indicated a modeled process load of 18%, which we felt was an appropriate compromise between the LEED default value and the CBECS data. Therefore, the process load energy costs remained at 18% in the model and were not over-inflated to meet the 25% LEED default value.

The design assisted the protection of indoor air quality (IAQ) by controlling indoor pollutant and chemical sources in a variety of ways. Pedimat™ entryway systems were installed at each major building entrance to remove pollutants such as dirt and pollen from peoples' shoes as they enter the building. The LEED requirements also address chemical storage areas, some of which required minor design modification. The architect and mechanical engineer coordinated to ensure that all janitor's closets, laundry areas, high-volume copy rooms, art supply storage areas, and science class preparation/storage areas were physically separated from adjacent spaces with full height walls, self-closing doors, and sufficient ventilation to provide negative pressure. Lastly, minimum efficiency reporting value (MERV) 13 filtration media, as defined by ASHRAE Standard 52.2-1999, was specified for HVAC equipment.

Construction

Similar to design, certain construction strategies were relatively easy to achieve based on the nature of the project and the best practices that had already been implemented.

One construction-phase prerequisite involves construction activity pollution prevention by using erosion and sedimentation control mechanisms. The deployment and maintenance of these control measures, which included, for example, silt fence around disturbed soils, stormwater inlet protection, and temporary or permanent vegetation on slopes for soil stabilization, were the responsibility of the site contractor. These measures were inspected throughout construction by Moseley Architects' Construction Contract Administrator and LEED Coordinator, Timmons Group's Construction Administrator, and also by Virginia Department of Environmental Quality and Henrico County officials. According to Steve Raugh, Civil Engineer with Timmons Group, "Obtaining this prerequisite was simply a matter of documenting what the project was already required to do . . . adhere to the requirements of the Virginia Erosion and Sediment Control Handbook."

The concept of construction waste management involves diverting construction and demolition waste away from disposal in a landfill by salvaging it for reuse or recycling. As the design and construction industries have evolved during the green building movement, so has the waste management industry. There are now numerous services that will collect co-mingled waste and haul it to their facility for separation and recycling. For this project, S.B. Cox was utilized for co-mingled construction waste recycling, and only required masonry waste to be separated out.

FIGURE 7. Construction Waste Recycling.

From the contractor's standpoint, the only requirement was to set up the dumpsters. The on-site superintendents then made sure the materials were deposited in the proper dumpster. The monthly waste reports provided by the recycling service were easily transferred into the LEED documentation template. In total, over 90% of the 3,380 tons of construction waste generated were diverted from a landfill.

Other strategies that lend themselves well to school construction are the uses of building materials with recycled and regional content. Recycled-content materials are defined as building materials manufactured with either pre-consumer (recovered from a manufacturing/industrial process) or post-consumer (recovered after consumer use) recycled content. One material that contains a very high recycled content is steel, since for steel manufacturers using recycled steel is not only an environmental choice but also a financial must. Glen Allen High School was constructed with a great deal of steel framing and decking, along with other steel elements such as the metal roof panels and metal lockers.

Other material choices required more of a conscious decision to incorporate recycled content, such as the use of carpet by Interface®, a company well-known for its emphasis on carpet recycling and environmental impact reduction. Another beneficial material choice was the use

FIGURE 8. Steel Construction.

of Allied Concrete Company® concrete masonry units (CMU). The CMU alone represented about five percent of the total project material costs. Allied units have a high recycled content and are also 100% regional since all materials are manufactured and extracted within a 500-mile radius of the site. Allied Concrete has demonstrated its commitment to sustainability by achieving Cradle-to-Cradle Silver certification on its concrete products, which involves a rigorous evaluation of a product's entire life cycle, including manufacturing process, chemical composition, and end-of-life recoverability, among other things.

From the contractor's perspective, the most difficult task was obtaining the information from the manufacturers. Some manufacturers have this information readily available in the right format, some make an attempt to provide the correct information but do not understand the requirements entirely, and some cannot provide it at all. However, in the end, this project tallied approximately 36% recycled content materials and 31% regional content materials. These percentages are calculated by comparing the recycled or regional material value against the total project base building material value. Had every building material manufacturer been able to provide complete documentation, these numbers would probably be higher, but projects can only take credit for what can be documented.

