McCOMB/PIKE COUNTY
ITS MASTER PLAN
SYSTEMS ENGINEERING ANALYSIS

Prepared for:

Mississippi Department of Transportation

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MCCOMB /PIKE COUNTY ITS MASTER PLAN
SYSTEM ENGINEERING ANALYSIS

Executive Summary

The purpose of this Master Plan is to outline the requirements to support an Intelligent Transportation System (ITS) communication network for the Mississippi Department of Transportation (MDOT) and other public agencies within the McComb/Pike County region. This master plan will provide a framework for further development of the System Engineering Analysis (SEA) for a regional ITS network to include the City of McComb, Pike County and surrounding agencies. This study is intended to follow the Federal Highway Administration (FHWA) system engineering requirements as outlined in Title 23–Code of Federal Regulations, Section 940. This ITS master plan will become part of the regional MDOT ITS system for this area. It is intended to assess the following components for the City's ITS communication network system:

- Identify the portions of the regional ITS architecture
- Identify the system users/stakeholders
- Assist in identifying communication needs and requirements
- Analysis of alternative system configurations and technology
- Provide a framework for developing system concepts
- Provide guidelines for developing an implementation plan

The use of the system engineering approach is not new to the ITS practice. FHWA Rule 940 provides policies and procedures for implementing Section 5206(e) of the Transportation Equity Act of 21st Century (TEA 21), Public Law 105-178, 112 Stat. 457 pertaining to the conformance with the National ITS architecture and supporting standards. This rule basically states that all ITS projects-funded with Federal Highway Trust Funds must be based on a SEA. The "V" Diagram or Model is the visual illustration of a SEA used for ITS with each step involved as the project progresses through the development stages. The left side of the diagram provides a top-down approach for the system planning and design development while the right side provides the bottom-up implementation approach to the system. **Figure 1** shows the FHWA "V" Diagram.

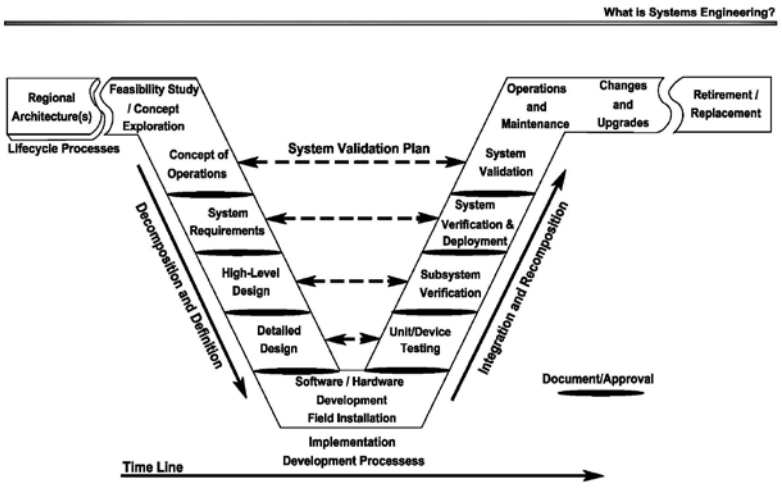


Figure 1: Systems Engineering "V" Diagram

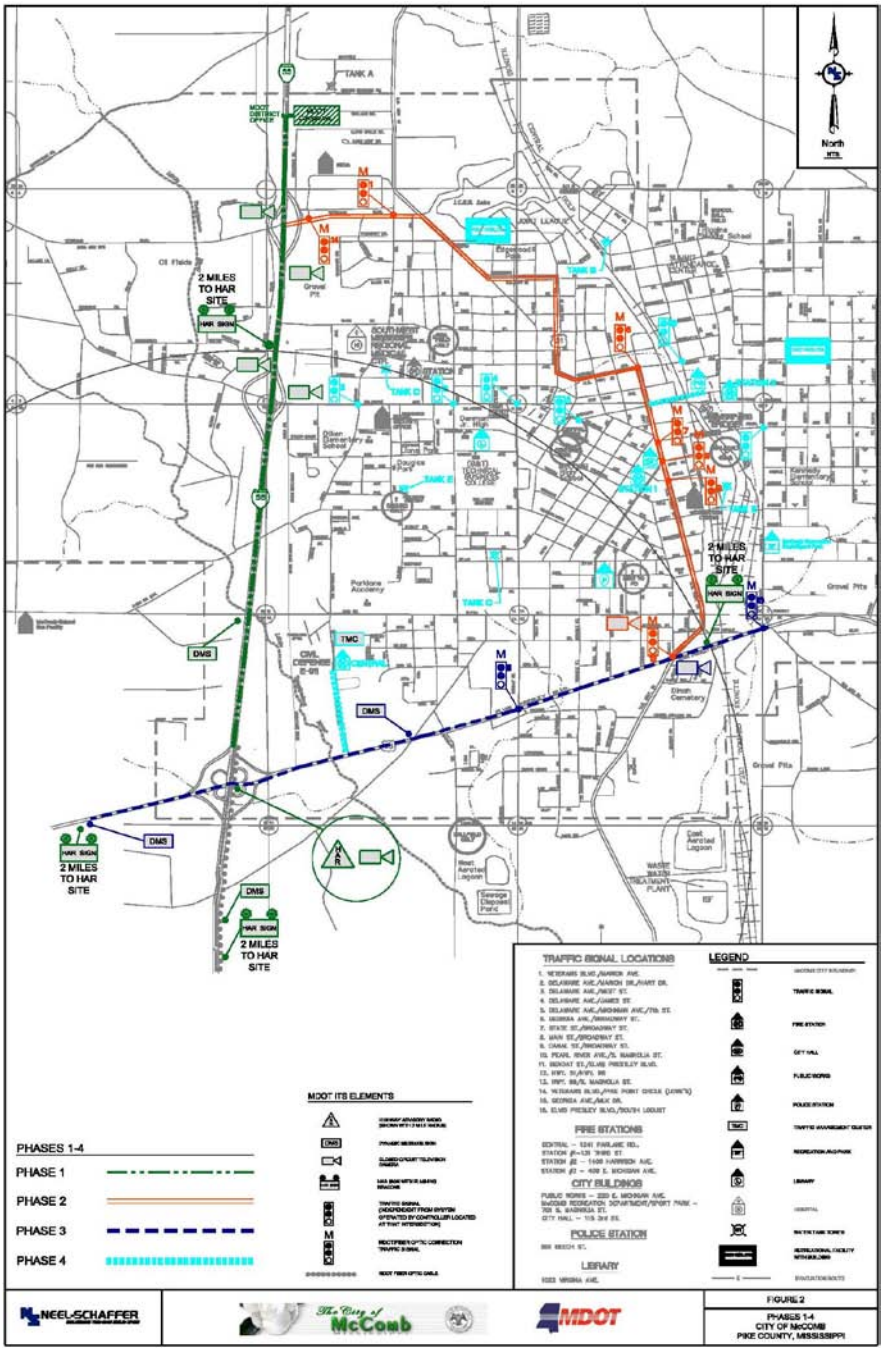
SEA is an inter-disciplinary approach and a means to enable the realization of successful systems. System Engineering requires a broad knowledge of the overall network development in keeping the "big picture" concept in mind towards a focused objective. To assist in the development of the necessary infrastructure, MDOT is coordinating with the City of McComb for the preparation of this ITS

master plan as the preliminary steps in the implementation of the SEA for a regional ITS system for this area. This plan will provide MDOT and the local agencies the framework for planning its communication network, coordinating system integration, and expanding the ITS network to include other needs for the city, schools, hospitals, and other public agencies. This ITS network will tie into the MDOT freeway management system which will allow the City of McComb and Pike County to coordinate the local and regional transportation system with the MDOT statewide ITS system.

This ITS master plan will identify the user needs of the local stakeholders for communication and ITS requirements. The stakeholder committee is comprised of local city officials and other public sector representatives. The members include staff department heads from the City of McComb and other public agencies, such as the McComb school district and the Pike County emergency management agency, participated in a needs assessment for an ITS network. The objectives to identify the system users, provide a preliminary layout for the regional fiber-optic network connection of an existing backbone system, build consensus with the other public agencies in approving a regional communication system, and form a partnership for the development and implementation of the communication system. The public partnership will work cooperatively to seek funding from local, county, state, and federal grant programs to implement the communication system.

For this study, the proposed McComb/Pike County ITS network is comprised of an existing system and the proposed MDOT freeway ITS system. **Figure 2** (See Appendix for 11"x17" size) illustrates the initial ring configuration of the proposed fiber optic network backbone system and the proposed MDOT ITS communication with the freeway ITS elements.

