TRAFFIC SEPARATION STUDY

FOR

LANDIS, NORTH CAROLINA

AND

THE NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

RAIL DIVISION

ENGINEERING AND SAFETY BRANCH

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

RAIL DIVISION

NS NORFOLK SOUTHERN

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AUGUST 1997

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VOLUME II

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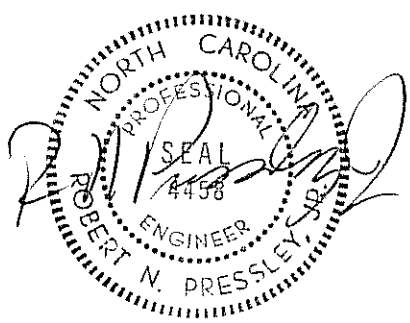

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CONCLUSIONS:

Accommodating the **Transit 2001 Plan** goal of two-hour passenger train service between Raleigh, Greensboro, and Charlotte will require a substantial reduction in the number of streets that cross the railroad at grade, as well as major modifications to many of those that remain.

Rail freight traffic along the Norfolk Southern (NS) will increase due to the division of CONRAIL routes between Norfolk Southern (NS) and CSX.

Vehicular traffic in the Landis Area will continue to increase as growth and expansion in Rowan County continues.

Grade crossing safety is an issue at Mills St. and Round St., as demonstrated by the seven (7) recorded accidents.

The potential for vehicles to que across the tracks is an issue at Mills St. and Ryder Ave. The geometry of the Central Ave. crossing is poor and requires attention.

RECOMMENDATIONS:

Near-Term

• Close the Round Street crossing	$8,000.00
Remove pavement/install guardrail and curb & gutter/landscape	$5,500.00
• Close the Mills Street crossing	$8,000.00
Remove pavement/install curb & gutter/landscape	$8,000.00
• Install rubberized crossing at Ryder Ave. and modify approaches	$30,000.00
• Reconstruct the Central Avenue Extension crossing	$92,000.00
Install long-gate arms	$15,000.00
TOTAL	$166,500.00

Long-Term

- Support the construction of the **PROPOSED KIMBALL RD** extension project and its grade separation with the Norfolk Southern Railway.

- Support the construction of the **PROPOSED CANNON FARMS RD** connector to **AIRPORT DR** south of town. This project will relieve traffic in downdtown Landis.

- Support the construction of a grade separation structure at **22nd STREET** in **Kannapolis.** This project will provide greater mobility for both **Landis and Kannapolis.**

- At such time as the **KIMBALL ROAD** project is in place, remove the **Central Avenue Extension** crossing of the Norfolk Southern.

TRAFFIC SEPARATION STUDY
FOR LANDIS, NORTH CAROLINA
AND THE
NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

PURPOSE OF THE STUDY

The **Town of Landis** and the **North Carolina Department of Transportation (NCDOT)** have entered into a cooperative agreement to evaluate certain local street at-grade crossings of the **Norfolk Southern Railway** in **Landis.** The purpose of the evaluation is to determine if any of the crossings are candidates for closure or grade separation, or if not, are there improvements that can be made to the local street and crossing network that will enhance public safety. The study includes four (4) public street crossings of the railroad from E. Round St. north to Central Ave.

Preamble

Highway/railway at-grade crossing collisions are the number one cause of death in the railroad industry. In 1996, there were 4,159 train-vehicle collisions with 471 deaths nationwide. North Carolina had 140 collisions, 9 deaths and 53 injuries. There are 4,756 public street grade crossings of railroads in North Carolina.

Deaths and injuries at grade crossings have steadily declined in this country since 1978 due to an aggressive safety program by the United States Department of Transportation, the various state Departments of Transportation and the railroad companies. These efforts have included improved automatic warning devices, roadway improvements, elimination of sight obstructions, construction of crossing separation structures, and closure of some crossings.

The **NCDOT**, through its **Rail Division** has a substantial program in place to improve rail crossing safety. The program is endorsed and supported by the **USDOT**, **Federal Railroad Administration** and **Federal Highway Administration** and the various railroad operating companies. To be successful, however, requires the support of local government and the citizens of North Carolina. Highway/railway safety cannot be mandated from Raleigh, but must be endorsed, supported and enforced at the local level. These series of studies, undertaken through a cooperative agreement between state and local government, are part of a continuing effort to enhance the safety of all who travel North Carolina's streets, highways and railways.

The Landis Study

The Town of Landis is served by the Norfolk Southern (NS) Railway* Mainline which

*For purposes of this study, the railroad will be referred to as the Norfolk Southern (NS); however, Norfolk Southern (NS) is the operating company with the railroad right-of-way being owned by the North Carolina Railroad (NCRR), which is owned by the State of North Carolina (75%) and private shareholders (25%).

extends from Charlotte to Raleigh and points north and south. Train movements over the four crossings included in this study are 34 per day according to information supplied by the NS Division Superintendent. **See Figures 1 and 2.**

Vehicular crossing volumes range from a low of approximately 1,400/day at E. Round St. to over 4,700 at Ryder Ave.

Both East Mills St. and East Round St. have had significant accidents during the last ten years for which records are available with Mills St. having a fatality in 1988.

The evaluation of the Landis crossings included the following:

- Twenty-four hour automatic traffic counts were obtained for the crossings as well as other streets within the network.

- A Level of Service (LOS) analysis was conducted for the signalized intersections of US 29A/Ryder Ave. and Central Ave./Ryder Ave.

- Interviews with state and local officials were conducted to gain insight into problems and potential improvements to each crossing.

- Data was collected from the Rowan Co. School System, the Landis Fire Chief, and the Rowan County Emergency Medical Service as to frequency of use of each crossing, as well as service impacts that might occur should a crossing be closed or modified.

- Available historic information and mapping was utilized in the development of report conclusions and recommendations.

Based upon the above described evaluation, this report will:

- Identify impacts of any proposed crossing closure on adjacent property and the roadway network.

- Include conclusions and recommendations necessary to accommodate any proposed crossing closure.

- Identify candidate crossings for grade separation.

- Recommend corrective action for any identified safety issues relating to the four (4) crossings.

- Include preliminary cost estimates for recommended improvements.

EXISTING TRANSPORTATION SETTING

The Town of Landis is located in southeastern Rowan Co just north of Kannapolis. The population from 1990 census data is just over 2500. Overall population growth in Rowan Co has been about 1.5% for the last several years. For purposes of this report, future traffic volumes were projected at 2% per annum.

Traffic along the Norfolk Southern (NS) continues to grow with significant freight operations based in Charlotte to the south and Linwood to the north, as well as the expansion of NCDOT sponsored rail passenger service in the corridor.

Ryder Ave. is the most significant of the four (4) crossings evaluated in Landis serving as the primary connector between US 29A, the central business district (CBD) and US 29 which passes to the east of the downtown. It is also the only connector between West Landis and East Landis that crosses the NS. Mills St. parallels Ryder Ave. approximately 450 feet to the south, and provides another means of access to the CBD. E. Round St. provides primary access to a Dominion Yarn Corp plant west of the tracks while also providing access to a residential area east of the tracks. Central Ave. Extension provides the only crossing on the north end of town.

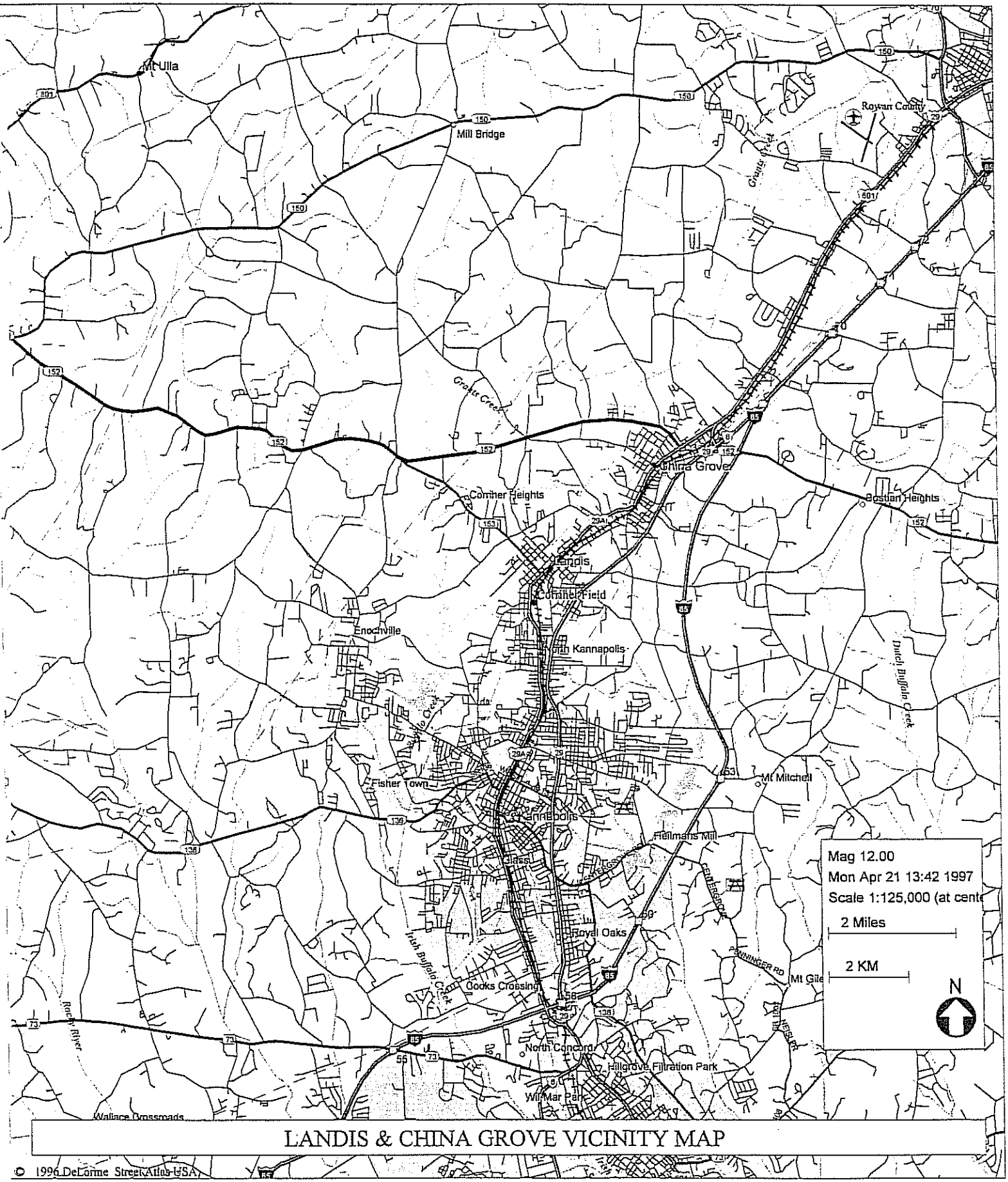
US 29A (Main St.) to the west and Central Ave. to the east, provide paralleling access to Mills St, Ryder Ave. and Central Ave. The distance between the two streets is less than 200 feet in most places. Both streets also connect to E. Round St, however, the separation between the two increases to approximately 800 feet.

The NS operates one mainline track throughout the Landis study area. Operating speeds range from 30 to 45 MPH for merchandise trains, 60 MPH for intermodal, and up to 79 MPH for passenger trains.

EVALUATION CRITERIA

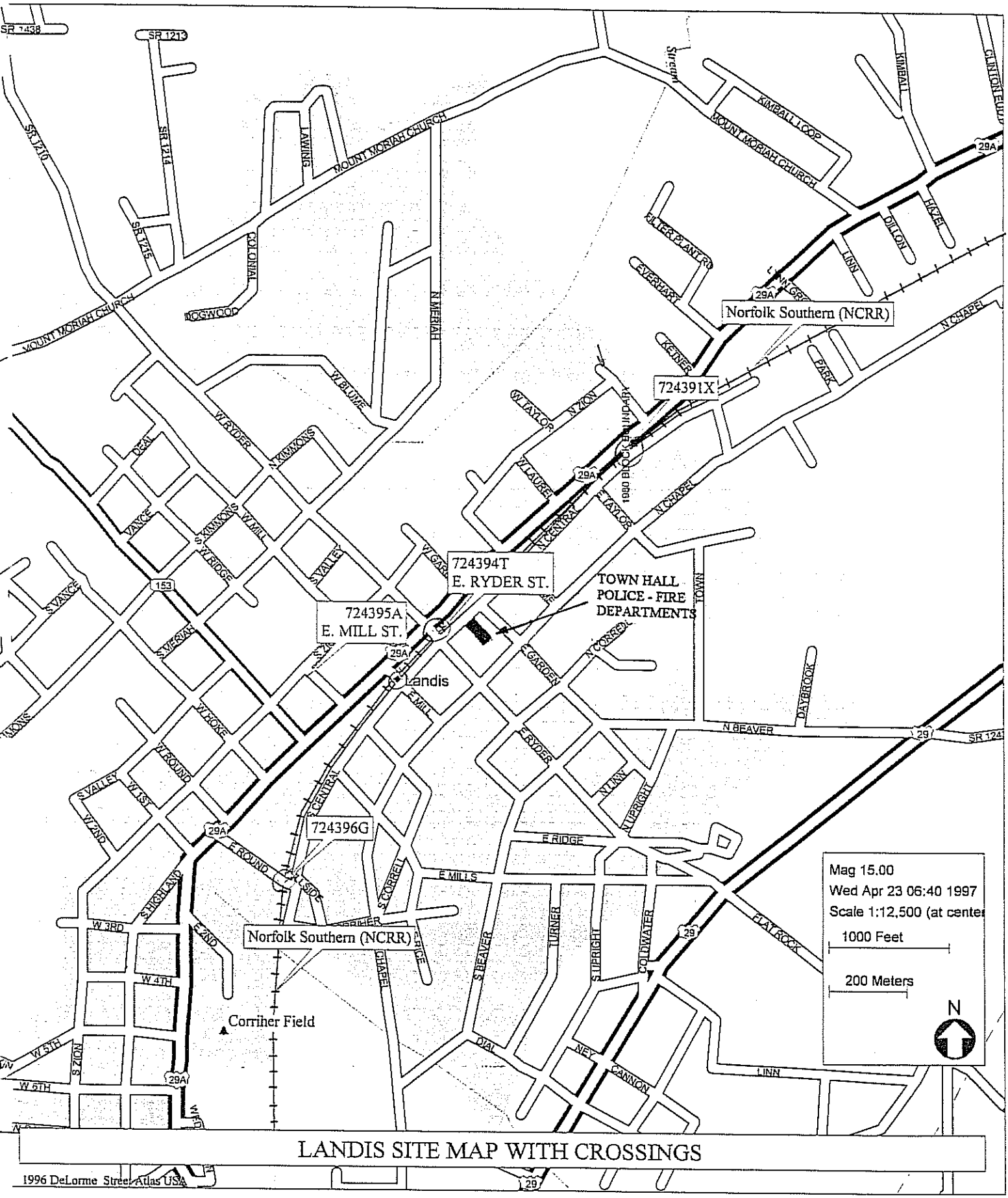
All crossings were initially evaluated using the criteria developed for the NCDOT rail crossing closure program.