Worth Bugg, the Project Engineer with KBS who managed the LEED construction effort states: "Overall, I believe this project seemed to go very smoothly without many issues during the LEED process. It was clear to me that the industry was changing and more and more companies would have the information needed for the LEED process readily available as the project progressed. In the future I think credits like Certified Wood will become easier once the suppliers buy into the industry to make buildings more environmentally friendly. The companies that had already embraced the LEED system were extremely successful and positioned themselves to be used again in the future on LEED projects."

FIGURE 9. Recycling bins.

Operations

Although the vast majority of the LEED rating system, as applied to a new construction project, is design- and construction-related, there are a handful of credits that have operational implications. One operations-related prerequisite is tobacco smoke control. All HCPS facilities prohibit smoking inside the building, and locating an outdoor smoking area 25 feet from building openings did not present a problem. Another prerequisite that affects building operations is the requirement for storage and collection of recyclables.

The design accounted for small bins located throughout the building, satellite collection space in each academic wing, a main recycling storage room near the loading dock, and a separate enclosure for a co-mingled recycling dumpster. A bit of research revealed that one area co-mingled recycling collector was already serving several Richmond-area schools and was therefore a natural fit for this project. The new LEED for Schools rating system also included a new requirement to compost landscaping debris on site, or otherwise divert it from a landfill. Given the large property size, a suitable area for composting was easily located on site.

These were the strategies that were determined to be easily achieved with little or no modification to the existing design. Although we were well on our way, we were still not within the range of LEED certification, much less the goal of LEED Silver. Several more LEED strategies required the team to go back to the drawing board.

SOMETIMES YOU HAVE TO WORK FOR IT

Design

Meeting the requirements of the new LEED for Schools prerequisite, "Minimum Acoustical Performance," was probably the biggest challenge to overcome on the path to LEED certification. Because it had never been piloted by the USGBC, there were no good precedents set for cost-effective compliance with the requirements. And because it was set at the prerequisite level, compliance was not optional. Over time, the USGBC received feedback from a number of school districts across the country about the financial burden and uncertainty of compliance that this new prerequisite was placing on LEED-hopeful schools. In response to these concerns the USGBC eventually published a "Performance/Intent Equivalent Alternative Compliance Path" (PIEACP) in April 2008, which allowed additional flexibility in achievement routes. However, given the narrow window of time during which the LEED adaptations were included in this design, this project was caught squarely in the crosshairs of the new, unpiloted prerequisite requirements. Certain alternate paths in the PIEACP were utilized, if the change in course could be made quickly. However, we were far enough into making many of the changes needed to meet the original requirements, that changing course again at the last minute was impossible.

The prerequisite addressed three main elements: sound transmission, reverberation, and background noise. The original prerequisite requirements for sound transmission were to design classrooms and core learning spaces to meet the ANSI standard S12.60-2002 Design Requirements and Guidelines for Schools. This required core learning space wall construction to meet specific sound transmission class (STC) ratings to prevent sound from passing from space to space. For example, wall assemblies between two classrooms had to meet an STC of 50; those between classrooms and corridors had to meet STC 45. For many schools, standard wall construction consists of lightweight CMU, constructed to just above the ceiling, which does not provide adequate sound transmission reduction to meet the original LEED STC requirements. Therefore, classroom walls were upgraded to medium-weight CMU and all walls were constructed full height to the deck above. On the first floor, the full height walls were constructed of CMU. On the second floor, the additional weight of the full height CMU walls caused structural concerns, so the upper portion of the wall above the panel ceiling was constructed of gypsum board. Since we were well into making these design changes when the PIEACP was published, and since its modifications to the STC requirements were somewhat vague, we went ahead and demonstrated compliance with the original requirements. Through information acquired by field testing, published data (Housing and Urban Development's "Sound Transmission Class Guide") and with the assistance of Stewart Acoustical as a consultant, Moseley Architects developed wall systems that met the various STC minimums for each adjacency.

