Charlotte Region HOV/HOT/Managed Lanes Analysis

Technical Memorandum Task 1.3

EVALUATION CRITERIA

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1.0 EVALUATION PROCESS

The process of determining feasibility for any managed lane strategy is based on applying technical evaluation criteria that have been found to be good indicators of whether managed lanes will work for a given corridor or area. The purpose of this memorandum is to present evaluation criteria meeting this function and provide a basis in the study of how each will be applied. Such criteria can help determine if any managed lane strategy is technically feasible, and if so, what specific type of treatment and operation is most appropriate and when. The technical feasibility process considers whether there is enough demand to justify a dedicated lane. The process weighs potential to implement managed lane treatments and their effectiveness, in terms of mobility (time savings or speed improvements), financial effectiveness (revenue generation) and impacts on others (physical ability to add lanes and handle access).

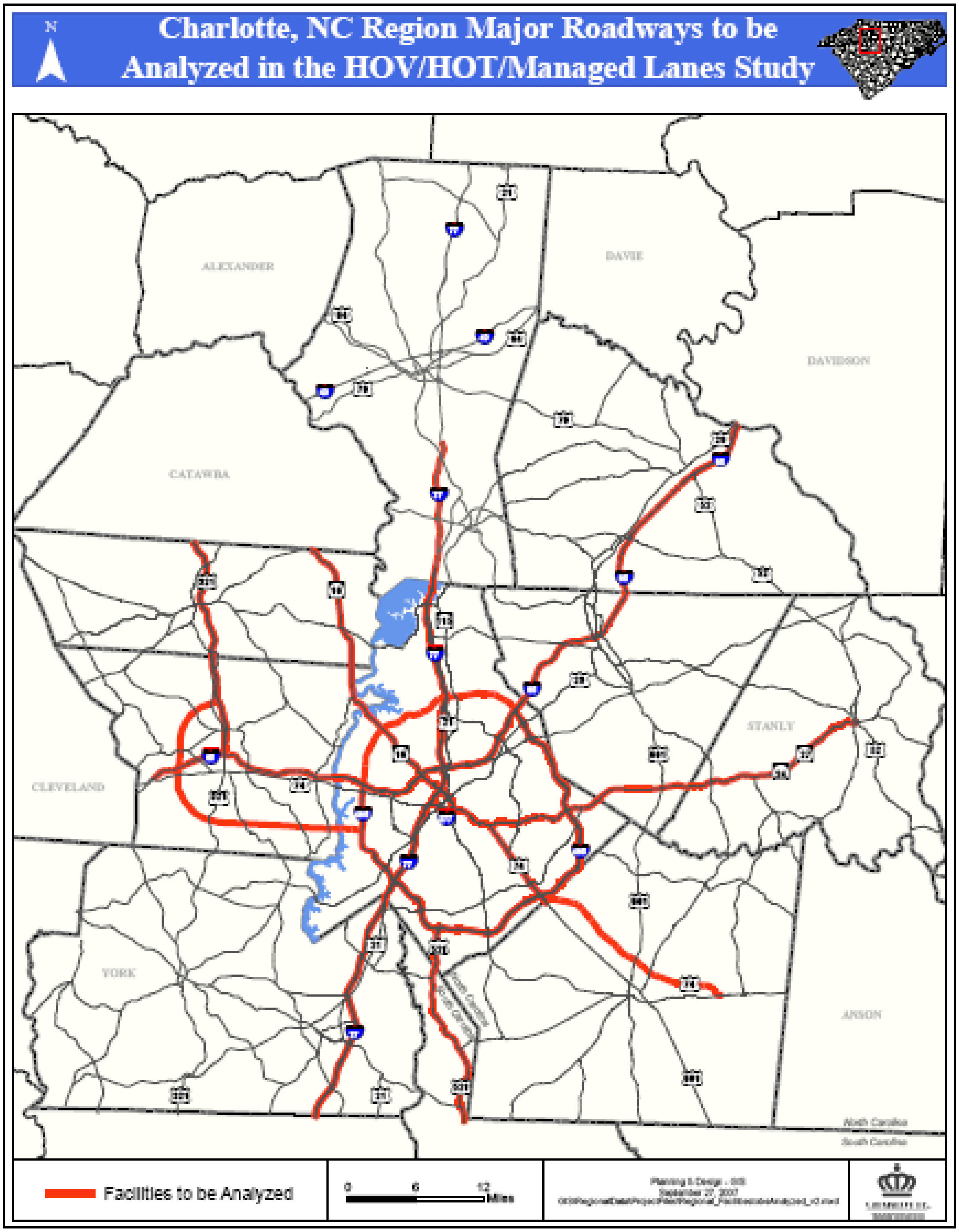
The first stage of technical feasibility is screening candidate corridors to determine if sufficient congestion and demand is present or forecast to justify any special lane treatments. This phase of the analysis is termed the *screening* stage. Initial screening criteria to be applied must meet general warrants or thresholds and includes:

- Presence of congestion (line-haul along a corridor or at bottlenecks)
- Demand (vehicles and persons)
- Travel patterns
- Physical attributes (the ability to add or preserve space for a lane or roadway either through some adjustments in the current roadway geometry or through roadway widening)

The ability to create demand that could generate revenue for high occupancy/toll (HOT) lanes is also tested in the screening stage. Screening criteria can also respond to specific study goals and objectives if data exists from which to differentiate among the candidate corridors (see table below).

Corridor	Description	Length (Miles)
US-521	Between SC-5 in Lancaster County, SC and I-485 South near Ballantyne/ Pineville area.	18.1
NC-24/ NC-27	Between US-74 in Charlotte and US-52 in Albemarle	35.6
Garden Parkway	Starting at US-321 north of Gastonia, going west and south to I-85, then heading east to Charlotte, terminating at I-485 near Charlotte-Douglas Airport.	27.4
US-321	Starting at I-85 (exit 17) in Gastonia and going north and terminating at Lincoln/ Catawba County line.	17.5
NC-16	Starting at Lincoln/ Catawba County line at NC-150 and going southeast toward Charlotte; terminating at I-277/ I-77 interchange	27.5
US-74	Between I-277 loop in Charlotte to east of Wingate, terminating at Marshville	33.4
I-85 South	Between US-74 (Exit 10) and I-77 (Exit 38) in Charlotte.	28.3
I-85 North	Starting at I-77 (Exit 38) in Charlotte, going through Cabarrus County and terminating at Rowan/ Davidson County line near Long Ferry Road (Exit 81)	41.8
I-77 South	Between Chester/York County line (Exit 73 in York County, SC) and I-85 in Charlotte.	31.5
I-77 North	Between I-85 in Charlotte (including existing HOV lanes) and US-21/NC-115 (Exit 42) between Mooresville and Troutman in Iredell County.	27.8
I-485	Includes the entire I-485 loop around Charlotte in Mecklenburg County. These circumferential corridors are between the major arterial corridors as follows:	65.4
	Between I-77 South and US-74 East =16.6	
	Between US-74 East and I-85 North = 20.3	
	Between I-85 North and I-77 North = 6.7	
	Between I-77 North and I-85 South = 11.9	
	Between I-85 South and I-77 South = 9.9	

Figure 1-1: Corridors Under Consideration



For corridors found feasible a more *detailed evaluation* is performed to determine specific types of managed lane strategies for subsequent consideration in the regional transportation plan. Detailed evaluation criteria pivot off of this determination to look at potential for specific high occupancy vehicle (HOV), HOT, Truck Only/ Toll (TOT) or related Toll/Express lane options. Depending on screening findings, some of the candidate evaluation criteria may be adjusted in order to assess specific strategies in more detail. As a minimum, the detailed evaluation stage will evaluate the following criteria:

- Travel time savings
- Connectivity (ingress/egress and direct access needs)
- Transit potential
- Person and vehicle demand and capacity potential for each viable strategy
- Costs and cost effectiveness
- Revenues for each type of managed lane strategy based on several revenue different revenue goals.
- Impacts/benefits to adjacent general purpose lanes
- Ability to implement one of potentially several different types of managed lane treatments
- Network needs

Criteria for each of these evaluation stages, along with thresholds, parameters and data sources, are presented in the next sections.

