SUSTAINABLE STREETS AND HIGHWAYS: AN ANALYSIS OF GREEN ROADS RATING SYSTEMS

A Thesis
Presented to
The Academic Faculty

By

Ana Athalia Plaut Eisenman

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science in Civil Engineering

Georgia Institute of Technology

May 2012

SUSTAINABLE STREETS AND HIGHWAYS: AN ANALYSIS OF GREEN ROADS RATING SYSTEMS

Approved by:

Dr. Michael D. Meyer, Advisor
School of Civil & Environmental Engineering
Georgia institute of Technology

Dr. Michael P. Hunter, Co-Advisor
School of Civil & Environmental Engineering
Georgia Institute of Technology

Dr. Michael O. Rodgers
School of Civil & Environmental Engineering
Georgia Institute of Technology

Date Approved: January 13, 2012

To my parents, Mina, Hugh, and John

ACKNOWLEDGEMENTS

I would like to thank Lisa Baxter for finding me in the elevator on my first day at Georgia Tech. Lisa made all transitions I encountered during my interim as a graduate student so much easier than they would have been without her. It was through Lisa that I met Dr. Michael Meyer, beat him at a game of Hearts, and was eventually invited to join the Transportation Group at Georgia Tech.

Dr. Meyer helped me find my passion for transportation engineering, even when I had eyes only for structural engineering. His seminal work both in academia as well as during his interim as Director of Transportation Planning and Development for Massachusetts is both inspiring and has brought his students, including myself, many anecdotes and accounts that will certainly help shape future decisions in our transportation careers. One must mention how agreeable Dr. Meyer is; he's constantly available to students, even while traveling, and always happy to assist with any advice or aid that a student may need.

This thesis could not have been completed without the time and energy spent by Habte Kassa and the team he brought together to work on it. Thank you Samuel Woods, Chester Thomas, and Nebiat Abraham. Your ideas and input have ensured that your peers at GDOT may actually accept and implement a version of the final product.

David P. Eisenman is perhaps the most unusual parent I know; although, perhaps I believe so because he is my own father. His love of knowledge – and need to share it with everyone one he meets – will likely ensure that I, myself, maintain an unofficial status of 'lifetime student.' While I may not have been appreciative then, his critique of my writing, always accompanied by sheets painted red with mark-ups, has ensured that I dot my i's and cross my t's at least well enough (though he probably could still find numerous corrections).

My mother, Patricia Plaut, has been an educator all my life and has been all the tougher on my own schooling for it. While always granting me my own voice, she has been sure to teach me that sometimes 'this isn't an option' – most recently letting me know that I could not start working until I completed this thesis. The daughter of a mechanical engineering, with whom she was very close, my mother was not going to let her daughter slip through the cracks with math and science. Math enrichment class may not have been my favorite way to spend some summer afternoons growing up, but then I returned voluntarily in high school. While I hate to admit it, I'll have to say that my mom is (almost) always right.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACEC	American Council of Engineering Companies
ACPA	American Concrete Pavement Association
APWA	American Public Works Association
ASCE	American Society of Civil Engineers
BE^2ST	Building Environmentally and Economically Sustainable Transportation
DOT	Department of Transportation
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GDOT	Georgia Department of Transportation
GDP	Gross Domestic Product
GHP	Green Highways Partnership
GSHC	T&DI/ASCE 1st Green Streets and Highways Conference
IDOT	Illinois Department of Transportation

I-LAST	Illinois Livable and Sustainable Transportation
IRTBA	Illinois Road and Transportation Builders Association
LCA	Life Cycle Assessment
LCCA	Life-Cycle Cost Analysis
LEED	Leadership in Energy and Environmental Design
MTO	Ministry of Transportation (Canada)
OMR	Office of Materials and Research (specifically at GDOT)
PI	Principal Investigator
ppm	parts per million (air pollution unit of measurement)
SIPRS	Sustainable Infrastructure Project Rating System
STARS	Sustainable Transportation and Access Rating System
STEED	Sustainable Transportation Environmental Engineering and Design
T&DI	Transportation and Development Institute
TRIS	Transportation Research Information Service

SUMMARY

As sustainability increasingly becomes a concern to society, it is in state transportation agencies' best interests to embrace and adopt initiatives that will both educate their employees and the communities they serve on how transportation systems and system operations can be viewed within such a context. One of the strategies some state departments of transportation (SDOTs) have adopted for providing a more sustainable approach to highway design is a "green streets and highways rating system." Adopting a strategy such as the one proposed in this thesis for the Georgia Department of Transportation will enable an agency to compare projects based on sustainability goals and outcomes. Such a rating system can provide several benefits to a state department of transportation. As a public relations tool, publishing the sustainability rating results of completed projects can promote an "environmentally friendly" image of the agency. In some cases, this could be used to garner increased support for an agency's program. Comparing the ratings of proposed projects during the early programming process may also help in the selection of more sustainably effective and efficient projects. Additionally, a project in the project planning phase could use the green rating criteria to identify those areas where changes in design could result in more environmentally sensitive designs. A green streets and highways rating tool is an important means of fostering an environmental ethic in a transportation agency, one that could become more important in years to come.

CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 Research Objectives

There are two main objectives of this study. The first objective was to evaluate emerging transportation sustainability rating systems to determine best practices and methods that might be applied in the Georgia Department of Transportation (GDOT). The second was to propose a straightforward Georgia-specific rating system that would enable uniform consideration of sustainability characteristics for state DOT projects. This thesis proposes a rating system that is specific to the GDOT, but which bears some semblance to operational systems that have been used in other states.

1.1.2 Research Methods

1.1.2.1 Literature Review

A comprehensive literature review was used to define how the concept of sustainability pertains to transportation systems and to identify a number of rating systems in operation today or proposed by professional organizations. Sustainability, while considered an important concept by various disciplines, has a somewhat elusive definition since it is viewed through many professional lenses. In addition to providing an overview of sustainability as it pertains to the transportation industry, the literature review also outlines federal initiatives, programs that have emerged in academia and consulting, as well as state and local based programs.

1.1.2.2 Scorecard Development

The literature review provided a base on which to prepare a draft scorecard, which was then modified to be more specific to GDOT's needs and desires. The draft scorecard developed based on the examples found in the literature review as well as the knowledge and experience of the research team. The initial 'Test Scorecard' went through a series of reviews and trials, championed by a small task force of GDOT practitioners as well as the research team. During a series of meetings, the team utilized the scorecard to rate several existing GDOT projects to become familiar with the practice of rating projects, as well as to evaluate the usefulness of initial scorecard metrics with GDOT practices and parameters. The scorecard evolved through team input in each successive meeting until it was deemed sufficiently refined for a pilot application. At the final meeting of the rating team, a number of recent projects were scored to demonstrate the scorecard's use. The evolution of the scorecard, as compared to the original, can be found in the Analysis section, while the final scorecard is published in the Results section of this document.

1.1.3 Research Scope

The research utilizes standardized scoring to compare the relative measure of sustainable goals achieved in transportation infrastructure projects. Because this area of interest is an emerging topic, many programs are still evolving and have yet to amass any considerable amount of data related to program-specific scoring methods. In fact, some of the systems reviewed in this thesis have not yet been finalized nor have had a chance to officially rate any projects. While a more comprehensive study may be completed in subsequent years after several of these systems have collected a sufficiently large sample of scored projects, at the moment, this thesis was confined to investigate only those that were currently available. The scorecard, however, has been designed to evolve over time as the needs and desires of GDOT change.

1.1.4 Research Contribution

Sustainability is certainly not a new concept, although it is a concept that has not been readily applied in civil engineering. One of the often used terms to describe the application of sustainability characteristics in infrastructure design is "green design." There is often a tradeoff when making 'green' decisions because sustainability concepts can often conflict with one another and furthermore have gained a reputation for costing more than baseline practices, perhaps unjustly so. Additionally, many of these concepts are measured with entirely different units that are not easily converted to a common metric such that costs and benefits can be weighed among sustainable choices.

Similar to LEED certification for buildings, emerging sustainability initiatives in the transportation arena were investigated as a baseline to develop a new sustainable streets and highways rating system for GDOT. While rating systems for street and highway infrastructure are gaining momentum across the nation, there is no current system for GDOT. This thesis aims to provide at least a starting point for Georgia to launch a rating initiative that will likely align with national, if not global, practices in the future. The main goal of the literature review was to explore state-of-the-art sustainable transportation engineering practices, and review the emerging rating systems that promote these practices. This thesis explored modifications and/or improvements for pavement and road sustainability ratings that catered specifically to the State of Georgia.

This research examines the advantages and disadvantages of different road rating systems currently being used or that are in development phases. It is expected that the results will be of great interest to Georgia transportation officials given that this thesis will test several Georgia projects utilizing a framework that considers the Georgia perspective.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review will start with a definition of sustainability – a definition that is often elusive as it depends on the lens with which an individual or group perceives a particular facet of life and human interaction with the environment. After this background information has been presented, the literature review will introduce emerging green streets and highways rating systems. These emerging programs give insight into the unique challenge of defining sustainability, particularly as it relates to transportation infrastructure.

2.2 Defining Sustainability

Generally, sustainability can be defined as having four objectives: system effectiveness, environmental integrity, conservation of economic resources, and consideration of social quality of life (Jeon, 2007). The latter three areas are often grouped together and called the Triple Bottom Line and are often the main categories considered under transportation sustainability goals. While it is certainly important to consider the tenets of the Triple Bottom Line, it is equally important to not compromise the efficiency and effectiveness of a transportation system (AASHTO, 2011).

The concept of sustainable design and construction, while already present in the building construction industry, is beginning to emerge in the infrastructure industry as well. The transportation industry has started to adopt initiatives that promote environmental stewardship and that consider more than simply the efficiency of the transportation system. These initiatives also consider social equity concerns derived from mode choice availability and access to critical institutions, such as medical facilities and the workplace. Sustainability initiatives in this arena also attempt to consider economic concerns that arrive from utilizing new methods, materials, and construction practices. Fortunately, many 'more sustainable' options in these areas are evolving to provide benefits, such as lower maintenance costs, or longer useful life, that may equilibrate or even lessen lifetime cost of a project, even if some options are more costly up front. It is important to consider long-term effects, when possible, rather than focus solely on the near future (Jeon, 2007).

The scientific community has defined sustainability in numerous ways with both quantitative and qualitative evaluations. While quantitative approaches may provide a more scientific basis for decision-making, a qualitative approach based on norms would likely be better understood and accepted by the general public. Additionally, quantifying sustainability is no simple feat. Each individual facet of sustainability is measured and quantified by different units. Consider for a moment how to weigh air pollutants (often measured volumetrically comparing the volume of a pollutant per standard volume of air – reported as parts per million, ppm; or micrograms per cubic meter, $\mu g/m^3$) against water pollutants (can be measured by pH, turbidity, suspended sediment, specific conductance, hardness, etc.). How can one determine the combined effect of a change in both, or the net benefit of reducing one over the other, when the method for counting each type of pollutant is distinct, and perhaps complex on its own? Furthermore, computations become increasingly complex as one considers not only the current effects that infrastructure imposes on the environment, but also the lifecycle cost of each individual material and piece of equipment necessary to create infrastructure. Lifecycle analyses contemplate the processes necessary to reap raw materials, manufacture, transport the final product, as well as its lifetime use. Each step of the way has environmental, economic, and potential social implications that would need to be considered, again, for each individual component of the entire construction process. The complexity of fully engaging a quantitative method for determining the net sustainability characteristics of large infrastructure projects has likely led to a majority of the existing sustainability rating systems to follow a largely qualitative approach. This complexity with creating a quantitative approach, as well as an interest in following the lead of other initiatives, resulted in a more qualitative approach for this thesis as well.

2.2.1 Transportation-Specific Sustainability Metrics

Transportation infrastructure constitutes a considerable portion of the built environment. Each and every infrastructure investment in the transportation sector can have long-lasting implications not only for the transportation system itself, but also upon its interaction with larger environmental, economic, and social systems. According to AASHTO, the transportation sector worldwide is responsible for 22% of global energy consumption, 25% of fossil fuel use, and 30% of global air pollution along with greenhouse gases. It also accounts for 10% of the world's gross domestic product (GDP). With such significant shares in energy use, and both natural and economic resources, small adjustments to reduce each of these impacts from the transportation sector could lead to important benefits (FHWA, 2011).

As mentioned previously, transportation sustainability should at the very least consider environmental integrity, impacts on economic development, and the social quality of life. System effectiveness can be considered as a fourth attribute necessary for transportation system sustainability, since a less effective system would not be an acceptable alternative. Table 1 denotes some of the necessary attributes for each of these four characteristics.

Table 1: Necessary Considerations for the Core Elements of Sustainability (Jeon, 2007)

Environmental	Resource preservation (such as fossil fuels, land, etc.)
	Air and noise pollution prevention
	Greenhouse effect prevention
Economic	Economic efficiency
	Financial affordability
	Regional economic development through improved accessibility
Social Factors	Social equity related to income and minority groups
	Public health
	Safety and security
	Accessibility to various services
System Effectiveness	System performance for multimodal transportation systems (regional highway, transit, etc.)

Sustainability-related improvements can be made during all stages of a project. It is possible and desirable to consider social, economic, and environmental mitigation strategies during the planning and design phases. Construction methods are continually evolving to use renewable or less fuel, as well as to reduce impacts on the environment. While new equipment and processes may initially be costly, many new practices involve sourcing local materials, rather than transporting materials over long distances, while others utilize recycled content that may be extracted from the existing project site.

While incorporating sustainability concepts in design is certainly not a new concept, determination of what constitutes green design is a more recent undertaking, particularly in large-scale engineering projects. Considering just the materials aspect of sustainability for a moment, there have been initiatives worldwide to improve road materials and standards to better accommodate changes in energy availability and to improve the impact of roads on the environment. In South Africa, for example, the road surfacing industry responded to a presidential call to reduce the country's greenhouse gas emissions by vigorously pursuing bituminous emulsions rather than hot mix materials (South African Institution of Civil Engineers, 2010). In another example, the use of improved and recycled materials is one of many methods that can improve construction and maintenance impacts on the environment (Wathne, 2010). The impact of choosing to use a pavement mix that contains recycled content can positively impact the project in many ways. Recycled content may be less costly than purchasing new content; it also may reduce costs to both the environment and agency by reducing material transport necessary to arrive at the project site, if it can be utilized from on-site (previously considered) construction waste or come from a local facility. Of course recycling can help construction-related waste from going straight to a landfill, and can aid the reduction in mining natural resources that may or may not be renewable. Finally, research conducted at several universities has shown that certain levels of recycled content in both asphalt and concrete can actually increase the life of a pavement, and may prevent natural processes that degrade pavements, which could reduce lifetime maintenance costs. Iowa State University tested the performance of post-consumer shingles in asphalt pavements; the results were encouraging, with marked improvement in rutting resistance without compromising low temperature cracking resistance, which was confirmed by separate research conducted at the University of Illinois (TD&I/ASCE, 2010). The University of Saskatchewan, alternatively, studied the re-use of concrete and asphalt rubble materials; this research found that utilizing recycled materials in road construction provided superior structural performance while waste rubble was diverted from landfills, and leading to a cost saving of approximately 55% over using virgin sourced aggregates (T&DI/ASCE, 2010). The careful selection and use of pavement materials is only one area in which transportation infrastructure planning and design could promote sustainability, however. At the American Society of Civil Engineers (ASCE) and Transportation and Development Institute (TD&I) First Green Streets and Highways Conference (GSHC), hosted in 2010, Leif Wathne of the American Concrete Pavement Association (ACPA) explained that many decision-makers miss the target of a green pavement, focusing solely on the production, construction phases, and materials, while "the use phase of a pavement's life-cycle can have an enormous impact on its sustainability footprint" (T&DI/ASCE, 2010). His presentation included the following figure that notes a variety of areas to consider for truly 'green' pavement.

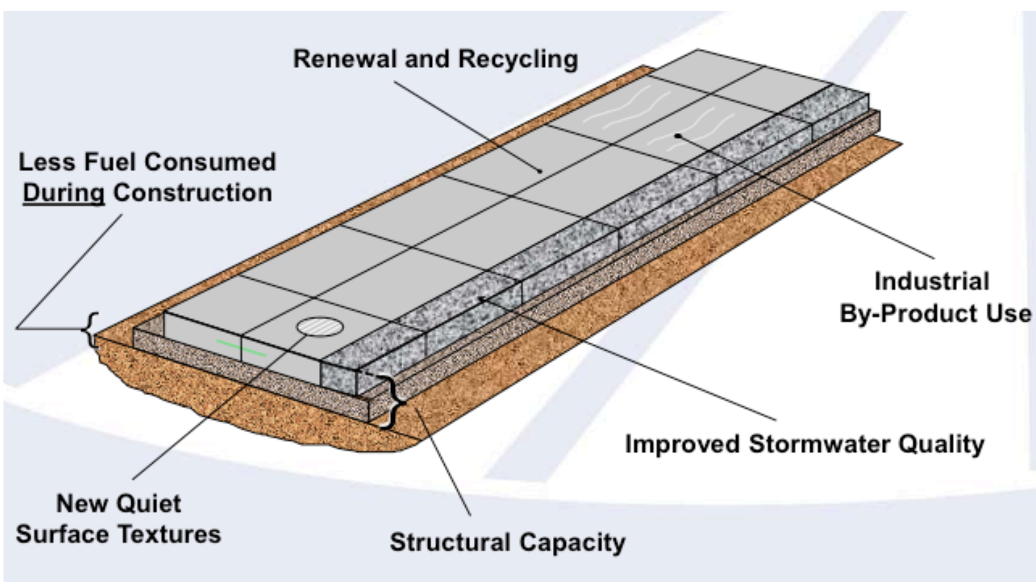


Figure 1: Areas of pavement sustainability beyond longevity (Wathne, 2010)

There is often a concern about tradeoffs when making 'green' decisions because sustainability concepts can often conflict with one another and also with economic decisions. As research continues to push previously understood limits of material use, recycling and reuse, one might find that material transport costs become negligible due to increased availability of adequate, if not better, materials closer by. As demonstrated by the recycled pavement example above, reducing transport needs as well as repurposing previously considered waste carries the dual benefit of reducing economic and environmental costs. While not guaranteed, these methods could also increase local work. Finally, detailed maintenance and improvement schedules can mitigate the deterioration of an infrastructure project and extend its life, further reducing lifecycle costs associated with a particular project.