Criteria used in evaluating the Landis crossings include:



LANDIS & CHINA GROVE VICINITY MAP

FIGURE 1



LANDIS SITE MAP WITH CROSSINGS

FIGURE 2

- Accident history
  This report utilizes the accident classification system developed by the Federal Highway Administration and others, and in general use around the country. Under this system, accidents are classified as follows:

  - K - Killed
  - Class A - Injured and transported to hospital
  - Class B - Injured and treated on-scene
  - Class C - Complains of injury but not treated
  - PDO - Property damage only

- Vehicle traffic - Present and future
- Train traffic
- Truck traffic/Truck route
- Hazardous materials
- Type roadway (thoroughfare, collector, local access, etc.)
- Type of property being served (residential, industrial, commercial)
- School bus route
- Emergency route
- Type warning devices present
- Redundant crossing (yes/no)
- Potential for grade separation (high, med, low)
- Feasibility of implementing roadway improvements (high, med, low)
- Economic impact if crossing closed (high, med, low)

The evaluations are shown on **Table 1.**

Level of Service Analysis

Level of Service (LOS) is a measure of congestion for signalized and unsignalized intersections as well as roadway segments. To the motorist, an intersection or road operating at an LOS of A, would be virtually free of congestion with almost no delay or interruption to travel. On the other hand, an LOS of F would mean considerable delay, stop and go driving and could require the motorist to sit through 2 or 3 red signal indications before clearing a signalized intersection.

The US 29A/Ryder Ave./Central intersection was subjected to a detailed volume/ capacity analysis in accordance with the procedures contained in the Highway Capacity Manual Special Report 209 (1994) as published by the Transportation Research Board, Washington, D.C. The procedures contained in the Manual for Level of Service Analysis (LOS) have been validated by considerable research and field testing and have been further enhanced by modern computer analysis techniques.

Analysis techniques are prescribed in the Highway Capacity Manual for both unsignalized and signalized intersections. The analysis determines the amount of delay the motorist experiences in clearing the intersection which determines its Level of Service.

Unsignalized Intersections

Operating characteristics of roadway intersections and driver behavior are mandated by the traffic laws of the State of North Carolina. These laws require traffic from minor or side streets to yield right-of-way to traffic on the major or through street. This basic "rule of the road" has yielded the following assumptions being used in the analysis of unsignalized intersections.

- Major street flows are not affected by minor (stop sign controlled) street movements.
- Left turns from the major street to the minor street are influenced only by opposing major street through-flow.
- Minor street right turns are impeded only by the major street traffic coming from the left.
- Minor street left turns are impeded by all major street traffic plus opposing minor street traffic.
- Minor street through traffic is impeded by all major street traffic.

The LOS for both unsignalized and signalized intersections is based upon the amount of delay (calculated in seconds/vehicle) to a motorist waiting to execute a maneuver. Delay is calculated for all vehicles through the intersection during the peak hour or peak 15-minute analysis period. Criteria used to determine LOS of unsignalized intersections are as follows:

Level of Service	Average Total Delay (Sec/Veh)
A	≤ 5
B	$>5 \leq 10$
C	$>10 \leq 20$
D	$>20 \leq 30$
E	$>30 \leq 45$
F	>45

In that paralleling roadways exist and Mills St. is relatively close to Ryder Ave., a Level of Service analysis was conducted as part of this study for the unsignalized intersections of US29A/Mills St. and Central Ave./Mills St.

Signalized Intersections

A Level of Service analysis was conducted for the signalized intersections of US 29A/Ryder Ave. and Central Ave./Ryder Ave. The analysis was conducted using 1997 traffic volumes as well as for projected 2010 volumes. The analysis was repeated with Mills St. closed at the NS and again with both Mills St. and E. Round St. closed. The 2010 volumes which were used in the analyses were projected from 1997 volumes at an annual rate of growth of 2%.

The LOS criteria for signalized intersections is based upon stopped delay per vehicle in seconds. The criteria from the Highway Capacity Manual are:

Level of Service	**Description**	Stopped Delay **Per Vehicle (Seconds)**
A	Very low delay, good progression; most vehicles do not stop at intersection	5.0
B	Generally good signal progression and/or short cycle length; more vehicles stop at intersection than level of service A.	$>5 \leq 15$
C	Fair progression and/or longer cycle length: significant number of vehicles stop at intersection than level of service A.	$>15 \leq 25$
D	Congestion becomes noticeable; individual cycle failures; longer delays from unfavorable progression, long cycle length, or high volume/ capacity ratios; most vehicles stop at intersection.	$>25 \leq 40$
E	Considered limit of acceptable delay, indicative of poor progression, long cycle length, high volume/ capacity ratio; frequent individual cycle failures.	$>40 \leq 60$
F	Unacceptable delay, frequently an indication of oversaturation (i.e. arrival flow exceeds capacity.)	>60

Level of Service

Intersection	1997 Volumes	2010 Traffic	2010 (1)	2010(2)
US 29A/Ryder	B	B	B	B
Ryder/Central	B	B	B	C
US 29A/Mills	A	A	N/A	N/A
Mills/Central	A	A	N/A	N/A

(1) Mills St. closed @ NS
(2) Mills St. and Round St. closed @ NS

TRAFFIC VOLUME

Based on the 24-hr. traffic volumes, the 4 at-grade crossings in Landis rank in terms of vehicles served:

1. Ryder Ave. (SR 1210) 4,700 VPD
2. Mills St. 2,420 VPD
3. Central Ave. 1,810 VPD
4. E. Round St. 1,400 VPD

ACCIDENT HISTORY

Two crossings in Landis have recorded accidents for the ten-year period for which records are available-Mills St. and Round St. Round St. has had a total of four crossing collisions resulting in four Class A injuries and two Class C. Mills St. has had three collisions resulting in one fatality (1988), one Class A injury and One Class B injury.

COST OF RAILWAY/HIGHWAY COLLISIONS

According to a report prepared by, and first published by, the Federal Highway Administration in 1991, accident costs by 1995 were as follows:

Fatal accident	$2,780,000.00
Injury accident	$55,000.00
Property damage only accident	$3,000.00

TABLE 1
EVALUATION OF STREET/RAILROAD AT-GRADE CROSSINGS

CROSSING #	RAILROAD	MUNICI-PALITY OR COUNTY	STREET NAME	MAINTENANCE RESPONSIBILITY (CITY/NCDOT)	SECONDARY ROAD NUMBER	STREET CLASS.	WARNING DEVICES (TYPE)*	24 HR ADT	ADT (PRO-JECTED) 2020	24 HR TRAIN VOL.	12 YR ACCIDENT HISTORY (NUMBER) 1984-95	SCHOOL BUS ROUTE (Y/N)	EMER-GENCY ROUTE (Y/N)
724391X	NS	Landis	Central	City	---	Local	5	1810	—	34	0	Y	Y
724394T	NS	Landis	Ryder	NCDOT	1210	Thoroughfare	5	4700	9700	34	0	Y	Y
724395A	NS	Landis	Mills	City	---	Local	5	2420	—	34	3(1K)(88)	Y	N
724396B	NS	Landis	Round	City	—	Local	5	1400	—	34	4	Y	N

* Type 1: Unmarked
Type 2: Crossbucks
Type 3: Stop signs/Crossbucks
Type 4: Flashing signals & bells
Type 5: Flashing signals, bells & gates

TABLE 1
EVALUATION OF STREET/RAILROAD AT-GRADE CROSSINGS (LANDIS)

STREET NAME	DESIG-NATED TRUCK ROUTE (Y/N)	% TRUCKS	HAZARDOUS MATERIALS (Y/N)	CROSSING CONDITION (GOOD, FAIR, POOR)		REDUN-DANT CROSSING (Y/N)	ADEQUATE STORAGE SPACE (Y/N)	PROPERTY SERVED	ECONOMIC IMPACT IF CLOSED (HI,MED, LOW)	NEED FOR ENHANCED WARNING DEVICES	NEED FOR ROADWAY IMPVTS (HI, MED, LOW)	FEASI-BILITY OF IMPLE-MENTING RDWAY IMPVTS (HI,MED, LOW)	POTEN-TIAL FOR GRADE SEPARA-TION (HI,MED LOW)
				GEOMETRY	SIGHT DISTANCE								
Central	N	1%	N	Poor	Fair	N	Y	Res	Med	S&M	High	High	Low
Ryder	Y	2%	Y	Good	Fair	N	N	Comm	High	S&M	Low	High	Low
Mills	N	1%	N	Good	Fair	Y	N	Comm	Low	S&M	Low	High	Low
Round	N	1%	N	Fair	Fair	N	Y	Ind/Res	Med	S&M	Med	Low	Low

Utilizing these numbers, the accidents occurring in Landis during the 10-year period have cost the community, in addition to the pain and suffering of the survivors, almost $2,800,000.00.

MENU OF AVAILABLE TRANSPORTATION SYSTEM ENHANCEMENTS

As growth in the greater Rowan Co. area continues, and with train traffic expected to increase along the Norfolk Southern (NS) due to the recent agreement between Norfolk Southern (NS) and CSX to purchase CONRAIL, the potential for traffic delays and accidents at the crossings is certain to increase.

The Norfolk Southern (NS) line from Washington, D.C. to Atlanta, GA, including the segment that comprises this report, has been designated by the USDOT as a **High Speed Rail Corridor**. Governor Jim Hunt has declared the line from Raleigh to Charlotte as a vital link in the **Transit 2001 Program**. A significant objective of the **Program** is to have two-hour passenger train service in place between Raleigh and Charlotte early in the next century. In order to accomplish this goal, significant changes will have to be made to the rail line that will affect many of the crossing streets and the communities they serve. The menu of system enhancements available for consideration follows:

- **Grade Separation Structures**

In recommending highway/railroad grade separation structures, there are many factors that must be considered. Among these factors are:

- Traffic volumes (both vehicle & train)
- Accident history
- Topography
- Construction impacts
- Costs

Traffic Volumes in the 15,000 to 20,000 vehicles per day (VPD) range and above are generally considered to be the threshold for consideration of a grade separation structure for local streets. Volumes of 30,000 VPD and more can be accommodated without significant delay provided train traffic is low.

The **NCDOT** uses an **"exposure index"** to determine whether or not a grade separation structure is warranted at either an existing or proposed railway/highway crossing. The exposure index is determined by multiplying the number of trains per day over the railroad by the number of vehicles per day (in the design year)* on the roadway. In other words, for a railroad with 5 trains per day and a roadway with 2,000 vehicles per day, the exposure index would be 10,000. The threshold for consideration for construction of either an overpass or an underpass is an exposure index of 15,000 in rural areas and 30,000 in urban areas.

*The Design Year is that future year when the improved roadway is expected to reach its theoretical vehicle carrying capacity. In other words, a roadway designed with a 20-year design life, and constructed in 1997, would reach its capacity in 2017. In computing the exposure index, the projected traffic volumes for 2017 would be used in the formula.

Accident History is another of the factors used when considering grade separation structures. Even though traffic volumes for vehicles and trains may be low, if frequent collisions between railroad and highway traffic is occurring, then a separation structure may be warranted.

Topography, or the lay of the land, is another important consideration. Where the street, railroad and surrounding land are all at about the same elevation, the construction of grade separation structures is made considerably more difficult.

Construction Impacts are of considerable importance in that they may be of such a magnitude as to do greater harm to the community than if the present conditions remain. Construction impacts can include acquisition and the subsequent relocation of families and businesses; destruction of the natural environment such as woodlands and wetlands; and, disruption of historical and archaeological sites. While the effects of some of the impacts may only be temporary, some can forever alter the character of a neighborhood or community.

Costs for grade separation structures can easily exceed $1 million and must, therefore, receive careful consideration before proceeding with funding and construction.

- **Crossing Protection Devices Upgrade**

Generally, the most cost effective way to deal with safety issues at an at-grade railroad crossing is to upgrade the crossing protection devices.

Crossing protection devices include signs, signals, bells and gates used to warn motorists of the pending crossing and, in the case of bells, signals and gates, alert the motorist to the train approaching the crossing. Passive devices, which include advance warning signs, railroad crossbucks and standard stop signs, are generally used on low volume crossings with good site distance. Active devices, which include signals, bells and gates, are used on higher volume crossings with greater accident potential or where existing conditions warrant more positive control. These devices rank from lowest to highest as follow:

Type	Description
1.	Unmarked
2.	Railroad crossbucks
3.	Standard stop signs (limited sight distance) & crossbucks
4.	Flashing signals and bells
5.	Flashing signals, bells & gates

The crossings in Landis are protected as follows:

E. Round St.	Flashing signals, bells & gates
Mills St.	Flashing signals, bells & gates
Ryder Ave.	Flashing signals, bells & gates
Central Ave.	Flashing signals, bells & gates

- **Advanced Crossing Protection Devices**

The NCDOT Rail Division has recently completed testing of more advanced crossing protection devices in the form of four-quadrant gates and barrier medians. These devices are appropriate for use on multi-lane, high-volume crossings of high-speed mainline railroads where significant numbers of motorists are ignoring the existing devices. The installation consists of dual gates across the entire approach width, and a barrier median on each approach to prevent motorists from crossing the roadway centerline in an attempt to get around the gates.

