RockSol
Consulting Group, Inc.

February 16, 2017

Atkins North America, Inc.
7604 Technology Way, Suite 400
Denver, Colorado 80237

Attention: Mr. Matt Aguirre, PE
Transportation Engineer

Subject: Life Cycle Cost Analysis, North I-25 Reconstruction Project – ARE#1 Segment from Hillsboro Tributary to North of State Highway 402 (SH402), Larimer County, Colorado, CDOT Project No. IM 0253-255(21506), RockSol Project Number 292.05

Dear Mr. Aguirre:

RockSol Consulting Group, Inc. (RockSol) has performed a Life Cycle Cost Analysis (LCCA) for the subject project as part of the pavement design evaluation. Per Section 13.2 of the 2017 CDOT ME Pavement Design Manual (PDM), a Life Cycle Cost Analysis (LCCA) comparing asphalt and concrete should be prepared for all surface treatment projects with more than $2,000,000 initial pavement cost where both pavement types are considered feasible alternatives as determined by the CDOT Regional Materials Engineer.

This LCCA is based on planned reconstruction (new pavement) and overlay construction for northbound and southbound I-25 between approximate Mile Post (MP) 254.8 to MP 255.8, located between the Hillsboro Tributary and just north of SH402 (Project Station No. 3323+00 to 3378+00). The proposed I-25 mainline configuration for the Additional Requested Elements number one (ARE#1) area includes widening to the inside median area for express lane construction as well as outside areas as needed for the *2-plus-1* lane configuration. Table 1 lists the approximate widths and lengths based on information provided in the project plans (*Exhibit 1-C1: ARE #1, SH 402 on FEIS Alignment, ROD4 Selected Preferred Alternative Configuration,* dated 1/26/2017) where new pavement construction is proposed.

For this project, two pavement types were considered for the LCCA; rigid pavement consisting of portland cement concrete pavement (PCCP) and flexible pavement consisting of hot mix asphalt (HMA) and stone matrix asphalt (SMA). An Annual Growth Rate of 2.6 percent was used for pavement thickness designs. A summary of evaluated pavement sections is presented in Table 2.

Table 1 – ARE#1 Segment Project Area Description

Station No.	New Pavement Construction			
	Average Width (ft)	Length (ft)	Area (SF)	Area (SY)
3323+00 to 3378+00	128	5,500	704,000	78,222

Table 2 – Evaluated Pavement Section Summary (New Pavement Construction)

North I-25 Mainline ARE#1 Segment Station and Mile Post	Full Depth Pavement Section (20 year SMA/HMA and 30 Year PCCP)		
Station No. 3323+00 to 3378+00 MP 254.8 to MP 255.8	SMA over HMA (inches) (Note 1)	ABC (inches)	R-40 (inches)
	13.0	**6.0**	**24**
	PCCP (inches)	ABC (inches)	R-40 (inches)
	14.0	**6.0**	**24**

Note 1: 3 inches of SMA over 10 inches of new HMA.
ABC = CDOT Class 6 Aggregate Base Course. R-40 = R-Value of subgrade material for the minimum designed depth beneath ABC.

The PCCP pavement sections presented in Table 2 include ¼ inch allowance for future diamond grinding.

This LCCA is based on phasing for the initial pavement construction to be completed off the outside shoulder of northbound I-25, then traffic will be shifted onto the newly constructed pavement so new pavement can be constructed for the proposed southbound I-25 configuration. RockSol understands that two lanes of traffic will be required to remain open for northbound and southbound I-25 during construction for this project. Initial pavement construction near overpasses will be governed by the construction phasing of the proposed bridge structures within the limits of the LCCA site. The estimate length of time for pavement construction is estimated to be significantly less than the estimated length of time for the construction of the proposed bridge structures planned for this project. The proposed construction phasing scheduled was not developed at the time of this LCCA.

Based on recent construction projects and traffic control permitting requirements for Region 4 along I-25, a workzone speed limit of 65 miles per hour (mph) and a workzone length of 1 mile (full project limit) was used for initial construction for long term traffic control purposes. A workzone speed limit of 55 mph and a workzone length of 1 mile was used for rehabilitation construction for short term operations.

LCCA Input Summary

The LCCA was performed using a 40-year analysis period and a 30-year initial design period for rigid pavement, assuming an initial/base construction year of 2020. Based on Section 13.3.3 of the 2017 CDOT ME PDM, a triangular distribution with the most likely value of 27 years (2047)

was used for the first rigid pavement rehabilitation cycle. The rigid pavement rehabilitation analysis included a ½ percent slab replacement in the travel lanes and 100 percent diamond grinding of ¼ inch and longitudinal and transverse joint resealing.

The LCCA was performed using a 40-year analysis period and a 20-year initial design period for flexible pavement, assuming an initial/base construction year of 2020. Rehabilitation of the flexible pavement included a 3-inch mill and overlay with 2 inches of SMA and 1.5 inches of HMA at year 2034 and a 2-inch mill and overlay with 2.5 inches of SMA at year 2047 based on Table 13.1 in the 2017 CDOT ME PDM and discussions with CDOT Region 4 Materials.

Additional factors used in the LCCA for both flexible and rigid pavements include a discount rate of 2.22 percent, Cost of Engineering (CE) of 22.1 percent, Traffic Control Cost of 15 percent for the initial construction and rehabilitation operations. A Preliminary Engineering (PE) of 10 percent was used for the rehabilitation operations.

Annual maintenance costs used for the LCCA are $1,027 per lane mile for HMA and $640 per lane mile for PCCP per Section 13.5.3 of the 2017 CDOT PDM.

Sources for evaluation of material costs and production rates included:

1) 2017 CDOT Pavement Design Manual (Chapter 13).
2) CDOT Colorado Construction Cost Index Report, Calendar Year 2016, Second Quarter.
3) 2013 through 2016 CDOT Cost Data Information and Bid Tabs.
4) Discussions with CDOT Region 4.
5) Discussions with representatives from the Colorado Asphalt Pavement Association (CAPA) and American Concrete Pavement Association (ACPA).
6) CDOT Engineering Estimates and Marketing Analysis information.
7) Recent E-470 Asphalt Paving Material Prices

Pricing for PCCP was evaluated with CDOT data for large projects considered appropriate for comparison and a plot of that price data is attached. Most of the price data was for PCCP ranging from 10 to 12 inches. Also evaluated was Table 13.19 of the 2017 CDOT M-E PDM which lists prices for PCCP, 12 or greater inches, with a normalized average price per square yard of $38.36. This value is slightly higher than the price indicated in the price plot attached.

Also strongly considered was a recent PCCP paving project, I-25 from Lincoln to County Line that included PCCP which was 13-inches thick and was for nearly 75,000 square yards. For that project three bidders provided costs for the PCCP which were $38.50, $49.50, and $52.00 per square yard ($2.96, $3.81, and $4.00 per square yard-inch, respectively). ACPA has provided an estimated unit price of PCCP of $3.50 to $3.75 per square yard-inch. Based on this range of PCCP pricing, RockSol is using PCCP pricing that is consistent with the I-25 Lincoln to County Line bidding prices and the ACPA pricing estimate.

Pricing for SMA and S mix asphalt was evaluated using prices for projects bid after 2012 and a plot of the price data is included in Appendix A. Tack coat (emulsified asphalt – slow setting) was included as a cost item for this LCCA. Of the projects evaluated for cost, most listed tack coat as a separate cost item but some did not. Where tack coat was not listed as a separate cost item in the cost data, it was included in the SMA/ HMA cost data. To appropriately compare SMA/HMA costs for all projects evaluated, where tack coat was included in the HMA/SMA costs, an average cost for tack coat per ton of HMA/SMA was subtracted from the HMA/SMA unit costs for this LCCA.

Table 3 presents the basic material, construction and rehabilitation costs, and production rates.

Table 3 - Material, Construction and Rehabilitation Costs and Production Rates

Operation/Material	Production Rate	Minimum Cost ($)	Most Likely Cost ($)	Maximum Cost ($)
10-inches - HMA Grading S (100) PG 64-22 (price per ton)	2,200 tons/day (75%) 1,800 tons/day (25%)	60.00	65.00	70.00
3-inches - SMA (Fiber)	1,800 tons/day (75%) 1,500 tons/day (25%)	90.00	95.00	100.00
Planing/Milling (HMA) SY	2 days ahead of paving operations	2.04	2.27	2.50
Tack Coat Material (Emulsified Asphalt – Slow Setting) (SY)	Performed ahead of paving operations (same day/night)	0.28	0.38	0.48
Rigid Pavement 13.5 to 14.0 inches (price per SY-in)	5,500 (75%)(SY/day) 2,880 (25%) (SY/day) [Production rate includes time required to achieve strength and sealing]	3.25	3.50	3.75
Rigid Slab Replacement (SY) (includes removal/replacement)	5 Panels per day/night	125	150	175
Grinding Concrete Pavement (SY)	7,040 SY/day	3.00	3.50	4.00
Sawing and Sealing Concrete Joints (linear feet)	10,000 LF/day	2.25	2.75	3.25

The area for the ARE#1 Segment is approximately 78,222 square yards (SY). Using the production rates of 5,500 SY per day for normal production (75 percent of the time) and 2,880 SY per day for lower production (25 percent of the time), the initial construction for the rigid alternative was determined to be 18 days.

A total of 12,907 tons of SMA and 43,022 tons of HMA was determined based the total area and design thicknesses. Tack coat placement was based on total project square yardage, number of lifts for HMA/SMA placement, and an application rate of 0.1 gallons per square yard. Based on 25 percent of the total tons for low production days, 75 percent for normal production days and the production rates listed in Table 3 for SMA and HMA material types, a total of 29 days was determined for initial construction of the flexible alternative.

User costs are included in the LCCA for both pavement alternatives for initial pavement construction and for their respective rehabilitation operations. User cost information from the LCCA is attached.

LCCA Output Summary

Based on the results of the LCCA, the probabilistic analysis indicates the rigid pavement option is less costly than the flexible pavement option by a difference of 41.6 percent at the 75 percentile as shown in Table 4. CDOT uses the 75 percentile as the basis for comparison of pavement alternatives. The output results for CDOT User Cost Website and RealCost are included in Appendix B.

Table 4 – Probabilistic LCCA Results (40 Year Analysis)

Statistics	Alternative 1 – Flexible Pavement			Alternative 2 – Rigid Pavement		
	LCCAOutput: Alternative 1: Agency Cost	LCCAOutput: Alternative 1: User Cost	Flexible Pavement Total	LCCAOutput: Alternative 2: Agency Cost	LCCAOutput: Alternative 2: User Cost	Rigid Pavement Total
Probability Function	(Thousands)	(Thousands)	(Thousands)	(Thousands)	(Thousands)	(Thousands)
Minimum	6915.39	342.12	7257.51	4993.25	329.30	5322.55
Maximum	9171.32	386.50	9557.82	6214.84	410.36	6625.20
Mean	8197.67	371.80	8569.47	5690.19	379.37	6069.56
Median	8214.70	372.57	8587.27	5694.31	384.51	6078.81
Standard Deviation	363.30	6.43	369.73	213.49	17.94	231.43
Percentile (5%)	7557.74	360.40	7918.14	5340.68	344.72	5685.40
Percentile (25%)	7969.85	368.14	8337.98	5547.23	366.48	5913.71
Percentile (75%)	8451.20	376.30	**8827.50**	5841.31	393.02	**6234.33**
Percentile (95%)	8765.85	380.77	9146.62	6041.77	401.19	6442.96

The cost and duration indicated on the User Cost output sheets are based on the total pavement area (new and overlay pavement sections) as outlined in Table 1 for the ARE#1 Segment Project limits. Based on the CDOT User Cost website, user costs for initial and rehabilitation construction operations for the flexible and rigid pavement alternatives are outlined in Table 5.

Table 5 – LCCA User Costs Summary

Operation	Flexible Pavement	Rigid Pavement
Initial Construction (2020)	$326,257	$326,257
Rehabilitation 2034	$28,603	----
Rehabilitation 2047	$45,591	$111,230
Total	**$400,451**	**$437,487**

Prepared by:
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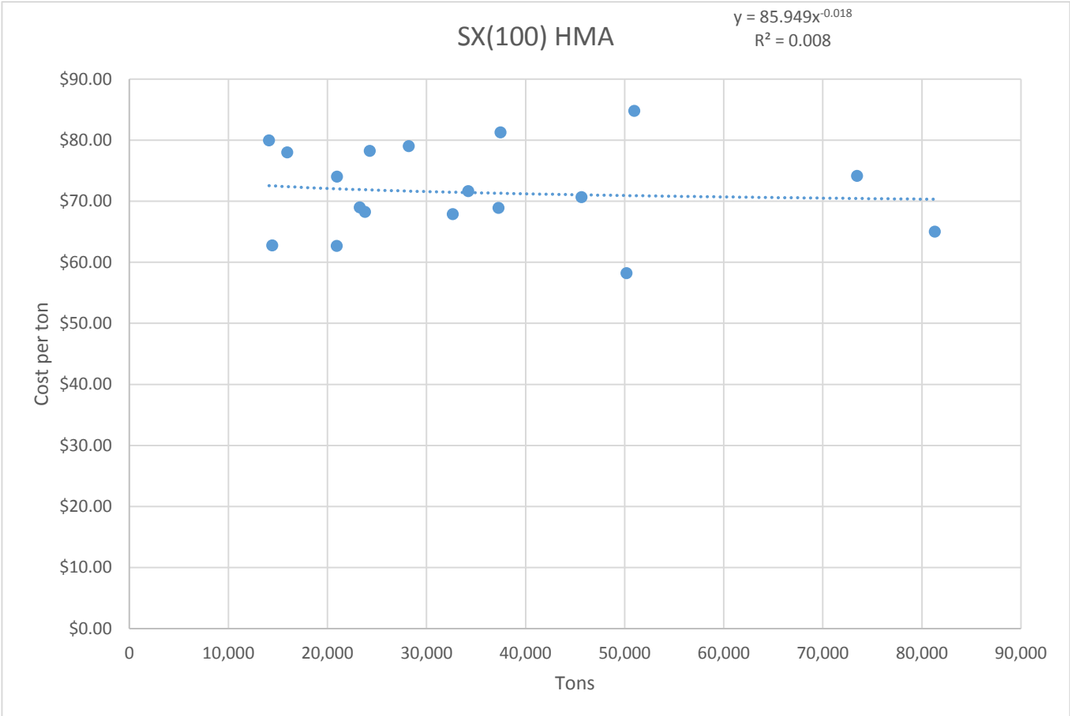
Attachments
Appendix A: SMA, HMA, PCCP Unit Cost Information
Appendix B: LCCA Input and Output Summary Sheets