Figure 2 – Proposed Phases 1-4



McCOMB/PIKE COUNTY ITS MASTER PLAN
SYSTEM ENGINEERING ANALYSIS

1. Purpose

This ITS Master Plan and SEA is intended to document the initial planning and development process that follows the FHWA minimum systems engineering requirements as outlined in Title 23 – Code of Federal Regulations, Section 940. The study will document the following items:

- Identify the portions of the regional ITS architecture
- Identify the system users/stakeholders
- Identify communication needs and requirements
- Analyze alternative system configurations and technology
- Provide a framework for developing system concepts
- Provide guidelines for developing an implementation plan

2. Description of Project

MDOT ITS Communication and Freeway Management System
MDOT is proposing a statewide ITS communication system along the freeways in coordination with the MDOT Hurricane Response/Incident Management Projects. As part of these ITS projects, MDOT is planning to install fiber optic communication along I-55, US 51 and US 98 which will be tied back to the District Traffic Management Center as well as to the state headquarters in Jackson, Mississippi. In addition to the fiber optic communication, MDOT will deploy several ITS freeway elements to assist in managing traffic, provide traveler information, and assist in incident response and emergency evacuations. These ITS elements include the following:

- Backbone fiber optic communication
- Closed Circuit Television Cameras (CCTV)
- Highway Advisory Radio (HAR)
- Advance HAR warning signs with flashing beacons
- Dynamic Message Signs (DMS)

This ITS deployment plan is to relieve congestion, enhance traffic safety, and facilitate mobility along the transportation corridors by the implementation of the city's ITS master plan for an Advanced Traffic Management System (ATMS) which will tie into the MDOT statewide ITS communication system to integrate incident management and provide real time traffic conditions to assist in managing traffic operations and traffic safety improvements.

Figure 2 (see Appendix for a 11"x17" size) illustrates the locations of a proposed new fiber optic communication network in relation to the existing city facilities and MDOT roadway system. The proposed new communication network would use the following streets and highways:

- I-55 from the north to the south
- US 51 from the west to the south to US 98
- US 98 from west at I-55 to the east at Old Hwy 24

The proposed McComb/Pike County ITS master plan has identified four phases in the implementation of a regional ITS communication and system elements. As noted, **Figure 2** illustrates the four phases and the various ITS elements and communication for each phase. The following is a detail description of each phase.

McComb/Pike County ITS Master Plan Deployment Phasing

- **Phase 1** - I-55 Communication and ITS Elements
  - Install two 2-inch Conduit and Fiber Optic Cable on I-55.
  - Install five CCTV Sites.
  - Install two DMS Sites.
  - Install one HAR Site with four Advance Beacon Signs.
  - New Traffic Management Center (TMC) at MDOT District Office.

- **Phase 2** - US 51 Fiber Optic Communication
  - Install two 2-inch Conduit and Fiber Optic Cable.
  - Install one CCTV site at the intersection of I-55 and US 98.
  - Connect existing MDOT traffic signals.

- **Phase 3** - Completion of the communication network with the southern section
  - Install two 2-inch Conduit and Fiber Optic Cable along US 98.
  - Install One CCTV Site.
  - Install two DMS Sites.
  - Connect existing MDOT traffic signals.

- **Phase 4** – Citywide traffic signals and TMC facility
  - Install two 2-inch Conduit and Fiber Optic Cable to Central Fire Station and to the Public Works Offices.
  - Install new TMC at Central Fire Station.
  - Connect City Hall.
  - Connect Fire Stations 1 and 3.
  - Connect the existing traffic signals to the communication system.
  - Connect Parks and Recreation Sites.
  - Install citywide wireless communication network.

See **Figures 3-6** in the Appendix for the details of each ITS site location and the phasing.

MDOT, partnering with the City of McComb and Pike County, is considering options to provide a Citywide/Regional ITS Communication System for various city department needs as well as other public agencies within the area. The city currently depends on a leased service communication network that connects staff at all city facilities for voice, data and video communications. The existing communication network is currently a leased lined system from a private provider. Due to increasing cost as the city continues to utilize more communication applications, the need to provide a city communication network is essential to cut future costs and be able to expand for the growth of the city needs.

A fiber optic communication backbone network is currently being considered by the McComb School District, similar to the system being provided for the Natchez School District. This communication fiber optic backbone system is a private network which the school district contracts with a private company for communication service. Typically, the private provider will install the fiber optic communication on an aerial system within the city streets using the existing utility poles.

In addition, the City of McComb can implement a citywide wireless network using the latest wireless broadband communication technology. This new system can provide high-speed wireless communication and data networking. The city's water towers can be used to mount the wireless antennas/dishes which can then communication to the various city field elements such as traffic signals, park and recreation cameras, lift and pump station. These elements can communicate back to the city's future traffic management center and to other city workstations.

Figure 2 also identifies the following existing city site locations which will need to be connected. These facilities are the following:

- School sites
- Traffic Signals (along Delaware, US 51, Elvis Presley Boulevard (US 98)
- Water Tanks (D, E and F)
- Fire Stations – Station 1 and 3 and Central (Parklane Drive)
- Police Station – (21st Street)
- City Hall
- Public Works (E. Michigan)
- Water and Sewer (pump and lift stations)
- Water and Sewer Treatment Plants
- Recreation and Parks (various sites)
- Civil Defense 911 – Central Fire Station
- Hospital/Medical Center (Marion Drive)

All of the existing city facilities are located close to the existing fiber optic backbone communication line, except for water tank C, library, recreation building, police, public works and the central fire station. These facilities could be connected to a separate fiber line or a wireless broadband communication network. The communication system will need to be flexible to accommodate dynamic changes as the network expands and connects into a redundant system. The system will use an open architecture framework to be compatible with other systems and compatible to the MDOT ITS network. The master plan will consider the connection of all sites as the basic parameter to be included in the completion of the SEA.

3. Identification of the ITS Architecture

This project has the potential to become a public partnership between the city, school district, hospital/medical center, and MDOT, as it ties into the state and regional ITS communication network. Part of the system analysis is the user need requirements. The following identifies the city user and other participating agency needs as it relates to the ITS standard elements. These needs are categorized using the ITS standards for system elements and key functional requirements. They are grouped into the following:

Table 1 – User Needs and Functional Requirements

Users	User System Elements	Key Functions
• Police	Incident Management Surveillance	1. Direct incident response units to locations. 2. Identify and verify incidents. 3. Monitor the incident. 4. Provide information to field unit. 5. GPS to track vehicles.
• Fire	Incident Management	1. Direct incident response. 2. Monitor the incident. 3. Provide information to field unit. 4. GPS to track vehicles.
• Schools	En-Route Driver Information	1. Provide traffic information to buses. 2. Notify bus drivers of incidents. 3. GPS to track vehicles.
• Public Works	En-Route Driver Information Surveillance	1. Provide traffic information to travelers. 2. Notify maintenance of incident. 3. Provide real time information of traffic. 4. Identify and verify incidents. 5. GPS to track vehicles.
• Traffic	Traffic Control Surveillance	1. Provide sharing traffic signal information. 2. Provide agency communication. 3. Implement traffic management strategies. 4. Monitor traffic and signal timings. 5. Process, update, and retrieve traffic data. 6. Identify and verify incidents.
• Parks	Surveillance Archived Data Function	1. Monitor remote parks and area. 2. Identify and verify park security. 3. GPS to track vehicles.
• Emergency Management	Incident Management Emergency Notification Emergency Management	1. Monitor the incident. 2. Provide information to field units. 3. Notify 1st and 2nd responders of incident. 4. Coordinate traffic control.

4. Identification of the System Users

The Communication Master Plan/SEA identifies the potential system city users and other participating agency partners. These are the stakeholders who will utilize the system when it is developed. These system users include other public agencies within the City of McComb, which could benefit in teaming with the city in developing this communication network. The network will be designed to handle the needs of today and allow expansion for future agency needs. These system users will identify their communication needs and define their particular communication requirements. These requirements should maintain compatibility with the basic communication framework provided in this plan. Avoiding unique or vendor specific technologies will ensure communication with other users.

