Taxonomy for Geotechnical Assets, Elements, and Features

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ABSTRACT

The advent of transportation asset management has spawned the need to develop precise definitions on nomenclature regarding the assets under consideration. While definitions for specific geotechnical assets have been discussed for more than 10 years, no classification has been established within the geotechnical or asset management community. Proper classification facilitates effective asset management and the development of best practices by helping ensure that all assets are appropriately recognized and uniquely identified. This paper presents a geotechnical taxonomy for transportation infrastructure assets with the goal that this type of classification will facilitate communication and advancement in geotechnical and transportation asset management. The taxonomy is based on practical definitions and distinctions based on the current state of practice with transportation asset management and the requirements of the MAP-21 legislation. Geotechnical Assets are defined as physical and independent assets that are within the right-of-way and an integral part of a transportation corridor. Generally they can be considered as one of four types: slope, embankment, subgrade and earth retaining structure. Geotechnical Elements are defined as parts of other managed asset classes (bridges, tunnels, pavements, etc.), and Geotechnical Features exist outside the right-of-way but impact performance of a corridor through their own performance. The classes of independent geotechnical assets, geotechnical elements and geotechnical features are distinguished from one another and from other physical and non-physical geotechnical assets by the way in which they can be managed.

Keywords: Geotechnical, Engineering Geology, Transportation, Highway, Corridor, Asset, Management, Classification, Taxonomy, Feature, Element
INTRODUCTION

Institutional geotechnical knowledge, geotechnical data, and geotechnical infrastructure components all add value to a highway agency so all can be considered “geotechnical assets” in a broad sense, but they are quite different and different approaches are desired to best capture their value. Taxonomy is a system of classification and a term familiar to most through biology: the classification of plant and animal kingdoms, and so on, but it is also used in business and other sciences (1). The term is sometimes used to emphasize a classification based more on principles than simple attributes, and that is why it is used here. This taxonomy is more about separating things such as the knowledge of a workforce or the subsurface conditions in an area, from an integral piece of highway infrastructure, than it is, for example, about distinguishing a retaining wall from a slope. It will facilitate effective asset management and the development of best practices by helping ensure that all assets are appropriately recognized and uniquely identified.

For many years, the Federal Highway Administration (FHWA) has promoted activities to enhance and preserve these vastly different types of geotechnical assets. The FHWA conducts program reviews which help state departments of transportation (DOTs) maintain a corporate capacity with respect to knowledge and skills, and help them build in succession planning to maintain knowledge in the workforce. The FHWA has also been a proponent of data management, spatial, and otherwise. Developing the Deep Foundation Load Test Database (DFLTD) (2) and participating in the development of the Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) are examples of this. Finally, the FHWA has been supporting inventory and condition assessment programs such as Rockfall Hazard Rating System (RHRS) (3) and the Retaining Wall Inventory Program (WIP) (4) for physical parts of highway infrastructure for more than 20 years. These efforts are linked through this taxonomy in such a way that the recognition of the importance of workforce and data assets is maintained, even as the geotechnical discipline embraces the expanding use of transportation asset management.

Recently, with the reorganization of the FHWA office structure and language included in the Moving Ahead for Progress in the 21st Century Act (MAP-21), transportation asset management and performance management have become central to the way the federal highway program is delivered. MAP-21 required that performance objectives are set, measures are established to track progress towards these objectives, targets are established to indicate the desired level of performance, and resources are allocated in a prioritized way to help ensure these targets are met. While no geotechnical assets are specifically a part of the agency’s reorganization or the MAP-21 legislation, the management of some geotechnical assets (the infrastructure components) is aligned with the practice of transportation asset management, and can benefit from these developments.