Table 2: Summary of Attributes Considered by Major Rating Systems

Name	FHWA	Green-roads	BE^{2}ST	SIPRS	STEED	Green-LITES	I-LAST	STARS
Water	Y	Y	Y	Y	Y	Y	Y	Y
Runoff Quantity	Y	Y	~	Y	yy	Y	Y	Y
Water Quality	Y	Y	~	Y	yy	~	Y	Y
Aquatic Habitat	Y	Y		Y	yy	~		~
Air	Y	Y	Y		Y	~		
Light		Y		Y	Y	Y	Y	
Noise	Y	Y	Y	Y	Y	Y	Y	
Carbon			Y	Y				Y
Materials	Y	Y	Y		Y	Y	Y	Y
Local Materials		Y		Y	yy	Y		
Recycling	Y	Y	Y	Y	yy	Y		
Waste	Y	Y	Y	Y		~		
Energy	Y	Y	Y	Y	Y	Y	Y	Y
Electricity	Y				yy	Y	Y	
Fuel	Y					Y		Y
Ecology	Y	Y		Y	Y	Y	Y	Y
Community	Y	~	Y	Y	Y	Y	Y	Y
History					Y			
Other Modes	Y	Y		Y	Y	Y	Y	Y
Lifecycle Cost	Y	Y	Y	Y	Y			Y
VMT reduction					yy			Y

There are areas within each project phase that one could quickly pinpoint as needing improved practices in order to become more sustainable. In the rating systems that will be evaluated in the Literature Review, there are a number of metrics that are common to all or several of the current sustainability programs. Some common metrics are outlined in Table 2 along with the rating systems to which they apply.

To ensure that each of the tenets of the Triple Bottom Line is being considered, one can attempt to consider the environment, economy, and social quality per phase. However, one will quickly note that many metrics overlap, both in phase of development, as well as among social, economic, and environmental considerations. For example, maintaining or improving air quality can affect the environment as much as it can affect the social quality of an area. It may even have economic implications with respect to funding of future projects through the Clean Air Act. Air quality can additionally be mitigated during construction as well as during its use phase. This simple example again reinforces the complexity that encompasses the design and implementation of a rating tool designed to emphasize sustainability.

2.2.2 Atlanta Area Sustainability Concerns

The Metro Atlanta area has a wide range of regional sustainability issues that could be considered as part of public policy. A high automotive dependency is paired with limited transit options. Roadway congestion and traffic delay are major concerns in the metro region, which have been linked to air quality, respiratory health issues and stress, each of which emphasizes the need to conserve and improve upon system effectiveness. Limited transit options also lead to social equity issues in the region and have been the subject of environmental justice complaints against the transportation agencies (Jeon, 2007). Additionally, the region maintains concerns with water consumption, contamination, and erosion. Mobility 2030, the region's past regional transportation plan, articulates the following Atlanta long-range regional transportation goals, which conform rather well to the Triple Bottom Line, and the additional tenet of system effectiveness:

1. *Improving accessibility and mobility*
2. *Maintaining and improving system performance and preservation*
3. *Protecting and improving environmental quality of life*
4. *Increasing safety and security* (Jeon, 2007)

However, research done at the Georgia Institute of Technology noted that Mobility 2030 failed to specify "social equity and public health concerns from a social sustainability perspectives," which could have been included in the third goal under 'quality of life,' but had not been explicitly defined. The same research noted that "some economic vision may also need to be included in the goal" to ensure that Mobility 2030 truly captures the economic dimension of sustainability (Jeon, 2007).

Metro Atlanta has the 11th most congested freeway system in the United States. Vehicle ownership in Georgia has continued to rise since the mid-70's. The state's transit systems have been utilized at a declining rate per capita in the past 10 years (Jeon, 2007). It is clear that Atlanta and Georgia both face sustainability challenges. The use of a sustainability rating system as part of project planning may help achieve some element of improved sustainability as the state's and regional transportation program evolves.

2.3 Current and Emerging Transportation Sustainability Programs

2.3.1 Federal Initiatives

2.3.1.1 Green Highways Partnership

In 2002, the Federal Highway Administration (FHWA) identified project environmental streamlining, along with safety and congestion mitigation, as one of its three "vital goals" (Green Highways Partnership, 2008). This led to the creation of the Green Highway Partnership (GHP), which took a national leadership role in "green highway" conversations, particularly as they related to road design. The goals and supporting initiatives of the partnership are shown in Figure 2 below. The idea was to consolidate environmental regulations for roadwork into a targeted effort that would result in enhanced environmental sensitivity for each project. The FHWA collaborated with the US EPA's Mid-Atlantic Region 3 to form the partnership. Since the initial meetings, forty-five organizations have joined the partnership including seven DOTs. A complete list of partners can be found at the GHP's website <www.greenhighwayspartnership.org> (Green Highways Partnership, 2008).

The GHP has identified several concepts that foster a more environmentally sensitive project outcome. The focus on dialogue, and particularly citizen participation, forms an important part of the Partnership's approach: "Plans are screened to comply with environmental standards, the concerns of officials and citizens, the necessities of construction and engineering firms, and the insight of all other perspectives involved." In tailoring road projects to fit the environment, more voices as part of the project development process are seen as a benefit. “The scope of green planning is expansive; it must incorporate each and every perspective that will be impacted by the construction of a highway” (Green Highways Partnership, 2008).

Green Highways

Provides an opportunity to highlight effective practices.

Advances cost-effective, environmental streamlining opportunities.

Integrates planning and market-based opportunities.

Encourages innovations.

Explores regulatory flexibility.

Provides networking opportunities.

Facilitates pilot projects.

Provides an umbrella for transportation and green-infrastructure initiatives.

Figure 2: Benefits of the Green Highway Program (Osterhues, 2006)

Also unique to the GHP approach is the emphasis on continued monitoring. “Monitoring and evaluation systems ensure that issues, threats, and opportunities can be dealt with appropriately.” One FHWA representative stated, “Green Highways represents the next logical step in the evolution of FHWA and State Department of Transportation efforts in environmental streamlining and stewardship” (Green Highways Partnership, 2008).

In many ways, the foundations of the GHP approach were established in the most recent SAFETEA-LU legislation. MPOs are required to mention any existing environmental plans or inventories. The law gives MPOs the responsibility of evaluating the environmental impacts of their transportation plans and determining the need for mitigation. Projects that do call for an EIS are required to coordinate with other agencies and to seek public participation early in the process. A Maryland Highway official calls such involvement “essential” (Osterhues, 2006).

The initial focus of the GHP was mainly on pilot projects. Pilot projects not only establish relationships among agencies, they demonstrate green highway technology in a way that is educational and inspirational. Taking a broader view, the partnership is pursuing a comprehensive approach to green highways. The Maryland State Highway Administration, a key player in the partnership, has begun exploring an "environmental stewardship approach" to transportation projects. This comprehensive approach begins with studying the overall environmental conditions of the project area, weighs environmental concerns in the decision process, integrates regulatory requirements, and attempts to go beyond minimum standards for mitigation (Osterhues, 2006).

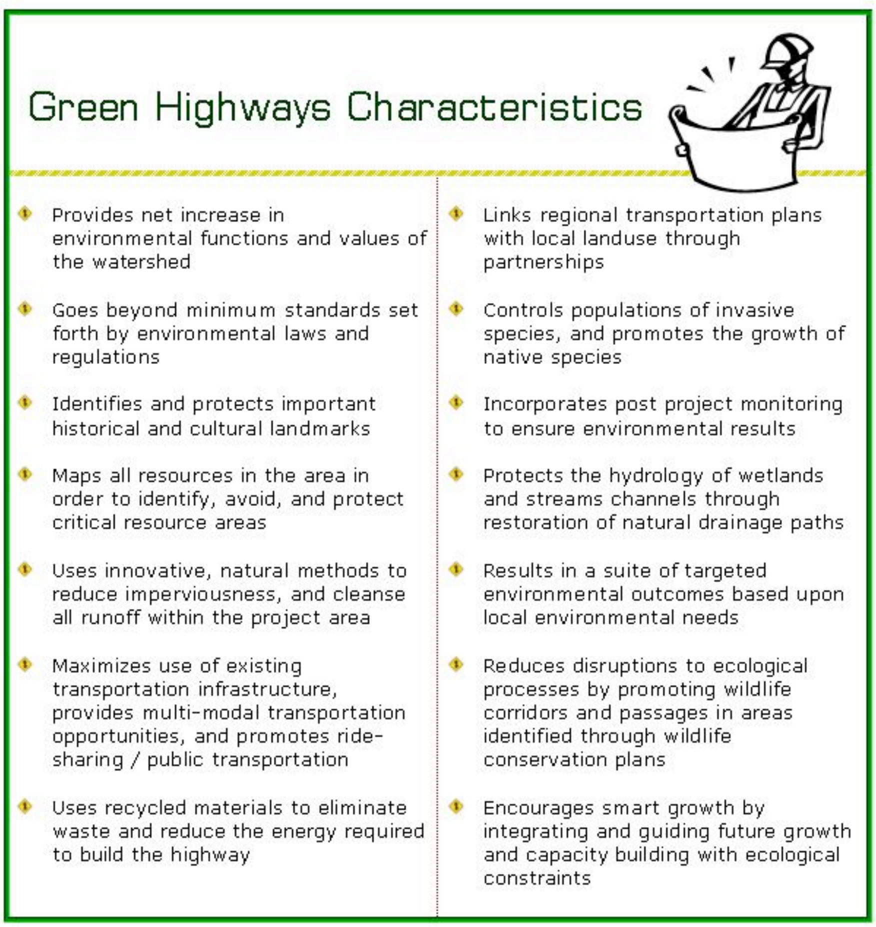


Figure 3: Green Highway Characteristics (Green Highways Partnership, 2008)

At present, there are not list of “requirements” for what constitutes a green highway. This is because the focus of GHP is to go beyond what is required in considering the environment. Instead, the partnership discusses green highway “characteristics.” As can be seen from the list in Figure 3, the scope of considerations is broad and inclusive (Green Highways Partnership, 2008). Nevertheless, particular design elements have been identified that can contribute to the greening of highways. The GHP website shows what a green highway with these elements may look like:

> “The lanes of this hypothetical highway are paved with a special kind of concrete that incorporates industrial waste products such as fly ash and boiler slag. Concrete manufacturers have found these additives can save energy and reduce the raw materials needed in concrete production. The highway shoulders are made from some sort of pervious pavement, such as porous concrete or asphalt. These types of pavement reduce runoff from the roadway, instead allowing it to percolate into the gravel below.
>
> Stormwater and pollutants that do run-off from the road are captured in a bioretention swale, which treats contaminants and stores water, giving it more time to soak into the ground. Similarly, stormwater wetlands, built in addition to existing wetlands, further help treat pollution and control runoff. In some cases, the highways project may be an opportunity to restore damaged existing wetlands as well. Likewise, stream restoration helps restore healthy, natural hydrology and ecology. Highways passing along or near bodies of water may retain strips of existing forest as to buffer the riparian habitat from highway impact. Local conditions are important in how a project deals with stream and wetlands. If the hydrology has seen only minimal negative impact from humans, intervention during the project may be detrimental to its health. On the other hand, if the habitat is badly damaged by human activity, a complete reconstruction may be necessary in order to return the area to a healthy natural state. When the project is finished, soil amendments help restore the ground to its normal, uncompacted and chemically complete state. Good soil composition will also help filter stormwater pollutants.
>
> Additionally, a green highway project considers wildlife needing to cross the right-of-way. This is especially important when a highway bisects an important habitat. Not only do vehicles kill millions of animals every year, but animals are a

> threat to motorists as well, with collisions killing over 200 people per year. Wildlife crossings help accommodate this movement and reduce risks. These often take the form of a culvert under the road or a tunnel with vegetation above the road. Fences or barriers divert animals to the crossing" (Green Highways Partnership, 2008)

In order to further spur the conversation about environmentally-friendly highway design, GHP is offering an incentive. The Partnership has developed an industry-funded cash prize that will recognize "individuals and projects that embody the principles that the GHP promotes" (Green Highways Partnership, 2008).

2.3.1.2 FHWA Sustainable Highways Self-Evaluation Tool

The FHWA rolled out the Beta version of their Sustainable Highways Self-Evaluation Tool at the end of 2010. It is available on the website *www.sustainablehighways.org* as a first generation test version to be refined over time responding to user experience. As the title implies, it is meant to be a self-evaluation tool that enables the incorporation of sustainable principles into system planning and processes, project development, and transportation systems management, operations and maintenance. However, the tool is not meant to replace FHWA's other goals, priorities or policies; sustainability should not become the only criterion considered in the decision making process. The use of the tool is entirely voluntary and should be "considered a complement to support many existing policies with sustainable initiatives." The FHWA does not plan to require the use of this tool for any project owners or agencies, or as a prerequisite to receive funds under any existing program, or even still as a method to determine compliance with environmental regulation or clearance. There are three main modules that correspond to phases of a project:

- System Planning and Processes
- Project Development
- Transportation Systems Management, Operations and Maintenance

Within these modules there are a total of 68 specific credit categories, the majority of which, 39, fall in Project Development. A total of 411 points are available within the 68 categories. Six main principles exist for FHWA Sustainable Highway Self-Evaluation Tool:

- Ecology
- Equity
- Economy
- Context
- Performance
- Education

The online tool allows a user to search either by these main principles, or by a long list of benefits including but not limited to reducing raw material use, optimizing habitat and land use, improving economic prosperity, increasing aesthetics, improving human health and safety, and creating energy.

Each credit is linked both to a scoring schedule that tracks a user's self-evaluation, and also to a page that includes a detailed description of the credit. Each credit page includes a clearly defined Goal, then Requirements that include a point breakdown to assist self-assessment. The webpage also includes a downloadable PDF with an expanded explanation of the credit.

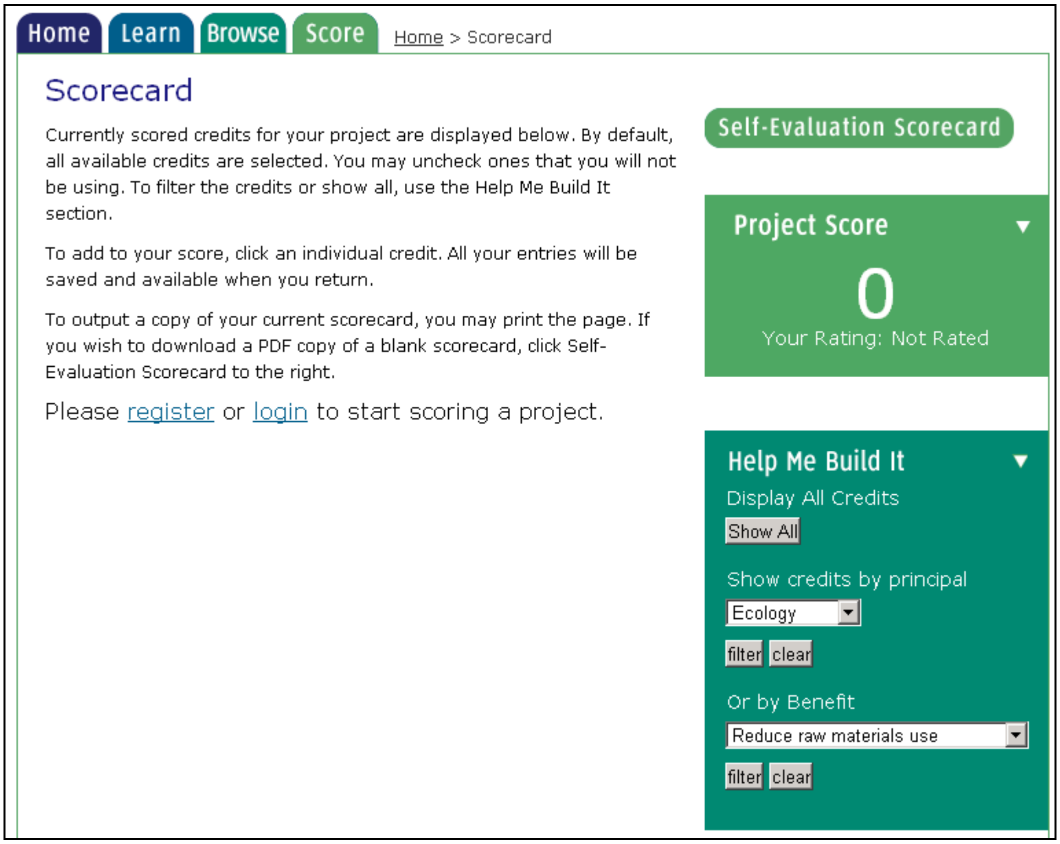


Figure 4: FHWA Self-Evaluation Scorecard (Federal Highway Administration, 2011)

AASHTO has reviewed the FHWA Sustainable Highways Self-Evaluation Tool. In its report, a general concern was expressed with the structure and content of the beta version of the tool. One particular critique noted that some concepts overlap within the modules, and that the tool should perhaps clarify the intended linkages between modules as well as perhaps reassess the interaction among credits to avoid double-counting. Another concern stated that many sustainability credits do not consider all three aspects of the "Triple Bottom Line" – environmental, economic, and quality of life perspectives and should perhaps be consolidated or clarified to create "a more focused and more manageable tool" (AASHTO, 2011).

AASHTO believes a strong partnership between the FHWA and state DOTs is extremely important to ensure the tool is implemented. This is a shared goal with the FHWA. Since the beta version is extremely new, there has not been much feedback as of yet. This year (2012) should be a critical time for state, local, and private agencies to test the tool and provide feedback.

2.3.2 Programs with Academic Origins

<u>2.3.2.1 Greenroads – University of Washington</u>

Greenroads is a rating system (similar to LEED) that set standards by which a road can be certified as being "green." It was started in 2007 by the University of Washington and developed jointly with CH2M HILL. It applies to both construction and rehabilitation projects. Greenroads sees itself as providing for three needs:

1. *A holistic way of considering roadway sustainability*
2. *A defined and quantitative means to assess roadway sustainability, and*
3. *A tool for decision-makers, agencies, consultants and contractors that enables informed design and construction decisions regarding sustainability* (Washington & Hill, 2009a).

Greenroads is not directly related to the Green Highways Partnership, though they are pursuing the same ultimate goals. But, whereas GHP focuses on organizational cooperation and improving standards, Greenroads is seen as a tool for quantifying efforts to be environmentally conscious. In this sense, it might be understood more as a performance measure than a rating system.

In order to become "Greenroads Certified" a project must conform to 11 basic requirements. Beyond these "project requirements," a project may pursue additional "voluntary credits." Depending on how many of these credits the project receives, it will be awarded some level of recognition. Projects are certified at one of four levels: Certified, Silver, Gold, or Evergreen – the highest ranking. Projects seeking certification will submit appropriate documentation to reviewers. Reviewers may then request further studies before making a final determination (Washington & Hill, 2009a).

Over 50 pilot projects have undergone review and are waiting to be implemented. Twelve pilot projects have been featured on the website. Applications were open for pre-screening (March 15, 2011 – April 30, 2011) for those interested in becoming one of the first projects to become Greenroads certified. However, other than pilot projects, no projects as of yet have undergone review or been certified. Additionally, all future projects will be completed for a fee, and be done gratis as the previous pilot projects (Washington & Hill, 2009a). There is some question if a certified "Greenroad" would be more expensive than a conventional highway. However, those who have developed Greenroads argue that green highways will prove cheaper over their lifecycle. A similar claim is made of LEED certified buildings.

Greenroads follows a structured philosophy in assessing green highways:

> *"We are aware of other ideas on sustainability and roads. We believe we stand out because:*
>
> - *We strive to make each best practice defensible through empirical evidence and sound engineering. If a credit is not defensible then we consider eliminating it. We would like to make the system more than just our opinion on what is and is not more sustainable. Thus, we expend great effort in*

tracking down empirical evidence that will guide us to what the best credits should be and how important they are.