Stakeholder involvement is a critical component of the needs assessment and the development of the system life-cycle of the project. Without effective stakeholder involvement, the system engineering and development will not include the key local issues and needs of the system users. In addition, this will increase the risk of not getting a valid set of requirements to build the system or obtain user buy-in on future upgrades and changes. The following is a list of potential system stakeholder users:

System Users – Stakeholders:

Agency

1. **Mississippi Department of Transportation (MDOT)**

2. **City of McComb**
   a. Utilities
   b. Public Works
   c. Traffic Engineering
   d. Parks and Recreation
   e. Planning/GIS
   f. Public Safety Services (Police/Fire)

3. **McComb Unified School District**

4. **McComb Hospital**

5. **Southwest Community College**

6. **Public Library**

7. **Pike County Emergency Management**

8. **Pike County Sheriff's Department**

MDOT/City of McComb Traffic Management Center (TMC)
A regional Traffic Management Center (TMC) can be implemented at the city's Central Fire Dispatch facility, which can utilize the proposed communication system network. Currently, this is the site location of the city's central master controller for controlling traffic signals. The system is connected using radio frequency antennas at each of the intersections. The Proposed TMC will give the city the ability to monitor traffic conditions, control traffic signals, and assist in incident management on the local city streets. In addition, this system will be tied into the MDOT Statewide ITS network to share information and video on both the local and state facilities. The proposed communication system will provide the city and state with the ability to provide real-time traffic management, traveler information, and incident management. The TMC will process and transfer information over the communication system to respond to incident and traffic management issues. The TMC will also be able to provide real-time traffic information to travelers through dynamic message signs and highway advisory radio sites. Through the monitoring, control, and sharing of information, the city's staff and MDOT will be able to undertake effective proactive measures to reduce congestion, improve travel safety, and improve air quality by using ITS elements to inform travelers of route conditions, especially in regards to a hurricane evacuation response.

MDOT ITS Traffic Management
MDOT is in the process of implementing a freeway ITS communication system with various elements as part of the Statewide ITS Program. MDOT is planning to eventually install a fiber optic backbone communication network along I-55 which will connect this area into the MDOT District traffic management center as well as to the main office in Jackson, Mississippi. In addition to the fiber optic communication, MDOT will also deploy several ITS freeway elements to assist in managing traffic, provide traveler information, and assist in incident response and emergency evacuations.

Proposed City/School Communication Network
The City of McComb is interested in sharing an existing backbone fiber optic system that is used by the school district for communication to all their school sites. This school network will link all of the public schools within the City of McComb. Because of the funding available to the school district to implement a private/public communication system, the funds for this type of service is only for the annual lease and maintenance of the network.

Communication for City Hall/Downtown/Public Works
City Hall is the focal point for many of the users for the city communication services within the City of McComb. The location of City Hall is within the downtown area which also includes various other city facilities. The city currently uses a private telephone service provider for telephone and computer data services to connect to the other city facilities. The other facilities include a fire station, police station, community parks, medical center, and hospital and are located along the existing communication network. The close proximity of public schools and city facilities, as well as to the regional hospital and medical centers, provide an opportunity to economically expand the existing communication network.

Citywide Wireless Communication Network
The City of McComb has the opportunity to use existing water towers to implement a citywide wireless broadband communication network. This type of mobile broadband communication is the newest wireless technology in providing high speed communication to the various facilities without a hard line fiber optic cable. It was identified in the stakeholder meetings the need to connect to several city facilities. These sites include parks and recreation security cameras, utility pump and lift stations and potentially other city sites. Since these sites are all over the city, the use of fiber optic cable for communication would be extremely costly. Typically for sites that are scattered citywide, a wireless broadband communication network can be implemented at a more cost feasible range.

5. Needs Assessment Requirement

The Communication Master Plan is designed to address the existing and future communication needs of MDOT, the city, and other public agencies, which can benefit from a regional communication network. This process starts with a concept exploration of the needs and requirements. A needs assessment is the initial start of the exploration, which is identified in the system engineering process. As part of the needs assessment, the following elements are identified, reviewed, and prioritized. These elements include:

- Identify the stakeholders
- Elicit needs
- Validate needs
- Prioritize needs
- Perform gap analysis
- Prepare cost comparison

For the McComb stakeholders, the city departments identified the need for an internal city communication network which could benefit the city and other regional services. In addition, the other public agencies such as the county, emergency management and school district were included in the initial stakeholder working group meetings to discuss the possible opportunities of sharing the existing school communication network. At these working group meetings, stakeholders identified needs and requirements within their respective department goals and objectives.

In addition, other agencies, such as the school district, commented on additional needs to expand and tie the existing communication network into a backbone ring. Based on the information collected at these working group meetings, the user needs are identified with their key functional requirements. These needs and requirements are summarized in **Table 1**. It is apparent for the City of McComb that the use of the existing school communication network appears to be the preferred choice to tie into and expand this existing network since it is available.

Concept exploration is used to perform an initial feasibility and benefit analysis and needs assessment for the proposed ITS projects from the regional architecture. This results in a case specific benefit analyses for alternative project concepts. The result of this process is a definition of potential problems, key technical issues, and refinements to the needs, goals, objectives, and vision. This level identifies the constraints and benefits of moving forward into system development. The concept exploration will include the following:

- Define the vision
- Define the goals and objectives
- Identify the constraints
- Define evaluation criteria
- Identify candidate solutions
- Identify alternative concepts
- Evaluate the alternative concepts
- Document results

Functional Requirement Definitions

In the National ITS Architecture, user services describe what the system will do from the user's perspective. There are thirty-three (33) user services that have been identified by the US DOT and ITS America. A set of requirements covering each of these user services form the basis for the National ITS Architecture definition.

A review of the functional requirements of the thirty-three (33) user services contained in the National Architecture was completed to determine which of those requirements are applicable to the McComb Communication Master Plan. Based on this review, the travel and traffic management user service bundles contain the high-level functional requirements, or user service requirements, applicable for the majority of the city and stakeholder needs. The other two service bundles are key elements for specific users such as police, fire and emergency management. The following user service bundles and services have been identified through the stakeholder meetings as needed services. They are the following:

User Service Bundles	**User Services**
1. Travel and Traffic Information	En-route Driver information Traffic control Incident management
2. Emergency Management	Emergency Notification Emergency Vehicle Management
3. Information Management	Archived Data Function

Within the travel and traffic management user service bundle, there are three user services that contain requirements applicable to this project. These are as follows:

1. En-route Driver Information
2. Traffic Control
3. Incident Management

The first user service requirement, en-route driver information, is described as follows:

"En-route driver information provides vehicle drivers with information that will allow alternative routes to be chosen for their destination. Driver information consists of two major functions, which are: (1) Driver Advisory and (2) In-vehicle signing. The potential decrease in traffic demand on congested routes may also provide benefits in highway safety, reduced air pollution and decreased congestion."

En-route driver information will be disseminated from the MDOT Hurricane Response/Incident Management projects through DMS and HAR providing freeway travelers information regarding specific incidents, roadwork, and other real-time information.

The second user service requirement, traffic control, is described as follows:
"ITS will include A traffic control (TC) function. Traffic Control provides the capability to efficiently manage the movement of traffic on streets and highways. Four functions are provided, which are: 1) Traffic Flow Optimization, 2) Traffic Surveillance, 3) Control, and 4) Traveler Information. This will also include control of network traffic signals systems with eventual integration of freeway control."

The City of McComb has several traffic signals connected to a main signal system to time and management traffic signal operations. As part of this project, the local signal system will communicate with the MDOT freeway traffic management center to coordinate and better control traffic signal operations along city streets and highways. The specific high-level traffic control requirements, as stated in the National ITS Architecture, are as follows:

Traffic control shall include a traffic surveillance function.

- Traffic surveillance will include a wide-area surveillance capability to include several jurisdictions including MDOT.
- The wide area surveillance will acquire sufficient data to provide the system with the knowledge of the existing conditions.

Traffic control shall include a device control function.

- Device control will communicate control data to the traffic signal, DMS, and surveillance cameras.
- Device control will provide the operator with the capability to manually override the system's automatic controls.

The third user service requirement, Incident Management, is described as follows:

"ITS will include an Incident Management (IM) function. Incident Management will identify incidents, formulate response actions, and support initiation and ongoing coordination of those response units and actions. Four major functions are provided, which are: 1) Incident Identification, 2) Response Formulation, 3) Response Implementation, and 4) Predict Hazardous Conditions."

As part of the MDOT Hurricane Response/Incident Management Projects, the high-level Incident Management requirements are as follows:

Incident Management will provide an incident identification function to identify incidents.

- The incident identification function will use information from the following types of sources, where available, to identify probable incidents: traffic flow sensors, public safety sources, public cell phone inquiries, media sources, etc.
- Incident Management will provide a response formulation function to formulate appropriate response actions to each identified incident and revise those actions when necessary.

