Thruway Authority

New York State Department of Transportation

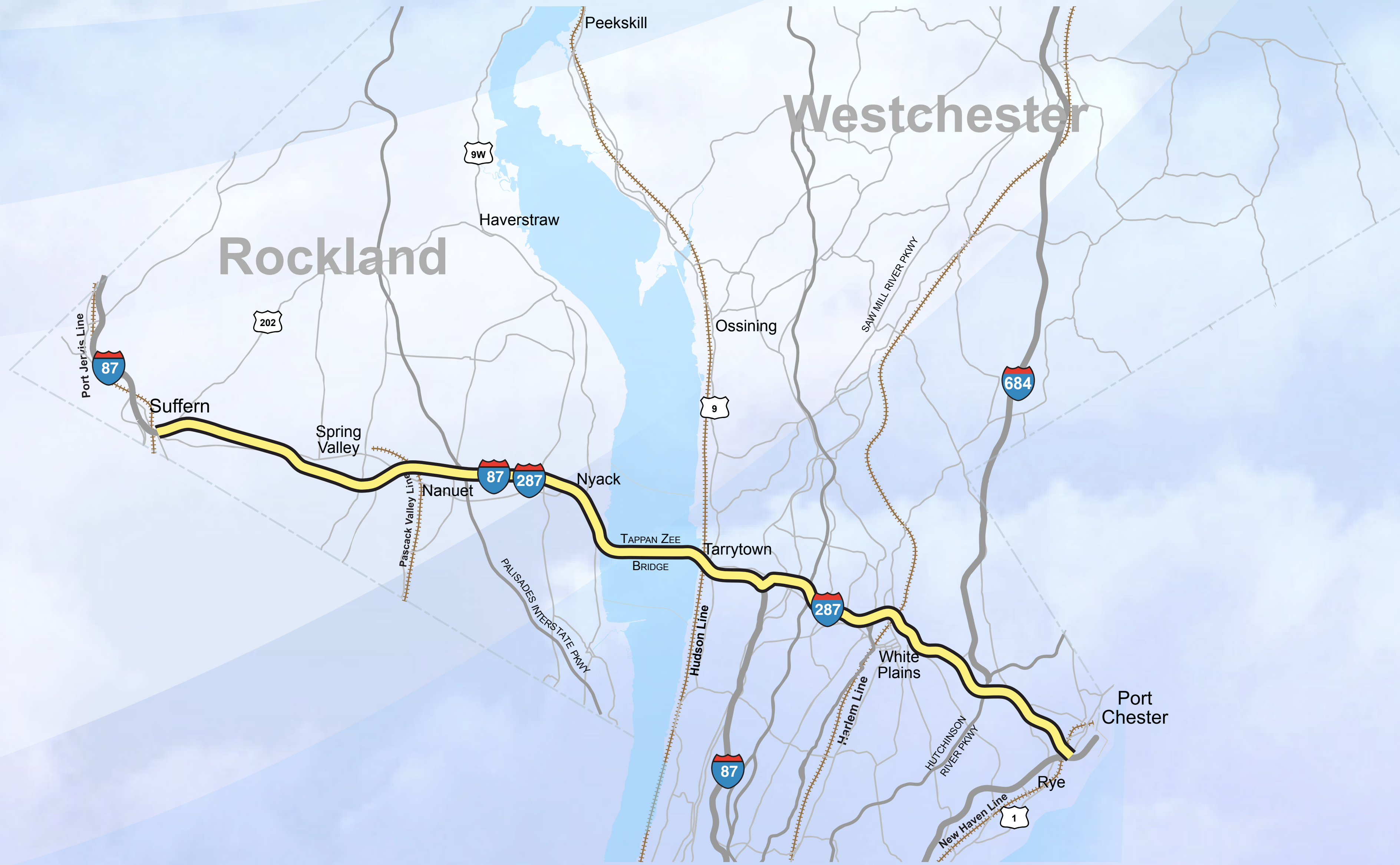
Metro-North Railroad

New York State Department of Transportation
New York State Thruway Authority
Metropolitan Transportation Authority/Metro-North Railroad

Tappan Zee Bridge/I-287 Corridor Project

Cost Estimates for DEIS Build Alternatives (TP5) DRAFT 2

May 2011



NYSDOT, NYSTA, and MTA-Metro North

Tappan Zee Bridge / I-287 Corridor Project

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Cost Estimates for DEIS Build Alternatives

May 2011

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Executive Summary

Tappan Zee Bridge/I-287 Corridor Project

The Project Sponsors – the New York State Department of Transportation (NYSDOT), the New York State Thruway Authority (NYSTA), and Metro-North Railroad (MNRR), an agency of the Metropolitan Transportation Authority (MTA) in cooperation with the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) as co-lead agencies, are preparing an Environmental Impact Statement (EIS) for the Tappan Zee Bridge /I-287 Corridor Project in Rockland and Westchester Counties, New York (NY).

Purpose and Need

The purpose and need of the project is to address the transportation safety, mobility and capacity needs of the Tappan Zee Bridge/I-287 Corridor. Towards that end, the EIS process will evaluate alternatives that address the following needs of the Corridor:

- Preserve the existing river crossing as a vital link in the regional and national transportation network.
- Provide a river crossing that has structural integrity, meets current design criteria and standards, and accommodates transit.
- Improve highway safety, mobility and capacity throughout the Corridor.
- Improve transit mobility and capacity throughout the Corridor and travel connections to the existing north-south and east-west transit network.

Project Alternatives

The scoping process explores a broad range of alternatives and options, and then evaluates them to reduce the number considered in the environmental process. The evaluation process identifies and eliminates those that fail to meet the project purpose and needs and selects those for further consideration that best meet the project's purpose, needs, goals and objectives.

Transit mode alternatives for the I-287 corridor were identified and evaluated in the *Transit Mode Selection Report (TMSR,* May 2009*).* The basic question of whether the Tappan Zee Bridge should be rehabilitated or replaced was addressed in the *Alternatives Analysis for Rehabilitation and Replacement of the Tappan Zee Bridge (R&R Report,* March 2009*).* The results of these two reports are a set of five transit alternatives with a common Replacement Tappan Zee Bridge (RTZB) element, for evaluation in the EIS process:

- Alternative A – No build
- Alternative B – Full-Corridor Busway and Rockland CRT
- Alternative C – Busway in Rockland/Bus Lanes in Westchester and Rockland CRT
- Alternative D – BRT in HOV/HOT Lanes in Rockland/Busway in Westchester and Rockland CRT
- Alternative E – BRT in HOV/HOT Lanes in Rockland/Bus Lanes in Westchester and Rockland CRT

These broadly defined project alternatives form the basis of a planning level vision for a fully integrated transit and highway system along the I-287 corridor starting in Rockland County, continuing across the Tappan Zee Bridge and terminating in Westchester County, fulfilling the project's Purpose and Need.

RTZB Options

Two feasible design options were identified in TP09 for the Replacement Tappan Zee Bridge (RTZB) for further evaluation in the EIS. The two design options identified are:

- <u>Single Level Option:</u> this option would comprise two parallel roadway structures with a CRT guideway structure between them.
- <u>Dual Level Option:</u> this option would comprise two parallel roadway structures. The two roadways would be on the upper levels of deep steel trusses. The CRT guideway would be on the lower level of one of the structures.

Tiering

The project will follow a two-tiered analysis approach to expedite the delivery of integrated, multimodal transportation improvements in a way that allows each modal element to advance at its own pace.

The current environmental process includes a concurrent Tier 1 transit analysis and Tier 2 bridge and highway analysis. At the conclusion of the current environmental process, approved Tier 2 elements can be constructed, while accommodation can be provided for approved Tier 1 elements.

The Tier 1 transit analysis will define and assess the mode choices, alignments, and general locations of stations, termini, and facilities resulting in selection of one of the project's five transit alternatives.

The concurrent Tier 2 bridge and highway analysis will focus on selection of an RTZB configuration and inclusion of various highway improvements along the corridor. This analysis will incorporate modifications to the highway elements consistent with decisions made as part of the Tier 1 transit analysis.

Phasing

All four Build Alternatives have two phases, matching the Tiering analysis structure.

Initial Build Phase:

- The RTZB would be constructed (with the extra lanes for future BRT, but without the CRT components)
- The existing bridge would be demolished
- Highway Improvements would be made, including:
  - Acceleration lanes and climbing lanes
  - Modifications to interchanges to accommodate these new lanes
  - Resurfacing or full-depth replacement of segments of I-287
- A new Toll Plaza
- Relocating existing Thruway and State Police facilities
- All work necessary to accommodate the selected future BRT and CRT Alternatives including:
  - Widening I-287
  - Lengthening overpass bridges
  - Constructing short sections of BRT and CRT tunnels below I-287 at the shorelines.

Final Build Phase:

- The CRT and BRT would be constructed on the RTZB (including adding the central CRT structure in the Single Level Option or the CRT lower deck in the Dual Level Option)
- CRT would be constructed throughout the corridor including:
  - Tunnels
  - Pavement
  - Access ramps, flyovers and stations
  - All CRT systems.

Purpose of Report

This report has been prepared to support the assessment of the four feasible corridor build alternatives that will be considered in the DEIS (Alternatives B, C, D and E). It presents the estimated construction costs for the four build alternatives, and describes the methodology used to develop the estimates.

Cost estimates were developed during the scoping phase to support the selection of feasible alternatives to be considered in-depth in the DEIS. Since the alternatives were only developed to a concept level, the cost estimates could only be developed to a corresponding level of detail.

With the selection of the four build corridor alternatives and the two RTZB design options, summarized in the *SSD*, the detailing of the corridor and bridge components was updated and advanced. Benchmark 1 drawings and *Construction of the Feasible Alternatives for the Replacement Tappan Zee Bridge and Landings (TP6/7)* were issued to further inform the DEIS. This additional work has provided a more detailed base of information for construction cost estimates, and the reduction in the number of feasible build alternatives to be considered in the DEIS makes it practical to provide correspondingly more detailed DEIS construction cost estimates.

Estimate Results

The total costs of the RTZB Only (Abutment-to-Abutment), and of the four Alternatives in the Initial Build Phase (including the RTZB), Final Build Phase (including additional RTZB work to accommodate CRT) and the combined Totals (including all work in both phases) are summarized in Table EX-1. There are two RTZB Options – Single Level and Dual Level, as selected in *TP 9*. Each of the four Initial Phase Alternatives has the two RTZB Options, resulting in a total of 8 options. Each of the four Final Build Phase Alternatives has the two RTZB Options, and also two CRT Hudson Line Connection Options – a Long Tunnel Option (Long) and a Short Tunnel Option (Short), resulting in 16 Options.

DEIS Alternatives Cost Summary
(Costs in millions, Year 2015)

DEIS Alternative		Initial Build - RTZB Only (Abutment-to-Abutment)		Initial Build Phase (Including RTZB)		Final Build Phase		Initial Build + Final Build Total	
		Option	Total Cost	Option	Total Cost	Option	Total Cost	Option	Total Cost
B	Full-Corridor Busway Rockland CRT	Single Level	$4,936	Single Level	$7,105	Single / Long	$9,998	Single / Long	$17,163
						Single / Short	$9,375	Single / Short	$16,540
		Dual Level	$5,106	Dual Level	$7,275	Dual / Long	$9,676	Dual / Long	$17,010
						Dual / Short	$9,053	Dual / Short	$16,388
C	Busway in Rockland Bus Lanes in Westchester Rockland CRT	Single Level	$4,936	Single Level	$7,123	Single / Long	$9,227	Single / Long	$16,409
						Single / Short	$8,604	Single / Short	$15,787
		Dual Level	$5,106	Dual Level	$7,293	Dual / Long	$8,904	Dual / Long	$16,257
						Dual / Short	$8,282	Dual / Short	$15,634
D	BRT in HOV / HOT Lanes in Rockland Busway in Westchester Rockland CRT	Single Level	$4,936	Single Level	$9,541	Single / Long	$7,883	Single / Long	$17,483
						Single / Short	$7,260	Single / Short	$16,861
		Dual Level	$5,106	Dual Level	$9,710	Dual / Long	$7,561	Dual / Long	$17,331
						Dual / Short	$6,938	Dual / Short	$16,708
E	BRT in HOV / HOT Lanes in Rockland Bus Lanes in Westchester Rockland CRT	Single Level	$4,936	Single Level	$9,558	Single / Long	$7,112	Single / Long	$16,730
						Single / Short	$6,489	Single / Short	$16,107
		Dual Level	$5,106	Dual Level	$9,728	Dual / Long	$6,790	Dual / Long	$16,577
						Dual / Short	$6,167	Dual / Short	$15,955

DEIS Alternatives Cost Estimate Summary

Estimate Methodology

The project was organized into measurable components segregated by transportation mode (RTZB, Highway, BRT and CRT) and construction phase (Initial Build and Final Build).

Because the RTZB would be a unique and complex undertaking, a significant level of engineering detail was developed for construction of the RTZB, presented in TP 6/7 and the Benchmark 1 drawings. This level of engineering justified a detailed, activity-based, bottom-up estimate for the two RTZB Options (Single Level and Dual Level) in both phases. This method is similar to how contractors generate bids. The build-up was done in *Heavy Bid*, a commercial construction estimating software by Heavy Construction Software Solutions, and with spreadsheets.

The level of engineering detail developed for the construction of the Highway, BRT and CRT components throughout the corridor is less than that developed for the RTZB options, and the construction of these components is more conventional. This lesser level of development does not justify full bottom-up estimates, so a more conventional cost estimate was done for those components by doing a build-up of representative unit costs.

Bottom-Up Estimate for RTZB Components

Work Breakdown Structure

A Work Breakdown Structure (WBS) was developed for each of the two RTZB Options (Single Level and Dual Level), for each phase (Initial Build and Final Build). A WBS is a project management tool used to organize, plan, coordinate, schedule and estimate a complex group of activities. It is a hierarchical system in which a top level activity has sub-levels associated with it in a “tree” structure. The top level of a WBS is often identified as Level 1, whereas subsequent lower levels are numbered consecutively i.e. Level 2, Level 3 etc. When this system is used by contractors to prepare bids, the activities in the various levels are referred to as “bid items”, a term adopted for this report.

Each bid item in Level 1was broken down into one or more sub-levels to group together items with similar characteristics. At the lowest sub-level each item was broken down into specific construction tasks or activities that can be estimated. A bid item for Project Indirect Costs (typically called General Conditions and Overhead) was included, broken down into the ancillary activities and equipment that are not directly associated with any particular construction task.

Quantities, Materials, Labor and Equipment

The quantities associated with each bid item (e.g. linear feet of piles in a given zone) were taken-off from the Benchmark 1 CAD files and TP 6/7. The quantities of specific materials required for each construction task were then calculated (e.g. cubic yards of concrete to fill the piles, pounds of associated rebar, etc.) A specific crew was assigned to each construction task, with equipment specific to the task, based on experience and published resources. Material costs were developed from research with local and regional suppliers, supplemented by published resources such as Engineering News Record (ENR) Material Cost Reports, Material Cost Trend Reports, and Historical Cost Indices, and RS Means Cost Books. Labor and equipment rates were developed from union contracts and published resources, including the NYSDOT Prevailing Wage Rates and Davis Beacon Wage Rates. Productivity and cycle rates were defined for each crew (cubic yards of concrete per shift, etc.) based on experience, published resources and consultation with contractors who have done similar work at a similar scale. All of this information was input in *Heavy Bid*.

Base Year and Escalation Rate

The estimate was begun in 2010, so all labor, material and equipment costs have been researched in year 2010 dollars. The current schedule sets 2015 as the midpoint of construction for the Initial Build Phase, so Initial Build costs were escalated to that year. To maintain a common base year for dollars between the two phases, the Final Build Phase costs were also escalated to 2015.

The historical values of the ENR Construction Cost Index were used to develop a conservative inflation rate common to both the Initial and Final Build phases. The average change in this index over the previous 100 years is 4.8% per year; the average over the previous 50 years is 4.9% per year. An inflation rate of 4.5% was selected. Escalating both phases at 4.5% per year for 5 years serves to compensate for the fact that the Final Build Phase was not escalated out to its currently unknown midpoint of construction.

Bid Item Costs

The *Heavy Bid* software then calculated the cost of each construction task, and aggregated the individual task costs into subtotals at each level of the WBS “tree”. The total of the Level 1 direct and indirect bid item aggregated costs constitute the Base Construction Cost and were the target output from *Heavy Bid*.

Contingencies, Add-ons, Soft Costs and Escalation

These factors were applied as compounding percentages:

Risk-based contingencies were developed by Monte Carlo simulation using the @Risk commercial software package:

Single Level Option:	25%
Dual level Option:	23%
Average, used for both:	24%

Add-ons were developed from experience:

MPT:	1%
Profit:	12%

Soft costs were structured according to NYSDOT practice, developed from experience:

Design Engineering:	2%
Program Management:	2%
Construction Management:	3%
Construction Inspection:	2%
Construction Support Services:	1%
Total:	10%

All costs were escalated to the project midpoint of construction (2015) using an inflation rate of 4.5% per year compounded over 5 years:

Escalation:	25%

Representative Unit Cost Estimate for all Highway, BRT and CRT Components

A WBS was developed in *Heavy Bid* for each Highway, BRT and CRT component for both phases. It was structured to work-up representative unit costs for a range of bid items that could be multiplied by bid item quantities to generate bid item costs. The various bid items of the WBS were broken down into associated construction tasks required to complete the representative bid items. The construction tasks and bid items were aggregated in a spreadsheet format into high-level items and totaled.

Three types of representative bid items were developed:

Representative Segments: Unit costs for the items that are common throughout the corridor were determined by developing and estimating a representative segment of the item. For example, Thruway Pavement and Finishes was addressed by developing a representative Thruway cross section and estimating the cost of constructing a 100 ft. long segment using *Heavy Bid*. This cost was divided by the number of square feet of pavement in the 100 ft. long segment, to arrive at a square foot cost for Thruway Pavement.

Representative Discrete Items: Unit costs for some of the bid items were determined by developing and estimating a representative example of the item. For example, the bid item “Bridges”, which includes both overpasses and on-line Thruway bridges, was addressed by developing a typical precast, prestressed, concrete multi-girder bridge with a deck area of 10,000 sq. ft. and estimating the cost of constructing it. This cost was divided by 10,000 sq. ft. to arrive at a square foot cost for the bid item “Bridges”.

Parametric Items: Some of these high-level items were built-up from sub-levels organized by parameters that drive the cost of the features. For example, the driving parameters for the cost of retaining walls are the height of the wall and whether it retains a cut or a fill section. Typical designs for retaining walls of various height ranges retaining either cut or fill were developed and the cost of a 100 ft. long segment of each was estimated. These costs were divided by 100 ft. to arrive at a linear foot cost for each of the different types of Retaining Walls.

Contingencies, Add-ons, Soft Costs and Escalation

The percentages used for the RTZB components were also used for the Highway, BRT and CRT components with these exceptions:

Initial Build Phase Contingencies: Risk-based contingencies were developed by Monte Carlo simulation using the @Risk commercial software package to be consistent with the RTZB components (see Chapter 9):

Landings:	33%
Highways:	24%

Final Build Phase Contingencies: The NYSDOT recommended contingency was applied:

All components:	30%

The MPT associated with these components would be greater than that associated with constructing the RTZB adjacent to the existing bridge:

MPT:	2.5%

Risk-Based Contingencies

Since the RTZB and Landing work would be highly complex, a probabilistic approach was taken to selecting the appropriate contingency to be applied to the construction cost, using Monte Carlo simulations.

Five simulations were run, for the following Initial Build Phase components:

1. Single Level Bridge Option
2. Dual Level Bridge Option
3. Rockland Corridor – Busway
4. Rockland Corridor – BRT in HOV / HOT Lanes
5. Rockland and Westchester Landings (combined).

Identifying Key Uncertainties

There are many higher-level risks that can affect the ultimate project cost that are not accounted for in the construction contingency. These include risks to the schedule (litigation, design delays, political opposition, permitting, etc.), risks due to market timing (availability of skilled labor, ROW acquisition costs, etc.), construction claims from design errors and omissions, etc. These risks will be estimated and managed separately in a process under development and are not included in this construction estimate. The construction contingency analysis focuses on the uncertainties in the various factors that form the *Heavy Bid* input data.

The assessment of uncertainty focused on the four input factors that tend to be the most uncertain and have the greatest impact on costs at this stage of the project:

1. *Construction Tasks*: While a large number of construction tasks were estimated the list is not exhaustive, and field conditions can require additional unanticipated tasks.
2. *Bid Item Quantities*: Although the quantities have been taken-off the CAD drawings with precision, the drawings are still at only 15% development, so there is still uncertainty in the quantities.
3. *Material Quantities*: As the designs are only to 15%, the material quantities associated with each bid item quantity are still rough estimates.
4. *Crew Productivity Rates*: Even at final design, these assumptions are not certain.

Quantifying the Uncertainty

The uncertainty was expressed as a potential minimum and maximum cost for each Level 1 bid item. As an example:

Highway, BRT and CRT Level 1 bid item: Rock Excavation

Construction Tasks: ***Moderate Uncertainty*.** Without field investigation of the rock to establish its characteristics, it is not known if additional construction tasks, such as rock bolting to stabilize rock faces, would be required.

Bid Item Quantities: ***High Uncertainty*.** The quantity of rock to be excavated has been estimated from topographic surveys, with no specific investigation of the rock formations, quality of rock, etc.

Material Quantities: ***Low Uncertainty*.** Few materials would be needed for excavation.

Crew Productivity Rates: ***High Uncertainty*.** The production rates are sensitive to the rock characteristics, which are not yet established.

Based on this qualitative assessment, the following range of potential costs was assigned to this bid item:

Minimum: 80% of Base Construction Cost

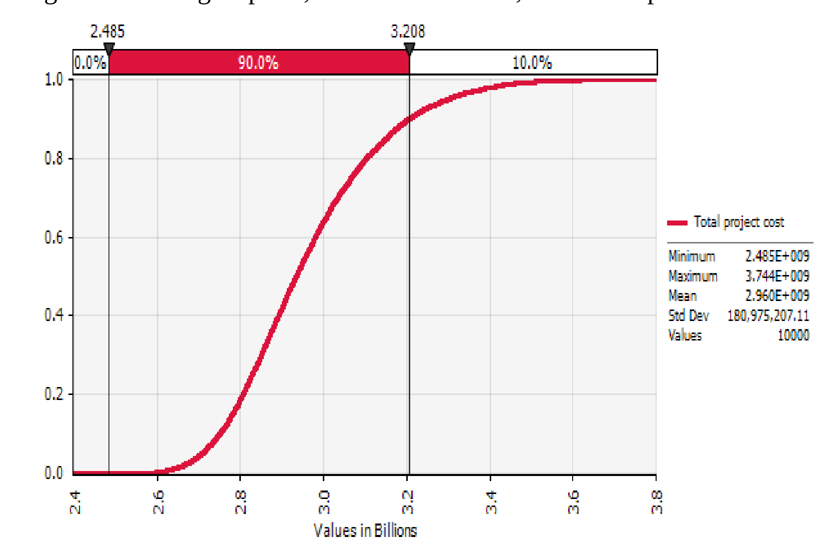
Maximum: 200% of Base Construction Cost.

Similar assessments of uncertainty were done for each Level 1 bid item of the five Initial Build components. These assessments were the input variables for the five Monte Carlo simulations.

Monte Carlo Simulations

The result of each simulation was an artificial database of 10,000 randomly chosen possible values for the total Base Construction Cost plus Contingency. The 10,000 samples from each simulation were fit to five individual Normal Probability Distributions.

The Figure below presents the Cumulative Distribution Function for the Base Construction Cost plus Contingency of the Single Level Bridge Option, Initial Build Phase, as an example.



Cumulative Distribution Function for Single Level Bridge Option, Initial Build Phase

FHWA guidance suggests using an 85% one-sided confidence limit. At this early stage of planning and design, a more conservative 90% confidence limit was selected, shown in the Figure above. Based on this artificial Probability Distribution Function, the true construction cost would be expected to be less than or equal to this limit with 90% confidence.

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Dual Level Bridge Final Build Phase - Heavy Bid Output Reports

Appendix I

Highway, BRT and CRT Representative Unit Costs - Heavy Bid Output Reports

Abbreviations

BRT	Bus Rapid Transit
CRT	Commuter Rail Transit
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HIR	Highway Improvements Report
HOV/HOT	High Occupancy Vehicle/High Occupancy Toll
MNRR	Metro-North Railroad
MTA	Metropolitan Transportation Authority
NYSDOT	New York State Department of Transportation
NYSTA	New York State Thruway Authority
R&R	Alternatives Analysis for Rehabilitation and Replacement of the Tappan Zee Bridge
RTZB	Replacement Tappan Zee Bridge
SSR	Scoping Summary Report
TAOR	Transit Alignment Options Report
TMSR	Transit Mode Selection Report
TP	Technical Paper
TP 1	Bridge Options Development Report (BODR)
TP 2	Foundations for the Feasible Alternatives for the RTZB
TP 3	Risk Assessment of the Feasible Alternatives for the RTZB
TP 4	Possible Bridge Types and Operation
TP 5	Cost Estimate for Feasible Alternatives of the RTZB
TP 6/7	Construction of the Feasible Alternatives for the RTZB and Landings
TP 8	Visualizations of the Feasible Alternatives for the RTZB
TP 9	Feasible Alternatives for the Replacement Tappan Zee Bridge
TP 10	Tunnel and Trestle Report
TZB	Tappan Zee Bridge
USDOT	US Department of Transportation

1 Introduction

1.1 Project Overview

The Project Sponsors – the New York State Department of Transportation (NYSDOT), the New York State Thruway Authority (NYSTA), and Metro-North Railroad (MNRR), an agency of the Metropolitan Transportation Authority (MTA) in cooperation with the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) as co-lead agencies, are preparing an Environmental Impact Statement (EIS) for the Tappan Zee Bridge (TZB)/I-287 Corridor Project in Rockland and Westchester Counties, New York (NY).

