GROUND-BASED IMAGE AND DATA ACQUISITION SYSTEMS FOR ROADWAY INVENTORIES IN NEW ENGLAND A SYNTHESIS OF HIGHWAY PRACTICE

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16. Abstract

Across New England, the use of ground-based imaging technologies ranges from very sophisticated, to very simple, to not used at all. The primary objective of this project is to quantify and summarize the use of ground-based imagery in the six New England states and to provide an overview of the benefits of ground-based imaging technologies. A secondary objective is to determine what kind of linkage exists between roadway databases and GIS systems across the New England states and provide information to the states about the potential benefits of linking these tools.

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SUMMARY Transportation is a broad and important subject; data required by engineers, planners, and field workers cover many different topics. State transportation agencies, therefore, generally require one or more maintainable databases of roadway data. These databases range from very basic to exceptionally intricate and include information from physical attributes of the roadway (termed "roadway inventories"), to collision records, signal timings, and utility data, among others. In many cases, data are collected and maintained by different groups within the transportation community. For example, the police may maintain collision records, while traffic characteristics are maintained by a transportation-operations agency. Many data sets may be acquired from ground-based imagery, a technology commonly known as videologging.

A videolog is the result of recording continuous images of a roadway. From this video, roadway inventories and data such as centerline location, signs, guardrails, and geometric road characteristics can be collected. Along with the video, other data are often collected simultaneously using other collection equipment and techniques. These data include, but are not limited to, chainage, pavement conditions, vehicle attitude, and GPS coordinates.

Across New England, the use of ground-based imaging technologies ranges from very sophisticated, to very simple, to not used at all. The primary objective of this project is to quantify and summarize the use of ground-based imagery in the six New England states and to provide an overview of the benefits of ground-based imaging technologies.

Data collected in the ground-based imaging process are also potentially very useful in Geographic Information Systems (GIS). These systems store and manage geo-spatially referenced information and provide rapid access to many users. GIS can act as a database manager and analysis tool for the transportation data collected during the imaging process.

A secondary objective of this project is to determine what kind of linkage exists between roadway databases and GIS systems across the New England states and provide information to the states about the potential benefits of linking these tools.

CHAPTER 1

INTRODUCTION

Background

Government Aid and Mandates

The need for collection of highway data was first recognized in the United States in 1892 with the Good Roads Movement. Although this bill did not pass, it was the first attempt to require some level of examination of the condition of the nation's roadways. The following year, a bill passed that allowed the Secretary of Agriculture to "make inquiry regarding public roads" and "make investigation for a better system of roads" (Ritter 1994). This bill also provided $10,000 towards the development of the Office of Road Inquiry (ORI), the predecessor of today's Federal Highway Administration. This office was strictly limited to investigating and disseminating information and was not tasked to develop a formal system of organization for maintaining roadways.

In 1904, the ORI, renamed the Office of Public Roads Inquiry (OPR), attempted to inventory all roads outside of major cities in the United States. This was the largest undertaking of this office at that time. The inventory mainly focused on roadway laws, expenditures, and revenue streams. The only physical characteristic of the road collected at that time was mileage classified by surface type. Between 1893 and 1916, some states formed their own Departments of Transportation and took over the data collection. The ORI/OPR continued to collect roadway data in the remaining states.

The 1916 Federal Aid Road Act formulated a method of federally funding states for building and maintaining roadways. This act also required that each state form a department of transportation.

In 1920 the Bureau of Public Roads (BPR), formally the ORI/OPR, surveyed all roads and began a roadway classification process, determining what roads were in the greatest need of improvement and developing a system to allocate funds towards the maintenance of these roadways.

The 1934 Hayden-Cartwright Act denied federal funds to any state that diverted federal highway revenues for other purposes. Also included in this act was a proviso that permitted states to use 1½ percent of their matched federal-aid towards planning for future work. This type of investigation included the collection and analysis of data to be used in the planning process. The accord between the states and the BPR specifically allowed for three types of planning surveys: road inventory, traffic, and financial investments. This marks the beginning of the federal government specifically funding states in the roadway inventory and data collection process. These data items included: width, type and condition of the roadway, and location of all farms, residences, schools, businesses, industrial plants, hospitals, and any other facilities that the roads must serve.

The Federal Highway Act of 1944, the resulting Federal-Aid Highway Act of 1956, and the Highway Revenue Act of 1956 greatly increased the number of highways that the nation had to construct and maintain. Consequently these acts increased the amount of funding provided for inventory and data collection.

In 1965, the now Federal Highway Administration was mandated by congress to report biennially on the condition, performance, and future investment needs of the nation's highway system. This requirement called for the gathering of a very large workforce in each state to collect and maintain the nation's roadway data.

In 1978, the Highway Performance Monitoring System (HPMS) was initiated. This system is currently used by the federal government to acquire roadway inventory and perform data collection. HPMS acts as a large database of roadway information for the nation's highway system. Data from the HPMS is used in state-specific formulas for the apportionment of Federal-Aid funds. HPMS specifies the minimum data collection requirement for states, such as pavement roughness data and lane and shoulder width. Many states collect additional data for their own programs (Ritter 1994).

Over time, some roadway characteristics were identified as so crucial to the performance of roadways that specific monitoring systems were developed. Two such areas are bridge and structural data and pavement data.

The 1968 Federal Highway Act established the National Bridge Inspection Program (NBIP), which mandates states to periodically inventory and inspect all structures on public roads. Bridge inspection was further stressed in the 1995 Intermodal Surface Transportation Efficiency Act (ISTEA) by the formation of a Bridge Management System (Phares, Washer and Moore 1999).

Pavement management systems were first recognized as a valuable tool in the 1956 to 1960 AASHO road test. These tests were the first attempt to develop a system that rates pavement condition regardless of pavement type. A pavement management system was another management system specified by ISTEA.

Pavement is typically monitored in two areas: physical attributes and a measurement of rider comfort. Physical attributes include the typical pavement distress characteristics of rutting (physical displacement of the pavement due to repetitive loads of vehicles), faulting (potholes), cracking (physical cracks), patching (seals for cracks or fillers for potholes), and raveling (the physical disintegration of the pavement from the surface downward) (Sime 1984). Measurement of rider comfort started as a subjective value assigned to the roadway based upon a user's comfort while traveling along that road compared to all other roads. Soon, professionals realized that surface roughness is a good indicator of rider comfort. By measuring surface roughness in a quantitative way, the subjectivity of human discretion is eliminated. This was the basis for establishing the International Roughness Index (IRI).

The IRI is the surface roughness evaluation system of choice, chosen more for the sake of uniformity than for its advantages over other systems. The IRI measures roughness in m/km with a value of zero being perfectly flat. Conceivably, IRI has no upper limit, but a road with a value of 8 m/km is considered to be almost impassable. The Federal Government has required states to report the IRI values of its roads since 1990 as part of the HPMS (Sayers and Karamihas 1997).

In 1980, only 5 states had anything resembling a pavement management system, now all 50 states have some form of system. The mandate put forth by ISTEA to specifically develop Pavement Management Systems has since been removed. However, policy statements by the FHWA and state transportation agencies have clarified that pavement management is still a part of HPMS and is thus still required (Finn 1998).

Technology

The earliest forms of roadway inventory and data collection, beginning in the mid 1890's, relied solely on manual collection. This method was loosely organized and inefficient. Only rudimentary data, such as mileage, lane width, and road conditions were collected by the federal government or state transportation agencies. All other necessary data were left to be collected by local officials on a project-by-project basis. This type of data collection was termed a "windshield survey," meaning that the appropriate data were collected as the recorder drove down a road noting any significant data and their location relative to the road's mileage. This was a time consuming and tiresome process. The data were often stored on note cards arranged by mileage along the roadway. Any management and manipulation of these data were done by hand. Often, roadway data were kept by the agency that collected it and not distributed elsewhere, requiring the user to locate and go to the data since distribution was tedious.

As the nation's roadway network continued to grow, a larger and larger workforce was needed to collect the data. Over the course of the first half-century of the 1900's, roadway planners and designers added more sophisticated to their trade. As a result additional data points pertaining to the roadway's geometric features were required to be maintained. Not only were there more roads to collect data for, but also more data needed to be collected. Collectors realized that obtaining and maintaining roadway data through the "windshield survey" was very inefficient. Out-of-date, incorrect, and poorly managed data became the result of overworked personal and a rapidly growing interstate highway system.

Prior to the 1960's, the cost involved in roadway inventory and data collection was strictly limited to the cost of employing the data collectors and maintainers. New technologies, developed in the 1960's, began to allow for better systems of collecting, storing, and manipulating roadway data. Mainframe computers allowed for more efficient data warehousing and distribution. Policy makers recognized the potential benefits of using these new technologies and adjusted the funding to include them. As computers became more sophisticated into the 1970's, they were used to process roadway data to produce profile and curvature data (Ritter 1994).

Images

Also in the 1970's, the value of taking images of roadways was recognized. Many transportation agencies began using 35-millimeter cameras on a van with the shutter of the camera being triggered by the van's drive train. The technical term for this practice became known as ground-based imaging, but was commonly referred to as photologs, and later, videologs. These systems took images of the roadway at constant intervals along the road. The film could then be viewed with a special viewer that allowed the user to scan forwards or backwards at an adjustable rate. This allowed for roadway inventories and data to be extracted in an office instead of the field. By moving most of the work into the office, the hazards to field collection personal were minimized. This new practice was also more efficient. More roads could be covered in less time, allowing for more up-to-date data. Photologs were also valuable from a distribution perspective. The film could be reproduced and sent to any desired location as long as that location had the appropriate viewer.

These systems had shortcomings. 35 mm photologs have poor image quality, and copying the film is time consuming. The vans used to collect the images could not travel faster than 45 mph, considerably slower than some operating highway speeds. Linear referencing problems existed because the images were recorded at set intervals during the actual vehicle miles traveled. If this mileage was different from the state defined mileposts, the collector did not know where the image for a stretch of road was physically located. The image retrieval process was also tedious. First, storage density for 35mm film is low. Literally, hundreds to thousands of reels of film were required to photolog an entire state. Then, to locate a specific section of road after the correct reel was located, the user had to scan through up to 100 feet of film to identify the desired location (Orth and Singh 1994).

In the early 1980's, video tape recorders (VHS) became a common format for recording images. This analog videotape offers the appearance of continuous images. Typical 35mm camera photolog systems took an image of the road approximately every 52.8 ft. Common videotape records 30 separate images every second. If a van carrying a video tape recorder is traveling at 45 mph, an image is taken every 2.2 ft. The increase in precision of the videotape system is obvious. The VHS, and later SVHS (higher recording quality), formats became very common in all types of video applications. As a result, recorders and players of these formats became mass-produced and the hardware price was very cost efficient.

Analog videotape proved valuable in pavement management systems. The rapid image acquisition allowed for a high enough level of scrutiny that pavement could effectively be evaluated from these images. Now, not only could the fieldwork of roadway inventorying be eliminated, but so could a large portion of fieldwork required for pavement management. Video also allowed for more rapid and effective pavement maintenance by being able to record and evaluate more pavement more quickly. With the advent of videotape, the term photolog matured to videolog.

Although analog videotape does not improve the accessibility of the images over 35 mm systems, the number of tapes needed to videolog an entire state is much lower than that of the 35mm reels. It would take approximately 100 tapes to record the entire state of Maine. However, once the correct tape is located, scanning through the tape to reach the correct image takes longer. Videotape also has lower image quality than 35mm film. On the other hand, analog videotapes can be reproduced easier and cheaper than 35 mm film, but whenever a tape is reproduced, the analog signal must be amplified. This process creates “noise” that degrades the quality (Anderson).

In the mid 1980’s, Connecticut pioneered a laser videodisc system. In this system, the images from a 35 mm camera system are transferred onto a laser disc. These laser discs can then be viewed on a computer with the appropriate player and software. This system greatly improves accessibility. The number of laserdiscs required to store images for a state is much lower than that of any tape system. One laser disc can contain 108,300 photolog images or the equivalent of 80 35mm reels. This reduces the number of storage devices needed for videologs of a state from triple to double digits. Laser discs are better for accessibility because of their rapid access capabilities. A user need only input some form of linear referencing and the viewing software will almost instantly display the appropriate image. Also, duplicating laser discs does not diminish the quality of the image.

A limiting factor with a laser disc system is that it does nothing to improve the image quality of 35 mm film. It simply provides the user with increased accessibility to the same images. It also greatly increases the direct processing cost of the images. To transfer them onto a laser disc requires capitol investments in recording and viewing hardware, investments that were quite sizeable in the mid 1980’s. It complements a good linear referencing system, but does not solve the linear referencing problems of accuracy (Hudson and Seitz 1996).

Technologies that were developed over the past two decades have given way to the current generation of ground-based imaging. The newer systems combine the benefits of videotape and laser disc systems while eliminating many of their drawbacks. Digital videotape eliminates the “noise” problem of analog tapes. Digital videotape uses binary numbers to represent each pixel of the image. It is much more efficient to copy film in this format, since binary numbers are not as susceptible to the loss that greatly effects analog signals. This is better for distribution because now the images can be copied multiple times without any degradation of quality. However, digital images require large amounts of storage space. The average video of 30 frames per second requires 27 megabytes of memory per second. An average audio file requires one fifth of a megabyte per second. Video images were first stored on laser discs and digital videotape, then CDs, and most recently DVDs. DVDs offer about 1.5 times the storage space of laser discs. Connecticut can supply video of all of its state-maintained highways on 20 DVDs. These higher-volume storage devices use the same retrieval methods as laser discs.

In the late 1980's, it became economically feasible to capture high quality freeze frame or "still" video images. This greatly enhanced the quality of the video used in roadway inventory and data collection. After the video was captured, it would be digitized and stored on digital tape or disc. This required an investment in hardware that would perform the digitization. Digital cameras have eliminated this need. With these cameras, the images are captured and stored directly as a digital computer file. These files can then be directly transferred to a laser disc, CD, or DVD. The rapid expansion of computer technology in the 1990's resulted in computers with enough storage space to contain all of the video images directly on a hard drive. The state of Connecticut currently maintains ten 40 GIG hard drives that contain an up-to-date account of all of the state's roadways. Currently, roadway images can be captured directly onto a hard drive onboard the collection van during the collection process. The van then returns to its base at the end of the day and downloads the newly collected data into the main storage location. If the roadway has been videologged before, the new files can overwrite the older files. Having all of the video images stored in one location provides advantages for access and distribution. The central storage site can become the location for a network that supplies video images to anyone who can access the network. The advantages to storing and distributing the data in this way is that the production cost of the discs is eliminated and every time the data are updated, new discs need not be issued. This allows users immediate access to the most up-to-date data available. Having all of the data in one centralized location also means that maintenance of the data can be more easily monitored.

Drawbacks to this new system are that it is susceptible to the problems of any network, the more users on the network, the slower the retrieval and viewing process becomes. The centralized location means that if anything happens to the network servers, the system may be unusable until the problem is fixed. The size of the video files is still an issue and the investment for computers is still costly. Compression strategies have been used to reduce file sizes. These strategies eliminate data behind repetitive display. In other words, if a pixel in a video is blue for 90 consecutive frames, compression strategies can eliminate the data necessary to display the pixel in frames 2 thru 90. Instead, the program is instructed to display the same color that it was last told until new instructions come along. The current compression strategy of choice in ground-based imaging is JPEG which can reduce a file up to $1/20^{th}$ of its original size (Anderson).

The final issue is security. By having all of the data on a server, they can be accessible to outside manipulation. This requires that the servers be protected with up-to-date firewall technology.

The videolog process moved the inventorying practice from the field into the office. Until recently, inventories were manually extracted from the video. Technology has advanced now to the development of image processing software. At the present stage of development, this type of software allows users to semi-automatically acquire the physical dimensions of an object from the image where the image is manually identified and on-line tools are used to measure necessary parameters. This type of software may lead to the future possibility of completely automating inventory collection where the software would recognize pre-defined patterns, thus identifying specified objects. These objects would then be automatically inventoried without user input.

Other Data

The videologging process usually takes place on a data collection vehicle. Many states use an Automated Roadway Analyzer, ARAN, which is a proprietary term of Roadware Group Inc. Along with images, equipment on ARAN vehicles collect other data. These include data that are required by the federal government in its pavement management, bridge management, and highway performance monitoring systems. Technologies in this data collection have advanced over the years as well. Surface roughness and texture are now monitored with sophisticated laser systems that measure the pavement surface. Also, pavement condition can be monitored with more advanced methods of rutting and roughness measurements. Advanced gyroscopes provide accurate roll, yaw, and pitch measurements. The availability of GPS coordinates provides for a referencing system that is more accurate than any of its predecessors. These data can be used to produce a road's horizontal/vertical curvature and longitudinal profile. Combining the roadway curvatures and profiles with GPS coordinates can quickly produce accurate centerline maps of roadways. This information is extremely valuable for use in Geographic Information Systems, which will be discussed later.

ISSUES AROUND GROUND-BASED IMAGING

Many issues exist in designing and implementing ground-based imaging and data collection systems for roadway inventory and data collection.

State specific systems- First, the imaging and data collection process varies from state to state with no one method being a best practice. For this reason each state should assess what it requires from an inventory and data collection system and then design the system accordingly, as opposed to implementing a system designed for another state.

Acceptance of image and data collection systems- Many states still rely on a labor-intensive method of manual roadway inventory and data collection. The first issue becomes why more states are not using ground-based imaging. Some states may resist converting to ground-based imaging because they are comfortable with an existing system and do not want to change. Some states use ground-based images in their simplest form. For states to expand their capabilities, they should be educated about the benefits of using more developed systems. Ground-based imaging is a technology-dependant tool. As the technology improves, so does the general efficiency of the system. The primary problem cited was lack of adequate and consistent funding, as identified from a 42-state survey about choosing a roadway inventory and data collection system. Convincing policy makers to procure these systems is difficult because of a lack of tangible results that the public can see (Hummer, Schefler, Khattak, and Karimi 1999).

Once a ground-based imaging system is in place, additional issues arise, including what to record and what information is to be extracted from the imagery.

Level of implementation- Is it important to record roads of all jurisdictions or only those directly maintained by the state's transportation agency? Ground-based imaging can be an effective tool at the local level. Many town department of public works could benefit from the reduction in labor and increased efficiency that ground-based imaging systems offer but cannot afford the initial capital investment. The state has to determine if recording and analyzing local roads is a valuable service and how much funding it can afford to assist individual towns in the process.

Roadway features- What information is to be extracted from videologs? It is possible to inventory signs, signals, lane width, clearance, and intersecting roads, to name just a few items. Almost anything that is visible along the roadway can be inventoried.

Image acquisition- What views are required and how are the images processed/edited? While a driver's eye view is essential, other views such a right, left, and rear views can assist in the roadway inventory collection process by providing other angles from which to see the inventory item in case it is obstructed, and to pick out items that may not be apparent in only a front view. The distance interval between image acquisitions is important to balance the cost of additional images with the benefit of more information. For example, should there be 10 or 5 meters between each frame? A smaller interval means more information must be stored and thus more videotape or disk space is required. If the distance interval between frames is too large, data items might be lost. Therefore, a balance must be struck between the cost and the quantity of the data. Other related decisions include how often a road is recorded, how many passes are made on a road, and at what interval images are edited/processed.

Pavement images- Filming the pavement surface is valuable in pavement evaluation. Many states use visual-based rating techniques to evaluate the status of pavements. This type of technique assigns a value based on the number and type of cracks within a given section of roadway and are subject to the opinions of personnel performing the investigation. When rating the pavement in the field, the danger to personnel is high due to traffic exposure. Implementing an automated pavement rating system will minimize problems such as safety hazards to field personnel, subjectivity of observations, and time constraints associated with manual methods. Having the pavement surface image also allows more people to review the same pavement section and thus increases the effectiveness of the evaluation procedure.

The state may have to evaluate whether it wants to perform the collection process in house or if it should contract this out to another agency or private contractor.

Storage media- Another important issue is the medium on which the images are stored. 35mm film used to be the medium of choice. However this proved to be inefficient because of the high number of rolls of film required to record an entire state, the high duplication cost, limited access, and tedious process of viewing specific locations on the film. Videotape offers advantages in higher storage capacity, ease of duplication, and better access because the tapes can be played on any common VCR. Viewing specific locations on the tape is still a monotonous process due the necessity of fast forwarding and rewinding the tape to get to the desired location. Storing the images as digital image files seems to be the most effective and efficient storage process. These files can be stored on CD, laser disk, DVD, and/or hard drive. Digital images offer the highest level of efficiency in storage, duplication, access, and viewing. Duplication of files is relatively easy since files stored on a hard drive can simply be copied to another hard drive. CD reproduction or “burning” is now a process that can be completed on a PC while DVD burning is still done professionally and costs approximately $150 a copy, although DVD writers are becoming a cost effective alternative. Locating and viewing specific images is easier because the user can input a linear referencing value and specifically designed software will rapidly display the appropriate image. Many states require that the videologs be stored on more than one type of medium to accommodate users with limited access to the appropriate technologies.

Additional roadway data- Along with the actual videologging, many state agencies simultaneously collect other data. These data include, but are not limited to, surface roughness, grade, GPS coordinates, gyroscope measurements of roll, yaw and pitch, transverse profile measurements, and skid number. The technology and hardware required to collect these data vary in sophistication. The state has to determine what data are critical and economically feasible to collect and what distance interval between data points is required. Collecting all of these data in one pass is timely and efficient. However, the extensive amount of technologies in the van requires that the data collection personnel onboard be highly qualified and aware of how to operate all of the systems properly.

Distribution- With the easy duplication of digital image files, the state can make this information available both internally and externally. On one hand, the belief is that all of this information should be made readily available for everyone. On the other, issues of security and liability may limit the amount agencies are willing to release. Connecticut was one of the first states to stress the necessity of making the videologs readily available to many of its employs. They started with photolog videodisc retrieval stations (PLV's) and evolved into using PC's loaded with DigitalHIWAY software accessing images by DVD or over a network (Hudson and Seitz 1996). Today over one hundred PC's in Connecticut have access to the videologs and the number continues to rise on a monthly basis. Some states make CDs or DVDs available to outside individuals and companies, from in-route navigation companies to law practices. Many states are weary of providing videolog information to outside parties for fear that the information could be used inappropriately. Each state needs to establish what level of availability is appropriate to its goals and purpose.

Other roadway inventory and data collection systems- In addition to ground-based imaging, other sophisticated techniques are currently being used in roadway inventory collection. These include “backpack-based” data collection and satellite data collection. Backpack-based data collection is efficient in areas where the inventory elements are spaced close together. It requires a relatively low initial cost. During this method the data collection staff walks from one inventory item to the next. Within the backpack are a location-referencing device, often a GPS receiver, which locates the item from satellite signals, and a storage device such as a laptop or pen-based computer to store descriptive data about the inventory item. The drawbacks of backpack-based data collection are that it offers little choice in technologies, is physically demanding, and data collection generally stops for adverse weather conditions.

Satellites or airborne photography provide high-resolution images of the earth’s surface. The images are then processed manually using image-processing software to collect the necessary inventory items. These systems are used quite regularly to produce centerline maps of the roadway networks used in GIS. Aerial photos provide a potential for automation of inventory collection. No physical collection manpower is required and the images inexpensively cover a large area. The disadvantages of these photos are that the cost depends on the coverage of the image not the roadway network, adverse weather affects the image quality, and the agency has no control over the collection schedule.

Because many items cannot be identified from the air, current airborne or satellite imagery will never replace ground-based imagery for certain inventory activities. Combinations of these systems may offer the most productive and efficient method of inventory and data collection. Table 1 summarizes the advantages and disadvantages of the different methods of roadway inventory and data collection.

TABLE 1

ADVANTAGES AND DISADVANTAGES OF MAJOR MEANS OF INVENTORY DATA COLLECTION
(Hummer, Schefler, Khattak, and Karimi 1999)

Means	Relative Advantages	Relative Disadvantages
Videolog	Can collect data at highway speeds	Primarily uses crew of two collectors
	High data accuracy possible	Skilled crew required for operation
	Much choice in on-board technologies	Data collection slowed by several conditions
		Requires large initial investment if buying
Backpack	Lower initial cost	Little choice in technologies
	Efficient in areas with multiple elements	Physically demanding
		Collection stops in adverse weather
Satellite	Potential for high level of automation for inventory extraction	Cost depends on size of image, not on the size of the roadway network
	No collection crew required	Cannot collect many inventory elements
	Covers large area inexpensively	Automated processing algorithms incomplete
		Adverse weather affects image quality
		No control over collection schedule

Videologging and other automated techniques are being implemented by state transportation agencies. However, according to a 1999 report, 75 percent of 42 state transportation agencies interviewed still use non-automated methods of inventory collection (Hummer, Schefler, Khattak, and Karimi 1999).

INCORPORATING GROUND-BASED IMAGERY INTO GIS

Geographic Information Systems (GIS) have rapidly become an important tool in transportation, primarily to store, manage, analyze, and display pertinent characteristics at a specific geographic location. These characteristics can be almost anything from crime rate to environmental classification to traffic level.

GIS provides a unique opportunity for transportation officials to effectively manage infrastructures and roadway inventories. Data associated with these systems are, by their nature, spatially referenced. Instead of personnel having to go into the field to take measurements, a time consuming process, GIS systems allow transportation officials to point to an item within the GIS and get any relevant information such as condition, height, or size. Ground-based images containing the inventory item and its surroundings can easily be incorporated into this environment.

When collecting ground-based images, a spatial reference is collected. Spatial referencing is a method of locating any item within that reference system. This can be by precise latitude and longitude, state plane coordinates, state-defined mileposts, chainage, or another system. These references are needed for integrating information within a GIS. The issues associated with integrating image data into GIS are presented in the following sections.

GIS software- The first issue is the GIS system that the state predominantly uses. Every GIS software package is unique. When recording ground-based images, collection of spatially referenced data that allows for the easiest transfer into the most commonly used GIS system(s) will eliminate or minimize integration at a later date.

Data warehousing- Next is the location where the data are stored. Many GIS agencies are moving toward a centralized warehouse. Some states rely on distributed and local warehousing.

Maintaining data within the GIS - The GIS agency has to determine what data they want to obtain and maintain on their system that ground-based imaging and data collection could provide. If cost, storage, and security are not issues, almost all data collected from the ARAN vehicle could be included. Currently, many different technologies are used to perform the roadway inventory and digitization processes for GIS. The state should perform an analysis to see if changing their techniques is economically feasible or necessary.

METHODOLOGY

The purpose of this project is to provide a state-of-the-practice of ground-based image and data collection in the six New England states. A state-of-the-practice report is not only a summary of the current practices being performed by each state, but is also a summary of potential technologies and applications associated with ground-based image and data collection. The latter can serve to assist states in deciding if and how to upgrade their system.

State-specific information was gathered by surveying each state and is described in task 1 below. Information about potential technologies and applications of ground based image and data collection was gathered through an extensive background search that included the history of roadway inventories, pavement management techniques, summaries of audio and digital video, GIS applications, and more as listed in the reference section at the back of this report.

Six tasks are defined to perform this project (Hancock 2000).

•*Task 1: Survey of Transportation Departments in New England*- Survey all states by questionnaire for current collection practices, including what, how, where, and when efforts are focused. The questionnaire should provide information sufficient to execute Tasks 2 through 4.

This survey is intended to gather information that will provide an overview of each state's roadway inventory and data collection techniques. The survey will call for information regarding the use of ground-based images, highway features and attributes collected, data confirmation practices, automation of inventory/data collection, and database management and analysis. The surveys are to be sent to the primary contact in each state's transportation agency in charge of ground-based imaging or roadway inventory and data collection. A copy of the surveys sent to each state is presented in Appendix A. In addition to this survey another survey is to be designed that will inquire about GIS practices in each state. The purpose of the second survey is to determine what roadway information is being maintained by each GIS agency and if those agencies are using data collected in the ground-based imaging process. A copy of the survey sent to the GIS agencies is presented in Appendix B.

•*Task 2: Road-Inventory Data Elements*- Assemble a list of road-inventory data elements and/or types of images collected by the states.

This task is designed to establish what roadway inventory items each state maintains that can be collected by use of ground-based imagery. Table 2 lists some of the inventory elements and images that can be collected.

TABLE 2

ROADWAY IMAGES, INVENTORY ELEMENTS AND REFERENCING SYSTEMS

Roadway Geometrics	•Horizontal/Vertical Curvature •Number of Lanes •Vertical Under Clearance	•Grade •Lane/Shoulder Width •Cross Slope
Roadway Features	•Intersecting Roads •Town Lines •HOV Lanes	•Bridges and Other Structures •Linear Referencing Calibration Points •Rumble Strips
Roadway Appurtenances	•Guardrails •Signals	•Signs •Crash Cushions
Pavement	•Pavement Surface	
Referencing Systems	•Chainages •GPS (Global Positioning Systems) Points •Over-the-Road Distances (odometer)	•State Defined Mileposts
Video Images	•Driver's Eye View •Rear View	•Left/Right Side View •Pavement Surface

Along with the roadway inventory items, data elements that are being collected simultaneously with the videologs are of interest. These data include, but are not limited to, surface roughness, texture, roll, yaw, pitch, and skid number.

Finally, it is advantageous to know what each state produces from all of the roadway inventory and data collected. These include longitudinal profile, transverse profile, rutting, average texture depths, shim quantities, centerline maps of roadway sections, three-dimensional views of a roadway, and curb to curb plans.

The resulting final outcome of this task will be a set of tables of what items are collected and how they are spatially referenced by state.

•*Task 3- State Data Warehousing Practices*- Determine how the states process, validate, and store individual data items and/or images.

The questions that need to be answered to complete task three are:

•To what extent is the imagery being captured? (views and passes on the roadways)
•What is the collection cycle?
•What are the editing practices?
•What medium is used for video and data storage?

The end product of this task will be a series of tables that answer the above questions by state.

•*Task 4: Data Distribution*- Determine the method (stand-alone or network system) and format (graphic or tabular-data; analog or digital images) employed to distribute processed items to the end user.

The purpose of this task is to identify distribution practices for these data, both internally and externally, of each state. These practices range from distributing the images on videotape to users, to putting these images on a network accessible to multiple users. The advantages and disadvantages of each distribution practice will be discussed. Finally a table of distribution practices by state will be produced.

•*Task 5: State Visits*- Visit each state to augment, confirm, and detail tasks 1 through 4.

This task is intended to verify the information provided by the surveys and to make the state contacts aware of the particular goals of this project. In addition, the visits will provide a hands-on feel of the practices of each state. These visits will be conducted with the appropriate data collection and GIS administers and anyone else identified by the state that should be involved in the process.

•*Task 6: Final Report*- The information gathered in the first five tasks will then be compiled into a final report that will provide a synthesis of practice as to the state of ground-based image usage for roadway inventory and data collection in the six New England states. This report will discuss issues pertaining to ground-based image usage along with historical information, summaries of ground-based image usage in other states outside of New England and future plans towards the advent of more advance activities.

CHAPTER 2

OVERVIEW OF NEW ENGLAND PRACTICES

All of the states in New England have a significant level of unity in the required inventory and data elements that must be collected and maintained. There are, however, distinct differences in the methods by which these elements are collected. This synthesis provides an overview of what is being done in this region and is intended to provide each state with the opportunity to learn about beneficial procedures from each other. Table 3 lists some general characteristics of each New England state for comparative purposes (Weber 2001).

TABLE 3

GENERAL NEW ENGLAND CHARACTERISTICS

State	Area (mi^2)	Approximate Population
Connecticut	5,544	3,400,000
Maine	35,387	1,270,000
Massachusetts	10,555	6,350,000
New Hampshire	8,969	1,240,000
Rhode Island	1,545	1,050,000
Vermont	9,615	610,000

Every New England state, with the exception of New Hampshire, conducts some form of ground-based imaging for roadway inventory and data collection. The extent and sophistication of this usage varies from nominal to extensive.

CONNECTICUT

Connecticut is a pioneer in ground-based imaging systems for roadway inventory and data collection; many states look to it as a leader for implementing and managing these systems.

Starting in 1980, Connecticut began to maintain a complete highway photolog. This system consisted of a series of consecutive photographs of each state highway and the surrounding environment. Along with the photographs, measurements of highway geometrics and records of highway location, date, and time were kept. The entire 4,000-mile state highway system was photologged at an interval of every 0.01 miles. This corresponded to 800,000 frames of 35mm color film and 63 megabytes of data.

Responding to a Federal Highway Administration (FHWA) sponsored study to develop pavement management systems (PMS), the Connecticut Department of Transportation began using video laserdiscs in 1984. Prior to 1980, Connecticut had no systematic method for pavement evaluation. Between 1980 and 1984, Connecticut maintained an inventory of pavement data through intensive field evaluations. Pavement was evaluated using a subjective but effective visual rating system, which later became the WISECRACKS system. Laserdiscs were implemented to improve the efficiency, accuracy, and safety of data collection for monitoring pavement condition. The entire state highway system could be maintained on 670 100-ft reels of 35mm film, which were then transferred to approximately 30 laserdiscs. The improved accessibility led to more rapid evaluations and the pavement evaluation process was moved from the field to the office, eliminating hazards to field collection personnel.

By the early 1990’s, Connecticut had a fully developed Photolog Laser Videodisc-Based Pavement Rating System (PRS) in place. This system allowed the photolog images to be evaluated by a trained user from an office. Some of the many advantages of this system included the safe, controlled environment for evaluation, unlimited re-rating, direct computer entry of distress data, and automated computer analysis of the data.

Connecticut’s PRS relied on Photolog Laser Videodisc viewing stations (PLV). These first viewing stations were costly and cumbersome by today’s standards. Many different hardware and software items were required to drive the system. A typical workstation included a PC, video monitor, graphics generator, graphics tablet, video printer, and laser videodisc player. By 1993, Connecticut had 15 PLV stations.

The rapid improvement in computer technology in the 1990’s allowed these viewing stations to become less and less complicated. In 1992, Connecticut began converting its PLV stations to MINI-PLV’s. These new workstations condensed the required hardware and resulted in the viewing station looking like a PC with an additional laser videodisc player. The MINI-PLV moved all of the specialized hardware to specialized internal components within a PC.

As viewing station technology advanced, so did the technology for acquiring and distributing images. 35-mm film became analog videotape, which then went to digital images that are stored directly onto hard drives. Laserdiscs evolved to CDs and then to DVDs. Video imaging allowed for continuous image acquisition while CDs, and DVDs allowed for higher volumes of storage.

The state of Connecticut soon realized that the videolog technology could be used for other purposes. In 1988, ConnDOT started using videologs to collect bridge data, which was expanded to the bridge management system that was mandated by ISTEA in 1991 when laser videodiscs were used to store bridge inspection photographs. Videologs were soon used for many different functional areas including: safety analysis, project development and design, highway-sign inventory, legal evidence, public hearings, construction documentation, planning and inventory, and maintenance.

Currently Connecticut is at the forefront of videolog technology. The idea of a PLV station has evolved to videologs being directly accessible through a PC. A software package called DigitalHIWAY and a DVD drive are all that are needed to access the videologs.

In addition to the distribution of DVDs, Connecticut has begun LAN (Local Access Network) distribution. This LAN is a network of computers that allows for the distribution of images and software files to licensed users across the state. The data are stored and maintained on one central server with access granted to users. This totally eliminates the need to distribute the images and additional data on a separate storage device. All costs involved with processing and distributing could virtually be eliminated. In the first year of using the LAN, Connecticut experienced a 300% increase in use of the image and data. At the time of this report, Connecticut has 101 PCs running DigitalHIWAY with that number continuing to rise monthly.

The data acquired in the videologging process have also been used to produce a centerline layer of the state's roadways. This information has been used to update existing centerline files for use by GIS agencies. The system is also currently being used to inventory ramp data for the GIS.

MAINE

Maine has a mature ground-based image and data collection system. The system has been developed primarily to support the pavement management system since it was initiated in 1989. Images of the driver's eye view, left side, right side and pavement surface are collected. Pavement surface images are used with other data to assign a Pavement Condition Rating (PCR).

In Maine, as with many northern states, rutting is a problem due to the many freeze-thaw cycles and the numerous loads the pavement has to endure. Rutting is the distortion of the pavement from the original cross section. It is often associated with grooves in the pavement corresponding to tire paths of vehicles. Freeze-thaw cycles magnify the rutting problem with the distortion occurring in a chaotic manner. As rutting becomes sever, roads have to be repaired which requires that the ruts are filled to return the road to its original cross slope. Initially, crude volume estimates were performed to determine how much filler, referred to as shim, was needed to correct the road profile. Often these estimates were below the actual amount required, resulting in projects being over budget.

Early in the use of its data collection vehicle, Maine recognized that using its transverse profiling capabilities could assist in making more accurate shim calculations. The profiling is accomplished using a 12-foot bar attached horizontally on the front of the ARAN at 18 inches above the ground. Every 4 inches along the bar are ultrasonic sensors that detect the distance of the pavement from the bar. A roll gyroscope is also used to determine the true horizon. Both the ultrasonic sensors and the roll gyroscope are programmed to take readings at every 50-foot station along the road. This system results in a more accurate calculation of a road’s transverse profile.

Maine DOT developed a software program called Automated Shim Analysis Program (ASAP), to calculate its shim quantities. This program compares the existing transverse profile of a road as determined by the data collection, to its desired cross slope. It then estimates the amount of filler needed to bring the road to the desired cross slope. A users guide for ASAP is included as Appendix C.

The benefits of automating the shim calculations are substantial. Maine DOT reports that in its first two seasons of this activity, the state saved a significant sum (estimated at $350,000 in 1992). Another benefit is safety. Survey crews are no longer needed to take cross-section elevations in the middle of the highway. The procedure is faster as the collection van takes data while traveling down the highway at speeds between 30 and 40 mph. These benefits in reduced labor and time and improved safety have given Maine a rapid return on its investment.

Maine is also taking the initiative in incorporating the images and collected data into the statewide GIS system. This will greatly increase the data's accessibility and exposure, allowing it to be utilized to its fullest potential. Currently under development in Maine is a centerline roadway layer in the state's GIS system that will allow a user to point to a section of roadway, which will show the corresponding videolog image. The user can then "move" through the images to simulate traveling down the highway. Along with the images, roadway inventory data that are in the state's GIS database can be displayed.

MASSACHUSETTS

Ground-based imaging and data collection in Massachusetts is used primarily for and is under the jurisdiction of pavement management. A collection vehicle collects surface roughness and roadway geometric data to evaluate the condition of the roadway. Along with these data, GPS and mileage points are collected for referencing and a videolog of the driver's eye view is kept. These videologs are then sent to the Bureau of Transportation Planning and Development within the Massachusetts Highway Department where they are used for linear referencing and are available to be viewed by authorized users.

NEW HAMPSHIRE

New Hampshire uses several data collection activities as the source for its roadway inventory data. Videolog images are not collected. In general, data collection is the responsibility of the nine regional planning agencies (RPA) with some additional data collection performed by consulting agencies. New Hampshire DOT provides a manual of instructions for road inventory, which is included in Appendix D. The nine RPA's then collect the data to these standards and report the data back to the central DOT office. The DOT acts as a warehouse for the data and supplies it to the state's GIS. The state of New Hampshire has no plans to implement a single data collection unit for the entire state and sites the large initial capital investment as the reason.

