An Evaluation of the Fairmont Gateway Connector Roundabouts from a Cost-Benefit and Public Opinion Perspective

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Excerpt from RP-275
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(Co-PI) Dr. David Martinelli
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Acknowledgements

- West Virginia Division of Highways
- Donald Williams and Michael Pumphrey
  - Project Monitoring and Support
- Jason Nelson (WVDOT)
  - Bid Sheets
- Technical Advisory Committee
  - Ray Lewis (WVDOT)
  - Danny Donlin (formerly with WVDOT)
  - Bruce Kenney (WVDOT)
  - Richard Warner (WVDOT)
  - Fred Shoukrey (WVDOT)
  - Hamilton Duncan (FHWA)
  - Bill Austin (Morgantown MPO)

Outline

- Background
- Benefit-Cost Analysis
  - Identifying costs
  - Quantifying benefits
- Cost-Effectiveness Analysis
  - Identifying total lifetime cost
  - Estimating total use
- Public Perception
  - Pre-survey
  - Post-survey

Background

- Part of Gateway Connector
- Opened in December 2010
- First two roundabouts in West Virginia

Financial Analysis : Benefit-Cost Analysis

Identifying Costs

- Capital Costs
- Operation and Maintenance Costs

Estimation of Construction Costs

- Signage
- Pavement Markings
- Equipment
- Pavement Structural Components
- Lighting Costs

Estimation of Construction Costs

- **Signage**
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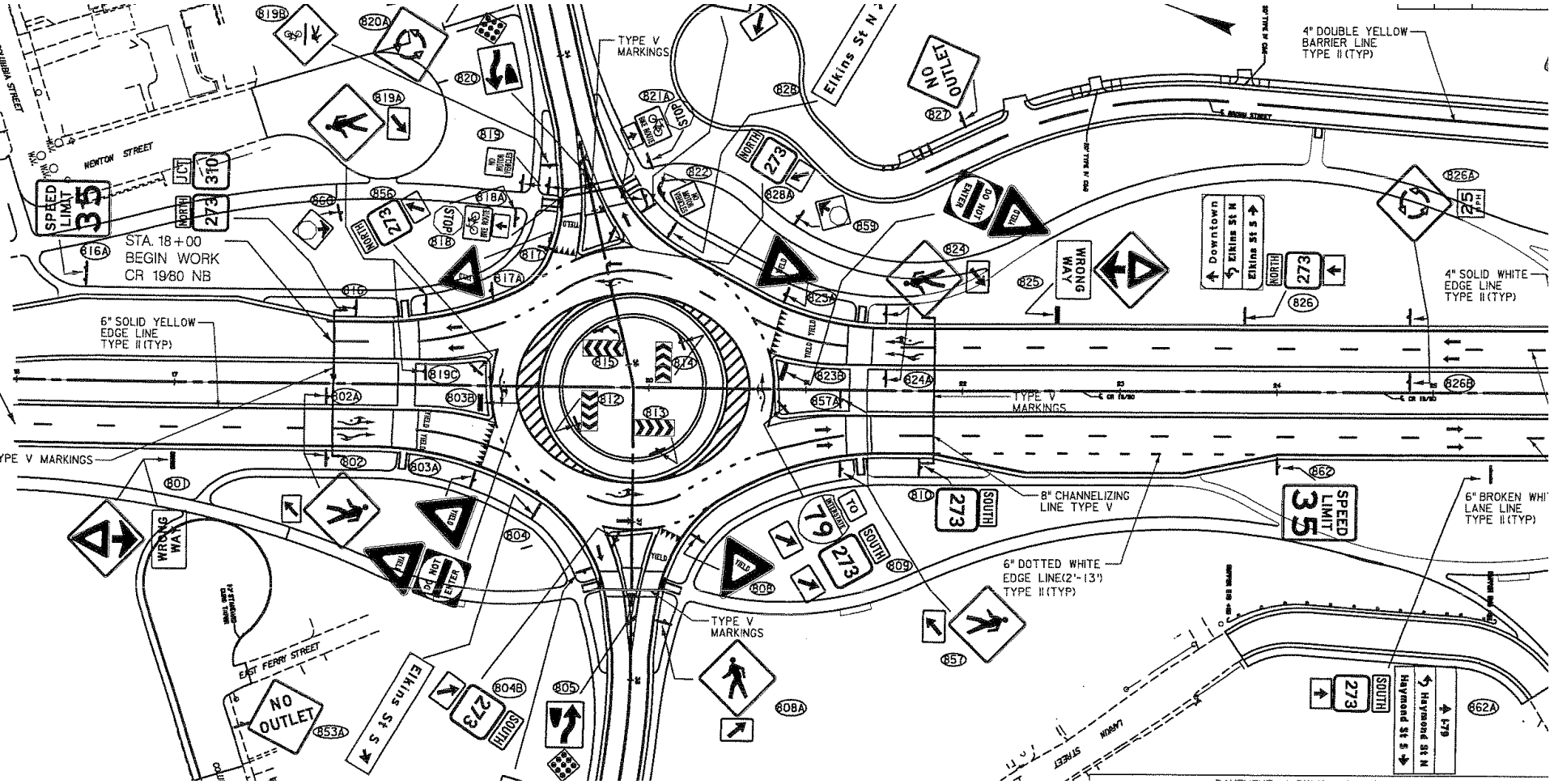
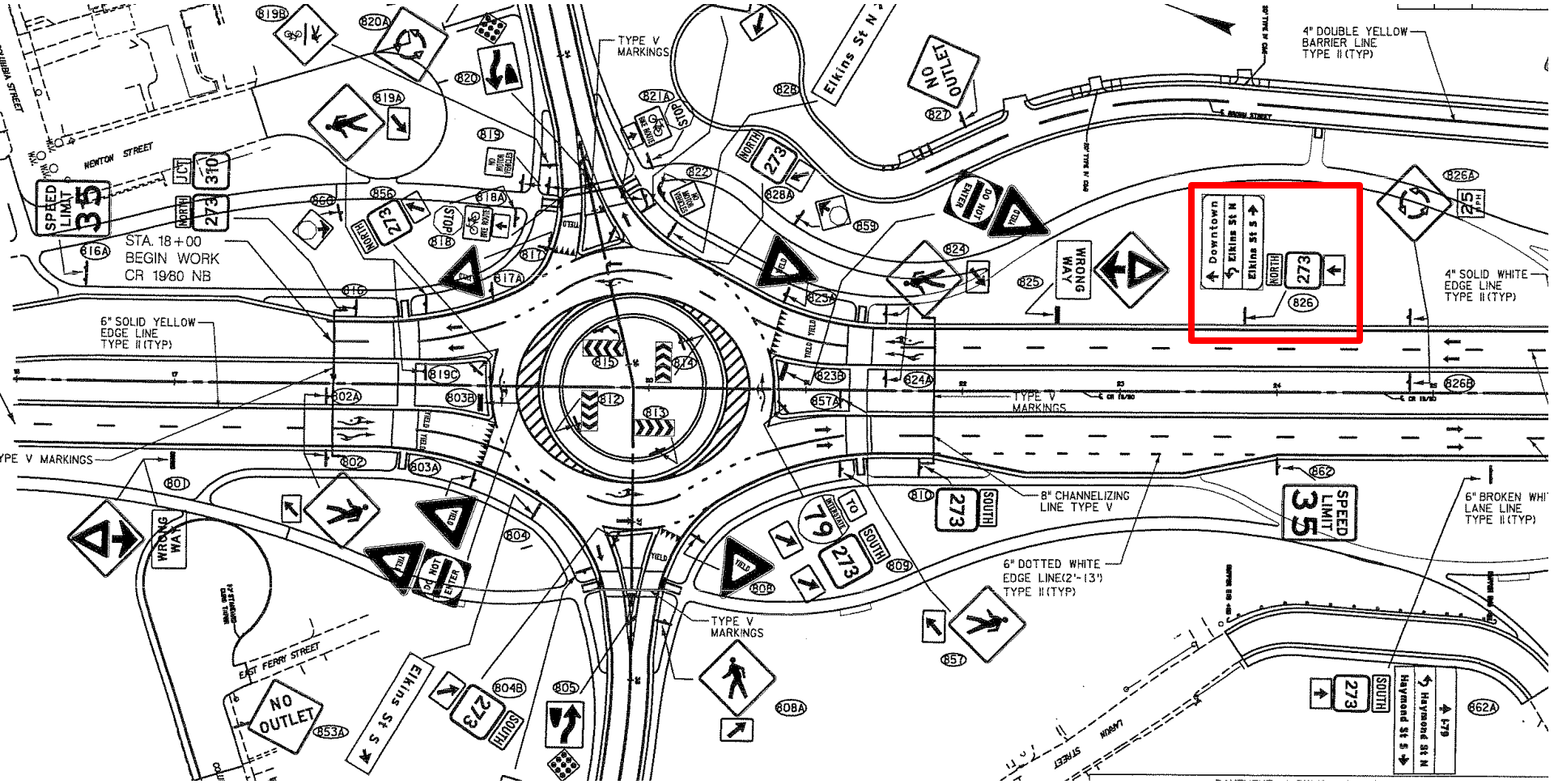
- Lighting Costs