- *Greenroads is weighted. Points are awarded for best practices that are commensurate with their impact on sustainability. We have submitted a paper to a respected journal discussing our weighting process.*
- *We desire to produce an online life cycle assessment tool for roadways that can be completed in 10 minutes or less. This is a long-term goal but we think we can do it and we've started work.*
- *We desire to make the submission and tracking process entirely online. Thus, this website (www.greenroads.us).”*

> “*One should also consider the basic assumption we use in design and construction. Currently, the typical thought is to try and be "less bad" while we ought to be thinking how to actually be good; one of the points from William McDonough and Michael Braungart's Cradle to Cradle (2002)”* (Washington & Hill, 2009a).

Greenroads’ primary focus appears to be pavement management, but could perhaps be used to consider the evaluation of new construction from rehabilitation to system management activities. One must question if ‘pavement management’ encompasses all areas of a sustainable roadway network. Additionally, few explanations are offered for exactly what measures should be taken for the project to attain “Reasonably Possible” and “Maximum Possible” credits. There is also a question of how life-cycle assessment and life-cycle cost analysis (LCA/LCCA) actually impact a project. Given the premise that Greenroads can be used to identify where better practices can be applied in project development, it is prudent to question how the Greenroads system will ensure the contractor/ owner is aware of such practices, and if the contractor is meant to make changes with respect to these outcomes on his own. Greenroads recognizes that it has not focused on the financial impacts, and does not contain a section that considers economic sustainability. The cost-benefit, for example, of a material with a superior LCA score, but that has a cost-prohibitive price has not been considered. This is an especially important issue, particularly when considering its impact on financially constrained projects, such as those found in public works.

2.3.2.2 BE^2ST – University of Wisconsin

Building Environmentally and Economically Sustainable Transportation (BE^2ST), the University of Wisconsin's green highway construction rating system, was presented at the First Green Streets and Highways conference in 2010. This system is based fundamentally on LCA/LCCA along with pavement performance measurements via the program M-EPDG. Since it is steeped strongly in pavement performance, Jincheol Lee stated:

> *"Rating systems not based on science can create 'greenwashing'"* (T&DI/ASCE, 2010)

BE^2ST is one of the only transportation sustainability rating tools, to date, that employs lifecycle analysis techniques and provides a quantitative assessment of the impacts associated with a highway construction project. Unlike many rating systems built on arbitrary point systems, this rating system utilizes rigorous measurement methods and programs such as AHP, M-EPDG, LCA and LCCA.

The system is based on the 3R's – Reduce, Reuse and Recycle – and aims for specific target reductions, such as a 20% reduction in CO_2 emissions. The six main criteria that BE^2ST are based upon are: Human Health/Safety (10% less RCRA hazardous waste), Greenhouse Gas Emissions (24%), Energy Use (10%), Water Consumption (10%), Material Reuse/Recycling (20%), and Lifecycle Cost (10%) – see Figure 5. Since greenhouse gas emissions, energy use, water consumption, and hazard material waste production are all typically measured in completely different units, each category is considered separately and by percent reduction from conventional construction practices.

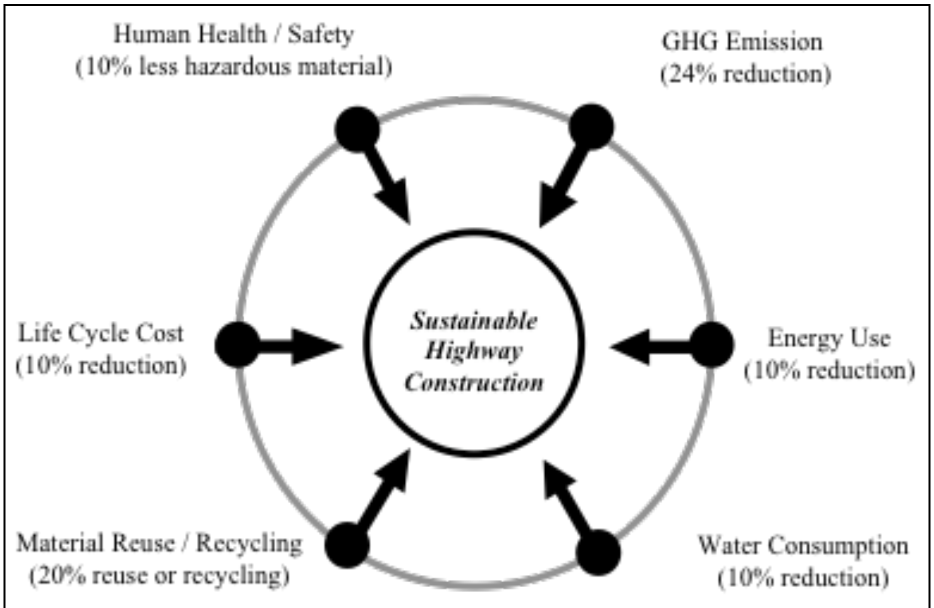


Figure 5: Six Main Criteria of BE^{2}ST (T&DI/ASCE, 2010)

An initial assessment is done to compare conventional and recycled or alternative materials that could be used for the project. Each of the four categories mentioned above is evaluated for material production, transportation, and construction to determine the overall difference between conventional and alternative materials in emissions, energy use, and waste. For projects that contain a mix of conventional and alternative materials, LCA analysis can be done for each layer or portion of the project to determine the total impact of alternative methods. To emphasize the economy of utilizing sustainable practices, BE^{2}ST also requires a life cycle cost analysis, which often showcases savings that may not be initially apparent with sustainable design. For example, research has shown that some recycled-material pavements have a longer service life than conventional pavements, which reduces maintenance and replacement costs over a pavement's lifetime (TD&I/ASCE, 2010).

2.3.2.3 University of Waterloo

A recent master's thesis from the University of Waterloo by Peter Cheuk Pan Chan is a preliminary investigation that demonstrates Ontario's initiative to provide a green performance rating system for roads. Pan Chan focuses strongly on pavement materials, management, and design, but also considers land use planning, public transit, walkways and bikeways, and alignment – see Figure 6. The report additionally utilizes cost as a strong metric with scaling factors (Pan Chan, 2010).

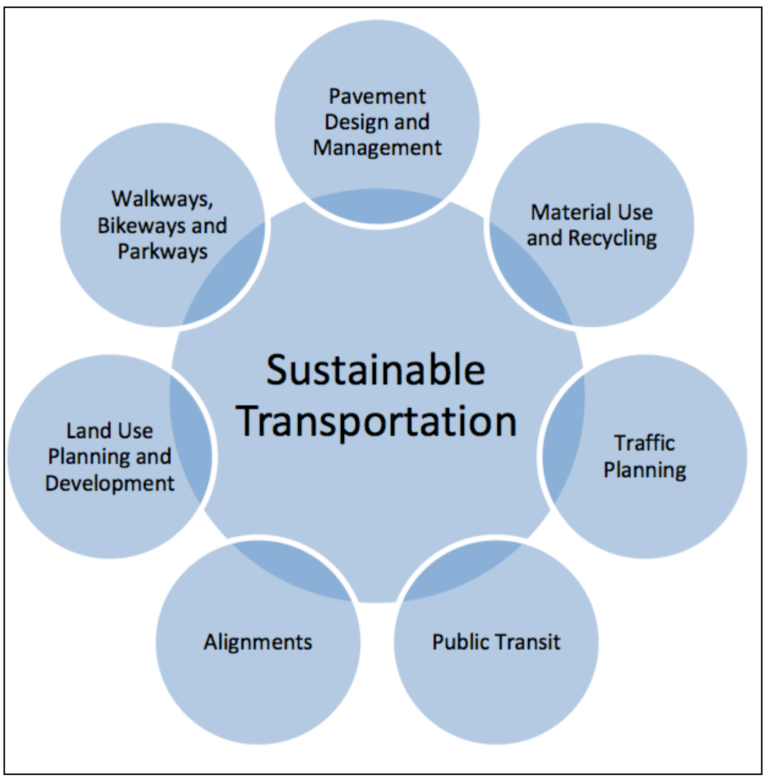


Figure 6: Main Criteria for University of Waterloo Rating System (Pan Chan, 2010)

Pan Chan focused much of his literature review on pavement materials, maintenance, and rehabilitation. He additionally reviewed design and construction practices, as well as several green initiatives such as LEED, Greenroads, and GreenLITES.

GreenPave was a separate project carried out by the Ministry of Transportation (MTO, Canada) in the Material Engineering Research office. This rating system "is exclusively used by the MTO to environmental sustainability at the project level" (Pan Chan, 2010). The project categories for GreenPave are shown below in Table 3.

Table 3: GreenPave Points Categories (Pan Chan, 2010)

Category	Point ID	Description	Max Credit
Pavement Technologies	PT-1	Long-Life Pavement Designs	3
	PT-2	Permeable Pavements	1
	PT-3	Quiet Pavements	3
	PT-4	Cool Pavements	2
Materials and Resources	MR-1	Recycled Content	6
	MR-2	Reuse of Pavement	3
	MR-3	Local Materials	3
	MR-4	Construction Quality	2
Energy and Atmosphere	EA-1	Reduce Energy Consumption	3
	EA-2	GHG Emission Reduction	2
	EA-3	Improve Rolling Resistance	1
	EA-4	Pollution Reduction	3
Innovation & Design Process	I-1	Innovation in Design	2
	I-2	Exemplary Process	2
Maximum Credits			36

Pan Chan's research led to a project level and network level sustainable pavement framework that can be seen in Figure 7. The frameworks center on the GreenPave program, and utilize an iterative method to improve upon sustainability indicators and produce decision alternatives. Social equity is one area where Pan Chan's research appears to be lacking.

Figure 7: Project and Network Level Framework Interaction (Pan Chan, 2010)

While Pan Chan's report contains much useful analysis of sustainable roadway design and planning, its purpose was to propose a framework for creating an analysis tool, not to actually produce its own rating system, which was the purpose of this thesis.

2.3.3 Programs from Consultants and Professional Organizations

2.3.3.1 SIPRS – ASCE, ACEC, APWA

The Sustainable Infrastructure Project Rating System is based on the "Triple Bottom Line" of economic, environmental and social impacts to assess infrastructure and aid in verifying whether civil engineering projects are sustainable. This tool is still in preliminary stages and lacks some portions of the System Manual, which is available at <www.asce.org/Sustainability/ISI-Rating-System/> for download. The managing agencies point out that "the common denominator for infrastructure is the community" and that unlike buildings, the efficiency of an infrastructure is not mainly self-contained, but rather measured by how they interact with other infrastructure in the community in which they are built (ASCE, ACEC, APWA, December, 2010).

SIPRS distinguishes itself from other rating systems by emphasizing not only the performance contribution of a project, but also the "pathway contribution" – see Figure 8. SIPRS explains that performance differs from 'pathway' with the following fundamental questions:

- *Performance Contribution: "Did you do the project right?"*
- *Pathway Contribution: "Did you do the right project?"* (ASCE, ACEC, APWA, December, 2010)

The pathway contribution is essentially forecasting the long-term externalities incurred by a project. The preliminary SIPRS System Manual, Version 1.1 (December 2010) gives an example of pathway vs. performance:

"… a new highway may rate high in its performance contribution by, among other things, the use of substantial amounts of recycled concrete. However from a pathway contribution standpoint, that highway would rate low if that highway causes additional congestion and urban sprawl" (ASCE, ACEC, APWA, December, 2010)

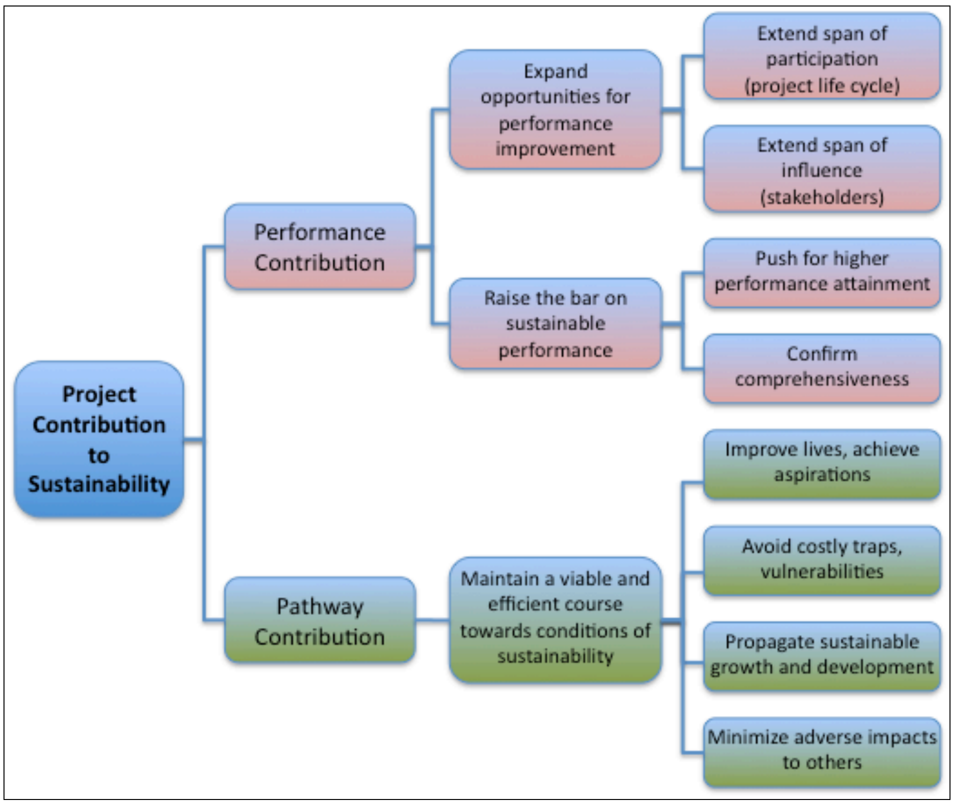


Figure 8: SIPRS rating system flowchart (ASCE, ACEC, APWA, December, 2010)

While SIPRS has a strong emphasis on assessing future impacts, it also acknowledges the difference in scope that, for example, a repair project could have versus a new project. Scoring for SIPRS therefore aims to acknowledge excellence at priority-levels for the project. The ten main categories in the SIPRS system are shown in the Table 4. According to an informal poll taken among several project practitioners, developers of the SIPRS system determined a preliminary priority weighting of each section, also included in the table. Subsections (not shown) are also weighted individually within a section's weight.

Table 4: Sample weight scale for SIPRS rating sections (ASCE, ACEC, APWA, December, 2010)

	Section	# Subsections	Weight (%)
1	Pathway	5	12.6
2	Project Strategy & Management	12	10.6
3	Community: Long & Short Term Effects	10	10.7
4	Land Use & Restoration	12	8.9
5	Landscapes	3	7.0
6	Ecology & Biodiversity	7	8.8
7	Water Resources & Environment	6	11.5
8	Energy & Carbon	7	11.7
9	Resource Management Including Waste	8	8.2
10	Transportation	6	10.0
	TOTAL	**76**	**100%**

Besides the ten main categories in the SIPRS scoring sheet, there are 76 subcategories. Each subcategory is worth points on a scale from one to ten. Each ten-point item is then weighted against other subsections for a total of 100% possible, similar to the weighting of the sections themselves. If there is a section or activity that is not applicable or underrepresented in the project, it can be weighed proportionally to ensure fair evaluation between small and large projects. At present SIPRS is still in the development stage. No projects have been rated, but some organizations have overviewed the rating system and provided feedback (ASCE, ACEC, APWA, December, 2010).

2.3.3.2 STEED – H.W. Lochner, Inc.

Sustainable Transportation Environmental Engineering and Design (STEED) is the green performance rating system designed by H.W. Lochner, Inc. At the First Green Streets and Highways conference in 2010, Gary Demich of H.W. Lochner, Inc. presented the rating system. He initiated his presentation with the following question and statement:

> "It's arguable that nearly every highway improvement contributes to added sprawl, energy use and GHG emissions.' – So is 'sustainable highway' an oxymoron? Which [sustainability rating] system you use isn't as important as how you use it." (T&DI/ASCE, 2010)

STEED is a 35-page document organized by categories and checklists. Applying STEED to a project is a four-stage process in which each stage of design, construction, etc. is evaluated. By evaluating a project in each stage of project completion, the overall project intentions can be tracked to determine if the objectives were met, "and, if not, during which stage things either improved or deteriorated." While one project may not uphold all of the intentions from the planning to environmental stages, or environmental to design and then construction, the goal of measuring the project at each of the four stages is ultimately to learn where and how sustainable practices can be effectively integrated so that future project sustainability can be maximized.

Use of materials is one emphasis of the STEED program. This area concludes that on the project site, recycling existing materials can be a great way to promote sustainability in several areas. Recycled content results in less energy use required to import new materials and export old, besides obvious benefits of reusing materials that may otherwise be discarded as construction debris. In addition to recycling on site, some materials can be salvaged for reuse elsewhere. Some on-project examples of material recycling are utilizing crushed concrete for a base material or aggregate, utilizing asphalt to form foamed asphalt base or recycling it into HMA at a plant for reuse, and finally clean wood scraps can be used as mulch for project landscaping. At the same token, excess deconstructed materials can be salvaged and taken off-site to be reused in other projects. Additionally, construction debris can be minimized while also minimizing construction costs. Formwork may be essential for construction, but it creates a sizeable amount of construction debris. Ensuring that formwork is not built for single use, but rather is capable of multiple uses can reduce waste materials, besides reducing costs associated with formwork materials. To maximize material use overall, some careful design work that utilizes standard material dimensions can quickly reduce the amount of scrap material on site. It can also reduce the use of power tools necessary to cut, shape and form necessary construction materials, reducing energy use associated with construction as well as potentially increasing labor efficiency.

There are no arbitrary award levels. Demich explained that assigning award levels can sometimes compromise the goal of reaching for the highest possible level of sustainability. Award levels can potentially inhibit a project from attaining its highest potential. Then again, sometimes setting minimum level criteria can prove unattainable without resorting to extreme and unreasonable measures. Demich's viewpoint on award levels is that "they limit the imagination and encourage inappropriate value engineering. Remember the ultimate goal: sustainability, not gold, silver, 47 points, etc." (T&DI/ASCE, 2010).

2.2.4 Programs from State or Local Departments of Transportation

2.3.4.1 GreenLITES – New York State

GreenLITES (Leadership in Transportation Environmental Sustainability) is an environmental rating program utilized by the New York State Department of Transportation (NYSDOT) and modeled after the Greenroads program (CH2M Hill, University of Washington, 2009). Viewing the program as a performance measure for sustainability, all NYSDOT projects undergo GreenLITES evaluation (NYSDOT, 2008).

While project costs may be higher than conventional, GreenLITES projects are thought to have fewer externalities. Benefits to society are assumed to justify the extra expense. The GreenLITES philosophy of sustainability, as set forth on the website, is focused on natural resources.