APPENDIX A

SMA, HMA, PCCP UNIT COST INFORMATION



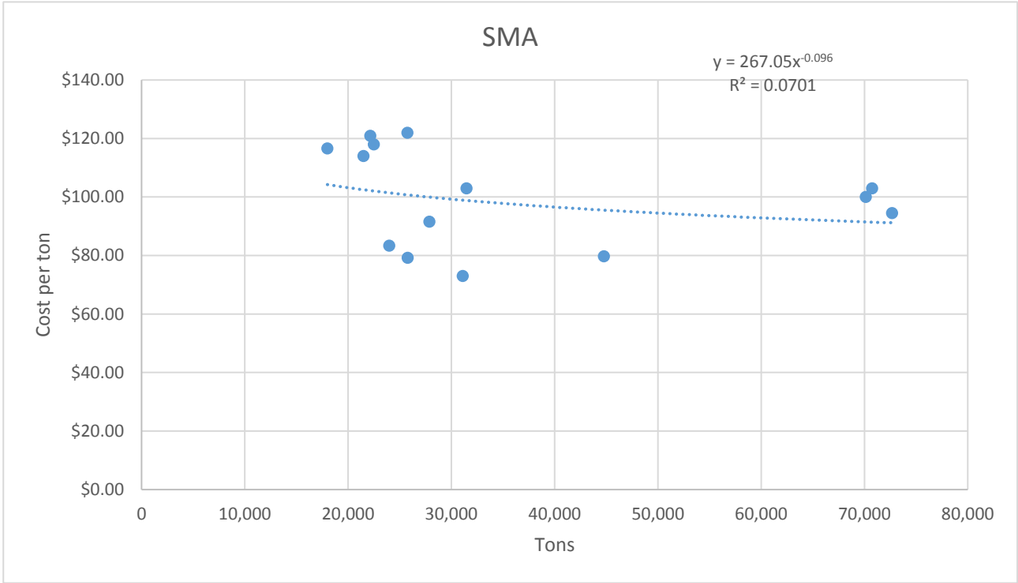
HMA

300000 tons

Unit Price
$ per ton

$68.49

Bid Date	Contract ID	Location	Awarded To	Quantity (tons)	Unit Cost ($/ton)	Total Cost ($)	Unit Price Tack Coat ($)	Quantity (gal)	Total Cost Tack Coat ($)
FEB 07 2013	C18825	US 50, LA JUNTA # EAST, 4-LANE	MARTIN MARIETTA MATERIALS	50,170	$58.21	$2,920,396	$2.81	21,522.00	$60,477
MAR 28 2013	C19014	I 25A, MIDWAY NORTH, Site 1, Site 2, Site 3, and	SCHMIDT CONSTRUCTION COMPANY	37,258	$68.90	$2,567,076	$2.51	13,283.00	$33,340
APR 18 2013	C18736	SH30: FLORIDA TO 1ST & SH83: JEWELL TO	BRANNAN SAND AND GRAVEL, LLC	23,247	$69.00	$1,604,043	$3.09	8,050.00	$24,875
MAR 13 2014	C19655	I-25, BUTTE CREEK SOUTH (MP 50-59)	APC SOUTHERN CONSTRUCTION COMPANY, LLC	73,458	$74.14	$5,446,195	$2.85	22,012.00	$62,734
MAR 13 2014	C19655	I-25, BUTTE CREEK SOUTH (MP 50-59)	APC SOUTHERN CONSTRUCTION COMPANY, LLC	14,104	$79.97	$1,127,897	$2.85	4,224.00	$12,038
Apr-14		I-25 SANTA FE ALAMEDA INTERCHANGE (S(100)	HAMON INFRASTRUCTURE, INC.	28,199	$79.00	$2,227,721			$0
Mar-15	C19456	SH58 Resurfacing	APC CONSTRUCTION CO., LLC	14,412	$62.74	$904,209	$4.93	8,736.10	$43,069
		US 50 Wills to Purcell (S(100) PG64-22))		20,957	$74.00	$1,550,818			$0
FEB 12 2015	C19654	SH 47 FROM DILLION DR TO PCCP SECTION, MP	MARTIN MARIETTA MATERIALS	34,200	$71.63	$2,449,761	$4.89	11,736.00	$57,389
MAR 12 2015	C20225	SH 16 & SH 21 SYRACUSE TO BRADLEY	ROCKY MOUNTAIN MATERIALS & ASPHALT, INC.	32,631	$67.89	$2,215,319	$5.24	14,731.00	$77,190
APR 16 2015	C20365	S85 FY15 OVERLAY BRIGHTON TO FT LUPTON	AGGREGATE INDUSTRIES - WCR, INC.	24,274	$78.25	$1,899,441			$0
APR 23 2015	C20487	US 71 from M.P. 18.9 to M.P. 27	A and S CONSTRUCTION CO.	15,937	$78.00	$1,243,056	$4.00	15,088.00	$60,352
FEB 04 2016	C20519	I25 from Aguilar North	APC SOUTHERN CONSTRUCTION COMPANY, LLC	45,632	$70.65	$3,223,926	$2.90	18,192.00	$52,757
FEB 18 2016	C19626	I-25 120th to SH7 S(100) PG64-22 Mix	HAMON INFRASTRUCTURE, INC.	81,292	$65.00	$5,283,980	$6.00	26,904.00	$161,424
MAR 03 2016	C21267	I-76: EAST OF BRUSH TO MERINO	SIMON CONTRACTORS	37,462	$81.25	$3,043,788			$0
MAR 24 2016	C20846	C-470 RESURFACING: S. ROONEY RD TO KEN	APC CONSTRUCTION CO., LLC	20,931	$62.66	$1,311,536	$4.64	12,240.00	$56,794
April 11 2016		I-25 Arapahoe Rd. Interchange S(100) PG64-22	EKS	50,960	$84.80	$4,321,408	$3.18	13,338.95	$42,418
MAR 24 2016	C20655	US 85 RESURFACING MP 240-246 SOUTHBOUND	COULSON EXCAVATING COMPANY	23,794	$68.25	$1,623,941			$0



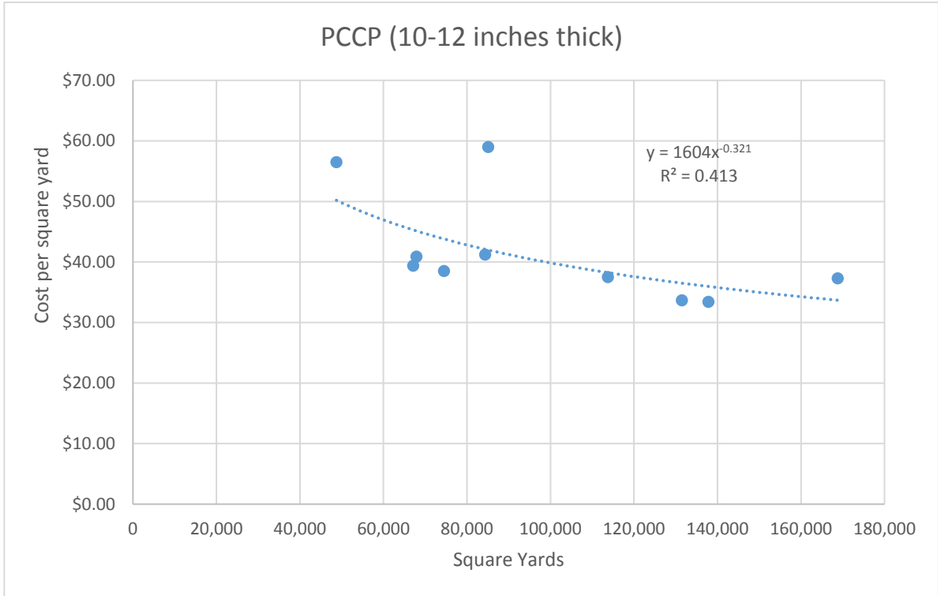
SMA

50000 tons

Unit Price
$ per ton

$94.51

Bid Date	Contract ID	Location	Awarded To	Quantity (tons)	Unit Cost ($/ton)	Total Cost ($)	Unit Price Tack Coat ($)	Quantity (gal)	Total Cost Tack Coat ($)
MAR 14 2013	C18449	C470: SANTA FE TO WADSWORTH RE	APC CONSTRUCTION CO., LLC	25,776	$79.25	$2,042,748	$5.74	4,939.35	$28,352
02/14/13	C19258	I-76 Resurfacing	MARTIN MARIETTA MATERIALS	23,977	$83.34	$1,998,243	$2.56	9,018.00	$23,086
APR 18 2013	C19314	I-70 WEST OF FLAGLER	MARTIN MARIETTA MATERIALS	72,667	$94.50	$6,867,032	$2.40	25,652.00	$61,565
FEB 27 2014	C17800S	I-25 RUBBLIZATION HARMONY ROAD	AGGREGATE INDUSTRIES - WCR, INC.	21,483	$114.00	$2,449,062			$0
04/10/14	C17890	Arapahoe Road Resurfacing (2014)	Hamon	31,476	$103.00	$3,242,028	$3.00	10,857.56	$32,573
03/05/15	C19456	SH 58 US6-SH93 to I-70 (2015)	APC CONSTRUCTION CO., LLC	27,872	$91.55	$2,551,682	$4.93	16,882.92	$83,233
02/18/16	C19626	I-25: 120th Ave to SH7	Hamon	70,138	$100.00	$7,013,800	$6.00	22,211.32	$133,268
03/24/16	C20846	C470: Resurfacing (2016) STU4701-129	APC CONSTRUCTION CO., LLC	44,772	$79.75	$3,570,567	$4.64	26,145.52	$121,315
		E470		70,731	$102.98	$7,283,878			$0
04/14/16	C20836	I-25, NHPP0252-445	Brannan Sand and Gravel	25,750	$122.00	$3,141,500	$2.00	16,521.00	$33,042
02/11/16	C20583	I-25 Climbing Lane (2016)	SEMA	22,500	$118.00	$2,655,000	$3.90	7,490.88	$29,214
04/11/16		I-25 Arapahoe Road Interchange	EKS	17,994	$116.60	$2,098,100	$3.18	4,711.05	$14,981
JUN 02 2016	C20929	I 25 OVERLAY, MLK BYPASS NORTH	SCHMIDT CONSTRUCTION COMPANY	22,135	$120.94	$2,677,007	$3.25	8,355.00	$27,154
DEC 22 2016	C20902	I-70 MP 158.5 TO 168	OLDCASTLE SW GROUP, INC.	31,096	$73.00	$2,270,008	$2.00	21,447.00	$42,894



PCCP

140000 square yards

Unit Price $ per Sq yd $35.75

Bid Date	Contract ID	Location	Awarded To	Quantity (SQ YD)	Sq Yd- In ($)	Total Cost
JAN 24 2013	C15402	Ft. Morgan to Brush (Phase III)	CASTLE ROCK CONST. CO. OF COLO, LLC	137,818	$33.40	$4,603,121
JAN 17 2013	C19303	I-70 GLENWOOD CANYON PCCP PHASE 4	INTERSTATE HIGHWAY CONSTRUCTION	84,334	$41.23	$3,477,091
AUG 15 2013	C16259-	I-70 TOWER TO COLFAX	AMES CONSTRUCTION, INC.	113,731	$37.50	$4,264,913
JUL 17 2014	C19273	SH86:I-25 TO WOODLANDS BLVD.	CONCRETE WORKS OF COLORADO INC.	48,733	$56.50	$2,753,415
MAY 03 2012	C17757	SH 85 IN GREELEY 5TH TO US 34	CASTLE ROCK CONST. CO. OF COLO, LLC	131,455	$33.67	$4,426,090
JAN 24 2013	C15402	Ft. Morgan to Brush (Phase III)	CASTLE ROCK CONST. CO. OF COLO, LLC	168,771	$37.30	$6,295,158
JUN 26 2014	C16602	I-25 LINCOLN TO COUNTY LINE (12.5")	INTERSTATE HIGHWAY CONSTRUCTION	67,134	$39.40	$2,645,080
		I-25 at Crossroads (12.5")		85,064	$59.00	$5,018,776
		I-25: Lincoln to County Line (13")	INTERSTATE HIGHWAY CONSTRUCTION	74,487	$38.50	$2,867,750
FEB 19 2015	C19029	I-70 SEIBERT-EAST	CASTLE ROCK CONST. CO. OF COLO, LLC	67,876	$40.90	$2,776,128

APPENDIX B

LCCA INPUT AND OUTPUT SUMMARY SHEETS

LCCA Initial and Rehab Costs - IM 0253-255 (21506) - ARE#1 Segment
RockSol Project No. 292.05_February 15_2017

Initial Construction Cost (Year 2020)	Area (SY)	Thickness	Directions	PE (%)	CE (%)	Traffic (%)	Minimum Cost (SQ YD-IN)	Most Likely Cost (SQ YD-IN)	Maximum Cost (SQ YD-IN)	Minimum Total	Most Likely Total	Maximum Total
14" PCCP Mainline I-25	78,222	14 in	both	0	0.221	0.15	$3.25	$3.50	$3.75	$4,879,527	$5,254,876	$5,630,224
									Initial Total	**$4,879,527**	**$5,254,876**	**$5,630,224**

Rehabilitation Cost (Year 2047)

		Directions	PE (%)	CE (%)	Traffic (%)	Minimum Cost	Most Likely Cost	Maximum Cost	Minimum Total	Most Likely Total	Maximum Total
1/2 % Slab Replacement	400 SY	both	0.1	0.221	0.15	$125.00	$150.00	$175.00	$73,550	$88,260	$102,970
100% Grinding	78,222 SY	both	0.1	0.221	0.15	$3.00	$3.50	$4.00	$345,194	$402,726	$460,258
Joint Restoration Transverse	46,934 LF	both	0.1	0.221	0.15	$2.25	$2.75	$3.25	$155,340	$189,860	$224,380
Joint Restoration Longitudinal	49,500 LF	both	0.1	0.221	0.15	$2.25	$2.75	$3.25	$163,833	$200,240	$236,647
								Rehab Total	**$737,916**	**$881,086**	**$1,024,255**

LCCA Initial and Rehab Costs - IM 0253-255 (21506) - ARE#1 Segment
RockSol Project No. 292.05_February 15_2017