Incident Management will include a response implementation function to provide the services to implement a response coordinated with all appropriate agencies.

- The response implementation function will provide decision support capabilities needed to implement coordinated incident response actions by all participating institutions.
- The response implementation function will provide the capability to disseminate information related to response status to other agencies and user services.

The three travel and traffic management service bundles have been identified by the users through the stakeholder meetings as the key traffic and traveler function requirements. As mentioned, the other two bundles are functional requirements for the police, fire, and emergency management users. These high-level requirements represent the general functions as defined in the National ITS Architecture to be performed by each of the proposed project phasing that is to be deployed by the City of McComb in coordination with the MDOT freeway communication projects.

6. Analysis of Communication and Technology Options

A communication network is simply a group of connected devices which are communicating with each other. An example of these connection devices are telephones and computers. A communication network is the transmission of data in analog or voice communication between two or more devices. There are a number of different types of communication technologies available for ITS system applications. Some of these technologies are listed below but may not be suitable for the city's needs. However, it is important that this SEA identify the various elements as required by MDOT for the SEA analysis. The following is a list of various technologies currently being used throughout the communication industry:

- Fiber Optic Cable
- Cellular Digital Package Data
- Global System for Mobile Communication
- Radio Frequency (spread spectrum)
- Terrestrial Microwave Links
- Area Radio Network
- Telephone Leased Lines
- Code-Division Multiple Access (CDMA)

The critical factors in the selection of a preferred communication alternative are as follows:

- High reliability and availability
- Low capital and operating cost
- Provisions for high bandwidth capacity and transmission speed
- Protection of the interconnected server, workstations and controllers from unauthorized access

General advantages of a direct wire communication connection versus a wireless system are the following:

- Bandwidth is limited only to the devices
- Life span of 15+ years
- Connections can only be interrupted by invasive measures
- Maintenance is generally less than the wireless
- Security of the cable in the ground or on aerial lines

General disadvantages of direct wire connection versus a wireless system are as follows:

- Susceptible to being broken by construction activities or weather problems for aerial installations
- Requires costly conduit for underground installations
- Installation cost is higher than that of wireless
- Limited to serve fixed locations (no connections to mobile operations)

Fiber Optic Cable (Single Mode)

Fiber-optic cable is fast becoming the medium of choice for most telecommunication applications. It has a very high capacity and uses light to transmit signals, making it immune to electromagnetic interference. It can be placed underground in conduits, directly buried, or strung up along utility poles. Fiber-optic communication uses a beam of light that is generated by a laser diode. This pulse of light with wave lengths between 850 and 1550 nanometers turn on and off depending on the logic state of the transmitted data bits. Fiber-optic cables are typically bundled with multiple fibers, providing several data channels. Data rates of up to 2.4 Gigabytes (2.4 billion bytes) per second can be accommodated by using Time Division Multiplexing (TDMP). Data can be

transmitted over several miles (20 to 30) and the transmission range is rarely a limitation provided communication hubs and fiber-optic repeaters are installed.

To ensure quality performance, the bend radii must be limited to avoid signal attenuation (data loss). This requires pull-box entry and interval characteristics different from those used for coax cable installation. Special installation requirements are also needed for the placement of the fiber-optic cable during construction to avoid damaging the fiber-optics. In addition, splicing fiber-optic cable to interface with traffic signal controllers will require a unit to convert the controller's electric signals into light signals which could be transmitted over the fiber-optic lines. Many cities are finding that fiber-optic cable is ideal as a trunk line (backbone), which is then spliced off into another medium to serve peripheral locations.

The advantages of the use of single mode fiber optic cable are as follows:

- Allowable distance between transmission equipment, transmission rate, and bandwidth capacity is significantly greater than any other communication method, thereby providing nearly unlimited future system expansion.
- Lighting protection devices are not required.
- Ratio of cable diameter to bandwidth capacity is very small.
- Provides highest level of security when properly monitored.
- Not susceptible to electro-magnetic and radio frequency interference.
- Not susceptible to corrosion.
- Provides high transmission reliability if quality materials are used and tested.
- Pre-terminated fiber available for quick installations and no splicing required.

The disadvantages of single mode fiber optic cable are as follows:

- Splicing and connector termination requires specialized equipment and skilled technicians.
- Technician training is required for repairing and replacing and testing fiber cable.
- Test equipment is more complex and expensive relative to copper testing.
- Susceptible to breaking if the fiber bends are smaller than the recommended bending radius or excessive load is applied in the installation.
- Requires devices to convert from optical to electrical end users.
- Substantial capital cost of the installation.
- Preterminated fiber requires additional planning since the fiber is dropped off the backbone and no longer continuous beyond the drop point.

Cellular Digital Packet Data (CDPD)

CDPD is a packet switched full duplex data communication system that cellular carriers use specifically for data transmission and as a means of filling unused voice channel capacity.

The advantages of CDPD are as follows:

- Eliminates need for incurring underground cable installation costs.
- Not susceptible to electro-magnetic interference and limited susceptibility to radio frequency interference.
- Maximum flexibility in locating and moving the required modem.

The disadvantages of CDPD are as follows:

- Requires payment of a recurring service fee.
- Major carriers plan to discontinue CDPD services with the migration to 3G technologies.
- Transmission speed limited to 28.8 Kbps.
- Dependent on cellular coverage provided by existing infrastructure.
- Requires separate modem for each controller.

Global System for Mobile Communication (GSM)
CDMA is the dominant technology for cellular and/or PCS networks in North America. GSM is the dominant technology for cellular and/or PCS networks in other countries such as Europe. Cellular and PCS differ primarily in their respective operational frequency band of 800 MHz for cellular and 1900 MHz for PCS.

The advantages for GSM are as follows:

- Lower cost of the data rate plans for wireless WANS, process for these plans have fallen significantly creating a more compelling demand to switch to wireless data networks for remote device communication
- New technology gives wireless gateways the ability to maintain an always on connection without being charged for the total airtime
- Maximum flexibility in locating and moving the required gateways
- Transmission speed of Mbps can be achieved with EDGE technology where service is available

The disadvantages are as follows:

- Airtime costs excessive for continuous communication service
- Only two providers in one area
- Actual data throughput is reduced due to protocol overhead
- Remote areas may not have service

Radio Frequency (Spread Spectrum)
This medium of communication, originally developed for military purposes, uses a coded message spread over a range of frequencies instead of one narrowband frequency. This enables a large number of individual transmissions to share the same frequency band without interfering with each other. As with other radio media, it requires a line of sight between the source transmitter and receiver. The bandwidth is spread by means of a code which is independent of the data. The independence of the code distinguishes this from standard modulation schemes in which the data modulation will always spread the spectrum. Frequency hopping and direct sequence systems are the most widely used implementation of this technology.

Most cities are interested in wireless spread spectrum radio communication because they require a power level of less than one watt and have a minimal licensing requirement to obtain frequency use through the federal government. This power level would be sufficient to transmit control and surveillance data and compressed video signals, but would be unsuitable for transmitting high quality, full motion video. The technology appears to hold promise, but has not been widely applied in traffic signal systems.

The advantages of radio frequency transmission are as follows:

- Eliminates need for incurring underground cable installation cost
- Not susceptible to electro-magnetic interference
- Provides a low probability of intercept and includes anti-jam features
- Radio frequency interference with narrowband communication is minimized by use of lower spectral power density and for hopping implementation an ability to reconstruct the data when some frequencies are blocked
- Does not require a FCC license to operate

The disadvantages of radio frequency transmission are as follows:

- Requires overhead location to mount antennas that maintain line of sight
- Requires routing cable and conduit from antenna to modem installed in cabinet

- Requires separate modem for each controller
- Limited susceptibility to radio frequency interference
- Requires highest equipment expenditure including sufficient spares, operating and maintenance cost
- Antenna is susceptible to vandalism
- Requires special skills and equipment to maintain
- Requires the most training to maintain
- Limited bandwidth, streaming video not an option

Terrestrial Microwave Links

Terrestrial Microwave is a line of sight technology that cannot extend beyond the earths horizon. Long distance terrestrial transmission of data is accomplished using relay points known as Hops. Typically, each Hop consists of a tower with one antenna for receiving and another for transmitting. Terrestrial Microwave Linkks operate in the low-gigahertz range, typically at 4-6 GHz, 11 GHz, 18 GHz and 21-23 GHz. Microwave transmission uses directional beams of radio waves sent and received by parabolic dish antennae. Microwave links offer the advantage of long distance communication without the need for costly underground or aerial cables. Microwave communication is capable of providing high-capacity, high-data rate transmission over many miles at a substantial lower cost. This technology is limited to line of sight transmissions and is subject to interference from wave reflection, heavy rains, and atmospheric effects. The Federal Communication Commission (FCC) has varying licensing requirements for different power levels and frequencies. Depending on the configuration, high quality, full motion video can be transmitted using microwaves.