Screen Shot of Page 8 of Bid Sheet 8



Screen Shot of Page 8 of Bid Sheet 8

SIGNING QUANTITIES

PUBLIC ROADS DIV.	STATE DIST. NO.	STATE PROJECT NO.	FEDERAL PROJECT NO.
W.V.	4	X325-19/80 0.00 08	

ASSEMBLY NUMBER	SIGN NUMBER	PROPOSED LOCATION	EXISTING LOCATION	PLAN SHT. NO.	FABRICATION DET. SHT. NO.	SIGN DISPOSITION	POSITION IN RELATION TO TRAVEL LANES	SIGN							SUPPORTS											FOUNDATIONS		
								LENGTH FT.	HEIGHT FT.	FLAT SIGN .080 S.F.	FLAT SIGN .100 S.F.	FLAT SIGN .080 OVERLAY S.F.	EXTRUDED PANEL S.F.	INTERNALLY ILLUMINATED S.F.	INSTALL REUSED SIGN S.F.	U-CHANNEL 2.00 #/FT.	U-CHANNEL 3.00 #/FT.	U-CHANNEL 4.00BB #/FT.	U-CHANNEL 6.00BB #/FT.	SQUARE TUBE 2"	SQUARE TUBE 2½"	SQUARE TUBE N/A	A-572 S4x7.7 L.F.	A-572 W6x12 L.F.	A-572 W8x18 L.F.	A-572 W10x22 L.F.	DIA. FEET	DEPTH FEET	CLASS B CONC. REINF. C. Y.
826	826A	23+50		SP 6	SP 9	NEW	RT	6.00	4.00	24.00											13.50							
	M3-1					NEW	RT	2.00	1.00	2.00											14.00							
	M1-6					NEW	RT	2.50	2.00	5.00																		
	M6-3					NEW	RT	1.75	1.25	2.19																		

Screen Shot of Page 5 of Bid Sheet 8 for Assembly 826

	Sign							Support					Foundations			TOTAL
Assembly Number	Sign Number	Type of Sign	Sign ($/ ft^2)	Sign Area	Extruded Panel ($/ft^2)	Extruded Panel	Total Sign Cost	Support ($/ ft)	Support Length	A572 ($/ft)	A572 Support	Total Support Cost	Class B Concrete Reinforment ($/yd^3)	Class B Concrete Reinforment	Total Foundation Cost	
826	826a	Directions	23.5	24	24.5		733.44	73.2	13.5	58.5		678.24	1300		0	1411.68
	M3-1			2			61.12		14			703.36			0	764.48
	M1-6			5			152.8					0			0	152.8
	M6-3			2.19			66.9264					0			0	66.9264

