Final Report

Senior Thesis

Ingleside at King Farm

Rockville, MD

Joseph Podwats

2008-2009 construction management option

AE Faculty Consultant: Dr. David Riley

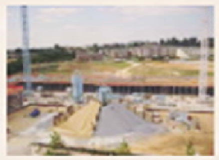
Date of Submission: 4/7/2009

Joseph Podwats
construction management option
2008-2009

Ingleside at King Farm

Rockville, Maryland

Owner: Ingleside Presbyterian Retirement Community
General Contractor: Turner Construction Company
Project Delivery: CM Joint-Venture with Turner-Konover
GMP Contract: $97,000,000 (construction only)
LEED: Seeking LEED Certification



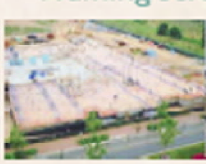
Construction:
- Start 3/14/2007 and Finish 1/15/2009
- On-Site Temporary Batch Plant and use of 2 Tower Cranes

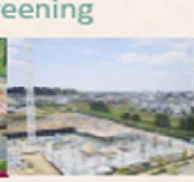
Architects:
- Arthur Shuster
- CSD People Architecture

Engineers:
- Loiederman Soltesz Associates, Inc.
- Morabito Consultants, Inc.
- Siegel, Rutherford, Bradstock and Ridgway, Inc.

Architectural & Site Features:
- 790,000 SF Continuing Care Retirement Community (CCRC)
- Colonial and Second Empire Architecture Styles
- 8 Levels including Below Grade Parking Garage
- Independent Living Units, Assisted Living Units, Skilled Nursing Units, Dementia Units, Theater, Restaurants, Shops, Olympic Size Swimming Pool, Tennis Court, and Roof Gardens
- Ground/Split Face Masonry and Stucco Facade
- Open Courtyard
- Metal Shingle Mansard Roof
- Sustainable Elements

Structural System:
- Reinforced Continuous Concrete Footing
- Reinforced Concrete Columns w/Two-Way Post-Tensioned Flat Plate Floors and Drop Panels on top Floor
- Steel Roof Structure with Light Gauge Steel Framing Screening





Mechanical System:
- Constant Volume Air System
- Induced Draft Cooling Towers w/Plate and Frame Heat Exchanger
- Gas-Fired Rooftop A/C Units and Makeup Air Units serves Common Areas
- Living Units served by Horizontal/Vertical Water Source Heatpump Units
- Ductless Split Systems
- Gas-Fired Forced Draft Hot Water Boilers

Lighting/Electrical System:
- 480/277V 3 Phase Electric Service w/750KW Emergency Generator Set
- Compact Fluorescent Down Lighting in Main Living and Corridors, Incandescent Decorative Dining and Roof Garden Lighting, and HID Outdoor and Pool Lighting

Plumbing System:
- PEX Tubing Supply Water Supply Lines in Living Units
- Grease Recovery Unit for Food Service

www.engr.psu.edu/ae/thesis/portfolios/2009/jmp5051

Table of Contents

Credits & Acknowledgements

Turner Konover
A Joint Venture

- Gary Thompson
- Karim Najjar
- Eric Min
- Tom Fedor

SRBR
Siegel, Rutherford, Bradstock & Ridgway, Inc.

- Patrick Lange

Ingleside at King Farm

- Bobby Bell, Jr.

Energy Efficient Kama Building Systems

- Lightship Group, LLC - Traves Ogilvies

Accelerated building technologies
A Dietrich Metal Framing | NOVA Chemicals Joint Venture

- Jeff Peskowitz

Davis

- Bill Moyer
- T.J. Sterba

Penn State

- Dr. David Riley
- Professor Robert Holland
- Professor Kevin Parfitt
- Stephen Dung Tat

Executive Summary

Introduction:

This is the last technical document that is part of a year-long senior thesis. Ideas behind the choice of Analysis Topics that will be presented in this report stemmed from previous investigations into the existing conditions, cost and schedule analysis, and alternative methods associated with a real construction project, Ingleside at King Farm. Research, findings, and suggestions presented in this report are based solely the interpretation of the construction project from a student's perspective.

Problem Identification:

Some of the problem areas identified for Ingleside at King Farm included building envelope performance, building orientation and footprint design, mechanical system design, construction waste management, and water efficient landscaping. An evaluation of each area can potentially improve constructability, accelerate the schedule, and/or add value to the project.

Technical Analysis Methods:

Preliminary methods were developed on four of the five problems areas. The methods include research on alternative products and construction types, implementation of alternative mechanical system design, implementation of a waste management plan, and curb appeal of alternative landscaping. The primary focus of each construction management analysis activity is to improve sustainability of the project as a whole.

Depth Studies:

These studies will build upon the Technical Analysis Methods and each study will present the research and results of performing the Technical Analysis.

Breadth Studies:

In addition to a comprehensive construction management related analysis of each proposed method, the breadth studies will provide information on areas outside of construction management. There are structural impacts associated with proposing the alternative exterior wall system; this depth will address that. On a project level, there is a sustainability breadth associated with each Analysis.

Critical Industry Issue:

The Partnership for Achieving Construction Excellence (PACE) Roundtable Meeting consists of industry professionals and aspiring professionals that discuss industry issues. This thesis will address the issue of *Energy & Economy*.

Summary of Research Goals and Conclusions:

This section acknowledges whether or not earlier proposed research goals were met and provides a short overview of this report. Most of the proposed research goals were achieved. In an attempt to achieve some of the goals, unexpected results were revealed.

Introduction

This is the last technical document that is part of a year-long senior thesis. Ideas behind the choice of Analysis Topics that will be presented in this report stemmed from previous investigations into the existing conditions, cost and schedule analysis, and alternative methods associated with a real construction project, Ingleside at King Farm. Research, findings, and suggestions presented in this report are based solely the interpretation of the construction project from a student's perspective.

Overall, the construction of Ingleside at King Farm has been in a seemingly continuous state of catching up from the owner's perspective and the sustainability perspective. Ingleside at King Farm was not calling for LEED Certification from the beginning, which caused a "scurry" to earn LEED credits during design and construction. Where possible, the details of each of the Analysis Topics in the *Depth Study* will focus on realistic implementation by bringing new or alternative solutions to the table that will not have adverse effects on the schedule or design. Before presenting the results of this thesis, the next few sections of this report will provide a background on *General Building Data*, *Architecture*, *Primary Engineering Systems*, *Additional Engineering and Engineering Support Systems*, and *Client Information.*

General Building Data:

Project Location and Site:
1623 Piccard Drive Unit A
Rockville, MD 20850
11.5 acre site in suburban Washington, DC

Building Occupant:
King Farm Presbyterian Retirement Community, Inc.

Occupancy or function types (type of building):
Senior Living: Continuing Care Retirement Community

- Special needs housing
- Health Care
- Interpretive Care
- Community complex consisting of apartments
- and other amenities

Size:
677,559 Square Feet

Number of stories above grade:
7 stories above grade

Total Levels:
8 levels total with Below-Grade Garage

Primary project team:
Owner:
Ingleside Presbyterian Retirement Community

Owner's Representative: Jeffrey Powell Company

General Contractor:
Turner Construction Company

Construction Manager:
Turner-Konover

Architects:
Arthur Shuster

CSD People Architecture

Engineers:
Loiederman Soltesz_Associates

Morabito Consultants, Inc.

Siegel, Rutherford, Bradstock and Ridgway Inc.

Consultants:
Culinary Design Service

ECS, Ltd.

Mandel & Associates, INC.

Whitlock Dalrymple Poston & Associates, Inc.

Dates of construction (start – finish):
Construction Start (Footings): 3/14/2007

Construction Finish (Original Substantial Completion): 1/15/2009

Cost Info:
$97,000,000-GMP Overall Project Cost (construction only; "bricks and mortar")

$101,900,000-Current Indicated Cost
$1,500,000-Upgrades (counters, finishes, etc.)

$3,400,000-Change Orders

Project delivery method:
Construction Manager; Joint Venture

Architecture:

Architecture (design and functional components):
The building appears to be a large mansion designed with a combination of Colonial and Second Empire architecture styles. There are 13 different apartment unit floor plans in the various living units. It has 8 levels consisting primarily of an above grade structure and a below grade parking garage. There is a large open courtyard on the south side of the building; laid out between the 2 major wings of the building.

The building incorporates some sustainable elements into the design such as the use of high-efficiency faucets, lo flush toilets, cross linked polywater tubing (PEX). low E glass, high-efficiency air handling equipment, plantings over the plaza (garage roof slab), feature pond on the project's North side, low VOC coatings.

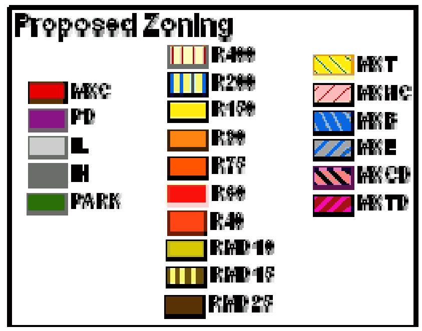
The building serves primarily as a Continuous Care Retirement Community with a multitude of functional components. There are 244 Independent Living Units, 43 Assisted Living Units, 16 Skilled Nursing Units, 10 Dementia Units to house residents with varying requirements. It also contains Restaurants and a Theatre Room for entertainment. Residents have access to an Olympic Size Swimming Pool and Tennis Court to keep active.

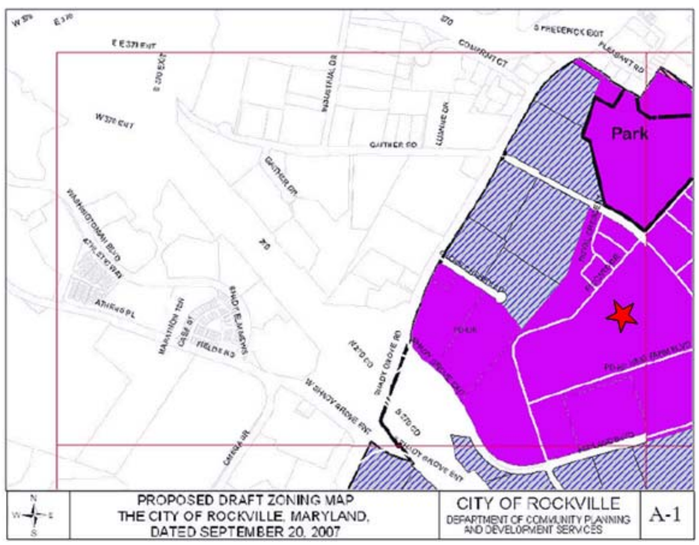
Buildings constructed in Rockville, MD must comply with the major building codes enforced by the Inspection Services Division of the Community Planning and Development Services Department. In addition, they must comply with the Rockville City Code. Enforced codes are listed below. http://www.rockvillemd.gov/business/licenses/isd.htm

- 2006 International Building Code
  - 2006 International Plumbing Code
  - 2006 International Mechanical Code
  - 2005 National Electrical NFPA-70
  - 2006 NFPA-1
- 2006 NFPA-101
- 2002 NFPA 13, 13R, 13D
- 2002 NFPA 72
- Rockville City Code http://www.rockvillemd.gov/government/citycode.htm
- Ingleside is located in a Planned Development Zone.

Key to terms:

MXC: Commercial
PD: Planned Development
IL: Light Industrial
IH: Heavy Industrial
R: Residential zone (# corresponds to density)
RMD: Residential moderate density
MXT: Mixed Use Transitional
MXNC: Mixed Use Neighborhood Commercial
MXB: Mixed Use Business
MXE: Mixed Use Employment
MXCD: Mixed Use Corridor District
MXTD: Mixed Use Transit District





http://www.rockvillemd.gov/zoning/maps052108/GridA-1.pdf

There were no historical requirements for this project.

The building envelope consists of 3 major assemblies; split face masonry, ground face masonry, and simulated stucco. The garage level is constructed primarily of split face masonry on a poured concrete wall with a 2" air space. The ground/first floor consist of 5/8" foil faced gypsum board, 6" metal studs, 6" batt insulation (unfaced), 5/8" exterior sheathing, Tyvek building wrap, 2" air space, and ground face masonry. The second floor through the seventh floor consist of 5/8" foil faced gypsum board, 6" metal studs, 6" batt insulation (unfaced), 5/8" exterior sheathing, and simulated stucco.

The roofing system also varies. The most prominent portion of the roof is a mansard style roof constructed out of light gauge metal framing with metal shingles. The concealed portion of the roof consists of a roof membrane on 1½" metal deck supported by 8" steel "C" channels and steal beams. The 7th floor has low roofs that green roof gardens and are constructed either from poured in place concrete or metal deck with roof insulation system, membrane roof waterproofing system, and a protection layer.

There are 3 basic types of windows that also form 7 different window assemblies; double hung, picture, and bay. The mansard roof contains dormer windows, which project out from the roof structure. The windows are all manufactured with PVC frames and 5/8" double light insulating glass set with marine glazing.

<u>Primary Engineering Systems:</u>

<u>Construction:</u>

Turner and Konover entered into a joint venture contract to deliver this project as a CM agent; fees are divided giving Turner 51% and Konover 49%. Turner is the General Contractor (GC) and they cover the protection of the safety contractor and labor. The developer, Penrose Group, helped finance this project for the owner to bring affordable living to Rockville seniors.

Construction equipment used for this project includes tower 2 tower cranes with a 230' reach and a maximum lifting capacity of approximately 13 tons. They're used primarily to hoist concrete buckets from the on-site batch plant into place for the construction of the superstructure. The footprint of the building is very long so this requires the use of somewhat large cranes, which must be placed in close enough proximity that they are at risk of crossing paths. Careful coordination will maintain safety.

Some special systems associated with the project include a Surveillance System and a Visual/Voice Nurse Call System. More detailed explanations of the main engineering systems are called out below, which also corresponds to Technical Assignment 1.

<u>Electrical:</u>

Power is fed from 2 locations; one on the west end and one on the east end. Both services #1 and #2 have a 4000 Amp Main at 480/277 V. They are 3-phase with 4 wires. This creates an interesting coordination issue trying to keep the panel feeders in order. A 750 KW Emergency Generator is also located in the basement and provides power for some of the critical items listed below:

- Emergency Lighting
- Fire pump
- Elevators
- Door Controls
- Food Service Refrigerators/Freezers
- Toilet Exhaust Fans
- Water Source Heatpumps

- Standpipe Power
- Day Tanks
- Boilers

Lighting:

The lighting for common areas is primarily provided using a form of compact fluorescent lighting, which is in line with the anticipated LEED rating and energy conservation effort. The lighting controls are somewhat typical and do not have any provisions for occupancy sensors/timers. On/off is the primary control of the interior systems. The exterior systems utilize primarily High Intensity Discharge (HID) lighting for the pathways and roof gardens.

Mechanical:

Ingleside at King Farm's Mechanical Rooms & Boiler Room are located in the Northwest end of the Garage. There are Gas-Fired Rooftop Units, which make a Constant Volume Air System throughout and maintain a positive pressure in the corridors to prevent cross-contamination between living units. Induced Draft Cooling Towers are located on the roof with a Plate and Frame Heat Exchanger in Garage to serve the Heatpump Loop. This Heatpump loop contains Water Source Heatpump Units in each of the living units for individual control. Gas-Fired Forced Draft Hot Water Boilers in the basement provide the hot water for the Water Source Heatpump Units. Electric baseboard used to provide an additional stage of heat when needed. Ductless Split Systems serve the memory assist living units.

The Garage is partially finished. The parking area is heated with small individually controlled electric Unit-Heaters and the exhaust gases are removed with large exhaust fans on the north side of the building. The offices and storage areas are served by their own Water Source Heatpumps.

Structural:

This structural system is a two-way framing system that contains a 8" concrete Post-Tensioned floor systems and a 12" first floor. The post-tensioned superstructure consists of flat plate floor slabs with 8.5' x 8.5' x 10" drop panels on the first floor and 10' x 10' x 5.25" drop panels on the seventh floor. The drop panels for the first floor help support the structure and central courtyard above the Garage and the drop panels on the seventh floor prevent the rooftop mechanical equipment from causing punching shear with the columns, which would cause collapse. In addition to the concrete structure, the seventh floor exterior walls are framed using steel columns. The roof is framed using light gauge steel for the sloped sections, which is supported by a concrete roof slab around the perimeter of the building. The middle portion of the roof is constructed with K-Joists supporting 20 gauge galvanized roof deck. Excluding shaft walls, the building has four one foot thick shear walls to support lateral loads such as wind. The shear walls extend from the Garage through the seventh floor.

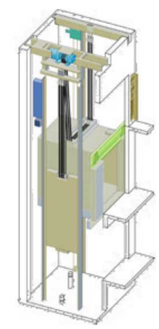
Additional Engineering and Engineering Support Systems:

Fire Protection:

Ingleside at King Farm is to be a fully sprinklered building using automatic wet pipe system and dry system in areas prone to freezing such as the garage. This is an active system. The Fire Protection Systems and Equipment are regulated by the National Fire Protection Association Pamphlet 13 (NFPA 13). An NFPA 101 code search determined the fire construction type as Type I-332 Construction; building elements are of noncombustible materials.

Transportation:

Transportation throughout the building is handled via a quantity of 7 OTIS Gen2 Machine Roomless elevators. Although the name implies that the elevators do not require a machine room, they still require a remote space for some of the power distribution and controls. These elevators are the new generation of inter-building transportation and are geared to more efficient use of space, energy reduction, and reduced installation time. The maintenance costs and energy savings with these elevators are significant and will be realized immediately by the owner.



Telecommunications:

All the telecommunications, phone and internet (CAT5E) and cable TV (CATV), are fed from the east side of the building through 4" conduits as directed by the CATV company and Verizon. Each living unit has provisions for hard-wired internet hook up, telephone, and TV.

Special Systems, Special Uses or Unique Aspects of the Building:

The Garage was not previously explained in great detail. It is partially finished and is used for the administrative staff offices and some resident storage. Some other items that were not previously detailed include the additional amenities. Ingleside at King Farm is intended to provide its senior residents with affordable and comfortable living. Everything to sustain a happy, healthy, and stress-free life is found under the roof and between the walls of this building. The first floor features the majority of the community gathering spaces such as the Bistro, the Bar, the Full-Service Kitchens, the Demonstration Kitchens, the Common Dining Restaurants, the Private Dining, the Market Place, the Multi Purpose Room and Auditorium, the Game Room, the Conference Room, the Sitting Room, the Library, the Computer Room, the Living Room, the Bank, the Mail Room, the Beauty Salon and Massage Room, the Arts/Crafts Room, the Fitness Room and access to the future Pool area. Each area is essentially a separate space and each has its own design challenges associated with it.

The site lies between 2 Forest Conservation areas to the east and west of the property. This provides an appealing buffer between adjacent land owners. In addition to the natural vegetation surrounding the property, the project calls for a fairly large amount of landscaping and roof garden work. Included in the plans are 24 different species of deciduous shade trees, ornamental trees, and evergreen trees totaling 198. There will be 740 deciduous and evergreen shrubs, which is broken up into 19 species. 24 different species of ornamental grasses, perennials, and groundcovers add up to 3,291 units.

Although this helps beautify the property, it does not contribute to the water efficiency of the site. Further research is required to determine if there are opportunities to maintain the site appearance and reduce water usage with the use of more native plant species and alternative treatments. On the contrary, some facility owners report that extensive landscaping surrounding your building reduce HVAC equipment maintenance/operation costs, reduce cleaning costs, and improve indoor air quality (IAQ).

Client Information:

The owner, Ingleside Presbyterian Retirement Community, Inc. (IPRC), currently owns two continuing care retirement communities (CCRC) at other locations. They are named Ingleside at Rock Creek and Westminster at Lake Ridge. IPRC is looking to expand with a new community. Rock Creek and Westminster are both accredited by the Continuing Care Accreditation Commission (CCAC). They are not-for-profit life care communities. Rock Creek is located in NW Washington, D.C. and Westminster is located in Lake Ridge, VA. They offer housing and health care services primarily to Presbyterian Church members age 65 and up. The members are capable of independent and limited assisted living. Residents have access to a Medicare certified Health Care Center since health is one of IPRC's primary considerations.