RHODE ISLAND

Rhode Island is the only state in New England that uses a contractor to perform its ground-based image and data collection. The state performed a cost analysis between procuring its own ground-based imaging and data collection system and paying a contractor to do the collection and decided that surveying the small number of roads in the state was not worth the large capital investment and required maintenance of a state system. By hiring a contractor, the state eliminated the equipment costs and the actual collection process. The contractor delivers the images and data to state defined specifications. The primary limitation of this approach is that the state must rely on an outside party.

Rhode Island uses the images and data collected for pavement management and some roadway inventories. The roadway images are stored on a network where authorized users are allowed to view the images and the corresponding coordinates. This is used to a limited extent for linearly referencing roadway inventory items on Rhode Island's GIS. The videolog images are also used, as needed, to inventory other roadway items for specific projects.

VERMONT

At the time of this report, Vermont was undergoing an upgrade to its ground-based image and data collection system. This provided a unique opportunity to observe the issues that a state addresses when upgrading to a new technology.

Vermont maintains two separate image and data collection vehicles, one for pavement management and another for roadway inventories and roadway geometric data collection. The latter vehicle is the one that is being upgraded from videotape to digital image files as the collection medium. The image files will then be stored at a central server to provide access to authorized users. Improved technology on the new vehicle will collect curve, grade, roll, pitch, GPS, and related data. The older van collected curve and grade data but Vermont did not feel that these data were reliable enough to distribute.

The technology on the new Vermont system is state-of-the-art. This new technology requires that users become comfortable in using and maintaining the system. Some of the problems that Vermont is facing are a small staff for a high workload, server space problems, and time to validate the accuracy of the new system. A year's worth of data is to be collected and their accuracy confirmed before plans for implementing the system are complete.

Vermont uses and plans to use ground-based image and data collection for pavement management (a separate system), roadway inventory, and roadway geometric data collection. When the upgraded system comes fully online, the state's GIS office plans on using the images and data to maintain much of its transportation data.

CHAPTER 3

State of the Practice of Ground-Based Imagery and Data Collection In New England

The six New England states offer a diverse cross-section of ground-based imagery and data collection systems. Each state has independently developed a system that they feel best addresses the needs of their state. The ingenuity behind some of the practices is impressive and new ideas continue to unfold. New technologies are also constantly advancing the possibilities of more efficient procedures. A comparison of these systems will allow ideas to be exchanged and assist in improving systems where the best ideas survive, thereby maximizing their abilities and efficiency.

New Hampshire does not maintain a single roadway inventory and data collection system as described in chapter two. For this reason they are not included in the comparison tables in this chapter.

New England states experience a variety of climate and weather conditions that cause some unique roadway problems for the region. Improved techniques to solve these region-specific problems could be identified by understanding the practices across the states in New England.

Roadway Inventories

Roadway inventories are used across all transportation and highway agencies for planning, design, operations, and maintenance purposes. These inventories include roadway geometrics, roadway features and appurtenances, and physical roadway data. Many different practices exist to collect these data, ranging from use of satellite imagery to manual collection. Many states combine different practices to get a complete list of roadway inventories. This section focuses on roadway inventories being collected by each state through a ground-based image and data collection system. If specific data elements are not listed here, this in no way means the data are not collected by the state. The data may be collected by other means. Table 4 lists what geometries and features each state collects through the use of the resulting videolog on a regular basis. Linear referencing calibration points are incorporated into the imagery and associated data fields as roadway location references.

TABLE 4

ROADWAY GEOMETRY/FEATURES EXTRACTED FROM IMAGERY

Connecticut	Vertical under clearance Intersecting roads	Signs Guardrails
Maine	Number of lanes Linear referencing calibration points incorporated into imagery	
Massachusetts	Lane width Number of lanes	Bridges and other structures State defined mileposts
Rhode Island	Number of lanes Shoulder widths Linear referencing calibration points incorporated into imagery	Lane width
Vermont	Number of lanes Shoulder widths Lane width Vertical under clearance *Intersecting roads *State defined mileposts *These data are planned to be collected once the system upgrade is completed	*Signals *Guardrails *Bridges and other structures *Crash cushions *Signs *Rumble strips

The use of ground-based images to inventory roadway features and appurtenances is being explored but is not yet standard practice in New England. The formal collection process for these data is performed by other means, most often manual collection. Rhode Island uses its ground-based images to collect specific sets of roadway features and appurtenances on an as-needed basis for specific projects. Other states, such as Maine, use videologs for quality control of its previously collected inventories.

For efficiency, many states simultaneously collect physical roadway data elements with the same vehicle that collects images. These data often are used in pavement evaluation, determining existing roadway profiles, and identifying linear/spatial referencing points. As the ARAN traverses the roadway, these data are collected at set distance intervals. These intervals are determined by the requirements to accurately represent each data element. Table 5 identifies additional data collected by each state concurrently with the images, and the interval at which they are recorded.

TABLE 5

DATA COLEECTED AND ASSOCIATED ACQUISITION DISTANCE INTERVALS

State	Data	Interval
Connecticut	Surface Roughness	0.01 km
	Transverse profile measurements	0.005 km
	Crossfall/slope Roll Yaw Pitch Grade Mileage GPS coordinates	0.004 km
Maine	Surface Roughness Transverse profile measurements Crossfall/slope Roll Pitch Yaw Grade	0.02 mi
	Mileage	0.001 mi
Massachusetts	Surface Roughness Transverse profile measurements Crossfall/slope Roll Pitch Yaw Mileage GPS coordinates	0.02 km
Rhode Island	Surface Roughness	0.1 km
	Crossfall/slope Grade GPS coordinates	0.0167 km
	Mileage	Continuous
Vermont*	Crossfall/slope Roll Yaw Pitch Grade Mileage GPS coordinates Surface Roughness is collected by another ground-based image and data collection vehicle	0.01 mi

*The state of Vermont has two ground-based image and data collection systems, one specifically for pavement management and the other for inventory collection.

These data can then be used to calculate specific roadway properties beyond the raw roadway data including roadway curvatures, roadway profiles, centerline roadway maps and more. Table 6 summarizes the additional information processed from the captured data.

TABLE 6

INFORMATION PRODUCED FROM THE CAPTURED DATA

	Connecticut	Maine	Massachusetts	Rhode Island	Vermont
Horizontal curvature	X			X	X
Vertical curvature	X			X	X
Longitudinal profile	X		X		
Transverse profile	X	X	X		
Rutting	X	X	X	X	
Shim quantities and milling		X			
Centerline maps	X				

Image Acquisition

Each New England state has a different method for acquiring the videologs. The degree of sophistication used in obtaining the images often prescribes their usefulness during the data analysis stage.

Table 7 lists the number of centerline miles of roadway videologged by each state. The state of Maine logs more than twice as many miles as any other New England state while Rhode Island logs the least. The number of miles logged is important in determining if the image acquisition process should be performed in-house or by a contractor. If the state maintains a relatively small number of centerline miles, it may not be economically efficient to procure its own ground-based image and data collection system. The initial investment for the system and the required maintenance will outweigh the economic benefit of internally maintaining the system as determined by Rhode Island, which is the only state in New England that uses a contractor to obtain its videologs.

TABLE 7

APPROXIMATE CENTERLINE MILES LOGGED

Connecticut	4000
Maine	9000
Massachusetts	2900
Rhode Island	1000
Vermont	4000

Table 8 lists the mediums employed for storing images.

TABLE 8

MEDIUM EMPLOYED FOR IMAGE STORAGE

	Connecticut	Maine	Massachusetts	Rhode Island	Vermont
Analog Videotape		X	X		
Digital Videotape	X				X
CD, DVD and/or Hard Drive	X	X		X	

Digital images are the current media for state-of-the-art of ground-based image and data acquisition and storage systems. They allow for ease of distribution and a level of image analysis that was not obtainable through analog videotapes. Analog videotapes can be digitized and distributed as digital files at increased cost and reduced image quality. Digital videotape improves the image quality but not the accessibility issues.

In their earliest forms, ground-based image and data acquisition systems generally only recorded roadway images of the pavement surface and a driver's eye view. As the systems advanced, the benefit of recording additional views for roadway inventory collection became apparent. Right and left side views improve visibility of inventory elements that may not have been apparent in only a driver's eye view. These additional views greatly assist in associating the inventory elements with their surroundings. Table 9 is a list of roadway views used by each state.

TABLE 9

ROADWAY VIEWS RECORDED

	Connecticut	Maine	Massachusetts	Rhode Island	Vermont
Driver's eye	X	X	X	X	X
Right	X	X			X
Left		X			
Pavement surface	X	X		X	

Some states acquire these images by recording images in both directions of travel along the roadway while some only record in one direction. Recording in both directions or making additional passes on a road improves inventory data collection but increases expense. Collection cycles of the states also vary. Some states collect data on their roads annually. Larger states or states with a larger number of roads may videolog their roads with a longer collection cycle. The number of collection vans, length of the image collection season, and amount of roadway dictates the length of the collection cycle. Table 10 is a list of the extent of collection and collection cycles of roadway images for each state.

TABLE 10

EXTENT OF WHICH IMAGERY IS CAPTURED

	Connecticut	Maine	Massachusetts	Rhode Island	Vermont
One direction on all roads		X			
Both directions on all roads	X			X	X
Both directions on divided roads One direction on undivided roads			X		
Once a year	X				
Once every 2 years		X		X	
Once every 3 years			X		
Once every 4 years					X

In collecting the images, the distance interval in image acquisition is important. This distance interval is often different from that employed for data collection due to different operating systems and collection needs. Videotape offers the appearance of continuous images. Typical systems that rely on digital image files have larger distances between acquiring the images. An interval that is too large will result in loosing some roadway inventory elements; an interval that is to small will result in unnecessary money spent on storage space for the additional image files. Table 11 is a summary of the distance intervals between image acquisitions by state.

TABLE 11

DISTANCE INTERVAL BETWEEN IMAGE ACQUISITION

Connecticut	Continuous and .01 km (~33 ft)*
Maine	Continuous
Massachusetts	Continuous
Rhode Island	Every .06 meters (~2.4 inches)
Vermont	Every .01 miles

* Both videotape and digital image files maintained

Processing, Storage, and Distribution

After the images and data have been obtained, they are often filtered to yield more helpful information or decrease the size of the files for post processing and storage. Table 12 lists the filtering intervals between images, by view, for each state and whether this filtering is done in-house or by a contractor.

TABLE 12

IMAGE FILTERING

Connecticut	Front, Right side view stored every 10 m Pavement surface editing varies Done In-house
Maine	No filtering performed
Massachusetts	Front view stored every 20 m Done in-house
Rhode Island	Front, Pavement surface stored every 16 m Done by a contractor
Vermont	No filtering performed

The filtered images are stored for later use and distribution. The method of storing images is important for image quality, storage space, and ease of distribution. Maintaining images digitally is rapidly becoming the most efficient means by which to store images. Before the images can be stored as digital image files, they are compressed to reduce the file size. Image resolution also directly effects file size. The higher the resolution the more detailed the image, but the more storage space needed. Table 13 lists the compression strategies, image resolution, and file size for those states that maintain images as digital files.

TABLE 13

DIGITAL IMAGE STORAGE CHARCTERISTICS

	Connecticut	Maine	Vermont
Compressed as JPEG files	X	X	X
Resolution of 640x480 pixels	X	X	
Resolution of 1300x1300			X
Average file size is 50K		X	
Average file size is 180K			X
Once every 3 years			
Average file size is 60K for driver's view Average file size is 75K for side view	X X		

*Massachusetts does not maintain digital files
**A contractor maintains Rhode Island's compression information

Often, a state will wish to distribute these images to other users within the state government. In the past, this required making copies of the images on the specified medium and sending them to the user. Currently, the state-of-the-practice is storing images on hard drives and distributing the images over a network. This new process has raised some interesting questions about security and liability such as unauthorized users acquiring access to the data. By making the images available over a network, the need for storing the images on portable storage mediums has been eliminated.

Along with distributing images internally, some states make images, and the associated data, available to external parties. Interested parties range from lawyers to companies producing in-vehicle navigation systems. The state of Connecticut distributes the images externally for a fee of $5 for individual photographic quality images and $13.17 for DVDs containing part of the state's roadway network to cover cost of reproduction. Most states are prohibited from selling images or data for a profit. Table 14 lists the distribution practices for the images and associated data for each state.

TABLE 14

DIGITAL IMAGE STORAGE CHARCTERISTICS

	Connecticut	Maine	Massachusetts	Rhode Island	Vermont
Images and data are distributed internally and externally	X				
Images only are distributed internally and externally		X			
Images and data are distributed internally but not externally			X		
Images only are distributed internally but not externally				X	
Images are not distributed					X
Data are not distributed		X		X	X

Summary

The information presented in this chapter shows the difference in scale and development of ground-based image and data collection systems throughout the New England states. Connecticut is a leader in this technology and constantly promotes the growth of such systems within their state and without. Rhode Island demonstrates the need to consider the economic pros and cons of acquiring and in-house system. Area-wise, Rhode Island is the smallest state, with a correspondingly smaller amount of centerline miles compared to other states. This led policy makers to suspect that procuring their own system would not be as economically viable as hiring a contractor to perform the collection process. On the other hand, Maine is the largest New England state and maintains the largest number of centerline miles. Maine is also sparsely settled. The vast distances of unpopulated roadways require a strong centralized roadway management system. Incorporating the data and images collected from the ARAN into the state GIS system eliminates many long-distance field trips and maximizes data availability. Vermont demonstrates the conversion process from older ground-based image and data collection systems to a state-of-the-art system. The experiences of this state could be valuable in identifying potential problems for other states that plan to go through this conversion in the future. Massachusetts effectively uses an older system to acquire videologs for pavement management and has a complete library of images. However, the state is limited by resources to make full use of their system.

CHAPTER 4

Using GIS

Geographic Information Systems (GIS) have rapidly become an important tool in transportation to store, manage, analyze, and display pertinent characteristics of information at a geographic location. These characteristics can be almost anything from crime rate to environmental classification to traffic level.

GIS provides a unique opportunity for transportation officials to effectively manage infrastructure and roadway inventories. Data associated with these systems are, by their nature, spatially referenced. GIS systems allow transportation officials to point to an item on a map and get any stored information such as condition, height, or size. The ability to display a videolog image containing the inventory item and its surroundings within the GIS system is also possible.

When collecting ground-based images, a spatial reference is also collected. This can be latitude and longitude, state plane coordinates, state defined mileposts, chainage, or another system. These references are necessary for integrating information within a GIS.

Each of the six New England states has a GIS system, with some states having multiple systems. In states like Massachusetts and Maine, the state's transportation agency is responsible for providing the transportation data to a centralized agency that manages and distributes statewide GIS-based information.

Transportation data is often gathered by many different sources, often regional planning agencies responsible for collecting all of the data within their region. This data collection relies on time consuming manual collection with multiple trips required to collect the necessary information. Use of an ARAN vehicle and associated image collection to gather much of the necessary transportation data in one pass provides a mostly automated process. Some states have realized this potential and have begun using ground-based image and data collection for this purpose. Other states still rely on older methods. A comparison of GIS practices as they relate to ground-based imagery of New England states is presented.

Several GIS software packages are used by state transportation agencies. Evaluating the pros and cons of each system is beyond the scope of this project. However, knowing the systems in use by each state may provide useful information to others. Table 15 lists the Geographic Information Systems used by each state agency in New England.

TABLE 15

GIS SYSTEMS

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
ArcInfo/ArcView		X	X	X	X	X	X	X
Integraph	X							
GDS						X		
Computer Aided Drafting/Design (CAD)					X			X

Each state uses several spatial location referencing systems to locate objects in the system as indicated in Table 16.

TABLE 16

FORMS OF SPATIAL LOCATION REFERENCING

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
Latitude and longitude	X	X			X			
State plane coordinates	X		X	X	X	X	X	X
Mileposts	X		X		X	X	X	X
UTM, link-node			X					

Geographic Information Systems typically operate on several databases, which are usually warehoused in three different ways: centralized, distributed, and local. For a centralized warehouse, data are maintained in a single location that is accessed by remote users. For a distributed warehouse, data are maintained at several locations throughout the state that are accessed by remote users. For local warehouses, the data are maintained on local systems with access only to local users. Maintaining data in a centralized warehouse allows the data providers more and easier control over data maintenance and quality. Table 17 lists the warehousing techniques by state.

TABLE 17
WAREHOUSING TECHNIQUES

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
Centralized	X	X	X	X	*	X	X	X
Distributed					X			
Local								

* MASS Highway is in the process of moving to a centralized warehouse.

The transportation data included within the GIS framework by each state ranges from basic road centerlines to advanced planning information. Table 18 lists the transportation data maintained within each state's GIS. Often these data are dependant upon the class of road. Roads of higher classification, such as interstates and state highways, often have the highest level of data collection.

TABLE 18

TRANSPORTATION DATA WITHIN THE GIS

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
Route number	X		X	X	X	X	X	X
Speed limit			X		X		X	X
Number of lanes	X		X		X	X	X	X
Lane width	X		X		X	X	X	X
Shoulder widths	X		X		X	X	X	X
Median type	X		X		X	X		X
Median width	X		X		X	X		X
Curbs present	X		X		X	X		X
Sidewalk width					X			
Vertical under clearance			X			X		X
Intersecting roads	X		X		X	X	X	X
Bridges	X		X		X	X	X	X
Town lines	X	X	X	X	X	X	X	X
Linear referencing calibration points			X		X		X	
State defined mileposts					X	X	X	X
HOV lanes					X			
Rumble strips			X					X
Gaurdrails							X	X
Signs			X					X
Signals							X	X
Crash cushions							X	
Surface roughness			X		X	X	X	X
Grade						X	X	X
Crossfall or cross slope							X	
Mileage	X		X		X	X	X	X
Road surface type	X		X		X	X		X
Transverse profile measurements								
GPS coordinates	X	X	X			X	X	X
Yaw							X	X
Roll								X
Pitch								X
Skid number								
Toll Road			X		X	X		

Table 19 lists the distance intervals between data points and the update cycle.

TABLE 19

DISTANCE INTERVAL BETWEEN DATA POINTS AND DATA UPDATE CHARACTERISTICS

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
Continuous data	X	X	X		X		X	
Variable data intervals						X		
.01 mi data interval								X
Continuously updated		X						
Yearly updates	X							
Updated every 2 years							X	
Updates vary			X		X	X		X
No response				X				

Many different sources are used to obtain transportation data. Satellite and aerial photography, along with manual field collection are often the primary sources. Data collected by the ARAN vehicle, specifically the videologs, have become integrated into some state systems. Table 20 lists the means by which roadway data are acquired for each state.

TABLE 20

DATA ORIGIN

Connecticut	Pen based computers used in field data collection
Maine (Office of GIS)	GPS DOQQ's SPOT imagery Roads originally digitized using 1:24,000 USGS topo maps
Maine (DOT)	GPS Engineering files Roadway inventory Videologs
Massachusetts (MassGIS)	No response
Massachusetts (MASS Highway)	Data acquired in-house by individual DPW's
New Hampshire	Data acquired in-house and by contractors
Rhode Island	Videologs Aerial photography
Vermont	No response

One key issue is whether data associated with ground-based imagery and data collection is specifically being used by GIS agencies in the New England states. Table 21 describes the specific videolog usage within GIS agencies in New England and plans for using videolog imaging in the future.

TABLE 21

VIDEOLOG USAGE

Connecticut	Videolog is used for specific projects Plans to use images in future GIS activities
Maine (Office of GIS)	Videolog not used
Maine (DOT)	Videolog is GIS linked and is used for inventory quality check, Plans to use images in future GIS activities
Massachusetts (MassGIS)	Videolog not used
Massachusetts (MASS Highway)	Videolog is used for linear referencing Plans to use images in future GIS activities
New Hampshire	Videolog is not used No plans to use images in future GIS activities
Rhode Island	Videolog is used as a data collection source Plans to use images in future GIS activities
Vermont	Videolog is currently not used Plans to use images in future GIS activities

The state GIS agency often does not perform the data collection internally but compiles and maintains databases from outside agencies. For this reason, it is valuable to know what agencies are specifically collecting data. Of the six New England states, only Maine and Rhode Island rely on outside contractors for any data gathering. In Maine, a contractor is used for roadway digitizing following standards set by the state. Rhode Island uses contractors for the entire videologging process. These companies are TMT and Lamdatech International, respectively.

All GIS agencies need to digitize roadways in their state for use within the system. This process can be completed using several different hardware and software packages, all of which have slightly different processes. Table 22 lists the processes by which the roads are digitized in each state.

TABLE 22

MEANS OF ROADWAY DIGITATION

Connecticut	GPS receiver and Intergraph Microstation
Maine (Office of GIS)	Contracted out to Maine office of GIS standards
Maine (DOT)	ArcInfo is used to digitize the roads which is originally performed by various contractors
Massachusetts (MassGIS)	Roads are originally from USGS 100,000 scale DLGs
Massachusetts (MASS Highway)	ArcInfo is used to digitize the roads
New Hampshire	Spatial location collected using Trimble GPS equipment, ArcView/ArcGIS/GDS are used to digitize the roads
Rhode Island	ArcInfo is used to digitize the roads
Vermont	ArcInfo is used to digitize the roads

Finally, data available on these state systems are potentially valuable to many outside users. Some states make this data fully available to outside users while others choose to make it available to internal users only. This distribution may be done by giving outside users access to the GIS, or providing data sets on CD or diskette upon request. Table 23 lists the external distribution practices of each state.

TABLE 23

EXTERNAL DISTRIBUTION

	Connecticut	Maine (Office of GIS)	Maine (DOT)	Massachusetts (Mass GIS)	Massachusetts (MASS Highway)	New Hampshire	Rhode Island	Vermont
Data are externally distributed	X	X	X	X	X	X		X
Data are not externally distributed							X	

Summary

All six New England states have GIS agencies. Each of these agencies maintains some transportation data. The purpose of this section is to demonstrate the potential of using data collected from ground-based image and data collection within the GIS. Often roadway inventories are collected from aerial photography and some form of manual field collection. Of the six New England states, only Rhode Island uses their ground-based imaging system to provide data for the state's GIS. Maine uses their system to perform quality checks of the existing roadway inventories that are collected through other means. They are also developing a system by which the videologs are viewable through the GIS. Connecticut and, in the near future, Vermont maintain a state-of-the-art ground-based image and data collection system. These states have recognized the relative ease with which they could develop these systems to provide the majority of the required transportation data to the state's GIS and are working to develop such a system. Massachusetts uses the videologs to linearly reference some of the roadway inventories provided on the GIS. Without an upgrade of the ground-based image and data collection system, Massachusetts lacks the technology to develop a strong videolog-GIS linked program. New Hampshire, having no videolog system, maintains its transportation data through manual collection done by the state's regional planning agencies.

A strong videolog-GIS linked program has the potential to act as a single collection source for much, if not all, of a state's GIS transportation data needs. This could be used to reduce repetitive, time consuming and costly data collection processes.

CHAPTER 5

Ground-Based Imagery and Data Collection Outside New England

Ground-based image and data collection systems are not unique to the New England states. In fact, the majority of states throughout the country have some type of "videolog" system. This chapter is intended to provide a cross-section of the state-of-the-practice of ground-based image and data collection systems outside of New England.

Florida

The Florida Department of Transportation recently contracted the Connecticut Transportation Institute (CTI) to perform a synthesis-of-practice of its system and to make recommendations towards its improvement. The resulting synthesis-of-practice report for Florida's videolog program was provided y one of this reports authors, John Hudson a special services officer for the CTI (Dougan, Hudson, and Bower 2001).

Florida is responsible for approximately 11,927 centerline miles of state roads within an area of 45,477 square miles. To deal with maintaining this vast system, Florida realized the cost effectiveness of using an enhanced ground-based image and data collection system to assist in all functional areas.

CTI first surveyed users of Florida's imaging system. The majority of the 79 personnel surveyed felt that the videolog images were useful and had saved countless man-hours by eliminating field trips. These users also identified *decreasing the collection cycle*, *adding additional roadway views,* and the *collection of physical roadway data on condition and geometry* as ways of improving the system. Based on their evaluation CTI identified a number of problems that reduced the effectiveness of the system.

The current system in Florida divides data collection between several different operational units. A contractor for the Transportation Statistics Office provides videolog images; Pavement Management collects rider-comfort data (IRI) and the results of other pavement analysis; the State Materials Office maintains pavement distress data; and the Transportation Statistics Office collects roadway inventory data through annual surveys. A single comprehensive image and data acquisition system could collect all of the data maintained by these units in one pass by an ARAN vehicle. The CTI performed a cost analysis for the state of Florida using the experiences of the Connecticut DOT and estimated that a ground-based image and data collection system would save the state of Florida $8,757,100 annually. When compared to contracting an outside agency to perform the collection process, at a cost to the state estimated to be $2,394,000, results a benefit-cost ratio of 3.7. Doing the collection in-house was estimated to cost the state $1,261,200 for a benefit-cost ratio of 6.9. The advantages of using a contractor include elimination of (1) equipment costs and (2) the need to obtain and keep trained personnel in this state-of-the-art field. Having the units in-house allows for more flexibility in schedule changes and in project level usage.

An important recommendation was that the management of this system should fall under the control of a single government agency which would be responsible for all contracts, data and image processing, technical support, software development, upgrades, training of staff and promoting the use within Florida DOT.

The CTI also recommended many specific improvements to the nature of the system. One was to incorporate the videolog images and associated data into a GIS where the information can be retrieved by selecting a location on a map. This is intended to improve accessibility over the current system where users must input specific mileposts. Many users thought this was cumbersome and were unfamiliar with the milepost system.

Another recommendation was to improve the operational characteristics of the distribution network. Users identified the current network as having a slow access rate. It was also recommended that the state develop image-processing software to perform geometric calculations on the images, which would eliminate additional field trips. To obtain additional useful data, it was recommended that the data collection vans be equipped with additional cameras to obtain right-of-way, left, and pavement views. It was also suggested to make additional passes on multi-lane roads, reducing the image interval from 0.01 miles to 0.005 miles and shortening the collection cycle. Decreasing the interval would capture data that was currently being lost between frames while shortening the collection cycle would improve the timeliness of the data.

Arkansas

The state of Arkansas has maintained images and data for the majority of its state and national roadways since 1993. The state's current system collects images for the driver's eye, right, and pavement views for 16,500 centerline miles. Along with the images, the state collects a full range of physical roadway data and uses the system to assist in pavement management. The images are digitized and compressed as JPEG files for distribution to internal Arkansas DOT users over an intranet. The state has recently started collecting GPS data and is using it to move towards integrating the images and other data into a GIS. Arkansas is also beginning to develop image-processing software to enhance their data collection activities.

Iowa

The state of Iowa has produced videologs for the past twenty years. Currently, the state maintains about 20,000 miles of roadway and annually updates half of the videologs in each direction. Images are acquired digitally and distributed internally over an intranet, as well as on CD's. The Iowa system is designed for collecting roadway inventory elements and obtains supplemental images of the right and left side views. The state of Iowa is satisfied with the condition of its roadway inventory database and is considering increasing the collection cycle for the sake of cost effectiveness from every two years to every four years.

Ohio

Ohio maintains about 19,290 miles of roadway. Images are maintained in both directions and are collected on a three-year collection cycle. The images are initially stored on analog laser discs and then distributed over an intranet to internal users. The images are occasionally distributed to outside users on DVDs for a fee. The primary driving force behind Iowa's videolog program was the need for assistance with litigation. The state finds the videologs invaluable in court for proving culpability. Some physical roadway data are collected during the videolog process and the van is occasionally used for specific projects. Occasionally, the system is used for specific roadway inventory collection, but the state is satisfied with the current field collection system. Using videologs for litigation is an issue that many states are concerned about since images could be used against them. By developing their videolog system with litigation purposes in mind the state of Ohio shows another application where videologs are economically efficient.

Texas

The state of Texas uses their videolog system primarily as a pavement management system. The state records driver's eye and pavement views onto videotape. Along with images, GPS and state defined mileposts are collected for referencing. The interesting thing about Texas's system is that they only maintain images for approximately 2-3,000 miles of roadways around the state's major metropolitan areas. Texas is very large with a large amount of roadways that are rural interstates, which get relatively little use. Because of cost, the state only maintains videologs on the most heavily used roadways around major cities. These are the roads that need the most maintenance and are crucial to the state's vitality. Other states with large sections of open road might want to consider the experiences of Texas when developing their system.

Other States

In the report on Florida performed by the Connecticut Transportation Institute, several other Transportation agencies were surveyed about the state of their ground-based image and data acquisition systems. Seven state transportation agencies, one city planning agency and one county planning agency were surveyed. The resulting information is presented in Appendix E.

Summary

Ground-based imaging systems are not unique to the New England states. The cross-section of states investigated in this section displays issues that are common to all states along with issues that are state or region specific. The synthesis-of-practice of

Florida performed by the CTI demonstrates the need to develop a single, centralized, well-managed data collection system. Videolog systems have the highest potential of delivering this type of system at the lowest cost to the state. Texas presents a region specific issue with videolog usage. Much of the roadways in a large state such as Texas are rural. For economic efficiency Texas only videologs those roadways that are greatly effected by urban traffic. Ohio, with a system developed to assist in litigation, has shown that videologs can save a state significant money by easily and effectively proving culpability. This section and the results of the CTI surveys in Appendix E demonstrate that many states are moving towards newer technology and have recognized the benefits with maintaining a state-of-the-art system.

CHAPTER 6

Conclusions

With the completion of the nation's Eisenhower highway network, planners and engineers have had to change their focus from constructing new roadways to maintaining and repairing existing ones. This is generally under the jurisdiction of state transportation agencies that must evaluate their systems. The data needed to evaluate roadways include geometric data, pavement data, data on roadway features, traffic data, and more. These data are required not only for roadway evaluations but also in response to federal mandates related to funding allocation.

The data required for a complete roadway evaluation cover many different functional areas. Different agencies within the state department of transportation are often required to collect the specific data that they need. Collection of these data often requires a detailed inspection of the roadways by each different functional area. These field inspections are time consuming and hazardous to field collection personnel. Efficiency of roadway data collection could be greatly improved by use of available technologies, particularly videologs, thus moving evaluation processes from the field to the office.

Modern ground-based image and data collection systems combine improved videologging practices with automated roadway data collection to supply data for comprehensive roadway evaluations. These systems have shown their ability to reduce field trips and greatly improve the operational efficiency of data collection systems. The capability of these systems has been greatly enhanced over the past few years.

Within New England, the use of ground-based image and data collection systems differs significantly. Connecticut has been a pioneer with these systems for decades.

They have promoted the use of these systems and publicly documented their development. Maine has also initiated some innovative techniques with their shim quantity analysis and incorporation of videologs and associated data into an enterprise GIS. Vermont and Rhode Island have also begun to use the abilities of the modern systems. Massachusetts has a system in place that would benefit from an upgrade and increased managerial support. New Hampshire has no system in place and relies upon the regional planning agencies for data collection.

The New England states provide a good cross-section of issues concerning the development and implementation of ground-based image and data collection systems. New Hampshire feels that procuring a system is not economically viable due to the large capital investment needed for obtaining system hardware and training personnel. Connecticut, to make its system the most efficient, complements its system with a wide range of training programs and advocates the use of the system throughout the state.

Every state interested in obtaining a system should perform a benefit-cost analysis to determine the advantages versus the cost. Typically, small dominantly rural states will have the smallest benefit/cost ratios and may feel it is to their advantage to keep their current data collection systems in place. States that choose to do this should also take into account the impact that this decision may have in the future. The federal government is also considering enhancing the Highway Performance Monitoring System and may encourage use of a single automated data collection system.

Massachusetts demonstrates the need to promote the abilities of ground-based image and data collection systems throughout upper level management. In this state, the system is under utilized because many users are simply unaware of its potential.

Videologs remain in archives while data that could easily be drawn from them are collected by other means or not collected at all.

Ground-based image and data collection systems can be the primary source of geometric and physical roadway characteristics. Below is a summary of the benefits of having a current well-developed system.

•Videologs have the potential to provide state agencies with complete roadway inventories. By taking a driver's eye, right side, and left side view, all roadway inventory elements can be cataloged from the videologs in the office instead of in the field. In addition, image-processing techniques allow for the physical characteristics of these inventory elements to be obtained from the images. Although not yet fully automated, these techniques have saved substantial resources both in time and money and should be used as much as practical by states with videolog capability.

•Videolog images, in conjunction with distress evaluations of the pavement surface, allow for pavement inspections to be performed in the office instead of the field.

•Digital images greatly improve the resolution of videolog images. The images can be compressed as JPEG files and easily stored on CD, DVD, or a computer hard drive. Duplication of the images does not degrade the image quality, as did duplication of analog videotapes. Agencies can now acquire complete videologs of an entire state cost effectively. Digital images also assist in image processing techniques.

•Videologs have proven to be extremely useful for determining culpability in court cases concerning roadway characteristics. Ohio describes this use as invaluable for the savings it provides in legal matters.

•Modern systems have the ability to automate the collection of nearly all physical roadway data including the physical characteristics of the roadway such as curvature, grade, transverse profile, cross slope, and pavement data such as IRI values and texture. These data are stored as a digital file on CD, DVD, or hard drive and easily distributed.

•Many software programs have been developed to process these data and obtain horizontal and vertical curvature, roadway profiles, rutting, and shim quantities. These processed data can then be used to produce centerline maps and curb-to-curb plans.

•Linear and spatial referencing systems, such as state defined mileposts and GPS coordinates, allow each inventory element and image to be "tagged" with its geographic location. This allows for accurate placement of the inventory element and associated data into a GIS. These data can then be used in spatial analyses available through the GIS.

•The ability to store the videolog images and associated data on hard drives provides for the capability of network level distribution. In these systems, the data are stored on a central server and any authorized user can access the images and data. This virtually eliminates the production and distribution costs. Many states are moving toward this type of internal (and external) distribution, despite concerns over data security.

•Many states have a central GIS agency that maintains and distributes data across many different categories, one of which is roadways and their characteristics. The images and data collected can be easily incorporated into these systems. Within this expanded environment, roadway data can be used in both transportation and non-transportation related projects. A real advantage to the inclusion of imagery is the ability to quantify the impact of roadways on their surroundings in a way that is easily understood by all users. This is revolutionary to the planner and the implications go well beyond the transportation field.

Maximum effectiveness of a ground-based image and data collection system could be realized in a single, well-managed, well-promoted data collection system that provides nearly all of the data collection needs of the state at a relatively low cost. The system can be very user friendly and operate seamlessly between data collection, processing, and manipulation so that a relatively unskilled user could efficiently operate the system. A key to implementing this is education of users about the images, their use and analysis potential. Several companies specialize in developing these systems specifically for individual states. These companies will also perform the data collection. Appendix F lists suppliers and contact information.

REFERENCES

1. Anderson, Steve; "Computer Video: The Basics"; accessed at Utah State University: <http://www.usu.edu/~sanderso/multinet/vidpix.html>; June 2001.

2. Dougan, Charles E.; Hudson, John H.; Bower, David G.; 2001; "Florida Department of Transportation Videolog Program"; University of Connecticut School of Engineering; Storrs, CT.

3. Ease, Said; Chan, Yupo; 2000; "Urban Planning and Development Applications of GIS"; American Society of Civil Engineers, Reston, VI.

4. Federal Highway Administration: Highway Performance Monitoring System; accessed at: <http://www.fhwa.dot.gov/ohim/hpmspage.htm>; June 2001.

5. Finn, Fred; 1998; "Pavement Management Systems — Past, Present, and Future"; accessed at Federal Highway Administration: Public Roads, Vol 62, No 1 <http://www.tfhrc.gov/pubrds/julaug98/pavement.htm>; June 2001.

6. Hancock, Kathleen L; 2000"A Proposal to Conduct a Study Entitled Ground-Based Imaging and Data Acquisition for Roadway Inventories in New England: A Synthesis of Practice", The University of Massachusetts, Amherst, Civil and Environmental Engineering Department, The Transportation Center, Amherst, MA.

7. Hudson, John H.; Seitz, Robert L.; 1996; "Evaluation of Videowindows Photolog Laser Videodisc Viewing System"; *Transportation Research Record*; Vol 1536; National Academy Press, Washington D.C.; pp136-139.

8. Hummer, Joseph E.; Schefler, Craig R.; Khattak, Aemal J.; Karimi, Hassan A.; 1999; "Choosing an Inventory Data Collection System"; *Transportation Research Record*; Vol 1690; National Academy Press, Washington D.C.; pp126-134.

9. Kalikiri, Vinod K.; Garrick, Norman W.; Achenie, Luke E.; 1994; "Image-Processing Methods for Automated Distress Evaluation"; *Transportation Research Record*; Vol 1435; National Academy Press, Washington D.C.; pp45-51.

10. Maine DOT; 1992; "Maine DOT Calculates Bituminous Overlay Quantities-ASAP", *TR News*; Issue 159; National Academy Press, Washington D.C.; pp32-33.

11. Orth, Paul A.; Singh, Chan; 1994; "Acquisition and Implementation of the SDDOT Videologging System"; Report No. SD90-17-X; South Dakota Department of Transportation, Pierre, SD.

12. Phares, Brent M; Washer, Glenn; Moore, Mark; 1999; "Introducing FHWA's NDE Validation Center"; accessed at Federal Highway Administration: Public Roads, Vol 62, No 4 <http://www.tfhrc.gov/pubrds/janfeb99/intro.htm>; June 2001.

13. Ritter, Joyce; 1994; "The History of Highway Statistics"; accessed at Federal Highway Administration <http://www.fhwa.dot.gov/ohim/1994/text/history.htm>; June 2001.

14. Sayers, Michael W; Karamihas, Steven M; 1997; "The little Book of Profiling: Basic Information about Measuring and Interpreting Road Profiles".

15. Sime, James M.; 1984; "Pavement Management in Connecticut Pase II – Development, Part2- Visual Rating of Pavement Distress from Photolog Inventory, Interim Report"; Report Number 887-3-84-8; Connecticut Department of Transportation, Wethersfield CT.

16. Weber, Ray; "States and Capitals"; accessed at: <http://www.50states.com/>; December 2001.

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•*Mass GIS*

•*Massachusetts Highway Department*

•*New Hampshire Department of Transportation*

•*Ohio Department of Transportation*

•*Rhode Island Department of Transportation*

•*Texas Department of Transportation*

•*Vermont Agency of Transportation*

APPENDIX A

State Transportation Agency Survey

Photolog Images and Data Acquired on State Roadways

Many state transportation agencies acquire roadway images and other applicable data items by use of ground-based imaging and data collection technology traditionally referred to as *photolog* or *videolog*.

This questionnaire has been sent to all New England States and is intended to survey the use of ground-based imaging and data acquisition and retrieval in each state's transportation agency.

After the surveys have been completed and returned, a summary will be made synthesizing the extent to which this technology is used. Finally, the information gathered will be shared during state visits and in the form of a final report.

Part I of this survey covers imaging. Part II covers data collected from ground-based imaging and any derived information.