The purpose of this paper is to clarify language and ideas so that geotechnical engineers and engineering geologists (geoprofessionals), other disciplines, and asset managers can communicate effectively within one organization and between different ones. Within the FHWA and most DOTs there are now individuals that work primarily on transportation asset management. Their focus is on meeting the requirements of MAP-21 and they are developing useful plans, measures, and procedures for doing so. Often they do not engage their geoprofessional counterparts but it will soon become evident that geotechnical asset management will help them meet their objectives by helping to improve performance and minimize lifecycle cost of a corridor and all that is within it. The principles and terminology of this taxonomy, which are summarized in Figure 1, are proposed to help with communication among geoprofessionals and asset managers, and others involved in program delivery.
The adjective “Geotechnical” means the asset is comprised of earth, pertains to earth, or its performance is achieved through earth interaction with a structure or inclusion.

Inclusions are any and all non-earth modifications: pipes, anchors, grids, fabrics, grouts, etc.

Predominant distinction in how feature is managed. Assets with inclusions are “modified”.

Established management systems for other structures that have (or could have) geotechnical elements.

High slopes, shorelines, and structures typically owned by others outside the ROW that are sources of risk because they can impact performance.

Investigation and test results, lab and field equipment, key personnel

FIGURE 1 Proposed Geotechnical Asset Taxonomy.
Most states are doing something now to manage their geotechnical assets; typically, they are starting with inventory and assessment, and some don’t even recognize their actions as the beginning of geotechnical asset management. States are starting with different assets (slopes, walls, embankments, etc.) for different reasons. Additionally, some states are embracing Geographic Information Systems (GIS) to get the best long-term value from their field and laboratory data by making it more readily retrievable and reusable. A common language and understanding of ideas (the management principles that distinguish the taxonomy categories) will allow states to get the most benefit from the work they each are doing individually. Thus, the two primary motivations for defining this taxonomy of geotechnical assets are: (a) facilitating communication within a transportation department that will allow asset managers, geoprofessionals, and other disciplines to work together as appropriate to meet their organization’s asset management needs, and (b) facilitating sharing of new experience between transportation departments.

This paper contains answers to the questions:

- What is a geotechnical asset?
- What can be done to manage one?
- How does an asset differ from an element or a feature?

Because the intent is to prepare for alignment with transportation asset management plans, the focus here is on the branch of the taxonomy tree that defines geotechnical assets that can and should be managed with transportation asset management principles; assets such as knowledge and data are distinguished from this group and are recommended to be considered separately.

PHYSICAL ASSETS

The American Association of State Highway Transportation Officials (AASHTO) defines an “asset” as follows:

An asset is the physical transportation infrastructure (e.g., travel way, structures, other features and appurtenances, operations systems, and major elements thereof); more generally, can include the full range of resources capable of producing value-added for an agency: e.g., human resources, financial capacity, real estate, corporate information, equipment and materials, etc., an individual, separately-managed component of the infrastructure, e.g., bridge deck, road section, streetlight. (2).

The first and third parts of this three part definition are about physical infrastructure assets of the type where Transportation Asset Management (TAM) approaches such as meeting performance objectives at minimum life cycle cost can be applied. The second part of this definition includes aspects such as knowledge, data and equipment. Thus, the first order separation in the taxonomy is based on whether or not the asset is a physical part of infrastructure that can be managed as such. This distinction is shown in Figure 2. Non-physical assets are distinguished from physical ones by the fact that they are not a component of physical infrastructure. Non-physical assets may be material items such as drilling or laboratory equipment, or they may be knowledge-based, such as data, or human resources. There is value in managing these non-physical assets through workforce planning, equipment
maintenance and replacement plans, and data management systems, like a Geographic
Information System (GIS) to permit query and retrieval of subsurface information. Doing so
will generally result in faster project delivery with less cost and higher quality.

In contrast, physical assets form a part of the highway infrastructure. The ‘geotechnical’
adjective means the asset is comprised of earth (soil and rock), pertains to earth, or its
performance is achieved through the earth’s interaction with a structure or inclusion. Inclusions
are defined as any and all non-earth modifications: pipes, anchors, grids, fabrics, grouts, etc., and
are a distinguishing trait for a later part of the taxonomy. The geotechnical assets which can and
should be part of a transportation asset management plan are part of this set and the discussion of
taxonomy follows this branch.