The new community is dedicated to providing its senior residents with an active, comfortable lifestyle and high-quality, long-term health care. The new location will have many of the same amenities as the other communities such as a swimming pool and restaurants in addition to some new features like the theater and market place. It is located in the heart of an intergenerational planned community, King Farm; hence the name Ingleside at King Farm. The residents of the new community will also have access to full healthcare services that range from temporary rehabilitation to long term care. The owner wants residents to enjoy a stress free lifestyle with the convenience of a small town and atmosphere of a metropolitan area.

As a not-for-profit, maintaining a tight budget will be very important in order to keep costs to a minimum while still promoting a quality image for prospective residents. IPRC promotes the quality of senior living at their other facilities and this facility is no different from that aspect and this project is expected to present the same positive image of senior living. There were $1.5 million in upgrades on this project that were primarily related to improving the quality of the counters and other finishes. Another important part of the Ingleside at King Farm project is the desire to achieve the U.S. Green Building Council's (USGBC) LEED Certification and marketing the benefits of the sustainability movement to prospective residents.

The schedule is important with this project as it is in any project that involves residencies. Ingleside anticipated holding an open house for current depositors on 9/21/2008 to show them how their particular living units would look. In a note from the Ingleside at King Farm website, it mentions that the open house will unfortunately be postponed until the life safety systems are in place. Currently the life safety systems are not in place since the building is still under construction. The City of Rockville will not approve of the open house event until the life safety code requirements have been met. This open house is very important to the owner to be able to showcase the new living units and potentially use the open house to attract more residents.

According to the Ingleside at King Farm website, the tentative opening date will be by the end of the first quarter in 2009. As the project nears closing, this date will become more crucial since they given current depositors the word to begin selling their personal homes and scheduling settlement (move-in) beginning 3/15/2008. There is no phased occupancy on the calendar for this project, but the site plan shows the addition of two additional assisted living facilities for the second phase of construction. There are no plans to construct Phase 2 at this time due to the current condition of the housing market. During the construction process, the owner is interested in the life safety systems sequence as mentioned in order to get occupancy. Another sequencing issue that the owner is interested in is completing the SER Review and receiving the Stripping Letter for the PT concrete slabs, which gives the OK to remove the forms on the slab and reshore the structure. Without the approval to do this, the project cannot move forward and will cause delays in scheduling tenant settlement. Another sequencing issue is the timely delivery and installation of major mechanical equipment and appliances for the living units. The major equipment ties into the localized heatpumps in the living units to insure optimum comfort of each resident while the appliances add the final touch to the units and make the residents feel like they've got a place to call their own.

The keys to completing the project to the owner's satisfaction are to bring the project to a timely completion of a facility that will withhold the reputation of the IPRC name and meet the owner's USGBC LEED certification expectations. The environment is an important thing to protect and will uphold the quality of the residents and surrounding community. They are well known in the D.C. metropolitan area for their CCAC accredited continuing care retirement communities, so they certainly want to keep the good faith in the area.

Problem Identification

Construction projects are each unique and pose many challenges for designers, managers, and builders since there are a multitude of variables that are entered into the design and construction equation. One of the most powerful or influential variables of any project is time. Too much time spent on any one piece of the project could inhibit completion and cause a project to fall behind schedule. Too little time spent on any one piece of the project sacrifices quality and could potentially blind the project team from realizing significant savings and also cause the owner to miss out on great value engineering suggestions. Owners can often save money by following these suggestions. In addition, builders can cut costs by following a well developed plan. This sums up the challenges presented above by noting that not enough time was spent on developing the bid documents and construction documents up front.

The contents of this section will mainly focus on implementing additional sustainable practices or incorporating additional green features into the project. Through doing so, the goal will be to evaluate how the time spent early on in the building process will ultimately effect schedule and budget. In an effort to spread the word about the importance and value of sustainable practices, this assignment will expectantly inspire new thinking and show how sufficient planning is a worthwhile investment of time. It is frequently dismissed in lieu of traditional, or standard, methods in order to stay ahead of schedule in the early phases of a project. Ingleside at King Farm, like all construction projects, has several features that could benefit from additional planning. Each of the items identified below were developed for a previous report and needed further research and evaluation to determine their feasibility. The identified problems will be addressed in the *Depth Study* section of this report.

Building Envelope Performance:

In addition to improving constructability, the thermal conductivity and performance of the exterior wall could be improved by investing in the early design of the building envelope, which would improve the overall building performance as a whole and reduce energy costs to the owner. Increasing the thermal resistivity of the building envelope is almost always a good investment that will reduce operation costs, energy usage, and decrease demand consumption. It is possible that improving insulating properties of the building envelope could be done through changing insulating materials or changing wall construction type. A preliminary suggestion on an alternative wall construction type would be the use of a prefabricated product by Kama Energy Efficient Building Solutions (kama-EEBS).

Kama walls eliminate cold bridges and provide a strong thermal break in the wall system. The product is GreenSpec Listed and Greenguard Indoor Air Quality Certified, which are attributes of its sustainable characteristics. Additionally, the product literature advertises that it can add as many as 23 LEED points to a project. These are all strong claims that will need careful analysis.

Construction Waste Management:

During a site visit to Ingleside at King Farm, it was evident that construction waste is a big issue with this project. Piles of trash were found in various locations throughout the building due to overflowing dumpsters. Some of the trash piles were large enough to fill a room rendering that area unworkable and blocking trash chutes from being used when dumpsters were empty. This type of issue can cause a safety hazards such as tripping and can slow down a project. Trash is a huge consideration, especially on larger projects. Trash costs money to dispose of and adds considerably to landfills, which existing ones only have twenty years of capacity left in the U.S. based on our current trash generation. This project, although pursuing LEED Certification, did not have an effectively executed waste management plan, which could've gained the project an additional LEED point under credit 2.1.

Water Efficient Landscaping:

Landscaping adds significant curb appeal to a building and helps set the feel for a building. The landscaping is important for creating a quality atmosphere in this continuing care retirement community so sacrificing landscaping is not an option to the owner. Alternative water efficient landscaping is an option, though, that may contribute to the LEED Certification credits. Consideration must be given to the layout and plant type in order not to detract from atmosphere of the community. A recent conversation with the owner's son, who is tracking the LEED documentation, revealed that there have been numerous conversations with the City of Rockville about the potential for achieving this credit. Further investigation into the curb appeal and variety of native species of plants would be required to determine if the proper balance between aesthetics and sustainability could be reached.

Technical Analysis Methods

Although there are many opportunities to address change in the design of a project, not all of the ideas are feasible. Some of them appear to be more achievable than others. This section will focus on four of the problems and challenges addressed in *Problem Identification*. A description of the analysis methods and the type of design and construction analyses will be given along with anticipated research required to analyze the problem or challenge. The four areas of technical analysis will be Building Envelope Performance, Mechanical System Design, Construction Waste Management, and Water Efficient Landscaping. These Analysis Methods created for an earlier report will be further developed in the *Depth Study* section below.

<u>Activity I-Building Envelope Performance:</u>

The exterior wall was noted earlier as one of the constructability challenges. It is also an area with room for performance improvement. In order to improve the performance of the system, the first task must be to evaluate and understand the existing design and construction of the system in terms of thermal resistivity. Once this information is understood, the next task will be to research alternative materials such as the kama-EEBS wall and research alternative wall construction types to determine the best fit for the project. These alternatives will be compared against the existing system for energy performance, material cost, labor cost, and duration of construction.

Material costs will be calculated using a detailed cost estimate of the current building envelope and compared to a cost estimate of the proposed kama-EEBS system. Labor calculations will be done based on existing schedule durations to show variance in labor costs between the two systems and impacts that the proposed system might have on project duration. An extra task will include the anticipated LEED points that can be added to the project by using an alternative construction type and it will be compared to the current system.

This proposed system addresses the critical issue of a lack of time to design the exterior skin by the CM. It will also improve constructability, require much less installation time, and prove to be an achievable value engineering idea by potentially adding LEED points.

<u>Activity III-Construction Waste Management:</u>

Implementing construction waste management practices into the Ingleside at King Farm project would not be difficult if well planned. The first task to evaluating this would be to develop an achievable and affordable execution plan that can be shared with workers so they know the plan and understand the importance of following the plan. Additional research will be performed to learn how to achieve buy-in from the project management team and the workers. Next, the required amount of additional dumpsters will be determined along with pricing for the additional dumpsters so trash can be separated from recyclables. Site impact and logistics will also be considered for the additional dumpsters.

A list of local recyclers will then be created to show where specific materials can be taken and a list of manufacturers offering products with minimal packaging will be provided for commonly used items such as adhesives, fasteners, and insulation. Window, door, equipment, and furnishings manufacturers will also be contacted to inquire about the feasibility of reducing their packaging. It's anticipated that maintaining a clean site could improve productivity, so a schedule comparison will be provided showing the negative impact that trash can have on a schedule. Finally, a cost comparison of how much money that will be saved on tipping fees will be provided and compared to current trash build up, which will reveal an estimated reduction in tonnage saved from landfill waste.

A clear and affordable construction waste management plan will improve site safety. The reduction or elimination in site clutter will improve productivity by reducing loss time due to unworkable areas of the site. If the plan is well developed and achievable, it may uncover significant savings that could potentially be passed on to the owner.

Activity III-Water Efficient Landscaping:

Designing a water efficient landscape, like implementing a construction waste management plan, is not a difficult task if it is properly planned. In order to evaluate this, research on the currently specified plants will be done to determine approximate water consumption requirements. These requirements will be compared to a weather study showing the average expected rainfall for the location, which will determine the amount of additional watering required for the landscaping. This study is likely to show an excess amount of water is required beyond what can be absorbed from expected rainfall.

Reeds

Once the data is revealed, the highest consumers of water will be studied to find opportunities for reducing the amount of that species, removing that species, or replacing that species with a different species. Research on native species of plants will be performed to find alternatives to the currently specified species. The consumption will be recalculated with each alternative species until the consumption falls below the naturally occurring rainfall.

There will likely be a cost difference between the two design solutions, so a cost comparison will be provided primarily on the difference in plant cost. If it is anticipated that there will be a significant difference in labor associated with the alternatives an estimated labor cost will also be provided. There will also likely be a difference in maintenance and operational costs associated with alternative solutions so an estimate of labor and water usage costs will be provided for each. Cost will not be the only consideration for the alternatives.

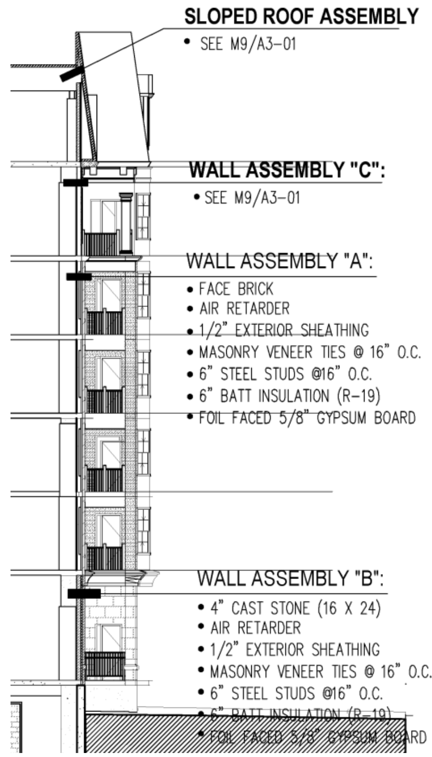
In order to maintain the curb appeal of the building, a form of survey will be required to determine if alternative species, such as sea grass and reeds, will be acceptable. A survey with a set of side-by-side photos, or renderings, of the landscaped areas can be distributed to poll which alternatives are more pleasing to the eye. If it is determined that the current design is comparable to the alternative, then a study will be performed to determine if additional LEED points can be achieved.

Incorporating a water efficient landscaping plan is anticipated to improve constructability since most alternatives will include native species, which should not require extensive labor to plant. It may accelerate the schedule since native species will be easier to acquire and will have shorter lead times. The alternative landscaping will also add value to the project by saving the owner first cost and lifecycle costs.

Sea Grass

Depth Studies

Analysis I – Building Envelope Performance



The intent of this Analysis was to evaluate the opportunity to use an alternative above grade exterior wall system without negatively impacting the structural system. While this analysis focused on the performance of the exterior wall portion of the building envelope, it is important to note that the exterior walls are not the only contributing factor in poor envelope performance. Other key elements of envelope performance include window and roof performance. This Analysis did, however; show a potential for improvement in constructability, reduction in construction duration, and an improvement in thermal and energy performance through the study of two distinct and innovative products.

Both products researched were very similar in their use of an expanded polystyrene (EPS) insulation integrated into the steel stud framing. They are both prefabricated off site and delivered in manageable sections to be installed as infill construction or in a curtain wall fashion. In this case, the application would be infill construction.

These systems allow for faster building enclosure which has many quantifiable savings associated with it. This Analysis will not focus on all these savings, but one example includes less energy spent to heat or cool the building during construction. Another example is the overall duration of the project is reduced in terms of being able to start interior finishes sooner, which could translate into earlier return-on-investment for the owner.

Current Design Overview:

There are three exterior wall types; cast stone, face brick, and EIFS. Each type consists of steel stud infill construction as a backing. This design is more labor intensive than the proposed alternatives and has a low whole-wall assembly R-Value. It is believed that there is room for improvement in constructability and energy performance of this system.

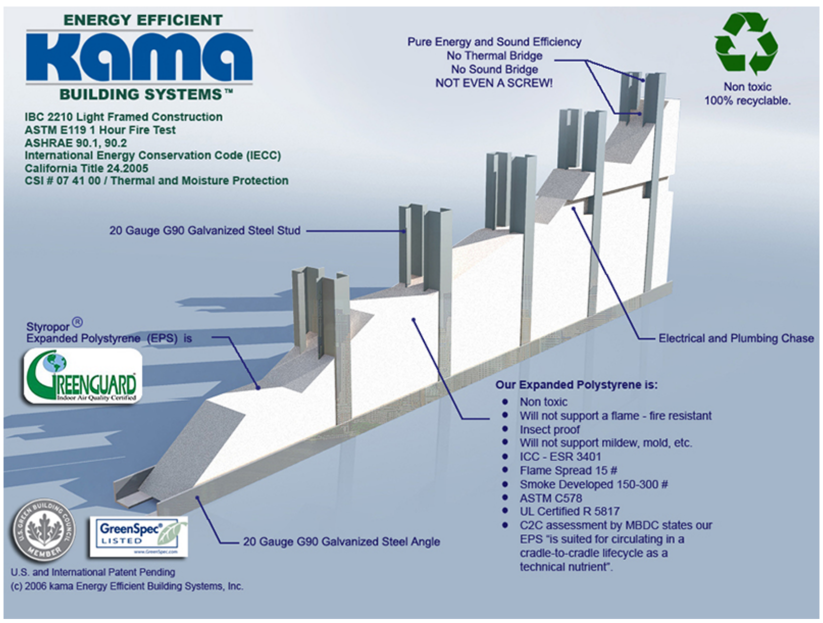
Each wall assembly has a varying total wall assembly R-Value. The R-Values were calculated by summing the R-Values of the materials at the cavity and at the studs and assumed an 85% : 15% cavity to stud ratio with 16" o.c. framing. Assembly A has an R-Value of 25.61 in the cavity and 6.61 at the studs for a total wall assembly R-Value of 17.89. In the same order, Assembly B has values 25.91, 6.91, and 18.34. Assembly C's values are 23.22, 4.22, and 13.86.

Alternative Design Options:

Kama-EEBS Wall System:

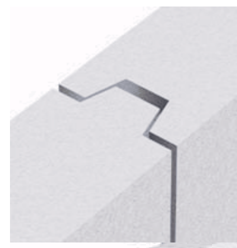
As the diagram below depicts, this product eliminates thermal bridges between indoor and outdoor conditions, improves acoustics, improves energy performance, and does not support a flame or mold, mildew, or moisture. A kama-EEBS wall system will easily replace metal stud construction of the current design to help improve constructability and reduce duration. The product supports the current exterior and interior finishes.

Further research reveals that the product significantly improves thermal performance in each of the wall assemblies. Using the kama-EEBS wall system, Assemblies A, B, and C have total wall assembly R-Values of 30.61, 30.91, and 28.22 respectively.



Accel-E Steel Thermal Efficient Panel:

The Steel Thermal Efficient Panel (STEP) wall system. It's manufacture designed the wall system with the same intent as the kama-EEBS manufacturer. This wall system varies slightly in thermal performance and construction, though. Again, one goal in discovering alternative wall systems was to find a product that would be a direct replacement for the steel stud construction without negatively impacting the current structural system. Accel-E panels will also easily replace the currently designed exterior wall design because it too supports the same interior and exterior finishes. One word of caution with the accel-E product is that it is not as customizable as the kama-EEBS product. Their manufacturing process does not allow them to produce curved walls.



The diagrams show that this product does not completely eliminate thermal bridges like the kama-EEBS does. It's design does greatly reduce the effects of thermal bridging with the staggered web steel framing, which resemble an S-shaped steel stud. These embedded studs form an open cavity on the interior side, which is used for plumbing and electrical components or additional insulation. Like the kama-EEBS product, it does improve acoustics compared to the traditional construction and also does not support a flame or mold, mildew, and moisture.

These panels are joined end-to-end with tongue and groove joints. On the exterior side, the S-shaped studs are exposed so that exterior finishes may be easily fastened to the wall system. Accel-E panels are delivered with all the necessary accessories required for construction such as the top and bottom tracks and Spazzer Bars used for lateral bracing.

In terms of thermal performance, using the accel-E panels would result in total wall assembly R-Values for Assemblies A, B, and C of 30.26, 30.56, and 27.87 respectively. One note to remember here is that this wall system does not eliminate the thermal bridging as the kama-EEBS product does.

Cost and Schedule Comparison:

Both proposed alternates would add significant cost to this portion of the project. The cost estimates were only calculated on the portion of the exterior wall that would change, so it is not to be assumed that the prices shown are the cost of the entire wall assembly. The current design was used as a baseline and includes overhead and profit for the material and labor.

The proposed alternates are priced differently and only include overhead and profit for the labor since the overhead and profit for material is figured into to square foot cost. Additionally, the price includes design fees for fabrication and delivery. Both systems also offer on-site "technical support" included in the price.

See below for a cost comparison.

Façade Square Footage: 225,578 SF

- Current Design:
    - Material: $1.79 / SF of wall ➔ Total Material: $272,306.74
    - Labor: $393,690.21
    - **Total Cost: $665,996.95**
- kama-EEBS:
    - Material: $6.10 / SF of wall ➔ Total Material: $1,376,025.80
    - Labor: $52,492.03
    - **Total Cost: $1,428,517.83 ➔ 2.1 times the original cost**
- accel-E:
    - Material: $6.50 / SF of wall ➔ Total Material: $1,466,257.00
    - Labor: $44,618.22
    - **Total Cost: $1,510,875.22 ➔ 2.2 times the original cost**

These systems are very efficient in terms of reducing construction durations. To maintain schedule, three carpenters would be required to perform the baseline design and it was assumed one carpenter would perform the labor for the alternates. The actual schedule to finish the framing and insulation shows an approximate 30 week duration.

Building Perimeters:
3,411' 10" x 14' First Floor
3,032' 6" x 10' Second through Sixth Floors
2,615' 9" x 10' Seventh Floor

Total Façade Linear Footage: 21,186 LF

- Current Design:
    - Production: 279.3 LF / day
    - Duration: 32.2 weeks
    - Procurement: 6 to 7 weeks
    - **Total Duration: 38.2 to 39.2 weeks**
- kama-EEBS:
    - Production: 187.13 LF / day
    - Duration: 25.8 weeks
    - Procurement: 6 to 8 weeks upon shop drawings
    - 60% cycle reduction
    - **Total Duration: 31.8 to 33.8 weeks**
- accel-E:
    - Production: 195.51 LF / day
    - Duration: 21.9 weeks
    - Procurement: 4 weeks upon shop drawings
    - 66% cycle reduction
    - **Total Duration: 25.9 weeks**

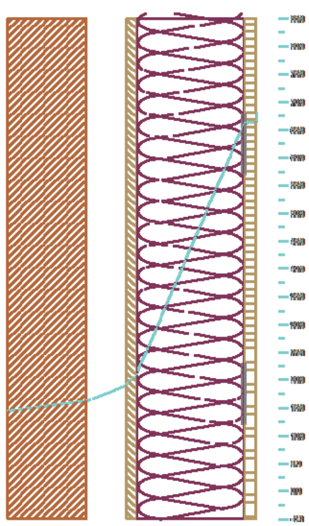
Energy Efficiency Comparison:

Thermal performance of a building envelope is not solely reliant on the exterior wall system. In dealing with the mechanical engineer for the project it was learned that the proposed wall systems do in fact perform well, but they are, unfortunately, unable to produce significant energy savings in terms of heat gain or loss for this project. This is partially due to the code requirements for conditioned ventilation air in the common spaces, skilled nursing units, and memory assist units. Conditioning outdoor air consumes a great deal of energy in comparison to heat gain or heat loss through the envelope.