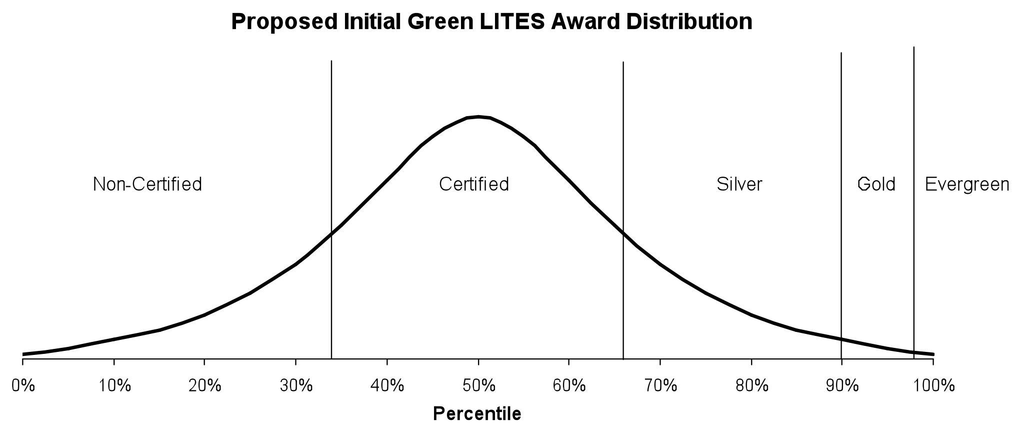
> "Sustainability" is commonly understood to describe any human use of resources that does not exhaust those resources. As we improve safety and mobility in New York State, transportation sustainability at NYSDOT is a philosophy that ensures we:
>
> - Protect and enhance the environment.
> - Conserve energy and natural resources.
> - Preserve or enhance the historic, scenic, and aesthetic project setting characteristics.
> - Encourage public involvement in the transportation planning process.
> - Integrate smart growth and other sound land-use practices.
> - Encourage new and innovative approaches to sustainable design, and how we operate and maintain our facilities (NYSDOT, 2008).

The primary purpose of the GreenLITES program is as a DOT performance measure to "recognize good practices, and identify where we need to improve." Moreover, the program keeps the DOT accountable to the public, providing "a way to demonstrate to the public how we are advancing sustainable practices." By recognizing exemplary projects, NYSDOT helps educate on and encourage use of environmentally conscience practices (NYSDOT, 2008).

Certification of GreenLITES projects occurs through an internal process at the NYSDOT. Project proposals do not need to be reviewed in this system. Instead, projects are scored when plans are submitted to the DOT. All plans submitted since September 25, 2008 are reviewed by GreenLITES. Local governments, non-government organizations, and other NYS agencies may also request GreenLITES review (NYSDOT, 2008).

The intention is that environmental consideration enters early into the planning process. At design approval, before plans are drafted, a preliminary GreenLITES scorecard is filled out for the project. The Design Project Manager and the Regional Environmental Contact fill out the final scorecard (NYSDOT, 2008). Outside of NYSDOT, project sponsors take the lead in GreenLITES assessment. The sponsor will begin by using the publicly available scorecard to self-assess their project. This assessment is then sent to the GreenLITES Program Manager for review. The program manager may award certification, or may request additional information needed to verify criteria for innovation or that other additional categories are met. In cases where the sponsor applies for innovation credits or elects to add their own criteria, the project is set before a review team for final decision. GreenLITES projects are recorded by the state and an announcement of certification is sent by email as a pdf attachment. The appropriate logo may then be applied to the plan set (NYSDOT, 2008).

Projects may be GreenLITES certified at four levels, as shown in Figure 9. The names of these four levels are similar the levels are inspired by similar Greenroads and LEED rankings. In order to gauge what point levels should correspond to each ranking, GreenLITES benchmarked their scoring against the distribution shown in Figure 9. NYSDOT has not mentioned the need to re-calibrate the rankings. Rather, as the program builds momentum, it is hoped that more projects will be receiving higher rankings (NYSDOT, 2009).



Name	Point Range	Percentile Range	Approximate Std Dev Range	% of Dept Projects
Non-certified	0 – 14	< 33%	$< -0.5\sigma$	33%
Certified	15 – 29	33 – 67%	-0.5σ – 0.5σ	34%
Silver	30 – 44	67 – 90%	0.5σ – 1.5σ	23%
Gold	45 – 59	90 – 98%	1.5σ – 2.5σ	8%
Evergreen	60 & up	> 98%	$> 2.5\sigma$	2%

Figure 9: GreenLITES Award Frequency (Transportation, 2008b)

As of Earth Day (April 22, 2009) GreenLITES began acknowledging operations practices that work towards sustainability (Transportation, 2008a). This included all projects that do not submit plans, such as mowing, road resurfacing and bridge-painting (Transportation, 2008b).

2.3.4.2 I-LAST – State of Illinois

The Illinois Livable and Sustainable Transportation Rating System and Guide (I-LAST) is a "cooperative effort of the Illinois Department of Transportation (IDOT) and the engineering and construction community" (IDOT, 2010). The rating system was "initiated" by the Illinois chapter of the American Council of Engineering Companies (ACEC-IL), but IDOT and the Illinois Road and Transportation Builders Association (IRTBA) copyright the document (IDOT, 2010). Most of the IDOT involvement came from the Chicago District 1.

Released in late 2009 after 2 years in development, I-LAST seems to follow very closely the GreenLITES model. However, the philosophy described within is very different. I-LAST describes itself as a checklist for documenting practices. It does not claim to be a comprehensive guide to sustainable practice. The introduction is explicit that not all of the credits are necessarily applicable to a project. Thus, a project with a higher score is not necessarily "better", "greener" or "more sustainable" than a lower-scoring project. The guide steers users away from trying "cookbook" approaches, but aspires that "creative thought may lead to innovative solutions" (IDOT, 2010). Regarding this framework, it is perhaps surprising that the Innovation section is worth no more than 3 points of the 219 points available.

What I-LAST does attempt to do is compile a guide of all "potentially sustainable practices" for highways. A statement of intent and explanation of the rationale behind its inclusion preface each sub-category. A statement of rationale also prefaces some individual criteria, and additionally a list of useful references follows each section.

“Scoring” a project – since it is not based on the absolute total of the points – is instead based on comparing the project score with what credits might be potentially relevant. So while there are 219 points in the system, scores will be given as a fraction of something less. Ideally, the potential score should be determined before project design, in order to set some sustainability goal. Looking back on this goal, professionals can ponder what led to the project reaching or not reaching this goal.

The document will be “revised as the state of the art evolves – utilizing the input of industry users” (IDOT, 2010). As it stands now, I-LAST is a voluntary rating system. However, there is a possibility that with time the evaluation will become required on IDOT projects, once the rating system has been duly tried. As it is now, it is at the volition of each IDOT districts if a project will be I-LAST evaluated. To ensure there is no obligation at this time, the document includes strong legal language that prevents I-LAST from being invoked on a project, and it forbids that it be in any way be used to challenge IDOT or AASHTO standards.

2.2.4.3 STARS – City of Portland, Oregon

The Sustainable Transportation and Access Rating System (STARS) developed by the DOT for the City of Portland, Oregon is unique in that it backs-up the definition of a green highway to the point of asking “Is a highway necessary?” It is a voluntary, points-based system that intends to be mode-neutral. It breaks issues down into 6 categories and 29 subcategories. Currently only in Version 0.5, it was undergoing further development of 12 of the 29 subcategories during the summer of 2010.

In describing the advantages of the STARS system, Peter Hurley (Project manager at the Portland Office of Transportation in Oregon) follows what he calls the ABCs. A stands for access; STARS, instead of beginning with a road project, begins by considering the access needs. B represents the focus of the system on quantifying benefits, which can be compared with costs. C indicates the program's particular attention to climate and carbon emissions.

Compared to Greenroads and GreenLITES, Hurley considers STARS to be broader, but not as deep. Other programs go deeper into the specifics of how to construct a highway, focusing heavily on materials. This is not the intent of STARS. Hurley believes that when one asks "Should we do green highways?" the answer will be "yes," but that the intent to build green highways encompasses more than the simple intention to create green highways; creating green highways will absolutely need a methodology for exploring exactly what exactly what building green highways encompasses.

The Portland Office of Transportation began pondering the feasibility of a sustainability rating system in July of 2008. By the middle of 2009 they had determined that it would be feasible and began looking at markets for their system. Credits will come in three types: Choosing, doing, and validating. The introductory materials point out that STARS will not be appropriate for safety-only and freight-only projects. It also includes a disclaimer that it does not replace legally mandated review processes.

Further plans are involve a version of STARS for employer programs and for comprehensive planning. The STARS material openly acknowledges LEED and expresses the desire to mesh with the site-selection criteria found in LEED-ND.

CHAPTER 3: METHODOLOGY

3.1 Evaluation of Existing and Emerging Programs and Trends

This task, through the literature review presented in Chapter 2, established the context for this thesis by considering emerging rating systems for transportation sustainability as potentially applied in the Georgia context. The literature review provided a summary of current applications of green roads rating systems. The primary source for this information was the Transportation Research Information Service (TRIS), but included data compiled from scholarly articles as well as the actual instruction manuals provided for the various rating systems that are already in place. The research team members additionally utilized their contacts with state DOT officials outside of Georgia to identify other practices. Finally, the First T&DI Green Streets and Highways Conference (GSHC) held by ASCE in November of 2010 provided a large number of contacts, resources, and knowledge that was useful for this report. The analysis of emerging programs and trends will be discussed in Chapter 4.1.

3.2 Scorecard Development

3.2.1 Selection of an Initial Framework

From the information gathered in the literature review, the project assessed the application contexts, advantages, and disadvantages of the various rating systems considered. Of the programs considered in the literature review, the project team chose one existing framework to act as a template and starting point for the development of a system that might be used by GDOT. Consideration among the diverse set of programs identified was widely based on the research team's experience with road design, as well as information obtained from a team consisting of GDOT engineers, planners, and environmental specialists along with the project team. The selection of an initial framework will be discussed in Section 4.2.1.

3.2.2 Modification to Reflect the Georgia Experience

This task enabled the research team to interface with practicing engineers, planners, and environmental specialists at GDOT. Several meetings allowed the team to test the initial framework on a number of current GDOT projects. By reviewing projects with the initial system, the project team was able to obtain a sense of what the GDOT engineers considered critical to road design aimed at minimizing environmental impacts. Additionally, this portion of the project allowed for an estimation of the time commitment necessary to complete a project rating and review. It was also a good test of general understanding of how points would be allocated and how projects of different sizes and scopes would relate to one another. Modification of the initial framework to better fit the Georgia experience will be elaborated upon in Section 4.2.2.

3.3 Preparation of a Final Scorecard

A final meeting was held with the GDOT team to produce a final scorecard that is presented in this report. While the majority of modifications from the original framework came from meetings at GDOT headquarters, there were also some scorecard modifications generated outside the team meetings and gathered from the Office of

Materials and Research (OMR) at GDOT in order to ensure that the wording would be as understandable as possible throughout the organization. The resultant scorecard can be found in Chapter 5.

3.4 Future Project Plans

A draft manual will accompany the final scorecard and will be presented to a broader audience during a workshop scheduled for late January 2012. There are several methods of application that will be presented along with the draft manual and final scorecard. These methods will be outlined in the final chapter of this report, Chapter 7, which details future research considerations necessary to aide the success of a potential green streets and highways rating system for the state of Georgia.

The workshop will likely include GDOT engineers as well as officials from other transportation agencies (to be determined in cooperation with GDOT) in order to present the results of the project, and to discuss the potential application of this or some similar rating system in Georgia. This workshop will likely be a one-half day event, and would be designed to be interactive. A workshop summary and report will follow from feedback generated from this workshop, and will be incorporated in the draft manual in order to create a final manual and report.

CHAPTER 4: ANALYSIS

4.1 Evaluation of Existing and Emerging Programs and Trends

Sustainability attributes should attempt to encompass all environments affected by construction and maintenance practices. However, a rating system should also leave room for unforeseen challenges at certain sites, and for innovations that may not lie within the scope of the current field of rated attributes.

A challenge of point systems is that they are vague with respect to actual environmental impact reduction. Additionally, points may not have equivalent implications across categories; for example – one point for implementing a bike rack in a bike-inaccessible area should not be equal to one point for placing 30 miles of 15% recycled material pavement.

However, computationally complex rating systems may require so many man-hours and specialized expertise that the cost of completing such an analysis may become infeasible for a public institution. Computational rating systems also may focus entirely on construction equipment, practices and materials, such that they may miss more subtle sustainable ingenuity, such as application of alternative transportation modes to promote less single-occupant vehicular traffic. Alternatively, the focus could potentially focus so greatly on alternative transportation that the impact of construction practices and materials could be missed. As an example, while the BE^2ST rating system does an excellent job identifying benefits of reducing water consumption, it completely ignores storm water mitigation and any other sustainable initiatives relating to the surrounding environment. Clearly, there must be a certain balance among measureable environmental impacts, such as LCA/LCCA, as well as the less clearly measureable implications of alternate transportation modes.

Rating system philosophies vary. They can be objective or element focused, normative or explanatory, use metrics or rules of thumbs, and/or they can compare sustainability measures per absolute or relative terms. A GDOT green streets and highways rating system thus may plausibly focus on a broad overall objective, or on a set of specific individual elements. Furthermore, a GDOT rating system could be tailored for a trained specialist or for the average layperson to review; it could utilize lifecycle analyses (LCA/LCCA) or a simple point system to measure the broad and complex concept of sustainability. This report specifically identifies the differences inherent in existing rating systems. The next step in the process of developing a rating system is to begin discussing these philosophies to determine what type of rating system is best suited for GDOT. The following list includes some questions to consider about user and system characteristics.

4.2 Scorecard Development

4.2.1 Selection of an Initial Framework

New York State's GreenLITES program provided the basis for an initial framework that would be developed and tailored to Georgia's unique character and regional differences. The research team considered this program to be the most developed and DOT-friendly program of all considered systems. GreenLITES provides a sustainability performance measure that allows the New York DOT to recognize good practices as well as identify areas that need improvement. The program keeps the institution accountable to the public, but also provides "a way to demonstrate to the public how [they] are advancing sustainable practices" (NYSDOT, 2008). Unlike Greenroads, all evaluations are done in-house, eliminating the need to hire a third-party consultant, which would incur a potentially large additional cost. In particular, the Design Project Manager and the Regional Environmental Contact fill out the final scorecard. Of course, evaluation in-house creates the potential for biased results. However, the project team has agreed that there are methods to eliminate the potential for bias within project ratings. Some possible methods to rate projects with the least probable amount of bias can be found in the Results section in this report, Chapter 5.

4.2.2 Modification to Reflect the Georgia Experience

The following matrix provides a comparison between the final scorecard generated from meetings with GDOT engineers and the GreenLITES framework that provided a basis for the design of this rating system. While many of the individual metrics remain the same in the final scorecard, there was a certain amount of re-arrangement to better reflect what the project team and consulting GDOT engineers deemed most appropriate. Additionally, many items were re-worded or modified to better reflect the experience in Georgia, since the region it resides in is quite different from New York. There were a few items from GreenLITES that were removed entirely. Some lacked relevance for Georgia, while others were excluded because they reflected already specified areas of GDOT's practice. The project team and consulting GDOT engineers decided that items already included in the GDOT specifications did not surpass expectations for projects or go ‘above and beyond’ typical design. While noteworthy for the institution, these should not be considered to avoid granting ‘free points’ that would be allocated to each and every project. In the manual that will be created to accompany the final scorecard, these specified items would be noted as areas in which Georgia, perhaps, exceeds national requirements, but not necessarily surpasses its own institutional standards. In this manner, the project team intends to convey the noteworthy contributions GDOT is already making to environmental stewardship. However, the scorecard will still be meant to provide a means for assessing areas in which projects go above and beyond the norm. The following pages include a comparison matrix between the original GreenLITES template and the final scorecard.

The final scorecard, which reflects all of the changes noted in the comparison matrix above, is provided in the Results section. At the moment, this scorecard is thought to encompass a significant opportunity for improving sustainability stewardship at GDOT. However, concepts in sustainability are rapidly advancing as many scientific fields attempt to better mitigate and understand the use of natural resources and the interaction of people-made infrastructure with the environment. While this scorecard has been finalized for the purpose of this thesis, please note that this document and the intended program that will center around it is meant to evolve over time as sustainable transportation infrastructure practices also evolve.