The I-287 Corridor extends 30 miles between the Village of Suffern in Rockland County and the Village of Port Chester in Westchester County. The counties are linked by the Tappan Zee Bridge (TZB) over the Hudson River.

One of the key steps in preparation of the EIS is the development and refinement of the EIS alternatives. As this project has transit, highway and bridge elements, the process of defining these components of the EIS alternatives is documented in a number of studies by the Project Sponsors:

Transit components:

- *Transit Mode Selection Report (TMSR)*
- *Transit Alignment Options Report* (*TAOR*)

Highway components:

- *Highway Improvements Report* (*HIR*)

Bridge components:

- *Alternatives Analysis for Rehabilitation and Replacement of the Tappan Zee Bridge (R&R Report).*
- *Tunnel and Trestle Report (TP 10)*
- *Bridge Options Development Report* (*BODR*)
- *Feasible Alternatives for the Replacement Tappan Zee Bridge* (*TP 09*)

This process is presented in Figure 1-1, which shows the parallel development of the three transit, highway and bridge studies leading to the development of the EIS alternatives. Early in the process, project scoping provided a forum for the public to provide comments and feedback on the Project Purpose and Need, potential alternatives, and environmental analysis being considered in the EIS. Scoping was closed in the Spring of 2009.

Project Purpose and Need

As articulated during Scoping, the Purpose and Need for the Tappan Zee Bridge/I-287 Corridor Project builds on the problems and deficiencies in the corridor, and states the basis for identifying and selecting solutions to effectively and efficiently address those needs, while respecting the natural and human environment.

On February 14, 2008, a revised *Notice of Intent* for the project was published in the *Federal Register* (Vol. 73 No. 31) which stated:

"The purpose and need of the project is to address the transportation safety, mobility and capacity needs of the Tappan Zee Bridge/I-287 Corridor."

It specifically identified that:

". ., the EIS will evaluate alternatives that address the following needs of the Corridor:

- Preserve the existing river crossing as a vital link in the regional and national transportation network
- Provide a river crossing that has structural integrity, meets current design criteria and standards, and accommodates transit
- Improve highway safety, mobility and capacity throughout the Corridor
- Improve transit mobility and capacity throughout the Corridor and travel connections to the existing north-south and east-west transit network"

Based upon these project purposes and needs, the *Scoping Summary Report* (*SSR*, May 2009) identified five goals ". . .to address the bridge, highway and transit needs of the corridor:

- Improve the mobility of people, goods and services for travel markets served by the Tappan Zee/I-287 corridor by providing for non-motorized travel, such as bicycle and pedestrian traffic
- Maximize the flexibility and adaptability of new transportation infrastructure to accommodate changing long term demand
- Maintain and preserve vital elements of the transportation infrastructure
- Improve the safety and security of the transportation system
- Avoid, minimize and/or mitigate any significant adverse environmental impacts caused by feasible and prudent corridor improvements."

The project goals and objectives were developed to indicate how the project will address the Purpose and Need. Objectives are used to measure progress in the attainment of goals. Project alternatives developed to respond to the Purpose and Need are evaluated by how well they meet the goals (e.g., Improve Mobility) by determining their likely performance against various objectives (e.g., reduce traffic congestion, improve travel times, etc.). All levels of evaluation conducted throughout the development of the EIS will be consistent with the Purpose and Need and the project's goals and objectives.

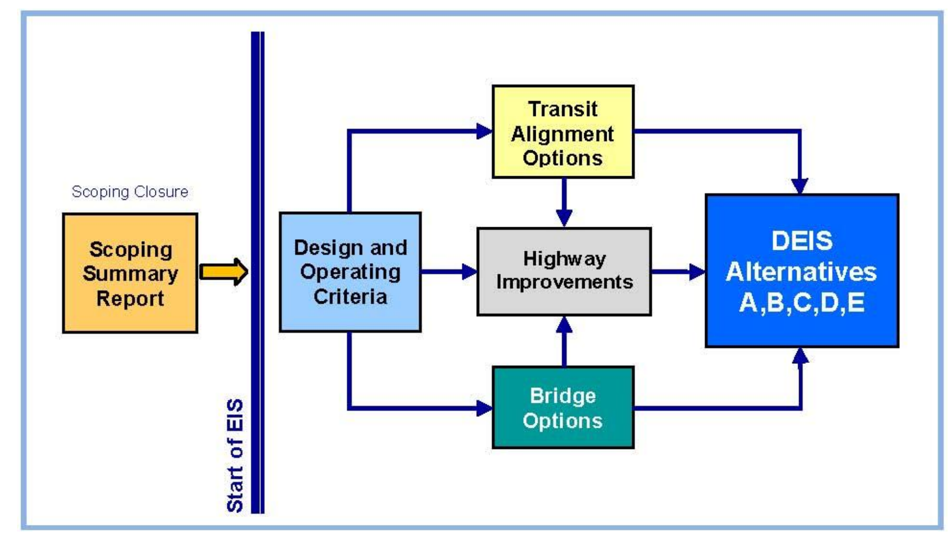


Figure 1-1 - Alternatives Development Roadmap

Project Alternatives

The scoping process explores a broad range of alternatives and options – then evaluates them to reduce the number considered in the environmental process. The evaluation process identifies and eliminates those that fail to meet the project purpose and needs and selects those for further consideration that best meet the project's purpose and needs and goals and objectives.

The results of the scoping studies, summarized in the *Scoping Summary Report*, are a set of five transit alternatives with a common replacement Tappan Zee Bridge (RTZB) element for evaluation in the DEIS:

- Alternative A – No build
- Alternative B – Full-Corridor Busway and Rockland CRT
- Alternative C – Busway in Rockland/Bus Lanes in Westchester and Rockland CRT
- Alternative D – BRT in HOV/HOT Lanes in Rockland/Busway in Westchester and Rockland CRT
- Alternative E – BRT in HOV/HOT Lanes in Rockland/Bus Lanes in Westchester and Rockland CRT

These broadly defined project alternatives form the basis of a planning level vision for a fully integrated transit and highway system along the I-287 corridor starting in Rockland County, continuing across the Tappan Zee Bridge and terminating in Westchester County, fulfilling the project's Purpose and Need.

Bridge Options

The *Feasible Alternatives for the Replacement Tappan Zee Bridge* (*TP 09*) report concluded that two alternatives for a RTZB should be evaluated in the DEIS, illustrated in Figure 1-2:

- Single Level Option: this option would comprise two parallel roadway structures with a CRT guideway structure between them.
- Dual Level Option: this option would comprise two parallel roadway structures. The two roadways would be on the upper levels of deep steel trusses. The CRT guideway would be on the lower level of one of the structures.

Tiering

The revised *Notice of Intent* also announced the Project Sponsors decision to prepare the NEPA documentation for this project using a tiered analysis approach. With this approach, the project will be able to expedite the delivery of integrated, multimodal transportation improvements in a way that allows each modal element to advance at its own pace.

The current environmental process includes a concurrent Tier 1 transit analysis and Tier 2 bridge and highway analysis. At the conclusion of the current environmental process, approved Tier 2 elements can be constructed, while accommodation can be provided for approved Tier 1 elements.

The Tier 1 transit analysis will define and assess the mode choices, alignments, and general locations of stations, termini, and facilities resulting in selection of one of the project's four transit alternatives. Subsequent Tier 2 transit analyses will define and evaluate supporting elements of the transit system such as stations and access for the selected alternative. Optional means of modifying the existing corridor elements to accommodate the future provision of transit have been evaluated and documented in the *Transit Alignment Options Report* (*TAOR*) for each of the project's transit alternatives.

The Tier 2 bridge and highway analysis will focus on selection of an RTZB configuration and inclusion of various highway improvements along the corridor. This analysis will incorporate modifications to the highway elements consistent with decisions made as part of the Tier 1 transit analysis.

Because the tiering process will provide the transit elements after the TZB has been replaced and the highway improvements have been made, it is necessary to define not just what the complete system will entail (called "Full Build" in this report), but also what will be constructed at the conclusion of each EIS tier. In this report, the work that will be constructed following the combined Tier 2 Highway and Bridge / Tier 1 Transit EIS is identified as the "Initial Build Phase", while the work that will be constructed following the Tier 2 Transit EIS is identified as the "Final Build Phase."

Figure 1-2 - Single Level and Dual Level Options to be Evaluated in the DEIS

1.2 Purpose of Report

This report has been prepared to support the assessment of the four feasible corridor build alternatives described in Section 1.1 above that will be considered in the DEIS (Alternatives B, C, D and E). It presents the estimated construction costs for the four build alternatives and provides:

- DEIS Alternatives Cost Estimate Summaries (See Appendix A).
- DEIS Alternatives Component Cost Estimate Summaries (See Appendix B).
- Unit Cost and Quantity Summaries for the Highway, BRT and CRT Components (See Appendix C).
- Output Reports from the estimating software (See Appendices E through I).
- Description of the estimating methodology (Chapter 3).
- Description of the alternative components and assumptions (Chapters 4 through 8).
- Description of risk-based contingency models (Chapter 9 and Appendix D)
- Comparison with previous estimate methodologies (Chapter 10).

1.3 DEIS Milestone Estimates

Estimates were previously developed and issued in support of the scoping phase, described in Chapter 10. Many alternatives have been screened-out since then, and further design development has been accomplished, including issuing updated drawings (Benchmark 1) and developing a detailed construction methodology and schedule for the replacement bridge, presented in *Construction of the Feasible Alternatives for the Replacement Tappan Zee Bridge and Landings (TP6/7)*.

The alternatives analysis process has reduced the number of project components in the feasible build alternatives to the following:

- A CRT alignment in Rockland
- A Busway alignment in Rockland
- A BRT in HOV / HOT lanes configuration in Rockland
- Two structural alternatives for the RTZB (Single Level and Dual Level)
- Two alternative CRT shoulder tunnel alignments in Westchester to connect to the Hudson Line (Short Tunnel and Long Tunnel)
- A BRT in Bus Lanes configuration in Westchester
- A BRT in HOV / HOT lanes configuration in Westchester
- An alignment for the Tarrytown South Connector (TTSC), a connector between BRT and the Metro-North Hudson Line in Westchester.

This additional work has provided a more detailed base of information for construction cost estimates, and the reduction in the number of feasible build alternatives to be considered in the DEIS makes it practical to provide correspondingly more detailed DEIS construction cost estimates.

1.4 Future Estimates

These estimates will be updated as appropriate for inclusion in the FEIS.

2 DEIS Alternatives Cost Estimate Summary

Table 2-1 presents a summary of the DEIS Alternatives cost estimates. A breakdown of these alternative totals by project component is presented in Appendix A.

Phasing

All four Build Alternatives have two phases, matching the Tiering analysis structure. The complete scopes for each phase are presented in detail in Chapters 4 through 8, and are summarized below.

Initial Build Phase: The RTZB would be constructed, the existing bridge would be demolished and Highway Improvements would be made, including acceleration lanes, climbing lanes, modifications to interchanges to accommodate these new lanes, resurfacing or full-depth replacement of segments of I-287, a new Toll Plaza and relocating existing Thruway and State Police facilities. Certain work necessary to accommodate the selected future BRT and CRT Alternatives would be done as well, including widening I-287 to accommodate BRT in HOV/HOT lanes or in a central Busway, lengthening overpass bridges, and constructing short sections of BRT and CRT tunnels below I-287 at the shorelines.

Final Build Phase: The CRT and BRT would be constructed, including further modifications to I-287 to accommodate the selected option, lengthening additional overpass bridges, adding the central CRT structure in the Single Level Option or the CRT lower deck in the Dual Level Option, tunnels, pavement, access ramps and flyovers, BRT and CRT stations, and all CRT systems.

Summary Table

The total costs of the RTZB Only (Abutment-to-Abutment), and of the four Alternatives in the Initial Build Phase (including the RTZB), Final Build Phase (including additional RTZB work to accommodate CRT) and the combined Totals (including all work in both phases) are summarized in Table 2-1.

There are two RTZB Options – Single Level and Dual Level. Each of the four Initial Phase Alternatives has the two Bridge Options, resulting in a total of 8 options. Each of the four Final Build Phase Alternatives has the two RTZB Options, and also two CRT Hudson Line Connection Options – a Long Tunnel Option (Long) and a Short Tunnel Option (Short), resulting in 16 Options.

DEIS Alternatives Cost Summary
(Costs in millions, Year 2015)

DEIS Alternative		Initial Build - RTZB Only (Abutment-to-Abutment)		Initial Build Phase (Including RTZB)		Final Build Phase		Initial Build + Final Build Total	
		Option	Total Cost	Option	Total Cost	Option	Total Cost	Option	Total Cost
B	Full-Corridor Busway Rockland CRT	Single Level	$4,936	Single Level	$7,105	Single / Long	$9,998	Single / Long	$17,163
						Single / Short	$9,375	Single / Short	$16,540
		Dual Level	$5,106	Dual Level	$7,275	Dual / Long	$9,676	Dual / Long	$17,010
						Dual / Short	$9,053	Dual / Short	$16,388
C	Busway in Rockland Bus Lanes in Westchester Rockland CRT	Single Level	$4,936	Single Level	$7,123	Single / Long	$9,227	Single / Long	$16,409
						Single / Short	$8,604	Single / Short	$15,787
		Dual Level	$5,106	Dual Level	$7,293	Dual / Long	$8,904	Dual / Long	$16,257
						Dual / Short	$8,282	Dual / Short	$15,634
D	BRT in HOV / HOT Lanes in Rockland Busway in Westchester Rockland CRT	Single Level	$4,936	Single Level	$9,541	Single / Long	$7,883	Single / Long	$17,483
						Single / Short	$7,260	Single / Short	$16,861
		Dual Level	$5,106	Dual Level	$9,710	Dual / Long	$7,561	Dual / Long	$17,331
						Dual / Short	$6,938	Dual / Short	$16,708
E	BRT in HOV / HOT Lanes in Rockland Bus Lanes in Westchester Rockland CRT	Single Level	$4,936	Single Level	$9,558	Single / Long	$7,112	Single / Long	$16,730
						Single / Short	$6,489	Single / Short	$16,107
		Dual Level	$5,106	Dual Level	$9,728	Dual / Long	$6,790	Dual / Long	$16,577
						Dual / Short	$6,167	Dual / Short	$15,955

Table 2-1 - DEIS Alternative Cost Summary

3 Estimate Methodology

3.1 General Approach

The project was organized into measurable components segregated by transportation mode (RTZB, Highway, BRT and CRT) and construction phase (Initial Build and Final Build).

Because the RTZB would be a unique and complex undertaking, a significant level of engineering detail was developed for construction of the bridge, presented in *Construction of the Feasible Alternatives for the Replacement Tappan Zee Bridge and Landings (TP6/7)* and the Benchmark 1 drawings. This level of engineering justified a detailed, activity-based, bottom-up estimate for the two RTZB Options (Single Level and Dual Level) in both phases. This method is similar to how contractors generate bids.

The level of engineering detail developed for the construction of the Highway, BRT and CRT components is less than that developed for the bridge options, and the construction of these components is more conventional. A more conventional conceptual estimate approach was taken for these components in which detailed build-ups of representative unit costs were multiplied by bid item quantities.

The estimates were guided by the construction methodology and schedule presented in TP 6/7 and the Benchmark 1 Drawings. This estimate should be read and reviewed in conjunction with those resources. A list of the Benchmark 1 drawings used for the estimate is provided in Section 3.7.

All of the estimates made use of the *Heavy Bid* construction estimation software by Heavy Construction Software Solutions (HCSS). HCSS houses a proprietary database of labor rates, material costs, and equipment rental and purchase rates, which was modified and supplemented by project-specific and region-specific data. This software is the industry's leading software package for infrastructure projects both large and small, and is widely used by contractors as well as engineers and planners.

3.2 Project Components

3.2.1 Initial Build Phase

The Initial Build Phase consists of the following eight project components, all of which are defined in greater detail in Chapters 4 through 8:

Bridge Components:

1. Single Level Bridge Option.
2. Dual Level Bridge Option.

Highway, BRT and CRT Components:

3. Rockland highway improvements with accommodations for the Busway Option and CRT.
4. Rockland highway improvements with accommodations for the BRT in HOV / HOT Lanes Option and CRT.
5. Rockland landing with accommodations for the Busway Option and CRT.
6. Rockland landing with accommodations for the BRT in HOV / HOT Lanes Option and CRT.
7. Westchester landing with accommodation for the Busway Option and CRT.
8. Westchester landing with accommodation for the BRT in HOV / HOT Lanes Option and CRT.

The actual BRT and CRT components would not be constructed in the Initial Build Phase, but all Initial Build Phase construction would accommodate the future addition of BRT and CRT.

3.2.2 Final Build Phase

The Final Build Phase consists of the following 13 components, all of which are defined in greater detail in Chapters 4 through 8:

Bridge Components:

1. Adding the CRT superstructure and systems to the Single Level Bridge Option.
2. Adding the CRT lower level and systems to the Dual Level Bridge Option.

Highway, BRT and CRT Components:

3. Busway Option in Rockland corridor with CRT.
4. BRT in HOV / HOT lanes option in Rockland corridor with CRT.
5. Complete the Rockland landing for the Busway Option and CRT.
6. Complete the Rockland landing for the BRT in HOV / HOT Lanes Option and CRT.
7. Complete the Westchester landing for Busway Option and CRT.
8. Complete the Westchester landing for the BRT in HOV / HOT Lanes Option and CRT.
9. CRT Hudson Line Connection – Short Tunnel Option.
10. CRT Hudson Line Connection – Long Tunnel Option.
11. Tarrytown South Connector (BRT to Hudson Line Connection).
12. Westchester Corridor Busway Option.
13. Westchester Corridor Buslanes Option.

3.3 Bottom-Up Estimate for Bridge Components

3.3.1 Work Breakdown Structure

The estimating process began with developing a Work Breakdown Structure (WBS) for each of the two RTZB Options (Single Level and Dual Level), for each phase (Initial Build and Final Build).

A WBS is a project management tool used to organize, plan, coordinate, schedule and estimate a complex group of activities. It is a hierarchical system in which a top level activity has sub-levels associated with it in a "tree" structure. The top level of a WBS is often identified as Level 1, whereas subsequent lower levels are numbered consecutively i.e. Level 2, Level 3 etc. When this system is used by contractors to prepare bids, the activities in the various levels are referred to as "bid items", a term adopted for this report.

The WBS is specific to each project component. For example, Level 1 of the WBS for both RTZB Options in the Initial Build Phase contains the following 13 bid items:

- Site Access, Plant, Staging Areas, Laydown Areas
- Dredge
- Temporary Access Trestle
- Approach Substructure Piles
- Approach Substructure Pilecaps and Piers
- Approach Superstructure
- Main Span Substructure Piles
- Main Span Substructure Pilecaps and Pylons
- Main Span Superstructure
- Abutments

- Deck and Appurtenances
- Existing Bridge Demolition
- Project Indirect Costs

Each bid item in Level 1was broken down into one or more sub-levels to group together items with similar characteristics. For example:

- Approach Substructure Piles
    - Zone 1 – Pier 1 to Pier 3
    - Zone 1 – Pier 4 to Pier 8
    - Zone 2 – Pier 9 to Pier 14

      …
    - Zone 6 – Pier 58 to Pier 62

At the lowest sub-level each item was broken down into specific construction tasks or activities. For example:

- Zone 4 – Pier 42 to Pier 48
    - Furnish Materials
    - Set Crane Barge – Spud Piles
    - Transport Material
    - Pile Template
    - Bracing Framework and Deck
    - Drive Piles – Lower
    - Weld Huts: Construct / Relocate
    - Weld Piles
    - QA / QC Welds
    - Drive Piles - Upper
    - Cut Piles
    - Excavate Piles and Haul Muck
    - Drill Rock Socket
    - Place Rebar
    - Place Concrete
    - Remove Template and Temporary Structures
    - Place Soffit

3.3.2 Quantities, Materials, Labor and Equipment

To build-up the estimates for each construction task, the following was done:

1. The quantities associated with each bid item (e.g. linear feet of piles in a given zone) were taken-off from the Benchmark 1 CAD files and TP 6/7.
2. The quantities of specific materials required for each construction task were then calculated (e.g. cubic yards of concrete to fill the piles, tons of associated rebar, etc.)
3. A specific crew was assigned to each construction task, with equipment specific to the task, based on experience and published resources.
4. Material costs were developed from published resources such as Engineering News Record (ENR) Material Cost Reports, Material Cost Trend Reports and Historical Cost Indices, RS Means Cost Books, and research with local and regional suppliers.
5. Labor and equipment rates were developed from union contracts and published resources, including the NYSDOT Prevailing Wage Rates and Davis Beacon Wage Rates.
6. Productivity and cycle rates were defined for each crew (cubic yards of concrete per shift, etc.) based on experience, published resources and consultation with contractors who have done similar work at a similar scale.

3.3.3 Indirect Costs

A detailed build-up of Project Indirect Costs (General Conditions and Overhead) was done in *Heavy Bid*, encompassing the following:

- Project Indirect Costs
    - Variable Indirect Costs
        - Salary Indirect
            - Superintendents
            - Engineers
            - Project Controls
            - Office Administration
            - Purchasing and Warehouse
            - QA / QC
            - Safety
        - Union Indirects
            - Mechanics
            - Mechanical Maintenance
            - Mechanics Truck
            - Bull Gang
        - Survey
        - Employee Land Transportation – Labor
        - Marine Transportation – Labor
    - Fixed Indirect Costs
        - Equipment Mobilization / Demobilization
        - Equipment Set-up
        - Site Access
        - Sub-contractor Mobilization
        - Personnel Expenses
        - Field Office Set-up
        - Field Office – Trailers
        - Office Furniture and Equipment
        - Field Office Operation
        - Storage and Trades Facilities
        - Project Identification
        - Project Vehicles
        - Temporary Utilities
        - On-site Equipment moves
        - Support Facilities

- Dock Facilities
- Owner's Field Office Set-up
- Owner's Field Office Equipment
- Owner's Field Office Operation
- Health and Safety
- Environmental Safety
- Inspection and Testing
- Engineering Subconsultant Services
- Drawings and Documentation
- Bonds, Insurance, Fees
- Project Equipment
- Vehicle Maintenance
- Project Closeout

These items in turn were broken down further. As examples:

- Superintendents
  - General
  - Project
  - Assistant
  - Civil
  - Concrete
  - Electrical
  - Excavation
  - Pile / Foundations
  - Marine
  - Mechanical
  - Earth Support
  - Structural
  - Utility
- Field Office Operation
  - Office Expenses
  - Utility Charges
  - Yard Rental
  - Cellular Phones
  - Nextel Units
  - Local Phone Service
  - Long Distance Phone Service
  - Internet Service
  - Software Maintenance
  - Radio Antenna Fee
  - Copier Service Agreement
  - Fax Service Agreement
  - Dumpster Service
  - Janitorial Service
  - Drinking Water Service
  - Postage Expenses
  - Security Patrol
- Bonds, Insurance, Fees
  - Bonds
  - Insurance
  - Damages and Deductibles
  - Permits
  - Business Fees
  - DRB and Partnering
  - Liquidated Damages
  - Home Office Expenses
  - J/V Management Fees

3.3.4 Costs Not Included

1. *Right-of-Way Acquisition*: Costs for obtaining property for ROW will be developed by NYSDOT's property unit. NYSDOT typically does not include this cost in the construction estimate, but tracks it separately.
2. *Environmental Mitigation*: Should the EIS process reveal environmental impacts, mitigation may be required. This cost will be addressed at a later date after impacts and probable mitigation have been identified and studied.
3. *Vessel Collision Protection*: The level and extent of vessel collision protection required has not been determined yet, and no allowance has been included in the estimate.

3.3.5 Base Year and Escalation Rate

The estimate was begun in 2010, so all labor, material and equipment costs have been researched in year 2010 dollars. The current schedule sets 2015 as the midpoint of construction for the Initial Build Phase, so Initial Build costs were escalated to that year.

NYSDOT is currently using an annual inflation rate of 3% for escalating their programmed projects estimated in 2011 dollars to year 2015 dollars. This is appropriate for projects already progressing through design and procurement, so that necessary projects are not crowded out by overly conservative inflation estimates. However, a low inflation rate would not be sufficiently conservative for a project that is still in the DEIS stage and has a very long time line.

The mid-point of construction for the Final Build Phase is currently unknown, but is anticipated to be at least 10 years beyond 2015. As this is uncertain, and to provide a common base year for dollars between the two phases, the Final Build Phase costs were also escalated to 2015.

The historical values of the ENR Construction Cost Index was used to develop a more conservative inflation rate common to both the Initial and Final Build phases. The average changes in this index over long time frames are:

Previous 100 years:	4.8% per year
Previous 50 years:	4.9% per year.

An inflation rate of 4.5% was selected for both the Initial and Final Build Phases. This common rate would be overly conservative for just the Initial Build Phase, but escalating both phases at 4.5% per year for 5 years serves to compensate for the fact that the Final Build Phase was not escalated out to its currently unknown midpoint of construction.

3.3.6 Bid Item Costs

The *Heavy Bid* software then calculated the cost of each construction task, and aggregated the individual task costs into subtotals at each level of the WBS "tree". The Level 1 bid item aggregated costs were the target output from *Heavy Bid*. The remainder of the estimate was done in a spreadsheet format, presented in Appendix B.

The *Heavy Bid* software also can aggregate the Level 1 costs into a total cost, and can generate various reports, aggregating the information in different formats. Unit costs can be generated by the software at each level in the WBS structure by dividing the generated cost by the unit quantity associated with each item at each level.