SURVEY INFORMATION:

Name of individual completing survey:____

Name of department, agency:____

Location: City or town:____

Street address:____

Telephone: (____) - ________ - ___________

Fax: (____) - ________ - ___________

E-mail: ______________________________

Comments:____

Please return surveys to:

Jason DeGray
Transportation Center
University of Massachusetts at Amherst
214 Marston Hall
Amherst, MA 01003

For questions, please call: Kathleen Hancock
(413) 545-0228
hancock@ecs.umass.edu

I. Images

A. Acquisition:

1. Where — Approximate Centerline Mileage

- Interstate highways: ____________
- U.S. Federal roads: ____________
- State-maintained highways: ____________
- Local roads: ____________
- Other facilities: (describe) ____________________ ____________

____________________ ____________

Total: ____________

2. By whom: — Approximate % of Total Centerline Miles

- In-house: Name of Unit__________________________ ____________
- Contractor: Name of Contractor____________________ ____________

3. Medium employed for image acquisition: — Approximate % of total Centerline Miles

- Film: ____________
- Videotape: Analog ________ ____________

  Digital ________
- CD, DVD or Hard Drive ____________
- Other: (describe) _____________________ ____________

4. Areas of the highway environment are captured: (Check all that apply.)

____ Driver's eye view ahead ____ Right side view

____ Left side view ____ Rear view along road

____ Other: (describe)____

5. Indicate the extent to which imagery are being captured.

a. Directional (Check only one.)

____ One direction on all roads ____ Both directions on all roads

____ One direction only on undivided two-lane roads ____ Both directions on undivided two-lane roads

____ Both directions on divided roads ____ Multiple passes on divided roads of three or more lanes

____ Other: (describe)____

b. Collection cycle: Images are acquired: (Check only one.)

____ once a year ____ once every two years

____ alternating in one direction one year and in the other direction the next year

____ Other: (describe)____

c. Distance interval for image acquisition

____ Continuous ____ Every 0.01 miles ____ Other

B. Image Editing / Processing:

1. Editing interval: what is the distance interval between each video/photo frame selected, (e.g., 10 meters; 0.01 mile)? Enter **NE** if no editing is performed or **NA** if not applicable.
   Front view ________________

   Left side view _____________

   Right side view ____________

   Rear view along road _______

   Pavement surface __________

   Other (describe)____

2. Editing done by: ____In-house ____Contractor ____Both

C. Storage:

1. If images are stored digitally, please provide the following information:

   a. Compression strategy (i.e., how do you compress your files, e.g., JPEG, Bit Map, TIF, MPEG, etc)?

      ____

   b. Image resolution in pixels (e.g., 640 X 480 pixels)? _________________________

   c. Average file size of stored image? ____

2. Medium used to store images: (Check all that apply.)

	Videotape	CD	DVD	Hard Drive	Other
Front View	___	___	___	___	___
Right side view	___	___	___	___	___
Left side view	___	___	___	___	___
Rear view along road	___	___	___	___	___
Pavement surface	___	___	___	___	___
Other:__________	___	___	___	___	___

D. Internal Distribution of images: ____Yes ____No

If yes, please provide a detailed explanation of how your state currently distributes images to internal users (within the department). This explanation should include the hardware and software components involved as well as the distribution of the viewing stations with respect to management and operational units within your department. (An organizational chart of your department including the number of viewing stations or, perhaps, the viewing capability superimposed next to each unit could be attached to this survey to serve this purpose.)

____

____

____

____

E. External Distribution: _____Yes ______No

Please provide a detailed explanation of how your state currently distributes images to non-state or private sector users.

____

____

II. DATA

A. Data Acquisition:

1. If any of the following physical data items are being collected simultaneously with the images, enter "**S**" if by the same vehicle collecting the images or enter "**O**" if by other vehicles made on separate passes.

____ Surface roughness (Intern'l Roughness Index (IRI) or other index)

____ Crossfall or cross slope

____ Texture

____ Roll (deflection about longitudinal axis of vehicle)

____ Yaw (heading – rotation about vertical axis of vehicle)

____ Pitch (deflection about transverse axis of vehicle)

____ Grade

____ Cumulative mileage or chainage

____ Transverse profile measurements

____ GPS coordinates (x,y,z)

____ Skid number

____ Other: (describe) ____

2. At what intervals are the data output to files (e.g., 0.001 km; 0.01 mile, etc.)?

______ Surface roughness (Int'l Roughness Index, IRI, or other index)

______ Crossfall or cross slope

______ Texture

______ Roll (deflection about longitudinal axis of vehicle)

______ Yaw (heading – rotation about vertical axis of vehicle)

______ Pitch (deflection about transverse axis of vehicle)

______ Grade

______ Cumulative mileage or chainage

______ Transverse profile measurements

______ GPS coordinates (x,y,z)

______ Skid number

______ Other: (describe) ____

3. Indicate roadway geometry that is extracted from imagery. (check all that apply)

____ Number of lanes

____ Shoulder widths

____ Lane width

____ Vertical under clearance

4. Indicate roadway features or appurtenances that are extracted from imagery. (check all that apply)

____ Intersecting roads

____ State-defined mileposts

____ Rumble strips

____ Signs

____ Crash cushions

____ Bridges and other structures

____ HOV lanes

____ Guardrails

____ Signals

5. Indicate references that are incorporated into data files resulting from imagery or onto the imagery itself.

____ Town lines

____ Linear referencing calibration points

B. Processing:

1. Is any of the following information calculated from captured data? If so, are the calculations performed in house or by using a commercially available computer program? (Check all that apply.)

	In House	**Comm. Avail.**	**Program Name**	**Available**
____ Horizontal curvature	____	____	___________________	Yes___No___
____ Vertical curvature	____	____	___________________	Yes___No___
____ Longitudinal profile	____	____	___________________	Yes___No___
____ Transverse profile	____	____	___________________	Yes___No___
____ Rutting	____	____	___________________	Yes___No___
____ Average texture depths	____	____	___________________	Yes___No___
____ Shim quantities	____	____	___________________	Yes___No___

2. Are any of the above data used to produce the following? (Check all that apply.)

____ Centerline maps of roadway sections

____ Three dimensional views of a roadway

____ Curb to curb plans.

C. Storage:

Indicate the medium on which data are stored (i.e., diskettes, CDs, DVD, hard drives).

	Diskette	Videotape	CD	DVD	Hard Drive	Other
____ Surface roughness	____	____	____	____	____	____
____ Grade	____	____	____	____	____	____
____ Crossfall or cross slope	____	____	____	____	____	____
____ Cum. mileage/chainage	____	____	____	____	____	____
____ Texture	____	____	____	____	____	____
____ Transverse profile measurements	____	____	____	____	____	____
____ GPS coordinates (x,y,z)	____	____	____	____	____	____
____ Vehicle attitude	____	____	____	____	____	____
____ Skid number	____	____	____	____	____	____
____ Horizontal curvature	____	____	____	____	____	____
____ Vertical curvature	____	____	____	____	____	____
____ Longitudinal profile	____	____	____	____	____	____
____ Transverse profile	____	____	____	____	____	____
____ Rutting	____	____	____	____	____	____
____ Average texture depths	____	____	____	____	____	____
____ Shim quantities	____	____	____	____	____	____

D. Distribution:

Do you make any of this information available outside of your department? If yes, please provide the appropriate contact information for any such person/department/agency.

Name of department, agency: ____

Name of contact individual: ____

Location:

City or town: ____

Street address: ____

Telephone: (____) - ________ - ___________

Fax: (____) - ________ - ___________

E-mail: ______________________________

Additional information: ____

____

E. External distribution:

Do you make any of this information publicly available? If yes please indicate the means by which it is available.

Publicly Available		CD	Web	By Contact
Yes ____ No ____	if yes	____	____	____

If this information is made available to the public by requesting the information directly "by contact", please provide the appropriate contact information were request should be sent.

Name of department, agency: ____

Name of contact individual: ____

Location:

City or town: ____

Street address: ____

Telephone: (____) - ________ - ___________

Fax: (____) - ________ - ___________

E-mail: ______________________________

Additional information: ____

____

APPENDIX B

GIS Agency Survey

Video / Photolog and GIS

Many state transportation agencies acquire roadway images and other applicable data items using ground-based imaging and data collection technology traditionally referred to as *photolog* or *videolog*. These data are potentially valuable for use in GIS applications.

This questionnaire has been sent to information system departments across the six New England states. The intent is to gather information about what data you collect and manage and if/how you use video/photologs.

After the surveys have been completed and returned, a summary will be developed about the extent to which GIS is used in conjunction with ground-based imaging technology. Finally, the information gathered will be shared during state visits and in the form of a final report.

SURVEY INFORMATION:

Name of individual completing survey:____

Name of department,

agency:____

Location: City or town:____

Street address:____

Telephone: (____) - ________ - ___________

Fax: (____) - ________ - ___________

E-mail: ______________________________

Additional information:____

____

Please return surveys to:

Jason DeGray
Transportation Center
University of Massachusetts at Amherst
214 Marston Hall
Amherst, MA 01003

For questions, please call: Kathleen Hancock
(413) 545-0228
hancock@ecs.umass.edu

I. **Geographic Information Systems**

What Geographic Information System (GIS) do your agency use? (check all that apply)

___None

___CADD (Computer Aided Drafting/Design) only

___ArcInfo / ArcView

___Integraph

___Caliper

___Other (describe)_________________________

What forms of spatial location referencing systems does your agency use? (check all that apply)

___Latitude and longitude

___State plane coordinates

___Mileposts

___Chainage

___Other (describe)____

What form of data warehousing does your agency use? (check all that apply)

___Centralized warehouse: (data are located in a single location with remote access to users.)

___Distributed warehouse: (data are located in distributed locations with remote access to users.)

___Local: (data are located on local systems with local access only.)

___Other (describe)____

II. Roadway Information

A. Data Provided:

1 Does your agency collect or manage any of the following data and are they spatially referenced (does it explicitly have location attached to it)? (Please check all that apply.)

	Interstates	Other Federal Roads	State Roads	Local Roads	Other
Route number					
Speed limit					
Number of lanes					
Lane width					
Shoulder widths					
Median type					
Median width					
Curbs present					
Sidewalk width					
Vertical under clearance					
Intersecting roads					
Bridges					
Town lines					
Linear referencing calibration points					
State-defined mileposts					
HOV lanes					
Rumble strips					
Guardrails					
Signs					
Signals					
Crash cushions					
Surface roughness (IRI or other index)					
Grade					
Crossfall or cross slope					
Cumulative mileage / chainage					
Road surface type					
Transverse profile measurements					
GPS coordinates (x,y,z)					
Yaw (heading – rotation about vertical axis of vehicle)					
Roll (deflection about longitudinal axis of vehicle)					
Pitch (deflection about transverse axis of vehicle)					
Skid number					
Toll road					
Other (specify)__________________					

3. If applicable, what is the distance interval between data points?

____ Continuous ____ Every .01 miles

____ Other

4. How often are the data updated?

____

6. When was the last time the data were updated?

____

II. Data Source

F. Means

6. By what means is the roadway data acquired, where do you get your data?

____

____

7. If videolog imaging is used for any of the above please describe how.

____

____

____

____

8. Does your agency plan to use videolog imaging in the future in association with GIS activities?

____ Yes

____ No

____ Unknown

III. Data Background

A. Origin

1. If data were gathered by an outside agency please describe by who, and provide the appropriate contact information.

____

____

____

____

____

B. Manipulation

1. What GIS software and hardware was used to digitize the roads?

____

____

C. Distribution

Do you make any of this information available outside of your department? If yes please provide the appropriate contact information for any such person/department/agency.

Name of department, agency: ____

Name of contact individual: ____

Location:

City or town: ____

Street address: ____

____

Telephone: (____) - ________ - ___________

Fax: (____) - ________ - ___________

E-mail: ______________________________

Additional information: ____

____

____

____

____

____

APPENDIX C

Maine Automated Shim Analysis Program User's Guide

*A*UTOMATED *S*HIM *A*NALYSIS *P*ROGRAM for Windows

Version 00.12.06

Customized Software Developed and Written By

Keith A. Fougere, P. E.

Maine's ARAN operation and software supported through:

Maine Department of Transportation
Bureau of Planning, Research & Community Services
Pavement Management Section
16 Statehouse Station
Augusta, Me. 04333

(207) 624 - 3304

*Base translation and raw processing
programs supplied by the Roadware Corporation.*

TABLE OF CONTENTS

INTRODUCTION

The new ASAP has been tested and is believed to provide results similar to the original version, however, as with any new software, you should question the results until you feel comfortable with them. Any bugs found or enhancements desired should be forwarded to the Pavement Management section.

There will be two folders on DOTAUG1\$Com-Cons\ named 'Asap' and 'AsapProjects'. The 'Asap' folder contains the latest version of the asap program. The 'AsapProjects' folder contains the latest version of this manual and all of the shim runs in the state that have been requested and completed. There is also a readme file in the asap folder showing the latest information about the program. The instructions to access DOTAUG1\$Com-Cons\asap are given in the installation section of this manual.

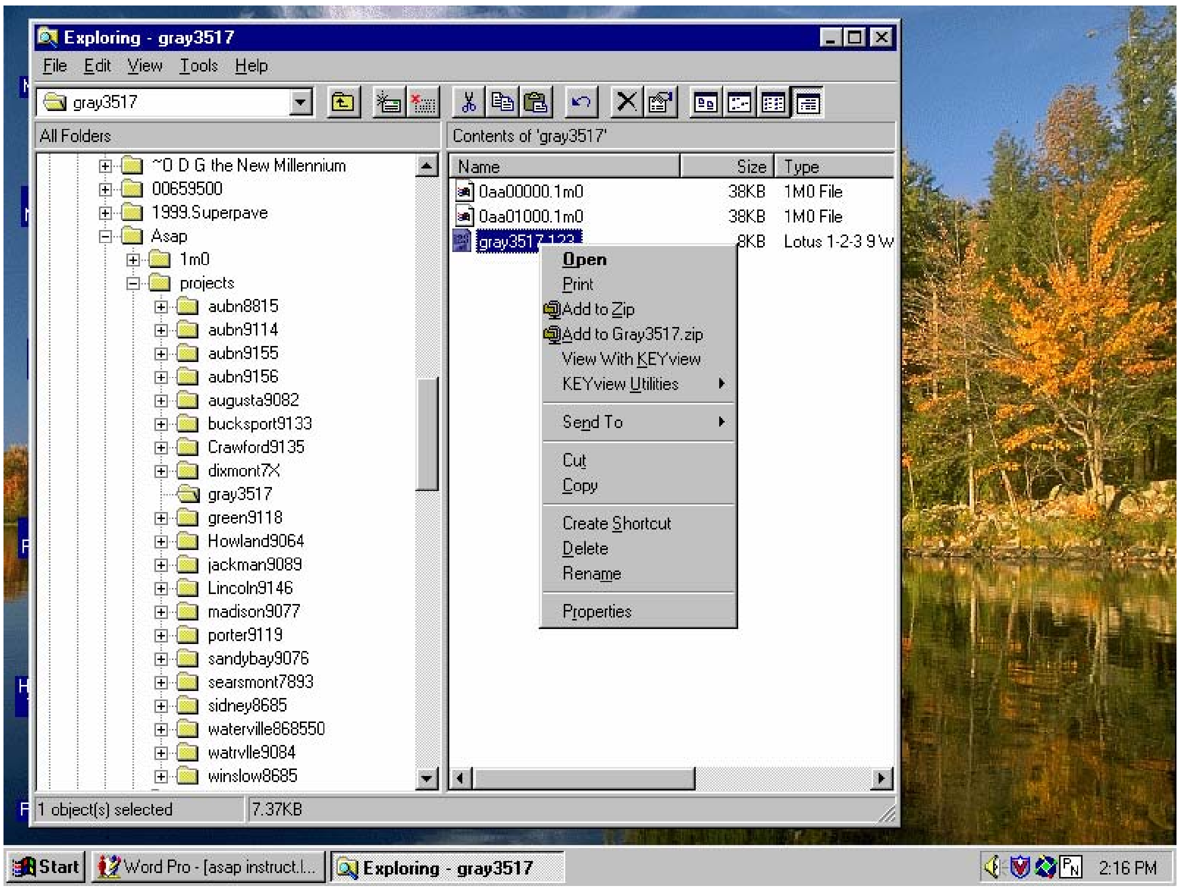
The first section of this manual is the User Guide, assuming the Shim program has already been installed on your computer. If it has not been installed, follow the instructions beginning on page 5 of this manual.

USER GUIDE

Printing the Field Sheets

Before using the Shim program, you will need to print the field sheet to get the file numbers, file direction (upchain or downchain) and rutbar width. From Windows Explorer scroll down to the drive that connects to DOTAUG1\$Com-cons and double click. Then double click ‘asapprojects’. Double click the project you are looking for and then <u>right</u> click on the excel file and select ‘print’.

.



Opening the ASAP program

From the desktop double click the ASAP program icon and select the path to the ARAN shim data files. These files can be accessed from a disk in Drive a: or in the DOTAUG1\ $Com-Cons\'asapprojects' folder. Click on the project needed so that the 1M0 files show in the left window. Click the 'copy 1M0 files' button and then the 'process 1M0' button. The program will not run if these steps are not followed. The .1mo files <u>must</u> be copied using the 'copy 1mo' button. Placing them in the C:\program files\asap\1mo directory without using the command button will not work at present. Once you have copied the 1m0 files, you will be working only on your PC's hard drive. If a project needs to be moved to another computer, files with the '.shm' extension in the C:\program files\asap folder will need to be copied to the same folder on the new computer.

Next click the 'list raw files' button and highlight the file for the upchain run. These files are shown on the field sheet you just printed. Click the 'select upchain ' button and repeat for the downchain. Select the proper width (shown on field sheet) and then process the run.

Once the project has been loaded you will be presented with a cross section of the first station. In the upper left corner, there are drop down menu's, which are hopefully self-explanatory. Be sure to set slopes to existing from the 'Slopes Menu'

Following are a few notes relating to these menus.

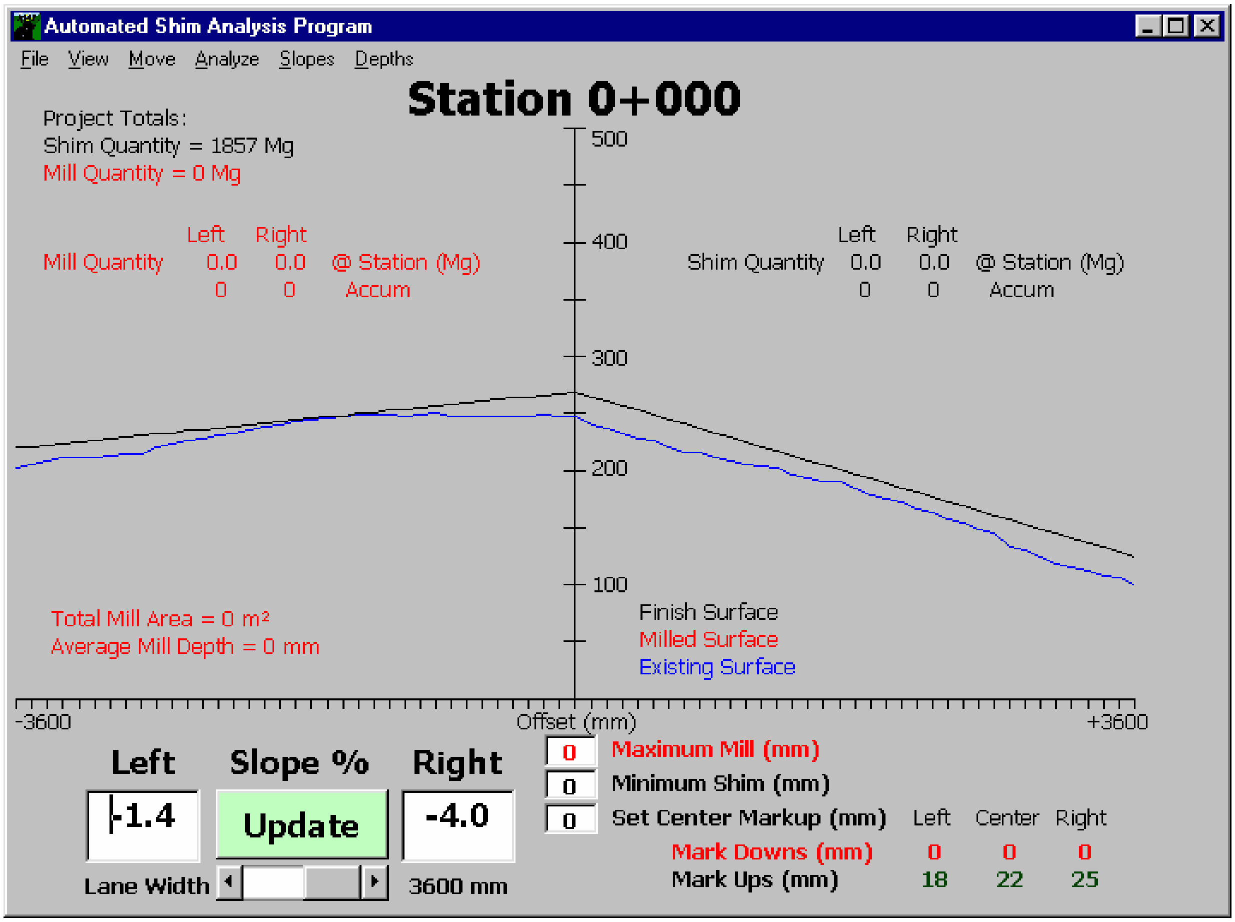
File Menu - Load slopes and depths- If loading a previous job, use this to reload info.
- Save slopes and depths - SAVE OFTEN
View Menu - Zoom in and out - will change the vertical scale
Show and Hide - will toggle info on the cross section off and on.
Move Menu - Shows the F keys that can be used to move from station to station.

Slopes - 'Set slopes on a range of stations' will allow the same slopes to be applied to a group of stations. Be sure to enter a slope in each box or it will kick you out of the program

Reloading a project

If the project has already been processed and is the last one accessed, you can click the 'Plot Current Job' button to return to the job you are working on. If the job has been processed but is not the last one you worked on, then click on the 'List Raw Files' button and load the correct upchain and downchain files.

Once the first station is shown you will have to 'Load slopes and depths' from the File menu to get previously <u>*saved*</u> information to load.



Entering Desired Slopes and Depths

Before entering any info, go to the 'Slopes' menu and select 'Set all slopes to existing'. This will ensure the job is beginning with the proper transverse profile.

Double click in the white text boxes to enter the information required for that station. After entering click on the 'Update' button to view the changes. The white text boxes and update button change design parameters for the current cross section only. (Except for the lane width, which is reset for the entire project). The menu items change design parameters for the entire project.

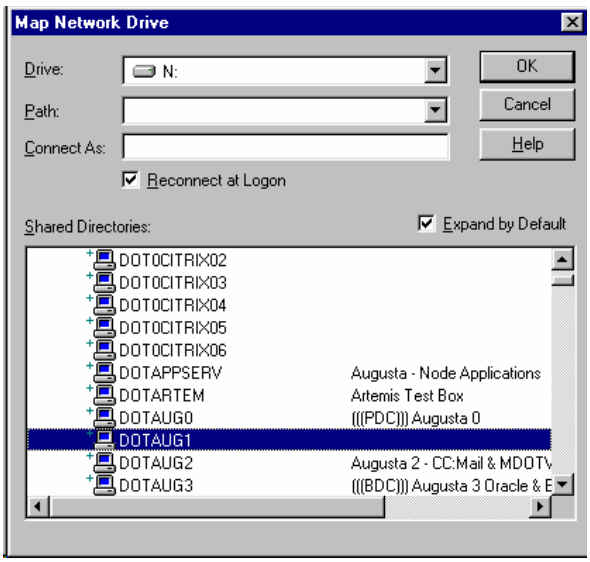
If you should need to analyze a narrower section of roadway, you can change the lane width in the box below the Update button. This will affect the entire project and allowances should be made for missing quantities if necessary.

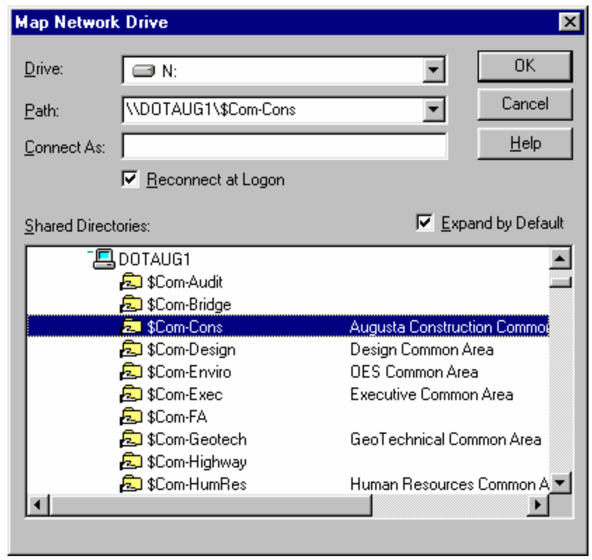
REMEMBER TO 'SAVE SLOPES AND DEPTHS' OFTEN

INSTALLATION INSTRUCTIONS

Mapping a drive from 'Windows Explorer' to DOTAUG1/$Com-cons.

From Windows explorer click on the 'Tools Menu' and then click on 'Map Network Drive'. Use the drive letter automatically selected or choose a letter not in use from the drop down box by clicking on the down arrow and clicking on the desired letter. Check off the box that says 'Reconnect at Logon'. Next look at the list of 'shared directories' and double click on 'DOTAUG1', then double click on the '$Com-Cons folder. You have now mapped a drive that can be accessed from Windows Explorer by scrolling down to the $Com-Cons drive. This is where the 'ASAP' and 'ASAPprojects' files will be kept.



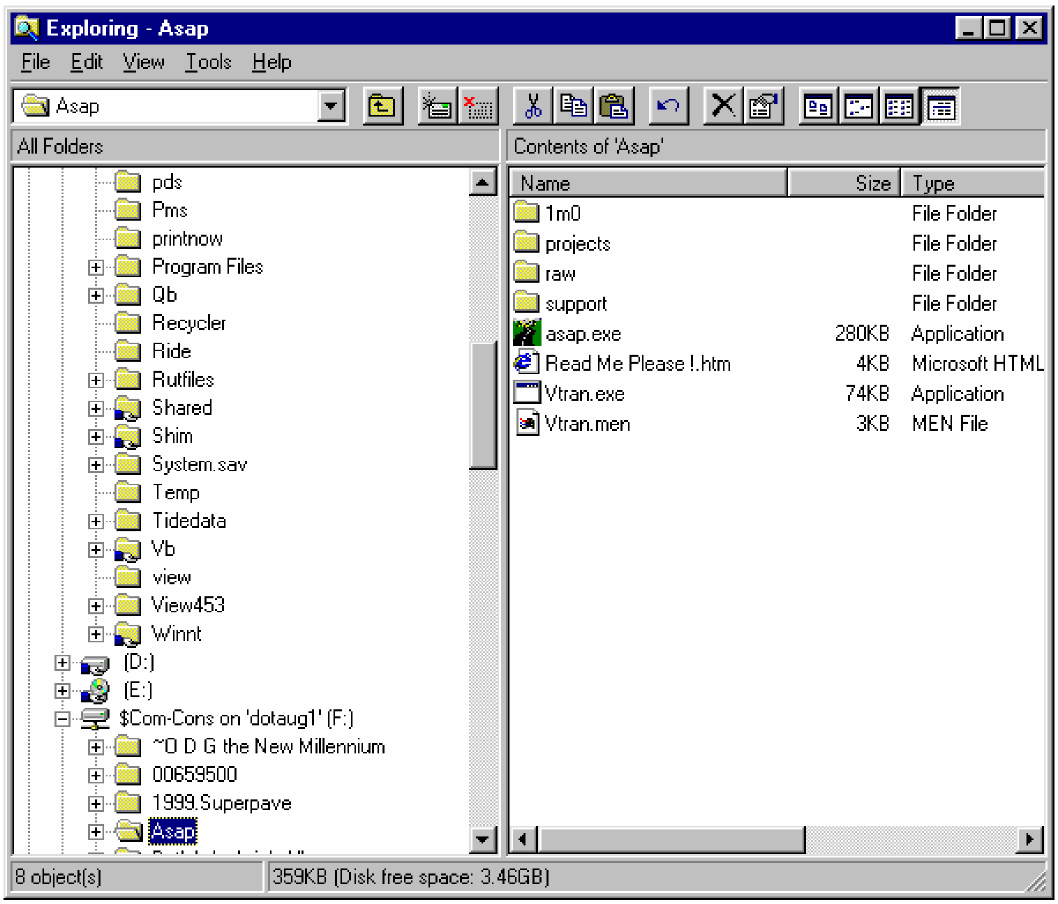


Copying the ASAP program to the 'C:\Program files' folder

Open Windows Explorer and scroll down to the left section of the window to the $Com-Cons folder and double click. Next find the ASAP folder and right click and then left click on 'copy'. Now scroll up to the 'Program Files' folder and right click and then left click on 'paste'. You should now have the ASAP folder under the 'program files' folder. To check, double click on the 'program files' folder. If the ASAP folder is not listed, repeat the previous steps. The ASAP program has to be in the 'program files' folder in order to run properly.

Open c:\program files\asap and click and drag the asap.exe file onto the desktop
To run the shim program just double click the ASAP icon on the desktop.

If you experience problems starting or running the program, check the readme file in the asap folder, you may need to copy files from C:\program files\asap\support to the C:\winnt\system32 folder.



Updating the Program

To update to the latest version, copy DOTAUG1\$Com-cons\asap\asap.exe to C:\program files\asap. NOTE that there is an asap *folder* and an asap *file*. Do not copy the whole folder as you may lose any saved work from the 1mo and raw files. You should get a message asking you to replace the existing file. Click yes. The latest User Manual is located in the 'asapprojects' folder.

NOTES

1. We have found that some existing slopes are not coming in correctly. Please go to the slopes menu and select the 'set slopes to existing on all stations before beginning your project.

2. REMEMBER TO 'SAVE SLOPES AND DEPTHS' OFTEN.

3. Check to see if you have the latest versions of the asap program and the user manual.

4. Questions can be directed to Bob Watson (624-3304) or Don Young (624-3294)

5. If you experience problems starting the program, make sure the desktop Icon shortcut is pointing to C:\program files\asap. You can check this by right clicking on the icon and select 'properties' and the shortcut tab. The target window should read
"C:\Program Files\Asap\asap.exe" and the 'Start in' window should read
"C:\program files\asap"

Sample Output

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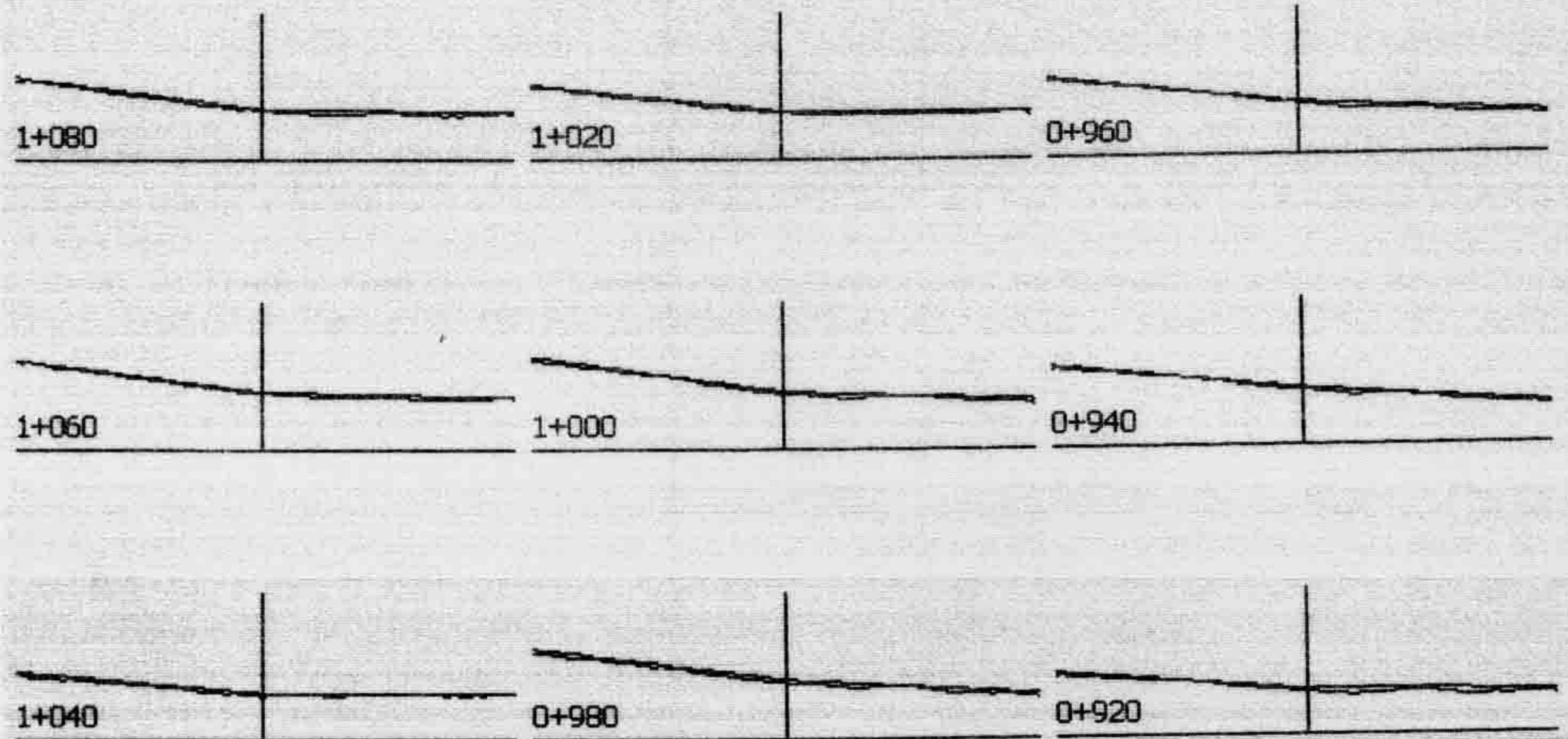
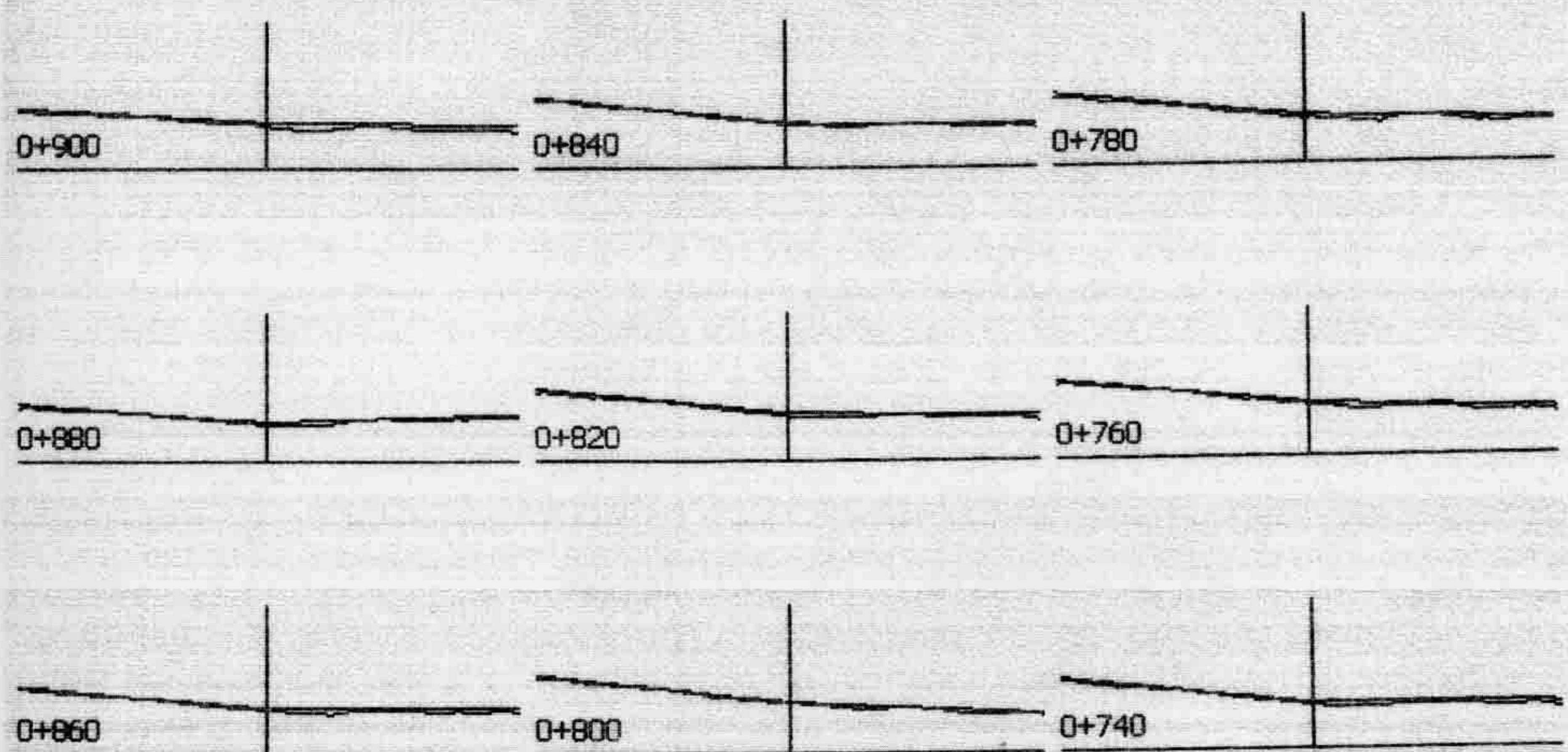


Station	1+080	1+060	1+040	1+020	1+000	0+980	0+960	0+940	0+920
Slopes	3.0 -0.3	3.1 -0.6	2.0 0.0	2.5 0.0	3.3 -0.8	3.0 -1.3	2.5 -1.0	2.3 -1.5	1.8 -0.1
Mark Ups	13 3 14	3 2 17	1 10 8	9 5 25	9 10 19	14 10 16	6 7 13	10 7 12	11 10 15
Shim@Sta	0.9 1.5	1.1 1.2	1.1 1.2	1.0 1.4	1.4 1.4	1.2 1.7	0.8 1.6	0.9 1.8	1.0 2.6
Accum	45 104	44 102	43 101	42 100	41 98	39 97	38 95	37 94	36 92

0000 BRUNSW ICK 91



Station	0+900	0+880	0+860	0+840	0+820	0+800	0+780	0+760	0+740
Slopes	1.3 -0.3	1.8 0.8	2.0 -0.1	2.5 -0.2	2.3 -0.2	2.6 -1.1	2.3 -0.4	2.3 -0.6	2.6 0.0
Mark Ups	12 14 27	10 8 20	5 6 21	8 5 13	15 11 20	10 3 5	13 10 11	14 11 17	6 9 21
Shim@Sta	0.9 2.3	0.7 1.6	0.7 1.3	0.9 1.3	0.9 1.4	1.1 1.5	1.2 2.0	1.0 1.7	1.1 2.1
Accum	35 89	34 87	34 85	33 84	32 83	31 81	30 80	29 78	28 76