Another upgrade that the design team determined necessary was the addition of door seals and thresholds for classroom doors. This prevents sound transmission from the corridor to the classroom by sealing the spaces around the door. However, this creates a potential maintenance issue for the owner as door seals degrade over time and need to be replaced. Ultimately, it had to be done to meet the STC requirements in the prerequisite during design, so the project could maintain eligibility for LEED certification. In addition to the general requirements for "core learning spaces," certain learning spaces also had special situations, such as the walls between the art classrooms and the pottery/ceramics studio. The owner wished to have large windows between these rooms for teachers to be able to supervise both spaces. Since these windows were located between two learning spaces, they were reviewed as a classroom-to-classroom wall assembly for LEED purposes, with a goal of STC 50. To even approach this level of performance, a one-inch thick glass assembly with two panes of laminated glass and a half-inch air space was required, which is much more heavy-duty than a standard window assembly between classrooms.

FIGURE 10. Full Height Walls.

The original prerequisite requirements for reverberation required that each core learning space under 20,000 cubic feet must meet the ANSI Standard S12.60-2002. The reverberation time had to be calculated at three different bands and all three results for each space had to meet the ANSI limits. This proved to be extremely complex and labor-intensive—given the variety of core learning spaces in a large high school—since the calculation inputs (room volume, surface area of each different wall, floor, and ceiling material, and various furnishings) differed between each space. Fortunately the PIEACP that had been published by the USGBC provided a much simpler compliance path that we were able to follow fairly easily by modifying the specified ceiling materials. In accordance with the alternate compliance path, classroom acoustical panel ceilings were specified to meet a noise reduction coefficient (NRC) of at least 0.70. Radar™ ClimaPlus™ acoustical panel ceilings, manufactured by USG, were ultimately selected since they had an NRC of 0.70 and met all other specified performance requirements.

The third element—mechanical background noise reduction—was accomplished by modifying the location of terminal units and fan units to be over the corridors instead of the classrooms, and also by providing lined transfer grilles, lined returns, and acoustical wrap on long duct runs. The worst-case scenario core learning spaces (those closest to the loudest RTUs) were evaluated with software developed by Stewart Acoustical, and were all determined to comply with the 45 dBA limit.

One area in which major design changes were made in the name of LEED certification was in water efficiency. The competition fields at the high school were planned to be watered by an in-ground irrigation system. By adding moisture sensors, a rain gauge, and efficient fixtures to the design, the owner is still able to irrigate while reducing the amount of potable water use by 50% compared to a standard baseline system.

The LEED for Schools rating system offered a new optional credit for process water reduction in kitchen and laundry equipment. The project food-service consultants identified two

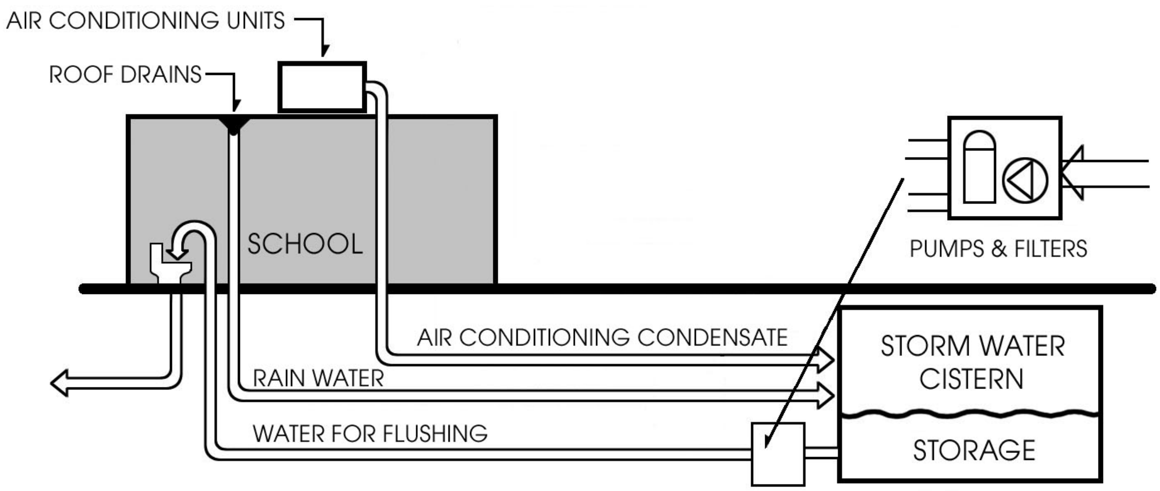
FIGURE 11. Food Steamer.