3.3.7 Contingencies, Add-ons, Soft Costs and Escalation

These factors were applied as compounding percentages:

Risk-based contingencies were developed by Monte Carlo simulation using the @Risk commercial software package:

Single Level Option:	25%
Dual level Option:	23%
Average, used for both:	24%

Add-ons were developed from experience:

MPT:	1%
Profit:	12%

Soft costs were structured according to NYSDOT practice, developed from experience:

Design Engineering:	2%
Program Management:	2%
Construction Management:	3%
Construction Inspection:	2%
Construction Support Services:	1%
Total:	10%

All costs were escalated to the project midpoint of construction (2015) using an inflation rate of 4.5% per year compounded over 5 years:

Escalation:	25%

3.4 Highway, BRT and CRT Component Estimates

3.4.1 Work Breakdown Structure (WBS)

A WBS was developed in *Heavy Bid* for each Highway, BRT and CRT component for both phases. It was structured to develop representative unit costs for a range of bid items that could be multiplied by unit quantities to generate item costs. The various bid items of the WBS were aggregated in a spreadsheet format into the following high-level items:

Highway

- Demolition
- Earthwork – Cut / Fill
- Rock Excavation
- Retaining Walls
- Side Slopes Areas, Vegetated Stone Slopes
- Bridges
- Thruway Pavement & Finishes
- Interchange Ramps
- Drainage
- Local Road Pavements & Finishes
- Pedestrian Facilities
- Utilities

Bus Rapid Transit

- Earthwork
- Rock Excavation
- Retaining Walls
- Viaduct
- Tunnels
- Station Access Ramps
- Stations
- Depots
- Bridges
- Pavements and Finishes
- Intelligent Transportation Systems (ITS)
- Drainage
- Utilities

Commuter Rail Transit

- Earthwork
- Rock Excavation
- Retaining Walls
- Viaduct
- Bridges
- Tunnels
- Stations
- Track Infrastructure
- Signal Systems
- Substations, Vent buildings, Access Shafts
- Drainage
- Utilities

3.4.2 Representative Unit Costs

Three types of representative bid items were developed: Representative Segment Items, Representative Discrete Items, and Representative Parametric Items.

3.4.2.1 Representative Segment Items

Unit costs for the items that are common throughout the corridor were developed by designing and estimating a representative segment of the item. For example, the bid item "Thruway Pavement and Finishes" was addressed by developing a representative Thruway cross section. The bid item was broken down into construction tasks in *Heavy Bid*:

- Thruway Pavement & Finishes
  - Prep, Grade, Roll
  - Subbase

- 4" Edge Drain Pipe
- Final Line and Grade
- Lift 1 Base Course
- Lift 2 Base Course
- Binder Course
- Tack Coat
- Wearing Course / Top Course
- Guard Rail
- Center Wall Divider
- Lane Markings
- Signage

The various material quantities associated with a 100 linear ft. segment of highway were calculated and a *Heavy Bid* estimate was done the same way as the Single Level and Dual Level Options were done, with crews, equipment, productivity rates, material costs, etc. *Heavy Bid* calculated the cost of each task and aggregated them into a cost for the representative Thruway segment. This was divided by the area of a 100 linear ft. segment to generate the representative unit cost ($16 per sq. ft.). This was the target output from *Heavy Bid*, and the remainder of the estimate was done in a spreadsheet format.

The total sq. ft. of highway to be reconstructed was taken-off from the Benchmark 1 CAD files and multiplied by the representative unit cost to obtain the construction cost of Thruway Pavement and Finishes.

3.4.2.2 Discrete Representative Items

Unit costs for discrete items were determined by developing and estimating a representative example of the item. For example, the bid item "Bridges", which includes both overpasses and on-line Thruway bridges, was addressed by developing a typical precast, prestressed concrete multi-girder bridge with a deck area of 10,000 sq. ft. This bid item was broken down into the following construction tasks:

- Bridges
  - Site Preparation and Clearing
  - Piles
  - Excavate Abutment
  - Abutment
  - Column Foundation – Pile Cap
  - Columns
  - Girders – Precast
  - Deck
  - Finishes

The various material quantities associated with the example bridge were calculated and a *Heavy Bid* estimate was done the same way as the Single Level and Dual Level Options were done, with crews, equipment, productivity rates, material costs, etc. *Heavy Bid* calculated the cost of the example bridge and divided by 10,000 to generate the representative unit cost ($285 per sq. ft.) This was the target output from *Heavy Bid*, and the remainder of the estimate was done in a spreadsheet format.

The total sq. ft. of bridges in the corridor was taken-off from the Benchmark 1 CAD files and multiplied by the unit cost to obtain the construction cost of the overpass and on-line bridges.

3.4.2.3 Parametric Items

Some of the bid items were built-up from sub-levels organized by parameters that drive the cost of the features. For example, the driving parameters for the cost of retaining walls are the height of the wall and whether it retains a cut or a fill section:

- Retaining Walls
  - < 6 ft. Retained Fill
  - 6 ft. to 15 ft. Retained Fill
  - 16 ft. to 25 ft. Retained Fill
  - > 25 ft. Retained Fill
  - < 6 ft. Retained Cut
  - 6 ft. to 15 ft. Retained Cut
  - 16 ft. to 25 ft. Retained Cut
  - > 25 ft. Retained Cut

A typical section of retaining wall was developed for each height of retained fill and retained cut, and a typical length assumed (100 ft.). Then each bid item was broken down into construction tasks. For example:

- 16 ft. to 25 ft. Retained Fill
  - Earthwork Fill
  - Concrete Wall
  - Compacted Subbase
  - Soil Anchors
  - Drainage Swale – Clean Fill
  - Drain Rock
  - K-Rail Guide Rail
  - Clean Fill Under Thruway
  - Grade and Compact

The various material quantities associated with each type of retaining wall were calculated and *Heavy Bid* estimates were done the same way as the Single Level and Dual Level Options were done, with crews, equipment, productivity rates, material costs, etc. *Heavy Bid* calculated the costs of the typical retaining walls and divided by 100 to generate the representative linear ft. unit costs (e.g. $3,333 per linear ft. for retained fill walls from 6 ft. to 15 ft. high). This was the target output from *Heavy Bid*, and the remainder of the estimate was done in a spreadsheet format.

The respective lengths of each type of wall along the corridor were taken-off from the Benchmark 1 CAD files and multiplied by the corresponding unit costs developed in *Heavy Bid*, and these were totaled to obtain the cost of Retaining Walls.

3.4.3 Bid Item Costs

The unit costs developed in *Heavy Bid* and the corresponding unit quantities were transferred to a spreadsheet format and multiplied to arrive at bid item costs, presented in Appendix C. These values were rolled-up into the estimate spreadsheet format with the Bridge Option costs, in Appendix B.

3.4.4 Contingencies, Add-ons, Soft Costs and Escalation

The percentages used for the Bridge components were also used for the Highway, BRT and CRT components with the following exceptions:

Initial Build Phase Contingencies: Risk-based contingencies were developed by Monte Carlo simulation using the @Risk commercial software package to be consistent with the Bridge components (see Chapter 9):

Landings:	33%
Highways:	24%

Final Build Phase Contingencies: The NYSDOT recommended contingency was applied:

All components:	30%

The MPT associated with these components would be greater than that associated with constructing the RTZB adjacent to the existing bridge:

MPT:	2.5%

3.5 *Heavy Bid* Reports

The *Heavy Bid* software can present the input and results from the estimate build-up in a variety of report formats. Selected *Heavy Bid* reports have been included as Appendix E through Appendix I under separate cover in electronic format, since they run to several hundred pages each. One report format, the Detailed Cost Reports, are provided for the four RTZB Options (Single Level Initial Build, Single Level Final Build, Dual Level Initial Build, and Dual Level Final Build, in Appendices E through H, respectively) and for the Highway, BRT and CRT Components (Appendix I). The other three reports are provided for the four RTZB Options only, in their respective Appendices, but do not apply to the Highway, BRT and CRT Components, since the *Heavy Bid* analysis for those components were only used to develop representative unit costs.

3.5.1 Concise Bid Report

This is a single page, high level report presenting the Level 1 bid items with the following data:

1. Quantities (linear feet of approach piles, square feet of deck, etc.)
2. Calculated unit prices
3. Cost of the bid item
4. Bid Total (sum of the bid items).

3.5.2 Cost and Price Report

This is a high level report in two parts.

The first part presents a breakdown of the Level 1 bid items into:

1. Direct labor
2. Permanent material
3. Construction material
4. Equipment
5. Subcontractors
6. Direct total
7. Indirect charge
8. Total cost
9. Total cost unit price
10. Markup
11. Balanced bid total
12. Balanced bid unit price.

Note that the indirect charge is a share of the indirect costs charged to each bid item proportionally. The balanced bid total is the direct cost of each bid item plus the indirect charge and markup, and the balanced bid unit cost is the corresponding unit cost.

The second part is a breakdown of the Level 2 indirect costs into labor, material, equipment, etc.

3.5.3 Labor Use Report

This is a high level report that lists every labor category by trade with the following data:

1. Project total manhours
2. Hourly base rate
3. Total base salaries
4. Total labor burdens
5. Total of base salaries and burdens.

3.5.4 Detailed Cost Report

This report is a detailed recap of how each lowest level construction task was estimated and how those costs roll up the WBS “tree”. It presents:

1. Each construction task, organized within the WBS tree.
2. The bid item quantity associated with each task (linear feet of piles, etc.)
3. The quantities of materials required for the task, their units and unit costs, and the costs of each material.
4. The equipment assigned to the task, their units (hours, shifts, etc.) their costs of ownership, costs of operation and total costs.
5. The crew assigned to the task, including all trades, number of workers in each trade and foremen, the hours required, base wage rate, the burdened costs of each trade and the total labor cost.
6. The total cost of the item, and the calculated unit cost of the item.
7. The roll-up of sub-level costs to each succeeding higher level of the WBS.

3.6 Additional Estimate Assumptions

3.6.1 Replacement Tappan Zee Bridge

1. Temporary facilities for construction activities are included in the estimate as an allowance for potential works. Staging areas and potential locations are identified in TP6/7.
2. The temporary access trestles have not been designed. A general configuration was assumed for a suitable structure to be constructed on each shore to access pier locations where water levels are low.
3. Piling activities are based on researched production rates and routines for work performed on comparable projects. Pile dimensions, soil conditions, and associated driving metrics were researched and estimated.
4. Precast segmental concrete construction has been assumed for the Single Level Option. The setup facilities for a casting yard are included in the estimate as an allowance based on size and scale of the project. The precast facility production rates are based on similar routines from comparable projects.

3.6.2 Highway, BRT and CRT

1. Cut / Fill quantities were based on neat line calculations without taking into consideration swell, shrink, and compaction ratios. General soil conditions were assumed for all earthworks, except where hard rock is denoted.
2. The existing utility layout was evaluated and reasonable assumptions made on the quantity of each utility that would need to be replaced.
3. Drainage estimates include the cost to install a 48" dia. Reinforced Concrete Pipe (RCP) with a series of connections, and an estimate of water quality treatment areas.
4. Pedestrian facilities have been taken off per square foot as indicated on the drawings. A square foot unit cost was developed using *RSMeans Cost Works* as a basis for construction costs for pedestrian facilities.
5. CRT Track and infrastructure costs have been estimated based on a detailed build- up for a general configuration of track on ballast or direct fixation. No design cross sections have been developed yet for this project, so a representative cross section adapted from previously estimated rail projects has been used for all elements of the track work and associated infrastructure.
6. Viaduct for CRT and BRT were estimated with a similar build-up. No design structure has been developed yet for this project, so a representative build-up was generated based on previously estimated work for similar structures.

3.7 Reference Drawings

All drawings used in the estimate are at project Benchmark 1 - issued for the Environmental Impact Analysis:

1. Initial Build Highway BRT HOV HOT Alternative Plan, Profile, Typical and Critical Cross Sections
2. Initial Build Highway Busway Alternative Plan, Profile, Typical and Critical Cross Sections
3. Full Build BRT HOV HOT Alternative Plans and Profiles, Typical and Critical Sections and Construction Sequence Plans
4. Full Build Busway Alternative Plans, Profiles, Typical and Critical Sections
5. Buslane Alternative Westchester Corridor
6. Busway Alternative Westchester Corridor
7. Hudson Line Connection Short Tunnel Option
8. Hudson Line Connection Long Tunnel
9. Tarrytown Connector South Crossing Option
10. Bridge Single Level - Full Build
11. Bridge Dual Level - Full Build
12. Bridge Single Level - Initial Build
13. Bridge Dual Level - Initial Build
14. Bridge Construction - Rockland Dual Level
15. Bridge Construction - Rockland Single Level
16. Bridge Construction - Westchester Dual Level
17. Bridge Construction - Westchester Single Level

4 Rockland Corridor Scope

Two feasible corridor alternatives were identified in the *SSD* for Rockland: BRT in Busway plus CRT; and BRT in HOV / HOT Lane plus CRT. Each option has an Initial Build Phase and a Final Build Phase. The cost estimates reflect the scope of work in each of the construction phases. The work within the Rockland Corridor would be the same with either the Single Level or Dual Level Bridge Options.

Elements common to the Busway and HOV / HOT options include:

1. Construction of new facilities in Rockland for the NYSTA and State Police.
2. Set-up and operation of a large in-land staging area in Rockland.

4.1 Busway Option

In Rockland, this option comprises:

1. Highway improvements, including adding climbing and acceleration lanes and reconstructing associated highway sections and interchange ramps.
2. BRT in a dedicated Busway on the north side of the I-281 ROW with access ramps and stations.
3. CRT on a dedicated alignment on the south side of the I-287 ROW, with stations.

4.1.1 Initial Build Phase

The work in this phase would comprise highway improvements and all modifications necessary to accommodate the future Busway and CRT. This phase extends from Station 427+00 just west of Interchange 14A and Chestnut Ridge Road to Station 800+00 just west of Interchange 10.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. Bridges carrying roadways or railroads over I-287 would be lengthened to accommodate highway widening. No roads would be closed while replacing these crossings; temporary bridges would be provided to maintain traffic during reconstruction.
2. Bridges carrying the Thruway over local roads or waterways would be widened to accommodate the highway improvements. Bridge condition ratings for the existing structures have been evaluated to determine rehabilitation or replacement on a case-by case basis.
3. I-287 Interchange Ramps would be modified for the highway improvements only. Interchange modifications required for future BRT and CRT would be identified and constructed in the Final Build Phase.
4. Full depth pavement would be constructed for all new (widened) sections of I-287. Mill and fill treatment has been assumed for the segments of I-287 highway and ramps that would not be widened.
5. Rock cuts would be excavated for highway improvements only. Additional rock cuts required for the future transit components would be identified and constructed in the Final Build Phase.
6. Storm Water Management facilities have been located to accommodate the Full Build impervious area but sized for the Initial Build runoff requirements only. Expansion of capacity for the Full Build requirements would be accomplished in the Final Build Phase.
7. Culverts crossing under I-287 would be extended to the Full Build footprint where practicable.

4.1.2 Final Build Phase

The work in this phase would comprise the dedicated Busway to the north of the Thruway and the CRT to the south. This phase extends from Station 70+00 just west of Hillburn Station to Station 800+00 just west of interchange 10.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The Busway and CRT would run parallel to I-287 through Rockland County.
2. Segments of the CRT would run at-grade, on viaducts and in tunnels.
3. The Busway would run at-grade, except where it crosses from the north side of I-287 to the south side in a tunnel under I-287 in the vicinity of Waldron Ave. This segment of I-287 would be reconstructed to accommodate the tunnel.
4. The at-grade segments of Busway and CRT would cross over streams and roadways on new structures adjacent and parallel to the on-line I-287 bridges crossing the same features.
5. I-287 ramps would be modified to accommodate the Busway and CRT.
6. I-287 overpass bridges not reconstructed in the Initial Build Phase would be reconstructed as necessary to accommodate BRT and CRT. No roads would be closed while replacing these crossings; temporary bridges would be provided to maintain traffic during reconstruction.
7. Busway station access ramps would be constructed.
8. Rock cuts for the transit components would need to be completed adjacent to the I-287 mainline. MPT would be required on the mainline I-287 to do this work.
9. All Stormwater Management Facilities would be enlarged to receive the additional runoff from the transit components.

4.2 BRT in HOV / HOT Lanes Option

In Rockland, this corridor option comprises:

1. Highway improvements, including adding climbing and acceleration lanes and reconstructing associated the highway sections and interchange ramps.
2. BRT in shared HOV / HOT lanes in the center of the Thruway, with access ramps, flyovers and stations.
3. CRT on a dedicated alignment to the south of the Thruway.

The work would be accomplished in separate Initial Build and Final Build Phases.

4.2.1 Initial Build

The work in this phase would comprise highway improvements, addition of the HOV / HOT lanes, and all modifications necessary to accommodate the future BRT access ramps and CRT. This phase begins at Station 135+00 just west of the Wayne Avenue underbridge and continues to Station 800+00 west of Interchange 10.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The two HOV / HOT lanes would be constructed in the center of I-287 throughout the Corridor.
2. The central median would be widened where necessary to accommodate the five future BRT station access fly-over ramps.
3. Bridges carrying roadways or railroads over the I-287 would be lengthened to accommodate the highway improvements. No roads would be closed while replacing these crossings; temporary bridges would be provided to maintain traffic during reconstruction.
4. Bridges carrying I-287 over local roads or waterways would be widened to accommodate the highway improvements. Bridge condition ratings for the existing structures have been evaluated to determine rehabilitation or replacement on a case-by case basis.

5. I-287 Interchange Ramps would be modified for the highway improvements only. Interchange modifications required for future BRT and CRT would be identified and constructed in the Final Build Phase.
6. Full depth pavement would be constructed for all new (widened) sections of I-287. Mill and fill treatment has been assumed for the segments of I-287 highway and ramps that would not be widened.
7. Rock cuts would be excavated for highway improvements only. Additional rock cuts required for the future CRT and BRT Access Ramps would be constructed in the Final Build Phase.
8. Storm Water Management facilities have been located to accommodate the Full Build impervious area but sized for the Initial Build runoff requirements only. Expansion of capacity for the Full Build requirements would be accomplished in the Final Build.
9. Culverts crossing under I-287 would be extended to the Full Build footprint where practicable.

4.2.2 Final Build Phase

The work in this phase would comprise the BRT Lanes, Access Ramps and stations and the CRT to the south. This phase extends from Station 72+95 at Hillburn Station to 800+00 west of Interchange 10.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The CRT would be similar to CRT in the Busway Option.
2. The additional BRT access ramp fly-overs and stations would be constructed. MPT would be required on the I-287 mainline to do this work.
3. I-287 ramp modifications and new parallel structures for the CRT would be identified and constructed in this phase.
4. I-287 overpass bridges not reconstructed in the Initial Build Phase would be reconstructed as necessary to accommodate BRT and CRT. No roads would be closed while replacing these crossings; temporary bridges would be provided to maintain traffic during reconstruction.
5. The at-grade segments of CRT would cross over streams and roadways on new structures adjacent and parallel to the on-line I-287 bridges crossing the same features.
6. Rock cuts for the transit components would need to be excavated adjacent to the I-287 mainline. MPT would be required on the I-287 mainline to do this work.
7. All Stormwater Management Facilities would be enlarged to receive the additional runoff from the transit components.

5 Tappan Zee Bridge Scope

Estimates have been prepared for both the Single Level and Dual Level Options. Each Option has an Initial Build Phase and a Final Build Phase. The cost estimates reflect the scope of work in each of the construction phases.

5.1 Single Level Option

The Single Level Bridge, Option 3 in the TP 9 report, would extend from the west abutment in Rockland just west of River Road at Station 842+70 to the east abutment in Westchester at Station 1004+50. It comprises the following components:

1. Two parallel approach highway structures, each carrying four traffic lanes and one Busway lane or one shared BRT / HOV / HOT lane, with a shared use path for pedestrians and bicycles on one structure only.
2. A CRT approach structure located between the two highway structures.
3. A combined main span structure carrying the highway, BRT and CRT.

5.1.1 Initial Build Phase

The work of this phase would comprise the erection of the highway approach and main span structures. The structures would be able to accommodate the future BRT and CRT components.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. Extensive inland staging areas, shorefront laydown and erection areas and in-water access platforms would be required, defined in TP 6/7.
2. Extensive dredging would be required to accommodate construction barges.
3. Each approach structure would be independently supported.
4. The approach and main span foundations would be large diameter driven steel pipe piles with embedment lengths up to 300 ft. Each would be filled with reinforced concrete.
5. The approach piers would be reinforced concrete.
6. The approach superstructures would be precast, post-tensioned concrete boxes with span lengths of 230 ft. Although concrete boxes could be used with greater span lengths, this span length would permit the use of lighter (and possibly more economical) superstructures such as multiple steel girders or trapezoidal steel tubs. However, this span length with concrete box superstructures was selected for the DEIS because it generates the greatest impacts to the river habitat (more piers with more or larger piles), disclosing the upper bound of potential environmental impacts.
7. The main span would be a three-span cable-stayed structure with concrete pylons. The span lengths would be similar to the existing, with a 1,200 ft. central navigation span and two 600 ft. side spans.
8. The main span superstructures would be two independent trapezoidal steel boxes.

5.1.2 Final Build Phase

The work of this phase would comprise the addition of the CRT superstructure and systems between the two traffic structures.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. Post-tensioned cross-struts would be added to the existing independent approach piers to carry the CRT superstructure.
2. The approach superstructure would also be a precast, post-tensioned concrete box.
3. The main span superstructure would be a trapezoidal steel box, supported by new stay cables from the existing concrete pylons.
4. The work would be done from the existing roadways with limited lane closures, so there would be no new dredging.
5. The CRT guideway would include two tracks, a maintenance traffic lane and an emergency walkway, with all power, signal, control and security systems.

5.2 Dual Level Option

This was Option 5 in *TP 9*. It comprises the following components:

1. Two parallel, dual level, approach highway structures, each carrying four traffic lanes and one Busway lane or one shared BRT / HOV / HOT lane on the upper levels, with an upper level shared use path for pedestrians and bicycles on one structure only.
2. A CRT guideway on the lower level of one of the approach roadways.
3. A combined, dual level, main span structure carrying the highways, BRT and shared use path on the upper levels and CRT on the lower level of one half.

5.2.1 Initial Build Phase

The work of this phase would comprise the erection of the highway approach and main span structures. The structures would be able to accommodate the future BRT and CRT components.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. Extensive inland staging areas, shorefront laydown and erection areas and in-water access platforms would be required, defined in TP 6/7.
2. Extensive dredging would be required to accommodate construction barges.
3. Each approach structure would be independently supported.
4. The approach and main span foundations would be large diameter driven steel pipe piles with embedment lengths up to 300 ft. Each would be filled with reinforced concrete.
5. The approach piers would be reinforced concrete.
6. The approach pan superstructures would be deep steel trusses with span lengths of 430 ft. The lower levels would consist of bracing only.
7. The main span would be a three-span cable-stayed structure with concrete pylons. The span lengths would be similar to the existing, with a 1,200 ft. central navigation span and two 600 ft. side spans.
8. The main span superstructures would be deep steel trusses.
9. The North trusses would be designed for the full loading of both the highway and CRT while the South trusses would be designed only for highway loading.

5.2.2 Final Build Phase

The work of this phase would comprise the addition of the CRT deck, rail and systems on the lower level of one of the structures.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. All work would be done on the lower deck of the superstructure with minimal impact on traffic operations and no dredging.
2. The bracing would be removed from the lower level of one of the structures and replaced with a steel floorbeam and stringer CRT superstructure.
3. The CRT deck would be concrete with concrete curbs or crash walls to restrain derailed trains.
4. The CRT guideway would include two tracks, a maintenance traffic lane and an emergency walkway, with all power, signal, control and security systems.

5.2.3 Step 4 – Validation of Assumptions

There are highly technical and challenging components of work in this estimate. Input from contractors who have performed this type and scale of work on similar projects was obtained for key activities including:

- Dredging
- Pile Driving
- Underwater Concrete Placement
- Cofferdam Construction
- Gantry Crane Launching
- Heavy Lifting of Segments
- Post-tensioning
- Cable Stays and Anchorages
- Formwork
- Marine Transportation.

6 Landings Scope

The two feasible corridor alternatives extend to the landings as well: BRT in Busway plus CRT; and BRT in HOV / HOT Lanes plus CRT. Each option has an Initial Build Phase and a Final Build Phase. The cost estimates reflect the scope of work in each of the construction phases. The work at the landings would be similar for both the Single Level and Dual Level Bridge Options.

6.1 Rockland Landings

The extents of the Rockland Landing work are from station 800+00 just west of Interchange 10 to the west shore of the river.

Elements common to the Busway and HOV / HOT options include:

1. Possible use of a staging area at Interchange 10 with a temporary haul road to the shore.
2. A waterfront staging area somewhere along the west shore of the river.
3. A temporary platform on the Rockland shore at the bridge site for staging and to accommodate NYSTA dock and maintenance facilities.

6.1.1 Busway Option

In Rockland, the work would comprise:

1. Reconstructing I-287 within these limits.
2. CRT in the center of I-287.
3. Busway in the center of I-287.

6.1.1.1 Initial Build Phase

The work in this phase would comprise highway improvements and all modifications necessary to accommodate the future Busway and CRT.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. I-287 would be reconstructed to its Final Build width to accommodate the future Busway and CRT.
2. The CRT alignment would begin at the abutment on grade and transition down into a cut and finally into a tunnel with its portal roughly at station 831. The open cut, and cut-and-cover tunnel would be constructed up to Interchange 10 in this phase.
3. Interchange 10 would be re-configured.
4. The Broadway Bridge over I-287 would be reconstructed to the Full Build length.
5. The Esposito Trail Bridge over I-287 would be constructed.
6. The Shared Use Path would be constructed on the north side of I-287 with a maintenance road below it.
7. The Rockland Landing Stormwater Treatment Area would be constructed.