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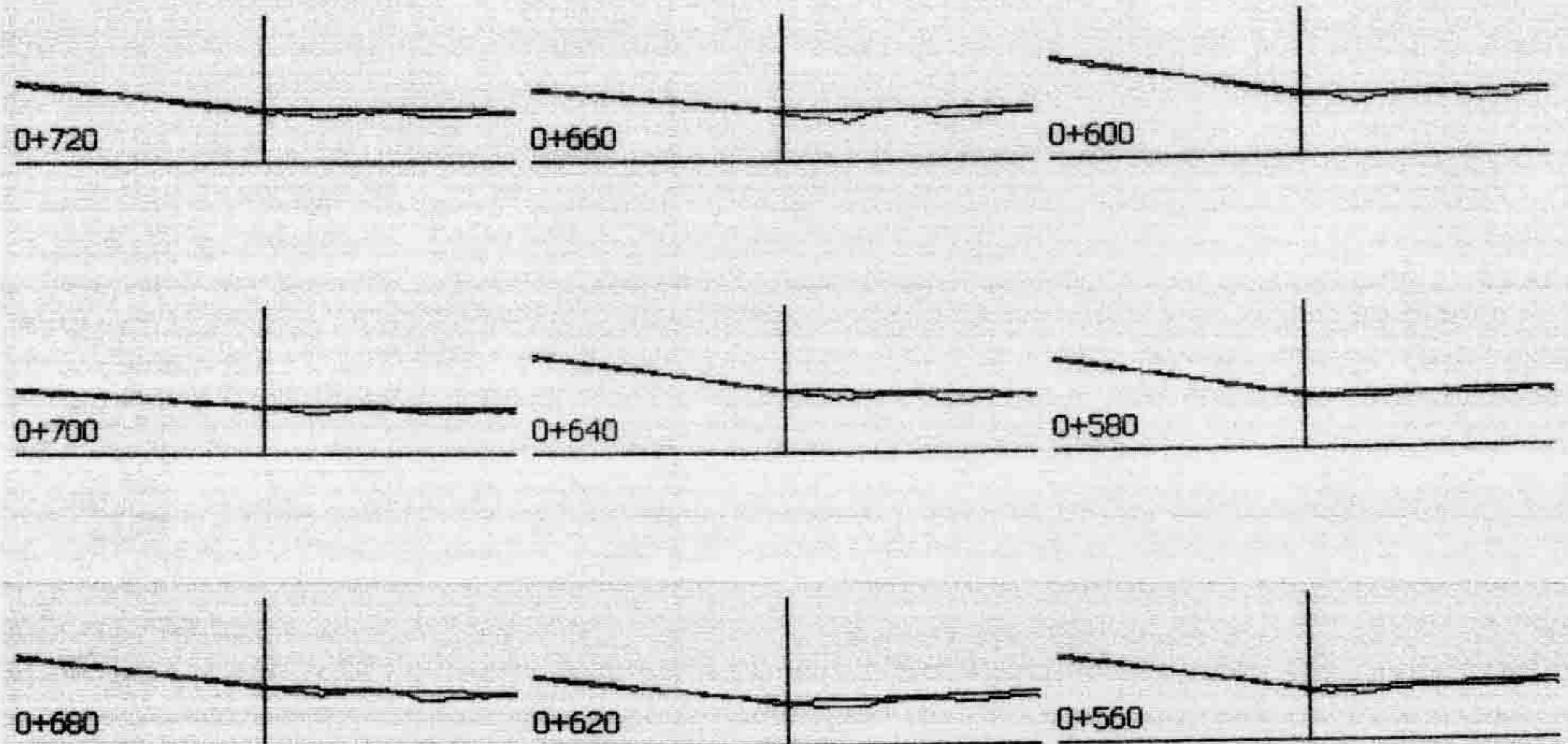

Station	0+720	0+700	0+680	0+660	0+640	0+620	0+600	0+580	0+560
Slopes	2.7 -0.1	1.6 -0.3	2.8 -0.8	2.2 0.3	3.4 -0.4	2.5 0.9	3.7 0.1	3.7 0.5	3.5 0.8
Mark Ups	10 10 21	8 9 15	13 12 13	8 10 20	9 10 10	5 13 21	13 13 13	7 7 18	8 10 26
Shim@Sta	0.9 2.5	0.7 2.5	0.7 3.1	0.5 3.1	0.7 2.7	1.0 2.9	0.9 2.4	0.6 2.2	0.5 2.5
Accum	27 74	26 72	25 69	25 66	24 63	24 60	23 57	22 55	21 53

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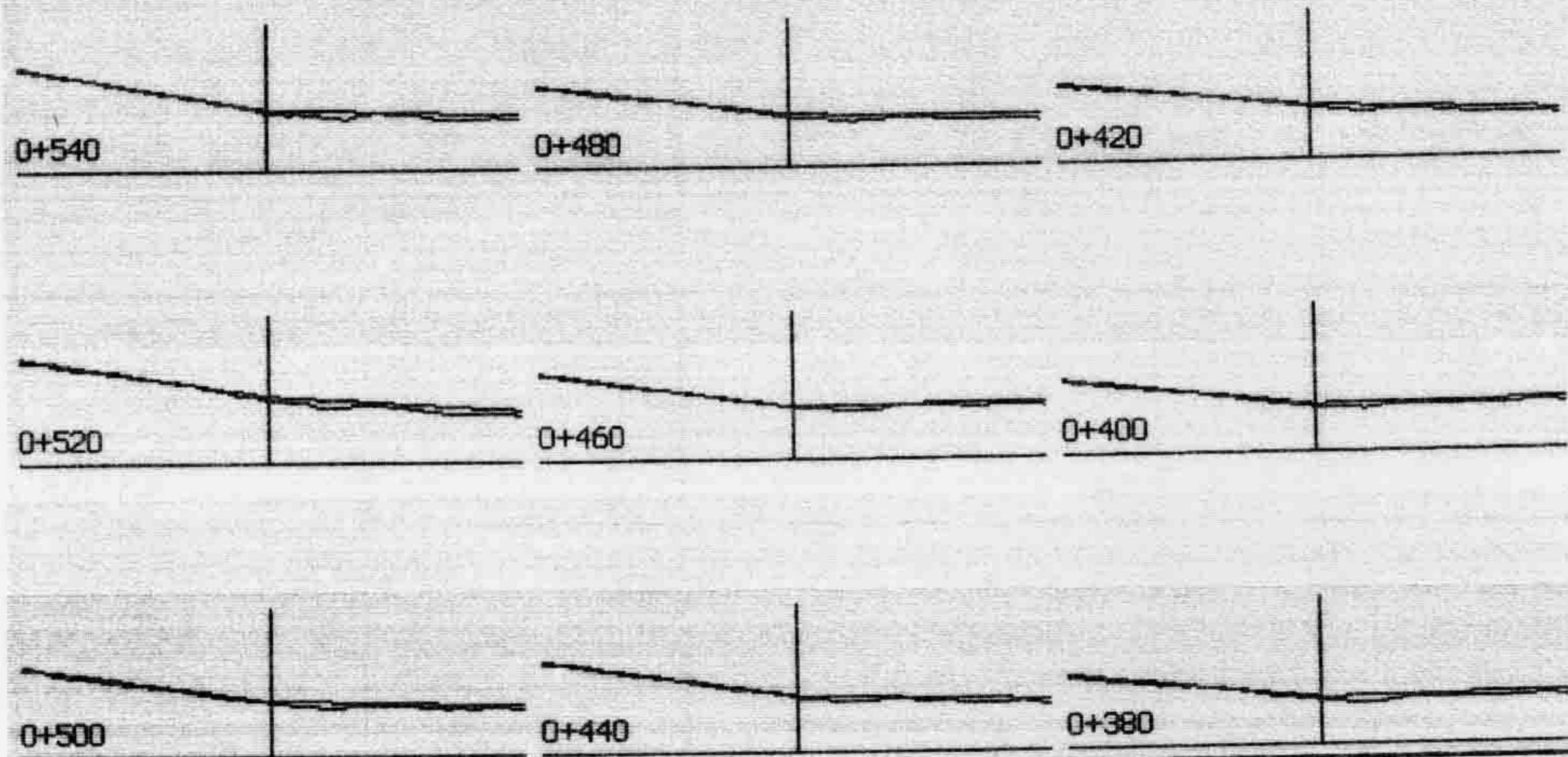

Station	0+540	0+520	0+500	0+480	0+460	0+440	0+420	0+400	0+380
Slopes	4.1 -0.6	3.7 -1.5	3.2 -0.5	2.9 -0.3	3.2 0.3	3.4 -0.5	2.3 -0.7	2.6 0.3	2.5 0.4
Mark Ups	8 8 18	16 13 19	11 6 19	9 11 21	2 7 17	9 10 21	8 12 22	8 9 18	8 11 24
Shim@Sta	0.6 2.6	0.9 2.4	0.9 2.4	0.8 2.1	0.6 1.7	0.7 2.2	0.8 2.1	1.0 2.1	0.8 2.1
Accum	21 50	20 48	19 45	18 43	17 41	17 39	16 37	15 35	14 33

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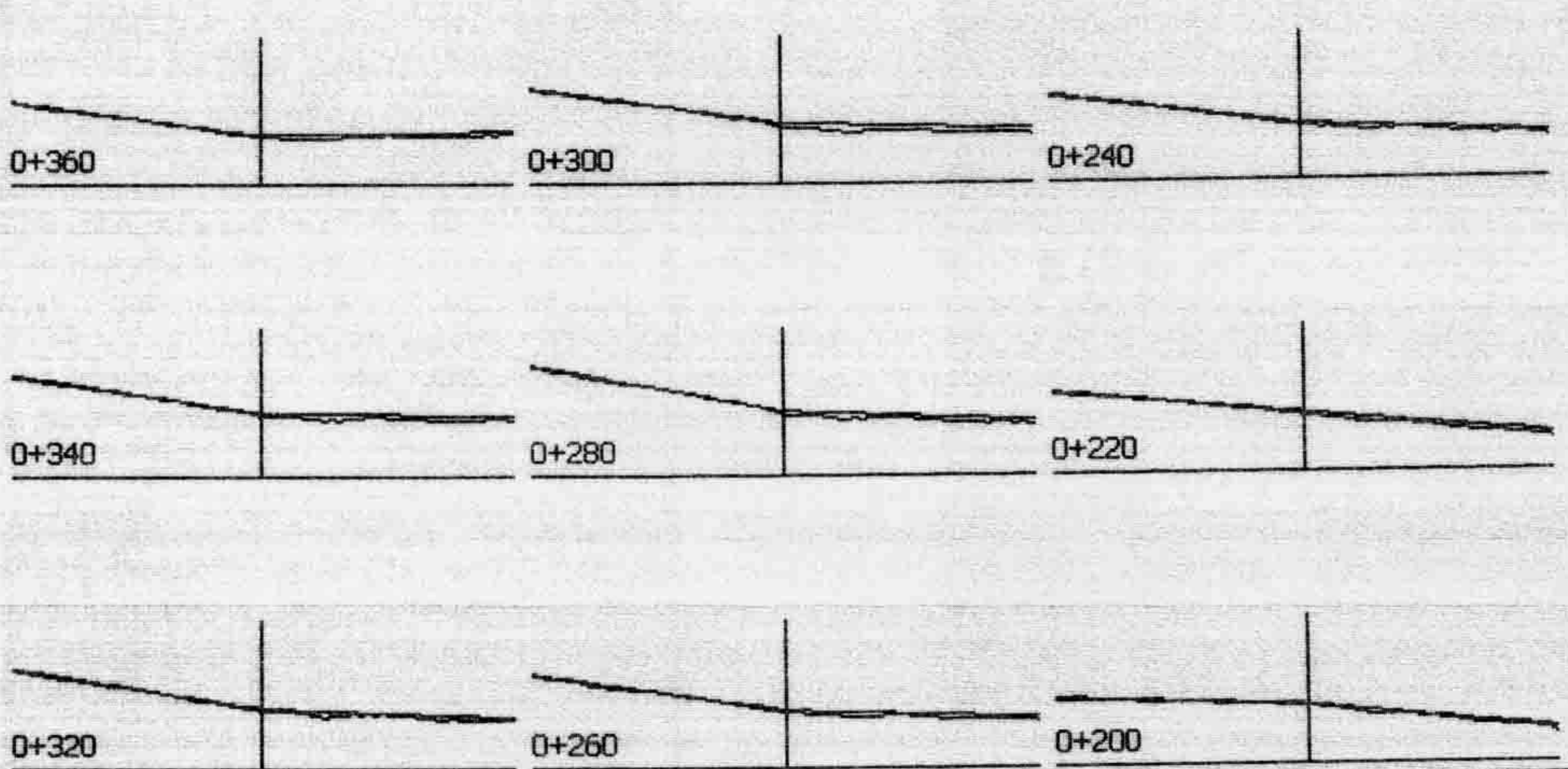
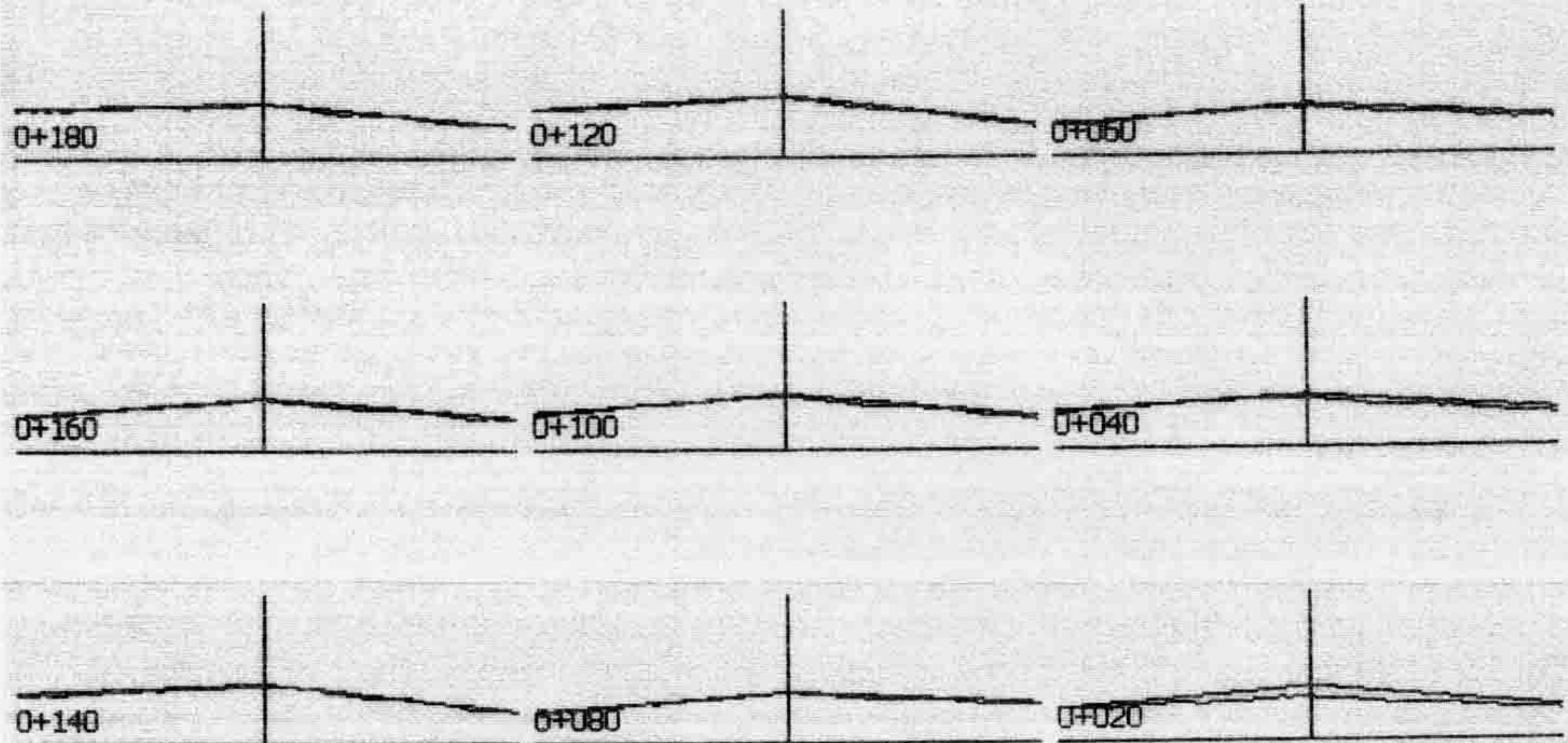


Station	0+360	0+340	0+320	0+300	0+280	0+260	0+240	0+220	0+200
Slopes	3.2 0.3	3.6 -0.4	3.7 -1.0	3.4 -0.6	4.4 -0.9	3.4 -0.7	3.0 -0.9	2.2 -2.1	0.8 -2.4
Mark Ups	7 8 16	7 13 13	7 8 19	8 16 20	6 12 17	7 11 17	9 7 19	7 12 14	4 7 14
Shim@Sta	0.7 2.1	0.7 2.1	0.7 2.5	0.7 2.7	0.7 2.1	0.7 1.7	0.8 1.9	0.6 1.7	0.6 1.1
Accum	13 31	13 29	12 26	11 24	11 21	10 19	9 17	8 15	8 14

0000 BRUNSW ICK 91



Station	0+180	0+160	0+140	0+120	0+100	0+080	0+060	0+040	0+020
Slopes	-0.5 -2.3	-1.8 -2.0	-0.9 -2.8	-1.3 -2.8	-1.8 -2.1	-1.9 -1.1	-1.7 -1.2	-1.4 -1.5	-2.0 -2.0
Mark Ups	3 3 7	2 3 7	8 10 7	2 5 11	2 7 13	0 5 5	7 10 10	6 12 20	0 38 10
Shim@Sta	0.6 1.0	1.0 0.9	1.1 0.8	0.7 1.3	0.5 1.4	0.5 1.6	0.7 2.3	2.0 3.4	0.0 0.0
Accum	7 13	7 12	6 11	4 10	4 9	3 7	3 6	2 3	

APPENDIX D

New Hampshire Manual of Instructions For Road Inventory

MANUAL OF INSTRUCTIONS FOR ROAD INVENTORY

This manual intends to instruct members of inventory parties regarding the general duties and field measurements pertaining to collecting roadway feature data. It will not answer all questions that may arise from performing the work, but it will enable employees to engage in this task with a clear understanding of their principal duties. If additional information, instruction, or guidance is needed, the employee should ask his immediate supervisor.

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Part I
Measurements & Inventory of Roadways

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Section II
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Section III
Inventory of Roads

Part II
Roadway Dictionary

Section I

Section II
Roadway Inventory codes

PART I

Measurements & Inventory of Roadways

SECTION I

Measurements of Roadway Features

1- TRAFFIC LANE:

A traffic lane is a portion of roadway used to channel traffic. Traffic lanes are separated from other portions of a highway by striping. Local roads, however, are rarely striped.

Number of lanes :

The number of lanes is equal to the number of through lanes in both directions. It does not include auxiliary lanes.

Lane width :

Take the measurement where the width is constant. Lane widths of 9 to 12 feet are common. The 12 ft. lane width is most desirable, and it is generally used on high speed, free flowing highways. In urban areas, the use of 11 foot lanes is acceptable. An 11 foot lane width is also used for continuous two-way left-turn lanes, and lanes adjacent to painted medians. Lanes 10 feet wide are used on low speed roads. Lanes 9 feet wide are used on low volume roads in rural and residential areas. Lane widths less then 6 feet or greater then 18 feet are not allowed.

Two lane highways: Measure, to the nearest foot, the distance between the centerline (the middle of centerline striping) and the shoulder stripe. There are situations where the traffic lane and the shoulder have the same surface type or appearance with no delineation to distinguish the lane from the shoulder. In such cases, use a reasonable width based on the actual width used by traffic. For example, consider a 32-foot wide paved surface with centerline striping only. This could be reported as two 12-foot lanes with 4-foot shoulders.

In some situations striping is placed inside the edge of the pavement to keep traffic, particularly trucks, from breaking the pavement edge. Ignore this striping, especially on the outside lanes of multilane facilities, and code the actual lane width. For example, a two-lane roadway containing a solid stripe 1 foot inside the edge of the shoulder break with 11 ft. widths from centerline to edge-striping should be coded as two 12 ft. lanes.

Multilane undivided highways: Generally, all traffic lanes on a multilane highway are of equal width. In urban areas unequal width lanes are often used. Currently, the roadway inventory database does not allow unequal lane widths. Data collectors must measure the entire width of the traveled way and divide by the number of lanes to find the average width.

Multilane divided highways:
Measure and average, as explained above, to obtain lane widths for each direction.

Auxiliary lanes :
Passing lanes, truck lanes, exclusive left turn lanes, and exclusive right turn lanes are inventoried if they are 1000 ft. or longer (measured from the beginning of the taper to the end of the taper).

Continuous two-way left-turn lane: A continuous turning lane is not a median (See Fig. I.1.1). It may contain painted bays for directing traffic turns. Inventory continuous turning lanes if they are 1000 ft. or longer. Measure from where the taper begins to where the taper ends.

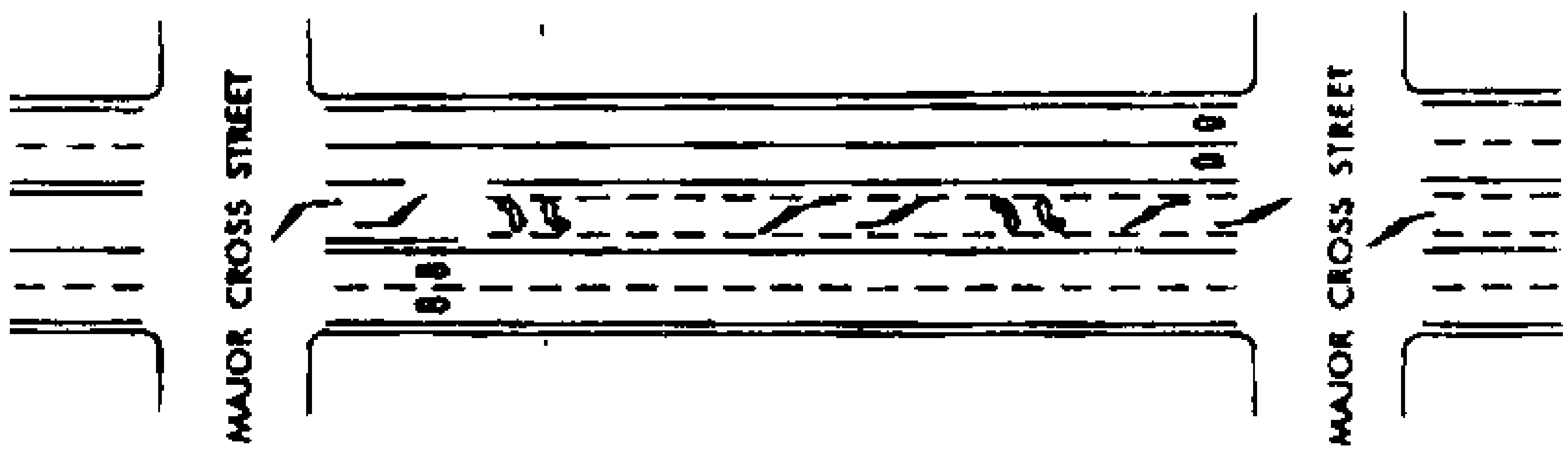


Figure I.1.1 Continuous two-way left-turn lane

Turning lanes: Inventory single turning lanes if they are 1000 ft. or longer. If an intersection includes more than one turning lane, the combined lengths of the turning lanes should meet the above criteria. Fig. I.1.2a and Fig. I.1.2b illustrate situations where the combined lengths of the turning lanes are 1000 ft.

FIGURE I.1.2a - Exclusive Right Turn Lane

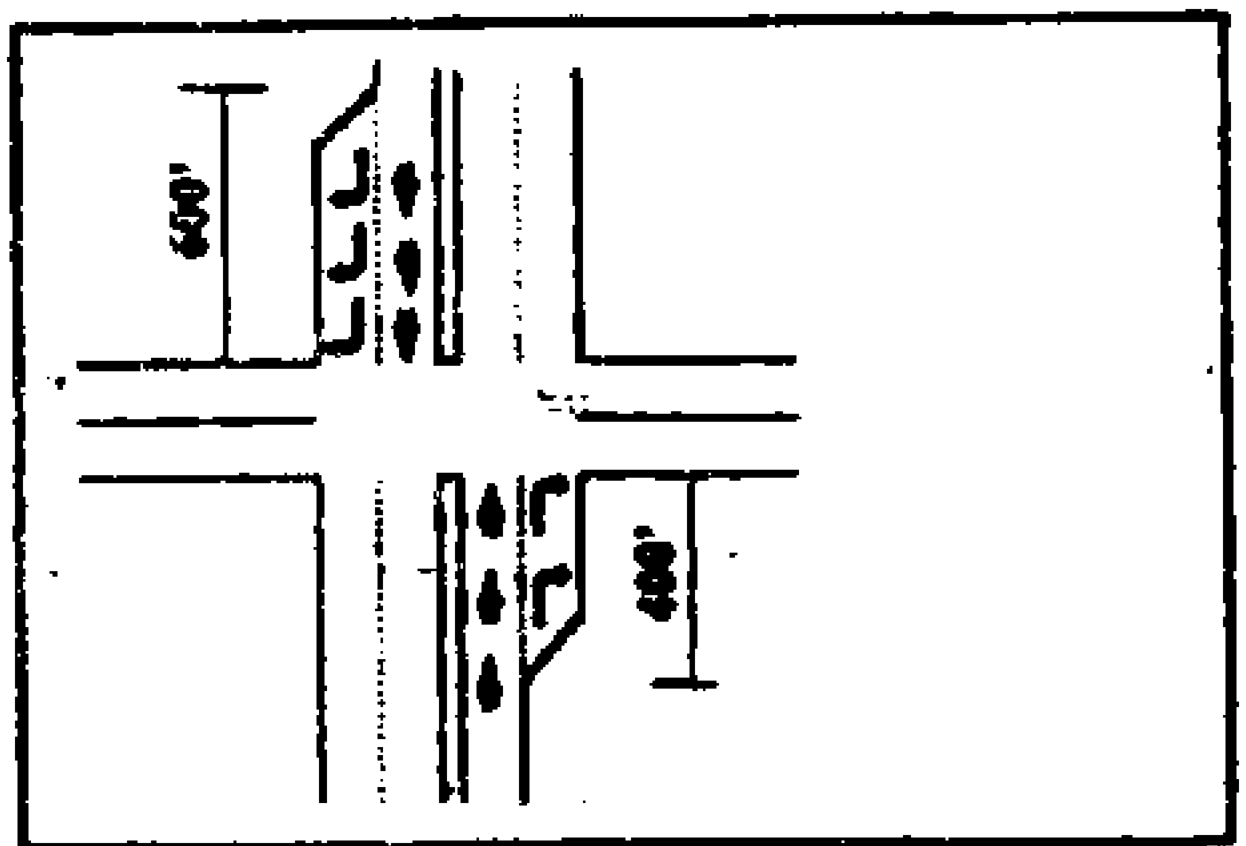


Figure I.1.2a - Exclusive Right Turn Lane

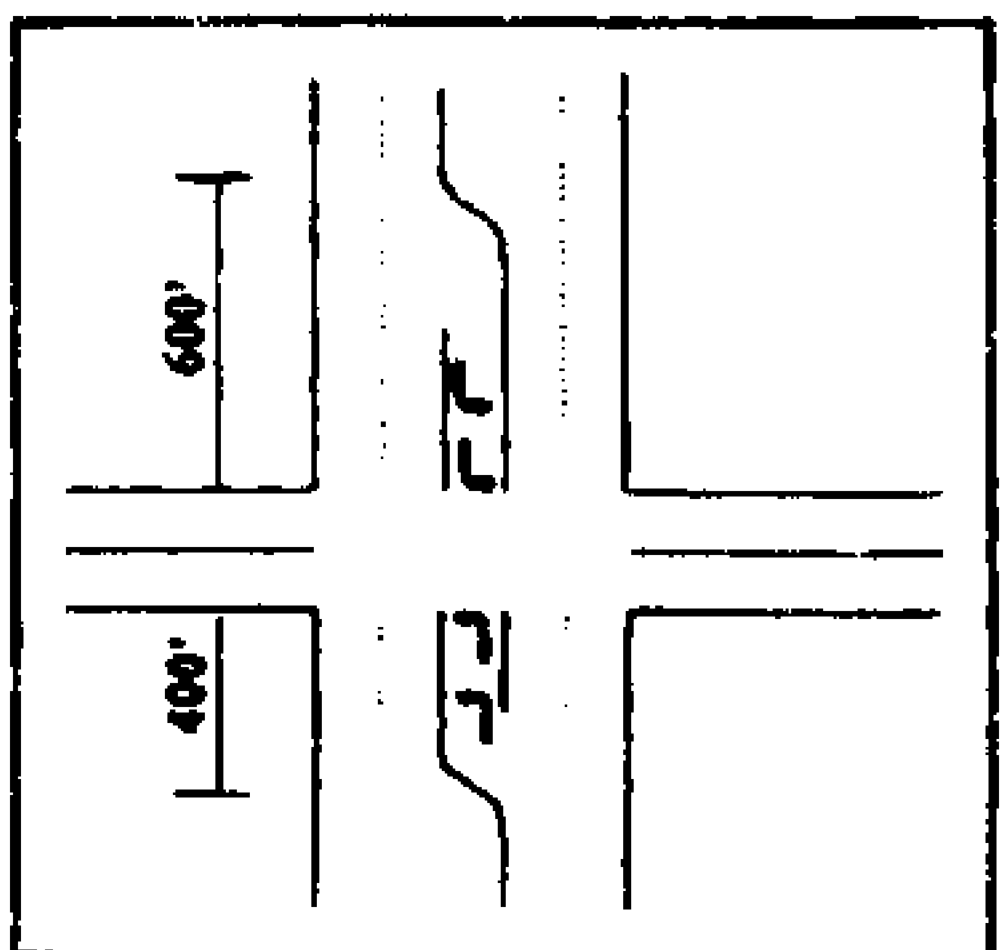


Figure I.1.2b - Left Turn Bays

FIGURE I.1.2b - Left Turn Lane Bays

Surface type :

Surface type can not be exactly determined without looking at the construction plans. The following classification is helpful and should be used for field verification.

20 - Unimproved: A natural surface maintained to permit motor vehicles, but not conforming to the requirements for a graded and drained road . (Unpaved)

40 - Gravel: Soil, Gravel, or Stone -- A road surface consisting of mixed soil, stabilized soil, gravel, or stone. (Unpaved)

51 - Bituminous Surface Treated: An earth road, a soil-surfaced road, a gravel road, or a stone road to which a bituminous surface course has been added by any process (with or without a seal coat).

61 - High Flexible: A mixed bituminous or bituminous penetration road over a flexible base.

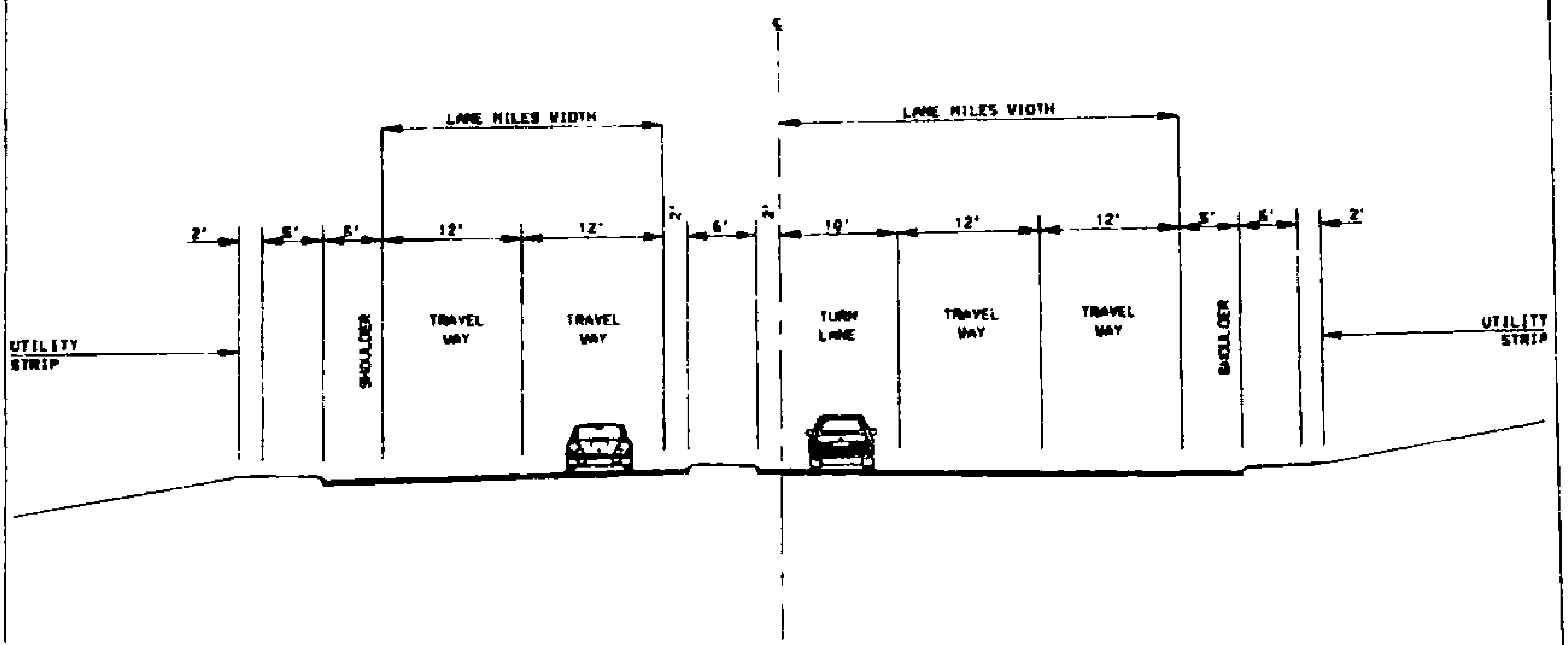
62 - Composite; Flexible over Rigid: Includes any bituminous concrete, sheet asphalt, or rock asphalt, greater then 1" thick, over a rigid pavement.

72 - High Rigid, Reinforced Jointed: Reinforced (with mesh or equivalent) Portland cement concrete pavement that has been jointed.

80 - Brick, Block or Other Combination -- A road consisting of paving brick; stone, asphalt, wood and other block, steel, or wood, with or without a bituminous wearing surface of less than 1 inch.

2-LANE MILE WIDTH: Pavement Width

Lane mile width is measured from edge line (where shoulder begins) to edge line and includes traveled ways, auxiliary lanes, and painted medians, if longer than 1000 feet. It does not include other types of medians, bicycle lanes, parking lanes, or shoulders. See Figure 1.2.1.



LANE MILES WIDTH
LANE MILES WIDTH
2'
5'
5'
12'
12'
2'
6'
2'
10'
12'
12'
5'
5'
2'
UTILITY STRIP
SHOULDER
TRAVEL WAY
TRAVEL WAY
TURN LANE
TRAVEL WAY
TRAVEL WAY
SHOULDER
UTILITY STRIP

FIGURE 1.2.1

3- SHOULDER :

Shoulder is defined as the portion of the roadway that is contiguous with the traveled way use for accommodating of stopped vehicles, for emergency use, and for lateral support of the sub-base, the base, and the surface course.* (See Fig.I.3.1)

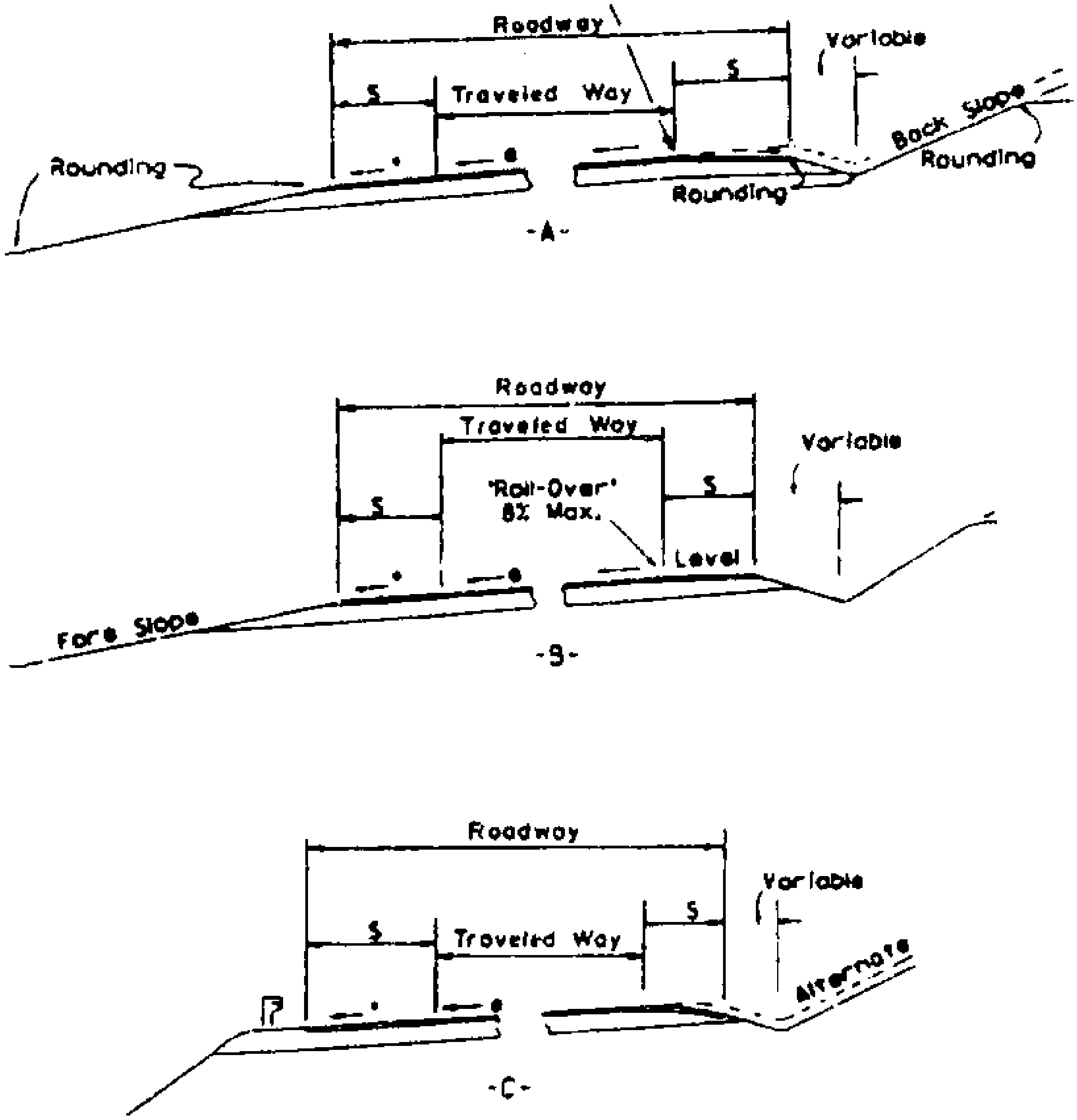


Fig.I.3.1 S = Useable Shoulder

Shoulder width :

Data collectors must be able to distinguish between shoulders, parking lanes, and bike lanes. Any paved or unpaved areas between the traveled way and the edge of pavement or curbing is considered to be a shoulder unless the following cases exist:

- A parking lane exits with **appropriate striping or signing**. Traffic signs that allow parking along a roadway for limited hours do not constituted a park lane.
- A bike lane exists with **appropriate signing**.