In tests recently completed at Sugar Creek Rd. in Charlotte (1996) in cooperation with Norfolk Southern (NS), violations dropped from almost 45 per week with standard gates and signals, to less than 2 per week with the advanced protection devices.

Video imaging is another technique that is being used to improve crossing safety. Under this program, video cameras are set up at certain crossings to record events as well as the vehicle and license plate of violators. This information is then provided to law enforcement officials for enforcement purposes.

- **Crossing Closure/Crossing Consolidation**

The most effective way to deal with railroad/highway crossing safety issues is to close low-volume redundant crossings. Crossings that connect to the same street network and are within a quarter mile (+/- 1300 feet) of each other, are considered to be redundant. Crossing consolidation is another way to treat crossings that may be relatively close to each other. Consolidation of two or more crossings into one can be accomplished by utilizing or building roads that parallel the tracks or by replacing several crossings with a grade separation structure.

- **Street Improvements**

Street improvements are an effective way to treat capacity and safety problems associated with a particular section of roadway, an intersection or a railroad crossing. These improvements can range from simply remarking the existing pavement to obtain a turn lane to total reconstruction of the roadway. In many cases, the more minor the improvement, the greater the benefits.

- **Traffic Signals**

As traffic volumes increase within a roadway network or at a particular intersection, the addition of a traffic signal(s) to the system may be warranted. Traffic signals are not a "cure-all" for traffic problems. Signals have distinct advantages and disadvantages. They are:

Advantages[1]

1. They can provide for the orderly movement of traffic.

2. Where proper physical layouts and control measures are used, they can increase the traffic-handling capacity of the intersection.

3. They can reduce the frequency of certain types of accidents, especially the right-angle type.

4. Under favorable conditions, they can be coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route.

5. They can be used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

Disadvantages[1]

1. Excessive delay may be caused.

2. Disobedience of the signal indications is encouraged.

3. The use of less adequate routes may be induced in an attempt to avoid such signals.

4. Accident frequency (especially the rear-end type) can be significantly increased.

Because of these advantages/disadvantages, it became necessary to develop a series of "warrants" for signal installation. The warrants are prescribed in the Manual on Uniform Traffic Control Devices (MUTCD) and are:

Warrant 1 - Minimum vehicular volume
Warrant 2 - Interruption of continuous traffic
Warrant 3 - Minimum pedestrian volume
Warrant 4 - School crossings
Warrant 5 - Progressive movement
Warrant 6 - Accident experience
Warrant 7 - Systems

(1) Manual on Uniform Traffic Control Devices, USDOT, Federal Highway Adm., Washington, D.C. 1988

Warrant 8 - Combination of warrants
Warrant 9 - Four hour volumes
Warrant 10 - Peak hour delay
Warrant 11 - Peak hour volume

Minimum criteria are established for each of the warrants and one or more must be met before installation of a new traffic signal can be considered.

SAFETY AND MOBILITY ISSUES

- Vehicles Queuing Across Railroad Tracks

Queuing of vehicles across the tracks usually occurs due to the nearby presence of traffic signals, intersections or paralleling roadways.

The crossings in Landis are all impacted by either a nearby traffic signal or a parallel roadway. Therefore, the potential for vehicles to que across the tracks is very real. This is especially true for Ryder Ave. and Mills St. and to a lesser extent, Round St. and Central Ave.

- Traffic Signal Preemption

The Manual on Uniform Traffic Control Devices requires that preemption of traffic signals occur when the signal is within 200 feet or less of the crossing. Both signals on Ryder, at US 29A and Central Ave., meet this criteria. Signal preemption is in place and was operating properly during field observations.

- Humped Crossings

A "humped" crossing is one at which the elevation of the railroad is generally higher than that of the approaching roadway. This humped affect causes cars and trucks to ascend on one approach to cross the track and descend on the other side. When the humping is severe enough, vehicles, especially low-hanging trucks, tend to drag over the crossing and can become hung such that the vehicle can go neither forward nor backward. Maintenance of the railroad tends to exacerbate the hump over time in that work on the track ballast generally raises the roadbed about three inches per occurrence. Over a ten-year period, the railroad will rise about one foot (1').

Of the four crossings in Landis, Central Ave. is the most severely humped. The other three are only slightly humped, however, this condition has been made worse by recent track work which has raised the grade along the tracks about three inches. With the exception of Central Ave., crossing profiles are generally acceptable.

- Grade Crossing Condition

The condition of the grade crossing surface can affect both safety and mobility. A poorly maintained crossing surface can contribute to accidents that may or may not involve a train.

Also, a crossing in poor condition may cause operating speeds over the crossing to be lowered, thereby, impacting roadway capacity.

All crossing surfaces in the Landis Study have recently been reworked and are in good condition. Only the Central Ave. crossing shows signs of vehicles dragging over the crossing.

- Vehicles Driving Around Automatic Gates

This occurs when motorists perceive that the automatic gates have lowered but a train is not approaching the crossing; when the gates fail in the lowered position (Fail Safe); or when impatience causes a driver or pedestrian to maneuver around the gates even when an approaching train is in sight. Field observations did not indicate a problem of this nature at any of the four crossings.

- Improved Signs and Markings

Installation and maintenance of required traffic control signs and markings is consistently an issue with state and municipal street and highway departments. And, to some extent, maintenance of the railroad signs, signals, and gates at crossings can be an issue with the railroad company.

Pavement markings need replacement at both Ryder Ave. and Central Ave. There is no evidence that pavement markings ever existed at Round St. and Mills St. The Manual on Uniform Traffic Control Devices requires that railroad legends be in place on each approach to a crossing that has automatic gates and signals in place. Round St. and Mills St. meet this criteria.

- Roadway Improvements

Roadway improvements are proposed for the Central Ave. crossing and are detailed in the **RECOMMENDATIONS SECTION** of this report.

- Roadway Grade Separation

Providing a roadway grade separation can eliminate safety, queuing and delay problems at a railroad grade crossing. Highway grade separations can either be on a bridge over the railway or the roadway can cross beneath the rail line.

Overpasses require greater length for the same design speed. The total elevation difference is greater because the standard rail vertical clearance of 23 feet exceeds the typical highway clearance of 16 or 16-1/2 feet (even though the structure depth is usually greater for the rail bridge typically provided at an underpass). More importantly, the vertical curve in the middle of the facility, the "crest" curve on an overpass is longer for a given design speed than the "sag" curve at an underpass, due to stopping sight distance requirements.

The visual and noise impacts associated with overpasses can make them undesirable for use

in residential areas, downtowns, or near historic structures. For the Landis study, none of the crossings meet the criteria for a grade separation structure as described above under **Menu of Available Transportation System Enhancements**. However, the Town of Landis has requested the evaluation of a structure at Rice St. This will be discussed in the **Recommendations Section** of this report.

The design, and ultimately the feasibility, of a highway grade separation is heavily influenced by property access considerations and the location and connectivity of roadways which parallel the tracks and connect to the cross street. Where an existing frontage road is immediately adjacent to the railroad, the street crossing can clear this facility as well. If necessary, a connection to the frontage road can be provided by directional ramps similar to freeway on-and-off ramps that provide access to the frontage road for traffic to-and-from points on the same side of the railway line as the frontage roadway.

Design standards for mainline railroads are very restrictive as far as the ability to modify the railroad grade or profile. For purposes of the study, changes in the profile of the Norfolk Southern (NS) line were not considered.

- Other Mobility Factors

  - The Rowan Co. School System reports utilization of all four crossings in Landis with volume ranging from one bus per day at Round St. to six per day at Ryder Ave. The Landis Fire Chief reports that his department primarily uses Ryder Ave. to get to the west side of the tracks with an occasional use of Mills St. when Ryder is congested. Rowan Co. Emergency Medical Service reports utilization of Ryder and Central and ranks both "very important" in meeting response time criteria.

  - Landis town officials report that truck loading operations at the Dominion Yarn plant, located at W. Ryder and US 29A, occasionally cause problems by trucks pulling onto the Ryder crossing in order to back into the plant loading dock. Town officials also acknowledged that the Central Ave. crossing has a poor alignment and bad sight distance and needs corrective action.

  - **THE KANNAPOLIS-CONCORD THOROUGHFARE PLAN** was adopted by the Town of Landis on March 4, 1996. The **PLAN** has two proposed projects that impact the recommendations that follow in the **Recommendations Section.**

    - NC 153 is a minor thoroughfare that connects NC 152 to US 29A utilizing a portion of W. Rice St. A new thoroughfare is proposed south of town that will connect Cannon Farms Rd. with Airport Dr. which crosses into and serves Kannapolis as well. With this connector in place, volumes on Rice St. are expected to decrease.

    - North of Landis and south of China Grove, Kimball Rd. is proposed to be extended, with a grade separation structure at the NS, to connect

with Old Beattys Ford Rd.

- **VOLUME III (KANNAPOLIS)** of this series of studies, recommends a grade separation structure at 22nd St. in Kannapolis. Should this structure be constructed, it would be less than one mile from the town limit of Landis and would provide access for Landis traffic by way of US 29A (Main St) and Central Ave./US 29.

CONCLUSIONS

Accommodating the **Transit 2001 Plan** goal of two-hour passenger train service between Raleigh and Charlotte will require a substantial reduction in the number of streets that cross the railroad at grade, as well as major modifications to many of those that remain.

Freight train traffic along the Norfolk Southern (NS) will increase due to the division of CONRAIL routes between Norfolk Southern (NS) and CSX.

Vehicular traffic in the Landis Area will continue to increase as growth and expansion in Rowan County continues.

Grade crossing safety is an issue at Mills St. and Round St., as demonstrated by the seven (7) recorded accidents.

The potential for vehicles to que across the tracks at Mills St. and Ryder Ave. is an issue. The geometry of the Central Ave. crossing is poor and requires attention.

RECOMMENDATIONS

I. E. ROUND STREET---carries the least amount of daily traffic of the four in Landis but has a substantial accident record. Access from the residential area is provided by Central Ave., so, it appears that Round St. is used primarily to gain access to US 29A. This same access can be accomplished by using Central Ave. and Ryder Ave. Given the low crossing volume, the high accident rate and the goals of the **Piedmont High Speed Rail Corridor**, it is recommended that the E. Round St. crossing be closed.

Near-term Recommendation: Close the crossing.

Estimated cost:

Close the crossing $8,000.00
Remove pavement/install guard rail and curb & gutter/landscape $5,500.00

See Figures 3 & 4.

Impacts of the Recommendation: closing the crossing will require those living east of the tracks who wish to access US 29A south, to drive an additional 0.8 miles to reach the intersection of US29A and E. Round St. Assuming that half the traffic on Round St. wishes

to make this maneuver (700 vehicles per day), and that it takes 3 minutes to accomplish, the annual cost to the community to close the crossing will be approximately $175,000. As shown above, however, the cost of one fatality at any of the crossings would result in a community cost of almost 16 times this amount. The positive impacts of closing the crossing are: (1) the potential for rail/highway collisions is eliminated; (2) the noise impacts associated with the blowing of train horns is eliminated; and, (3) the implementation of the **Piedmont High Speed Rail Corridor** is enhanced.

II. E. MILLS STREET---parallels Ryder Ave. approximately 450 feet to the south and serves as a relief valve for Ryder overflow. Given the accident history at the crossing, the fact that it can be closed with no detrimental impacts on the local street network and the goals established for the **Piedmont High Speed Rail Corridor,** it is recommended that the Mills St. crossing be closed.

Near-term Recommendation: Close the crossing.

Estimated cost:

Close the crossing $8,000.00
Remove pavement/install curb & gutter/landscape $8,000.00

See Figures 5 & 6.

Impacts of the Recommendation: Closing Mills St. will require some minor adjustments in local travel patterns for area drivers as well as a change in bus routing by the Rowan Co School system. Mills St. is also used on occasion by the Fire Department, its closing, however, should have no measurable impact on fire response times.

There should be no measurable impact on the one adjacent business in that it will retain access to Central Ave. The positive impacts of closing the crossing are: (1) the potential for rail/highway collisions is eliminated; (2) the noise impacts associated with the blowing of train horns is eliminated; and, (3) the implementation of the **Piedmont High Speed Rail Corridor** is enhanced.

III. RYDER AVE.---provides primary access to the Landis CBD and serves as the connector between West and East Landis as well as connecting to the US 29 By-pass. While there is a local perception that congestion is an issue at the crossing, it appears to be primarily confined to shift changes at Dominion Yarn. The Level of Service analyses conducted for the intersections on either end of the crossing, show that they are currently operating at an LOS of B and will continue to operate at B with projected 2010 volumes. Furthermore, both intersections will continue to operate at B in 2010 with Mills closed and Ryder/US 29A will continue to operate at B with both Mills and Round closed while Ryder/Central will fall to C with both closed.

Based upon the overall analysis of the crossing and the role Ryder Ave. plays in the local street network, it should continue in its present form. However, in light of the fact that Ryder will be the only crossing of the NS in the Landis CBD, a rubberized crossing is

warranted, as well as some minor modifications to the approach grades to the crossing.

Near Term Recommendation: Install a rubberized crossing and modify the crossing approach grades.

Estimated Cost: $30,000.00

See Figures 7 and 8.

IV. CENTRAL AVENUE---as indicated above, both the approach angle and sight distance of the Central Ave. crossing are poor and require modification. A survey was conducted to determine if a better location for the crossing could be found between Garden St. and the current location. There are no other locations where the topography of the paralleling roadways and the railroad match to a degree that would warrant relocation of the crossing. It is recommended, therefore, that the existing Central Ave. crossing be reconstructed such that it crosses the NS at a 90 degree angle. The approach grade on both sides of the crossing should be raised to reduce the "hump" which will require that a portion of both Central Ave. and US 29A be reconstructed as well.

Near-term Recommendation: reconfigure the existing crossing/install long-gate arms.

Estimated cost:

Roadway	$80,000.00
Relocate automatic warning devices	$12,000.00
Install long-gate arms	$15,000.00

See Figures 9 & 10.

Impacts of the Recommendation: to implement the recommendation will require that some fill material be placed along the frontage of houses on Central Ave. and US 29A. However, the positive impacts from a safety perspective of a much improved crossing, more than offset the temporary impacts of the construction.