ASSETS ALONG THE CORRIDOR

Physical assets are either part of a transportation corridor and contribute to the function of
moving people and goods from one end to the other, or they are not on a corridor. Most
transportation geotechnical assets are part of a corridor. The earliest work in classifying
geotechnical assets didn’t even consider an alternative: Sanford Bernardt et al. (6) only
considered assets that would be part of a corridor (Table 1). They described geotechnical assets
based on the interaction of the geotechnical assets with other types of assets and indicated that
the boundaries are often blurred. They categorized geotechnical assets in terms of function as
“exclusively geotechnical,” “partially geotechnical,” and “minimally geotechnical” to
indicate the degree of interaction with other assets, as shown in Table 1. The taxonomy
presented herein is slightly different and is based on how the assets will be managed, but it
includes everything in Table 1.
## TABLE 1 Summary of Highway Components That May Be Considered Geotechnical Assets (From Sanford Bernhardt et al. (6))

<table>
<thead>
<tr>
<th>Asset function category</th>
<th>Interaction with other assets</th>
<th>Asset</th>
<th>Purpose</th>
<th>Performance objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exclusively geotechnical</td>
<td>Indirect</td>
<td>Embankments and slopes</td>
<td>To provide for gradual grade changes in vertical alignment</td>
<td>Provide satisfactory support for roadway without intruding on pavement or other transportation structures</td>
</tr>
<tr>
<td>Partially geotechnical</td>
<td>Direct</td>
<td>Tunnels and earth retaining structures</td>
<td>To retain earthen materials so that highway can be constructed in restricted right-of-way</td>
<td>Satisfactorily retain earth materials to prevent intrusion or damage to highway structures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Culverts and drainage channels</td>
<td>To provide control of surface waters</td>
<td>Prevent accumulation of water on pavement and prevent damage to highway structures from erosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Foundations</td>
<td>To transmit structural loads to supporting ground</td>
<td>Satisfactorily support structure without excessive deformations</td>
</tr>
<tr>
<td>Minimally geotechnical</td>
<td>Direct</td>
<td>Pavement subgrade</td>
<td>To serve as foundation for pavement</td>
<td>Satisfactorily support pavement without damaging or reducing the life of the pavement</td>
</tr>
</tbody>
</table>

The Sanford Bernhardt et al. (6) work provides the starting point for most other renditions of geotechnical asset definitions. A recent summary of Geotechnical Asset Management concepts and strategies (7) provides another summary of identified geotechnical assets in 10 types (see Table 2). The identified assets include embankments and slopes, foundations, earth retaining structures, subgrades, and drainage features. Most of the identified assets are within the corridor and highway right-of-way, however, material and quarry sites are now included. Material sites, quarries, and stockpiles are geotechnical assets that are not particularly tied to a corridor, and can be set aside for alternative management schemes, as shown in Figure 2. It is also possible to manage these assets separate from a corridor, but using similar principles, and Alaska has taken this approach (8).

Geotechnical assets along a corridor should be part of a fully developed transportation asset management plan and the discussion of taxonomy follows this branch, as indicated by the arrow in Figure 2. Note that “GAM Section” is identified on the continuing branch of taxonomy in Figure 3. A Geotechnical Asset Management (GAM) Section is a hypothetical length of corridor where the geotechnical attributes are similar and the section could perhaps be measured and managed as one asset. The idea, introduced by David Stanley and Paul Thompson in their work for the Alaska Department of Transportation and Public Facilities (AKDOT&PF), is that inventory and assessment of the geotechnical assets in the section would be done by the same people at perhaps the same time, and combining assets into a section would be a good way to realize efficiency. Experience will inform us of whether this is a useful concept or not.
TABLE 2 Geotechnical assets identified by Vessely (7)