6.1.1.2 Final Build Phase

The work of this phase would comprise adding the CRT tracks and systems and the Busway Lanes.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The Busway Lanes would be constructed. They would begin at the abutment at grade and transition down into an open cut and finally into a cut-and-cover tunnel with its portal at approximately Station 820 before Interchange 10. The tunnel would shift the Busway to the south side of I-287 and emerge just beyond Interchange 10. I-287 would be reconstructed in the vicinity of the tunnel.
2. The CRT tunnel would be extended to the east limit of the landing to meet the Rockland Corridor Tunnel.
3. The CRT track and systems would be installed.

6.1.2 BRT in HOV / HOT Lanes Option

In Rockland, the work would comprise:

1. Reconstructing I-287 within these limits.
2. CRT in the center of I-287.
3. BRT in HOV / HOT lanes in the center of I-287.

6.1.2.1 Initial Build Phase

The work in this phase would comprise highway improvements and all modifications necessary to accommodate the future BRT and CRT.

Scope

The work of this phase would be so similar to the Initial Phase of the Busway Option that a separate estimate is not warranted. The Busway Initial Build Phase estimate was used for both BRT options.

6.1.2.2 Final Build Phase

The work of this phase would comprise adding the CRT tracks and systems and the Busway Lanes.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The HOV / HOT Lanes would be constructed in the center of I-287.
2. The CRT tunnel would be extended to the east limit of the landing to meet the Rockland Corridor Tunnel.
3. The CRT tracks and systems would be installed.

6.2 Westchester Landings

The extents of the Westchester Landings are from the east shore of the river to the East Abutment at Station 1070+00 east of Interchange 9.

Elements common to the Busway and Buslanes options include:

1. An in-land staging area with temporary haul road to the shore.
2. A waterfront staging area somewhere on the east shore of the river.
3. A temporary platform at the shore as a staging area.
4. Relocation of the NYSTA and State Police facilities to Rockland.
5. Reconstruction and reconfiguration of the Toll Plaza.

6.2.1 Busway Option

In Westchester, the work would comprise:

1. Reconstructing I-287 within these limits.
2. CRT in the center of I-287.
3. Busway in I-287.
4. Interface with the Hudson Line Connector Tunnel (Short Tunnel or Long Tunnel).

5. Interface with the Tarrytown South Connector.

6.2.1.1 Initial Build Phase

The work in this phase would comprise highway improvements and all modifications necessary to accommodate the future Busway and CRT.

Scope

The Initial Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. I-287 would be reconstructed to its Final Build width to accommodate the future Busway and CRT.
2. Interchange 9 would be re-configured.
3. The cut-and-cover portion of the CRT Hudson Line Connector Tunnel (Short Tunnel or Long Tunnel) that crosses below I-287 would be constructed.
4. The BRT open cut in the center of I-287 and the tunnel under I-287 that continues it to the future Tarrytown BRT Station would be constructed.
5. The Tarrytown South Connector tunnel crossing below the Toll Plaza from the future Tarrytown BRT Station would be constructed.

6.2.1.2 Final Build Phase

The work of this phase would comprise installing the CRT tracks and systems.

6.2.2 Bus Lanes Option

In Westchester, the work would comprise:

1. Reconstructing I-287 within these limits.
2. CRT in the center of I-287.
3. Bus Lanes in I-287.
4. Interface with the Hudson Line Connector Tunnel (Short Tunnel or Long Tunnel).
5. Interface with the Tarrytown South Connector.

6.2.2.1 Initial Build Phase

The work in this phase would comprise highway improvements and all modifications necessary to accommodate the future Bus Lanes and CRT.

Scope

The work of this phase would be so similar to the Initial Phase of the Busway Option that a separate estimate is not warranted. The Busway Initial Build Phase estimate was used for both BRT options.

6.2.2.2 Final Build Phase

The work of this phase would comprise installing the CRT tracks and systems.

Scope

The work of this phase would be so similar to the Final Phase of the Busway Option that a separate estimate is not warranted. The Busway Final Build Phase estimate was used for both BRT options.

7 Hudson Line Connections Scope

Both the BRT and CRT would provide connections to the existing Metro-North Hudson Line in Westchester. These connectors fall largely within the limits of the Westchester Corridor, but portions fall within the limits of the Westchester Landing zone. Therefore, portions of this work have been estimated with the Initial Build Phase of the Westchester Landing, and the bulk of the work has been estimated with the Final Build Phase of the Westchester Corridor.

7.1 CRT Connection to Hudson Line

The CRT connection from the Tappan Zee Bridge to the Hudson Line in Westchester has two alignment options: a Long Tunnel and a Short Tunnel. These two emerged as feasible options from the *Tunnel and Trestle Report (TP 10).* The portions of these tunnels within the landing limits would be constructed during the Initial Build Phase (see Chapter 5). The remainder of these options would be constructed during the Final Build Phase.

7.1.1 Long Tunnel Option

The work of the Long Tunnel Option would comprise the following, accomplished during the Westchester Corridor Final Build Phase, except as noted:

1. Construction access shaft north of I-287.
2. Tunnel box from I-287 access shaft back to the tunnel box constructed in the Westchester Landing Initial Build Phase.
3. Bored tunnel from the I-287 access shaft down to the southwest corner of the Requa House property.
4. Cut-and-cover tunnel from end of the bored tunnel at Requa House southward under the Hudson Line.
5. Double track floodwall-protected portal from the end of the cut-and-cover tunnel to Hudson Line grade.
6. Miscellaneous track relocations.
7. Interlocking south of Sunnyside.
8. 5,000 feet of river wall, 2,500 feet of which is 2 feet into the Hudson River.
9. 1,200 foot diversion of an unnamed stream at New County Park.
10. Inboard staging area (likely at the foot of the Requa House property).
11. Vent shaft and fan building.
12. Interlocking south of Lyndhurst.

7.1.2 Short Tunnel Option

The work of the Short Tunnel Option would comprise the following, accomplished during the Westchester Corridor Final Build Phase, except as noted:

1. Cut-and-cover tunnel box from south of the Thruway to a portal in the northwest corner of the Kraft property.
2. Bridge span from the portal to a pier inboard of the Hudson Line.
3. Curved thru-truss bridge span from the pier to an abutment over Hudson Line Tracks 3 & 1.
4. Retained fill up from 25 ft. above Hudson Line grade at the abutment down to grade.
5. Relocation of outboard Hudson Line tracks.
6. 1,000 feet of river wall, inboard of the Hudson River.
7. Interlocking south of Lyndhurst.

7.2 BRT Connection to Hudson Line

The Tarrytown South Connector (TTSC) would be a BRT connection from the Broadway BRT Station to the north of I-287 in Westchester to the Existing Metro-North Hudson Line Tarrytown Station. A portion of the connector in a tunnel that crosses below the I-287 Toll Plaza would be constructed in the Initial Build Phase of the Westchester Landing (see Chapter 5). The remainder of the connector would be constructed during the Final Build Phase.

7.2.1 TTSC

The work of the TTSC would comprise the following, accomplished concurrently with the Westchester Corridor Final Build Phase, except as noted:

1. A 400 ft. long tunnel under the toll plaza from the proposed Broadway BRT Station to the north of I-287 to a portal south of the Toll Plaza (constructed during the Westchester Landing Initial Build Phase).
2. A 1,000 foot long structure beginning at the tunnel portal just south of the Toll Plaza (at elevation 103 ft.). The alignment curves north just in-board of and parallel to the Hudson Line and descends at a 7% grade, passing below the RTZB approach and reaching the Hudson line grade west of North Tappan Landing Road.
3. Busway on grade for a length of 3,500 ft. until reaching the Tarrytown Station.
4. BRT Station at the Hudson Line Tarrytown Station.

8 Westchester Corridor Scope

Two feasible corridor alternatives were identified in the *SSD* for Westchester: BRT in Busway; and BRT in Bus Lanes on local streets. There is no work in the Westchester Corridor in the Initial Build Phase; all work within the corridor would be accomplished during the Final Build Phase. The work within the Westchester Corridor would be the same with either the Single Level or Dual Level Bridge Options.

8.1 Busway Option

In Westchester, this corridor option comprises:

1. BRT in a dedicated Busway along the ROW's of I-287, the Cross Westchester Expressway and the Metro North New Haven Line for most of the corridor.
2. BRT on local streets at various locations.
3. Associated highway, interchange and ramp modifications to accommodate the Busway.

8.1.1 Final Build Phase

The work in this phase would comprise construction of the Busway and stations along with all associated highway and local street improvements and modifications. It extends from the BRT Tarrytown Station just north of the I-287 Toll Plaza, through White Plains to Port Chester, terminating at a BRT Station adjacent to the Metro-North New Haven Line at Westchester Ave., at Station 20743+00.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

1. The entire Westchester Corridor Busway would be constructed in this phase, running at-grade, aligned as follows:
   a. The Busway would begin at the BRT Tarrytown Station and run along the north side of the I-287 ROW, exiting north at Interchange 8 onto Benedict Ave. where the first station would be located.
   b. The alignment would turn east onto White Plains Road, then continue along the north side of the Cross Westchester Expressway ROW.
   c. The remainder of the alignment would generally be along the ROW of the Cross Westchester Expressway, deviating from it onto local streets and then returning to it.
   d. The alignment would turn north after Boston Post Road, at Interchange xx. The final segment would run along the west side of the Metro-North New Haven Line ROW to a BRT terminus Station at Westchester Ave. in Port Chester.
2. Connection ramps of various highways would be re-aligned to accommodate the Busway.
3. I-287 Interchange 9 would be reconstructed as part of the Initial Build Phase of the Westchester Landing.

10. Mill and fill treatment has been assumed for the segments of I-287 highway and ramps that would be affected but not widened.
11. The Busway would cross over streams and roadways on new structures adjacent and parallel to the on-line I-287 and Cross Westchester Expressway bridges crossing the same features.
12. Rock cuts for the Busway would need to be completed adjacent to the I-287 and Cross Westchester mainlines. MPT would be required on the highway mainlines to do this work.

8.2 BRT in Bus Lanes Option

In Westchester, this corridor option comprises:

1. BRT in Bus Lanes along the ROW's of the Cross Westchester Expressway and the Metro North New Haven Line for most of the corridor.
2. BRT on local streets at various locations, particularly in White Plains.
3. Associated highway, interchange and ramp modifications to accommodate the Busway.

8.2.1 Final Build Phase

The work in this phase would comprise construction of the Bus Lanes and stations along with all associated highway and local street improvements and modifications. It extends from the BRT Tarrytown Station just north of the I-287 Toll Plaza, through White Plains to Port Chester, terminating at a BRT Station adjacent to the Metro-North New Haven Line at Westchester Ave., at Station 20743+00.

Scope

The Final Build plans, sequence of construction and estimate are based on the following scope assumptions:

4. The entire Westchester Corridor Bus Lanes would be constructed in this phase, running at-grade, aligned as follows:
   a. The Bus Lanes would begin at the BRT Tarrytown Station and run along the north side of the I-287 ROW, exiting immediately at Interchange 9 onto the median of White Plains Road.
   b. The Bus Lanes would continue along White Plains Road until its interchange with the Cross Westchester Expressway.
   c. The Bus Lanes would continue along the south side of the Expressway ROW unitl exiting after Hillside Ave. onto local streets through White Plains.
   d. The Bus Lanes would re-join the Expressway at Interchange xx, continuing to Boston Post Road.
   e. The alignment would turn north after Boston Post Road, at Interchange xx. The final segment would run along the west side of the Metro-North New Haven Line ROW to a BRT terminus Station at Westchester Ave. in Port Chester.
5. Connection ramps of various highways would be re-aligned to accommodate the Bus Lanes.
6. I-287 Interchange 9 would be reconstructed as part of the Initial Build Phase of the Westchester Landing.

13. Mill and fill treatment has been assumed for the segments of the Expressway and ramps that would be affected but not widened.
14. The Bus Lanes would cross over streams and roadways on new structures adjacent and parallel to the on-line Cross Westchester Expressway bridges crossing the same features.
15. Rock cuts for the Bus Lanes would need to be completed adjacent to the Cross Westchester mainline. MPT would be required on the Expressway mainline to do this work.

9 Risk-Based Contingency

The development of the various components of the project has been done at a planning level. Key elements of each project component have been identified and designed to 15% completion, which leaves substantial uncertainty in the cost estimates.

Since the RTZB would be a unique and complex undertaking the Initial Build Bridge and Landing components have been studied in greater detail (Tier 2) than the Final Build Highway, BRT and CRT components (Tier 1). The greater complexity and more detailed study of the Initial Build Components justify a more detailed assessment of the uncertainty in the Initial Build cost estimates, using a probabilistic method. The construction contingency addresses the uncertainties in the construction estimating process.

The full results of the construction contingency modeling are presented in Appendix D.

9.1 Programmatic Risks

There are many higher-level risks that can affect the ultimate project cost that are *not accounted for in the construction contingency*. These include, but are not limited to:

1. Schedule delays:
   a. Growth of EIS scope
   b. Legal challenges to the EIS Record-of-Decision
   c. Political challenges to the project
   d. Design delivery
   e. Legal challenges to contract award
   f. Design changes during construction
   g. Permitting and environmental mitigation
   h. Legal challenges to Right-of-Way acquisitions
2. Market timing:
   a. Skilled labor availability
   b. Material availability; cost increases due to large-scale or international forces
   c. Equipment availability
   d. Cost of Right-of-Way acquisitions
3. Construction claims: design errors and omissions
4. Geotechnical: substantially different site conditions.

These programmatic risks will be accounted for and managed in a separate process under development.

9.2 Assessment of Uncertainty

9.2.1 Approach

If a database of percent errors between pre-construction estimated costs and actual construction costs for bid items was available that could be aggregated similarly to the Level 1 bid items for this project, statistical analysis of that database could be done to establish contingencies with very high confidence. Since no such database exists, Monte Carlo Simulations were used to artificially create an approximation of that database. The simulations were done in the commercial simulation software *@Risk*.

9.2.2 Identifying Risk Variables

Given the large number of construction tasks that have been estimated to build-up the total cost, it would be unwieldy to develop a contingency amount for each task. Additionally, Monte Carlo simulations become less useful as the number of variables in the simulation models increase. As a consequence of the Law of Large Numbers the result tends strongly towards the average of the assumed range of total error when large numbers of variables are included. The Level 1 bid items were modeled since they provide an appropriate number of variables (9 to 13 bid items) for the simulations. Five simulations were run, for the Level 1 bid items of the following five Initial Build Phase components:

1. Single Level Bridge
2. Dual Level Bridge
3. Rockland Corridor – Busway
4. Rockland Corridor – BRT in HOV / HOT Lanes
5. Rockland and Westchester Landings (combined).

9.2.3 Identifying Key Uncertainties

First, a measure of the degree of uncertainty associated with each Level 1 bid item was developed. These were subjective judgments, based on the experience and expertise of the engineers involved in the project. A logical structure was used to identify the key uncertainties in the construction cost estimate, focusing on the estimate input factors.

The bottom-up cost estimates for the Initial Build components were based on the following nine *Heavy Bid* inputs:

1. *Construction Tasks*: Each bid item was broken down into one or more construction tasks, at which level the detailed estimate was done.
2. *Bid Item Quantities*: Taken-off from the Benchmark 1 CAD files and TP 6/7 (e.g. total length of approach piles in each zone).
3. *Material Quantities*: The calculated quantities needed for each construction task (cubic yards of concrete in the approach piles, pounds of associated rebar, etc.)
4. *Material Costs*: The unit costs of the various materials.
5. *Crew Make-ups:* Specific crews designated for each construction task (which trades, how many of each, etc.)
6. *Labor Rates:* The cost of labor, including salary and all burdens (benefits, taxes, etc.)
7. *Crew Productivity Rates:* The production rates of each specific crew in each construction task (cubic yards of concrete placed in a shift, etc.)
8. *Equipment:* The equipment selected for each specific construction task (cranes, trucks, weld units, etc.)
9. *Equipment Rates:* The cost of either purchasing or leasing the equipment, along with operating costs.

It would again be practically and mathematically undesirable to assess the uncertainty in all nine input factors for each Level 1 bid item of all five components, for the same reasons it would be undesirable to assess the uncertainty in every construction task.

While there is some degree of uncertainty associated with each of these factors, the uncertainty associated with some is greater than others. Experienced estimators can make reasonable judgments about the make-up of specific crews and the equipment required for a given construction task, and experience has shown that cost estimates are relatively insensitive to these input assumptions. Material costs were researched with regional suppliers; labor rates were established from regional union contracts; and equipment costs are well documented in published resources. A conservative inflation rate has been applied to these (and all) costs to allow for escalation of theses rates. The uncertainty associated with these input factors has been greatly reduced by this research and the conservative inflation rate itself is a contingency.

Therefore, the assessment of uncertainty focused on the remaining four factors:

1. *Construction Tasks*: While a large number of construction tasks were estimated the list is not exhaustive, and field conditions can require additional unanticipated tasks.
2. *Bid Item Quantities*: Although the quantities have been taken-off from the CAD drawings with precision, the drawings are still at only 15% development, so there is still uncertainty in the quantities.
3. *Material Quantities*: As the designs are only to 15%, the material quantities associated with each bid item quantity are still rough estimates.
4. *Crew Productivity Rates*: Even at final design, these assumptions are not certain.

9.2.4 Quantifying the Uncertainties

The uncertainty associated with the four key estimate factors was qualitatively assessed for each bid item. As an example:

Highway, BRT and CRT Level 1 bid item: Rock Excavation:

Construction Tasks: ***Moderate Uncertainty*.** Without field investigation of the rock to establish its characteristics, it is not known if additional construction tasks, such as rock bolting to stabilize rock faces, would be required.

Bid Item Quantities: ***High Uncertainty*.** The quantity of rock to be excavated has been estimated from topographic surveys, with no specific investigation of the rock formations, quality of rock, etc.

Material Quantities: ***Low Uncertainty*.** Few materials would be needed for excavation.

Crew Productivity Rates: ***High Uncertainty*.** The production rates are sensitive to the rock characteristics, which are not yet established.

With high uncertainty in two of the estimate model input factors and moderate uncertainty in a third, we judged that the actual cost of rock excavation could range from 20% below the estimate cost to twice the estimate cost. This is consistent with our experience on other construction projects.

This range was expressed as percentages of the Base Construction Cost of Rock Excavation:

Minimum: 80% of Base Construction Cost

Maximum: 200% of Base Construction Cost.

The Base Construction Cost was multiplied by these percentages to derive minimum and maximum costs for Rock Excavation.

Similar assessments of uncertainty were done for each Level 1 bid item of the five Initial Build components. A summary of this assessment for the Single Level Bridge, Initial Build Phase is presented in Table 9-1as an example.

Single Level Bridge - Initial Build							
Simulation Input Variables							
		Range (%)			Range ($)		
WBS Cost Elements	Base Construction Cost	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Site Access Set Up	$ 31,648,907	99%	100%	115%	$ 31,332,418	$ 31,648,907	$ 36,396,244
Dredging	$ 65,724,230	90%	100%	125%	$ 59,151,807	$ 65,724,230	$ 82,155,288
Temporary Access Trestle	$ 152,250,224	75%	100%	200%	$ 114,187,668	$ 152,250,224	$ 304,500,448
Approach Piles	$ 514,890,264	95%	100%	300%	$ 489,145,751	$ 514,890,264	$ 1,544,670,793
Approach Pilecaps and Piers	$ 265,390,227	90%	100%	150%	$ 238,851,204	$ 265,390,227	$ 398,085,341
Approach Superstructures	$ 378,080,651	95%	100%	175%	$ 359,176,619	$ 378,080,651	$ 661,641,140
Main Span Piles	$ 75,160,468	95%	100%	300%	$ 71,402,444	$ 75,160,468	$ 225,481,403
Main Span Pilecaps and Pylons	$ 123,507,252	95%	100%	150%	$ 117,331,889	$ 123,507,252	$ 185,260,878
Main Superstructure	$ 146,262,992	90%	100%	300%	$ 131,636,693	$ 146,262,992	$ 438,788,976
Abutments	$ 20,060,136	90%	100%	115%	$ 18,054,122	$ 20,060,136	$ 23,069,156
Deck & Appurtenances	$ 61,761,498	99%	100%	130%	$ 61,143,883	$ 61,761,498	$ 80,289,947
Demolition of Existing TZB	$ 235,659,741	95%	100%	175%	$ 223,876,754	$ 235,659,741	$ 412,404,546
Contractor Indirect Costs	$ 491,674,838	95%	100%	150%	$ 467,091,096	$ 491,674,838	$ 737,512,257
Total Cost	**$ 2,562,071,429**				**$ 2,382,382,350**	**$ 2,562,071,429**	**$ 5,130,256,417**

Table 9-1 - Simulation Input Variables – Single Level Bridge

9.2.5 Limitations of a Deterministic Approach

If a deterministic approach were used with these assessments the results would be unrealistic. The maximum Total Cost works out to twice the estimated Base Construction Cost. This would represent a 100% contingency, which is unrealistically large. This cost could only be realized if the worst case (maximum) costs were realized on all 13 bid items, a highly unlikely circumstance. Even the average of the total minimum-to-maximum range, $3,756,319,384, would represent a 47% contingency, which is also unrealistically large. The extremes tend to dominate the results of deterministic methods, leading to excessive contingency estimates.

Probabilistic methods provide a more rational and objective way to account for the fact that combinations of extreme values are unlikely to occur.

9.3 Monte Carlo Simulation

9.3.1 Methodology

This method treats the true construction cost of each bid item as a Random Variable, just as statistical analysis of an actual database would. All that is known about each Random Variable are the three input values in Table 9-1 above: the minimum value, most likely value, and maximum value. Random Variables with this characteristic are best described by the Triangular Distribution Function, illustrated in Figure 9-1. Since the maximum and minimum values are not symmetrical about the most likely value, the shape of the distribution is markedly asymmetric.

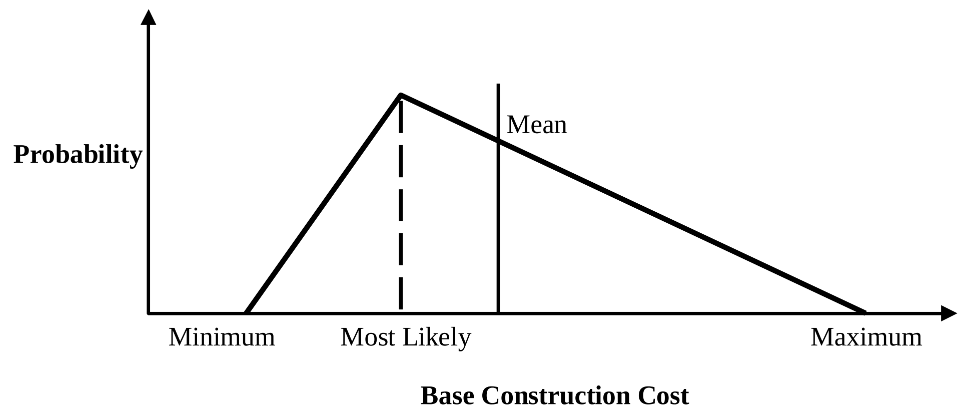


Figure 9-1 - Typical Asymmetric Triangular Probability Distribution Function

To create the artificial database, the software generated a random number between 0 and 1 for each bid item, multiplied the difference between the maximum and minimum values for each bid item by the corresponding random number, and then added the product to the minimum value. This created one possible value of each Random Variable that fell somewhere between the minimum and maximum values. The possible values for all of the Level 1 bid items calculated this way then were summed. This sum was one possible value of the Total Base Construction Cost plus Contingency, which is also a Random Variable. This completed one iteration of the simulation.

The simulation was run for 10,000 iterations, providing a database of 10,000 randomly generated possible values for the Total Base Construction Cost plus Contingency. Since this Random Variable is the sum of other Random Variables it is Normally Distributed (regardless of the distributions of the individual Random Variables being summed), illustrated in Figure 9-2. Since the underlying distributions are asymmetric, the resulting Normal Distribution also is asymmetric, although to a lesser degree than the underlying triangular distributions.

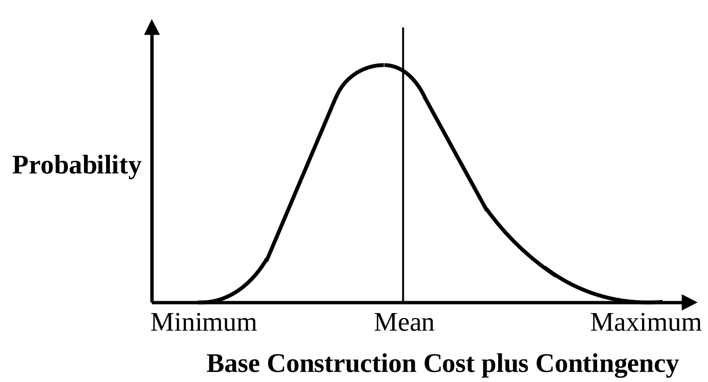


Figure 9-2 - Typical Asymmetric Normal Distribution

The results of a probabilistic analysis using the Normal Distribution are dominated by the strong central tendency (values around the mean are most probable), not by the extreme values, providing more realistic results.

9.3.2 Presentation of Results

Figure 9-3 presents the Cumulative Distribution Function for the Base Construction Cost plus Contingency of the Single Level Bridge Option, Initial Build Phase.