Initial Construction Costs (Year 2020)	Total	Units	Directions	PE (%)	CE (%)	Traffic Cost (%)	Minimum Cost	Most Likely Cost	Maximum Cost		Minimum Total	Most Likely Total	Maximum Total
SMA	12,907	tons	both	0	0.221	0.15	$90.00	$95.00	$100.00		$1,592,595	$1,681,072	$1,769,550
HMA S(100)PG 64-22	43,022	tons	both	0	0.221	0.15	$60.00	$65.00	$70.00		$3,538,990	$3,833,906	$4,128,821
Tack Coat	234,666	SY	both	0	0.221	0.15	$0.28	$0.38	$0.48		$90,084	$122,256	$154,429
										Total	**$5,221,668**	**$5,637,234**	**$6,052,800**
Rehabilitation Costs (Years 2034 and 2047)													
2034 SMA	8,604	tons	both	0.1	0.221	0.15	$90.00	$95.00	$100.00		$1,139,084	$1,202,366	$1,265,648
2034 HMA	6,453	tons	both	0.1	0.221	0.15	$60.00	$65.00	$70.00		$569,542	$617,004	$664,465
Tack Coat	78,222	SY	both	0.1	0.221	0.15	$0.28	$0.38	$0.48		$32,218	$43,725	$55,231
Milling (2034)	78,222	SY	both	0.1	0.221	0.15	$2.04	$2.27	$2.50		$234,732	$261,197	$287,661
										Total	**$1,975,575**	**$2,124,291**	**$2,273,006**
2047 SMA	10,756	tons	both	0.1	0.221	0.15	$90.00	$95.00	$100.00		$1,423,987	$1,503,097	$1,582,208
Tack Coat	78,222	SY	both	0.1	0.221	0.15	$0.28	$0.38	$0.48		$32,218	$43,725	$55,231
Milling (2047)	78,222	SY	both	0.1	0.221	0.15	$2.04	$2.27	$2.50		$234,732	$261,197	$287,661
										Total	**$1,690,937**	**$1,808,018**	**$1,925,100**

INPUT WORKSHEET			
1. Economic Variables			
Value of Time for Passenger Cars ($/hour)	$18.50		
Value of Time for Single Unit Trucks ($/hour)	$43.50		
Value of Time for Combination Trucks ($/hour)	$49.50		
2. Analysis Options			
Include User Costs in Analysis	Yes		
Include User Cost Remaining Life Value	Yes		
Use Differential User Costs	Yes		
User Cost Computation Method	Specified		
Include Agency Cost Remaining Life Value	Yes		
Traffic Direction	Both		
Analysis Period (Years)	40		
Beginning of Analysis Period	2020		
Discount Rate (%)	2.2		
Number of Alternatives	2		
3. Project Details			
State Route	025A		
Project Name	North I-25 ARE#1 Segment		
Region	Region 4		
County	Larimer and Weld Counties		
Analyzed By	RockSol Consulting Group, Inc.		
Mileposts			
Begin	254.80		
End	255.80		
Length of Project (miles)	1.00		
Comments	LCCA Analysis - February 15, 2017		
4. Traffic Data			
AADT Construction Year (total for both directions)	91,717		
Cars as Percentage of AADT (%)	90.0		
Single Unit Trucks as Percentage of AADT (%)	2.0		
Combination Trucks as Percentage of AADT (%)	8.0		
Annual Growth Rate of Traffic (%)	2.6		
Speed Limit Under Normal Operating Conditions (mph)	75		
No of Lanes in Each Direction During Normal Conditions	2		
Free Flow Capacity (vphpl)	2095		
Rural or Urban Hourly Traffic Distribution	Rural		
Queue Dissipation Capacity (vphpl)	2057		
Maximum AADT (total for both directions)	224,256		
Maximum Queue Length (miles)	5.0		
5. Construction			

Probabilistic Life Cycle Cost Analysis Worksheet

Alternative 1	Flexible Alternative		
Number of Activities	3		
Activity 1	Initial Flexible Construction Completed 2020		
Agency Construction Cost ($1000)	$5,637.23		
User Work Zone Costs ($1000)	$326.26		
Work Zone Duration (days)	29		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.7		
Activity Structural Life (years)	20.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost ($1000)	1.027		
Work Zone Length (miles)	1.00		
Work Zone Speed Limit (mph)	65		
Work Zone Capacity (vphpl)	1750		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
Inbound	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
Outbound	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
Activity 2	2034 Flex Rehab 3" Mill and 2.0" SMA & 1.5		
Agency Construction Cost ($1000)	$2,124.29		
User Work Zone Costs ($1000)	$28.60		
Work Zone Duration (days)	10		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.3		
Activity Structural Life (years)	10.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost ($1000)	1.027		
Work Zone Length (miles)	1.00		
Work Zone Speed Limit (mph)	55		
Work Zone Capacity (vphpl)	1400		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
Inbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			
Outbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			

Probabilistic Life Cycle Cost Analysis Worksheet

Activity 3	2047 Flex Rehab 2" Mill and 2.5" SMA Fill		
Agency Construction Cost ($1000)	$1,808.02		
User Work Zone Costs ($1000)	$45.59		
Work Zone Duration (days)	8		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.3		
Activity Structural Life (years)	10.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost ($1000)	1.027		
Work Zone Length (miles)	1.00		
Work Zone Speed Limit (mph)	55		
Work Zone Capacity (vphpl)	1400		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
Inbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			
Outbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			

Probabilistic Life Cycle Cost Analysis Worksheet

Alternative 2	Rigid Alternative		
Number of Activities	2		
Activity 1	Initial Rigid Construction Completed 2020		
Agency Construction Cost ($1000)	$5,254.88		
User Work Zone Costs ($1000)	$326.26		
Work Zone Duration (days)	18		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	27.7		
Activity Structural Life (years)	30.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost ($1000)	0.64		
Work Zone Length (miles)	1.00		
Work Zone Speed Limit (mph)	65		
Work Zone Capacity (vphpl)	1750		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
Inbound	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
Outbound	Start	End	
First period of lane closure			
Second period of lane closure			
Third period of lane closure			
Activity 2	2047 Rigid Rehab 1/2% Slab, 100% Grinding		
Agency Construction Cost ($1000)	$881.09		
User Work Zone Costs ($1000)	$111.23		
Work Zone Duration (days)	21		
No of Lanes Open in Each Direction During Work Zone	2		
Activity Service Life (years)	13.0		
Activity Structural Life (years)	13.0		
Maintenance Frequency (years)	1		
Agency Maintenance Cost ($1000)	0.64		
Work Zone Length (miles)	1.00		
Work Zone Speed Limit (mph)	55		
Work Zone Capacity (vphpl)	1400		
Traffic Hourly Distribution	Week Day 1		
Time of Day of Lane Closures (use whole numbers based on a 24-hour clock)			
Inbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			
Outbound	Start	End	
First period of lane closure	20	24	
Second period of lane closure	0	6	
Third period of lane closure			

Deterministic Results

Update Results

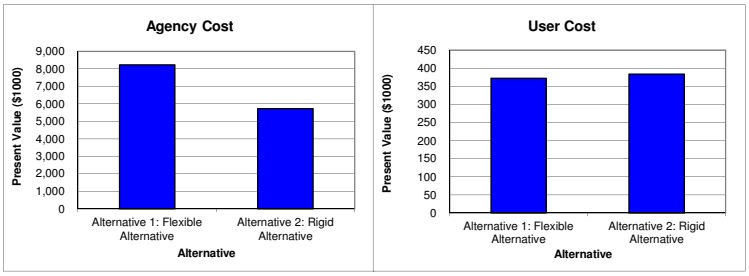
Total Cost

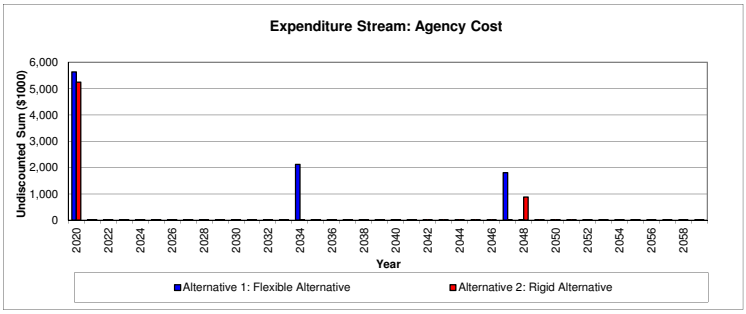
Total Cost	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Undiscounted Sum	*$9,607.54*	*$400.45*	*$6,115.10*	*$431.78*
Present Value	**$8,224.02**	**$372.49**	**$5,728.79**	**$384.03**
EUAC	$312.36	$14.15	$217.58	$14.59

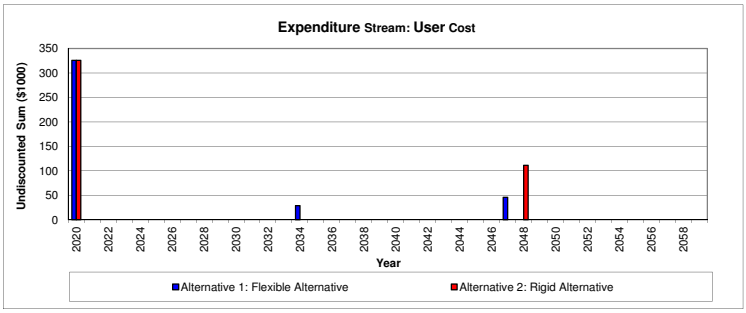
Lowest Present Value Agency Cost	**Alternative 2: Rigid Alternative**
Lowest Present Value User Cost	**Alternative 1: Flexible Alternative**

Expenditure Stream

Year	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
2020	$5,637.23	$326.26	$5,254.88	$326.26
2021	$1.03		$0.64	
2022	$1.03		$0.64	
2023	$1.03		$0.64	
2024	$1.03		$0.64	
2025	$1.03		$0.64	
2026	$1.03		$0.64	
2027	$1.03		$0.64	
2028	$1.03		$0.64	
2029	$1.03		$0.64	
2030	$1.03		$0.64	
2031	$1.03		$0.64	
2032	$1.03		$0.64	
2033	$1.03		$0.64	
2034	$2,124.29	$28.60	$0.64	
2035	$1.03		$0.64	
2036	$1.03		$0.64	
2037	$1.03		$0.64	
2038	$1.03		$0.64	
2039	$1.03		$0.64	
2040	$1.03		$0.64	
2041	$1.03		$0.64	
2042	$1.03		$0.64	
2043	$1.03		$0.64	
2044	$1.03		$0.64	
2045	$1.03		$0.64	
2046	$1.03		$0.64	
2047	$1,808.02	$45.59	$0.64	
2048	$1.03		$881.09	$111.23
2049	$1.03		$0.64	
2050	$1.03		$0.64	
2051	$1.03		$0.64	
2052	$1.03		$0.64	
2053	$1.03		$0.64	
2054	$1.03		$0.64	
2055	$1.03		$0.64	
2056	$1.03		$0.64	
2057	$1.03		$0.64	
2058	$1.03		$0.64	
2059	$1.03		$0.64	
2060			($45.18)	($5.70)

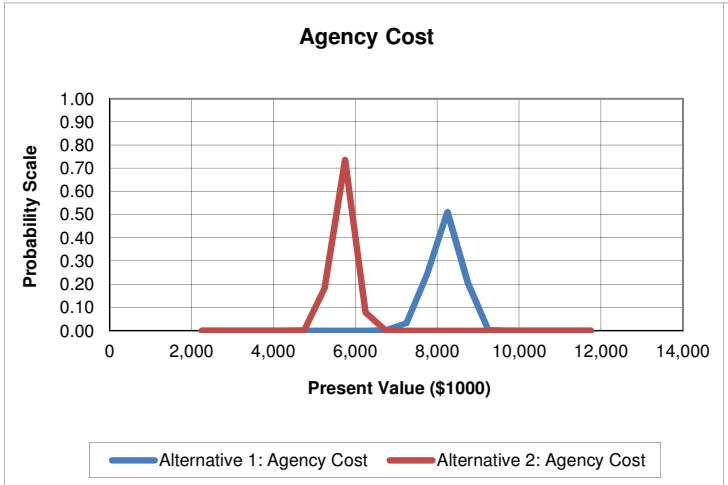


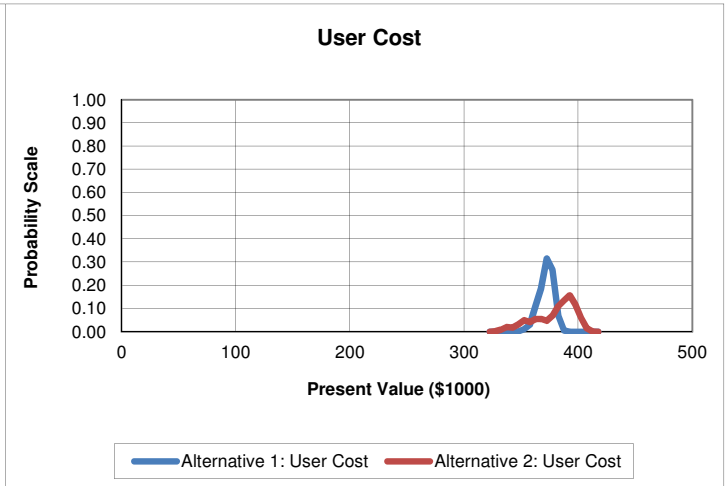


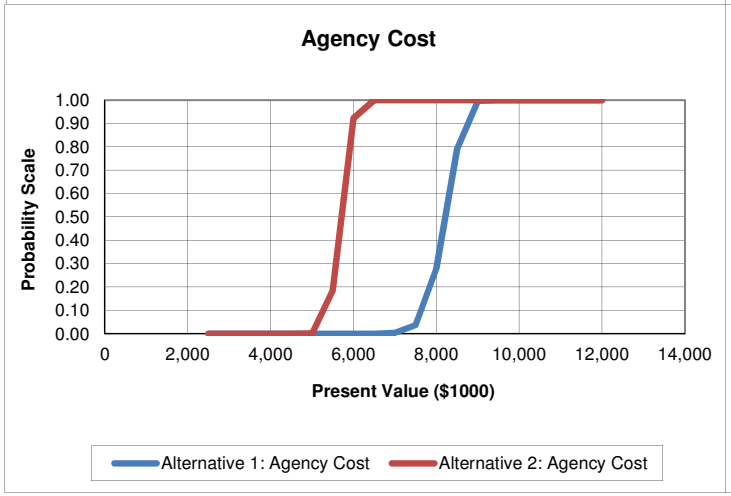


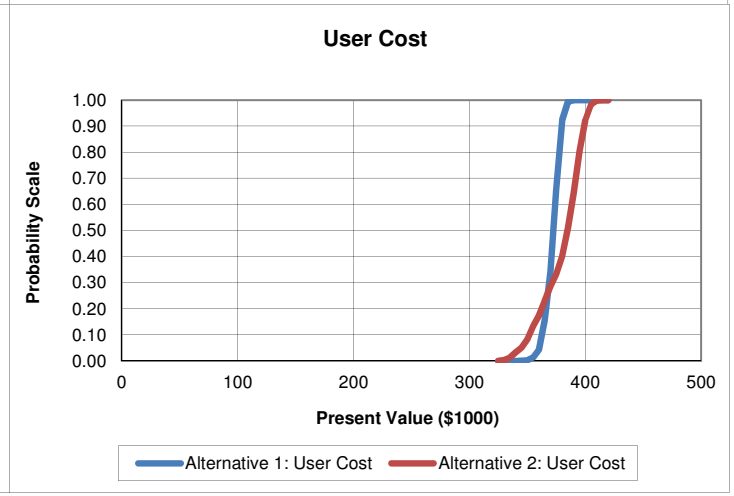
Probabilistic Results

Total Cost				
	Alternative 1: Flexible Alternative		Alternative 2: Rigid Alternative	
Total Cost (Present Value)	Agency Cost ($1000)	User Cost ($1000)	Agency Cost ($1000)	User Cost ($1000)
Mean	$8,197.67	$371.80	$5,690.19	$379.37
Standard Deviation	$363.30	$6.43	$213.49	$17.94
Minimum	$6,915.39	$342.12	$4,993.25	$329.30
Maximum	$9,171.32	$386.50	$6,214.84	$410.36