It is difficult to find a calculation method that will accurately compare a typical steel stud assembly to the prefabricated system. Calculations were performed in Excel to give an approximated R-Value for each assembly; the currently specified Assemblies were compared to the results obtained from the Opaque program. Opaque was not able to accommodate the assemblies of the proposed system and the program was only used to verify that the currently specified wall assembly calculations were reasonable. See below for comparison of thermal performance results.

Assembly A

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
Face Brick	0.45	0.45
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
6" Batt Insulation	19	0
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	25.61	6.61
U Values	0.039047247	0.15128593
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	17.89	



Opaque Total R-Value = 22.64 & Total U-Value = .04

Assembly B

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
4" Cast Stone	0.75	0.75
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
6" Batt Insulation	19	0
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	25.91	6.91
U Values	0.038595137	0.1447178
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	18.34	

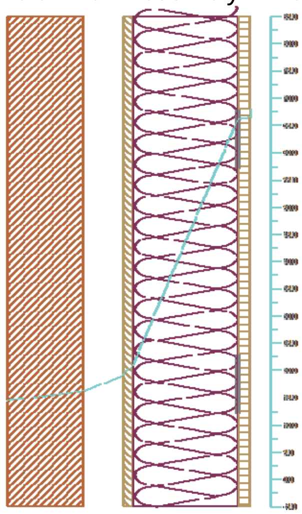


Figure 1: Opaque Total R-Value = 22.64 & Total U-Value=.04

Assembly C

Material	R Value at Cavity	R Value at Studs
EIFS (Stucco Finish)	0.08	0.08
Air Retarder	0	0
5/8" Exterior Gypsum Board	0.48	0.48
6" Batt Insulation	19	0
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	23.22	4.22
U Values	0.043066322	0.236966825
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	13.86	

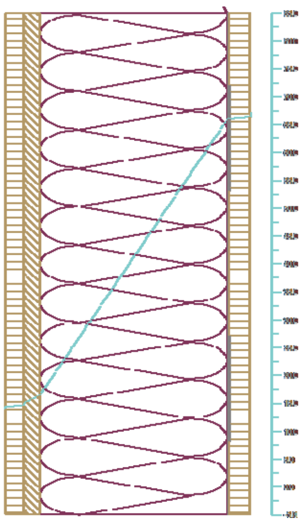


Figure 2: Opaque Total R-Value = 20.80 & Total U -Value = .05

Assembly A with kama-EEBS

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
Face Brick	0.45	0.45
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
2" x 6" Panel (5 1/2") Includes Stud Depth & Insulation	24	24
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	30.61	30.61
U Values	0.032669062	0.032669062
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	30.61	

Assembly B with kama-EEBS

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
4" Cast Stone	0.75	0.75
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
2" x 6" Panel (5 1/2") Includes Stud Depth & Insulation	24	24
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	30.91	30.91
U Values	0.03235199	0.03235199
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	30.91	

Assembly C with kama-EEBS

Material	R Value at Cavity	R Value at Studs
EIFS (Stucco Finish)	0.08	0.08
Air Retarder	0	0
5/8" Exterior Gypsum Board	0.48	0.48
2" x 6" Panel (5 1/2") Includes Stud Depth & Insulation	24	24
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	28.22	28.22
U Values	0.035435861	0.035435861
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	28.22	

Assembly A with accel-E

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
Face Brick	0.45	0.45
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
2" x 6" Panel (5 1/2") Does Not Include Stud Depth	23.65	23.65
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	30.26	30.26
U Values	0.033046927	0.033046927
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	30.26	

Assembly B with accel-E

Material	R Value at Cavity	R Value at Studs
Inside Air Film	0.68	0.68
Outside Air Film	0.17	0.17
Air Space	1	1
4" Cast Stone	0.75	0.75
Air Retarder	0	0
1/2" Exterior Sheathing	0.65	0.65
2" x 6" Panel (5 1/2") Does Not Include Stud Depth	23.65	23.65
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	30.56	30.56
U Values	0.032722513	0.032722513
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	30.56	

Assembly C with accel-E

Material	R Value at Cavity	R Value at Studs
EIFS (Stucco Finish)	0.08	0.08
Air Retarder	0	0
5/8" Exterior Gypsum Board	0.48	0.48
2" x 6" Panel (5 1/2") Does Not Include Stud Depth	23.65	23.65
Foil Faced 5/8" Gypsum Board	3.1	3.1
Densglass	0.56	0.56
Total Wall R Values	27.87	27.87
U Values	0.035880875	0.035880875
Percentage for 16" o.c. Framing	85%	15%
Total Wall Assembly R Value	27.87	

Current Design:

As noted earlier, there are three different wall assemblies with varying total wall assembly R-Values. Assembly A has an R-Value of 25.61 in the cavity and 6.61 at the studs for a total wall assembly R-Value of 17.89. In the same order, Assembly B has values 25.91, 6.91, and 18.34. Assembly C's values are 23.22, 4.22, and 13.86. Thermal performance is calculated differently for the current design than it is for the proposed alternatives due to the thermal bridging created by the metal studs.

Kama-EEBS Wall System:

Further research reveals that this product significantly improves thermal performance in each of the wall assemblies. Using the kama-EEBS wall system, Assemblies A, B, and C have total wall assembly R-Values of 30.61, 30.91, and 28.22 respectively.

Accel-E Steel Thermal Efficient Panel:

In terms of thermal performance, using the accel-E panels would result in total wall assembly R-Values for Assemblies A, B, and C of 30.26, 30.56, and 27.87 respectively. One note to remember here is that this wall system does not eliminate the thermal bridging as the kama-EEBS product does, but was assumed to be negligible.

LEED Analysis:

Evaluating the potential for earning LEED credits yielded interesting results. Again, the baseline is the current steel stud construction. The current wall system did not earn any LEED credits, so there is plenty of opportunity to earn points with the proposed alternatives.

If using the kama-EEBS system, there is an estimated 33% decrease in mechanical system capacity, which results in a 19.8% energy performance optimization to earn EA Credit 1.3. EQ Credit 4.1 and EQ 7.1 are earned for the use of low emitting materials and thermal comfort design respectively. Sealants and adhesives must also comply with Credit 4.1 to earn the point. A large portion of the construction waste associated with the exterior wall assemblies will be retained at the manufacturing plant. In terms of a percentage of the whole exterior wall assembly that will see waste savings, the steel stud construction with R-19 batt insulation is approximately 50% of the remaining portion of the wall, which contains brick, cast stone, stucco, etc. Integrating the use of this product into the implementation of a construction waste management plan is the way to earn the maximum amount of LEED credits for this project; it will contribute to diverting the desired 75% of Construction and Demolition (C&D) debris from landfill by reducing on-site waste. This will result in two points being earned for MR Credits 2.1 and 2.2. Kama-EEBS will directly add three LEED points to the project and contribute to earning two additional points.

Similar to the kama-EEBS in terms of contributing to waste diversion, the accel-E product will help earn MR Credits 2.1 and 2.2. Where the accel-E product is weak is energy performance optimization; 16.8% was not enough to earn the next point under EA Credit 1.3. Accel-E does still qualify for EQ Credit 7.1 for thermal comfort design, though. This product directly adds one LEED point to the project and contributes to earning two additional points. See LEED Analysis Tables in the *Breadth I – Sustainability* section of this report for more information.

Design Time and Procurement:

Design time for using alternative systems will not significantly change with the use of one of the proposed alternates. The difference lies in the procurement.

The current design requires six to seven weeks to procure the steels studs through a supplier, and the CM, GC, or subcontractor would be responsible for performing their own quantity take offs to determine how much to order. If the decision is made to use the kama-EEBS wall system, it will take six to eight weeks upon the manufacturer receiving shop drawings. The accel-E product surpasses both of the other options and takes only 4 weeks for fabrication and delivery upon receiving the shop drawings. The major difference in procurement is where the responsibility is placed.

Originally, it was thought that the proposed alternates would require more careful attention to procurement. This is not the case, though, since the responsibility lies with the manufacturer to read the shop drawings to produce the walls.

Constructability Comparison:

Constructability of the current design was difficult at the time the exterior enclosure began on this project due to incomplete construction documents. This wall just was not clearly detailed and left confusion as to how to construct so Turner-Konover took the role of designer on the project and employed their own staff to finish detailing the exterior wall. The actual constructability of the current design, once detailed, is standard in terms of difficulty level, but a full constructability review reveals room for improvement.

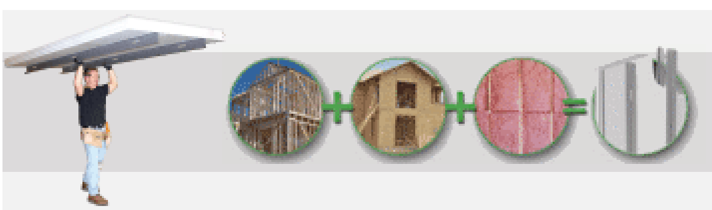
The primary enclosure systems and assemblies were not identified and coordinated. The secondary enclosure elements such as the specific trim materials and lintels were not identified. Design documents lacked evidence that the exterior moisture control systems and assemblies were clearly identified and coordinated such as water proofing, damp proofing, weeps, and caulking. This same issue holds true for the thermal control systems and assemblies such as clearly identifying and coordinating insulation and caulking. With the incomplete construction documents and the mismatch between architectural drawings and structural drawings as noted in an earlier report, the design possibly contained coordination issues with the ceiling and wall locations not matching the window wall framing. This could lead to issues of missing information on joining of dissimilar materials or sill and head flashing. Some of these issues for the infill construction portion of the project could easily be addressed by utilizing one of the proposed alternates (General Contractor's Council Associated Builder's and Contractors, Virginia Chapter). Typically, a constructability review will take place early in a project during the conceptual design stage. Proposing an alternative exterior wall system, or any system, is better reviewed early on, but a system such as the kama-EEBS or accel-E products allow for a more dynamic change out because the systems have already been engineered to perform well and designed to meet or exceed all building codes. It does not impinge on the architecture of the project and still supports the currently specified interior and exterior finishes. These systems are essentially a direct replacement of the current infill construction and save significant construction time due to the framing and insulation being integrated into one piece.

To see a video of the kama-EEBS system being constructed, visit the website http://kama-eebs.com/images/KAMA_QuickTime.mov. It will show the fast production rate achievable with this system. The whole video is approximately 47 seconds long and shows the workers install four panels of the wall system. The video does cut away, but it is estimated that it takes approximately 37 seconds to install the first three panels; not including the time required to join the panels together. It is estimated that there may have been a 10 to 15 minute elapsed time for the installation of the first three panels based on the movement of the shadow from the under floor conduits in the foreground of the video.

This means that it takes approximately 12.3 seconds to erect and 5 minutes to join a typical eight foot wide panel (5.205 minutes per panel). There is a total of 21,186 LF of façade on Ingleside at King Farm so there would be approximately 2,649 panels. Total time would be 13,784 minutes, which is 229.7 hours, or 29 days. These results vary from the estimates above because this video depicts many more carpenters performing the work. This estimate also does not include the time required to install the top and bottom tracks.



Accel-E's product, again is very similar in constructability and a more detailed video is available at http://www.accbt.com/accbt_video.html. This product also requires a top and bottom track, or channel, similar to that of the current design. The sales representatives are very familiar with their competitor, kama-EEBS, and they claim that the accel-E product is much easier to construct, but this is a bias opinion and each project should be evaluated for desired results before choosing the best option. In either case, the ease of construction is evident in this system as well, and the product's website shows a carpenter easily carrying a panel over his head. As in the kama-EEBS product, the accel-E product contains the framing, sheathing, and insulation in one piece using the embedded steel stud design. This design, as seen in the figure, gives the carpenter something to grasp as he is setting the panel in place. This might be the key determining factor in choosing this option over the kama-EEBS wall system, especially on projects with multiple stories. It would allow for installation from the interior of the building much easier. The kama-EEBS product might require the use of scaffolding or mobile lifts in order to hold the panels from accidentally falling to the ground.



If using one of these prefabricated products, damage caused by accidents or other unforeseen events may really put a damper on the project schedule if pieces are unavailable during building enclosure. This would not cause significant delays if using the current design because the supplies are more readily available. The main idea is that these systems can easily be installed using no special equipment, just the standard tools that a carpenter already has. They are comparable in price, availability, and performance.

All the special components or accessories required to construct these systems are included in the square foot price and both manufacturers provide these items with each order. When the systems are delivered, a company representative stays on-site to train the installers on how to construct the systems and seal the joints. Each project goes together like a puzzle and the pieces are numbered so that the carpenters know which piece goes where and also so they know where to start.

Delivery & Storage:

Delivery of the kama-EEBS or accel-E panels creates an interesting coordination issue with lay down area since all 2,649 (+ or -) pieces are essentially delivered at once. Each floor will probably hold in the neighborhood of 378 panels. If each floor's panels were stored by area, then the building would have approximately 5 lay down areas per floor taking up an area of 19' x 20' each, or 380 SF each. It is ideal to time the delivery so that the concrete work is complete and so that and shoring has been removed.

Industry Acceptance:

Industry acceptance can be explained from different points of view so there is no simple answer to explain how well these proposed alternatives are accepted. On one hand, the first cost of the material itself is much higher. This may deter owners and designers from accepting this on their projects. On another hand, it saves on required labor, which is not supportive of a poor economy. From the engineer's or architect's perspective, the products offer certain degree of flexibility in their designs. An advocate of the sustainability movement may suggest, the use of the product based on the small environmental impact the products offer.

Summary and Conclusions:

Both kama-EEBS and accel-E have developed great products. There are many benefits to using each system that make them attractive choices for this project. The continuing care retirement community is owned by a client that cares about the health and well-being of its community and its surrounding communities. Being environmentally responsible, they have already adopted the LEED rating system so the perfect choice seems to be the kama-EEBS system.

This system earns an additional three LEED points for the project for optimizing energy performance, thermal comfort design, and low emitting materials. These are important considerations for a senior living facility. This product is made from recycled materials and is also 100% recyclable. This did not earn additional LEED points, nor did it detract from LEED points, because the project was already on track to receive MR Credits 4.1 and 4.2 for recycled content. The product contributes to reduction of on-site was and helps earn two more LEED points. Another note to make is that the product also did not detract from the project earning points for MR Credits 5.1 and 5.2 Regional Materials.

This product even excels beyond LEED's requirements. As mentioned, it's made from recycled materials, and is 100% recyclable, so its lifecycle "score" is high. It does not support a flame, mold, moisture, or mildew so this is another attribute of its code compliance, health characteristics, and contribution to building longevity. The product is also resistant to insects so the building requires less chemicals for pest control, which saves costs and promotes the health and well-being of the community.

First cost is always a concern when choosing whether or not to pursue LEED certification. The kama-EEBS product is the least costly of the two alternatives, which both offer the same basic solution. Although the two products offer virtually the same solution, kama-EEBS earns more points and costs less, so it is the obvious choice between the two options.

Analysis II – Alternative Mechanical System

This Analysis has been removed from the scope for this thesis due to some of the findings that will be discussed below. The original intent was to investigate the opportunity to utilize the site pond as a "heat sink" to improve sustainability, reduce schedule, reduce first cost, and eliminate the placement of cooling towers on the roof. Another goal for this Analysis was to investigate the possibility of utilizing a more centralized mechanical system to serve the living units; rather than using separate pieces of equipment for each unit. These would have offered multiple benefits to the owner.

Eliminating cooling towers from the project by utilizing the site pond with the water source heatpumps would result in significant energy savings and would contribute to the goal of achieving LEED certification. It would also reduce the schedule by approximately 10 to 15 days for installation of the towers. This doesn't include the 50 days required for fabrication and delivery or any time required for commissioning. The project would have saved the owner significant equipment costs and would possibly result in structural system costs due to the omission of cooling tower placement on the roof. A more centralized HVAC distribution could improve the construction program by dealing with less pieces and reducing schedule. It could potentially result in a lower first cost through total equipment and labor savings. It would also provide valuable savings to the owner since major components of energy consumption is pump motor load and fan motor load.

One issue with these items is that the site pond, without modifications, is used for storm water management so the heat sink source would not be continuously present without the use of a makeup water system and civil redesign to contain the water while efficiently managing storm water. There are potential code issues involved with using potable water to supplement the pond source as well and working with local water authorities may be difficult. The pond loop idea also does not seem feasible because it might require a deeper/wider excavation to meet load requirements, but this will be difficult due to future plans to develop the rest of the site. Another project consideration against the use of a pond system is that the mechanical engineer on the project had never designed this type of system before, which might result in a higher engineering fee to covering consulting costs. Traditional geothermal wells may also present a challenge in maintaining an open site for future development.

One area of improvement that the mechanical engineer mentioned might be more feasible is the use of a series of centralized exhaust systems for the ILU's. This would replace the individual exhaust fans that discharge at the exterior wall. Doing so, would result in an aesthetic improvement to the façade because a centralized system would extend up through the roof. Roof mounted energy recovery units could then be used as a way to pre-condition the ventilation air. This would significantly reduce heating and cooling loads, but would require the use of valuable floor space for shafts.

Another option mentioned for reducing energy consumption would be to use a demand ventilation control option. This system uses carbon dioxide sensors in the common spaces to determine how much outdoor air is required in the space in lieu of having a static cfm setpoint to bring in a constant volume of unconditioned air. It would increase or decrease outdoor air to the common spaces as needed depending on oxygen being used up by the occupants.

Analysis III – Construction Waste Management

Managing construction waste is a major challenge and concern considering the monetary cost and environmental impacts. There are a limited quantity of Construction and Demolition (C&D) Waste Landfills in the D.C. Metropolatan and some trash, depending on volume may need to be hauled outside of this area in order to be disposed of properly. This also depends on the type of materials being thrown away and the volume of trash.

This site will be significantly impacted by the use of a construction waste management plan, but not necessarily in a negative way. The main impact for the use of multiple dumpsters is the space they take away approximately 2,000 SF of valuable staging space from the courtyard and surrounding site. In hopes of improving site cleanliness and construction efficiencies while maintaining order of waste removal, the construction waste management site plan shows the desired flow of waste from the building through the main corridors, which are shaded in light green. See Appendix A. This may seem like a trivial piece of coordination data or a wasted plan, but it will leave no guessing as to what is to be done with the trash. The large green arrows at the exits indicate the primary route for removing recyclable materials, the large red arrows show locations of the trash chutes, and the smaller green/red arrows show the desired flow throughout the building.

There are 4 separate dumpsters shown on the waste management waste flow plan at each location, but this will vary depending on the phase of the project and in actuality there may be more or less dumpsters than what is currently shown. The flow of waste will not change, though, just the quantities and types of dumpsters. Dumpster types include Wood, Metals, Concrete/CMU, Drywall, Cardboard, Paper, and Trash.

Safety Concerns, Schedule Impacts, and Site Impacts:

One fact that may catch the attention of builders and construction managers the most is that maintaining a clean site can reduce accidents on the project and will aid public relations (Federated Insurance, 2007). According to Federated Insurance, safety efficiency is not just a function of picking up the trash, but is also a function of overall good housekeeping. Maintaining good housekeeping makes business sense also because reducing accidents on site will reduce insurance claims and help a company keep a low Experience Modification Rating (EMR). This results in reduced costs on insurance premiums.

In interviewing the CM, it was learned that there were many complexities associated with trash generation and the CM was not able to specify all of the concerns. A superintendent on the project mentioned that dealing with trash was one of the biggest recurring issues on projects. This type of mentality and attitude can surely trickle down through the workers on the project and will inevitably affect the morale on the project. As will be stated in the *Schedule Reductions of Implementation*, morale can decrease operating incomes for companies. Morale will also affect focus and efficiency, which has a definite impact on the schedule. Quantifying this is next to impossible because there are major and subtle ramifications associated with poor project morale.

