Prioritizing Highway Projects for Improvement of Evacuation

March 2014

T14-01

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Prioritizing Highway Projects for Improvement of Hurricane Evacuation

PREPARED BY:

the *heartbeat* of HAMPTON ROADS TPO
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REPORT DOCUMENTATION

TITLE
Prioritizing Highway Projects for Improvement of Hurricane Evacuation

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ABSTRACT

This document records recent analysis undertaken by HRTPO staff to identify and prioritize—according to cost effectiveness—highway projects designed to improve hurricane evacuation in Hampton Roads.

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REPORT DATE
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IMPETUS

Under current conditions, in the event of a hurricane it is possible that only a portion of the people living in homes in low-lying areas of Hampton Roads will be able to evacuate. For persons with household vehicles, evacuation success is primarily a function of these variables: a) strength of the hurricane, b) the capacity of the evacuation highways, and c) the start of the evacuation process. Due to the number of households in low-lying areas, and given the current capacity of evacuation highways (including the planned reversal of I-64), it may take 36 hours to clear evacuation highways for a Category 3 storm.[1] However, due to the uncertainty associated with the final path of an approaching storm, local citizens and governments may not begin evacuation 36 hours before the arrival of tropical storm force winds. According to a recent report prepared for the Southeast Virginia / Northeast North Carolina Regional Catastrophic Planning Project, "…due to the geography and location of the region, it will be rare to have the lead time needed…".[2]

Therefore, to increase the likelihood of evacuation success, it is desirable to increase the capacity of evacuation highways. Given that no prioritized list of highway projects for improving evacuation exists for Hampton Roads, the purpose of this study is to prepare a prioritized list of highway projects that improve evacuation.

ORIGINAL ANALYSIS PLAN

Given the staff time available for this project, the original plan for executing the subject prioritization was to obtain highway hurricane projects—and and delay data with which to calculate their cost effectiveness—from existing studies via a literature review.

[1] *Virginia Hurricane Evacuation Study, Transportation Analysis, Commonwealth of Virginia, Coastal Jurisdictions, Summary Report* (FEMA/USACE/VDEM, May 2008), p. 3-21.

[2] *Phase 3 Planning Support to VMASC and the HR RCPT, Final Technical Memorandum* (FEMA/Atkins, June 2013, p. 22.

LITERATURE REVIEW FOR PROJECTS AND DELAY

A review of recent hurricane studies was conducted to identify highway projects for improvement of evacuation and to locate delay data with which to calculate project cost effectiveness. Based on the information available in existing studies, the original analysis plan was refined.

I. Documents Reviewed

The following recent hurricane studies were reviewed (see Appendix A for review information from each document):

A. SE Virginia / NE North Carolina Regional Catastrophic Planning Project

Evacuation Behavioral Study (SocResearch Miami, March 2010)

Evacuation and Transportation Plan Review Findings Report (Dewberry/PBS&J, March 2010)

Evacuation Traffic and Evacuee Participation Monitoring Report (Dewberry/PBS&J, April 2010)

Report on Transportation Requirements for Evacuation (Dewberry/PBS&J, draft Aug. 2010)

Mass Evacuation Annex (Dewberry/PBS&J, Aug. 2010)

Evacuation Scenarios Analysis and Traffic Modeling Report (Dewberry/PBS&J, draft August 2010)

Barco Diversion/NC-VA Border Traffic Control Plan Analysis (Dewberry/Atkins, Aug. 5, 2011)

Assessment of VDOT Bowers Hill Improvement Alternatives to Ease Evacuation (Atkins, draft Oct. 2011)

Phase 3 Planning Support to VMASC and the HR RCPT (Atkins, June 2013)

B. Other Efforts

An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan (Phase 1) (VTRC, Jan. 2006)

An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan – Phase 2 (VTRC, Apr. 2008)

Virginia Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008)

Hampton Roads Hurricane Evacuation Transportation Study (VMASC, June 27, 2008)

Highway Evacuations in Selected Metropolitan Areas: Assessment of Impediments (FHWA, April 2010)

Hurricane Evacuation Modeling of the Hampton Roads Region (VCTIR, draft May 2012)

Behavioral Study Report; Refuge of Last Resort Study Report; Shelter Study Report; Housing Study Report (VMASC, June 2013)

II. Refinement of Analysis Plan

The above review of recent evacuation documents—conducted to obtain hurricane highway projects and delay data with which to calculate project cost effectivess—revealed:

a) evacuation-improving highway projects:

The Assessment of VDOT Bowers Hill Improvement Alternatives to Ease Evacuation (Atkins, draft Oct. 2011) identified a preferred highway project for lane reversal on the Southside—reversal of VA168/I-64/US58 in Chesapeake and Suffolk[3]—and estimated its clearance-time reduction (19 hours).

The Highway Evacuations in Selected Metropolitan Areas (FHWA, April 2010) includes a statement of the impediment provided by traffic signal timing (see Appendix A for details) which led staff to consider the potential benefit of special event signal timing for hurricane evacuation.

b) delay data:

The Virginia Hurricane Evacuation Study, or VHES (VDEM/USACE/FEMA, May 2008) produced an Abbreviated Transportation Model (ATM) spreadsheet which estimates the clearance time[4] for 31 "Critical Roadway Segments".

Given that the review revealed only one specific hurricane highway project (VA168/I-64/US58 Southside reversal), plus pointed to one type of hurricane highway project (special evacuation signal timing), the original analysis plan outlined above for this FY14 evacuation highway project prioritization was refined as follows:

Refined Analysis Plan

Use the 31 Critical Roadway Segments in the VHES to develop a list of highway projects designed to improve the evacuation of vehicles using those segments, considering the above projects (the Chesapeake/Suffolk reversal project and the retiming of signals along signalized evacuation routes) as possible candidates.

Ask VDOT to estimate the cost of the above projects, and use those costs, and the clearance times and number of evacuating vehicles from the VHES, to calculate the cost effectiveness of the subject projects.

[3] Note that an earlier Southside reversal project—different from the preferred one in the Atkins document—is partially funded in VDOT's Six-Year Improvement Program [see Appendix C for details].