Long Term Recommendation: At such time as the Kimball Rd. project described above in the **Safety and Mobility Issues Section** is constructed, then the Central Ave. crossing should be closed.

V. RICE STREET PROPOSED GRADE SEPARATION: present traffic volumes on W. Rice Rd., which carries NC 153 traffic, approaches 5000 vehicles per day. Volumes for the year 2020, as projected by the NCDOT Statewide Planning Branch in the preparation of the areawide Transportation Plan, are 4100. The reduction in traffic is brought about by the implementation of other transportation improvement projects as described above in the **Safety and Mobility Section** of this report.

While it is physically possible to construct a separation structure at Rice St., the cost of such a project, including right-of-way and the associated roadway work necessary, can be in the range of $2 to 4 million. To build the separation structure would certainly mitigate the

impacts associated with the above recommendations to close Round St. and Mills St., however, there are other more worthy projects proposed as part of either the **Kannapolis-Concord Thoroughfare Plan** or contained in other volumes in this series of studies.

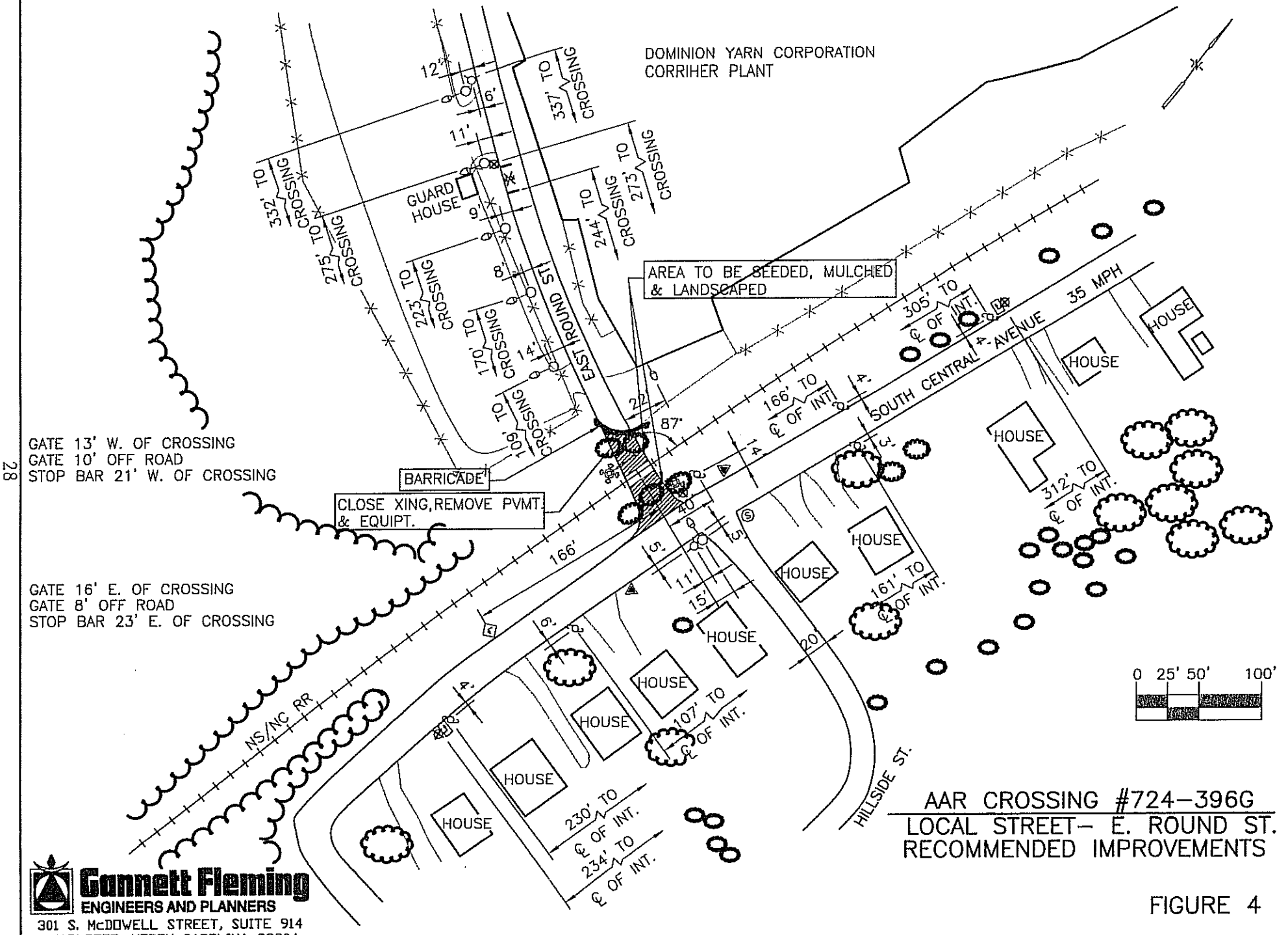
Municipality: Landis

Crossing Number: 724396G *Street Name:* E. Round St.

Eastbound Approach

Westbound Approach

FIGURE 3



AAR CROSSING #724-396G
LOCAL STREET- E. ROUND ST.
RECOMMENDED IMPROVEMENTS

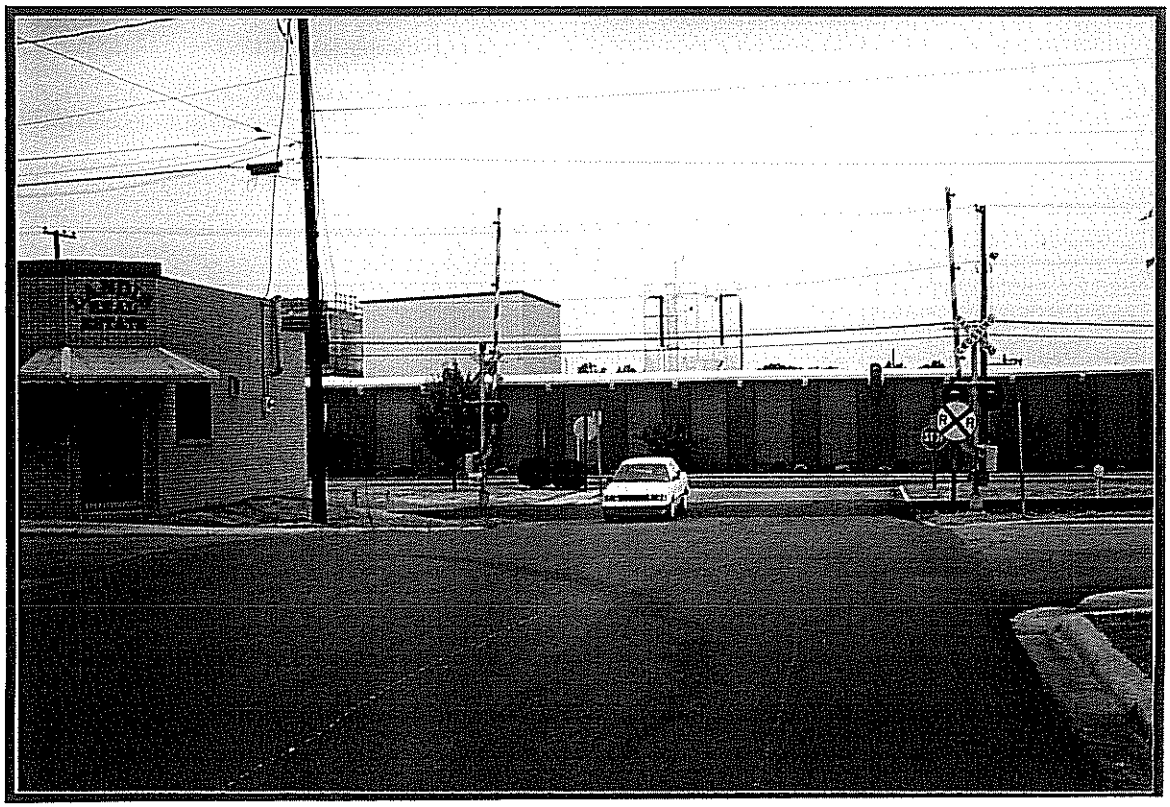
FIGURE 4

Gannett Fleming
ENGINEERS AND PLANNERS
301 S. McDOWELL STREET, SUITE 914
CHARLOTTE, NORTH CAROLINA 28204

Municipality: Landis

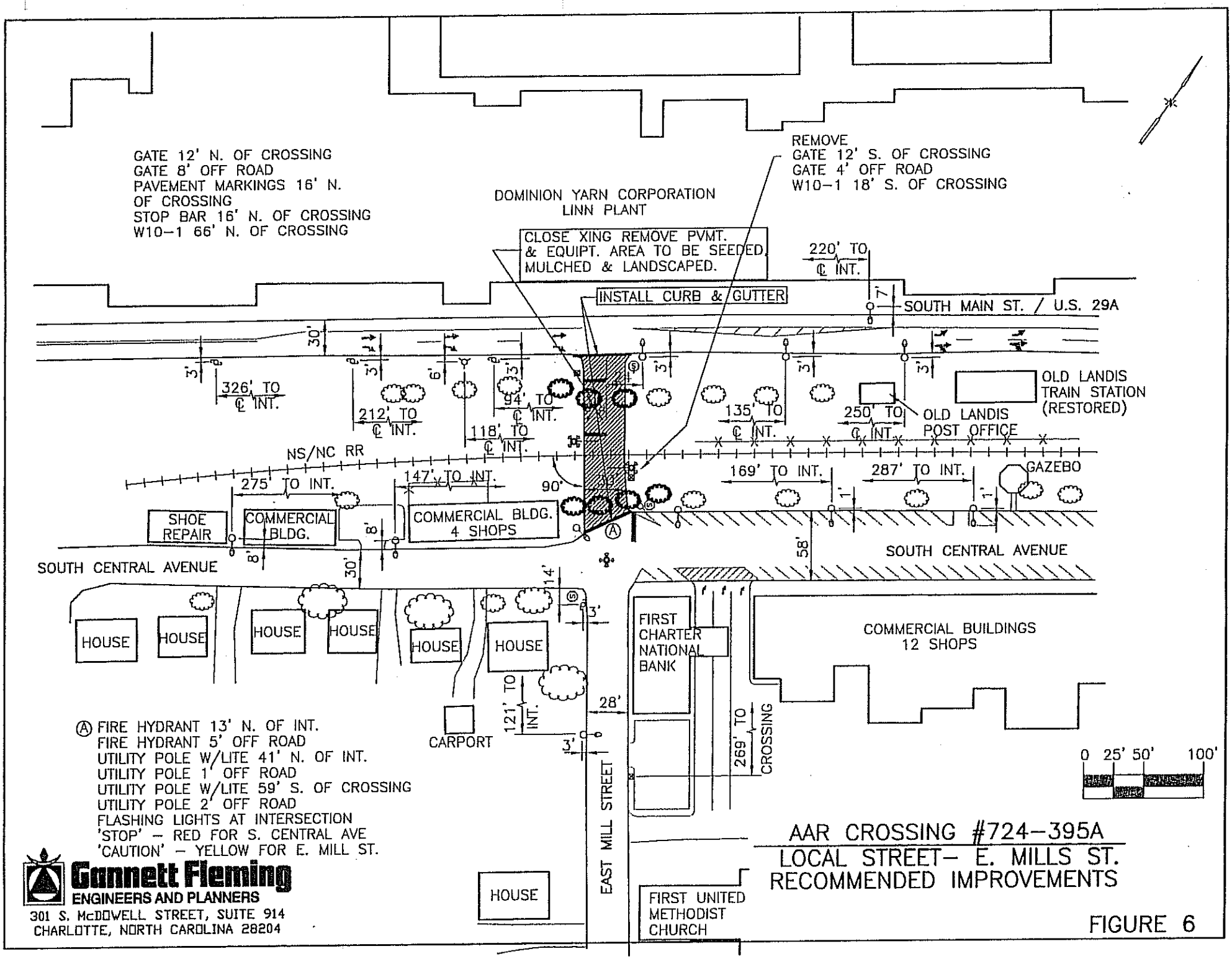
Crossing Number: 724395A *Street Name:* E. Mills St.