Table 5: Scorecard Comparison Matrix with GreenLITES

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
1-1		3	Avoidance of previously undeveloped lands (open spaces or 'greenfields').	S-1a	2	Avoidance of previously undeveloped lands (open spaces or "greenfields").	same wording, increased possible points
1-2		2	Was the alignment modified or was a design effort made to avoid a State Buffered water or wetland? Is there a minimum 100 ft buffer between the natural water course/wetland and the construction limits?	S-1b	2	Selecting an alignment that establishes a minimum 100-foot buffer zone between the edge of pavement and a natural watercourse or significantly sized natural wetland to serve the purpose of stormwater filtration.	re-worded
1-3		2	Was a design effort made to minimize the footprint of the project (ex.- retaining walls, elevated freeway, etc.)?	S-1c	2	Alignments which minimize overall construction "footprint." Examples: use of retaining walls, selecting design option with minimal footprint.	re-worded
1-4		2	Adjust alignment to avoid or minimize impacts to social/environmental resources (parklands, wetlands, historic sites, farmlands, residential and commercial buildings, etc.).	S-1e	1	Adjust alignment to avoid or minimize impacts to social/environmental resources (avoidance of parklands, wetlands, historic sites, farmlands, residential and commercial buildings, etc.).	re-worded, increased possible points
1-5		2	Align roadway and other highway features/structures within ROW as to enable future development of separated multi-use paths or other bike/ped facilities.	S-1f	1	Alignments that optimize benefits among competing constraints (the goal is not always the minimum-length alignment, but the one with the best benefit overall).	re-worded, increased possible points
1-6		1	Micro-adjustments that do not compromise safety or operation but make the difference in providing sufficient clear area for tree planting.	S-1g	1	Micro-adjustments that do not compromise safety or operation but that might make the difference in providing sufficient clear area for tree planting.	same
1-7		1	Provide a depressed roadway alignment, if applicable.	S-1i	1	Provide a depressed roadway alignment.	same
1-8		1	Minimize use of lands that are part of a significant contiguous wildlife habitat.	S-4g	1	Minimize use of lands that are part of a significant contiguous wildlife habitat.	More relevant in this section - moved from Sect. 4
1-9			*Innovation*				
1-10			*Innovation*				
				S-1d	1	Design vertical alignments which minimize total earthwork.	Excluded - already required, not considered 'above and beyond'
				S-1h	1	Clear zones seeded with seed mixtures that help to reduce maintenance needs and increase carbon sequestration.	More relevant in another section, where it is already present Sect. 14
				S-1j	1	Use of launched soil nails as a more cost effective option to stabilize a slope rather than, for example, closing a road to construct a retaining wall which may negatively affect traffic flow and neighboring properties.	Excluded
2-1		2	Adjust or incorporate highway features to respond to the natural and/or built unique character or sense of place of the area (identify and emulate place-distinctive elements such as landmarks, views, historic bridges & buildings, parkways, characteristic use of materials, a notable tree stand, etc.).	S-2a	2	Adjust or incorporate highway features to respond to the unique character or sense of place (both natural and built) of the area ("Unique character" means whatever identifiable elements make a place distinctive, memorable, important to the community, etc. - landmarks, views, historic bridges & buildings, parkways, characteristic use of materials, a notable stand of trees, etc.).	re-worded
2-2		2	Incorporate local or natural materials for substantial visual elements (ex.- bridge fascia, retaining walls).	S-2b	2	Incorporate local or natural materials for substantial visual elements (e.g., bridge fascia, retaining walls).	same
2-3		2	Projects applying 'Walkable Communities' and/or 'Complete Streets' concepts.	S-3d	2	Projects applying "Walkable Communities" and/or "Complete Streets" concepts.	More relevant in this section, than Sect. 3
2-4	a	2	Visual enhancements (screen objectionable views, enhance scenic views, strategic placement of vegetation, burying utilities, etc.).	S-2c	2	Visual enhancements (screening objectionable views, strategic placement of vegetation, enhancing scenic views, burying utilities, etc.).	same
	b	1	Protect existing viewsheds permanently via environmental or conservation easements.	S-2i	1	Permanently protect viewsheds via environmental or conservation easements.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
2-5	a	1	Where appropriate for urban projects, include period or community appropriate street furniture/lighting/appurtenances.	S-2d	1	Period street furniture/lighting/appurtenances.	re-worded
	b	1	Color anodizing of aluminum elements (ITS cabinets, non-decorative light poles, etc.)	S-2j	1	Color anodizing of aluminum elements (ITS cabinets, non-decorative light poles, etc.)	same
2-6	a	1	Inclusion of visually-contrasting (colored and/or textured) pedestrian crosswalk treatments beyond ADA standard and in conjunction with surrounding aesthetic.	S-2e	1	Inclusion of visually-contrasting (colored and/or textured) pedestrian crosswalk treatments.	re-worded
	b	1	Site materials selection & detailing to reduce overall urban heat island effect.	S-2h	1	Site materials selection & detailing to reduce overall urban "heat island" effect.	same
2-7		1	Decorative bridge fencing (in lieu of standard chain link).	S-2k	1	Decorative bridge fencing (in lieu of standard chain link).	same
2-8		1	Use of concrete form liners (for bridge approach barriers, parapet walls, retaining walls, noise walls, bridge piers & abutments, etc.).	S-2l	1	Use of concrete form liners (for bridge approach barriers, parapet walls, retaining walls, noise walls, bridge piers & abutments, etc.)	same
2-9		1	Imprinted concrete/asphalt mow strips, gores and medians/islands.	S-2m	1	Imprinted concrete/asphalt mow strips, gores and/or snow storage areas.	same
2-10			*Innovation*				
2-11			*Innovation*				
				S-2f	1	Planting of native species.	More relevant in another section, moved to Sect. 5
				S-2g	1	Follows the NYS Bridge Manual, Section 23 - Aesthetics.	Excluded - NY-specific
3-1	a	2	Use of more engaging public participation techniques/enhanced outreach efforts that go above the GDOT required minimum. Was the public involved in the design beyond being informed?	S-3a	2	Use of more engaging public participation techniques (e.g. charette, task force).	Combined with S-3b
				S-3b	2	Enhanced outreach efforts (e.g. newsletters, project-specific Web page, communications issued in multiple languages).	Partially combined with S-3a
	b	1	Project reports and community outreach materials are available online on a separate web page beyond the standard project specific web page.	S-3h	1	Project reports and community outreach materials available online other than the standard project specific web page.	same
	c	1	... are provided in multiple languages.				Taken from S-3b as a separate issue
3-2		2	Projects better enabling use of public transit (ex.- bus shelters, 'Park & Ride').	S-3c	2	Projects better enabling use of public transit (e.g. bus shelters, 'Park &Ride').	same
3-3		2	Projects that increase transportation efficiencies for moving freight (ex.- dedicated rail, intermodal facilities, the use of unit trains to remove trucks from highways and conserve fuel).	S-3e	2	Projects that increase transportation efficiencies for moving freight through features such as dedicated rail or intermodal facilities or the use of unit trains to remove trucks from highways and conserve fuel.	re-worded
3-4		2	Was land or another resource donated to the project by public or private entities as a project-specific agreement (ex.- advanced technology, environmental betterment, financial assistance).	S-3f	2	Project-specific formal agreement with public or private entities enabling environmental betterment, technological advancement, or financial assistance or relief to the Department.	re-worded
3-5		2	Project is consistent with local and regional plans beyond those generated by the ARC/local MPO, and/or local Smart Growth-based master/comprehensive plans (ex.- waterfront revitalization plans, greenway plans, the Scenic Byway program, other statewide non-transportation plans with regional components).	S-3g	2	Project is consistent with local and regional plans beyond those generated by the MPO; (e.g., waterfront revitalization plans, greenway plans, the Scenic Byway program, and other statewide non-transportation plans with regional components) and/or local Smart Growth-based master/comprehensive plans.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
3-6		2	Establishment of a new recreational access facility (trailhead parking, boat launch, info/map kiosk, etc.).	S-3j	2	Establishment of a new recreational access facility (trailhead parking, car top boat launch, info/map kiosk).	same
3-7		2	Establishment of a new recreational facility (pocket park, roadside overlook, roadside picnic rest area, etc.).	S-3k	2	Establishment of a new recreational facility (pocket park, roadside overlook, roadside picnic rest area, etc.).	same
3-8		1	Enhancement of an existing recreational facility or enhancement of an existing recreational facility access.	S-3l	1	Enhancement of an existing recreational facility or enhancement of an existing recreational facility access.	same
3-9			*Innovation*				
3-10			*Innovation*				
				S-3d	2	Projects applying "Walkable Communities" and/or "Complete Streets" concepts.	More relevant in another section - moved to Sect. 1
4-1	a	3	Mitigation of habitat fragmentation through use of significant techniques (ex.- raised roadways to conserve ecological continuity of rare plant/ wildlife communities and migration corridors, dedicated 'eco viaducts').	S-4a	3	Mitigation of habitat fragmentation through use of significant techniques such as consolidated stream, wetland or ecological mitigation areas, or creation of dedicated "eco viaducts." (Raised roadways that serve to avoid impacts to ecologically important areas such as rare plant communities, diminishing habitats and wildlife migration corridors.).	re-worded
	b	2	Partial mitigation of habitat fragmentation through techniques such as over sizing culverts or providing wildlife crossing structures that allow for the safe passage of aquatic and/or non-aquatic species passage across highways without their crossing directly on the roadway (US Army Corp of Engineers regional conditions).	S-4c	2	Partial mitigation of habitat fragmentation through techniques (United States Army Corp of Engineers (USACE) regional conditions) such as over-sizing culverts to accommodate aquatic and non-aquatic species passage.	Combined with S-4e
				S-4e	2	Wildlife crossings that are structures that allow for the safe passage of wildlife across highways without their crossing directly on the roadway. Examples include wildlife overpass/underpass and amphibian tunnels.	Combined with S-4c
4-2		2	Protect new or expanded habitat with environmental/ conservation easement.	S-4n	1	Permanently protects the new or expanded habitat through an environmental or conservation easement.	re-worded, increased possible points
4-3		2	Provide for enhancements to existing wildlife habitat (ex.- bird & bat houses, nesting boxes/ areas, avoiding sensitive habitat, etc.).	S-4b	2	Providing for enhancements to existing wildlife habitat (e.g. bird & bat houses, nesting boxes, osprey poles, turtle nesting areas, avoiding piping plover habitat).	re-worded
4-4		2	Wetland restoration, enhancement, or establishment that is above and beyond what is required to obtain a wetland-related permit.	S-4f	2	Wetland restoration, enhancement, or establishment that is above and beyond what is required to obtain a wetland-related permit.	same
4-5		1	Use of wildlife mortality reduction measures such as right of -way fence, deer signs, etc.	S-4h	1	Use of wildlife mortality reduction measures such as right-of -way fence, moose signs, etc.	re-worded
4-6		1	Stream restoration/enhancement.	S-4k	1	Stream restoration/enhancement.	same
4-7		1	Installation of mowing markers to protect natural areas/wetlands.	S-4l	1	Installation of mowing markers to protect natural areas and wetlands.	same
4-8			*Innovation*				
4-9			*Innovation*				
				S-4d	2	Use of natural-bottomed culverts.	Excluded - already required, not considered 'above and beyond'

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
				S-4g	1	Minimize use of lands that are part of a significant contiguous wildlife habitat.	More relevant in another section - moved to Sect. 1
				S-4i	1	Wetland restoration, enhancement, or establishment that is required to obtain a wetland-related permit.	Excluded - already required, not considered 'above and beyond'
				S-4j	1	Provide mitigation required by permit to offset wetland impacts due to construction.	Excluded - already required, not considered 'above and beyond'
				S-4m	1	Inclusion of scheduling and logistic requirements to avoid disrupting wildlife nesting or breeding activities.	Excluded - already required, not considered 'above and beyond'
5-1		2	Avoidance/protection of significant contiguous stands of established, desirable trees/ plant communities, especially those showing signs of self-regeneration.	S-5a	2	Avoidance/protection of significant contiguous stands of established, desirable trees/veg communities, especially those showing signs of self-regeneration.	re-worded
5-2	a	2	Designs which demonstrate, through a combination of preservation and new planting, an anticipated ultimate net increase in tree canopy cover within the project limits (new trees at projected maturity).	S-5b	2	Designs which demonstrate, through a combination of preservation and new planting, an anticipated ultimate (new trees at projected maturity) net increase in tree canopy cover within the project limits.	re-worded
	b	1	Designs which demonstrate no ultimate net loss of tree canopy within the project limits (minimum one-to-one replacement) or, if overall available planting area has been reduced, mitigation with trees to the extent possible for trees lost (either on or offsite).	S-5g	1	Designs which demonstrate, through a combination of preservation and new planting, no ultimate (new trees at projected maturity) net loss of tree canopy within the project limits (minimum one-to-one replacement of trees lost) or, if overall available planting area has been reduced, mitigation with trees to the extent possible (either on or off-site) for trees lost.	re-worded
5-3		2	Use of native species for seed mixes and other plantings. Re-establishment or expansion of native vegetation into reclaimed work areas or abandoned roadway alignments. (ex.- native seed mixes, "re-forestation" approach w/ multiple seedlings rather than traditional large nursery stock, etc.).	S-5c	2	Re-establishment or expansion of native vegetation into reclaimed work areas or abandoned roadway alignments. (e.g. native seed mixes, "re-forestation" approach w/ multiple seedlings rather than traditional large nursery stock, etc.).	Combined with S-5e, S-2f
5-4		2	Use of trees, large shrubs or other suitable vegetation in lieu of traditional turf grass.	S-5h	1	Planting trees, shrubs and/or plant material in lieu of traditional turf grass.	re-worded, increased possible points
5-5		1	Avoidance/protection of individual existing significant trees and localized areas of established desirable vegetation within the project limits.	S-5f	1	Avoidance/protection of individual significant trees and localized areas of established desirable vegetation.	re-worded
5-6		1	Removal of undesirable plant species, in particular removal/burial of invasive species, to preserve desirable overall species diversity.	S-5i	1	Removal of undesirable plant species, in particular removal/burial of invasive species, to preserve desirable overall species diversity.	same
5-7		1	Preserving, replacing, or enhancing vegetation associated with historic properties or districts, or which maintain the character of unique areas.	S-5j	1	Preserving, replacing, or enhancing vegetation associated with historic properties or districts, or which maintain the character of unique areas.	same
5-8			*Innovation*				
5-9			*Innovation*				
				S-5d	2	Use of trees, large shrubs or other suitable vegetation (beach rose, honeysuckle & shrub willows) as living snow fences.	N/A
				S-5e	1	Use of native species for seed mixes and other plantings.	Combined with S-5c

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID	GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
6-1	2	In addition to the Erosion, Sedimentation, and Pollution Control plans for the project construction, was an effort made to design and maintain post-construction BMPs, which improve water quality or nearby habitat through the use of stormwater retrofitting, stormwater crediting strategies, stream restoration, sediment points, swales, etc.)	W-1a	2	Improve water quality and/or nearby habitat through the use of stormwater retrofitting, stormwater crediting strategies, stream restoration, additional wetland protection, and inclusion of permanent stormwater mgt practices.	major re-wording
6-2	2	Demonstrate a reduction of pollutant loadings to adjacent water resources.	W-1c	2	Demonstrate, through the use of models, a reduction of pollutant loadings to adjacent water resources by the use of Best Management Practices (BMPs).	re-worded
6-3	2	Reduction in overall impervious area (post-project impervious surface area to be less than existing).	W-1d	2	Reduction in overall impervious area (post-project impervious surface area to be less than existing).	same
6-4	1	Design includes more than minimum erosion & sediment control practices.	W-1e	1	Project designs that include sound erosion and sediment control practices.	re-worded
6-5	1	Requirements for staged construction such that < 5 acres of bare soil is exposed at any time (GDOT specifies < 17 acres).	W-1f	1	Requirements for staged construction so that less than five acres of bare soil are exposed at any given time and site runoff is controlled.	re-worded
6-6		*Innovation*				
6-7		*Innovation*				
			W-1b	2	Detecting and eliminating any non-stormwater discharges from unpermitted sanitary or other residential, commercial or industrial sources that enter the Right-Of-Way or flows that ultimately discharge to the ROW.	Excluded - already required, not considered 'above and beyond'
			W-1g	1	Detecting and documenting non-stormwater discharges from unpermitted sanitary or other residential, commercial or industrial sources that enter the right-of-way or flows that ultimately discharge to the right-of-way but which cannot be eliminated for reasons beyond our control.	Excluded - already required, not considered 'above and beyond'
7-1	2	Design features that make use of highly permeable soils to remove surface pollutants from runoff (ex.- wet or dry swales, infiltration trenches or basins, bioretention cells or rain gardens, grass buffers and stormwater wetlands that treat water quality and water quantity requirements in accordance with GA DOT)	W-2a	2	Design features that make use of highly permeable soils to remove surface pollutants from runoff through infiltration trenches or basins, bioretention cells or rain gardens, grass buffers and stormwater wetlands that treat water quality and water quantity requirements in accordance with NYSDOT Highway Design Manual Chapter 8, Appendix B, subsections 2.3.2 and 2.3.3.	re-worded
7-2	2	Use of other structural BMPs including sand filters, filter bags, stormwater treatment sys (ex.- oil/grit separators and hydrodynamic devices), underground detention systems or catch basin inserts.	W-2b	2	Use of other structural BMPs including wet or dry swales, sand filters, filter bags, stormwater treatment systems (e.g., oil/grit separators and hydrodynamic devices), underground detention systems or catch basin inserts.	re-worded
7-3	2	Inclusion of permeable pavement if practical (ex.- grid pavers), or Porous European mix and open graded friction course (according to the University of Texas, this type of pavement system may provide significant filtration of roadway pollutants and can be used on high volume roadways).	W-2c	2	Inclusion of "permeable pavement" such as grid pavers where practical.	re-worded
7-4	1	Include grass channels, where appropriate (per research at Georgia Tech, utilizing turf reinforcing mat, TRM, may facilitate the use of grass channels where previously they were not installable).	W-2e	1	Include grass channels, where appropriate.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
7-5			*Innovation*				
7-6			*Innovation*				
				W-2d	1	Minimize the project's overall impervious surface area increase.	Excluded - concept embedded elsewhere
				W-2f	2	Designate qualified environmental construction monitor to provide construction oversight in sensitive environmental areas.	Excluded - already required, not considered 'above and beyond'
8-1	a	2	Specify that 80-100% of topsoil removed for grading is reused on site if soil survey deems treatment reasonable.	M-1a	2	Specify that 75% or more of topsoil removed for grading is reused on site.	re-worded
	b	1	Specify that 50% or more of topsoil removed for grading is reused on site if soil survey deems treatment reasonable.	M-1k	1	Specify that 50% or more of topsoil removed for grading is reused on site.	re-worded
8-2		2	Reuse of excess fill ('spoil') within the project corridor to minimize project site material in and out.	M-1c	2	Reuse of excess fill ("spoil") within the project corridor to minimize project site material in and material out.	re-worded
8-3	a	2	Recycling and reuse of Portland Cement Concrete pavement via rubblizing or crack and seating of the current PCC.	M-1d	2	Specify rubblizing or crack and seating of Portland Cement Concrete pavement.	re-worded
	b	2	Reuse of previous pavement as subbase during full-depth reconstruction projects.	M-1e	2	Reuse of previous pavement as subbase during full-depth reconstruction projects.	same
	c	2	Specify the processing of demolished concrete to reclaim scrap metals and to create a usable aggregate material.	M-1g	2	Specify the processing of demolished concrete to reclaim scrap metals and to create a usable aggregate material.	same
8-4	a	2	Reuse of excess excavated material, asphalt pavement millings, or demolished concrete by another municipality or state agency.	M-1f	2	Arranging for the reuse of excess excavated material, asphalt pavement millings, or demolished concrete by another municipality or state agency.	re-worded
	b	1	Reuse at nearby abandoned quarries to help fulfill an approved EPD reclamation plan.	M-1j	2	Use surplus excavated material, demolished concrete, or millings at nearby abandoned quarries to help fulfill an approved DEC reclamation plan.	re-worded, decreased possible points
8-5	a	2	Reuse of major structural elements such as bridge piers, bridge structure, etc. if warranted and appropriate and does not compromise the feature life cycle.	M-1u	2	Reuse of major structural elements such as bridge piers, bridge structure, etc. if warranted and appropriate and does not compromise the feature life cycle.	same
	b	1	Reuse of elements of the previous structure (ex.- stone veneer, decorative railing, etc.).	M-1n	1	Reuse of elements of the previous structure (stone veneer, decorative railing, etc.).	same
8-6		1	Reuse of granite curbing (i.e.- remove and reset versus remove and replace).	M-1m	1	Reuse (i.e., remove and reset versus remove and replace) of granite curbing.	re-worded
8-7	a	2	Salvaging removed trees for lumber or similar uses other than standard wood chipping (ex.- allow community removal of plants and trees).	M-1h	2	Salvaging removed trees for lumber or similar uses other than standard wood-chipping (e.g. - milling valuable heartwood from ash trees whose outer wood was infected by ash borers, necessitating removal).	re-worded
	b	1	Specifying the recycling of chipped untreated wood waste for use as mulch and/or ground cover (Note: pressure/ preservative-treated or painted/coated wood must be disposed of properly).	M-1p	1	Specifying the recycling of chipped untreated wood waste for use as mulch and/or ground cover. (Pressure/preservative-treated or painted/coated wood cannot be used as mulch and must be disposed properly).	re-worded
	c	1	Incorporate an on-site location for chipped wood waste disposal from clearing and grubbing operations rather than burning.	M-1o	1	Designing an on-site location for chipped wood waste disposal from clearing and grubbing operations.	re-worded
8-8		1	Project documents make scrap metals available for reuse/recycling.	M-1q	1	Project documents make scrap metals available for reuse or recycling.	re-worded
8-9		1	Specify the salvage/moving of houses rather than demo for disposal in landfills.	M-1t	1	Specify the salvage/moving of houses rather than demo for disposal in landfills.	same

