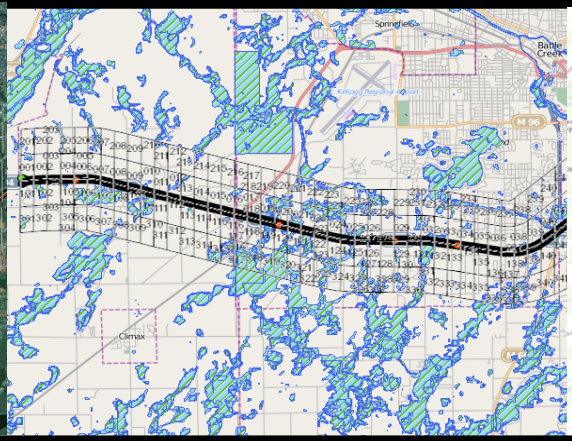
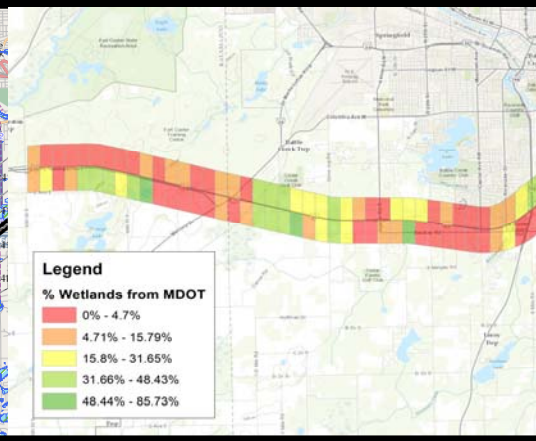
Decision Framework for Corridor Planning within the Roadside Right-of-Way

MDOT ORBP Reference Number: OR12-014

FINAL REPORT





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16. Abstract

A decision framework was developed for context-sensitive planning within the roadside ROW in Michigan. This framework provides a roadside suitability assessment model that may be used to support integrated decision-making and policy level considerations for ROW use and development. The model accommodates a broad range of potential types of ROW developments and corridor conditions, while considering a diverse range of roadside contextual features, including land use (current and future), land cover, environmental features, natural resources, and plant and animal habitats, among other features. The primary function of the model is to determine the area(s) along a highway corridor that are most (or least) suitable for development within the roadside ROW. Calculation of a suitability index for each area along a corridor provides a relative indication of the overall suitability for development within the roadside ROW. The roadside suitability assessment was demonstrated using a 20-mile pilot section of I-94 in Kalamazoo and Calhoun Counties within Michigan. Five types of non-traditional ROW development were considered for the corridor, including solar and wind power production, vegetation management/landscaping, agriculture/farming, and green infrastructure. The resulting suitability index scores showed good relative agreement with standard land-use planning considerations. Robust and accurate statewide geospatial data is crucial for effective utilization of this model. To that end, recommendations for reconciliation of gaps in the existing geospatial datasets were provided.

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EXECUTIVE SUMMARY

Roadside public rights-of-way (ROW) serve many societal, economic, and environmental functions within the highway corridor. Many of these functions require development or installation of various features and/or components within the ROW. Until recently, such developments have typically been limited to projects that include transportation infrastructure, public utilities, or drainage. However, several states, including Michigan, have begun to investigate non-traditional types of development within the roadside ROW. Such projects have involved renewable energy production, including wind, solar and biofuels, or other non-traditional uses such as vegetation management and environmental preservation/remediation.

Decisions related to roadside development are often complex and require consideration of many factors related to areas both within and adjacent to the corridor. Although state and federal policies and guidelines exist to help guide planning and permitting decision for traditional uses of roadside ROW, non-traditional developments are typically not covered within these documents. Additional complications arise when project permitting requests originate from outside sources, particularly private entities, as special partnership agreements may be necessary. Furthermore, extensive data requirements are often necessary to assist in determining suitable locations for such projects.

As a result, research was undertaken to develop a framework for landscape-level context-sensitive planning related to development within the roadside ROW on corridors owned by the Michigan Department of Transportation (MDOT). Several tasks were required during development of this framework, including identification of roadside functions and values, identification and prioritization of relevant contextual datasets, availability of such datasets in a geocoded format, and development of analytical procedures. The resulting framework provides a roadside suitability assessment model to support integrated decision-making and policy level considerations for ROW use and development. The model accommodates a broad range of potential types of ROW developments and corridor conditions, while considering a diverse range of roadside contextual features, including land use (current and future), land cover, environmental features, natural resources, and plant and animal habitats, among other features.

The primary function of the model is to determine the area(s) along a highway corridor that are most (or least) suitable for development within the roadside ROW. This suitability assessment process involves an initial assessment of several critical criteria followed by a

subsequent spatial analysis of relevant roadside contextual features using a geographic information system (GIS). A Roadside Suitability Index (RSI) is calculated for each roadside area along a corridor (or series of corridors) that is being considered. The RSI provides an indication of the overall suitability of the particular area for a proposed development within the roadside ROW, relative to all areas under consideration. A summarized list of steps for the roadside suitability assessment is provided as follows:

1. Assemble necessary GIS shapefiles;
2. Using GIS, create a grid to subdivide the desired section(s) of roadside corridor into cells of uniformly sized area;
3. Compute the raw data scores for each contextual feature within each cell using GIS and scale the raw data scores relative to all sections under consideration;
4. Determine ratings (weights) for each of the contextual features with respect to the compatibility (or lack thereof) of a proposed development in the adjacent ROW;
5. Calculate the Roadside Suitability Index (RSI) for each cell as the scaled raw score (Step 3) multiplied by the rating (Step 4) sum totaled over all contextual features.
6. Using the RSI, determine the relative suitability of the proposed roadside ROW development for each section of the corridor.

Robust and accurate statewide GIS enterprise data is crucial for effective utilization of this framework and for roadside corridor planning and management in general. To those ends, a plan was prepared to reconcile gaps in the existing geospatial datasets. The recommended data gap reconciliation efforts are summarized as follows, with highest priority tasks listed first:

1. Georeference MDOT ROW lines and excess parcel boundaries statewide;
2. Georeference MDOT's Real Estate Management Information System (REMIS).
3. Georeference Michigan's current and proposed non-motorized facilities.
4. Perform global positioning system (GPS) field data collection to provide shapefiles for floodplains, well logs, and billboards for all MDOT ROW statewide.
5. Establish a program to require georeferencing of all contract soil boring activity performed within MDOT ROW statewide.
6. Develop a georeferenced underground utility location dataset for MDOT ROW.
7. Develop a shared online GIS repository to allow for sharing of local zoning and master land use plans that are typically maintained within local agencies.

The roadside suitability assessment process was demonstrated using a 20-mile pilot section of Interstate 94 between Exits 88 and 108 in Kalamazoo and Calhoun Counties. Five types of non-traditional ROW development were considered for the corridor, including: solar power generation, wind power generation, vegetation management/landscaping, agriculture/farming, and green infrastructure (i.e., stream mitigation, wetland mitigation, etc.). A grid of ¼ mile long by ½ mile wide (80 acre) areas was established along both sides of the 20-mile corridor. A default set of compatibility ratings was developed for each type of development based on the average ratings obtained from members of the MDOT Research Advisory Panel for this project. From there, RSI scores were calculated for each area considering each of the proposed non-traditional development types.

Comparison of the RSI scores along the pilot corridor found the results to generally be in-line with standard land-use planning considerations. In the case of wind and solar power generation and agricultural uses (including biofuel), the most suitable areas for such developments within the roadside ROW were typically adjacent to rural and predominately agricultural lands. The most suitable areas for vegetation management in the ROW were locations with forested areas in and/or adjacent to the ROW. Wetland or forested/open areas tended to be the most suitable candidates for green infrastructure. Urbanized areas were typically the least suitable for each of the proposed development types. Additionally, wetlands, areas with rare species, and forested areas in or immediately adjacent to the ROW were generally not suitable for solar, wind, or agricultural developments.

The initial suitability assessment of the pilot corridor was based on consideration of all contextual data, including data originating from both geospatial and non-geospatial sources. However, consideration of non-geospatial data required manual creation of a GIS shapefile, which utilized a considerable amount of time and resources. A subsequent recalculation of the RSI scores was performed for the pilot corridor using only the 21 contextual features derived from an existing statewide geospatial dataset with broad statewide coverage. A comparison of the RSI scores based on the geospatially sourced data versus the original scores that also included data from non-georeferenced sources found that the overall conclusions pertaining to the suitability of each area along the corridor were similar, but not identical. An additional suitability assessment was performed using a limited subset of seven comprehensive contextual features derived from three reliable geospatial datasets with broad statewide coverage. The RSI

scores generated based on these seven comprehensive features showed reasonably good agreement with scores generated using the full set of geospatially-sourced data, but showed less agreement with the scores from the full set of 33 contextual features. Although the use of this limited subset of contextual features would undoubtedly simplify the analytical process, thereby reducing time and/or resource constraints, additional testing is necessary at other locations to verify the accuracy.

It is impractical to assume that manual shapefile creation would typically be performed when using this process to assess other corridors throughout Michigan. Consequently, the 21 contextual features derived from geospatially sourced data with broad statewide coverage are recommended for statewide application of the roadside suitability assessment model. The recommended contextual features are listed as follows (the subset of seven comprehensive features is shown in boldface):

- **Agricultural Land Cover (% of area)**
- **Commercial/Industrial Land Cover (% of area)**
- **Residential Land Cover (% of area)**
- **Forest or Open Land Cover (% of area)**
- **Open Water (% of area)**
- **Wetlands (% of area)**
- **Average BioRarity Index (% of area)**
- Tribal Lands (% of area)
- Federal Lands (% of area)
- DNR Lands (% of area)
- Presence of MDOT Redbook Site (% of area)
- Wild and Scenic Waterways (length in mi)
- Trout Streams (length in mi)
- Total Maximum Daily Load (TMDL) Impaired Watersheds (% of area)
- Protected Wellhead (% of area)
- Number of Interchanges or Intersections
- Presence of Rest Area
- Number of Bridges
- Number of Monitoring Wells
- Number of Historical Sites
- MDOT Heritage Routes (length in mi)

Utilization of the suitability assessment framework for roadside development will benefit MDOT in several ways. The outcomes will enhance the ability for MDOT to make proper decisions pertaining to the use of ROW for non-traditional development. In addition, comparison of various developmental alternatives and/or contextual prioritization strategies will provide a better understanding of the impacts to competing interests or constraints with respect to agency needs or adjacent land uses. Further, inclusion of local data and stakeholders will help to ensure that developments within MDOT ROW are consistent with local objectives.

CHAPTER 1:
INTRODUCTION AND BACKGROUND

Roadside public rights-of-way (ROW) serve many functions, including safety, drainage, navigation, mobility, aesthetics, basic roadside services, parking, utility transmission, and enforcement. Many of these functions require development or installation of various features and/or components within the ROW (*1*), which include:

- Drainage features,
- Bridges and interchanges,
- Intersections and driveways,
- Rest areas,
- Roadside parks and scenic turnouts,
- Carpool parking lots,
- Weigh stations,
- Signage (static and dynamic),
- Roadside safety devices,
- Data collection devices,
- Vegetation and landscaping,
- Environmental preservation,
- Utilities,
- Lighting,
- Noise barriers and fences,
- Non-motorized facilities, and
- Roadway widening.

Decisions related to roadside development are often complex and require consideration of many constraints related to the area adjacent to the corridor, particularly the context of the surrounding land uses. For example, urbanized areas typically have built-out infrastructure, as well as higher population densities and land values, limiting the potential for acquisition of additional property that would be necessary for large-scale roadside developments within the right-of-way. This typically results in constrained urban roadside rights-of-way that are utilized for utility transmission, signage, noise barriers, and roadside safety devices, with little opportunity for large-scale development. Conversely, rural areas are generally less developed, with lower population densities and land values. Consequently, such areas often include larger-scale development, such as rest areas, roadside parks, and weigh stations. However, rural areas are also more likely to include environmentally sensitive areas, such as wetlands, waterways, watersheds, habitats, and wellheads, which may preclude certain types of developments.

Historically, roadside developments within the public ROW were typically initiated and maintained by either the jurisdictional entity or public utility, and development requests from outside entities were rare. However, the nationwide emphasis on renewable energy production coupled with maturation of the associated technology has led to several recent roadside ROW

development projects across the United States that have involved renewable energy, including wind or solar power generation and biofuel farming (*2*). Other non-traditional roadside ROW uses have also been implemented or proposed in several locations nationwide, including general farming, vegetation/forestry management, and environmental preservation or remediation. While established planning guidelines and permitting procedures for traditional roadside ROW development purposes, including utility transmission, have existed for many years (*3*), non-typical development requests present additional challenges that are generally not covered within the traditional planning/permitting processes for roadside development. As a result, roadway agencies have begun to seek additional guidance related to planning for non-traditional developments within the roadside ROW.

PROBLEM AND OBJECTIVES

Development within the roadside rights-of-way has been a common practice for roadway agencies for many years. Until recently, such developments have typically been limited to projects that include transportation infrastructure, public utilities, or drainage. However, several states, including Michigan, have begun to investigate, and in some cases pilot test, non-traditional types of development within the roadside ROW. Although state and federal policies and guidelines exist to help guide planning and permitting decision for traditional uses of roadside ROW, many of these non-traditional utilizations are not covered within these documents. Additional complications arise when such project permitting requests originate from outside sources, particularly private entities, as special partnership agreements may be necessary. Furthermore, extensive data requirements are often necessary to assist in determining suitable locations for such projects. As a result, a framework for context-sensitive planning within the roadside ROW was desired by the Michigan Department of Transportation (MDOT).

Research was undertaken by the Wayne State University – Transportation Research Group (WSU-TRG) to develop this framework for MDOT and address issues associated with planning for proposed roadside ROW development. The resulting framework would serve as a comprehensive corridor planning model to support integrated decision-making and policy level considerations for ROW use and development, while considering a broad range of roadside functions and values. The objectives of this research were as follows:

- Investigate existing geospatial datasets for applicability and compatibility to corridor contextual analysis by MDOT, including land use (current and future), land cover, zoning, environmental, property values, and growth patterns, among other datasets;
- Identify gaps within the existing geospatial datasets that are needed for MDOT to perform corridor contextual analyses and provide prioritized recommendations for future data collection to fulfill statewide data needs;
- Identify stakeholders to engage during the roadside corridor planning process;
- Develop a geographic information system (GIS) based procedure to compile contextual features and characteristics along MDOT corridors based on the available data;
- Create a decision framework that utilizes the available geospatial datasets along with other considerations to assess the suitability for development within the roadside ROW;
- Using the proposed framework, analyze a 20-mile pilot section of I-94 in Kalamazoo and Calhoun Counties between Exits 88 and 108. This will involve: 1) Identifying affected stakeholders, resource/regulatory agencies, local planning interests and community partners within the pilot area; 2) Obtaining all necessary datasets for the pilot corridor, including both geospatial and non-geospatial; 3) Analyzing and mapping the contextual features and characteristics along the pilot corridor; and 4) Assessing the suitability for roadside development along the pilot corridor considering various types of developments.
- Verify that the framework can be replicated for other MDOT corridors statewide.

SUMMARY OF TASKS

The research tasks that were performed to accomplish the project objectives are listed below and are summarized within the following flowchart. A full description of all work performed as a part of this research is provided in the chapters that follow.

- Task 1: Review of Literature and Practice
- Task 2: Conduct Agency Focus Group for Pilot Corridor
- Task 3: Assess and Obtain Required Datasets
- Task 4: Develop Contextual Analysis Framework
- Task 5: Identify Stakeholders
- Task 6: Perform Contextual Analysis for Pilot Corridor
- Task 7: Develop and Submit Deliverables

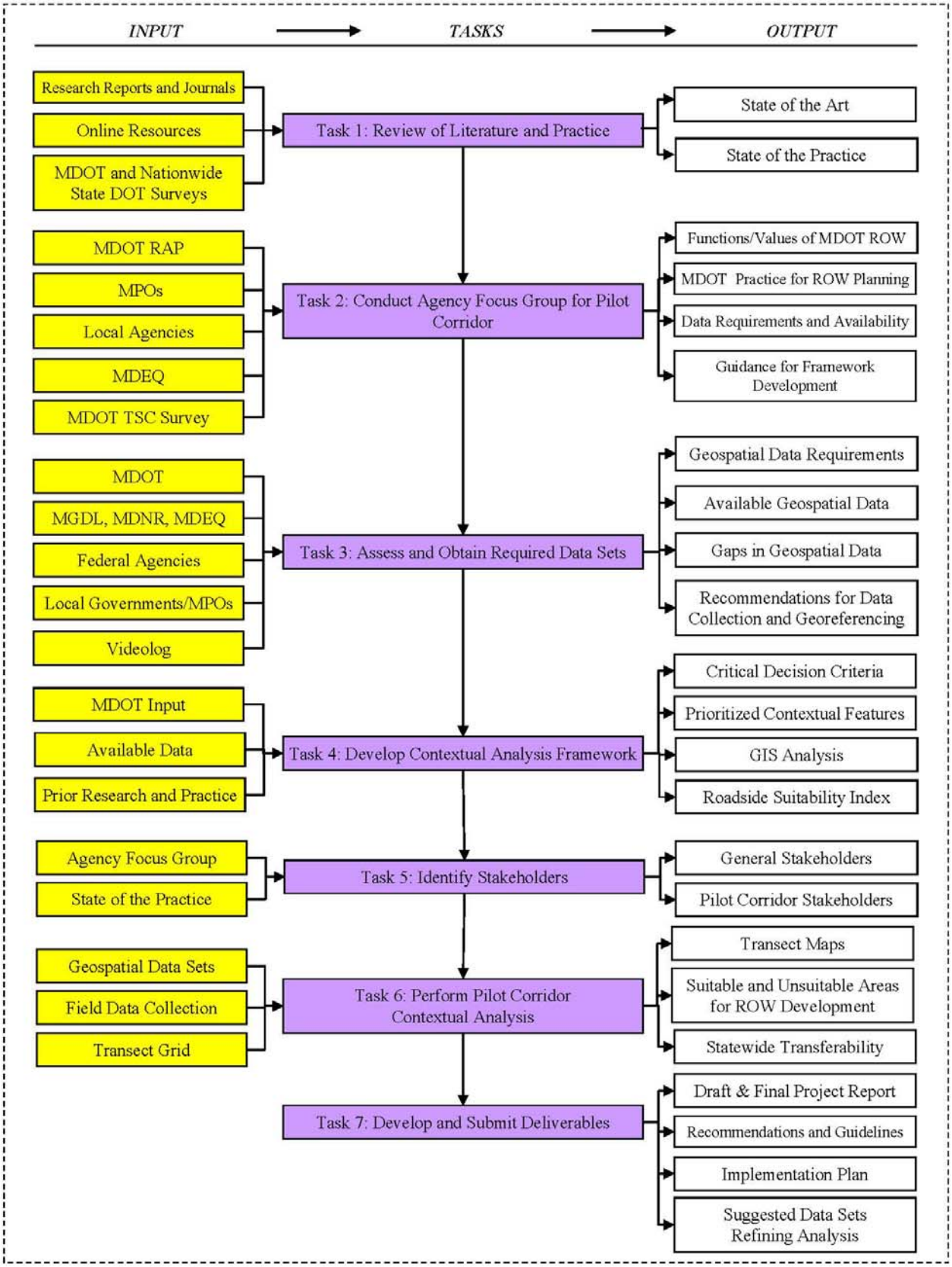


Figure 1. Flowchart of Study Methodology

CHAPTER 2:
LITERATURE REVIEW

In order to establish an understanding of current policies and procedures related to alternative utilization of highway ROW, a comprehensive review of all relevant research and current practices was performed in the early stages of this research project. Several subtopics pertaining to alternative uses were reviewed, including:

- Policies and guidelines for non-transportation roadside development,
- Context sensitive corridor planning,
- Geospatial data and GIS applications,
- Suitability assessment for roadside development, and
- Case studies of non-traditional roadside ROW development.

Relevant literature documents were identified from queries of the United States Department of Transportation's (USDOT) National Transportation Library Integrated Search (TRIS/TRID Online). These documents included peer-reviewed papers in transportation and safety journals, published reports, and state and federal guideline and policy documents. Each document or news article was summarized, evaluated, and critically reviewed. The following subsections present the salient findings from the literature review.

POLICIES AND GUIDELINES FOR NON-TRANSPORTATION ROW DEVELOPMENT

Utility Accommodation Policies

Prior to 1998, non-transportation related developments, including public utilities, were typically not allowed within the interstate ROW. Since 1988, the FHWA has allowed states to decide whether or not public utilities may be allowed within interstate ROW (*3*). The impetus for this policy change was to conserve land and financial resources by including public utilities within the public ROW (*4*). States have since been encouraged to develop and maintain an FHWA-approved Utility Accommodation Policy (UAP), which establishes the process by which public utility development occurs within an interstate ROW, in addition to defining what constitutes a utility (*5*). Most states, including Michigan, rely on AASHTO's definition of a utility facility. The definition that follows is from Michigan's UAP.