Output Distributions

Alternative 1: Agency Cost

Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
2500	2250	0.00	0.00
3000	2750	0.00	0.00
3500	3250	0.00	0.00
4000	3750	0.00	0.00
4500	4250	0.00	0.00
5000	4750	0.00	0.00
5500	5250	0.00	0.00
6000	5750	0.00	0.00
6500	6250	0.00	0.00
7000	6750	0.00	0.00
7500	7250	0.03	0.04
8000	7750	0.24	0.28
8500	8250	0.51	0.79
9000	8750	0.21	1.00
9500	9250	0.00	1.00
10000	9750	0.00	1.00
10500	10250	0.00	1.00
11000	10750	0.00	1.00
11500	11250	0.00	1.00
12000	11750	0.00	1.00

Alternative 1: User Cost

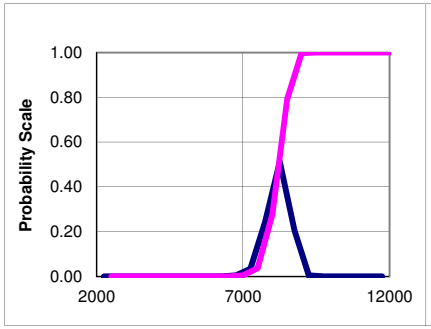
Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
325	322.5	0.00	0.00
330	327.5	0.00	0.00
335	332.5	0.00	0.00
340	337.5	0.00	0.00
345	342.5	0.00	0.00
350	347.5	0.00	0.00
355	352.5	0.01	0.01
360	357.5	0.03	0.04
365	362.5	0.11	0.16
370	367.5	0.19	0.34
375	372.5	0.32	0.66
380	377.5	0.27	0.92
385	382.5	0.07	0.99
390	387.5	0.01	1.00
395	392.5	0.00	1.00
400	397.5	0.00	1.00
405	402.5	0.00	1.00
410	407.5	0.00	1.00
415	412.5	0.00	1.00
420	417.5	0.00	1.00

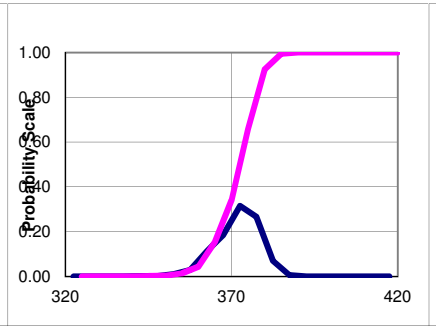
Alternative 2: Agency Cost

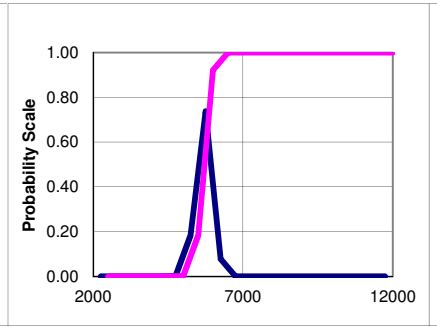
Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
2500	2250	0.00	0.00
3000	2750	0.00	0.00
3500	3250	0.00	0.00
4000	3750	0.00	0.00
4500	4250	0.00	0.00
5000	4750	0.00	0.00
5500	5250	0.18	0.18
6000	5750	0.74	0.92
6500	6250	0.08	1.00
7000	6750	0.00	1.00
7500	7250	0.00	1.00
8000	7750	0.00	1.00
8500	8250	0.00	1.00
9000	8750	0.00	1.00
9500	9250	0.00	1.00
10000	9750	0.00	1.00
10500	10250	0.00	1.00
11000	10750	0.00	1.00
11500	11250	0.00	1.00
12000	11750	0.00	1.00

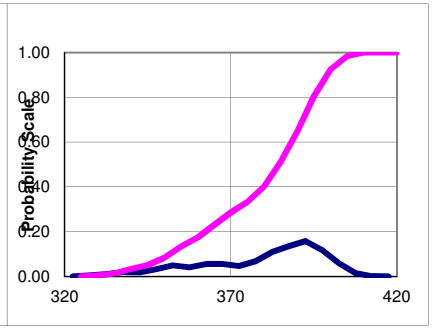
Alternative 2: User Cost

Bin	Mid Point	Rel. Freq.	Cum. Rel. Freq.
325	322.5	0.00	0.00
330	327.5	0.00	0.00
335	332.5	0.01	0.01
340	337.5	0.02	0.03
345	342.5	0.02	0.05
350	347.5	0.03	0.08
355	352.5	0.05	0.13
360	357.5	0.04	0.17
365	362.5	0.06	0.23
370	367.5	0.06	0.29
375	372.5	0.05	0.33
380	377.5	0.07	0.40
385	382.5	0.11	0.51
390	387.5	0.14	0.65
395	392.5	0.16	0.80
400	397.5	0.12	0.92
405	402.5	0.06	0.98
410	407.5	0.02	1.00
415	412.5	0.00	1.00
420	417.5	0.00	1.00

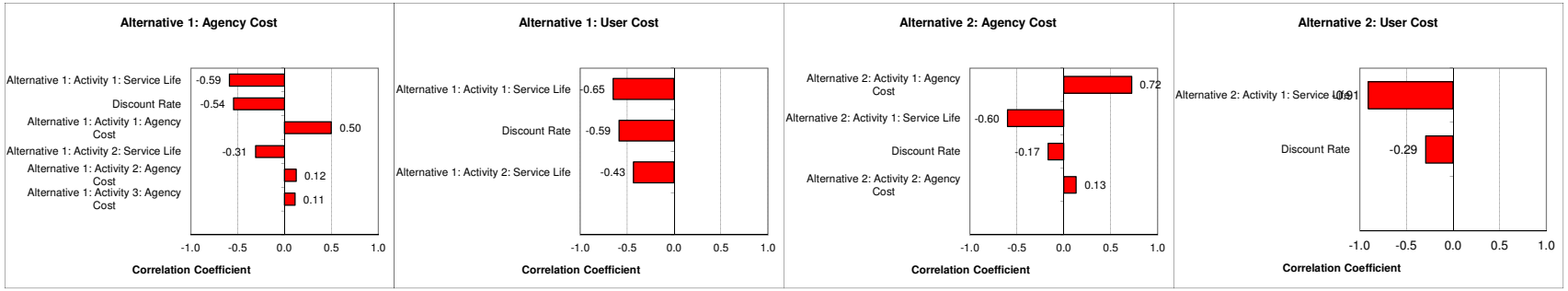








Tornado Graphs



Alternative 1: Agency Cost

Input Variable	Corr. Coeff.
Alternative 1: Activity 1: Service Life	-0.59
Discount Rate	-0.54
Alternative 1: Activity 1: Agency Cost	0.50
Alternative 1: Activity 2: Service Life	-0.31
Alternative 1: Activity 2: Agency Cost	0.12
Alternative 1: Activity 3: Agency Cost	0.11

Alternative 1: User Cost

Input Variable	Corr. Coeff.
Alternative 1: Activity 1: Service Life	-0.65
Discount Rate	-0.59
Alternative 1: Activity 2: Service Life	-0.43

Alternative 2: Agency Cost

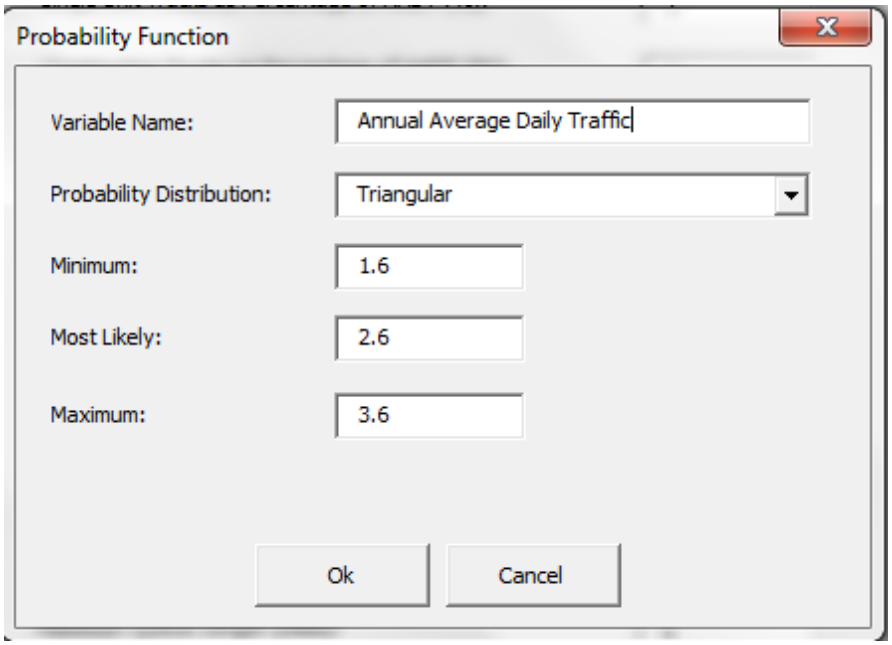
Input Variable	Corr. Coeff.
Alternative 2: Activity 1: Agency Cost	0.72
Alternative 2: Activity 1: Service Life	-0.60
Discount Rate	-0.17
Alternative 2: Activity 2: Agency Cost	0.13

Alternative 2: User Cost

Input Variable	Corr. Coeff.
Alternative 2: Activity 1: Service Life	-0.91
Discount Rate	-0.29

