Project Traffic Forecasting

NCHRP 255 Review

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Federal Highway Administration
Washington, DC

September 25, 2008

255

NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT 255

HIGHWAY TRAFFIC DATA FOR URBANIZED AREA PROJECT PLANNING AND DESIGN

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

Background and History

What is NCHRP 255?

- Standardized procedures to translate…
  - travel model assignments
  - land use information
  - historical data
  - other factors

  …into information to support project development decisions

- Methods to scale analysis to decisions and decision timeframes

- Complement to NCHRP 187 – Quick Response Guide
  (Updated as NCHRP 365)

- Published by the Transportation Research Board's National Cooperative Highway Research Program in 1982

Where can I get a copy?

- Out of print
- http://www.oregon.gov/ODOT/TD/TPAU/references.shtml
- NCHRP 255 report front piece on TMIP website http://tmip.fhwa.dot.gov

From: Eileen Delaney [mailto:EDelaney@nas.edu]
Sent: Wednesday, March 27, 2002 8:11 AM
To: GILLETT Michael H
Subject: Re: NCHRP report 255
Sure, you have permission to post NCHRP Report 255 on your web site. Just make sure the entire report is posted, especially the title and author page.
Eileen

Who authored NCHRP 255 and where are they now?

Neil Pederson
Administrator
Maryland State Highway Administration

Don Samdahl
Principal
Mirai Associates, Seattle WA

Mirai
Transportation
Planning &
Engineering

Why was NCHRP 255 Developed?

- Improve relationship: systems planning ↔ project development and design
- Use planning products to support project development, decisionmaking, and design
- Account for
  - Variance in the detail and precision of forecasts
  - Uncertainty in land-use forecasts
  - Assumptions (explicit and implicit) of project forecasting
- Reduce time and effort to provide project-level forecasts
- Improve consistency and analytic quality of input data and output forecasts
- Improve understanding; focus on the story, not the details.

Instant Poll
Usage

How many agencies on-line today apply NCHRP 255 procedures…

1. Routinely – Several times a year or more
2. Occasionally – A few times a year
3. Sometimes – A few times in the last several years
4. Rarely – Once or twice in the last ten years
5. Seldom – Tried it once and didn't understand it
6. Never

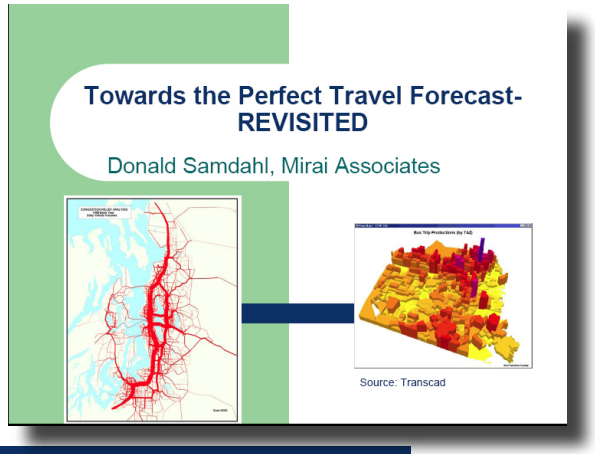
Please answer honestly

Instant Poll
NCHRP 255 Procedures

For those agencies that apply NCHRP 255 routinely or occasionally, which procedures do you use?

1. Traffic volume forecast refinement
2. Traffic data for alternative network assumptions
3. Traffic data for more detailed networks
4. Traffic data for different forecast years
5. Turning movements
6. Design hour volume or time-of-day
7. Directional distribution
8. Vehicle classification
9. Speed, delay, and queue length
10. Traffic data for pavement design

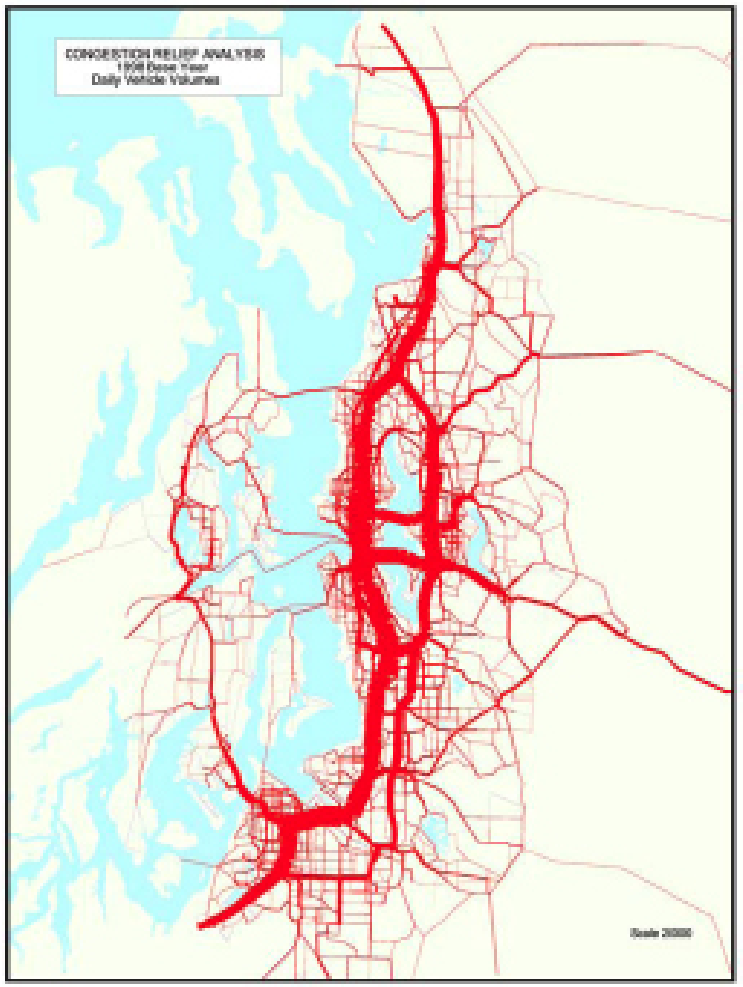
Can we Achieve a Perfect Forecast?



In 1982 we said "**NO**"

In 2005 we say "Quite Frankly, **NO**"

- Every forecast has errors
- GIN/GAO
- New applications keep pushing the envelope



“Essentially, all models are wrong, but some are useful…”

George Box,
Professor Emeritus of Statistics, University of Wisconsin,
Pioneer in the areas of quality control, time series analysis,
design of experiments, and Bayesian inference.

“…The practical question is how wrong do they have to be to not be useful.”

George Box

Logical Consequences

If…	Then…
• The the initial state is not completely known or represented • The initial state is not stable • Fundamental relationships in the initial state change over time • Data collected in the initial state are inaccurate • Data collected in the initial state are anomalous	The forecast may not be accurate

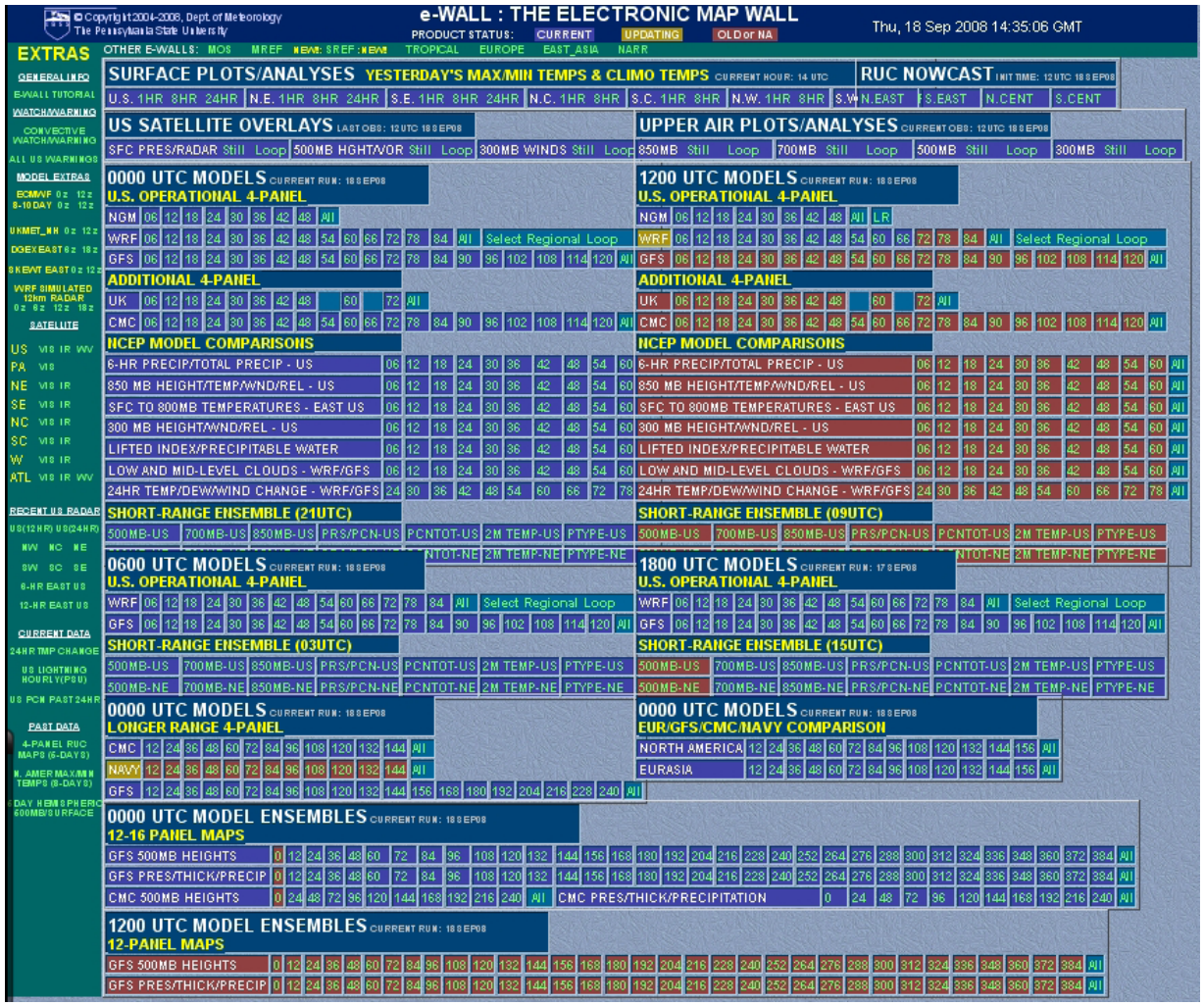
Model Constraints

- Models are imperfect, ongoing works in progress
- Good forecasts require thoughtful interpretation of model outputs; Raw model output takes effort to understand
- Forecast inaccuracies can be accounted for
- Agencies have more work than staff/time
- Long timeframes to provide project-level answers

Goals

- Quicker Response
- Utilizes Models, Data Sources, and Data Surveys
- Communication
- Consistency
- Analytic Quality

Model outputs ≠ forecasts



"Don't take what the model presents to you for everything that it is worth. Study the model and ask yourself some questions about the situation the model is presenting to you versus current patterns."
- PSU e-Wall tutorial

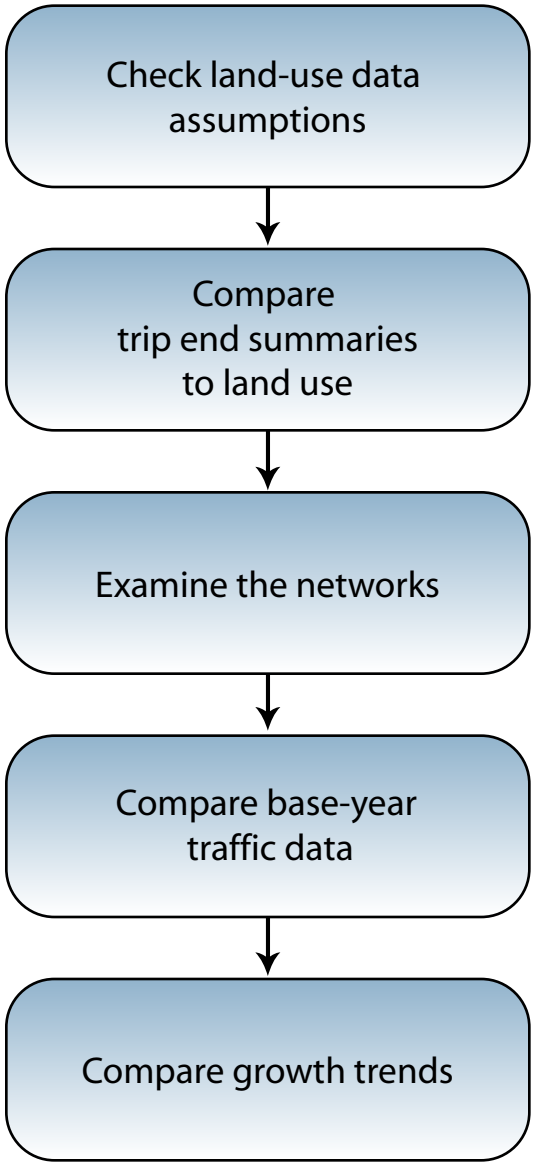
E-Wall tutorial:
http://www.personal.psu.edu/adb241/eWallTutorial/forecast.htm

E-wall:
http://www.meteo.psu.edu/~gadomski/ewall.html

Fundamentals

- Pay attention to validation
- Account for validation inaccuracies
- Scale analysis to geography, density, and decision
- Account for changes in capacity—especially on facilities not in the model
- Account for the pace of growth
- Integrate model forecasts into other facets of your organization

Process Flow - Preliminary Checks



- **Existing LU data still accurate?**
- **Future LU forecasts still valid?**
- **Sub-zonal allocations understood?**

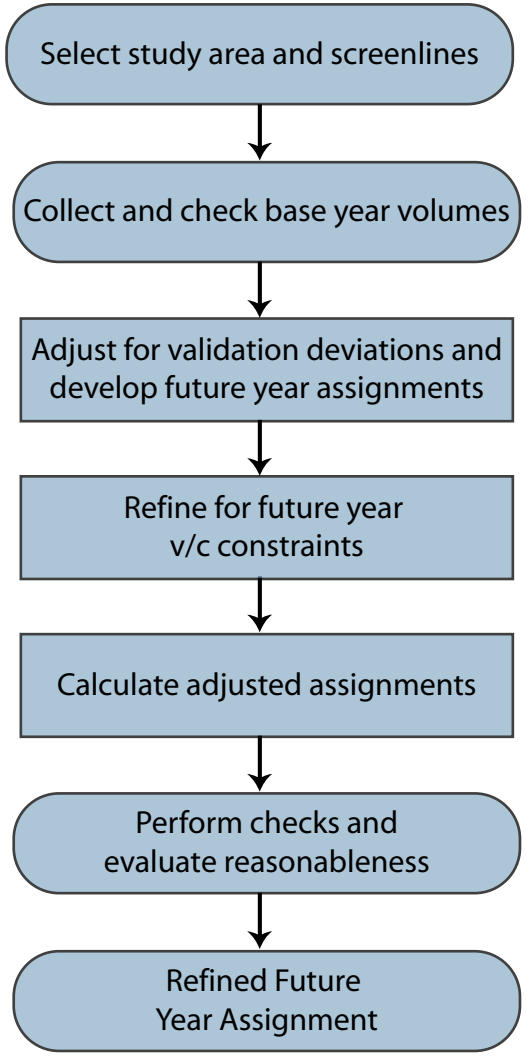
- **Total trip ends consistent w/LU?**
- **Trip ends stratified by mode; purpose consistent w/LU?**
- **Sub-zonal allocations understood?**

- **Check link capacities, impedances, and distances**
- **Check centroids, connectors**
- **Understand travel paths**

- **Check link assignment deviation (max of one travel lane)**
- **Compare vmt (model vs. counts)**