types of kitchen equipment (ice machines and pre-rinse spray valves) that could easily demonstrate compliance with the water-use limits required by the credit. However, to earn the credit, four types of equipment must comply. The dishwasher on the project is a conveyor system which provided water usage as 0.17 gallons per plate, and the LEED water use limits are defined in gallons per rack. Foodservice Consultants Studio turned to the manufacturer (Hobart), who was able to provide a conversion demonstrating that the water use of their equipment was well below the LEED gallons per rack limit. The fourth piece of equipment proved even more challenging. The available options included in this project were clothes washers and food steamers. A commercial-grade clothes washer/extractor was planned for the project to handle large volumes of laundry such as athletic uniforms. Based on research with various manufacturers, there were no models available that could meet the LEED limit of 7.5 gallons per cubic feet per cycle, since this limit was more suited to residential-grade washers. This left food steamers as the only option. The problem with meeting the two gallons per hour limit for the food steamers was that the selected model that automatically fills and drains would have to change to a connectionless model that requires manual filling and draining. The owner did not desire a connectionless model since it increases the possibility of injury, because employees would need to carry large pans of boiling water from the steamer to the sink.

The team decided to attempt an alternate approach by developing a process water budget. The most water-efficient, boiler-less, automatic fill-and-drain steamer was selected, with a water use of four gallons per hour (gph). Although slightly over the LEED limit of two gph, this is still far less than boiler steamer models that use an average of 40 gph. Since the first three pieces of equipment were specified below the LEED water limits, we were able to demonstrate that given daily use estimates, the small overage from the steamers would be offset by the overachievement of the other equipment. The final calculations estimate that if equipment was specified that exactly met the LEED limits, approximately 574 gallons of water would be used by those four pieces of equipment each day. Even though the food steamer was slightly over the limit, the actual specified equipment is estimated to use 469 gallons per day, therefore saving over 100 gallons per day above and beyond the LEED limits. This concept is not new to LEED projects since the same approach is allowed for budgeting out non-compliant low-emitting materials in the indoor environmental quality category. However, since this was a new concept for water efficiency, a Credit Interpretation Request (CIR) was submitted and ultimately the process water reduction credit was awarded to the project.

The final area that was re-designed to maximize water efficiency was the bathroom fixture water use. The simplest way to approach water efficiency in bathrooms is to specify low-flow and low-flush fixtures. Low-flow showers, sinks, and metering lavatories were an easy decision and helped contribute to the water use reduction. Low-flush water closets and urinals were researched, including dual-flush or 1.28 gallon per flush water closets and waterless or pint-flush urinals. However, a more innovative approach was researched and ultimately implemented—a 50,000-gallon fiberglass cistern (manufactured by Highland Tank®) was installed underground

FIGURE 12. Cistern Flow Diagram.



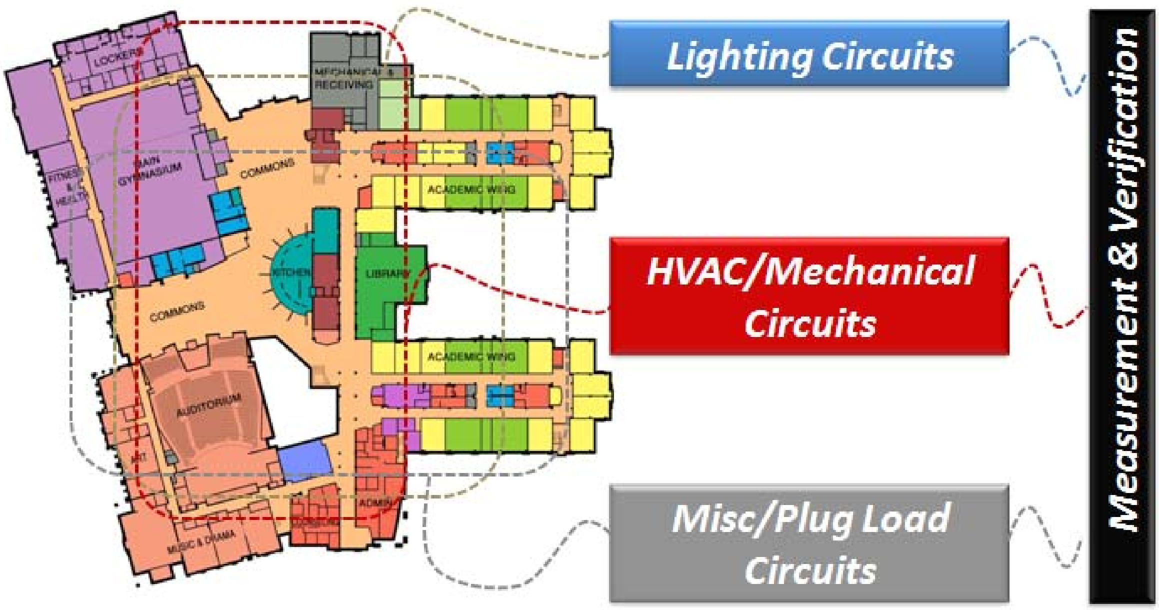
to collect and store stormwater from a portion of the roof, which is then reused for water closet flushing. This required significant redesign to identify an adequate area of the roof whose drainage could be diverted to the system, and to add treatment equipment such as filters, a day tank, ultraviolet disinfection, chlorination equipment, booster pumps, and potable water backup in the event that cistern water was not available. Since the low-flush plumbing equipment was still relatively new at that time, and since non-potable water was to be used for flushing, the owner decided to utilize standard water closets with a 1.6-gallon flush, and 0.5-gallon flush urinals. Even with these fixtures, the calculations indicated that given the LEED-provided fixture usage estimates and average area rainfall, overall bathroom water use would be reduced by approximately 80%, and the cistern could provide 100% of the building's flushing needs (barring long periods of extremely dry weather conditions).