Eastbound Approach



Westbound Approach

FIGURE 5



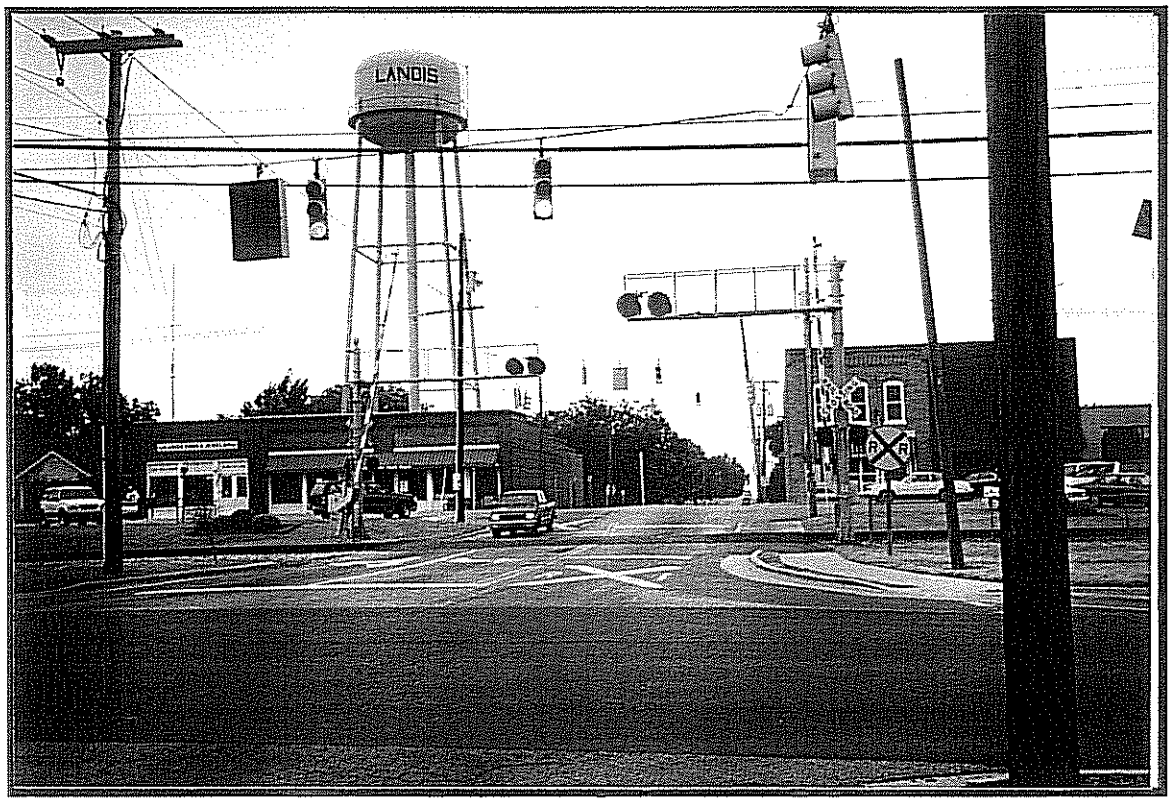
Gannett Fleming
ENGINEERS AND PLANNERS
301 S. McDOWELL STREET, SUITE 914
CHARLOTTE, NORTH CAROLINA 28204

AAR CROSSING #724-395A
LOCAL STREET– E. MILLS ST.
RECOMMENDED IMPROVEMENTS

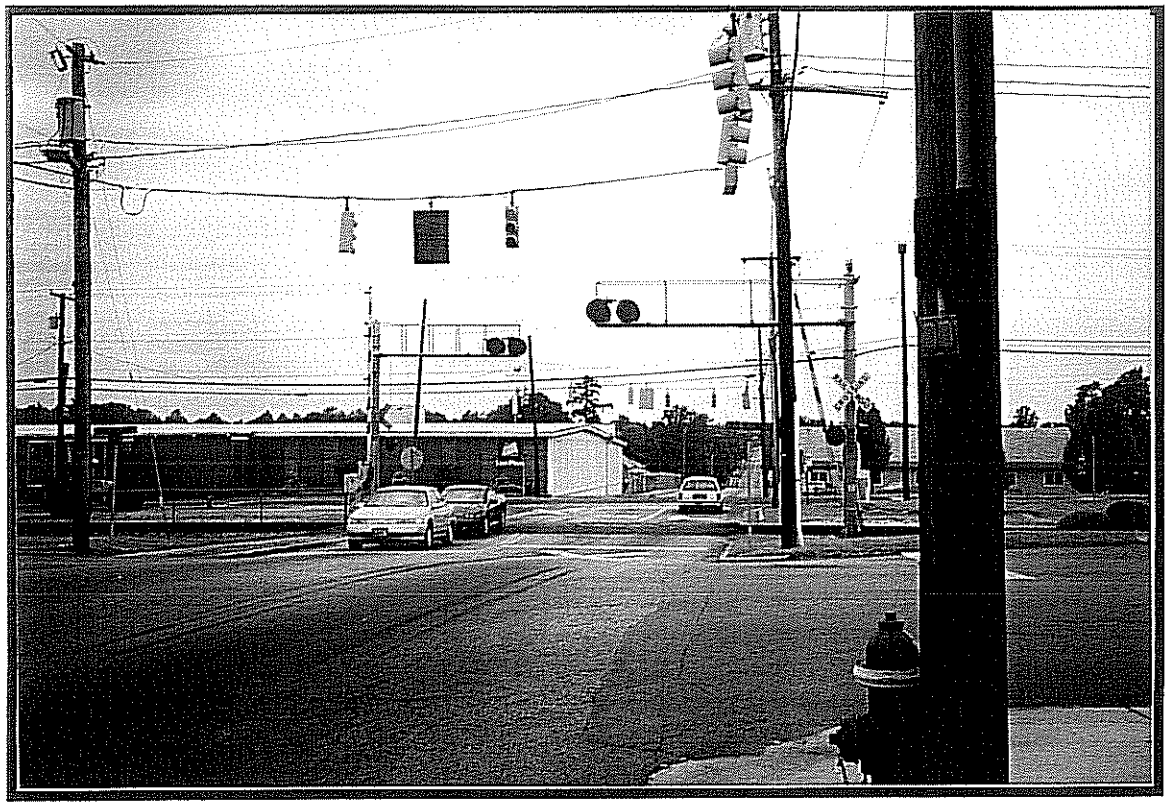
FIGURE 6

Municipality: Landis

Crossing Number: 724394T *Street Name:* E. Ryder St.

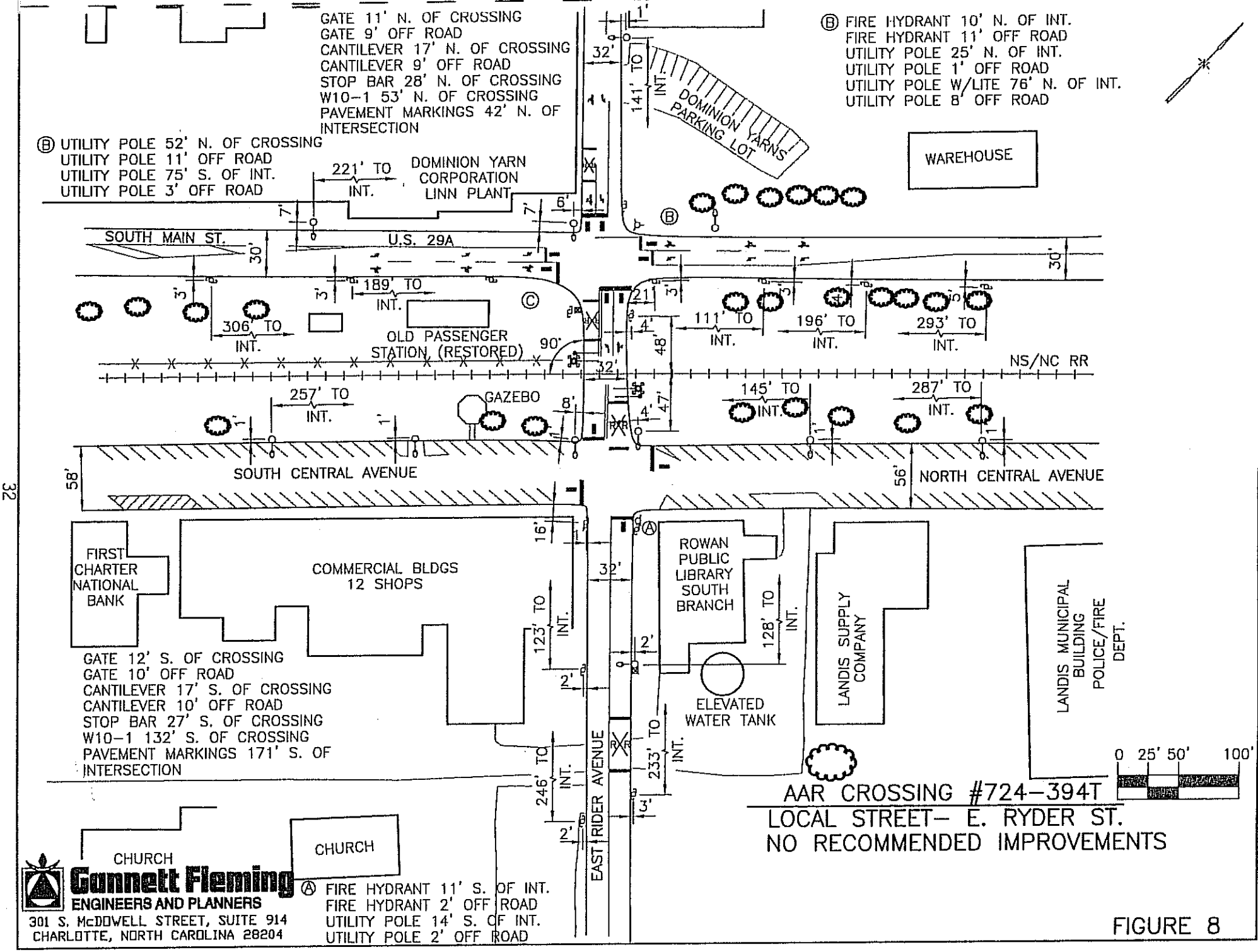


Eastbound Approach



Westbound Approach

FIGURE 7



Gannett Fleming
ENGINEERS AND PLANNERS
301 S. McDOWELL STREET, SUITE 914
CHARLOTTE, NORTH CAROLINA 28204

FIGURE 8

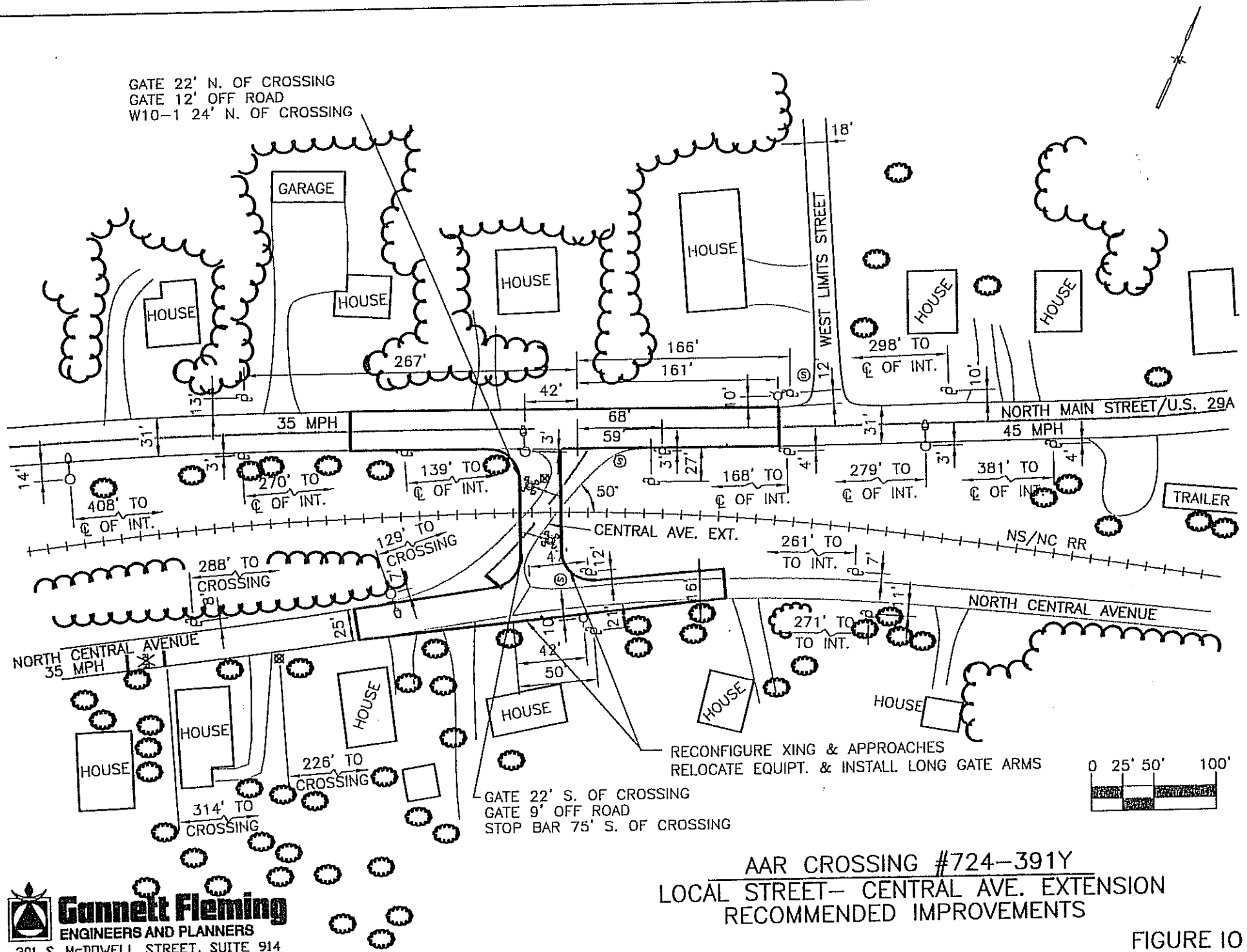
Municipality: Landis

Crossing Number: 724391Y *Street Name:* Central Ave. Ext.