[4] "Clearance time is the time required to clear the roadway of all vehicles evacuating in response to a hurricane situation." (VHES, Transportation Analysis, Summary Report, VDEM/USACE/FEMA, May 2008, p. 3-16.)

IDENTIFICATION OF HIGHWAY PROJECTS FOR IMPROVING HURRICANE EVACUATION

Given that the literature review revealed only one specific hurricane highway project (VA168/I-64/US58 Southside reversal) plus one type of hurricane highway project (special evacuation signal timing), staff used the 31 Critical Roadway Segments in the Virginia Hurricane Evacuation Study (VHES) to develop a list of highway projects designed to improve the evacuation of vehicles using those segments, considering the Chesapeake/Suffolk reversal project and the retiming of signals along signalized evacuation routes as possible candidates.

Criteria

Staff idenitified a hurricane improvement project to address the evacuation delay on VHES Critial Roadway Segments with large need for evacuation improvement, considered to be those segments with an estimated **clearance time exceeding 18 hours**. The primary exceptions were:

- segments covered by a committed highway project
- segments covered by a hurricane improvement project already identified in this study.

The table below records the process of examining each of the 31 Critical Roadway Segments. For each segment, the table contains either a hurricane improvement project or explanation of project omission.

Table 1- Identification of Highway Projects for Improving Hurricane Evacuation (page 1 of 4)

Source: HRTPO (addressing high clearance times from ATM.xlsx)

Key

Segments with a hurricane evacuation improvement project identified.

This database: Critical Roadway Segments from Abbreviated Transportation Model (ATM) of Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), sorted by Clearance Time

Segment (Critial Roadway Segments from ATM[4])	Clearance Time, hours (from ATM[4])	Highway Project for Improvement of Evacuation (identified by HRTPO staff)	Comment (by HRTPO staff)
US 58 Suffolk Bypass	**35.8**	168/64/58 Southside Reversal (i.e. the highlighted option in VDOT's 12-15-11 HRTPO Board presentation [Option 2]- two crossovers: one on Rt 168 [Oak Grove Connector] and one on I-264 approaching Bowers Hill.)	n.a.
Constance Rd btwn. Wilroy Rd & Main St	**34.3**	See Southside Reversal project above.	It is expected that the Southside Reversal project (above) would lower the clearance time of this segment because evacuees approaching the 58/58Bus split (on the regular WB lanes) near the SPSA landfill have a choice between the Suffolk Bypass and Portsmouth Blvd / Constance Rd. Therefore, no evacuation improvement project is identified for this segment.
Portsmouth Blvd btwn. Suffolk Byp & Nans. Pkwy	**30.8**	See Southside Reversal project above.	It is expected that the Southside Reversal project (above) would lower the clearance time of this segment because evacuees approaching the 58/58Bus split (on the regular WB lanes) near the SPSA landfill have a choice between the Suffolk Bypass and Portsmouth Blvd / Constance Rd. Therefore, no evacuation improvement project is identified for this segment.
Suffolk Bypass btwn. Ports. Blvd & Godwin Blvd	**30.8**	See Southside Reversal project above.	This segment is covered by the "US 58 Suffolk Bypass" segment above.

Table 1- Identification of Highway Projects for Improving Hurricane Evacuation (page 2 of 4)

Segment (Critial Roadway Segments from ATM[4])	**Clearance Time, hours** (from ATM[4])	**Highway Project for Improvement of Evacuation** (identified by HRTPO staff)	**Comment** (by HRTPO staff)
St Pauls Blvd btwn. Brambleton Ave & I-264	**27.7**	n.a. (see comment)	The calculation of this 27.7 hours for this segment was based on 32,010 evacuating vehicles, an inordinately high number given a) that it's 40% of the total Norfolk evacuating vehicles (81,896) and b) that only 10,732 evacuating vehicles from Norfolk are attempting to evacuate by western gateways (US13, US58, US460, VA10), and c) there are many other ways to reach I-264 in Norfolk.
US 17 (JCMB[3]) btwn. I-64 and Victory Blvd	**24.8**	Evacuation Timing Plans for US 17 Signals (for all signals from I-64 to Gloucester Courthouse, i.e. beyond the area of significant background traffic, excluding signals in York County [which have an adaptive timing system rendering special timing plans unnecessary])	n.a.
US 460 btwn. Suffolk Bypass and Windsor	**24.8**	n.a. (see comment)	The committed Commonwealth Connector (US 460) project will address this high clearance time.
I-264- Downtown Tunnel	**24.1**	n.a. (see comment)	The new Midtown Tunnel tube (under construction) will address this high clearance time.
I-64 WB- HRBT	**23.2**	HRBT Build-8 Alternative (add 2 lanes in each direction from I-564 to I-664 [DEIS, Dec. 2012])	n.a.
US 460 westbound out of region	**22.8**	n.a. (see comment)	The committed Commonwealth Connector (US 460) project will address this high clearance time.
I-64 btwn. I-564 and Bay Ave	**22.4**	See HRBT project above.	This segment is covered by the HRBT project above.

Table 1- Identification of Highway Projects for Improving Hurricane Evacuation (page 3 of 4)