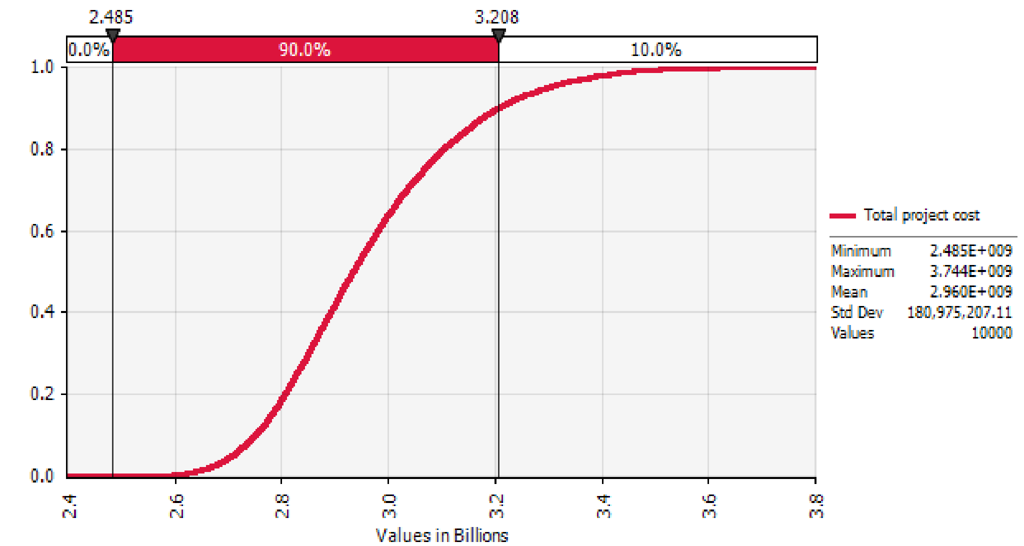


Figure 9-3 - Cumulative Distribution Function for Single Level Bridge Option, Initial Build Phase

A one-sided confidence limit is typically selected to represent the Total Base Construction Cost plus contingency. FHWA guidance suggests using an 85% confidence limit. At this early stage of planning and design, a more conservative 90% confidence limit was selected. Based on this artificial Probability Distribution Function, the true construction cost would be expected to be less than or equal to this limit with 90% confidence.

The small table to the side of Figure 10-3 shows that the minimum of the 10,000 values for the Base Construction Cost plus Contingency generated in the simulation was $2.485 billion (rounded), which is greater than the deterministic minimum of $2.382 billion; the maximum simulation value was $3.744 billion, far less than the deterministic maximum of $5.130 billion. The highly unlikely circumstance of many maximum or minimum values of the 13 bid item costs occurring simultaneously did not appear in 10,000 iterations, suggesting that such extreme cases are too unlikely to base contingencies on.

The 90% confidence limit and corresponding contingency are presented in Table 9-2.

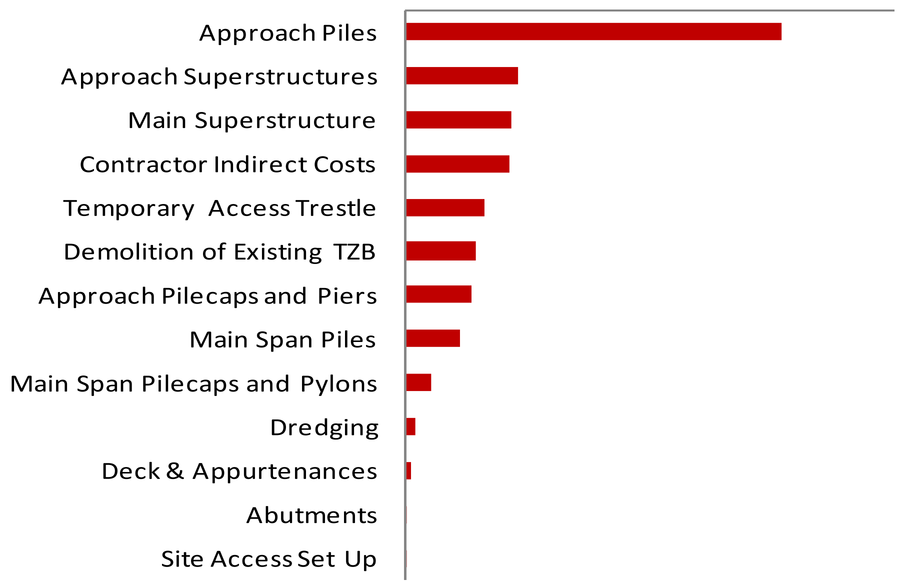
Simulation Results		
90% Confidence Limit on Total Cost:	$	3,207,538,947
Contingency Required for 90% Confidence ($):	$	645,467,518
Contingency Required for 90% Confidence (%):		**25%**

Table 9-2 - Simulation Results for the Single Level Bridge Option, Initial Build Phase

Note that the 25% contingency is significantly less even than the average value from the deterministic approach discussed in Section 9.2.5, which was 47%.

9.4 Sensitivity

A Tornado Diagram was generated for each simulation, illustrated in Figure 9-4. This is a sensitivity analysis tool that shows the relative influence of each bid item on the total Construction Cost plus Contingency. Specifically, the diagram shows the relative change in the total cost due to a +1 standard deviation increase in each Level 1bid item cost (as calculated from each individual triangular distribution).



Tornado Diagram – Single Level Bridge Initial Build Phase

Figure 9-4 - Relative Influence on Total Cost

The bid items are listed in the order of greatest influence on total cost, which is a combination of the size of the Base Construction Cost and the expected minimum – maximum range. Efforts to decrease the uncertainty of the bid items with the greatest influence on the total cost through enhanced field investigation, detailed design, development of detailed construction methods and staging, etc. during later stages of design would be expected to yield the greatest cost benefit. This analysis will assist the design and management team to focus their efforts on the most sensitive elements of the project at each stage.

10 Comparison with Previous Cost Estimates

10.1 Scoping Estimates

Construction cost estimates were prepared during the scoping phase as part of the alternatives screening process. The estimates for the numerous transit and bridge alternatives under consideration during scoping were prepared initially in 2004 in support of the *Transit Mode Selection Report (TMSR)* and the *Alternatives Analysis for Rehabilitation and Replacement of the Tappan Zee Bridge Report (R&R Report)*, and were updated for final issue in 2008. These estimates were intended to support comparison between the alternatives. The alternatives were developed to the concept level only, so the cost estimates could only be developed to a corresponding level, relying on conservative assumptions for General Conditions, Overhead and Profit, Soft Costs, and Contingency.

A comparison of the methods used in the Scoping Phase estimates and the DEIS estimates is presented in Table 10-1.

10.2 TP 9 Bridge Estimates

More detailed cost estimates were undertaken in 2010 to better inform the comparison of the six bridge options considered in *Feasible Alternatives for the Replacement Tappan Zee Bridge (TP 9)*. These were detailed bottom-up estimates in *Heavy Bid*. They included Work Breakdown Structures with many more construction tasks than used in the earlier scoping estimates, and updated labor, equipment and material costs. However, the *TP 9* estimates used the same assumptions for General Conditions, Overhead and Profit, Soft Costs, and Contingency as the earlier Scoping estimates. The final issue of these estimates was in 2011.

10.3 DEIS Estimates

Only Options 3 and 5 from *TP 9* were selected for consideration in the DEIS. The *TP 9* cost estimates for these two options formed the starting point for the DEIS estimates of the Single Level and Dual Level Options, respectively, in this report. The build-ups in *Heavy Bid* were updated and extended, Monte Carlo simulations were added for the Initial Build contingencies, and new assumptions were adopted for General Conditions, Overhead and Profit, and Soft Costs. The estimates were structured specifically to support the DEIS and were generally more rigorous, to increase confidence in the DEIS costs.

Estimate Methodology Comparison		
Element	**Scoping Estimates**	**DEIS Estimates**
Objective	Comparison between alternatives; to support selection of alternatives to be included in the DEIS	To support selection of the preferred alternative; increase confidence in the estimates for public release in DEIS
Limits of RTZB	From Broadway Bridge in Rockland to Broadway Bridge in Westchester	Abutment-to-abutment
Terminus of BRT in Westchester	White Plains	Port Chester
Quantity take-off	Hand scaled from hard copies of 300 scale drawings	Generated electronically from 100 scale CAD files (Benchmark 1)
Estimate method	Representative unit cost method, with bottom-up unit costs developed in spreadsheet format	*Initial Build:* Detailed build-up from Work Breakdown Structure with hundreds of individual construction tasks; based on methodology in TP 6/7; done in *Heavy Bid,* commercial heavy construction estimating software *Final Build:* Representative unit cost method, with bottom-up unit costs developed in *Heavy Bid*
Labor rates	NYSDOT Prevailing Wage Rates	Regional union contracts
Material and equipment costs	Estimating subconsultant's proprietary database and published resources	Research with local and regional suppliers and published resources
Base Construction Cost	Total of direct construction costs	Total of direct construction costs plus Project Indirect Costs (equivalent to General Conditions and Overhead)
Contingency	30% of Base Construction Cost	*Initial Build:* Risk-based Monte Carlo simulations: Bridge, Highway: 24% of Base Construction Cost Landings: 33% of Base Construction Cost *Final Phase:* All components: 30% of Base Construction Cost
General Conditions, Overhead and Profit	*General Conditions*: 15% of Base Construction Cost *Overhead and Profit*: 15% of Base Construction Cost	*General Conditions and Overhead:* Bridge: Detailed build-up (called Project Indirect Costs and included in Base Construction Cost); equal to 24% of project direct construction cost Highway, BRT, CRT: 25% of Base Construction Cost *Profit:* All components: 12% of Base Construction Cost plus Contingency plus Add-ons
Soft Costs	30% of Base Construction Cost; included the agency costs for NYSDOT, NYSTA, Metro North	10% of Base Construction Cost plus Contingency plus Add-ons; does not include agency costs
Base year for dollars	2004	2010
Escalation	To 2007 at 6% per year (19%); then to 2012 at 4.5% per year (25%)	To 2015 at 4.5% per year (25%)

Table 10-1 - Comparison of Scoping Phase and DEIS Cost Estimate Methodologies

Appendix A

DEIS Alternatives Summary

DEIS Alternatives - Summary

TZB / I-287 Corridor Study
DEIS Cost Estimates
3 May 2011

Initial Build - Highway and Bridge Tier 2
(Costs in millions; Year 2015 dollars)

EIS Alternative			Rockland				Bridge		Westchester		Project Total
			Corridor		Landings				Landings		
			Busway	HOV / HOT	Busway	HOV / HOT	Single Level	Dual Level	Busway	Buslanes	
B	Full-Corridor Busway Rockland CRT	Single Level	$ 1,210		$ 397		$ 4,936		$ 563		**$ 7,105**
		Dual Level	$ 1,210		$ 397			$ 5,106	$ 563		**$ 7,275**
C	Busway in Rockland Bus Lanes in Westchester Rockland CRT	Single Level	$ 1,210		$ 397		$ 4,936			$ 580	**$ 7,123**
		Dual Level	$ 1,210		$ 397			$ 5,106		$ 580	**$ 7,293**
D	BRT in HOV/HOT Lanes in Rockland Busway in Westchester Rockland CRT	Single Level		$ 3,645		$ 397	$ 4,936		$ 563		**$ 9,541**
		Dual Level		$ 3,645		$ 397		$ 5,106	$ 563		**$ 9,710**
E	BRT in HOV/HOT Lanes in Rockland Bus Lanes in Westchester Rockland CRT	Single Level		$ 3,645		$ 397	$ 4,936			$ 580	**$ 9,558**
		Dual Level		$ 3,645		$ 397		$ 5,106		$ 580	**$ 9,728**

Average:	**$ 8,417**
Minimum:	**$ 7,105**
Maximum:	**$ 9,728**
Range:	**$ 2,623**

Initial Build			
EIS Alternative	Cost Range		
B	$7,105	to	$7,275
C	$7,123	to	$7,293
D	$9,541	to	$9,710
E	$9,558	to	$9,728

Final Build - Transit Tier 1
(Costs in millions; Year 2015 dollars)

EIS Alternative			Rockland				Bridge		Westchester							Project Total
			Corridor		Landings				Landings		CRT Connection			Corridor		
			Busway	HOV / HOT	Busway	HOV / HOT	Single Level	Dual Level	Busway	Buslanes	Long Tunnel	Short Tunel	TTSC	Busway	Buslanes	
B	Full-Corridor Busway Rockland CRT	Single / Long	$ 6,178		$ 138		$ 714		$ 19		$ 923		$ 91	$ 1,935		$ 9,998
		Single / Short	$ 6,178		$ 138		$ 714		$ 19			$ 300	$ 91	$ 1,935		$ 9,375
		Dual / Long	$ 6,178		$ 138			$ 392	$ 19		$ 923		$ 91	$ 1,935		$ 9,676
		Dual / Short	$ 6,178		$ 138			$ 392	$ 19			$ 300	$ 91	$ 1,935		$ 9,053
C	Busway in Rockland Bus Lanes in Westchester Rockland CRT	Single / Long	$ 6,178		$ 138		$ 714			$ 19	$ 923		$ 91		$ 1,164	$ 9,227
		Single / Short	$ 6,178		$ 138		$ 714			$ 19		$ 300	$ 91		$ 1,164	$ 8,604
		Dual / Long	$ 6,178		$ 138			$ 392		$ 19	$ 923		$ 91		$ 1,164	$ 8,904
		Dual / Short	$ 6,178		$ 138			$ 392		$ 19		$ 300	$ 91		$ 1,164	$ 8,282
D	BRT in HOV/HOT Lanes in Rockland Busway in Westchester Rockland CRT	Single / Long		$ 4,079		$ 122	$ 714		$ 19		$ 923		$ 91	$ 1,935		$ 7,883
		Single / Short		$ 4,079		$ 122	$ 714		$ 19			$ 300	$ 91	$ 1,935		$ 7,260
		Dual / Long		$ 4,079		$ 122		$ 392	$ 19		$ 923		$ 91	$ 1,935		$ 7,561
		Dual / Short		$ 4,079		$ 122		$ 392	$ 19			$ 300	$ 91	$ 1,935		$ 6,938
E	BRT in HOV/HOT Lanes in Rockland Bus Lanes in Westchester Rockland CRT	Single / Long		$ 4,079		$ 122	$ 714			$ 19	$ 923		$ 91		$ 1,164	$ 7,112
		Single / Short		$ 4,079		$ 122	$ 714			$ 19		$ 300	$ 91		$ 1,164	$ 6,489
		Dual / Long		$ 4,079		$ 122		$ 392		$ 19	$ 923		$ 91		$ 1,164	$ 6,790
		Dual / Short		$ 4,079		$ 122		$ 392		$ 19		$ 300	$ 91		$ 1,164	$ 6,167

Average:	**$ 8,312**
Minimum:	**$ 6,167**
Maximum:	**$ 9,998**
Range:	**$ 3,831**

Final Build			
EIS Alternative	Cost Range		
B	$9,053	to	$9,998
C	$8,282	to	$9,227
D	$6,938	to	$7,883
E	$6,167	to	$7,112

Full Build - All Components
(Costs in millions; Year 2015 dollars)

EIS Alternative			Rockland				Bridge		Westchester							Project Total
			Corridor		Landings				Landings		CRT Connection			Corridor		
			Busway	HOV / HOT	Busway	HOV / HOT	Single Level	Dual Level	Busway	Buslanes	Long Tunnel	Short Tunel	TTSC	Busway	Buslanes	
B	Full-Corridor Busway Rockland CRT	Single / Long	$ 7,387		$ 535		$ 5,650		$ 582		$ 923		$ 151	$ 1,935		**$ 17,163**
		Single / Short	$ 7,387		$ 535		$ 5,650		$ 582			$ 300	$ 151	$ 1,935		**$ 16,540**
		Dual / Long	$ 7,387		$ 535			$ 5,498	$ 582		$ 923		$ 151	$ 1,935		**$ 17,010**
		Dual / Short	$ 7,387		$ 535			$ 5,498	$ 582			$ 300	$ 151	$ 1,935		**$ 16,388**
C	Busway in Rockland Bus Lanes in Westchester Rockland CRT	Single / Long	$ 7,387		$ 535		$ 5,650			$ 600	$ 923		$ 151		$ 1,164	**$ 16,409**
		Single / Short	$ 7,387		$ 535		$ 5,650			$ 600		$ 300	$ 151		$ 1,164	**$ 15,787**
		Dual / Long	$ 7,387		$ 535			$ 5,498		$ 600	$ 923		$ 151		$ 1,164	**$ 16,257**
		Dual / Short	$ 7,387		$ 535			$ 5,498		$ 600		$ 300	$ 151		$ 1,164	**$ 15,634**
D	BRT in HOV/HOT Lanes in Rockland Busway in Westchester Rockland CRT	Single / Long		$ 7,724		$ 519	$ 5,650		$ 582		$ 923		$ 151	$ 1,935		**$ 17,483**
		Single / Short		$ 7,724		$ 519	$ 5,650		$ 582			$ 300	$ 151	$ 1,935		**$ 16,861**
		Dual / Long		$ 7,724		$ 519		$ 5,498	$ 582		$ 923		$ 151	$ 1,935		**$ 17,331**
		Dual / Short		$ 7,724		$ 519		$ 5,498	$ 582			$ 300	$ 151	$ 1,935		**$ 16,708**
E	BRT in HOV/HOT Lanes in Rockland Bus Lanes in Westchester Rockland CRT	Single / Long		$ 7,724		$ 519	$ 5,650			$ 600	$ 923		$ 151		$ 1,164	**$ 16,730**
		Single / Short		$ 7,724		$ 519	$ 5,650			$ 600		$ 300	$ 151		$ 1,164	**$ 16,107**
		Dual / Long		$ 7,724		$ 519		$ 5,498		$ 600	$ 923		$ 151		$ 1,164	**$ 16,577**
		Dual / Short		$ 7,724		$ 519		$ 5,498		$ 600		$ 300	$ 151		$ 1,164	**$ 15,955**

Average:	**$ 16,559**
Minimum:	**$ 15,634**
Maximum:	**$ 17,483**
Range:	**$ 1,849**

Full Build			
EIS Alternative	Cost Range		
B	$16,388	to	$17,163
C	$15,634	to	$16,409
D	$16,708	to	$17,483
E	$15,955	to	$16,730

Appendix B

DEIS Alternative Components Summary

DEIS Alternatives - Component Summary

I-287 / Tappan Zee Bridge Corridor Project
DEIS Cost Estimates
3 May 2011

Initial Build - Highway and Bridge Tier 2

(Costs in millions)

Element		Alternative Components												
		Rockland				Bridge		Westchester						
		Corridor		Landings				Landings		CRT Hudson Line Connection			Corridor	
		Busway	HOV / HOT	Busway	HOV / HOT	Single Level	Dual Level	Busway	HOV / HOT	Long Tunnel	Short Tunnel	TTSC	Busway	Buslane
BRIDGE (Abutment to Abutment)														
Site Work														
Site Access and Staging Areas						$ 31.65	$ 31.65							
Dredge and Armor						$ 65.72	$ 65.72							
Temporary Access Trestle						$ 152.25	$ 152.25							
West Approach														
Piles						$ 439.13	$ 318.55							
Cap and Pier						$ 199.18	$ 146.45							
Superstructure						$ 266.93	$ 516.40							
Main Span														
Piles						$ 75.16	$ 75.16							
Cap and Pylon						$ 123.51	$ 123.51							
Superstructure						$ 146.26	$ 146.26							
East Approach														
Piles						$ 75.76	$ 37.49							
Cap and Pier						$ 66.21	$ 63.05							
Superstructure						$ 111.15	$ 224.52							
Abutments														
East and West						$ 20.06	$ 20.06							
Misc.														
Deck, Signage, Lighting, and Appurtenances						$ 61.76	$ 61.76							
Demolition of Existing Bridge						$ 235.66	$ 235.66							
Track Infrastructure														
Indirect Construction Costs						$ 491.67	$ 431.70							
BASE CONSTRUCTION COST						**$ 2,562.07**	**$ 2,650.20**							
Construction Contingency														
Single Level	24%					$ 614.90								
Dual Level	24%						$ 636.05							
SUBTOTAL						**$ 3,176.97**	**$ 3,286.25**							
Construction Add-ons														
MPT	1%					$ 31.77	$ 32.86							
Profit	12%					$ 381.24	$ 394.35							
TOTAL CONSTRUCTION COST						**$ 3,589.97**	**$ 3,713.46**							
Soft Costs														
Design Engineering	2%					$ 71.80	$ 74.27							
Program Management	2%					$ 71.80	$ 74.27							
Construction Management	3%					$ 107.70	$ 111.40							
Construction Inspection	2%					$ 71.80	$ 74.27							
Construction Support Services	1%					$ 35.90	$ 37.13							
(Soft Costs) SUBTOTAL						**$ 359.00**	**$ 371.35**							
(Total Contruction & Soft Costs) SUBTOTAL						**$ 3,948.97**	**$ 4,084.80**							
Escalation to 6/2015 (4.5% yearly)	25%					$ 987.24	$ 1,021.20							
BRIDGE TOTAL						**$ 4,936.21**	**$ 5,106.01**							
HIGHWAY														
Demolition - Structures		$ 14.37	$ 33.86	$ 3.29	$ 3.29			$ 9.34	$ 9.34					
Earthwork		$ 9.05	$ 16.60											
Rock Excavation		$ 104.63	$ 433.29											
Retaining Walls - Fill			$ 33.73	$ 3.73	$ 3.73			$ 1.59	$ 3.02					
Retaining Walls - Cut			$ 166.23	$ 21.59	$ 21.59			$ 3.02	$ 3.02					
Vegetated Rock Slope		$ 0.09	$ 56.32											
Noise Walls		$ 0.35	$ 17.37											
Bridge - Thruway on structure		$ 26.15	$ 42.67					$ 44.27	$ 48.69					
Bridge - Structures over Thruway		$ 37.82	$ 89.14	$ 7.29	$ 7.29									
Bridge - Temporary Bridges		$ 18.91	$ 44.57											
Thruway Pavement & Finishes		$ 83.71	$ 132.52	$ 13.64	$ 13.64			$ 20.72	$ 21.66					
Interchange Ramps		$ 76.64	$ 154.17	$ 18.98	$ 18.98			$ 3.00	$ 3.00					
Drainage		$ 33.76	$ 82.26	$ 10.00	$ 10.00			$ 10.00	$ 10.00					
State and Local Roads														
Local Road Pavement & Finishes		$ 8.36	$ 61.15											
Pedestrain Facilities														
Paths, Connections, etc.		$ 12.50	$ 25.00	$ 7.50	$ 7.50			$ 85.00	$ 85.00					
Utilities														
All - Public and Private		$ 69.34	$ 104.75	$ 10.00	$ 10.00			$ 10.00	$ 10.00					
BUS RAPID TRANSIT														
Earthwork														
Rock Excavation														
Retaining Walls - Fill														
Retaining Walls - Cut														
Viaduct														
Bridges														
Tunnels - Cut / Cover												$ 22.75		
Texas T - Ramps														
Texas T - Bridges														
Texas T - At Grade Pavements														
Stations														
Depots														
Pavement and Finishes														
Interchange Ramps														
Intelligent Transportation Systems (ITS)														
Drainage														
Utilities														
COMMUTER RAIL TRANSIT														
Earthwork														
Retaining Walls - Fill														
Retaining Walls - Cut														
Viaduct														
Tunnels - Cut / Cover				$ 55.65	$ 55.65			$ 28.00	$ 28.00					
Bridges														
Tunnels - TBM														
Stations														
Track Infrastructure														
Signal Systems														
Drainage														
Substations, Vent Buildings, Access Shafts														
SUBTOTAL		**$ 495.67**	**$ 1,493.63**	**$ 151.67**	**$ 151.67**			**$ 214.94**	**$ 221.72**			**$ 22.75**		
Indirect Costs	25%	$ 123.92	$ 373.41	$ 37.92	$ 37.92			$ 53.74	$ 55.43			$ 5.69		
BASE CONSTRUCTION COST		**$ 619.59**	**$ 1,867.04**	**$ 189.58**	**$ 189.58**			**$ 268.68**	**$ 277.15**			**$ 28.44**		
Construction Contingency														
Landings	33%			$ 62.56	$ 62.56			$ 88.66	$ 91.46			$ 9.38		
Highway	24%	$ 148.70	$ 448.09											
(Base Construction & Contingency) SUBTOTAL		**$ 768.29**	**$ 2,315.13**	**$ 252.15**	**$ 252.15**			**$ 357.34**	**$ 368.61**			**$ 37.82**		
Construction Add-ons														
MPT	2.5%	$ 19.21	$ 57.88	$ 6.30	$ 6.30			$ 8.93	$ 9.22			$ 0.95		
Profit	12%	$ 92.19	$ 277.82	$ 30.26	$ 30.26			$ 42.88	$ 44.23			$ 4.54		
TOTAL CONSTRUCTION COST		**$ 879.69**	**$ 2,650.82**	**$ 288.71**	**$ 288.71**			**$ 409.15**	**$ 422.06**			**$ 43.31**		
Soft Costs														
Design Engineering	2%	$ 17.59	$ 53.02	$ 5.77	$ 5.77			$ 8.18	$ 8.44			$ 0.87		
Program Management	2%	$ 17.59	$ 53.02	$ 5.77	$ 5.77			$ 8.18	$ 8.44			$ 0.87		
Construction Management	3%	$ 26.39	$ 79.52	$ 8.66	$ 8.66			$ 12.27	$ 12.66			$ 1.30		
Construction Inspection	2%	$ 17.59	$ 53.02	$ 5.77	$ 5.77			$ 8.18	$ 8.44			$ 0.87		
Construction Support Services	1%	$ 8.80	$ 26.51	$ 2.89	$ 2.89			$ 4.09	$ 4.22			$ 0.43		
(Soft Costs) SUBTOTAL		**$ 87.97**	**$ 265.08**	**$ 28.87**	**$ 28.87**			**$ 40.92**	**$ 42.21**			**$ 4.33**		
(Total Construction & Soft Costs) SUBTOTAL		**$ 967.66**	**$ 2,915.90**	**$ 317.58**	**$ 317.58**			**$ 450.07**	**$ 464.27**			**$ 47.64**		
Escalation to 6/2015 (4.5% yearly)	25%	$ 241.91	$ 728.98	$ 79.39	$ 79.39			$ 112.52	$ 116.07			$ 11.91		
HIGHWAY & TRANSIT TOTAL		**$ 1,210**	**$ 3,645**	**$ 396.97**	**$ 396.97**	**$ -**	**$ -**	**$ 562.59**	**$ 580.33**	**$ -**	**$ -**	**$ 59.55**	**$ -**	**$ -**
COMPONENT TOTALS		**$ 1,209.57**	**$ 3,644.88**	**$ 396.97**	**$ 396.97**	**$ 4,936.21**	**$ 5,106.01**	**$ 562.59**	**$ 580.33**	**$ -**	**$ -**	**$ 59.55**	**$ -**	**$ -**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**