A shoulder cannot exist between a traffic lane and a parking lane contained in the roadway Do not include parking or bicycle lanes as part of the shoulder width when parking and, or, bicycle lanes exist on both sides of the roadway. There is no shoulder under these circumstances (See Fig. I.3.2a & 2b). Figure I.3.2c contains an example where the bike lane is outside of the roadway. A shoulder width of 8 feet is reported under this circumstances.

Measure from the edge of the traveled way to the edge of pavement. If the shoulder is not paved, measure from the edge of the traveled way to the intersection of the shoulder and natural ground. (See Fig I.3.1) If both a shoulder and curbing exists, ignore the curbing and report the shoulder. If the distance between the travel way or edge striping is narrow. (1 to 2 feet), then ignore the shoulder and report the curbing.

On divided highways, left shoulder width should also be included in the median width.

Shoulder Type :

Shoulder type should be specified as one of the following:

1- None -- No shoulders or curbs exist.
2- Surfaced with bituminous material -- A bituminous course over a granular or stabilized base.
5- Stabilized -- A gravel or other granular material, with or without admixture, capable of supporting most loads even under wet conditions.
6- Combination -- A part of the shoulder width is surfaced and/or a part is stabilized, and/or a part is turf, etc.
7- Earth -- Natural earth with or without turf.
8- Curbed -- No shoulders exist, or shoulder is very narrow, then the section is curbed.

If the shoulder type changes back and forth between types along the length of the road for short distances, select the predominant type.

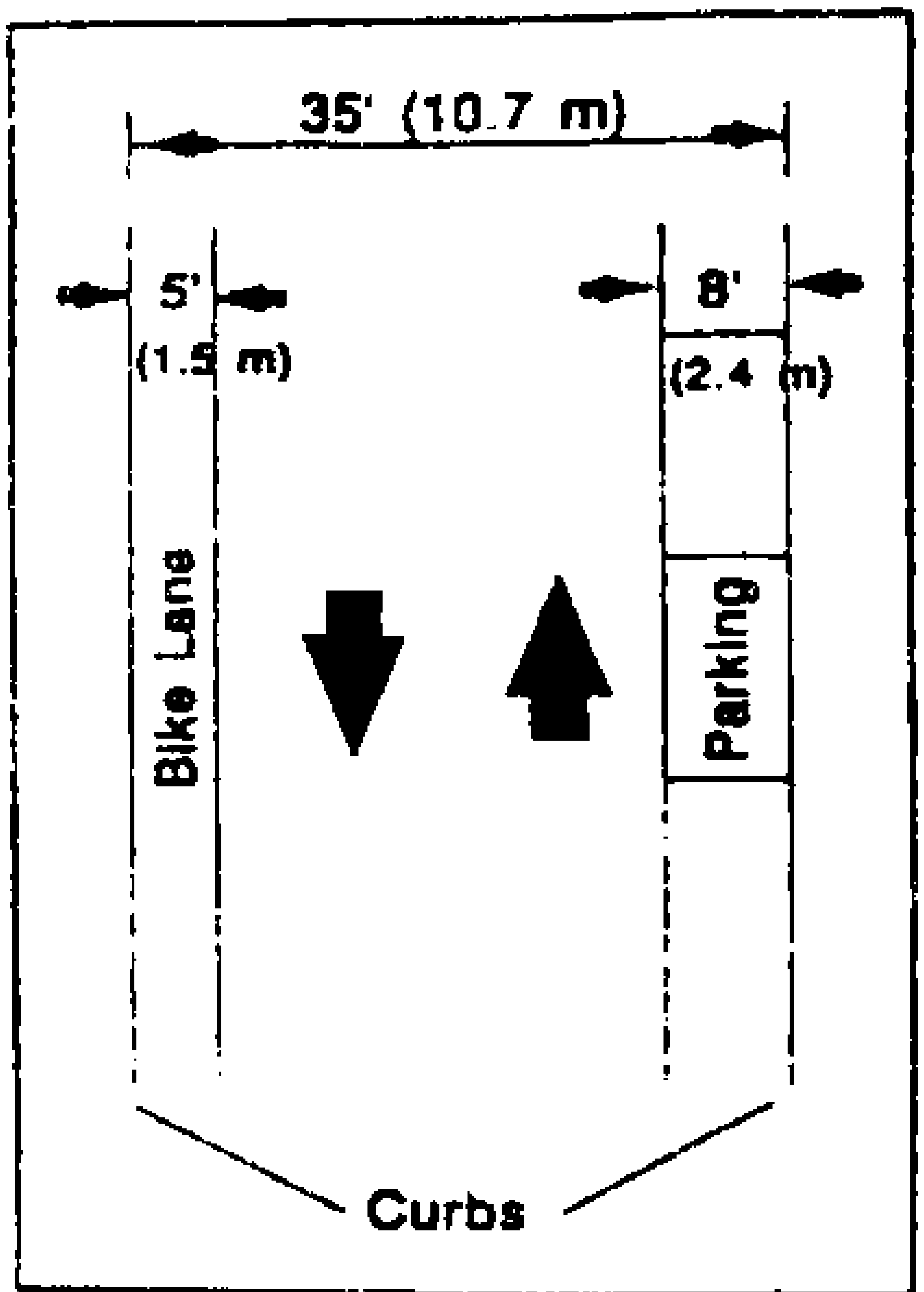


Figure 1.3.1a - Bike lane in roadway

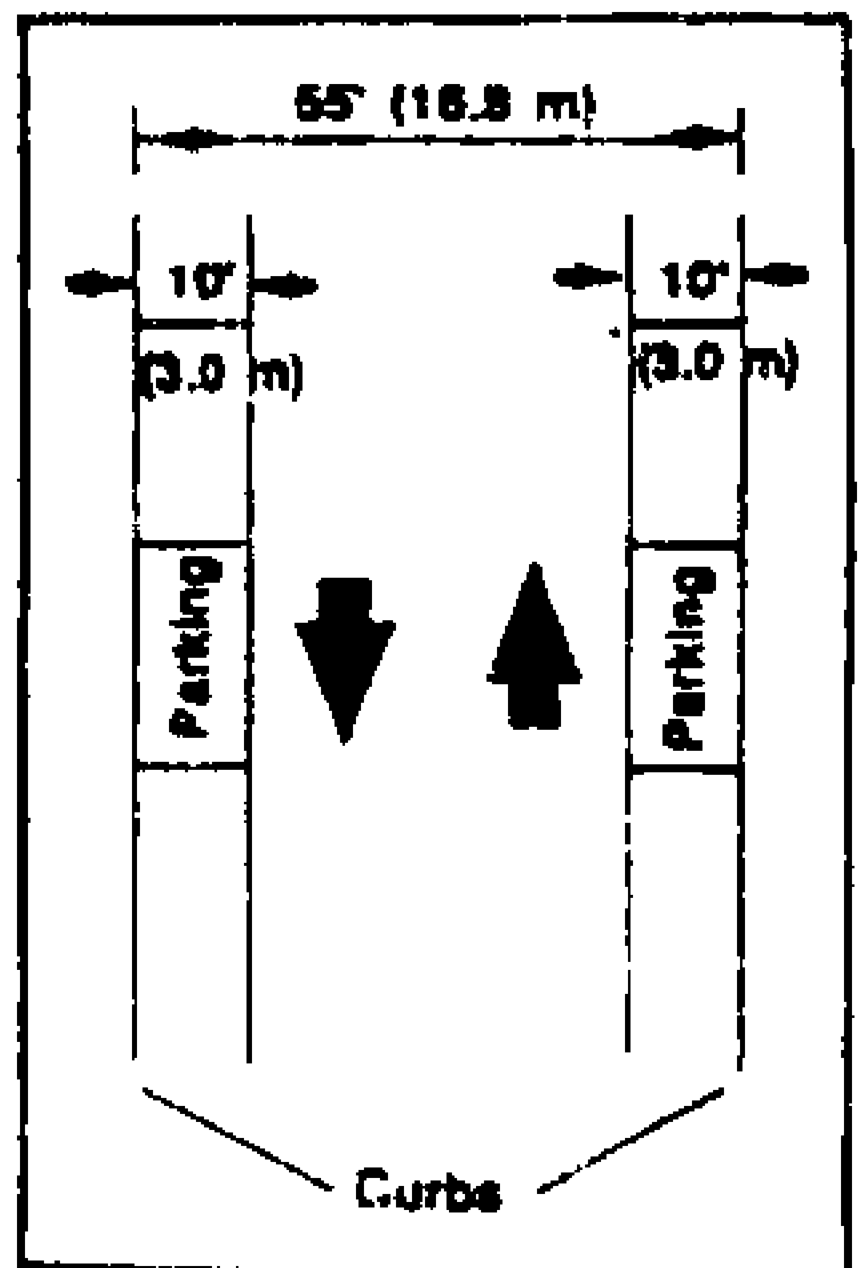


Figure 1.3.1b - Both side parking

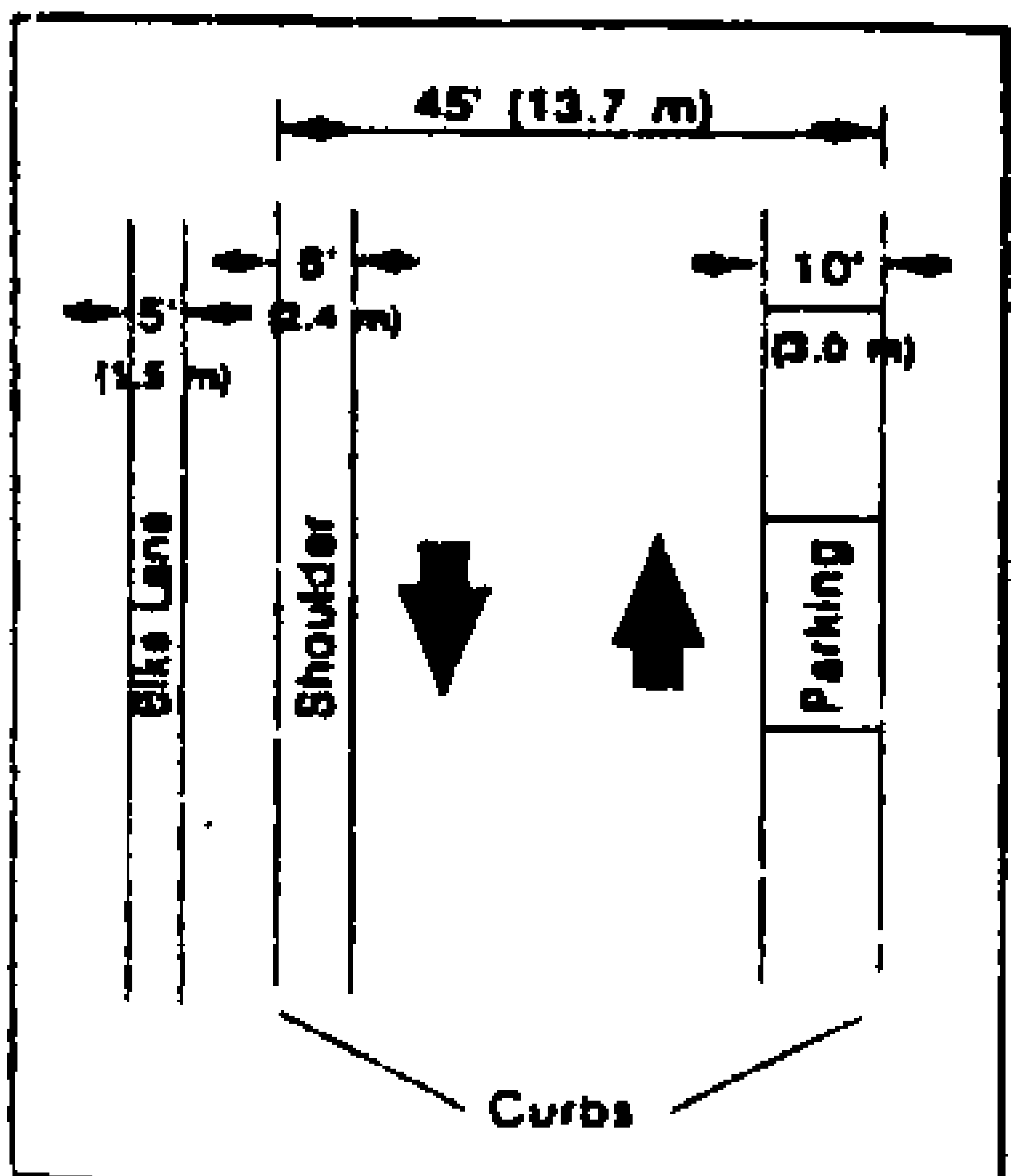


Figure 1.3.1c - Bike lane <u>not</u> in roadway

4-.MEDIAN:

According to AASHTO, a median separates opposing traffic, provides a recovery area for out of control traffic, provides a stopping area, allows space for speed changes, provides for left-turning and U-turning vehicles, minimizes headlight glare, and provides width for future lanes.

All medians (a single median or a chain of medians) longer than 1000 feet must be measured and inventoried. The following guide line will help data collectors to distinguish between the turning lanes and medians

1- A continuous turning lane is not a median (See Fig. I.1.1).
2- Continuous crosshatching (painted pavement) that is at least 4 feet wide may be considered a median.
3- According to the HPMS manual "turning lanes or bays are not considered medians unless a median exists on the major portion of roadway, and the turning lanes/bays are cut into the median at the intersections, entrances to commercial enterprises etc " (Fig.I.4.1). For financial purposes, the roadway inventory approach is different The turning lanes or bays should be inventoried as a separate features and not included as part of medians, even if the median exists on the major portion of roadway

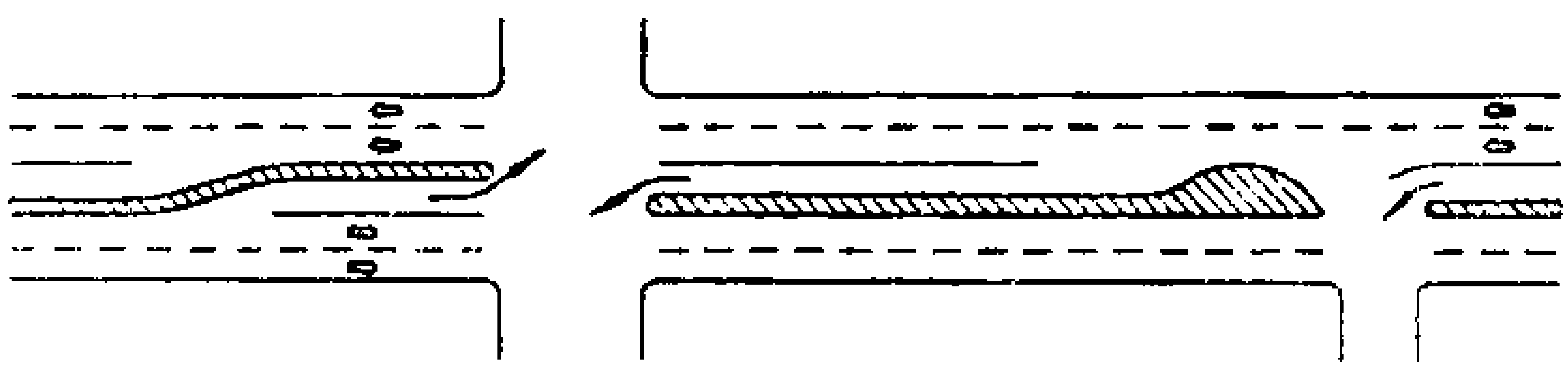


Fig I.4.1 Multi-lane highway with median and left-turn channels

Median Type:

Medians may be depressed, raised, or flush with the traveled way surface. A narrow median width warrants a median barrier which normally consists of guard-rail or concrete barrier, but could consist of a line of closely-spaced (large) trees or of thick impenetrable shrubbery on most of the section. Fig. I.4.2 & I.4.3 show several types of medians A median should be categorized as one of the following:

1- Curbed
2- Positive barrier (guard-rail, concrete barrier or closely-spaced trees)
3- Unprotected (Painted or rural unprotected)
4- None

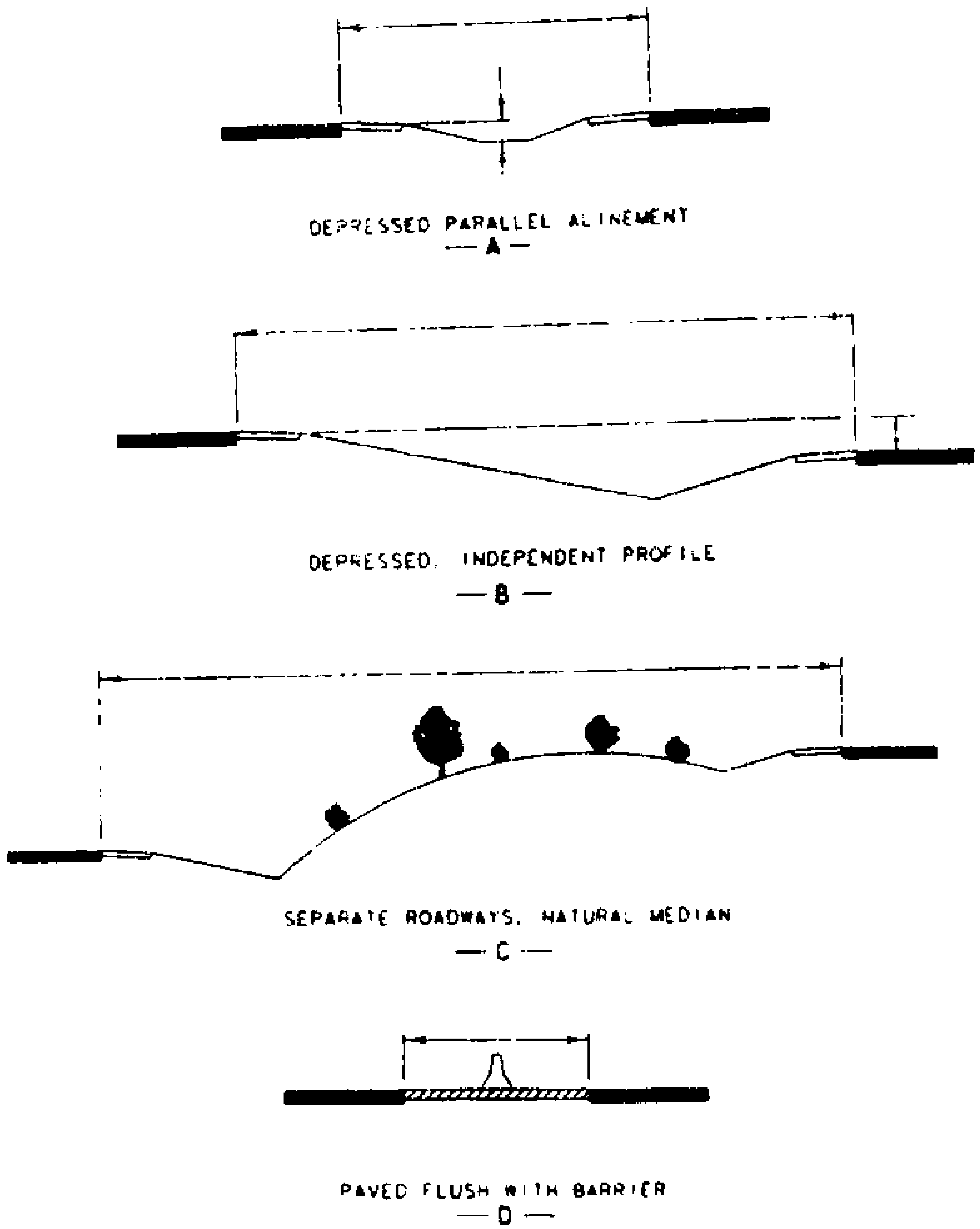


Figure I.4.2 Typical rural median

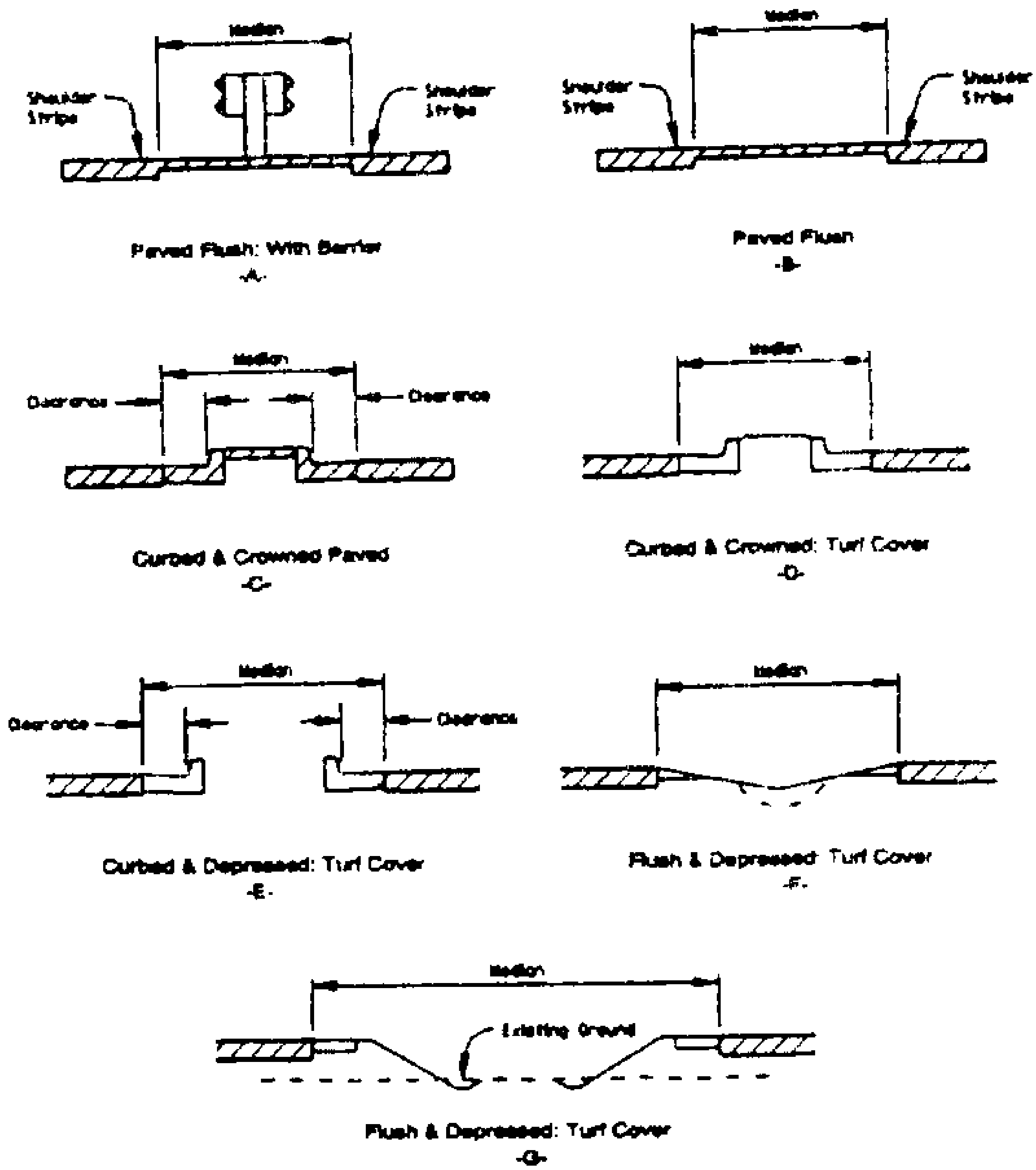


Figure 1.4.3 Typical median on divided highways

Median width :

Median width on divided highways is measured between the through-lane edges and includes the left shoulders (See Fig.I.4.4). Take the measurement where the width is constant.

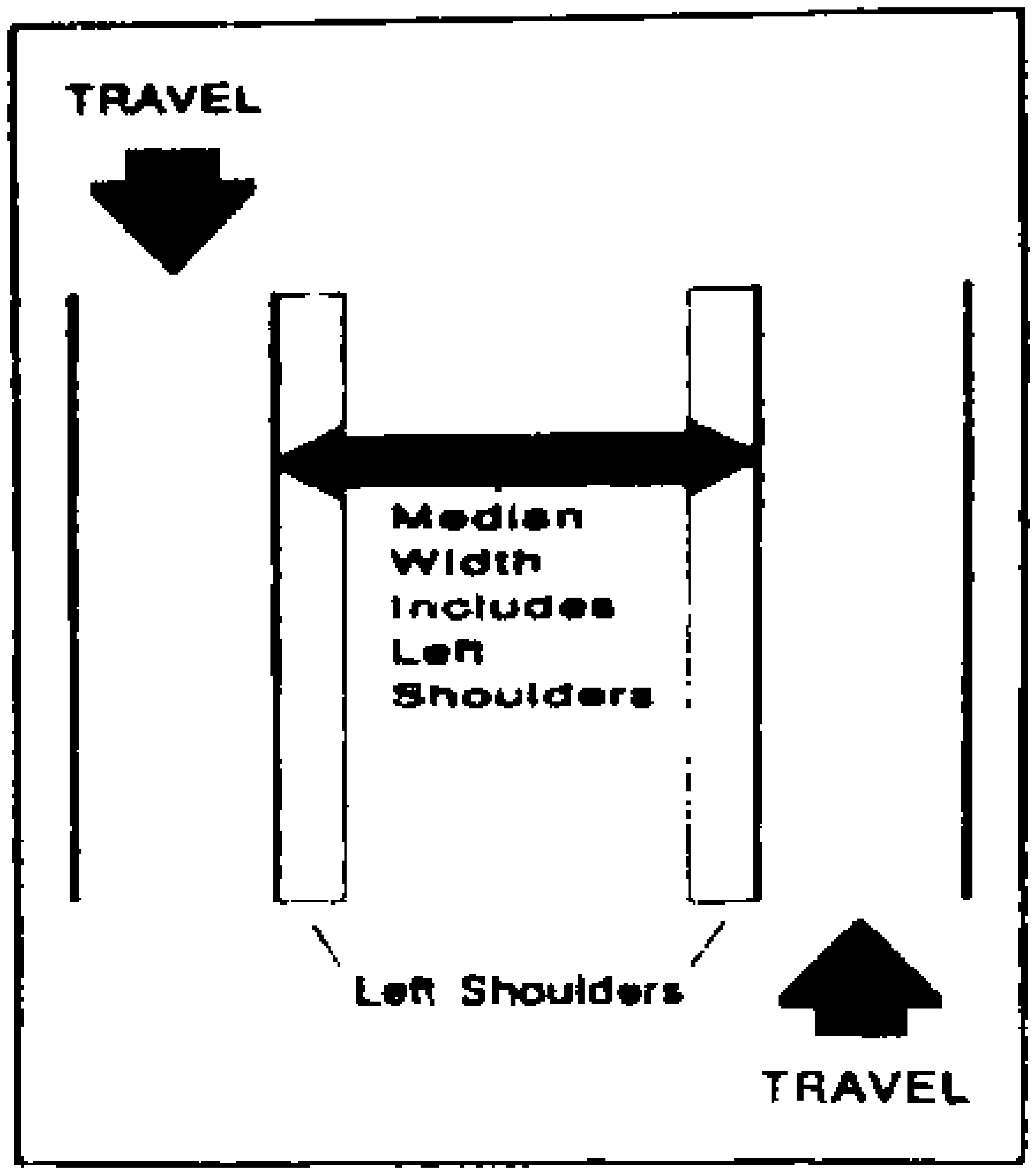


Figure I.4.4 Median measurement

Median length :

Fig.I.4.5 illustrates a single curbed median (type 1) and its breakdown. To inventory a type 1 median, a minimum length of at least 1000 is suggested. This includes section n+1 and section n+2. To inventory a type 3 median, a minimum length of at least 1000 feet (including the taper) is required.

TYPICAL INVENTORY SECTIONS:

SECTION n	2 TRAFFIC LANES, 12' WIDE LT. & RT. SHOULDER, 10' WIDE
SECTION n + 1	2 TRAFFIC LANES, 12' WIDE LT. & RT. SHOULDER, 10' WIDE ISLAND [illegible] WIDE
SECTION n + 2	3 TRAFFIC LANES, 12' WIDE LT. & RT. SHOULDER, 10' WIDE ISLAND 4' WIDE

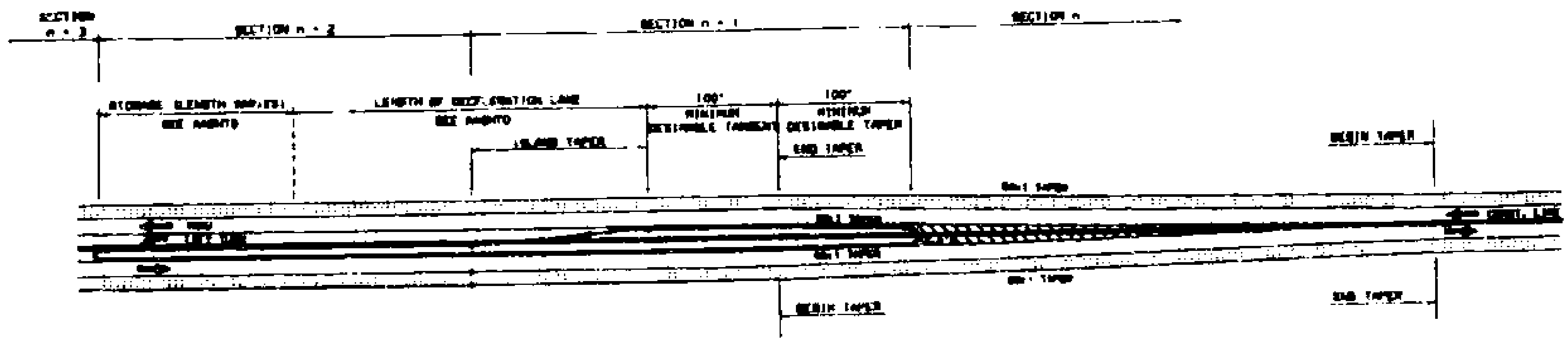


FIGURE 1.4.5

SECTION II

MEASUREMENTS OF TURNING ROADWAYS (ramps and slip ramps)

1-GENERAL INFORMATION:

A turning roadway is a connecting roadway for traffic turning between two intersection legs. Turning roadways include ramps (Fig.II.1.1, page 21) and slip ramps or sleepers (Fig.II.2.5a & II.2.5b, page 26&27) - see definitions for ramps and slip ramps. Turning roadways, like roadways, require a unique inventory number. The turning roadway's functional class and system class are the same as for the intersecting highway with the highest functional class and system class.

The data associated with turning roadways are mainly used internally. Submission of this data to FHWA is not required. Also, FHWA does not permit states to include the ramp miles in the Public Road Mileage Certificate. Ramp mileage is included in the reports produced for internal use, such as the Classified Road Mileage (used for the Block Grant Aid program).

2- FIELD MEASUREMENTS FOR RAMP INVENTORY

To maintain consistency in ramp and slip ramps measurements, the following guidelines have been developed. Measurements should include the following components: deceleration lane, ramp proper, and acceleration lane.

- **Deceleration lane** (Fig.II.2.1, page 22)

  Length : Measure from the taper beginning to the concrete nose.
  Lane width : Varies. Assume 12 foot lane.
  Shoulder width . Measure from the shoulder beginning (lane stripe) to the edge of pavement.
  Lane Mile Width (LMW) : Varies. This field should be filled for financial purposes. To report LMW width, multiply the number of the lanes by 12 (Lane width).

- **Ramp proper** :

  Length : Starts at the concrete nose of the exit terminal and ends at the concrete nose of the entrance terminal. (See Fig.II.2.1 & II.2.2, page 22&23).
  Lane width : Measure where the width is constant.
  - **One-lane ramps**: Measure the width between the two lane stripes. If a curbed ramp does not have lane striping, measure from curb to curb (See Fig.II.2.3 & II.2.4, page 24&25).

Multiple lane ramps: Measure the distance between left and right lane stripes for one single lane.

Shoulder width :

Start from the lane stripe and end at the edge of pavement or curbing

Lane Mile Width(LMW):

Measure the width between the left and right shoulder stripes. If there is no striping (curbed ramps), measure from curb to curb. If no curb exists, measure from shoulder break to shoulder break

- **Acceleration lane** : (Fig.II.2.2, page 23)

Length . Measurement from the concrete nose of the entrance terminal to the end of the taper

Lane width. **Shoulder width and, Lane Mile Width**:

For width measurements, follow the instructions for deceleration lanes

In some cases a ramp may have only two components, for example, a ramp with a T-intersection at its terminal (See Fig.II.2.5a & II.2.5b, page 26&27). If no acceleration lane is present, the ramp proper ends either at the intersection, or it ends at the beginning of the slip ramp which enters the intersection

Auxiliary lanes and Weaving sections (Fig.II.2.6, page 28) :

Weaving sections should be included in the measurement of ramps. This rule is applied to auxiliary lanes, if they mainly serve the traffic associated with the ramp. Otherwise, auxiliary lanes need to be inventoried as part of the main highway. The following cases may exist:

1- Auxiliary lane following a ramp Assume that the acceleration lane starts at the entrance terminal and ends at the end of the taper on the auxiliary lane. Lane width, shoulder width, and TW-TW should be measured from of the auxiliary lane

2- Auxiliary lane preceding a ramp: Assume that the deceleration lane starts at the beginning of the taper on the auxiliary lane and ends at the concrete nose of the exit terminal. Lane width, shoulder width, and TW-TW should be measured from the auxiliary lane. An example is a right turn lane.

3- Weaving sections: Assume the entrance terminal of the first ramp (acceleration lane) extends to the mid point of the weaving section. This point will also be the beginning point for the deceleration lane of the second ramp.

3- FIELD MEASUREMENTS OF SLIP RAMPS FOR INVENTORY

In general, a majority of slip ramps are simple curved connections between two legs of an intersection (See Fig.II.2.5a & II.2.5b, page 26&27). This simplified form of ramp requires a simple measurement procedure.

Length : Measure from the center line of the first intersection leg, along the center line of the slip ramp, to the center line of the other intersection leg.

Lane width, Shoulder width and Lane Mile Width: Measure where the width is constant. Follow the guideline for ramp proper measurements.

4-CROW'S FOOT:

A Crow's foot is very similar to a slip ramp. A Crow's foot exists to allow drivers to maneuver to either slightly decrease their travel path or increase their sight distance. Crow's feet do not require inventory number, however, they are measured as part of the main road, if they are longer than 250 feet and are paved. For measurement, increase the pavement width to include the crow's feet.

5-DIRECTION OF INVENTORY:

Ramps follow the direction of the higher order connecting highway (the direction of travel for an off-ramp or on ramp on interstate I-89 north bound is north). Order of highways depend on their functional classification. If two connecting highways have the same functional classification, the highway with the lower route number governs.