Segment (Critial Roadway Segments from ATM[4])	**Clearance Time, hours** (from ATM[4])	**Highway Project for Improvement of Evacuation** (identified by HRTPO staff)	**Comment** (by HRTPO staff)
I-64 in Western NN	**22.1**	I-64 Peninsula Widening (54 Mile portion of Alt. 2B in I-64 Peninsula DEIS, i.e. widen to 6-8 lanes from mm 254 [Bland Blvd] to mm 200 [I-295])	Note: Even with reversal, these outbound lanes (2 regular WB and 2 reversed EB) have a high clearance time (22.1 hours).
US 58 westbound out of region	**20.8**	US 58 Widening (widen to 6 lanes from Suffolk Bypass [at Holland Rd] to I-95)	Note: Due to lack of significant destinations and cross highways between Suffolk and Emporia, this widening must continue west until reaching I-95 at Emporia.
I-64- High Rise Bridge	**18.8**	See Southside Reversal project above.	The Southside Reversal project (above) covers this segment via the Rt 168 crossover included in that project.
Park Ave btwn. PA Rd and Brambleton Ave	17.7	n.a. (see comment)	Less than 18 hour clearance.
I-264 westbound just east of BH[1]	16.5	n.a. (see comment)	Less than 18 hour clearance.
Fox Hill Rd btwn. Woodland Rd and Mercury Blvd	16.5	n.a. (see comment)	Less than 18 hour clearance.
Mercury Blvd btwn. Fox Hill Rd and Lasalle Ave	15.7	n.a. (see comment)	Less than 18 hour clearance.
I-64 toward BH just east of BH[1]	13.5	n.a. (see comment)	Less than 18 hour clearance.
Dam Neck Rd btwn. Gen Booth Blvd & Holland Rd	11.4	n.a. (see comment)	Less than 18 hour clearance.
Rt 10 westbound out of region	10.9	n.a. (see comment)	Less than 18 hour clearance.
US 17 out of region	10.8	n.a. (see comment)	Less than 18 hour clearance.
US 60 westbound out of region	9.7	n.a. (see comment)	Less than 18 hour clearance.
I-264 WB- Newtown Rd to I-64	8.7	n.a. (see comment)	Less than 18 hour clearance.
VA 168 south of I-64	8.6	n.a. (see comment)	Less than 18 hour clearance.
US 13 southbound out of region	7.1	n.a. (see comment)	Less than 18 hour clearance.
Northampton Blvd btwn. Dia. Sprs. Rd and I-64	6.2	n.a. (see comment)	Less than 18 hour clearance.

Table 1- Identification of Highway Projects for Improving Hurricane Evacuation (page 4 of 4)

Segment (Critial Roadway Segments from ATM[4])	Clearance Time, hours (from ATM[4])	Highway Project for Improvement of Evacuation (identified by HRTPO staff)	Comment (by HRTPO staff)
I-64 Peninsula out of region	n.a.	n.a. (see comment)	ATM gives no reversal-based clearance time for this segment, so see similar "Western NN" segment above.
I-64 btwn. exits 242 and 238	n.a.	n.a. (see comment)	ATM gives no reversal-based clearance time for this segment, so see similar "Western NN" segment above.
I-64 btwn. HRCP[2] and JCMB[3]	n.a.	n.a. (see comment)	ATM gives no reversal-based clearance time for this segment, so see similar "Western NN" segment above.
I-64 btwn. I-664 and Mercury Blvd	n.a.	n.a. (see comment)	ATM gives no reversal-based clearance time for this segment, so see similar "Western NN" segment above.

Notes

[1]BH: Bowers Hill

[2]HRCP: Hampton Roads Center Pkwy

[3]JCMB: J Clyde Morris Blvd

[4]ATM: Abbreviated Transportation Model (ATM) of Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008) Scenario: Category 3, I-64 reversal, high seasonal occupancy, medium response (6 hr's), heavy background traffic

Concerning the second project above—Evacuation Timing Plans for US 17 Signals—note that a linked pair of signal coordination projects (currently without an evacuation timing component) are under development: "Signal Coordination Along Route 17"(UPC 98806) funded via regional Congestion Management Air Quality (CMAQ) funds in the FY14 VDOT Six-Year Improvement Program (SYIP) (see details in Appendix C), and "Route 17 Signal System Upgrades" (UPC 103763) in the VDOT Project Pool.

Estimation of Delay Savings Expected from Hurricane Highway Projects

In order to calculate the cost effectiveness of the five (5) evacuation-improving highway projects identified above, the delay savings of each project was estimated using the clearance times from the Virginia Hurricane Evacuation Study (VHES) as shown in the table found on the following pages.

Note that these calculations exclude the effect of vehicles shifting from an unimproved evacuation corridor to the subject improved corridor. The fact that delay savings at the improved corridor will be lower than the savings calculated below is mitigated by the fact the delay savings at the unimproved corridors is not included in the calculation below.

Table 2- Delay Savings for Hurricane Highway Projects
(page 1 of 2)

Source: HRTPO (addressing high clearance times from ATM.xlsx)

Project #1: 168/64/58 Southside Reversal

Clearance Time	35.8	hours	Source:	Abbreviated Transportation Model (ATM)[1]
Response Period	6	hours	Source:	Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), p. 2-12
Maximum Delay	29.8	hours		
Average Delay / Maximum Delay	0.5		Source:	estimate
Average Delay	14.9	hours		
Delay Reduction from Project	40%		Source:	19 hours / 48 hours = 0.40; Adkins document, p. 5[2]
Evacuating Vehicles	97,700	vehicles	Source:	Abbreviated Transportation Model (ATM)[1]
Avg. Delay Savings	**582,292**	veh-hrs		

Project #2: US 17 Evacuation Timing Plans (I-64 to Gloucester Courthouse)

Clearance Time	24.8	hours	Source:	Abbreviated Transportation Model (ATM)[1]
Response Period	6	hours	Source:	Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), p. 2-12
Maximum Delay	18.8	hours		
Average Delay / Maximum Delay	0.5		Source:	estimate
Average Delay	9.4	hours		
Delay Reduction from Project	25%		Source:	estimate[3]
Evacuating Vehicles	26,332	vehicles	Source:	Abbreviated Transportation Model (ATM)[1]
Avg. Delay Savings	**61,880**	veh-hrs		

Project #3: HRBT Build-8 Alternative (DEIS)

Clearance Time	23.2	hours	Source:	Abbreviated Transportation Model (ATM)[1]
Response Period	6	hours	Source:	Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), p. 2-12
Maximum Delay	17.2	hours		
Average Delay / Maximum Delay	0.5		Source:	estimate
Average Delay	8.6	hours		
Delay Reduction from Project	50%		Source:	4 lanes existing vs. 8 lanes proposed, i.e. 100% increase in capacity[4]
Evacuating Vehicles	61,993	vehicles	Source:	Abbreviated Transportation Model (ATM)[1]
Avg. Delay Savings	**266,570**	veh-hrs		

Table 2- Delay Savings for Hurricane Highway Projects
(page 2 of 2)

Source: HRTPO (addressing high clearance times from ATM.xlsx)

Project #4: I-64 Peninsula Widening (Alt. 2B, DEIS, mm254 to mm200)