2.0 SCREENING STAGE

The purpose of screening criteria is to principally define fatal flaws before proceeding into more detailed evaluations for each candidate corridor or corridor segment. All selected evaluation criteria, either for screening or more detailed evaluations, should be able to serve as effective measures of likely effectiveness and comparative differentiators between corridors and corridor segments. In the screening stage such criteria are often qualitative in context, while in subsequent detailed evaluations, criteria become more quantitative in application. Selection and adoption of screening criteria should also respond to available data and agency stakeholder and study team knowledge of various agency plans, companion studies and corridor attributes.

A number of national planning guidelines primarily addressing HOV and HOT lanes are appropriate for identifying and adopting screening criteria. These include the American Association of State Highway and Transportation Officials (AASHTO) Guide for High-Occupancy Vehicle Facilities [1], National Cooperative Highway Research Program (NCHRP) 414 HOV Systems Manual [2], and the Parsons Brinckerhoff HOV Facilities Planning, Operation and Design Guide [3]. HOT lane guidelines can be found in the Federal Highway Administration (FHWA) HOT Lane Guide [4]. While truck lanes and bottleneck bypass treatments are more limited in application, some prior screening thresholds may be considered such as those from the Handbook for Planning Truck Facilities on Urban Highways [5].

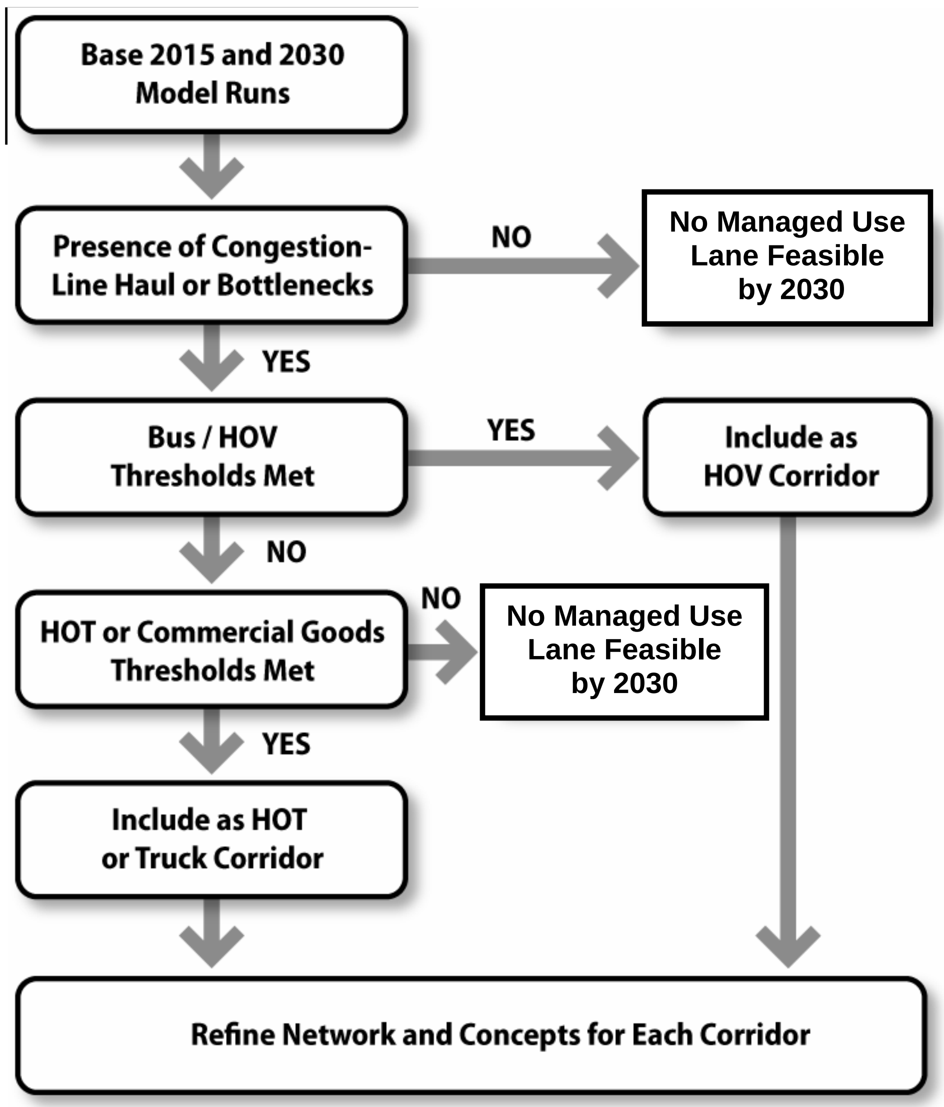
Guidelines from AASHTO [1] provide the following listing of potential screening criteria for HOV application on highways and streets:

- Congestion levels along a corridor or at isolated traffic bottlenecks (required for any managed lane option)
- Travel patterns (responds to HOV, HOT and truck potential)
- Vehicle demand for HOV, HOT and truck options (responds to overall potential for effectiveness through different eligibilities)
- Patronage demand for transit and rideshare service (responds to HOV lane person carrying potential)
- Tolling potential (responds to HOT lane potential)
- Physical ability to add managed lanes, or conversely, to borrow or convert existing lanes based on current corridor operations.

2.1 SCREENING PROCESS

The screening process involves meeting certain thresholds for the above list of criteria. If thresholds are not met, then the candidate is not typically carried forward. Sometimes these screening criteria are evaluated successively since the presence of congestion must exist to generate any potential benefits which in turn, affect demand. The following diagram illustrates how these criteria are often applied.

Figure 2-1: Screening Process



2.2 CRITERIA FOR SCREENING

This section discusses screening criteria and how each is applied. A summary of all criteria discussed below is presented in Table 2-1.

2.2.1 Presence of Congestion

The presence of recurring traffic congestion indicates that congestion management strategies, including managed lanes, are appropriate to consider. Common measures usually available for existing and forecast years include volume/capacity (v/c) information or average travel speed at the corridor and corridor link level. While both commute periods can ideally be considered, in many studies a proxy for congestion is determined by one of the two peak periods, typically the AM peak. The presence of congestion for this study needs to be defined in two dimensions—length and duration. Length is ascertained by how much of the different segments of a corridor are meeting the congestion threshold. Duration may be obtained by an understanding of the current hours a given corridor is congested and what this correlates to in future years for a peak hour factor. Typically managed lanes are not warranted unless the following congestion thresholds are met:

- Speeds below 35 mph on freeways and 20 mph on primary arterials and/or volume/capacity above 1.0.
- Congested durations of at least two hours, and preferably three hours for each peak period by 2030.
- Congested segments are identified as either "line-haul," defined as successive corridor segments, or bottlenecks. While the definition of a bottleneck is somewhat subjective, its intent is to address an isolated location that may be remedied by transportation system management treatments other than added lane capacity along the corridor.

Specific traffic bottlenecks or congestion points may cause significant delays, and they are often found at interchange merges, bridges and signals. The existence of bottlenecks may point to the need for isolated dedicated lane or signal/metering treatment such as direct access ramps, shoulder use or other queue bypass strategies.

Screening for presence of congestion is usually provided at a corridor or corridor segment level on a matrix where qualitative rankings are made to comparatively present findings. Often quantitative values are available to support the qualitative rankings, such as congestion (i.e., volume/capacity or travel speed data for peak hours or peak period) and demand (peak vehicle and/or person demand for buses, other HOVs and toll-paying users for HOT viability). Similar values or inputs are obtained for other criteria. Refer to Table 2-1 for application of this and other screening thresholds.

If congestion is not evident or forecast, then the candidate corridor should not be pursued further in the study (although it still may provide a key link without lane dedication to other candidates in a defined network).