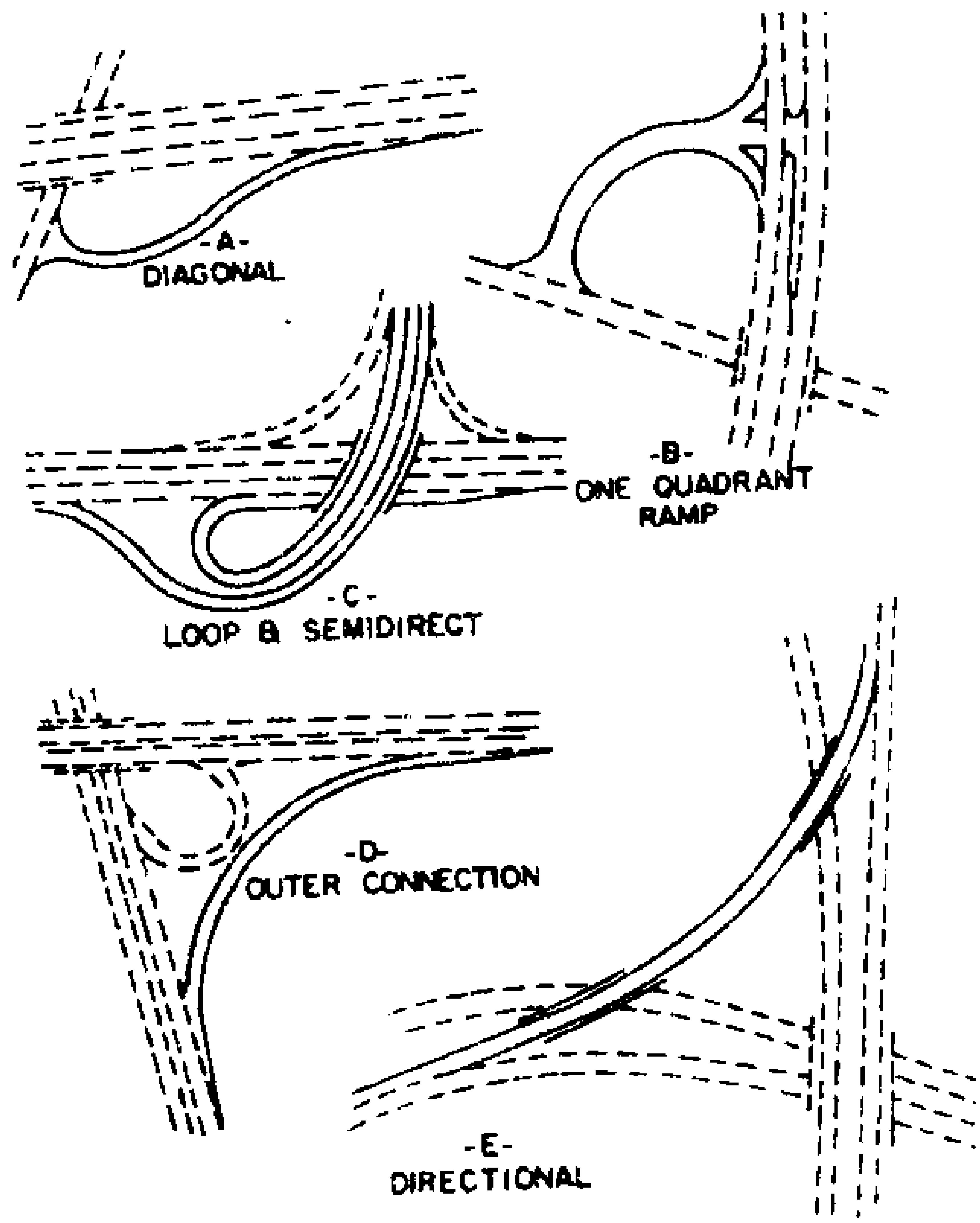
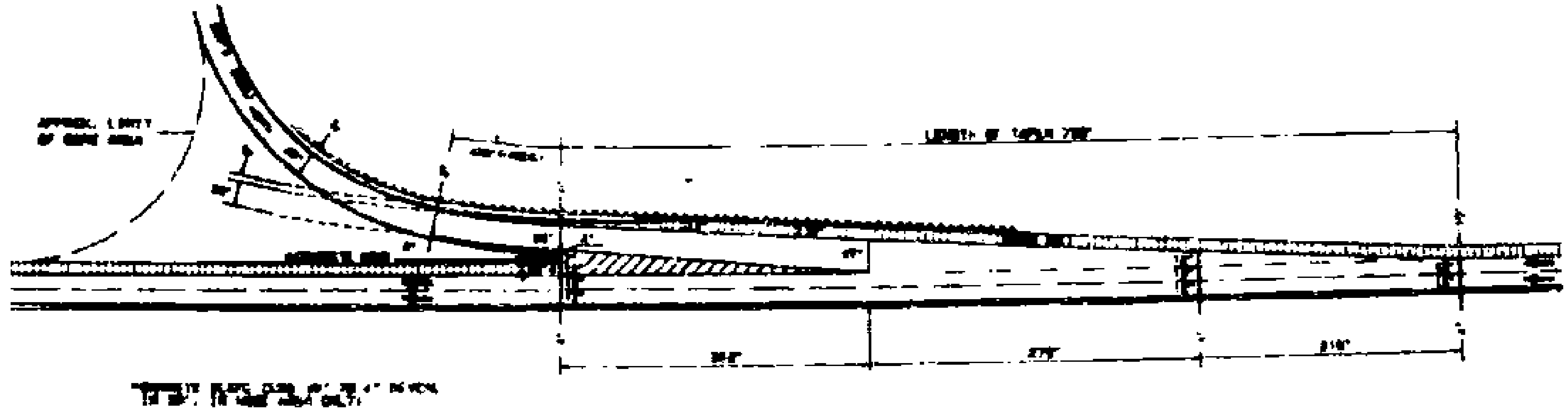
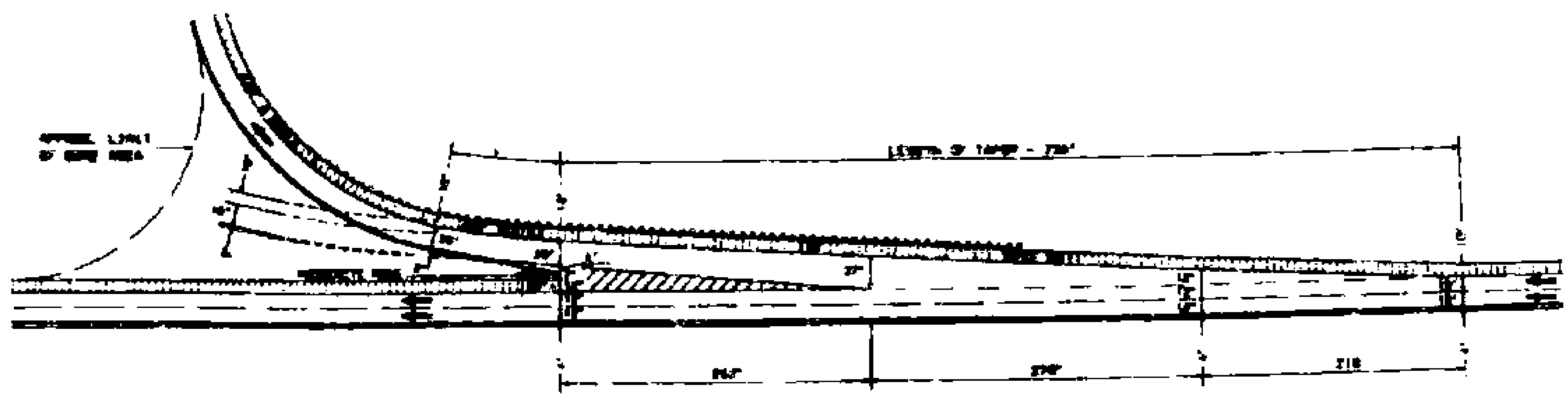


Figure II.1.1 Different types of ramps

FIGURE II.2.1 - Deceleration lane with curbed ramp

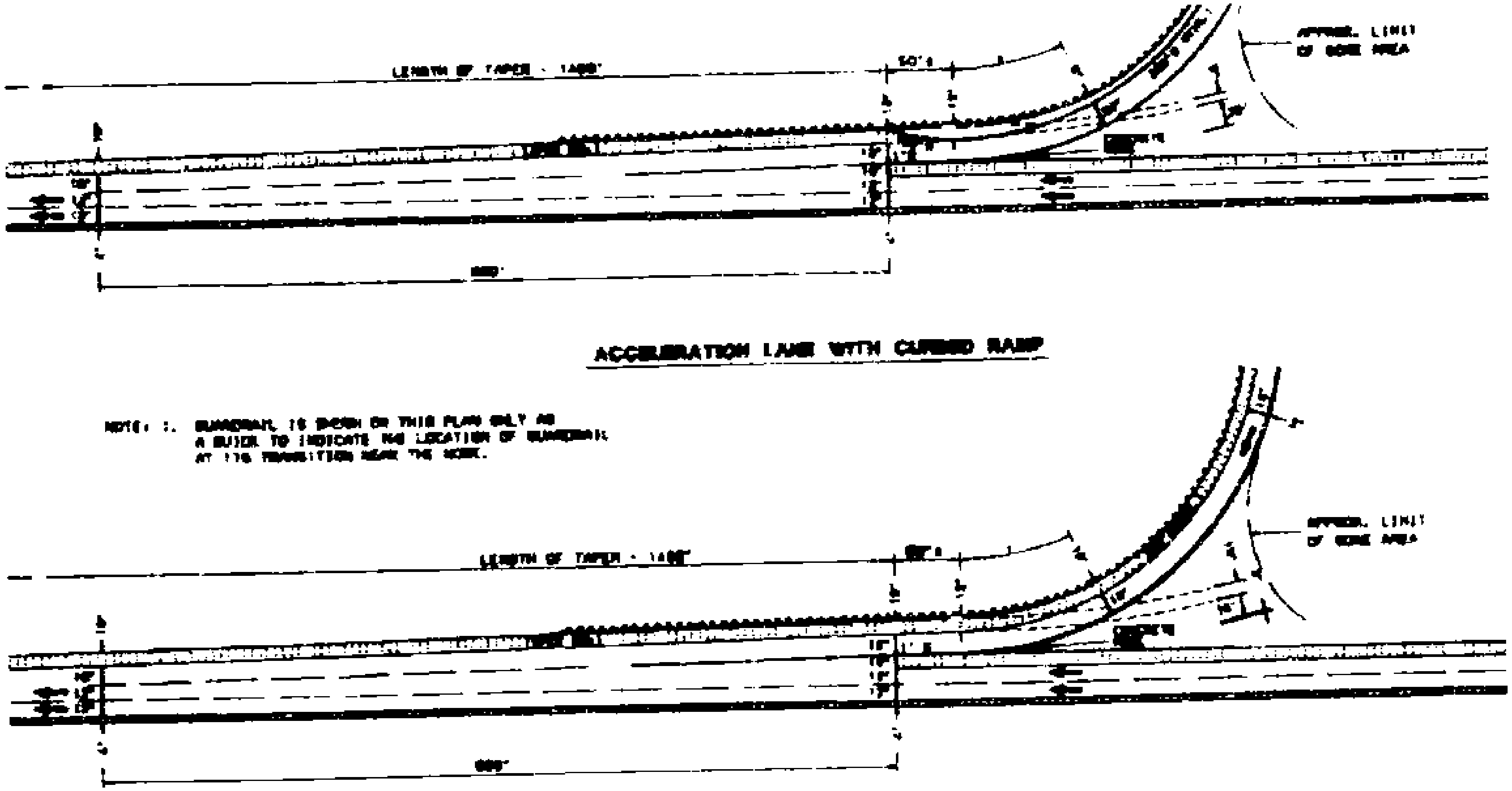


DECELERATION LANE WITH CURBED RAMP



DECELERATION LANE WITH UNCURBED RAMP

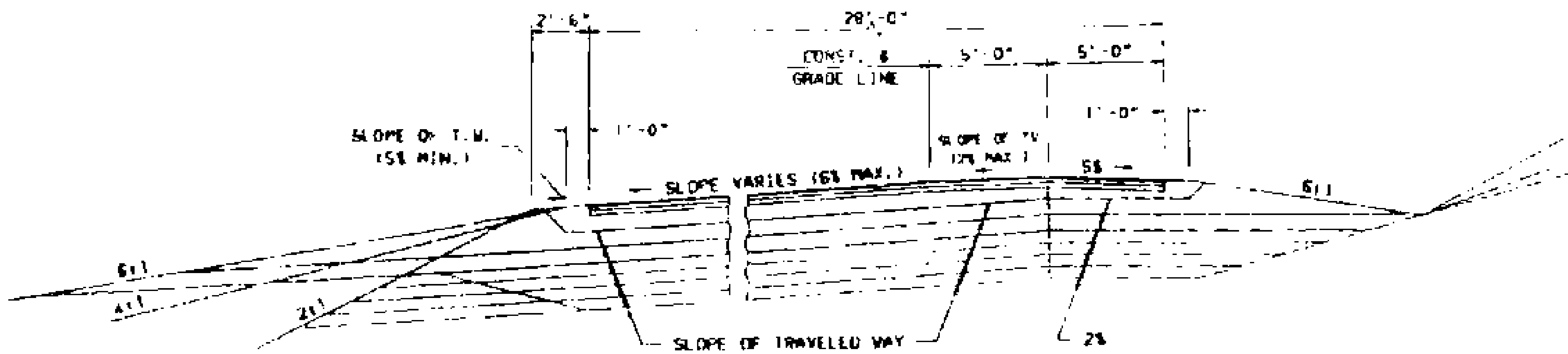
FIGURE II.2.1



ACCELERATION LANE WITH CURBED RAMP

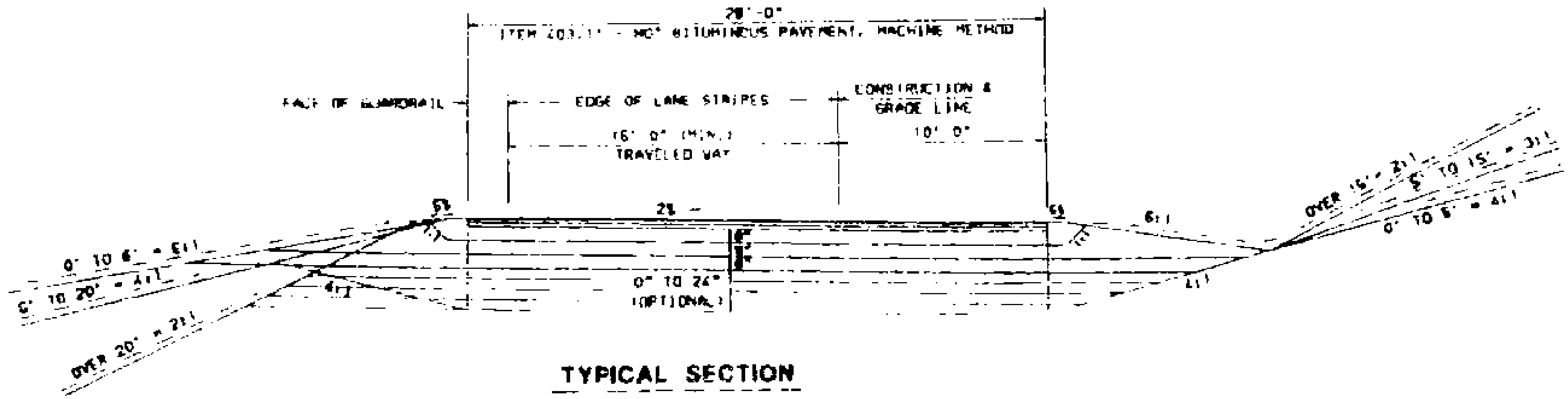
ACCELERATION LANE WITH UNCURBED RAMP

FIGURE 11.2.2



SUPERELEVATED SECTION

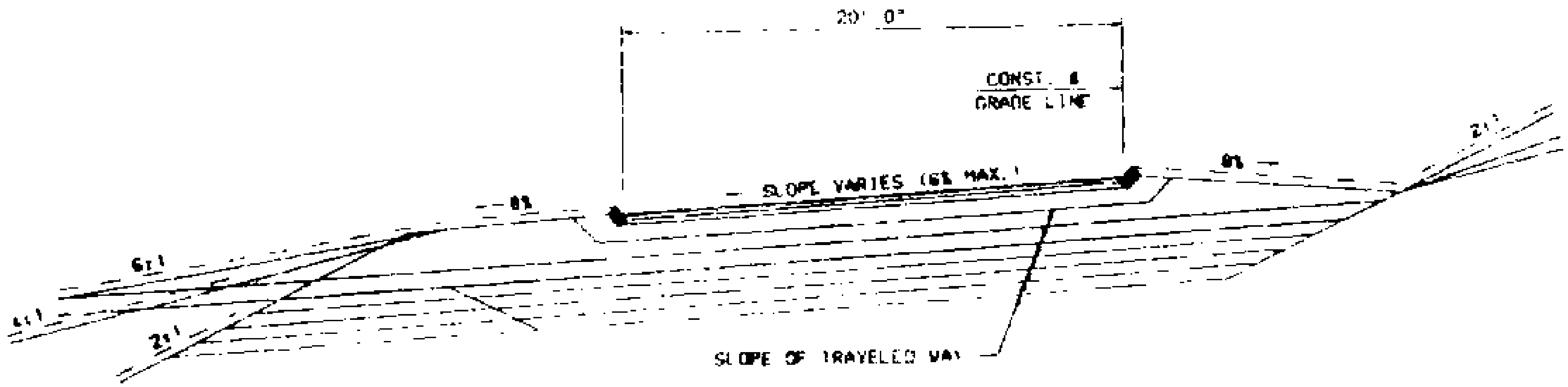
(FOR CURVES TO THE LEFT)



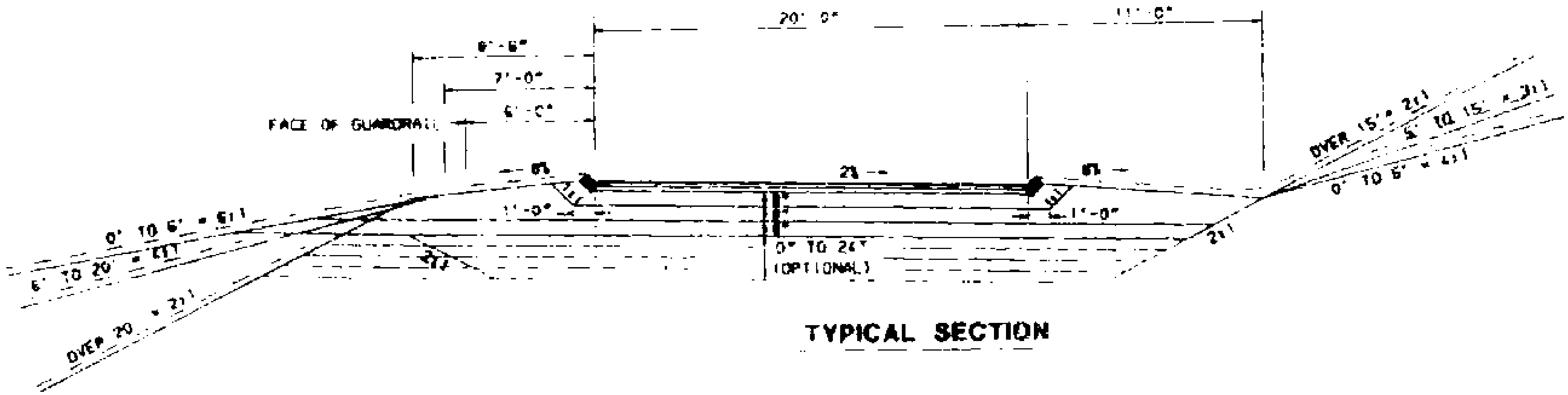
TYPICAL SECTION

UNCURBED RAMP

FIGURE 11.2.3



SUPERELEVATED SECTION

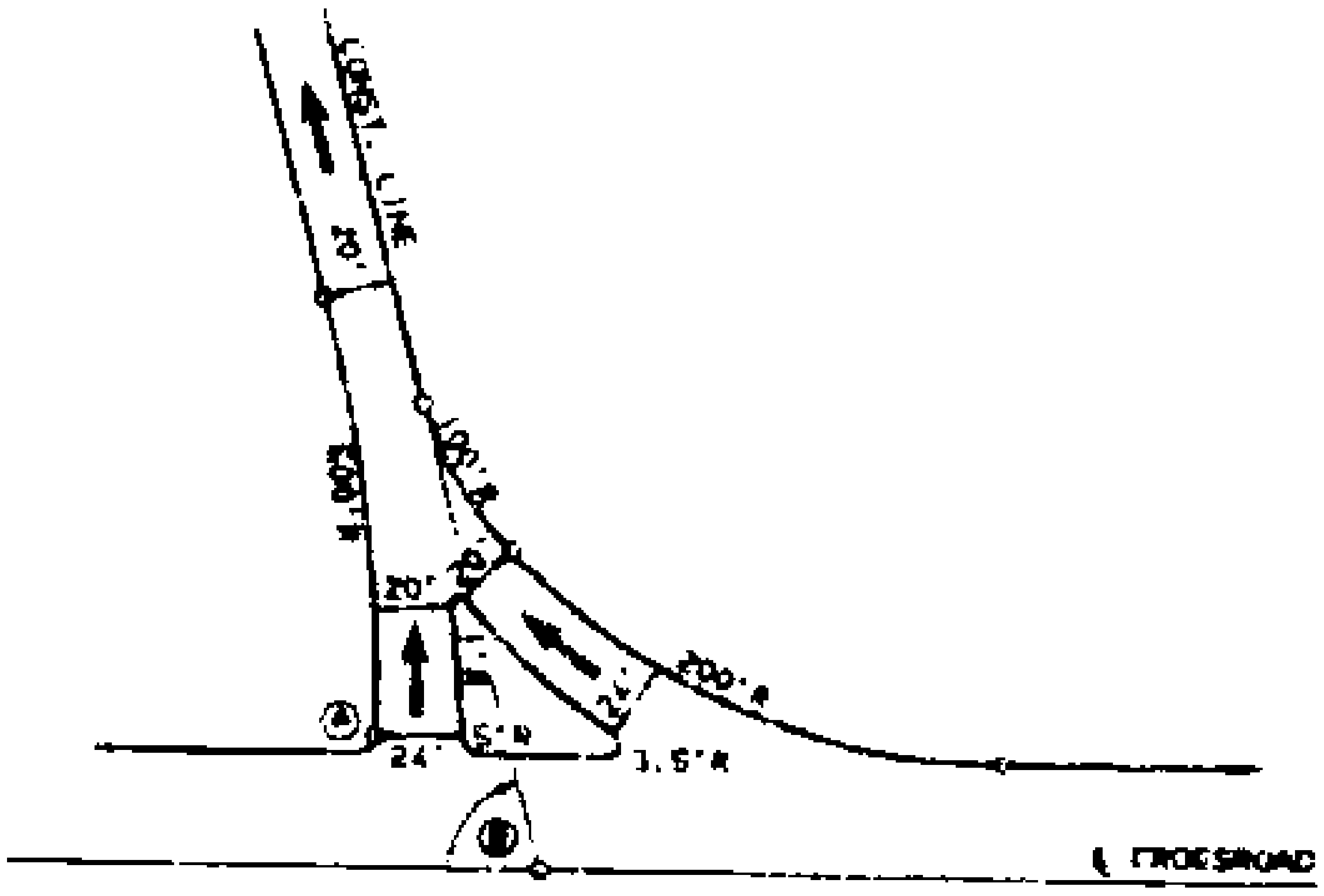


TYPICAL SECTION

CURBED RAMP

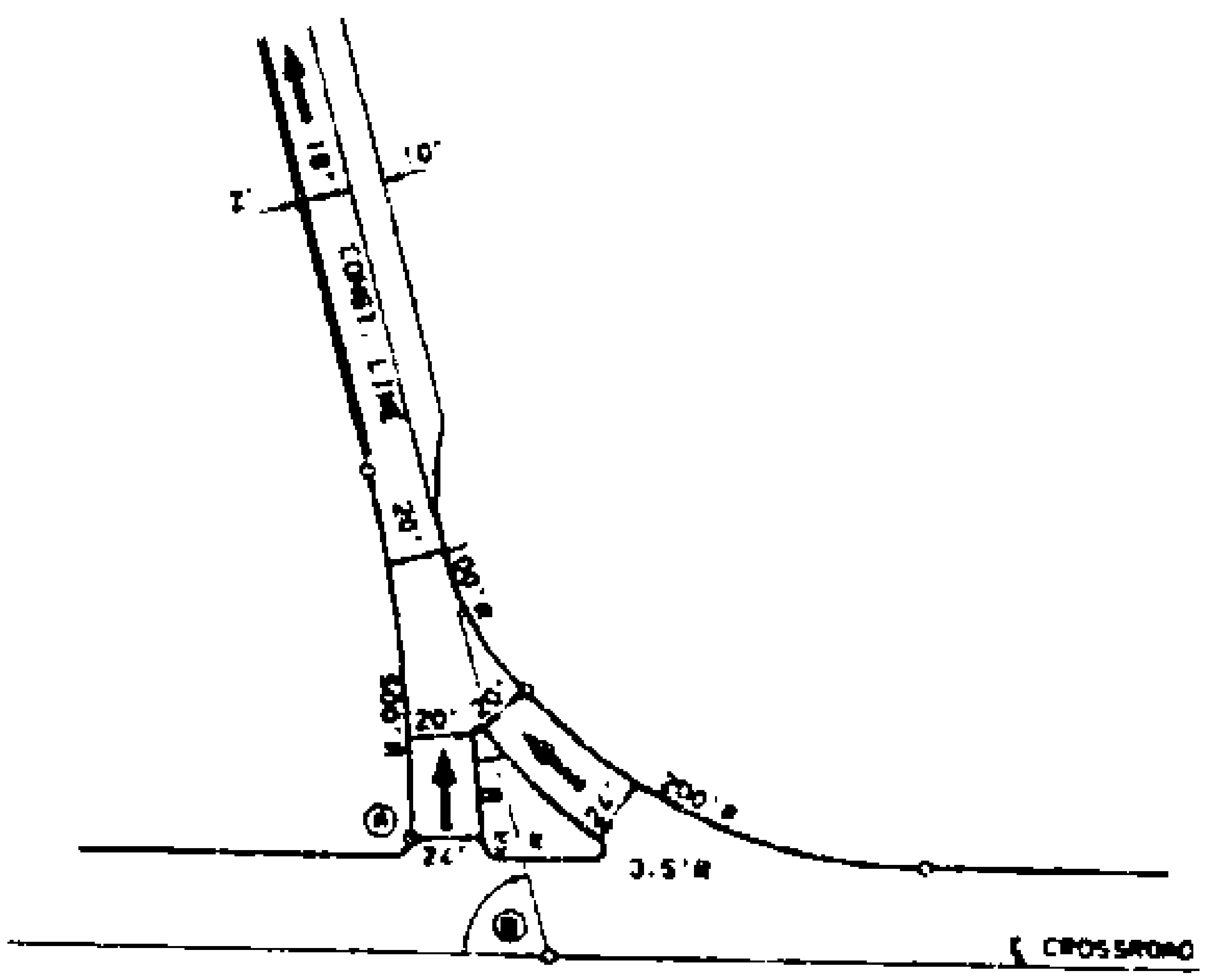
FIGURE 11.2.4

SLIP RAMPS



CHANNELIZED RAMP ENTRANCE (YIELD CONDITION)

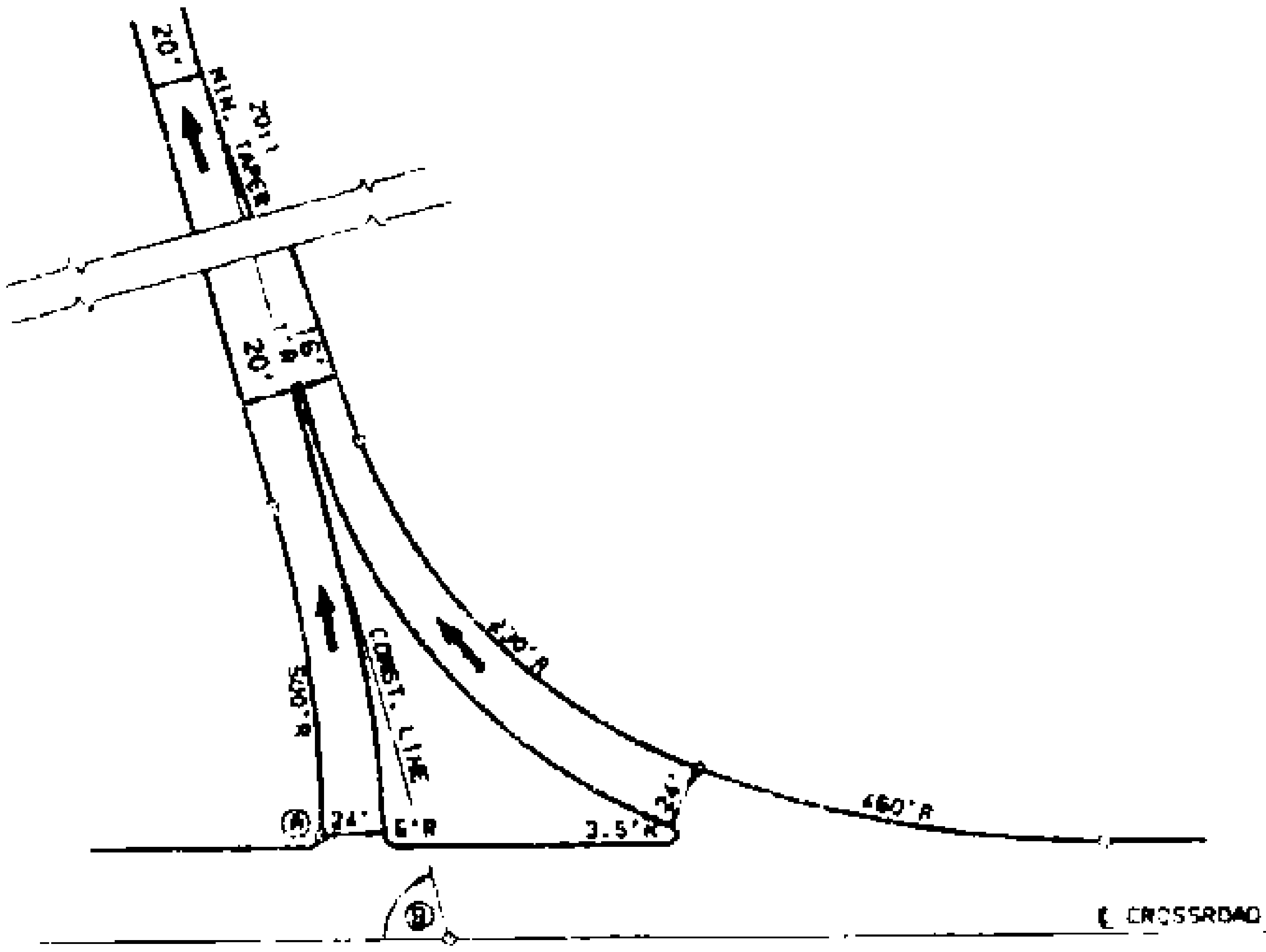
CURBED RAMP TERMINALS



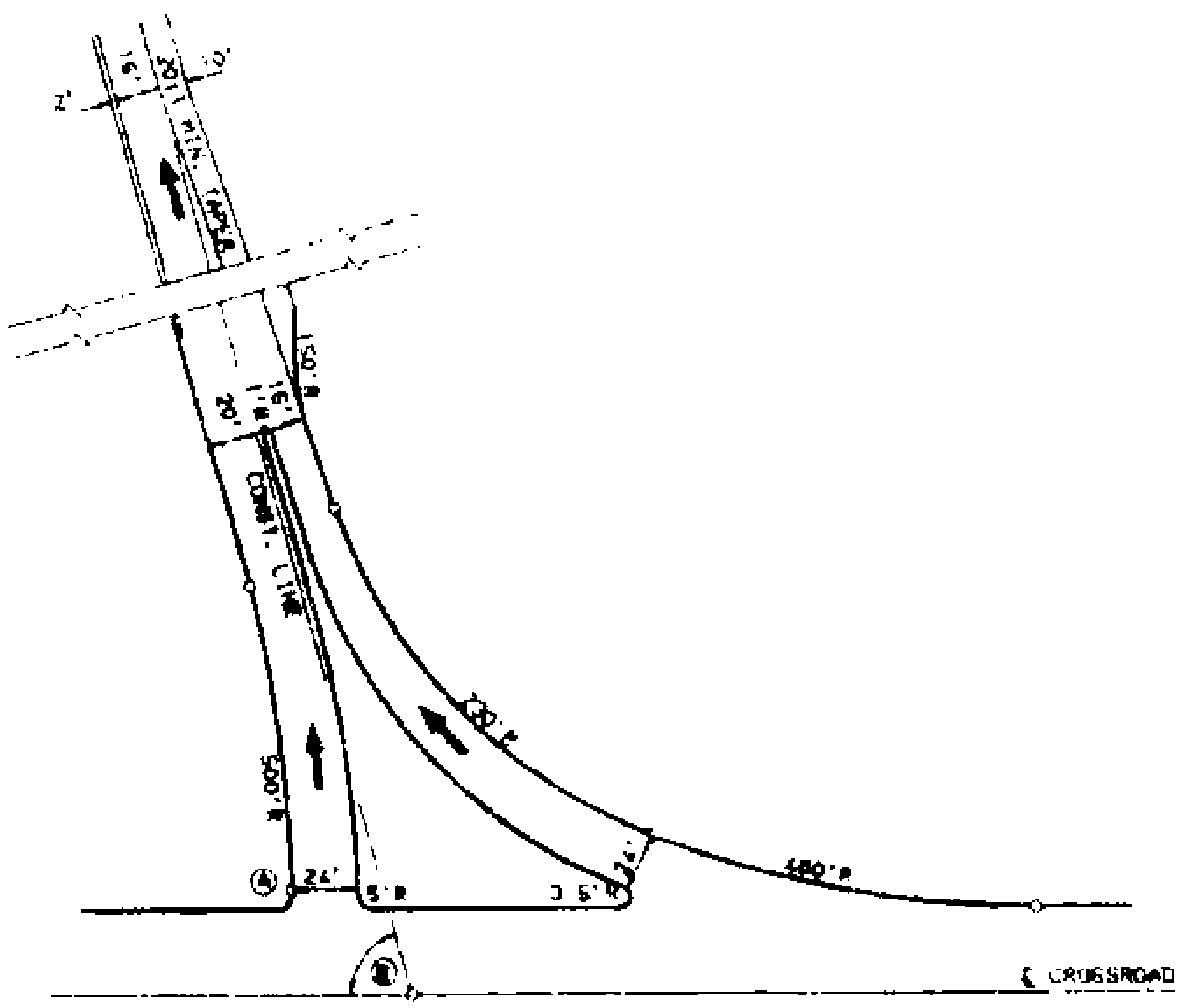
CHANNELIZED RAMP ENTRANCE (YIELD CONDITION)

UNCURBED RAMP TERMINALS

FIGURE II.2.5a

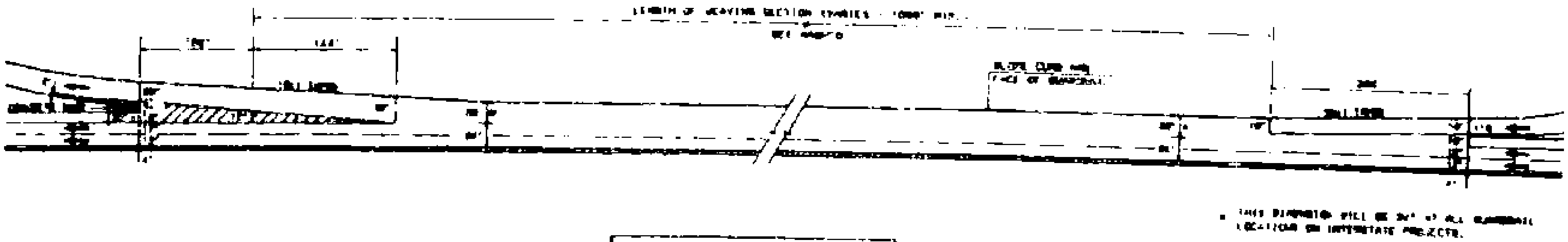


CHANNELIZED RAMP ENTRANCE (MERGE CONDITION)

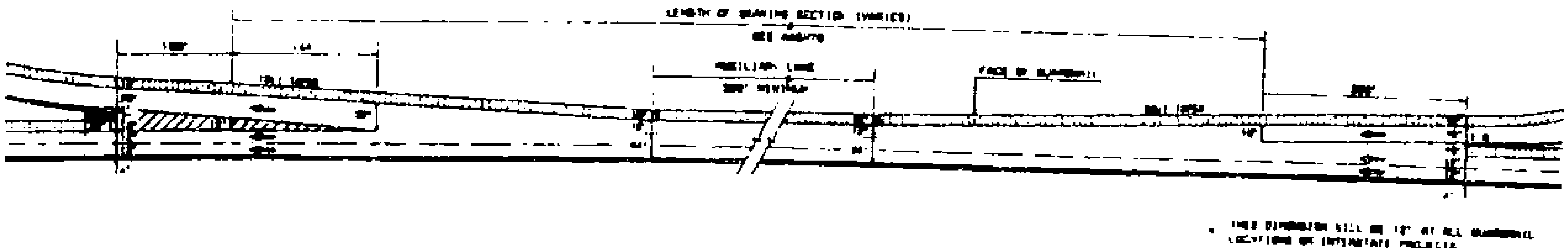


CHANNELIZED RAMP ENTRANCE (MERGE CONDITION)

FIGURE 11.2.5b



WEAVING SECTION - CURVED



WEAVING SECTION - UNCURVED

FIGURE II.2.6

SECTION III
INVENTORY OF ROADS

DOT personnel inventory roadways for different reasons such as planning, technical, statistical, financial purposes, or state and federal requirements. Data collectors must be consistent and follow the same procedures to avoid redundancy or discrepancies.

Three pieces of information are required to uniquely define a roadway statewide, the three digit NH town number (see Appendix B), the four digit roadway inventory number, and direction. On non-divided highways, the direction code will always be 'B'. On divided highways, the direction code will be 'N', 'S', 'E', or 'W', depending on the intended travel direction of the specific barrel being inventoried. The direction key is not governed by the direction of one-way roads, and should not be confused with the travel direction or inventory direction.

1- ROADWAY INVENTORY NUMBERS :

In assigning inventory numbers to the town roads or state highways, follow the following guidelines. Note: Current inventory numbers may vary from this scheme, but this guideline should be followed for all newly inventoried roads.

Inventory Numbers	*Class*
0001 through 0050	State Primary Highways
0051 through 0075	State Secondary & Recreational Highways
0076 through 0199	Rural Class V or VI Town Roads
0200 through 0989	City Streets. These numbers may be used for rural roads if no number in their associated category is available.
0990 through 0999	Intestates, Turnpikes, and other limited access highways
1000 through 4999	Large City Streets
5000 through 6899	Ramps
6900 through 6999	Traffic Circles
7000 through 9999	Reserved

Changes to inventory numbers that have already been assigned to routes/roads are not allowed without approval of the GIS committee.

Data collectors should be familiar with different inventory cases to properly collect road inventory features. The following guidelines were developed to ease this task.

1- A roadway begins and ends within the same town (See Fig.III.1.1, case 1). Start recording mileage (zero milepoint) at the intersection of the centerlines of the road to be inventoried and the connecting road. End recording the mileage at the intersection of the centerlines of the road to be inventoried and the second connecting road.

2- A roadway begins and ends at the town lines (See Fig III.1.1, case 2). Start recording mileage (zero milepoint) at the first town line crossing. End recording the mileage at the next town line crossing.

3- Normally the inventory number of state highways and routes do not change as a result of crossing either county or town lines, however, this is not true for class V roads (town maintained roads). The inventory number of a class V road that goes through several towns changes as it crosses a county line or a town line (See Fig III.1.2, case 3A & 3B).

4- Gap sections: A gap section occurs when two highways are concurrent. To avoid duplication in recording the physical length of highways, roadway inventory rules do not allow more than one inventory number for concurrent routes. This is one of the most important roadway inventory rules.

IF		**ONLY**
Within the same Town	**Several Highways Run Concurrent**	**One Inventory Number Is Allowed**

Roadway inventory rules force all concurrent highways, except the one with the highest order, to end at the beginning of the concurrence, and restart when the concurrence ends (gap section). The following instructions will help data collectors to assign the gap sections properly.

a-If two highways run concurrently, the higher order highway takes priority and its inventory number is used for both highways for the entire length of concurrent segment (See Fig.III.1.3). If both highways are in the same category, the one with the lower route number takes priority over the one with the higher route number.

THE ROUTE HIERARCHY

INTERSTATE
US
NH
UNNUMBERED ROADS

b- A gap section does not exist if the concurrence starts at the town line. In this case, assume that the lower order highway begins (with its own inventory number) where the concurrence ends (See Fig.III.1.4).

c- If the concurrence does not end within the same town or ends at the town line, a gap section is not required. In this case, assume that the lower order highway ends where the concurrence begins (See Fig.III.1.5).

The gap sections should be shown on the field straight-line diagrams, accompanied with the reason for the gap.

6- Inventory numbers assigned to town roads or city streets are unique within the same town or city. Care should be taken when assigning a number to a new road to avoid duplicating inventory numbers.

7- Direction of the inventory for routes is the same as on the **US & STATE ROUTE NUMBERS** listing reported by the Bureau of Traffic. Roads that have bi-direction travel are typically inventoried south to north or west to east, however, where concurrence occurs, all features of the higher order highway, including its direction, will take priority over those of the lower order highway.

Town maintained roads are also inventoried from south to north or west to east, however, dead end roads are an exception and do not follow the inventory rule. If a dead end road branches from the main road heading toward south (or east), the direction of inventory is from south to north (or east to west). The reason is that the data collectors always need a fixed point to start an inventory. In the above example, the end of the road is not a fixed point because there is always a possibility of extending the road. The data collectors are forced to use the intersection of the main road with the inventoried road as the beginning point and proceed to inventory southerly (or easterly).

8 - Inventory numbers used for Ramps are in the 5000 series (5000 - 5999). Ramps are typically coded in ascending order along a route. At interchanges, ramps are assigned to the highway with a higher functional classification. If the functional classifications of the intersecting highways are the same, Route Signing and Route Number will govern.