Screen Shot of Excel Sheet of Roundabout Signs for Assembly 826

			Sign					Support					Foundations			TOTAL
Assembly Number	Sign Number	Type of Sign	Sign ($/ ft^2)	Sign Area	Extruded Panel ($/ft^2)	Extruded Panel	Total Sign Cost	Support ($/ ft)	Support Length	A572 ($/ft)	A572 Support	Total Support Cost	Class B Concrete Reinforment ($/CY)	Class B Concrete Reinforment	Total Foundation Cost	
709	W3-2a	Yield Ahead	23.5	9	24.5		211.5	73.2	12.5	58.5		915	1300		0	1126.5
	R5-1A			6			141		12.5			915			0	1056
709A	709A	Downtown, Haymond Sign		24			564				12.5	731.25		0.3	390	1685.25
	M3-1			2			47				13.5	789.75		0.3	390	1226.75
	M1-6			5			117.5					0			0	117.5
	M6-3			2.19			51.465					0			0	51.465
710A	W2-6	Roundabout Sign		9			211.5		13			951.6			0	1163.1
	W13-1			2.25			52.875		13			951.6			0	1004.475
710B	W2-6	Roundabout Sign		9			211.5		13			951.6			0	1163.1
	W13-1			2.25			52.875		13			951.6			0	1004.475
801	W3-2a	Yield and Wrong Way	30.56	9			275.04	50.24	12			602.88			0	877.92
	R5-1A			6			183.36					0			0	183.36
802	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
802A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
803A	R1-2	Yield and Do Not Enter		9			275.04		12.5			628			0	903.04
803B	R1-2	Yield		9			275.04		12.5			628			0	903.04
	R1-5			9			275.04					0			0	275.04
804	804	Elkins St N		4			122.24		11			552.64			0	674.88
804A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
804B	M3-3	273 S Sign		2			61.12		13.5			678.24			0	739.36
	M1-6			5			152.8					0			0	152.8
	M6-2L			2.19			66.9264					0			0	66.9264
805	R4-7	Divided Highway		5			152.8		12			602.88			0	755.68
	XR-9			2.25			68.76					0			0	68.76
807	W2-6	Roundabout		6.25			191		12.5			628			0	819
	W13-1			2.25			68.76					0			0	68.76
808	R1-2	Yield		9			275.04		12.5			628			0	903.04
808A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
809	M4-5a	273 and I79 Directions		2			61.12		13			653.12			0	714.24
	M1-1			4			122.24		13.5			678.24			0	800.48
	M6-2Ra			2.19			66.9264					0			0	66.9264
	M3-3			2			61.12					0			0	61.12
	M1-6			5			152.8					0			0	152.8
	M6-2R			2.19			66.9264					0			0	66.9264
810	M3-3	273 S Sign		2			61.12		12			602.88			0	664
	N1-6			5			152.8					0			0	152.8
812	R6-1R	Turn sign		10			305.6		11.5			577.76			0	883.36
813	R6-1R	Turn sign		10			305.6					0			0	305.6
814	R6-1R	Turn sign		10			305.6					0			0	305.6
815	R6-1R	Turn sign		10			305.6					0			0	305.6
816	M3-1	N273/Junction 310		2			61.12		12			602.88			0	664
	M1-6			5			152.8		12.5			628			0	780.8
	M201			2.19			66.9264					0			0	66.9264
	M1-6			5			152.8					0			0	152.8
817	R1-2	Yield		9			275.04		12			602.88			0	877.92
817A	817	Downtown		4			122.24		11			552.64			0	674.88
819A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
819B	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
819C	W11-2	N273		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
820	R4-7	Divided Highway		5			152.8		12			602.88			0	755.68
	XR-9			2.25			68.76					0			0	68.76
820A	W2-6	Roundabout		6.25			191		12			602.88			0	793.88
	W13-1			2.25			68.76					0			0	68.76
821B	W11-2B	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
823A	R1-2	Yield		9			275.04		12.5			628			0	903.04
823B	R1-2	Do Not Enter		9			275.04		12.5			628			0	903.04
	R1-5			9			275.04					0			0	275.04
824	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
824A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	M6-2RD			2.19			66.9264					0			0	66.9264
825	W3-2a	Wrong Way and Yield		9			275.04		12			602.88			0	877.92
	R5-1A			6			183.36					0			0	183.36
826	826a	Directions (Downtown and Elkins St)	24				0		13.5			678.24			0	678.24
	M3-1		2				0		14			703.36			0	703.36
	M1-6		5				0					0			0	0
	M6-3		2.19				0					0			0	0
826A	W2-6	Roundabout		9			275.04		14			703.36			0	978.4
	W13-1			2.25			68.76					0			0	68.76
826B	W2-6	Roundabout		9			275.04		14			703.36			0	978.4
	W13-1			2.25			68.76					0			0	68.76
828	828	Elkins St N		4			122.24		11			552.64			0	674.88
828A	M3-1	N273		2			61.12		13.5			678.24			0	739.36
	M1-6			5			152.8					0			0	152.8
	M6-2L			2.19			66.9264					0			0	66.9264
856	M3-1	N273		2			61.12		13.5			678.24			0	739.36
	M3-6			5			152.8					0			0	152.8
	M6-2R			2.19			66.9264					0			0	66.9264
857	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	W16-7R			2.19			66.9264					0			0	66.9264
857A	W11-2	Pedestrians		6.25			191		13			653.12			0	844.12
	W16-7R			2.19			66.9264					0			0	66.9264
859	W3-1	Pedestrians Stop		2.25			68.76		11			552.64			0	621.4
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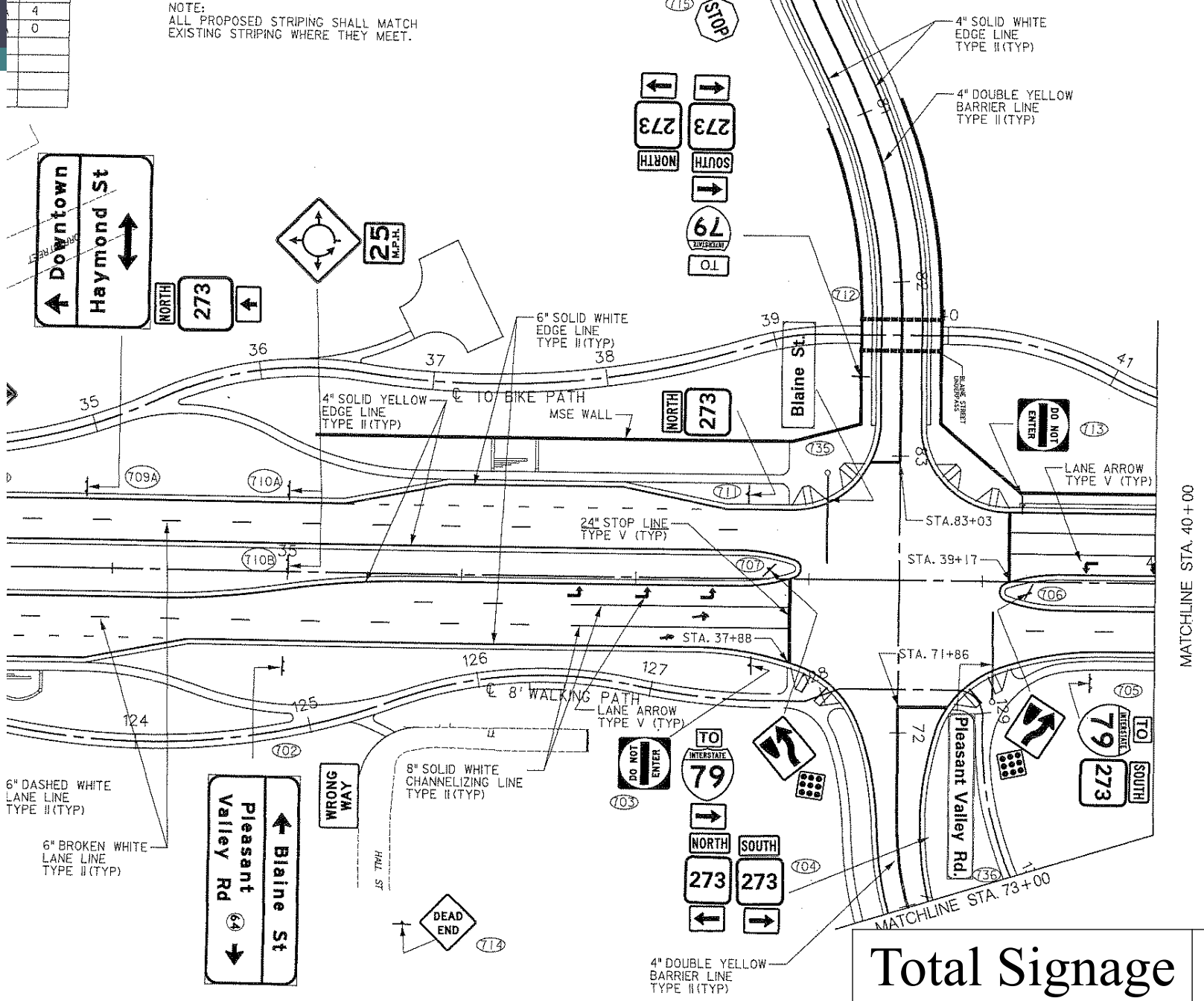
Roundabout Signage Total	$47,761



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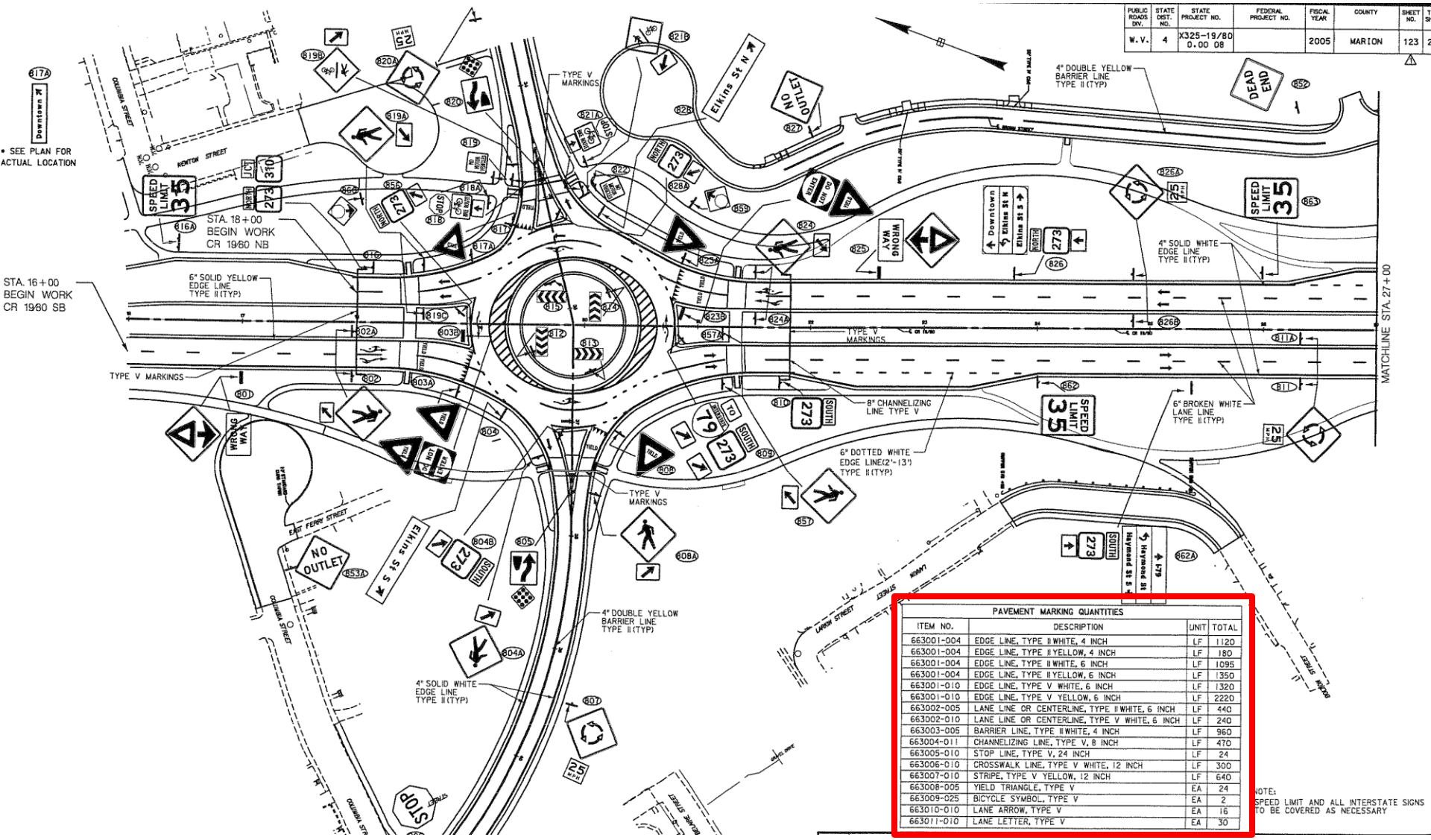
Total Signage Cost of Signal	$20,769