<table>
<thead>
<tr>
<th>Geotechnical Asset Type</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankments and Slopes (to include rock slopes, cut slopes, landslides, and rockfall sites)</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td></td>
<td>Perry et al., cuttings (9)</td>
</tr>
<tr>
<td></td>
<td>Perry et al., embankments (10)</td>
</tr>
<tr>
<td></td>
<td>Kelly (11)</td>
</tr>
<tr>
<td></td>
<td>Stanley and Pierson (12)</td>
</tr>
<tr>
<td></td>
<td>American Association of Highway and Transportation Officials (AASHTO) (5)</td>
</tr>
<tr>
<td>Tunnels</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td></td>
<td>American Association of Highway and Transportation Officials (AASHTO) (5)</td>
</tr>
<tr>
<td>Earth Retaining Structures (retaining walls, reinforced soil slopes, and earth and rock buttresses)</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td></td>
<td>Brutus and Tauber (13)</td>
</tr>
<tr>
<td></td>
<td>DeMarco et al. (4)</td>
</tr>
<tr>
<td></td>
<td>Stanley and Pierson (12)</td>
</tr>
<tr>
<td>Culverts or Drainage Channels</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td></td>
<td>DeMarco et al. (4)</td>
</tr>
<tr>
<td></td>
<td>American Association of Highway and Transportation Officials (AASHTO) (5)</td>
</tr>
<tr>
<td>Foundations</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td></td>
<td>Stanley and Pierson (12)</td>
</tr>
<tr>
<td>Pavement Subgrade</td>
<td>Sanford Bernhardt et al. (6)</td>
</tr>
<tr>
<td>Subgrade and Land within Right-of-Way</td>
<td>United Kingdom Department for Transport (14)</td>
</tr>
<tr>
<td>Buried Reinforcing Elements, Rock Bolts, Tieback Anchors, and other Buried Structural Elements</td>
<td>Stanley and Pierson (12)</td>
</tr>
<tr>
<td>Material and Quarry Sites</td>
<td>Stanley and Pierson (12)</td>
</tr>
<tr>
<td>Horizontal Drains</td>
<td>Stanley and Pierson (12)</td>
</tr>
</tbody>
</table>

THE IMPORTANCE OF RIGHT-OF-WAY

There are two types of geotechnical assets along a corridor: those within the right-of-way (ROW) and those outside of it, and both of them serve to contribute to the performance of the corridor. When these assets perform well, the corridor performs well with respect to multiple objectives, such as fewer accidents, longer lasting infrastructure, fewer interruptions to service, less damage to vehicles, etc. These are performance metrics that can be rolled up and measured at the corridor level and it is therefore possible to look at the corridor as being the high-level asset being managed. However, geotechnical “assets” outside of the right-of-way are not owned by the highway agency and as such they cannot be fully managed using the TAM principles that apply to ROW Assets, such as programmed maintenance, rehabilitation, and replacement.

Hence, a distinction is made here.

The term “Feature” is used here specifically to identify physical assets outside of the agency’s ROW ownership. These Features, which may introduce geotechnical impacts from outside the right-of-way, are identified in Figure 3 as “Outside-ROW Features” (not assets). For example, an adjacent slope of several hundred feet or a designated Wild and Scenic River that shares the valley bottom are Outside-ROW Features. How they perform will have impact on the performance of the highway corridor through their impact on slopes, walls, and embankments but the agency does not have complete authority to manage them, for example, by placing riprap or by scaling or flattening the slope. Features should be inventoried and understood to the extent practicable, but significant management activities may be limited – and may require special easements.
ROW Assets and Outside-ROW Features are identified in Figure 3. Outside-ROW Features are categorized as water bodies, slopes, or structures that might have an impact on the geotechnical performance of the right-of-way corridor. These features can be inventoried and catalogued for their potential impact, particularly from an extreme events perspective. They are more likely to be a liability than a positive asset because of the impact they could cause to the performance of the corridor and the fact that they are owned or managed by others, or perhaps not managed at all. Retaining walls, bridges or embankment at the edge of the right of way are examples of the Structures category. Examples of Water Bodies are rivers, reservoirs, lakes or oceans – of course it is the water’s interaction with earth that is the consideration here and this mostly occurs along shorelines. Slopes outside of the right-of-way can be above or below the road and are often much larger than engineered cut or fill slopes within the right-of-way in the same area. Though Outside ROW Features cannot be managed in the same way as ROW Assets, the risk to corridor performance can be managed (lowered), if funding mechanisms are available for such work, by (a) understanding the type and extent of features present, (b) having contingency plans to limit consequences of events initiating outside the right-of-way, and (c) making design and use changes within the right-of-way.