Clearance Time	22.1	hours	Source:	Abbreviated Transportation Model (ATM)[1]
Response Period	6	hours	Source:	Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), p. 2-12
Maximum Delay	16.1	hours		
Average Delay / Maximum Delay	0.5		Source:	estimate
Average Delay	8.05	hours		
Delay Reduction from Project	33%		Source:	estimate[5]
Evacuating Vehicles	101,857	vehicles	Source:	Abbreviated Transportation Model (ATM)[1]
Avg. Delay Savings	**270,583**	veh-hrs		

Project #5: US 58 Widening (6 lanes from Holland Rd to I-95)

Clearance Time	20.8	hours	Source:	Abbreviated Transportation Model (ATM)[1]
Response Period	6	hours	Source:	Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008), p. 2-12
Maximum Delay	14.8	hours		
Average Delay / Maximum Delay	0.5		Source:	estimate
Average Delay	7.4	hours		
Delay Reduction from Project	33%		Source:	estimate[6]
Evacuating Vehicles	51,613	vehicles	Source:	Abbreviated Transportation Model (ATM)[1]
Avg. Delay Savings	**126,039**	veh-hrs		

Notes

[1]Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008)

[2]Assessment of VDOT Bowers Hill Improvement Alternatives to Ease Evacuation (Atkins, Draft, Oct. 2011)

[3]60% signal G/C for "main street" existing timing vs. 80% G/C hurricane timing, i.e. 33% increase in capacity or 25% decrease in delay

[4]100% increase in capacity results in 50% decrease in delay

[5]2 lanes WB existing vs. 3 lanes WB proposed west of exit 247 (DEIS, pg. 11-9), i.e. 50% increase in capacity or 33% decrease in delay

[6]2 lanes WB existing vs. 3 lanes WB proposed, i.e. 50% increase in capacity or 33% decrease in delay

Cost Effectiveness

Combining the above-calculated delay savings with project costs (from VDOT[5]) and the number of evacuating vehicles using the project (from the VHES), staff calculated two cost effectiveness measures as shown in the table at right:

- Cost per Evacuating Vehicle
- Cost per Hour of Delay Saved

Regardless of the measure used, the first two projects—168/64/58 Southside Reversal and Evacuation Timing Plans for US 17 Signals—are much more cost effective than the other three projects.[6]

Table 3- Cost Effectiveness of Hurricane Highway Projects

Source: HRTPO (addressing high clearance times from ATM.xlsx)

Project	VDOT[2,4] Cost Estimate, avg. cost, $m	Evacuating Vehicles (from ATM[1])	Cost per Evacuating Vehicle, $ (quotient of numbers at left)	Delay Savings, veh-hrs (source[3])	Cost per Hour of Delay Saved, $
168/64/58 Southside Reversal (i.e. the highlighted option in VDOT's 12-15-11 HRTPO Board presentation [Option 2]- two crossovers: one on Rt 168 [Oak Grove Connector] and one on I-264 approaching Bowers Hill.)	$10	97,700	**$102**	582,292	**$17**
Evacuation Timing Plans for US 17 Signals[4] (for all signals from I-64 to Gloucester Courthouse, i.e. beyond the area of significant background traffic, excluding signals in York County [which have an adaptive timing system rendering special timing plans unnecessary])	$0.019	26,332	**$0.72**	61,880	**$0.31**
HRBT Build-8 Alternative[5] (add 2 lanes in each direction from I-564 to I-664 [DEIS, Dec. 2012])	$4,950	61,993	**$79,848**	266,570	**$18,569**
I-64 Peninsula Widening[2] (54 Mile portion of Alt. 2B in I-64 Peninsula DEIS, i.e. widen to 6-8 lanes from mm 254 [Bland Blvd] to mm 200 [I-295])	$3,165	101,857	**$31,073**	270,583	**$11,697**
US 58 Widening (widen to 6 lanes from Suffolk Bypass [at Holland Rd] to I-95)	$1,225	51,613	**$23,734**	126,039	**$9,719**

Notes

[1] ATM: Abbreviated Transportation Model (ATM) of Va. Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008) Scenario: Category 3, I-64 reversal, high seasonal occupancy, medium response (6 hr's), heavy background traffic

[2] Note: The I-64 Peninsula Widening cost estimate is an extraction of the cost of the subject 54 mile project from the cost of the entire 75 mile VDOT DEIS project performed by HRTPO staff using the DEIS cost estimate details. See "Extracting 54 mile (254-200mm) DEIS Estimate from 75 mile (265-190mm) DEIS Estimate" in appendix.

[3] See "Delay Savings for Hurricane Highway Projects" in this report.

[4] Note: The cost estimate shown here for the timing plans is a modification of the cost estimate received from VDOT in that the cost of plans for signals in York County (which have an adaptive system) were excluded.

[5] Source: I-64 Hampton Roads Bridge-Tunnel Draft EIS and Draft Section 4(f) Evaluation (VDOT, Dec. 2012), p. S-5.

[5] In response to a request transmitted to Eric Stringfield (VDOT), Ray Hunt (VDOT) transmitted cost estimates to HRTPO via 10-2-13 and 10-10-13 emails.

[6] It should be noted that the last three projects may be highly cost effective if examined considering their impact on *daily* traffic, as opposed to their impact on *evacuation* traffic (as considered in this report).

CONCLUSION

Findings

As seen in Table 3 above and Figure 1 at right, the cost effectiveness of the five hurricane highway projects place those projects into two categories:

- Highly Cost Effective for Evacuation
  - 168/64/58 Southside Reversal
  - Evacuation Timing Plans for US 17 Signals

- Less Cost Effective for Evacuation
  - HRBT Build-8 Alternative
  - I-64 Peninsula Widening
  - US 58 Widening

Recommendation

Given the high cost effectiveness of the 168/64/58 Southside Reversal and Evacuation Timing Plans for US 17 Signals in Newport News and Gloucester, staff recommends that the HRTPO Board and VDOT consider funding these two projects.