Estimation of Construction Costs

- Signage
- **Pavement Markings**
- Equipment
- Pavement Structural Components
- Lighting Costs



Screen Shot of Page 8 of Bid Sheet 8

PAVEMENT MARKING QUANTITIES			
ITEM NO.	DESCRIPTION	UNIT	TOTAL
663001-004	EDGE LINE, TYPE II WHITE, 4 INCH	LF	1120
663001-004	EDGE LINE, TYPE II YELLOW, 4 INCH	LF	180
663001-004	EDGE LINE, TYPE II WHITE, 6 INCH	LF	1095
663001-004	EDGE LINE, TYPE II YELLOW, 6 INCH	LF	1350
663001-010	EDGE LINE, TYPE V WHITE, 6 INCH	LF	1320
663001-010	EDGE LINE, TYPE V YELLOW, 6 INCH	LF	2220
663002-005	LANE LINE OR CENTERLINE, TYPE II WHITE, 6 INCH	LF	440
663002-010	LANE LINE OR CENTERLINE, TYPE V WHITE, 6 INCH	LF	240
663003-005	BARRIER LINE, TYPE II WHITE, 4 INCH	LF	960
663004-011	CHANNELIZING LINE, TYPE V, 8 INCH	LF	470
663005-010	STOP LINE, TYPE V, 24 INCH	LF	24
663006-010	CROSSWALK LINE, TYPE V WHITE, 12 INCH	LF	300
663007-010	STRIPE, TYPE V YELLOW, 12 INCH	LF	640
663008-005	YIELD TRIANGLE, TYPE V	EA	24
663009-025	BICYCLE SYMBOL, TYPE V	EA	2
663010-010	LANE ARROW, TYPE V	EA	16
663011-010	LANE LETTER, TYPE V	EA	30

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663010-010	LANE ARROW, TYPE V	EA	16
663011-010	LANE LETTER, TYPE V	EA	30

Pavement Markings	Unit Price	Quantity	Total
Yield Triangles	36.25	24	870
Lane Arrow	284.85	16	4557.6
Lane Letters	72.51	30	2175.3
Cross Walk	7.25	300	2175
Stop Line	12.43	24	298.32

Roundabout Pavement Total	$10,076.22

PAVEMENT MARKING QUANTITIES			
ITEM NO.	DESCRIPTION	UNIT	TOTAL
663001-004	EDGE LINE, TYPE II WHITE	LF	2500
663001-004	EDGE LINE, TYPE II YELLOW	LF	1400
663002-005	LANE LINE OF CENTERLINE, TYPE II WHITE	LF	305
663003-005	BARRIER LINE, TYPE II	LF	950
663004-004	CHANNELIZING LINE, TYPE II (8")	LF	415
663005-010	STOP LINE, TYPE V (24")	LF	133
663009-025	BICYCLE SYMBOL, TYPE V	EA	0
663010-010	LANE ARROW, TYPE V	EA	4
663011-010	LANE LETTER, TYPE V	EA	0

NOTE:
ALL PROPOSED STRIPING SHALL MATCH EXISTING STRIPING WHERE THEY MEET.

4" SOLID WHITE EDGE LINE TYPE II (TYP)

4" DOUBLE YELLOW BARRIER LINE TYPE II (TYP)

6" SOLID WHITE EDGE LINE TYPE II (TYP)

4" SOLID YELLOW EDGE LINE TYPE II (TYP)

24" STOP LINE TYPE V (TYP)

LANE ARROW TYPE V (TYP)

6" DASHED WHITE LANE LINE TYPE II (TYP)

6" BROKEN WHITE LANE LINE TYPE II (TYP)

6" SOLID WHITE CHANNELIZING LINE TYPE II (TYP)

Downtown Haymond St

Blaine St

Pleasant Valley Rd

Pleasant Valley Rd.

MSE WALL

℄ 10' BIKE PATH

℄ 8' WALKING PATH

LANE ARROW TYPE V (TYP)

STA. 31+90
EGIN WORK
R 1980

STA. 83+03

STA. 39+17

STA. 37+88

STA. 71+86

MATCHLINE STA. 40+00

MATCHLINE STA. 73+00

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663003-005	BARRIER LINE, TYPE II	LF	950
663004-004	CHANNELIZING LINE, TYPE II (8")	LF	415
663005-010	STOP LINE, TYPE V (24")	LF	133
663009-025	BICYCLE SYMBOL, TYPE V	EA	0
663010-010	LANE ARROW, TYPE V	EA	4
663011-010	LANE LETTER, TYPE V	EA	0

PAVEMENT MARKING QUANTITIES			
ITEM NO.	DESCRIPTION	UNIT	TOTAL
663001-004	EDGE LINE, TYPE II WHITE	LF	2500
663001-004	EDGE LINE, TYPE II YELLOW	LF	1400
663002-005	LANE LINE OF CENTERLINE, TYPE II WHITE	LF	305
663003-005	BARRIER LINE, TYPE II	LF	950
663004-004	CHANNELIZING LINE, TYPE II (8")	LF	415
663005-010	STOP LINE, TYPE V (24")	LF	133
663009-025	BICYCLE SYMBOL, TYPE V	EA	0
663010-010	LANE ARROW, TYPE V	EA	4
663011-010	LANE LETTER, TYPE V	EA	0

PAVEMENT MARKING QUANTITIES			
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663001-004	EDGE LINE, TYPE II WHITE	LF	2500
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663002-005	LANE LINE OF CENTERLINE, TYPE II WHITE	LF	305
663003-005	BARRIER LINE, TYPE II	LF	950
663004-004	CHANNELIZING LINE, TYPE II (8")	LF	415
663005-010	STOP LINE, TYPE V (24")	LF	133
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PAVEMENT MARKING QUANTITIES			
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663001-004	EDGE LINE, TYPE II WHITE	LF	2500
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663009-025	BICYCLE SYMBOL, TYPE V	EA	0
663010-010	LANE ARROW, TYPE V	EA	4
663011-010	LANE LETTER, TYPE V	EA	0

Pavement Markings	Unit Price	Quantity	Total
Arrows	155	4	620
Stop Lines	11	133	1463

Total for Pavement Markings of Signal	$2083.00

Estimation of Construction Costs

- Signage
- Pavement Markings
- **Equipment**
- Pavement Structural Components
- Lighting Costs