Utility Facilities and/or Utilities - Privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, cable television, power, electricity, light, heat, gas, oil, crude products, water, steam, waste, storm water not connected with highway drainage, and other similar commodities, including fire and police signal systems and street lighting systems, which directly or indirectly serve the public. The term utility shall also mean the utility company inclusive of any wholly owned or controlled subsidiary (*6*).

Under a UAP, utilities are generally allowed within the interstate ROW and without FHWA review as long as the entity is a public utility and the development does not interfere with the safety or operation of the highway. While differences exist between the UAPs of various states, each generally follows the guidelines recommended by AASHTO's *A Guide for Accommodating Utilities within Highway Right-of-Way* (*5*). Further, federal requirements state that any actions performed in the ROW on federal-aid roadways or receiving federal funding must abide by the National Environmental Policy Act (NEPA) (*7*). Other state or local environmental regulations may also apply.

Airspace Lease Agreements

Other interstate ROW developments may also be accommodated through an FHWA-approved airspace lease, although developments utilized for commercialization purposes remain strictly prohibited (*4, 5*). Project permitting via airspace lease is only necessary for projects that are not already covered under an approved UAP, or in the event a private utility has submitted a request (*5*). Permitting via airspace lease requires a written agreement defining the responsibilities of all involved parties, provisions for lease revocation, adequate liability insurance, requirements of the utility, access by the transportation agency, and other policy issues related to the development. All funds generated by the state agency from airspace leases must be used for transportation purposes. (*2*).

Permitting and Installation of Facilities

In addition to the various definitions found within each UAP, there are a number of basic standards for placing utilities in the highway right-of-way, most of which are generally derived from the AASHTO guides. Any utility entity desiring to place lines or facilities in the highway

ROW must submit the request in writing on the state department of transportation's permit request form (*6, 9*). Michigan's UAP states that any permit request will include, "…specifications for and methods of installation, requirements for preservation and restoration of highway facilities, appurtenances, natural features, and vegetation on the state highway ROW, [and] limitations on the activities within the state highway ROW" (*6*). Federal guidance has recently been provided to improve coordination and cooperation between the various entities involved with utility installation/maintenance projects within the ROW. This was done to help streamline the planning process and coordinate installation and maintenance work (*4*). Coordination of such activities would potentially reduce the number of days requiring roadside ROW access and reduce the number of dig-in incidents with existing underground facilities.

Whenever feasible, new installations should be placed as close to the ROW line as possible (*6, 10*). This practice not only improves safety along the highway by keeping the clear zone free of objects but also reduces the chances for future relocation in the event the highway facility is expanded or otherwise improved (*6, 10*). Any appurtenances that must be placed in the clear zone that are over 4 inches tall must be of a breakaway construction and/or have shielding (*10*).

Accommodating Renewable Energy Production

Public ROW is viewed as a convenient and cost effective location for accommodating renewable energy production including wind, solar, and biofuels. While there are no UAPs that explicitly prohibit the installation of renewable energy facilities in the highway ROW, specific guidance is typically not provided within the state UAPs. Such ambiguity has caused confusion, potentially resulting in subjective or inconsistent application of the UAP (*5*). It is worth noting that Michigan is one of only two states that provides specific language in the UAP to allow installation of renewable energy facilities within the ROW.

In 2009 the FHWA released additional guidance to further clarify this subject, noting that while most policies did not specifically refer to alternative energy production, they were still flexible enough to allow for their development in the right-of-way (*3*). However, it was recommended that states review their policies and make any changes necessary to provide greater clarification. In addition to the state UAPs, it may be necessary to review any state laws that may be considered obstacles to inclusion of alternative energy production. Other issues related to renewable energy production in the ROW include tax and energy credits that could

support their development, the need for suitability/feasibility studies, identifying required environmental clearances and visual impacts associated with projects, and any zoning changes that may be needed to facilitate development.

CONTEXT SENSITIVE CORRIDOR PLANNING

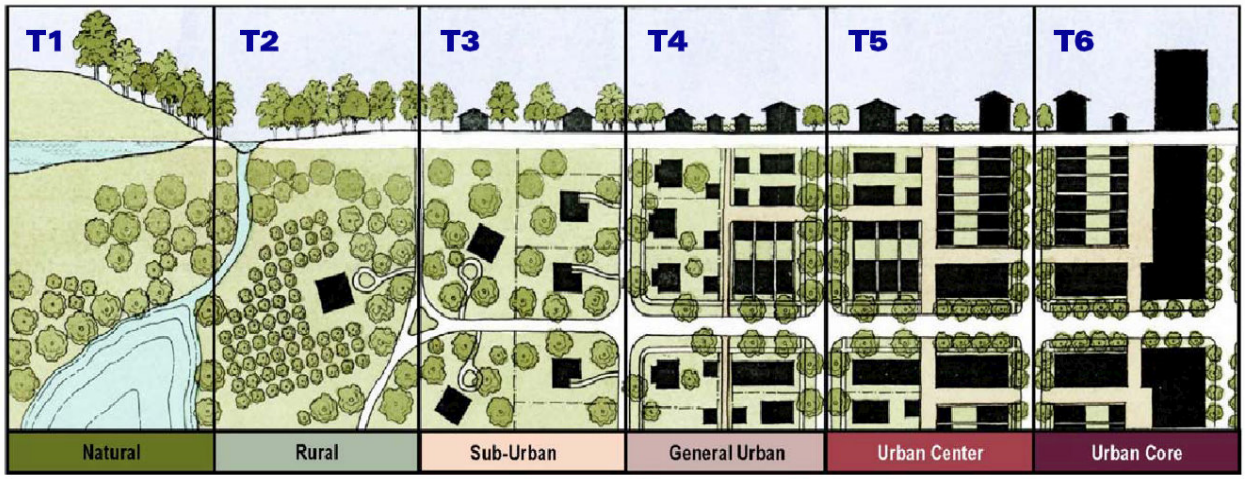
Traditional methods of urban and regional planning were primarily based on land use regulation. Land use was zoned in varying levels of commercial, residential, or protected functions, and transportation systems were designed to accommodate such functions. This method of planning often contributed to suburban sprawl and urban decay. Furthermore, zoning restrictions often varied across jurisdictional boundaries, causing disjointed land uses across such boundaries.

Transect Approach

Recently, new planning strategies have been introduced in an effort to more effectively influence community development or redevelopment while preserving the integrity of different types of urban and rural environments. One such method, known as the transect approach, is an analytical method and planning strategy that seeks to organize all land uses and physical elements of a human habitat in a manner that preserves the integrity of the environment (*11, 12*). The transect approach includes two broad goals:

- Link urban elements to the natural surrounding elements in an integrated system and
- Create immersive environments that help to preserve the integrity of the area.

The transect approach provides a natural ordering system for land use, where every element is identified and organized within the continuum of natural environment to dense urban environment in such a way as to "smooth" the transition between them. To create this integrated environment, six unique transects are defined based on the contextual environment within each zone. The six different transect zones include (from least to most developed): Rural Preserve, Rural Reserve, Sub-Urban, General Urban, Urban Center and Urban Core (*13*). The description of each zone and a graphical representation are detailed in the following figure.



ZONE	CHARACTERISTICS
T1: Rural Preserve (Natural)	- Open space that is legally protected from development. - Includes surface water, protected wetlands/habitats, conservation area and open space
T2: Rural Reserve	- Open space that is not yet protected from development, but with little development - May include flood plains; steep slopes; and aquifer recharge areas
T3: Suburban	- The most naturalistic, least dense, most residential habitat of a community - Single-family detached houses, minimal office and retail - Open space is rural in character - Highways and rural roads are prohibited
T4: General Urban	- The generalized, but primarily residential, habitat of a community - Single-family detached houses and row houses on smaller sized lots - Limited office, lodging, and retail spaces; all low-rise - Open space consists of greens and squares
T5: Urban Center	- The denser, fully mixed-use habitat of a community - Rowhouses, apartment houses, and offices above shops - Office, retail and lodging are permitted - Open space consists of squares and plazas
T6: Urban Core	- The densest residential, business, cultural and entertainment concentration of a region - Rowhouses, apartment houses, office buildings and department stores - Parking structures with few surface parking lots - Open space consists of squares and plazas

Figure 2. Transect Diagram and Description (*13*)

It is important to consider how transportation corridors interface with and influence the surrounding physical contexts. Each transportation corridor is defined by and also helps to define the surrounding infrastructure, landscape, land use activities, and the broader context of nearby communities. A continuing challenge faced by planners and designers of the transportation system is to balance the needs and interests of all stakeholders affected, including travelers, regional planning organizations, local businesses, community leaders, environmental agencies, and transportation agencies.

Contextual Considerations

Recently, "context sensitive design" or "context sensitive solutions" (CSS) have been introduced in an effort to provide balanced transportation options to consider the needs of all stakeholders, including the general public. While there are different definitions of what a context sensitive solution entails, one of the most straightforward definitions, provided by the FHWA, describes CSS as a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting (*14*). The main objective is to develop a vision for roadside development or preservation while considering the effects on economic, social, environmental, and other potential issues. Successful context sensitive planning efforts are comprehensive (consider multiple land use interactions), proactive (address issues early), and collaborative (include multiple stakeholders, including the general public).

To apply the tool of CSS in transportation planning, transportation context zones must be well aligned with the transect zones displayed in Figure 2 (*15*). Transportation infrastructure is blended into the surrounding environment and is well-suited for integration of transportation systems within the various transects. Any and all transportation alternatives should reflect those values identified by the community and stakeholders (*11*). This process leads to a transportation network that preserves and enhances scenic, aesthetic, historic, community, and environmental resources, while improving the safety and mobility of the transportation infrastructure.

An important aspect of context sensitive planning is the inclusion of environmental concerns related to the scope of the project (*11*). It is first necessary to determine whether the project in question will fall under NEPA requirements (*7*). If the project doesn't require federal funding, a federal permit, or other approval, it is not subject to NEPA rules. Environmental policies and procedures are instead controlled at the state and/or local level. Inclusion of a comprehensive group of stakeholders within the corridor planning process will help ensure that environmental and natural resources policies and concerns are accommodated.

Most of the best practices for context-sensitive corridor planning address the relationships and tradeoffs involved in balancing mobility needs, adjoining land uses, environmental preservation, and community interests (*16*). Of specific importance during the corridor planning process is to identify areas of future development or expansion, while considering natural preservation. In other words, as communities grow and expand, land needs to be set aside to "reserve" room for future infrastructure and development, while at the same time considering environmental and natural resource preservation (*17*). It is particularly

important to consider both the direct and cumulative effects on the environment and natural resources associated with any potential planning alternative or project (*18*). Although such concepts were devised for the planning of new corridors, they also apply to planning for right-of-way development and preservation.

New Zealand is aggressively pursuing context sensitive roadside planning by attempting to naturalize the environment along the roadside of highway corridors (*18*). The program seeks to identify opportunities to implement and test the performance and acceptance of new sustainable roadside landscaping designs that utilize indigenous species. As this program represented a vast departure from the forgiving roadside designs typical of the past several decades, it was necessary to ensure that safety would not be compromised. Evidence was provided to suggest that dense, brittle shrubbery close to the roadway would help maintain visibility and safety. Maintenance costs would also be reduced as no roadside mowing would be necessary. Additionally, a natural environment and cultural asset management system was deemed necessary to identify suitable locations for implementation.

GEOSPATIAL DATA AND GIS MAPPING APPLICATIONS

Information management is a particularly critical component for decisions related to roadside corridor planning. GIS software is particularly useful for highway agencies as it combines geocoded inventory data with mapping capabilities to provide unique spatial analysis strategies, including management of roadway and ROW features, infrastructure and asset management, surveying, and urban planning. Although numerous methods may be used to create georeferenced datasets, the most efficient methods involve the use of modern GPS-based surveying equipment, which provide substantial accuracy and efficiency advantages over manual georeferencing of data.

Many data sources currently used for roadside corridor planning throughout the United States are available in geospatial format, including those related to environmental, land-use, natural resource, and socio-economic contexts. However, certain information necessary for roadside corridor planning, including ROW boundaries, property values and ownership, underground utility information, DOT infrastructure, and other data are typically not broadly available in geospatial format (*19*), as these datasets tend to change rapidly and/or require considerable human resources to georeference.

Shared Data and Mapping Applications

Utilizing GIS to map and analyze geospatial data provides vast opportunities for conducting a wide range of analyses. One hurdle to effective utilization of geospatial data is locating, obtaining, and combining data from multiple sources. The most successful statewide GIS applications include collaboration between multiple departments and jurisdictions to provide GIS data and mapping tools within a single online repository. The Utah Department of Transportation developed and continues to maintain one such collaborative GIS application called UPlan. Initially launched in 2008, the main purpose of the application was to provide a means for various users, within UDOT and without, to upload, manage, and share geospatial data (*20*). UPlan offers a number of features including, "…group creation and user management, rapidly produced reports, publicly viewable map presets, incorporation of server-based or local data into preset maps, [and] utilization as a development tool" (*20*). These features make collaboration between different groups much easier as well as assisting in the development process. For example, users from different entities can upload datasets to create a layered map for viewing and analyzing expected impacts of a particular project (*20, 21*). The figure below displays a typical example of UDOT's statewide ROW GIS map that is shared within UPlan.

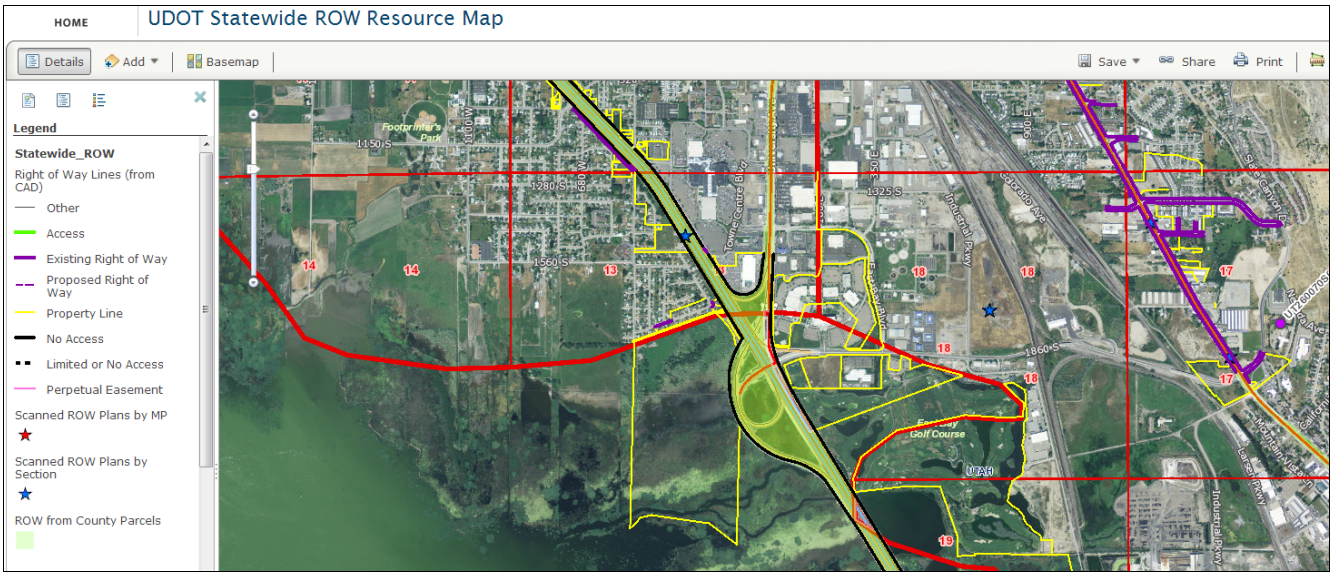


Figure 3. Typical Example from Utah UPlan ROW Resource Map (*21*)

Real Estate Information Management

As previously stated, another common geospatial data gap associated with roadside corridor planning involves the management of property ownership and valuation. Recently,

National Cooperative Highway Research Program (NCHRP) Report 695 (Project 8-55A) provided a framework for a comprehensive geospatial information management system for property acquisition to support statewide transportation planning purposes (*22*). Most importantly, NCHRP 695 provided recommendations for geospatial linkage of appraisal and property ownership information, in addition to state-owned land information, which have historically existed as non-geocoded entities.

The Virginia DOT was an original leader in development of a comprehensive GIS-based property information management. Developed in 2004, the Right-of-Way and Utilities Management System (RUMS) system supports ROW appraisal, acquisition, improvement, removal, relocation, legal, donation, grave relocation, utility design, easements, facility adjustments, assignment tracking, management of contractors, task orders, subcontractors, and property management for sale, lease, grouping, and historical tracking. Access is limited to select VDOT employees requiring such data. The system was noted to reduce staffing costs and improved scheduling and productivity (*22*).

The widespread appeal of RUMS led the Minnesota DOT to purchase RUMS from Virginia DOT. The system was modified for MnDOT purposes and retitled Right-of-Way Electronic Acquisition Land Management System (REALMS). The MnDOT REALMS system currently exists as a comprehensive management tool that supports ROW pre-acquisition, appraisal, acquisition, relocation, condemnation, and post-acquisition, in addition to other property management services, including parcel creation and plat updating. MnDOTs REALMS system has been noted as the only information management system with broad statewide coverage of multiple right-of-way areas that is currently integrated with an enterprise GIS (*22*).

Right-of-Way Data Management

Geocoded right-of-way information is typically not widely maintained within state agencies, largely due to the resources required to digitize and georeference roadway drawings necessary for determination of accurate ROW boundaries. Over the past decade, the Minnesota Department of Transportation has developed and maintained the Right-of-Way Mapping and Monitoring (RWMM) tool. Considered a model ROW mapping tool, RWMM is a publically accessible online application of several different GIS based map layers. Roadway plans were scanned, rasterized, and georeferenced within the RWMM application such that the footprint of each map is properly aligned for viewing within the RWMM. Although the ROW map raster

images exist for most MnDOT roadways statewide, specific ROW layers only exist for selected locations, as this typically requires an additional manual step of tracing the ROW boundary from the raster image. Maps are updated as projects across the state are conducted and completed. The map viewer also indicates whether a particular map has been included within the REALMS system, as indicated by the green shading. An example of the MnDOT RWMM viewer is displayed in the following figure.

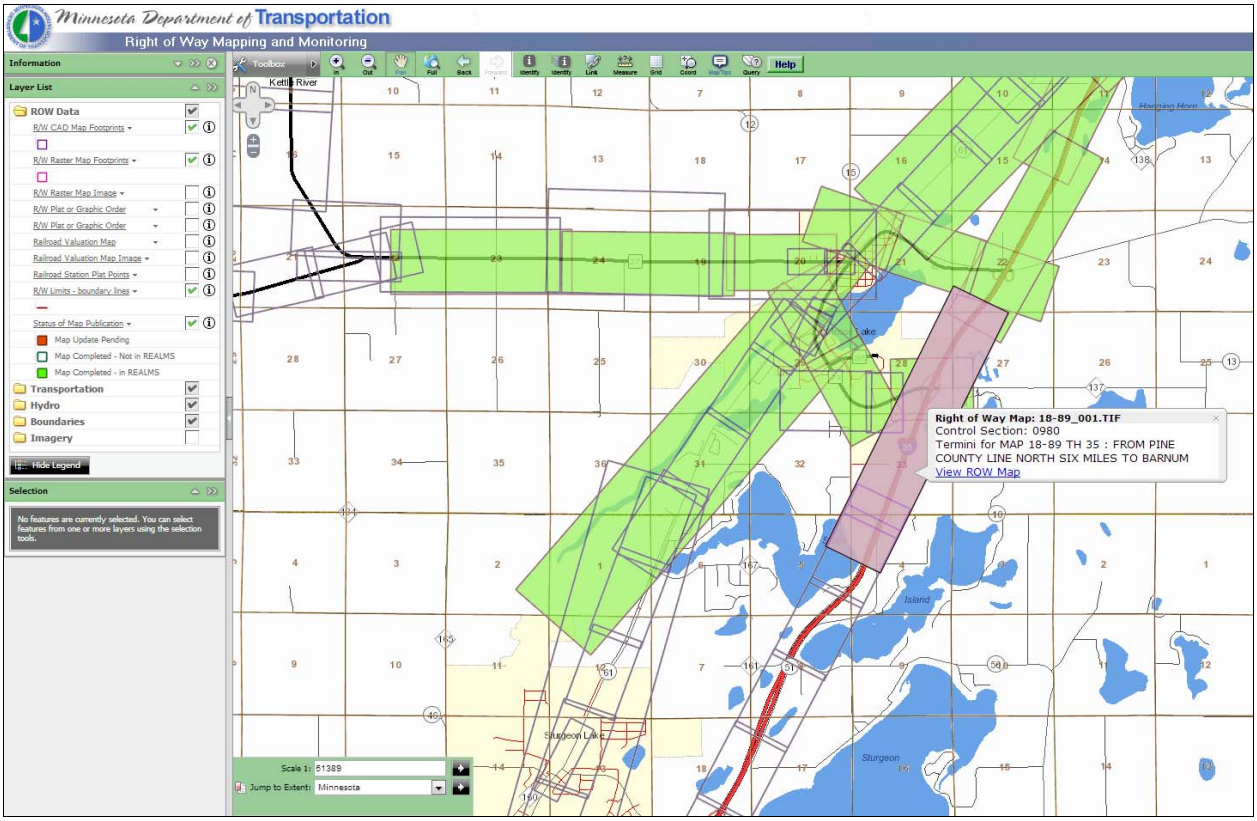


Figure 4. MnDOT ROW Mapping and Monitoring Viewer (*23*)

Environmental and Natural Resource Data

Select states have successfully integrated environmental and natural resource data into GIS for transportation planning and development purposes. To assist in the planning processes for a new roadway corridor, the Virginia DOT assembled a GIS database of natural land features in order to avoid isolation of patches of natural habitat by the construction of roads and other man-made infrastructure (*24*). Satellite imagery and GIS were utilized to locate habitat cores and natural connection corridors. The proposed roadway corridor options were subsequently aligned to avoid subdividing these habitat cores and connections.