2- ROAD INVENTORY SECTIONS :

A road may consists of several sections. Any of the following conditions force a new roadway section.

1- A change in the width of traveled ways. The new section will start when the full lane width is in place. This could happen when a painted median is added to a highway (minimum length of the median should be 1000' where it carries a full width) or when there is a change in the number of lanes. The new section will start when the full lane width is in place.

2- A change in shoulder width. The new section will start when the full shoulder width is in place.

4- Beginning and end of a median. See Medians.

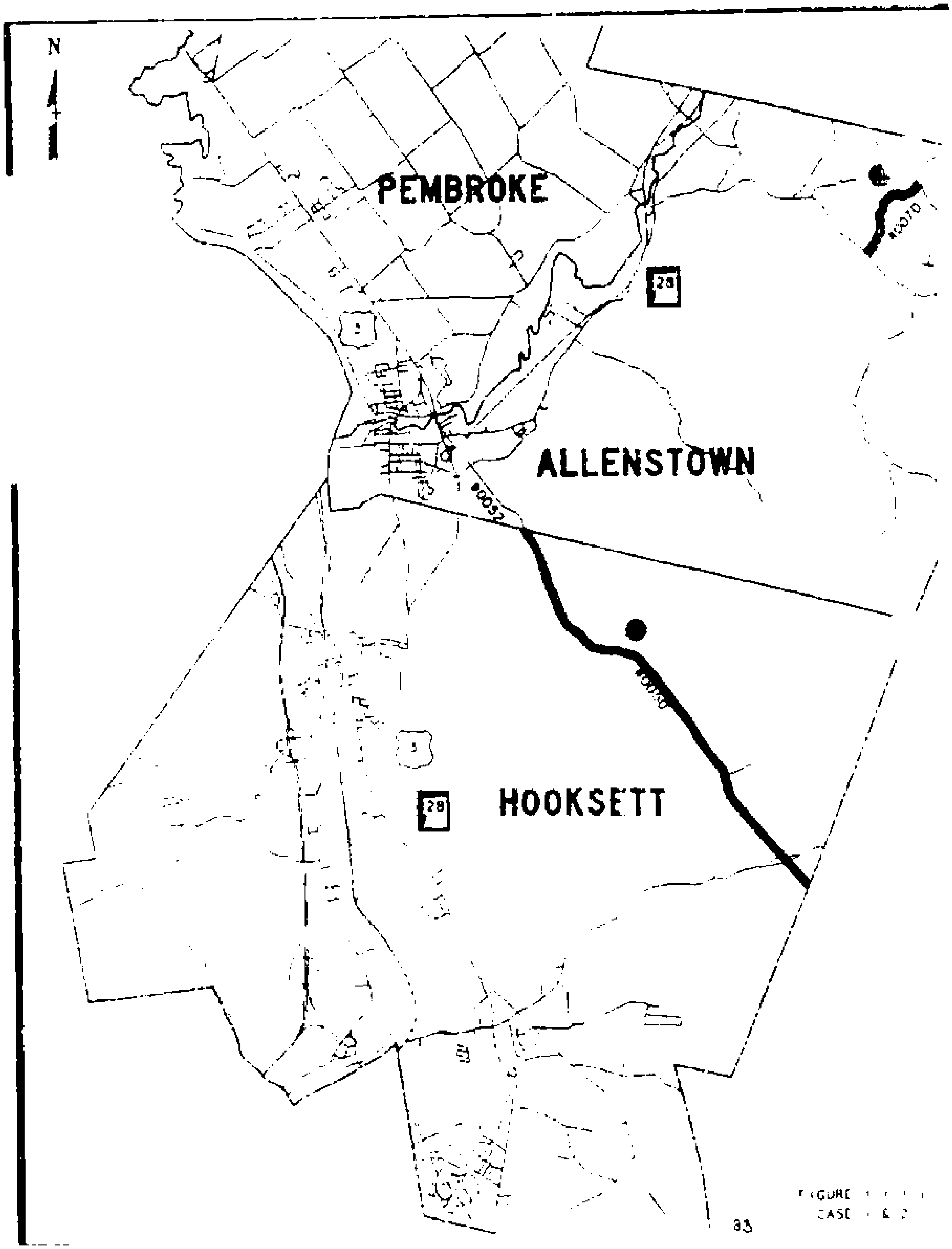
5- Surface type

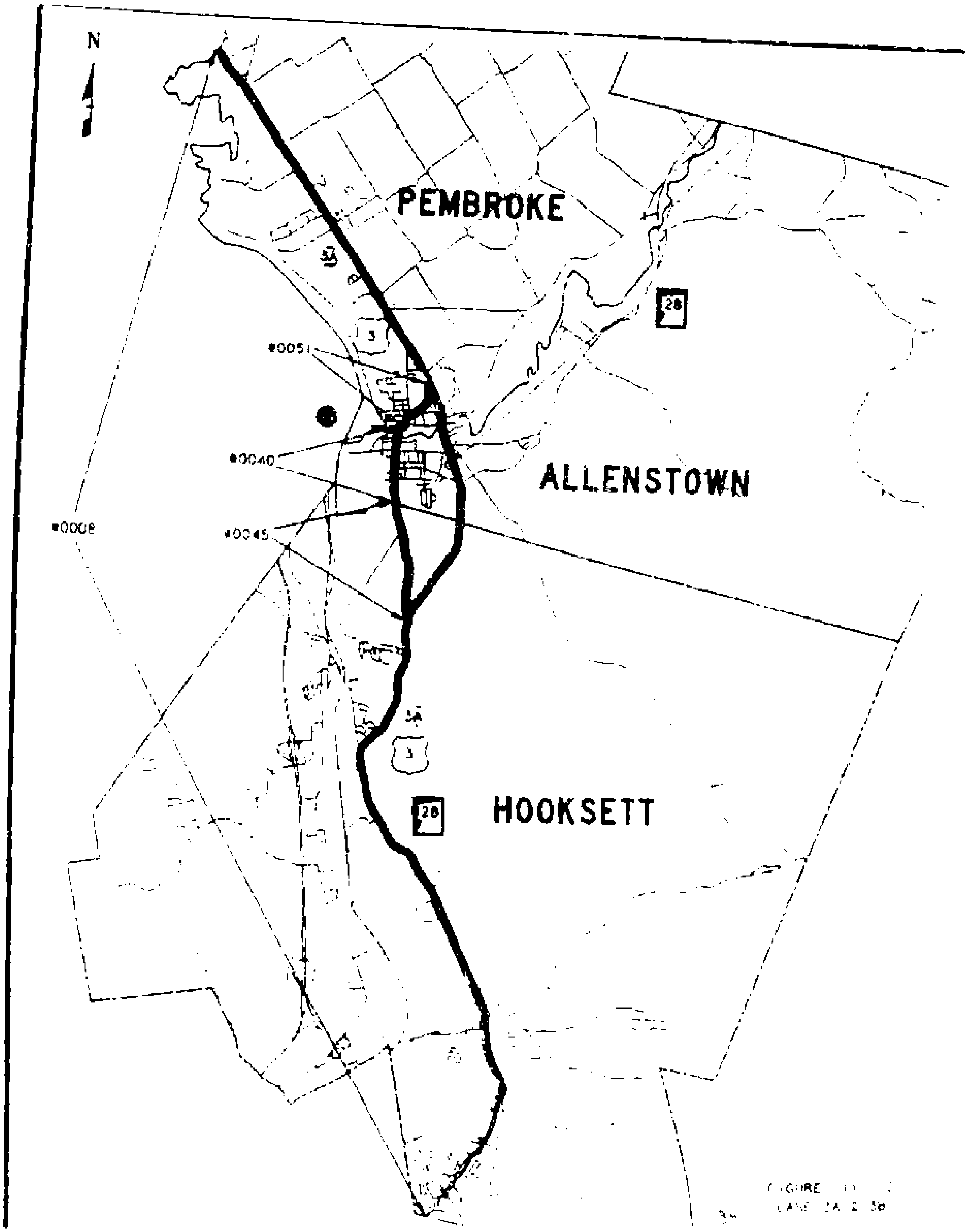
6- Shoulder type

7- ROW change (does not appear in SLD's)

8- Town line, County line

9- Change in an administrative attribute


N
PEMBROKE
ALLENSTOWN
HOOKSETT
28
3
#0032
#0070
33


N
PEMBROKE
ALLENSTOWN
HOOKSETT
#0051
#0040
#0045
#0008
28
3
3A

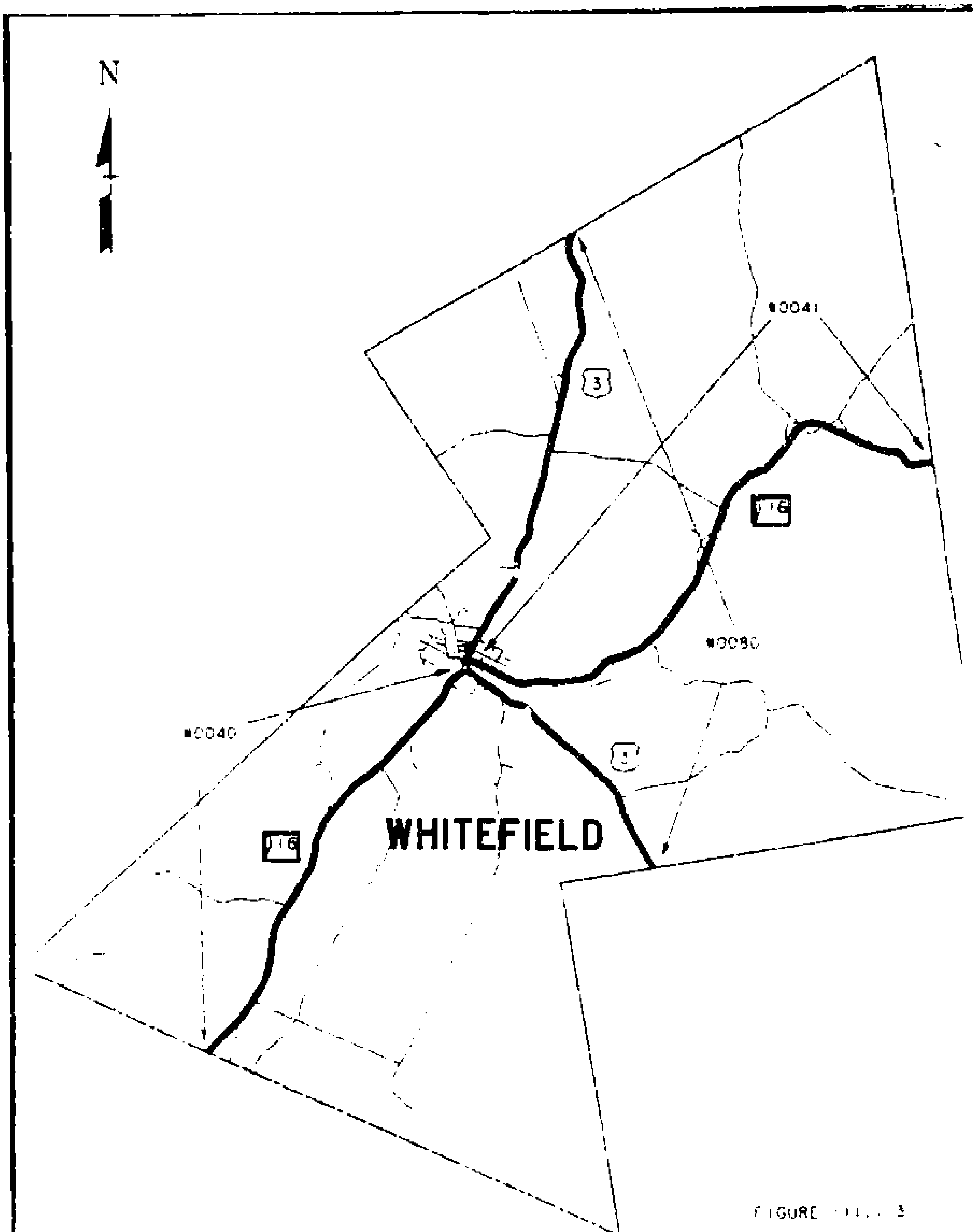


FIGURE [illegible] 3

35

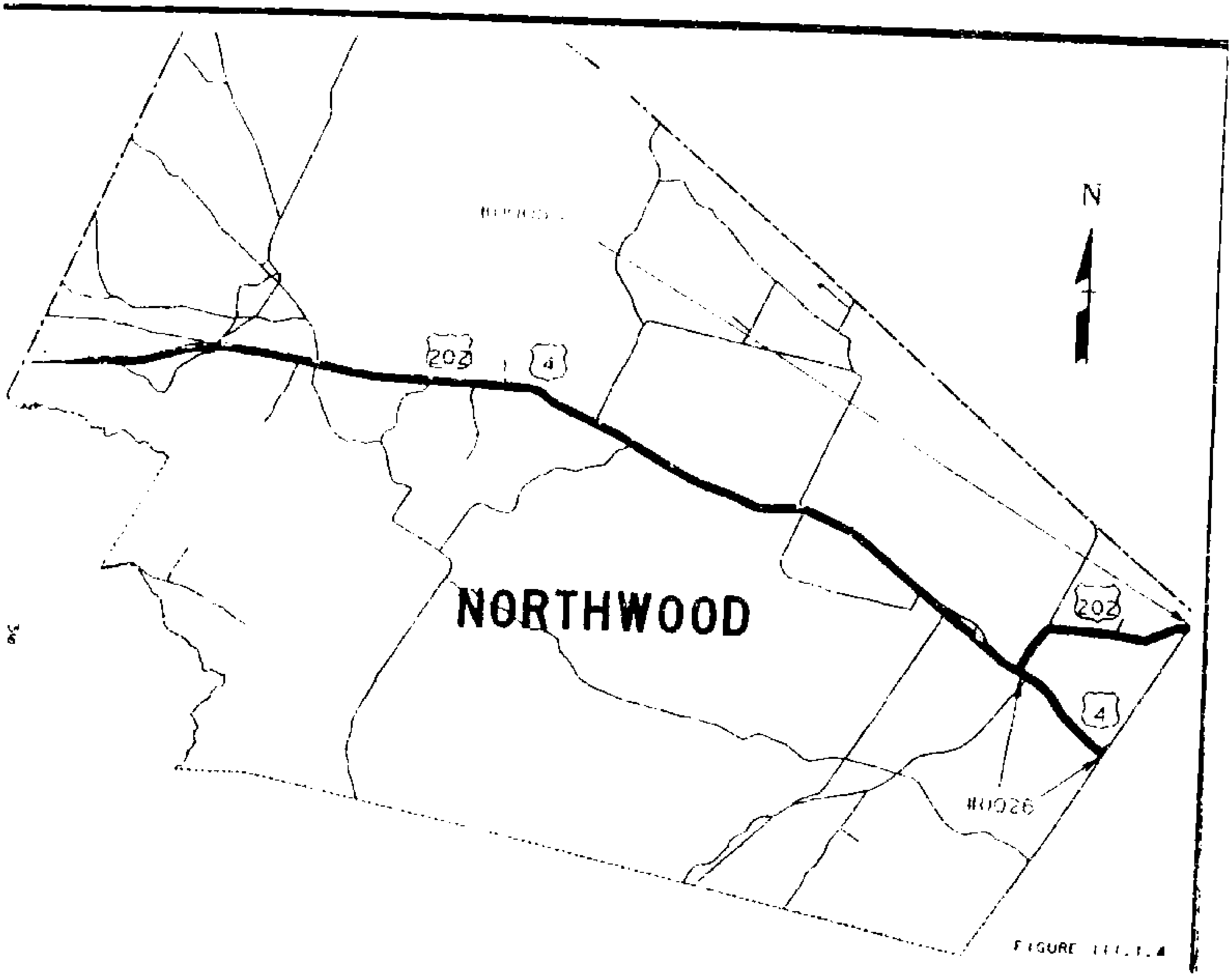
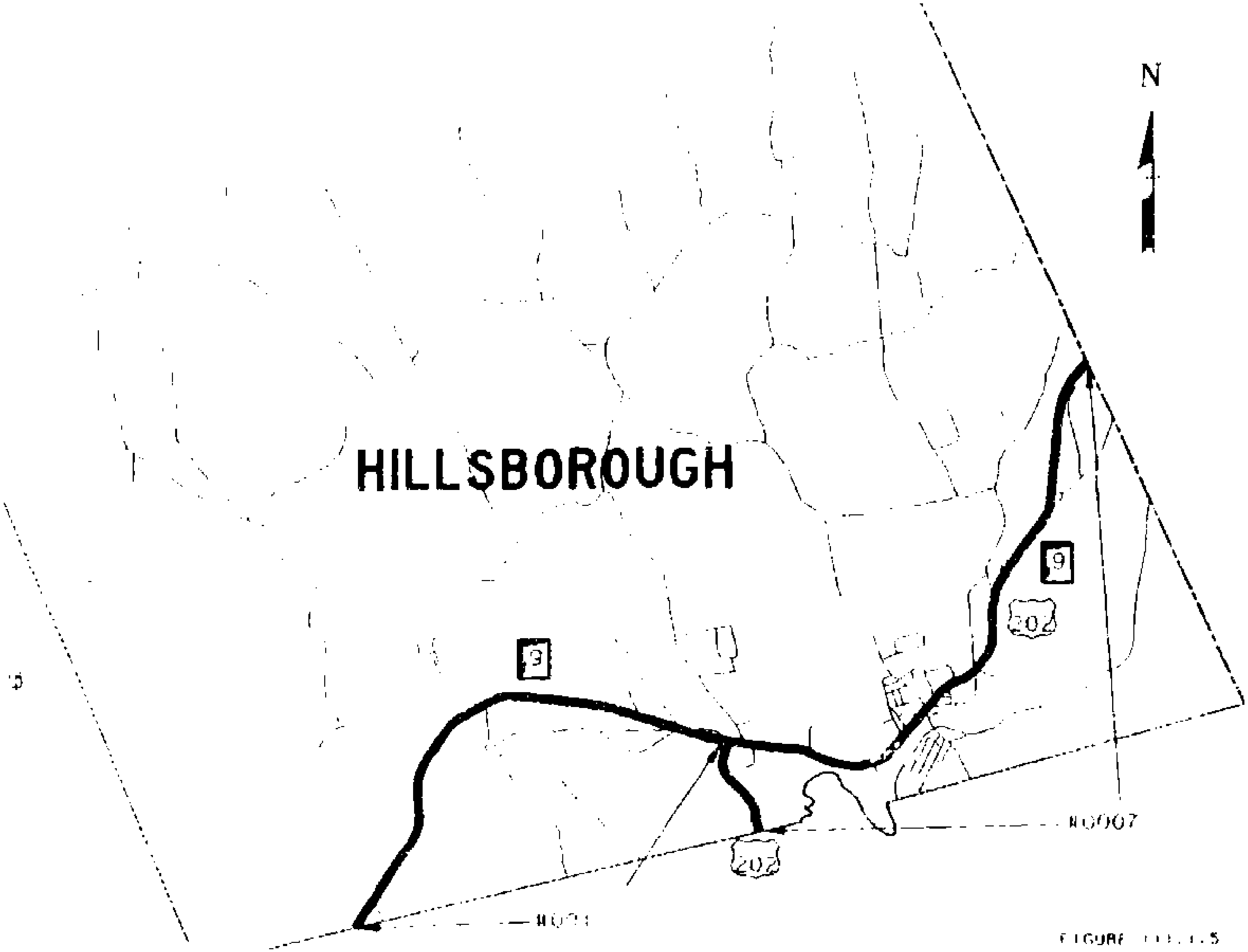


FIGURE III.1.4



FIGURE

Revised 2/1/01

Part II
DATA DICTIONARY

This dictionary contains brief explanation of the codes used in road feature data collection. For complete code definitions, consult the NHDOT Bureau of Transportation Planning's "Manual of Instructions for Inventory" and Federal Highway's "Highway Performance Monitoring System" (HPMS) manual.

Note: HPMS features are defined for Federal Highway's purpose of monitoring and analyzing highway conditions. These definitions may not be obvious or meet the needs of all users.

SECTION I

Attribute Dictionary

Field Names	Field Type	Description	Reference	Page
<<< Inventory Identifiers >>>				
COUNTY	CHAR (3)	Unique 3 digit code for each County		41
TOWN	CHAR (3)	Unique 3 digit town code		41
ROAD	CHAR (4)	4 digit inventory code		41
RAMP	CHAR (1)	Ramp Indicator (R = Ramp, [= Road)		41
DIRECTION	CHAR (1)	N,E,S,W for divided, B for non-divided		42
SEGMENT	CHAR(1)	Sequence order of roads broken by gaps		42
<<< Distances >>>				
MILEPOINT	NUM (7,3)	Milepoint to .001 miles		42
SECT_LEN	NUM (7,3)	Section Length to .001 miles		42
<<< Physical Attributes >>>				
PAVE_WDTH	CHAR (3)	Lane Mile Width (Feet)	NH/HPMS	42
SURF_TYPE	CHAR (2)	Pavement Surface Type	NH/HPMS	43
NO_LANES	NUM (2,0)	Number of Travel Lanes	NH/HPMS	43
LANE_WDTH	NUM (2,0)	Prevailing Traffic Lane Width (Feet)	NH/HPMS	43
SHOULDER_TYPE	CHAR (1)	Shoulder Type	NH/HPMS	43
SHLDR_RIGHT	NUM (2,0)	Shoulder Width Right (Feet)	NH/HPMS	44
SHLDR_LEFT	NUM (2,0)	Shoulder Width Left (Feet)	NH/HPMS	44
MEDIAN_TYPE	CHAR (1)	Median Type	NH/HPMS	44
MEDIAN_WDTH	NUM (3,0)	Median Width (Feet)	NH/HPMS	44
STREET	CHAR (18)	Street Name	NH/HPMS	45
<<< Administrative Attributes >>>				
SC	CHAR (2)	System Class	NH	46
FUNC_CLASS	CHAR (2)	Functional Class codes	HPMS	47
RURAL_URBAN	CHAR (1)	Rural Urban Codes	HPMS	47
URBAN_CODE	CHAR (3)	Urban Codes	HPMS	48
NON_ATT_AREA	CHAR (3)	Non-attainment Area	HPMS	48
UA_SAMP_TECH	CHAR (1)	Urban Area Sample Technique	HPMS	49
URBAN_LOC	CHAR (1)	Urban Location, Urban land use coding	HPMS	49
NHS	CHAR (1)	Nation Highway System codes	HPMS	49
UNBUILT_FACILITY	CHAR (1)	Identifies unbuilt facilities	HPMS	50
GLC	CHAR (2)	Government Level of Control	HPMS	50
SPEC_SYS	CHAR (2)	Special Systems	HPMS	51
TRK_ROUTE	CHAR (1)	Truck Route	HPMS	51
TOLL	CHAR (1)	Toll Code	HPMS	52
ACCESS_CONTROL	CHAR (1)	Access Control	HPMS	52
FACILITY_TYPE	CHAR (1)	Facility Type (1 = one-way, 2 = two way)	HPMS	52
TYPE_SECT_ID	CHAR (1)	Type Section ID, county record identifier	HPMS	52
FSECTION	CHAR(3)	Sequences inventory records	HPMS	53
ROW_WDTH	NUM (3,0)	Width of right of ways (feet)	HPMS	53
NDISTRICT	CHAR (2)	NHDOT's maintenance district		53
SUMMER_MAINT	CHAR (2)	Responsible for summer maintenance	NH	53
WINTER_MAINT	CHAR (2)	Responsible for winter maintenance	NH	54
CDC_COUNTER_TYPE	CHAR (2)	Traffic counter Type		54

CDC_COUNTER	CHAR (6)	Traffic counter code		54
SURVEY_DATE	DATE	Date record was updated or confirmed		55
TRAV_DIR	CHAR (1)	Direction of Inventory (N,S,E,W)		55
ORN	CHAR (4)	Old Road inventory Number	HPMS	55
FEATURE	CHAR (3)	Feature value (RDI, PS [Point Symbol])		55
HPMS_YN	CHAR (1)	Identifies HPMS sections (S,D,N)		55
<<< Route Attributes>>>				
ROUTE_SIGN_QUAL	CHAR (1)	Route Sign Qualifier, Specialized routing	HPMS	56
ROUTE_SIGN	CHAR (1)	Route Sign Code	HPMS	56
ROUTE_NO	CHAR (8)	Route Number	HPMS	56
INTERSTATE_RTE	CHAR (5)	Interstate route number		57
HI_ORDER	NUM (1,0)	Primary route assigned to a road		57
ROUTE_YN	CHAR (1)	Does this Section have a Route Number?		57
LRS_ROUTE	CHAR (10)	Linear Referencing System routes	HPMS	57
LRS_SUB_ROUTE	CHAR (2)	Linear Referencing System sub-routes	HPMS	57
<<< Primary Key>>>				
MAIN_KEY	CHAR (8)	Unique record ID		57
<<< District >>>				
PATROL_BEAT	CHAR (5)	Turning lane(s) width (feet)		58
PATROL_SUBBEAT	CHAR (2)	Sub-Routes of PATROL_BEAT		58
PATROL_SECT	CHAR (2)	Maintenance route		58
<<<Pavement Mgt >>>				
PVM_HWY	CHAR (5)	Pavement management highway identifier		58
PVM_SECT	CHAR (2)	Pavement management section identifier		58
PVM_SUBSECT	CHAR (2)	Pavement management sub-section identifier		58

Reference: NH = New Hampshire's - "Manual of Instructions for Inventory"
HPMS = Federal Highway's - "Highway Performance Monitoring System"

NOTE Records where SECT_LEN = '0' (zero) are used to indicate Gaps in the inventory number. Gaps occur were inventories overlap. These records have limited data.

Section II
Roadway inventory Codes

1-INVENTORY IDENTIFIERS:

The combination of Town, Road, and Direction uniquely identify a roadway within the state.

County: County
3 digit county code

Code	County
001	Belknap
003	Carrol
005	Cheshire
007	Coos
009	Grafton
011	Hillsborough
013	Merrimack
015	Rockingham
017	Strafford
019	Sullivan

Town: A three digit code that uniquely identifies each town, see appendix B

Road: A 4 digit code that uniquely identifies each road, within a town, in the inventory system.

Code	Description
0000 - 0075	Designated for state maintained roads
0076 - 4999	Designated for town roads
5000 - 6899	Ramps
6900 - 6999	Traffic Circles
7000 - 8999	Reserved
9000 - 9999	Highways/Intestates

Note: There are exceptions to this coding

Ramp: Indicates if the roadway is a ramp or road

Code	Description
R	Ramp
]	Road

Ramps are also coded with a 5000 series road inventory number.

Note: Ramps (inventory numbers between 5000 and 5999) have a seven (7) character coded street name.

Characters 1-3: Exit number, must have leading zeros
Character 4 : Space
Characters 5-7: Ramp letter(s)

Direction: Used to designate individual barrels of a divided highway since both barrels carry the same inventory number. N, S, E, & W, are used for divided highways only.

Code	Description
B	Non-divided highways
N	North bound
S	South bound
E	East bound
W	West bound

Segment: Dynamic Segmentation Sequence
Used to order segments of roadways, segments are created by GAP sections. All road inventory sections have a segment of 1 unless the road contains a gap. Sections after the first gap will be coded 2, etc

2-DISTANCES

MilePoint: Milepoint to .001 miles (Oracle), feet (Access). The milepoint at the beginning of each individual section of a road. It is measured from the centerline of the roadway

Sect_len: Section to .001 miles (Oracle), feet (Access). The length of a linear attribute, measured along the centerline of the highway.

3-PHYSICAL ATTRIBUTES

Pave_wdth: Lane Mile Width (feet)
Reference: Manual of Instructions for Inventory

This measurement is the width of the travel ways, to the nearest even foot, including painted medians. This width does not include shoulders or raised medians.

Surf_Type: Surface/Pavement Type

Reference: Manual of Instructions for Inventory /HPMS Item 43

A code that describes the road surface type.

Code	Description
80	Brick, Block or Other Combination
72	Reinforced Portland Concrete (Rigid)
62	Composite (Flexible Over Rigid)
61	High Flexible (Bit. Concrete)
51	Bituminous Surfaced Treated
40	Gravel
20	Unimproved Road

No_Lanes: Number of lanes:
Reference: Manual of Instructions for Inventory

Number of lanes that carries through traffic.

Lane_Wdth: Lane Width
Reference: Manual of Instructions for Inventory

Prevailing traffic lane width (through lanes) to the nearest even foot

Shoulder_Type: Shoulder type
Reference: Manual of Instructions for Inventory /HPMS Item 52

Code for the predominant type of shoulder for the section. If the left shoulder and right shoulder differ, the <u>right</u> shoulder should be considered to be the predominant type.

Code	Description
1	None -- No shoulders or curbs exist.
2	Surfaced with Bituminous Material
3	Surfaced with Portland Cement Concrete -- (not tied)
4	Surfaced with Tied Portland Cement Concrete
5	Stabilized -- A gravel or other granular material
6	Combination -- combination of codes 2-5, 7.
7	Earth -- Natural earth with or without turf.
8	Curbed -- No shoulders exist

Shldr_Left: Left shoulder
Reference: Manual of Instructions for Inventory /HPMS Item 53b

Width of the left shoulder, feet. No shoulders are coded "00"

Shldr_Right: Right shoulder 53a
Reference: Manual of Instructions for Inventory /HPMS Item

Width of the right shoulder, feet. No shoulders are coded "00".

Median_type: Median type
Reference: Manual of Instructions for Inventory /HPMS Item 33

A code describing the median type. A positive barrier would normally consist of guard-rail or concrete (Jersey type barrier), but could consist of a line of closely-spaced (large) trees or of thick, impenetrable shrubbery on most of the section. Turning lanes or bays are not considered medians unless a median exists on the major portion of the roadway, and the turning lanes/bays are cut into the median at intersection, entrances to commercial enterprises, etc.

A continuous turning lane is not to be considered a median. Continuous crosshatching that is a t least 4 feet wide may be considered a median, however, if a crosshatched portion of a roadway is used as a turning lane by law, it is to be considered a turning lane, not a median

Code	Description
0	Not on the PAS/NHS
1	Curbed
2	Positive Barrier
3	Unprotected
4	None

Median_Wdth: Median Width (feet)
Reference: Part I of Manual of Instructions for Inventory /HPMS Item 34

Exceptions

Code	Description
000	Undivided roadways
999	Median width 100 feet or greater.

Street: Street Name

Street names as issued by town officials. Always use one of the abbreviations listed below when appropriate.

Name	Abbr.	Name	Abbr.	Name	Abbr
Avenue	AV	Garden	GDN	Square	SQ
Boulevard	BLVD	Leaf	LEAF	Terrace	TER
Circle	CIR	Lane	LN	Turnpike	TPK
Corner	COR	Path	PATH	Trail	TRL
Court	CT	Park	PK	Way	WAY
Center	Ctr	Parkway	PKY	Interchange	INTERCHANGE
Drive	DR	Place	PL	Village	VIL
Extension	Ext	Ramp	R	Mountain	MT
Hill	HI	Road	RD	Pond	PD
Highway	HWY	Street	ST	Public Waters	PW

ROW_Wdth: Right of Way Width

4-ADMINISTRATIVE ATTRIBUTES

SC: System/Class, The States roadway system and class description
Reference: See Appendix C.

Code	Descriptions
11	State maintained primary system
14	State primary system within compact which is maintained by the Town or City (Urban extensions of Class I highways)
19	On the State primary system, maintained by the State Turnpike Authority.
22	State maintained secondary system
24	State secondary system within compact maintained by the Town or City (Urban extensions of Class II highways).
25	Extensions of the designated State secondary system, uncompleted and Town maintained.
27	Designed State secondary system. Uncompleted and maintained by the Federal agencies
29	On the State secondary system, maintained by the State Turnpike Authority.
33	State-maintained recreation roads.
44	Town and City maintained streets within compact areas.
55	Regularly maintained Town streets and roads outside of compact.
58	Town roads, or City streets maintained by Special Legislation.
66	Town or City streets **not** regularly maintained.
77	Federal agencies roads, maintained by the Federal agencies.
81	National system of Interstate and Defense highways State maintained.
89	National system of Interstate and Defense highways, maintained by the State Turnpike Authority maintained
99	Other highways and expressways not on the state primary or secondary systems maintained by the State Turnpike Authority.
00	Other toll roads not on the State Turnpike System ie private, Mt. Washington Toll Rd., Monadnock Toll Rd

LEGISLATIVE CLASS I - VI

Class	System / Class			
I	11	19	81	89
II	22	29		
III	33			
IV	14	24	44	
V	25	55	58	
VI	66			

Note:
Legislative Class I through VI are not carried in the Road Inventory Tables, but can be generally defined using the System / Class definitions.

Func_Class: Functional Class codes
Reference. HPMS Item 12, Appendix E.

A code describing the use of the roadway, according to the character of service they are intended to provide. Function class codes have two classifications; Rural and Urban.

Rural:

Code	Descriptions
00	Non-Public roads Example; Class VI
01	Principal Arterial -- Interstate
02	Principal Arterial -- Other
06	Minor Arterial
07	Major Collector
08	Minor Collector
09	Local

Urban

Code	Descriptions
00	Non-Public roads Example, Class VI
11	Principal Arterial -- Interstate
12	Principal Arterial -- Other Freeways and Expressways
14	Principal Arterial -- Other
16	Minor Arterial
17	Collector
19	Local

Rural_Urban: Rural/Urban codes
Reference. HPMS Item 9

A code describing rural/urban classification, assigned by the Federal Bureau of Census.

Code	Description	
1	Rural	
2	Small Urban Area	(5,000 to 49,999)
3	Urbanized Area	(50,000 to 199,999)
4	Urbanized Area	(200,000 or greater pop.)

Urban_Code: Urban area code

URBAN AREA CODE (UAC)

Small Urban	UAC	Urbanized	UAC
Gilford	707	Salem	104
Laconia	707	Plastow	104
Keene	711	Windham	104
Swanzey	711	Pelham	136
Berlin	701	*Manchester	165
Hanover	710	Auburn	165
Lebanon	708	Bedford	165
Milford	712	Goffstown	165
Boscawen	703	Hooksett	165
Bow	703	Litchfield	165
Canterbury	703	Londonderry	165
Concord	703	*Nashua	246
Franklin	706	Hudson	246
Derry	704	*Dover	283
Exeter	705	Durham	283
Hampton	709	Madbury	283
Stratham	705	*New Castle	283
Claremont	702	Newington	283
Pembroke	714	*Portsmouth	283
Allenstown	714	*Rochester	283
Londonderry	713	Rye	283
NOT LISTED	000	*Sommersworth	283

* The entire town/city is in Federal Aid Urban Area (FAUA). For the remaining towns see FAUA maps for FAUA sections.

Non_Att_Area: Non Attainment Area
Reference: HPMS Item 11

A code and description of the National Ambient Air Quality Standard (NAAQS) non-attainment area as defined by the EPA.

General Area coding

Code	Description
000	Not in non-attainment area
007	Boston Area
165	Manchester Area
246	Nashua Area
283	Seacoast (Portsmouth, Dover, Rochester, Maine)

Specific NH town coding

Code	County	Towns
000	003,007,009	All towns
165	019, 013	All towns
246	005	All towns
283	001,017	All towns
007	011	013, 063, 223, 229, 263, 297, 303, 309, 315, 359, 485
165	011	All towns not coded 007
007	015	021, 055, 113, 119, 135, 195, 199, 239, 243, 269, 341, 375, 399, 405, 409, 417, 489,
165	015	All town not coded 007

UA_Samp_Tech: Urban Area Sample Technique HPMS Item 10a
Reference. HPMS item 10a

A sequential code (1 -9) is used to consolidate all qualifying urbanized areas. (NH is not currently consolidating urbanized areas, and the field is coded 1)

Urban_loc: Urban Location
Reference: HPMS Item 31

Identifies areas with urban areas. Used only to identify type 4 Federal aid urban areas (Rural_Urban code), (population > 200,000).

NHS: National Highway System
Reference: HPMS Item 14

A code describing function in the NHS

Code	Description
0	This section is NOT on the NHS
1	This section in on the NHS but not an intermodal connector

2 -9 NHS intermodal connectors

2	Major Airport

3 Major Port facility
4 Major Amtrak station
5 Major Rail/truck terminal
6 Major Inter-city bus terminal
7 Major Public transit terminal or multi-modal passenger terminal
8 Major pipeline terminal
9 Major ferry terminal

UnBuilt_Facility. Unbuilt Facility
Reference. HPMS Item 15

A code designating roadways that are unbuilt or not open to traffic

Code	Description
0	Not on the National Highway System (NHS) and is open to public travel.
1	NHS section is built and open to public travel
2	NHS not built, but part of a short range improvement program.

GLC: Governmental Ownership (Governmental Level of Control)
Reference HPMS Item 20

A code used to identify the level of government that has responsibility for the facility. Where more than one code could be used for a section, the lowest numerical code shall be reported. Note: GLC relates to ownership of the road, not who maintains it.

Code	Description
01	State Highway Agency
03	Town or Township Highway Agency
04	Municipal Highway Agency
11	State Park, Forest, or Reservation Agency
12	Local Park, Forest, or Reservation Agency
21	Other State Agencies
25	Other Local Agencies
26	Private
31	State Toll Authority
32	Local Toll Authority
60	Other Federal Agencies (not listed below such as US Fish & Wildlife)
62	Bureau of Indian Affairs
64	US Forest Service
66	National Park Service
68	Bureau of Land Management
70	Military Reservation/Corps of Engineers

Spec_Sys: Special Systems
Reference. HPMS Item 21

Sub-systems for HPMS depicting other Federal/State roadway systems This field is used to identify the special funding categories.

Code	Description
00	Not on a Special System
01	Addition to the Interstate System (23 U.S.C. 139(c))
02	Addition to the Interstate System (23 U.S.C. 139(a)) approved before March 9, 1984
03	Addition to the Interstate System (23 U.S.C. 139(a)) approved on or after March 9, 1984
04	Future addition to the Interstate System(23 U.S.C. 139(b))
08	Strategic Highway Network (STRAHNET)
11	Appalachian Development Highway
13	Indian Reservation Roads and Bridges
15	National Forest Highway System
16	National Forest Development Roads and Trails
18	National Park Service Parkway
19	National Park Roads and Trails

Trk_Route: TRUCK ROUTE
Reference HPMS Item 23

Designated truck routes

Code	Description
1	Designated truck route -- Under Federal Authority or both Federal & State Authority
2	Designated truck route -- Only under State Authority
3	Parkway -- not on designated truck route.
4	Not a Parkway -- not on a designated truck route.

Toll: Toll
Reference: HPMS Item 24

A code indicating the toll status of the roadway.

Code	Description
1	Non-Toll
2	Toll
3	Interstate Toll segment under Secretarial Agreement (Section 105 of 1978 Federal-Aid Highway Act).
4	Interstate Toll segment under Secretarial Agreement now free of tolls.

Access_Control: Access Control
Reference: HPMS Item 32

A code designating the access control of traffic movement on to or off highways.