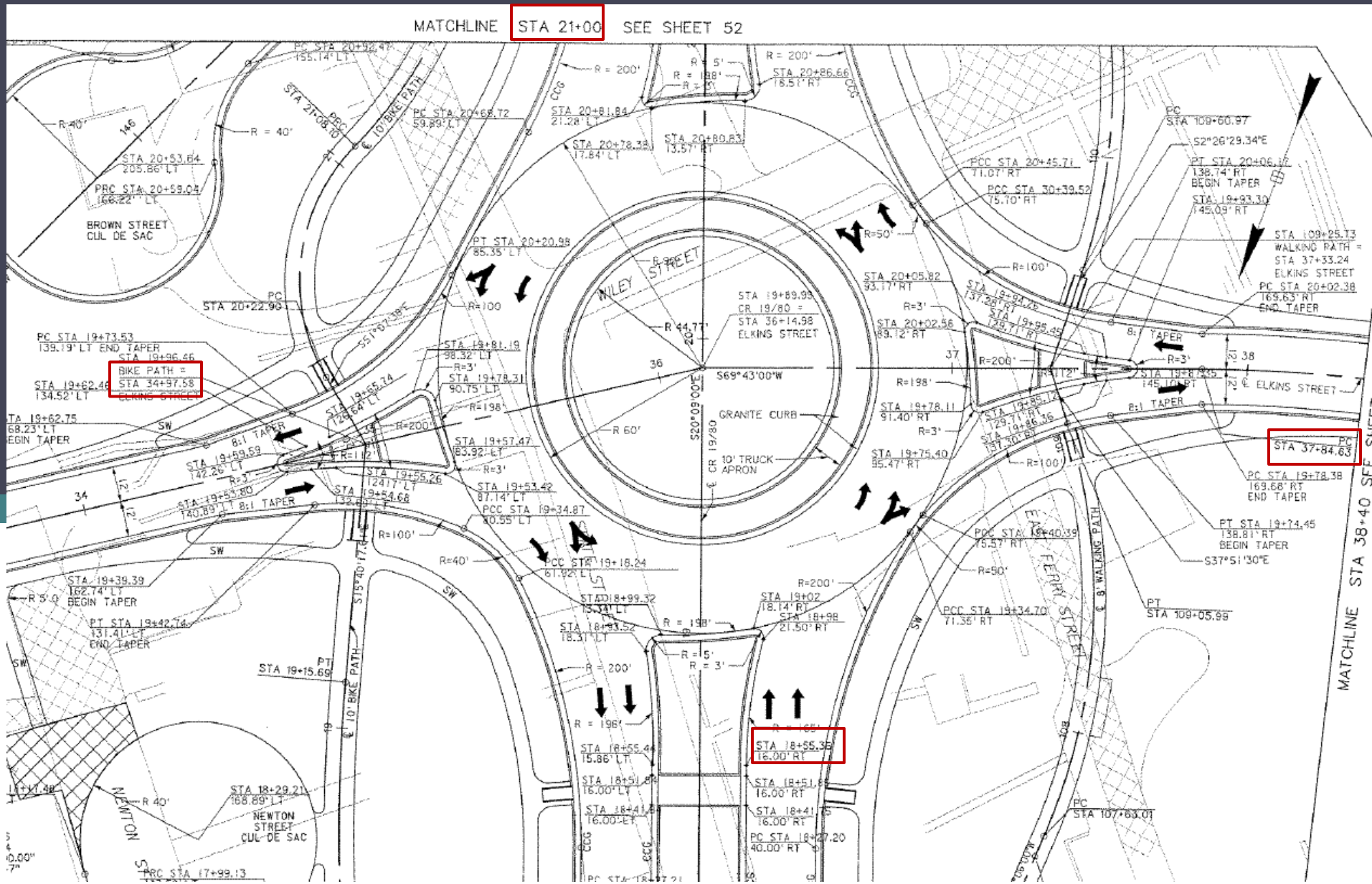
Estimating Equipment Costs

- Roundabout requires no operating equipment

- Signal equipment
  - Includes controller, detector, etc.
  - ~ $153,012.00

Estimation of Construction Costs

- Signage
- Pavement Markings
- Equipment
- **Pavement Structural Components**
- Lighting Costs



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PAVING QUANTITIES

LOCATION		ITEM 401001-011 PRINCIPAL HMA TYPE 37.5 TON	ITEM 401001-012 ALTERNATE HMA TYPE 37.5 TON	ITEM 401001-011 PRINCIPAL HMA TYPE 25 TON	ITEM 401001-012 ALTERNATE HMA TYPE 25 TON	ITEM 402001-011 PRINCIPAL HMA SKID TYPE 9.5 TON	ITEM 402001-012 ALTERNATE HMA SKID TYPE 9.5 TON	ITEM 408002-001 BITUMINOUS MATERIAL 'TACK' GAL	ITEM 311006-001 OPEN GRADE FREE DRAIN BASE CY	ITEM 207034-000 FABRIC FOR SEPARATION SY	ITEM 207002-000 SUBGRADE CY	ITEM 415005-001 REM. EXIST PVMT SURFACE SY	ITEM 307001-000 CLASS I AGGREGATE BASE COURSE CY	ITEM 606025-001 FREE DRAIN BASE TRENCH FT	ITEM 606030-001 OUTLET PIPE LF
STATION	STATION														
CR 19/80															
SOUTHBOUND															
16+00	18+56	226	215	123	117	57	54	21	93	1,024	139	0	0	256	5
21+28	29+01	751	713	407	387	188	179	68	303	3,294	454	0	0	775	15
NORTHBOUND															
18+00	18+56	50	48	27	26	13	12	5	21	226	31	0	0	56	5
21+28	29+01	752	714	408	388	188	179	68	303	3,29[illegible]	454	0	0	775	15
ROUNDABOUT															
18+56	21+28	1153	1095	525	499	243	231	105	368	4,255	583	0	0	1087	100
ROUNDABOUT															
29+01	31+90	1227	1166	565	537	261	248	112	413	4,573	620	0	0	1188	100
ELKINS STREET															
30+52	34+45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]								