- **Compare and understand historic growth and forecast trends in**
  - **vmt**
  - **households**
  - **population**
  - **employment**

Process Flow - Forecast Volume Refinements



Subareas, Screenlines, and Corridors

- Subarea should be sufficiently sized – ample boundaries are recommended; tight boundaries give misleading results
- Streets are not corridors
- Corridor = collection of facilities that capture major travel patterns
- Screenlines should capture trips along major travel desire lines

Subareas, Screenlines, and Corridors

- Area size and facility density should be considered
- Typical length of around 2 – 5 miles
- Link density should fall into chart range
- Trips should only cross screenline once
- Screenline should capture route choices

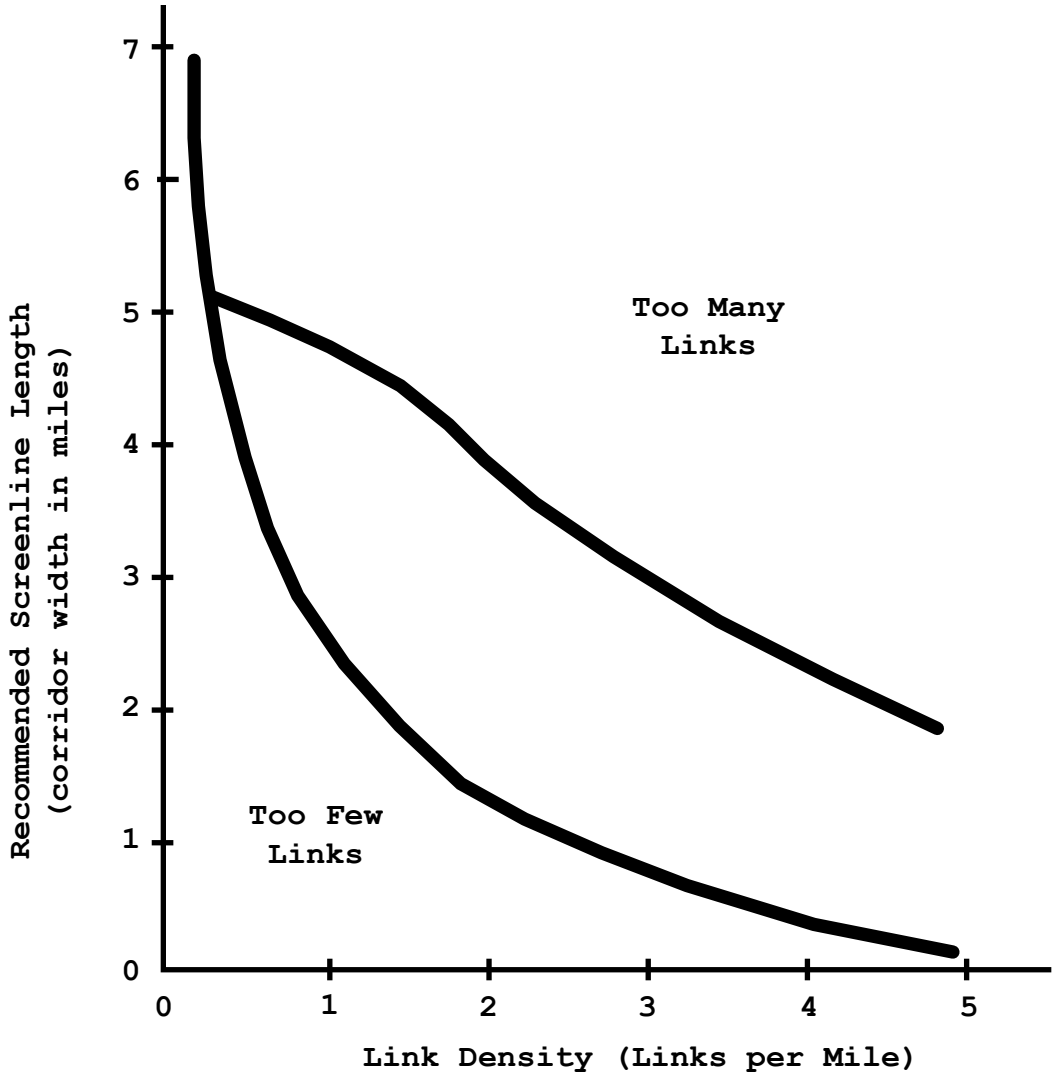
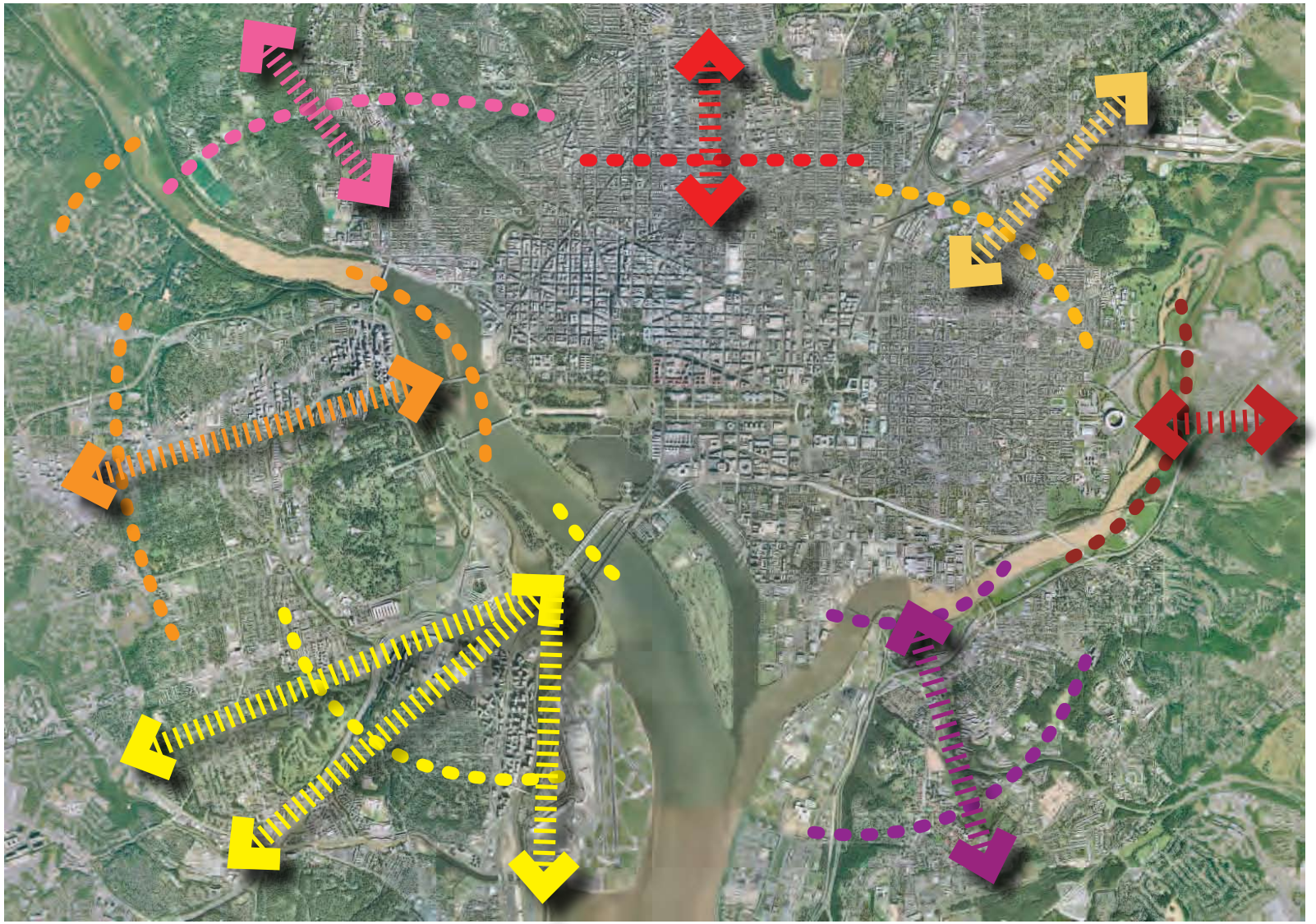


Figure A-7. Recommended screenline length.

Screenlines - Example from downtown Washington study



Screenlines - Example from Columbus, GA

COLUMBUS–PHENIX CITY
METROPOLITAN PLANNING ORGANIZATION

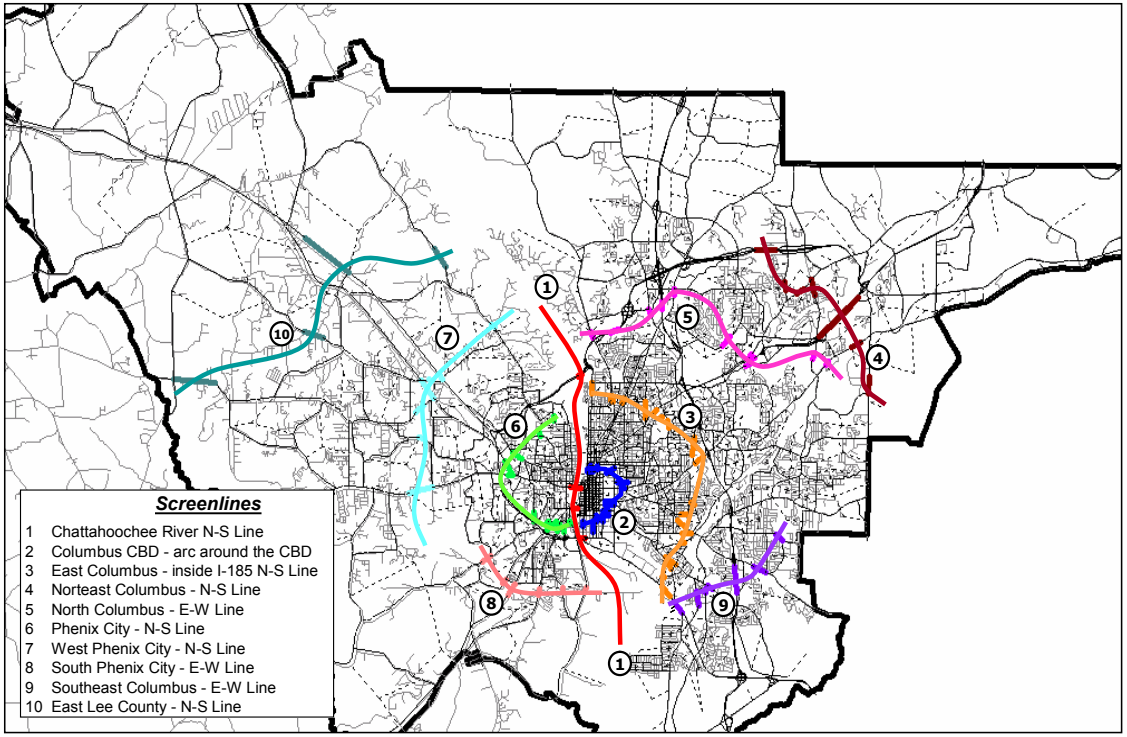
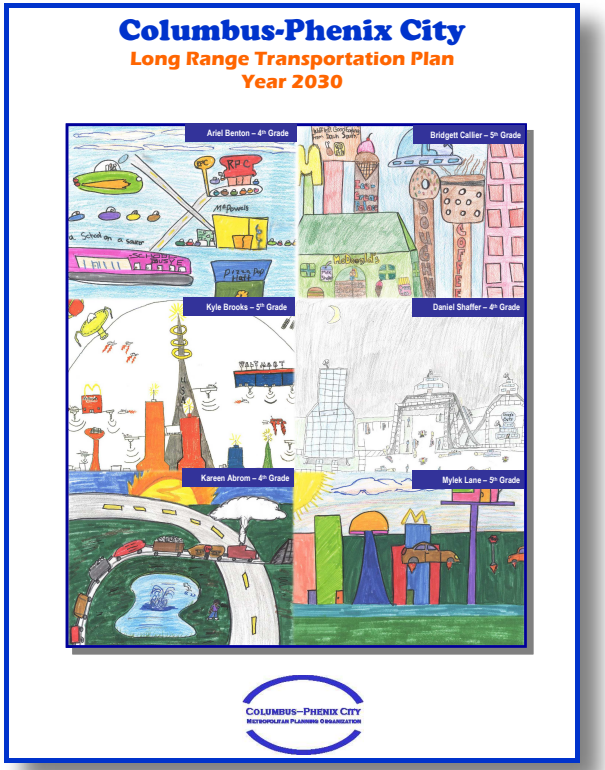


Figure B-4
C-PCTS Network Screenline Locations



Typical Application

"A post processing technique described in publication NCHRP-255 was used to adjust the 2030 forecasted volumes. This methodology compares the calibrated travel demand model output with actual traffic counts. The differences between the modeled traffic volumes and the actual traffic volumes are then used to adjust future traffic projections. Traffic projections are affected by a number of factors including:

- The available capacity of the roadway network.
- Type and location of land use in the surrounding area.
- The directness (or lack thereof) of available routes between various zones.
- The characteristics (i.e. design speed) of the roadways between zones."

Lexington NEBRASKA

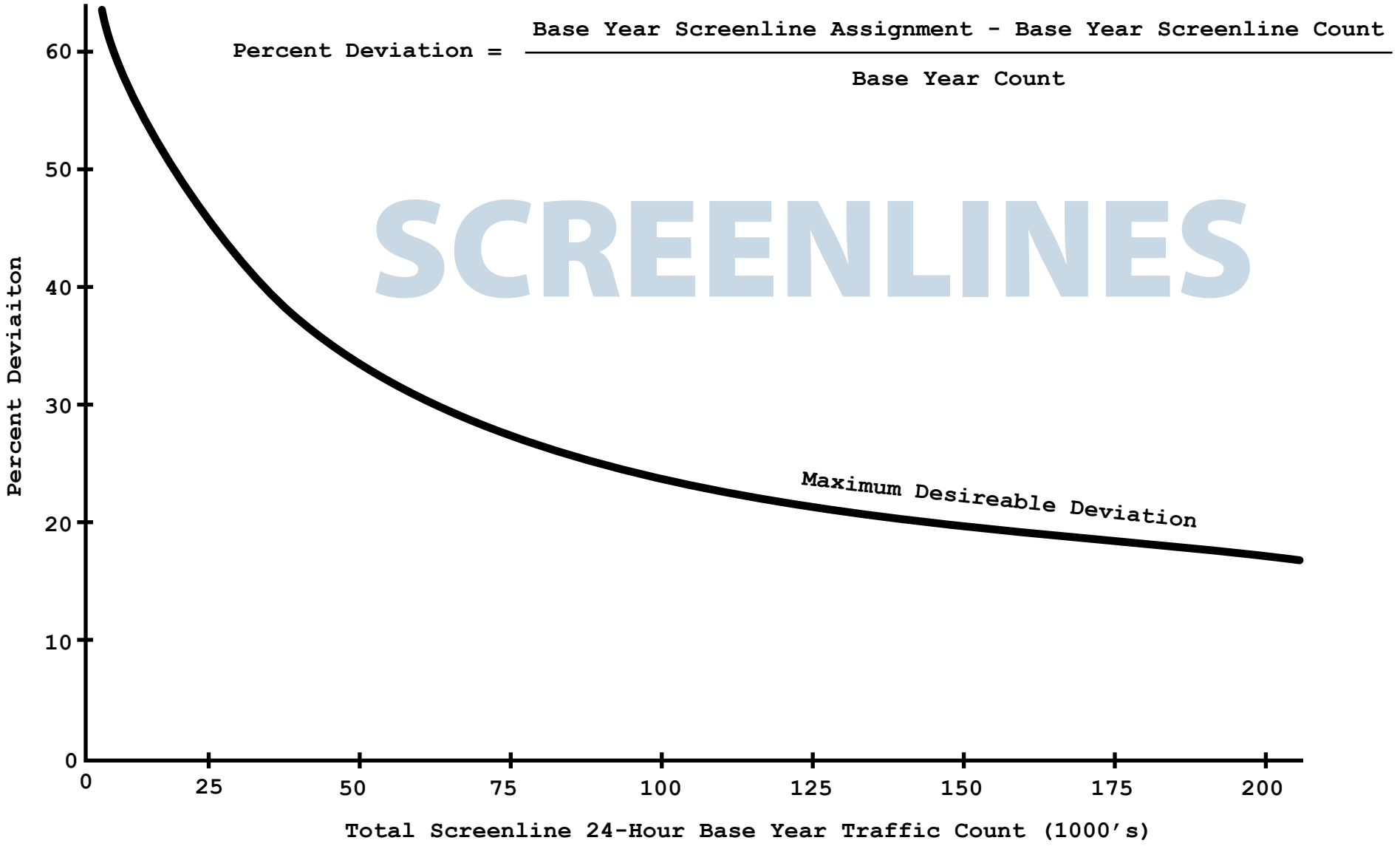


Figure A-9. Maximum desirable error for screenline volumes.