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
8-10		1	Implement a project specific innovative re-use of otherwise waste material.	M-1s	1	Obtain and implement a project specific DEC Beneficial Use Determination for the innovative re-use of otherwise waste material from a location within NYS.	re-worded
8-11			*Innovation*				
8-12			*Innovation*				
				M-1b	2	Design the project so that "cut-and-fills" are balanced to within 10 percent.	Excluded - part of the required design process, not "above and beyond'
				M-1i	2	Use surplus excavated material on nearby state highways for slope flattening to eliminate guide rail or as fill in areas designated by Park officials as acceptable for spoil disposal.	Excluded - already required, not considered 'above and beyond'
				M-1l	1	Design the project so that cut and fills are balanced to within 25 percent.	Excluded - part of the required design process, not "above and beyond'
				M-1r	2	Identify approved, environmentally acceptable and permitted sites in the contract documents for the disposal of surplus excavated material.	Excluded - repeats concepts already covered in this section
9-1		2	Use of porous pavement systems in light duty situations (ex.- sidewalks, truck turnarounds, rest stops, parking lots, police turnarounds).	M-2h	2	Use of porous pavement systems in light duty situations (e.g. sidewalks, truck turnarounds, rest stops, parking lots, police turnarounds).	same
9-2		2	Specify PCC pavement mixes with Recycled Concrete Aggregate (RCA).	M-2f	2	Specify PCC pavement mixes containing Recycled Concrete Aggregate (RCA).	same
9-3	a	2	Specify in-place recycling of hot mix asphalt pavements.	M-2c	2	Specify hot-in-place or cold-in-place recycling of hot mix asphalt pavements.	re-worded
	b	1	Specify asphalt pavement mixes containing Recycled Asphalt Pavement (RAP).	M-2e	2	Specify asphalt pavement mixes containing Recycled Asphalt Pavement (RAP).	same, decreased possible points
9-4		2	Specify use of recycled glass in pavements and embankments, as drainage material or filter media from adequate local sources.	M-2d	2	Specify the use of recycled glass in pavements and embankments, as drainage material or filter media where adequate local sources can be obtained.	same
9-5		1	Use recycled plastic extruded lumber, recycled tire rubber, crumb rubber, or recycled plastic (ex.- for noise barriers).	M-2b	2	Use recycled plastic extruded lumber or recycled tire rubber (e.g. for noise barriers).	Combined with M-2g, decreased possible points
				M-2g	2	Use crumb rubber or recycled plastic for noise barrier material.	Combined with M-2b, decreased possible points
9-6		1	Use tire shreds in embankments.	M-2a	2	Use tire shreds in embankments.	same, decreased possible points
9-7			*Innovation*				
9-8			*Innovation*				
				M-3a	2	Specify locally available natural light weight fill. Contact Geotechnical staff to help in locating these materials.	Excluded - part of the required design process, not "above and beyond'
				M-3b	2	Specify local seed stock and plants.	Excluded - concept embedded in Sect. 5
10-1		2	Project designs that utilize soil bioengineering treatments along water bodies/wetlands (the reliance on plant material for slope protection, rebuilding, stabilization, and erosion control).	M-4a	2	Project designs that utilize soil bioengineering treatments (the reliance on plant material for slope protection, rebuilding, stabilization, and erosion control) along water bodies/wetlands.	re-worded
10-2		2	Project designs utilize soil biotechnical engineering treatments along water bodies/wetlands (combination of structural elements/ plant materials to achieve slope protection, stabilization, rebuilding, and erosion control: vegetated crib walls, gabions, Geosynthetic Reinforced Earth Systems (GRES), geocells, and mats).	M-4b	2	Project designs utilizing soil biotechnical engineering treatments (combination of plant materials and structural elements to achieve slope protection, rebuilding, stabilization, and erosion control) along water bodies/wetlands. Examples are: vegetated crib wall, vegetated gabion, and vegetated mats.	re-worded
10-3		2	Projects using targeted biological control methods to reduce invasive species.	M-4c	2	Projects using targeted biological control methods to reduce invasive species, such as the release of specific types of beetles to control purple loosestrife.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
10-4		1	Project designs that utilize soil bioengineering treatments or soil biotechnical engineering treatments in upland areas.	M-4d	1	Project designs utilizing soil biotechnical engineering treatments (combination of plant materials and structural elements to achieve slope protection, rebuilding, stabilization, and erosion control) NOT along water bodies or wetlands. Examples include vegetated: crib walls, gabions, Geosynthetic Reinforced Earth Systems (GRES), geocells, and mats.	re-worded
10-5		1	Project designs utilizing soil biotechnical engineering treatments NOT along water bodies or wetlands.	M-4e	1	Project designs that utilize soil bioengineering treatments or soil biotechnical engineering treatments in upland areas.	re-worded
10-6			*Innovation*				
10-7			*Innovation*				
11-1		2	Project design substantially minimizes the need to use hazardous materials (ex.- steel or concrete RR ties instead of treated wood), increases the interval before reconstruction must be performed using hazardous or toxic materials, and/ or improves durability of components containing hazardous substances.	M-5a	2	Project design substantially minimizes the need to use hazardous materials to maintain the bridge or highway, or increases the interval before reconstruction must be performed using hazardous or toxic materials. The project design improves durability of components that contain hazardous substances.	re-worded
11-2		2	Project design specifies less hazardous materials or avoids generating contaminated wastes by reducing the volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) emitted during project construction (ex.- use of non-solvent traffic/bridge paints, lower VOC/nonhazardous air pollutant bridge deck sealers) and by eliminating or reducing toxic metals/components.	M-5b	2	Project design specifies less hazardous materials or avoids generating contaminated wastes by reducing the volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) emitted during project construction (e.g., use of non-solvent traffic or bridge paints, lower VOC/nonhazardous air pollutant bridge deck sealers) and by eliminating or reducing toxic metals/components.	same
11-3		1	Removing/disposing of contaminated soils beyond what is necessary for project construction.	M-5c	2	Removing and disposing of contaminated soils beyond what is necessary for project construction.	same, decreased possible points
11-4			*Innovation*				
11-5			*Innovation*				
				M-5d	2	Removing and disposing of contaminated soils, lead based paints, asbestos, tanks containing hazardous contents as necessary for project construction.	Excluded - if considered necessary, is not 'above and beyond'
12-1		2	Special use lane (HOV/Reversible/Bus Express).	E-1a	3	Special use lane (HOV/Reversible/Bus Express).	same, decreased possible points
12-2	a	2	Innovative interchange design and/or elimination of freeway bottlenecks (diverging diamond, single point urban, etc.).	E-1b	3	Innovative interchange design and/or elimination of freeway bottlenecks (diverging diamond, single point urban).	re-worded, decreased possible points
	b	1	Specify new roundabout(s).	E-1c	3	Specify new roundabout(s).	same, decreased possible points
12-3		2	Road Diet (reduction of travel lanes to incorporate a single bidirectional center turn lane and wider right-hand lanes to accommodate bicycles).				
12-4	a	2	Implementation of a corridor-wide access management plan.	E-1h	2	Implementation of a corridor-wide access management plan.	same
	b	1	Limiting/consolidating access points along highway.	E-1i	1	Limiting/consolidating access points along highway.	same
12-5	a	2	Installation of a closed-loop coordinated signal system.	E-1e	2	Installation of a closed-loop coordinated signal system.	same
	b	2	Improving a coordinated signal system and other signal timing and detection systems (ex.- GPS integration).	E-1j	1	Improving a coordinated signal system and other signal timing and detection systems.	re-worded, increased possible points
	c	1	Installing higher capacity controllers with features to improve flow and reduce delay at intersections.	E-1l	1	Installing higher capacity controllers (model 2070s) with features to improve flow and reduce delay at intersections.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID	GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
12-6	2	Installation of a transit express system (queue jumper, pre-emptive signals, etc)	E-1f	2	Installation of a transit express system (queue jumper, pre-emptive signals, etc)	same
12-7	1	Expand and anticipate expansion of Traffic Management/ Traveler Information System operation with existing system coverage (ex.- increase/improve density of devices, install conduit in anticipation of future expansion/needs, installation of VMS, CCTV, freeway detection, ramp metering, road weather information system and/or weigh in motion devices, travel time signs, etc.)	E-1g	2	Expansion of a Traffic Management Center / Traveler Information System operation; for example increasing system coverage significantly (installation of new CCTV, VMS, freeway detection, ramp metering, road weather information system and/or weigh in motion devices, travel time signs, etc.).	Combined with E-1d and E-1m, decreased possible points
			E-1d	3	Implementation of a robust Traffic Management Center / Traveler Information System operation (e.g., TMC, CCTV, VMS freeway detection, ramp metering, road weather info system and/or weigh in motion devices, travel time signs).	Combined with E-1g, decreased possible points
			E-1m	1	Infill and/or preparation for Traffic Management/Traveler Information System operation (installation of VMS, CCTV, etc.) with existing system coverage to increase or improve density of devices, installation of conduit in anticipation of future Traffic Management/Traveler Information System need, etc.	Combined with E-1g, decreased possible points
12-8	1	Inclusion of strategies to manage traffic during construction such as an incident management/ traveler information/ integrated traffic system (ex.- queue/speed warning, VMS with real time construction information, tow/HELP vehicles on site/standby, CCTV monitoring of construction zone, etc.).	E-1n	1	Inclusion of an integrated traffic/incident management/traveler information systems or strategies to manage traffic during construction (queue or speed warning, VMS with real time construction information, tow/HELP vehicles on site/standby, CCTV monitoring of construction zone, etc.).	same
12-9	1	Installation of isolated systems to provide for spot warning (queue warning, truck rollover, low bridge, no trucks allowed, etc.).	E-1o	1	Installation of isolated systems to provide for spot warning (queue warning, truck rollover, low bridge, no trucks allowed, etc.).	same
12-10	1	Adding bus turnouts.	E-1k	1	Adding bus turnouts.	same
12-11		*Innovation*				
12-12		*Innovation*				
13-1	2	Solar/battery powered street lighting or warning signs.	E-2a	2	Solar/battery powered street lighting or warning signs.	same
13-2	2	Replace overhead sign lighting with higher type retro-reflective sign panels.	E-2b	2	Replace overhead sign lighting with higher type retro-reflective sign panels.	same
13-3	2	Use of LED street lighting.	E-2c	2	Use of LED street lighting.	same
13-4	2	Solar bus stops.	E-2d	2	Solar bus stops.	same
13-5	1	Use of LED warning signs/flashing beacons.	E-2e	1	Use of LED traffic signals/warning signs/flashing beacons	same
13-6	1	Retrofit existing street/sign lighting with high efficiency types.	E-2e	1	Retrofit existing street/sign lighting with high efficiency types.	same
13-7		*Innovation*				
13-8		*Innovation*				

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
14-1	a	2	Provide new intermodal connections.	E-3b	3	Provide new intermodal connections.	same, decreased possible points
	b	1	Improve an existing intermodal connection (ex.- add BRT station, kiosks, etc.).	E-3f	1	Improve an existing intermodal connection (e.g. add BRT station, kiosks, etc.).	same
14-2	a	2	Provide new Park & Ride lots.	E-3a	3	Provide new Park & Ride lots.	same, decreased possible points
	b	1	Operational improvements of an existing Park & Ride lot.	E-3e	1	Operational improvements of an existing Park & Ride lot.	same
	c	1	Improved shading through vegetation at Park & Ride lots to cut down on heat island effect and the use of automotive air conditioning by waiting motorists.	E-3k	1	Improved shading through vegetation at Park & Ride lots to cut down on heat island effect and the use of automotive air conditioning by waiting motorists.	same
14-3		2	Increase bicycle amenities at Park & Rides and transit stations (bike lockers/shelters, Web-based reservations system for lockers, providing showers or partnering with health clubs for these services).	E-3c	2	Increase bicycle amenities at Park & Rides and transit stations (bike lockers/shelters, Web-based reservations system for lockers, providing showers or partnering with health clubs for these services).	same
14-4		2	Incorporate ITS technology to improve traffic flow.				Added
14-5		1	Reduce mowing areas outside of the clear zone, reestablishing natural ground cover and/or seeding with low maintenance seed species. Example: Incorporation of Conservation Alternative Mowing Practices (CAMPS) techniques/guidance into design plans.	E-3g	1	Reduce mowing areas outside of the clear zone, reestablishing natural ground cover and/or seeding with low maintenance seed species. Example: Incorporation of Conservation Alternative Mowing Practices (CAMPS) techniques/guidance into design plans.	re-worded
14-6		1	Use of warm or cold mix asphalt.	E-3h	1	Use of warm mix asphalt.	same
14-7		1	Documented analysis proving the project design reduces either the Department's or the local community's carbon footprint.	E-3i	1	Documented analysis proving the project design reduces either the Department's or the local community's carbon footprint (Send analysis to the GreenLITES Program Manager for determination of eligibility).	re-worded
14-8			*Innovation*				
14-9			*Innovation*				
				E-3j	1	Documented analysis proving the Work Zone Traffic Control scheme chosen is the alternative that overall requires the least amount of petroleum (Send analysis to the GreenLITES Program Manager for determination of eligibility).	Excluded - at the moment GDOT does not have a program that will determine least amount of petroleum
15-1		3	New grade-separated (bridge or underpass) bike/pedestrian crossing structure (this item is not for replacements or rehabs).	E-4a	3	New grade-separated (bridge or underpass) bike/pedestrian crossing structure (this item is not for replacements or rehabs).	same
15-2	a	2	New separated bike paths or work with local communities to create parallel bike routes where state roads are not suitable for cyclists.	E-4c	2	New separated bike path or shoulder widening to provide for on-road bike lane.	re-worded
	b	2	Separate bike lane at intersection.	E-4b	2	Separate bike lane at intersection.	same
	c	1	Shoulder widening or restoration to provide for on-road bike lane.	E-4k	1	Shoulder restoration for bicycling.	re-worded

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID		GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
15-3	a	2	Create new, extend existing, or make space available for future sidewalks to increase walkable areas and provide continuity for pedestrian travel.	E-4d	2	Create new or extend existing sidewalks.	Combined with E-4f, decreased possible points
				E-4f	2	Align roadway and other highway features/structures within ROW as to enable future development of separated multi-use paths or other bike/ped facilities.	Combined with E-4d, decreased possible points
	b	1	Sidewalk/bikeway rehabilitation, widening, realignment or repair.	E-4h	1	Sidewalk or bikeway rehabilitation, widening, realignment or repair.	re-worded
15-4	a	2	New curb bulb-outs and/or raised medians/ pedestrian refuge islands.	E-4o	1	New curb bulb-outs.	Combined with E-4p, increased possible points
				E-4p	1	New raised medians/pedestrian refuge islands.	Combined with E-4o, increased possible points
	b	1	New crosswalks.	E-4n	1	New crosswalks.	same
	c	1	New curbing (where none previously existed), to better define the edge of a roadway and to provide vertical separation of pedestrian facilities; does not include flush, mountable or bridge curbing.	E-4r	1	New curbing (where none previously existed), to better define the edge of a roadway and to provide vertical separation of pedestrian facilities; does not include flush, mountable or bridge curbing.	same
	d	1	Provide mid-block crossing where applicable/reasonable.				Added to address needs in Georgia
15-5	a	2	New pedestrian signals.	E-4e	2	New pedestrian signals.	same
	b	1	Upgrade pedestrian signals - include pedestrian buttons and/or addition of audible signal, countdown timers.	E-4i	1	Upgrading pedestrian signals - inclusion of pedestrian buttons and/or addition of audible signal, countdown timers.	re-worded
	c	1	"Pedestrian All Stop" phase programmed into a traffic signal and/or button actuated "No Turn on Red" LED sign where applicable/ reasonable.	E-4u	1	"All Stop" phase programmed into a traffic signal and/or button actuated "No Turn on Red" LED sign.	re-worded
	d	1	Installation of bicycle detectors (quadrupoles) at signalized intersections.	E-4t	1	Installation of bicycle detectors (quadrupoles) at signalized intersections.	same
15-6		1	New speed hump/ speed table/ raised intersection.	E-4q	1	New speed hump/speed table/raised intersection.	same
15-7		1	New or relocated highway barrier or repeating vertical elements (trees, lampposts, bollards, rural mailboxes, etc.) between roadway & walk/bikeway to better separate/delineate motorized and non-motorized travel ways.	E-4s	1	New or relocated highway barrier or repeating vertical elements (trees, lampposts, bollards, rural mailboxes, etc) between roadway & walk/bikeway to better separate/delineate motorized and non-motorized travel ways.	same
15-8		1	Installation of bikeway signs, "Share the Road" signs, and/or Sharrow (shared lane) pavement markings.	E-4j	1	Installation of bikeway signs, "Share the Road" signs, and/or Sharrow (shared lane) pavement markings.	same
15-9		1	Permanent digital "Your Speed is XX" radar speed reader signs.	E-4v	1	Permanent digital "Your Speed is XX" radar speed reader signs.	same

(Table 5: Scorecard Comparison Matrix with GreenLITES cont'd)

GDOT ID	GDOT Score	Description	Green LITES ID	Green LITES score	Description	Changes/ Justification
15-10	1	Provide motorists with advanced warning of pedestrian crossings where applicable (ex.- overhead flashing beacon, lighted "Crosswalk" sign, half signal, or pedestrian hybrid ('hawk') signal; advanced warning of crosswalk with signs and yield pavement markings).	E-4x	1	Advanced warning of crosswalk with signs and yield pavement markings (white triangles).	Combined with E-4w
			E-4w	1	Overhead flashing beacon, lighted "Crosswalk" sign, or half signal at pedestrian crossing.	Combined with E-4x
15-11	1	Make crosswalks more visible to motorists (ex.- in-street plastic pylon 'State law - Yield to Pedestrians' signs; utilize high visibility, reduced wear, staggered ladder bar crosswalks (modified Type L - sometimes referred to as a 'piano key' type crosswalk).	E-4aa	1	Add/replace crosswalks with high visibility, reduced wear, staggered ladder bar crosswalks (a modified Type L which avoids wheel paths, and is sometimes referred to as a 'piano key' type crosswalk).	Combined with E-4y
			E-4y	1	In street plastic pylon "State law - Yield to Pedestrians within Crosswalk" signs and/or pedestrian self service crosswalk flags.	Combined with E-4aa
15-12		*Innovation*				
15-13		*Innovation*				
			E-4g	2	Work with local communities to create parallel bike routes where state roads are not suitable for less experienced cyclists.	Removed - perhaps should be considered at a later date when state bicycle infrastructure increases.
			E-4l	1	Inclusion of five-rail bridge rail system for bicyclists.	Excluded
			E-4m	1	Installation of permanent bicycle racks.	Excluded
			E-4z	1	Use of durable cast iron detectible warning units embedded in concrete (rather than surface applied polyurethane, stamped concrete, concrete brick, etc.).	Excluded
16-1	2	Construction of a new noise barrier.	E-5a	2	Construction of a new noise barrier.	same
16-2	2	Incorporate traffic system management techniques to reduce prior noise levels (ex.- use of truck routes, progressive traffic signals, lowering speeds).	E-5b	2	Incorporate traffic system management techniques to reduce prior noise levels (e.g. use of truck routes, progressive traffic signals, lowering speeds).	same
16-3	2	Provide a buffer zone for adjacent receptors (ex.- hospitals, libraries, schools).	E-5c	2	Provide a buffer zone for adjacent receptors.	Combined with E-5d
			E-5d	2	Provide sound insulation to public schools.	Combined with E-5c
16-4	2	Diamond grinding of existing Portland Cement Concrete (PCC) pavement.	E-5e	1	Diamond grinding of existing Portland Cement Concrete (PCC) pavement.	same
16-5	1	Rehabilitation of an existing noise wall.	E-5f	1	Rehabilitation of an existing noise wall.	same
16-6	1	Berms designed to reduce noise.	E-5g	1	Berms designed to reduce noise.	same
16-7	1	Provide planting to improve perceived noise impacts.	E-5h	1	Provide planting to improve perceived noise impacts.	same
16-8		*Innovation*				
16-9		*Innovation*				
17-1	2	Retrofit existing light heads with full cut-offs.	E-6a	2	Retrofit existing light heads with full cut-offs.	same
17-2	1	Use cut-offs on new light heads.	E-6c	1	Use cut-offs on new light heads.	same
17-3		*Innovation*				
17-4		*Innovation*				
18-1		*Innovation*	I-1a			
18-2		*Innovation*	I-1b			
18-3		*Innovation*	I-1c			
18-4		*Innovation*	I-1d			
18-5		*Innovation*	I-1f			
18-6		*Innovation*	I-1g			

CHAPTER 5: RESULTS

5.1 Final Scorecard

The culmination of this portion of the project is provided below as the Final Scorecard. While, as mentioned previously, this scorecard is by no means a fixed document, at the moment it is thought to encompass current applications of sustainability within the transportation infrastructure arena as they relate to the State of Georgia. It is very similar in structure to GreenLITES, as it is composed of five main categories. However, many credits were re-worded to clarify the significance as well as relate verbiage to GDOT's practices. Some items, for various reasons, were excluded entirely, while others were combined to make the rating process less cumbersome. Combination of credits occurred in two distinct ways. Some credits tended to have the same concept, but were thought to exist better as a single line item, whereas other credits depicted varying degrees of the same concept, and were combined more as an 'a' or 'b' possibility of points. Therefore, the final number of credits that carry a distinct ID in the rating system created by this thesis exceeds the actual number of line items. The table below gives a summary of the changes that are described in more detail in the previous section in Table 5, which can be found in the Analysis section. The following table summarizes the final scorecard, including the sections, subsections, and number of credits, or distinct IDs, per each subcategory (which includes two optional innovation credits per each of the first seventeen sub-categories).