The state of Maine has undertaken a comprehensive statewide conservation geospatial data collaboration and sharing effort called Beginning with Habitat (BwH). The primary goal of this program is to help accommodate conservation of native plant and animal species through the landscape level planning efforts (*25*). This program includes federal, state, local, and non-governmental agencies that collaboratively assemble environmental, natural resource, transportation, and land use information from various sources into a combined GIS database and maps, which are available online for use by entities involved in planning and conservation. Figure 5 displays an excerpt from a typical high-value plant and animal habitat map. The geospatial data used to generate the various maps include, but are not limited to:

- Roads
- Hydrology
- Land cover
- Developed land
- Wetlands
- Riparian buffers
- Wells and well buffers
- Conservation lands
- Aquifers
- Drainage divides
- Essential wildlife habitats and plant communities
- Undeveloped habitat blocks and development buffers

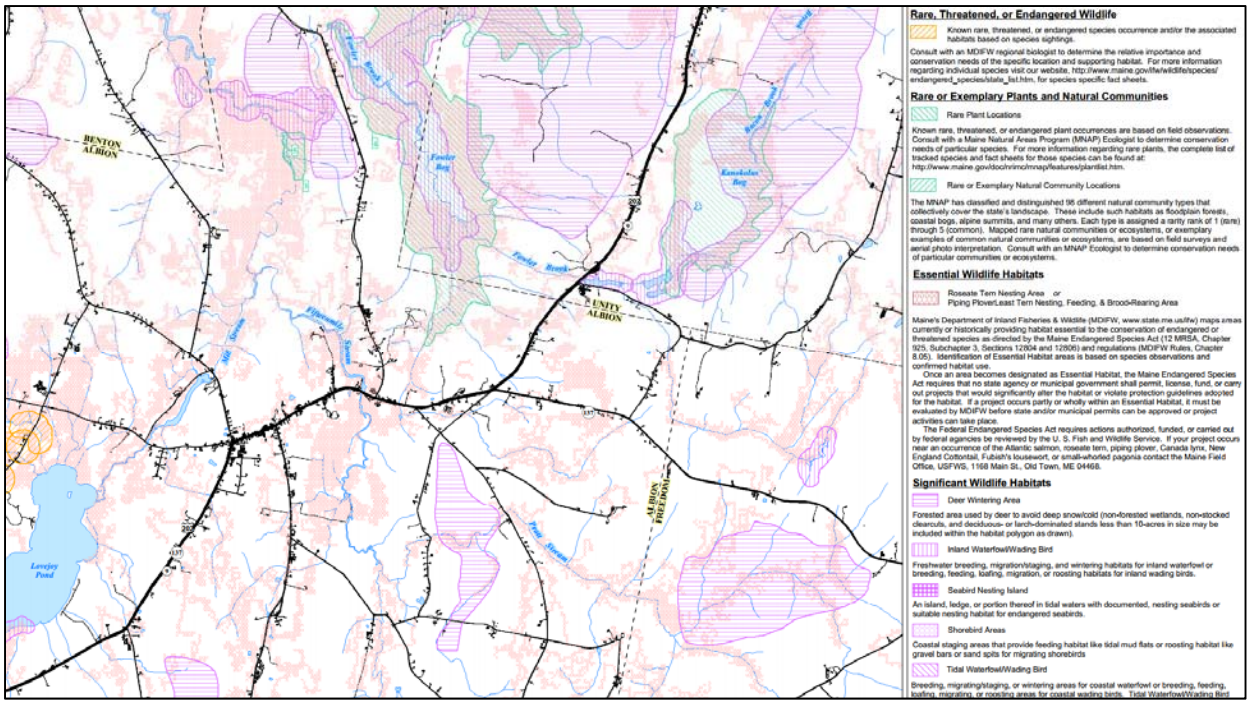


Figure 5. Excerpt from Typical High-Value Plant and Animal Habitat Map from *Beginning with Habitat* Program (*25*).

The website also provides a general "toolbox" which can be used by towns to help identify conservation-related actions, including land use ordinance tools, wetland/shoreland zoning tools, and performance standards as well as guidance for comprehensive planning, open space planning, development of a conservation commission, methods to identify priority habitats for protection, options for financing habitat protection efforts, and methods for conduct public outreach campaigns.

SUITABILITY ASSESSMENT FOR CORRIDOR DEVELOPMENT

Ultimately, it is necessary for roadway agencies to develop and apply criteria to assess the suitability of alternative development or use of the roadside ROW. In general, multiple criteria are necessary for a section of ROW to be deemed suitable for a particular type of development. Consideration should be given not only to the features that exist within the ROW, but also to the public or private land adjacent to the corridor. One of the key components to the assessment process is prioritizing the various criteria and subsequently scoring the roadside ROW areas under consideration.

Spatial analytical applications within GIS allow for the combination and weighting of several contextual layers, such as land cover, environmental, cultural, and socio-demographic, in order to compare various project alternatives. State-of-the-art applications center on a project decision criteria that allows for scoring of various locations by weighting and combining layers within the GIS map to generate the scores for each location (*26*). Weights are typically assigned based on stakeholder input considering prioritization of developmental constraints associated with the particular dataset. For example, it may be particularly important for a certain development to avoid protected lands and waterways, wetlands and environmentally sensitive areas, and high-value property. In this case, high (or low) weights would be assigned to these variables to assure avoidance of such areas. Such an analysis may be performed utilizing GIS to measure various contextual features within each area. Each area is then scored based on combination of the raw measurements with the assigned weights and then ranked to determine the most (or least) suitable area for development. Figure 6 provides a graphical example of this process (*26*). Such a suitability assessment for corridors must consider that 1) multiple stakeholders exist and have different priorities and values and 2) complex environmental or land use problems being addressed often do not have unique and perfectly correct solutions (*26*).

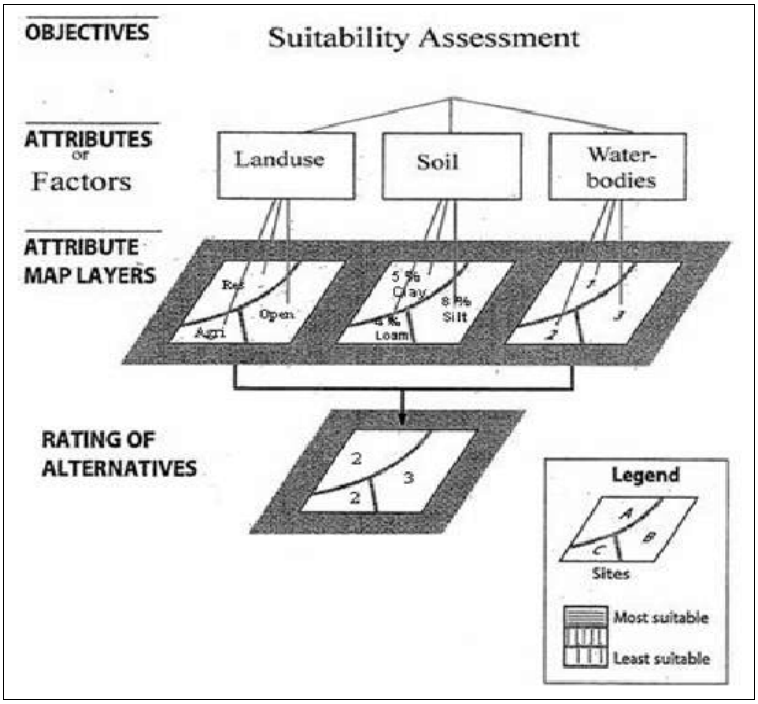


Figure 6. Suitability Assessment Scheme (*26*)

A study for the Colorado DOT recently established general criteria for assessing the suitability of roadside ROW for renewable energy production in order to maintain roadway safety (*27*). Note that these criteria do not necessarily specify considerations for land adjacent to the ROW. The ROW criteria are summarized as follows:

- ROW of less than or equal to 50 feet from the edge of pavement would not be suitable for renewable energy production.
- ROW extending 50 to 200 feet from the edge of pavement could more safely accommodate infrastructure and provide access to energy production sites.
- ROW on either side of the roadway extending 200 feet or more from the edge of pavement provide sufficient setback from the roadway to allow construction of large structures and facilities such as wind towers with long turbine blades with less buffering from the roadway (barriers, fencing, etc.) required.
- Additional 'remnant' parcels of land adjacent to the ROW that are greater than 1 acre and do not contain buildings or other infrastructure are suitable for development.
- Facilities including rest areas, maintenance yards, and offices should be considered individually to assess suitability.

CASE STUDIES OF RENEWABLE ENERGY GENERATION WITHIN ROADSIDE ROW

Roadway agencies have increasingly been exploring the use of highway rights-of-way for non-traditional purposes, particularly to host renewable energy generation facilities, including solar, wind, along with biofuel growth/harvesting. Many of these projects have been implemented on a small-scale basis and utilized to provide energy to nearby DOT infrastructure, such as rest-areas, freeway lights, and other energy consumers. The 2012 report by the FHWA entitled, *Alternative Uses of Highway Right-of-Way: Accommodating Renewable Energy Technologies and Alternative Fuel Facilities* provides details pertaining to several such pilot implementations by state DOTs throughout the United States (*2*). Several of the more notable case studies detailed in this FHWA report and in other literature sources are described here to showcase some of the issues faced by state DOTs during the development and maintenance process. Additional information pertaining to these and other case studies was obtained during the state DOT survey, the details of which are explained later in this report.

Solar Power

Solar power generation has been the most widely implemented type of renewable energy within roadside ROW in the Unites States. In 2008, the first solar highway project in the United States was implemented in Oregon (*2*, *28*). State statutes prevented the use of transportation funds, forcing ODOT to establish the project through a private/public partnership in order to take advantage of special tax credits. A unique financing strategy was utilized for construction of the project combining state and federal renewable energy tax credits, accelerated depreciation, and other grants. Although ODOT owns the land, the solar arrays are owned and managed privately. The electricity generated at the site is sold to ODOT at competitive prices and provides enough energy to offset over 1/3 of the electricity (130,000 kWh annually) needed for freeway illumination at the location. Selection of the location was based on several different criteria including meeting safety standards, no major roadway or roadside improvement expected within the next 20 years, within the service area of the utility, close to an existing ODOT electricity load, and shade-free southern exposure. The project was permitted using the same process already in use under the UAP, although additional review was performed. Additionally, a special gravel road was built to provide access to the site in order to comply with federal interstate access standards.

A second larger solar array near the Baldock Rest Areas on Interstate 5 has recently been completed at a cost of $10 million. The solar array produces nearly 2 million kWh of electricity annually, which is sufficient to provide power to both the northbound and southbound Baldock Rest Areas year round. Public response to the projects has been largely positive, and the importance of public outreach was noted by ODOT and the other project partners. ODOT plans to expand the use of roadside solar energy production, using a third-party "sales-leaseback" model, to provide the electricity needed for the DOT's transportation system (*28*).

a. I-5/205 Solar Array **b. Baldock Solar Array**

Figure 7. Oregon Solar Array Projects

In 2008, the Ohio legislature passed a Renewable Portfolio Standard that required 25% of electricity to be generated from renewable sources by 2025. To help meet this goal, the Ohio DOT was allowed to lease highway right-of-way to developers that would work towards this end. The Ohio DOT partnered with the University of Toledo to install a 100 kW solar array in the highway ROW to provide total power for the LED lighting on the Veteran's Glass City Skyway bridge. Funding was sourced through a combination of a federal earmark and state funds. The University of Toledo will be initially responsible for the operation and maintenance of the system, which will include monitoring performance, glare, and the impacts on snow melt and ice damming. ODOT will take over the system after the first year of operation. ODOT intends to expand solar production in the ROW and will base future implementation on results from this pilot project (*2*).

The Massachusetts DOT has recently entered a unique partnership with a local town government to install a solar panel system in the state ROW to help power the water treatment plant for the town. The town will lease the land from MassDOT with the solar panels installed and operated by a vendor who will sell the electricity back to the town. The project is to be funded by grants from the Massachusetts' Department of Energy and the Federal Recovery Act. Several issues have been identified, including lengthening of existing guardrails and determining

liability for the project. Additionally, the town would be required to relocate the installation in the event the DOT needs the land in the future (*2*).

A feasibility study for a proposed solar project along Highway 50 in California sought to identify suitable locations based on southern exposure, access to the site, various height and setback requirements, no competing interests for the land, close proximity to electrical facilities, and acceptable size for economic feasibility. This project was to be permitted via air space leases, but the project was never implemented due to economic issues. Other problematic issues identified during the feasibility study included safety, site access, security, glare potential, aesthetics, and further legal issues related to patent holders (*2*).

Wind Power

Wind power has not garnered as much attention as solar power for ROW development projects, largely due to the diminished power generation potential within most sections of roadside ROW (*27*). The Massachusetts DOT recently reviewed all buildings, structures, and right-of-way property the DOT owned to locate potential sites for renewable energy generation projects. GIS maps with solar and wind resource information were combined with maps of current MassDOT property to find potential sites for additional consideration. A 68 acre site was ultimately identified for a wind energy feasibility study, which was conducted over a period of 13 months. However, this project was ultimately not implemented due to local resistance, financial restrictions, and dearth of customers to purchase the electricity. Had it been implemented, this project would have been one of the first in-ROW solar or wind projects to generate electricity for purposes other than to power nearby facilities.

Successful wind power generation projects have been implemented by the Ohio DOT and Missouri DOT. The Ohio DOT received Department of Energy funding to install a 100-ft tall wind turbine at one of its maintenance facilities, which is expected to provide 65% of the electricity used by the facility. Some of the environmental concerns related to the project include ice throw, flickering of blades, fall radius, and bird deaths. ODOT is working with the Fish and Wildlife Service to monitor the turbines effects with regard to these issues. The Missouri DOT has installed two 1.2kW wind turbines in both directions at a rest area/welcome center on I-44 which provide power for lighting inside the center (*2*).

Biofuel Production

Several agencies are beginning to implement bioenergy generation within the roadside ROW as a part of the Freeways to Fuel (F2F) National Alliance. The F2F program investigates the use of roadside ROW and other non-traditional areas with agricultural potential for the growth of biofuel feedstock crops across the country. F2F initially began as a cooperative program between the Utah DOT and Utah State University to cultivate canola and safflower crops in order to produce alternative fuel feedstock and reduce roadside maintenance costs. Ultimately, it was concluded from the pilot test that arid conditions and heavily compacted soil will impede in-ROW biofuel cultivation in Utah (*2*).

One of the more successful F2F highway ROW bioenergy endeavors took place in North Carolina. Suitable sites were located in GIS based on consideration of several factors including site slope, width, and the shoulder width of the adjacent highway. The project initially included four square acre plots of a combination of canola and sunflower crops and was a partnership between the NCDOT and North Carolina State University. The two crops are rotated year round to help maximize output and are planted at least 10 feet from the roadway. No new safety issues have been associated with this project. The fuel produced was used to provide power for NCDOT's equipment. The project received favorable feedback and media coverage and the department is looking at ways to incorporate it into its general vegetative management program. The Tennessee DOT established a public-private partnership to plant switch grass along Interstate corridors in order to reduce mowing costs and erosion in the ROW and provide a source of biofuel material (*2*).

A 2010 pilot implementation project in Wisconsin investigated the potential for farming natural roadside grasses (biomass) for energy production within the ROW. The Wisconsin DOT entered into a partnership with Derr Solarmass LLC and Wisconsin's Office of Energy Independence. A 2.2 mile section of ROW was harvested with standard farming equipment and yielded 2.03 tons/acre. It was concluded that harvesting roadside biomass with farm equipment is feasible and the yield/quality was sufficient to warrant further study (*29*)

CHAPTER 3:
STATE-OF-THE-PRACTICE SURVEYS

An important component of this research was to survey personnel both within MDOT and state DOTs nationwide to determine the state-of-the-practice associated with non-traditional developments in the roadside rights-of-way. While there had been a wide range of research related to specific projects or planning methods related to alternative ROW uses, additional detail was necessary to further develop a strategic corridor planning model within Michigan. The survey sought valuable information pertaining to the various types of alternative requests for highway right-of-way use, the different procedures and polices used to govern those decisions, the outcome of relevant projects, and the availability and applicability of GIS applications to the right-of-way management process. These data were also important to help determine the different issues faced by states regarding requests for alternative right-of-way use and accommodation considerations. Special emphasis was placed on obtaining detailed responses from states cited in the 2012 USDOT report entitled *Alternative Uses of Highway Right-of-Way: Accommodating Renewable Energy Technologies and Alternative Fuel Facilities* (*2*).

SURVEY METHODS

The first survey was administered to the appropriate personnel within the MDOT Transportation Service Centers (TSCs) statewide. A similar, yet more detailed survey was also administered to appropriate DOT officials within each of the remaining 49 states; typically persons in positions related either to right-of-way development or property management. Sampling at these two levels (statewide vs. nationwide) allowed for a comparison to be made between Michigan's policies and practices and those of other states. While the specific questions varied between the statewide and the nationwide versions, the basic premise of both surveys was the same: obtain specific information related to alternative highway right-of-way development/use and the specific procedures utilized to facilitate implementation. The primary objectives were to:

- Determine the level and types of alternative highway right-of-way use both within Michigan and nationwide;
- Determine the policies and procedures used to accommodate such projects;
- Determine the role of GIS for planning and development within roadside corridors

The number of questions provided within the nationwide state DOT survey varied for each respondent based on whether the agency had been faced with a non-traditional ROW development/use request. Obviously, those who had experience with non-traditional ROW development requests were subjected to a longer survey. The questionnaire was designed to be as concise as possible to encourage a high level of response. The survey questionnaire included the following topics (the full questionnaire form is provided in Appendix A):

- Presence and type of alternative development requests/projects within the highway ROW
- Methods for handling such requests and accommodating projects
- Public outreach and other agency involvement
- Project results, energy output (where applicable), and return on investment
- General lessons learned from implementing such projects
- Potential for future expansion or new projects
- Geospatial data requirements and collection methods and utilization of GIS for ROW development decisions

The nationwide state DOT surveys were conducted by a team of two to three individuals in early 2013. To encourage a greater level of response, surveyors first contacted as many respondents as possible via phone to either obtain a response or obtain contact information for the appropriate person. Respondents were provided with the option of providing responses over the phone or submitting responses via the online survey form. It was occasionally necessary to perform call-backs to various respondents in order to obtained additional details.

As MDOT had not yet performed any high-profile renewable energy developments within the ROW, the survey of MDOT TSC personnel was less detailed than the nationwide state DOT survey. The questions focused on types of development/use requests from outside entities, number of requests, decision-making procedures, and necessary data. The MDOT TSC survey was distributed solely in an online format.

MDOT SURVEY RESULTS

A total of 19 completed responses were received from 14 of the 20 MDOT TSCs. The TSCs from which responses were received are shown in Table 1 along with the corresponding MDOT region. The responses are summarized in the following paragraphs with full responses provided in Appendix B.

Table 1. MDOT TSC Name and Region

TSC	Region	TSC	Region
Alpena	North	Jackson	University
Bay City	Bay	Kalamazoo	Southwest
Coloma	Southwest	Lansing	University
Davison	Bay	Marshall	Southwest
Gaylord	North	Muskegon	Grand
Grand Rapids	Grand	Newberry	Superior
Ishpeming	Superior	Traverse City	North

Of 14 responding TSCs, 11 reported their office had been faced with at least one non-traditional or non-transportation right-of-way use request from an outside entity. The number of requests each center was presented with over the past two years varied widely, ranging from 1 to 24 requests. The types of development requests received by the TSCs are displayed Figure 8 and are summarized as follows. Ten TSCs reported vegetation and forest management requests, three reported biofuel related requests, three reported wind power generation requests, and one reported solar power generation requests. Four of the service centers cited multiple types of requests, including wind power generation and vegetation management (Coloma), biofuel and vegetation management (Davison and Marshall), and wind and solar power generation as well as vegetation management (Muskegon). Other types of use requests that have been received included rain gardens, linear parks, murals/artwork, cell phone towers, private road crossing, off-road/snowmobile trails, water towers, pump stations, and seismic exploration.

Many of the responses regarding the TSC's procedures for handling alternative ROW use requests indicated following MDOT policy or guidelines in consultation with the MDOT region or central office. However, there was evidence of confusion as to how such requests should be processed. Some also noted consideration of the impacts on future potential utilization of the ROW. Most noted they would not perform any kind of public outreach in regards to the project.