Again, morale is playing a big part in maintaining a clean site, which can result in a safe site and an accessible site. Site accessibility in terms of specific construction areas is a major aspect of maintaining efficiency. This can be interrupted if certain areas of a project become overwhelmed with trash. The impact on the site could result in catastrophic accidents in the case of Ingleside at King Farm. One example is the possibility of a spark potentially setting stockpiles within the building on fire; burning out of control. This creates a vicious cycle of more safety concerns, schedule impacts, and site impacts.

Statistics:

By now, most CM's and GC's are aware of the LEED rating system, but some are not aware of the waste statistics associated with the construction industry. The following numbers are almost unfathomable, but very sobering. It's no wonder why the sustainability movement is heavily focused on buildings.

- Buildings contribute 30% to U.S. waste output each year (136 million tons)
- Buildings use 40% of our raw materials

(U.S. Green Building Council, 2008)

An issue with the above statistics is that the data is based on a study done in 1997. As time passes, these numbers are most likely becoming less accurate and quite possibly growing. So the waste problem is ongoing and growing, which means the cost of waste will grow as it becomes more and more difficult to manage trash flows at local landfills. Builders, or ultimately owners, will be forced to pay higher tipping fees to have the trash hauled to more distant landfills.

Trash Generation:

Ingleside at King Farm made a significant contribution to the C&D debris burden on local landfills. An estimated 536 tons or 1,072,000 pounds of trash was produced. In

terms of weight, this is equivalent to 268 average U.S vehicles being driven straight to the landfill (Hakim, 2004). In terms of volume, it's estimated that 8,542 CY of trash was hauled away, which is equivalent to approximately 10,629 GE refrigerators being tossed straight in the landfill. This is a daunting environmental issue.

Waste Reduction Options:

There are a few different ways to look at waste reduction. One way to look at it is the reduction of waste coming onto the site in the form of packing materials. Another way to look at it is the reduction of waste leaving the site in the form of fees paid for hauling trash. A third way to look at it is the amount of C&D debris that can be recovered in the form of reusable materials or shipping containers.

To alleviate some of these issues, it's recommended that designers, builders, and owners work together toward creating a project specific solution. In the case of Ingleside at King Farm, the project is situated in a region that has already begun to advocate the sustainability movement. This means that local companies and organizations are prepared to do "green" business. One example is the various hauling companies available in the Rockville area.

Reducing waste coming onto the site will eliminate clutter before it forms, but the whole project team must be in agreement to achieve a certain level of waste reduction, or waste diversion from landfill. Once everyone has bought into the idea, the designers should begin writing the proper language into the front end specifications. An example of the language should read "All material salvage and/or efficient use opportunities will be explored prior to disposal to a landfill (James G. Davis Construction Corporation, 2006)." This type of language will ensure that all the players are aware of the goals from the beginning and will bring forth the "capable" subs in the bidding process. By communicating the waste reduction goals up front and requiring subcontractor buy in through mandatory pre-award meetings, many issues will be avoided. Weekly meetings should also make mention of the project goals to divert as much waste as possible.

Implementing the plan is not the only requirement to reduce waste. It must also be enforced. Most haulers will issue fines for comingling materials in the wrong dumpster, which their recycling coordinators determine by dumpster inspections, so it makes sense to do weekly inspections of on site dumpsters before they are hauled. If foreign materials are found in a dumpster, the responsible subcontractor should be required to employ their own laborers to properly dispose of the materials. If fines are issued for missed materials, they should be diverted to the responsible subcontractor.

Another way to reduce waste before it becomes an issue is to work with the designers to optimize building dimensions so they match up with standard dimensional units of specific materials. This will reduce the need to cut materials to proper lengths and will reduce the amount of unsalvageable scraps. Sometimes the waste is small and project limitations result in odd dimensions, which can add significant waste to a project.

A very effective way to reduce waste is to request delivery of materials to be made with less packaging. This does two things. The first thing it does is places the waste disposal fees on the supplier. The second thing it does is force the supplier to reevaluate their packaging and shipping process to investigate options for reducing costs by reducing initial packaging and delivery materials. Another way to deal with the suppliers is to consider purchasing materials in bulk so there is less packaging materials to begin with. A better option is to seek suppliers that use returnable or reusable containers. Vendor procurement should be monitored for all subs on the project as well.

Often times, local communities and charitable organizations have a shortage of containers to store their supplies in. Since non-profit organizations such as the Ingleside at King Farm thrive off of cutting costs whenever possible, it is a good idea to search for local organizations that would take reusable containers off your hands. Local charities such as Habitat for Humanity's ReStore, will come to your site and pick up various materials such as paints, lumber, wiring, roofing, etc at no cost to the project. All donations are even tax deductable and Maryland has ten ReStore locations to serve Ingleside at King Farm (Habitat for Humanity Int'l, 2009).

Key Aspects of Waste Reduction:

- Contractual agreement and buy in with contractors and sub-contractors
- Continuous education of workers and initial waste reduction pre-award meeting
- Implementation and enforcement of the plan
- Optimize building dimensions
- Requesting minimal packaging and/or returnable containers
- Support local community

Site Impacts of Implementation:

The site may be cramped depending on which phase of the project is underway. Ingleside at King Farm is lucky to rest on an 11.5 acre site, so there is a great deal of space to accommodate the use of additional dumpsters. There are definitely impacts on both the site and on the spaces within the building if implementing a waste management plan. This Analysis focused on setting up four distinct locations on site to sort trash due to the size of the building footprint, this will be more efficient than having one location. The goal of this Analysis was not to develop a full construction waste management plan, but the site plan in Appendix A shows an example of what a proposed trash flow for Ingleside at King Farm would look like.

In addition to looking at the primary C&D debris that is generated on site, a project of this size is also capable of generating a large portion of trash from the workers themselves. This trash can be in the form of food waste from lunches, plastic cups, styrofoam cups, plastic and glass bottles, aluminum cans, plastic food wrappers, newspapers, etc. Items like this may be small in comparison to the C&D debris, but they all add up. At each trash chute, there should be bins placed to sort bottles, cans, newspapers, etc. This results in a very small impact on the site and was assumed to not add considerable cost to the project because the bins could be left over from a previous project and used on the next project. Another reason for not figuring this into the cost is that it is sometimes believed to be not feasible to monitor these small items, although there may be fines associated with comingling of foreign objects in certain bins.

Schedule Reductions of Implementation:

It is difficult to evaluate specific schedule reductions associated with implementing a construction waste management plan since it has not been proven. James G. Davis Construction Corporation is familiar with project success in implementing a waste management plan in the construction of ASHA National Office in Rockville, MD. It was noted that there's likely an improved sense of morale amongst workers by implementing the plan. This is likely to be the case with a project such as Ingleside at King Farm as well and will give purpose to the efforts of waste reduction as well. It's true that there is additional labor required to keep trash from being comingled with the recyclables and additional attention required for policing this issue. These issues can be covered through employing a few extra laborers to monitor and sort, so it is not expected to be detrimental to the schedule. A cautionary statement to CM's to maintain morale is to watch out for and avoid stockpiling certain types of trash on smaller sites where space restrictions do not allow for additional dumpsters. If this happens, there could potentially be additional safety issues associated with it. Ingleside at King Farm is an 11.5 acre site, so this is not an issue. In the event that it becomes an issue on this project, it can be resolved through monitoring and policing the proper and prompt disposal of debris with additional laborers, which, again, will not be detrimental to the schedule. For simplification, it is assumed that additional laborers will not be required to maintain schedule.

Although it is difficult to place blame for schedules on lack the lack of a waste management plan, prompt removal of waste from interior spaces will leave any and all spaces available for construction workers to carry out the tasks of their trades at any time. This will allow for a more flexible construction environment in the event that a certain area is blocked for other reasons such as being occupied by another trade, prolonged logistics of equipment delivery, or temporary material staging. Ultimately, this will translate into no lost time and improved morale on the site by allowing more opportunities to take constructive action toward project completion (Harrison, 2007).

Additionally, employees with higher morale have a higher employee engagement resulting in a 19.2% increase in operating income for their employers. Low employee engagement can translate into a 32.7% decrease in operating income so it is much better to strive toward high morale whenever possible. Improving morale through improved site safety and opportunity to progress rather than regress due to waste cluttered spaces will allow CM's, GC's, and Subs to gain a competitive advantage and differentiate themselves from their competitors (Talent Management Magazine, 2008). This competitive advantage can be a contributing factor in earning profits through repeat business from the owner and open doors to new to being awarded new bids with high profile clients.

Knowing of the potential profits associated high profile clients may sway some CM's and GC's to budget for employing a couple more laborers on their projects. It was not estimated for this project, but additional costs of employing more laborers could possibly be offset by realized savings on tipping fees due to the goal of 50% to 75% diversion from landfills. This means that smaller dumpsters could be used and/or that the pick up schedule might be reduced.

Basically, the idea is that a waste management plan does not have to hinder project completion once the learning curve straightens. It must be appropriately planned to keep order and avoid interfering with the trades. Proper monitoring and empowering the laborers to "police" the project for comingling while sorting will help keep the project on task without interfering with critical path tasks, or other tasks.

Waste Saved from Landfill:

Since the goal of this Analysis was not to develop a full construction waste management plan, there may be some ambiguity in the estimates. Estimates are based on data "extrapolated" from the National Association of Home Builders (NAHB) estimates developed for a typical 2,000 square foot home (Construction Waste Management (CIWMB), 2009). These figures were adjusted for the project type and were also based primarily on the ILU's, ALU's, and SNU's within the building so the actual waste generated and saved from landfill may be higher than these conservative estimates. These savings are also based on the use of an alternative exterior wall system as proposed earlier, which help divert more waste from landfill. On a project like Ingleside at King Farm, there's potential to save 268 tons of waste from landfill if diverting 50%. If diverting 75%, the savings from landfill jumps to 402 tons. These are significant savings from landfill.

Cost of Implementation:

Dumpsters and laborers are assumed to be on site and ready waste management by 3/15/2007 with the beginning of the Footings/Foundations as shown in the *Detailed Project Schedule 10-24-2008*, which is available by viewing Technical Assignment 2 on (Podwats, 2008). These will essentially remain on site throughout the duration and will be removed when the project is substantially complete on 1/15/2009 for a total duration of 549 days. Additional costs associated with implementing a construction waste management plan are associated with employing laborers to monitor and hero the plan to prevent comingling.

Direct costs of implementing a construction waste management plan show an increase in costs. Research and calculations done for this Analysis assumed a 40 CY dumpster size for the original plan (no waste management) and was based on cost of hauling full containers away. The goals of a construction waste management plan in terms of earning LEED credits is to divert 50% or 75% of C&D waste and debris from landfills. Since it is difficult to accurately estimate how effective implementation of this type of plan would be, the calculations for savings were very simple. Without a plan in place, the direct costs of waste are estimated to be $111,050 using 40 CY dumpsters minimal scrap metal recovery. The costs are not linear. By diverting 50%, the costs are $564,506, which is based on using 30 CY dumpsters and 50% scrap metal recovery. Diverting 75% results in a cost of $1,930,459, which is based on using 20 CY dumpsters and 100% scrap metal recovery. Dumpster costs and tipping fees savings would result in an overall savings on this project.

Unfortunately, dumpsters are not the only costs associated with a waste management plan. Labor is where significant cost is added, but this seems to be more the case with CM's and GC's that are not very familiar with the implementation, so they are not efficient at preventing comingling yet. This project is large and the schedule is not extremely long, so the learning curve on this project may be an issue. Overall, the size of the project justifies implementing a waste management plan to reap the environmental benefits of dealing with large quantities of excess building materials, but it might be more cost effective to be less ambitious with the goal to divert 75% and only aim for 50%.

LEED Analysis:

The *Requirements* and *Potential Technologies & Strategies* below are taken directly from the USGBC LEED Version 2.2 Rating System.

> *Requirements:*
>
> *Recycle and/or salvage at least 50% of non-hazardous construction and demolition debris. Develop and implement a construction waste management plan that, at a minimum, identifies the materials to be diverted from disposal and whether the materials will be sorted on-site or co-mingled. Excavated soil and*

land-clearing debris do not contribute to this credit. Calculations can be done by weight or volume, but must be consistent throughout.

Potential Technologies & Strategies:
Establish goals for diversion from disposal in landfills and incinerators and adopt a construction waste management plan to achieve these goals. Consider recycling cardboard, metal, brick, acoustical tile, concrete, plastic, clean wood, glass, gypsum wallboard, carpet and insulation. Designate a specific area(s) on the construction site for segregated or comingled collection of recyclable materials, and track recycling efforts throughout the construction process. Identify construction haulers and recyclers to handle the designated materials. Note that diversion may include donation of materials to charitable organizations and salvage of materials on-site.

(U.S. Green Building Council, 2005)

The USGBC does not offer many levels of LEED points for implementing waste reduction practices on construction projects, but this could be considered one of their shortcomings because the benefits of waste reduction go far beyond what LEED awards to projects. Although the verdict is still out, it is very likely that Ingleside at King Farm did not implement a construction waste management plan early enough to earn any credits and made a last minute attempt to gather data from project participants on their waste diversion efforts. If this project was to contain a waste management plan to divert 50% of its waste from disposal in a landfill it would've earned one point for MR Credit 2.1 Construction Waste Management. This is likely to be an easy achievement and it is believed the project would have been able to earn an additional point for MR Credit 2.2 Construction Waste Management for diverting 75%.

Brochure and Additional Information:

The informational brochure in Appendix B is a brief summary of some important information regarding a waste management plan and is meant to be used to convince companies to implement one on their projects.

Additional information that is worth noting includes the consideration of specific material handling for each type, or category, of waste. One example of this would be to specify that unused and salvageable pieces of drywall are to be donated to a local charity such as Habitat for Humanity. The waste management plan is suggested not only to improve site safety, worker morale, and protect the environment, but it is possible to improve community relations (Washington State Department of General Administration, 2008). Another addition to recycling is downcylcing, which is an old idea that is shedding new light on cradle-to-cradle considerations. Materials that can't be directly recycled can

be downcycled into lesser quality goods. A lot of plastic waste is downcycled.

During construction projects, waste removal can be ignored in an effort to keep a project on schedule, but it is important to keep up with the monitoring and sorting since site recovery of recyclables is sometimes a difficult task that some workers may neglect if cleanup responsibilities were left to them.

Although reducing waste and maintaining a clean site is ideal, recycling is currently posing economic challenges for CM's and GC's. Scraps taken to junk yards for salvage by CM's and GC's are now worth less money. This was the case for the ASHA National Office project mentioned earlier as well as they received an average of $.125 per pound for miscellaneous metals, which is a relatively low salvage price for metals.

Summary and Conclusions:

Although the perceived costs of implementing a construction waste management plan is intimidating, there is unquantifiable value added to the project. Additional labor costs should not be viewed as a negative aspect of implementing a construction waste management plan, especially given the current economic condition. Employing additional laborers helps promote and support a green economy and can help reduce unemployment rates in local communities. In some instances, implementing a construction waste management plan is a requirement of the local waste authority.

The public image that will be perceived by the use of implementing a waste management plan is a great way to keep in the spotlight. This will ultimately translate into marketing opportunities for the designers, builders, and owners. In terms of construction companies, it can lead to more bids with higher profile clients with increased profit margins.

This project is capable of earning two LEED credits for implementing a waste management plan. Implementing a waste management plan is also a good opportunity to educate surrounding communities about doing what's right. It is possible to save up to 75% of the waste from Ingleside at King Farm from entering a landfill, but these goals must be communicated early and communicated throughout the project.

If goals are not communicated early, it will be much more difficult to recover, as is the case with Ingleside at King Farm. One underlying goal of utilizing the prefabricated exterior wall system is to reduce on site waste generation. It's a goal that would easily be achievable after the project had already begun and would contribute to pulling the team together to divert a significant amount of waste.

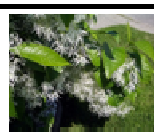
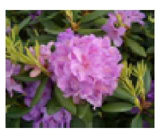
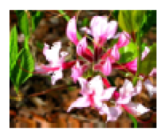
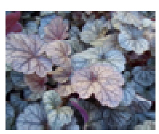
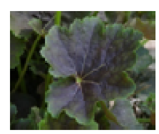
Analysis IV – Water Efficiency

This Analysis evolved from its original intent, which was to use alternative native landscaping in hopes of showing a water savings cost to the owner. The idea was that the project specified many exotic species that would require permanent irrigation and may not be fully adapted to the surrounding climate conditions. The other idea was that the owner would need to spend money on fertilizers to establish and maintain these species. Considering the type of facility, chemical fertilizers are not desirable for many reasons, and also jeopardize the health of surrounding communities and pollute the infamous Chesapeake Bay. One issue with performing an Analysis like this is that it is impossible to accurately quantify anticipated water savings. Other issues will be explained in the following sections. Traditional owners may never fully understand the benefits of utilizing native flora fauna such as promoting biodiversity.

Native Flora Fauna Research:

Ingleside at King Farm is located in Montgomery County in Maryland. It is home to a limited variety of native species of plants, but as many growers and nurseries attempt to turn a profit off the "beautification" of landscapes through exotic species, these native flora fauna become less available. Local organizations such as the Maryland Native Plant Society are dedicated to preserving, protecting, and restoring the habitats that once allowed these native species to flourish.

The Maryland Native Plant Society offers suggested plant lists for the different Maryland regions because the suggested plants vary by region. In the case of Ingleside at King Farm, a brief comparison of aesthetic appearance and similarities in species name was done to determine which specified plants could easily be swapped for native flora fauna. The picture below shows an example of three different plants that were compared for this project.

Specified			Proposed		
Name	Cost	Photo	Name	Cost	Photo
White Fringe Tree	$1,060		Chionanthus virginicus Fringetree	$462	
Dorsault Rhododendron	$160		Rhododendron periclymenoides Pinxter azalea	$256	
Silver Scrolls Coral Bells	$1,278		Heuchera americana Alumroot	$876	

(Maryland Native Plant Society, 1997-2005)
(Various nurseries were required as sources for plant pricing)

Weather & Climate Zone:

The weather data below is taken from Technical Assignment 1 from the Penn State AE e-Studio website (Podwats, 2008). This data gives a basis to create a rainwater harvesting system from. The average rainfall for the region was assumed to be a consistent 3.59 inches per month. In determining rainwater harvesting potential, precipitation in the form of snow was also assumed to be a potential source for rainwater collection because the weather data shows average temperatures were well above freezing for each month, which means any snow fall on the roof would easily melt.

2007 Weather Data www.wunderground.com

January: 40° F, 17 mph Rain: 13 Thunder: 0 Snow: 6 Fog: 1	February: 41° F, 21 mph Rain: 6 Thunder: 1 Snow: 9 Fog: 2	March: 49° F, 17 mph Rain: 10 Thunder: 0 Snow: 2 Fog: 0
April: 59° F, 23 mph Rain: 11 Thunder: 3 Snow: 2 Fog: 2	May: 65° F, 16 mph Rain: 6 Thunder: 3 Snow: 0 Fog: 2	June: 78° F, 13 mph Rain: 15 Thunder: 7 Snow: 0 Fog: 0
July: 81° F, 13 mph Rain: 16 Thunder: 6 Snow: 0 Fog: 0	August: 78° F, 10 mph Rain: 11 Thunder: 5 Snow: 0 Fog: 0	September: 76° F, 12 mph Rain: 7 Thunder: 2 Snow: 0 Fog: 0
October: 67° F, 15 mph Rain: 8 Thunder: 1 Snow: 0 Fog: 2	November: 50° F, 15 mph Rain: 9 Thunder: 0 Snow: 0 Fog: 1	December: 42° F, 18 mph Rain: 16 Thunder: 0 Snow: 5 Fog: 4

2008 Weather Data www.wunderground.com

January: 40° F, 18 mph Rain: 10 Thunder: 0 Snow: 4 Fog: 1	February: 41° F, 16 mph Rain: 9 Thunder: 1 Snow: 4 Fog: 2	March: 49° F, 21 mph Rain: 14 Thunder: 1 Snow: 0 Fog: 0
April: 59° F, 14 mph Rain: 16 Thunder: 4 Snow: 0 Fog: 2	May: 65° F, 20 mph Rain: 15 Thunder: 2 Snow: 0 Fog: 2	June: 78° F, 11 mph Rain: 15 Thunder: 14 Hail: 1 Snow: 0 Fog: 2
July: 81° F, 11 mph Rain: 14 Thunder: 8 Snow: 0 Fog: 1	August: 78° F, 11 mph Rain: 9 Thunder: 3 Snow: 0 Fog: 0	September 9/21: 76° F, 12 mph Rain: 5 Thunder: 0 Snow: 0 Fog: 0
October: N/A	November: N/A	December: N/A

This region of Maryland is located in a hardiness zone of 7A, which means the temperatures can get as low as 5° F to 10° F.