Table 2-1: Screening Criteria

Charlotte Region HOV/ HOT/ Managed Lanes Analysis

Screening No.	Criteria	Threshold(s) to be Met	Parameters	Source
Presence of Congestion				
1.A	Line- haul	• Freeways: Volume/capacity (V/C) greater than 1.0 and average speeds below 30 mph in the peak period. • Arterials: V/C greater than 1.0 and average speeds below 20 mph in the peak period.	• Travel speeds • Volume/capacity ratio	Regional model output based on existing and proposed roadways for 2013 and 2030
1.B	Bottlenecks (less than 0.5 miles)	• V/C below 1.0 • Speeds below 20 mph .	• Travel speeds • Volume/capacity ratio	Regional model output for 2013 and 2030.
HOV Demand				
2.A	Travel Patterns	• Freeway corridors: Average trip distances of 5 miles or more. • Arterial corridors: Average trip distances of 3 miles or more.	• Vehicle volumes • Threshold is either met or not met for each defined corridor or combination of corridors for a defined commute-shed.	• Regional model select link data for 2030. • Not applied to connecting route segments in core of region.
2.B	Person Moving Demand	• Parity or greater when compared to general purpose lane person movement in same corridor, on a per-lane basis, assuming 2000 persons/general purpose lane.	• Person moving demand basis for vehicles must be capped based on a maximum per-lane flow rate of 1650 passenger car equivalents (PCEs) per hour for freeways and 900 PCEs per hour on arterials. • Threshold is either met or not met.	• Carpool forecasts from model (2030 only) • Vehicle occupancy surveys from 2007 • Transit patronage estimates where number of carpools are below thresholds.
2.C	Vehicle Demand	• HOV Freeway: 600 PCEs/hour minimum • HOV Arterial: 200 PCEs/hour minimum	• Vehicle demand determined for peak period. • Maximum volume is 1650 PCEs/lane • Criteria is met or not met.	• HOV demand from regional model for 2013 and 2030 • Confirm through national sketch planning techniques for select corridors.

HOT or TOT Demand				
3.A	Travel Patterns	• Freeway corridors: Average trip distances of 5 miles or more for commuters or large trucks. • Arterial corridors: Average trip distances of 3 miles or more.	• Vehicle volumes • Threshold is either met or not met for each defined corridor • Not applied to connecting route segments in core of region.	Regional model link data for 2030
3.B	Vehicle Demand (2013 and 2030)	• HOT Freeway: 1000 PCEs/hour minimum • HOT Arterial: 400 PCEs/hour minimum • Commercial movement demand o 400 large trucks directionally/hour x two lanes= 800 trucks/hour o Common origins/destinations > 5 miles using corridor	• Vehicle demand must be capped based at a maximum per-lane flow rate of 1650 PCEs per hour for freeways and 900 passenger car equivalents per hour on arterials. • Criteria is met or not met for each vehicle group	Demand from regional model for 2013 and 2030
3.C	Revenue Potential	Forecast revenue (gross) for screening stage	Rapid toll optimization model results based on regional travel forecasts per corridor	• Regional model • Toll optimization model for 2013 and 2030
Physical Attributes				
4.A	Physical Feasibility-Add a lane	Space to add a managed lane (typically 16 ft per direction)	• ROW and roadway characteristics for each corridor	• Aerials • As builts • Project plans implemented by 2030
4.B	Physical Feasibility-Convert a lane	Ability to convert or borrow an existing lane or shoulder for a peak hour or direction, without more than one degradation in LOS for traffic in the remaining lanes; no spillover traffic onto other routes.	• Resulting volumes cannot exceed 2000 vph for conversion, or reductions in lane, shoulder widths acceptable.	• ADT/lane in peak hours for 2013 and 2030 • Current observed LOS on existing corridors

2.2.2 HOV Demand

HOV demand focuses on person and vehicle movement. Person movement represents the highest and best use of managed lane efficiency, while a minimum level of vehicle visibility is needed to determine if the lane can be adequately utilized by HOVs alone. The following criteria are considered in this stage. If HOV thresholds are met, then this managed lane candidate moves forward for more detailed evaluation. Candidates not meeting HOV demand thresholds are still viable HOT or TOT candidates.

Travel Patterns. Examining the specific travel patterns, including origins and destinations of commuters, is critical to determining the managed lane market, since access will typically need to be more restricted in whatever lane treatment is subsequently evaluated. Trips need to be long enough on a given route to generate time savings that cause spatial and modal shifts into the managed lane, thus reducing weaving, enhancing throughput capacity and improving safety and performance. At the screening stage, the best proxy is examining overall trip lengths or select link data for corridor segments between identified travel producers, such as residential areas, and attractions, which include major employment and activity centers.