Code	Description
0	Not Applicable; not on NHS or PAS
1	Full Access Control
2	Partial Access Control
3	No Access Control

Facility_Type: Facility type code
Reference. HPMS Item 22

A code defining the roadway travel ways and structure.

Code	Description
1	One-Way Roadway
2	Two-Way Roadway
3	One-Way Structure (Bridge, tunnel, causeway, ect)
4	Two-Way Structure (Bridge, tunnel, causeway, ect)

Type_Sect_ID: Type Section Identifier
Reference: HPMS Item 5

Identifies the distance's unit of measure for Federal reporting. NHDOT is currently submitting in milepoint.

Fsection: Federal Section

A numeric sequence of road attribute features as they occur along a roadway. Each RDI feature is assigned a sequential number starting at the zero milepoint.

ROW_Wdth: Average Width of Right-of-Way, in feet, for section. Changes in ROW width do not cause a new section break.

Ndistrict: District
The NHDOT's Maintenance districts number

Number	Maintenance District
1	Lancaster
2	Lebanon
3	Gilford
4	Swanzey
5	Hooksett
6	Durham

Summer_Maint: Summer Maintenance

A code defining summer maintenance responsibilities.

Code	Description	Responsible for maintenance
00	Not Maintained	All
15	Summer maintained	District 1
25	Summer maintained	District 2
35	Summer maintained	District 3
45	Summer maintained	District 4
55	Summer maintained	District 5
65	Summer maintained	District 6
71	Summer maintained	Out of State
72	Summer maintained	US Forest Service
73	Summer maintained	Private
74	Summer maintained	Special Agreement
75	Summer Maintained	NH Fish & Game (Class 3A)
76	Summer maintained	US Fish & Wildlife Service
85	Summer maintained	City/Town
95	Summer maintained	Turnpike

See Appendix D for detail

Winter_Maint: Winter Maintenance Code
A code defining winter maintenance responsibilities

Code	Description	Responsible for maintenance
00	Not Maintained	All
15	Winter maintained	District 1
25	Winter maintained	District 2
35	Winter maintained	District 3
45	Winter maintained	District 4
55	Winter maintained	District 5
65	Winter maintained	District 6
71	Winter maintained	Out of State
72	Winter maintained	US Forest Service
73	Winter maintained	Private
74	Winter maintained	Separate Agreement
75	Winter maintained	NH Fish & Game (Class 3A)
76	Winter maintained	NH Fish & Wildlife Service
85	Winter maintained	City/Town
95	Winter maintained	Turnpike

See Appendix D for detail

CDC_Counter_Type: Continuous Daily Counts - Counter Type
A code describing the counter type and use. Note exceptions exist

Code	Description
01	Permanent, Directional
02	Permanent, Composite counts
21	Short Term, Directional
22	Short Term, Composite counts
61	Short Term, Flow map, Directional
62	Short Term, Flow map, Composite
71	RPC, permanent, Directional
72	RPC, permanent, Composite counts
81	Special Short term, Directional
82	Special Short Term, Composite counts

CDC_Counter: Continuous Daily Counts - Counters codes
A 6 digit code uniquely defining traffic counters, assigned by Transportation Planning's traffic section.

Code: <3 digit town code><Counter Number, unique with town>
For 3 digit town code see appendix B

Survey_date: Survey Date
Date the road was last inventoried. If a portion of road was inventoried, the survey date will be updated for the entire road.

Trav_Dir: Travel Direction

Travel direction is used to indicate the direction of inventory (N,S,E,W).

Code	Description
N	North
S	South
E	East
W	West

ORN: Old Road Number
History of the previous road inventory number This fiels is being used only for the ramps.

Feature: Feature
A code that categorizes of road inventory items.

Code	Description
RDI	Road inventory. Linear physical and administrative features
RD	Cross Roads, Intersections
BRG	Bridges
CLV	Culverts
RR	RailRoad
MSC	Miscellaneous

HPMS_YN: Highway Performance Monitoring System

Code	Description
S	Sample Section
D	Donut Sample, Area around an urbanized area
N	Not a sample section

Note: there are no sample sections on Functional Classes of 08, 09 and 19

5-ROUTES

Route_sign_qual: Route Sign Qualifier
Reference HPMS Item 18

A code designating specific use of assigned routes.

Code	Description
0	No qualifier or not signed or not applicable
1	Alternate
2	Business Route
3	Bypass
4	Spur
5	Loop
6	Proposed
7	Temporary
8	Truck Route
9	None of the above

When one or more codes are applicable the lowest code is used.

Route_sign: Route Signing code
Reference. HPMS Item 17

A code specifying the manner in which a highway is signed with route markers.

Code	Description
0	Not signed or not applicable
1	Interstate
2	US
3	State
4	Off-Interstate Business Marker
5	County
6	Township
7	Municipal
8	Parkway Marker or Forest Route Marker
9	None of the above

When a route is signed with two or more identifiers, the code for the highest class of route shall be used. The highest class is code 1 and the lowest is code 8

Route_no: Route number
Reference. HPMS Item 19
Assigned route number.

Interstate_Rte: Interstate Route
Assigned interstate route number

Hi_Order: High Order
High Order route of coincidental routes

Hierarchy

1	Interstate
2	US
3	State
4	Off-Interstate Business Marker
5	County
6	Township
7	Municipal
8	Parkway Marker or Forest Route Marker

Route_YN: Route Yes/ No
Indicates a section of roadway having a route associated with it.

LRS_Route: Linear Referencing System Route
Reference: HPMS Item 7B

A Federal Highway Referencing code used to create a nationwide GIS system.

LRS_Sub_Route: Linear Referencing System Sub Route
Reference: HPMS Item 7B

Identifies the head and back routes with milepoints that have duplicate milepoint.

6-PRIMARY KEY

Main_Key: Main Key (Primary Key)
Main Key is a unique code assigned to each record, by the database management application, and has no specific meaning. The first character generally indicates the source of the data such as which team collected the data.

7-DISTRICT

Patrol_Beat: (*Formerly Patrol Beat*) Turn lane(s) width (feet), as of July 1997

Combined width of the turning lanes in a section of road.

Patrol_Subbeat: Patrol section beat
Defined sub-routes within the patrol_beat

Patrol_Sect: Patrol section
Defined maintenance routes used by the districts

8-PAVEMENT MANAGEMENT SECTIONS: The following section are defined by the Bureau of Road Maintenance, for pavement monitoring

PVM_HWY: Pavement section - highway identifier

PVM_SECT: Pavement section - highway section identifier

PVM_SubSect: Pavement section - highway sub-section identifiers

Section III
Point Symbols

Point Symbols are used to record features that occur along an inventoried road such as intersecting roads, cultural features, drainage structures, etc. The recording of these point features is highly desirable because of their value as visual reference points and for mapping.

When point features are collected, a normal record is created in the GPS_MAIN table, including a unique key value, but the entry for 'Feature' is one of six codes that refers to the table which will contains the attributes of the feature. The associated tables contain fields for each attribute of the feature, and are described below.

Feature codes for the GPS_MAIN table:

Code	Feature Table	Description
BRG	GPS_BRG	Bridge information
CLV	GPS_CULV	Culvert data
MSC	GPS_MISC	Cultural type features
PS	none	Used to force a break in the inventory section
RD	GPS_ROAD	Intersecting Roads
RR	GPS_RAIL	Railroad crossing data

Minimum fields for the Feature Tables:

GPS_BRG	Key, Feature Code, Bridge number, Town, Comment
GPS_CULV	Key, Feature Code. Shape, Type, Height, Width, Length, Comment
GPS_MISC	Key, Feature Code, Comment1, Comment2
GPS_ROAD	Key, Feature Code, Town ID, Road ID, Ramp Code, Direction, Street Name, Paved or Unpaved (P or U)
GPS_RAIL	Key, Feature Code, RR Number, Comment

The following is a list of the recommended point symbols, along with the asociated feature table and an indication of whether the feature is required (highly desirable)

FEATURE	CODE	ASSOC TABLE	REQUIRED
ABANDONED RAILROAD	R53	GPS_RAIL	N
AIRPORT LEFT	M21	GPS_MISC	Y
AIRPORT RIGHT	M22	GPS_MISC	Y
BEACH LEFT	D07	GPS_MISC	N
BEACH RIGHT	D08	GPS_MISC	N
BRIDGE OVER	B09	GPS_BRG	Y
BRIDGE UNDER	B10	GPS_BRG	Y
CAMPSITES LEFT	D01	GPS_MISC	N
CAMPSITES RIGHT	D02	GPS_MISC	N
CEMETERY LEFT	M05	GPS_MISC	Y
CEMETERY RIGHT	M06	GPS_MISC	Y
CHURCH LEFT	M03	GPS_MISC	Y
CHURCH RIGHT	M04	GPS_MISC	Y
COUNTRY CLUB LEFT	M19	GPS_MISC	N

COUNTRY CLUB RIGHT	M20	GPS_MISC	N
COUNTY LINE	L14	GPS_MISC	Y
CULVERT	C10	GPS_CULV	Y
ELECTRIC LINES OVER	L01	GPS_MISC	Y
FIRE STATION LEFT	M09	GPS_MISC	Y
FIRE STATION RIGHT	M10	GPS_MISC	Y
GRANGE LEFT	M15	GPS_MISC	N
GRANGE RIGHT	M16	GPS_MISC	N
HISTORIC MARKER LEFT	D51	GPS_MISC	Y
HISTORIC MARKER RIGHT	D52	GPS_MISC	Y
HOSPITAL LEFT	M13	GPS_MISC	Y
HOSPITAL RIGHT	M14	GPS_MISC	Y
MILE MARKERS	R60	GPS_ROAD	N
MISC LEFT	M17	GPS_MISC	N
MISC RIGHT	M18	GPS_MISC	N
NATIONAL FOREST BOUNDARY LEFT	D19	GPS_MISC	N
NATIONAL FOREST BOUNDARY RIGHT	D20	GPS_MISC	N
NATIONAL HISTORIC SITE LEFT	D49	GPS_MISC	N
NATIONAL HISTORIC SITE RIGHT	D50	GPS_MISC	N
PARK AND RIDE LEFT	R54	GPS_MISC	Y
PARK AND RIDE RIGHT	R55	GPS_MISC	Y
PARKING AREA LEFT	R56	GPS_MISC	N
PARKING AREA RIGHT	R57	GPS_MISC	N
PARKING LOT LEFT	R58	GPS_MISC	N
PARKING LOT RIGHT	R59	GPS_MISC	N
PICNIC GROUND LEFT	D03	GPS_MISC	N
PICNIC GROUND RIGHT	D04	GPS_MISC	N
PLAYGROUND LEFT	D05	GPS_MISC	N
PLAYGROUND RIGHT	D06	GPS_MISC	N
POLICE STATION LEFT	M07	GPS_MISC	Y
POLICE STATION RIGHT	M08	GPS_MISC	Y
POWER PLANT LEFT	L25	GPS_MISC	N
POWER PLANT RIGHT	L26	GPS_MISC	N
POWER SUBSTATION LEFT	L23	GPS_MISC	N
POWER SUBSTATION RIGHT	L24	GPS_MISC	N
PRIVATE ROAD RIGHT	P06	GPS_ROAD	N
PRIVATE ROAD LEFT	P04	GPS_ROAD	N
PUMPING STATION OIL/GAS LEFT	L29	GPS_MISC	N
PUMPING STATION OIL/GAS RIGHT	L30	GPS_MISC	N
RAILROAD @ GRADE	R52	GPS_RAIL	Y
RAMP LEFT ON	R37	GPS_ROAD	N
RAMP LEFT OFF	R36	GPS_ROAD	N
RAMP RIGHT ON	R35	GPS_ROAD	N
RAMP RIGHT OFF	R40	GPS_ROAD	N
REST AREA LEFT	D13	GPS_MISC	Y
REST AREA RIGHT	D14	GPS_MISC	Y
ROAD LEFT	R10	GPS_ROAD	Y
ROAD RIGHT	R11	GPS_ROAD	Y
ROAD CROSS NORMAL	R01	GPS_ROAD	Y
SCENIC SITE LEFT	D09	GPS_MISC	N
SCENIC SITE RIGHT	D10	GPS_MISC	N
SCHOOL LEFT	M01	GPS_MISC	Y
SCHOOL RIGHT	M02	GPS_MISC	Y
SEWAGE DISPOSAL PLANT LEFT	L27	GPS_MISC	N
SEWAGE DISPOSAL PLANT RIGHT	L28	GPS_MISC	N
SMALL PARK LEFT	D11	GPS_MISC	N
SMALL PARK RIGHT	D12	GPS_MISC	N
STATE FOREST BOUNDARY LEFT	D17	GPS_MISC	N
STATE FOREST BOUNDARY RIGHT	D18	GPS_MISC	N
STATE LINE	L15	GPS_MISC	Y
STATE MAINT. FACILITIES	M30	GPS_MISC	Y
STATE PARK LEFT	D15	GPS_MISC	Y

STATE PARK RIGHT	D16	GPS_MISC	Y
TOLL BOOTH	L17	GPS_MISC	N
TOWN HALL LEFT	M11	GPS_MISC	N
TOWN HALL RIGHT	M12	GPS_MISC	N
TOWN LINE	L13	GPS_MISC	N
TOWN MAINT FACILITIES	M40	GPS_MISC	Y
TRAIL CROSS	D24	GPS_MISC	N
TRAIL LEFT	D25	GPS_MISC	N
TRAIL RIGHT	D26	GPS_MISC	N
COMPACT LINE C/S	L12	GPS_MISC	Y
COMPACT LINE S/C	L11	GPS_MISC	Y

DEFINITIONS:

Roadway : The portion of a highway, including shoulders, for vehicular use. A divided highway has two or more roadways.*

Traveled way : The portion of the roadway for the movement of vehicles, exclusive of shoulders.*

Traffic Lane : The portion of the roadway separated from the other portions by two parallel lines to channalize vehicles traveling in the same direction.

Shoulders : The portion of the roadway contiguous with traveled way for accommodation of stopped vehicles, for emergency use and for lateral support of sub-base, base and surface course. *

Median : The portion of a divided highway separating the traveled way for traffic in opposing direction. *

Intersection : The general area where two or more highways join or cross. There are three types of intersections: intersections at grade, grade separations without ramps, and interchanges *

Channeled Intersection An at-grade intersection in which traffic is directed into definite paths by islands. *

Turning roadway : A connecting roadway for traffic turning between two intersection legs. *

Interchange : An interchange is a system of interconnecting roadways in conjunction with one or more grade separations that provides for the movement of traffic between two or more roadways or highways on different levels. *

Auxiliary lane : An auxiliary lane is defined as the portion of the roadway adjoining the traveled way for parking, speed change, turning, storage for turning, weaving, truck climbing, and other purposes supplementary to through_traffic. *

Weaving section : A Weaving section is a highway segment where the pattern of traffic entering and leaving at contiguous points access results in vehicle paths crossing each other. *

Ramp : The term "ramp" includes all types, arrangements, and sizes of turning roadways that connect two or more legs at an interchange. The components of a ramp are a terminal at each leg and a connecting road, usually with some curvature, and on a grade

(Fig.II.2.1)*. The term interchange indicates that there is one or more grade separations between the interconnecting roadways. ramps components are also being referred to as deceleration lane (exit terminal. Fig.II.2.1), ramp proper and acceleration lane (entrance terminal, Fig.II.2.2). In some cases due to geometric and physical characteristic of highways the entrance terminal may be very short and followed by either a weaving section or an auxiliary lane (Fig.II.2.3).

Slip ramp : An individual turning roadway which is separated from the normal traveled way by an island at a channalized intersection (Fig.II.2.4 & II.2.5a & II.2.5b).

* The definition is in accordance with American Association of State Highway and Transportation Officials (AASHTO).

** The definition is in accordance with Highway Performance Monitoring System (HPMS)

Divided Highways : A divided highway is a highway with separated lanes for traffic in opposite direction.*

Appendix B

Town Codes

ACWORTH	001	COLUMBIA	097
ALBANY	003	CONCORD	099
ALEXANDRIA	005	CONWAY	101
ALLENSTOWN	007	CORNISH	103
ALSTEAD	009	CRAWFORDS PURCHASE	105
ALTON	011	CROYDON	107
AMHERST	013	CUTTS GRANT	501
ANDOVER	015	DALTON	109
ANTRIM	017	DANBURY	111
ASHLAND	019	DANVILLE	113
ATKINSON	021	DEERFIELD	115
ATKINSON - GILMANTON ACADEMY GRANT	507	DEERING	117
AUBURN	023	DERRY	119
BARNSTEAD	025	DIXS GRANT	503
BARRINGTON	027	DIXVILLE	121
BARTLETT	029	DORCHESTER	123
BATH	031	DOVER	125
BEANS GRANT	033	DUBLIN	127
BEANS PURCHASE	035	DUMMER	129
BEDFORD	037	DUNBARTON	131
BELMONT	039	DURHAM	133
BENNINGTON	041	EAST KINGSTON	135
BENTON	043	EASTON	137
BERLIN	045	EATON	139
BETHLEHEM	047	EFFINGHAM	141
BOSCAWEN	049	ELLSWORTH	143
BOW	051	ENFIELD	145
BRADFORD	053	EPPING	147
BRENTWOOD	055	EPSOM	149
BRIDGEWATER	057	ERROL	151
BRISTOL	059	ERVINGS LOCATION	505
BROOKFIELD	061	EXETER	153
BROOKLINE	063	FARMINGTON	155
CAMBRIDGE	065	FITZWILLIAM	157
CAMPTON	067	FRANCESTOWN	159
CANAAN	069	FRANCONIA	161
CANDIA	071	FRANKLIN	163
CANTERBURY	073	FREEDOM	165
CARROLL	075	FREMONT	167
CENTER HARBOR	077	GILFORD	169
CHANDLERS PURCHASE	079	GILMANTON	171
CHARLESTOWN	081	GILSUM	173
CHATHAM	083	GOFFSTOWN	175
CHESTER	085	GORHAM	177
CHESTERFIELD	087	GOSHEN	179

CHICHESTER	089	GRAFTON	181
CLAREMONT	091	GRANTHAM	183
CLARKSVILLE	093	GREENFIELD	185
COLEBROOK	095	GREENLAND	187
GREENS GRANT	189	MADBURY	281
GREENVILLE	191	MADISON	283
GROTON	193	MANCHESTER	285
HADLEYS PURCHASE	509	MARLBOROUGH	287
HALES LOCATION	511	MARLOW	289
HAMPSTEAD	195	MARTINS LOCATION	291
HAMPTON	197	MASON	293
HAMPTON FALLS	199	MEREDITH	295
HANCOCK	201	MERRIMACK	297
HANOVER	203	MIDDLETON	299
HARRISVILLE	205	MILAN	301
HARTS LOCATION	207	MILFORD	303
HAVERHILL	209	MILLSFIELD	305
HEBRON	211	MILTON	307
HENNIKER	213	MONROE	311
HILL	215	MONT VERNON	309
HILLSBOROUGH	217	MOULTONBOROUGH	313
HINSDALE	219	NASHUA	315
HOLDERNESS	221	NELSON	317
HOLLIS	223	NEW BOSTON	319
HOOKSETT	225	NEW CASTLE	323
HOPKINTON	227	NEW DURHAM	325
HUDSON	229	NEW HAMPTON	329
JACKSON	231	NEW IPSWICH	333
JAFFREY	233	NEW LONDON	335
JEFFERSON	235	NEWBURY	321
KEENE	237	NEWFIELDS	327
KENSINGTON	239	NEWINGTON	331
KILKENNY	241	NEWMARKET	337
KINGSTON	243	NEWPORT	339
LACONIA	245	NEWTON	341
LANCASTER	247	NORTH HAMPTON	345
LANDAFF	249	NORTHFIELD	343
LANGDON	251	NORTHUMBERLAND	347
LEBANON	253	NORTHWOOD	349
LEE	255	NOTTINGHAM	351
LEMPSTER	257	ODELL	513
LINCOLN	259	ORANGE	353
LISBON	261	ORFORD	355
LITCHFIELD	263	OSSIPEE	357
LITTLETON	265	PELHAM	359
LIVERMORE	267	PEMBROKE	361
LONDONDERRY	269	PETERBOROUGH	363
LOUDON	271	PIERMONT	365
LOW - BURBANKS GRANT	273	PINKHAMS GRANT	367
LYMAN	275	PITTSBURG	369
LYME	277	PITTSFIELD	371

LYNDEBOROUGH	279
PLAISTOW	375
PLYMOUTH	377
PORTSMOUTH	379
RANDOLPH	381
RAYMOND	383
RICHMOND	385
RINDGE	387
ROCHESTER	389
ROLLINSFORD	391
ROXBURY	393
RUMNEY	395
RYE	397
SALEM	399
SALISBURY	401
SANBORNTON	403
SANDOWN	405
SANDWICH	407
SARGENTS PURCHASE	497
SEABROOK	409
SECOND COLLEGE GRANT	515
SHARON	411
SHELBURNE	413
SOMERSWORTH	415
SOUTH HAMPTON	417
SPRINGFIELD	419
STARK	421
STEWARTSTOWN	423
STODDARD	425
STRAFFORD	427
STRATFORD	429
STRATHAM	431
SUCCESS	517
SUGAR HILL	499
SULLIVAN	433
SUNAPEE	435
SURRY	437
SUTTON	439
SWANZEY	441
TAMWORTH	443
TEMPLE	445
THOMPSON - MESERVES PURCHASE	447
THORNTON	449
TILTON	451
TROY	453
TUFTONBORO	455
UNITY	457
WAKEFIELD	459
WALPOLE	461

PLAINFIELD	373
WARNER	463
WARREN	465
WASHINGTON	467
WATERVILLE VALLEY	469
WEARE	471
WEBSTER	473
WENTWORTH	475
WENTWORTHS LOCATION	477
WESTMORELAND	479
WHITEFIELD	481
WILMOT	483
WILTON	485
WINCHESTER	487
WINDHAM	489
WINDSOR	491
WOLFEBORO	493
WOODSTOCK	495

County Codes

BELKNAP	001
CARROLL	003
CHESHIRE	005
COOS	007
GRAFTON	009
HILLSBOROUGH	011
MERRIMACK	013
ROCKINGHAM	015
STRAFFORD	017
SULLIVAN	019

State/Country Codes

NEW HAMPSHIRE	600
MAINE	700
MASSACHUSETTS	800
VERMONT	900
CANADA	950

Appendix C

SC = SYSTEM & CLASS CODES

system class

system	class	
1		System one (1): This code indicates that the road is on the State Primary System as referred to by RSA 229:2
	1	Class one (1): This code indicates that the road is maintained by New Hampshire Department of Transportation
	4	Class four (4): This code indicates that the road is within a compact area and is maintained by the town or city. Class Four (4) would also indicate that the Commissioner of Transportation has established a compact section in the town or city RSA 229:5 IV. These roads are included in the "Block Grant Aid" mileage.
	9	Class nine (9): This code indicates that the road is maintained by the State Turnpike Authority or Agency. The roadway may or may not pass through compact sections. These roadways are exempt from RSA 229:5 IV
2		System two (2) shows all roads in the state that are part of the State Secondary System as referred to by RSA 229:4
	2	Class two (2). This code indicates that the road is maintained by the New Hampshire Department of Transportation
	4	Class four (4). This code indicates that the road is within a compact area and is maintained by the town or city. Class Four (4) would also indicate that the Commissioner of Transportation established a compact section in the town or city RSA 229:5 IV. These roads are included in the "Block Grant Aid" mileage.
	5	Class five (5). This code indicates that the road is maintained by the town/city. If the town/city upgrades these roadways to class (2) standards they become part of the State Secondary System as authorized by the Legislature. These roads are included in the "Block Grant Aid" mileage
	7	Class seven (7): This code indicates that the road is maintained by the Federal Agencies. This class can be used only if there is an agreement between the Federal Agencies and the NH Department of Transportation. An example of this class may be found in the Town of Carroll, NH on Cherry Mountain Road
	9	Class nine (9): This code indicates that the road is maintained by the State Turnpike Authority or Agency. These roadways may or may not pass through a compact.. Note: there is only one town with this S.C., Merrimack (297). This "SC" may not be assigned to roadways without the legislature authorization.
3		System three (3) consist of all recreational roads leading to, and within, state reservations designated by the Legislature RSA 229:5 III .
	3	Class three (3): This code indicates that the roadway is maintained by the NH Department

of Transportation Adding to or deleting from this class requires the Legislative change in hand.

3-A Class "3-A" consists of all new boating access highways RSA 230:45-47and shall have an access control code of 1 "limited access". Note only the Governor & Council may discontinue any class III-A highway.

4 System four (4) This code includes all street inside the compact delimited area as defined by the Commissioner of the Department of Transportation This will consist of all streets which are regularly maintained and open to traffic and met the conditions of a "public road".

4 Class four (4). This code includes all streets inside the compact delimited area, which are not extension of either the state primary or secondary systems, and met the conditions of a "public road"

5 System five (5) This system consists of all roadways outside of compact area and met the conditions of a public road and are maintained regularly by the city/town

5 Class five (5). This class consists of all town/city street or road outside of compact area (when a town/city road or street passes across the compact line it becomes an "SC" of "44"). Some class V roads are known as summer cottage roads. these roads RSA 231:79-81 are not maintained between Dec 10-Apr 10 but are still Class V Also, there road in towns which may carry the term winter road RSA 231:24 which means they are only winter maintained but are class V roads. Most roads will be maintained year round.

8 Class eight (8). This code indicates that the road is being maintained under special legislation (State of New Hampshire) by the town/city. Maintenance for these roads are paid out of a special fund. Sandwich Notch Road in the Town of Sandwich is the only road in this category, and is not being maintained in the winter Chapter 55 NH laws of 1955

6 System six (6) shall consist of all roads discontinued and subject to gates and bars except as provided in Class III-A (RSA 229:5 III-A) and those roads which have not been repaired or maintained in suitable condition for travel for 5 (five) years or more.

6 Class six (6) roads are non-public roads. These roads are not maintained They may have any surface type Their functional classification is always "00".
Note: Class six (6) is the only class which may have a pavement type of 20. this surface may not appear on a public road

7 System seven (7) shall consist of all Federal Agencies roads providing they meet the qualifications of a public road
Note: These roads must have a federal maintenance level of 3, 4, or 5 to qualify as a "public road"

7 Class seven (7): This code indicates that the road is maintained by the Federal Agencies

8 System eight (8): This code defines highways and their ramps that are part of the National

System of Interstates and Defense Highways RSA 229:3
Note: These roadways are also part of the State Primary System RSA 229:3 and are limited access highway and must have an access code = 1 (one)

1 Class one (1): This code indicates that the New Hampshire Department of Transportation is responsible for the roadway maintenance.

9 Class nine (9): This code indicates that the roadway is maintained by the State Turnpike Authority or Agency. These roadways may or may not pass through compacts and are limited access highways and are exempt from the compact sections laws RSA 229:5 IV & 230:44.

9 System nine (9). This code indicates that the roadway is part of the State Turnpike System, however it is not on the State Primary System or Secondary System. There has been only one road in this category (US 1 bypass in the City of Portsmouth prior to 1993, Road Inv #0990)

9 Class nine (9): This code indicates that the road is maintained by the State Turnpike Authority.

0 System zero (0) This code indicates that the roadway is a toll road but it is not on the State Turnpike System i.e. Private Sara Long Bridge, NH/Maine Bridge Authority, (Mt. Washington Toll Road and the Monadnock Toll Road.

0 Class zero (0) maintenance responsibility has not been determined in some cases.

MAINTENANCE CODES

SUMMER

00	Not Maintained	
15	Regular Maintenance	Dist. 1
25	Regular Maintenance	Dist. 2
35	Regular Maintenance	Dist. 3
45	Regular Maintenance	Dist. 4
55	Regular Maintenance	Dist. 5
65	Regular Maintenance	Dist. 6
70	Open Field	
71	Open Field	
72	US Forest Service Maintenance	
73	Private	
74	Separate Agreement	
75	NH Fish & Game (Class 3A)	must have access control = 1
76	US Fish & Wildlife Service	
77	Open Field	
78	Open Field	
79	Open Field	
85	Regular Maintenance Town/City	
95	Regular Maintenance Turnpikes	

WINTER

00	Not Maintained	
15	Regular Maintenance	Dist. 1
25	Regular Maintenance	Dist. 2
35	Regular Maintenance	Dist. 3
45	Regular Maintenance	Dist. 4
55	Regular Maintenance	Dist. 5
65	Regular Maintenance	Dist. 6
70	Open Field	
71	Open Field	
72	US Forest Service Maintenance	
73	Private	
74	Separate Agreement	
75	NH Fish & Game (Class 3A)	must have access control = 1
76	US Fish & Wildlife Service	
77	Open Field	
78	Open Field	
79	Open Field	
85	Regular Maintenance Town/City	
95	Regular Maintenance Turnpikes	

LEVEL OF SERVICE CODES

10-19	Reserved for District 1
20-29	Reserved for District 2
30-39	Reserved for District 3
40-49	Reserved for District 4
50-59	Reserved for District 5
60-69	Reserved for District 6
80-89	Reserved for Town/City
90-99	Reserved for Turnpike

00 <u>Not Maintained</u>

This code indicates that the road is not maintained. This code will always appear on State Class 6 roads and on roads not being maintained during winter or summer.

15 <u>Regular Maintenance Dist. 1</u>

The codes 10-19 reflect a Level Of Service (LOS) and are currently not being used. The code 15 was selected as the code for regular maintenance

70 = Open Field =

71 = Open Field =

72 US Forest Service Maintenance

This code indicates that the road is maintained by the US Forest Service.

73 Private

This field is not used at present but could be applied to Class VI road being maintained privately.

74 Separate Agreement

This would reflect a contract between a contractor and the state or a town/city to maintain certain roads. This can also apply to bridges, i.e. Sara Long Bridge which is owned by NH/Maine bridge authority

75 N.H. Fish & Game (F&G)

These roads are maintained by N.H. Fish & Game. These roads consist of boat launches to great ponds (must be at least 10 acres) with an access control of 1 "limited access" Note. Roads to the public water do not become Class 3A by virtue of road to a lake, they will stay Class V or VI as they were laid out.. A road must be laid out by the Governor & Council to become a Class 3A

76 US Fish & Wildlife (USF&G)

These roads are maintained by USF&W They will carry a SC=77 with a unique maintenance code. These roads must meet the "Public Road" qualification.

77 Open Field

78 Open Field

79 Open Field

Appendix E

FUNCTIONAL CLASSIFICATION
DEFINITION AND SYSTEM CHARACTERISTICS

DEFINITION

Functional Classification is the process by which streets and highways are grouped into classes, or systems according to the type of service they are intended to provide. Basic to this process is the understanding that individual roads or streets do not serve travel independently, rather travel involves movement thru a series of roadways in a logical manner by defining the part any particular road or street can play in serving traffic flowing through a highway network

FUNCTIONAL SYSTEM HIERARCHY

RURAL	SMALL URBAN	URBANIZED
Principal Arterial	Principal Arterial	Principal Arterial
Minor Arterial Roads	Minor Arterial Streets	Minor Arterial Streets
Collector Roads	Collector Streets	Collector Streets
Local Roads	Local Streets	Local Streets

SYSTEM CHARACTERISTICS
FUNCTIONAL SYSTEM FOR A "RURAL" AREA

01	Principal Arterial (Interstate)	The Interstate System of all presently designated routes currently rural in character. These corridors are used basically for Statewide and Interstate travel
02	Other Principal Arterial (OPA-R)	These (OPA) systems provide an integrated network of highways between cities and larger towns and usually has no stub connection except at coastal cities or international boundaries. This is at a statewide view.
06	Minor Arterials (Rural)	These are the feeder highways that serve a variety of traffic. They may serve as links between larger towns and some smaller cities. They also serve as traffic generators to and from urban or urbanized areas but are rural
07	Major Collector	These routes provide for service to local centers of government, but are of a lesser importance then those highways serving cities and larger towns. They also serve as traffic generators to schools, shipping & receiving points, while these routes do not serve a statewide condition, they are important to the county or region where they exist.
08	Minor Collector	This system should be consistent with the population of the areas because it is the last system before the local road system. It also provides service to the remaining smaller communities.
09	Local (Rural)	The local FC primarily provides access to adjacent land, also for travel of relatively short distance. This mileage will constitute the bulk of the "rural public road mileage"

SYSTEM CHARACTERISTICS
FUNCTIONAL SYSTEM FOR A URBAN AREA

11	Principal Arterial (Interstate	In an urban area are there to service both statewide and interstate trips as well as major movement of traffic within the urban and urbanized area. They carry a major portion of traffic entering and leaving the urban area. These highways are always limited access facilities with no At-Grade intersections. Intersections are of greater in number then a rural interstate (a divided highway).
12	Principal Arterial (Other Freeways & Expressways)	These are made up of other major highways, which have grade separated interchanges and are controlled access facilities and again are in an urban area. There is no firm spacing between interchanges but are there to service the needs of that particular urban area. Note: These highways are divided highways and have the same characteristics as interstates.
14	Other Principal Arterials (OPA-U)	These highways are made up of major roads but do not have the same characteristics as functional class 11 & 12 and related highways. They are usually not grade-separated highway but highways that serve the entire-urban area and are usually connected to a higher functional system. The traffic generation on them is from the movement to and from lesser or equal functional systems.
16	Minor Arterials (Urban)	The minor arterial system includes highways or streets that serve a lower level of traffic. Such highways may carry local bus routes or provide inter-urban connections, but should not penetrate into neighborhoods. This system should connect to rural collector roads where such roads have not been made principal arterial highways and connect to a higher urban arterial system.
17	Collector (Urban)	The urban street collector system services traffic from residential neighborhoods, commercial, and industrial areas. It is different than an arterial system because it penetrates residential neighborhoods, distributing trips from Arterials to local streets.
19	Local (Urban)	The local street system comprises all public roadway not on a higher functional class system. It serves to primarily provide direct access to abutting land and the access to the higher order functional class system. It has the largest level of ability and would usually have no bus routes and thru travel on this system would be discouraged.

Source: Highway Functional Classification: concepts, criteria, and procedures. FHWA, March 1989. Title 23, U.S.C. (23 CFR 470)

Public Road "A public road is any road under the jurisdiction of and maintained by a public authority and open-to public travel" (23 U.S.C. 101(a))

Appendix F

METRIC CONVERSION TABLES

	English Units (Feet)	Metric Units (Meters)
Lane Widths	9	2.7
	10	3.0
	11	3.3
	12	3.6
	13	3.9
	14	4.2
Shoulder Widths	4	1.2
	5	1.5
	6	1.8
	8	2.4
	10	3.0
	12	3.6
Median Widths	4	1.2
	6	1.8
	14	4.2
	16	4.8
	18	5.4
	20	6.0
	32	9.6

Bases of Conversion

NHDOT has chosen ASTM E 380-93 "Standard Practice For Use of The International System of Units" as the reference document for conversion and rounding.

The basis of metric conversion in New Hampshire by State Law is 39.97 inches = 1 meter, which is known as the U.S. Survey Foot. The New Hampshire State Plane Coordinate System of 1983 is based on the U.S. Survey Foot. The more common factor is 1 inch = 25.4 millimeters which is known as the International Foot.

U.S. Survey Foot.	1 m = 39.37 / 12 = 3.280833333 ft.
International Foot.	1 m = 3.280839895... ft.

Source. "*Metric Conversion Guide*", *New Hampshire Department of Transportation, May 1998*

APPENDIX E

Connecticut Transportation Institute Summary Tables of Other Transportation Agencies

List of Respondents

State DOT	City	County	Network Mileage
California			15,200
Connecticut			3,700
New York			16,500
Utah			5,900
Wisconsin			12,000
Arkansas			16,500
Tennessee			14,000
	Tucson, AZ		400
		Oakland, MI	2,600

Table 2

Summary of Data Collection and Distribution Methods
Employed by Other Transportation Agencies

12 Questionnaires Sent Out	10 to DOTs 1 to a city 1 to a county
9 Questionnaires Returned	7 DOTs, City & County

Question	Summarized Response		FDOT
Who Obtains Images	Agency	7	
	By Contract	2	←
Medium to Obtain Images	Film	2	
	Analog tape	2	←
	Digital Tape	1	
	CD-ROM or DVD	2	←
	Not Reported	2	
Area Recorded	Driver's Eye View	9	←
	Right Side View	3/9	
	Pavement View	1/9	
Extent of Imaging	Bi-Directional (All Roads)	8/9	←
	I-Ramps	1/9	
	1 way-2 lane undivided	1/9	
Collection Frequency	Once/year	2*	
	Once/2 years	3**	
	Other (3-10 yr.)	5	←
Distance Interval	Continuous video	2	←
	0.01/mile	6	←
	Other	1	
Editing	Agency	7	
	By Contract	1	←
	Both	1	
Edit Interval	0.005/mi	1	
	0.01/mi	4	←
	None	4	

Table 2 (Continued)

Storage Medium	Tape	2	←
	CD-ROM	2	←
	DVD	1	
	Hard Disk	6	←
	Laser Disk	1	
	Film	1	
Digital Storage Parameters	MPEG	1	
	Compression JPEG	6	←
	Resolution 640 x 480 to 1300 x 1030 pixels	6/9	←
	File Size 50-110 kb	6/9	←
	Not Reported	2	
Distribution System	Network (Server)	7/9	←
	Film	1/9	
	Laser Disk	1/9	
	CD-ROM		←
	Tape		←

* Arkansas Interstate Only
** Arkansas all non-Interstate

Table 3

Additional Data Obtained During Videolog Field Activities

Data Item	Number of Agencies	Interval
Roughness	3	1@10m 1@0.005mi 1@0.025mi
Grade	5	1@0.005mi 1@4m 1@0.025mi 1@0.01mi 1 unreported
Cross Slope	3	1@0.005mi 1@5m 1@0.025mi
Distance (Chainage)	6	1@0.005mi 3@0.01mi 1@4,5&10mi 1@0.025m
Texture	None	
Transverse Profile	3	1@0.005mi 1@4m 1@0.025mi
GPS*	5	1@0.005mi 1@10m 3@0.01mi
Heading	4	1@0.005mi 1@4m 1@0.025mi 1@0.01mi
Distress	1	1@0.01mi
Skid Number	None	

*One State to add GPS

Table 4

Processing, Storage and Distribution of Data Acquired by
Other Transportation Agencies

Data Item	Post Processing	Storage CD-ROM	Hard Disk	Digital Video Disk
Horizontal Curve	5	1	4	1
Vertical Curve	5	1	5	1
Longitudinal Profile	1	1	2	1
Transverse Profile	2	1	2	1
Rut	4	2	4	1
Texture	-	-	-	-
Shim Quantity	-	-	-	-
	Real Time			
Roughness		2	4	1
Grade		2	6	1
Cross-Slope		2	3	1
Distance		3	4	1
Texture			NONE	
Trans. Profile		2	3	1
GPS		3	6	1
Vehicle Altitude		2	4	1
Skid Number			NONE	

APPENDIX F

Contacts and System Providers

Contacts

Transportation Agency

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GIS

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System Providers

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Roadware has regional offices in Pennsylvania and Florida in North America. Contact for the name of an agent in regions outside of North America.

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