NCHRP 255

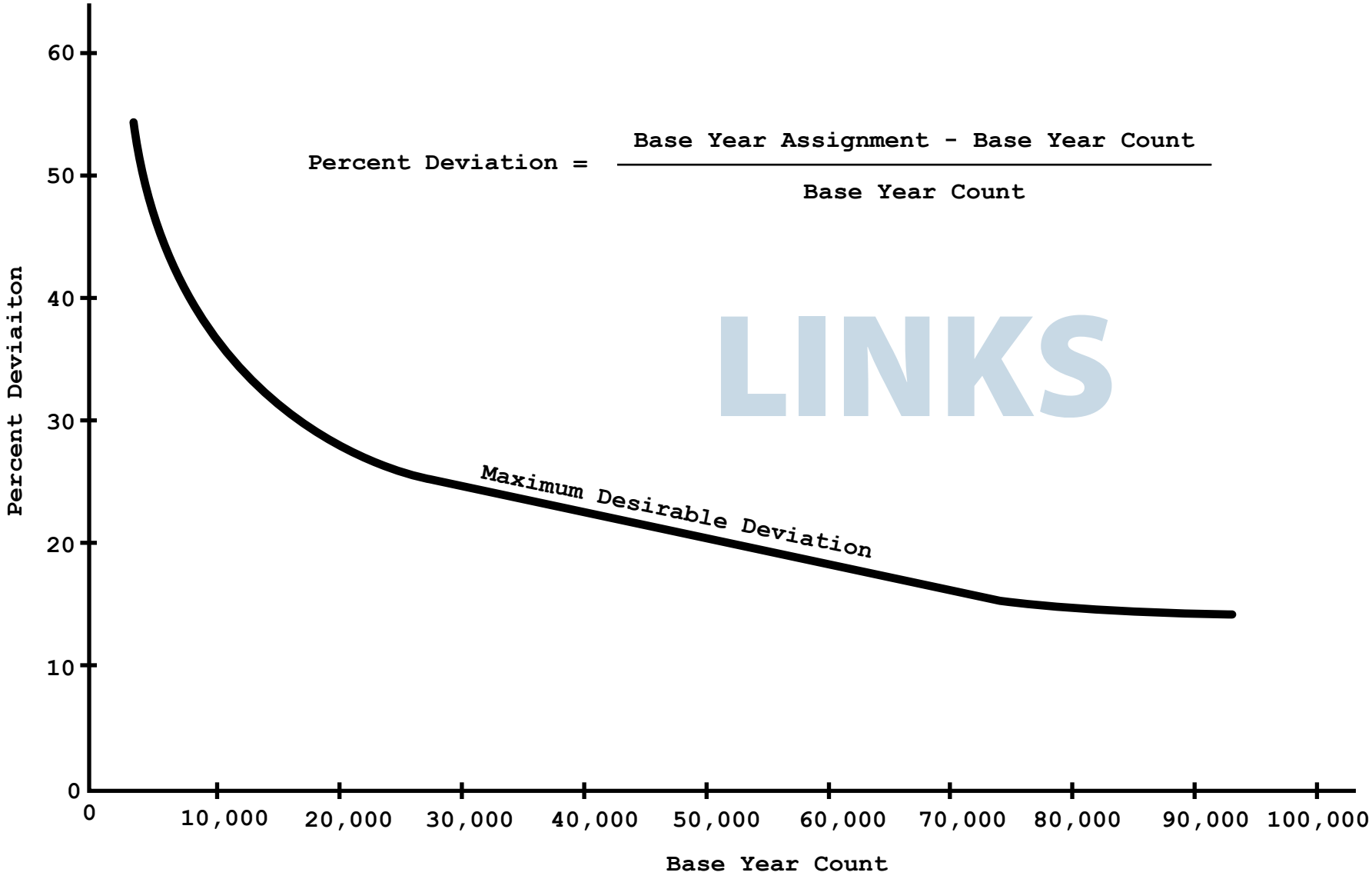
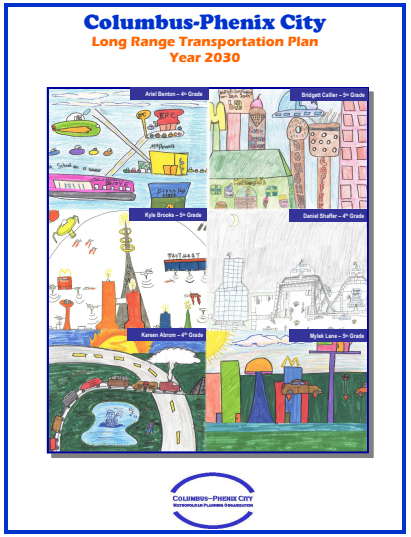


Figure A-3. Maximum desirable error for link volumes.

Screenlines - Example from Columbus, GA



COLUMBUS–PHENIX CITY
METROPOLITAN PLANNING ORGANIZATION

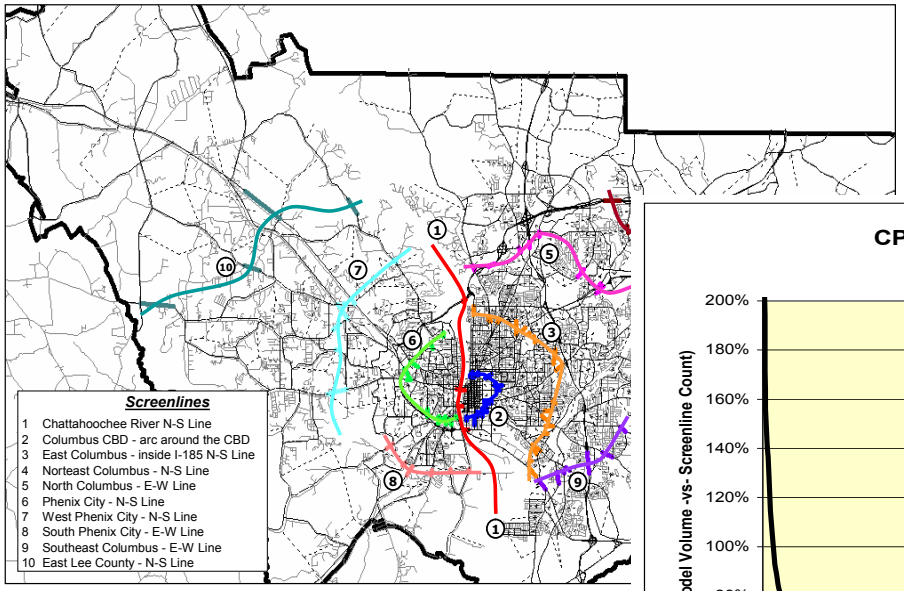
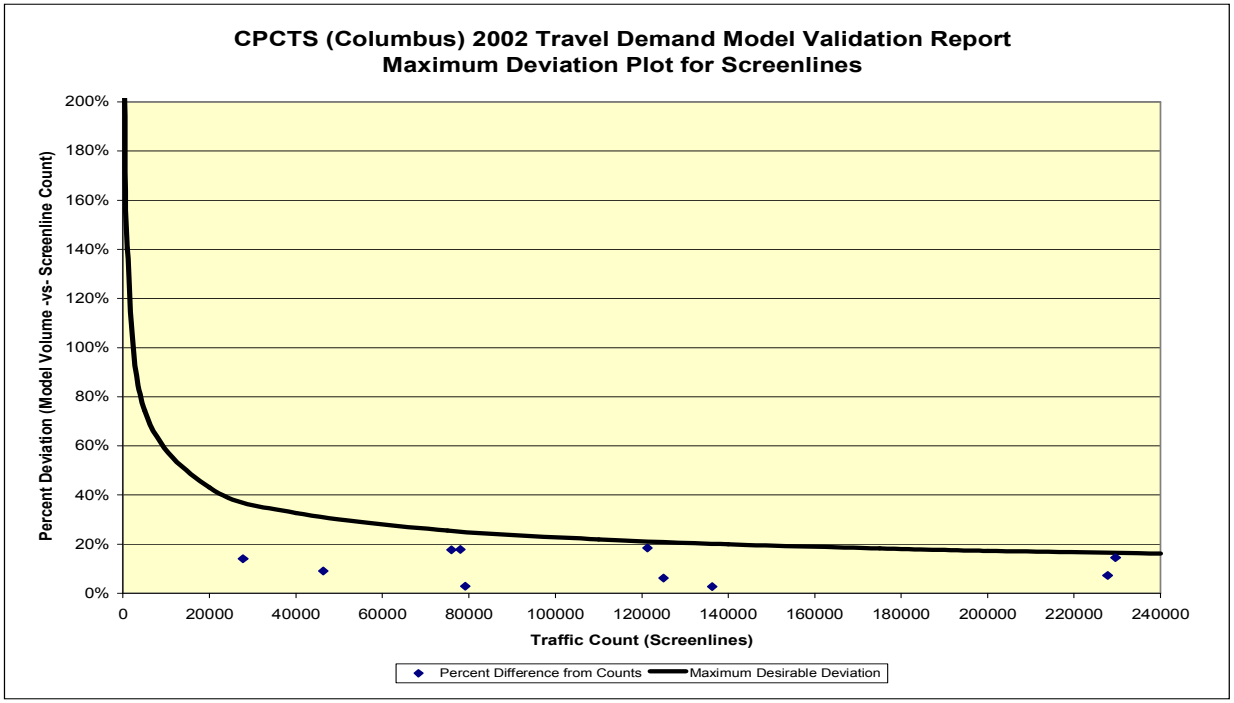
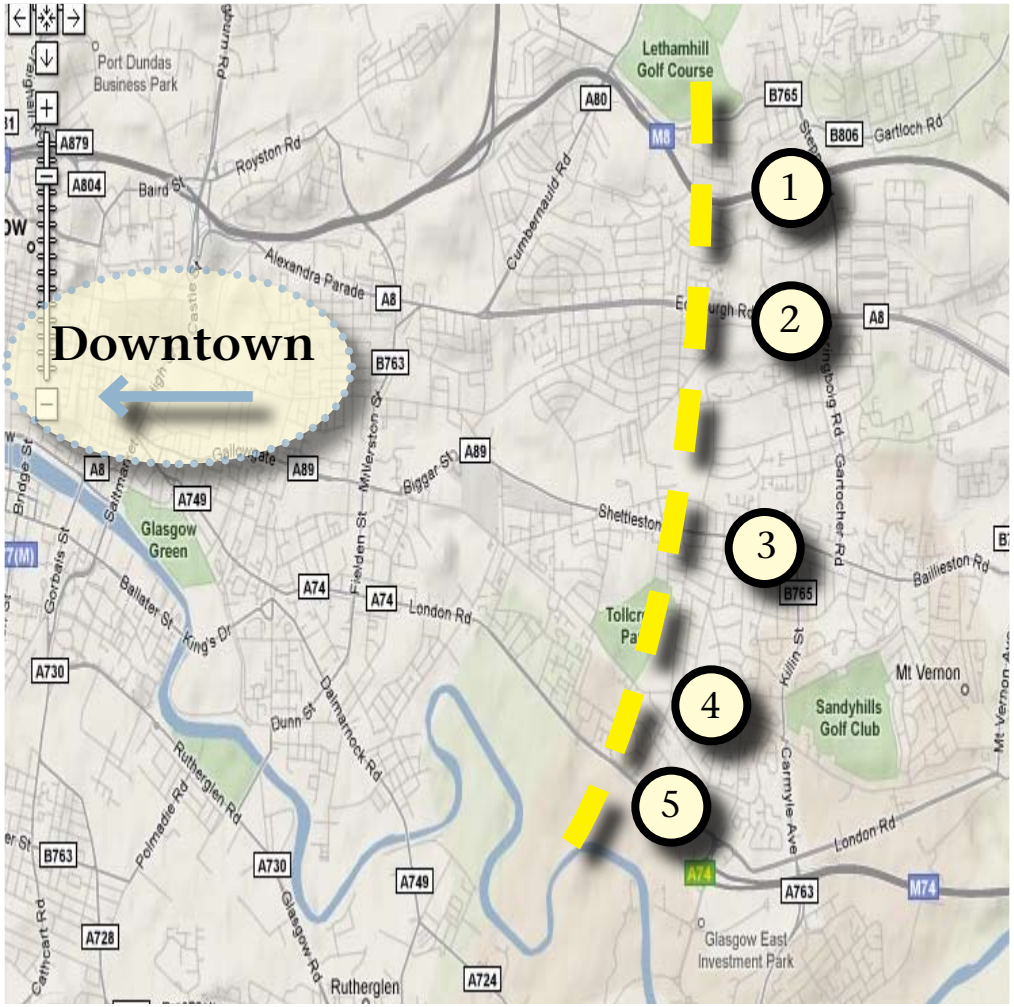


Figure B-4
C-PCTS Network Screenline Loc



Screenline Example – Link Factoring

Link	Base Count	Assignment	Difference	% Difference
1	121,600	92,800	-28,800	24%
2	37,400	47,200	9,800	26%
3	26900	27,600	700	3%
4	12800	12,500	-300	2%
5	29800	32,500	2,700	9%
Total	228,500	212,600	-15,900	7%



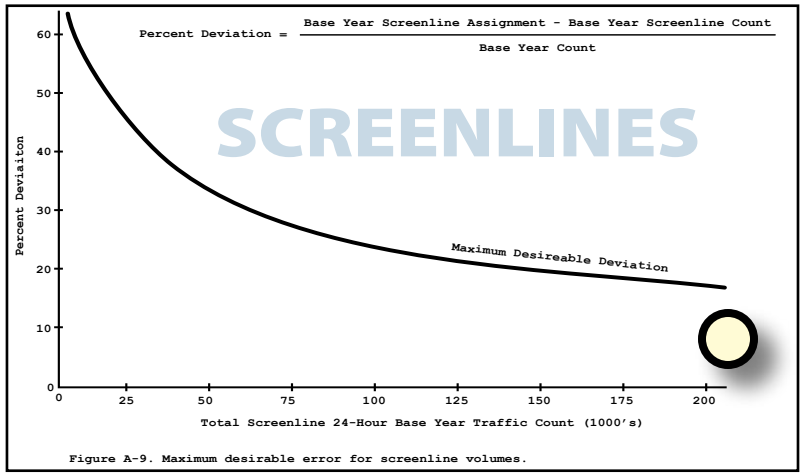


Figure A-9. Maximum desirable error for screenline volumes.