The advantages of terrestrial microwave transmission are as follows:

- Useful as a point-to-point trunk communication
- Can transmit data and limited number of full motion video channels
- Can control groups of traffic control devices
- Can use both analog and digital transmission
- Offers the highest data throughput rates of wireless technology

The disadvantages of terrestrial microwave transmission are as follows:

- Line of sight may be required based on the frequency.
- Requires FCC license
- Channel availability limited
- Possible interference due to rain, snow, and other atmospheric effects
- Require an antenna on towers
- Available bandwidth usually limited
- Typically most expensive wireless technology to implement

Area Radio Network (ARN)

Area Radio Network (ARN) is representative of a radio network usually operating in the UHF/VHF frequency band. These networks are normally used for in-house communications of equipment devices, maintenance staff, and personnel.

The advantages of ARN are as follows:

- Can operate traffic controllers or other devices
- Can provide voice communication to highway maintenance workers
- Can support 9600 baud data rate
- Can be cost effective depending on application

The disadvantages of ARN are as follows:

- Terrain may be limited
- Limited channel availability in urban areas
- Requires antenna at each site
- Turnaround time excessive for some application
- Service reliability may be limited use for some applications

Telephone Lease Lines

Telephone lease lines are lines which are permanently routed by the phone company between two points. Since they are not switched through the telephone network, they provide a more reliable connection with less noise than switched lines. These lease lines range in capacity from the basic phone service of (9600 baud) to T1 (1.54 Mbps) and T3 (43.7 Mbps). These lines have installation fees and fixed monthly service and mileage charges.

The advantages of the telephone line are as follows:

- Can operate traffic controllers or other devices
- Can provide video transmission at low fps
- Asymmetric Digital Subscriber (ADSL) can support full motion video

The disadvantages of the telephone line are as follows:

- ADSL leasing costs are high
- Limited video transmission availability

Code-Division Multiple Access (CDMA)

CDMA refers to any protocols used in so-called second generation (2G) and third generation (3G) wireless communications. As the term implies, CMDA is a form of multiplexing, which allows numerous signals to be transmitted in a single transmission channel, optimizing the use of available bandwidth. The technology is used in ultra-high-frequency (UHF) cellular telephone systems in the 800 MHz and 1.9 GHz bands. CDMA employs analog-to-digital conversation (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined patter (code) so that it can be intercepted only by a receiver whose frequency response is programmed with the same code, and so it follows along with the exact transmitter frequency. There are trillions of possible frequency-sequencing codes which enhance privacy and makes cloning difficult.

The CDMA channel is nominally 1.23 MHz wide. CMDA networks use a scheme called soft handoff which minimizes signal breakup as a handset passes from one cell to another. The combination of digital and spread-spectrum modes supports several times as many signals per unit bandwidth as analog modes. CDMA is compatible with other cellular technologies which allows for nationwide roaming. The original CDMA standards also known as CDMA One and still common in cellular telephones in the US only offers a transmission speed of up to 14.4 Kbps in its single channel form and up to 115 Kbps in an eight-channel form. CDMA 2000 and wideband CDMA delivers data many times fasters.

The advantages of CDMA are as follows:

- Frequency diversity
- Multi-path resistance
- Privacy/security
- Graceful degradation

The disadvantages with CDMA are as follows:

- Self jamming due to sequences are not exactly orthogonal
- Near-far problem in transmission
- Soft hand-off
- Not suitable for very high byte rates (like a WLAN)
- Monthly service subscription cost

7. Development of System Concepts

A brief summary of the various types of communication technologies identified in the previous section are used by cities, counties and state DOT for ITS communication. These communication system concepts are typical in communication technologies and their maturity levels are listed below.

	Technology	**Maturity**
•	Fiber Optic (Single Mode)	Proven
•	Cellular Digital Packet Data	Proven
•	Global System Mobile Communication	Proven
•	Radio Frequency (spread spectrum)	Proven
•	Terrestrial Microwave	Proven
•	Area Radio Network (ARN)	Proven
•	Leased Telephone Lines	Proven
•	Code-Division Multiple Access	Proven

Communication Network Concept

The communication or transmission media for the new network can utilize hard-line cable, wireless media, or a combination of both. A hard-line connection is by far the most expensive cost in implementing a communication network. However, it does provide the best option for safety, security, and maintenance. Hard line cable connection is still the most practical and proven method for agencies to provide ITS communication. The fiber-optic cable will provide the necessary high bandwidth capability required for the communication network.

MDOT ITS Communication and Hurricane Response/Incident Management

MDOT is implementing a Statewide ITS Communication Network along the freeways in coordination with the MDOT Hurricane Response/Incident Management Projects. As part of these ITS projects, MDOT is planning to install fiber optic communication along I-55, which will tie back to the MDOT District traffic management center as well as to the main ITS center in Jackson, Mississippi. In addition to the fiber optic communication, MDOT will deploy several ITS freeway elements to assist in managing traffic, provide traveler information and assist in incident response and emergency evacuations. These elements include the following:

- Backbone Fiber Optic Communication
- Closed Circuit Television Cameras (CCTV)
- Highway Advisory Radio (HAR)
- Advance HAR warning signs with flashing beacons
- Dynamic Message Signs (DMS)

8. Procurement Options

This project is in the initial preliminary planning study and deployment plan for the communication and various ITS elements within the City of McComb and adjacent regional facilities. As the project moves forward into the various implementation phasing as recommended, the city or MDOT will use typical State procurement procedures. It will probably go through the MDOT procurement process with the normal low-bid selection and construction process. It is noted that some of the ITS elements may be under a current state contract or that the state may also identify certain ITS equipment to be consistent with the statewide communication network. For implementation and construction, final specifications will be required for the communication and various ITS elements and that the manufacturer is qualified to provide these devices and communication system.

9. Identification of ITS Standards and Testing

As mentioned, this project is in the initial preliminary planning and deployment planning stage for the communication and ITS elements. As this project moves into the design and construction stages, all of the ITS devices, equipment and communication will meet the latest approved National Transportation Communication for ITS protocols (NTCIP) standards. In addition, the project will meet the latest MDOT ITS standards and specification for ITS construction projects. The specifications required for the various ITS elements and communication will meet compliance with the NEMA Standards Publications and the NTCIP requirements.

Communication Testing
All testing shall meet the latest state MDOT standards and specification for testing fiber optic cable and communication devices. The Contractor shall notify the city/state Project Engineer in writing, a minimum of seven (7) days before the scheduled start of any testing to permit attendance of the appropriate personnel. The Contractor shall be totally responsible for the documentation of the results of all tests.

During the fiber optic conductor cable tests, all transient suppression devices shall be disconnected. If any test is failed, repairs or cable replacement shall be made by the Contractor and the entire test series for the fiber optic cable shall be repeated. The cost or repairs including the replacement or reinstallation of cable shall be absorbed by the Contractor. All test equipment shall be provided by the Contractor and all tests shall be conducted in the presence of the city or state Project Engineer. The Contractor shall perform the tests and document the test results. The testing will include:

- Pre-installation OTDR Testing
- Post installation Testing
- Warranty and Maintenance
- As Built Documentation

The tests are completed and whether successful or not, the test results shall be furnished to the city/state agency for acceptance. The tests shall be conducted for all fibers including spares and shall include all field terminations. Test procedures shall be submitted to the city/state for approval prior to testing.

10. Implementation Plan

As part of this report, a preliminary implementation plan was prepared to identify the associated cost of the communication and ITS elements for each phase. This implementation plan will help guide and fund the proposed phasing of the communication network and various ITS elements for the McComb region.

To continue in the development and deployment of this ITS communication plan as outlined in this ITS Master Plan/System Engineering Analysis, the proposed phasing of the deployment is recommended in four phases:

McComb/Pike County ITS Master Plan Deployment Phasing

- **Phase 1** - I-55 Communication and ITS Elements
  - Install two 2-inch Conduit and Fiber Optic Cable on I-55.
  - Install five CCTV Sites.
  - Install two DMS Sites.
  - Install one HAR Site with four Advance Beacon Signs.
  - New Traffic Management Center (TMC) at MDOT District Office.