All or nearly all respondents indicated that information pertaining to roadside features/infrastructure, ROW lines, future ROW uses by MDOT, adjacent land uses, and environment/habitat are necessary during the decision-making process. A majority of respondents also indicated a need for zoning and planned unit development information. There was also overwhelming support for a statewide database of pertinent information to assist in the decision making process.

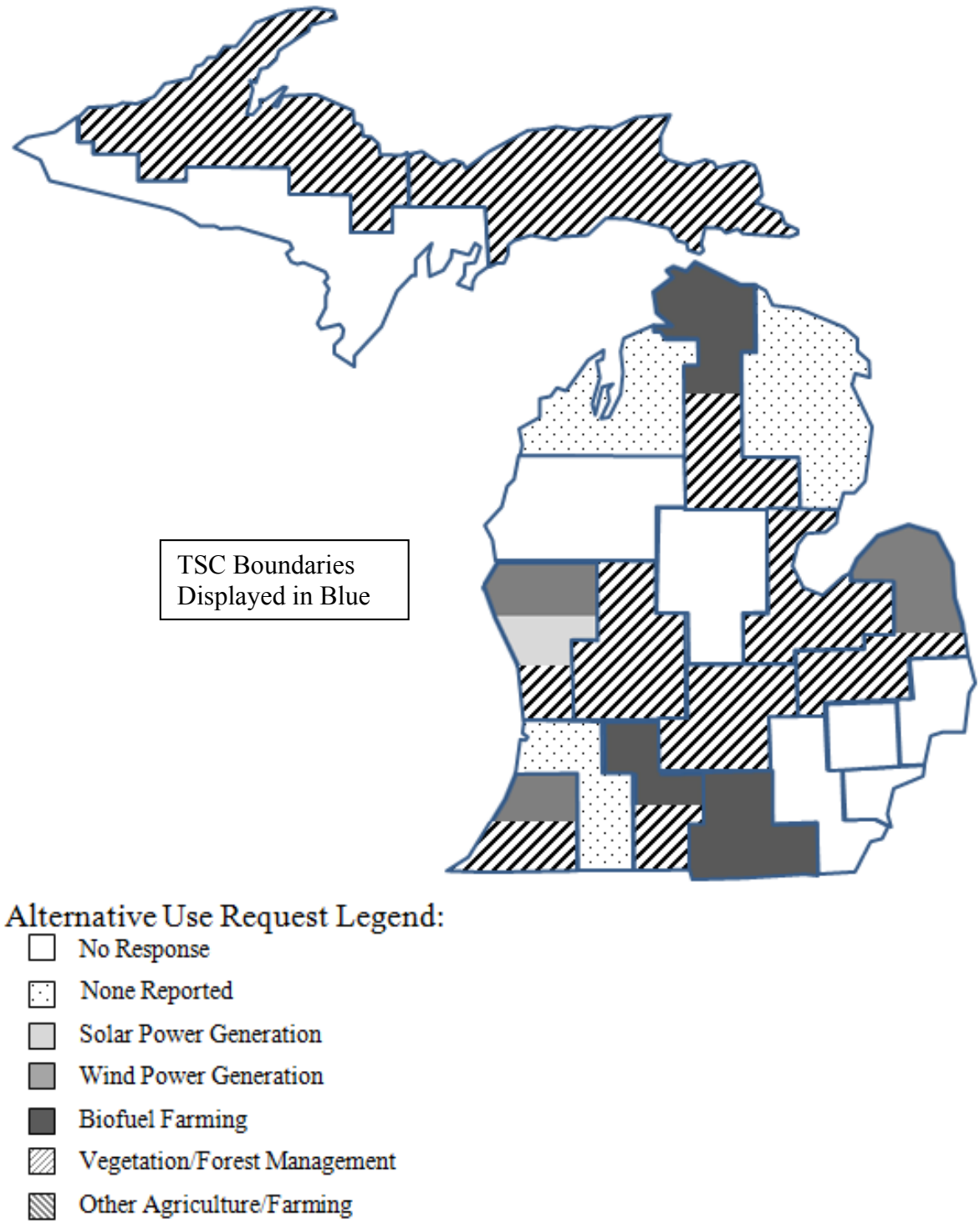


Figure 8. Michigan TSC Survey Responses Pertaining to Types of Requests for Alternative ROW Uses

NATIONWIDE STATE DOT SURVEY RESULTS

The nationwide state DOT survey received 45 individual responses from 42 states. Responses were received from all states except Georgia, Indiana, Nevada, New Hampshire, North Dakota, Texas, and West Virginia. Of the 43 states responding (including Michigan), 25 (58%) reported receiving non-traditional/non-transportation ROW use requests from outside entities, with 19 of these 25 states providing specific details related to the requests. A detailed summary of responses may be found in Appendix C.

Types of Projects

The most commonly reported type of development request was for solar power generation (58% of the 19 states providing details), followed by other agriculture/farming (42%), biofuel farming (37%), wind power generation (31%), and vegetation/forest management (31%). More than one type of alternative use request had been received by 10 of the states that had received such a request. A map depicting the types of requests by state is displayed in Figure 9.

As expected, several of the large scale or high profile projects identified in the literature review were noted within the survey responses, including the Oregon DOT's Solar Highways, Ohio DOT's solar projects, and North Carolina DOT's biofuel production. Of the responding states, Ohio and Oregon appear to be the states that are most actively implementing renewable energy production projects within the ROW. However, the survey uncovered a number of additional projects across each of the various types of developments. While there were some cases where the requests were initiated by the DOT or as a result of the state's highway plan, the majority of the requests originated from outside entities, either a private organization or another government agency. The following table summarizes the responses related to the current status of non-traditional developments within the DOT ROW.

Table 2. Types of Developments Reported by DOTs

Type of Development	Agency	Implementation Status	Additional Details
Solar	Arizona DOT	Pilot In Progress	A privately funded research project is under lease. Seeking to develop a partnership to generate power for freeway system.
	Colorado DOT	Planning	Solar power generation was accepted as a Volpe/FHWA Renewable Energy ROW Project.
	Ohio DOT	Implemented	Solar fields in ROW on Greenbelt Parkway and I-280.
	Oregon DOT	Implemented - Expanding	Two Solar Highway projects along I-5.
Biofuel	North Carolina DOT	Pilot Completed	Partnership with NC State produced biodiesel for DOT equipment. Expansion requires processing plant nearby.
	Utah DOT	Pilot In Progress	University of Utah biofuel farming research on a small area of ROW
	Wisconsin DOT	Pilot Completed	Partnership implemented pilot project to harvest natural biomass (roadside grasses) in the ROW to assess feasibility and energy production potential.
Agriculture	Illinois DOT	Ongoing	Switch grass or hay harvesting
	Kansas DOT	Ongoing	Joint-use agriculture
	Nebraska DOT	Ongoing	Hay production
Landscaping/ Vegetation Mgt.	California DOT	Ongoing	Mow and bale roadside grasses for vegetation management.
	Ohio DOT	Ongoing	Landscaping/maintenance projects at interchanges
	Tennessee DOT	Ongoing	Landscaping/maintenance projects at intersections/interchanges

Policies, Procedures, and Partnerships

The method used for authorizing and establishing the contractual agreements for the projects varied widely with a considerable degree of uncertainty with some of the respondents, although most were performed under standard permits, partnerships, or other arrangements. It is worth noting that very few alternative development projects have been established under UAPs or airspace lease agreements. While land ownership is always maintained by the DOT, the entity that ultimately "owns" the project depends greatly on the project itself. Only one of the solar installations (Ohio) is owned and operated by the DOT. All three implemented solar projects were utilized to provide on-site power, although Ohio and Oregon noted that the solar panels were grid-tied and generated excess electricity. Biofuel, agriculture, landscaping/vegetation management projects are typically operated and managed by an outside entity. Each of the three biofuel projects noted university involvement for research purposes.

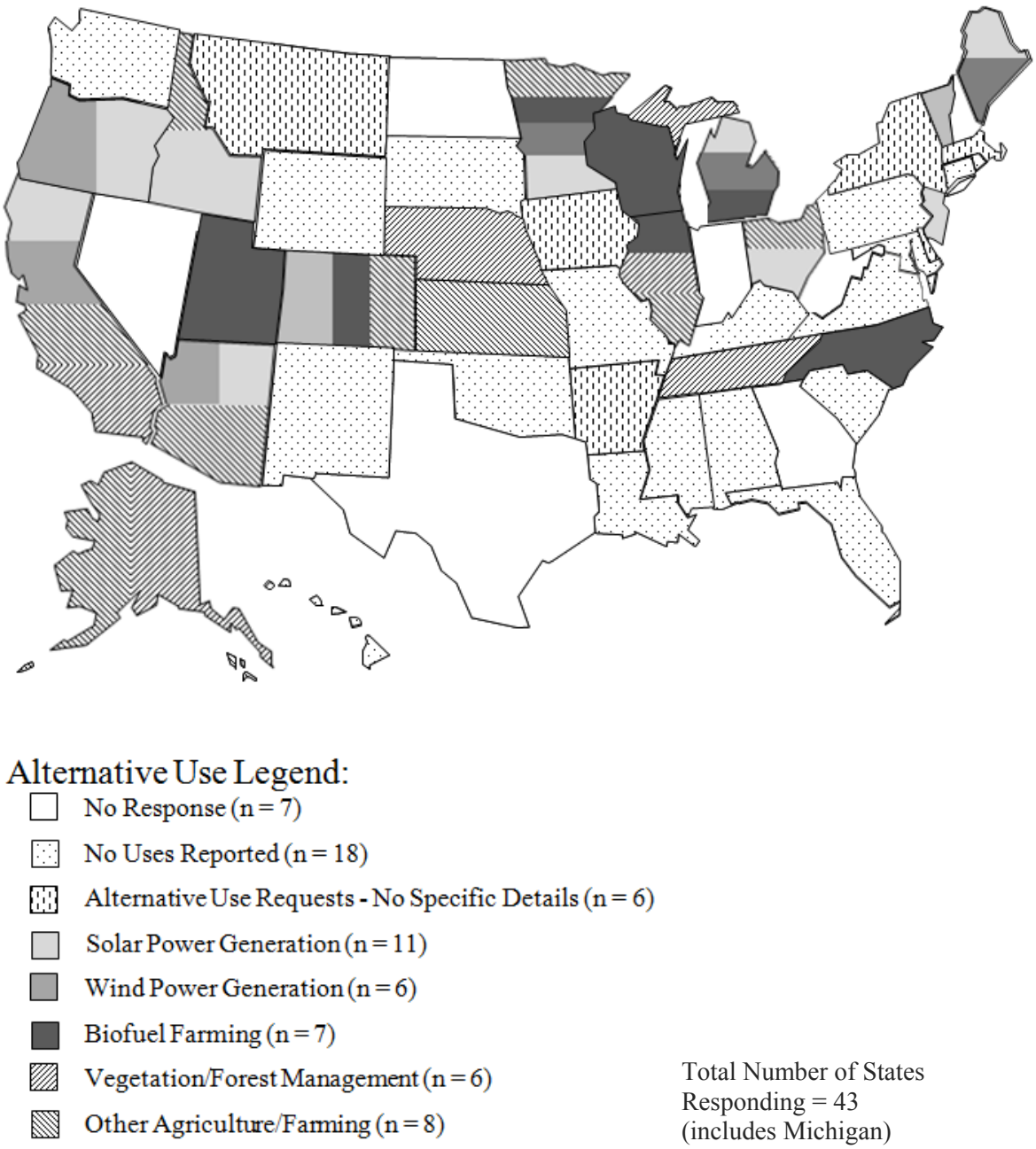


Figure 9. State DOT Survey Responses Pertaining to Types of Alternative ROW Uses

Project Evaluation and Lessons Learned

Many of the projects referenced had not been completed at the time of the survey, making it too early to gauge the overall success or benefits of the project. However, several projects have been evaluated to some degree. The Oregon Solar Highway is the oldest and most thoroughly evaluated of the noted projects. With a return on investment period of six years, this

project has been broadly successful, garnering widespread public acceptance and winning numerous awards. This success has prompted subsequent expansion of the ODOT Solar Highway program and has prompted investigation into other types of renewable energy projects, including wind and biofuel farming. The North Carolina biofuel cultivation pilot project was deemed successful, although it is currently unknown if this program will be expanded due to the necessity for a processing plant to be nearby. Wisconsin's natural biomass cultivation pilot project was deemed a success, although future program expansion remains unknown. Nebraska's ROW haying program and Tennessee's landscaping/maintenance programs were was also noted to work well using standard permitting (Nebraska) and licensing/leasing (Tennessee) procedures. The Ohio DOT has noted benefits associated with the solar and landscaping/maintenance projects, although the return on investment noted for the solar arrays is much longer than that given by the Oregon DOT. Both the Utah and Arizona DOTs are awaiting research results associated with their respective renewable energy projects. California provided somewhat negative findings related to renewable energy production within the ROW. Solar power production was found to be non-cost effective, while wind generation along median barriers was deemed too great of a traffic safety risk. Thus, neither source was deemed compatible with production within transportation corridors.

Several agencies noted the developmental potential possessed by the right-of-way, including revenue-generating opportunities through leases and other arrangements. However, agencies also emphasized the need for new policies to help manage ROW development issues. It was also noted that public outreach should be performed for all such projects as these projects tend to be unique and well publicized.

GIS Data Management and Use

The collection and maintenance of GIS data is performed by 30 of the 33 (91%) responding agencies. In most (60%) of the states, GIS data are collected solely in-house, while an additional 27% of states utilized a combination of agency and contracted forces to collect such data. Slightly more than half (56%) of the responding agencies utilize GIS data for ROW development requests and related decisions at least some of the time. GIS data is most commonly used for location selection or establishment of project limits (93%), or for identification of utilities (36%) or access locations (36%).

CHAPTER 4:
AGENCY FOCUS GROUP

One of the initial tasks towards development of the roadside corridor assessment framework was to convene a focus group of relevant state and local agency stakeholders for the section of I-94 corridor that was to be used for demonstration of the framework. The purpose of this meeting was to determine functions and values of MDOT ROW, prioritize ROW usage considerations, and identify issues associated with ROW development. The meeting was also important to identify additional stakeholders to engage in the roadside corridor planning process, particularly those that maintain relevant data that are not available from MDOT. A brief summary of the focus group discussion is provided in the sections that follow.

Stakeholder Participation

The following agencies participated in the focus group meeting:

- MDOT - Roadside Development
- MDOT - Right-of-Way
- MDOT - Real Estate
- MDOT - Environmental
- MDOT - Information Technology
- MDOT - Southwest Region
- MDOT - Kalamazoo TSC
- MDOT - Marshall TSC
- Kalamazoo Area Transportation Study (MPO for Kalamazoo County)
- Battle Creek Area Transportation Study (MPO for Calhoun County)
- Kalamazoo County Road Commission
- Calhoun County Road Commission
- Michigan Department of Natural Resources (MDNR)

Additional stakeholder groups were identified during the meeting to ensure a more complete understanding of issues and factors relevant to the roadside corridor planning process. Engagement of local agencies is particularly important as such agencies typically maintain zoning and land use data that are typically not possessed by MDOT. The additional stakeholders that were identified included:

- Staff associated with GIS, planning, assessment, and/or zoning within the various counties, cities, and townships that surround the corridor;
- Federal Highway Administration;
- Native American tribes with property ownership adjacent to the corridor;
- Department of Environmental Quality;

- Conservation groups, including watershed protection;
- County drain commissioners;
- Michigan State University extension service;
- Local police/emergency; and
- Airport authorities, where applicable.

Functions and Values of Roadside ROW

The participants were asked to identify different functions and values of MDOT roadside ROW. The responses were categorized as follows:

- Infrastructure and mobility, including: drainage, access, buildings and parking, signage, roadside safety, fences and walls, and multimodal uses.
- Utilities and equipment, including: intelligent transportation system (ITS) sensors, and permanent traffic recorders, and existing and potential utilities including facility lighting, renewable energy generation, and cell towers, among others.
- Environmental and natural resources, including: vegetation and wildlife habitats, specifically for endangered species and environmentally sensitive areas, historic and archaeological sites, wetlands, and detention/retention ponds.
- Miscellaneous, including: access rights, adjacent excess parcels, airspace issues, permitted activities and programs, maintaining sight distances and visibility in general, and aesthetic concerns.

Prioritization of ROW Use Considerations

The attendees were also asked to prioritize the considerations related to utilization of roadside ROW. In descending order of importance the priorities were ranked as follows:

1. Whether the proposed use is allowed under right-of-way/access/state law
2. Current or future transportation use by MDOT:
    a. Drainage
    b. Safety features
    c. Signage
    d. Future widening or other transportation needs
3. Utility use
4. MDOT cost savings or revenue generation
5. Other/Commercial uses

Impacts and Issues

The participants agreed that the impact of a particular development on the ROW and adjacent land is largely dependent on the type of project. For example, installation of permanent infrastructure, such as solar or wind production facilities, could restrict non-motorized uses and/or future lane additions to the facility if not planned properly. Consideration must also be given to the impacts that standard MDOT maintenance practices, such as roadway deicing, may have on roadside developments. Similarly, issues related to ROW access have the potential to negatively impact future biofuel projects or other projects that require regular ROW access. As with any construction or development project, environmental issues must be considered with ROW development projects. Lastly, there are economic concerns related to awarding contracts and/or developing partnerships with private entities. Some of these issues include ensuring the process is fair and competitive and that it provides a balance between societal and private interests. There also must be contingency plans in place in the event business partners are no longer able to work with the DOT or maintain the infrastructure for any number of reasons.

CHAPTER 5:
FRAMEWORK FOR ROADSIDE SUITABILITY ASSESSMENT

The ultimate goal of this research was to develop a framework for context-sensitive planning within MDOT roadside rights-of-way. It was necessary for this framework to be flexible enough to support a broad range of potential types of ROW development, corridor conditions, and contextual characteristics in order to be functional statewide. It was also important for the framework to be as concise and straightforward as possible to increase its usability.

Several tasks were required during development of this framework, including identification of roadside functions and values, identification and prioritization of relevant contextual datasets, availability of such datasets in a geocoded format, and development of analytical procedures. The resulting framework provides a roadside suitability assessment model to support integrated decision-making and policy level considerations for ROW use and development. Developmental considerations for the framework were based upon the extant research literature, results of a national state-of-the-practice survey, and input from a stakeholder focus group and the MDOT Research Advisory Panel (RAP). Details of the framework development are provided in the following sections. Demonstration of the roadside suitability assessment process for a 20-mile pilot section of the I-94 corridor is provided in Chapter 6.

STAKEHOLDER INVOLVEMENT

Stakeholders should be engaged early and often in the roadside corridor planning process. The importance of stakeholder engagement, including involvement of the general public, was a frequently noted theme throughout the literature, state-of-the-practice surveys, and focus group meeting. A diverse and comprehensive group of stakeholders will help ensure that virtually all important considerations are addressed. Additionally, a comprehensive group will facilitate the ability to obtain all necessary data, particularly data that is maintained locally. The following table lists the recommended stakeholder groups that should be invited to participate during the planning process for proposed roadside corridor developments throughout Michigan.

Table 3. Recommended Stakeholder Groups for Roadside Corridor Planning in Michigan

Jurisdiction	Stakeholder Group
Statewide	MDOT - Roadside Development Division
	MDOT - Right-of-Way Division
	MDOT - Real Estate Division
	MDOT - Environmental Division
	MDOT - Traffic and Safety Division
	MDOT - Information Technology Division
	Michigan Department of Natural Resources (MDNR)
	Michigan Department of Environmental Quality (MDEQ)
	Federal Highway Administration
	Michigan State University Extension Service;
Local or Regional	MDOT - Region Office
	MDOT - TSC
	Metropolitan Planning Organization or Regional Planning Commission (where applicable);
	County Road Commission
	Staff associated with GIS, planning, assessment, and/or zoning within the various counties, cities, and townships adjacent to the corridor
	Utility Companies
	Police/Emergency
	Conservation Groups
	Adjacent commercial/industrial property owners
	Adjacent or intersecting railroads (where applicable)
	Federal land management agency (i.e., National Forest Service) (where applicable)
	Native American tribes with property ownership adjacent to the corridor (where applicable)

POTENTIAL TYPES OF NON-TRADITIONAL ROW DEVELOPMENT

It was necessary for the framework to allow for consideration of non-traditional, non-transportation uses and associated developments that may potentially be proposed and/or implemented within Michigan. Several types of potential non-traditional, non-transportation related ROW uses were identified and may be considered within this framework, which include, but are not limited to:

- Solar power generation
- Wind power generation
- Biofuel cultivation
- Vegetation/forest management
- Other farming/agriculture
- Storm water quality improvement
- Stream mitigation
- Wetland mitigation
- Habitat mitigation

Additionally, the framework is flexible enough to accommodate decision-making related to traditional ROW developments, such as rest areas.