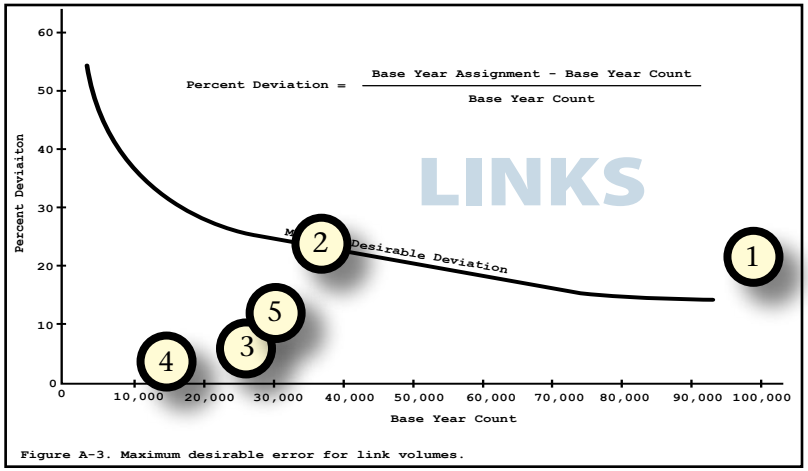


Figure A-3. Maximum desirable error for link volumes.

Link Factoring Example - Continued

①

Link	Base Count	Assignment	Difference	% Difference
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4	12800	12,500	-300	2%
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Total	228,500	212,600	-15,900	7%

②

Link	Base Count	Assignment	Capacity
1	53%	44%	55%
2	16%	22%	16%
3	12%	13%	12%
4	6%	6%	5%
5	13%	15%	12%
Total	100%	100%	100%

③

Link	Future Assignment	Adjust by Assignment	Adjust by Difference	Combined	
1	102,000	133,655	130,800	132,200	(+)
2	37,500	29,714	27,700	28,700	(-)
3	28,500	27,777	27,800	27,800	
4	14,000	14,336	14,300	14,300	
5	31,200	28,608	28,500	28,600	(-)
Total	213,200	234,090	229,100	231,600	(-)

Adjust by Assignment - Link 1

$$\text{Adjust by Assignment} = \frac{\text{Base Count}}{\text{Base Assignment}} * \text{Future Assignment}$$

$$= \frac{121,600}{92,800} * 102,000 = 133,700$$

$$\text{Adjust by Difference} = (\text{Base Count} - \text{Base Assignment}) + \text{Future Assignment}$$

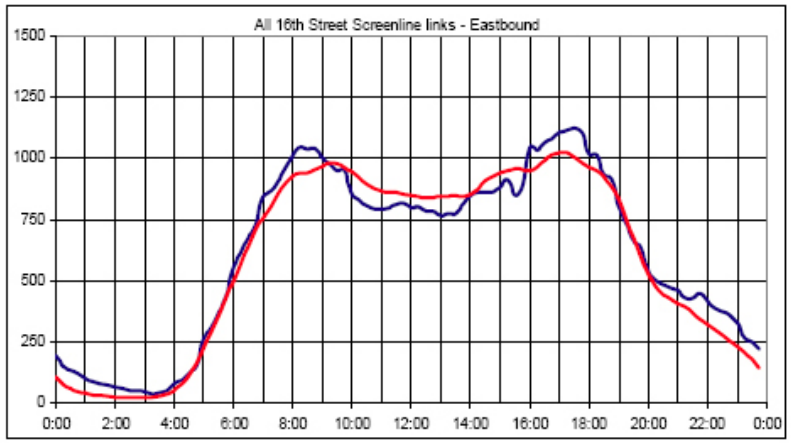
$$= (121,600 - 92,800) + 102,000 = 130,800$$

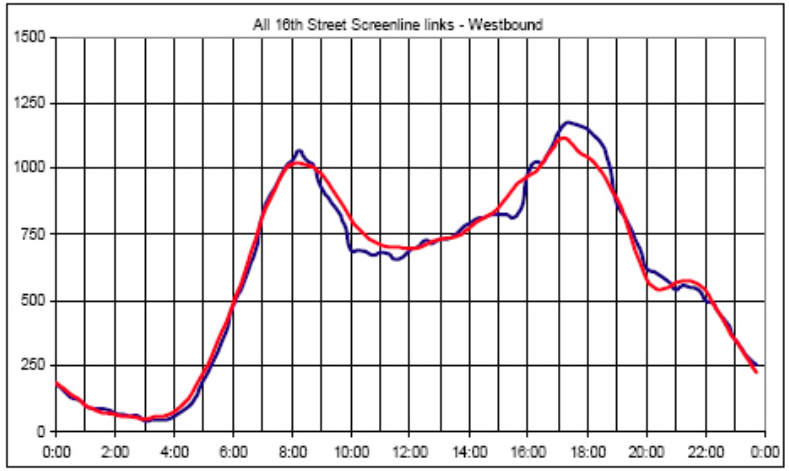
$$\text{Combine and Average} = (\text{Sum of adjusted assignments}) / 2$$

$$= (133,700 + 130,800) / 2 = 132,200$$

Screenlines - Example from Downtown Washington

- Screenline matching desirable by time-of-day for combined forecasting-simulation models





Capacity Change Adjustments

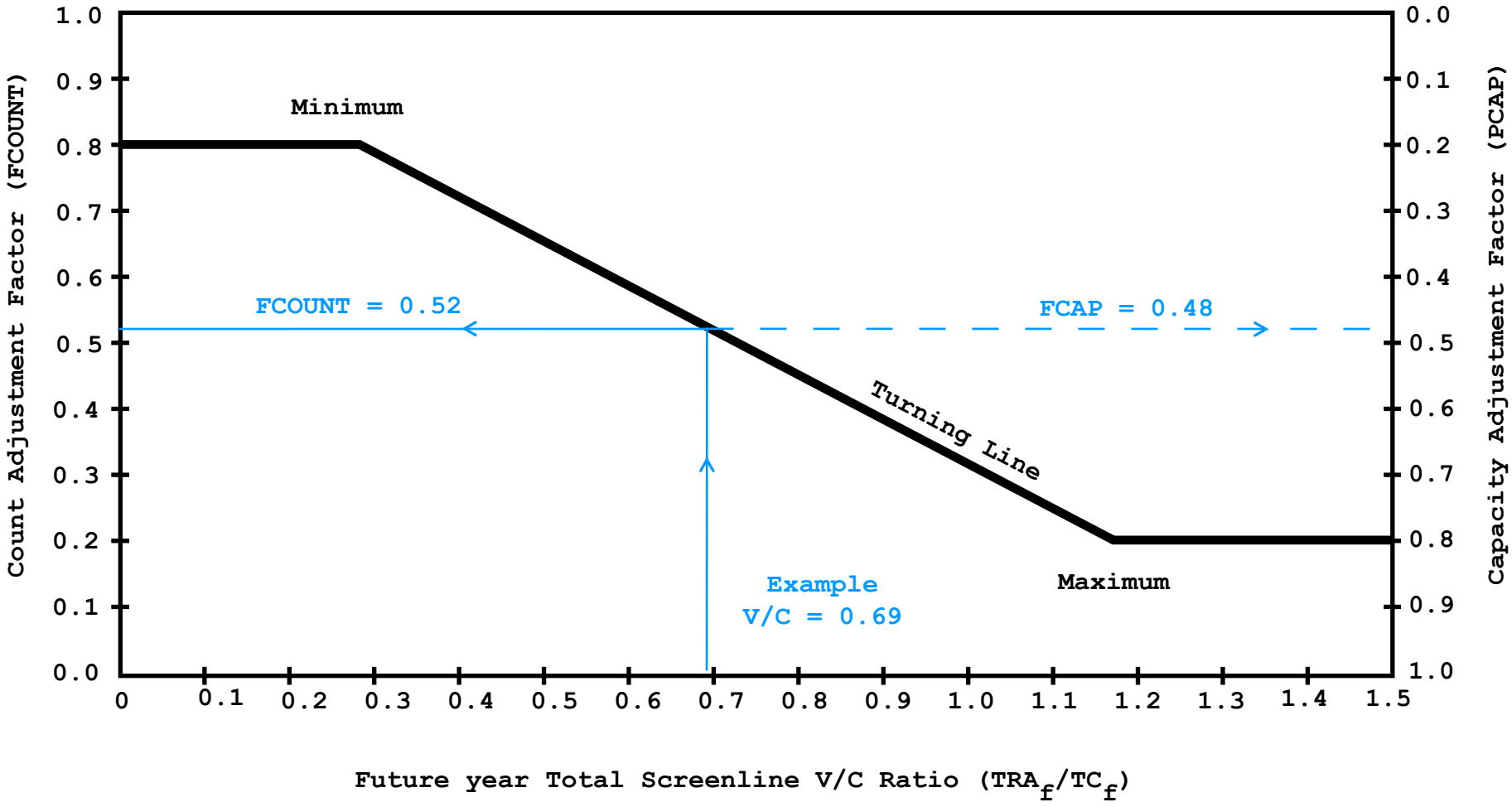


Figure A-10. CAPACITY and BASECOUNT adjustments.

Capacity Change Adjustments

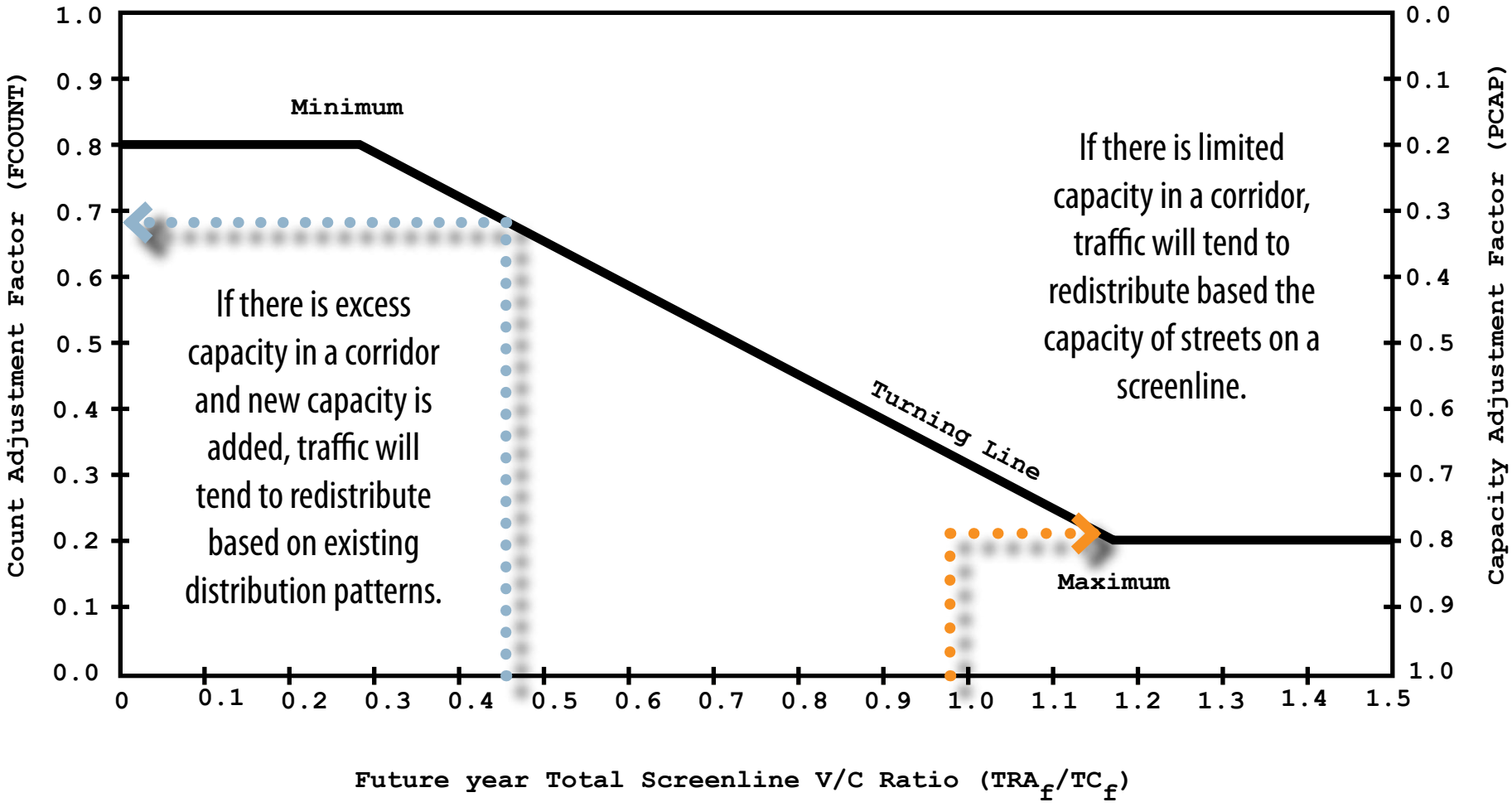


Figure A-10. CAPACITY and BASECOUNT adjustments.

Forecast Years - Growth Adjustments

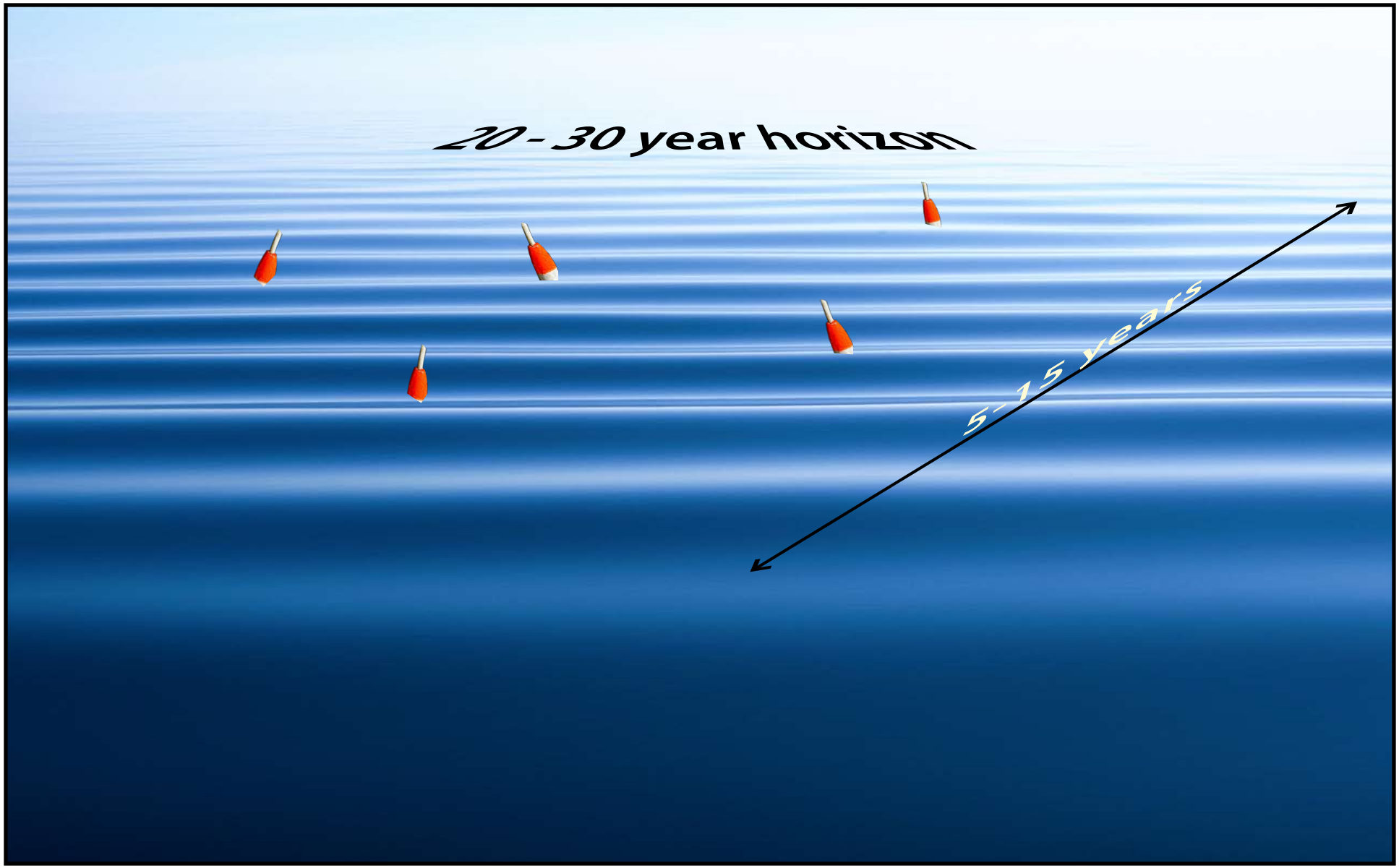


Table A-11. Relationships between land use trends and traffic growth

Growth Curve	Land-Use Trends
Linear	Constant land-use growth over time. More likely to occur in established, more densely developed areas. Often used for interpolating through traffic in slow-to-moderately growing regions. (n/N = 1.0 in Figure A-55)
Nonlinear - Increasing Growth Rate	Land-use growth will accelerate over time in a continuous fashion. Used for analyzing facilities in newly developing areas that will have a maximum amount of growth occurring in the latter years. (Suggested n/N range 1.5 to 5.0)
Nonlinear - Decreasing Growth Rate	Land-use growth will decelerate over time in a continuous fashion. Typically used to analyze facilities in areas where development has peaked and is expected to decrease sharply in the short-term followed by a leveling off in growth. (Suggested n/N range 0.2 to 0.5)
Nonlinear - Stepped	Land-use growth occurs in discrete groups of development spaced at intervals throughout the time period. Typically used to analyze areas with staged land-sue development occurring in clusters on intense development rather than in a continuous manner. Also used to forecast changes shortly after the opening of a major or new upgraded facility.