Since Inside-ROW Assets are owned and accessible by the highway agency, the agency has control over how they are built, maintained, and managed. The geotechnical assets which belong as part of a fully developed TAM plan are of this type and the discussion of taxonomy follows this branch. Asset management plans that also address Outside-ROW Features are addressing the risks posed to the corridor asset more thoroughly and are ultimately desirable.

DOTs that lease or make available their highway ROW for other types of assets, for example, cables, pipes and even transit, will find there is a symbiotic relationship between their highway assets and these other assets that are constructed on or within their structures (bridges, tunnels, embankments, subgrades, etc.). Their own asset management activities will impact...
these other assets just as management of these other assets will impact their highway structures. This recognition is an important part of any agreements and the challenge has been addressed for more congested environments (15, 16).

GEOTECHNICAL ASSETS AND GEOTECHNICAL ELEMENTS

ROW assets are separated into those that are independent assets, called Geotechnical Assets, and those that are part of another structure (asset) such as a bridge, tunnel, pavement, or perhaps culvert, called Geotechnical Elements (Figure 3). This is a distinction based on how they will be managed: whether there is an element that needs to be incorporated in an existing system, for example the National Bridge Inventory System (NBIS) for bridges or the National Tunnel Inventory System (NTIS) for tunnels, or whether an independent system is needed. A geotechnical element of another structure is best identified as exactly that because it is already captured, or could be, as an element of another asset. Thus, the term Geotechnical Element is defined herein to capture geotechnical assets that have a direct bearing on the performance of another already managed asset. Note that Sanford Bernhardt et al. (6) distinguished these assets not as “Geotechnical Elements”, but as having “Direct” interaction with other assets (Table 1).

The distinction between Geotechnical Assets and other assets with Geotechnical Elements is a pragmatic one because these other assets tend to have established inspection programs that support management programs, and in the cases of bridges, tunnels, and pavement systems have now been developed to comply with MAP-21 legislation. Thus, it is important to recognize the contribution of the geotechnical element(s) to these other assets, and to manage them through the existing platforms, and not create something new.

Generally, the extent to which geotechnical elements are included in existing management systems is minor. Many practitioners, including the engineers of bridges and pavements, and the fabricated parts of tunnels, think of the geotechnical elements as being essentially "as solid as rock" and in need of no service life attention except in a rare circumstance where a geotechnical failure occurs and needs to be dealt with. This has allowed the focus to be put on the fabricated structure, whether it is a pavement section, a bridge superstructure, or a tunnel lining or portal, where service life needs can be readily observed, and this is what has happened. As a consequence, the existing management systems for bridges, tunnels and pavements are not effective at capturing where geotechnical asset or element performance is the root cause of the performance of the observable structure. A future improvement of these systems can be the incorporation of geotechnical performance if and when appropriate geotechnical performance indicators, measurement tools and models of performance are established. Hence, the recognition of these indicators and establishment of these tools and models is a priority for geoprofessionals and for improved transportation asset management.

Culvert management systems are not required by federal law, but in recent years many states have recognized that their culverts are aging and that their failure results in major impacts to mobility and reliability, in addition to safety, and have begun programs to manage their culverts. The taxonomy presented herein can be used to explain to others how the geotechnical elements of other assets are managed and to help ensure that they are adequately reflected in existing systems, or that auxiliary systems are built to easily complement existing systems.

The Geotechnical Asset class shown in Figure 3 and further delineated in Figure 4 is the class of geotechnical asset that has not been captured in any way by legislation, and perhaps therefore has had the least attention. Slopes, embankments, subgrade, and earth retaining structures are the four general types of geotechnical assets along the roadway corridor. New
developments in geotechnical asset management focus on these four asset types because they
generally have not been managed in the past and yet their performance has a large bearing on
corridor performance. (17).