Person Moving Demand. Existing and likely levels of person movement—primarily transit, carpool and vanpool demand—are an early study indicator of managed lane effectiveness. Vehicle occupancy counts coupled with traffic forecasts for each user group are typically generated for this determination. Minimum existing demand is critical to determine whether a managed lane can be a success in its opening year. In general, a managed lane should move more people than a general purpose lane would at a reliable level of service.

The level of bus transit service represents the highest potential to improve person movement in a corridor, and thus, the highest level of effectiveness that may be achieved for a managed lane. Bus volumes, existing or forecast, often justify consideration of some type of managed lane treatment, particularly through traffic bottlenecks. Input values can include the number of buses in the peak hour or period or anticipated ridership levels.

Vehicle Demand. A minimum threshold for vehicle demand needs to be present for any managed lane strategy, and this value varies between freeway and arterial treatments, depending on the overall facility capacity as noted in Table 2-1.

2.2.3 HOT or TOT Demand

The same assessment for demand related to HOT or TOT feasibility is performed based on regional model output. Vehicle demand, travel patterns and potential for revenue generation are primary attributes. While the regional model will generate HOT demand, this demand will also be confirmed using a Toll Optimization Model that takes forecast traffic demand and tests this demand for HOT lane potential off-line. This approach yields both a parallel set of HOT lane vehicle demand and revenue generation based on assumptions that include value of time, vehicle classes allowed free use (typically 2+ or 3+), access to the lane and other attributes.

2.2.4 Physical Attributes

Screening physical roadway attributes for managed lane potential takes two perspectives: the general ability to add managed lanes, or the ability to convert or borrow existing lanes or shoulders for the respective peak period and direction. At this stage in the study, no detailed engineering investigations are performed. Potential lane additions involve a review of the prevailing widths of the existing or planned roadways and available rights-of-way, plus any improvements or conditions such as noise walls, retaining walls or other attributes that could influence the cost for lane additions. Conversion examines the current and forecast demand on remaining lanes and whether the potential exists to borrow temporarily or permanently some of these lanes or shoulders for managed lane use. Conversion options weigh potential safety impacts based on experience from other similar projects and do not specifically look at accident rates or operational issues with current traffic.

2.3 PRESENTATION OF FINDINGS

While data from these separate assessments will be both qualitative and quantitative in nature, findings will be presented in a matrix table and will be prepared in a “Consumer Reports” format in which ranges of output will be categorized and comparatively arrayed. For example, if the threshold is fully met, the cell will be given a fully filled-in circle. If the threshold is not met, then the circle will appear empty. If the threshold is marginally met, then it will receive a half filled-in circle. No criteria will be weighted. Overall findings will be averaged from the separate criteria for each potential strategy by horizon year. Outcomes will inevitably reflect various reasons why corridors do or do not meet screening criteria. Findings from screening will discuss these reasons and conditions that most influence the overall findings for each.

3.0 DETAILED EVALUATION STAGE

The detailed evaluation stage involves a more focused study of corridors found feasible.

Enhanced or more corridor and treatment-specific criteria are often applied to better define the costs, benefits and impacts which can help in this study to confirm feasibility, rank corridors for implementation and identify the specific type of managed lane treatment that is appropriate. These criteria can include travel time savings and travel time reliability, transit delay, system connectivity, opportunity to implement with other roadway improvements, overall trip distance, person throughput, vehicle throughput, agency and public support, financial viability, enforcement, cost effectiveness, physical characteristics of the corridor or roadway, support facility and service needs, safety, system staging and scheduling, environmental issues and impacts to other modes.

This section discusses potential detailed evaluation criteria and how each is applied for corridors passing the screening stage. A summary of the criteria discussed below is presented in Table 3-1.

3.1 CANDIDATE EVALUATION CRITERIA

While the adoption of detailed evaluation criteria is best performed once corridors are known the criteria identified and described in the following section appears appropriate for the level of data available for this region and the likely outcomes from screening. This list and its parameters will need to be reassessed at the conclusion of the screening stage.