Owner Acceptance:

Conversing with the owner proves that switching some of the specified plants for native flora fauna is in line with the owner's goals. It was also learned that plans for the next project may attempt to include the use of a rainwater harvesting system. The research and findings of this Analysis will hopefully assist the owner at buying into the use of a rainwater harvesting system for the next project. Acting as an assistant on the project to coordinate the LEED tracking on the project, the owner made some last minute attempts to earn additional LEED credits so this will not be out of the question.

Potential for Rainwater Collection:

Rainwater harvesting systems can collect water from a number of sources especially with a large site such as Ingleside at King Farm. Theoretically, there's potential for collection from the entire 11.5 acre site if the site design channeled all rainwater runoff so that it remained on site. This Analysis will assume that only the runoff for the roof will be collected, which is 1.94 acres. One acre of land is assumed to be able to collect 27,000 gallons of water from one inch of rainfall. This means that Ingleside at King Farm can collect approximately 188,044 gallons of water per month and a total of 2,256,530 gallons of water per year.

It is not feasible to attempt retaining all of this water because the cost of the cisterns. Additionally, the cisterns will require a significant amount of excavation and would potentially cause serious impacts on the schedule dues to the excavation required before placing the footings. This Analysis will attempt to show that it is feasible to install a cistern, or cistern system, capable of storing water equal to 21 days of the building's total water usage per year, which is estimated to be 20,056,750 gallons per year so the cistern system should be able to retain approximately 1,153,950 gallons.

Schedule Impacts for Using Alternative Landscaping and Water Efficient Fixtures with Rainwater Harvesting System:

Native Flora Fauna:

Native plants are important for biodiversity and for the most environmentally responsible solution, they should be purchased from local propagators as true natives; not cultivars. Part of the issue with planting natives and obtaining the plants from local propagators is the availability of certain species. Single family home owners are discouraged from digging up native species from the wild due to potentially endangering the species and because they may need certain natural fungi found in those soils that won't allow them to grow in your yard. For larger residencies and commercial projects such as Ingleside at King Farm, this would also be frowned upon, and makes it difficult to locate a local supplier that can satisfy a large order so careful planning must be taken in order to procure landscaping products in advance, and it may also be necessary to seek various suppliers.

As mentioned earlier, the Maryland Native Plant Society offers information about purchasing these species and lists events where some local organizations and nurseries come out to sell native plants (Maryland Native Plant Society, 2009). There is also a listing of 6 local non-profits and 34 local nurseries that propagate native species to purchase from if an event is missed, but it is best to contact the nurseries far in advance to secure sufficient quantities of the native species.

One example of how difficult it may be to procure the plants that a project requires is the local Adkins Arboretum, which primarily only sells twice a year and offers situational assistance for community projects. Another example is from the Chesapeake Native Nursery non-profit organization that states all their plants come from the community of enthusiasts and that quantities are limited so one year advance notice is suggested so the plants have time to grow.

The other key factor which makes plant procurement and landscaping difficult is the season in which the plants are being procured. Like most typical nurseries, local propagators will vary their selection at different times of year, which is actually a plus for a project using native species because the plants can be procured and be planted in the ideal season, whereas some exotic species may have a small window in which they can be planted although they may have been procured at a different time of year.

Because of the scarcity of some of the local propagators and nurseries that supply true natives, it is estimated that impacts on a project schedule could be greatly affected and cause delays in landscape completion. It is extremely difficult to put an exact time frame to procurement of plant species, but long lead times are anticipated to be 6 to 12 months or more, which is comparable to some major mechanical equipment pieces. Because of this, it's important to bring the landscape architect and the landscape contractors on board early to maintain schedule. It's also recommended that the landscape architect becomes familiar with local suppliers to assist and make suggestions in the procurement of the landscaping materials. Depending on design time and time between awarding a bid and construction start, another option would be to work with the owner prior to awarding the bid to assist in pre-purchasing the landscaping. This will prevent delays in landscape finishing and help ensure the early image of project "curb appeal" for the owner, which is important for the owner in dealing with potential depositors for the ILU residencies. It will also ensure that the plants are coming from local propagators and that potentially result in additional savings if the owner is able to get pricing locked in before the plants go on sale.

Water Efficient Fixtures:
There are no anticipated schedule impacts or differences in the use of alternative water fixtures since most of the proposed alternates are made by the same manufacturer as the currently specified fixtures.

Rainwater Harvesting System:
There are four options investigated for this system with varying impacts. The proposed option has the most savings associated with it and the schedule impacts associated with this option will be discussed. Using a rainwater harvesting system has minimal impact on the schedule, but there is additional excavation required to bury the cisterns and sewer piping during the time that the foundations are being dug out and the time sewer house connections are being made respectively.

Total additional time added to the schedule is approximately 3 days for to bury the cisterns and sewer piping and 1 day to backfill the cisterns and piping. It will take 1 day to set the tanks in place and See the Rainwater Harvesting Site Plan in Appendix C showing the location of the cistern system and additional trenching required for sewer lines.

The rainwater harvesting system requires approximately 40% more water distribution piping than the current system due to the placement of the cistern tanks and the tie-in to the current water distribution system. This will require additional installation of piping but it is not anticipated to add duration to the project due to the ability to increase manpower. Additional labor costs are included in the pricing below.

Cost Comparison of Alternative Landscaping:

Twelve specified species of plants were compared to similar native plant species. Through estimated projections based on currently available plant prices, native flora fauna could be 51% of the currently specified landscaping. This is considering that there is a similar looking species available. The current cost of landscaping (plants only) is approximately $66,000, which would mean that the first cost for plants could potentially be reduced to $33,600. See Appendix D for full estimate.

Cost of Water Efficient Fixtures and Rainwater Harvesting System:

Cost estimates for the fixtures are based only on certain fixtures within the ILU's, ALU's, SNU's, Public/Staff units. These fixtures include water closets, lavatories, showers, and urinals and the same manufacturer as currently specified was utilized where possible in order to maintain consistency and convenience in purchasing. See Appendix E for full estimate.

- Currently Specified Fixtures:
  $325,285.35

- Alternative Fixtures # 1 (17% Water Usage Savings):
  $456,075.50

- Alternative Fixtures # 2 (27.5% Water Usage Savings):
  $526,253.30

The rainwater harvesting system is estimated assuming the use of a siphonic roof drainage system. These systems are designed to operate at full bore so there is a reduced piping size required to drain the same volume of water from the roof. These drainage systems are common in rainwater harvesting systems because they reduce the required number of vertical drops and reduce the amount of underfloor drainage piping required in the basement. Typically they save in overall drainage piping costs, but in the case of Ingleside at King Farm they add cost due to the proposed location of the cistern tanks. The tanks are placed under the courtyard on the south side to reduce the risk of them floating in extreme cases if they were placed in wetter soils on the north side of the building where the pond is located. There could be some additional savings associated with the system if the tanks were placed nearer to the water distribution system. See Appendix F for full estimate.

- Currently Specified Drainage System:
  Horizontal/Vertical Drainage Piping: $37,724.90
  Total Cost: $53,125.01

- Rainwater Harvesting and Siphonic Roof Drainage:
  Horizontal/Vertical Drainage Piping: $44,594.40
  Total Cost: $897,321.17

Utility Savings and Payback:

It is hard to justify the cost of installing a rainwater harvesting system and installing water efficient fixtures for Ingleside at King Farm given the high first cost. This high first cost, as with many of the green construction options in industry today must not be the only consideration when opting against implementation. Conservative estimates based on the same building areas as the fixtures estimates were also performed here. The costs are calculated using the current utility rates for the region as provided by the utility company listed on the construction drawings. See below for estimated savings and see Appendix G for full estimate.

- Yearly Utility Usage & Cost with Current Design:
  Water Usage: 20,056,750 gallons / $90,857.08
  Sewer Usage: 18,051,075 gallons / $126,899.06

- Yearly Utility Usage & Cost with Rainwater Harvesting System:
  Water Usage: 17,80,220 gallons / $80,634.99 ➔ Savings: $10,222.08
  Sewer Usage: 16,020,198 gallons / $112,621.99 ➔ Savings $14,277.07

- Yearly Utility Usage & Cost with Rainwater Harvesting System & Alternative Fixtures # 1:
  Water Usage: 14,774,182.27 gallons / $66,927.05 ➔ Savings: $23,930.03
  Sewer Usage: 13,296,764.04 gallons / $93,476.25 ➔ Savings $33,422.81

- Yearly Utility Usage & Cost with Rainwater Harvesting System & Alternative Fixtures # 2:
  Water Usage: 12,905,159.21 gallons / $58,460.37 ➔ Savings: $32,396.71
  Sewer Usage: 11,614,643.29 gallons / $81,650.94 ➔ Savings $45,248.11

  (Washington Suburban Sanitary Commission, 2008)

The proposed solution is to go with the most expensive option although this sounds counterintuitive, but it has the shortest payback period due to the highest level of anticipated water and sewer savings. See scorecard in Appendix H for more information.

- Alternative 1 (just alternative landscaping):
  No payback due to difficulty quantifying water savings

- Alternative 2 – Alternative Landscaping & Rainwater Harvesting:
  51.3 year payback

- Alternative 3 – Alternative Landscaping, Fixtures 1, & Rainwater Harvesting:
  24.2 year payback

- Alternative 4 – Landscaping, Fixtures 2, & Rainwater Harvesting:
  18.8 year payback

LEED Analysis:

By utilizing a rainwater harvesting system with alternative fixtures # 2 this project will be able to earn WE Credit 3.1 Water Use Reduction 20% because it produces a 27.5% water reduction. Using the rainwater harvesting alone is not enough to earn this point, and there is not enough water savings to earn a point for the 30% Reduction. The proposed system adds 1 additional LEED point to the project. See Appendix H for scorecard and LEED calculations in Appendix I for more information.

Summary and Conclusions:

When swapping plants for any other species, it's important to consider the hardiness zone, which can be found in part through the National Park Service (National Park Service, 2009). If compromises for a native species cannot be met, then including the hardiness zone in the decision will at least ensure that the plant will survive the climate conditions of the project site. This will result in less water required after planting to establish a healthy root system and is especially important in for this Analysis because some of the originally specified species could not be easily matched and alternatives were only based on appearance. This was an effort to maintain a similar level of curb appeal for the owner.

An interesting find was that some of the native species found were actually very similar in species to the ones specified on the original landscape design, but came at less cost. This was confusing and made it unclear why the native species were not specified in the first place. It also made it easy to swap those species out for a native species for the purpose of this Analysis. Another interesting find was that most of the native species were only available in seed form or in smaller pots than the originally specified species. This translates into a lower first cost to the owner for going green, which is rarely the case.

One of the first steps to improving a building's water efficiency once it is constructed is to continually educate and remind its occupants of the importance of water conservation. By doing this, the occupants become more water conscious and will inevitably make efforts in their everyday lives to conserve in all areas; not just in water use. Until occupants become more water wise, alternative fixtures can help reduce utility costs. Unlike the native plant species, these add significant first cost to a project and it become more difficult to utilize more efficient fixtures in states that don't offer rebates for using the higher cost, more efficient fixtures. Currently, Maryland does not offer rebates for this (Kohler Co., 2009).

Because there are no rebates offered for water conservative fixtures in Maryland, the fixtures portion of this Analysis will focus on one major area of the project, the bathrooms. The building's total occupancy exceeds what is contained within the living and nursing units, but to maintain focus, this fixtures portion of the analysis will only cover the bathroom fixtures in these units and will be referred to as the "Units Method". Alternative bathroom fixtures will be suggested for the Independent Living Units, Assisted Living Units, Skilled Nursing Units, and Public/Staff restrooms. No alternates were specified for Nursing toilets due to height requirements for seat and to keep simplify procurement by ordering from one manufacturer. No alternates were specified for faucets due to green features already present in the specified fixtures, but there's potential for further savings by using a low flow sink aerator such as the .33 gpm model by Ecotech Water, LLC (Ecotech Water LLC, 2009).

In addition to using a rainwater harvesting system to meet water demands, there is potential to collect water from condensate drip pans. These drip pans for Ingleside at King Farm drain to sanitary sewer. Calculations were not performed to realize the full potential, but it is believed that there is a significant potential to add to current water needs. This water could be piped into the rainwater harvesting system to serve the building, or could be used to irrigate the landscape.

Part of the rainwater harvesting system is the siphonic roof drains and were priced one-for-one for this thesis. Realistically, if Ingleside at King Farm used siphonic roof drains, it is likely that the previously shown cost would go down further and result in a shorter payback because siphonic roof drains drain at full bore and can remove more water from the roof (Ross, 2006). Water recovered from siphonic roof drains is able to be used for non-potable applications. Further research into code issues, for example, would be required to determine allowable uses for the water such as toilets and urinal flushing, mechanical systems, custodial uses, and for site irrigation.

Assumptions, Clarifications, & Omissions:

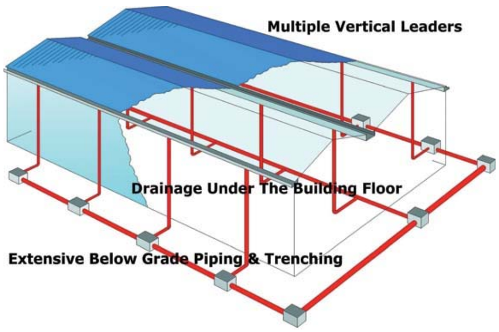
- Water distribution pump not sized or priced. System assumed to use existing booster pump system.
- Filtration system not be sized or priced.
- Siphonic roof drain sizes are manufactured to 4"; and due to complex calculations involved in determining piping and drain size all drains assumed to be this size for simplification.
- Additional excavation: 12,336 SF X 20 feet deep ➔ 9,138 BCY
- Original excavation: 64,945 BCY
- % of Total: 14% increase
- Area drains for courtyard act as roof drains for the garage. This Analysis didn't focus on this area, but if these drains are swapped out for siphonic drains there is potential for additional savings and additional rain water harvesting.
- Computer software that may be required for filtration and controls of distribution not priced.

Benefits of Siphonic Roof Drains:

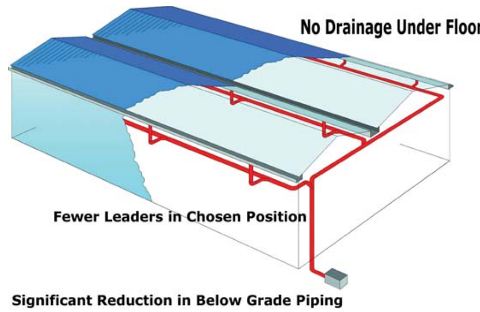
- Enhances construction program and reduces costs
- Benefits to the end user
- Negative pressure siphons water through horizontal piping
- Sustainable drainage saves trenching costs due to reduced amount of underground trenching and shallow trenching
- Reduces construction durations
- Fewer downpipes required freeing floor space

Siphonic roof drains precautions or limitations:

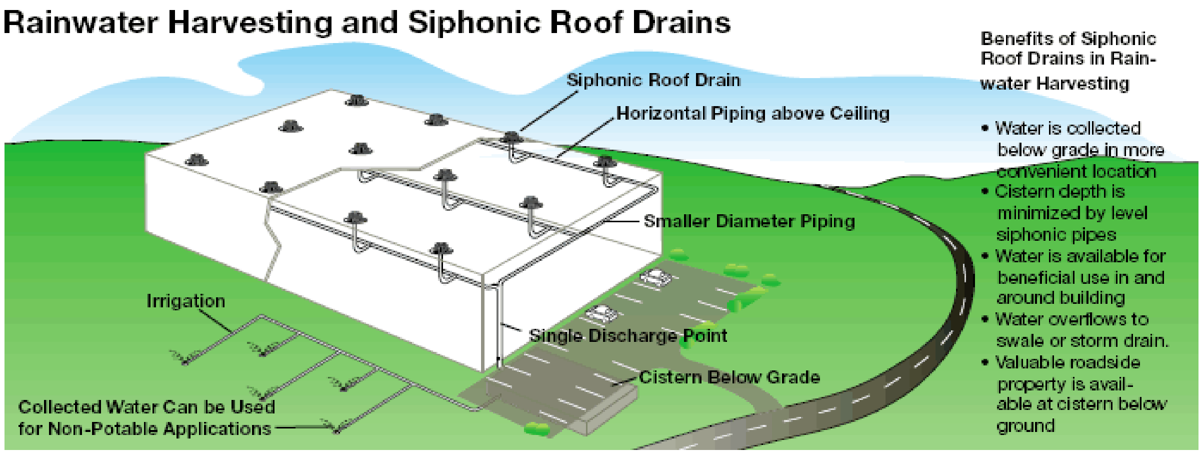
- Systems must be balanced to prevent the from being emptied by uneven friction losses in piping; must use a smaller diameter near the down pipes and larger diameters further from downpipes
- Account for suction pressures so the peak capacity of piping isn't exceeded
- Must operate fast enough to fill within a design storm



Typical gravity drainage piping design. Courtesy of HydroMax



Typical siphonic drainage piping design. Courtesy of HydroMax



Courtesy of JR Smith Manufacturing Company

Breadth Studies

Breadth I – Sustainability

The basis of thinking for this breadth was developed using the principles laid out in the LEED guidelines/checklists; some of the items presented in this thesis even reach beyond the attributes of the LEED system. Each Analysis has touched on the principles of sustainability so the whole thesis carries a common theme. This project is a good case study developing a LEED profile for senior living because at its start, it was the only Continuing Care Retirement Community that was pursuing LEED certification according to the owner. It is important in our future endeavors with the built environment that we protect the natural environment. It will ensure the health of our planet for generations to come.

Building Envelope Performance:

Health is an important aspect of senior living as well. Given the type of facility that Ingleside is, the elderly residents will undoubtedly seek comfort in their ILU's, so it is a good idea to strive toward earning EQ Credit 7.1 for thermal comfort, which is not just a nice gesture, it could help prevent complaints about cold drafts. It's also one aspect of the building that could prove to save valuable energy costs for the owner through the use of an alternative exterior wall system as discussed in *Analysis I - Building Envelope Performance*. The proposed alternative system earns EQ Credit 7.1, EA Credit 1.3 and EQ Credit 4.1 as shown in the LEED calculations. See Appendix I for more information.

Construction Waste Management:

This is a growing problem in the U.S. as population and consumption increases. Buildings contribute 30% to waste output each year. This is 136 million tons of waste (U.S. Green Building Council, 2005). Buildings also use 40% of all our raw materials, which takes away from everyone's supply and increases demand. There's a considerable amount of recoverable waste associated with construction projects that could help replenish the supply, alleviate demand, and decrease economic inflation rates. Another benefit of recovering some of this waste is a reduction in burden on landfills.

Ingleside at King Farm did not implement an effective construction waste management plan. Ramifications of this could easily go unnoticed to those that focus only on the details of the critical path on the construction schedule. A proposal to implement a construction waste management plan has been made in this thesis, and it is believed that the project could earn two additional LEED Credits by doing so. See Appendix I for more information and also Appendix B with attached informational brochure developed for this thesis.

Water Efficiency:

Again, as population increases, so does consumption. Some countries are not fortunate enough to have a readily available supply of clean drinking water. With a few exceptions, the U.S. is very fortunate to have a well developed infrastructure of water distribution and sewer systems. Increased demand and burden on local water and sewer authorities is making it more and more difficult to maintain the supply of water to communities based on current usage.