Future Steps

Given the high cost effectiveness of the Evacuation Timing Plans for US 17 Signals in Newport News and Gloucester, following the implementation of that project, staff recommends that the HRTPO Board and VDOT examine and consider similar evacuation timing plan projects for the following portions of VDOT evacuation routes:

- US 460 between Suffolk Bypass and I-295 near Petersburg
- Routes 32 and 10 between US 17 in Isle of Wight and I-295 near Hopewell
- US 17 between I-664 in Suffolk and I-64 in Newport News

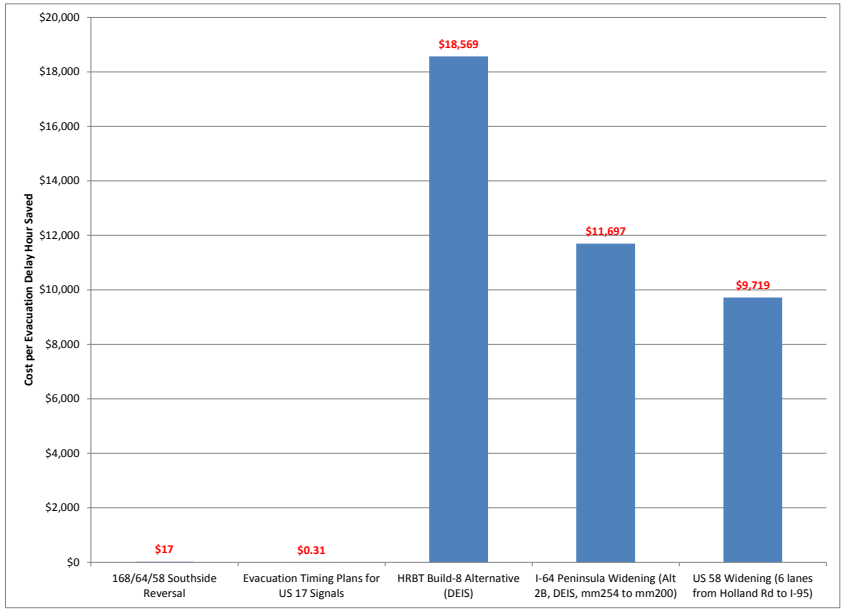

Figure 1- Cost Effectiveness of Hurricane Highway Projects
Source: HRTPO (addressing high clearance times from ATM.xlsx)

APPENDICES

Appendix A: Literature Review for Projects and Delay

A review of recent hurricane studies was conducted to identify highway projects for improvement of evacuation and to locate delay data with which to calculate their cost effectiveness.

A. SE Virginia / NE North Carolina Regional Catastrophic Planning Project

Evacuation Behavioral Study (SocResearch Miami, March 2010)

This study presents the findings of a survey of citizens conducted for the study. It contains therefore neither delay information by highway segment nor evacuation-improving highway projects.

Evacuation and Transportation Plan Review Findings Report (Dewberry/PBS&J, March 2010)

70 plans were submitted to the authors for this review, and the authors conducted 34 interviews. The report contains neither delay information by highway segment nor evacuation highway projects.

Evacuation Traffic and Evacuee Participation Monitoring Report (Dewberry/PBS&J, April 2010)

This document provides information concerning traffic monitoring devices (e.g. CCTV) along evacuation routes. The report contains neither delay nor project information.

Report on Transportation Requirements for Evacuation (Dewberry/PBS&J, draft Aug. 2010)

The purpose of this report is to analyze the existing balance between the number of people who need assistance evacuating (herein labeled "transportation-dependent") and the amount of transportation resources available to meet that need. Therefore, it contains neither highway delay numbers nor highway improvement projects.

Mass Evacuation Annex (Dewberry/PBS&J, Aug. 2010)

The purpose of the Annex is "to provide the framework and guidelines for organizing and implementing a mass evacuation" in the local metropolitan statistical area (MSA). It contains therefore neither delay information by highway segment nor evacuation highway projects.

Evacuation Scenarios Analysis and Traffic Modeling Report (Dewberry/PBS&J, draft August 2010)

This report presents in-area public shelter demand numbers (by locality), inland public shelter demand numbers, and revised clearance times for the region, but showing times only for "I-64 out", "US 58/Bowers Hl", and "local feeder routes". Consequently this study does not provide delay-related numbers by all pertinent highway segments, neither does it provide evacuation-improving highway projects.

Barco Diversion/NC-VA Border Traffic Control Plan Analysis (Dewberry/Atkins, Aug. 5, 2011)

This document reflects the authors' analysis of the North Carolina/Virginia Border Traffic Control Plan, PKA "Barco Diversion Plan", a plan designed to prevent NC evacuation traffic from adding to evacuation congestion in Hampton Roads.

In the section "Roadway Improvements to Ease Evacuation Congestion", the only Virginia project is the Chesapeake/Suffolk reversal project (see "Assessment of VDOT…" below.)

Assessment of VDOT Bowers Hill Improvement Alternatives to Ease Evacuation (Atkins, draft Oct. 2011)

This study produces clearance times to measure the effectiveness of four reversal alternatives that use reversed lanes between various crossovers in Chesapeake (that place traffic on the reversed lanes) and a crossover on Suffolk Bypass just west of the US 460 exit (that returns traffic to regular lanes).

The study indicates that the Chesapeake/Suffolk reversal of VA168/I-64/US58 can reduce clearance time at the Suffolk Bypass by 19 hours.

Phase 3 Planning Support to VMASC and the HR RCPT (Atkins, June 2013)

This study contains a variety of information: Census data adjustments, public shelter demand adjustments, suggested refuges of last resort (ROLR), best practices for servicing stranded vehicles, and master timeline review.

In order to identify potential ROLR locations, the study identifies six key congestion "hotspots":

1) I-64 at Wards Corner
2) I-64 at Bland Blvd
3) Williamsburg Area
4) High-Rise Bridge
5) Bowers Hill Interchange
6) Suffolk Bypass

The focus being on ROLR, no delay or clearance times were provided for these hotspots, and no highway improvement projects were identified.

Note that, in its master timeline review, the study indicates that VDOT will keep the MMMBT open during evacuations (a change from its previous intention to close it):

"Modeling by Praveen Edara for VCTIR and further analysis/opposition from the HRTPO…convinced officials that the closure was not needed. Atkins also confirmed through this effort that closing I-664 with a reversal of I-64 through the peninsula was not needed for a major hurricane."