Measurement and verification of the building's energy systems is a LEED strategy that is a little more difficult to achieve than it sounds at first blush. Essentially, the requirements involve developing a plan in accordance with published protocol, committing to tracking the building's energy performance for at least a year of stabilized operation, and providing a process for corrective action if the results indicate that anticipated energy savings are not being achieved. In accordance with Option D (whole-building calibrated simulation) of the International Performance Measurement & Verification Protocol (IPMVP), "measurement" of the building's energy use must be accomplished through a building metering strategy.

The metered data is then used to calibrate the design-phase energy model using the collected building data. Since the energy model is completed in design, it must utilize certain assumptions and estimations about the building's operation, occupancy, weather data, etc. The intent is to identify any areas in which the building is not performing as designed and not realizing anticipated energy efficiency. This accomplishes the "verification" portion of the LEED strategy. This has been a collaborative effort between the owner, mechanical engineer, electrical engineer, and LEED coordinator. This project is still within the one-year period of stabilized building operation, so the effort is ongoing.

This project pursued both Fundamental Commissioning (a LEED prerequisite) and Enhanced Commissioning (an optional credit). Although these two strategies span design and

FIGURE 13. Measurement & Verification.



construction, the bulk of the commissioning work is done during construction. The decision to pursue LEED was made as the project approached mid-construction documents, which meant that to pursue Enhanced Commissioning, the team had to work fast to get a commissioning agent on board in time for them to review the 50% drawings as required by the credit. The owner chose Facility Dynamics, a commissioning firm with LEED experience, to perform the building commissioning. The mid-construction documents set was dispatched with haste to the commissioning agent to perform the required review. Once performed, the team could focus on the construction-related tasks, the coordination of which was turned over to KBS.

Construction

One construction-phase consideration that required additional planning and follow-through by the contractor is the protection of IAQ, both through construction practices and material selection. KBS developed, implemented, and enforced a comprehensive Construction IAQ Management Plan that had to be adhered to for the duration of construction. This included enforcing a no-smoking policy that was supported by both KBS and HCPS, since all schools are a smoke-free zone.

Additionally, all absorptive building materials such as gypsum board, insulation, and ceiling tile were protected from moisture damage. Ductwork was protected from dust and water by storing it off the floor and covering the open ends; once the HVAC system was started, MERV 8 filters were installed at all returns to prevent pollutants from being pulled into the system. Extra effort was taken to clear water from the building prior to dry-in, to clean up spilled materials immediately, and to control interior dust and pollutants with housekeeping and ventilation efforts.