Eastbound Approach

Westbound Approach

FIGURE 9



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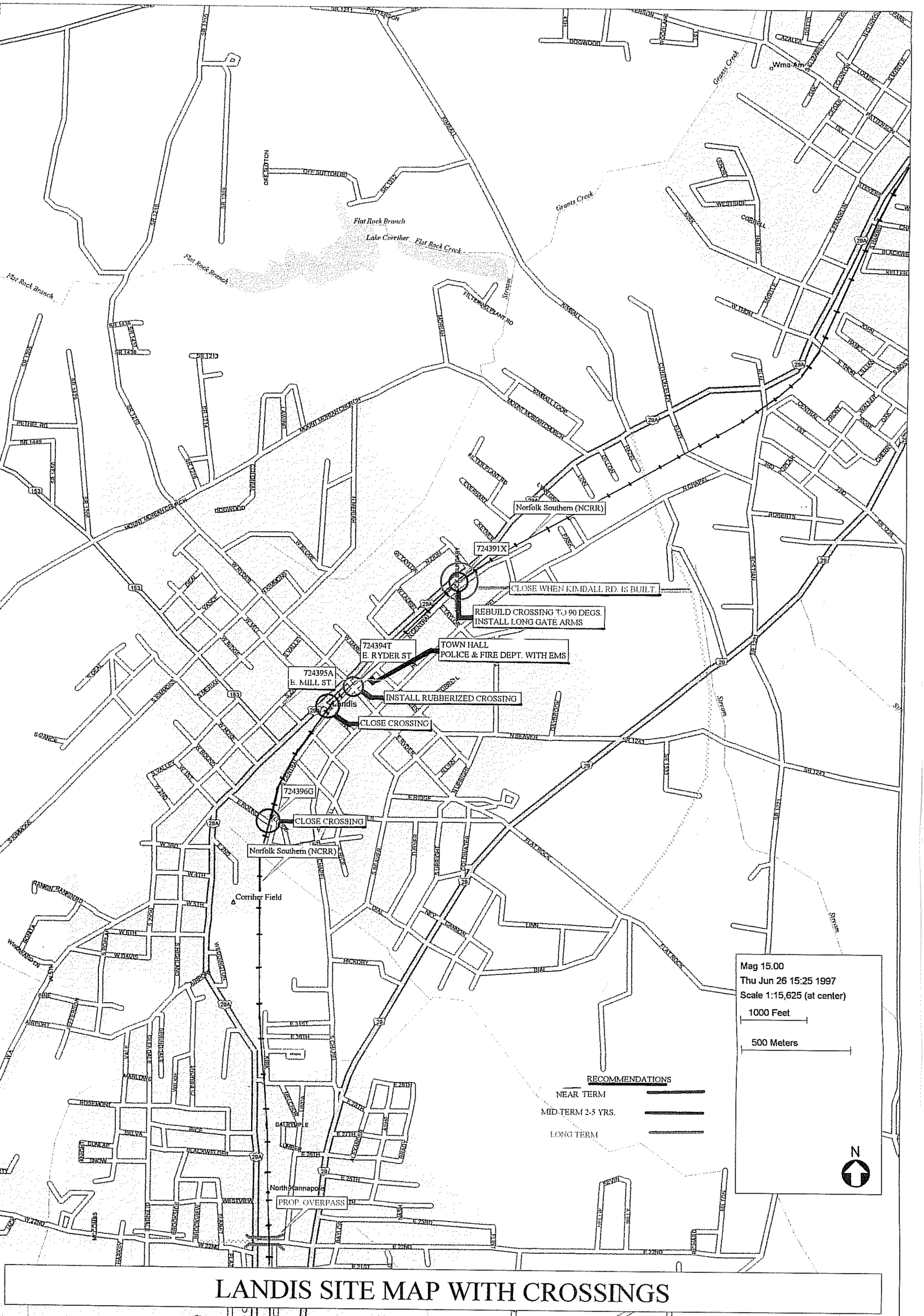
ENGINEERS AND PLANNERS
301 S. McDOWELL STREET, SUITE 914
CHARLOTTE, NORTH CAROLINA 28204

AAR CROSSING #724-391Y
LOCAL STREET- CENTRAL AVE. EXTENSION
RECOMMENDED IMPROVEMENTS

FIGURE 10



LANDIS SITE MAP WITH CROSSINGS

FIGURE 11

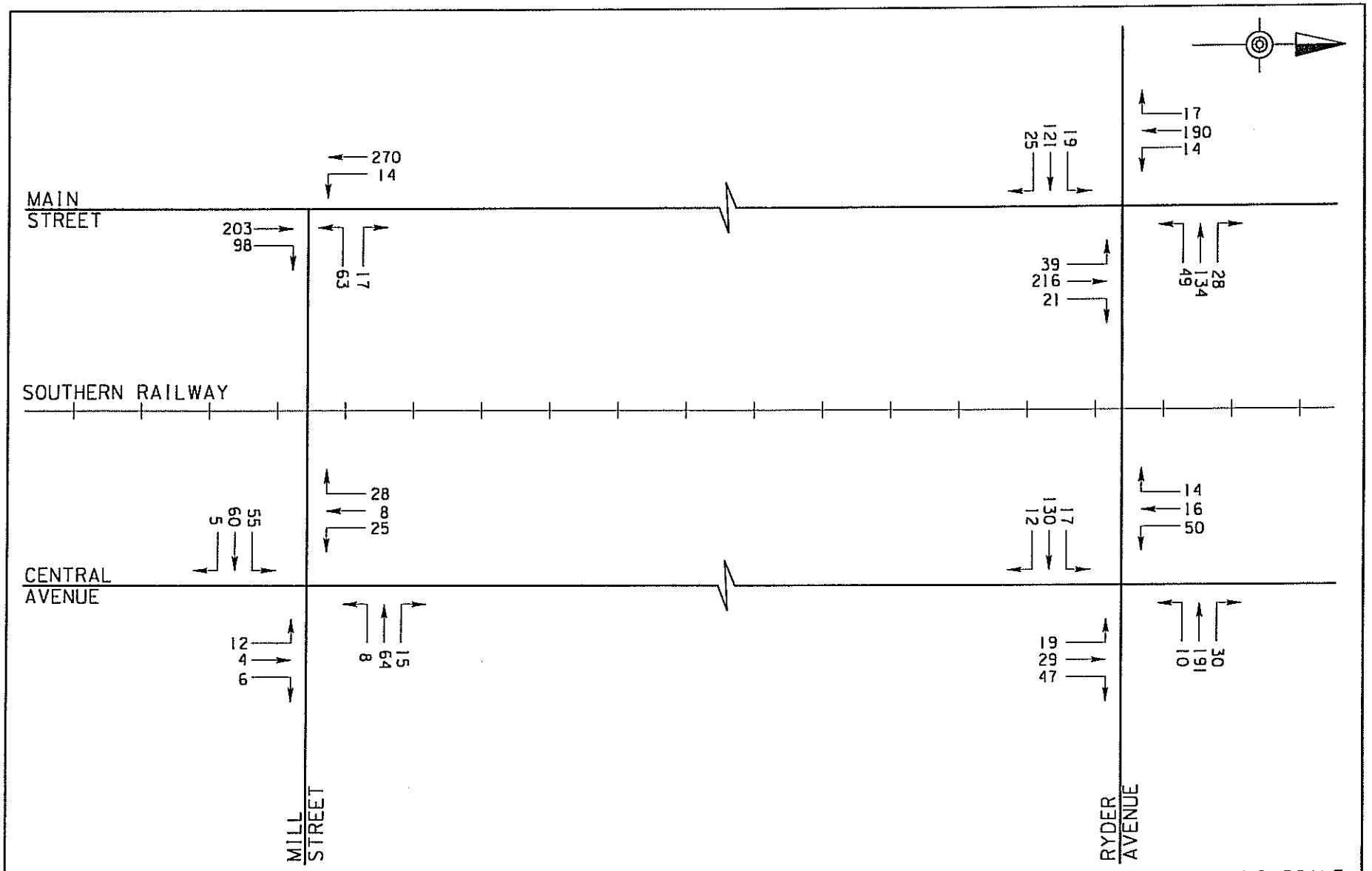
APPENDIX

EXHIBIT 4 CAPACITY ANALYSES SUMMARY (Landis Study Section)

Intersection	1997 Existing Conditions	2010 No Build Conditions	2010 Build Conditions
Main Street and Ryder Avenue (sig)	B	B	B
Central Avenue and Ryder Avenue (sig)	B	B	B
Main Street and Mill Street (unsig)	B	B	N/A
Central Avenue and Mill Street (unsig)	A	A	N/A

NOTES:

1. Capacity analysis results shown as Level of Service (LOS) for worst approach/ movement for unsignalized intersections and overall LOS for signalized intersections.
2. " * " means that LOS exceeds capacity.
3. N/A - not applicable



Gannett Fleming ENGINEERS AND PLANNERS	PIEDMONT HIGH SPEED RAIL CORRIDOR STUDY	APRIL 1997	EXHIBIT 1 1997 EXISTING PEAK HOUR TRAFFIC VOLUMES

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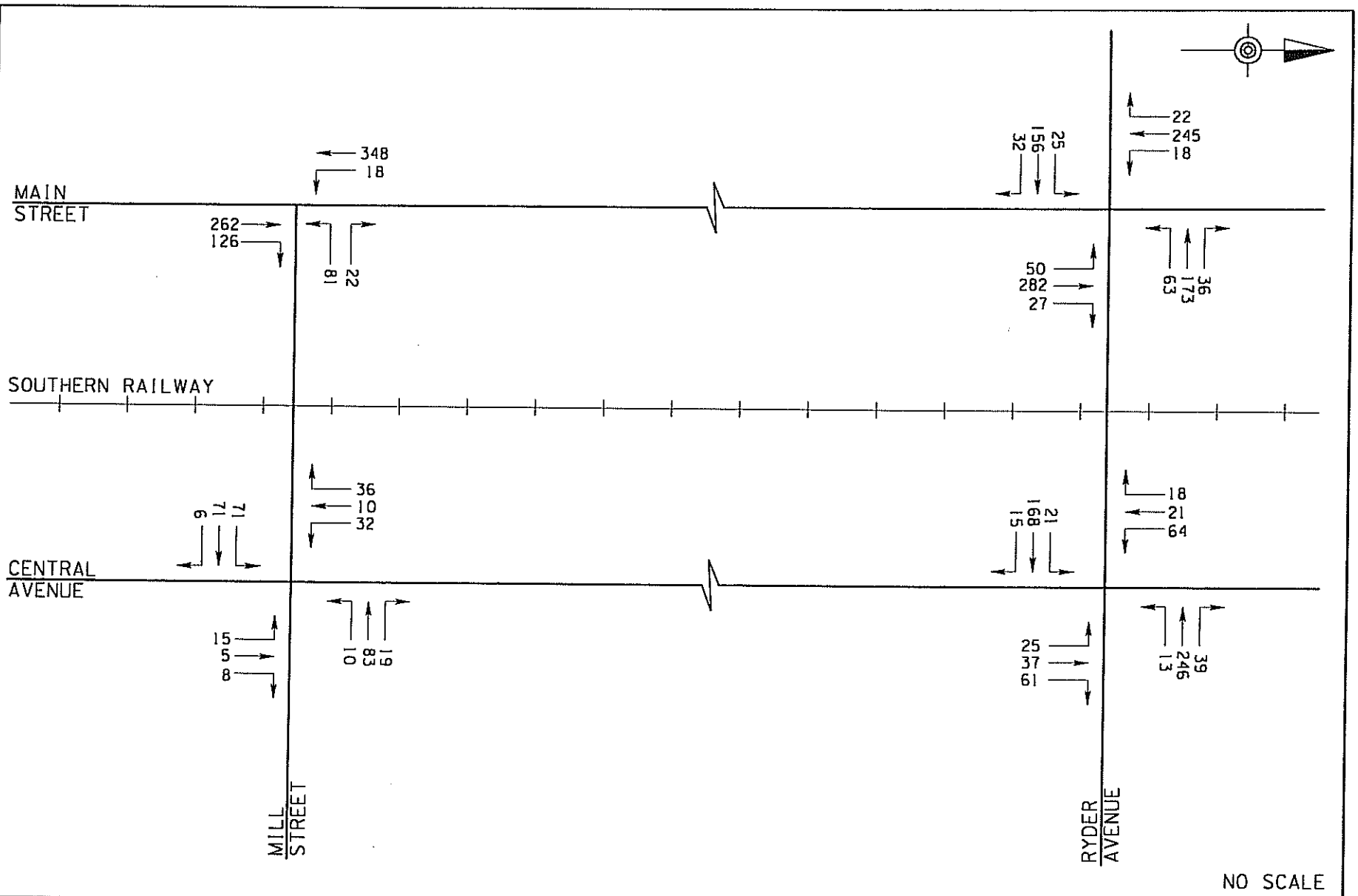

Gannett Fleming ENGINEERS AND PLANNERS	PIEDMONT HIGH SPEED RAIL CORRIDOR STUDY	APRIL 1997	EXHIBIT 2 2010 NO BUILD PEAK HOUR TRAFFIC VOLUMES

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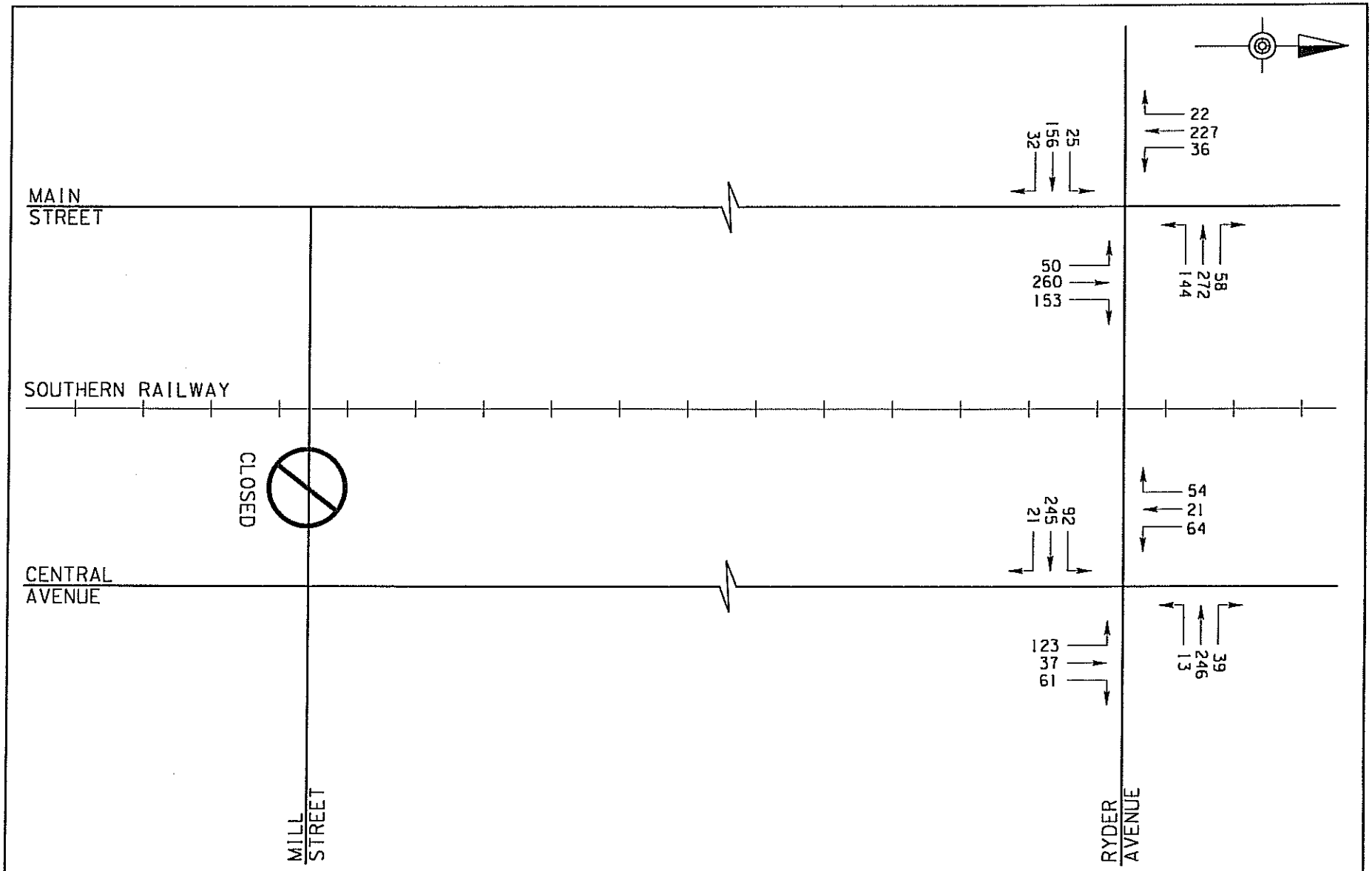