- **Phase 2** - US 51 Fiber Optic Communication
  - Install two 2-inch Conduit and Fiber Optic Cable.
  - Install one CCTV site at the intersection of I-55 and US 98.
  - Connect existing MDOT traffic signals.

- **Phase 3** - Completion of the communication network with the southern section
  - Install two 2-inch Conduit and Fiber Optic Cable along US 98.
  - Install One CCTV Site.
  - Install two DMS Sites.
  - Connect existing MDOT traffic signals.

- **Phase 4** – Citywide traffic signals and TMC facility
  - Install two 2-inch Conduit and Fiber Optic Cable to Central Fire Station and to the Public Works Offices.
  - Install new TMC at Central Fire Station.
  - Connect City Hall.
  - Connect Fire Stations 1 and 3.
  - Connect the existing traffic signals to the communication system.
  - Connect Parks and Recreation Sites.
  - Install citywide wireless communication network.

Figure 2 depicts the overall ITS plan and phasing scheme**. Figures 3-6** provides the details of each ITS site location and the phasing. The following pages (23-31) provide the figures and tables of the implementation phasing diagrams with cost estimates for each phase.

Figure 2 – Proposed Phases 1-4

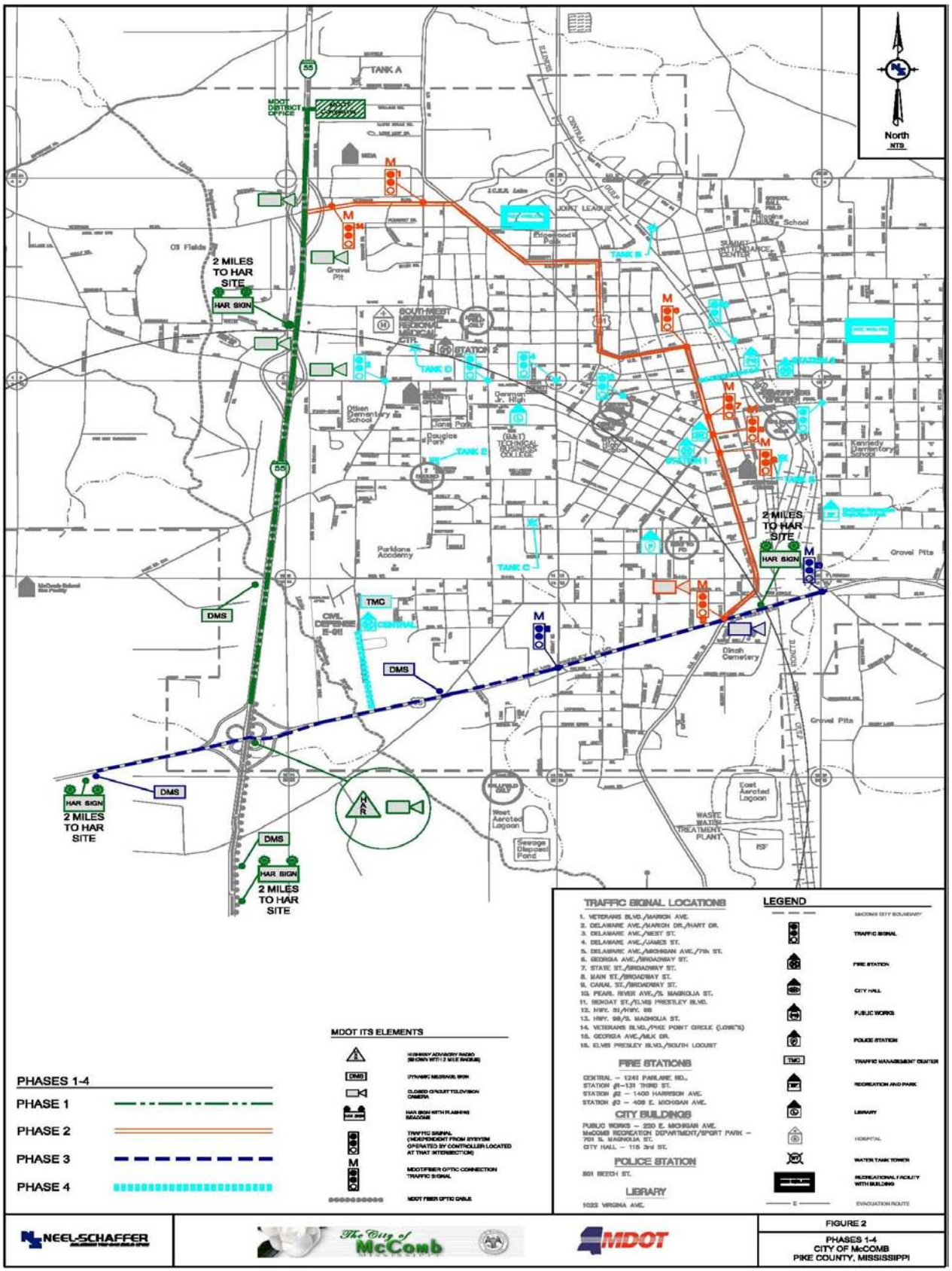


Figure 3 – Proposed Phase 1

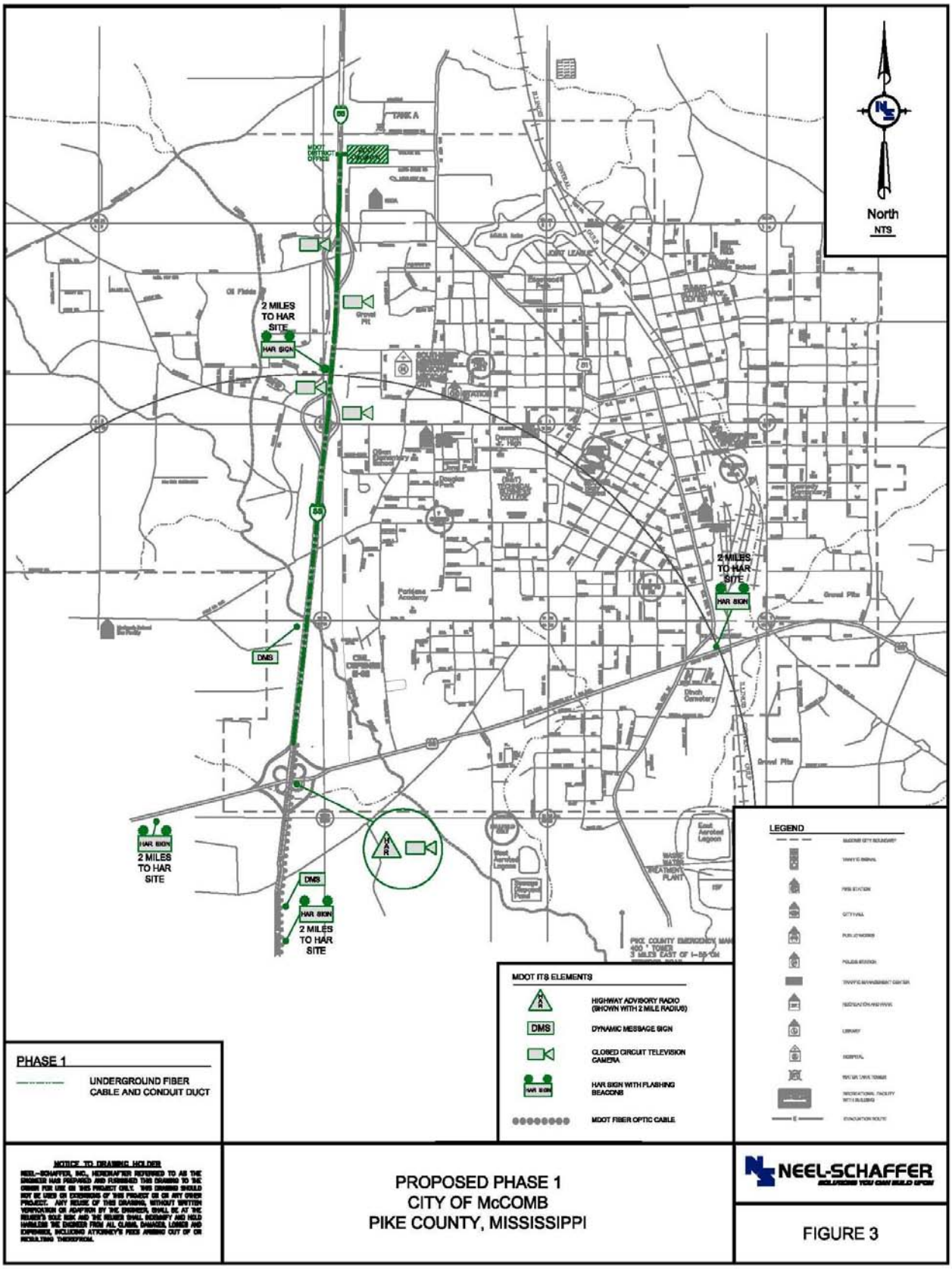


Table 2 – Proposed Phase 1 – I-55 Communication and ITS Elements

McComb/Pike County ITS
(Intelligent Transportation System)