DEIS Alternatives - Component Summary

I-287 / Tappan Zee Bridge Corridor Project
DEIS Cost Estimates
3 May 2011

Final Build - Transit Tier 1
(Costs in millions)

Element		Alternative Components												
		Rockland				Bridge		Westchester						
		Corridor		Landings				Landings		CRT Hudson Line Connection			Corridor	
		Busway	HOV / HOT	Busway	HOV / HOT	Single Level	Dual Level	Busway	HOV / HOT	Long Tunnel	Short Tunnel	TTSC	Busway	Buslane
BRIDGE (Abutment to Abutment)														
Site Work														
Site Access and Staging Areas														
Dredge and Armor														
Temporary Access Trestle														
West Approachs														
Piles														
Cap, Pier, and Cross beam						$ 9.81								
Superstructure						$ 105.15	$ 72.73							
Main Span														
Piles														
Cap and Pylon														
Superstructure						$ 79.16	$ 20.33							
East Approachs														
Piles														
Cap, Pier, and Cross beam						$ 5.97								
Superstructure						$ 44.01	$ 32.06							
Misc.														
Abutments														
Deck, Signage, Lighting, and Appurtenances														
Demolition of Existing Bridge														
Track Infrastructure						$ 39.66	$ 29.56							
Indirect Costs	24%					$ 65.06	$ 36.74							
BASE CONSTRUCTION COST						**$ 348.82**	**$ 191.42**							
Construction Contingency	30%					$ 104.65	$ 57.43							
SUBTOTAL						**$ 453.47**	**$ 248.84**							
Construction Add-ons														
MPT	2.5%					$ 11.34	$ 6.22							
Profit	12%					$ 54.42	$ 29.86							
TOTAL CONSTRUCTION COST						**$ 519.23**	**$ 284.92**							
Soft Costs														
Design Engineering	2%					$ 10.38	$ 5.70							
Program Management	2%					$ 10.38	$ 5.70							
Construction Management	3%					$ 15.58	$ 8.55							
Construction Inspection	2%					$ 10.38	$ 5.70							
Construction Support Services	1%					$ 5.19	$ 2.85							
(Soft Costs) SUBTOTAL						**$ 51.92**	**$ 28.49**							
(Total Contruction & Soft Costs) SUBTOTAL						**$ 571.15**	**$ 313.42**							
Escalation to 6/2015 (4.5% yearly)	25%					$ 142.79	$ 78.35							
BRIDGE TOTAL						**$ 713.94**	**$ 391.77**							
HIGHWAY														
Demolition - Structures		$ 11.97												
Earthwork														
Rock Excavation														
Retaining Walls - Fill													$ 29.81	$ 52.93
Retaining Walls - Cut													$ 158.27	$ 81.84
Vegetated Rock Slope														
Noise Walls														
Bridge - Thruway on structure		$ 7.24											$ 26.32	$ 47.19
Bridge - Structures over Thruway		$ 31.51												
Bridge - Temporary Bridges		$ 15.75												
Thruway Pavement & Finishes													$ 51.74	$ 41.56
Interchange Ramps														
Drainage		$ 83.61	$ 80.37							$ 10.00	$ 10.00	$ 5.00	$ 40.00	$ 40.00
State and Local Roads														
Local Road Pavement & Finishes		$ 24.36												
Pedestrian Facilities														
Paths, Connections, etc.		$ 12.50												
Utilities														
All - Public and Private		$ 111.58	$ 104.67							$ 10.00	$ 10.00	$ 5.00	$ 40.00	$ 40.00
BUS RAPID TRANSIT														
Earthwork		$ 0.56												
Rock Excavation		$ 202.14												
Retaining Walls - Fill		$ 124.65		$ 1.43								$ 1.33		$ 9.09
Retaining Walls - Cut		$ 438.54										$ 7.25		
Viaduct				$ 3.86								$ 14.02	$ 349.17	$ 102.28
Bridges		$ 29.90												
Tunnels - Cut / Cover		$ 49.00											$ 21.00	
Texas T - Ramps			$ 72.22											
Texas T - Bridges			$ 12.46											
Texas T - At Grade Pavements			$ 11.48											
Stations		$ 36.00	$ 36.00										$ 30.00	$ 30.00
Depots		$ 10.00	$ 10.00										$ 10.00	$ 10.00
Pavement and Finishes		$ 52.86		$ 0.94								$ 3.02		
Interchange Ramps		$ 117.68	$ 0.61											
Intelligent Transportation Systems (ITS)		$ 50.00	$ 50.00											
Drainage														
Utilities														
COMMUTER RAIL TRANSIT														
Earthwork										$ 8.38	$ 0.86			
Retaining Walls - Fill		$ 215.08	$ 253.22							$ 4.48	$ 11.62			
Retaining Walls - Cut		$ 76.90	$ 231.74	$ 13.78	$ 13.78					$ 86.09	$ 3.29			
Viaduct		$ 140.29	$ 140.29								$ 6.10			
Bridges		$ 29.21	$ 47.87								$ 4.28			
Tunnels - Cut / Cover		$ 192.50	$ 192.50							$ 52.50	$ 31.50			
Tunnels - TBM		$ 165.00	$ 165.00	$ 29.70	$ 29.70					$ 189.20	$ 39.60			
Stations		$ 33.00	$ 33.00											
Track Infrastructure		$ 82.84	$ 82.84	$ 4.36	$ 4.36			$ 1.53	$ 1.53					
Signal Systems		$ 38.00	$ 38.00											
Substations, Vent Buildings, Access Shafts		$ 32.00	$ 32.00					$ 6.00	$ 6.00					
SUBTOTAL		**$ 2,414.66**	**$ 1,594.27**	**$ 54.06**	**$ 47.84**			**$ 7.53**	**$ 7.53**	**$ 360.65**	**$ 117.25**	**$ 35.63**	**$ 756.32**	**$ 454.89**
Indirect Costs	25%	$ 603.67	$ 398.57	$ 13.51	$ 11.96			$ 1.88	$ 1.88	$ 90.16	$ 29.31	$ 8.91	$ 189.08	$ 113.72
BASE CONSTRUCTION COST		**$ 3,018.33**	**$ 1,992.84**	**$ 67.57**	**$ 59.80**			**$ 9.41**	**$ 9.41**	**$ 450.81**	**$ 146.56**	**$ 44.53**	**$ 945.39**	**$ 568.61**
Construction Contingency	30%	$ 905.50	$ 597.85	$ 20.27	$ 17.94			$ 2.82	$ 2.82	$ 135.24	$ 43.97	$ 13.36	$ 283.62	$ 170.58
(Base Construction & Contingency) SUBTOTAL		**$ 3,923.83**	**$ 2,590.69**	**$ 87.84**	**$ 77.74**			**$ 12.23**	**$ 12.23**	**$ 586.06**	**$ 190.53**	**$ 57.89**	**$ 1,229.01**	**$ 739.19**
Construction Add-ons														
MPT	2.5%	$ 98.10	$ 64.77	$ 2.20	$ 1.94			$ 0.31	$ 0.31	$ 14.65	$ 4.76	$ 1.45	$ 30.73	$ 18.48
Profit	12%	$ 470.86	$ 310.88	$ 10.54	$ 9.33			$ 1.47	$ 1.47	$ 70.33	$ 22.86	$ 6.95	$ 147.48	$ 88.70
TOTAL CONSTRUCTION COST		**$ 4,492.79**	**$ 2,966.34**	**$ 100.58**	**$ 89.01**			**$ 14.00**	**$ 14.00**	**$ 671.04**	**$ 218.16**	**$ 66.29**	**$ 1,407.22**	**$ 846.37**
Soft Costs														
Design Engineering	2%	$ 89.86	$ 59.33	$ 2.01	$ 1.78			$ 0.28	$ 0.28	$ 13.42	$ 4.36	$ 1.33	$ 28.14	$ 16.93
Program Management	2%	$ 89.86	$ 59.33	$ 2.01	$ 1.78			$ 0.28	$ 0.28	$ 13.42	$ 4.36	$ 1.33	$ 28.14	$ 16.93
Construction Management	3%	$ 134.78	$ 88.99	$ 3.02	$ 2.67			$ 0.42	$ 0.42	$ 20.13	$ 6.54	$ 1.99	$ 42.22	$ 25.39
Construction Inspection	2%	$ 89.86	$ 59.33	$ 2.01	$ 1.78			$ 0.28	$ 0.28	$ 13.42	$ 4.36	$ 1.33	$ 28.14	$ 16.93
Construction Support Services	1%	$ 44.93	$ 29.66	$ 1.01	$ 0.89			$ 0.14	$ 0.14	$ 6.71	$ 2.18	$ 0.66	$ 14.07	$ 8.46
(Soft Costs) **SUBTOTAL**		**$ 449.28**	**$ 296.63**	**$ 10.06**	**$ 8.90**			**$ 1.40**	**$ 1.40**	**$ 67.10**	**$ 21.82**	**$ 6.63**	**$ 140.72**	**$ 84.64**
(Total Construction & Soft Costs) SUBTOTAL		**$ 4,942.06**	**$ 3,262.97**	**$ 110.63**	**$ 97.91**			**$ 15.40**	**$ 15.40**	**$ 738.14**	**$ 239.97**	**$ 72.92**	**$ 1,547.94**	**$ 931.01**
Escalation to 6/2015 (4.5% yearly)	25%	$ 1,235.52	$ 815.74	$ 27.66	$ 24.48			$ 3.85	$ 3.85	$ 184.54	$ 59.99	$ 18.23	$ 386.99	$ 232.75
HIGHWAY & TRANSIT TOTAL		**$ 6,177.58**	**$ 4,078.71**	**$ 138.29**	**$ 122.38**			**$ 19.25**	**$ 19.25**	**$ 922.68**	**$ 299.97**	**$ 91.15**	**$ 1,934.93**	**$ 1,163.76**
COMPONENT TOTALS		**$ 6,177.58**	**$ 4,078.71**	**$ 138.29**	**$ 122.38**	**$ 713.94**	**$ 391.77**	**$ 19.25**	**$ 19.25**	**$ 922.68**	**$ 299.97**	**$ 91.15**	**$ 1,934.93**	**$ 1,163.76**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**

Appendix C

DEIS Alternatives Unit Cost and Quantity Backup for Highway, BRT and CRT

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Project
DEIS Cost Estimates
3 May 2011

Rockland Corridor

Elements	Unit Cost (2010 $)	Unit	Busway Initial Quantity	Busway Initial Subtotal	Busway Final Quantity	Busway Final Subtotal	HOV / HOT Initial Quantity	HOV / HOT Initial Subtotal	HOV / HOT Final Quantity	HOV / HOT Final Subtotal
THRUWAY										
Clear and Grub										
Clear and Grub	$ 8,172	acre	80	$ 656,612			149	$ 1,219,421		
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	cy	82,407	$ 1,227,870			296,759	$ 4,421,713		
Cut to Fill - Average Soils (long cycle)	$ 18	cy	82,407	$ 1,446,250			296,759	$ 5,208,125		
Cut to Dispose - Haul offsite	$ 23	cy								
Fill - From Cut	$ 6	cy	318,519	$ 1,911,111			664,815	$ 3,988,889		
Fill - Import	$ 25	cy	153,704	$ 3,804,167			71,296	$ 1,764,583		
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	cy								
Excavate and Remove Rock - Drill & Blast	$ 614	cy	170,370	$ 104,626,148			705,556	$ 433,288,722		
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf	6,784	$ 91,245			4,187,400	$ 56,320,530		
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf					1,650	$ 2,274,179		
Retained fill: 6' to 15'	$ 3,333	lf					2,750	$ 9,166,438		
Retained fill: 16' to 25'	$ 6,851	lf					1,850	$ 12,674,350		
Retained fill: > 25'	$ 12,816	lf					750	$ 9,612,000		
Retaining Wall - for Retained Cut										
Retained cut: < '6	$ 3,486	lf					6,360	$ 22,170,960		
Retained cut: 6' to 15'	$ 8,123	lf					3,900	$ 31,679,700		
Retained cut: 16' to 25'	$ 15,814	lf					1,750	$ 27,674,500		
Retained cut: > 25'	$ 23,528	lf					3,600	$ 84,700,800		
Flood Bound Wall	$ 7,900	lf								
Noise Walls										
Noise Walls	$ 1,759	lf	200	$ 351,800			9,875	$ 17,370,125		
Remove existing noise walls		lf					8,300	$ -		
Bridge - with Concrete Superstructure	$ 285									
New Bridge - xx over I-287	$ 285	sf	132,714	$ 37,823,490	110,546	$ 31,505,610	312,780	$ 89,142,300		
New Bridge - I-287 Over xx	$ 285	sf	91,742	$ 26,146,470	25,400	$ 7,239,000	149,736	$ 42,674,760		
Temporary Bridges	$ 143	sf	132,714	$ 18,911,745	110,546	$ 15,752,805	312,780	$ 44,571,150		
Existing Bridge Demo	$ 60	sf	106,171	$ 6,385,136	88,437	$ 5,318,589	250,224	$ 15,048,471		
Temp Bridge Demo	$ 60	sf	132,714	$ 7,981,420	110,546	$ 6,648,236	312,780	$ 18,810,589		
Thruway Pavement & Finishes - New	$ 16	sf	904,319	$ 14,550,493			4,504,018	$ 72,469,650		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Fine Grade	$ 0.64	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Thruway Pavement & Finishes - Mill / Pave	$ 9	sf	8,136,962	$ 69,164,177			7,064,404	$ 60,047,434		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Cold Mill	$ 1.52	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Interchange Ramps - includes earthwork, pave, a										
Ramp: < 6'	$ 96.17	sf	56,886	$ 5,470,727			91,543	$ 8,803,690		
Ramp: 6' to 15'	$ 132.95	sf	132,623	$ 17,632,228			640,480	$ 85,151,816		
Ramp: 16' to 25'	$ 188.40	sf	284,142	$ 53,532,353			319,632	$ 60,218,669		
Ramp: > 25'	$ 288.75	sf								
Additional Ramp Demolitions	$ 7.00	sf							87,500	$ 612,500
STATE AND LOCAL ROADS										
Earthwork										
Local Road Pavement & Finishes	$ 35	sf	238,794	$ 8,357,790	695,870	$ 24,355,450	1,747,159	$ 61,150,565		
1.5" HMA Wearing Course / Top Course	$ 5	sf								
2" Binder Course	$ 2	sf								
3" Base Course Lift - Crushed Stone	$ 52	cy								
1" Subbase - Drain Rock	$ 55	cy								
Sidewalk - Concrete CIP	$ 11	sf								
Edge Drain	$ 65	lf								
Fine Grade	$ 2	sf								
Striping	$ 1	lf								
Lighting	$ 50	lf								
Signage	$ 5	lf								
PEDESTRIAN FACILITIES										
Tool Booth (allowance)	$ 60,000,000	ls								
Pedestrian Facilities (allowance)	$ 25,000,000	ls	1	$ 12,500,000	1	$ 12,500,000	1	$ 25,000,000		
DRAINAGE										
Drainage										
Water Quality Treatment Areas	$ 13	sf			565,625	$ 7,172,125			524,375	$ 6,649,075
Storm Drainage- RCP 48"	$ 388	lf	87,000	$ 33,756,000	197,000	$ 76,436,000	212,000	$ 82,256,000	190,000	$ 73,720,000
Drainage (allowance)	$ 10,000,000	ls								
UTILITIES										
Electric - Duct Bank	$ 195	lf	26,000	$ 5,070,000	73,000	$ 14,235,000	61,000	$ 11,895,000	74,000	$ 14,430,000
Fiber - Duct Bank	$ 550	lf	84,480	$ 46,464,000	84,480	$ 46,464,000	84,480	$ 46,464,000	84,480	$ 46,464,000
Gas - Welded Steel Pipe 8"	$ 284	lf	21,000	$ 5,964,000	45,000	$ 12,780,000	45,000	$ 12,780,000	40,000	$ 11,360,000
Telephone / Info Cable - Duct Bank	$ 185	lf	19,000	$ 3,515,000	56,000	$ 10,360,000	39,000	$ 7,215,000	51,000	$ 9,435,000
Sewer - RCP 30"	$ 277	lf	13,000	$ 3,601,000	46,000	$ 12,742,000	51,000	$ 14,127,000	40,000	$ 11,080,000
Cable - Duct Bank	$ 185	lf	7,000	$ 1,295,000	21,000	$ 3,885,000	15,000	$ 2,775,000	13,000	$ 2,405,000
Water - Ductile Iron 12"	$ 202	lf	17,000	$ 3,434,000	55,000	$ 11,110,000	47,000	$ 9,494,000	47,000	$ 9,494,000
General Relocate (allowance)	$ 10,000,000	ls								
BUS RAPID TRANSIT										
Viaduct - Single Lane		lf								
CRT Viaduct: < 20'	$ 7,963	lf								
CRT Viaduct: 20' to 30'	$ 10,036	lf								
CRT Viaduct: 30' to 40'	$ 10,246	lf								
CRT Viaduct: 40' to 50'	$ 10,456	lf								
CRT Viaduct: + 50'	$ 14,295	lf								
Viaduct - Two Lane										
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf								
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
Clear and Grub										
Clear and Grub	$ 8,172	acre			69	$ 562,810				
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	cy								
Cut to Fill - Average Soils (long cycle)	$ 18	cy								
Cut to Dispose - Haul offsite	$ 23	cy								
Fill - From Cut	$ 6	cy								
Fill - Import	$ 25	cy								
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	cy								
Excavate and Remove Rock - Drill & Blast	$ 614	cy			329,167	$ 202,144,542				
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf								
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf			3,700	$ 5,099,673				
Retained fill: 6' to 15'	$ 3,333	lf			9,500	$ 31,665,875				
Retained fill: 16' to 25'	$ 6,851	lf			8,900	$ 60,973,900				
Retained fill: > 25'	$ 12,816	lf			2,100	$ 26,913,600				
Retaining Wall - for Retained Cut										
Retained cut: < '6	$ 3,486	lf			3,400	$ 11,852,400				
Retained cut: 6' to 15'	$ 8,123	lf			16,000	$ 129,968,000				
Retained cut: 16' to 25'	$ 15,814	lf			8,200	$ 129,674,800				

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Project
DEIS Cost Estimates
3 May 2011

Rockland Corridor

Elements	Unit Cost (2010 $)	Unit	Busway Initial Quantity	Busway Initial Subtotal	Busway Final Quantity	Busway Final Subtotal	HOV / HOT Initial Quantity	HOV / HOT Initial Subtotal	HOV / HOT Final Quantity	HOV / HOT Final Subtotal
Retained cut: > 25'	$ 23,528	lf			7,100	$ 167,048,800				
Flood Bound Wall	$ 7,900	lf								
Interchange Ramps - includes earthwork, pave										
Ramp: < 6'	$ 96.17	sf			31,176	$ 2,998,196				
Ramp: 6' to 15'	$ 132.95	sf			336,342	$ 44,716,669				
Ramp: 16' to 25'	$ 188.40	sf			368,095	$ 69,349,098				
Ramp: > 25'	$ 288.75	sf								
Additional Ramp Demolitions	$ 7.00	sf			87,500	$ 612,500				
Tunnels - Cut / Cover	$ 35,000	lf			1,400	$ 49,000,000				
Texas T Ramps - Retained Fill with Pavements	$ 141	sf							512,165	$ 72,215,265
Texas T - Over Bridges	$ 285	sf							43,722	$ 12,460,770
Texas T - At grade Pavements	$ 16	sf							639,972	$ 10,239,552
Texas T - Station Access	$ 26	sf							47,320	$ 1,244,516
Stations (allowance)	$ 6,000,000	ea			6	$ 36,000,000			6	$ 36,000,000
At Grade Bus Only Stations (allowance)	$ 3,000,000	ls								
Depots (allowance)	$ 10,000,000	ea			1	$ 10,000,000			1	$ 10,000,000
Busway Pavement & Finishes	$ 16	sf			3,303,500	$ 52,856,000				
Intelligent Transportation Systems (ITS)	$ 50,000,000	LS			1	$ 50,000,000			1	$ 50,000,000
Bridges	$ 285				104,929	$ 29,904,765				
COMMUTER RAIL TRANSIT										
Earthwork										
CRT in Retained Cut - no track										
CRT in retained cut: < '6	$ 1,378	lf			10,400	$ 14,334,216				
CRT in retained cut: 6' to 15'	$ 3,333	lf			17,000	$ 56,665,250				
CRT in retained cut: 16' to 25'	$ 6,851	lf			300	$ 2,055,300			31,300	$ 214,436,300
CRT in retained cut: + 25'	$ 12,816	lf			300	$ 3,844,800			1,350	$ 17,301,600
CRT on Retained Fill - no track										
CRT on retained fill: < '6	$ 3,486	lf			8,200	$ 28,585,200				
CRT on retained fill: 6' to 15'	$ 8,123	lf			12,400	$ 100,725,200			21,050	$ 170,989,150
CRT on retained fill: 16' to 25'	$ 15,814	lf			2,180	$ 34,474,520			5,200	$ 82,232,800
CRT on retained fill: + 25'	$ 23,528	lf			2,180	$ 51,291,040				
Viaduct	$ 12,215	lf			11,485	$ 140,293,869			11,485	$ 140,293,869
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf								
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
CRT Bridges	$ 285	sf			102,490	$ 29,209,650			167,949	$ 47,865,465
Tunnels - Cut / Cover	$ 35,000	lf			5,500	$ 192,500,000			5,500	$ 192,500,000
Tunnels - TBM	$ 22,000	lf			7,500	$ 165,000,000			7,500	$ 165,000,000
Tunnels - TBM	$ 22,000	lf								
Stations - At Grade (allowance)	$ 5,000,000	ea			3	$ 15,000,000			3	$ 15,000,000
Stations - Elevated (allowance)	$ 8,000,000	ea			1	$ 8,000,000			1	$ 8,000,000
Maintenance Facility (allowance)	$ 10,000,000	ls			1	$ 10,000,000			1	$ 10,000,000
Track Infrastructure	$ 1,090	lf			76,000	$ 82,840,000			76,000	$ 82,840,000
Direct Fixation	$ 1,333	lf								
Ballasted	$ 847	lf								
Signal Systems	$ 500	lf			76,000	$ 38,000,000			76,000	$ 38,000,000
Substations	$ 2,000,000	ea			11	$ 22,000,000			11	$ 22,000,000
Vent Buildings	$ 2,000,000	ea			3	$ 6,000,000			3	$ 6,000,000
Access Shafts	$ 2,000,000	ea			2	$ 4,000,000			2	$ 4,000,000
Subtotal Construction Cost				**$ 495,670,231**		**$ 2,414,664,488**		**$ 1,493,630,129**		**$ 1,594,268,862**

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Study
DEIS Cost Estimates
3 May 2011