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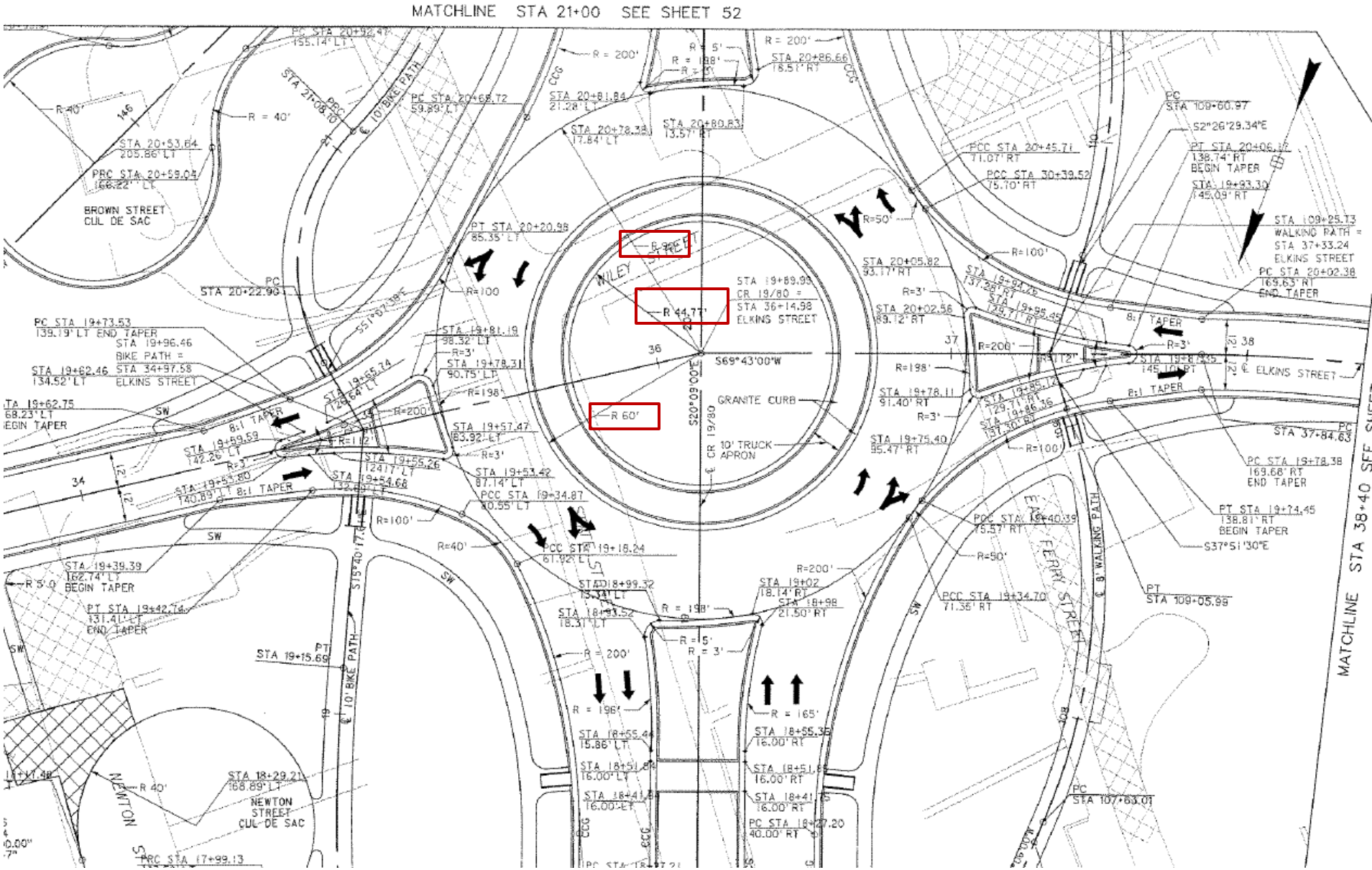
Item #	Description	Unit	Unit Cost	Quanitity	Totals
401001-011	Principal HMA Type 37.5	TON	86.4	1153	99619.2
401001-012	Alternate HMA Type 37.5	TON	86.4	1095	94608
401001-011	Principal HMA Type 25	TON	97.97	525	51434.25
401001-012	Alternate HMA Type 25	TON	97.97	499	48887.03
402001-011	Principal HMA Skid Type 9.3	TON	116	243	28188
402001-012	Alternate HMA Skid Type 9.5	TON	116	231	26796
408002-001	Biuminous Material 'Tack'	GAL	3	105	315
311006-001	Open Grade Free Drain Base	CY	146	388	56648
207034-000	Fabric For Separation	SY	2.21	4255	9403.55
207002-000	Subgrade	CY	51.88	583	30246.04
606029-001	Free Drain Base Trench	FT	13.98	1087	15196.26
606030-001	Outlet Pipe	LF	12.43	100	1243

Roundabout Pavement Cost	$462,584.33



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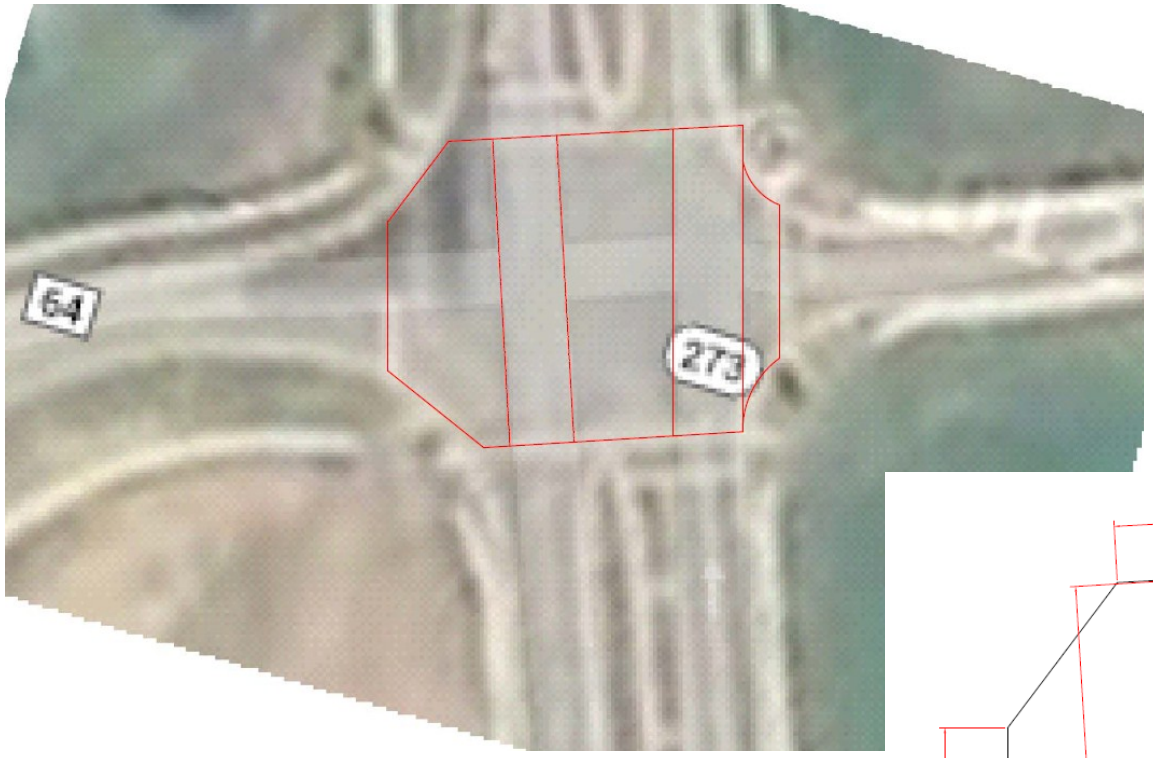
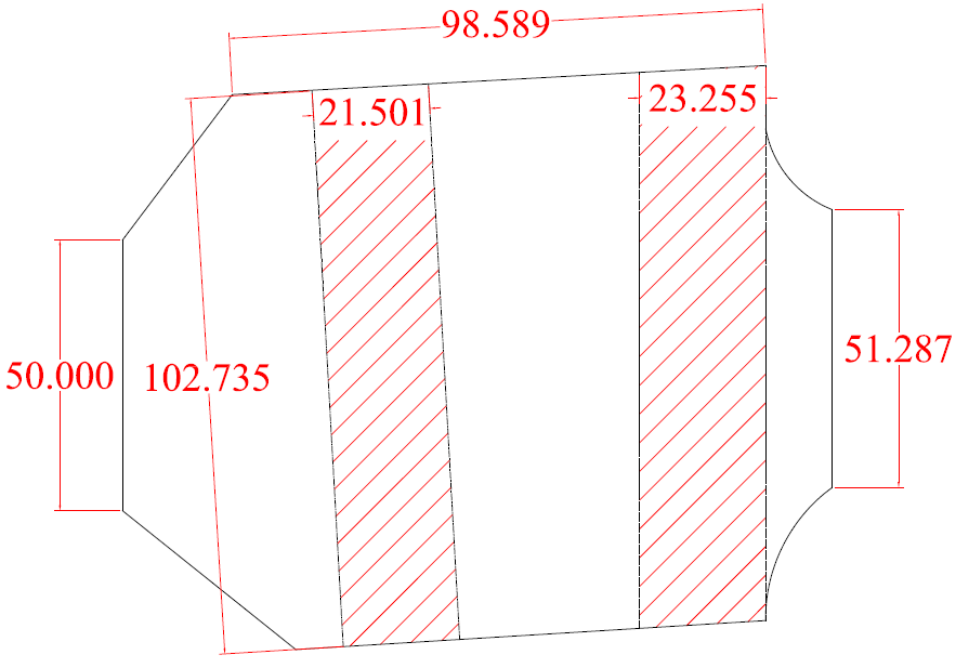