DATA REQUIREMENTS

A critical component towards development of this framework included the identification of contextual features data and other information necessary to assess the suitability of particular sections of corridor for development. It is desirable for each dataset to be georeferenced so that it may be imported into GIS applications, such as ArcGIS Desktop Version 10.1, for spatial analysis and mapping purposes. Data that exist as GIS shapefiles provide the distinct advantage of being directly importable into GIS software as a separate map layer, which can be overlaid onto the Michigan base map (*30*). Although the georeferencing task may be performed manually, it is impractical to assume that manual shapefile creation would typically be performed during the roadside corridor planning process. Various types of potentially useful contextual information were broadly identified use within this framework, which include:

- Adjacent land-use features and cover
  - Land cover
  - Land use (current and future)
  - Zoning
  - Federal lands
  - DNR lands
  - Tribal lands
  - Average property values
  - Historical or heritage sites
- Natural resources and environmental features
  - Rare species and habitat
  - Open water
  - Special waterways (i.e., trout streams, scenic waterways)
  - Impaired watersheds
  - Floodplains
  - Wetlands
  - Protected wellheads
- Right-of-way features and infrastructure
  - Interchanges/intersections
  - Drainage features
  - Bridges
  - ROW width
  - Excess parcels
  - Underground utilities
  - Rest areas/parks/parking lots
  - Signs and ITS devices
  - Terrain/slope
  - Monitoring wells
  - Excess Parcel availability
  - Billboards
  - Non-motorized mileage
  - Future ROW use

Upon identifying these potential contextual features, it was necessary to identify sources from which to obtain such data, assess the level of statewide data availability (both geospatial and non-geospatial), and prioritize the relative importance of each dataset.

DATA AVAILABILITY AND GAP ASSESSMENT

The Michigan Geographic Data Library (MGDL), administered through the Michigan Department of Technology, Management, and Budget (DTMB) is the primary repository for all official geocoded databases managed by the State of Michigan (*30*). The respective state agencies within Michigan are responsible for maintaining these databases, which are publically available and providing updates to the MGDL. MDOT also maintains several additional geodatabases at the regional or local level.

Available Data

Available shapefiles that were related to the necessary corridor planning information were obtained from MDOT, MGDL, MDNR, or MDEQ. Additionally, several other locally maintained datasets were identified, including zoning and master land use plans. The full list of available data from all sources is provided in Appendix D. Each dataset was reviewed to assess the relevancy, accuracy, and level of statewide coverage. Attributes of the data necessary for corridor contextual analysis are displayed in Table 4.

Non-State Maintained Data Sources

As previously stated, most official GIS shapefiles maintained by the State of Michigan are publically available through the MGDL online repository. The additional primary sources of relevant geospatial datasets were local agencies, the Michigan Natural Features Inventory (MNFI), and the National Land Cover Database (NLCD).

Local Agencies

Zoning, master land use plans, parcel information, and locations of sewer/water lines are almost exclusively maintained at the local level by counties, cities, and/or townships. An online search was conducted to identify the availability of such data in GIS format within counties and municipalities in Michigan. GIS data availability was classified in one of four categories:

- No GIS data available,
- GIS information available from department personnel, but not online,
- GIS information available online for download, or
- GIS information available online for download with an online viewer.

Table 4. Source, Format, and Statewide Coverage Level for Roadside Contextual Data

Data Category	Data Description	Data Source	GIS file?	Level of Coverage within Michigan
Adjacent Land Use Features and Cover	National Land Cover Database (2006)	U.S. Geological Survey	Yes	Statewide
	Master Land Use Plans	Local agency	Var.	Statewide (through locals)
	Zoning	Local agency	Var.	Statewide (through locals)
	Federal Land	MDOT	Yes	Statewide
	DNR Land	MGDL	Yes	Statewide
	Tribal Lands	U.S. Census	Yes	Statewide
	Average Adjacent Property Values	MDOT (Real Estate Division)	No	Statewide
	Historic Sites	MDOT	Yes	Statewide
	MDOT Heritage Routes	MDOT	Yes	Statewide
Natural Resources and Environmental Features	Biorarity Index (Statewide Rare Species Probability)	Michigan Natural Features Inventory (MSU Extension)	Yes	Statewide
	Redbook Sites (100 Highest Priority Rare Species Corridors)	MDOT – Based on Biorarity Data	Yes	Statewide
	Wild and Scenic Waterways	MDOT	Yes	Statewide
	Trout Lakes and Streams	MGDL/DEQ	Yes	Statewide (Incomplete around Lansing)
	TMDL Impaired Watersheds	MDOT/DEQ	Yes	Statewide
	Floodplains	MDOT	Yes	Regional - Missing Various Counties Throughout State
	Wetlands	MGDL (National Wetlands Inventory)	Yes	Statewide
	Wellhead Protection Areas	MDOT	Yes	Statewide
Right-of-way Features and Infrastructure	Future ROW Development/Use	MDOT (Region)	No	Statewide
	Interchanges/Intersections	MDOT	Yes	Statewide
	Culverts, Catch Basins	MDOT	Yes	Regional - Southwest and Bay Only
	ROW Lines	MDOT	No	Regional
	Underground Gas, Electric, Telecom	None	No	N/A
	Sanitary Sewer Lines and Water Lines	Local agencies	Var.	Statewide (through locals)
	Rest Areas, Roadside Parks, Carpool Lots	MDOT	Yes	Statewide
	Bridges	MDOT	Yes	Statewide
	MDOT Road Signs/ITS Devices	MDOT	Yes	Incomplete
	ROW Terrain/Slope	None	No	N/A
	Monitoring Wells	MGDL	Yes	Statewide
	Excess Parcels	MDOT (Region)	No	Statewide
	Billboards	MDOT	Yes	Regional - Metro Only
	Current and Proposed Non-Motorized Mileage	Michigan Trails and Greenways Map and MDOT	No	Statewide

Most of the surveyed counties or municipalities had such data available online, often presenting various layers via an online GIS viewer. Note that data available within MPO websites was included as a part of this assessment. Online GIS interfaces and datasets were available within slightly more than half of Michigan's counties. Twelve cities were also found to maintain an online GIS interface with several others providing GIS maps available for download. Figure 10 displays the GIS data availability within each county and several major cities within Michigan.

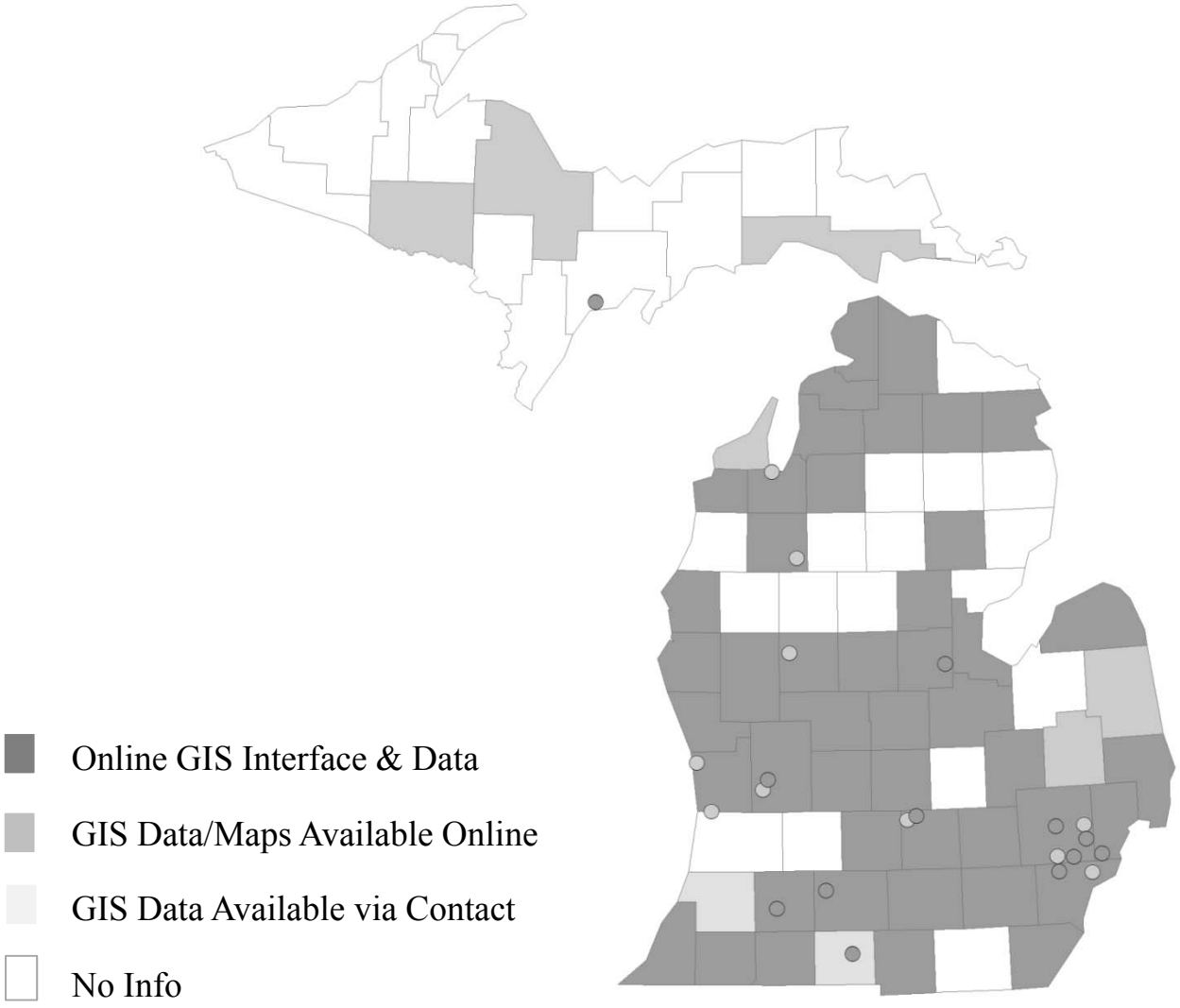


Figure 10. GIS Data Availability within Michigan Counties and Major Cities

Michigan Natural Features Inventory

The Michigan Natural Features Inventory (MNFI) is a database maintained by the Michigan State University Extension and is a collection of information tracking Michigan's threatened and endangered species, as well as species of special concern. The database has been incorporated into a GIS and reviewed for spatial accuracy. It is used by state and federal agencies, as well as research and non-governmental organizations. Species information is added as it becomes available, ensuring the data is as up to date as practically possible.

Biological Rarity Index

One of the tools developed based on the MNFI database is the Biological Rarity Index, which provides probability values that indicate the likelihood of one or more rare species being present within an area (*32*). The probabilities are calculated based on a number of different factors including the presence of available habitat, the accuracy and time period of the sighting(s), and whether the species is endangered globally or within the state. As defined by the MNFI the, "…probability represents the likelihood of encountering a rare species or high-quality natural community based on the age of the database record". The values are generated based on a 40 acre grid for the entire state and may assist in the prioritization of areas for conservation.

MDOT Redbook Program

MDOT utilizes the MNFI data to identify locations for inclusion within the Redbook Protection Program (*33*). The Redbook Protection Program includes the 100 highest priority locations that include threatened, endangered, and special concern species within 500 feet of MDOT ROW. MDOT actively manages the habitat within designated Redbook Sites by limiting in-ROW development and invasive species control.

National Land Cover Database

One of the more robust and accurate geocoded datasets for nationwide land cover assessment is the National Land Cover Database (NLCD), which is maintained by the United States Geological Survey (*34*). The 2006 NLCD provides the most recent land cover assessment for the United States, utilizing automated satellite imagery assessment technology with a spatial resolution of 30 square meters (0.22 acres) (*35*). The NLCD is extremely valuable because it provides an automated assessment of land cover that would otherwise require visual imagery assessment or field surveys. Validation has shown the automated land cover assessment process to provide accuracies of 78 to 85 percent, depending on the type of land cover (*36*). Specific

NLCD land covers are classified for further analysis into any of the eight common land use/land cover categories, as shown in Table 5. Note that selected NLCD land cover classifications that are not applicable to Michigan, such as permanent ice/snow cover, were omitted from the table.

Table 5. Land Use/Land Cover Classification based on NLCD Land Cover Assessment

Land Use/Land Cover	NLCD Code	NLCD Description
Forest	41, 42, 43	Deciduous Forest, Evergreen Forest, Mixed Forest
Rural Open Space	52, 81	Shrub/Scrub, Pasture/Hay
Agricultural	82	Cultivated Crops
Residential	21, 22	Developed (Open Space), Developed (Low Intensity)
Commercial/Industrial	23, 24	Developed (Medium Intensity), Developed (High Intensity)
Open Water	11	Open Water
Wetlands	90, 95	Woody Wetlands, Emergent Herbaceous Wetlands

Data Gap Assessment

Gaps in the necessary contextual datasets were identified if any of the following conditions were met: 1.) no dataset available, 2.) data available, but in non-georeferenced format or 3.) georeferenced dataset is available, but does not provide sufficient statewide coverage. Several gaps in the necessary data were identified and classified as follows:

- No dataset available
  - Type and location of underground gas, electric, and telecommunication utilities within ROW (Note: location of sanitary sewer lines, storm sewer lines, and water mains are typically available from the local agency)
  - ROW terrain/slope
  - Ditch information
- Data available, but in non-georeferenced format
  - ROW lines
  - Excess parcels
  - Soil borings
  - Non-motorized facilities
  - Zoning (local agency)
  - Master land use plan (local agency)
  - Planned unit developments (local agency)
  - Future ROW development/use

    - Average adjacent property value
- Georeferenced dataset available, but does not provide sufficient statewide coverage
    - Floodplains
    - Well logs
    - Billboards

Robust and accurate statewide GIS enterprise data is crucial for effective utilization of this framework and for roadside corridor planning and management in general. To those ends, a plan was prepared to reconcile gaps in the existing geospatial datasets. It is recommended that these gaps be addressed either by field data collection or by manually georeferencing existing datasets. Data gap reconciliation efforts should be considered as follows (in prioritized order):

1. Georeference MDOT ROW lines. An online ROW mapping viewer would be beneficial both within MDOT and for external uses. It is recommended that a method similar to the Minnesota Department of Transportation's widely popular Right-of-Way Monitoring and Management Program (RWMM) be considered on a regional basis as funds are available. See Figure 4 and the adjoining discussion for additional details about the MnDOT RWMM program.
2. Georeference excess MDOT parcel boundaries. This should be performed concurrently with the ROW lines.
3. Georeference MDOTs Real Estate Management Information System (REMIS). Georeferenced parcel and property information would be beneficial for project ROW scoping purposes.
4. Georeference Michigan's current and proposed non-motorized facilities. This would provide an online resource that would likely have broad public appeal.
5. Perform statewide global positioning system (GPS) field data collection to provide complete statewide coverage for floodplain, well logs, and billboards shapefiles within or near the MDOT ROW.
6. Establish a program to require georeferencing of all contract soil boring activity performed within MDOT ROW statewide.
7. Create and maintain a georeferenced underground utility location dataset for MDOT ROW. Although this is likely the most difficult and least feasible GPS data

collection task, it would ultimately be beneficial for MDOT to possess information related to the location of underground utilities.

8. Create and maintain a statewide geodatabase for zoning and master land use plans. Zoning and master plans are maintained at the local level. As such, this task may require a shared online GIS repository, similar to Utah's UPlan. Zoning is subject to frequent changes, which presents data maintenance challenges. However, changes to master land use plans tend to occur on a 20 year cycle. Additionally, in many areas, land use plans are only readily available in paper copy. It would also be beneficial to have GIS data for planned unit developments statewide.

ROADSIDE SUITABILITY ASSESSMENT MODEL

The primary component of the framework is the roadside suitability assessment model. This model was designed to support integrated decision-making and policy level considerations for ROW use and development. It was desirable for the model to be as data-driven as possible. However, many critical assessment criteria either do not rely on spatial data or the requisite spatial datasets were not available. As a result, the suitability assessment model was developed as a two-stage decision process. Stage 1 includes a series of yes/no questions that are critical for assessing the suitability for development/use of the roadside ROW. Stage 2 is the roadside corridor assessment based on prioritization and analysis of available spatial data. The second stage is only necessary if all criteria in the first stage assessment are met.

Stage 1 – Assessment of Critical Suitability Criteria

The first stage of the model largely relates to conditions within the ROW, although considerations for state and federal policy and future development of adjacent property are also included. Six critical yes/no criteria are included in this stage, in addition to two development-specific criteria. Each of the criteria must be satisfied in order to move to Stage 2 assessment. Stage 2 assessment involves calculation of a Roadside Suitability Index for each section of roadside ROW being considered. Conversely, if any Stage 1 condition is not met, the proposed development should not occur at the particular location under consideration and it is not necessary to include the particular location in a Stage 2 assessment.

Table 6. Critical Right-of-Way Development Suitability Criteria

Condition	Required Answer for Condition to be Met	Point of Contact for Necessary Information
1. Is the proposed development/use disallowed by state or federal policy related to right-of-way use or access?	NO	MDOT ROW Division
2. Does the roadside right-of-way currently include any infrastructure or features that will negatively impact or be impacted by the proposed development/use? This may include, but is not limited to features/infrastructure used for: drainage, safety, signage, utilities, intersections/interchanges, bridges, environmental/natural resource remediation/protection (including Redbook Program sites), non-motorized pathways, or rest areas/parks/turnouts.	NO	MDOT TSC or Region Office; may require field visit or imagery review or contact with MDOT Environmental Division
3. Is the roadside right-of-way committed for future development/use by MDOT or other entities that will negatively impact or be impacted by the proposed development/use? This may include, but is not limited to: roadway or interchange expansion, rest areas/parks/turnouts, signing or ITS, utilities, environmental/natural resource remediation/protection (including Redbook Program sites), or non-motorized pathways.	NO	MDOT Region Office; contact with MDOT Environmental Division may also be necessary
4. Will the proposed development/use negatively impact or be impacted by any planned future developments adjacent to the corridor? This may include, but is not limited to, transportation developments, planned unit developments, or other residential, commercial, or industrial developments.	NO	City, Township, or Village Zoning Office
5. Is the right-of-way of sufficient width (at least 50 ft from the roadway edge is suggested) and is the slope or terrain suitable for the proposed development/use?	YES	MDOT TSC or Region Office; may require field visit or imagery review
6. If frequent access is necessary, is the shoulder wide enough to allow direct access from the highway or is an allowable alternative access point available?	YES	MDOT TSC or Region Office; may require field visit or imagery review
7. SOLAR PROJECTS ONLY: Does the location provide an unobstructed south facing overhead view, or can obstructions be readily removed to provide such a view?	YES	Assessment of land cover beyond ROW fence and terrain.
8. WIND PROJECTS ONLY: Does the location possess adequate wind generation potential?	YES	MSU Land Policy Institute online "Michigan Wind Prospecting Tool". (*31*)

A site that meets all of the Stage 1 criteria does not possess any features that would preclude the location from further consideration for the proposed development/use. Such sites are eligible for the Stage 2 suitability assessment, which includes spatial analysis of a broad variety of contextual features that are important for roadside development considerations.

Stage 2 – Calculation of Roadside Suitability Index

The primary function of Stage 2 is to determine the areas along a particular highway corridor (or series of corridors) that are most (or least) suitable for a particular type of proposed development within the roadside ROW. This is accomplished though the calculation of a Roadside Suitability Index (RSI) based on analysis of roadside contextual features data within GIS. Consideration is given to contextual features that exist either within the roadside ROW or adjacent to the ROW. The RSI provides an indication of the overall suitability of the particular area for a proposed development within the roadside ROW, relative to all areas being considered.

A total of 33 contextual features were identified for calculation of the RSI, which are displayed in Table 7 along with the raw data units and the source data file. Additional contextual features were investigated, but ultimately excluded from the final list of variables due to a number of factors, including strong correlation with other variables utilized during the pilot assessment or inadequate statewide coverage, particularly for the pilot corridor. In the case of correlated data, the decision to retain or discard a dataset was largely based on whichever set had broader statewide coverage. Several steps are performed during this stage, including:

1. Assemble geocoded and non-geocoded datasets into a single GIS database;
2. Using GIS, create a grid to subdivide the desired section(s) of roadside corridor into cells of uniformly sized area;
3. Using GIS, compute the raw data scores for each contextual feature within each grid area and scale the raw data scores relative to all sections under consideration;
4. Determine ratings (weights) for each of the contextual features with respect to the compatibility (or lack thereof) with development in the adjacent roadside ROW;
5. Calculate the Roadside Suitability Index (RSI) for each cell as the scaled raw score (Step 3) multiplied by the rating (Step 4) sum totaled over all contextual features.
6. Using the RSI, determine the relative suitability of the proposed development within the adjacent ROW for each section of the corridor.