Rockland Landing

Elements	Unit Cost (2010 $)	Unit	Busway				HOV / HOT			
			Single Level Initial Quantity	Single Level Initial Subtotal	Single Level Final Quantity	Single Level Final Subtotal	Single Level Initial Quantity	Single Level Initial Subtotal	Single Level Final Quantity	Single Level Final Subtotal
THRUWAY										
Clear and Grub										
Clear and Grub	$ 8,172	*acre*								
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*								
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*								
Cut to Dispose - Haul offsite	$ 23	*cy*								
Fill - From Cut	$ 6	*cy*								
Fill - Import	$ 25	*cy*								
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	*cy*								
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*								
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf								
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf	250	$ 344,573			250	$ 344,573		
Retained fill: 6' to 15'	$ 3,333	lf	400	$ 1,333,300			400	$ 1,333,300		
Retained fill: 16' to 25'	$ 6,851	lf	300	$ 2,055,300			300	$ 2,055,300		
Retained fill: > 25'	$ 12,816	lf								
Retaining Wall - for Retained Cut										
Retained cut: < '6	$ 3,486	lf	650	$ 2,265,900			650	$ 2,265,900		
Retained cut: 6' to 15'	$ 8,123	lf	885	$ 7,188,855			885	$ 7,188,855		
Retained cut: 16' to 25'	$ 15,814	lf	470	$ 7,432,580			470	$ 7,432,580		
Retained cut: > 25'	$ 23,528	lf	200	$ 4,705,600			200	$ 4,705,600		
Flood Bound Wall	$ 7,900	lf								
Noise Walls										
Noise Walls	$ 1,759	lf								
Remove existing noise walls		lf								
Bridge - with Concrete Superstructure	$ 285		25,577	$ 7,289,445			25,577	$ 7,289,445		
New Bridge - xx over I-287	$ 285	sf								
New Bridge - I-287 Over xx	$ 285	sf								
Temporary Bridges	$ 143	sf								
Existing Bridge Demo	$ 60	*sf*	54,701	$ 3,289,718			54,701	$ 3,289,718		
Temp Bridge Demo	$ 60	*sf*								
Thruway Pavement & Finishes - New	$ 16	sf	626,775	$ 10,084,810			626,775	$ 10,084,810		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Fine Grade	$ 0.64	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Thruway Pavement & Finishes - Mill / Pave	$ 9	sf	417,850	$ 3,551,725			417,850	$ 3,551,725		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Cold Mill	$ 1.52	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Interchange Ramps - includes earthwork, pave, a										
Ramp: < 6'	$ 96.17	sf	18,000	$ 1,731,060			18,000	$ 1,731,060		
Ramp: 6' to 15'	$ 132.95	sf	30,000	$ 3,988,500			30,000	$ 3,988,500		
Ramp: 16' to 25'	$ 188.40	sf	27,000	$ 5,086,800			27,000	$ 5,086,800		
Ramp: > 25'	$ 288.75	sf	20,000	$ 5,775,000			20,000	$ 5,775,000		
Additional Ramp Demolitions	$ 7.00	sf	342,033	$ 2,394,231			342,033	$ 2,394,231		
STATE AND LOCAL ROADS										
Earthwork										
Local Road Pavement & Finishes	$ 35	sf								
1.5" HMA Wearing Course / Top Course	$ 5	*sf*								
2" Binder Course	$ 2	*sf*								
3" Base Course Lift - Crushed Stone	$ 52	*cy*								
1" Subbase - Drain Rock	$ 55	*cy*								
Sidewalk - Concrete CIP	$ 11	*sf*								
Edge Drain	$ 65	*lf*								
Fine Grade	$ 2	*sf*								
Striping	$ 1	*lf*								
Lighting	$ 50	*lf*								
Signage	$ 5	*lf*								
PEDESTRIAN FACILITIES										
Tool Booth (allowance)	$ 60,000,000	ls								
Pedestrian Facilities (allowance)	$ 25,000,000	ls	0.3	$ 7,500,000			0.3	$ 7,500,000		
DRAINAGE										
Drainage										
Water Quality Treatment Areas	$ 13	*sf*								
Storm Drainage- RCP 48"	$ 388	*lf*								
Drainage (allowance)	$ 10,000,000	*ls*	1	$ 10,000,000			1	$ 10,000,000		
UTILITIES										
Electric - Duct Bank	$ 195	lf								
Fiber - Duct Bank	$ 550	lf								
Gas - Welded Steel Pipe 8"	$ 284	lf								
Telephone / Info Cable - Duct Bank	$ 185	lf								
Sewer - RCP 30"	$ 277	lf								
Cable - Duct Bank	$ 185	lf								
Water - Ductile Iron 12"	$ 202	lf								
General Relocate (allowance)	$ 10,000,000	ls	1	$ 10,000,000			1	$ 10,000,000		
BUS RAPID TRANSIT										
Viaduct - Single Lane		lf								
CRT Viaduct: < 20'	$ 7,963	lf								
CRT Viaduct: 20' to 30'	$ 10,036	lf								
CRT Viaduct: 30' to 40'	$ 10,246	lf								
CRT Viaduct: 40' to 50'	$ 10,456	lf								
CRT Viaduct: + 50'	$ 14,295	lf								
Viaduct - Two Lane										
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf			325	$ 3,855,150				
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
Clear and Grub										
Clear and Grub	$ 8,172	*acre*								
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*								
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*								
Cut to Dispose - Haul offsite	$ 23	*cy*								
Fill - From Cut	$ 6	*cy*								
Fill - Import	$ 25	*cy*								
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	*cy*								
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*								
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf								
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf			310	$ 427,270				
Retained fill: 6' to 15'	$ 3,333	lf			300	$ 999,975				
Retained fill: 16' to 25'	$ 6,851	lf								
Retained fill: > 25'	$ 12,816	lf								
Retaining Wall - for Retained Cut										
Retained cut: < '6	$ 3,486	lf								
Retained cut: 6' to 15'	$ 8,123	lf								
Retained cut: 16' to 25'	$ 15,814	lf								

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Study
DEIS Cost Estimates
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Rockland Landing

Elements	Unit Cost (2010 $)	Unit	Busway Single Level Initial Quantity	Busway Single Level Initial Subtotal	Busway Single Level Final Quantity	Busway Single Level Final Subtotal	HOV / HOT Single Level Initial Quantity	HOV / HOT Single Level Initial Subtotal	HOV / HOT Single Level Final Quantity	HOV / HOT Single Level Final Subtotal
Retained cut: > 25'	$ 23,528	lf								
Flood Bound Wall	$ 7,900	lf								
Interchange Ramps - includes earthwork, pave										
Ramp: < 6'	$ 96.17	sf								
Ramp: 6' to 15'	$ 132.95	sf								
Ramp: 16' to 25'	$ 188.40	sf								
Ramp: > 25'	$ 288.75	sf								
Additional Ramp Demolitions	$ 7.00	sf								
Tunnels - Cut / Cover	$ 35,000	lf								
Texas T Ramps - Retained Fill with Pavements	$ 141	sf								
Texas T - Over Bridges	$ 285	sf								
Texas T - At grade Pavements	$ 16	sf								
Texas T - Station Access	$ 26	sf								
Stations (allowance)	$ 6,000,000	ea								
At Grade Bus Only Stations (allowance)	$ 3,000,000	ls								
Depots (allowance)	$ 10,000,000	ea								
Busway Pavement & Finishes	$ 16	sf			58,471	$ 935,536				
Intelligent Transportation Systems (ITS)	$ 50,000,000	LS								
Bridges	$ 285									
COMMUTER RAIL TRANSIT										
Earthwork										
CRT in Retained Cut - no track										
CRT in retained cut: < '6	$ 1,378	lf								
CRT in retained cut: 6' to 15'	$ 3,333	lf								
CRT in retained cut: 16' to 25'	$ 6,851	lf								
CRT in retained cut: + 25'	$ 12,816	lf			1,075	$ 13,777,200			1,075	$ 13,777,200
CRT on Retained Fill - no track										
CRT on retained fill: < '6	$ 3,486	lf								
CRT on retained fill: 6' to 15'	$ 8,123	lf								
CRT on retained fill: 16' to 25'	$ 15,814	lf								
CRT on retained fill: + 25'	$ 23,528	lf								
Viaduct	$ 12,215	lf								
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf								
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
CRT Bridges	$ 285	sf								
Tunnels - Cut / Cover	$ 35,000	lf	1,590	$ 55,650,000			1,590	$ 55,650,000		
Tunnels - TBM	$ 22,000	lf								
Tunnels - TBM	$ 22,000	lf			1,350	$ 29,700,000			1,350	$ 29,700,000
Stations - At Grade (allowance)	$ 5,000,000	ea								
Stations - Elevated (allowance)	$ 8,000,000	ea								
Maintenance Facility (allowance)	$ 10,000,000	ls								
Track Infrastructure	$ 1,090	lf			4,000	$ 4,360,000			4,000	$ 4,360,000
Direct Fixation	$ 1,333	lf								
Ballasted	$ 847	lf								
Signal Systems	$ 500	lf								
Substations	$ 2,000,000	ea								
Vent Buildings	$ 2,000,000	ea								
Access Shafts	$ 2,000,000	ea								
Subtotal Construction Cost				**$ 151,667,396**		**$ 54,055,131**		**$ 151,667,396**		**$ 47,837,200**

I-281 / Tappan Zee Bridge Corridor Study
DEIS Cost Estimates
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Westchester Landing

Elements	Unit Cost (2010 $)	Unit	Busway Single Level Initial Quantity	Busway Single Level Initial Subtotal	Busway Single Level Final Quantity	Busway Single Level Final Subtotal	HOV / HOT Single Level Initial Quantity	HOV / HOT Single Level Initial Subtotal	HOV / HOT Single Level Final Quantity	HOV / HOT Single Level Final Subtotal
THRUWAY										
Clear and Grub										
Clear and Grub	$ 8,172	*acre*								
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*								
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*								
Cut to Dispose - Haul offsite	$ 23	*cy*								
Fill - From Cut	$ 6	*cy*								
Fill - Import	$ 25	*cy*								
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	*cy*								
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*								
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf								
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf	550	$ 758,060			860	$ 1,185,329		
Retained fill: 6' to 15'	$ 3,333	lf	250	$ 833,313			550	$ 1,833,288		
Retained fill: 16' to 25'	$ 6,851	lf								
Retained fill: > 25'	$ 12,816	lf								
Retaining Wall - for Retained Cut								$ -		
Retained cut: < '6	$ 3,486	lf	400	$ 1,394,400			400	$ 1,394,400		
Retained cut: 6' to 15'	$ 8,123	lf	200	$ 1,624,600			200	$ 1,624,600		
Retained cut: 16' to 25'	$ 15,814	lf								
Retained cut: > 25'	$ 23,528	lf								
Flood Bound Wall	$ 7,900	lf								
Noise Walls										
Noise Walls	$ 1,759	lf								
Remove existing noise walls		lf								
Bridge - with Concrete Superstructure	$ 285		155,350	$ 44,274,750			155,350	$ 44,274,750		
New Bridge - xx over I-287	$ 285	sf					15,481	$ 4,412,085		
New Bridge - I-287 Over xx	$ 285	sf								
Temporary Bridges	$ 143	sf								
Existing Bridge Demo	$ 60	*sf*	155,350	$ 9,342,749			155,350	$ 9,342,749		
Temp Bridge Demo	$ 60	*sf*								
Thruway Pavement & Finishes - New	$ 16	sf	925,645	$ 14,893,628			984,116	$ 15,834,426		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Fine Grade	$ 0.64	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Thruway Pavement & Finishes - Mill / Pave	$ 9	sf	685,000	$ 5,822,500			685,000	$ 5,822,500		
1.5" HMA Wearing Course / Top Course	$ 126.00	ton								
2" Binder Course	$ 104.00	ton								
4.5" Base Course	$ 93.00	ton								
Subbase	$ 53.00	cy								
Cold Mill	$ 1.52	sf								
Lane Markings	$ 2.10	lf								
Signage	$ 188.00	lf								
Interchange Ramps - includes earthwork, pave, a										
Ramp: < 6'	$ 96.17	sf	12,500	$ 1,202,125			12,500	$ 1,202,125		
Ramp: 6' to 15'	$ 132.95	sf	13,500	$ 1,794,825			13,500	$ 1,794,825		
Ramp: 16' to 25'	$ 188.40	sf								
Ramp: > 25'	$ 288.75	sf								
Additional Ramp Demolitions	$ 7.00	sf								
STATE AND LOCAL ROADS										
Earthwork										
Local Road Pavement & Finishes	$ 35	sf								
1.5" HMA Wearing Course / Top Course	$ 5	*sf*								
2" Binder Course	$ 2	*sf*								
3" Base Course Lift - Crushed Stone	$ 52	*cy*								
1" Subbase - Drain Rock	$ 55	*cy*								
Sidewalk - Concrete CIP	$ 11	*sf*								
Edge Drain	$ 65	*lf*								
Fine Grade	$ 2	*sf*								
Striping	$ 1	*lf*								
Lighting	$ 50	*lf*								
Signage	$ 5	*lf*								
PEDESTRIAN FACILITIES										
Tool Booth (allowance)	$ 60,000,000	ls	1	$ 60,000,000			1	$ 60,000,000		
Pedestrian Facilities (allowance)	$ 25,000,000	ls	1	$ 25,000,000			1	$ 25,000,000		
DRAINAGE										
Drainage										
Water Quality Treatment Areas	$ 13	*sf*								
Storm Drainage- RCP 48"	$ 388	*lf*								
Drainage (allowance)	$ 10,000,000	*ls*	1	$ 10,000,000			1	$ 10,000,000		
UTILITIES										
Electric - Duct Bank	$ 195	lf								
Fiber - Duct Bank	$ 550	lf								
Gas - Welded Steel Pipe 8"	$ 284	lf								
Telephone / Info Cable - Duct Bank	$ 185	lf								
Sewer - RCP 30"	$ 277	lf								
Cable - Duct Bank	$ 185	lf								
Water - Ductile Iron 12"	$ 202	lf								
General Relocate (allowance)	$ 10,000,000	ls	1	$ 10,000,000			1	$ 10,000,000		
BUS RAPID TRANSIT										
Viaduct - Single Lane		lf								
CRT Viaduct: < 20'	$ 7,963	lf								
CRT Viaduct: 20' to 30'	$ 10,036	lf								
CRT Viaduct: 30' to 40'	$ 10,246	lf								
CRT Viaduct: 40' to 50'	$ 10,456	lf								
CRT Viaduct: + 50'	$ 14,295	lf								
Viaduct - Two Lane										
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf								
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
Clear and Grub										
Clear and Grub	$ 8,172	*acre*								
Earthwork										
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*								
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*								
Cut to Dispose - Haul offsite	$ 23	*cy*								
Fill - From Cut	$ 6	*cy*								
Fill - Import	$ 25	*cy*								
Rock Excavation										
Excavate and Remove Rock - Ripping	$ 361	*cy*								
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*								
Vegetated Rock Slope										
Vegetated Rock Slope	$ 13	sf								
Retaining Wall - for Retained Fill										
Retained fill: < '6	$ 1,378	lf								
Retained fill: 6' to 15'	$ 3,333	lf								
Retained fill: 16' to 25'	$ 6,851	lf								
Retained fill: > 25'	$ 12,816	lf								
Retaining Wall - for Retained Cut										
Retained cut: < '6	$ 3,486	lf								
Retained cut: 6' to 15'	$ 8,123	lf								
Retained cut: 16' to 25'	$ 15,814	lf								

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-281 / Tappan Zee Bridge Corridor Study
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Westchester Landing

Elements	Unit Cost (2010 $)	Unit	Busway				HOV / HOT			
			Single Level Initial Quantity	Single Level Initial Subtotal	Single Level Final Quantity	Single Level Final Subtotal	Single Level Initial Quantity	Single Level Initial Subtotal	Single Level Final Quantity	Single Level Final Subtotal
Retained cut: > 25'	$ 23,528	lf								
Flood Bound Wall	$ 7,900	lf								
Interchange Ramps - includes earthwork, pave										
Ramp: < 6'	$ 96.17	sf								
Ramp: 6' to 15'	$ 132.95	sf								
Ramp: 16' to 25'	$ 188.40	sf								
Ramp: > 25'	$ 288.75	sf								
Additional Ramp Demolitions	$ 7.00	sf								
Tunnels - Cut / Cover	$ 35,000	lf								
Texas T Ramps - Retained Fill with Pavements	$ 141	sf								
Texas T - Over Bridges	$ 285	sf								
Texas T - At grade Pavements	$ 16	sf								
Texas T - Station Access	$ 26	sf								
Stations (allowance)	$ 6,000,000	ea								
At Grade Bus Only Stations (allowance)	$ 3,000,000	*ls*								
Depots (allowance)	$ 10,000,000	ea								
Busway Pavement & Finishes	$ 16	sf			24,410	$ 390,560			24,410	$ 390,560
Intelligent Transportation Systems (ITS)	$ 50,000,000	LS								
Bridges	$ 285									
COMMUTER RAIL TRANSIT										
Earthwork										
CRT in Retained Cut - no track										
CRT in retained cut: < '6	$ 1,378	lf								
CRT in retained cut: 6' to 15'	$ 3,333	lf								
CRT in retained cut: 16' to 25'	$ 6,851	lf								
CRT in retained cut: + 25'	$ 12,816	lf								
CRT on Retained Fill - no track										
CRT on retained fill: < '6	$ 3,486	lf								
CRT on retained fill: 6' to 15'	$ 8,123	lf								
CRT on retained fill: 16' to 25'	$ 15,814	lf								
CRT on retained fill: + 25'	$ 23,528	lf								
Viaduct	$ 12,215	lf								
CRT Viaduct: < 20'	$ 9,579	lf								
CRT Viaduct: 20' to 30'	$ 11,652	lf								
CRT Viaduct: 30' to 40'	$ 11,862	lf								
CRT Viaduct: 40' to 50'	$ 12,072	lf								
CRT Viaduct: + 50'	$ 15,912	lf								
CRT Bridges	$ 285	sf								
Tunnels - Cut / Cover	$ 35,000	lf	800	$ 28,000,000			800	$ 28,000,000		
Tunnels - TBM	$ 22,000	lf								
Tunnels - TBM	$ 22,000	lf								
Stations - At Grade (allowance)	$ 5,000,000	ea								
Stations - Elevated (allowance)	$ 8,000,000	ea								
Maintenance Facility (allowance)	$ 10,000,000	ls								
Track Infrastructure	$ 1,090	lf			1,400	$ 1,526,000			1,400	$ 1,526,000
Direct Fixation	$ 1,333	lf								
Ballasted	$ 847	lf								
Signal Systems	$ 500	lf								
Substations	$ 2,000,000	ea			1	$ 2,000,000			1	$ 2,000,000
Vent Buildings	$ 2,000,000	ea			1	$ 2,000,000			1	$ 2,000,000
Access Shafts	$ 2,000,000	ea			1	$ 2,000,000			1	$ 2,000,000
Subtotal Construction Cost				**$ 214,940,949**		**$ 7,916,560**		**$ 221,721,077**		**$ 7,916,560**

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Study
DEIS Cost Estimates
3 May 2011

Hudson Line Connections

Elements	Unit Cost (2010 $)	Unit	CRT				BRT	
			Single Level Long Tunnel Quantity	Single Level Long Tunnel Subtotal	Single Level Short Tunnel Quantity	Single Level Short Tunnel Subtotal	TTSC Quantity	TTSC Subtotal
THRUWAY								
Clear and Grub								
Clear and Grub	$ 8,172	*acre*						
Earthwork								
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*						
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*	477,685	$ 8,383,375	49,167	$ 862,875		
Cut to Dispose - Haul offsite	$ 23	*cy*						
Fill - From Cut	$ 6	*cy*						
Fill - Import	$ 25	*cy*						
Rock Excavation								
Excavate and Remove Rock - Ripping	$ 361	*cy*						
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*						
Vegetated Rock Slope								
Vegetated Rock Slope	$ 13	sf						
Retaining Wall - for Retained Fill								
Retained fill: < '6	$ 1,378	lf	3,250	$ 4,479,443	1,550	$ 2,136,350		
Retained fill: 6' to 15'	$ 3,333	lf			1,530	$ 5,099,873		
Retained fill: 16' to 25'	$ 6,851	lf			640	$ 4,384,640		
Retained fill: > 25'	$ 12,816	lf						
Retaining Wall - for Retained Cut								
Retained cut: < '6	$ 3,486	lf	1,330	$ 4,636,380	320	$ 1,115,520		
Retained cut: 6' to 15'	$ 8,123	lf	1,330	$ 10,803,590	190	$ 1,543,370		
Retained cut: 16' to 25'	$ 15,814	lf	1,600	$ 25,302,400	40	$ 632,560		
Retained cut: > 25'	$ 23,528	lf						
Flood Bound Wall	$ 7,900	lf	5,740	$ 45,346,000				
Noise Walls								
Noise Walls	$ 1,759	lf						
Remove existing noise walls		lf						
Bridge - with Concrete Superstructure	$ 285							
New Bridge - xx over I-287	$ 285	sf						
New Bridge - I-287 Over xx	$ 285	sf						
Temporary Bridges	$ 143	sf						
Existing Bridge Demo	$ 60	*sf*						
Temp Bridge Demo	$ 60	*sf*						
Thruway Pavement & Finishes - New	$ 16	sf						
1.5" HMA Wearing Course / Top Course	$ 126.00	ton						
2" Binder Course	$ 104.00	ton						
4.5" Base Course	$ 93.00	ton						
Subbase	$ 53.00	cy						
Fine Grade	$ 0.64	sf						
Lane Markings	$ 2.10	lf						
Signage	$ 188.00	lf						
Thruway Pavement & Finishes - Mill / Pave	$ 9	sf						
1.5" HMA Wearing Course / Top Course	$ 126.00	ton						
2" Binder Course	$ 104.00	ton						
4.5" Base Course	$ 93.00	ton						
Subbase	$ 53.00	cy						
Cold Mill	$ 1.52	sf						
Lane Markings	$ 2.10	lf						
Signage	$ 188.00	lf						
Interchange Ramps - includes earthwork, pave, a								
Ramp: < 6'	$ 96.17	sf						
Ramp: 6' to 15'	$ 132.95	sf						
Ramp: 16' to 25'	$ 188.40	sf						
Ramp: > 25'	$ 288.75	sf						
Additional Ramp Demolitions	$ 7.00	sf						
STATE AND LOCAL ROADS								
Earthwork								
Local Road Pavement & Finishes	$ 35	sf						
1.5" HMA Wearing Course / Top Course	$ 5	*sf*						
2" Binder Course	$ 2	*sf*						
3" Base Course Lift - Crushed Stone	$ 52	*cy*						
1" Subbase - Drain Rock	$ 55	*cy*						
Sidewalk - Concrete CIP	$ 11	*sf*						
Edge Drain	$ 65	*lf*						
Fine Grade	$ 2	*sf*						
Striping	$ 1	*lf*						
Lighting	$ 50	*lf*						
Signage	$ 5	*lf*						
PEDESTRIAN FACILITIES								
Tool Booth (allowance)	$ 60,000,000	ls						
Pedestrian Facilities (allowance)	$ 25,000,000	ls						
DRAINAGE								
Drainage								
Water Quality Treatment Areas	$ 13	*sf*						
Storm Drainage- RCP 48"	$ 388	*lf*						
Drainage (allowance)	$ 10,000,000	*ls*	1	$ 10,000,000	1	$ 10,000,000	1	$ 5,000,000
UTILITIES								
Electric - Duct Bank	$ 195	lf						
Fiber - Duct Bank	$ 550	lf						
Gas - Welded Steel Pipe 8"	$ 284	lf						
Telephone / Info Cable - Duct Bank	$ 185	lf						
Sewer - RCP 30"	$ 277	lf						
Cable - Duct Bank	$ 185	lf						
Water - Ductile Iron 12"	$ 202	lf						
General Relocate (allowance)	$ 10,000,000	ls	1	$ 10,000,000	1	$ 10,000,000	1	$ 5,000,000
BUS RAPID TRANSIT								
Viaduct - Single Lane		lf						
CRT Viaduct: < 20'	$ 7,963	lf			160.00	$ 1,274,080		
CRT Viaduct: 20' to 30'	$ 10,036	lf			40.00	$ 401,440		
CRT Viaduct: 30' to 40'	$ 10,246	lf			340.00	$ 3,483,640		
CRT Viaduct: 40' to 50'	$ 10,456	lf			90.00	$ 941,040		
CRT Viaduct: + 50'	$ 14,295	lf						
Viaduct - Two Lane								
CRT Viaduct: < 20'	$ 9,579	lf					50	$ 478,950

Unit Cost and Quantity Summary - Highway, BRT and CRT

I-287 / Tappan Zee Bridge Corridor Study
DEIS Cost Estimates
3 May 2011

Hudson Line Connections

Elements	Unit Cost (2010 $)	Unit	CRT: Single Level Long Tunnel Quantity	CRT: Single Level Long Tunnel Subtotal	CRT: Single Level Short Tunnel Quantity	CRT: Single Level Short Tunnel Subtotal	BRT: TTSC Quantity	BRT: TTSC Subtotal
CRT Viaduct: 20' to 30'	$ 11,652	lf					50	$ 582,600
CRT Viaduct: 30' to 40'	$ 11,862	lf					75	$ 889,650
CRT Viaduct: 40' to 50'	$ 12,072	lf					1,000	$ 12,072,000
CRT Viaduct: + 50'	$ 15,912	lf						
Clear and Grub								
Clear and Grub	$ 8,172	*acre*						
Earthwork								
Cut to Fill - Average Soils (short cycle)	$ 15	*cy*						
Cut to Fill - Average Soils (long cycle)	$ 18	*cy*						
Cut to Dispose - Haul offsite	$ 23	*cy*						
Fill - From Cut	$ 6	*cy*						
Fill - Import	$ 25	*cy*						
Rock Excavation								
Excavate and Remove Rock - Ripping	$ 361	*cy*						
Excavate and Remove Rock - Drill & Blast	$ 614	*cy*						
Vegetated Rock Slope								
Vegetated Rock Slope	$ 13	sf						
Retaining Wall - for Retained Fill								
Retained fill: < '6	$ 1,378	lf						
Retained fill: 6' to 15'	$ 3,333	lf					400	$ 1,333,300
Retained fill: 16' to 25'	$ 6,851	lf						
Retained fill: > 25'	$ 12,816	lf						
Retaining Wall - for Retained Cut								
Retained cut: < '6	$ 3,486	lf					100	$ 348,600
Retained cut: 6' to 15'	$ 8,123	lf					850	$ 6,904,550
Retained cut: 16' to 25'	$ 15,814	lf						
Retained cut: > 25'	$ 23,528	lf						
Flood Bound Wall	$ 7,900	lf						
Interchange Ramps - includes earthwork, pave								
Ramp: < 6'	$ 96.17	sf						
Ramp: 6' to 15'	$ 132.95	sf						
Ramp: 16' to 25'	$ 188.40	sf						
Ramp: > 25'	$ 288.75	sf						
Additional Ramp Demolitions	$ 7.00	sf						
Tunnels - Cut / Cover	$ 35,000	lf					650	$ 22,750,000
Texas T Ramps - Retained Fill with Pavements	$ 141	sf						
Texas T - Over Bridges	$ 285	sf						
Texas T - At grade Pavements	$ 16	sf						
Texas T - Station Access	$ 26	sf						
Stations (allowance)	$ 6,000,000	ea						
At Grade Bus Only Stations (allowance)	$ 3,000,000	*ls*						
Depots (allowance)	$ 10,000,000	ea						
Busway Pavement & Finishes	$ 16	sf					188,600	$ 3,017,600
Intelligent Transportation Systems (ITS)	$ 50,000,000	LS						
Bridges	$ 285							
COMMUTER RAIL TRANSIT								
Earthwork								
CRT in Retained Cut - no track								
CRT in retained cut: < '6	$ 1,378	lf						
CRT in retained cut: 6' to 15'	$ 3,333	lf						
CRT in retained cut: 16' to 25'	$ 6,851	lf						
CRT in retained cut: + 25'	$ 12,816	lf						
CRT on Retained Fill - no track								
CRT on retained fill: < '6	$ 3,486	lf						
CRT on retained fill: 6' to 15'	$ 8,123	lf						
CRT on retained fill: 16' to 25'	$ 15,814	lf						
CRT on retained fill: + 25'	$ 23,528	lf						
Viaduct	$ 12,215	lf						
CRT Viaduct: < 20'	$ 9,579	lf						
CRT Viaduct: 20' to 30'	$ 11,652	lf						
CRT Viaduct: 30' to 40'	$ 11,862	lf						
CRT Viaduct: 40' to 50'	$ 12,072	lf						
CRT Viaduct: + 50'	$ 15,912	lf						
CRT Bridges	$ 285	sf			15,000	$ 4,275,000		
Tunnels - Cut / Cover	$ 35,000	lf	1,500	$ 52,500,000	900	$ 31,500,000		
Tunnels - TBM	$ 22,000	lf	8,600	$ 189,200,000	1,800	$ 39,600,000		
Tunnels - TBM	$ 22,000	lf						
Stations - At Grade (allowance)	$ 5,000,000	ea						
Stations - Elevated (allowance)	$ 8,000,000	ea						
Maintenance Facility (allowance)	$ 10,000,000	ls						
Track Infrastructure	$ 1,090	lf						
Direct Fixation	$ 1,333	lf						
Ballasted	$ 847	lf						
Signal Systems	$ 500	lf						
Substations	$ 2,000,000	ea						
Vent Buildings	$ 2,000,000	ea						
Access Shafts	$ 2,000,000	ea						
Subtotal Construction Cost				**$ 360,651,188**		**$ 117,250,387**		**$ 58,377,250**