Travel Time Savings. Various managed lane concepts identified for potential feasibility will be considered in context to the benefits they achieve. Peak travel speeds from model output will be compared with similar projects in other areas and speeds factored up or down in accordance with prevailing experience to arrive at estimated travel time savings for each corridor.

Reliability. Based on review of the candidate corridors, the provision of physical separation and shoulders will be determined which can affect reliability of the managed lane. Dual lane treatments will be given a higher ranking than single lane treatments. Reliability will be comparatively ranked among corridors and managed lane treatments.

Demand for Each Facility Type. Transit, HOV, HOT and commercial vehicle demand will be separately and collectively evaluated to identify the best mix of users for two time horizons—2013 and 2030—in order to confirm the specific operation policies that are and are not feasible. HOT demand will be compared between the regional model and toll optimization model based on added friction values included for limiting access and forcing some connecting movements through general purpose interchange connectors. Collective and individual vehicle demand by user group for specific types of managed lane treatments will still have to meet minimum thresholds.

Mobility Improvements: Connections. Where thresholds are met for direct access connections, these will be evaluated based on site conditions from aerial mapping. Access will be evaluated for each concept along feasible corridors, including the potential and appropriateness of continuous or designated access with adjacent traffic lanes. Overall needs will be defined and compared for effectiveness for each concept.

Costs and Cost Effectiveness. The capital, operation and maintenance costs incrementally associated with managed lane additions and pro-rata share for new corridors will be evaluated and estimated based on unit cost data from NCDOT-comparable roadway projects. This effort will not evaluate total project costs or total benefits that may be realized from factors associated with air quality improvements, overall corridor mobility and escalation differences if projects can be implemented sooner as a result of the added revenue generated (the level of evaluation for this criterion will not approach a traffic and revenue study.). Values in current year dollars will be provided for comparison among candidate managed lane treatments.

Revenue. Revenue generation responding to a variety of scenarios and goals will be tested on selected managed lane concepts, with findings provided in current year and discounted dollars on an annualized basis.

Impacts and Benefits to Other Traffic. Both benefits and impacts, in terms of level of service, speeds and impact on volume, will be evaluated for each managed lane concept. These impacts and benefits will attempt to qualify any safety related issues associated with the specific concept.

Network Needs. For specific managed lane treatments, any on- or off-line treatments that are required as a part of the investment to make the managed lane work will be evaluated and considered, with an estimate of cost

Physical Attributes. The corridor should be able to be widened within available right-of-way, based on a sketch planning review.

Environmental Impacts. Emission changes as a result of the travel speeds and vehicle volumes carried and displaced from the general purpose lanes will be assessed based on regional model output for each corridor, if each is coded with the appropriate assumptions for separate model runs.

Land Use Impact. To be reviewed with RTT and determined upon completion of Phase 1 screening.

3.2 PRESENTATION OF FINDINGS

While specific findings will be the subject of separate technical memoranda prepared during Phase II, overall findings will be presented in matrices and quantified to the extent possible for each type of managed lane treatment identified for each horizon year. A comparison of findings for each corridor will be ranked for overall effectiveness in accordance with pre-determined goals set adopted by the Regional Technical Team. These goals could include:

- Maximizing person throughput
- Maximizing cost effectiveness
- Reducing overall delay
- Maximizing overall net revenue

Results of the corridor and regional evaluation will be presented to agencies and project teams for consideration as part of their ongoing corridor planning and development activities.