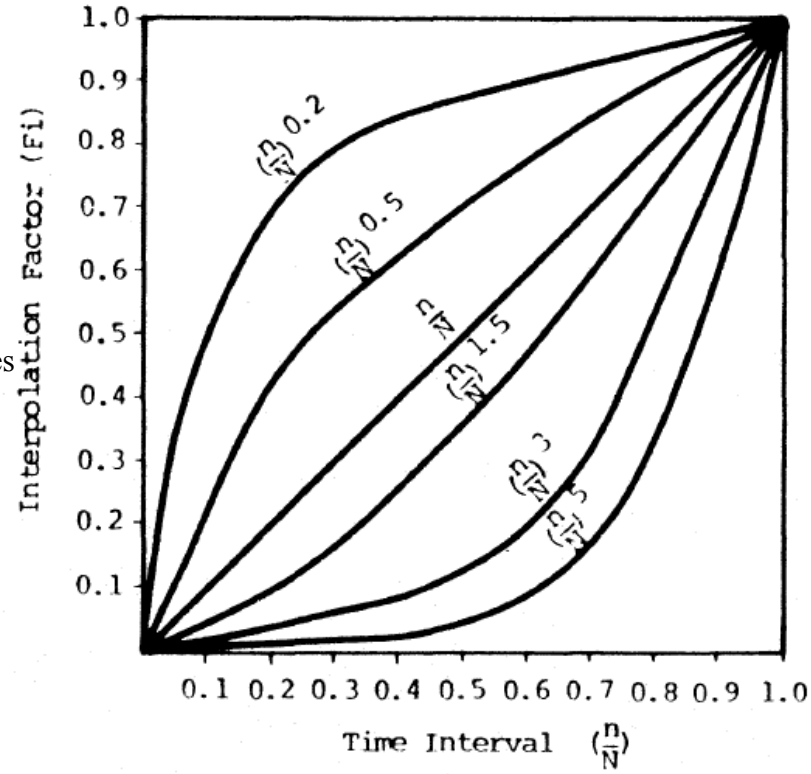


Figure A-55. Interpolation factor curves.

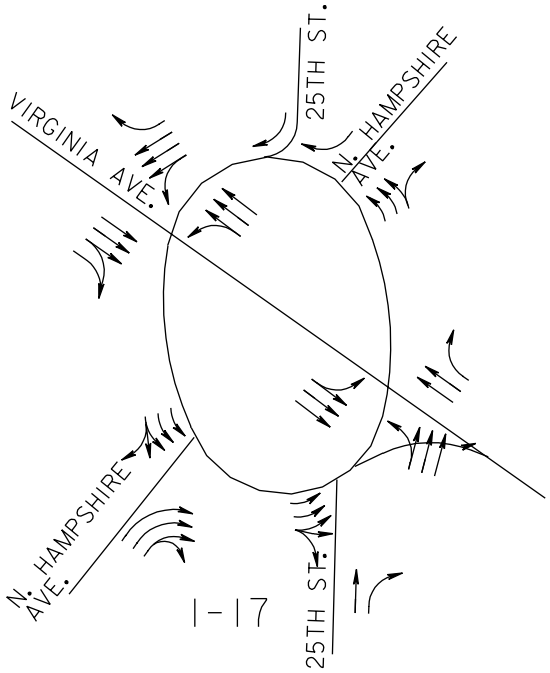
Turning Movement Adjustments

- "Often, the system-level forecasts do not provide any turning movement data." (NCHRP 255, p.102)

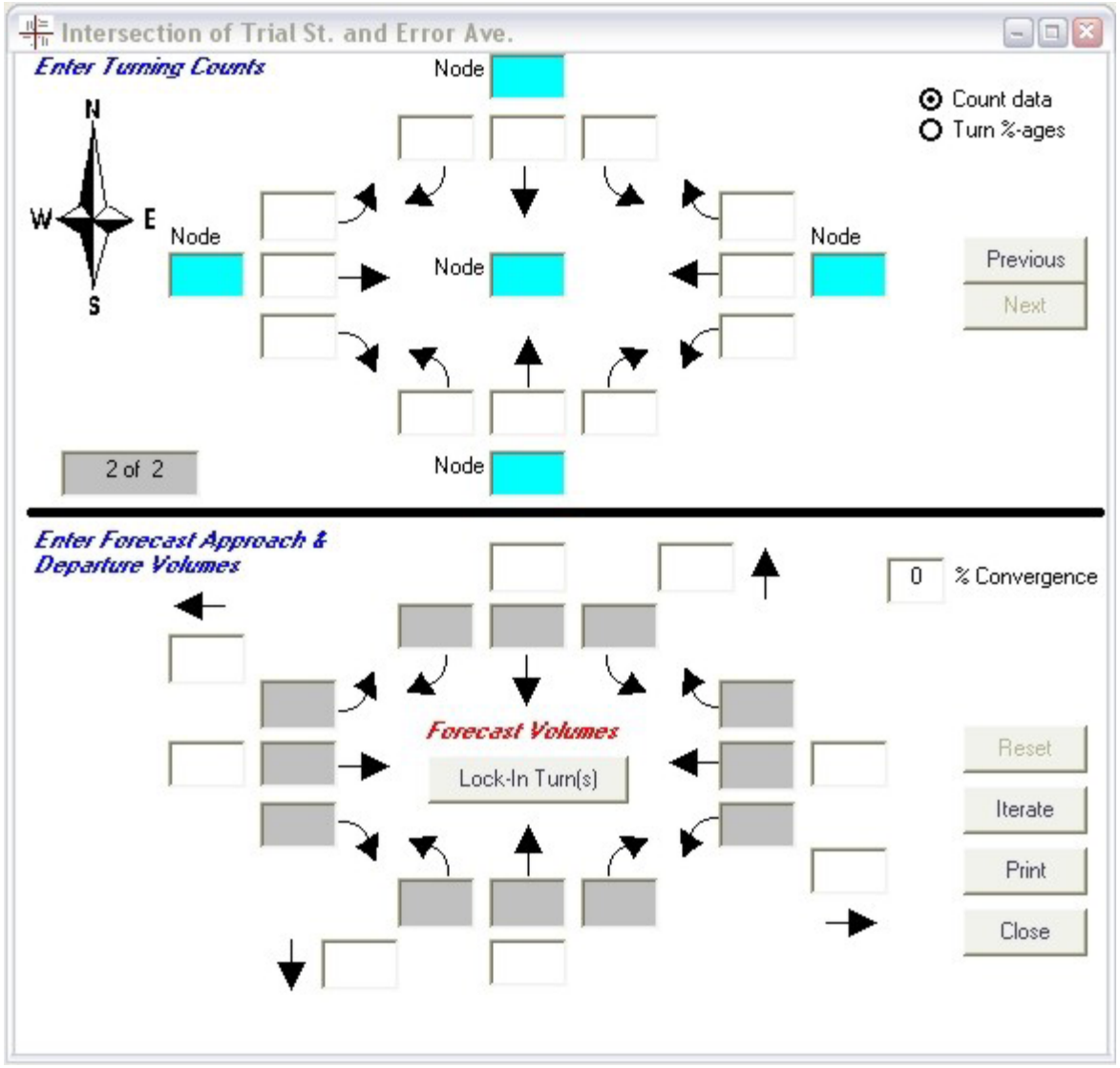
- Input requirements
  - future year turning movement forecasts
  - base year turning movement assignments
  - base year turning movement counts