Unfortunately, in today's society, it often requires a substantial investment to be able to do "what's right for the environment." Many residents, or clients, in the community are not able to afford some of the technologies available to do this, so it is up to the local businesses and governments. If local businesses and governments that have more financial resources to work with are able to begin reducing their burden on the infrastructure, it can help support the economy through investing in the companies developing sustainable technologies. It can also help maintain the balance of supply and demand to keep utility costs for the rest of the population at affordable rates. This principle applies to most of the sustainable elements of a project. In particular, a more water efficient approach to Ingleside at King Farm can prove to be a lucrative investment for more than just the environment.

At a 1.43% increase in project cost, it is believed that Ingleside at King Farm is able to increase water efficiency enough to earn WE Credit 3.1. It will have an estimated payback period of 18.8 years, which is sure to be a short enough payback to be a worthwhile investment. This estimate does not include inflation, so the payback period may actually be less.

Overall, there are some issues with going green that slow the industry progression in this realm. One major issue is owner perception of the cost of going green. Owners often feel they will never be able to justify the first cost of going green, but fail to realize the paybacks associated with some green systems. Design-Build and Integrated projects really benefit from going green because going green often requires an iterative evaluation process. A green project can help the owner realize some major savings that are not always easily quantifiable. This is where designers need to step up to the plate and present what the actual costs and benefits of green systems are. On a complete construction project, one small green element can have positive impacts on multiple systems within the building and result in real savings to the owner. A quick glance or alternate does not always present this.

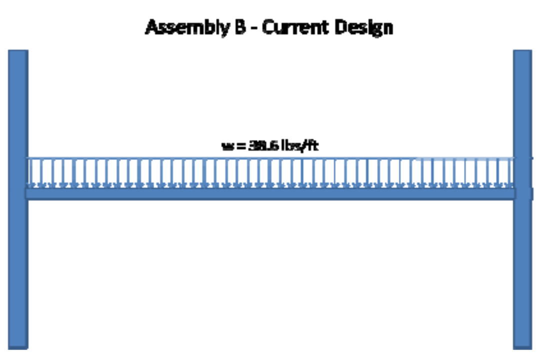
Breadth II – Structural Impacts of Alternative Building Envelope Construction

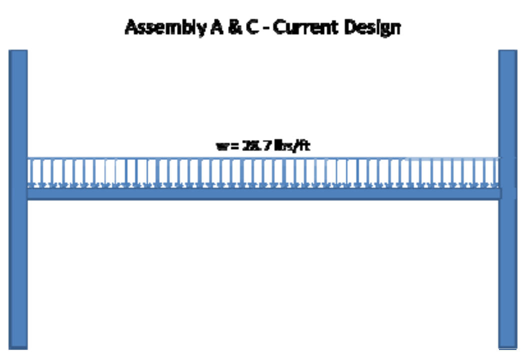
When making the decision to alter any building element, considerations must be made as to what building systems are impacted. A new exterior wall system is proposed for Ingleside at King Farm so this could potentially have a negative impact on the structural system. Since all the finish components of the wall will remain the same, the only change to the system is the framing itself. A simple calculation showing the pounds per square foot difference was performed.

The two systems act directly on the post-tension concrete floor system. Estimated impacts of the existing construction were determined along with estimated impacts of the two alternate wall systems. The diagrams and tables below show that the current system exerts a distribute load of 28.69 lbs/LF of wall on the floor system. The proposed kama-EEBS wall system exerts 11.25 lbs/LF of wall for Assemblies A and C, and it exerts 12.5 lbs/LF of wall for Assembly B. See the following tables for more information.

Current Design

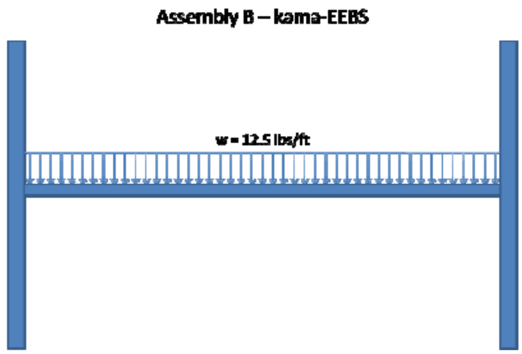
Dead Loads	Wall Height (ft)	Bay Width (ft)	Material Weight (lb/ft or lb/cf)	lbs/ft of wall
6" Metal Studs	10.00	29.50	2.09	15.68
6" Metal Track	10.00	29.50	1.92	3.84
Flat Strap Bracing	10.00	29.50	negligible	negligible
6" Batt Insulation	10.00	29.50	2.00	9.17
			Total	28.69





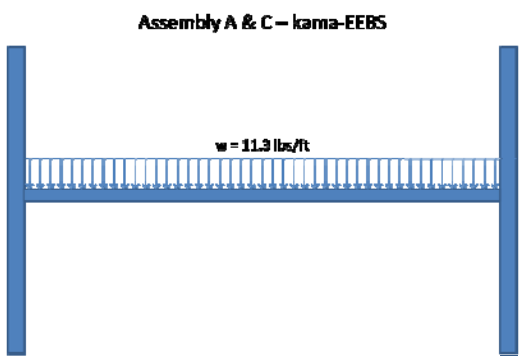
Assembly B - kama-EEBS

Dead Loads	Wall Height (ft)	Bay Width (ft)	Material Weight (lb/4' panel)	lbs/ft of wall
6" kama-EEBS EPS Wall System	14.00	29.50	50.00	12.50
			Total	12.50



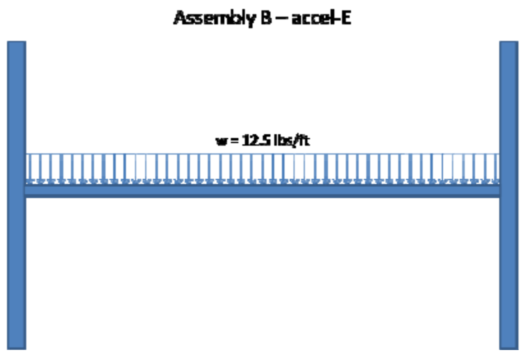
Assembly A & C - kama-EEBS

Dead Loads	Wall Height (ft)	Bay Width (ft)	Material Weight (lb/4' panel)	lbs/ft of wall
6" kama-EEBS EPS Wall System	10.00	29.50	45.00	11.25
			Total	11.25



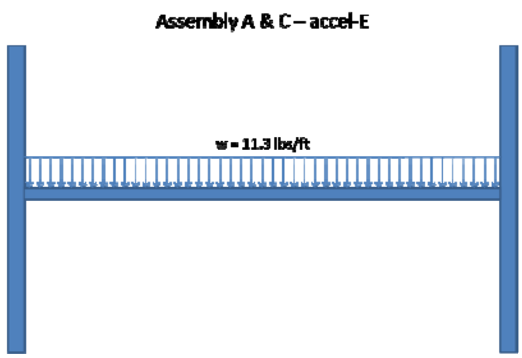
Assembly B - accel-E

Dead Loads	Wall Height (ft)	Bay Width (ft)	Material Weight (lb/4' panel)	lbs/ft of wall
5.5" accel-E EPS Wall System	14.00	29.50	50.00	12.50
			Total	12.50



Assembly A & C-accel-E

Dead Loads	Wall Height (ft)	Bay Width (ft)	Material Weight (lb/4' panel)	lbs/ft of wall
5.5" accel-E EPS Wall System	14.00	29.50	45.00	11.25
			Total	11.25



These numbers show that the only consideration required is the dead weight of the materials. The exterior walls do not carry any loads from the roof and will not be impacted by live loads from snow. A kama-EEBS wall system exerts approximately 41% of the currently specified wall system. Due to the realized reductions in dead weights on the floor system, no structural improvements or upgrades will be required. No structural downgrades or reductions will be required either because the weight of the exterior wall on the floor does not control the design of the columns or floor system.

Critical Industry Issue – Energy & Economy

Although the Analysis proposing an alternative façade may address industry issues dealing with the energy crisis, it doesn't attempt to solve another industry issue. The economy seems to worsen with each week as major corporations downsize and other employers experience hiring freezes. Construction is also affected by this and the trades are in need of labor. With the economy the way it is, some builders may be against the use of prefabricated systems and encourage owners to stick with a more labor intensive option such as the currently specified steel stud construction with batt insulation. By sticking with a more labor intensive construction, the builder is employing more man hours to help the economy. A project like this has potential to save around 7 weeks of labor, which means there's a lot at stake. Employing a labor crew for 7 weeks could help feed the families of those workers. It may offer a small window of employment for the trade, but it would help a little if the decision is made to keep to the specified design.

To combat the reduction labor for the project, implementing a construction waste management plan will likely have a greater positive impact on the economy because it will employ more man hours for a greater duration. It also helps promote the green economy in that it sends resources back into circulation to be manufactured into goods again. This is a great way to sustain an economy that goes beyond the construction industry.

In addition to sustaining the green economy through direct employment, the use of a rainwater harvesting system, native flora fauna, and alternative water fixtures helps set the stage for owners seeking long-term savings. The Water Efficiency Analysis is a perfect example of how owners might contemplate investing in systems that won't offer any cost benefits until further down the road. It creates a whole new type of projects for CM's and GC's to gain experience with. This is a positive aspect of new projects for the developing industry of the built environment.

Summary of Research Goals and Conclusions

The following will describe whether or not the proposed research goal were achieved. These goals are available under *Analysis I-Building Envelope Performance* in the Revised Thesis Proposal dated 4/2/2009.

Goals:

- To prove that upgrading the building envelope to a more thermally efficient design is a feasible alternative to reducing operational costs by solely integrating localized power generation features into Ingleside at King Farm.
    - In comparison to this project as a whole, the building envelope performance has little impact on the operational costs in terms of energy consumption. Most of the energy consumption associated with the building envelope would be associated with heat gains or losses through the roof or windows and although upgrading the exterior wall system to a more thermally efficient design is helpful, there is more energy consumption associated with conditioning outdoor air to meet code requirements for the common spaces, SNU's, and memory assisted units. Based solely on this goal, this option would not be feasible and was not achieved.
- To educate designers, engineers, CM's, and owners about the opportunity to incorporate affordable and sustainable technologies into their projects.
    - This Analysis proved that the proposed exterior wall system would increase total project cost by approximately 1.4%. This goal was achieved.
- To uncover opportunities to save costs in other areas of Ingleside at King Farm, such as a reduction mechanical equipment sizes.

  - Although it is believed that there would be a 19.8% improvement in optimizing energy performance, research could not prove that the proposed exterior wall system would definitely result in a reduction of mechanical equipment sizes for this project due to code requirements for outdoor ventilation. There is potential for significant mechanical system reductions on other projects. It did prove a reduction in labor costs, schedule, and on-site waste generation. This goal was achieved.
- To show the benefit of immediate cost savings to owners and long term economical and environmental benefits to society through a reduction in energy consumption.
  - The impacts of the exterior wall system on the energy consumption as a whole are small for this project, but there is still immediate energy savings associated with the proposed alternative. Long term benefits include the obvious reduced burden on the power grid. Another long term benefit is that the proposed product is made from recycled materials and is also 100% recyclable, which addresses issues with considering cradle-to-cradle aspects of a product. This goal was achieved.

Overall, this report has shown three Analysis Topics that present sustainable solutions to critical construction industry issues. All solutions are best implemented and worked into project planning at the earliest stage possible, but some of the items presented in this thesis can be easily implemented "on the fly", which would not have significant negative impacts on construction durations. There are opportunities for improvements on all construction projects, and Ingleside at King Farm is no exception. All things aside, the project team has built a successful project under the existing conditions and parameters of the project. Maintaining focus on the ultimate goal was very important for the Construction Manager and they rose to the challenge while taking charge of the design of the exterior wall system. With this stated, the current project team could easily utilize some of the ideas presented in this thesis to bring the project to the next level of LEED certification.

Bibliography

Construction Waste Management (CIWMB). (2009). Retrieved April 1, 2009, from Southern California Gas Company: http://www.socalgas.com/construction/builders/Builders%20Resource%20Guide/Construction%20Waste%20Management.htm

Ecotech Water LLC. (2009). *Ecotech Water Products.* Retrieved from Ecotech Water LLC: http://www.ecotechwater.com/pdf/ShwrAeroVac5_26_06final.pdf

Federated Insurance. (2007). *Housekeeping During Construction Operations.*

General Contractor's Council Associated Builder's and Contractors, Virginia Chapter. *Constructability Checklist.* Chantilly: General Contractor's Council Associated Builder's and Contractors, Virginia Chapter.

Habitat for Humanity Int'l. (2009). *Habitat ReStore Directory - Maryland*. Retrieved April 1, 2009, from Environmental Initiative: Habitat ReStores -- Habitat for Humanity Int'l: http://www.habitat.org/cd/env/restore_detail.aspx?place=45

Hakim, D. (2004, May 5). *All Classifieds*. Retrieved April 2, 2009, from The New York Times: http://www.nytimes.com/2004/05/05/business/05weight.html?ex=1399176000&en=60db96e1515d0b9d&ei=5007&partner=userland

Harrison, T. (2007, May 1). *Change morale, improve productivity*. Retrieved March 21, 2009, from ISA: http://www.isa.org/InTechTemplate.cfm?Section=Career_Front1&template=/ContentManagement/ContentDisplay.cfm&ContentID=61426

James G. Davis Construction Corporation. (2006, June 14). Waste Management Plan - ASHA National Office; Rockville, MD.

Kohler Co. (2009). *Find Rebates*. Retrieved 2009, from Kohler: http://www.us.kohler.com/savewater/rebates.htm

Maryland Native Plant Society. (1997-2005). *Plant Lists.* Retrieved February 2009, from Maryland Native Plant Society: http://www.mdflora.org/plantinfo/plantlists/tl_montg_bear_island_001.pdf

Maryland Native Plant Society. (2009, February 16). *Sources of Native Plants for the Middle Atlantic Region*. Retrieved 2009, from Maryland Native Plant Society: http://www.mdflora.org/

National Park Service. (2009). *National Park Service - Experience Your America*. Retrieved 2009, from National Park Service - U.S. Department of the Interior: http://www.nps.gov/

Podwats, J. (2008). *Technical Assignment 2 - Cost and Schedule Analysis; Ingleside at King Farm; Rockville, MD.*

Podwats, J. (2008, September 29). *Technical Assignments.* Retrieved 2009, from Joseph Podwats - Architectural Engineering Senior Thesis ePortfolio: http://www.engr.psu.edu/ae/thesis/portfolios/2009/jmp5051/Technical%20Assignments/Technical%20Assignment%201.pdf

Ross, B. (2006, May 1). *Understanding Siphonic Drainage - The Why's and How's*. Retrieved 2009, from pm engineer: http://www.pmengineer.com/CDA/Articles/Feature_Article/280ee3eac5a1b010VgnVCM100000f932a8c0____

Talent Management Magazine. (2008). *Rescue Employee Morale, Productivity With Strategic Recognition.* Retrieved March 21, 2009, from Opportunity Knocks.org: http://content.opportunityknocks.org/2009/01/22/rescue-employee-morale-productivity-with-strategic-recognition/

U.S. Green Building Council. (2008). *Green Building Research*. Retrieved April 2, 2009, from U.S. Green Building Council: http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1718

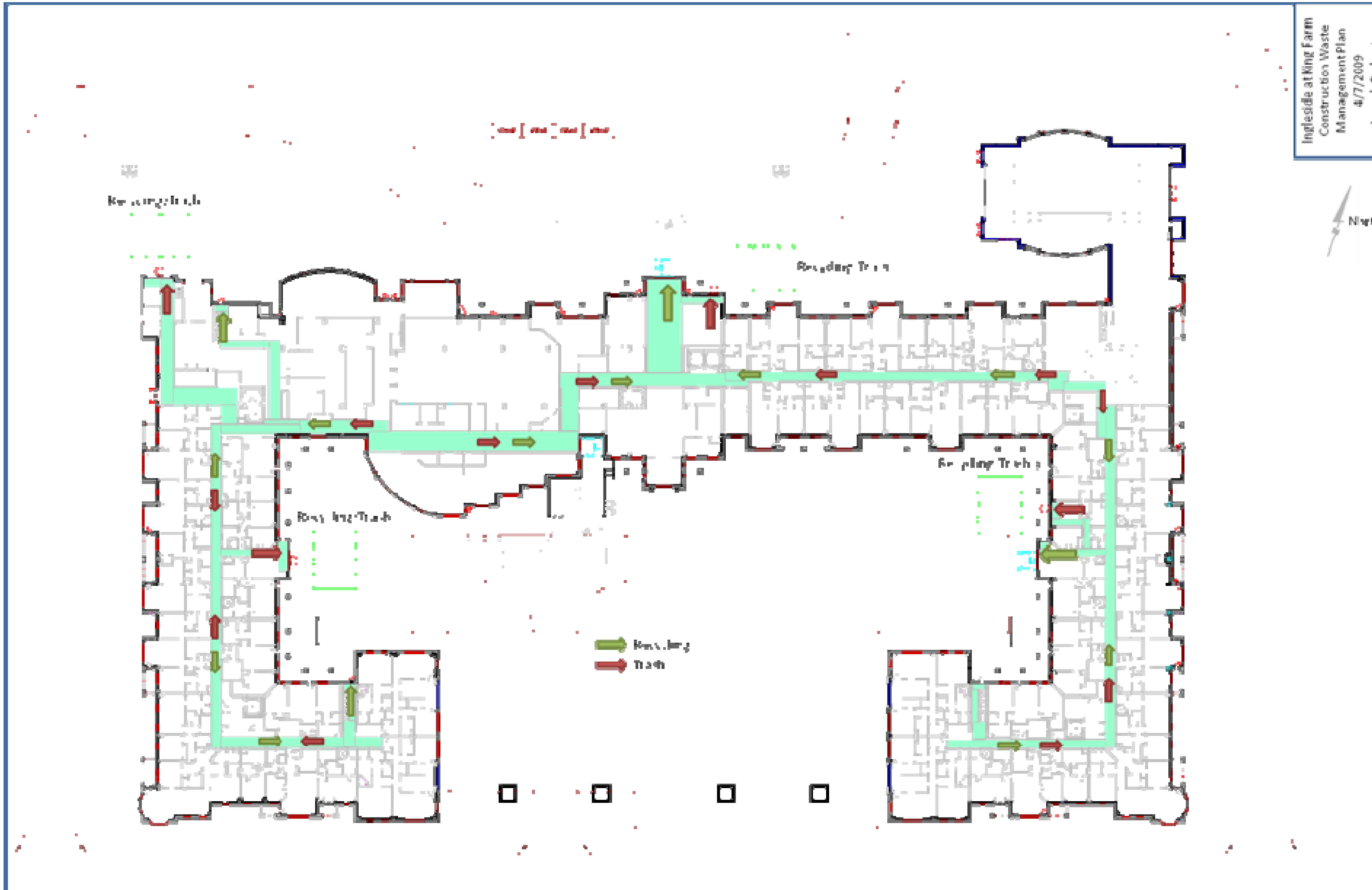
U.S. Green Building Council. (2005, October). *LEED for New Construction.* Retrieved February 2009, from U.S. Green Building Council: http://www.usgbc.org/ShowFile.aspx?DocumentID=1095

Washington State Department of General Administration. (2008, April 15). *Construction Waste Management Guidelines.* Retrieved March 22, 2009, from General Administration: State of Washington: http://www.ga.wa.gov/eas/CWM/guideline.html

Washington Suburban Sanitary Commission. (2008, July 1). *Water and Sewer Rate Schedule Effective July 1,2008*. Retrieved 2009, from Washington Suburban Sanitary Commission: http://www.wsscwater.com/service/rates.cfm