Table 6: Summary of Sections, Subsections, and Credits for the Final Scorecard

Category		Sub-Category	Items (IDs)
Sustainable Sites	1	Alignment	10
	2	Context Sensitive Solutions	11
	3	Land Use/ Community Planning	10
	4	Protect, Enhance, or Restore Wildlife Habitat	9
	5	Protect, Plant, or Mitigate for Removal of Trees and Plant Communities	9
Water Quantity and Quality	6	Stormwater Management (Volume and Quality)	7
	7	Best Management Practices	6
Materials and Resources	8	Reuse of Materials	12
	9	Recycled Content	8
	10	Bio-Engineering Techniques	7
	11	Hazard Material Minimization	5
Energy and Atmosphere	12	Improved Traffic Flow	12
	13	Reduce Electrical Consumption	8
	14	Reduce Petroleum Consumption	9
	15	Improve Bicycle & Pedestrian Facilities	13
	16	Noise Abatement	9
	17	Stray Light Reduction	4
Innovation	18	(Optional Innovation credits that do not fit in previous categories)	6

GreenLITES originally contained nineteen subcategories. One was excluded from this scorecard because the subcategory contained very few points and the project team deemed those line items appropriate to be combined with other line items or considered as embedded in another section. The excluded subsection, called “Local Materials” and originally placed within the Materials and Resources section, considered locally sourced materials, which was a theme that was prevalent throughout the scorecard. It was important to the project team to prepare a scorecard that was a concise and readable as possible. The following table notes the exclusions, additions, and change in total line items, etc.

Table 7: Summary of Results and Comparison to GreenLITES

GreenLITES Line Items (also IDs), excluding Innovation	181
GDOT Line Items, excluding Innovation	146
Excluded Line Items	22
Added Line Items	2
Line Items with Increase or Decrease in Point Allocation	24
Line Items that were Re-Worded	56
Line Items with No Change in Wording	73
- with increase or decrease in points	8
GDOT Items with Distinct ID, excluding Innovation	115
GDOT Innovation Credits (optional)	40
GDOT Total Items with ID, Including Innovation	155

The new scorecard rearranged and grouped similar concepts to help the readability of the document, and to expedite the process of considering similar alternatives. About forty percent of the original line items found in GreenLITES maintained the original wording in the new scorecard, although eight of the seventy-three items changed point allocation based on feedback from the team at GDOT. Fifty-six items, or about thirty percent of the original GreenLITES items, were re-worded to both reflect differences between New York and Georgia, and also to clarify meaning. A total of twenty-four line items have an increase or decrease in point allocation, again based on the discretion of the team at GDOT.

The GDOT scorecard minimized total lines necessary to consider from 181 to 146, or approximately a twenty percent reduction from the GreenLITES system total. This reduction occurred through the combination of similar line items, and the exclusion of a number of line items. A total of twenty-two items found in the GreenLITES program were excluded for various reasons that can be identified in the Analysis section within the comparison matrix Table 5. Excluded items typically were found not applicable in Georgia, or were already specified as a requirement within GDOT. The exclusion of required areas was meant to preserve the intent of the scorecard, to award initiatives that specifically go above and beyond requirements. There were two additions to the scorecard.

The final system considers 115 distinct credits, or IDs, some of which have options a, b, c, etc. There are an additional forty optional innovation credits that are distributed among each sub-section, and as a final category, also optional, for novel concepts that do not belong under one of the existing sections. In the GreenLITES system, as well as many others, innovation is an area that is considered its own category or subcategory. While numerous, the 115 distinct credits in the new system cannot possibly encompass every sustainable decision that can be made within a category and/or subcategory. The project team decided that a reminder at the end of each subcategory might spur some thought or recognition of relevant sustainability initiatives that go beyond what has been published in 'specs' or in this document. Thus, the project team decided that providing two lines per subcategory specifically for the purpose of fill-in innovation may stimulate additional social, economic, or environmental stewardship within that particular subcategory as well as provide a reminder that the sustainability arena is continually evolving. Below is a final copy of the scorecard created for this thesis.

Table 8: Final Scorecard

CATEGORY		ID	DESCRIPTION	POINTS AVAIL.	POINTS N/A	POINTS SCORE
SUSTAINABLE SITES	Alignment	1-1	Avoidance of previously undeveloped lands (open spaces or 'greenfields').	3		
		1-2	Was the alignment modified or was a design effort made to avoid a State Buffered water or wetland? Is there a minimum 100 ft buffer between the natural water course/wetland and the construction limits?	2		
		1-3	Was a design effort made to minimize the footprint of the project (ex.- retaining walls, elevated freeway, etc.)?	2		
		1-4	Adjust alignment to avoid or minimize impacts to social/environmental resources (parklands, wetlands, historic sites, farmlands, residential and commercial buildings, etc.).	2		
		1-5	Align roadway and other highway features/structures within ROW as to enable future development of separated multi-use paths or other bike/ped facilities.	2		
		1-6	Micro-adjustments that do not compromise safety or operation but make the difference in providing sufficient clear area for tree planting.	1		
		1-7	Provide a depressed roadway alignment, if applicable.	1		
		1-8	Minimize use of lands that are part of a significant contiguous wildlife habitat.	1		
		1-9				
		1-10				
	Context Sensitive Solutions	2-1	Adjust or incorporate highway features to respond to the natural and/or built unique character or sense of place of the area (identify and emulate place-distinctive elements such as landmarks, views, historic bridges & buildings, parkways, characteristic use of materials, a notable tree stand, etc.).	2		
		2-2	Incorporate local or natural materials for substantial visual elements (ex.- bridge fascia, retaining walls).	2		
		2-3	Projects applying 'Walkable Communities' and/or 'Complete Streets' concepts.	2		
		2-4 a	Visual enhancements (screen objectionable views, enhance scenic views, strategic placement of vegetation, burying utilities, etc.).	2		
		b	Protect existing viewsheds permanently via environmental or conservation easements.	1		
		2-5 a	Where appropriate for urban projects, include period or community appropriate street furniture/lighting/appurtenances.	1		
		b	Color anodizing of aluminum elements (ITS cabinets, non-decorative light poles, etc.)	1		
		2-6 a	Inclusion of visually-contrasting (colored and/or textured) pedestrian crosswalk treatments beyond ADA standard and in conjunction with surrounding aesthetic.	1		
		b	Site materials selection & detailing to reduce overall urban heat island effect.	1		
		2-7	Decorative bridge fencing (in lieu of standard chain link).	1		
		2-8	Use of concrete form liners (for bridge approach barriers, parapet walls, retaining walls, noise walls, bridge piers & abutments, etc.).	1		
		2-9	Imprinted concrete/asphalt mow strips, gores and medians/islands.	1		
		2-10				
		2-11				

(Table 8: Final Scorecard cont'd)

CATEGORY		ID		DESCRIPTION	POINTS AVAIL.	POINTS N/A	POINTS SCORE
SUSTAINABLE SITES	Land Use/Community Planning	3-1	a	Use of more engaging public participation techniques/enhanced outreach efforts that go above the GDOT required minimum. Was the public involved in the design beyond being informed?	2		
			b	Project reports and community outreach materials are available online on a separate web page beyond the standard project specific web page.	1		
			c	... are provided in multiple languages.	1		
		3-2		Projects better enabling use of public transit (ex.- bus shelters, 'Park & Ride').	2		
		3-3		Projects that increase transportation efficiencies for moving freight (ex.- dedicated rail, intermodal facilities, the use of unit trains to remove trucks from highways and conserve fuel).	2		
		3-4		Was land or another resource donated to the project by public or private entities as a project-specific agreement (ex.- advanced technology, environmental betterment, financial assistance).	2		
		3-5		Project is consistent with local and regional plans beyond those generated by the ARC/local MPO, and/or local Smart Growth-based master/comprehensive plans (ex.- waterfront revitalization plans, greenway plans, the Scenic Byway program, other statewide non-transportation plans with regional components).	2		
		3-6		Establishment of a new recreational access facility (trailhead parking, boat launch, info/map kiosk, etc.).	2		
		3-7		Establishment of a new recreational facility (pocket park, roadside overlook, roadside picnic rest area, etc.).	2		
		3-8		Enhancement of an existing recreational facility or enhancement of an existing recreational facility access.	1		
		3-9					
		3-10					
	Protect, Enhance or Restore Wildlife Habitat	4-1	a	Mitigation of habitat fragmentation through use of significant techniques (ex.- raised roadways to conserve ecological continuity of rare plant/ wildlife communities and migration corridors, dedicated 'eco viaducts').	3		
			b	Partial mitigation of habitat fragmentation through techniques such as over sizing culverts or providing wildlife crossing structures that allow for the safe passage of aquatic and/or non-aquatic species passage across highways without their crossing directly on the roadway (US Army Corp of Engineers regional conditions).	2		
		4-2		Protect new or expanded habitat with environmental/ conservation easement.	2		
		4-3		Provide for enhancements to existing wildlife habitat (ex.- bird & bat houses, nesting boxes/ areas, avoiding sensitive habitat, etc.).	2		
		4-4		Wetland restoration, enhancement, or establishment that is above and beyond what is required to obtain a wetland-related permit.	2		
		4-5		Use of wildlife mortality reduction measures such as right-of -way fence, deer signs, etc.	1		
		4-6		Stream restoration/enhancement.	1		
		4-7		Installation of mowing markers to protect natural areas/wetlands.	1		
		4-8					
		4-9					

(Table 8: Final Scorecard cont'd)

CATEGORY		ID	DESCRIPTION	POINTS AVAIL.	N/A	SCORE
SUSTAINABLE SITES	Protect, Plant or Mitigate Removal of Trees and Plant Communities	5-1	Avoidance/protection of significant contiguous stands of established, desirable trees/ plant communities, especially those showing signs of self-regeneration.	2		
		5-2 a	Designs which demonstrate, through a combination of preservation and new planting, an anticipated ultimate net increase in tree canopy cover within the project limits (new trees at projected maturity).	2		
		b	Designs which demonstrate no ultimate net loss of tree canopy within the project limits (minimum one-to-one replacement) or, if overall available planting area has been reduced, mitigation with trees to the extent possible for trees lost (either on or offsite).	1		
		5-3	Re-establishment or expansion of native vegetation into reclaimed work areas or abandoned roadway alignments. (ex.- native seed mixes, "re-forestation" approach w/ multiple seedlings rather than traditional large nursery stock, etc.).	2		
		5-4	Use of trees, large shrubs or other suitable vegetation in lieu of traditional turf grass.	2		
		5-5	Avoidance/protection of individual existing significant trees and localized areas of established desirable vegetation within the project limits.	1		
		5-6	Removal of undesirable plant species, in particular removal/burial of invasive species, to preserve desirable overall species diversity.	1		
		5-7	Preserving, replacing, or enhancing vegetation associated with historic properties or districts, or which maintain the character of unique areas.	1		
		5-8				
		5-9				
WATER QUALITY & QUANTITY	Stormwater Management (Volume & Quality)	6-1	In addition to the Erosion, Sedimentation, and Pollution Control plans for the project construction, was an effort made to design and maintain post-construction BMPs, which improve water quality or nearby habitat through the use of stormwater retrofitting, stormwater crediting strategies, stream restoration, sediment points, swales, etc.)	2		
		6-2	Demonstrate a reduction of pollutant loadings to adjacent water resources.	2		
		6-3	Reduction in overall impervious area (post-project impervious surface area to be less than existing).	2		
		6-4	Design includes more than minimum erosion & sediment control practices.	1		
		6-5	Requirements for staged construction such that < 5 acres of bare soil is exposed at any time (GDOT specifies < 17 acres).	1		
		6-6				
		6-7				
	Best Management Practices	7-1	Design features that make use of highly permeable soils to remove surface pollutants from runoff (ex.- wet or dry swales, infiltration trenches or basins, bioretention cells or rain gardens, grass buffers and stormwater wetlands that treat water quality and water quantity requirements in accordance with GA DOT)	2		
		7-2	Use of other structural BMPs including sand filters, filter bags, stormwater treatment sys (ex.- oil/grit separators and hydrodynamic devices), underground detention systems or catch basin inserts.	2		

(Table 8: Final Scorecard cont'd)

CATEGORY		ID	DESCRIPTION	POINTS AVAIL.	N/A	SCORE
WATER QUALITY & QUANTITY	Best Management Practices	7-3	Inclusion of permeable pavement if practical (ex.- grid pavers), or Porous European mix and open graded friction course (according to the University of Texas, this type of pavement system may provide significant filtration of roadway pollutants and can be used on high volume roadways).	2		
		7-4	Include grass channels, where appropriate (per research at Georgia Tech, utilizing turf reinforcing mat, TRM, may facilitate the use of grass channels where previously uninstallable).	1		
		7-5				
		7-6				
MATERIALS & RESOURCES	Reuse of Materials	8-1 a	Specify that 80-100% of topsoil removed for grading is reused on site if soil survey deems treatment reasonable.	2		
		b	Specify that 50% or more of topsoil removed for grading is reused on site if soil survey deems treatment reasonable.	1		
		8-2	Reuse of excess fill ('spoil') within the project corridor to minimize project site material in and out.	2		
		8-3 a	Recycling and reuse of Portland Cement Concrete pavement via rubblizing or crack and seating of the current PCC.	2		
		b	Reuse of previous pavement as subbase during full-depth reconstruction projects.	2		
		c	Specify the processing of demolished concrete to reclaim scrap metals and to create a usable aggregate material.	2		
		8-4 a	Reuse of excess excavated material, asphalt pavement millings, or demolished concrete by another municipality or state agency.	2		
		b	Reuse at nearby abandoned quarries to help fulfill an approved EPD reclamation plan.	1		
		8-5 a	Reuse of major structural elements such as bridge piers, bridge structure, etc. if warranted and appropriate and does not compromise the feature life cycle.	2		
		b	Reuse of elements of the previous structure (ex.- stone veneer, decorative railing, etc.).	1		
		8-6	Reuse of granite curbing (i.e.- remove and reset versus remove and replace).	1		
		8-7 a	Salvaging removed trees for lumber or similar uses other than standard wood chipping (ex.- allow community removal of plants and trees).	2		
		b	Specifying the recycling of chipped untreated wood waste for use as mulch and/or ground cover (Note: pressure/ preservative-treated or painted/coated wood must be disposed of properly).	1		
		c	Incorporate an on-site location for chipped wood waste disposal from clearing and grubbing operations rather than burning.	1		
		8-8	Project documents make scrap metals available for reuse/recycling.	1		
		8-9	Specify the salvage/moving of houses rather than demo for disposal in landfills.	1		
		8-10	Implement a project specific innovative re-use of otherwise waste material.	1		
		8-11				
		8-12				

(Table 8: Final Scorecard cont'd)

CATEGORY		ID	DESCRIPTION	POINTS AVAIL.	N/A	SCORE
MATERIALS & RESOURCES	Recycled Content	9-1	Use of porous pavement systems in light duty situations (ex.- sidewalks, truck turnarounds, rest stops, parking lots, police turnarounds).	2		
		9-2	Specify PCC pavement mixes with Recycled Concrete Aggregate.	2		
		9-3	Specify in-place recycling of hot mix asphalt pavements.	2		
		9-4	Specify use of recycled glass in pavements and embankments, as drainage material or filter media from adequate local sources.	2		
		9-5	Use recycled plastic extruded lumber, recycled tire rubber, crumb rubber, or recycled plastic (ex.- for noise barriers).	1		
		9-6	Use tire shreds in embankments.	1		
		9-7				
		9-8				
	Bio-Engineering Techniques	10-1	Project designs that utilize soil bioengineering treatments along water bodies/wetlands (the reliance on plant material for slope protection, rebuilding, stabilization, and erosion control).	2		
		10-2	Project designs utilize soil biotechnical engineering treatments along water bodies/wetlands (combination of structural elements/ plant materials to achieve slope protection, stabilization, rebuilding, and erosion control: vegetated crib walls, gabions, Geosynthetic Reinforced Earth Systems (GRES), geocells, and mats).	2		
		10-3	Projects using targeted biological control methods to reduce invasive species.	2		
		10-4	Project designs that utilize soil bioengineering treatments or soil biotechnical engineering treatments in upland areas.	1		
		10-5	Project designs utilizing soil biotechnical engineering treatments NOT along water bodies or wetlands.	1		
		10-6				
		10-7				
	Hazardous Material Minimization	11-1	Project design substantially minimizes the need to use hazardous materials (ex.- steel or concrete RR ties instead of treated wood), increases the interval before reconstruction must be performed using hazardous or toxic materials, and/ or improves durability of components containing hazardous substances.	2		
		11-2	Project design specifies less hazardous materials or avoids generating contaminated wastes by reducing the volatile organic compounds (VOCs) or hazardous air pollutants (HAPs) emitted during project construction (ex.- use of non-solvent traffic/bridge paints, lower VOC/nonhazardous air pollutant bridge deck sealers) and by eliminating or reducing toxic metals/components.	2		
		11-3	Removing/disposing of contaminated soils beyond what is necessary for project construction.	1		
		11-4				
		11-5				