- Assignments may be factored similarly to link factoring

- An iterative method is also presented

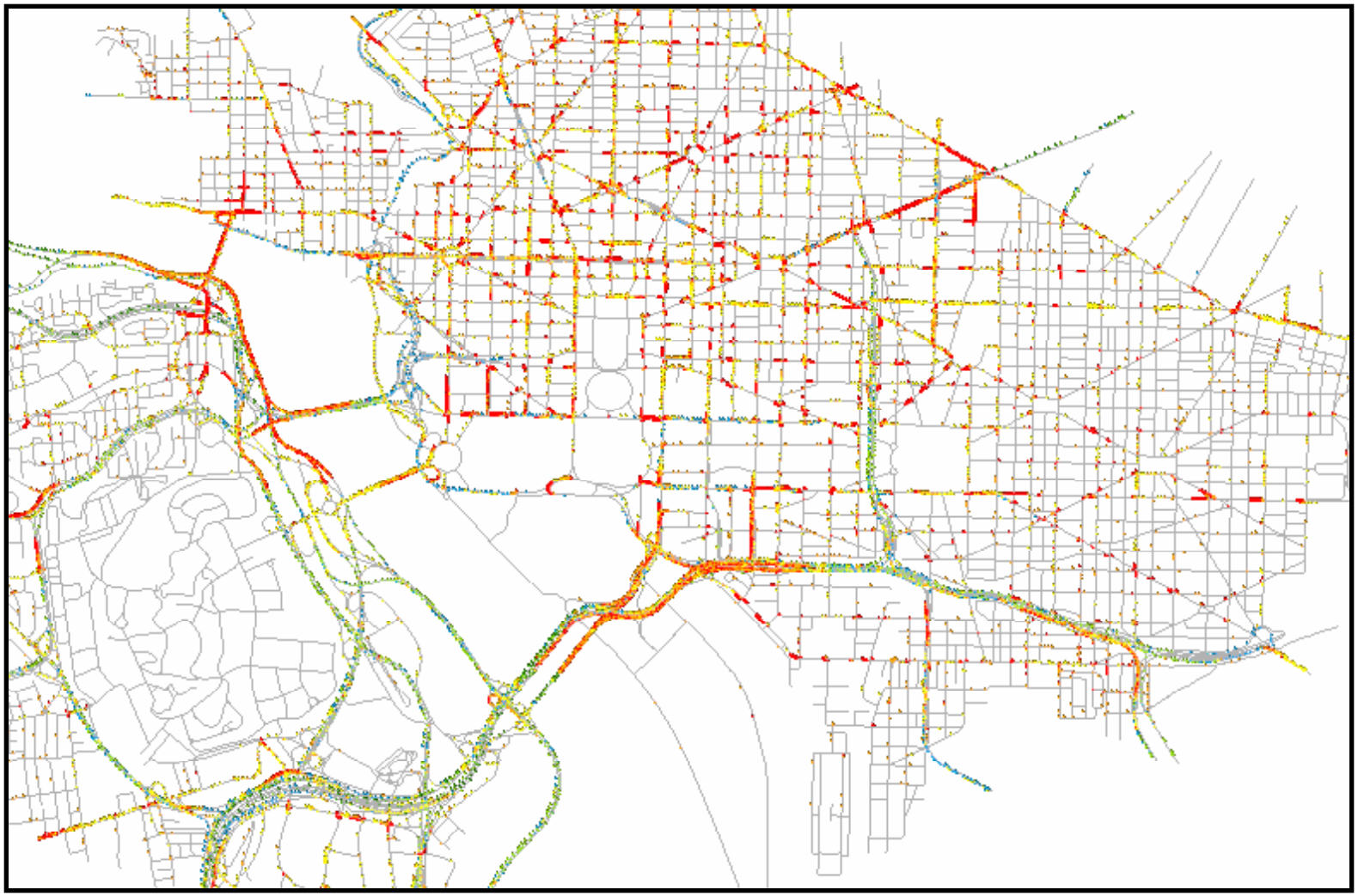


Turning Movement Adjustments – Iterative Method

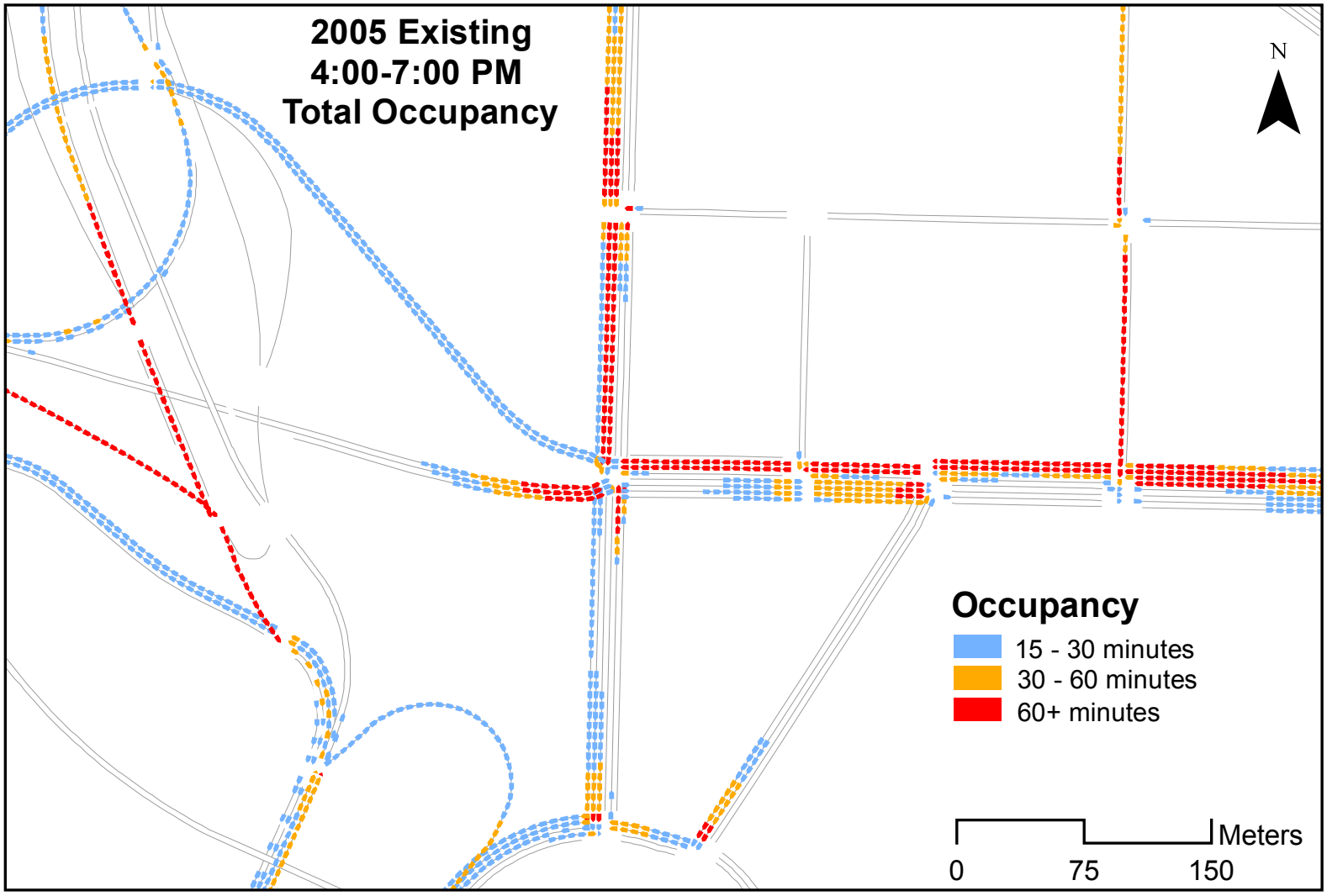


http://www.dowlinginc.com/downloads.php

Turning Movement Adjustments



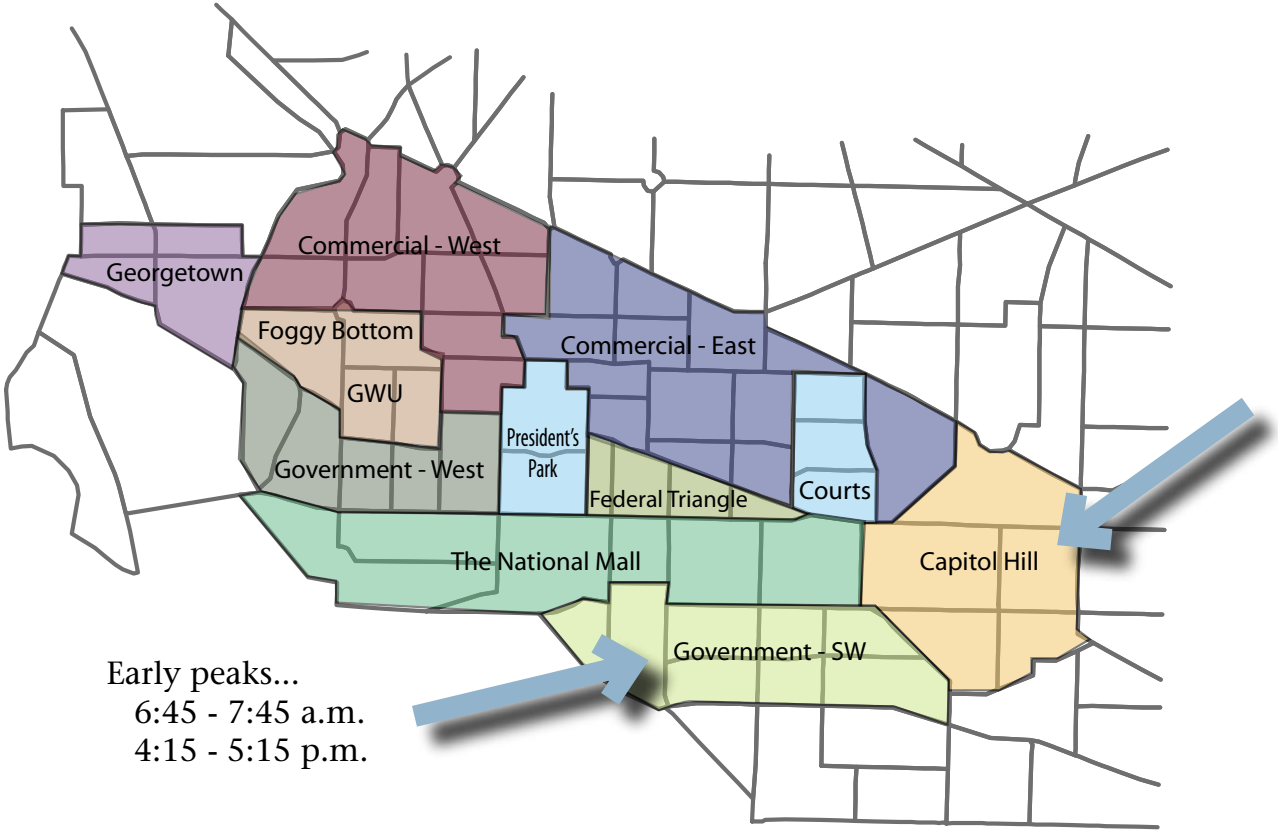
Turning Movement Adjustments



Time-of-Day Considerations

- Most States and MPOs have devised methods to convert 24-hour trip tables into assignments by time-of-day

- Evaluate for distinct peaking characteristics



Other Considerations

Simplified procedures are also presented to develop inputs for highway design considerations

- Design hour volumes
- Directional distribution
- Speed, delay, and queuing
- Vehicle classification
- Highway pavement design

Understanding Your Forecasts

Evaluation
and
Reasonableness Checks

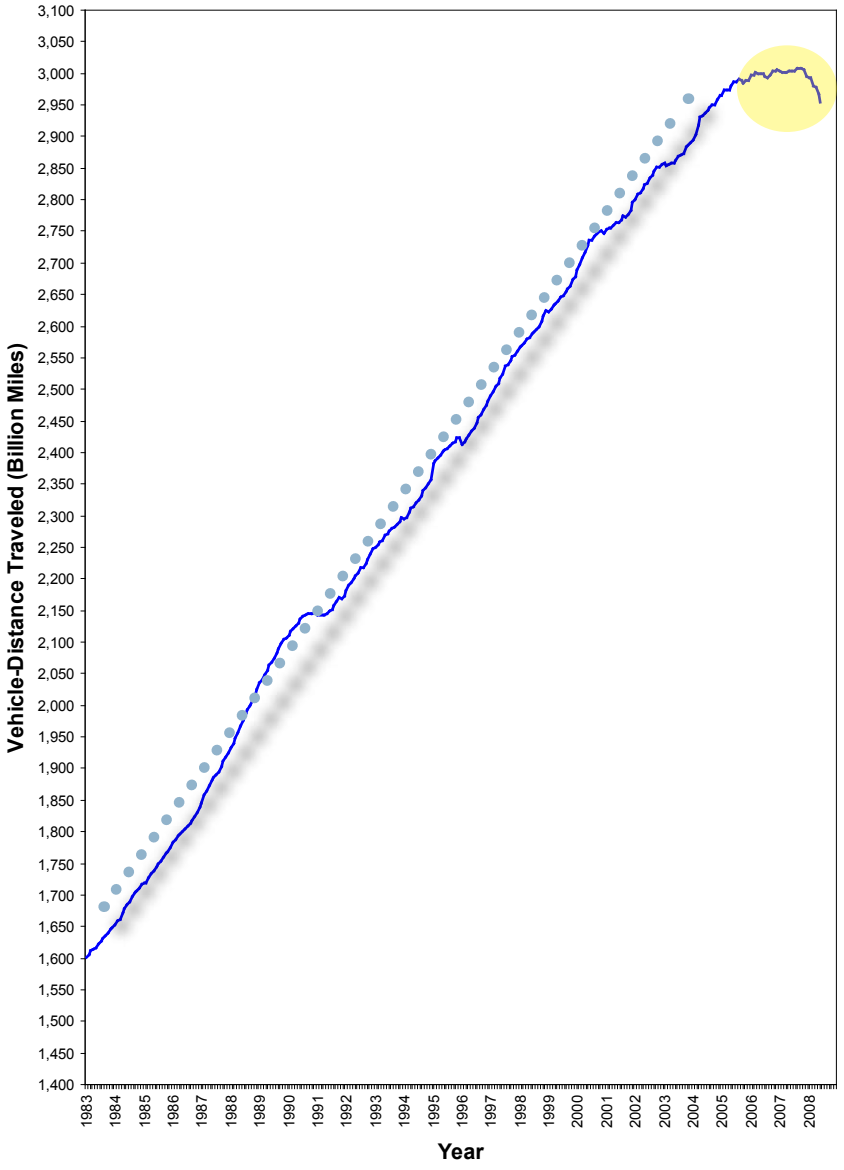
Sources of Uncertainty

- Inherent in
  - model structures
  - input data
    - land-use data
    - traffic counts
    - missing data
- Scale – from regional to project-level
- Cannot be overcome, but can be accounted for

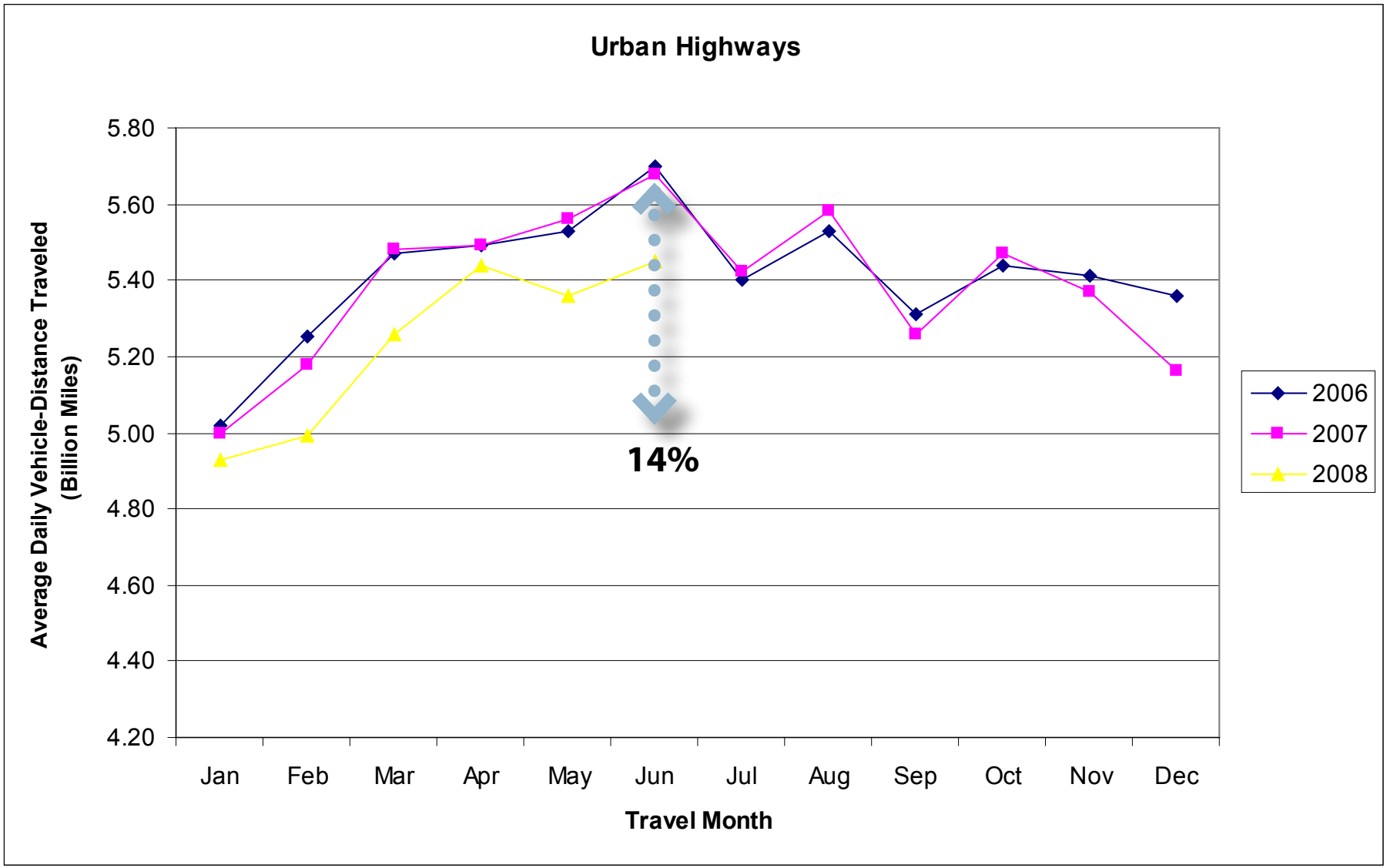
Sources of Uncertainty – Counts

- Travel Trend Instability
- Normal Variance
- Equipment

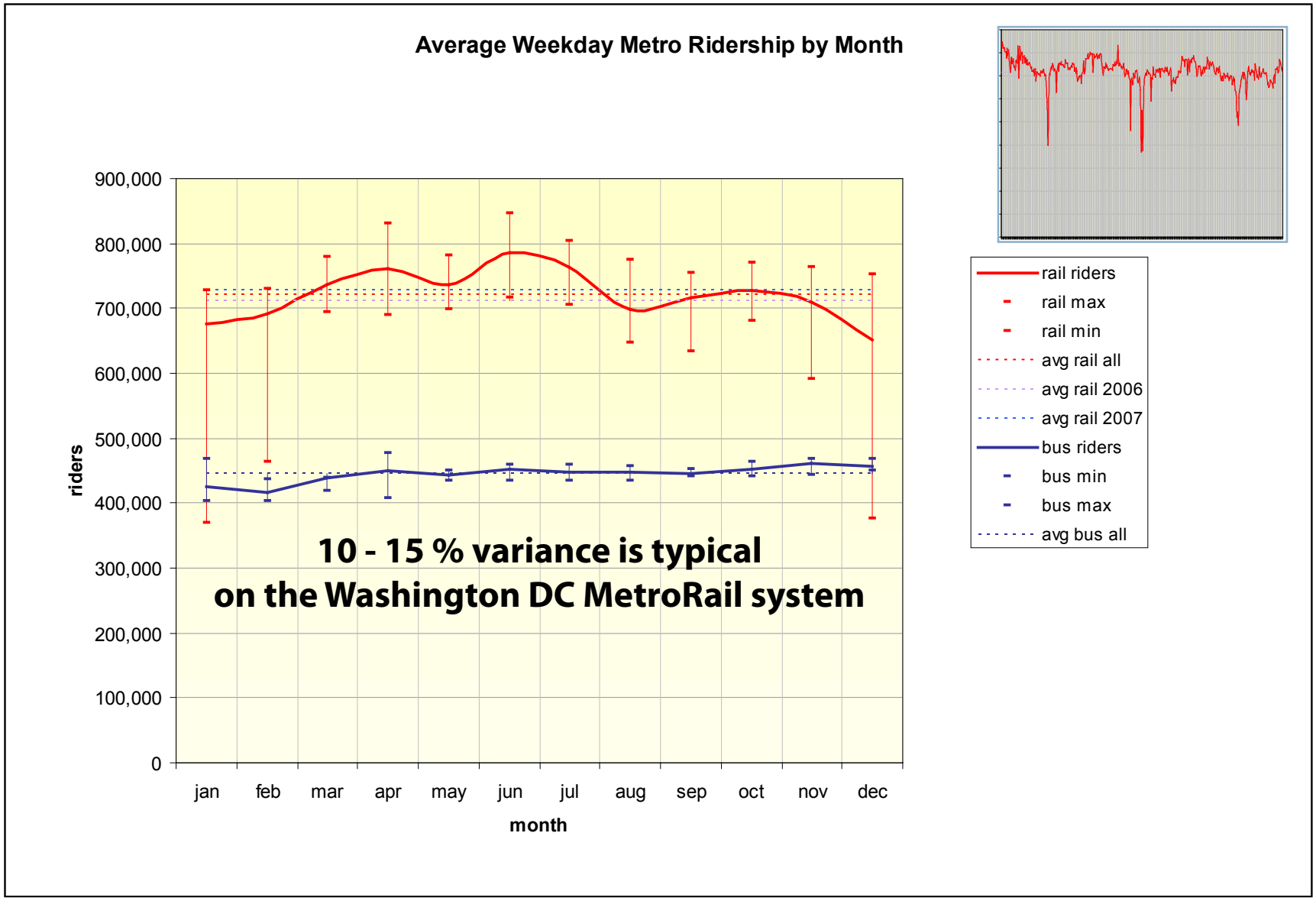
Figure 1 - Moving 12-Month Total on ALL Roads