Table 3-1: Detail Evaluation Criteria

Charlotte Region HOV/ HOT/ Managed Lanes Analysis

No.	Criteria	Threshold	Parameter/Value	Source
Travel Time Savings for each Facility Type				
1.	Average peak period speed	0.5 minutes per mile or more	Travel speeds within each segment weighted by type of facility. Concurrent flow limited to a 20 mph differential if unseparated. Value: Speed or travel time savings	Regional model output based on existing and proposed roadways for 2013 and 2030
Demand for each Facility Type (Task 2.5)				
2.A	HOV Vehicle Demand (2013 and 2030)	Meets or exceeds minimum thresholds from screening, based on access assumptions	Vehicle volumes in the peak period, by segment Value: peak hour vehicle volume	Regional model, 2013 and 2030
2.B	HOV Person Moving Demand (2030)	Meets or exceeds parity threshold when compared to a general purpose lane, based on access assumptions.	Person moving demand in the peak period, by segment Value: peak hour volume	Regional model for 2030 factored by vehicle occupancy survey data. Transit patronage output from regional mode for 2030.
2.C	HOT Vehicle Demand (2013 and 2030)	Meets or exceeds minimum thresholds for screening, based on access assumptions	Vehicle volumes in the peak period, by segment Value: peak hour volume	Regional model, 2013 and 2030
2.D	HOT Person Moving Demand (2030)	Meets or exceeds parity threshold when compared to a general purpose lane, based on access assumptions.	Person moving demand in the peak period, by segment Value: peak hour volume	Regional model for 2030 factored by vehicle occupancy survey data
2.E	Large Truck Demand (2030)	Meets or exceeds minimum threshold for screening, or can be considered in combination with HOT lane demand above if travel patterns justify.	Vehicle volumes in the peak period, by segment Value: maximum hourly volume	Regional model for 2030

Determination of Facility Type				
3.	Facility Type	Most feasible facility for each feasible strategy (HOV, HOT, etc.)	Type of facility, typical section and description	Corridor review
Mobility Improvements (Task 2.3)				
4.	Connectivity (for each facility type)	Access requirements: continuous or designated	• Access frequency and type • Direct connector requirements • Value: access plan for each strategy	• Regional model • Corridor review
Costs and Cost Effectiveness (Task 2.4)				
5.A	Roadway capital cost	Construction cost estimate for each facility type	• Current year dollars • Unit cost basis	• Corridor review • NCDOT unit price index
5.B	Operation and Maintenance cost	O&M annualized cost for each facility type	• Current year dollars • Annualized over life cycle	• Corridor review • NCDOT and City maintenance experience
5.C	Pricing costs	Similar installations using current technology	• Current year dollars • Cost per mile (distributed)	HOT lane project data and companion studies from other areas
5.D	Cost Effectiveness	1.0 or better	Total costs/time savings benefits (non-escalated)	Cost estimates and regional model output for travel time savings
Revenue (Task 2.5)				
6.A	Gross revenue	Revenue based on each facility type employing pricing.	• Annual and life-cycle stream • Based on one or more revenue optimizing assumptions	• Regional model link data • Toll optimization model
6.B	Net revenue	Revenue minus costs	• Annual and life-cycle stream • Based on one or more revenue optimizing assumptions	• Output from gross revenue assessment • Output from cost estimates
Impacts/Benefits on Other Traffic (Task 2.6)				
7.	Net Impacts to Other Traffic	Evaluation of each access or merge condition resulting from managed lane addition.	Forecast changes in LOS and delay time/time savings between before/after for each facility type.	• Regional model • HCM analysis based on traffic forecasts

Network Needs (Task 2.6)				
8.	Supporting Requirements	Transit, rideshare and related supporting program and facility needs to support forecast use	• General location on corridor map • Description of each facility provision	Evaluation of modal user needs based on other similar projects
Environmental Impact				
9.	Air Quality	Comparison to baseline (no build)	Emissions by type	Regional model output
Lane Use Impact				
10.	Land Use Goals	Level of mobility afforded to market size (number of people or households and businesses addressed)	TBD	Regional land use plans

4.0 REFERENCES

1. "Guide for the Design of High Occupancy Vehicles (2002 edition)," American Association of State Highway and Transportation Officials, Washington, D.C., November 2004.

2. "HOV Systems Manual", #414, National Cooperative Highway Research Program, Transportation Research Board, Washington, D.C., 1998.

3. "High-Occupancy Vehicle Facilities: A Planning, Design, and Operation Manual," Parsons Brinckerhoff Inc., New York, New York, December 1990.

4. "High-Occupancy (HOT) Lane Manual," Federal Highway Administration, Washington, D.C., 2003.

5. Douglas, James, *Handbook for Planning Truck Facilities on Urban Highways*, Parsons Brinckerhoff, New York, New York, 2004.