Appendix A

Construction Waste
Management Plan

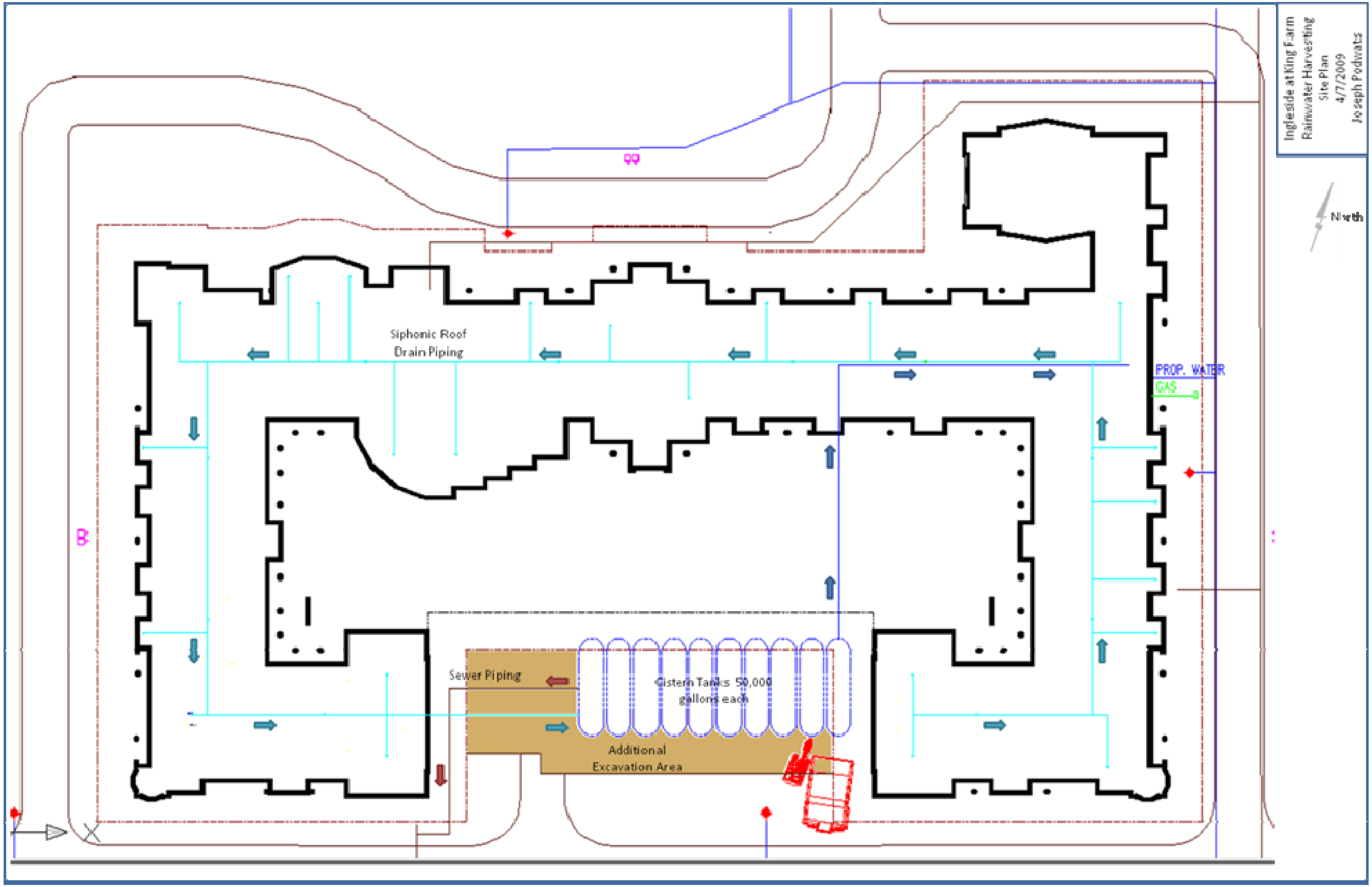


Appendix B

Construction Waste Management Informational Brochure
See full printout of Informational Brochure at back of report.

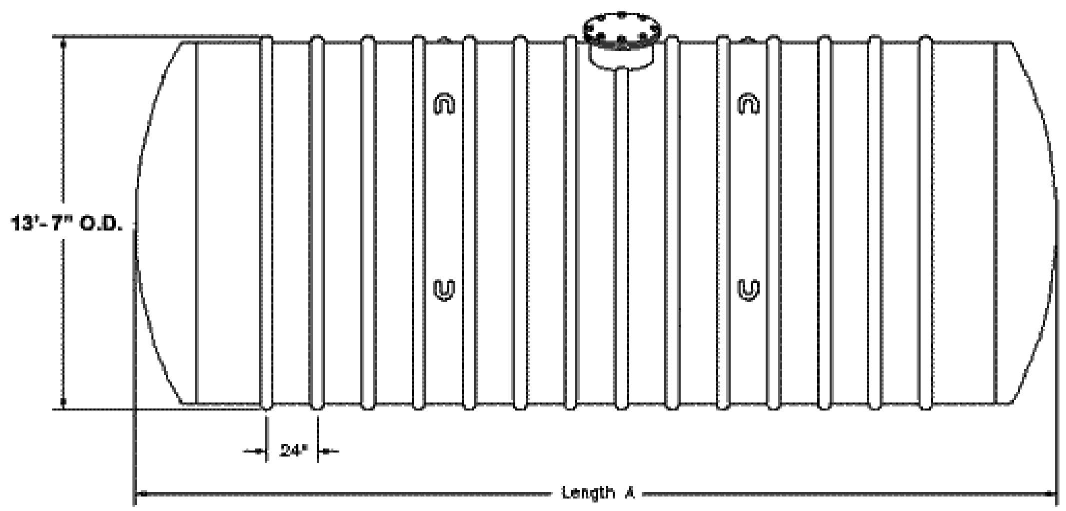
Appendix C

Rainwater Harvesting Site Plan



Water Storage Tank Manufacturer:
Darco Inc. http://www.undergroundwatertank.com/fiberproducts.html#14foot

13 Ft. Diameter Series Fiberglass Tanks



13 Ft. Diameter Fiberglass Tank			
***Capacity** (1)*	***Length** (2)*	***Dry Weight** (3)*	***Price** (4)*
50,000 *	**51' 6"**	**14,000**	**See "Quick Quote" at top of this page**
60,000 *	**61' 6"**	**16,000**	
75,000 *	**76' 8"**	**20,000**	
**** 13' diameter tanks may not be shippable through some states due to wide and tall load restrictions.***			
View Accessories for this product line			

(1) Listed capacities are nominal.
(2) Design shapes and dimensions may vary slightly.
(3) Listed weights are nominal.
(4) Price excludes additional tank appurtenances, accessories, freight, and taxes.
Prices subject to change.
Written quotes honored for thirty (30) days only.

Must be buried with bottom of tank at 18' below grade and groundwater is not present anywhere on site at this depth, so the tanks will not float.

DARCO INC UNDERGROUND TANKAGE

Home | Products | About Darco | FAQs
Installation | Drawings | Quick Quote | Contact Us

Underground Tank Project Estimate

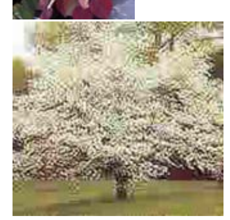
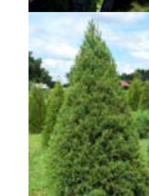
You are looking for an underground tank system to store 50,000 gallons of water. Here is your fiberglass tank estimate.

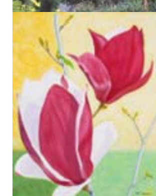
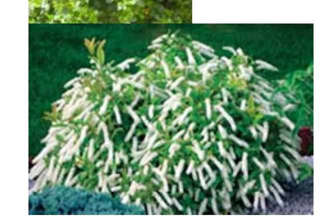
12' Diameter 50,000 Gallon storage tank	Included
Accessories (Average)	Included
Shipping	Included
Total Estimated Cost	**$70,601.30**
Required Deposit *(Balance COD)*	**$23,298.43**
Lead Time: 7 to 9 weeks	

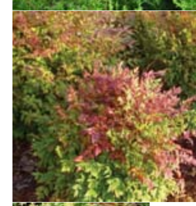
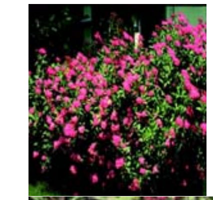
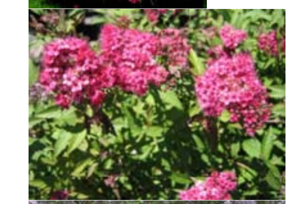
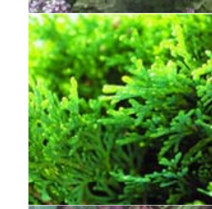
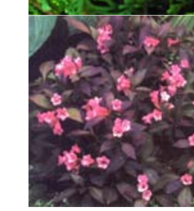
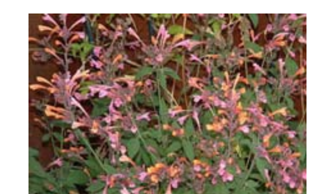
Tank Application: Rain Capture
Nearest Capital City to Site: Richmond, Virginia

Appendix D

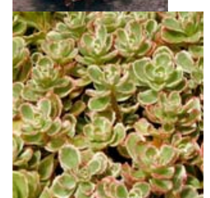
Plant Schedule

Qty.	Common Name	Unit Price	Extended Price	
18	Autumn Brilliance Serviceberry	$115.00	$2,070.00	
14	Armstrong or Bowhall Red Maple	$176.00	$2,464.00	
3	Bloodgood Japanese Maple	$250.00	$750.00	
8	October Glory Red Maple	$120.00	$960.00	
16	Dura Heat River Birch	$250.00	$4,000.00	
13	Forest Pansy Redbud	$135.00	$1,755.00	
12	White Flowering Dogwood	$200.00	$2,400.00	
6	Leyland Cypress	$265.00	$1,590.00	
7	White Fringe Tree	$150.00	$1,050.00	
3	Eastern Red Cedar	$9.95	$29.85	
11	Skyline Thornless Honeylocust	$225.00	$2,475.00	
10	Natchez Crapemyrtle	$250.00	$2,500.00	
2	Tonto Crape Myrtle	$200.00	$400.00	
7	Commanche Crapemyrtle	$33.02	$231.14	

12	Sarah's Favorite Crapemyrtle	$50.00	$600.00	
4	Sweetgum	$225.00	$900.00	
12	Prairifire Crabapple	$29.99	$359.88	
8	Alexander Magnolia	$23.15	$185.20	
2	Blackgum	$277.00	$554.00	
4	American Planetree	$39.95	$159.80	
5	Ivory Silk Japanese Tree Lilac	$44.95	$224.75	
10	Glenleven Littleleaf Linden	$10.50	$105.00	
4	Red Oak	$225.00	$900.00	
7	Green Vase Zelkova	$275.00	$1,925.00	
85	Prostrate Rock Cotoneaster	$8.00	$680.00	
24	Redosier Dogwood	$16.11	$386.64	
33	Dwarf Fothergilla	$9.67	$319.00	
12	Annabelle Hydrangea	$26.00	$312.00	
118	Inkberry	$24.00	$2,832.00	
59	Little Henry Sweetspire	$1.77	$104.43	

24	Blue Pacific Shore Juniper	$22.00	$528.00	
5	Mint Julep Juniper	$13.46	$67.30	
23	Harbour Dwarf Nandina	$34.95	$803.85	
101	Otto Luyken Cherry Laurel	$45.00	$4,545.00	
73	Gro-Low Fragrant Sumac	$2.01	$146.73	
16	Borsault Rhododendron	$10.00	$160.00	
13	Carefree Wonder Shrub Rose	$14.95	$194.35	
32	Nearly Wild Shrub Rose	$20.00	$640.00	
32	Anthony Waterer Spiraea	$24.00	$768.00	
4	Neon Flash Spiraea	$24.00	$96.00	
30	Dwarf Korean Lilac	$2.05	$61.50	
12	Holmstrup Eastern Arborvitae	$21.95	$263.40	
44	Midnight Wine Weigela	$22.00	$968.00	
67	Mexican Hyssop	$7.50	$502.50	
7	Deutchland False Spirea	$5.65	$39.55	
8	Fanal False Spirea	$12.95	$103.60	

92	Oertel's Rose Common Yarrow	$2.35	$216.20	
89	Overdam Feather Reed Grass	$16.00	$1,424.00	
34	Northern Sea Oats	$7.50	$255.00	
109	Calamint	$5.85	$70.05	
128	Leadwort	$7.50	$960.00	
98	Pardon Me Daylily	$7.50	$735.00	
146	Silver Scrolls Coral Bells	$8.75	$1,277.50	
121	Green Spice Coral Bells	$12.95	$1,566.95	
78	Stella de Oro Daylily	$7.50	$585.00	
27	John Clayton Honeysuckle	$7.95	$214.65	
52	Provence Lavender	$7.50	$390.00	
670	Big Blue Lilyturf	$5.25	$3,517.50	
491	Dwarf Fountain Grass	$13.32	$6,540.12	
60	Wild Sweet William	$6.00	$360.00	
30	Black Eyed Susan	$7.75	$232.50	
72	Stone Crop	$7.50	$540.00	

115	Blue Hill Sage	$7.50	$862.50	
160	Fuldaglut Stone Crop	$7.50	$1,200.00	
18	Tricolor Stone Crop	$8.00	$144.00	
181	Black Snowflake Foam Flower	$9.99	$1,808.19	

Total $66,009.63

Appendix E

Quantity Take Offs

Toilets

Type	ILU	ALU	Nursing	Public/Staff	Public/Staff ADA
Garage	2	0	0	2	0
First Floor	69	0	0	6	4
Second Floor	102	0	0	0	0
Third Floor	102	0	0	0	0
Fourth Floor	102	0	0	0	0
Fifth Floor	102	0	0	0	0
Sixth Floor	102	0	0	0	0
Seventh Floor	0	35	45	0	7
Totals	581	35	45	8	11

Lavatories

Type	ILU	ALU	Nursing	Public/Staff	Public/Staff ADA
Garage	2	0	0	2	0
First Floor	84	0	0	8	0
Second Floor	120	0	0	0	0
Third Floor	120	0	0	0	0
Fourth Floor	120	0	0	0	0
Fifth Floor	120	0	0	0	0
Sixth Floor	120	0	0	0	0
Seventh Floor	0	35	45	0	7
Totals	686	35	45	10	7

Showers

Type	ILU	ALU	Nursing	Public/Staff	Public/Staff ADA
Garage	2	0	0	2	0
First Floor	54	0	0	2	0
Second Floor	78	0	0	0	0
Third Floor	78	0	0	0	0
Fourth Floor	78	0	0	0	0
Fifth Floor	78	0	0	0	0
Sixth Floor	78	0	0	0	0
Seventh Floor	0	35	45	0	0
Totals	446	35	45	4	0

Urinals

Type	ILU	ALU	Nursing	Public/Staff	Public/Staff ADA
Garage	0	0	0	0	0
First Floor	0	0	0	2	0
Second Floor	0	0	0	0	0
Third Floor	0	0	0	0	0
Fourth Floor	0	0	0	0	0
Fifth Floor	0	0	0	0	0
Sixth Floor	0	0	0	0	0
Seventh Floor	0	0	0	0	0
Totals	0	0	0	2	0

Floor Plan	Toilets	Lavatories	Showers	People	Qty of Floor Plan	People
The Woodley	1	1	1	1	21	21
The Kalorama	1	1	1	1	1	1
The Takoma	2	2	1	2	46	92
The Grosvenor	2	2	2	2	33	66
The Lafayette	3	3	2	3	44	132
The Chevy Chase	2	3	2	3	24	72
The Bethesda	2	3	2	3	14	42
The Dumbarton	3	4	2	4	45	180
The Georgetown	2	3	2	3	10	30
The Potomac	3	4	3	4	12	48
ALU	1	1	0	1	35	35
SNU	1	1	1	1	45	45
Public/Staff				1	19	19
Garage ILU (Guest)				1	2	2
					Total	785

Current Fixtures (70 gallons/person/day estimated)

Fixture Type	Item	Water Usage (gallons/use or gpm)	Qty	Current Unit Price	Extended Current Price
Water Closet - ILU	Kohler: Wellworth Model K-3422	1.60	581	$255.85	$148,648.85
Water Closet - ALU	Kohler: Highline Comfort Height Model K-3427	1.60	35	$292.75	$10,246.25

Water Closet - Nursing	Kohler: Highcliff Height Model K-4368	1.60	45	$213.75	$9,618.75
Water Closet - Public/Staff	Kohler: Welcomme Model K-4349	1.60	8	$206.10	$1,648.80
Water Closet - Public/Staff ADA	Kohler: Highcliff Height Model K-4368	1.60	11	$292.75	$3,220.25
Lavatory - Nursing/ILU/ALU	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	766	$183.00	$140,178.00
Lavatory - Public/Staff/ADA	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	17	$183.05	$3,111.85
Shower - ILU	Alson Hand Held Shower #462BG	2.50	446	$14.96	$6,672.16
Shower - ALU/Nursing/Public/Staff	Alson Hand Held Shower #462BG	2.50	84	$14.96	$1,256.64
Urinal	Kohler: Bardon Model K-4960-ET w/Sloan Flush Valve Model No. 186-1	1.00	2	$341.90	$683.80
				Total Current Price	$325,285.35

Alternative Fixtures # 1

Fixture Type	Item	Water Usage (gallons/use or gpm)	Water Savings	Qty	Alternative # 1 Unit Price	Extended Alternative # 1 Price
Water Closet - ILU	Kohler: Kelston Comfort Height Model K-11453	1.28	20.00%	581	$390.80	$227,054.80
Water Closet - ALU	Kohler: Kelston Comfort Height Model K-11453	1.28	20.00%	35	$390.80	$13,678.00
Water Closet - Nursing	Kohler: Wellworth Model K-4406	1.28	20.00%	45	$187.10	$8,419.50
Water Closet - Public/Staff	Kohler: Wellworth Model K-4406	1.28	20.00%	8	$206.10	$1,648.80
Water Closet - Public/Staff ADA	Kohler: Highcliff Height Model K-4368	1.60	0.00%	11	$292.75	$3,220.25
Lavatory - Nursing/ILU/ALU	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	0.00%	766	$183.00	$140,178.00
Lavatory - Public/Staff	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	0.00%	17	$183.05	$3,111.85
Shower - ILU	Kohler: MasterShower Model K-8543	2.00	20.00%	446	$106.65	$47,565.90
Shower - ALU	Kohler: MasterShower Model K-8543	2.00	20.00%	84	$106.65	$8,958.60
Urinal	Kohler: Bardon Touchless Model K-4915	0.50	50.00%	2	$1,119.90	$2,239.80
		Average Estimated Water Savings	17.00%		Total Alternative # 1 Price	$456,075.50

Alternative Fixtures # 2

Fixture Type	Item	Water Usage (gallons/use or gpm)	Water Savings	Qty	Alternative # 2 Unit Price	Extended Alternative # 2 Price
Water Closet - ILU	Kohler: Wellworth Pressure Lite Model K-3531	1.00	37.50%	581	$490.65	$285,067.65
Water Closet - ALU	Kohler: Highline Comfort Height Model K-3519	1.00	37.50%	35	$563.75	$19,731.25
Water Closet - Nursing	Kohler: Wellworth Model K-4406	1.28	20.00%	45	$187.10	$8,419.50
Water Closet - Public/Staff	Kohler: Wellworth Model K-4406	1.28	20.00%	8	$206.10	$1,648.80
Water Closet - Public/Staff ADA	Kohler: Highcliff Height Model K-4368	1.60	0.00%	11	$292.75	$3,220.25
Lavatory - Nursing/ILU/ALU	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	0.00%	766	$183.00	$140,178.00
Lavatory - Public/Staff	4" Centers Delta: Model 2530-LHP w/H24 Handles & A24CL Accent Faucet	1.50	0.00%	17	$183.05	$3,111.85
Shower - ILU	Kohler: Forte Model K-10298	1.75	30.00%	446	$120.40	$53,698.40
Shower - ALU	Kohler: Forte Model K-10298	1.75	30.00%	84	$120.40	$10,113.60
Urinal	Kohler: Steward S Waterless Model K-4917	0.00	100.00%	2	$532.00	$1,064.00
		Average Estimated Savings	27.50%		Total Alternative # 2 Price	$526,253.30

Appendix F

Roof Drainage and Rainwater Harvesting System Estimates

Current Drainage System

Item	Qty (# or feet)	Unit Price (Labor & Materials)	Extended Price
3" Roof Drains	12	$325.00	$3,900.00
4" Roof Drains	12	$325.00	$3,900.00
6" Roof Drains	16	$465.00	$7,440.00
3" Horizontal Drain Piping	14	$19.85	$277.90
4" Horizontal Drain Piping	36	$20.40	$734.40
6" Horizontal Drain Piping	97	$28.55	$2,769.35
3" Vertical Drain Piping (3' for roof or floor penetrations)	260	$19.85	$5,161.00
4" Vertical Drain Piping	83	$20.40	$1,693.20
6" Vertical Drain Piping	623	$28.55	$17,786.65
4" Underslab Piping	456	$20.40	$9,302.40
Excavation Underfloor	101	$1.58	$160.11
		Total Price	$53,125.01