When it came to low-emitting materials, the architect had addressed this on the front-end by including the LEED requirements in the project specifications. The difficult part fell to the

FIGURE 14. Construction No Smoking Sign.

contractor—gathering vendor and manufacturer submittals, educating on-site workers and subcontractors about the requirements, and inspecting for unapproved materials. Per Worth Bugg, "Many submissions for these credits would be numerous pages of no useful information until on the second to last page near the bottom, you could find a VOC content. It was very difficult to have subcontractors understand that we needed information on most of the materials they installed on site (caulk, paint, sealant, glue, etc.). It required constant surveillance on site to make sure there was not a material that had not been checked."

Another construction-phase strategy that proved difficult to document was the use of Forest Stewardship Council (FSC) certified wood. All solid (non-recycled) wood in the project must be identified, including things that are rarely thought of such as rough carpentry. A material cost must be identified for each of these materials, and in the end 50% of the wood cost must be FSC-certified wood. Per Worth Bugg, "This credit was difficult in many different ways. First, you have to figure out where wood has been installed on site permanently. Initially it seems easy because things like wood flooring come immediately to mind, but then you forget about simple items like blocking in the bathrooms and [wood] panel ceilings. Personally, I believe this credit was the most difficult because FSC Certified Wood seemed to be just gaining momentum during the project, and many wood suppliers had not grasped the concept." On this project, the 50% requirement was met through the purchase and installation of FSC-certified wood doors, wood laboratory casework, and wood panel ceilings. Fortunately, this project's registration pre-dated (by only two weeks!) the requirement that all wood vendor invoices be submitted with the LEED application, thereby lightening the documentation requirements somewhat.

FIGURE 15. Certified Wood Doors.

Operations

Throughout the design and construction of this project, HCPS continued to make modifications to their operations both on a school-wide level in support of the LEED effort for the project, and also system-wide as they decided that some of these efforts were best practices that should be implemented at all schools.

For Glen Allen High School, the LEED School as a Teaching Tool innovation in design strategy was pursued, which turned out to be a very successful collaboration between the architect, school administration, and school teaching staff. The requirements of this credit include developing a curriculum that meets state and local standards, demonstrating that each school year, at least ten hours of instruction for each student will be based the high performance features of the building. The topics that lend themselves easily to studying sustainability are science and math, therefore these two department leaders, under the school Principal's oversight, worked with the Architect's LEED Coordinator to identify areas where features of the building could be used to teach lessons. The lessons were based on the Virginia Standards of Learning for science and math for each grade level (9–12). Some of the relationships developed included using energy and water use data for statistics, graphing, trending, and modeling. Another concept that the building and grounds can help teach is the heat island effect, and how air temperature is affected on different surfaces such as grass, concrete, or asphalt. Stormwater management is used as a teaching tool for learning about watersheds, natural resources, and ecology. The daylight patterns in the school are used to analyze solar patterns over the course of a day or from season to season. The curriculum items developed for the LEED application serve as a foundation that will continue to be developed and expanded by the school's teaching staff over the coming years.

To extend this educational opportunity to other building occupants and visitors, signage was placed throughout the building that points out the green features and provides a mechanism for a self-guided tour. Additionally, HCPS worked with the controls subcontractor (formerly AERO, now Automated Logic) to develop a touch-screen kiosk in the main entrance lobby that shows real-time energy and water use, as well as information and photos on the various green features of the building.

Green housekeeping and integrated pest management were two concepts that were pursued as LEED innovation strategies. After the written plans were developed by the HCPS Department of Construction and Maintenance, the principles of the plans started being implemented in all new schools and phased in system-wide as best practices for all existing schools. The HCPS plans state HCPS's commitment to provide a safer, healthier environment for school occupants, protect the Chesapeake Bay watershed, and be good stewards of the environment by reducing the amount of pollutants introduced into the indoor and local environments, while still maintaining clean and pest-free facilities.

The scope of the Green Housekeeping Plan involves reducing the exposure of building occupants to potentially hazardous chemicals generated by cleaning materials and practices. There are many different areas covered in the plan, such as maintaining entryway systems, isolating cleaning chemical storage and mixing areas, using Green Seal™-certified (or equivalent) cleaning products, cleaning equipment considerations, and staff training requirements among other considerations. The primary intent of the Integrated Pest Management Plan is to first utilize non-chemical pest control methods such as sealing potential pest entry points, removing food sources, physical removal such as utilizing traps or vacuuming, before resorting to pesticides or other chemical control methods.