It is this class of assets that needs to be managed with new systems of inventory,
condition assessment, performance measurement, and management. This is a huge task because
little has been done here in the past and the value can be questioned because many of these
features perform well for a long time without active management. For this reason alone, a risk-
basis is an appropriate way to plan an approach. A risk basis puts emphasis on where the
likelihood (e.g. high or steep slopes, or adverse climate) or consequence (e.g. high daily traffic or
no viable alternate routes) is high. Different states are applying a risk basis differently but all
that have started to manage these assets are prioritizing and making implicit or explicit decisions
based on risk. Anderson presents a means of visualizing and accounting for risk to multiple
performance goals that is useful for this purpose (18).

FIGURE 4 The four independent geotechnical assets of a corridor.

THE FOUR TYPES OF INDEPENDENT GEOTECHNICAL ASSETS

At this detailed level of classification of geotechnical assets, management principles are
no longer the key distinguishing factors, as all need to be managed in similar ways for similar
purposes, and all have little maturity in terms of the systems and practices for doing so. The
Slope category is intended to capture natural and cut slopes within the ROW, including rock
slopes, which have actually had some type of assessment and management program for many
years. The Rockfall Hazard Rating System (RHRS) was developed in the 1980s by the Oregon Department of Transportation with support from FHWA and other states \((19,20)\). In the years since, federal agencies and many states have adapted this to their needs and some states have expanded to include other slopes, particularly in the Northwest \((21)\).

The Embankment category captures embankment of an appreciable height, where settlement, wetting, surface erosion, and slope stability would need to be managed in order to maintain the performance and life of bridges, retaining walls, pavement, and other structures that are in direct contact. In concept, Embankments are separated from Slopes by the fact that they are constructed by placing soil and rock as fill. Subgrade is the material beneath the lowest engineered fill layer. In most cases it would be natural, in place earth, beneath the base or sub-base, but it could also be beneath embankment, and could be a treated material. Subgrade management issues include things such as frost heave, swelling or collapsing soils or bedrock, and karst and underground mines.

Earth retaining structures are retaining walls. Because these structures have more in common with a bridge, and often are part of the approach to a bridge, they are features that have more mature systems in place for management \((13)\). Soil nail walls and all walls that support cuts also fall in this category. Though safety, a major performance objective behind bridge management, is also important for earth retaining structures, other performance objectives take on a greater significance because earth retaining structures are comparatively safe. Other performance objectives that can be worked into management systems include durability, cost and aesthetics.

The slope, embankment, and subgrade features can be further delineated as to whether they are formed from rock or soil, or modified soil/rock to include inclusions and ground improvement measures, as shown in Figure 3. Earth retaining structures can be delineated into stabilized earth structures such as mechanically stabilized retaining structures or more traditional concrete or steel retaining structures. The basis for this suggested subdivision is that when considering the risk of failing to meet performance expectations, a different management approach would be taken depending on type. Some examples are that MSE walls might be inspected more frequently than concrete cantilever walls, or slopes modified by inclusion of horizontal drains or rock bolts might have different measures of performance. This management approach is a departure from management approaches used for bridges, tunnels or pavements. Since earth retaining structures that are internally stabilized rely on buried elements for stability, failure to meet performance expectations may not be as obvious in these structures.

There is less importance to using or referencing nationally consistent terminology within the taxonomy at a level of refinement beyond the four stand-alone Geotechnical Assets. A suggestion is provided in Figure 4, but because communication at this level will generally be with others in the same discipline, other agency preference could be more significant or efficient. At higher levels, the communication will broaden to include pavement engineers, structural engineers, asset managers, and senior leadership and this is where the taxonomy can help with understanding.

**SUMMARY**

A full taxonomy for geotechnical assets used in transportation infrastructure is proposed in Figure 1. The taxonomy defines terms and a structured relationship that will help geoprofessionals in one organization communicate with those in another organization and will help geoprofessionals communicate with other disciplines, asset managers, and senior leadership.
within their own organization. Full definitions for the terms are provided in the glossary that follows. The taxonomy is based on practical definitions and distinctions based on the current state of practice with transportation asset management and the requirements of the MAP-21 legislation.