Table 7. Contextual Features Used to Calculate the Roadside Suitability Index

Contextual Features	Units (within grid area unless specified otherwise)	Source Dataset Name	Coverage and File Type
Agriculture Land Cover	Percent of total area	National Land Cover Dataset, code 82 (NCDL, 2006)	Statewide shapefile
Commercial or Industrial Land Cover	Percent of total area	NCDL, codes 23,24	Statewide shapefile
Residential Land Cover	Percent of total area	NCDL, codes 21,22	Statewide shapefile
Forest or Open Land Cover	Percent of total area	NCDL, codes 41,42,43,52,81	Statewide shapefile
Tribal Lands	Percent of total area	TribalTract_2010Census_DP1	Statewide shapefile
Federal Lands	Percent of total area	ownership_federal_land	Statewide shapefile
DNR Lands	Percent of total area	state_dnr_ownership	Statewide shapefile
Property Value	Weighted average dollars per acre	Actual Value of Real Estate Adjacent to MDOT ROW	Statewide; requires manual extraction and georeferencing
Historic Site	Count	Historic Bridges, District, Markers, National Register, State Register	Statewide shapefile
MDOT Heritage Route	Distance in miles	Historical Heritage Routes	Statewide shapefile
BioRarity Index	Weighted average probability of rare species presence	MNFI BioDiversity	Statewide shapefile
MDOT Redbook Site	Presence (Yes or No)	redbook_sites	Statewide shapefile
Wild and Scenic Waterways	Distance in miles	wild_scenic_rivers	Statewide shapefile
Trout Streams	Distance in miles	trout_streams_2008	Statewide shapefile
Open Water	Percent of total area	NCDL, code 11	Statewide shapefile
Impaired Watershed (Total Maximum Daily Load)	Percent of total area	303D_poly_TMDL	Statewide shapefile
Wetlands	Percent of total area	NWI_Wetlands	Statewide shapefile
Wetlands in ROW	Percent of total ROW area	NWI_Wetlands	Requires manual tracing of the ROW line
Protected Wellhead	Percent of total area	Wellhead_Protected_Area	Statewide shapefile
Interchanges/Intersections	Count within ROW	mdot_all_roads	Statewide shapefile
Culverts within ROW	Distance in miles in ROW	mdot_culvert	Regional shapefile
Sewer and Water Lines	Distance in miles in ROW	Local Agency	Varies
ROW Area	Percent of total grid area	Scanned Raster Images	Requires manual tracing of the ROW line
Rest Areas	Percent of total distance along corridor	mdot_rest_area_2011	Statewide shapefile
Bridges	Count within ROW	mdot_bridge	Statewide shapefile
Roadsigns and ITS Devices in ROW	Count within ROW	Manual Count	Requires assessment of roadside imagery
Monitoring Wells in ROW	Count within ROW	mdot_monitoring_wells	Statewide shapefile
Adjacent Excess Parcels	Percent of total area	Scanned Raster Images	Requires manual tracing of the property boundary
Billboards	Count within ROW	Manual Count	Requires assessment of roadside imagery
Non-Motorized Mileage within ROW	Distance in miles in ROW	Michigan Trails and Greenways Map	Requires manual tracing of map
Wooded ROW Area	Percent of total distance along corridor	Manual Count	Requires assessment of roadside imagery
Wooded Beyond ROW	Percent of total distance along corridor	Manual Count	Requires assessment of roadside imagery
Laterally Steep ROW Slope	Percent of total distance along corridor	Manual Count	Requires assessment of roadside imagery

Grid Development

Analysis of the raw contextual features data and subsequent calculation of the RSI requires creation of a transect grid along both sides of the selected corridor. The grid is created within ArcGIS by offsetting a line parallel to the centerline of the corridor at a predetermined lateral distance on both sides of the corridor. For purposes of the pilot assessment, the offset distance was established as 1/2 mile on either side of the corridor. The next step was to place vertical lines at 1/4 mile increments along the entire corridor. This created uniform cells that were nominally 1/8 mi^2 (80 acres) in area. Each cell was assigned a unique identification number, beginning at the west end of the corridor with 001 on the on the north side and 101 on the south side. Similar to roadway stationing, the cell ID numbers increased incrementally while proceeding from west to east. Detailed information pertaining to grid creation in ArcGIS is found in Appendix E.

Figure 11. Excerpt of the Grid Created using GIS for Assessment of the Pilot Corridor

Computing Raw Scores and Rating Contextual Features

GIS is then utilized to calculate the quantity of each contextual feature within each cell according to the units displayed in Table 7. To the extent possible, the percent of total area or distance is utilized as the raw data value rather than the actual area or distance. This mitigates impacts due to slight differences between cell areas. The raw data scores are then entered into a spreadsheet for scaling, weighting, and computation of the RSI. In order to normalize the data

across all contextual features, it is necessary to scale the raw data between 0 and 1 based on the minimum and maximum observed values for all areas under consideration.

Each contextual feature must be rated on a -5 to 5 scale. A rating of 5 indicates that the contextual characteristic is compatible with the proposed type of development in the adjacent roadside ROW. Conversely, a rating of -5 indicates that the contextual characteristic is not compatible with the proposed development and the area should be avoided. A rating of 0 indicates that the contextual characteristic need not be considered for the proposed development. It is important to remember than such a suitability assessment must consider that stakeholders typically have different priorities and values. Consequently, ratings should typically be assigned based on aggregated input from all stakeholders. A default set of compatibility ratings was developed for various types of development and are presented in the following chapter.

Calculation of the Roadside Suitability Index

The relative suitability of each individual cell along the corridor may then be quantified based on the summation of scaled (0 to 1) scores for each of the contextual features multiplied by the rfor the particular feature, as follows:

$$RSI_i = \sum_j W_j S_{ij}$$

Where: RSI_i = roadside suitability index for cell "i" compared to all other cells under consideration for the proposed development.

S_{ij} = scaled value for cell "i" for the "jth" contextual feature

W_j = rating assigned to the "jth" contextual feature based on the compatibility of the particular feature with the proposed development.

The grid areas may then be ranked to determine the most (or least) suitable area for development. Positive scores suggest that the area is more suitable for the proposed type of development (in comparison to other candidate areas), while negative scores indicate incompatibility. It important to consider that the RSI is simply one tool in the decision-making process for roadside corridor planning. Ultimately, careful collective consideration should be given to all possible issues and opportunities, including those that may not be adequately accounted for within the suitability assessment presented here before a final decision is made.

CHAPTER 6:
DEMONSTRATION OF ROADSIDE SUITABILITY ASSESSMENT MODEL

The roadside suitability assessment model was demonstrated using an approximately 20-mile section of Interstate 94 between Mileopoints 88 and 108 in Kalamazoo and Calhoun Counties. This corridor is well-suited for demonstration of the model as it includes a variety of urban, suburban, rural, and natural contextual features. In addition, tribal lands, Fort Custer Army Center, and the Kalamazoo River are also adjacent to or intersect this corridor. Satellite imagery of the pilot corridor is shown in Figure 12. A grid of ¼ mile long by ½ mile wide (80 acre) areas along both sides of the 20-mile corridor was created using the procedure described in Appendix E. The pilot corridor overlaid with the grid is shown in Figure 13.

Land uses and land cover vary across the pilot study corridor. Land cover tends to be more urbanized with residential, commercial, and industrial uses in the middle 1/3 of the corridor, as the corridor passes through the City of Battle Creek. Agricultural land comprises much of the east and southwest portions of the corridor. Fort Custer exists as a large area of forested land, accounting for nearly all of the northwest 1/3 of the corridor. Wetlands and open water bodies are scattered throughout the corridor, with the Kalamazoo River intersecting the corridor approximately 6 miles west of the eastern limit of the study area.

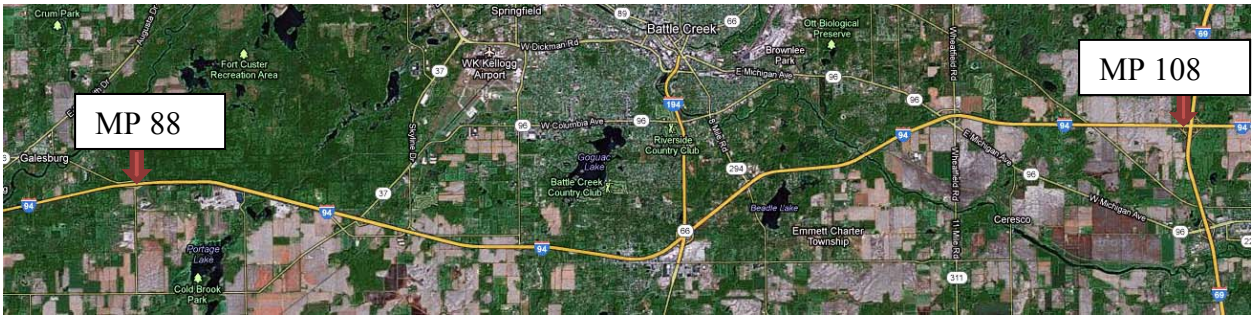


Figure 12. Satellite Imagery of I-94 Pilot Corridor

Figure 13. Pilot Section of I-94 with Analysis Grid Overlaid

Geodatabase Assembly

One of the primary tasks of the assessment was to obtain all necessary data for the pilot corridor, including both geospatial and non-geospatial datasets. In addition to state-maintained datasets, data were also obtained from the following local agencies: City of Battle Creek, Calhoun County, Kalamazoo County, Emmett Township, Marshall Township, and Charleston Township. Non-geospatial data required manual creation of each GIS shapefile. This was typically performed by scanning a paper map or importing an electronic map image and properly aligning the image into ArcGIS so that the particular feature could be traced into a shapefile. Shapefiles were created in this manner for ROW lines, master land use plans, excess parcel lines, sewer and water lines, and non-motorized paths.

It was also necessary to collect a limited amount of field data pertaining to the roadside that was not available from other sources. This included road signs and ITS devices, billboards, tree coverage both within and immediately adjacent to the ROW, and approximate foreslope/backslope grade. In order to obtain the roadside data safely and efficiently, a videolog was obtained for the corridor using a video camera with GPS capabilities. The still images extracted from this videolog were then imported into ArcGIS. The relevant data were manually extracted from each of the images and merged within the appropriate grid area in the shapefile. Details pertaining to video imagery collection and the process of merging into ArcGIS are provided in Appendix F.

Analysis

Stage 1 assessment of critical criteria showed that all conditions were met for the entire corridor and a subsequent Stage 2 suitability assessment should be performed considering all sections along the corridor. Five types of non-traditional ROW development were considered for the pilot corridor, including:

- Solar power generation
- Wind power generation
- Vegetation management/landscaping
- Agriculture/farming
- Green infrastructure (i.e., stream mitigation, wetland mitigation, etc.)

A default set of compatibility ratings was developed for each type of development based on the average ratings obtained from members of the MDOT Research Advisory Panel for this project, which are displayed in Table 8. The default ratings were generally in-line with standard land-use planning considerations.

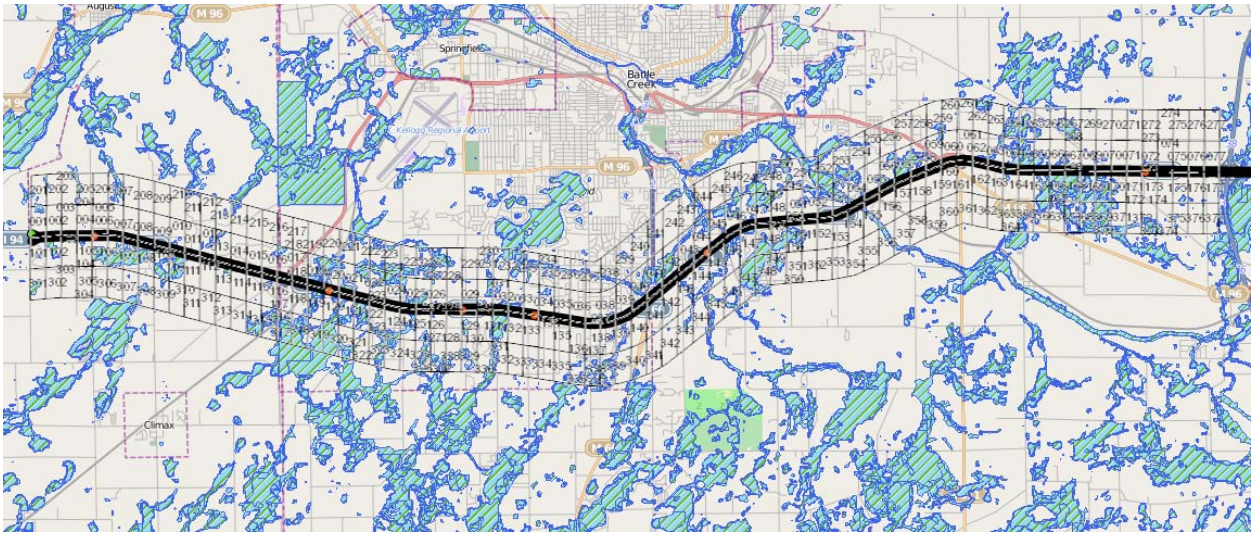
Table 8. Default Contextual Feature Compatibility Ratings based on Type of Non-Traditional ROW Development

	Proposed Type of Development Project				
Contextual Feature	**Wind**	**Solar**	**Vegetation Management/ Landscaping**	**Farming/ Agriculture**	**Green Infrastructure**
Agricultural Land Cover	4.3	2.0	0.7	5.0	1.9
Commercial or Industrial Land Cover	2.8	3.9	-2.3	-3.1	-0.3
Residential Land Cover	-2.1	-0.7	0.4	-0.2	2.4
Forest or Open Land Cover	1.9	0.0	5.0	3.0	4.0
Tribal Lands	1.4	1.4	2.3	1.4	2.3
Federal Lands	2.3	1.9	3.6	1.9	3.3
DNR Lands	2.0	1.6	4.6	1.8	4.4
Average Property Value	-2.2	-0.4	0.8	-1.0	0.7
Average BioRarity Index	-3.2	-3.1	2.1	-3.9	2.1
MDOT Redbook Site	-3.2	-3.1	2.1	-3.9	2.1
Wild and Scenic Waterways	-4.6	-4.4	2.4	-2.9	4.1
Trout Streams	-5.0	-5.0	2.4	-4.2	3.6
Open Water	0.9	-2.8	-1.7	-3.0	1.9
Impaired Watershed (TMDL)	-0.6	-1.1	2.1	-2.6	3.8
Wetlands	-3.0	-3.7	2.9	-3.8	3.7
Wetlands in ROW	-3.0	-3.7	2.9	-3.8	3.7
Protected Wellhead	1.0	-0.8	2.0	-3.4	2.4
Interchanges/Intersections	0.0	1.7	0.3	-1.7	0.3
Culverts within ROW	-0.9	-0.9	-0.3	-1.0	2.2
Sewer and Water Lines	-0.8	-0.8	-0.4	0.0	-0.9
ROW Area	3.6	3.7	4.3	4.1	4.4
Rest Area	3.0	3.3	2.2	0.7	3.7
Bridges	-2.4	-1.6	-0.2	-1.7	0.0
Roadsigns or ITS Devices	-1.2	1.6	0.6	-0.1	0.3
Monitoring Wells	-1.0	-0.8	1.0	-3.2	0.6
Adjacent Excess Parcels	3.6	3.7	4.3	4.1	4.4
Billboards	-1.6	1.8	0.9	0.7	-0.4
Non-Motorized Facilities within ROW	-0.1	0.0	1.2	-0.7	1.1
Wooded ROW	-2.8	-4.2	4.4	-4.0	2.2
Wooded Beyond ROW	-2.8	-4.2	4.4	-4.0	2.2
Laterally Steep ROW Slopes	-1.4	-0.8	1.8	-2.7	-1.0
MDOT Heritage Routes	-2.3	-2.3	2.4	0.3	1.7
Historic Sites	-4.1	-3.6	2.1	-0.1	0.6

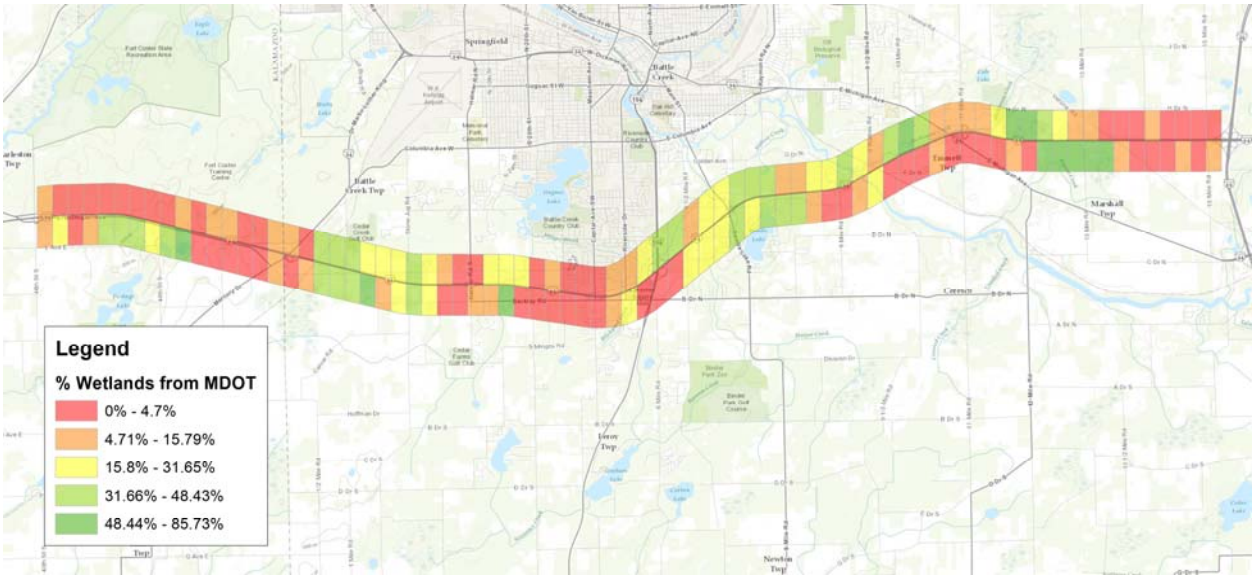
Note: A rating of -5 indicates that the contextual feature is not compatible with the proposed development.
A rating of 5 indicates that the contextual feature is compatible with the proposed development
A rating of 0 indicates that the contextual feature should not be considered for the proposed development.

Raw scores were computed based on the relative quantity of each contextual feature within each cell along the corridor. Figure 14 provides a visual comparison of how the wetland

shapefiles translated to calculation of the percent of wetlands within each cell. Additional graphical displays of the raw scores for various types of land cover are provided in Figure 15. The raw data were then appropriately scaled, multiplied by the compatibility ratings (Table 8), and summed over all contextual features to compute the RSI scores for each cell. The RSI scores for each cell are displayed for each of the five development types in color-shaded graphical and tabular formats in Figure 16 and Appendix G, respectively.