FIGURE 16. Touch-Screen Kiosk.

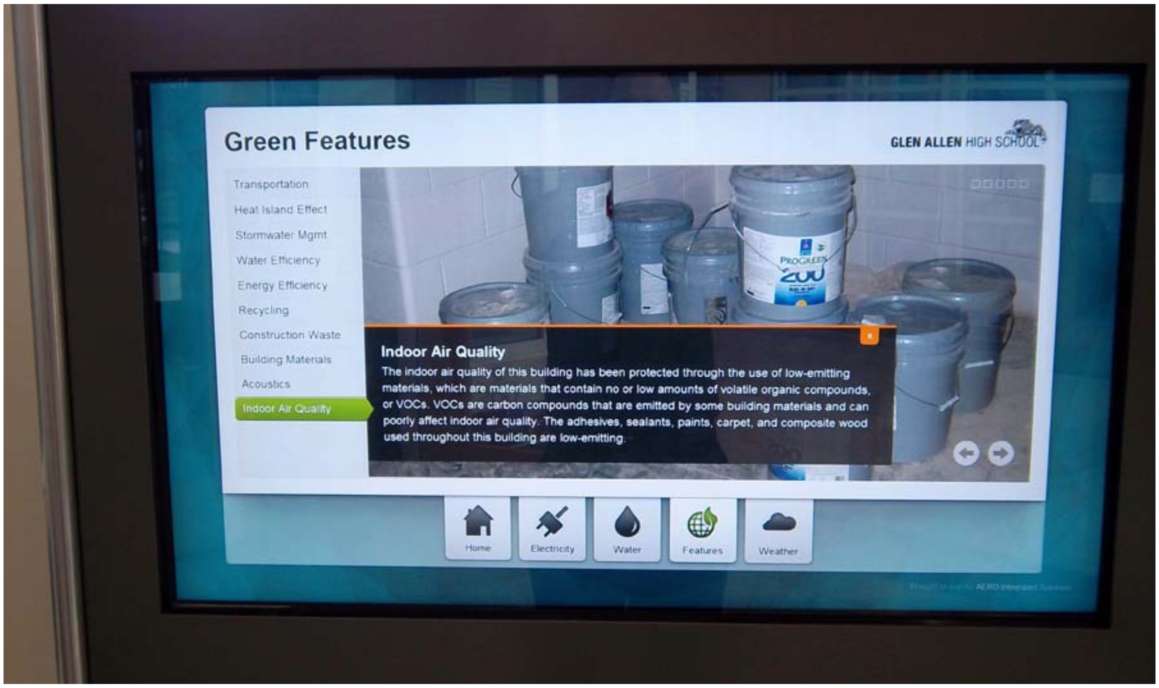


FIGURE 17. Classroom Resilient Floor.

This process led to some win-win opportunities to transition to maintenance products that were not only environmentally friendly but also perform better. Terrazzo was used for much of the flooring in the building for its durability and low maintenance, but certain areas such as classrooms have resilient tile flooring. To maintain these floors, Pearl Floor Finish, manufactured by Ultra Chem Labs, was selected since it contains zero volatile organic compounds and is Environmental Choice EcoLogo™-certified. The additional benefits are that it requires less product volume for the initial application and requires less labor since it contains no wax and therefore does not need to be stripped and re-applied from scratch annually like traditional resilient floor care materials do.

SOMETIMES IT JUST CAN'T BE DONE

As is to be expected—and as the LEED reviewers will not hesitate to tell you—not every strategy is appropriate for every project. This section describes some of the green design concepts that could not be implemented at Glen Allen High School for one reason or another.

Design

This project involved the new construction of a large facility in a previously undeveloped suburban location. This situation created some unavoidable hurdles, such as those related to

Site Selection. As Steve Raugh states, "While the school site was designed to impact as little of the natural environmental habitats of the site as possible, gaining access to the site was not possible without impacting wetlands which made this credit unobtainable." Additionally, the amount of grading required to level the site to accommodate the large building footprint and athletic complex precluded the project from being able to meet the strict grading limitations under Protect or Restore Habitat.