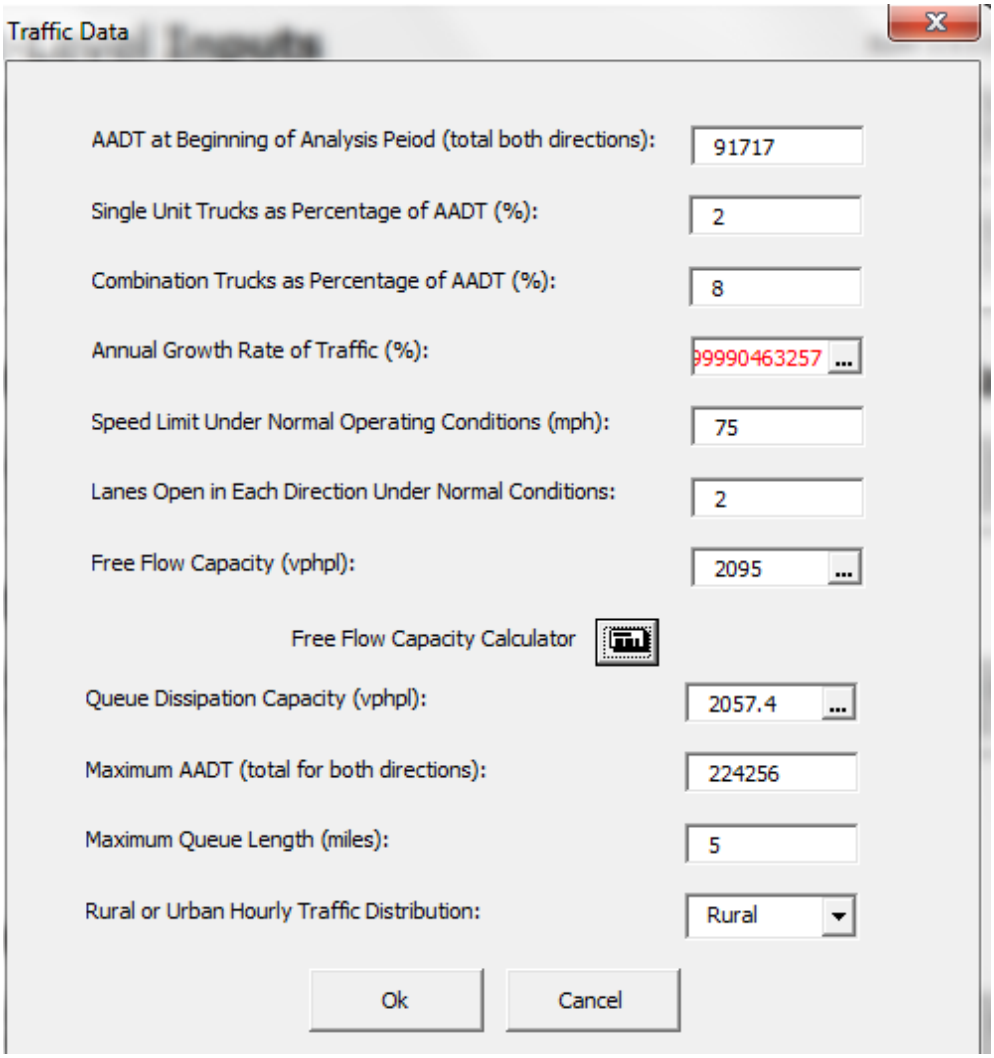
Extreme Tail Analysis

Input Variable		Alternative 1: Agency Cost				Alternative 1: User Cost				Alternative 2: Agency Cost				Alternative 2: User Cost			
Name	**Probability Function**	**5%**	**25%**	**75%**	**95%**	**5%**	**25%**	**75%**	**95%**	**5%**	**25%**	**75%**	**95%**	**5%**	**25%**	**75%**	**95%**
Discount Rate	LCCALOGNORMAL(2.22,0.38)	1.02	0.78	-0.66	-1.07	0.80	0.85	-0.71	-1.11	0.12	0.17	-0.24	-0.59	0.12	0.24	-0.56	-1.10
Annual Average Daily Traffic	LCCATRIANG(1.6,2.6,3.6)	-0.08	0.05	0.00	-0.06	-0.23	-0.03	-0.05	-0.26	-0.21	-0.05	0.00	-0.33	0.04	0.04	-0.01	-0.06
Alternative 1: Activity 1: Agency Co	LCCATRIANG(5221.668,5637.234	-1.40	-0.49	0.73	1.00	-0.15	-0.08	0.06	0.15	-0.26	-0.02	0.01	0.17	0.10	-0.02	0.12	-0.02
Alternative 2: Activity 1: Agency Co	LCCATRIANG(4879.527,5254.876	-0.03	0.00	-0.08	-0.21	-0.01	0.03	0.01	-0.21	-1.40	-0.91	1.00	1.63	-0.05	0.06	0.05	0.01
Alternative 1: Activity 1: Service Life	LCCATRIANG(6,14,21)	1.13	0.66	-0.88	-1.58	1.21	0.66	-1.07	-1.58	-0.18	-0.11	0.13	-0.03	-0.39	-0.10	0.10	0.03
Alternative 2: Activity 1: Service Life	LCCATRIANG(16,27,40)	-0.38	-0.07	0.04	0.48	0.09	-0.05	0.19	0.18	1.70	1.07	-0.55	-0.99	2.05	1.34	-0.95	-1.35
Alternative 1: Activity 2: Agency Co	LCCATRIANG(1975.575,2124.291	-0.02	-0.15	0.13	0.17	0.06	0.02	-0.03	-0.08	0.04	-0.15	0.03	0.00	-0.20	-0.19	0.07	0.07
Alternative 2: Activity 2: Agency Co	LCCATRIANG(737.916,881.086,1	-0.21	-0.14	0.02	-0.22	-0.26	-0.13	0.02	-0.23	-0.37	-0.18	0.23	0.57	-0.45	-0.09	0.15	0.06
Alternative 1: Activity 2: Service Life	LCCATRIANG(6,13,21)	1.10	0.58	-0.29	-0.70	1.40	0.64	-0.45	-0.93	-0.14	-0.08	-0.04	0.18	-0.39	-0.01	-0.03	-0.11
Alternative 1: Activity 3: Agency Co	LCCATRIANG(1690.937,1808.018	-0.21	-0.18	0.20	0.51	0.10	-0.13	0.07	0.27	0.25	0.06	0.01	0.12	0.06	0.09	0.02	0.31
Alternative 2: Activity 3: Agency Co	LCCATRIANG(1839.841,2197.822	0.09	0.12	0.00	0.01	0.08	0.07	-0.01	0.00	-0.20	-0.08	0.06	0.10	-0.16	-0.11	-0.12	-0.10
Alternative 1: Activity 3: Service Life	LCCATRIANG(6,13,21)	0.29	0.03	-0.02	0.40	-0.07	0.01	0.08	0.14	0.20	-0.01	-0.03	-0.07	0.04	0.02	-0.01	0.09
Alternative 1: Activity 4: Agency Co	LCCATRIANG(5455.233,5791.167	0.11	0.01	-0.01	0.15	0.03	0.01	-0.01	-0.04	0.10	0.01	0.06	0.20	-0.05	-0.02	0.06	0.20
Alternative 1: Activity 4: Service Life	LCCATRIANG(6,14,21)	0.12	0.15	-0.15	-0.14	0.31	0.10	-0.13	0.07	0.14	-0.11	-0.05	-0.23	0.09	0.03	-0.01	-0.23

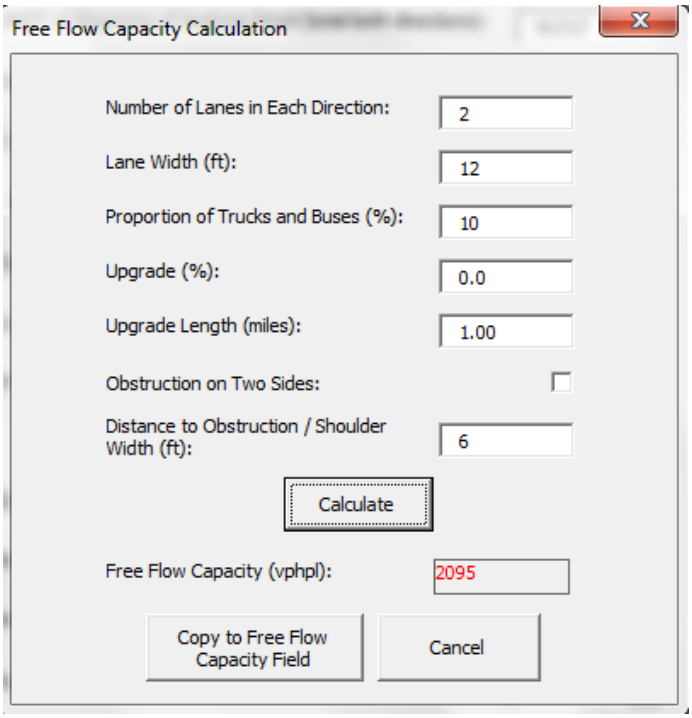


RealCost – Annual Average Daily Traffic Triangular Probability Distribution

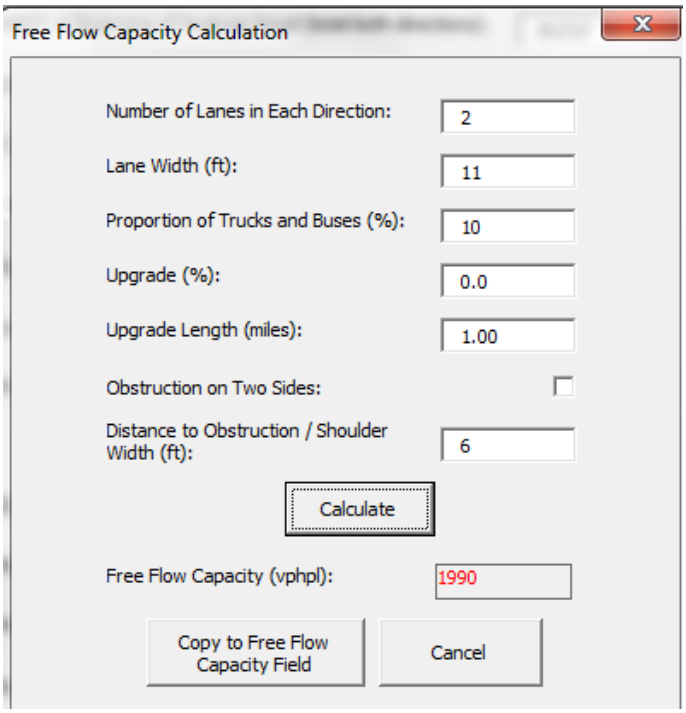
NOTE: Following Table 13.7 of the PDM, RockSol used an Annual Growth Rate of 1.6% (minimum), 2.6% (most likely) and 3.6% (maximum) in the RealCost Triangular Probability Function.



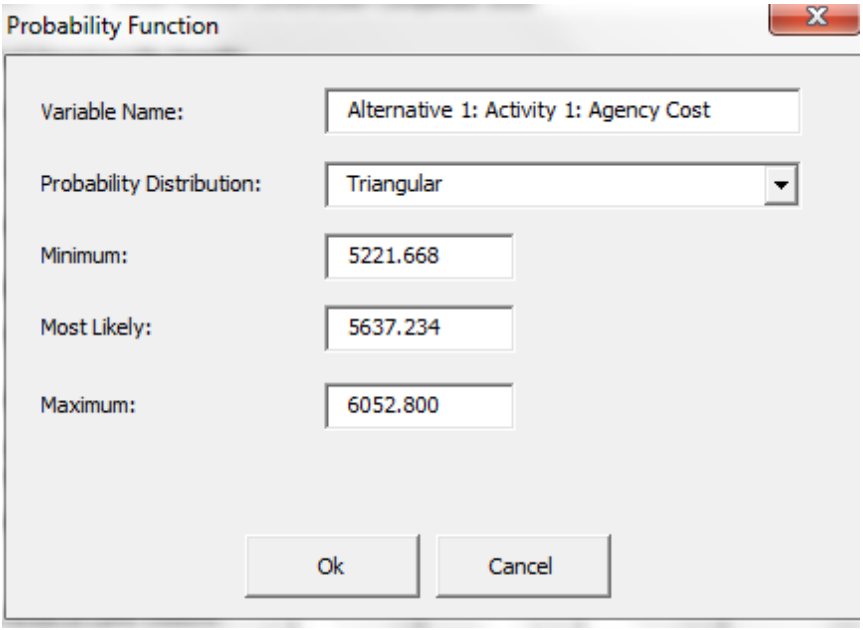
RealCost – Traffic Data



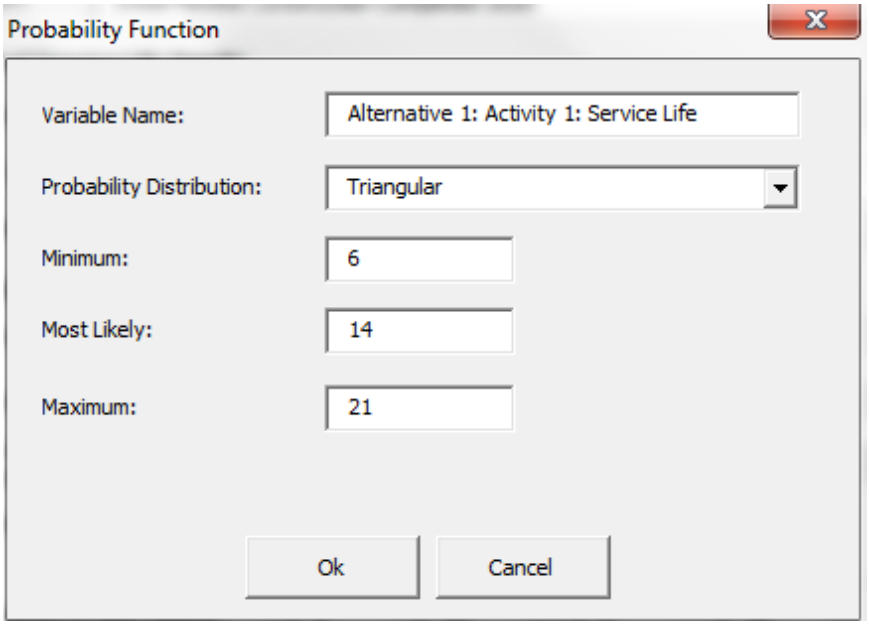
RealCost – Free Flow Capacity Calculation (12 ft Lane Width)



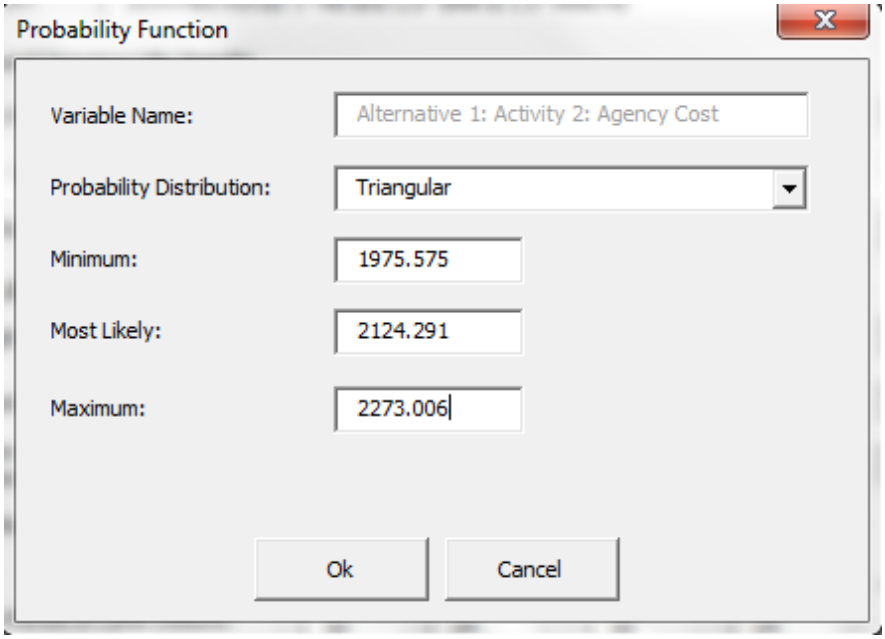
RealCost – Free Flow Capacity Calculation (11 ft Lane Width)



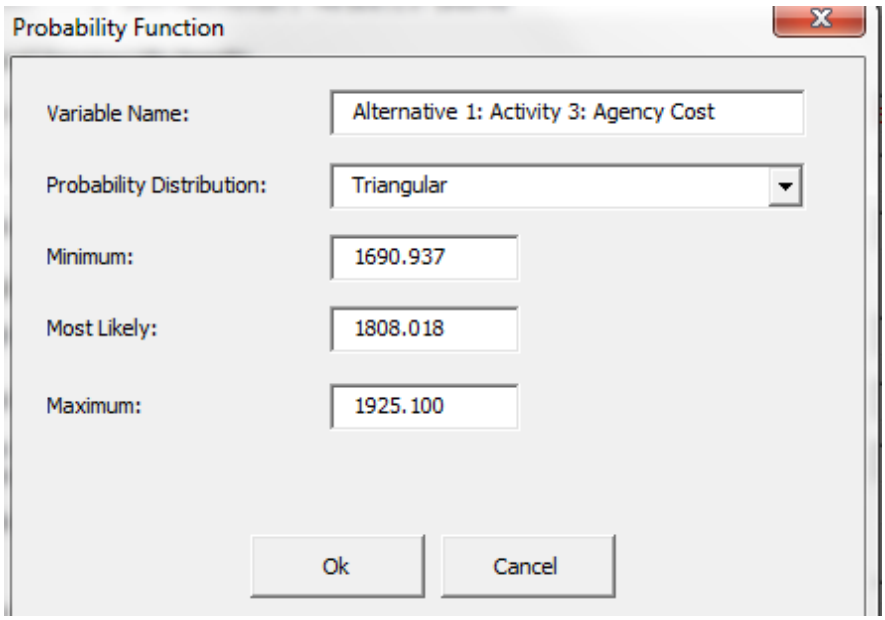
RealCost – Agency Cost for Initial Flexible Pavement Construction (Alternative 1: Activity 1)