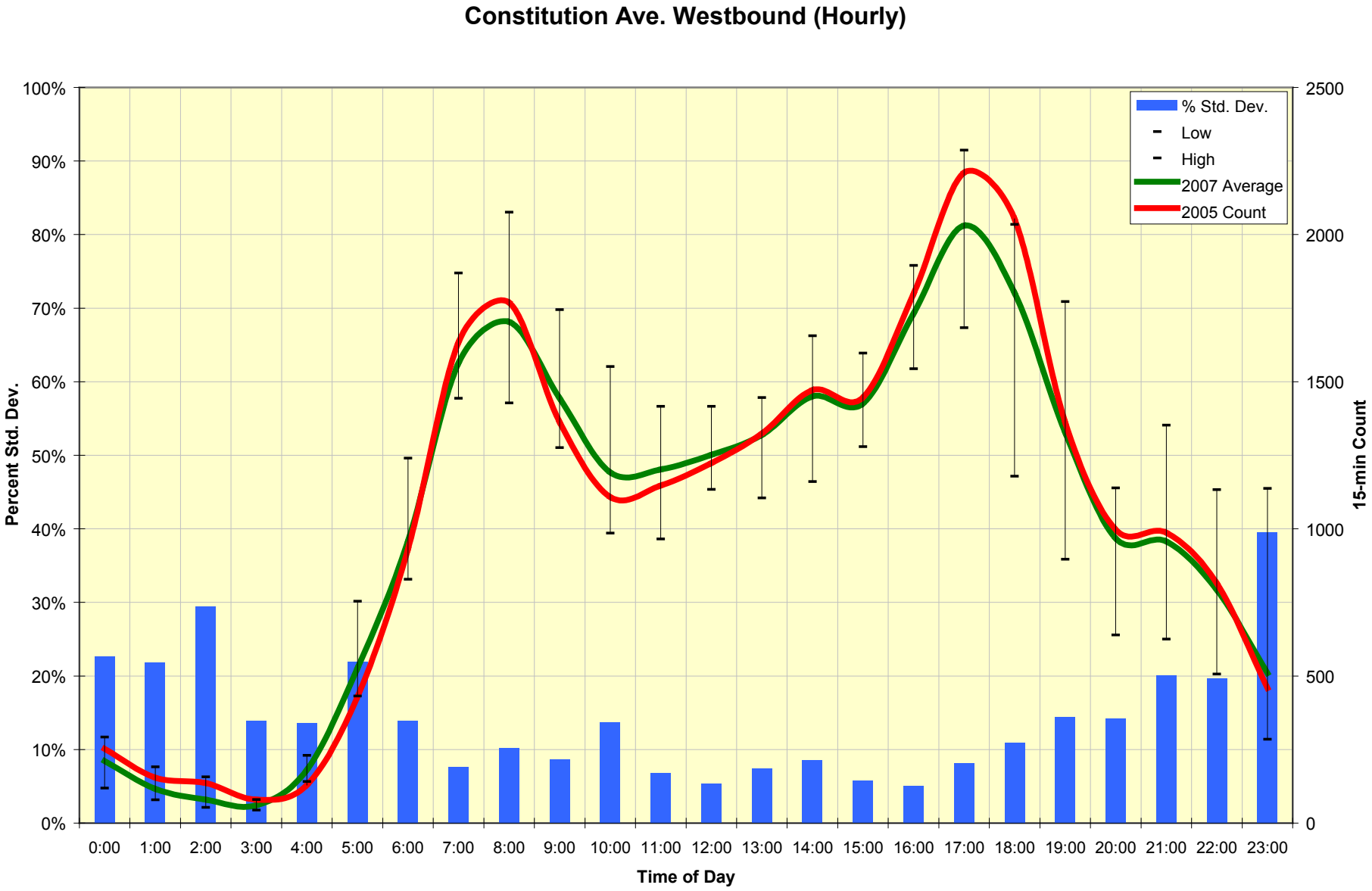
Sources of Uncertainty – Annual Variance



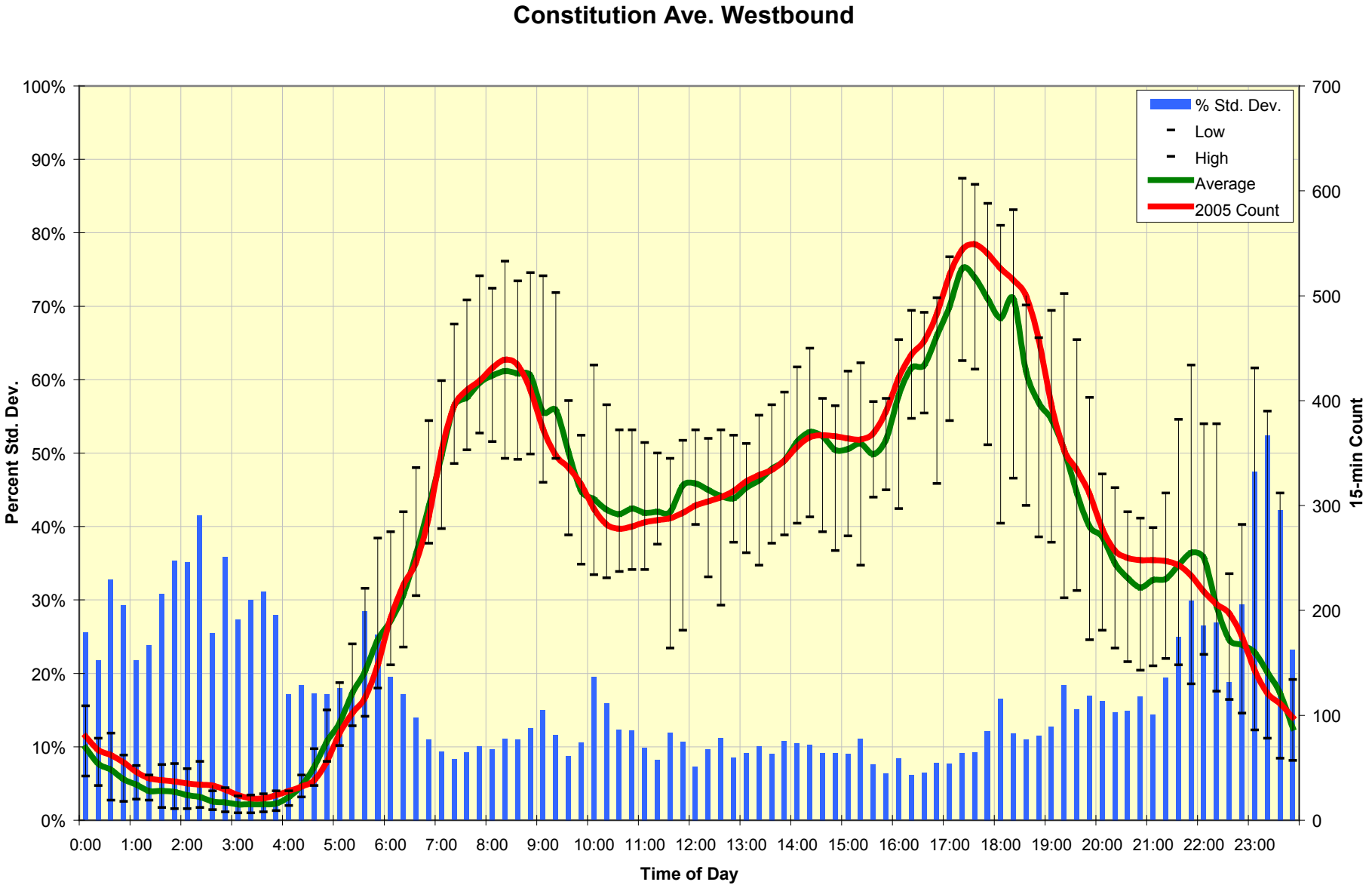
Sources of Uncertainty – Annual Variance



Sources of Uncertainty – Hourly Variance



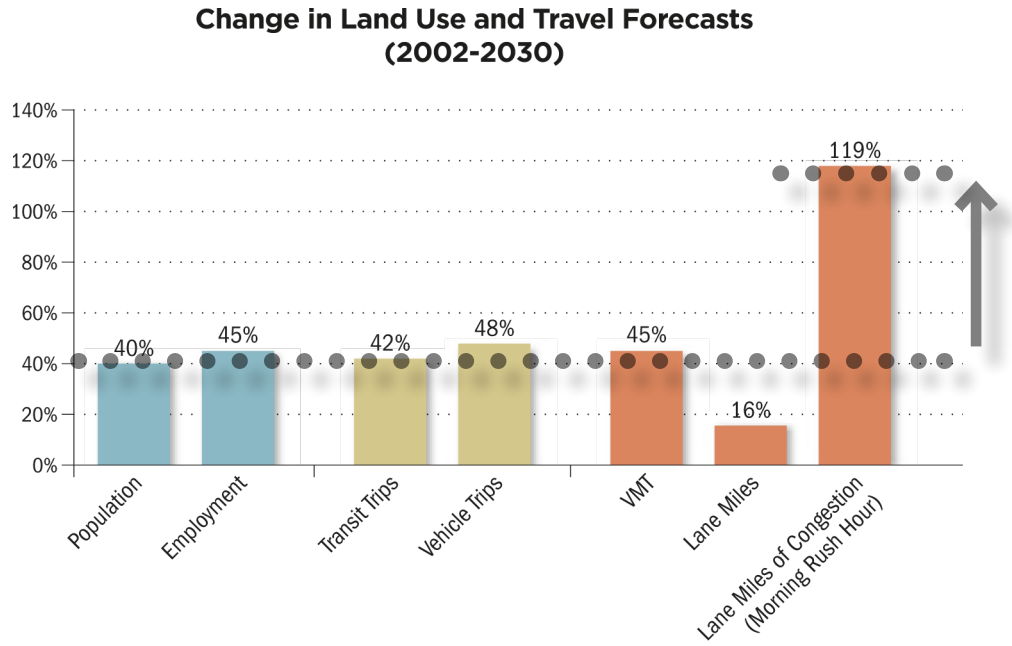
Sources of Uncertainty – 15 Minute Variance



Nonlinear Relationship - Growth and Congestion

- Population and employment up 40 - 45%
- Transit and auto trips up 42 - 48%
- Vehicle miles traveled up 45%

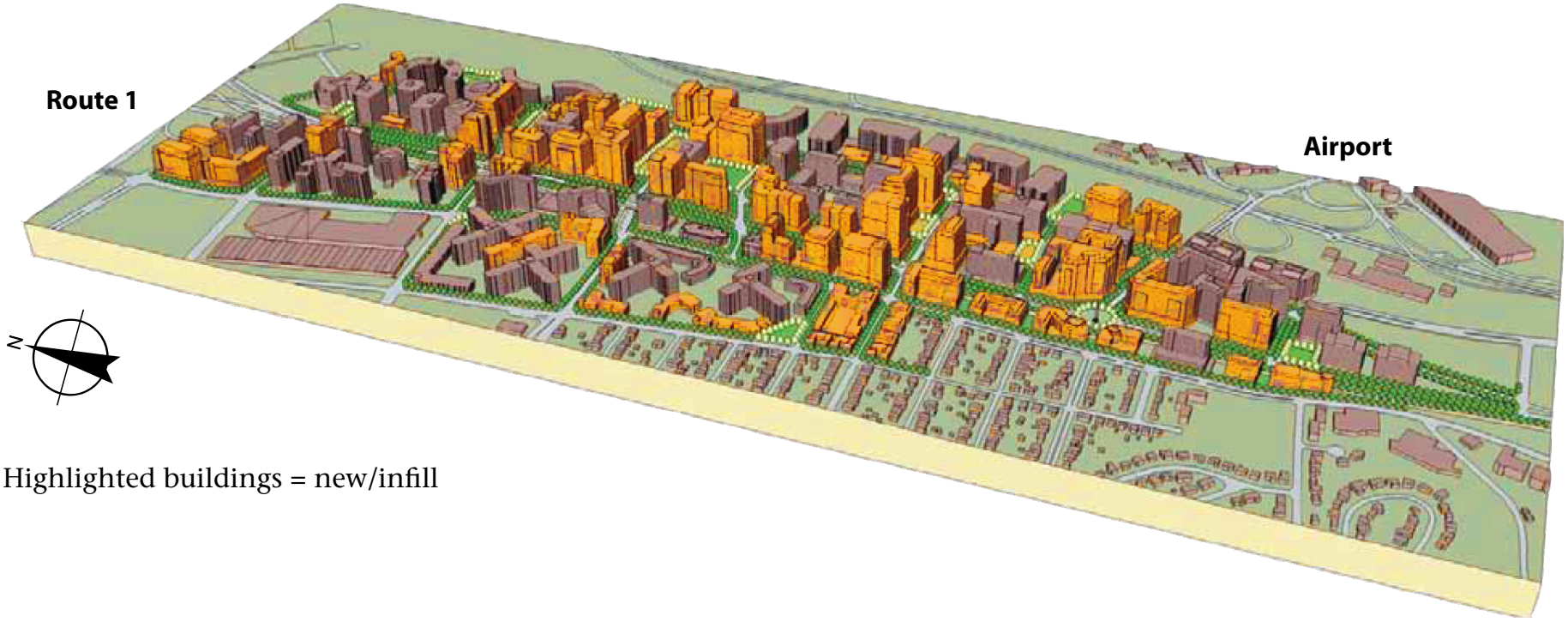
  ...but
- Congestion more than doubles because system is not being expanded