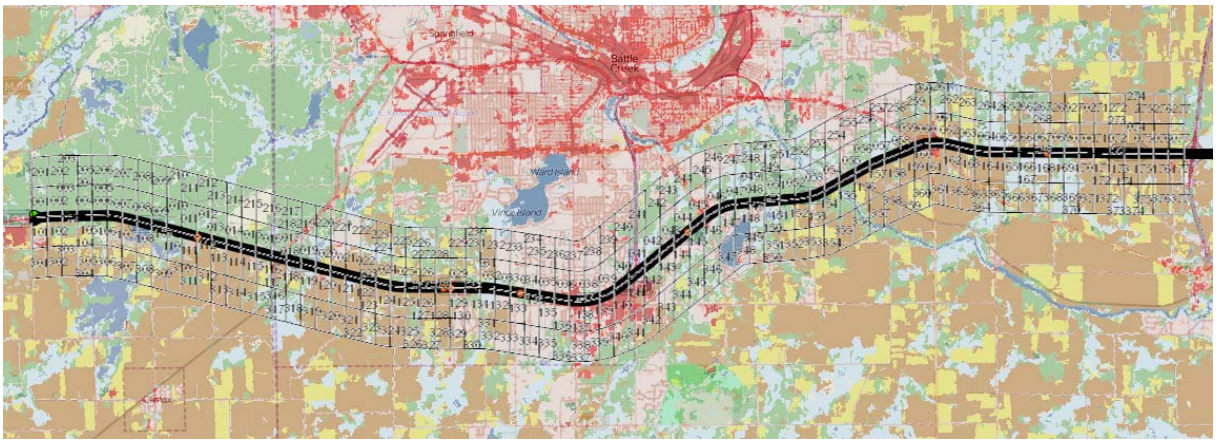


a. Wetland Shapefile with Grid (National Wetlands Inventory)

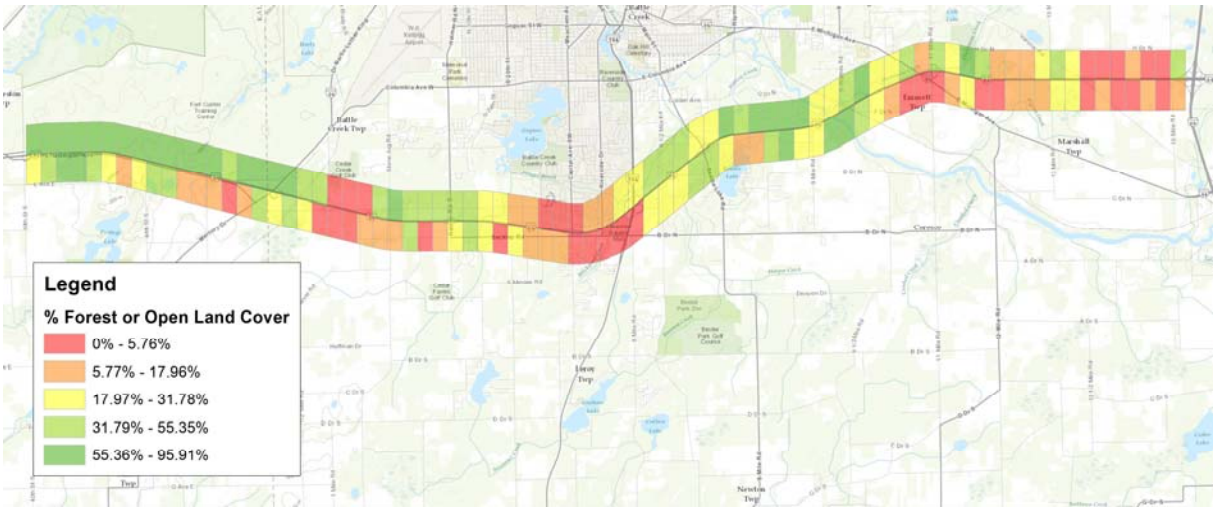


b. Percent Wetlands within Each Cell

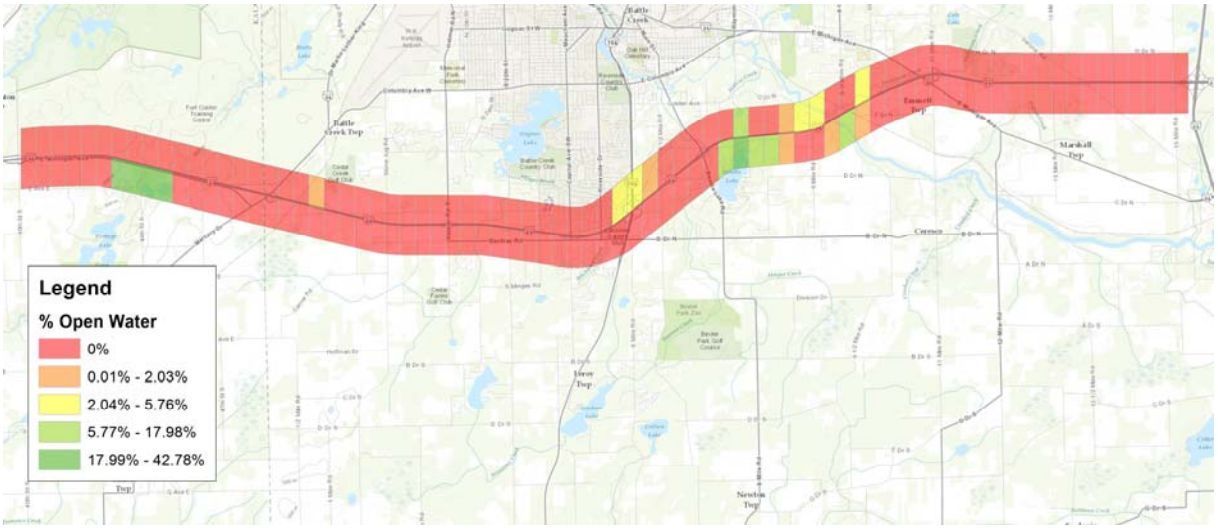
Figure 14. Comparison of Wetland Shapefile to Percent Wetland Area within Each Cell



a. Overall Land Cover (National Land Cover Database, 2006)

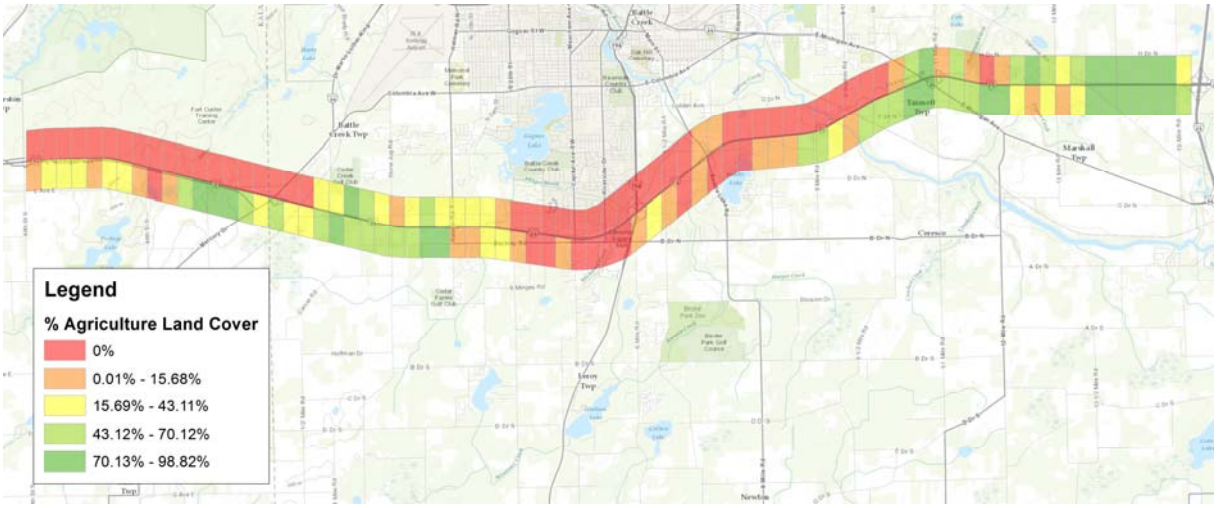


b. Percent Forested or Open Land Cover

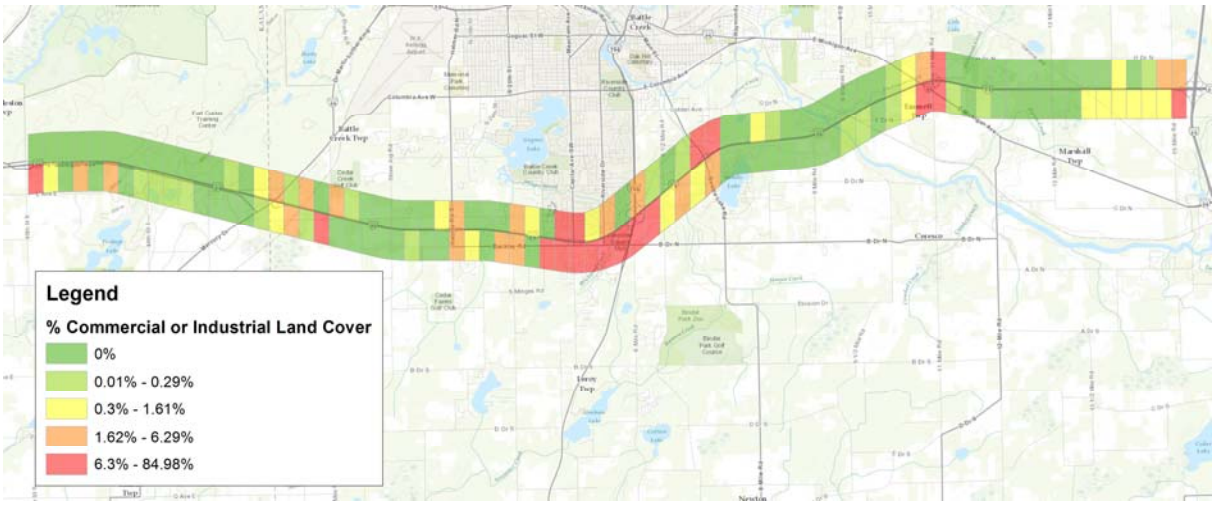


c. Percent Open Water

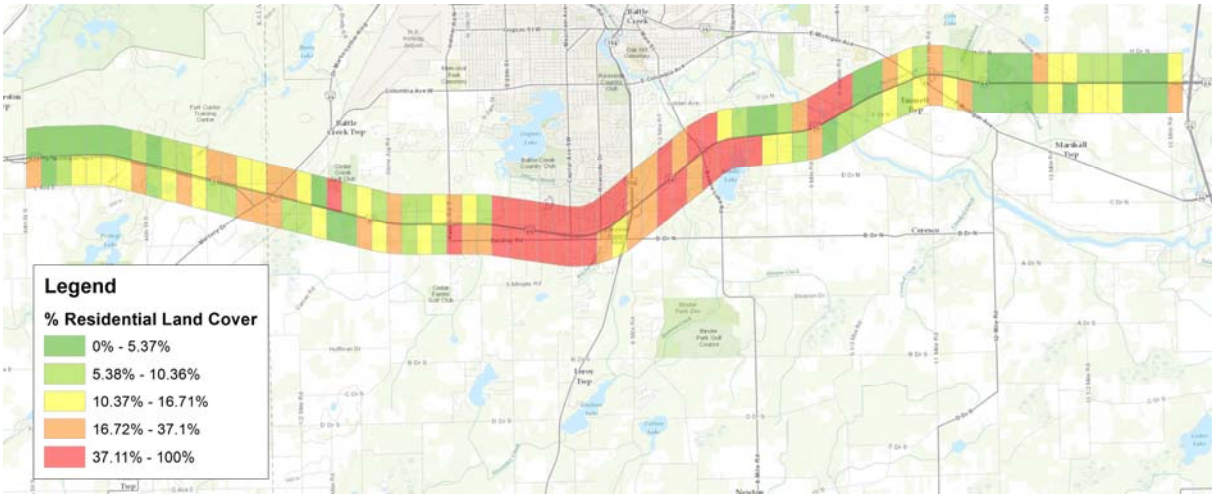
Figure 15. Land Cover Comparison for the Pilot Corridor



d. Percent Agricultural Land Cover

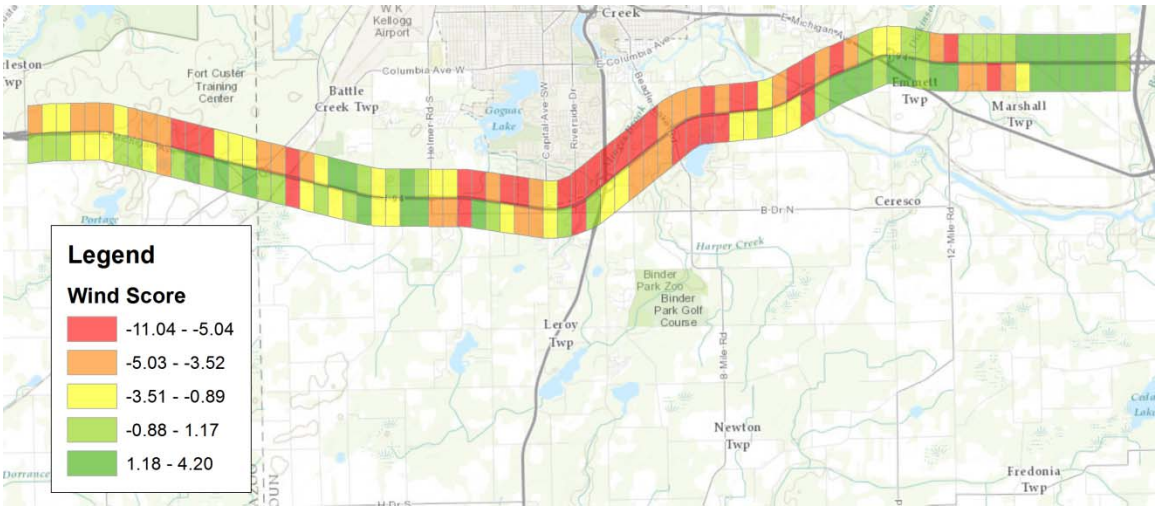


e. Percent Commercial or Industrial Land Cover

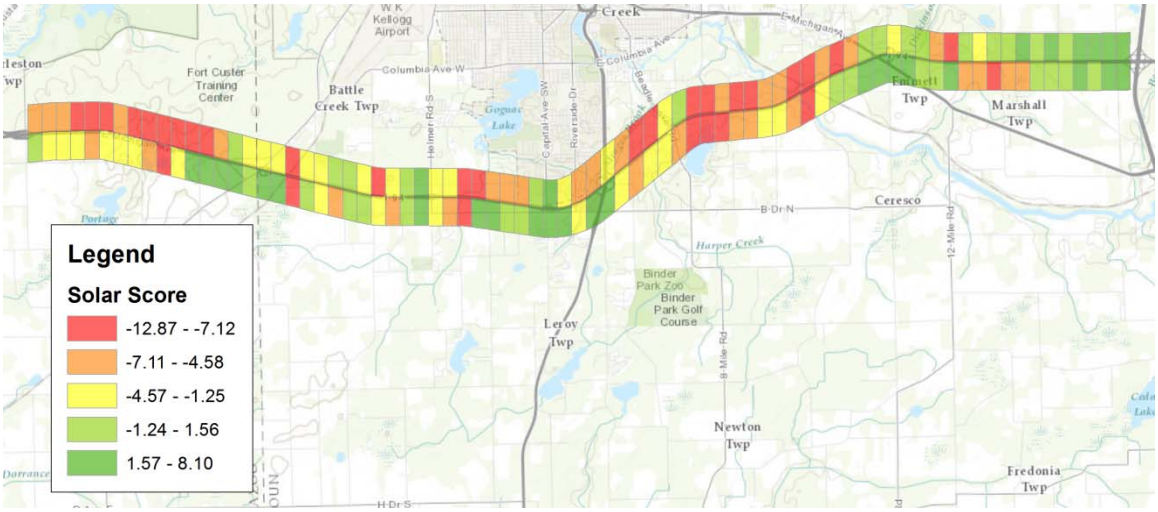


f. Percent Residential Land Cover

Figure 15 (Cont.). Land Cover Comparison for the Pilot Corridor



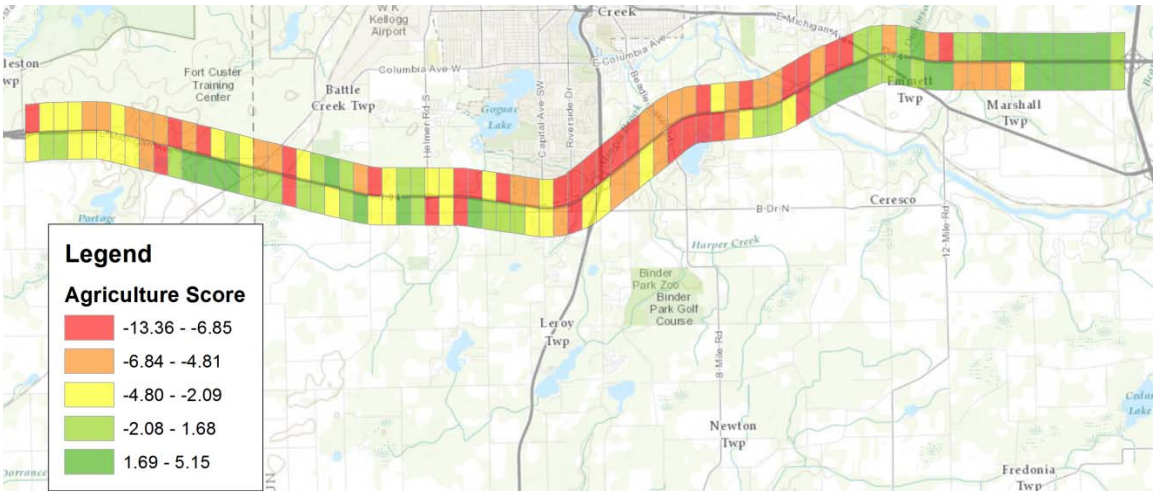
a. Wind Power Generation RSI Score



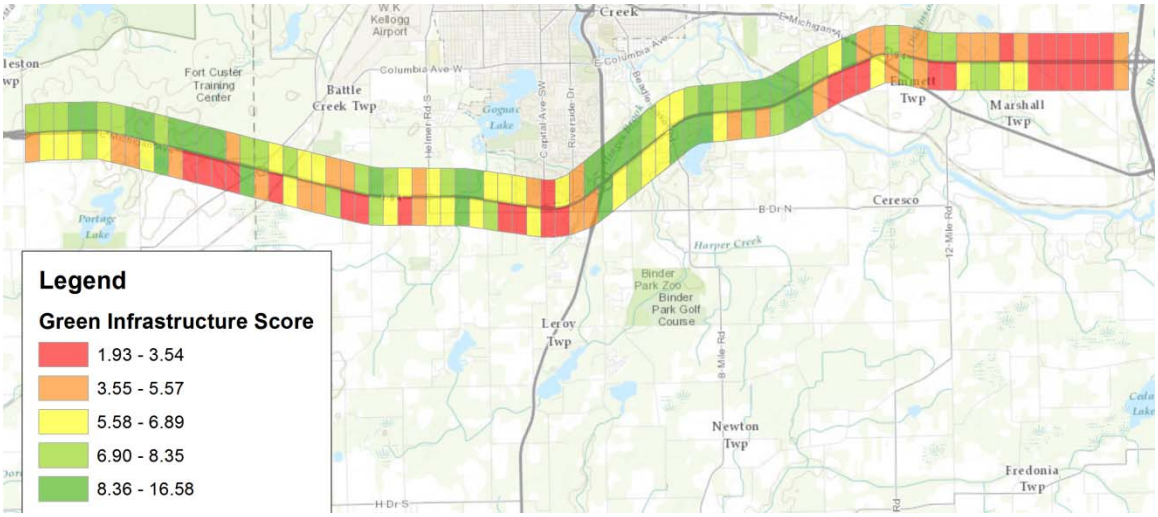
b. Solar Power Generation RSI Score

c. Vegetation Management RSI Score

Figure 16. Comparison of Roadside Suitability Index Scores based on Development Type



d. Agriculture RSI Score



e. Green Infrastructure RSI Score

Figure 16 (Cont.). Comparison of Roadside Suitability Index Scores based on Development Type

Discussion of Results

Comparison of the RSI scores along the pilot corridor found the results to generally be in-line with standard land-use planning considerations. As expected, the highest scoring (i.e., most suitable) sections for non-traditional ROW development varied based on the type of development being proposed. In the case of wind and solar power generation, the most suitable areas were found within the rural and predominately agricultural lands of the easternmost two-mile section of the corridor. This area was also the most suitable for agricultural development within the ROW. The most suitable areas for vegetation management within the ROW were adjacent to Fort Custer along the north side of the westernmost seven-mile section of corridor. This area was also found to be suitable for green infrastructure development. The wetland areas near the

Kalamazoo River crossing near southeast Battle Creek in the eastern 1/3 of the corridor were the most suitable for green infrastructure and were also highly suitable for vegetation management.

Urbanized areas, particularly residential areas, were typically the least suitable for each of the proposed development types. In particular, the area near the southern border of Battle Creek in the middle 1/3 of the pilot corridor should generally be avoided for all each of the five proposed types of ROW development, with the exception of green infrastructure. Additionally, wetlands, areas with rare species (Fort Custer), and forested areas in or immediately adjacent to the ROW were generally not suitable for solar, wind, or agricultural developments.

Considerations for Statewide Transferability

The initial suitability assessment of the pilot corridor was based on consideration of all contextual data, including data originating from both geospatial and non-geospatial sources. However, consideration of non-geospatial data required manual creation of a GIS shapefile, often by scanning and tracing printed maps, which utilized a considerable amount of time and resources from staff with considerable GIS experience. It is impractical to assume that manual shapefile creation would typically be performed when using this process to assess other corridors throughout Michigan. Further, it is also not possible to assume that locally sourced data will be available in a georeferenced format for integration with MDOT GIS data. Because the roadside suitability assessment must be transferrable for statewide use by MDOT staff, it was necessary that the RSI be calculated using GIS datasets that include broad coverage statewide.

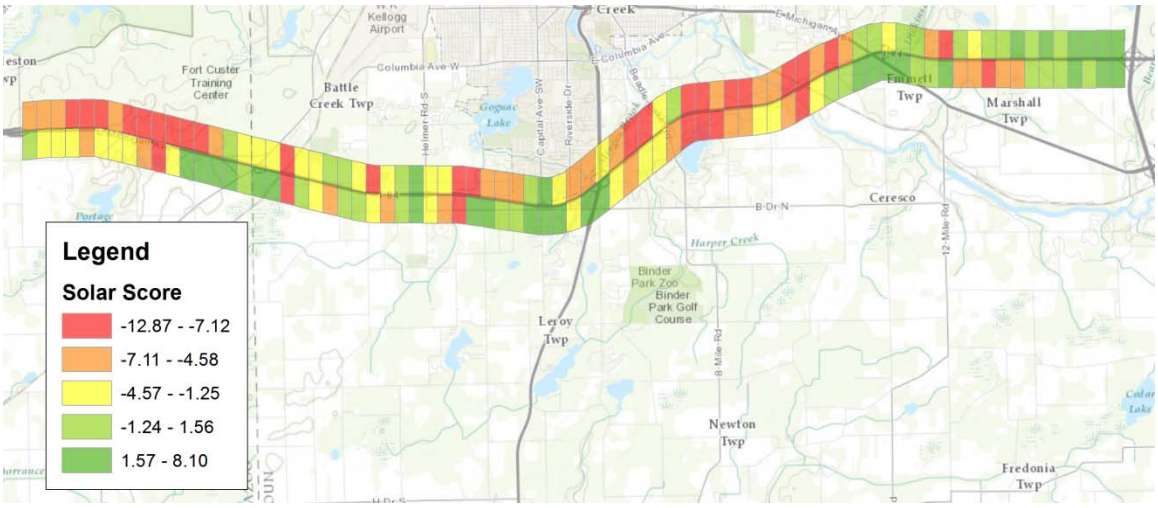
Of the original 33 contextual features, 21 were sourced from a GIS shapefile with statewide coverage, and thus, were retained for additional analysis. Furthermore, consideration was also given to utilizing a limited subset of comprehensive contextual features to further simplify the analytical process. It was necessary for this subset to include broad contextual considerations using statewide GIS data maintained by reliable sources. Ultimately, this subset included seven contextual features obtained from three sources. The contextual features utilized for comparison of the suitability index are displayed in Table 9.