"VDOT's May 2013 reversal plan states that VDOT will leave open I-664 north."

B. Other Efforts

An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan (Phase 1) (VTRC, Jan. 2006)

This effort used a microscopic simulation model (VISSIM) to "determine the performance characteristics with respect to traffic flow" of "the freeway portions of the evacuation routes" under VDOT's 2001 hurricane traffic control plan for Hampton Roads.

Due to its limitation to interstates, and lack of delay output by highway segment, it is not useful for this FY14 UPWP project.

An Operational Analysis of the Hampton Roads Hurricane Evacuation Traffic Control Plan – Phase 2 (VTRC, Apr. 2008)

As in Phase 1 above, this effort used VISSIM to evaluate the VDOT traffic control plan, but—unlike Phase 1—this effort examined arterial routes (in addition to interstate routes). The stated objectives were:

1. "estimate the traffic performance of evacuation routes and other major arterial streets"
2. "locate the major bottlenecks, congestion, or other operational difficulties"
3. "estimate the total network evacuation time"
4. "recommend amendments to the TCP [traffic control plan]"

The study identifies clogged evacuation highway segments (e.g. approach to Midtown Tunnel, approach to HRBT, and VB Blvd between Newtown Rd and Military Hwy), but the numerical results used to identify them seem counterintuitive. For example, a) Figure 3 (p. 16) shows that the base (i.e. uncongested) travel time of a 2 mile segment of arterial US 58 (VB Blvd from Newtown Rd to Military Hwy) is longer than that of a 6 mile segment of arterial US 58 (from Military Hwy to Midtown Tunnel), b) Figure 3 (p. 16) shows that the base/uncongested travel time of a 16 mile segment of US 58 (from Midtown Tunnel to Suffolk Bypass & Wilroy Rd) is less than 16.7 minutes, whereas Google Maps estimates the travel time at 24 minutes, and c) Figure 4 (p. 16) shows no clogging of I-64 between HRBT and Ft. Eustis Blvd, a segment that includes the 4-lanes-to-2-lanes bottleneck near NN/Williamsburg Airport. Therefore, the bottleneck and delay information from this report will not be used in this FY14 hurricane project.

Virginia Hurricane Evacuation Study (VDEM/USACE/FEMA, May 2008)

Although the study (abbreviated VHES) contains no list of highway projects for improving evacuation, it contains "clearance times" for key bottlenecks, i.e. the time it will take for evacuation-induced queues at these bottlenecks to clear. In addition, the study's Abbreviated Transportation Model (ATM) spreadsheet—the source of the report's clearance times—estimates the clearance times for 31 "Critical Roadway Segments".

(Note that the study's Abbreviated Transportation Model (ATM) also calculates "Worst Household Evacuation Commute Time", but only for evacuating via I-64 on the Peninsula.)

Hampton Roads Hurricane Evacuation Transportation Study (VMASC, June 27, 2008)

The Virginia Modeling, Analysis, and Simulation Center (VMASC) used a "macroscopic simulator" to "assess the viability of evacuating the Hampton Roads region" using the state's plan. The report contains neither delay by highway segment nor recommended highway projects.

Highway Evacuations in Selected Metropolitan Areas: Assessment of Impediments (FHWA, April 2010)

The authors conducted surveys of "local authorities" in 26 metropolitan areas in US to determine "the most significant impediments along NHS routes that may impact…evacuations". For Hampton Roads, Perry Cogburn (VDOT) was interviewed and stated the following impediments:

1. Traffic signal timing
2. Number of water crossings
3. Limited ITS deployment along key evacuation routes
4. Flood-prone infrastructure
5. Human resources to manage evacuation operations and tools

Being based on an interview, no delay information was provided.

Hurricane Evacuation Modeling of the Hampton Roads Region (VCTIR, draft May 2012)

This study, like the VHES above, produces clearance times used to test the efficacy of closing the MMMBT during evacuation, the I-64 Peninsula lane reversal, and the US 58 reversal. For this FY14 UPWP task, the clearance times of the VHES were considered the "official" times.

Behavioral Study Report; Refuge of Last Resort Study Report; Shelter Study Report; Housing Study Report (VMASC, June 2013)

Given that the first report reflects a survey of citizens, and the remaining reports deal with structures, these reports do not apply to this FY14 effort of prioritizing highway projects to improve evacuation travel times.

APPENDIX B: EXTRACTING 54 MILE (254-200 MILE MARKER) DEIS ESTIMATE FROM 75 MILE (265-190 MILE MARKER) DEIS ESTIMATE

Source: HRTPO using VDOT estimate (extracting 54 mile EIS est out of 75 mile EIS est.xlsx)

source for work below (unless otherwise stated): source1, appx. F, fourth page
source1: I-64 Peninsula Study, Alternatives Development Technical Memorandum, Oct. 2012
source2: I-64 Peninsula Study, Right of Way Technical Memorandum, Oct. 2012

Assumptions:
Alternative: Alt 1B (adding GP lanes in the median)
Work (e.g. lanes added, interchanges modified): per DEIS
Cost Level: Average Cost Estimate (as opposed to Low, High)
Year of Expenditure: 2017 (per DEIS)