Growth in congestion is roughly 3 times greater than growth in population and employment

source: MWCOG

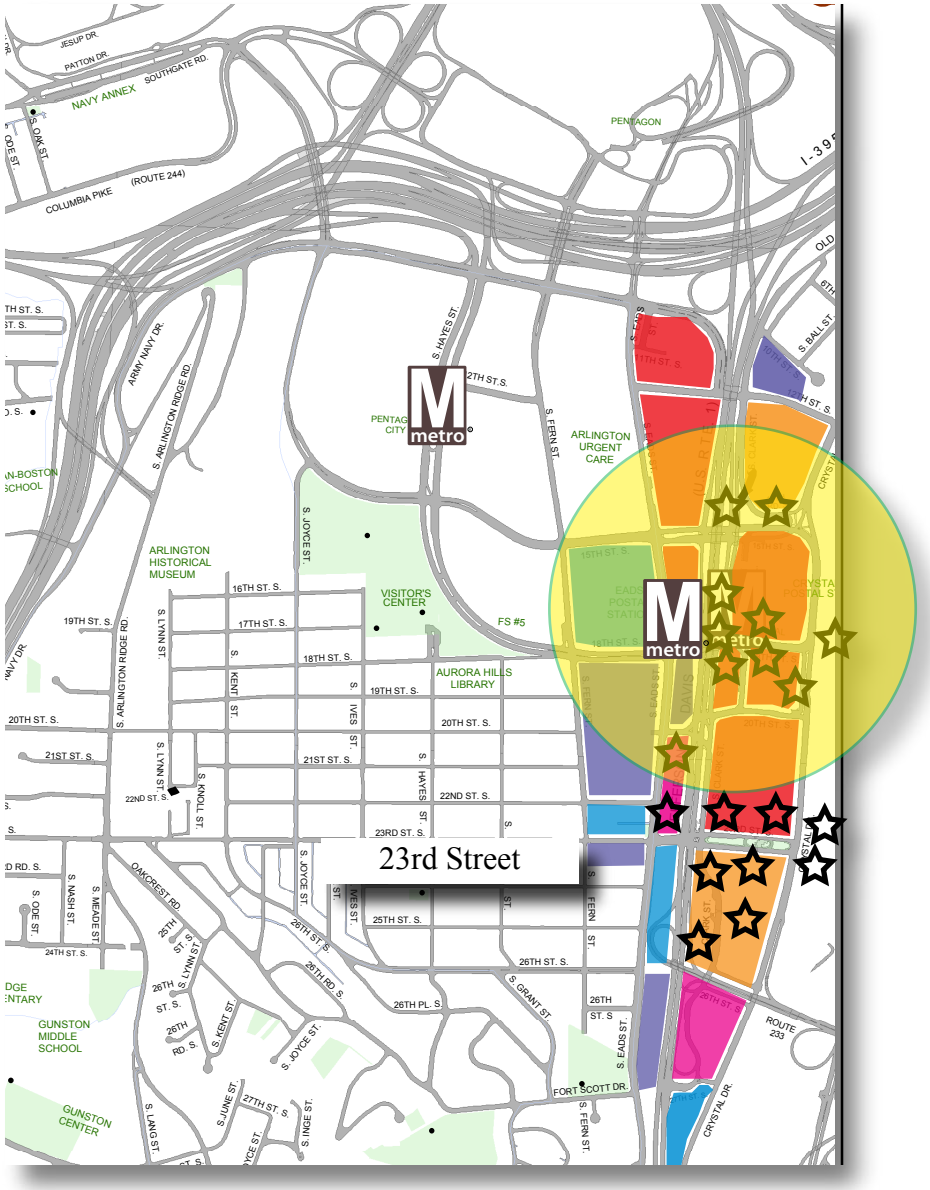
Sources of Uncertainty – Land Use Plans

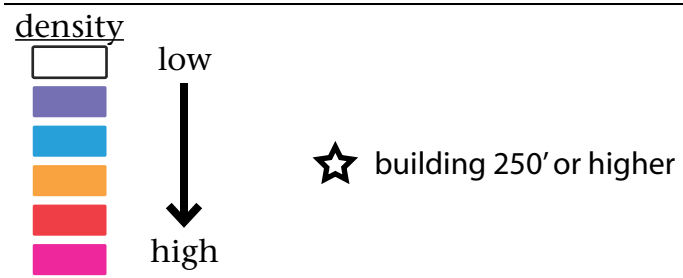


Highlighted buildings = new/infill

Sources of Uncertainty – Land Use Distribution

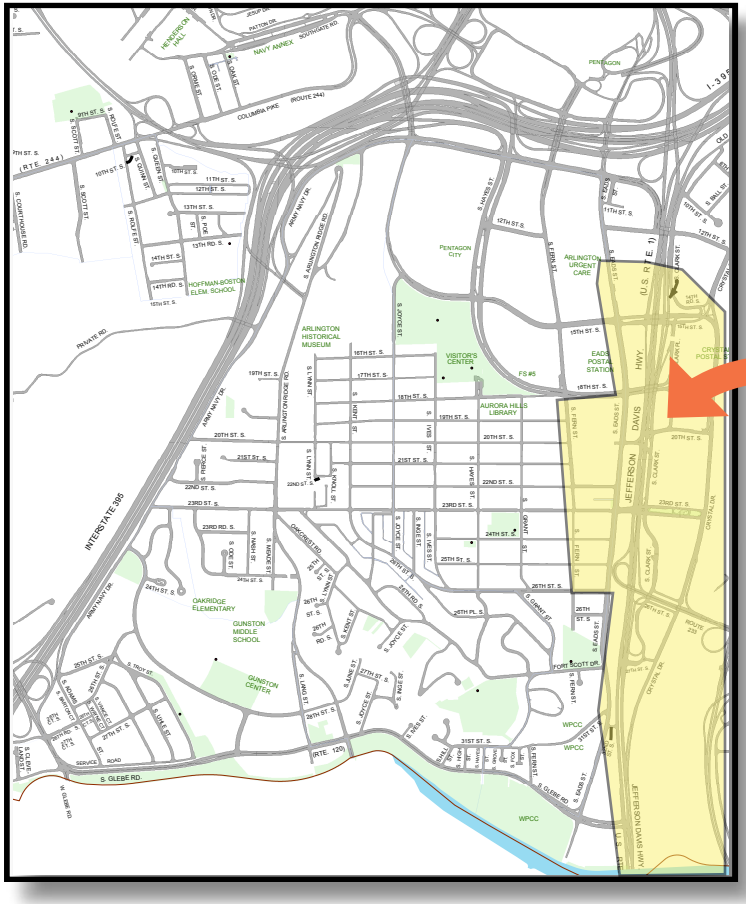
- Distribution of density
- Proximity to transit
- Difficult to discern at zone level
- Balkanization





Sources of Uncertainty – Consistency with Adopted Land Use Forecasts

- Local governments generally seek to maximize economic advantage
- The land use goals of individual jurisdictions are not always reflected in the regionally-adopted land use forecasts
- Quick response manual methods can be used to further test alternate scenarios



+ 8,250 employees

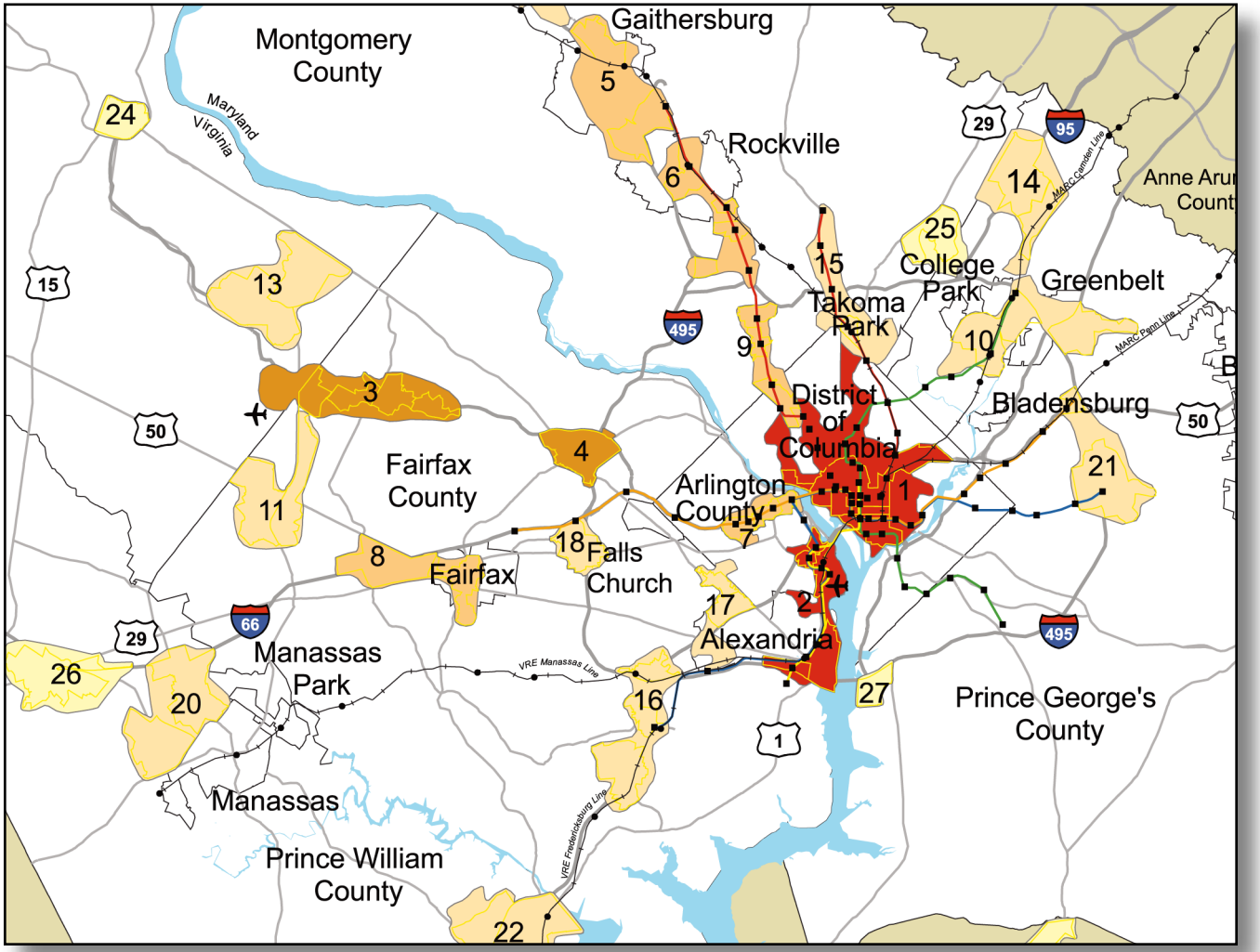
+ 10,000 residents

Compared to regional cooperative forecasts

But the GLUP said medium-density…

Sources of Uncertainty – Consistency with Adopted Land Use Forecasts

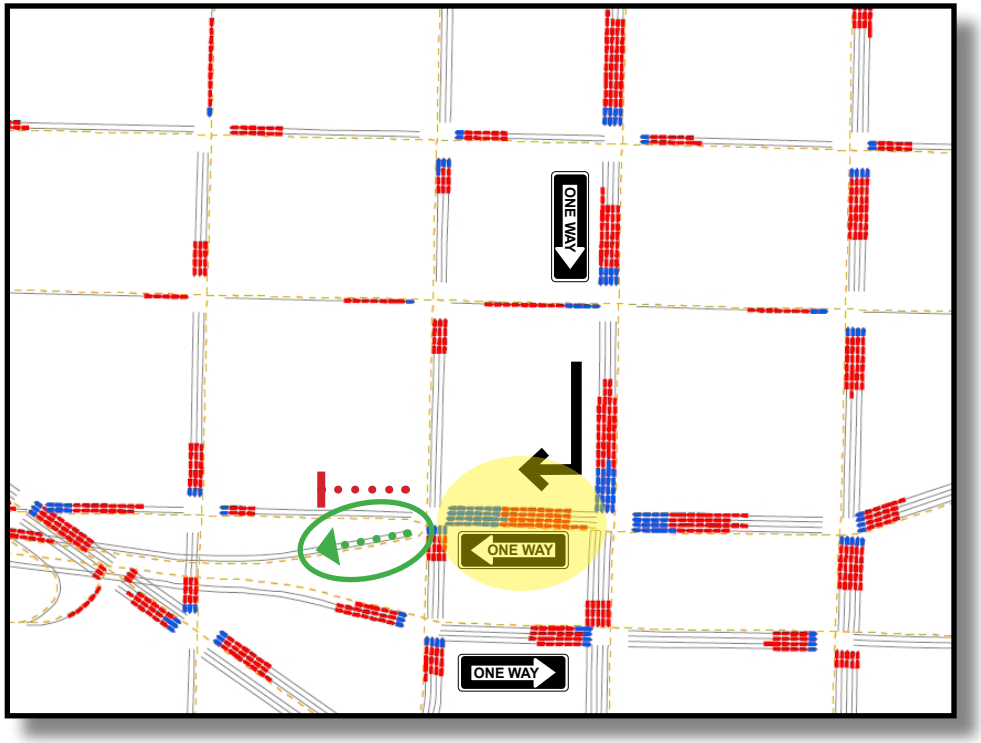
- Similar conditions across the region
- Local governments all competing for their share of the market
- MPO in a jam
- With this given, how much confidence do you have in 20 year turning movement estimates?



Network Checking

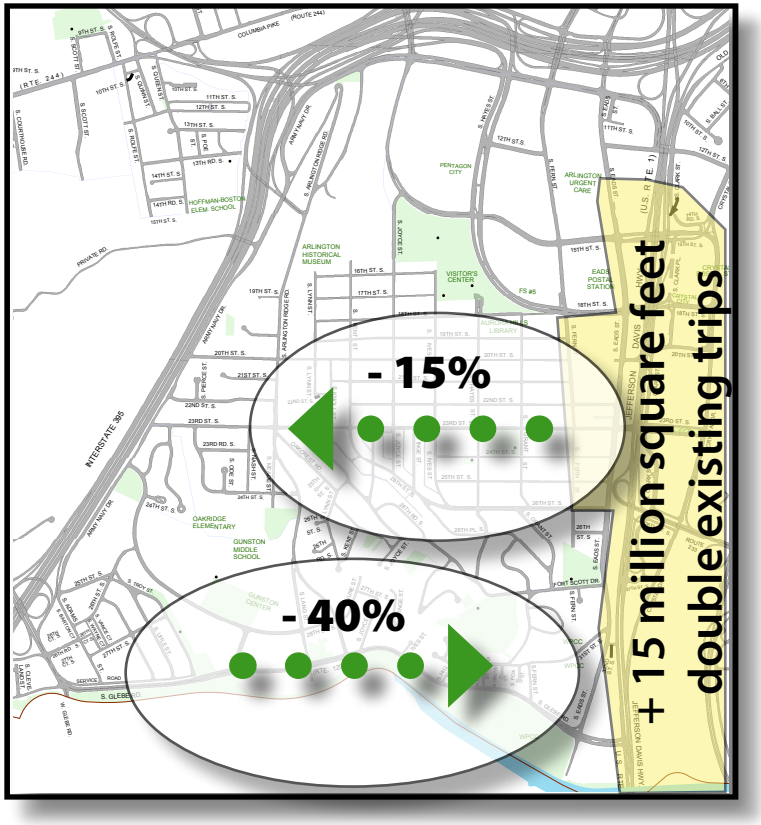
- Street reconfigured…
- …from two lanes in each direction to one lane in each direction + bike lane

Reasonableness – Field Checks



Reasonableness Checks

- Regionally, person trips up 48% – congestion up 120%
- Locally, person trips nearly double
- Transit trips up 168%
- Automobile trips up 50%



1. 15% drop in evening rush hour traffic

2. 40% drop in morning rush hour traffic

Results are not reasonable and do not withstand scrutiny

In an ideal world, there would be time to

- Backcast to known conditions
- Routinely review validation
- Periodically evaluate project forecasts
- Understand why the model does or does not match observed traffic conditions.
- Understand the model outputs and spend more time putting forecasts into context and perspective
- Document work

"You just never know until the road is open."

1982 – Need for Further Research

- Effects of over-capacity conditions on
  - land development
  - temporal distributions of travel
  - geographic distributions of travel
- More systematic techniques for deriving turning movement volumes from intersection link volumes
- Improved statistical basis for transferring time-of-day, directional distribution, and vehicle classification data to other settings. Truck time-of-day of special note.
- Improved specificity and standardization of traffic data for use in environmental and evaluation models.
- The quantification of additional factors contributing to or constraining travel growth
- The development of automated methods of the NCHRP procedures

25 Years Later…Contemporary Issues

- Congestion and network saturation
- Trip behavior/chaining; emergent travel pattern changes
- Fuel price volatility/less discretionary travel
- Evolving land use/development patterns
- Pricing

Summary

modeling ≠ forecasting

automated post-processing & factoring ≠ forecasting

precision ≠ truth

NCHRP presents ways to cope with these realities

Contextualize, understand, and communicate

State uncertainties

Should NCHRP 255 be updated?

Yes

- Over 25 years since publication (1982)
- Hard to find, hard to read (too many reproductions)
- Advances in models and modeling practices are not reflected in materials
- Context has changed. Majority of examples were geared towards new capacity
- NCHRP 187 (a companion report) has been updated
- Training materials and spreadsheets are outdated
- Progress by users who have worked with NCHRP 255 over long periods of time
- Reflect advances in the state of the practice
- Reflect advances in software

No

- Basics and fundamentals are still sound and remain relevant
- Procedures widely disseminated and used
- Could do more harm than good

"The best causes tend to attract to their support the worst arguments."

Sir Ronald Fisher (1890 - 1962), evolutionary biologist, geneticist and statistician. He was the father-in-law of George Box.

Instant Poll
Should NCHRP 255 be Updated?

☐ **Yes**

☐ **No**

Thank you