Project
Phase 1 - I-55 Communication and ITS Elements

1. Install two 2-inch Conduit and Fiber Optic Cable
2. Install five CCTV Sites
3. Install two DMS Sites
4. Install one HAR system with four Advance Beacon Signs
5. New TMC at the MDOT District Office

Phase 1 Implementation

Item	Quantity		Unit Cost		Extension
Two 2-inch Conduit	13,849.00	LF	$ 18	$	249,282.00
Fiber Optic Cable	15,234.00	LF	$ 2	$	30,468.00
CCTV Sites	5	EA	$ 40,000	$	200,000.00
DMS Sites	2	EA	$ 140,000	$	280,000.00
HAR Site and Signs	1	LS	$ 65,000	$	65,000.00
New TMC at the MDOT Office	1	EA	$ 80,000	$	80,000.00
Subtotal				**$**	**904,750.00**
Preliminary Engineering	8%			$	72,380.00
Construction Engineering	10%			$	90,475.00
Total Project				**$**	**1,067,605.00**

Federal Funding Requested Provided 80% Match

$ 854,084 **FY 2009**

Figure 4 – Proposed Phase 2

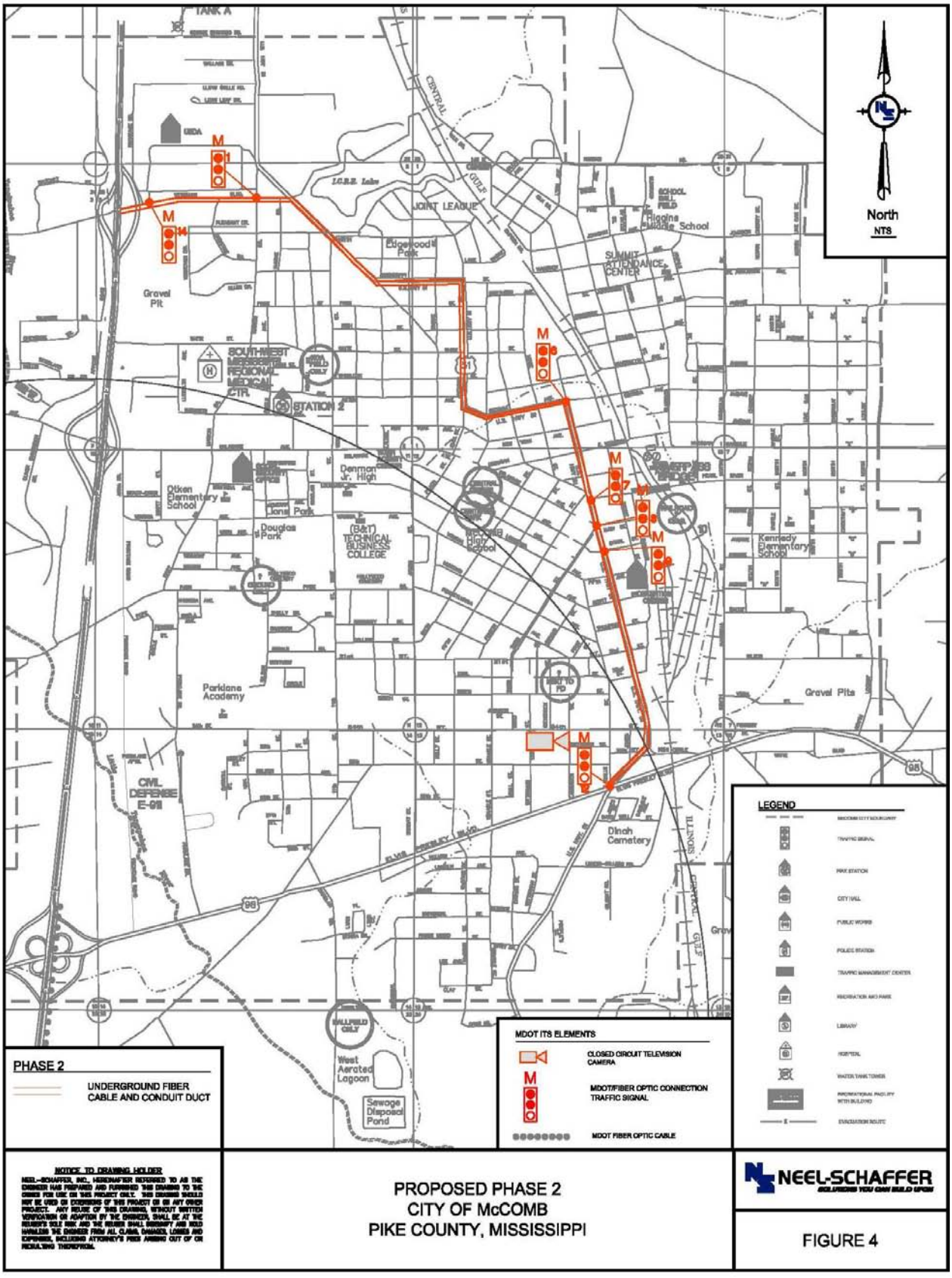


Table 3 – Proposed Phase 2 – Delaware Avenue and US 51

McComb/Pike County ITS
(Intelligent Transportation System)

Project
Phase 2 - Delaware Avenue and US 51

1. Install two 2-inch Conduit and Fiber Optic Cable
2. Install one CCTV Site
3. Connect existing MDOT Traffic Signals

Phase 2 Implementation Plan

Item	Quantity		Unit Cost		Extension
Two 2-inch Conduit	16,854.00	LF	$ 18	$	303,372.00
Fiber Optic Cable	18,539.00	LF	$ 2	$	37,078.00
CCTV Site	1	EA	$ 40,000	$	40,000.00
Signal Connections	8	EA	$ 5,000	$	40,000.00
Subtotal				**$**	**420,450.00**
Preliminary Engineering	8%			$	33,636.00
Construction Engineering	10%			$	42,045.00
Total Project				**$**	**496,131.00**