			original 75 mile estimate, $m			54 mile (254-200mm) estimate, $m		
EB Roadway								
From	To	Zone	Length, mi.	CMP Average, per mi., $m	Cost (average), $m	Length, mi.	Cost (average), $m	Ratio, 54mile est. / 75mile est.
190	193	Ric	3	$14.5300	$43.590	0	$0.000	
193	197	Ric	4	$12.2450	$48.980	0	$0.000	
197	200	Ric	3	$7.5000	$22.500	0	$0.000	
200	202.5	Ric	2.5	$12.2450	$30.613	2.5	$30.613	
202.5	205	Ric	2.5	$7.7300	$19.325	2.5	$19.325	
205	224	Ric	19	$7.3250	$139.175	19	$139.175	
224	241.5	HR	17.5	$8.8450	$154.788	17.5	$154.788	
241.5	247	HR	5.5	$9.5500	$52.525	5.5	$52.525	
247	255	HR	8	$14.7600	$118.080	7	$103.320	
255	256	HR	1	$17.1435	$17.144	0	$0.000	
256	265	HR	9	$19.4500	$175.050	0	$0.000	
			75		$821.769	54	$499.745	
	recap							
	Ric District		34		$304.183	24	$189.113	0.62
	HR District		41		$517.586	30	$310.633	0.60
			75		$821.769	54	$499.745	
EB Bridges								
Zone	Location		Area	CPSF Average, per area	Cost (average), $m	Area (pro-rated via above ratio)	Cost (average), $m	
Zone 1 (Ric)	Mainline		349,042	$305	$106.458	217,002	$66.186	
Zone 1 (Ric)	Overpass		51,215	$305	$15.621	31,841	$9.711	
Zone 2 (HR)	Mainline		190,435	$350	$66.652	114,291	$40.002	
Zone 2 (HR)	Overpass		113,155	$350	$39.604	67,911	$23.769	
			703,847		$228.335	431,044	$139.668	
	recap							
	Ric District				$122.078		$75.897	
	HR District				$106.257		$63.771	
					$228.335		$139.668	
EB Roadway and Bridges, subtotal					$1,050.103		$639.413	
	recap							
	Ric District				$426.261		$265.010	
	HR District				$623.843		$374.403	
					$1,050.103		$639.413	

			original 75 mile estimate, $m			54 mile (254-200mm) estimate, $m		
WB Roadway								
From	To	Zone	Length, mi.	CMP Average, per mi., $m	Cost (average), $m	Length, mi.	Cost (average), $m	Ratio, 54mile est. / 75mile est.
190	193	Ric	3	$14.4375	$43.313	0	$0.000	
193	197	Ric	4	$12.2450	$48.980	0	$0.000	
197	202.5	Ric	5.5	$7.5000	$41.250	2.5	$18.750	
202.5	224	Ric	21.5	$7.3250	$157.488	21.5	$157.488	
224	241.5	HR	17.5	$8.8450	$154.788	17.5	$154.788	
241.5	247	HR	5.5	$9.5500	$52.525	5.5	$52.525	
247	255	HR	8	$14.7600	$118.080	7	$103.320	
255	256	HR	1	$17.1435	$17.144	0	$0.000	
256	258	HR	2	$19.4500	$38.900	0	$0.000	
258	265	HR	7	$21.3950	$149.765	0	$0.000	
			75		$822.231	54	$486.870	
	recap							
	Ric District		34		$291.030	24	$176.238	0.61
	HR District		41		$531.201	30	$310.633	0.58
			75		$822.231	54	$486.870	

WB Bridges						
Zone	Location	Area	CPSF Average, per area	Cost (average), $m	Area (pro-rated via above ratio)	Cost (average), $m
Zone 1 (Ric)	Mainline	301,433	$305	$91.937	182,537	$55.674
Zone 1 (Ric)	Overpass	51,215	$305	$15.621	31,014	$9.459
Zone 2 (HR)	Mainline	162,784	$350	$56.974	95,192	$33.317
Zone 2 (HR)	Overpass	113,155	$350	$39.604	66,170	$23.160
		628,587		$204.136	374,913	$121.610
	recap					
	Ric District			$107.558		$65.133
	HR District			$96.579		$56.477
				$204.136		$121.610
WB Roadway and Bridges, subtotal				$1,026.367		$608.480
	recap					
	Ric District			$398.588		$241.371
	HR District			$627.780		$367.109
				$1,026.367		$608.480

		original 75 mile estimate, $m			54 mile (254-200mm) estimate, $m		
Interchanges							
Note: The DEIS estimate places large cost even on those interchanges with "None" under "Improvement Description" on Table 3 (pg. 18). (According to page 25, "tie in @ ramps = improvement cost".)							
Zone	Location	Quantity	CPEach Average, $m	Cost (average), $m	Quantity (based on location)	Cost (average), $m	Comment re Quantity
Zone 1 (Ric)	Urban, New	3	$58.585	$175.755	0	$0.000	beyond 54mi
Zone 1 (Ric)	Urban, Improve	3	$38.080	$114.240	1	$38.080	intx. 200
Zone 1 (Ric)	Rural, New	0	$49.795	$0.000	0	$0.000	n.a.
Zone 1 (Ric)	Rural, Improve	4	$38.080	$152.320	4	$152.320	all are w/in 54mi seg.
Zone 2 (HR)	Urban, New	5	$67.370	$336.850	2	$134.740	intx's 242, 250
Zone 2 (HR)	Urban, Improve	6	$52.725	$316.350	2	$105.450	intx's 243, 247
Zone 2 (HR)	Rural, New	2	$58.585	$117.170	2	$117.170	all are w/in 54mi seg.
Zone 2 (HR)	Rural, Improve	2	$52.725	$105.450	2	$105.450	all are w/in 54mi seg.
		25		$1,318.135	13	$653.210	
	recap						
	Ric District	10		$442.315	5	$190.400	
	HR District	15		$875.820	8	$462.810	
		25		$1,318.135	13	$653.210	
Construction (rdway, bridges, interchanges), subtotal				$3,394.606		$1,901.102	
	recap						
	Ric District			$1,267.164		$696.780	
	HR District			$2,127.442		$1,204.322	
				$3,394.606		$1,901.102	

Right of Way and Utilities	original 75 mile estimate, $m source: source2, p. 10				54 mile (254-200mm) estimate, $m			
Richmond District	ROW Take, acres	Portion of Total Take	ROW Cost, % of Const. Cost (average)	ROW Cost, $m	ROW Take, acres	Portion of Total Take	ROW Cost, % of Const. Cost (average)	ROW Cost, $m
Rural	26.9	17%	30%	$64.36	24	38%	30%	$80.24
Res./Sub. Low Density	30.1	19%	57.5%	$138.02	3	5%	57.5%	$19.12
Out. Bus. / Sub. High Density	71.7	45%	80%	$457.42	36	57%	80%	$316.85
CBD	30.2	19%	112.5%	$270.94	0	0%	112.5%	$0.00
	158.9	100%		$930.735	63	100%		$416.209
Hampton Roads District	ROW Take, acres	Portion of Total Take	ROW Cost, % of Const. Cost (average)	ROW Cost, $m	ROW Take, acres	Portion of Total Take	ROW Cost, % of Const. Cost (average)	ROW Cost, $m
Rural	53.1	12%	35%	$86.39	48	20%	35%	$85.94
Res./Sub. Low Density	204	45%	62.5%	$592.93	102	44%	62.5%	$327.72
Out. Bus. / Sub. High Density	169	37%	100%	$786.00	85	36%	100%	$434.43
CBD	31.4	7%	137.5%	$200.68	0	0%	137.5%	$0.00
	457.7	100%		$1,665.989	234	100%		$848.085
ROW & Utilities, subtotal				$2,596.724				$1,264.295
Total (Average Estimate)				$5,991.330				$3,165.397