Although alternative transportation is encouraged at the school, the owner did not wish to limit the parking capacity to meet, but not exceed, the minimum requirements of the county ordinance. Since the school is used for numerous large events such as concerts and athletic events, there would be many occasions that a minimally sized parking lot would not suffice, and there is no overflow parking available at surrounding facilities. In fact, surrounding residential neighborhoods were so concerned that their streets would be used for event parking that no connections to the surrounding neighborhoods were provided, not even for pedestrians or bicycles. The new LEED for Schools rating system required bicycle paths in two directions in order to meet the bicycle use and storage credit requirements. Bicycle paths to the rear of the property were not feasible since the neighborhoods did not want that connection. Bicycle paths to the front of the property were not feasible since it would require road widening through the wetland areas, and for safety reasons since Staples Mill Road is a very busy thoroughfare. Although bicycle racks are planned to be installed at the school, the bicycle path requirement could not be met.

The LEED strategy to reduce light pollution covers many different areas of lighting design, some of which could be met for this project and some of which could not. The requirement for interior lighting to either be shielded or automatically turned off at night was not a problem since all non-emergency lighting is automatically turned off after closing hours by the building automation system. Similarly, the lighting power density requirements and uplighting limitations did not present any issues since lighting power density had been limited for energy-efficiency reasons, and full cutoff, dark-sky compliant exterior fixtures are usually specified as a best practice. The problematic requirements were the light trespass limitations, particularly for sports lighting. Being located in a residential area (lighting zone 2) meant that with sports lighting off, no more than 0.10 footcandles could be measured at the boundary, and no more than 0.01 footcandles at ten feet beyond the boundary. This limitation presented some issues, such as where the two main entrances intersect with Staples Mill Road. However, what proved most difficult to meet was the limitation of 0.3 footcandles at the boundary with sports lighting on. For this project, the athletic fields were too close to the property boundary to be able to adequately light the fields while meeting that limit. Although light pollution was limited to the extent possible, not every facet of the LEED requirements could be met.

Even before LEED certification was pursued, the architect put a great deal of effort into strategically incorporating daylight while reducing glare. The result is a very bright, open, airy indoor environment with many views to the outside. However, daylight modeling and an analysis of the regularly occupied square footage with a view showed that we were short of meeting the LEED requirements for either of these optional credits. The analysis showed that approximately 85% of the regularly occupied spaces have a view to the outside and access to natural daylight. The daylight portion of the credit requires that at least 75% of the classroom square footage achieve 25 footcandles of natural daylight, which is a significant amount of daylight. Even though most classrooms have windows and transom windows were used

FIGURE 18. Daylight in Main Corridor.

to borrow light from corridors, there were too many spaces located either in the center of the academic wings with no exterior walls, or where daylight did not penetrate far enough into the room such that 75% of the room met the footcandle requirement. Without a major redesign of the building (for example, rotating all classrooms 90 degrees) to improve daylight penetration and increase the number of spaces with access to a view, these requirements could not be met.

Construction

The LEED planning for the project had included pursuit of the optional credit requiring building flushout or air-quality testing to be performed "after construction ends and prior to occupancy." Finding this window of time is tricky on every project since completion of construction includes punch list and final cleaning, and these activities often overlap with building occupancy. For a school, in particular, the date of occupancy cannot be delayed since it is driven by the school system's publicized start date. For this project, to allow the school administrators and teachers to have access to their workspaces well before school started, construction was completed and areas of the building were turned over in phases. The construction team could not determine a way that the flushout or testing could be performed on an area-by-area basis without being affected by the adjacent areas of the building still under construction; therefore although indoor air quality was protected to the extent possible during construction, the credit for verifying it before occupancy was not earned.

CONCLUSION

In the end, the team achieved a sustainable, functional building that serves to promote the project vision statement and cultivate new leaders of the next generation capable of responding to the ever-changing environment. The design team was entirely committed to designing an environmentally friendly building from day one, and welcomed the challenge of LEED certification even as construction documents were under production. KBS executed and diligently documented green construction practices to continue the sustainability effort. The new school opened in the fall of 2010, and HCPS has carried those green building principles through into the building operations and teaching curriculum. As a result of its sustainable features and careful design and construction considerations, the new Glen Allen High School surpassed its goals and expectations by becoming the first LEED Gold certified school in the county, setting an example for future projects to follow. As summarized by Al Ciarochi, "Achieving LEED Gold Certification was a collaborative effort that everyone had a part in, and Henrico County Public Schools is very proud of this achievement."

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