Federal Funding Requested Provided 80% Match

$ 396,905 FY 2010

Figure 5 – Proposed Phase 3

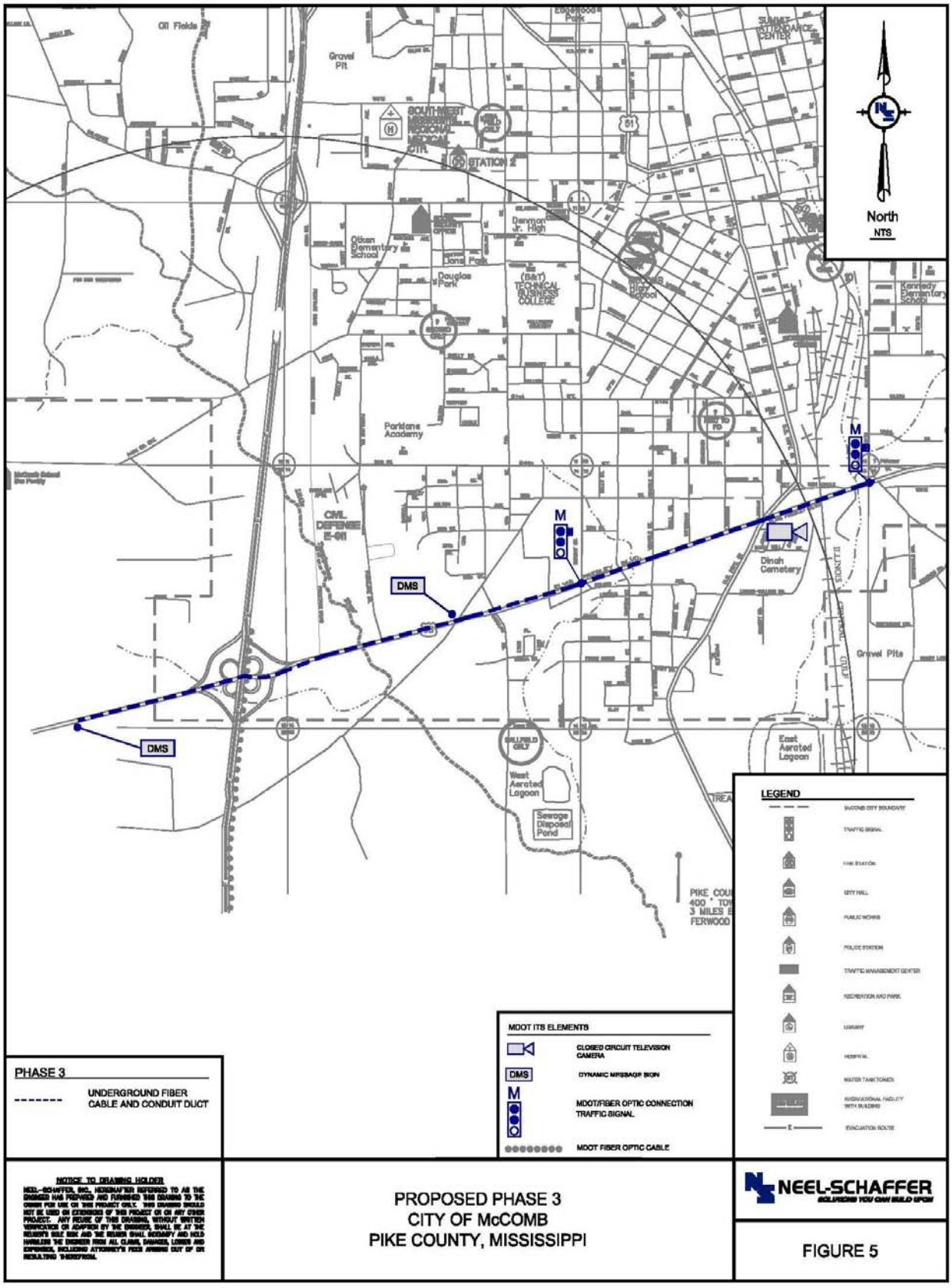


Table 4 – Proposed Phase 3 – Southern US 98 Communication and ITS Elements

McComb/Pike County ITS
(Intelligent Transportation System)

Project
Phase 3 - Southern US 98 Communication and ITS Elements

1. Install two 2-inch Conduit and Fiber Optic Cable
2. Install one CCTV Site
3. Connect existing MDOT Traffic Signals to network
4. Install two DMS Sites

Phase 3 Implementation Plan

Item	Quantity		Unit Cost		Extension
Two 2-inch Conduit	14,918.00	LF	$ 18	$	268,524.00
Fiber Optic Cable	16,410.00	LF	$ 2	$	32,820.00
CCTV Site	1	EA	$ 40,000	$	40,000.00
Signal Connections	2	EA	$ 5,000	$	10,000.00
DMS Sites	2	EA	$ 140,000	$	280,000.00
Subtotal				**$**	**631,344.00**
Preliminary Engineering	8%			$	50,507.52
Construction Engineering	10%			$	63,134.40
Total Project				**$**	**744,985.92**

Federal Funding Requested Provided 80% Match

$ 595,989 **FY 2011**

Figure 6 – Proposed Phase 4

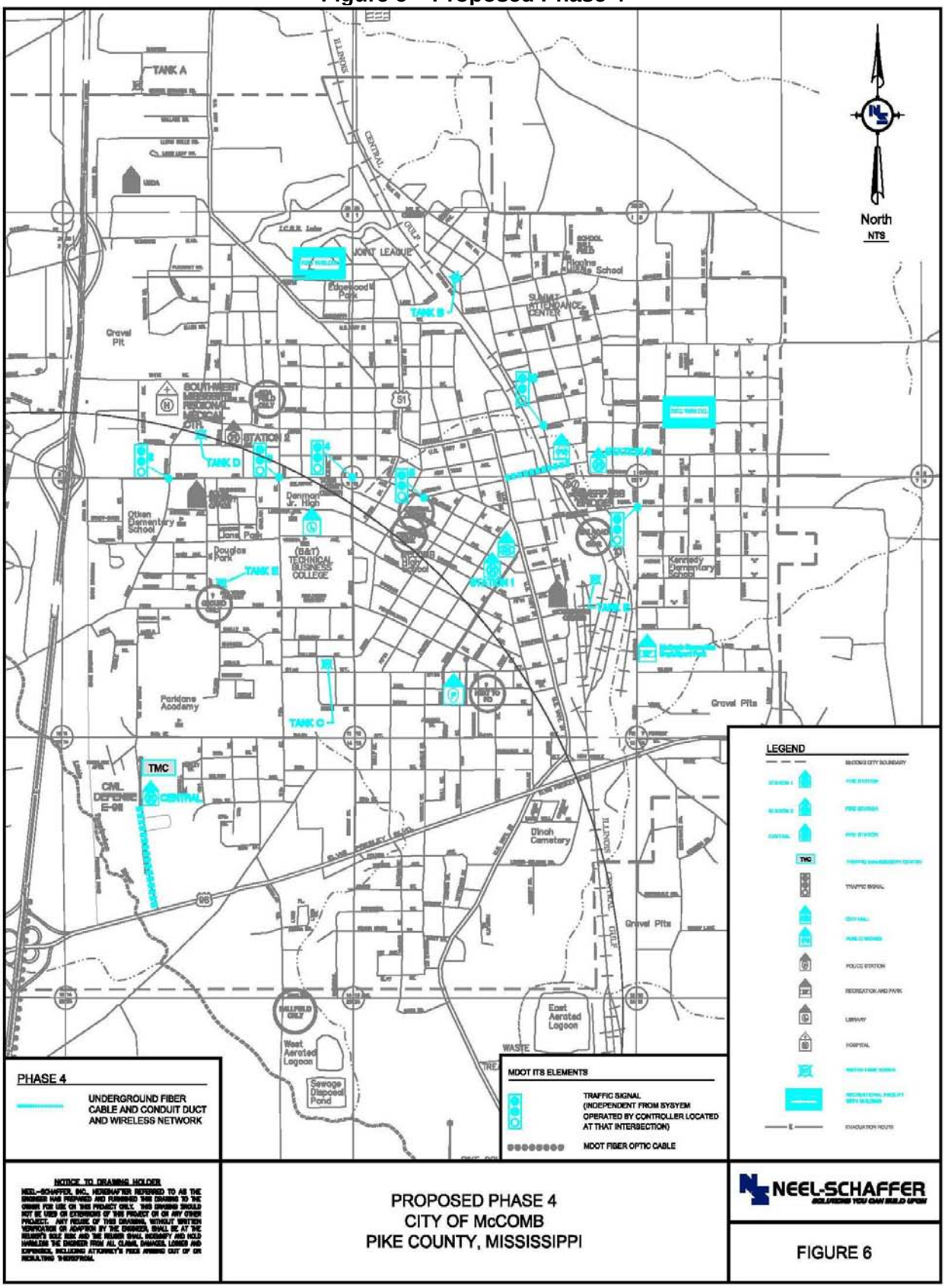


Table 5 – Proposed Phase 4 – Citywide Traffic Signals and TMC Facility

McComb/Pike County ITS
(Intelligent Transportation System)

Project
Phase 4 - Citywide Traffic Signals and TMC Facility

1. Install two 2-inch Conduit and Fiber Optic Cable to Central Fire Office and Public Works
2. Install new TMC at Central Fire Office
3. Connect City Hall
4. Connect Fire Stations 1 and 3
5. Connect existing Traffic Signals
6. Connect Parks and Recreation Sites
7. Citywide Wireless Network

Phase 4 Implementation Plan

Item	Quantity		Unit Cost		Extension
Two 2-inch Conduit	2,981.00	LF	$ 18	$	53,658.00
Fiber Optic Cable	3,279.00	LF	$ 2	$	6,558.00
City Hall/PW Connection	1	LS	$ 40,000	$	40,000.00
Central Fire Station TMC	1	EA	$ 100,000	$	100,000.00
Fire Station 1 and 3 Connection	1	LS	$ 40,000	$	40,000.00
Parks and Recreation Connection	1	LS	$ 65,000	$	65,000.00
Signal Connections	6	EA	$ 5,000	$	30,000.00
Citywide Wireless Network	1	LS	$ 250,000	$	250,000.00
Subtotal				**$**	**585,216.00**
Preliminary Engineering	8%			$	46,817.28
Construction Engineering	10%			$	58,521.60
Total Project				**$**	**690,554.88**

Federal Funding Requested Provided 80% Match

$ 552,444 FY 2012

APPENDIX