(Table 8: Final Scorecard cont'd)

CATEGORY		ID		DESCRIPTION	POINTS AVAIL.	N/A	SCORE
ENERGY & ATMOSPHERE	Improve Traffic Flow	12-1		Special use lane (HOV/Reversible/Bus Express).	2		
		12-2	a	Innovative interchange design and/or elimination of freeway bottlenecks (diverging diamond, single point urban, etc.).	2		
			b	Specify new roundabout(s).	1		
		12-3		Road Diet (reduction of travel lanes to incorporate a single bidirectional center turn lane and wider right-hand lanes to accommodate bicycles).	2		
		12-4	a	Implementation of a corridor-wide access management plan.	2		
			b	Limiting/consolidating access points along highway.	1		
		12-5	a	Installation of a closed-loop coordinated signal system.	2		
			b	Improving a coordinated signal system and other signal timing and detection systems (ex.- GPS integration).	2		
			c	Installing higher capacity controllers with features to improve flow and reduce delay at intersections.	1		
		12-6		Installation of a transit express system (queue jumper, pre-emptive signals, etc)	2		
		12-7		Expand and anticipate expansion of Traffic Management/ Traveler Information System operation with existing system coverage (ex.- increase/improve density of devices, install conduit in anticipation of future expansion/needs, installation of VMS, CCTV, etc.)	1		
		12-8		Inclusion of strategies to manage traffic during construction such as an incident management/ traveler information/ integrated traffic system (ex.- queue/speed warning, VMS with real time construction information, tow/HELP vehicles on site/standby, CCTV monitoring of construction zone, etc.).	1		
		12-9		Installation of isolated systems to provide for spot warning (queue warning, truck rollover, low bridge, no trucks allowed, etc.).	1		
		12-10		Adding bus turnouts.	1		
		12-11					
		12-12					
	Reduce Electrical Consumption	13-1		Solar/battery powered street lighting or warning signs.	2		
		13-2		Replace overhead sign lighting with higher type retro-reflective sign panels.	2		
		13-3		Use of LED street lighting.	2		
		13-4		Solar bus stops.	2		
		13-5		Use of LED warning signs/flashing beacons.	1		
		13-6		Retrofit existing street/sign lighting with high efficiency types.	1		
		13-7					
		13-8					
	Reduce Petroleum Consumption	14-1	a	Provide new intermodal connections.	2		
			b	Improve an existing intermodal connection (ex.- add BRT station, kiosks, etc.).	1		
		14-2	a	Provide new Park & Ride lots.	2		
			b	Operational improvements of an existing Park & Ride lot.	1		
			c	Improved shading through vegetation at Park & Ride lots to cut down on heat island effect and the use of automotive air conditioning by waiting motorists.	1		
		14-3		Increase bicycle amenities at Park & Rides and transit stations (bike lockers/shelters, Web-based reservations system for lockers, providing showers or partnering with health clubs for these services).	2		

(Table 8: Final Scorecard cont'd)

CATEGORY		ID		DESCRIPTION	POINTS AVAIL.	N/A	SCORE
ENERGY & ATMOSPHERE	Reduce Petroleum Consumption	14-4		Incorporate ITS technology to improve traffic flow.	2		
		14-5		Reduce mowing areas outside of the clear zone, reestablishing natural ground cover and/or seeding with low maintenance seed species. Example: Incorporation of Conservation Alternative Mowing Practices (CAMPS) techniques/guidance into design plans.	1		
		14-6		Use of warm or cold mix asphalt.	1		
		14-7		Documented analysis proving the project design reduces either the Department's or the local community's carbon footprint.	1		
		14-8					
		14-9					
	Improve Bicycle & Pedestrian Facilities	15-1		New grade-separated (bridge or underpass) bike/pedestrian crossing structure (this item is not for replacements or rehabs).	3		
		15-2	a	New separated bike paths or work with local communities to create parallel bike routes where state roads are not suitable for cyclists.	2		
			b	Separate bike lane at intersection.	2		
			c	Shoulder widening or restoration to provide for on-road bike lane.	1		
		15-3	a	Create new, extend existing, or make space available for future sidewalks to increase walkable areas and provide continuity for pedestrian travel.	2		
			b	Sidewalk/bikeway rehabilitation, widening, realignment or repair.	1		
		15-4	a	New curb bulb-outs and/or raised medians/ pedestrian refuge islands.	2		
			b	New crosswalks.	1		
			c	New curbing (where none previously existed), to better define the edge of a roadway and to provide vertical separation of pedestrian facilities; does not include flush, mountable or bridge curbing.	1		
			d	Provide mid-block crossing where applicable/reasonable.	1		
		15-5	a	New pedestrian signals.	2		
			b	Upgrade pedestrian signals - include pedestrian buttons and/or addition of audible signal, countdown timers.	1		
			c	"Pedestrian All Stop" phase programmed into a traffic signal and/or button actuated "No Turn on Red" LED sign where applicable/ reasonable.	1		
			d	Installation of bicycle detectors (quadrupoles) at signalized intersections.	1		
		15-6		New speed hump/ speed table/ raised intersection.	1		
		15-7		New or relocated highway barrier or repeating vertical elements (trees, lampposts, bollards, rural mailboxes, etc.) between roadway & walk/bikeway to better separate/delineate motorized and non-motorized travel ways.	1		
		15-8		Installation of bikeway signs, "Share the Road" signs, and/or Sharrow (shared lane) pavement markings.	1		
		15-9		Permanent digital "Your Speed is XX" radar speed reader signs.	1		
		15-10		Provide motorists with advanced warning of pedestrian crossings where applicable (ex.- overhead flashing beacon, lighted "Crosswalk" sign, half signal, or pedestrian hybrid ('hawk') signal; advanced warning of crosswalk with signs and yield pavement markings).	1		
		15-11		Make crosswalks more visible to motorists (ex.- in-street plastic pylon 'State law - Yield to Pedestrians' signs; utilize high visibility, reduced wear, staggered ladder bar crosswalks (modified Type L - sometimes referred to as a 'piano key' type crosswalk).	1		
		15-12					
		15-13					

(Table 8: Final Scorecard cont'd)

CATEGORY		ID	DESCRIPTION	POINTS AVAIL.	POINTS N/A	POINTS SCORE
ENERGY & ATMOSPHERE	Noise Abatement	16-1	Construction of a new noise barrier.	2		
		16-2	Incorporate traffic system management techniques to reduce prior noise levels (ex.- use of truck routes, progressive traffic signals, lowering speeds).	2		
		16-3	Provide a buffer zone for adjacent receptors (ex.- hospitals, libraries, schools).	2		
		16-5	Diamond grinding of existing Portland Cement Concrete (PCC) pavement.	2		
		16-6	Rehabilitation of an existing noise wall.	1		
		16-7	Berms designed to reduce noise.	1		
		16-8	Provide planting to improve perceived noise impacts.	1		
		16-9				
		16-10				
	Stray Light Reduction	17-1	Retrofit existing light heads with full cut-offs.	2		
		17-2	Use cut-offs on new light heads.	1		
		17-3				
		17-4				
INNOVATION	Innovation	18-1				
		18-2				
		18-3				
		18-4				
		18-5				
		18-6				

5.2 Recommended Use

Currently this thesis has not been presented to GDOT, and thus has no feedback with which to base an official manual or method of use. However, the project team has created several concepts for use that will be presented to GDOT soon. These will be discussed further in the Future Research section.

CHAPTER 6: CONCLUSIONS

Sustainability has gained momentum and strength over much of the past decade. Many disciplines are considering methods to consider the relative ‘greenness’ of projects undertaken, and the transportation sector is no exception. There are programs emerging to consider the level of sustainability of a project from consulting, academia, state and local DOTs, as well as Federal and international initiatives that consider how the current population is managing environmental and economic stewardship for generations to come. While not yet mandatory, there may be a day when a sustainability rating system meant for the transportation sector becomes obligatory. This thesis presented an overview of the current and emerging trends and programs in transportation sustainability in order to select a design basis that could be catered to the State of Georgia. This effort helps enable GDOT to adopt a rating system for sustainable streets and highways in order to stay ahead of the curve, and to ensure that the institution is able to refer to a system that caters to Georgia’s unique regional differences.

It was necessary to produce a system that would be simple to use and efficient. The New York State GreenLITES program was selected in order to model a new Georgia-specific system from the solid foundation of an already highly functional program. GreenLITES was also deemed credible for GDOT because the New York DOT has been able to use the program widely and successfully across a broad range of projects and over a longer period of time. The other programs have been less tested thus far, but have the potential to provide useful insight and guidance in the future.

However, GreenLITES is catered specifically to New York State, and does not consider regional differences in Georgia. Thus, feedback from a small team of GDOT practitioners was necessary in order to capture critical components for roadway sustainability in Georgia. The scorecard evolved from GreenLITES into a scorecard that has been catered to, and will be presented to a broader audience at GDOT in the near future. The final scorecard has fewer line items than GreenLITES, and perhaps is more concise and easier to read; similar criteria were combined or rearranged to aid the flow of going through the worksheet.

In addition to the physical changes to the scorecard, the project team also intends to propose a slightly different method of implementation for the rating of projects. Several considerations for implementation will be further documented in the Future Research section of this report, Chapter 7. Most notably, the project team would highly recommend that scoring and point allocation change to reflect a normalized score. Because project sizes and types vary immensely, and because the scorecard presented in this thesis covers a wide range of metrics, the implication of scoring based on a non-normalized point system is unreasonable. It is inevitable that the wide variety of sustainable initiatives encompassed in the scorecard will not always apply in entirety to the varying scopes of each and every project presented. Therefore, the project team chose to add a column to the scoring system, in which the user can note whether or not a specific item is even applicable to that particular project. Totals will be scored not over the entire points available, but the points available specifically to that project. In this way, the project team believes that projects will be considered more efficiently and effectively than otherwise.

CHAPTER 7: FUTURE RESEARCH

7.1 Implementation Considerations for GDOT

Ideally, the rating process will take a minimal amount of time, in order to make a negligible dent in man-hours and cost for each project. Beyond man-hours, there are several other areas of consideration that will be discussed during the final meeting with GDOT and transportation officials. The following list of questions needs to be addressed before preparing the final manual for implementation:

- How much time would be spent rating projects?
  - How many projects does GDOT do yearly? Would all projects be rated or only some projects?
  - How much time is GDOT willing to devote to rating projects?
- Who will rate projects?
  - Project engineer only?
    - Will there be too much bias?
    - What about variation in point awarding between project engineers?
  - Prepare a committee (maybe changing yearly) that rates others' projects?
    - Should this committee rate the project with the project engineer?
    - Will having a committee reduce individual bias/ add consistency in rating?
    - How many people should be part of this committee?
- Would the rating system be used primarily in project selection or for awarding completed projects?
  - How do we help ensure a rating system contributes to the evolution of more sustainable projects?
- Should there be a program review process at specified intervals to promote program evolution and relevancy?
  - How about program review at the one-year mark.
- How does GDOT record the benefits/ costs of utilizing the rating system program? What should GDOT consider to best evaluate the rating system?
  - Point distribution of projects rated over a period?
  - Number of projects that were positively changed (became more sustainable) by utilizing the rating system?
    - How do we record changes that were influenced specifically by the rating system?

- In project selection, can GDOT discern that the ‘most sustainable’ projects – as measured by the rating system – were the ‘right’ projects to choose?

Point allocation is an area with which the new scorecard should likely differ from GreenLITES. As stated in the literature review, comparing and contrasting areas of sustainability is a highly complex process due to the potential for overlap as well as the difficulty in finding a common unit for all comparison values. Additionally, the scope of each individual project may cause that particular job to be excluded entirely from a certain number of the items that the scorecard includes. A small repair project cannot possibly be considered for the same number of items as a several-mile new construction project. Because of this discrepancy between project size, type, etc., the project team decided that it would be important to propose to GDOT to consider only the points available and applicable to each project’s scope, instead of counting points across the board. For this to work, the project team added a column titled “Not Applicable” to the scoring system that previously only included ‘Points Available’ and ‘Score.’ This column should allow practitioners to consider a project against points it could possibly achieve, rather than all points that may be applicable to any and every type and size of project. With this new version of scoring, it would be challenging to categorize all project types and sizes to consider an overall point allocation for each. Thus, the project team has proposed that points are normalized across each subcategory in order to determine a percent achievement determined by points awarded against available points per project. This normalization would allow GDOT to consider the percent achievement across categories, and overall, for each project. GDOT may further want to categorize percent achievements into categories, or ‘award levels,’ to better present the results to the public. This may be important since the general public likely is familiar and comfortable with the typical grading scale in schools, for which 100-90% is an A, 90-80% is a B, etc. This familiar scale would not be analogous to the sustainability rating scale, since all points allocated are actually "above and beyond" what is required, not a grade-level considering all possible areas that should and must be completed. Similar to the GreenLITES award level scale shown in Figure 9 in the Literature Review section, GDOT may wish to create a scale that considers normalized, rather than prescriptive, point allocation.

GDOT may wish to consider making their own rating tool available for use outside their institution. This could be available solely as a self-evaluation tool, meant to provide information only. Alternatively, GDOT could sponsor a program that would review both in-house and projects outside of GDOT and award outstanding leadership in environmental stewardship. In order to provide this program with minimal additional man-hours, the New York DOT provides a publicly available scorecard for self-evaluation by project sponsors. Although GDOT would have to create a steward of the program, or a team of individuals to run the program, the concept is not that this team or individual would do the assessment, but rather consider the self-evaluation that a project sponsor would send in.

It would be important to review the program after a year of use in order to determine how effective the rating system has been, the benefits associated with rating projects, and to review the areas in which GDOT has both exceeded expectations, as well as the areas which are lacking and could use improvement. Thereafter, if the program is considered successful and worth pursuing in future years, it is likely that it would need to be reviewed on a regular basis to ensure that the program is keeping up to date with the state of the art in sustainable practices.

7.2 Limitations of this Thesis

The final scorecard is only relevant if research in the area of sustainability remains unchanged. As multi-disciplinary research teams continue to consider how to measure sustainable attributes and implement new approaches to reduce the consumption of energy and natural resources, so must the scorecard evolve to continually consider the current state-of-the-art. By nature, anything that is the state-of-the-art in its area must continually evolve to keep up with the times. However, regardless of the new and improved methods that become available, practitioners will have to start considering questions such as "Are we building ultra-durable roads that may outlast their demand?" While remote, there is a possibility that transportation, as we know it, highly dependent on roadways, will become obsolete. For instance, there may be a day when air travel constitutes the majority of the transport of people, goods, and services.

Perhaps the most notable limitation of the type of rating system chosen is its subjectivity and its potential to be manipulated by the reviewer. A subjective system may be unavoidable, however, in order to maintain an efficient and straightforward rating system without involving complex comparisons (utilizing LCA/LCCA analyses) among the numerous sectors that encompass the infrastructure industry.

It is important to consider the ‘big picture,’ the overall life and implications of the infrastructure project being undertaken. As noted in the Literature Review, one must consider if the building of roads and infrastructure is sustainable in of itself. Is it sustainable to build this road? Is there an alternative that would produce much more benefit for the far future, while still meeting the demands of today?

REFERENCES

AASHTO. (2011). *AASHTO Comments Concerning FHWA's Sustainable Highways Self-Evaluation Tool.* Washington, D.C.: AASHTO.

Anderson, J. (2010, June). Taking Credit: New tool can help managers recognize LEED points. *Roads & Bridges* , 30-33.

ASCE, ACEC, APWA. (December, 2010). *Sustainable Infrastructure Project Rating System: Version 1.1.* Institute for Sustainable Infrastructure.

CH2M Hill, University of Washington. (2009, May 28). *Greenroads*. Retrieved October 11, 2010 from The Greenroads Rating System: http://www.greenroads.us

Demich, G. (2010). STEED: A Greenscale for Continuous Improvement. *Sustainability in Highway Design* (p. 51). Denver: H.W. Lochner, Inc.

Federal Highway Administration. (2011, January). *Transportation Planning for Sustainability Guidebook*. Retrieved January 10, 2011 from FHWA Highways & Climate Change: www.fhwa.dot.gov/hep/climate/resources.htm#sustain

FHWA. (2011). *Transportation Planning for Sustainability Guidebook.* Federal Highway Administration. Atlanta: Federal Highway Administration.

Green Highways Partnership. (2008, September 4). *Green Highways Partnership*. Retrieved September 30, 2010 from Sustainable Transportation, Stormwater, Stewardship, Ecosystems, Recycling: http://www.greenhighways.org/index.cfm

IDOT, I. A.-I. (2010, January 8). Illinois - Livable and Sustainable Transportation Rating System and Guide. Illinois Department of Transportation.

Jeon, C. M. (2007). *Incorporating Sustainability into Transportation Planning and Decision Making: Definitions, Performance Measures, and Evaluation.* Georgia Institute of Technology, Civil and Environmental Engineering. Atlanta: Georgia Institute of Technology.

Lee, J., Edil, T. B., Benson, C. H., & Tinjum, J. M. (2010). The Wisconsin Green Highway Construction Rating System. *Use of BE2ST in Highways for Green Highway Construction Rating in Wisconsin* (pp. 480-491). Denver: University of Wisconsin.

Muench, S. (2009). The green road to urban design: Revitalization meets sustainability in Bothell, Washington. *American Planning Association National Planning Conference.* Minneapolis: APA.

Muench, S., Anderson, J., & Soderlund, M. Greenroads A Sustainability Performance Metric for Roadways. *Journal of Green Building , 5* (2), 114-128.

NYSDOT. (2008). *GreenLITES Project Design Certification Program*. Retrieved November 25, 2008 from New York State Department of Transportation: https://www.nysdot.gov/programs/greenlites

NYSDOT. (2009, April 22). *NYSDOT Press Releases*. Retrieved May 28, 2009 from State Transportation Commissioner Glynn Celebrates Earth Day: Announces GreenLITES Expansion & Adoption by Thruway and Bridge Authorities: https://www.nysdot.gov/press-releases/2009/2009-04-22

Osterhues, M. (2006). On the Way to Greener Highways. *Public Roads* , 41-45.

Oxtoby, D. (2010, July 31). A university strives fo the high road to sustainability. *Science News* , 32.

Pan Chan, P. C. (2010). Quantifying Pavement Sustainability for Ontario. *University of Waterloo* .

Soderlund, M., Muench, S. T., A., W. K., Uhlmeyer, J. S., & Weston, J. (2008). Green Roads: Sustainability Rating Systems for Roadways. *Transportation Research Board 87th Annual Meeting* (p. 21). Washington, D.C.: TRB.

South African Institution of Civil Engineers. (2010, August). Road Surfacing Industry Suggests Greening its Footprint for Sustainable Development. *Magazine of the South African Institution of Civil Engineers* , 64.

T&DI/ASCE. (2010). *T&DI/ASCE Green Streets and Highways Conference.* T&DI/ASCE. Denver: T&DI/ASCE.

Wathne, L. (2010). Sustainability and Pavements: Are We Focusing on the Right Things? *T&DI/ASCE Green Streets and Highways Conference.* Denver: ACPA.