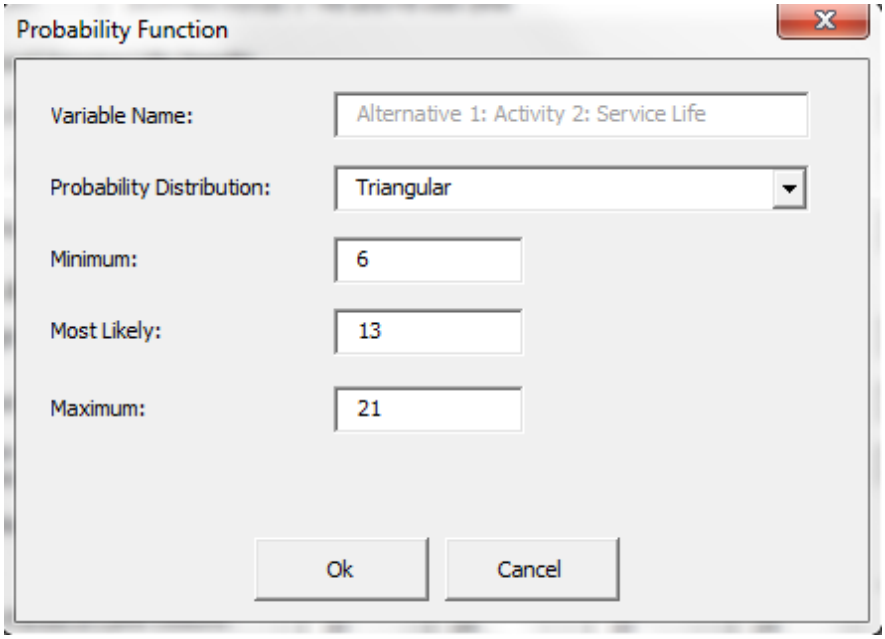
RealCost – Service Life for Initial Flexible Pavement Construction (Alternative 1: Activity 1)



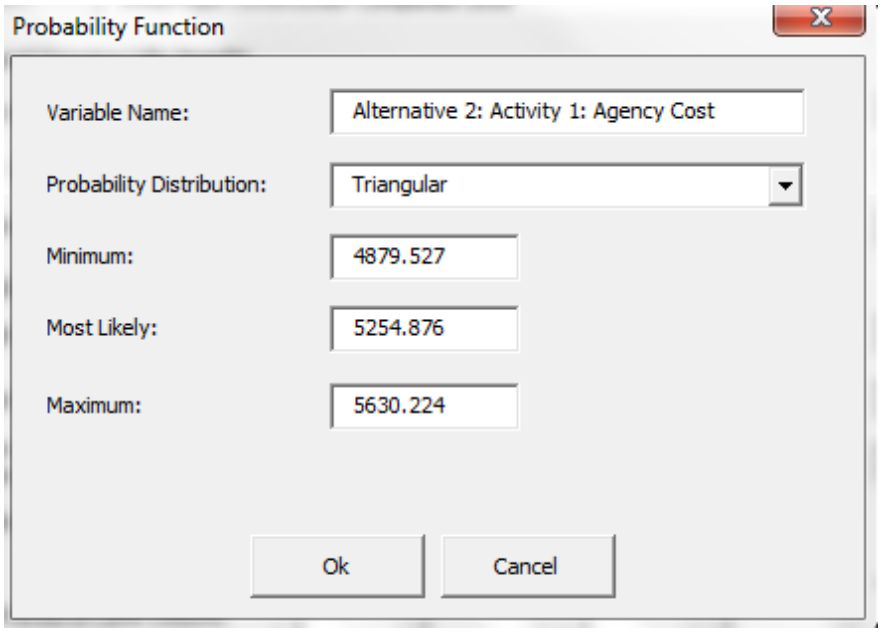
RealCost – Agency Cost for SMA and HMA Pavement Rehabilitation at 2034
(Alternative 1: Activity 2)



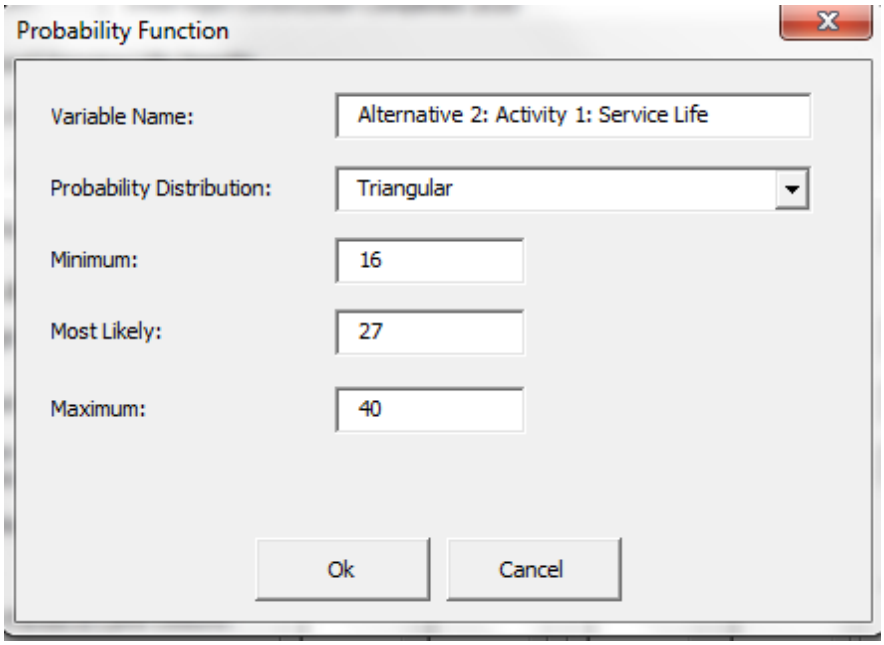
RealCost – Agency Cost for SMA Pavement Rehabilitation at 2047
(Alternative 1: Activity 3)



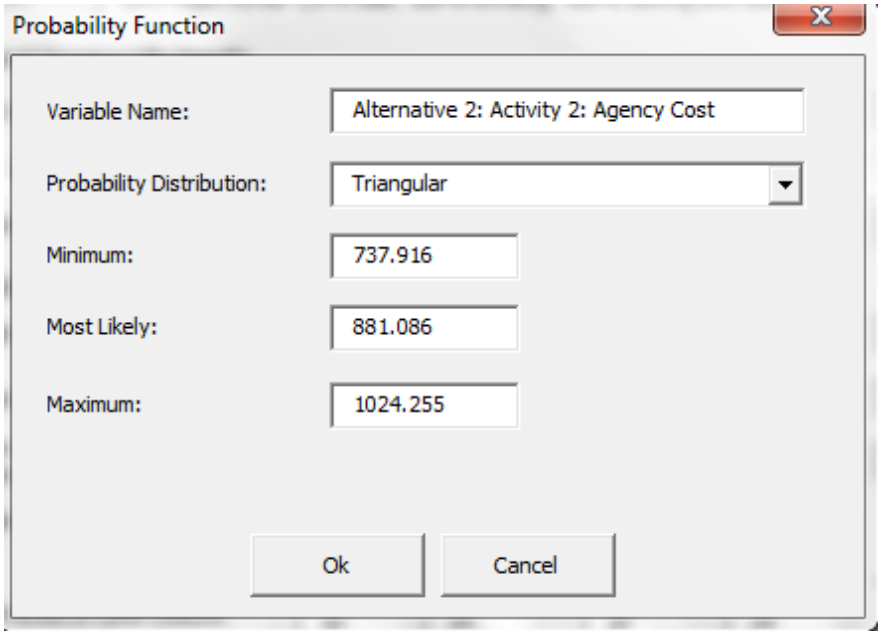
RealCost – Service Life for SMA and HMA Pavement Rehabilitation 2034 and 2047 (Alternative 1: Activities 2 and 3)



RealCost – Agency Cost for Initial Rigid Pavement Construction (Alternative 2: Activity 1)



RealCost – Service Life for Initial Rigid Pavement Construction (Alternative 2: Activity 1)



RealCost – Agency Cost for Rigid Pavement Rehabilitation at 2047 (Alternative 2: Activity 2)

COLORADO Department of Transportation

CDOT Report - Summary Input and Output for the Crossover Strategy

Project Code	21506	
Project Name	North I-25 - ARE#1	
Freeway Name	025A	
Input Filename	Flex 2020.WZM	
Project Start Date	2020	
Project End Date	2020	
Design Speed	75 mph	
Speed Limit	75 mph	
Workzone Speed Limit	65 mph	
Grade	2.0 %	
Workzone Length	1.00 miles	
Functional Class	Rural Interstate (Weekday)	
	PRIMARY	SECONDARY
Total Number of Lanes	2	2
Number of Open Lanes	2	2
Number of Temporary Lanes	0	0
AADT	45,858	45,858
Percentage of Single Unit Trucks	2.0 %	2.0 %
Percentage of Combination Trucks	8.0 %	8.0 %

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	PRIMARY COST	SECONDARY COST	DURATION
403-HMA (3-in SMA & 10-in HMA)	$163,128.44	$163,128.44	29
TOTAL ADDL. USER COST	$163,128.44	$163,128.44	29

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 29 DAYS : INBOUND = $1,307,253.31 OUTBOUND = $1,307,253.31

Disclaimer:

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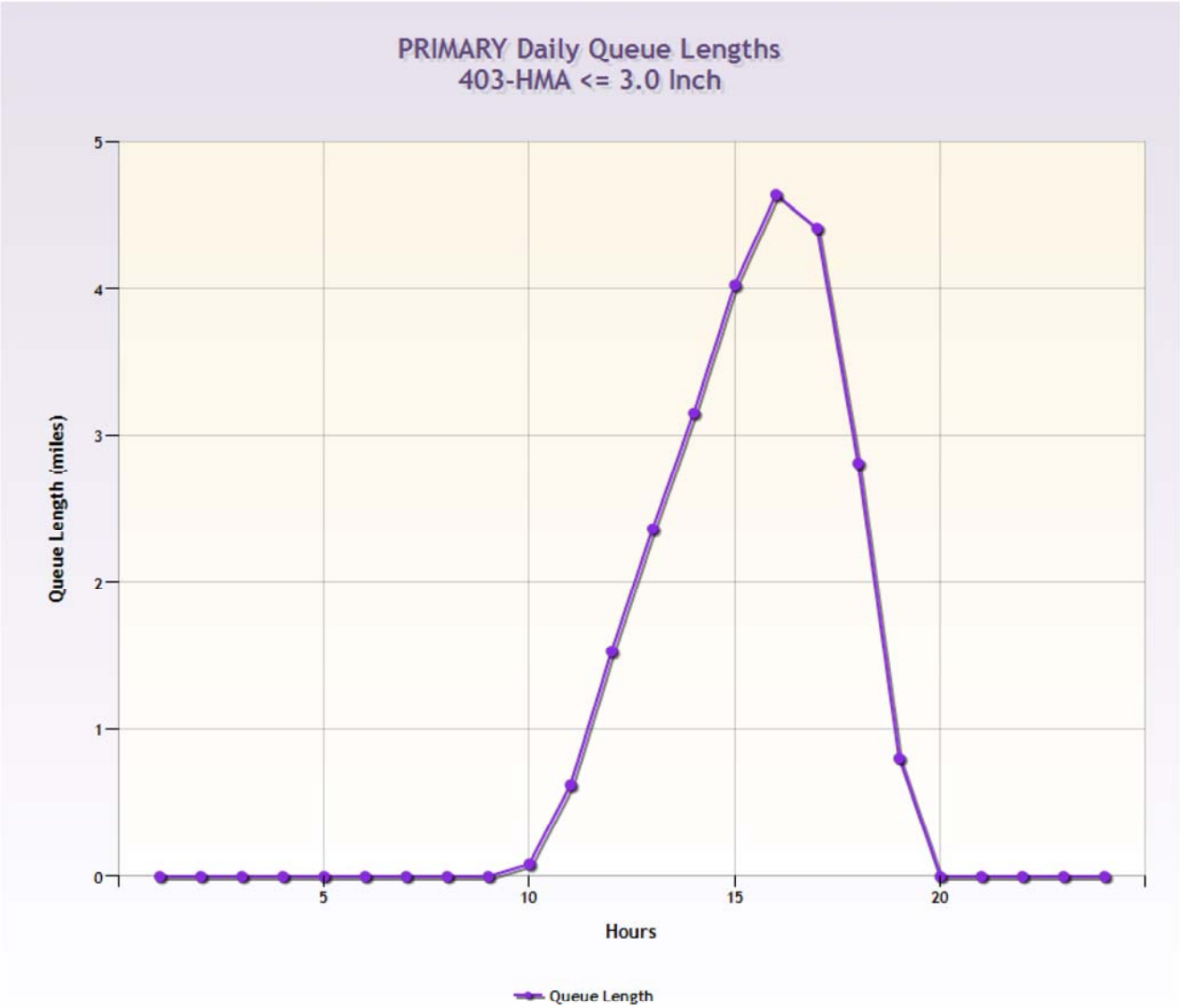
COLORADO Department of Transportation

User Cost Queue Graph

◉ PRIMARY ○ SECONDARY

Type of Work: 403-HMA <= 3.0 Inch



COLORADO Department of Transportation

CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code	21506
Project Name	North I-25 - ARE#1
Freeway Name	025A
Input Filename	Flex Rehab_2034.WZM
Project Start Date	2034
Project End Date	2034
Design Speed	75 mph
Speed Limit	75 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	1.00 miles
Functional Class	Rural Interstate (Weekday)

Total Number of Lanes	2
Number of Open Lanes	1
Number of Temporary Lanes	1
AADT, Directional	62,964
Percentage of Single Unit Trucks	2.0 %
Percentage of Combination Trucks	8.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Asphalt (Planing)	$5,661.38	2
403-HMA (2-in SMA & 1.5-in HMA)	$22,941.50	8
TOTAL ADDL. USER COST	$28,602.88	10