Appendix D

Construction Contingency Models

Single Level Bridge - Initial Build

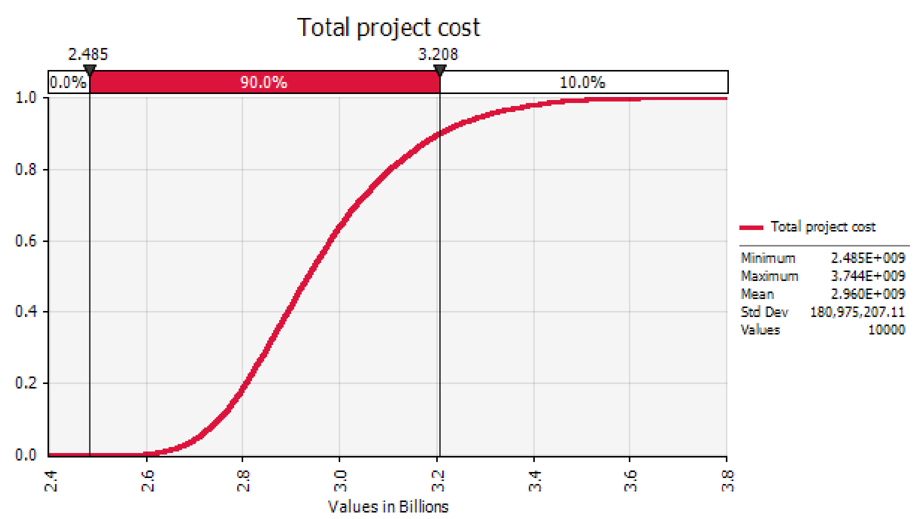
Simulation Input Variables

WBS Cost Elements	Base Construction Cost	Range (%) Minimum	Range (%) Most Likely	Range (%) Maximum	Range ($) Minimum	Range ($) Most Likely	Range ($) Maximum
Site Access Set Up	$ 31,648,907	99%	100%	115%	$ 31,332,418	$ 31,648,907	$ 36,396,244
Dredging	$ 65,724,230	90%	100%	125%	$ 59,151,807	$ 65,724,230	$ 82,155,288
Temporary Access Trestle	$ 152,250,224	75%	100%	200%	$ 114,187,668	$ 152,250,224	$ 304,500,448
Approach Piles	$ 514,890,264	95%	100%	300%	$ 489,145,751	$ 514,890,264	$ 1,544,670,793
Approach Pilecaps and Piers	$ 265,390,227	90%	100%	150%	$ 238,851,204	$ 265,390,227	$ 398,085,341
Approach Superstructures	$ 378,080,651	95%	100%	175%	$ 359,176,619	$ 378,080,651	$ 661,641,140
Main Span Piles	$ 75,160,468	95%	100%	300%	$ 71,402,444	$ 75,160,468	$ 225,481,403
Main Span Pilecaps and Pylons	$ 123,507,252	95%	100%	150%	$ 117,331,889	$ 123,507,252	$ 185,260,878
Main Superstructure	$ 146,262,992	90%	100%	300%	$ 131,636,693	$ 146,262,992	$ 438,788,976
Abutments	$ 20,060,136	90%	100%	115%	$ 18,054,122	$ 20,060,136	$ 23,069,156
Deck & Appurtenances	$ 61,761,498	99%	100%	130%	$ 61,143,883	$ 61,761,498	$ 80,289,947
Demolition of Existing TZB	$ 235,659,741	95%	100%	175%	$ 223,876,754	$ 235,659,741	$ 412,404,546
Contractor Indirect Costs	$ 491,674,838	95%	100%	150%	$ 467,091,096	$ 491,674,838	$ 737,512,257
Total Cost	**$ 2,562,071,429**				**$ 2,382,382,350**	**$ 2,562,071,429**	**$ 5,130,256,417**

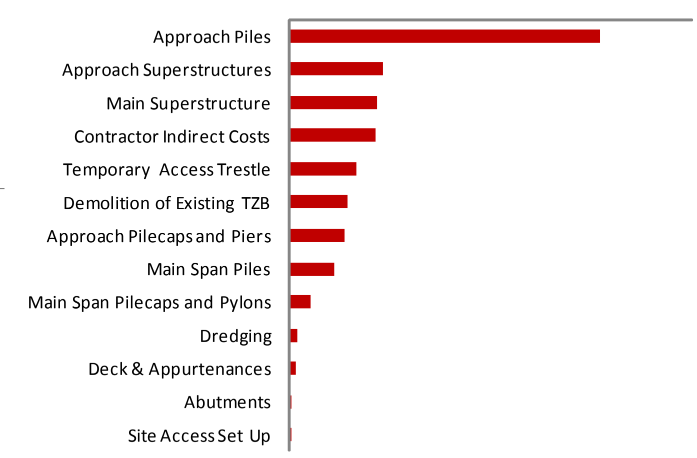
Simulation Results

90% Confidence Limit on Total Cost:	$ 3,207,538,947
Contingency Required for 90% Confidence ($):	$ 645,467,518
Contingency Required for 90% Confidence (%):	**25%**

ARUP



Cumulative Distribution Function



Relative Influence on Total Cost

Dual Level Bridge - Initial Build

Simulation Input Variables

WBS Cost Elements	Base Construction Cost	Range (%) Minimum	Range (%) Most Likely	Range (%) Maximum	Range ($) Minimum	Range ($) Most Likely	Range ($) Maximum
Site Access Set Up	$ 31,648,907	99%	100%	115%	$ 31,332,418	$ 31,648,907	$ 36,396,244
Dredging	$ 65,724,230	90%	100%	125%	$ 59,151,807	$ 65,724,230	$ 82,155,288
Temporary Access Trestle	$ 152,250,224	75%	100%	200%	$ 114,187,668	$ 152,250,224	$ 304,500,448
Approach Piles	$ 356,046,647	95%	100%	300%	$ 338,244,314	$ 356,046,647	$ 1,068,139,940
Approach Pilecaps and Piers	$ 209,497,843	90%	100%	150%	$ 188,548,059	$ 209,497,843	$ 314,246,765
Approach Superstructures	$ 740,918,448	95%	100%	175%	$ 703,872,525	$ 740,918,448	$ 1,296,607,284
Main Span Piles	$ 75,160,468	95%	100%	300%	$ 71,402,444	$ 75,160,468	$ 225,481,403
Main Span Pilecaps and Pylons	$ 123,507,252	95%	100%	150%	$ 117,331,889	$ 123,507,252	$ 185,260,878
Main Superstructure	$ 146,262,992	90%	100%	300%	$ 131,636,693	$ 146,262,992	$ 438,788,976
Abutments	$ 20,060,136	90%	100%	115%	$ 18,054,122	$ 20,060,136	$ 23,069,156
Deck & Appurtenances	$ 61,761,498	99%	100%	130%	$ 61,143,883	$ 61,761,498	$ 80,289,947
Demolition of Existing TZB	$ 235,659,741	95%	100%	175%	$ 223,876,754	$ 235,659,741	$ 412,404,546
Contractor Indirect Costs	$ 431,700,594	95%	100%	150%	$ 410,115,564	$ 431,700,594	$ 647,550,891
Total	**$ 2,650,198,980**				**$ 2,468,898,142**	**$ 2,650,198,980**	**$ 5,114,891,766**

Simulation Results

90% Confidence Limit on Total Cost:	$ 3,248,486,657
Contingency Required for 90% Confidence ($):	$ 598,287,678
Contingency Required for 90% Confidence (%):	**23%**

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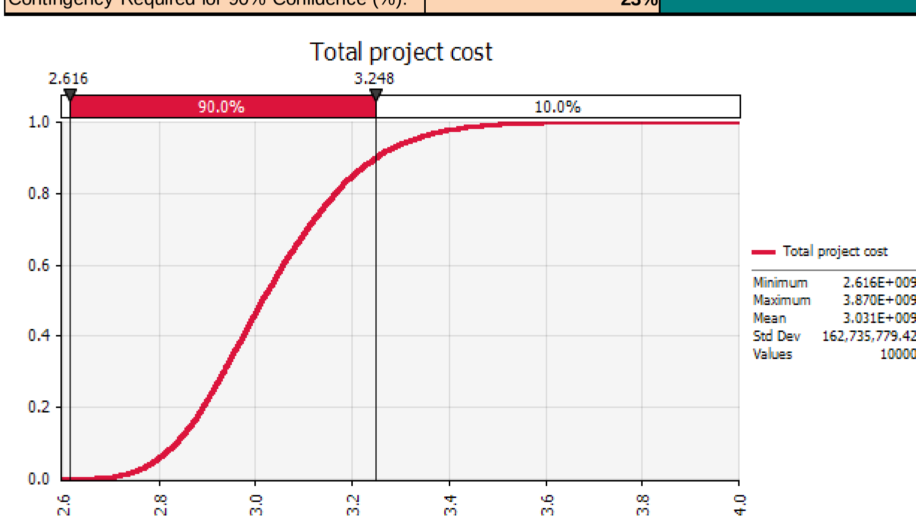
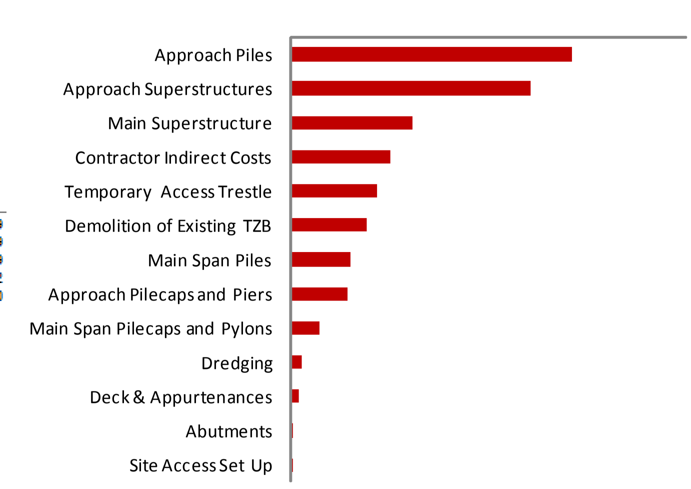


Cumulative Distribution Function



Relative Influence on Total Cost

Rockland Highway - Busway - Initial Build

Simulation Input Variables

WBS Cost Elements	Base Construction Cost	Range (%) Minimum	Range (%) Most Likely	Range (%) Maximum	Range ($) Minimum	Range ($) Most Likely	Range ($) Maximum
Demolition	$ 2,750,000	90%	100%	130%	$ 2,475,000	$ 2,750,000	$ 3,575,000
Earthwork	$ 9,050,000	75%	100%	150%	$ 6,787,500	$ 9,050,000	$ 13,575,000
Rock Excavation	$ 104,630,000	80%	100%	200%	$ 83,704,000	$ 104,630,000	$ 209,260,000
Retaining Walls, Side Slopes, Noise Walls	$ 440,000	95%	100%	200%	$ 418,000	$ 440,000	$ 880,000
Bridges	$ 38,750,000	90%	100%	175%	$ 34,875,000	$ 38,750,000	$ 67,812,500
Pavements and Finishes	$ 92,074,000	95%	100%	150%	$ 87,470,300	$ 92,074,000	$ 138,111,000
Interchange Ramps	$ 76,635,000	95%	100%	200%	$ 72,803,250	$ 76,635,000	$ 153,270,000
Drainage	$ 33,756,000	95%	100%	300%	$ 32,068,200	$ 33,756,000	$ 101,268,000
Utilities	$ 69,340,000	90%	100%	300%	$ 62,406,000	$ 69,340,000	$ 208,020,000
Pedestrian Facilities	$ 12,500,000	90%	100%	300%	$ 11,250,000	$ 12,500,000	$ 37,500,000
Contractor Indirect Costs	$ 108,100,000	95%	100%	150%	$ 102,695,000	$ 108,100,000	$ 162,150,000
Total	**$ 548,025,000**				**$ 496,952,250**	**$ 548,025,000**	**$ 1,095,421,500**

Simulation Results

90% Confidence Limit on Total Cost:	$ 680,500,792
Contingency Required for 90% Confidence ($):	$ 132,475,792
Contingency Required for 90% Confidence (%):	**24%**

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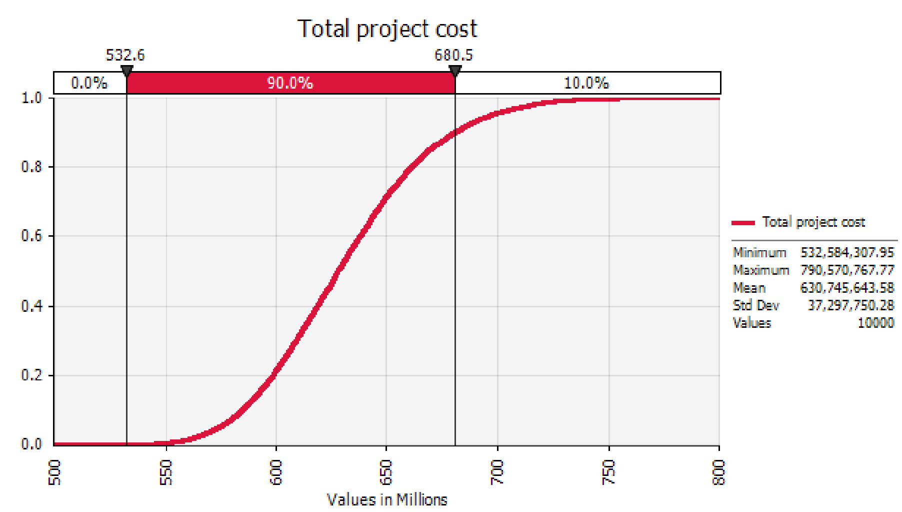
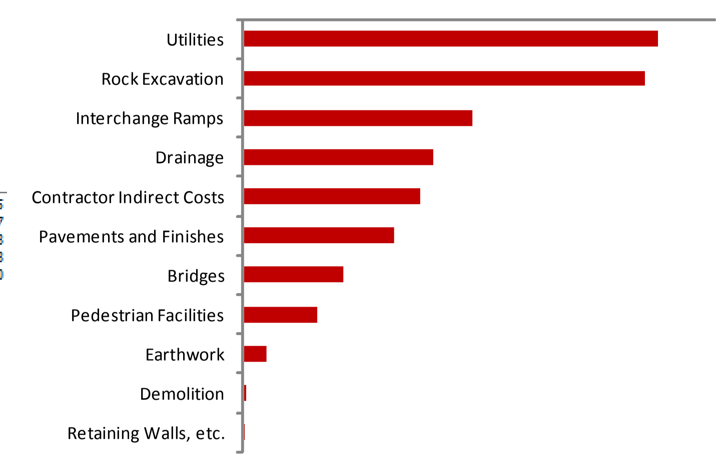


Cumulative Distribution Function



Relative Influence on Total Cost

Rockland Highway - HOV / HOT - Initial Build

Simulation Input Variables

WBS Cost Elements	Base Construction Cost	Range (%) Minimum	Range (%) Most Likely	Range (%) Maximum	Range ($) Minimum	Range ($) Most Likely	Range ($) Maximum
Demolition	$ 33,860,000	90%	100%	130%	$ 30,474,000	$ 33,860,000	$ 44,018,000
Earthwork	$ 16,600,000	75%	100%	150%	$ 12,450,000	$ 16,600,000	$ 24,900,000
Rock Excavation	$ 433,290,000	80%	100%	200%	$ 346,632,000	$ 433,290,000	$ 866,580,000
Retaining Walls, Side Slopes, Noise Walls	$ 273,650,000	95%	100%	200%	$ 259,967,500	$ 273,650,000	$ 547,300,000
Bridges	$ 131,810,000	90%	100%	250%	$ 118,629,000	$ 131,810,000	$ 329,525,000
Pavements and Finishes	$ 194,670,000	95%	100%	150%	$ 184,936,500	$ 194,670,000	$ 292,005,000
Interchange Ramps	$ 154,170,000	95%	100%	200%	$ 146,461,500	$ 154,170,000	$ 308,340,000
Drainage	$ 82,260,000	95%	100%	300%	$ 78,147,000	$ 82,260,000	$ 246,780,000
Utilities	$ 104,350,000	90%	100%	300%	$ 93,915,000	$ 104,350,000	$ 313,050,000
Pedestrian Facilities	$ 25,000,000	90%	100%	300%	$ 22,500,000	$ 25,000,000	$ 75,000,000
Contractor Indirect Costs	$ 346,250,000	95%	100%	150%	$ 328,937,500	$ 346,250,000	$ 519,375,000
Total	**$ 1,795,910,000**				**$ 1,623,050,000**	**$ 1,795,910,000**	**$ 3,566,873,000**

Simulation Results

90% Confidence Limit on Total Cost:	$ 2,222,728,913
Contingency Required for 90% Confidence ($):	$ 426,818,913
Contingency Required for 90% Confidence (%):	**24%**

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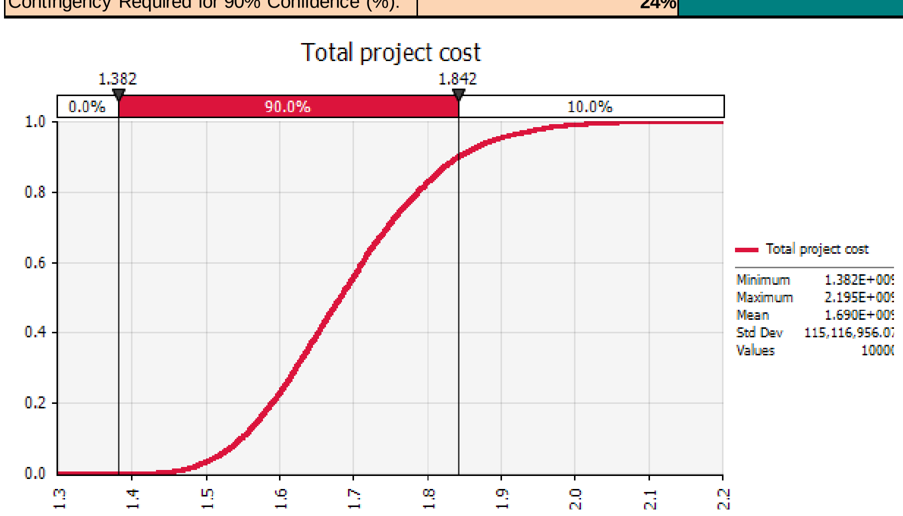
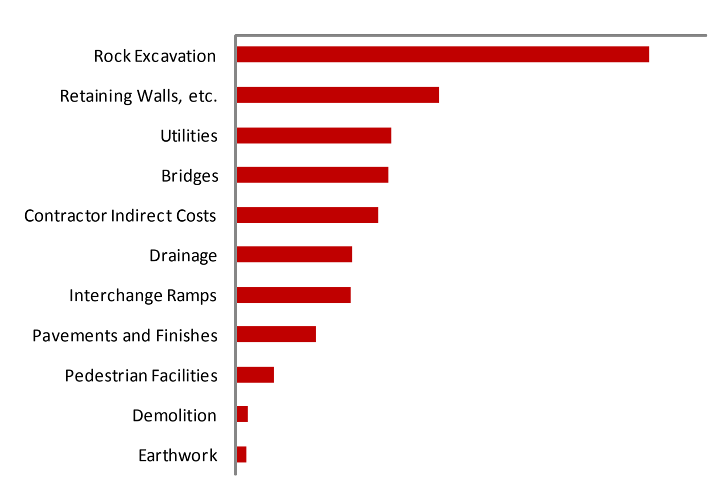


Cumulative Distribution Function



Relative Influence on Total Cost

Rockland and Westchester Landings - Initial Build

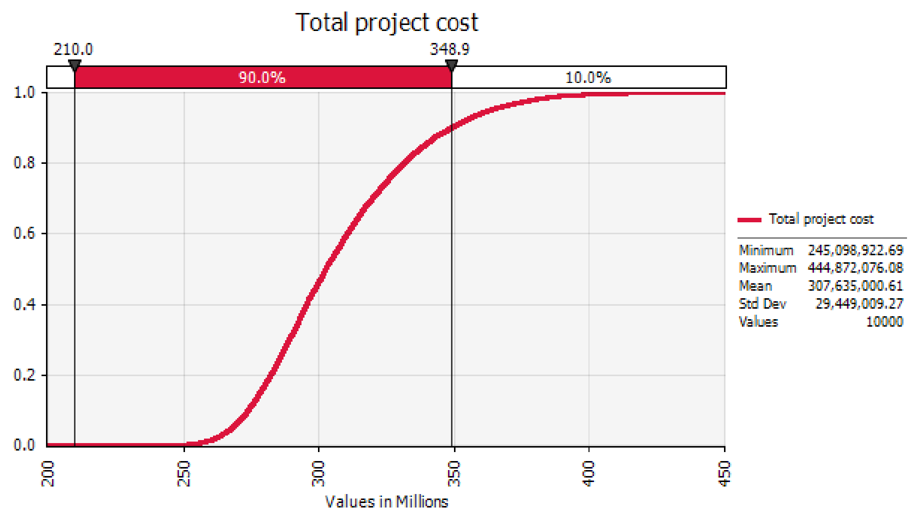
Simulation Input Variables

WBS Cost Elements	Base Construction Cost	Range (%) Minimum	Range (%) Most Likely	Range (%) Maximum	Range ($) Minimum	Range ($) Most Likely	Range ($) Maximum
Demolition	$ 12,630,000	90%	100%	130%	$ 11,367,000	$ 12,630,000	$ 16,419,000
Retaining Walls, Side Slopes, Noise Walls	$ 29,930,000	95%	100%	200%	$ 28,433,500	$ 29,930,000	$ 59,860,000
Bridges	$ 28,010,000	90%	100%	250%	$ 25,209,000	$ 28,010,000	$ 70,025,000
Pavements and Finishes	$ 34,360,000	95%	100%	150%	$ 32,642,000	$ 34,360,000	$ 51,540,000
Interchange Ramps	$ 21,980,000	95%	100%	200%	$ 20,881,000	$ 21,980,000	$ 43,960,000
Drainage	$ 20,000,000	95%	100%	300%	$ 19,000,000	$ 20,000,000	$ 60,000,000
Utilities	$ 20,000,000	90%	100%	300%	$ 18,000,000	$ 20,000,000	$ 60,000,000
Cut and Cover Tunnels	$ 83,650,000	90%	100%	300%	$ 75,285,000	$ 83,650,000	$ 250,950,000
Contractor Indirect Costs	$ 58,390,000	95%	100%	150%	$ 55,470,500	$ 58,390,000	$ 87,585,000
Total	**$ 308,950,000**				**$ 274,921,000**	**$ 296,320,000**	**$ 683,920,000**

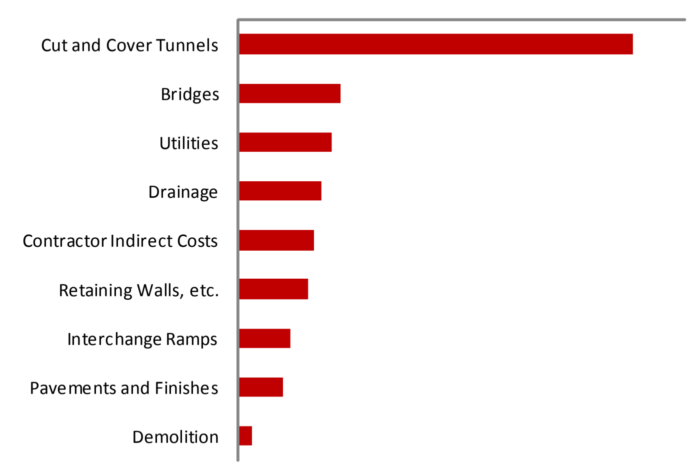
Simulation Results

90% Confidence Limit on Total Cost:	$ 411,888,615
Contingency Required for 90% Confidence ($):	$ 102,938,615
Contingency Required for 90% Confidence (%):	33%

ARUP



Cumulative Distribution Function



Relative Influence on Total Cost

Appendix E

Single Level Bridge Initial Build Phase - Heavy Bid Output Reports

Provided under separate cover

Appendix F

Single Level Bridge Final Build Phase - Heavy Bid Output Reports

Provided under separate cover

Appendix G

Dual Level Bridge Initial Build Phase - Heavy Bid Output Reports

Provided under separate cover

Appendix H

Dual Level Bridge Final Build Phase - Heavy Bid Output Reports

Provided under separate cover

Appendix I

Highway, BRT and CRT Representative Unit Costs - Heavy Bid Output Reports

Provided under separate cover