Google Maps view of Pleasant Valley Road and Rt. 273 Intersection (above)

AutoCad used to find dimensions of intersection (below)



AREA: 12302.65 SQ FT

- 14,137.17 ft²

Roundabout Area

Roundabout Paving Cost

- $462,584.33

- 12,302.65 ft²

Signal Area

Signal Paving Cost

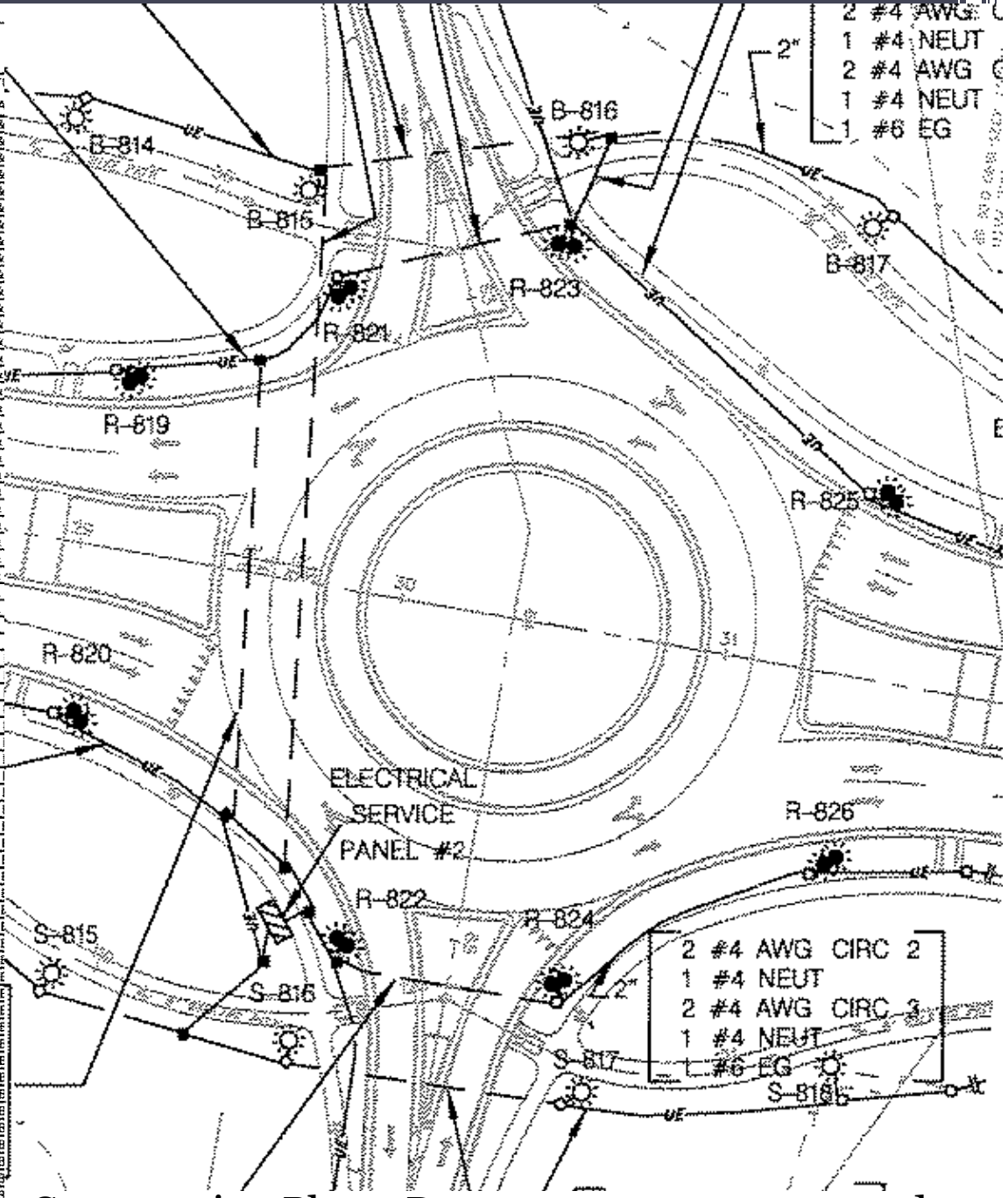
- $402,556.83

Estimation of Construction Costs

- Signage
- Pavement Markings
- Equipment
- Pavement Structural Components
- **Lighting Costs**

LIGHT POLE SCHEDULE

LIGHT POLE No.	COVERAGE AREA	LUMINAIRES/ WATTAGE	MOUNTING HEIGHT	SERVICE PANEL No.	CIRCUIT No.	FIXTURE PHASE
R-801	WV 273	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-4 & 5	A &
R-802	WV 273	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-2 & 3	A &
R-803	ELKINS ST.	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-4 & 5	A &
R-804	ELKINS ST.	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-2 & 3	A &
R-805	ELKINS ST.	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-4 & 5	A &
R-806	ELKINS ST.	DUAL 150w HPS	18 ft.	EXISTING-1	EXISTING-2 & 3	A &
R-807	WV 273	DUAL 150w HPS	18 ft.	2	4 & 5	A &
R-808	WV 273	DUAL 150w HPS	18 ft.	2	2 & 3	A &
R-809	WV 273	SINGLE 150w HPS	18 ft.	2	5	A &
R-810	WV 273	SINGLE 150w HPS	18 ft.	2	3	A &
R-811	WV 273	SINGLE 150w HPS	18 ft.	2	4	A &
R-812	WV 273	SINGLE 150w HPS	18 ft.	2	2	A &
R-813	WV 273	SINGLE 150w HPS	18 ft.	2	5	A &
R-814	WV 273	SINGLE 150w HPS	18 ft.	2	3	A &
R-815	WV 273	SINGLE 150w HPS	18 ft.	2	4	A &
R-816	WV 273	SINGLE 150w HPS	18 ft.	2	2	A &
R-817	WV 273	SINGLE 150w HPS	18 ft.	2	5	A &
R-818	WV 273	SINGLE 150w HPS	18 ft.	2	3	A &
R-819	WV 273	DUAL 150w HPS	18 ft.	2	4 & 5	A &
R-820	WV 273	DUAL 150w HPS	18 ft.	2	2 & 3	A &
R-821	HAY MOND ST.	DUAL 150w HPS	18 ft.	2	4 & 5	A &
R-822	HAY MOND ST.	DUAL 150w HPS	18 ft.	2	2 & 3	A &
R-823	HAY MOND ST.	DUAL 150w HPS	18 ft.	2	4 & 5	A &
R-824	HAY MOND ST.	DUAL 150w HPS	18 ft.	2	2 & 3	A &
R-825	WV 273	DUAL 150w HPS	18 ft.	2	4 & 5	A &
R-826	WV 273	DUAL 150w HPS	18 ft.	2	2 & 3	A &
R-827	ELKINS ST.	SINGLE 150w HPS	18 ft.	EXISTING-1	EXISTING-5	A &
R-828	ELKINS ST.	SINGLE 150w HPS	18 ft.	EXISTING-1	EXISTING-4	A &
R-829	ELKINS ST.	SINGLE 150w HPS	18 ft.	EXISTING-1	EXISTING-3	A &
R-830	ELKINS ST.	SINGLE 150w HPS	18 ft.	EXISTING-1	EXISTING-2	A &
R-831	HAY MOND ST.	SINGLE 150w HPS	18 ft.	2	4	A &
R-832	HAY MOND ST.	SINGLE 150w HPS	18 ft.	2	2	A &
B-801	BIKE PATH	SINGLE 50w HPS	12 ft.	EXISTING-1	EXISTING-3	A &
B-802	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-803	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-804	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-805	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-806	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-807	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-808	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-809	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-810	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-811	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-812	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-813	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-814	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-815	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-816	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
B-817	BIKE PATH	SINGLE 50w HPS	12 ft.	2	2	A &
B-818	BIKE PATH	SINGLE 50w HPS	12 ft.	2	3	A &
S-801	SIDEWALK	SINGLE 50w HPS	12 ft.	EXISTING-1	EXISTING-4	A &
S-802	SIDEWALK	SINGLE 50w HPS	12 ft.	EXISTING-1	EXISTING-6	A &
S-803	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-804	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-805	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-806	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-807	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-808	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-809	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-810	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-811	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-812	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-813	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-814	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-815	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-816	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &
S-817	SIDEWALK	SINGLE 50w HPS	12 ft.	2	4	A &
S-818	SIDEWALK	SINGLE 50w HPS	12 ft.	2	5	A &