Gannett Fleming ENGINEERS AND PLANNERS	PIEDMONT HIGH SPEED RAIL CORRIDOR STUDY	APRIL 1997	EXHIBIT 3 2010 BUILD PEAK HOUR TRAFFIC VOLUMES

FILE: c:\211\traffic\30709\us29nc5b.dgn
DATE: 2-May-97 15:02

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) MAIN STREET
Analyst: RJT File Name: MSRA97EX.HC9
Area Type: Other 5-1-97 PEAK
Comment: 1997 EXISTING CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	1	1	<	1	1	<	1	1	<	1	1	<
Volumes	19	121	25	49	134	28	39	216	21	14	190	17
Lane W (ft)	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination		1	2	3	4			5	6	7	8
EB	Left	*				NB	Left	*			
	Thru	*					Thru	*			
	Right	*					Right	*			
	Peds						Peds				
WB	Left	*				SB	Left	*			
	Thru	*					Thru	*			
	Right	*					Right	*			
	Peds						Peds				
NB	Right					EB	Right				
SB	Right					WB	Right				
Green		25.0P				Green		25.0P			
Yellow/AR		5.0				Yellow/AR		5.0			

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Mvmts	Group: Cap	Adj Sat Flow	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	L	514	1143	0.039	0.450	7.0	B	7.5	B
	TR	817	1815	0.187	0.450	7.5	B		
WB	L	540	1201	0.096	0.450	7.2	B	7.5	B
	TR	817	1815	0.208	0.450	7.6	B		
NB	L	444	986	0.092	0.450	7.2	B	7.9	B
	TR	827	1838	0.301	0.450	8.0	B		
SB	L	399	887	0.038	0.450	7.0	B	7.8	B
	TR	828	1840	0.263	0.450	7.9	B		

Intersection Delay = 7.7 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.255

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) MAIN STREET
Analyst: RJT File Name: MSRA10NB.HC9
Area Type: Other 5-1-97 PEAK
Comment: 2010 NO BUILD CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	1	1	<	1	1	<	1	1	<	1	1	<
Volumes	25	156	32	63	173	36	50	282	27	18	245	22
Lane W (ft)	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left	*				NB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
WB Left	*				SB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green	25.0P				Green	25.0P		
Yellow/AR	5.0				Yellow/AR	5.0		

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Group: Mvmts	Adj Sat Flow Cap	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	L	441	979	0.059	0.450	7.1	B	7.7	B
	TR	817	1815	0.242	0.450	7.8	B		
WB	L	475	1056	0.139	0.450	7.4	B	7.8	B
	TR	816	1814	0.270	0.450	7.9	B		
NB	L	360	799	0.147	0.450	7.4	B	8.4	B
	TR	828	1839	0.393	0.450	8.5	B		
SB	L	312	693	0.061	0.450	7.1	B	8.2	B
	TR	828	1840	0.339	0.450	8.2	B		

Intersection Delay = 8.1 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.331

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) MAIN STREET
Analyst: RJT File Name: MSRA10BD.HC9
Area Type: Other 5-1-97 PEAK
Comment: 2010 BUILD CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	1	1	<	1	1	<	1	1	<	1	1	<
Volumes	25	156	32	144	173	58	50	260	153	36	227	22
Lane W (ft)	12.0	12.0		12.0	12.0		12.0	12.0		12.0	12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left	*				NB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
WB Left	*				SB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green	25.0P				Green	25.0P		
Yellow/AR	5.0				Yellow/AR	5.0		

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Mvmts	Group: Cap	Adj Sat Flow	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	L	407	905	0.064	0.450	7.1	B	7.7	B
	TR	817	1815	0.242	0.450	7.8	B		
WB	L	475	1056	0.320	0.450	8.2	B	8.1	B
	TR	807	1793	0.301	0.450	8.0	B		
NB	L	382	850	0.139	0.450	7.4	B	9.5	B
	TR	792	1759	0.550	0.450	9.8	B		
SB	L	204	453	0.186	0.450	7.6	B	8.1	B
	TR	827	1838	0.317	0.450	8.1	B		

Intersection Delay = 8.5 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.435

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) CENTRAL AVENUE
Analyst: RJT File Name: CARA97EX.HC9
Area Type: Other 5-1-97 PEAK
Comment: 1997 EXISTING CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes		> 1	<		> 1	<		> 1	<		> 1	<
Volumes	17	130	12	10	191	30	19	29	47	50	16	14
Lane W (ft)		12.0			12.0			12.0			12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left	*				NB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
WB Left	*				SB Left	*		
Thru	*				Thru	*		
Right	*				Right	*		
Peds					Peds			
NB Right					EB Right			
SB Right					WB Right			
Green	25.0P				Green	25.0P		
Yellow/AR	5.0				Yellow/AR	5.0		

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Group: Mvmts	Cap	Adj Sat Flow	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	LTR	701	1558	0.240	0.450	7.8	B	7.8	B
WB	LTR	728	1618	0.335	0.450	8.2	B	8.2	B
NB	LTR	669	1487	0.149	0.450	7.4	B	7.4	B
SB	LTR	609	1353	0.140	0.450	7.4	B	7.4	B

Intersection Delay = 7.8 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.242

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) CENTRAL AVENUE
Analyst: RJT File Name: CARA10NB.HC9
Area Type: Other 5-1-97 PEAK
Comment: 2010 NO BUILD CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes		> 1	<		> 1	<		> 1	<		> 1	<
Volumes	21	168	15	13	246	39	25	37	61	64	21	18
Lane W (ft)		12.0			12.0			12.0			12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left	*				NB Left	*			
Thru	*				Thru	*			
Right	*				Right	*			
Peds					Peds				
WB Left	*				SB Left	*			
Thru	*				Thru	*			
Right	*				Right	*			
Peds					Peds				
NB Right					EB Right				
SB Right					WB Right				
Green	25.0P				Green	25.0P			
Yellow/AR	5.0				Yellow/AR	5.0			

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Group: Mvmts	Cap	Adj Sat Flow	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	LTR	687	1526	0.313	0.450	8.1	B	8.1	B
WB	LTR	724	1609	0.434	0.450	8.8	B	8.8	B
NB	LTR	659	1464	0.196	0.450	7.6	B	7.6	B
SB	LTR	576	1279	0.188	0.450	7.6	B	7.6	B

Intersection Delay = 8.2 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.315

HCM: SIGNALIZED INTERSECTION SUMMARY Version 2.4d 05-01-1997

Gannett Fleming, Inc.

Streets: (E-W) RYDER AVENUE (N-S) CENTRAL AVENUE
Analyst: RJT File Name: CARA10BD.HC9
Area Type: Other 5-1-97 PEAK
Comment: 2010 BUILD CONDITIONS

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes		> 1	<		> 1	<		> 1	<		> 1	<
Volumes	92	245	21	13	246	39	123	37	61	64	21	54
Lane W (ft)		12.0			12.0			12.0			12.0	
RTOR Vols			0			0			0			0
Lost Time	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Signal Operations

Phase Combination	1	2	3	4		5	6	7	8
EB Left	*				NB Left	*			
Thru	*				Thru	*			
Right	*				Right	*			
Peds					Peds				
WB Left	*				SB Left	*			
Thru	*				Thru	*			
Right	*				Right	*			
Peds					Peds				
NB Right					EB Right				
SB Right					WB Right				
Green	25.0P				Green	25.0P			
Yellow/AR	5.0				Yellow/AR	5.0			

Cycle Length: 60 secs Phase combination order: #1 #5

Intersection Performance Summary

	Lane Group: Mvmts	Cap	Adj Sat Flow	v/c Ratio	g/C Ratio	Delay	LOS	Approach: Delay	LOS
EB	LTR	573	1273	0.658	0.450	11.7	B	11.7	B
WB	LTR	710	1578	0.442	0.450	8.9	B	8.9	B
NB	LTR	537	1193	0.432	0.450	8.9	B	8.9	B
SB	LTR	522	1160	0.280	0.450	8.0	B	8.0	B

Intersection Delay = 9.8 sec/veh Intersection LOS = B

Lost Time/Cycle, L = 6.0 sec Critical v/c(x) = 0.545

Gannett Fleming, Inc.
209 Senate Avenue
Camp Hill, PA 17011-
Ph: (717) 763-7211

Streets: (N-S) MAIN STREET (E-W) MILL STREET
Major Street Direction.... NS
Length of Time Analyzed... 15 (min)
Analyst..... RJT
Date of Analysis..... 5/1/97
Other Information.....1997 EXISTING CONDITIONS
Two-way Stop-controlled Intersection

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	> 1	0	0	0	0	0	> 0	< 0
Stop/Yield			N			N						
Volumes		203	98	14	270					63		17
PHF		.95	.95	.95	.95					.95		.95
Grade		0			0						0	
MC's (%)				0						0		0
SU/RV's (%)				0						0		0
CV's (%)				2						2		2
PCE's				1.02						1.02		1.02

Adjustment Factors

Vehicle Maneuver	Critical Gap (tg)	Follow-up Time (tf)
Left Turn Major Road	5.00	2.10
Right Turn Minor Road	5.50	2.60
Through Traffic Minor Road	6.00	3.30
Left Turn Minor Road	6.50	3.40

Worksheet for TWSC Intersection

Step 1: RT from Minor Street	WB	EB
Conflicting Flows: (vph)	214	
Potential Capacity: (pcph)	1079	
Movement Capacity: (pcph)	1079	
Prob. of Queue-Free State:	0.98	

Step 2: LT from Major Street	SB	NB
Conflicting Flows: (vph)	317	
Potential Capacity: (pcph)	1211	
Movement Capacity: (pcph)	1211	
Prob. of Queue-Free State:	0.99	
TH Saturation Flow Rate: (pcphpl)	1700	
Major LT Shared Lane Prob. of Queue-Free State:	0.99	

Step 4: LT from Minor Street	WB	EB
Conflicting Flows: (vph)	512	
Potential Capacity: (pcph)	535	
Major LT, Minor TH Impedance Factor:	0.99	
Adjusted Impedance Factor:	0.99	
Capacity Adjustment Factor due to Impeding Movements	0.99	
Movement Capacity: (pcph)	527	

Intersection Performance Summary

Movement	Flow Rate (pcph)	Move Cap (pcph)	Shared Cap (pcph)	Avg. Total Delay (sec/veh)	95% Queue Length (veh)	LOS	Approach Delay (sec/veh)
WB L	67	527 >					
			591	7.1	0.5	B	7.1
WB R	18	1079 >					
SB L	15	1211		3.0	0.0	A	0.1

Intersection Delay = 0.9 sec/veh

Gannett Fleming, Inc.
209 Senate Avenue
Camp Hill, PA 17011-
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Streets: (N-S) MAIN STREET (E-W) MILL STREET
Major Street Direction.... NS
Length of Time Analyzed... 15 (min)
Analyst..... RJT
Date of Analysis..... 5/1/97
Other Information.....2010 NO BUILD CONDITIONS
Two-way Stop-controlled Intersection

	Northbound			Southbound			Eastbound			Westbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	1	1	0	> 1	0	0	0	0	0	> 0	< 0
Stop/Yield			N			N						
Volumes		262	126	18	348					81		22
PHF		.95	.95	.95	.95					.95		.95
Grade		0			0						0	
MC's (%)				0						0		0
SU/RV's (%)				0						0		0
CV's (%)				2						2		2
PCE's				1.02						1.02		1.02

Adjustment Factors

Vehicle Maneuver	Critical Gap (tg)	Follow-up Time (tf)
Left Turn Major Road	5.00	2.10
Right Turn Minor Road	5.50	2.60
Through Traffic Minor Road	6.00	3.30
Left Turn Minor Road	6.50	3.40

Worksheet for TWSC Intersection

Step 1: RT from Minor Street	WB	EB
Conflicting Flows: (vph)	276	
Potential Capacity: (pcph)	1003	
Movement Capacity: (pcph)	1003	
Prob. of Queue-Free State:	0.98	

Step 2: LT from Major Street	SB	NB
Conflicting Flows: (vph)	409	
Potential Capacity: (pcph)	1094	
Movement Capacity: (pcph)	1094	
Prob. of Queue-Free State:	0.98	
TH Saturation Flow Rate: (pcphpl)	1700	
Major LT Shared Lane Prob. of Queue-Free State:	0.98	

Step 4: LT from Minor Street	WB	EB
Conflicting Flows: (vph)	662	
Potential Capacity: (pcph)	438	
Major LT, Minor TH Impedance Factor:	0.98	
Adjusted Impedance Factor:	0.98	
Capacity Adjustment Factor due to Impeding Movements	0.98	
Movement Capacity: (pcph)	428	

Intersection Performance Summary

Movement	Flow Rate (pcph)	Move Cap (pcph)	Shared Cap (pcph)	Avg. Total Delay (sec/veh)	95% Queue Length (veh)	LOS	Approach Delay (sec/veh)
WB L	87	428 >					
			486	9.6	0.9	B	9.6
WB R	23	1003 >					
SB L	19	1094		3.3	0.0	A	0.2

Intersection Delay = 1.2 sec/veh

Gannett Fleming, Inc.
209 Senate Avenue
Camp Hill, PA 17011-
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Streets: (N-S) CENTRAL AVENUE (E-W) MILL STREET
Major Street Direction.... EW
Length of Time Analyzed... 15 (min)
Analyst..... RJT
Date of Analysis..... 5/1/97
Other Information.....1997 EXISTING CONDITIONS
Two-way Stop-controlled Intersection