APPENDIX C: VDOT FY14 SIX-YEAR IMPROVEMENT PROGRAM

VDOT Virginia Department of Transportation

Six-Year Improvement Program

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Line Item Details

Project Summary

UPC	95050
Project	RTE. 58 - LANE REVERSAL
Scope of Work	Safety
Description	FROM: RTE 58 & RTE 13 Interchange TO: I-264 & I-64 Interchange
Report Note	MPO project
Fund Source	BOND/STP

Project Location

District	Hampton Roads	Jurisdiction	Hampton Roads District-wide
Road System	Primary	Length	15.5000 MI
Route	0058	Street	RTE. 58
MPO Area	Hampton Roads		

Estimates & Schedule

	Estimated Cost (Thousands)	Schedule
Prelim. Eng. (PE)	$950	Complete
Right of Way (RW)	$0	N/A
Construction (CN)	$0	N/A
Total Estimate	**$950**	

Required Allocations

Values in Thousands of Dollars

Fund Sources	Previous Allocations	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Required After FY2019
Bond Proceeds: CPR Bonds	$600	$0	$0	$0	$0	$0	$0	
RSTP (STP Regional): Federal	$800	$0	$0	$0	$0	$0	$0	
RSTP (STP Regional): State Match	$200	$0	$0	$0	$0	$0	$0	
Total Funding	**$1,600**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**($650)**

 VDOT Six-Year Improvement Program v1.0

VDOT Virginia Department of Transportation

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Line Item Details

Project Summary

UPC	98806
Project	SIGNAL COORDINATION ALONG ROUTE 17
Scope of Work	Safety
Description	FROM: Coleman Bridge TO: Route 17/17B Intersection
Report Note	MPO Project.
Fund Source	CM

Project Location

District	Fredericksburg	Jurisdiction	Gloucester County
Road System	Primary	Length	11.3000 MI
Route	0017	Street	Route 17
MPO Area	Hampton Roads		

Estimates & Schedule

	Estimated Cost (Thousands)	Schedule
Prelim. Eng. (PE)	$364	Underway
Right of Way (RW)	$0	N/A
Construction (CN)	$1,836	FY2015
Total Estimate	**$2,200**	

Required Allocations

Values in Thousands of Dollars

Fund Sources	Previous Allocations	FY2014	FY2015	FY2016	FY2017	FY2018	FY2019	Required After FY2019
($)CMAQ: Federal	$576	$0	$0	$0	$0	$0	$0	
($)CMAQ: MPO - Federal	$528	$0	$771	$0	$0	$0	$0	
($)CMAQ: MPO - State Match	$132	$0	$193	$0	$0	$0	$0	
Total Funding	**$1,236**	**$0**	**$964**	**$0**	**$0**	**$0**	**$0**	**$0**

 VDOT Six-Year Improvement Program v1.0

APPENDIX D: PUBLIC COMMENTS

The following public comment was received via 1-14-14 email:

Outstanding report.

Please consider noting that additional traffic signal timing type projects should be considered due to the following facts.

1. High B/C ratios
2. Quick implementation timeframes
3. Low costs

The following routes are suggested as possible additions to the list of this type of project.

1. Route 460 in Suffolk and west into the VDOT maintenance areas
2. Route 10 in Suffolk west into the VDOT maintenance areas
3. Route 17 in Suffolk and Isle of Wight between I-664 and the James River Bridge

Robert E. Lewis, P.E., FITE
City Traffic Engineer
City of Suffolk
757-514-7603 (O)
757-923-2491 (F)
relewis@suffolkva.us
www.suffolk.va.us

In response to this comment, the "Future Steps" sub-section was added under the "Conclusion" section.

The following public comment was received via 1-31-14 email:

Gloucester County
Administrator's Office

Telephone 804-693-4042 P. O. Box 329, Gloucester, Virginia 23061 Fax 804-693-6004

January 31, 2014

HRTPO
Attn: Robert N. Case, P.E., PhD.
723 Woodlake Drive
Chesapeake, Virginia 23320

RE: Prioritizing Highway Projects for Improvement of Hurricane Evacuation

Dear Mr. Case:

Thank you for the opportunity to review the referenced planning document. Gloucester recognizes the importance of the Route 17 corridor for the safe evacuation of citizens living both on the Virginia Peninsula and the Middle Peninsula. To this extent, we do believe that improvement to the signal coordination and timing specifically for evacuation is a worthy project. According to your analysis, this project is also one of the more cost effective projects with respect to improving traffic throughput.

With this said, I believe it may be important for you to realize that VDOT currently has two projects in the public input stage to improve signal timing along Route 17 in Gloucester (UPC 103763 and UPC 98806). If regional funding is available to implement the recommendations of the referenced plan, there may be opportunities to supplement the funding of these existing projects to expand their scope to include evacuation timing capabilities in a more cost effective manner compared to allowing them to move forward independently and be followed by a separate project to provide for evacuation timing.

Thank you again for the opportunity to provide comment.

Sincerely,

Garrey W. Curry, Jr., P.E.
Assistant County Administrator
for Community Development

pc: file
Brenda Garton, County Administrator
Anne Ducey-Ortiz, Director of Planning and Zoning
Creig Moore, Emergency Management Coordinator

LAND OF THE LIFE WORTH LIVING

In response to this comment, a note was added to the "Identification of Highway Projects for Improving Hurricane Evacuation" section and an email reply was sent describing opportunities for funding (CMAQ and RSTP) available from the HRTPO.