The primary outcomes from this taxonomy are as follows:

1. There are four general types of independent Geotechnical Assets that contribute to the performance of a transportation corridor: slopes, embankments, subgrade, and earth retaining structures. These Geotechnical Assets are within ROW and their management is encouraged but not required by the MAP-21 legislation. Systems for inventorying, assessing and measuring the performance of these assets are not well established and are an important area for research and development.

2. Geotechnical Elements have direct impact on the performance of other managed assets such as bridges, tunnels, pavements and, in many states, culverts. Bridge, tunnel, and pavement management is required by the MAP-21 legislation and systems for doing so are generally established. Specific requirements for bridges, tunnels and pavements are now being established through the federal rule making process. Geotechnical Element recognition, and the appropriate training of inspectors and managers, are the portals through which geotechnical influence on performance of these other assets can be managed. Alternate systems of management are generally not beneficial from an administrative standpoint, but communication and understanding of how geotechnical elements contribute to the asset’s performance is important. Secondary systems to augment the characterization of geotechnical elements and communicate its significance may be of value.

3. Geotechnical Assets and Geotechnical Elements are within the ROW and can be fully managed with TAM principles and tied to an agency’s TAM plan. Outside-ROW Features, including Geotechnical Features such as slopes, as well as the shoreline and bottom of water bodies, retaining walls, and structure foundations can impact the performance of Geotechnical Assets, and also other assets through their impact on the Geotechnical Elements. Outside ROW Geotechnical Features cannot be managed the same way as assets within the ROW but the performance risk they pose can be managed.

4. Not all Geotechnical Assets are physical assets that comprise or contribute to vital links within a corridor. Material sites and stockpiles are other physical assets that can be managed similarly to those within a corridor.

5. Non-physical assets include data on subsurface conditions and material properties, exploration equipment and institutional knowledge. These are very important but should be managed in a different way than the physical assets that are the focus of this paper.

GLOSSARY

- **Corridor and/or GAM Section**: A hypothetical length of corridor, wherein the geotechnical attributes are similar and the section could perhaps be measured and managed as one asset.
- **Data**: A collection of facts from which conclusions may be drawn.
• **Earth Retaining Structure**: A structure that retains or holds back any material, usually earth, and prevents it from sliding or eroding away (retaining wall).

• **Embankment**: A raised structure (soil or rock) used to hold back water or carry a roadway.

• **Equipment**: Things you need for a specific purpose.

• **Geotechnical Asset**: Institutional geotechnical knowledge, geotechnical data, and geotechnical infrastructure components that add value to a highway agency.

• **Geotechnical Element**: A geotechnical asset that is an element of another asset, such as bridges, tunnels, pavement, and culverts.

• **Inclusion**: Any and all non-earth modification, including pipes, bars, tendons, strips and sheets that contribute drainage or strength, for example.

• **Independent Geotechnical Asset**: A geotechnical asset that is independent from other assets.

• **Inside-ROW Asset**: The physical asset that lies within the right-of-way (ROW).

• **Knowledge**: Familiarity, awareness, or understanding gained through experience or study.

• **Material Sites**: A site where materials are gathered for use.

• **Modified**: Describing an independent geotechnical asset that has inclusions.

• **Non-Corridor**: Physical asset not part of or contributing to the corridor.

• **Non-Physical Asset**: An asset not part of the physical infrastructure.

• **Outside-ROW Feature**: Physical asset outside of the ROW, such as water bodies, slopes, or structures.

• **Physical Asset**: A tangible item of value that derives its worth from its ability to be sold, used, or bartered.

• **Right-of-Way (ROW)**: The strip of land over which facilities, such as highways, are built.

• **Slope**: A surface of which one end or side is at a higher level than another; a rising or falling surface.

• **Stockpiles**: A large supply of materials that are kept for future use.

• **Subgrade**: A layer of rock or earth leveled and graded for a foundation, such as a road.

• **Water Bodies**: The part of the earth’s surface covered with water, such as a river, lake, or ocean.
REFERENCES