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	> 1	< 0	0	> 1	< 0	0	> 1	< 0	0	> 1	< 0
Stop/Yield			N			N						
Volumes	55	60	5	8	64	15	12	4	6	25	8	28
PHF	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95
Grade		0			0			0			0	
MC's (%)				0						0		0
SU/RV's (%)				0						0		0
CV's (%)				2						2		2
PCE's	1.10			1.02			1.10	1.10	1.10	1.02	1.10	1.02

Adjustment Factors

Vehicle Maneuver	Critical Gap (tg)	Follow-up Time (tf)
Left Turn Major Road	5.00	2.10
Right Turn Minor Road	5.50	2.60
Through Traffic Minor Road	6.00	3.30
Left Turn Minor Road	6.50	3.40

Worksheet for TWSC Intersection

Step 1: RT from Minor Street	NB	SB
Conflicting Flows: (vph)	66	75
Potential Capacity: (pcph)	1282	1269
Movement Capacity: (pcph)	1282	1269
Prob. of Queue-Free State:	0.99	0.98
Step 2: LT from Major Street	**WB**	**EB**
Conflicting Flows: (vph)	68	83
Potential Capacity: (pcph)	1591	1565
Movement Capacity: (pcph)	1591	1565
Prob. of Queue-Free State:	0.99	0.96
TH Saturation Flow Rate: (pcphpl)	1700	1700
RT Saturation Flow Rate: (pcphpl)	1700	1700
Major LT Shared Lane Prob. of Queue-Free State:	0.99	0.96
Step 3: TH from Minor Street	**NB**	**SB**
Conflicting Flows: (vph)	214	209
Potential Capacity: (pcph)	842	847
Capacity Adjustment Factor due to Impeding Movements	0.95	0.95
Movement Capacity: (pcph)	802	807
Prob. of Queue-Free State:	1.00	0.99
Step 4: LT from Minor Street	**NB**	**SB**
Conflicting Flows: (vph)	225	212
Potential Capacity: (pcph)	784	798
Major LT, Minor TH Impedance Factor:	0.94	0.95
Adjusted Impedance Factor:	0.96	0.96
Capacity Adjustment Factor due to Impeding Movements	0.93	0.95
Movement Capacity: (pcph)	731	762

Intersection Performance Summary

Movement		Flow Rate (pcph)	Move Cap (pcph)		Shared Cap (pcph)	Avg. Total Delay (sec/veh)	95% Queue Length (veh)	LOS	Approach Delay (sec/veh)
NB	L	14	731	>					
NB	T	4	802	>	845	4.4	0.0	A	4.4
NB	R	7	1282	>					
SB	L	27	762	>					
SB	T	9	807	>	940	4.1	0.1	A	4.1
SB	R	30	1269	>					
EB	L	64	1565			2.4	0.0	A	1.1
WB	L	8	1591			2.3	0.0	A	0.2

Intersection Delay = 1.7 sec/veh

Gannett Fleming, Inc.
209 Senate Avenue
Camp Hill, PA 17011-
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Streets: (N-S) CENTRAL AVENUE (E-W) MILL STREET
Major Street Direction.... EW
Length of Time Analyzed... 15 (min)
Analyst..... RJT
Date of Analysis..... 5/1/97
Other Information.....2010 NO BUILD CONDITIONS
Two-way Stop-controlled Intersection

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	> 1	< 0	0	> 1	< 0	0	> 1	< 0	0	> 1	< 0
Stop/Yield			N			N						
Volumes	71	77	6	10	83	19	15	5	8	32	10	36
PHF	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95
Grade		0			0			0			0	
MC's (%)				0						0		0
SU/RV's (%)				0						0		0
CV's (%)				2						2		2
PCE's	1.10			1.02			1.10	1.10	1.10	1.02	1.10	1.02

Adjustment Factors

Vehicle Maneuver	Critical Gap (tg)	Follow-up Time (tf)
Left Turn Major Road	5.00	2.10
Right Turn Minor Road	5.50	2.60
Through Traffic Minor Road	6.00	3.30
Left Turn Minor Road	6.50	3.40

Worksheet for TWSC Intersection

Step 1: RT from Minor Street	NB	SB
Conflicting Flows: (vph)	84	97
Potential Capacity: (pcph)	1255	1236
Movement Capacity: (pcph)	1255	1236
Prob. of Queue-Free State:	0.99	0.97
Step 2: LT from Major Street	**WB**	**EB**
Conflicting Flows: (vph)	87	107
Potential Capacity: (pcph)	1558	1524
Movement Capacity: (pcph)	1558	1524
Prob. of Queue-Free State:	0.99	0.95
TH Saturation Flow Rate: (pcphpl)	1700	1700
RT Saturation Flow Rate: (pcphpl)	1700	1700
Major LT Shared Lane Prob. of Queue-Free State:	0.99	0.94
Step 3: TH from Minor Street	**NB**	**SB**
Conflicting Flows: (vph)	277	270
Potential Capacity: (pcph)	781	787
Capacity Adjustment Factor due to Impeding Movements	0.94	0.94
Movement Capacity: (pcph)	731	736
Prob. of Queue-Free State:	0.99	0.98
Step 4: LT from Minor Street	**NB**	**SB**
Conflicting Flows: (vph)	292	274
Potential Capacity: (pcph)	717	735
Major LT, Minor TH Impedance Factor:	0.92	0.93
Adjusted Impedance Factor:	0.94	0.94
Capacity Adjustment Factor due to Impeding Movements	0.91	0.94
Movement Capacity: (pcph)	652	689

Intersection Performance Summary

Movement		Flow Rate (pcph)	Move Cap (pcph)		Shared Cap (pcph)	Avg. Total Delay (sec/veh)	95% Queue Length (veh)	LOS	Approach Delay (sec/veh)
NB	L	18	652	>					
NB	T	6	731	>	768	4.9	0.0	A	4.9
NB	R	9	1255	>					
SB	L	35	689	>					
SB	T	12	736	>	872	4.6	0.3	A	4.6
SB	R	39	1236	>					
EB	L	83	1524			2.5	0.0	A	1.2
WB	L	11	1558			2.3	0.0	A	0.2

Intersection Delay = 1.9 sec/veh

Date: 3/10/97 Time: 4:00-6:00PM Weather: Sunny, 80°		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: RLC Location: 29A/Main St. @ Ryder	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	NB	3	42	10	55
4:15-4:30	NB	11	50	5	66
4:30-4:45	NB	15	33	16	64
4:45-5:00	NB	13	48	13	74
5:00-5:15	NB	5	52	2	59
5:15-5:30	NB	11	55	8	74
5:30-5:45	NB	10	56	3	69
5:45-6:00	NB	13	53	8	74
TOTAL		81	389	65	535
4:00-4:15	SB	7	51	2	60
4:15-4:30	SB	5	47	9	61
4:30-4:45	SB	7	43	7	57
4:45-5:00	SB	4	37	5	46
5:00-5:15	SB	3	45	6	54
5:15-5:30	SB	5	49	2	56
5:30-5:45	SB	3	50	4	57
5:45-6:00	SB	3	46	5	54
TOTAL		37	368	40	445

Date: 3/10/97 Time: 4:00-6:00 PM Weather: Sunny, 80°		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: RLC Location: Ryder @ 29A/S. Main St.	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	EB	1	34	5	40
4:15-4:30	EB	5	32	6	43
4:30-4:45	EB	7	28	4	39
4:45-5:00	EB	5	23	3	31
5:00-5:15	EB	3	36	7	46
5:15-5:30	EB	3	22	7	32
5:30-5:45	EB	6	35	3	44
5:45-6:00	EB	7	28	8	43
TOTAL		37	238	43	318
4:00-4:15	WB	22	25	7	54
4:15-4:30	WB	17	33	9	59
4:30-4:45	WB	15	32	9	56
4:45-5:00	WB	11	41	8	60
5:00-5:15	WB	10	30	8	48
5:15-5:30	WB	10	42	5	57
5:30-5:45	WB	16	33	8	57
5:45-6:00	WB	13	29	7	49
TOTAL		114	265	61	440

Date: 3/10/97 Time: 4:00-6:00PM Weather: Sunny		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: BKC Location: Central @ Ryder	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	NB	5	11	22	38
4:15-4:30	NB	7	5	6	18
4:30-4:45	NB	4	10	11	25
4:45-5:00	NB	3	3	8	14
5:00-5:15	NB	1	3	15	19
5:15-5:30	NB	1	3	8	12
5:30-5:45	NB	3	4	7	14
5:45-6:00	NB	2	1	8	11
TOTAL		26	40	85	151
4:00-4:15	SB	15	4	6	25
4:15-4:30	SB	14	3	3	20
4:30-4:45	SB	11	5	2	18
4:45-5:00	SB	10	4	3	17
5:00-5:15	SB	7	6	1	14
5:15-5:30	SB	12	6	3	21
5:30-5:45	SB	7	7	4	18
5:45-6:00	SB	14	3	3	20
TOTAL		90	38	25	153

Date: 3/10/97 Time: 4:00-6:00 PM Weather: Sunny		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: BKC Location: Ryder @ Central	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	EB	5	34	1	40
4:15-4:30	EB	4	32	2	38
4:30-4:45	EB	3	38	6	47
4:45-5:00	EB	5	26	3	34
5:00-5:15	EB	3	39	5	47
5:15-5:30	EB	2	26	0	28
5:30-5:45	EB	0	28	2	30
5:45-6:00	EB	0	31	1	32
TOTAL		22	254	20	296
4:00-4:15	WB	3	49	8	60
4:15-4:30	WB	2	45	4	51
4:30-4:45	WB	2	48	11	61
4:45-5:00	WB	3	49	7	59
5:00-5:15	WB	2	46	7	55
5:15-5:30	WB	3	52	4	59
5:30-5:45	WB	2	52	5	59
5:45-6:00	WB	1	41	7	49
TOTAL		18	382	53	453

Date: 3/6/97 Time: 4:00-6:00PM Weather: SUNNY		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: BKC Location: 29A/Main @ Mills	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	NB	N/A	55	27	82
4:15-4:30	NB	N/A	57	28	85
4:30-4:45	NB	N/A	38	26	64
4:45-5:00	NB	N/A	53	17	70
5:00-5:15	NB	N/A	53	14	67
5:15-5:30	NB	N/A	54	23	77
5:30-5:45	NB	N/A	41	27	68
5:45-6:00	NB	N/A	63	15	78
TOTAL		N/A	414	177	591
4:00-4:15	SB	6	64	N/A	70
4:15-4:30	SB	6	80	N/A	86
4:30-4:45	SB	1	62	N/A	63
4:45-5:00	SB	1	64	N/A	65
5:00-5:15	SB	2	55	N/A	57
5:15-5:30	SB	2	52	N/A	54
5:30-5:45	SB	2	67	N/A	69
5:45-6:00	SB	2	84	N/A	86
TOTAL		22	528	N/A	550

Date: 3/6/97 Time: 4:00-6:00 PM Weather: Sunny-60°		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: RLC Location: Mills @ Central	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	EB	18	18	2	38
4:15-4:30	EB	15	15	2	32
4:30-4:45	EB	14	16	1	31
4:45-5:00	EB	8	11	0	19
5:00-5:15	EB	6	11	0	17
5:15-5:30	EB	15	10	5	30
5:30-5:45	EB	13	12	1	26
5:45-6:00	EB	11	7	1	19
TOTAL		100	100	12	212
4:00-4:15	WB	1	17	5	23
4:15-4:30	WB	2	20	2	24
4:30-4:45	WB	2	17	4	23
4:45-5:00	WB	3	10	4	17
5:00-5:15	WB	1	24	2	27
5:15-5:30	WB	2	11	1	14
5:30-5:45	WB	0	17	2	19
5:45-6:00	WB	3	13	2	18
TOTAL		14	129	22	165

Date: 3/6/97 Time: 4:00-6:00PM Weather: Sunny-60°		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: RLC Location: Central @ Mills	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	NB	2	0	0	2
4:15-4:30	NB	3	2	0	5
4:30-4:45	NB	3	0	3	6
4:45-5:00	NB	4	2	3	9
5:00-5:15	NB	2	4	1	7
5:15-5:30	NB	3	2	0	5
5:30-5:45	NB	1	2	0	3
5:45-6:00	NB	1	1	2	4
TOTAL		19	13	9	41
4:00-4:15	SB	8	5	8	21
4:15-4:30	SB	7	0	5	12
4:30-4:45	SB	8	1	8	17
4:45-5:00	SB	2	2	7	11
5:00-5:15	SB	5	2	2	9
5:15-5:30	SB	5	3	7	15
5:30-5:45	SB	3	0	1	4
5:45-6:00	SB	1	5	1	7
TOTAL		39	18	39	96

Date: 3/6/97 Time: 4:00-6:00 PM Weather: Sunny		MANUAL TRAFFIC COUNT SUMMARY IN PASSENGER CAR EQUIVALENTS (PCE'S)		Counted by: BKC Location: Mills @ 29A/Main	
Time	**Approach**	**Left-Turn**	**Through**	**Right-Turn**	**Total**
4:00-4:15	EB	N/A	N/A	N/A	N/A
4:15-4:30	EB	N/A	N/A	N/A	N/A
4:30-4:45	EB	N/A	N/A	N/A	N/A
4:45-5:00	EB	N/A	N/A	N/A	N/A
5:00-5:15	EB	N/A	N/A	N/A	N/A
5:15-5:30	EB	N/A	N/A	N/A	N/A
5:30-5:45	EB	N/A	N/A	N/A	N/A
5:45-6:00	EB	N/A	N/A	N/A	N/A
TOTAL		N/A	N/A	N/A	N/A
4:00-4:15	WB	17	N/A	3	20
4:15-4:30	WB	18	N/A	1	19
4:30-4:45	WB	19	N/A	8	27
4:45-5:00	WB	9	N/A	5	14
5:00-5:15	WB	21	N/A	6	27
5:15-5:30	WB	11	N/A	5	16
5:30-5:45	WB	15	N/A	3	18
5:45-6:00	WB	9	N/A	3	12
TOTAL		119	N/A	34	153