Rainwater Harvesting System

Item	Qty	Unit Price (Labor & Materials)	Extended Price
Darco Cistern (50,000 gallon 13' x 51'-6" includes shipping and crane)	10	$70,601.30	$706,013.00
Cistern Flanged Nozzles & Flexible Pipeline Couplings	9	$2,000.00	$18,000.00
2-4" Siphonic Roof Drains	40	$1,866.03	$74,641.20
4" PVC Horizontal Drain Piping	2096	$20.40	$42,758.40
4" PVC Vertical Drain Piping	90	$20.40	$1,836.00
8" Schedule 40 Water Distribution Piping	300	$85.42	$25,626.00
8" Schedule 40 Sewer Piping	164	$85.42	$14,008.88
Excavation	9138	$1.58	$14,437.69
		Total Price	$897,321.17

Units Method

Qty People	Average Water Usage (gallons per person/day)	Average Water Usage (gallons/day)	Average Water Usage (gallons/year)	Total Potential Rainfall Collection (gallons/year roof only)	Tank Size (21 Days of Use)
785	70	54,950.00	20,056,750.00	2,256,530.40	1,153,950.00

Appendix G

Utility Savings

Utility Usage & Cost Comparison of Current Design to Rainwater Harvesting	Usage with Current Design	Usage with Rainwater Harvesting	Rate (per 1000 gallons)	Cost with Current Design	Cost with Rainwater Harvesting	Cost Savivgs (per year)
Water (rates approved July 1, 2008)	20,056,750.00	17,800,219.60	$4.53	$90,857.08	$80,634.99	$10,222.08
Sewer (rates approved July 1, 2008)	18,051,075.00	16,020,197.64	$7.03	$126,899.06	$112,621.99	$14,277.07

Additional Utility Usage & Cost Savings for Water Efficient Fixtures (Alternative # 1)	Usage with Rainwater Harvesting	Usage with Alternative Fixtures # 1		Cost with Rainwater Harvesting	Cost with Alternative Fixtures # 1	
Water (rates approved July 1, 2008)	17,800,219.60	14,774,182.27	$4.53	$80,634.99	$66,927.05	$23,930.03
Sewer (rates approved July 1, 2008)	16,020,197.64	13,296,764.04	$7.03	$112,621.99	$93,476.25	$33,422.81

Additional Utility Usage & Cost Savings for Water Efficient Fixtures (Alternative # 2)	Usage with Rainwater Harvesting	Usage with Alternative Fixtures # 2		Cost with Rainwater Harvesting	Cost with Alternative Fixtures # 2	
Water (rates approved July 1, 2008)	17,800,219.60	12,905,159.21	$4.53	$80,634.99	$58,460.37	$32,396.71
Sewer (rates approved July 1, 2008)	16,020,197.64	11,614,643.29	$7.03	$112,621.99	$81,650.94	$45,248.11

Determining the following was not part of the intent of this thesis, but shows potential savings for each connection that the project could eliminate in Rockville, MD through the WSSC.

Potential Savings

Item	Qty	Price
Storm Drainage Inlet (8')	1	$3,300.00
Field Connection	1	$500.00
Sewer Manhole	1	$3,500.00
Drop Manhole	1	$4,500.00
	Total	$11,800

Appendix H

Scorecard

Analysis I-Building Envelope Performance

	Cost per SF (No O&P)	SF	Material Cost	Labor Cost (1 Carpenter)	Total Cost	Production (LF/day)	Duration (weeks)	Procurement (Lead Time)	Constructability (1-10)	Structural Impacts	Whole Wall R-Value (average)	Performance (1-10)	Life Cycle (1-10)	Industry Acceptance (Yes/No)	Value Added (Yes/No)	LEED Credits
kama-EEBS (60% cycle reduction)	**$6.10**	**225,578**	**$1,376,025.80**	**$52,492.03**	**$1,428,517.83**	**195.51**	**25.8**	**6 to 8 weeks upon shop dwgs**		**Direct Replacement**	**29.91**	**10**	**10**		**Yes**	**5**
accel-E Steel Thermal Efficient Panel (S.T.E.P.) (66% cycle reduction)	$6.50	225,578	$1,466,257.00	$44,618.22	$1,510,875.22	187.13	21.9	4 weeks upon shop dwgs		Direct Replacement	29.56	10			Yes	3
Current Design (base line)	$1.79	225,578	$272,306.74	$131,230.07	$403,536.81	139.65	64.4	6 to 7 weeks		N/A	16.70	5				0

Analysis III-Construction Waste Management

Option	Cost	Waste (tons)	Duration (weeks)	Value Added (Yes/No)	LEED Credits
No Waste Management	$111,050.00	536	N/A	No	0
Divert 50%	$564,506.00	268	N/A	Yes	1
Divert 75%	**$1,930,459.00**	**134**	**N/A**	**Yes**	**2**

Analysis IV-Water Efficiency

	Landscape Cost	Fixtures Cost	Drainage System	Water Usage (gal)	Sewer Usage (gal)	Water Cost	Sewer Cost	Water Savings/Year	Sewer Savings/Year	Total First Cost	Total Savings/Year	Payback (years)	Value Added (Yes/No)	LEED Credits
Current Design	$66,009.63	$325,285.35	$53,125.01	20,056,750	18,051,075	$90,857.08	$126,899.06	$0.00	$0.00	$444,419.99	$0.00	N/A	No	0
Alternative # 1 (Alternative Landscaping)	$33,664.91	$325,285.35	$53,125.01	20,056,750	18,051,075	$90,857.08	$126,899.06	$0.00	$0.00	$412,075.27	$0.00	N/A	Yes	0
Alternative # 2 (Altern Landscaping & Rainwater Harvesting)	$33,664.91	$325,285.35	$897,321.17	17,800,220	16,020,198	$80,634.99	$112,621.99	$10,222.08	$14,277.07	$1,256,271.43	$24,499.15	51.3	Yes	0
Alternative # 3 (Altern Landscaping, Fixtures 1, & Rainwater Harvesting)	$33,664.91	$456,075.50	$897,321.17	14,774,182	13,296,764	$66,927.05	$93,476.25	$23,930.03	$33,422.81	$1,387,061.58	$57,352.84	24.2	Yes	0
Alternative # 4 (Altern Landscaping, Fixtures 2, & Rainwater Harvesting)	**$33,664.91**	**$526,253.30**	**$897,321.17**	**12,905,159**	**11,614,643**	**$58,460.37**	**$81,650.94**	**$32,396.71**	**$45,248.11**	**$1,457,239.38**	**$77,644.82**	**18.8**	**Yes**	**1**

	First Cost	Total LEED Credits Earned	
Totals for Proposed Alternates	**$4,816,216.21**		**8**

Proposed alternates appear highlighted and in bold. These were the options that were summed to determine total cost and total LEED points earned.

Appendix I

LEED Analysis

Analysis I - Building Envelope Performance				
Current Design:				
Assembly	R Value			
Assembly A R Value	17.89			
Assembly B R Value	18.34			
Assembly C R Value	13.86			
Average	16.70			
kama-EEBS Design: 33% decrease in Mech Sys Capacity			Additional Credits	Additional Points
Assembly	R Value	% Improvement		
Assembly A R Value	30.61	171.10%		
Assembly B R Value	30.91	168.54%		
Assembly C R Value	28.22	203.61%		
Average	29.91	179.16%		
EA Credit 1-Optimize Energy Performance	**19.80%**		**Credit 1.3**	**1**
EQ Credit 4-Low-Emitting Materials	**sealants/adhesives must also comply**		**Credit 4.1**	**1**
EQ Credit 7-Thermal Comfort: Design			**Credit 7.1**	**1**
MR Credit 2-Construction Waste Management	**contributes**		**Credit 2.1**	**0**
MR Credit 2-Construction Waste Management	**contributes**		**Credit 2.2**	**0**
accel-E Design: 28% decrease in Mech Sys Capacity				
Assembly	R Value	% Improvement		
Assembly A R Value	30.26	169.14%		
Assembly B R Value	30.56	166.63%		
Assembly C R Value	27.87	201.08%		
Average	29.56	177.06%		
EA Credit 1-Optimize Energy Performance	**16.80%**		**None-does not improve from current**	**0**

EQ Credit 7.1-Thermal Comfort: Design			**Credit 7.1**	**1**
MR Credit 2-Construction Waste Management	**contributes**		**Credit 2.1**	**0**
MR Credit 2-Construction Waste Management	**contributes**		**Credit 2.2**	**0**
Analysis III - Construction Waste Management				
No Waste Management Plan				
Divert 50%				
Divert 75%				
MR Credit 2-Construction Waste Management	**must meet Prereq 1 and 50% diverted**		**Credit 2.1**	**1**
MR Credit 2-Construction Waste Management	**must meet Prereq 1 and 75% diverted**		**Credit 2.2**	**1**
Analysis IV - Water Efficiency				
Design	**Water Usage**	**LEED Credits**	**Additional Credits**	**Additional Points**
Current Design		SS 6.1, SS 6.2		
Rainwater Harvesting with Alternative # 1				
WE Credit 3.1-Water Use Reduction 20% Reduction	**17.00%**		**Credit 3.1**	**0**
Rainwater Harvesting with Alternative # 2				
WE Credit 3.1-Water Use Reduction 20% Reduction	**27.50%**		**Credit 3.1**	**1**
WE Credit 3.2-Water Use Reduction 30% Reduction	**27.50%**		**Credit 3.2**	**0**

Proposed alternates appear highlighted and in bold. These were the options that were summed to determine total cost and total LEED points earned.

LEED for New Construction v 2.2
Registered Project Checklist

Project Name: Ingleside at King Farm – Current Design

Project Address: Rockville, MD

Yes	?	No			
24	6	36	**Project Totals** (Pre-Certification Estimates)		69 Points
			Certified: 26-32 points · Silver: 33-38 points · Gold: 39-51 points · Platinum: 52-69 points		

Yes	?	No			
8	0	6	**Sustainable Sites**		14 Points
Yes			Prereq 1	Construction Activity Pollution Prevention	Required
0	0	1	Credit 1	Site Selection	1
1	0	0	Credit 2	Development Density & Community Connectivity	1
0	0	1	Credit 3	Brownfield Redevelopment	1
1	0	0	Credit 4.1	Alternative Transportation, Public Transportation	1
1	0	0	Credit 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	1
1	0	0	Credit 4.3	Alternative Transportation, Low-Emitting & Fuel Efficient Vehicles	1
0	0	1	Credit 4.4	Alternative Transportation, Parking Capacity	1
0	0	1	Credit 5.1	Site Development, Protect or Restore Habitat	1
1	0	0	Credit 5.2	Site Development, Maximize Open Space	1
1	0	0	Credit 6.1	Stormwater Design, Quantity Control	1
1	0	0	Credit 6.2	Stormwater Design, Quality Control	1
1	0	0	Credit 7.1	Heat Island Effect, Non-Roof	1
0	0	1	Credit 7.2	Heat Island Effect, Roof	1
0	0	1	Credit 8	Light Pollution Reduction	1

Yes	?	No			
0	2	0	**Water Efficiency**		5 Points
0	1	0	Credit 1.1	Water Efficient Landscaping, Reduce by 50%	1
0	1	0	Credit 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	1
0	0	0	Credit 2	Innovative Wastewater Technologies	1
0	0	0	Credit 3.1	Water Use Reduction, 20% Reduction	1
0	0	0	Credit 3.2	Water Use Reduction, 30% Reduction	1

Powered by Adobe LiveCycle

Last Modified: May 2008 1 of 4

LEED for New Construction v 2.2
Registered Project Checklist

Yes	?	No			
4	2	11	**Energy & Atmosphere**		17 Points
Yes			Prereq 1	Fundamental Commissioning of the Building Energy Systems	Required
Yes			Prereq 1	Minimum Energy Performance	Required
Yes			Prereq 1	Fundamental Refrigerant Management	Required

*Note for EAc1: All LEED for New Construction projects registered after June 26, 2007 are required to achieve at least two (2) points.

Yes	?	No			
2	2	6	Credit 1	Optimize Energy Performance	1 to 10
			Credit 1.1	10.5% New Buildings / 3.5% Existing Building Renovations	1
			➡ Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
			Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
			Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
			Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
			Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
			Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
			Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
			Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
0	0	3	Credit 2	On-Site Renewable Energy	1 to 3
			Credit 2.1	2.5% Renewable Energy	1
			Credit 2.2	7.5% Renewable Energy	2
			Credit 2.3	12.5% Renewable Energy	3
0	0	1	Credit 3	Enhanced Commissioning	1
0	0	1	Credit 4	Enhanced Refrigerant Management	1
1	0	0	Credit 5	Measurement & Verification	1
1	0	0	Credit 6	Green Power	1

Powered by Adobe LiveCycle

Last Modified: May 2008 2 of 4

LEED for New Construction v 2.2
Registered Project Checklist

Yes	?	No	Materials & Resources		13 Points
4	0	9			
Yes			Prereq 1	**Storage & Collection of Recyclables**	Required
0	0	1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
0	0	1	Credit 1.2	**Building Reuse**, Maintain 95% of Existing Walls, Floors & Roof	1
0	0	1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
0	0	1	Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
0	0	1	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
0	0	1	Credit 3.1	**Materials Reuse**, 5%	1
0	0	1	Credit 3.2	**Materials Reuse**, 10%	1
1	0	0	Credit 4.1	**Recycled Content**, 10% (post-consumer + 1/2 pre-consumer)	1
1	0	0	Credit 4.2	**Recycled Content**, 20% (post-consumer + 1/2 pre-consumer)	1
1	0	0	Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured	1
1	0	0	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured	1
0	0	1	Credit 6	**Rapidly Renewable Materials**	1
0	0	1	Credit 7	**Certified Wood**	1

Yes	?	No	Indoor Environmental Quality		15 Points
3	2	10			
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
0	0	1	Credit 1	**Outdoor Air Delivery Monitoring**	1
0	0	1	Credit 2	**Increased Ventilation**	1
0	0	1	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
0	0	1	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
0	0	1	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1	0	0	Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
0	0	1	Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
0	0	1	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
0	0	1	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1	0	0	Credit 6.1	**Controllability of Systems**, Lighting	1
0	0	1	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
0	1	0	Credit 7.1	**Thermal Comfort**, Design	1
0	1	0	Credit 7.2	**Thermal Comfort**, Verification	1
0	0	1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
1	0	0	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Powered by Adobe® LiveCycle™

Last Modified: May 2008 3 of 4

LEED for New Construction v 2.2
Registered Project Checklist

Yes	?	No	Innovation & Design Process		5 Points
5	0	0			
1	0	0	Credit 1.1	**Innovation in Design:** Provide Specific Title	1
1	0	0	Credit 1.2	**Innovation in Design:** Provide Specific Title	1
1	0	0	Credit 1.3	**Innovation in Design:** Provide Specific Title	1
1	0	0	Credit 1.4	**Innovation in Design:** Provide Specific Title	1
1	0	0	Credit 2	**LEED® Accredited Professional**	1

Powered by Adobe® LiveCycle™

Last Modified: May 2008 4 of 4

Additional Information:

Links:

U.S. Green Building Council:
www.usgbc.org

Whole Building Design Guide - Construction Waste Management Database:
www.wbdg.org/tools/cwm.php

Construction Waste Management Database

Habitat for Humanity:
www.habitat.org/env/restores.aspx

Habitat for Humanity ReStore

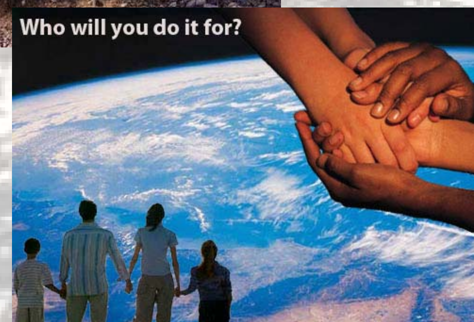
Sustainable Packaging Coalition:
www.sustainablepackaging.org

Waste Management:
www.wm.com

WASTE MANAGEMENT

Penn State AE Senior Thesis e-Studio:
www.engr.psu.edu/ae/thesis/portfolios/2009/jmp5051

eStudio



This informational brochure is not a comprehensive guide for developing a construction waste management plan. The purpose of this brochure is to encourage CM's, contractors, subcontractors, facility managers, and owners to do their part for the economy, the environment, and the community. If considering a CWMP, consult a professional to determine availability of local services and resources. This brochure has been developed as part of a senior thesis project under The Pennsylvania State University's architectural engineering program. To see more information leading to the development of this brochure, visit Joseph Podwats's Penn AE Senior State AE Senior Thesis e-Studio.

Greening Your Projects

Developed By:
Joseph Podwats
Penn State University
Architectural Engineering-CM Senior Thesis
Ingleside at King Farm
Advisor: Dr. David Riley

Phone: 570-510-0238
E-mail: jmp5051@psu.edu

PENNSTATE 1855

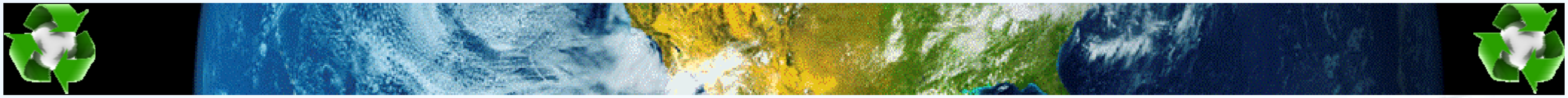
Greening Your Projects

Construction Waste Management Information

Designed for Construction Managers, Contractors, Subcontractors, Facility Managers, and Owners.

Developed By:
Joseph Podwats
Penn State University
Architectural Engineering-CM
Senior Thesis
Ingleside at King Farm

PENNSTATE 1855



Why should I implement a construction waste management plan (CWMP)?

One of the most important things to do in business is conserve resources. This is also one of the most important things to do to save the planet, improve the economy, and protect the overall health of the communities. Resources are important to survival. Implementing a plan to reduce, reuse, and recycle helps preserve fuels required to haul trash to distant landfills due to local ones being capped. A reduction in material usage translates into savings on multiple levels; CM's, GC's, Subs, Owners.

Seen this type of mess on your projects before?

Although difficult to comprehend and quantify the benefits, implementing a CWMP in conjunction with a clean-minded attitude and a goal of maintain cleanliness on site can improve IAQ during construction.

Implementing a CWMP is a socially, economically, and environmentally responsible thing to do.

Statistics

- Buildings contribute 30% to U.S. waste output each year (136 million tons)
- Buildings use 40% of our raw materials

Benefits

- Reduced solid waste, less burden on landfills and trash removal services, promotes green economy
- Savings on tipping fees
- Promotes well-being of local community
- Improved productivity on the construction site
- Morale and operating income will be boosted
- Public image improved and awarded more bids
- Improved Indoor Air Quality and working conditions
- Contributes to overall health of job site
- Improve site safety and cleanliness
- Can reduce or eliminate construction delays

How It Can Be Done:

Green Purchasing Practice

Consider buying materials and supplies in bulk with less packing or buying from suppliers that use sustainable packaging materials. Return reusable containers and packing materials to the supplier. Reuse non-returnable containers on the jobsite wherever possible. Develop a list of uses for plastic containers and find local organizations to see if they can use them. Request deliveries to be made with minimal packing.

Greening The Trades

Setup a recycling orientation for subs as they enter the site. Employ additional laborers where necessary to promote and support a green economy. Make the laborers in charge of preventing comingling.

Thinking

We don't throw away leftover food, why would we throw away leftover materials? Donate unused materials to local organizations such as Habitat for Humanity.

Training

Educate the subs about the plan.

Monitoring

Appoint and train a "green" leader to track cleanup and answer questions about recycling.

Rewarding

Offer incentives to workers such as approving more overtime hours.

Greening the Specs

- Make participation mandatory
- Use bid alternates to determine feasibility
- Require recycling to the extent practical
- Require a draft waste plan
- Require recycling of specific items
- Require proof of waste diverted from landfill
- Provide list of local waste/recycling services
- Provide list of local community organizations

www.engr.psu.edu/ae/thesis/portfolios/2009/jmp5051