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 10 DAYS = $118,195.07

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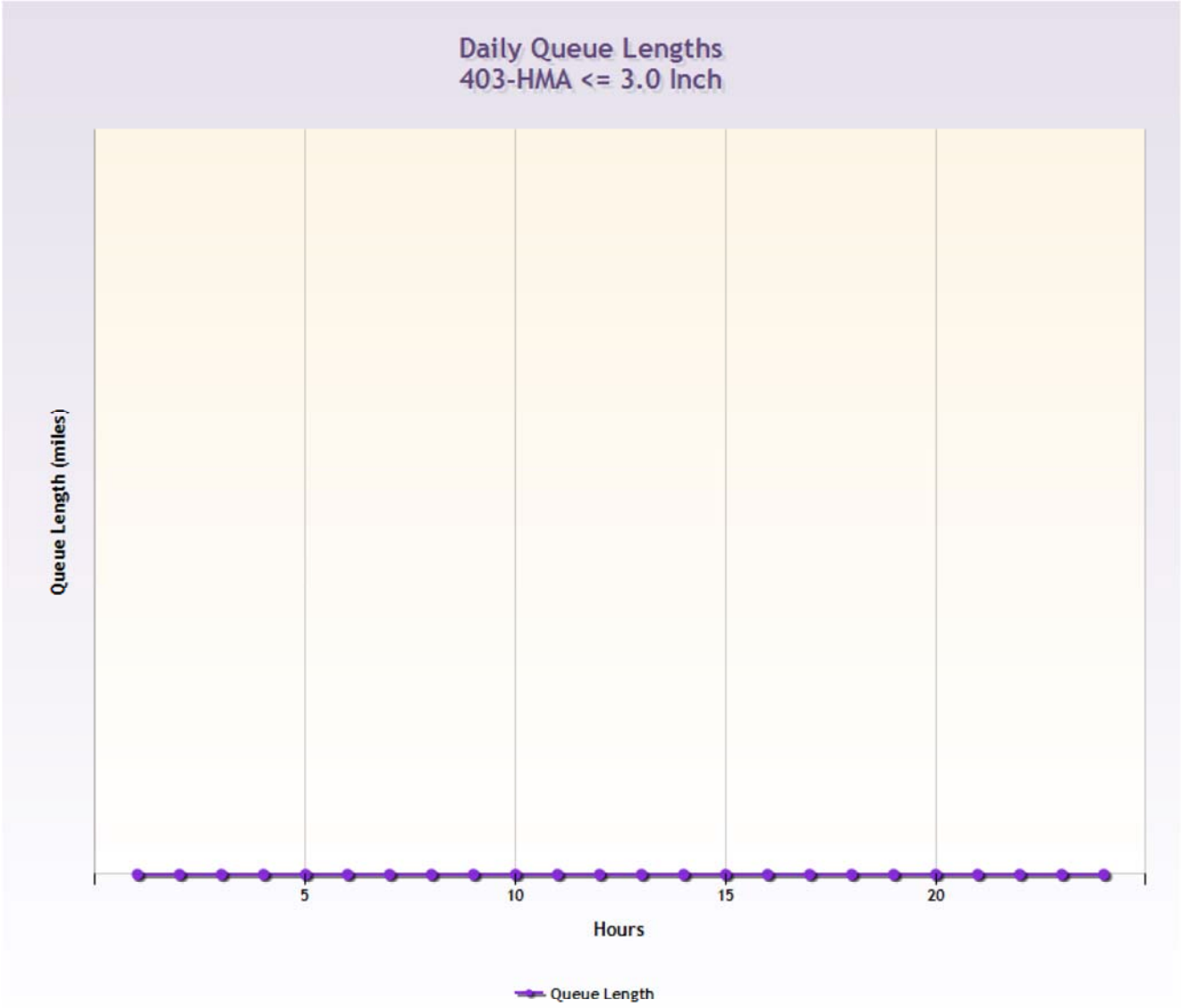
COLORADO Department of Transportation

User Cost Queue Graph

Type of Work: 403-HMA <= 3.0 Inch



COLORADO Department of Transportation

CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code	21506
Project Name	North I-25 - ARE#1
Freeway Name	025A
Input Filename	SMA 2047.WZM
Project Start Date	2047
Project End Date	2047
Design Speed	75 mph
Speed Limit	75 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	1.00 miles
Functional Class	Rural Interstate (Weekday)

Total Number of Lanes	2
Number of Open Lanes	1
Number of Temporary Lanes	1
AADT, Directional	78,846
Percentage of Single Unit Trucks	2.0 %
Percentage of Combination Trucks	8.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Asphalt (Planing)	$9,194.45	2
403-HMA Stone Matrix Asphalt	$36,396.27	6
TOTAL ADDL. USER COST	$45,590.73	8

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 8 DAYS = $118,311.25

Disclaimer:

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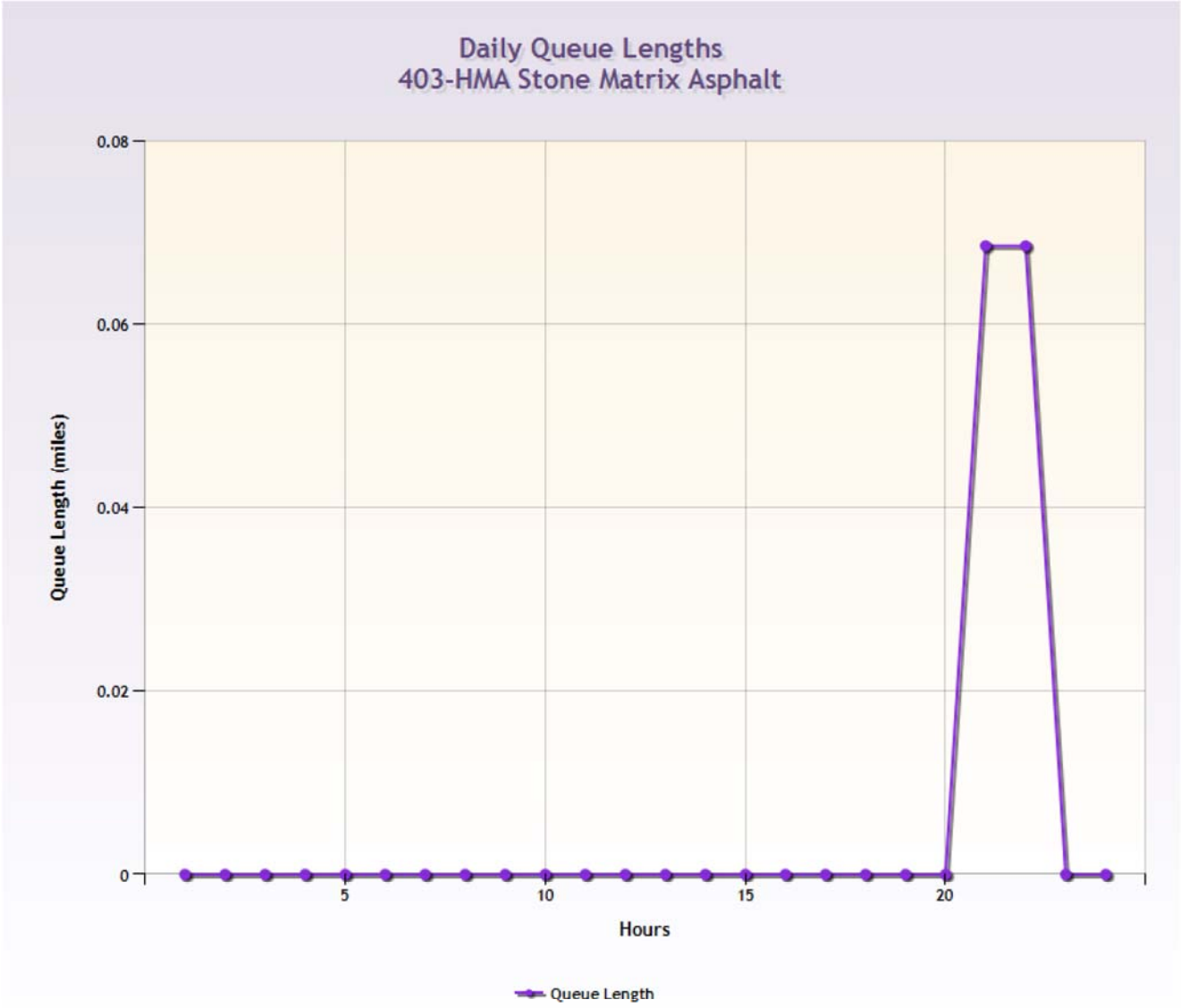
COLORADO Department of Transportation

User Cost Queue Graph

Type of Work: 403-HMA Stone Matrix Asphalt



COLORADO Department of Transportation

CDOT Report - Summary Input and Output for the Crossover Strategy

Project Code	21506	
Project Name	North I-25 - ARE#1	
Freeway Name	025A	
Input Filename	PCCP_2020.WZM	
Project Start Date	2020	
Project End Date	2020	
Design Speed	75 mph	
Speed Limit	75 mph	
Workzone Speed Limit	65 mph	
Grade	2.0 %	
Workzone Length	1.00 miles	
Functional Class	Rural Interstate (Weekday)	
	PRIMARY	SECONDARY
Total Number of Lanes	2	2
Number of Open Lanes	2	2
Number of Temporary Lanes	0	0
AADT	45,858	45,858
Percentage of Single Unit Trucks	2.0 %	2.0 %
Percentage of Combination Trucks	8.0 %	8.0 %

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	PRIMARY COST	SECONDARY COST	DURATION
412-Concrete Pavement <= 14.0 inch	$163,128.44	$163,128.44	18
TOTAL ADDL. USER COST	$163,128.44	$163,128.44	18

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 18 DAYS : INBOUND = $811,398.60 OUTBOUND = $811,398.60

Disclaimer:

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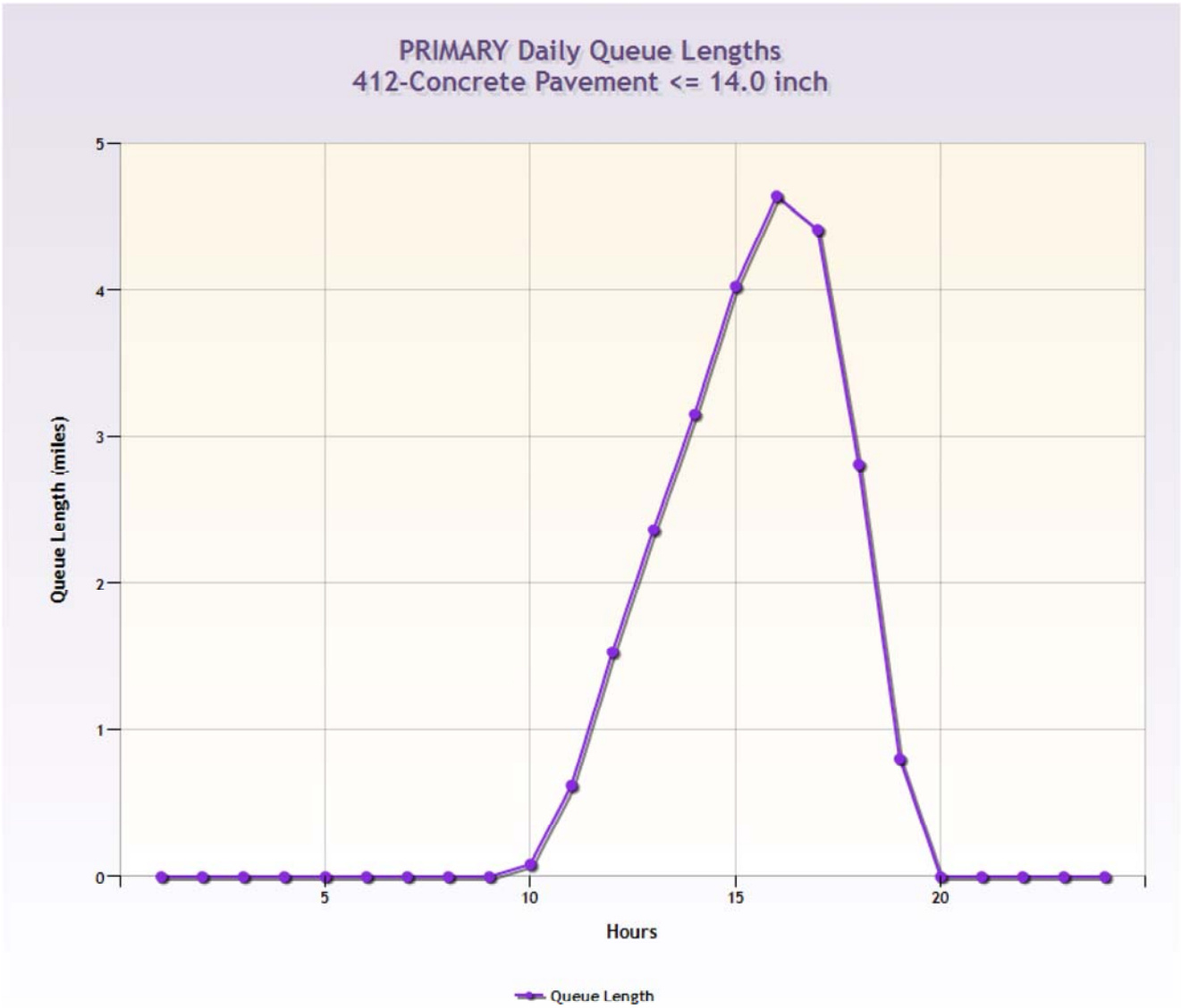
COLORADO Department of Transportation

User Cost Queue Graph

◉ PRIMARY ○ SECONDARY

Type of Work: 412-Concrete Pavement <= 14.0 inch



COLORADO Department of Transportation

CDOT Report - Summary Input and Output for the Single Lane Closure Strategy

Project Code	21506
Project Name	North I-25 - ARE#1
Freeway Name	025A
Input Filename	PCCP Rehab 2047.WZM
Project Start Date	2047
Project End Date	2047
Design Speed	75 mph
Speed Limit	75 mph
Workzone Speed Limit	55 mph
Grade	2.0 %
Workzone Length	1.00 miles
Functional Class	Rural Interstate (Weekday)

Total Number of Lanes	2
Number of Open Lanes	1
Number of Temporary Lanes	1
AADT, Directional	78,846
Percentage of Single Unit Trucks	2.0 %
Percentage of Combination Trucks	8.0 %
Work in Both Directions	NO

ADDITIONAL USER COST DUE TO WORKZONE

TYPE OF WORK	COST	DURATION
202-Removal of Concrete (Diamond Grinding)	$50,569.50	11
412-Routing & Sealing PCCP Cracks	$60,660.46	10
TOTAL ADDL. USER COST	$111,229.96	21

TOTAL USER COST FOR NORMAL CONDITION (WITH NO WORKZONE)
FOR A DURATION OF 21 DAYS = $310,567.02

Disclaimer:

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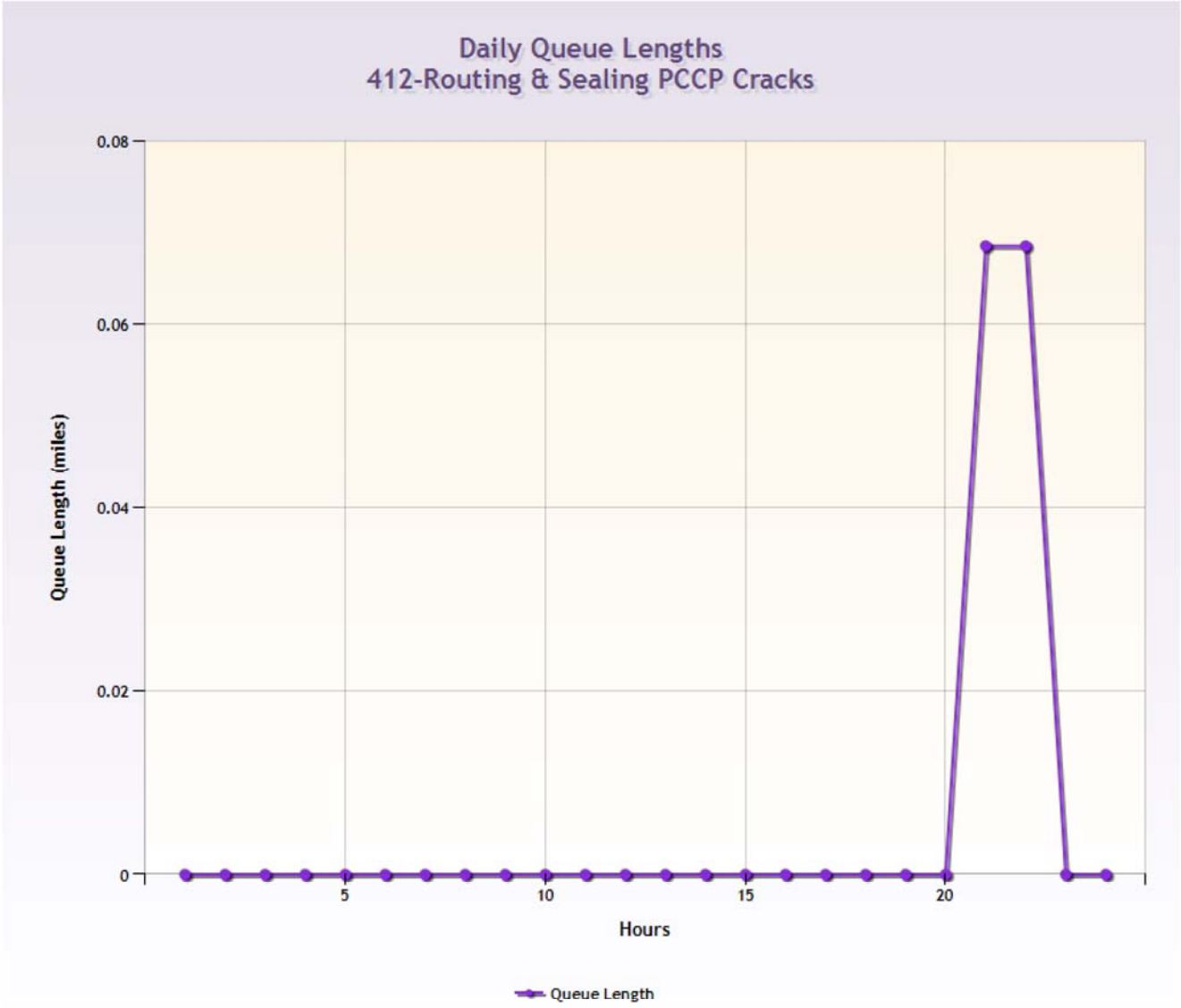
COLORADO Department of Transportation

User Cost Queue Graph

Type of Work: 412-Routing & Sealing PCCP Cracks



Edit Hourly Distribution | Edit Parameters | Edit Costs | Reset | Guide | Analyze | Save | Summary Report | Hourly Report | Q Graph | User Cost Graph

Select File to Open: Browse...

File Open: PCCP 2020.WZM
Last Modified: 02-10-17

Project Code:	21506	Freeway Name:	025A
Name of the Project:	North I-25 - ARE#1	Region:	R4
Project Start Date:	2020	Project End Date:	2020
Author & Comments:	RockSol Consulting Group, Inc.	Design Speed:	75 mph
Length of Closure:	1.00 miles	Speed Limit:	75 mph
Percent Grade:	2	Work Zone Speed Limit:	65 mph

Type of Closure: ○ Single Lane ◉ Cross Over

Primary Direction				Secondary Direction			
Total Number of Lanes:		2		Total Number of Lanes:		2	
Number of Open Lanes:	2	0	Number of Temporary Lanes	Number of Open Lanes:	2	0	Number of Temporary Lanes
Single Unit Trucks [%]:	2.00 %	8.00 %	Combination Trucks [%]	Single Unit Trucks [%]:	2.00 %	8.00 %	Combination Trucks [%]
AADT:		45858		AADT:		45858	

Type of Work

202-Removal of Concrete
202-Removal of Concrete (Diamond Grinding)
202-Removal of Asphalt
202-Removal of Asphalt (Planing)
203-Unclassified Excavation
203-Unclassified Excavation (C.I.P.)
203-Embankment Material
203-Embankment Material (C.I.P.)
203-Muck Excavation
203-Rolling

Function Class: Rural Interstate (Weekday)

Total Duration (days): 18

Normal Capacity per Lane: 1789.0 Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Primary Capacity per Lane	Secondary Capacity per Lane	
412-Concrete Pavement <= 14.0 inch	18	N/A	1750	1750	✖

Initial Construction (2020) UserCost Screenshot for Rigid Pavement Alternative

Edit Hourly Distribution | Edit Parameters | Edit Costs | Reset | Guide | Analyze | Save | Summary Report | Hourly Report | Q Graph | User Cost Graph

Select File to Open: Browse...

File Open: PCCP 2047.WZM
Last Modified: 02-10-17

Project Code:	21506	Freeway Name:	025A
Name of the Project:	North I-25 - ARE#1	Region:	R4
Project Start Date:	2047	Project End Date:	2047
Author & Comments:	RockSol	Design Speed:	75 mph
Length of Closure:	1.00 miles	Speed Limit:	75 mph
Percent Grade:	2	Work Zone Speed Limit:	55 mph

Type of Closure: (•) Single Lane ( ) Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	2	Number of Open Lanes:	1
Single Unit Trucks [%]:	2.00 %	Number of Temporary Lanes:	1
Combination Trucks [%]:	8.00 %	Average Annual Daily Traffic:	78846
[ ] Work on Both Directions		[ ] Pilot Car Operation Please select stop time:	15 Minutes

Type of Work

202-Removal of Concrete
202-Removal of Concrete (Diamond Grinding)
202-Removal of Asphalt
202-Removal of Asphalt (Planing)
203-Unclassified Excavation
203-Unclassified Excavation (C.I.P.)
203-Embankment Material
203-Embankment Material (C.I.P.)
203-Muck Excavation
203-Rolling

Function Class: Rural Interstate (Weekday)

Total Duration (days): 21

Normal Capacity per Lane: 1789.0 Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Concrete (Diamond Grinding)	11	N/A	1459	✖
412-Routing & Sealing PCCP Cracks	10	N/A	1366	✖

UserCost Screenshot for Rigid Pavement 2047 Rehabilitation

Edit Hourly Distribution | Edit Parameters | Edit Costs | Reset | Guide | Analyze | Save | Summary Report | Hourly Report | Q Graph | User Cost Graph

Select File to Open: Browse...

File Open: Flex 2020.WZM
Last Modified: 02-10-17

Project Code:	21506	Freeway Name:	025A
Name of the Project:	North I-25 - ARE#1	Region:	R4
Project Start Date:	2020	Project End Date:	2020
Author & Comments:	RockSol Consulting Group, Inc.	Design Speed:	75 mph
Length of Closure:	1.00 miles	Speed Limit:	75 mph
Percent Grade:	2	Work Zone Speed Limit:	65 mph

Type of Closure: ○ Single Lane ◉ Cross Over

Primary Direction				Secondary Direction			
Total Number of Lanes:		2		Total Number of Lanes:		2	
Number of Open Lanes:	2	0	Number of Temporary Lanes	Number of Open Lanes:	2	0	Number of Temporary Lanes
Single Unit Trucks [%]:	2.00 %	8.00 %	Combination Trucks [%]	Single Unit Trucks [%]:	2.00 %	8.00 %	Combination Trucks [%]
AADT:		45858		AADT:		45858	

Type of Work

202-Removal of Concrete
202-Removal of Concrete (Diamond Grinding)
202-Removal of Asphalt
202-Removal of Asphalt (Planing)
203-Unclassified Excavation
203-Unclassified Excavation (C.I.P.)
203-Embankment Material
203-Embankment Material (C.I.P.)
203-Muck Excavation
203-Rolling

Function Class: Rural Interstate (Weekday)

Total Duration (days): 29

Normal Capacity per Lane: 1789.0 Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Primary Capacity per Lane	Secondary Capacity per Lane	
403-HMA (3-in SMA & 10-in HMA)	29	13.00	1750	1750	✖

Initial Construction (2020) UserCost Screenshot for Flexible Pavement Alternative

Edit Hourly Distribution | Edit Parameters | Edit Costs | Reset | Guide | Analyze | Save | Summary Report | Hourly Report | Q Graph | User Cost Graph

Select File to Open: Browse...

File Open: Flex 2034.WZM
Last Modified: 02-10-17

Project Code:	21506	Freeway Name:	025A
Name of the Project:	North I-25 - ARE#1	Region:	R4
Project Start Date:	2034	Project End Date:	2034
Author & Comments:	RockSol Consulting Group, Inc.	Design Speed:	75 mph
Length of Closure:	1.00 miles	Speed Limit:	75 mph
Percent Grade:	2	Work Zone Speed Limit:	55 mph

Type of Closure: ◉ Single Lane ○ Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	2	Number of Open Lanes:	1
Single Unit Trucks [%]:	2.00 %	Number of Temporary Lanes:	1
Combination Trucks [%]:	8.00 %	Average Annual Daily Traffic:	62964
☐ Work on Both Directions		☐ Pilot Car Operation Please select stop time:	15 Minutes

Type of Work

202-Removal of Concrete
202-Removal of Concrete (Diamond Grinding)
202-Removal of Asphalt
202-Removal of Asphalt (Planing)
203-Unclassified Excavation
203-Unclassified Excavation (C.I.P.)
203-Embankment Material
203-Embankment Material (C.I.P.)
203-Muck Excavation
203-Rolling

Function Class: Rural Interstate (Weekday)

Total Duration (days): 10

Normal Capacity per Lane: 1789.0 Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Asphalt (Planing)	2	N/A	1459	✖
403-HMA (2-in SMA & 1.5-in HMA)	8	3.50	1408	✖

UserCost Screenshot for Flexible Pavement 2034 Rehabilitation

Edit Hourly Distribution | Edit Parameters | Edit Costs | Reset | Guide | Analyze | Save | Summary Report | Hourly Report | Q Graph | User Cost Graph

Select File to Open: Browse...

File Open: SMA 2047.WZM
Last Modified: 02-10-17

Project Code:	21506	Freeway Name:	025A
Name of the Project:	North I-25 - ARE#1	Region:	R4
Project Start Date:	2047	Project End Date:	2047
Author & Comments:	RockSol Consulting Group, Inc.	Design Speed:	75 mph
Length of Closure:	1.00 miles	Speed Limit:	75 mph
Percent Grade:	2	Work Zone Speed Limit:	55 mph

Type of Closure: ◉ Single Lane ○ Cross Over

Enter The Following Data Per Direction

Total Number of Lanes:	2	Number of Open Lanes:	1
Single Unit Trucks [%]:	2.00 %	Number of Temporary Lanes:	1
Combination Trucks [%]:	8.00 %	Average Annual Daily Traffic:	78846
☐ Work on Both Directions		☐ Pilot Car Operation Please select stop time:	15 Minutes

Type of Work

202-Removal of Concrete
202-Removal of Concrete (Diamond Grinding)
202-Removal of Asphalt
202-Removal of Asphalt (Planing)
203-Unclassified Excavation
203-Unclassified Excavation (C.I.P.)
203-Embankment Material
203-Embankment Material (C.I.P.)
203-Muck Excavation
203-Rolling

Function Class: Rural Interstate (Weekday)

Total Duration (days): 8

Normal Capacity per Lane: 1789.0 Vehicles per hour per lane

Type of Selected Work	Duration	Depth	Work Zone Capacity per Lane	
202-Removal of Asphalt (Planing)	2	N/A	1459	✖
403-HMA Stone Matrix Asphalt	6	2.50	1366	✖

UserCost Screenshot for Flexible Pavement 2047 Rehabilitation

For Future Rehabilitations

Edit Hourly Traffic Distribution Factors

Current Functional Class: Rural Interstate (Weekday)

Hour 0 - 1:	0.0165	Hour 12 - 13:	0.0000
Hour 1 - 2:	0.0137	Hour 13 - 14:	0.0000
Hour 2 - 3:	0.0128	Hour 14 - 15:	0.0000
Hour 3 - 4:	0.0136	Hour 15 - 16:	0.0000
Hour 4 - 5:	0.0166	Hour 16 - 17:	0.0000
Hour 5 - 6:	0.0232	Hour 17 - 18:	0.0000
Hour 6 - 7:	0.0000	Hour 18 - 19:	0.0000
Hour 7 - 8:	0.0000	Hour 19 - 20:	0.0000
Hour 8 - 9:	0.0000	Hour 20 - 21:	0.0298
Hour 9 - 10:	0.0000	Hour 21 - 22:	0.0256
Hour 10 - 11:	0.0000	Hour 22 - 23:	0.0212
Hour 11 - 12:	0.0000	Hour 23 - 24:	0.0175

Sum of Hourly Distribution: 0.1905

OK Cancel

For Initial Construction

Edit Hourly Traffic Distribution Factors

Current Functional Class: Rural Interstate (Weekday)

	Primary	Secondary		Primary	Secondary
Hour 0 - 1:	0.0165	0.0165	Hour 12 - 13:	0.0675	0.0675
Hour 1 - 2:	0.0137	0.0137	Hour 13 - 14:	0.0681	0.0681
Hour 2 - 3:	0.0128	0.0128	Hour 14 - 15:	0.0683	0.0683
Hour 3 - 4:	0.0136	0.0136	Hour 15 - 16:	0.0656	0.0656
Hour 4 - 5:	0.0166	0.0166	Hour 16 - 17:	0.0602	0.0602
Hour 5 - 6:	0.0232	0.0232	Hour 17 - 18:	0.0523	0.0523
Hour 6 - 7:	0.0380	0.0380	Hour 18 - 19:	0.0435	0.0435
Hour 7 - 8:	0.0495	0.0495	Hour 19 - 20:	0.0359	0.0359
Hour 8 - 9:	0.0590	0.0590	Hour 20 - 21:	0.0298	0.0298
Hour 9 - 10:	0.0648	0.0648	Hour 21 - 22:	0.0256	0.0256
Hour 10 - 11:	0.0683	0.0683	Hour 22 - 23:	0.0212	0.0212
Hour 11 - 12:	0.0685	0.0685	Hour 23 - 24:	0.0175	0.0175

Sum of Hourly Distribution: Primary: 1.0000 / Secondary: 1.0000

OK Cancel

UserCost Screenshot for Hourly Traffic Distibution Factors for Initial and Rehabilitation Pavement Construction Operations