The roadside suitability index was recalculated for all areas of the corridor for each proposed development type using 1.) the 21 GIS shapefiles with broad statewide coverage and 2.) the limited subset of seven comprehensive contextual features with broad statewide GIS coverage. The RSI scores for each of the three analyses are displayed for each of the five development types both in Figure 17 (graphical) and Appendix G (tabular).

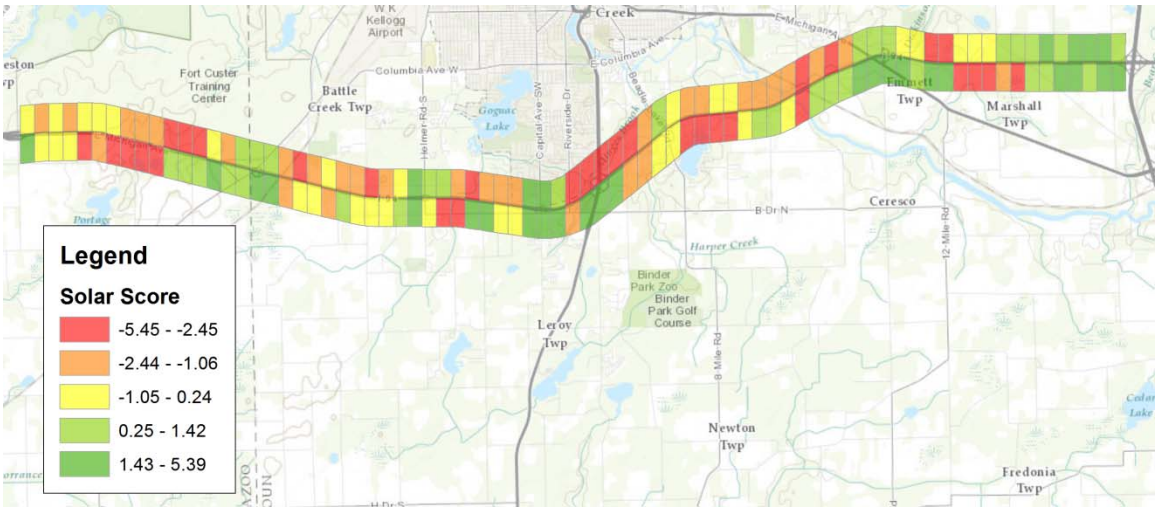
Table 9. Comparison of Contextual Features Utilized for Suitability Index Calculation

Contextual Feature	All Data	All Geospatial Data with Statewide Availability	Comprehensive Subset of Geospatial Data with Statewide Availability
Agricultural Land Cover	X	X	X
Commercial or Industrial Land Cover	X	X	X
Residential Land Cover	X	X	X
Forest or Open Land Cover	X	X	X
Tribal Lands	X	X	
Federal Lands	X	X	
DNR Lands	X	X	
Average Property Value	X		
Average BioRarity Index	X	X	X
MDOT Redbook Site	X	X	
Wild and Scenic Waterways	X	X	
Trout Streams	X	X	
Open Water	X	X	X
Impaired Watershed (TMDL)	X	X	
Wetlands	X	X	X
Wetlands in ROW	X		
Protected Wellhead	X	X	
Interchanges/Intersections	X	X	
Culverts within ROW	X		
Sewer and Water Lines	X		
ROW Area	X		
Rest Area	X	X	
Bridges	X	X	
Roadsigns or ITS Devices	X		
Monitoring Wells	X	X	
Adjacent Excess Parcels	X		
Billboards	X		
Non-Motorized Facilities within ROW	X		
Wooded ROW	X		
Wooded Beyond ROW	X		
Laterally Steep ROW Slopes	X		
MDOT Heritage Routes	X	X	
Historic Sites	X	X	
TOTAL CONTEXTUAL FEATURES	**33**	**21**	**7**

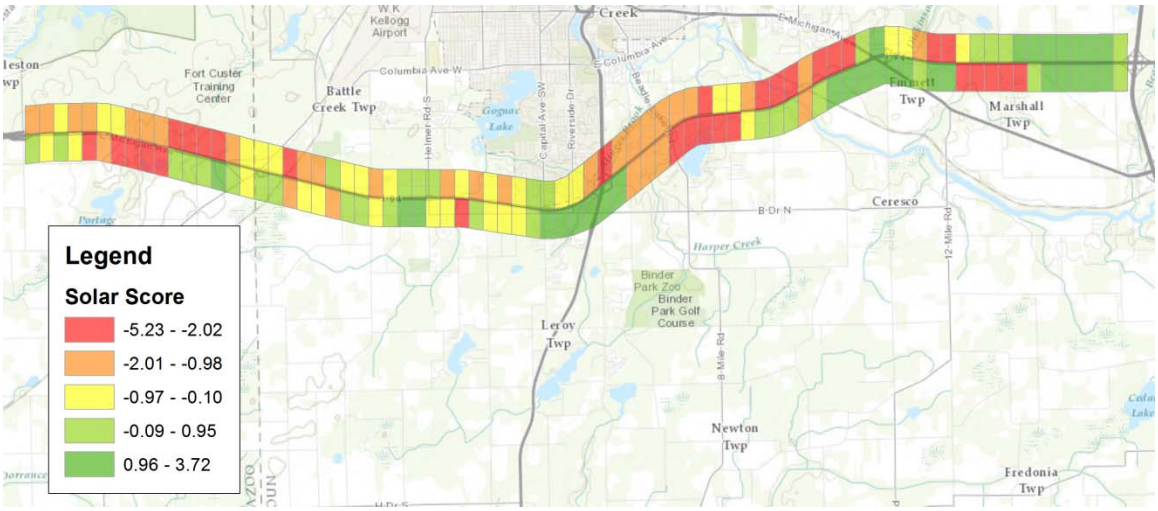
Comparison of the RSI scores computed using only the statewide GIS data with the original scores found that the overall conclusions pertaining to the relative suitability of each area along the corridor were similar, but not identical. The RSI scores generated based on the limited subset of seven comprehensive features showed reasonably good agreement with scores generated using all geospatially-sourced data, but showed less agreement with the scores from the full set of 33 contextual features. Although the use of this limited subset of contextual features would undoubtedly simplify the analytical process, thereby reducing time and/or resource constraints, additional testing is necessary at other locations to validate the accuracy.



a. RSI Score Based on All Available Data



b. RSI Score Based on All GIS Datasets with Statewide Availability



c. RSI Score Based on Subset of GIS Datasets with Statewide Availability

Figure 17. Roadside Suitability Index Scores for Solar Power – Comparison of Datasets

CHAPTER 7:
SUMMARY AND RECOMMENDATIONS

The overall purpose of this research was to develop a decision framework for landscape-level context-sensitive planning related to development within the roadside ROW on MDOT corridors. Several tasks were required during development of this framework, including identification of roadside functions and values, identification and prioritization of relevant contextual datasets, availability of such datasets in a geocoded format, and development of analytical procedures. The resulting framework provides a roadside suitability assessment model to support integrated decision-making and policy level considerations for ROW use and development. The model accommodates a broad range of potential types of ROW developments and corridor conditions, while considering a diverse range of roadside contextual features, including land use (current and future), land cover, environmental features, natural resources, and plant and animal habitats, among other features.

The primary function of the model is to determine the area(s) along a highway corridor that are most (or least) suitable for development within the roadside ROW. This suitability assessment process involves an initial assessment of several critical criteria followed by a subsequent spatial analysis of relevant roadside contextual features using a geographic information system (GIS). A Roadside Suitability Index (RSI) is calculated for each roadside area along a corridor (or series of corridors) that is being considered. The RSI provides an indication of the overall suitability of the particular area for a proposed development within the roadside ROW, relative to all areas under consideration. A summarized list of steps for the roadside suitability assessment is provided as follows:

1. Assemble necessary GIS shapefiles;
2. Using GIS, create a grid to subdivide the desired section(s) of roadside corridor into cells of uniformly sized area;
3. Compute the raw data scores for each contextual feature within each cell using GIS and scale the raw data scores relative to all sections under consideration;
4. Determine ratings (weights) for each of the contextual features with respect to the compatibility (or lack thereof) of a proposed development in the adjacent ROW;

5. Calculate the Roadside Suitability Index (RSI) for each cell as the scaled raw score (Step 3) multiplied by the rating (Step 4) sum totaled over all contextual features.
6. Using the RSI, determine the relative suitability of the proposed roadside ROW development for each section of the corridor.

Robust and accurate statewide GIS enterprise data is crucial for effective utilization of this framework and for roadside corridor planning and management in general. To those ends, a plan was prepared to reconcile gaps in the existing geospatial datasets. The recommended data gap reconciliation efforts are summarized as follows, with highest priority tasks listed first:

1. Georeference MDOT ROW lines and excess parcel boundaries statewide;
2. Georeference MDOT's Real Estate Management Information System (REMIS).
3. Georeference Michigan's current and proposed non-motorized facilities.
4. Perform global positioning system (GPS) field data collection to provide shapefiles for floodplains, well logs, and billboards for all MDOT ROW statewide.
5. Establish a program to require georeferencing of all contract soil boring activity performed within MDOT ROW statewide.
6. Develop a georeferenced underground utility location dataset for MDOT ROW.
7. Develop a shared online GIS repository to allow for sharing of local zoning and master land use plans that are typically maintained within local agencies.

The roadside suitability assessment process was demonstrated using a 20-mile pilot section of Interstate 94 between Exits 88 and 108 in Kalamazoo and Calhoun Counties. Five types of non-traditional ROW development were considered for the corridor, including: solar power generation, wind power generation, vegetation management/landscaping, agriculture/farming, and green infrastructure (i.e., stream mitigation, wetland mitigation, etc.). A grid of ¼ mile long by ½ mile wide (80 acre) areas was established along both sides of the 20-mile corridor. A default set of compatibility ratings was developed for each type of development based on the average ratings obtained from members of the MDOT Research Advisory Panel for this project. From there, RSI scores were calculated for each area considering each of the proposed non-traditional development types.

Comparison of the RSI scores along the pilot corridor found the results to generally be in-line with standard land-use planning considerations. In the case of wind and solar power

generation and agricultural uses (including biofuel), the most suitable areas for such developments within the roadside ROW were typically adjacent to rural and predominately agricultural lands. The most suitable areas for vegetation management in the ROW were locations with forested areas in and/or adjacent to the ROW. Wetland or forested/open areas tended to be the most suitable candidates for green infrastructure. Urbanized areas were typically the least suitable for each of the proposed development types. Additionally, wetlands, areas with rare species, and forested areas in or immediately adjacent to the ROW were generally not suitable for solar, wind, or agricultural developments.

The initial suitability assessment of the pilot corridor was based on consideration of all contextual data, including data originating from both geospatial and non-geospatial sources. However, consideration of non-geospatial data required manual creation of a GIS shapefile, which utilized a considerable amount of time and resources. A subsequent recalculation of the RSI scores was performed for the pilot corridor using only the 21 contextual features derived from an existing statewide geospatial dataset with broad statewide coverage. A comparison of the RSI scores based on the geospatially sourced data versus the original scores that also included data from non-georeferenced sources found that the overall conclusions pertaining to the suitability of each area along the corridor were similar, but not identical. An additional suitability assessment was performed using a limited subset of seven comprehensive contextual features derived from three reliable geospatial datasets with broad statewide coverage. The RSI scores generated based on these seven comprehensive features showed reasonably good agreement with scores generated using the full set of geospatially-sourced data, but showed less agreement with the scores from the full set of 33 contextual features. Although the use of this limited subset of contextual features would undoubtedly simplify the analytical process, thereby reducing time and/or resource constraints, additional testing is necessary at other locations to verify the accuracy.

It is impractical to assume that manual shapefile creation would typically be performed when using this process to assess other corridors throughout Michigan. Consequently, the 21 contextual features derived from geospatially sourced data with broad statewide coverage are recommended for statewide application of the roadside suitability assessment model. The recommended contextual features are listed as follows (the subset of seven comprehensive features is shown in boldface):

- **Agricultural Land Cover (% of area)**
- **Commercial/Industrial Land Cover (% of area)**
- **Residential Land Cover (% of area)**
- **Forest or Open Land Cover (% of area)**
- **Open Water (% of area)**
- **Wetlands (% of area)**
- **Average BioRarity Index (% of area)**
- Tribal Lands (% of area)
- Federal Lands (% of area)
- DNR Lands (% of area)
- Presence of MDOT Redbook Site (% of area)
- Wild and Scenic Waterways (length in mi)
- Trout Streams (length in mi)
- Total Maximum Daily Load (TMDL) Impaired Watersheds (% of area)
- Protected Wellhead (% of area)
- Number of Interchanges or Intersections
- Presence of Rest Area
- Number of Bridges
- Number of Monitoring Wells
- Number of Historical Sites
- MDOT Heritage Routes (length in mi)

Utilization of the suitability assessment framework for roadside development will benefit MDOT in several ways. The outcomes will enhance the ability for MDOT to make proper decisions pertaining to the use of ROW for non-traditional development. In addition, comparison of various developmental alternatives and/or contextual prioritization strategies will provide a better understanding of the impacts to competing interests or constraints with respect to agency needs or adjacent land uses. Further, inclusion of local data and stakeholders will help to ensure that developments within MDOT ROW are consistent with local objectives.

REFERENCES

1. MDOT State Long Range Transportation Plan 2005 – 2030 Highway/Bridge Technical Report. Michigan Department of Transportation, Lansing, MI, November 2006.
2. Research and Innovative Technology Administration. Alternative Uses of Highway Right-of-Way: Accommodating Renewable Energy Technologies and Alternative Fuel Facilities. Rep. N.p.: U.S. Department of Transportation - Research and Innovative Technology Administration, 2012. Print.
3. Federal Highway Administration. Information: Guidance on Utilization of Highway Right-of-Way. Rep. N.p.: FHWA, 2009.
4. Stamatiadis, Nikiforos, Adam Krik, Don Hartman, Theodore Hopwood, and Jerry Pigman. Quantitative Benefits of Context Sensitive Solutions. Rep. no. 642. Washington, D.C.: Transportation Research Board, 2009. Print.
5. Office of Program Administration. Program Guide - Utility Relocation and Accommodation on Federal-Aid Highway Projects. Rep. 6th ed. N.p.: Federal Highway Administration, 2003. Print.
6. Michigan Department of Transportation. MDOT Utility Accommodation Policy. Rep. N.p.: Michigan Department of Transportation, 2011. "NEPA Regulations." *NEPA*. N.p., n.d. Web. May 2013. <http://ceq.hss.doe.gov/welcome.html>.
7. Research and Innovative Technology Administration. *Alternative Uses of Highway Right-of-Way: Accommodating Renewable Energy Technologies and Alternative Fuel Facilities*. Rep. N.p.: U.S. Department of Transportation - Research and Innovative Technology Administration, 2012.
8. Minnesota Department of Transportation Procedures for Accommodation of Utilities on Highway Right of Way. Minnesota Department of Transportation. Revised November 8, 2005
9. American Association of State Highway and Transportation Officials. A Guide for Accommodating Utilities within Highway Right-of-Way. Rep. N.p.: American Association of State Highway and Transportation Officials, 2005.
10. Neuman, Timothy R., Marcy Schwartz, Leofwin Clark, James Bednar, Don Forbes, David Vomacka, Craig Taggart Edaw, Marie Glynn, Kevin Slack, and Doug Abere. A Guide to Best Practices for Achieving Context Sensitive Solutions. Rep. no. 480. Washington, D.C.: Transportation Research Board, 2002.
11. Talen, E. Help for Urban Planning: The Transect Strategy. Journal of Urban Design, Vol. 7, No. 3, Carfax Publishing, Taylor and Francis, 2002.
12. The Lexicon of the New Urbanism. Duany Planter-Zyberk & Co, 2002.
13. Integration of Context Sensitive Solutions in the Transportation Planning Process. Federal Highway Administration, Office of Planning, 2007.
14. Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities, Fact Sheet, Institute of Transportation Engineers, undated.
15. Lindquist K., Best Practices in Corridor Planning, Washington DOT Research Office, unpublished literature review, June 11, 2007

16. Williams, Kristine M., and Robert Frey. Corridor Preservation Best Practices. Rep. Tampa: Center for Urban Transportation Research, 2003. Print.
17. SHRP 2. *A SHRP 2 Capacity Project Brief: Planning Transportation Projects for Better Environmental Outcomes*. Rep. N.p., May 2013. Web. May 2013. <http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_PB_C06_2013-05.pdf>.
18. Meurk, Colin D., Robert H. Watts, Simon R. Swaffield, and Shaun Awatere. A Natural Environment and Cultural Asset Management System for New Zealand's State Highway Network: Towards a Practical Concept and Application. Rep. no. 503. Wellington: NZ Transport Agency, 2012.
19. Hancock, K. Developing a Logical Model for a Geo-Spatial Right-of-Way Land Management System. NCHRP Project 8-55, Transportation Research Board, Washington D.C., 2011.
20. Higgins, Catherine. "Planning Made Simpler." UDOT. Utah Department of Transportation, 22 June 2010. Web. 19 Mar. 2013.
21. Uplan Map Center. Utah Department of Transportation, n.d. Web. May 2013. <http://uplan.maps.arcgis.com/home/>.
22. Hancock, Kathleen L. Guide for Implementing a Geospatially Enabled Enterprise-wide Information Management System for Transportation Agency Real Estate Offices. Rep. no. 695. Washington, D.C.: Transportation Research Board, 2011. Right of Way Mapping and Monitoring. Minnesota Department of Transportation, n.d. Web. May 2013.
23. Right of Way Mapping and Monitoring. Minnesota Department of Transportation, n.d. Web. May 2013. <http://gisservices.dot.state.mn.us/geocortex/essentials/web/viewer.aspx?site=rwmm>.
24. Donaldson, Bridget M., and Joseph T. Weber. Use of a GIS-Based Model of Habitat Cores and Landscape Corridors for the Virginia Department of Transportation's Project Planning and Environmental Scoping. Rep. no. VTRC 07-R14. Charlottesville: Virginia Transportation Research Council, 2006.
25. "About Beginning with Habitat." Beginning with Habitat: About BwH. Beginning with Habitat, n.d. Web. 24 Apr. 2013. <http://www.beginningwithhabitat.org/about_bwh/index.html>.
26. Sadasivuni, R, C.G. O'Hara, R. Nobrega, and J. Dumas. A Transportation Corridor Case Study for Multi-Criteria Decision Analysis. American Society for Photogrammetry & Remote Sensing, Annual Conference, Baltimore Maryland, 2009.
27. Kreminski, Rick, Arthur Hirsch, and Jane Boand. *Assessment of Colorado Department of Transportation Rest Areas for Sustainability Improvements and Highway Corridors and Facilities for Alternative Energy Source Use*. Rep. no. CDOT-2011-3. Denver: Colorado Department of Transportation, 2011.
28. "Office of Innovative Partnerships and Alternative Funding Innovative Partnerships Program." Office of Innovative Partnerships and Alternative Funding Innovative Partnerships Program. N.p., n.d. Web. May 2013. <http://www.oregon.gov/ODOT/HWY/OIPP/Pages/inn_solarhighway.aspx>.

29. Derr, J. Wisconsin Ditchmass: A 2010 Road Shoulder Biomass Energy Harvesting Pilot Project, Final Report for the Wisconsin Department of Transportation & the Wisconsin Office of Energy Independence, 2011.
30. The Michigan Geographic Data Library, Michigan Department of Technology, Management, and Budget, http://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext, Accessed March 2012.
31. Michigan Wind Prospecting Tool. Michigan Land Policy Institute. http://www.landpolicy.msu.edu/WPT/. Accessed March 2013.
32. "Biological Rarity Index and Probability Value - 40 Acre Grid." *Biological Rarity Index and Probability Value*. Michigan State University Extension. http://mnfi.anr.msu.edu/data/rarityindex.cfm. Accessed Apr 24th 2013.
33. Schuen, D. and Ulrika Z. Redbook Protection Manuals Presentation, Michigan DOT, http://mnfi.anr.msu.edu/symposium/MDOT_Protected_Areas_Program.pdf. Accessed April 2013.
34. National Land Cover Database. United States Geological Survey, Department of the Interior. http://www.mrlc.gov/nlcd2006.php. Accessed March 2013.
35. Wickham, James D.; Stehman, Stephen V.; Gass, Leila; Dewitz, Jon; Fry, Joyce A.; Wade, Timothy G., Accuracy assessment of NLCD 2006 land cover and impervious surface, In *Remote Sensing of Environment*, *130,* Elsevier, Amsterdam, Netherlands, pp 294 – 304, 2013.
36. Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, *PE&RS*, Vol. 77(9):858-864.