Construction Plans, Document 134 pages 29 and 30

		Pole Item Number	Pole Type	Cost per Unit	Light bulb item	Light Bulb Type	Cost per Unit	Totals
Dual Type Lighting	8	662010-005	18 ft	4529.16	662007-001	Dual 150W	1358.31	57966.24
Bike Path Lighting	4	662010-006	12 ft	3485.34	662007-001	Single 50W	1358.31	19374.6

Roundabout Lighting Total	$77,340.84

		Pole Item Number	Pole Type	Cost per Unit	Light bulb item	Light Bulb Type	Cost per Unit	Total
Dual Type Lighting	4	662010-005	18 ft	4529.16	662007-001	Dual 150W	1358.31	28983.12
Bike Path Lighting	4	662010-006	12 ft	3485.34	662007-001	Single 50W	1358.31	19374.6

Signal Lighting Total	$48,357.72

Summary of Construction Costs

Inputs						
	Sign Cost	Pavement Marking Cost	Equipment	Pavement Structural Components	Lighting	Total Capital Cost of Roundabout
Roundabout	47760.81	9777.90	0.00	462584.33	67653.54	$587776.58
	Sign Cost	Pavement Marking Cost	Equipment	Pavement Structural Components	Lighting	Total Capital Cost of Signalized Intersection
Signal	20769.19	2083.00	153012.00	486415.07	38670.42	$617091.44

Operation and Maintenance Costs

- Roundabout
  - Landscaping
- Signal
  - Maintenance
    - Detection Loops
    - Control Equipment
    - Bulbs
  - Operations
    - Power Costs
- FHWA estimates ~ $5000

Quantifying benefits

- Operational (delay savings)
- Environmental (fuel savings)
- Crashes

Operational Improvements

- Service life ~ assumed 25 years
- Current traffic count – taken August 7th, 2013
- Programmed into SIDRA (roundabout) and SYNCHRO (signal)
- 1% (years 7-13), 2% (years 14-19), 3% (years 20-25) traffic growth rates assumed
- Value of one person's time $12.50 (Belenky, 2011)
- 3% inflation rate

Cutout of Roundabout Delay Spreadsheet

Service Year	Calendar Year	Delay (sec/veh)	Average Flow (veh/hr)	Vehicles per Day	Delay (hrs/year)	Value of 1 Hour of Public's Time	$/year
1	2011	4.95	1472	11776	4048	12.50	50600.00
2	2012	4.95	1472	11776	4048	12.88	52138.24
3	2013	4.95	1472	11776	4048	13.26	53676.48
4	2014	4.95	1472	11776	4048	13.66	55295.68
5	2015	4.95	1472	11776	4048	14.07	56955.36
20	2030	5.9	3083	24664	10105.39	21.92	221510.12
21	2031	5.9	3083	24664	10105.39	22.58	228179.68
22	2032	5.9	3083	24664	10105.39	23.25	234950.29
23	2033	5.9	3083	24664	10105.39	23.95	242024.06
24	2034	5.9	3083	24664	10105.39	24.67	249299.94
25	2035	5.9	3083	24664	10105.39	25.41	256777.93

Cutout of Signal Delay Spreadsheet

Service Year	Calendar Year	Delay (sec/veh)	Average Flow (veh/hr)	Vehicles per Day	Delay (hrs/year)	Value of 1 Hour of Public's Time	$/year
1	2011	4.35	1353.5	10828	3270.958	12.50	40886.98
2	2012	4.35	1353.5	10828	3270.958	12.88	42129.94
3	2013	4.35	1353.5	10828	3270.958	13.26	43372.91
4	2014	4.35	1353.5	10828	3270.958	13.66	44681.29
5	2015	4.35	1353.5	10828	3270.958	14.07	46022.38
20	2030	18.85	3031.5	24252	31746.54	21.92	695884.19
21	2031	18.85	3031.5	24252	31746.54	22.58	716836.91
22	2032	18.85	3031.5	24252	31746.54	23.25	738107.09
23	2033	18.85	3031.5	24252	31746.54	23.95	760329.67
24	2034	18.85	3031.5	24252	31746.54	24.67	783187.18
25	2035	18.85	3031.5	24252	31746.54	25.41	806679.62

Net Operational Delay

- Roundabout total delay = $3,260,071.98
- Signal total delay = $6,499,596.71

- Net Benefit = ROUNDABOUT
- Saved $3,239,524.74

Environmental Benefits

- Service life ~ assumed 25 years
- Current traffic count – taken August 7th, 2013
- Programmed into SIDRA (roundabout) and SYNCHRO (signal)
- 1% (years 7-13), 2% (years 14-19), 3% (years 20-25) traffic growth rates assumed
- Cost of one gallon of gas, $3.65 (2011), use a 3% inflation rate (USEIA, 2012)
- Rate of Fuel Consumption ~ 1 gal/1 idling hour (California Energy Commission, 2013)

Cutout of Roundabout Fuel Consumption Spreadsheet

Service Year	Calendar Year	Delay (sec/veh)	Average Flow (veh/hr)	Vehicles per Day	Delay (hrs/year)	Cost of 1 Gallon of Gasoline	$/year
1	2011	4.95	1472	11776	4048	3.65	14775.20
2	2012	4.95	1472	11776	4048	3.76	15220.48
3	2013	4.95	1472	11776	4048	3.87	15665.76
4	2014	4.95	1472	11776	4048	3.99	16151.52
5	2015	4.95	1472	11776	4048	4.11	16637.28
20	2030	5.9	3083	24664	10105.39	6.40	64674.49
21	2031	5.9	3083	24664	10105.39	6.59	66594.51
22	2032	5.9	3083	24664	10105.39	6.79	68615.59
23	2033	5.9	3083	24664	10105.39	6.99	70636.67
24	2034	5.9	3083	24664	10105.39	7.20	72758.80
25	2035	5.9	3083	24664	10105.39	7.42	74981.99

Cutout of Signal Fuel Consumption Spreadsheet

Service Year	Calendar Year	Delay (sec/veh)	Average Flow (veh/hr)	Vehicles per Day	Delay (hrs/year)	Cost of 1 Gallon of Gasoline	$/year
1	2011	4.35	1353.5	10828	3270.958	3.65	11939.00
2	2012	4.35	1353.5	10828	3270.958	3.76	12298.80
3	2013	4.35	1353.5	10828	3270.958	3.87	12658.61
4	2014	4.35	1353.5	10828	3270.958	3.99	13051.12
5	2015	4.35	1353.5	10828	3270.958	4.11	13443.64
20	2030	18.85	3031.5	24252	31746.54	6.40	203177.87
21	2031	18.85	3031.5	24252	31746.54	6.59	209209.71
22	2032	18.85	3031.5	24252	31746.54	6.79	215559.02
23	2033	18.85	3031.5	24252	31746.54	6.99	221908.33
24	2034	18.85	3031.5	24252	31746.54	7.20	228575.10
25	2035	18.85	3031.5	24252	31746.54	7.42	235559.34

Net Environmental Benefit

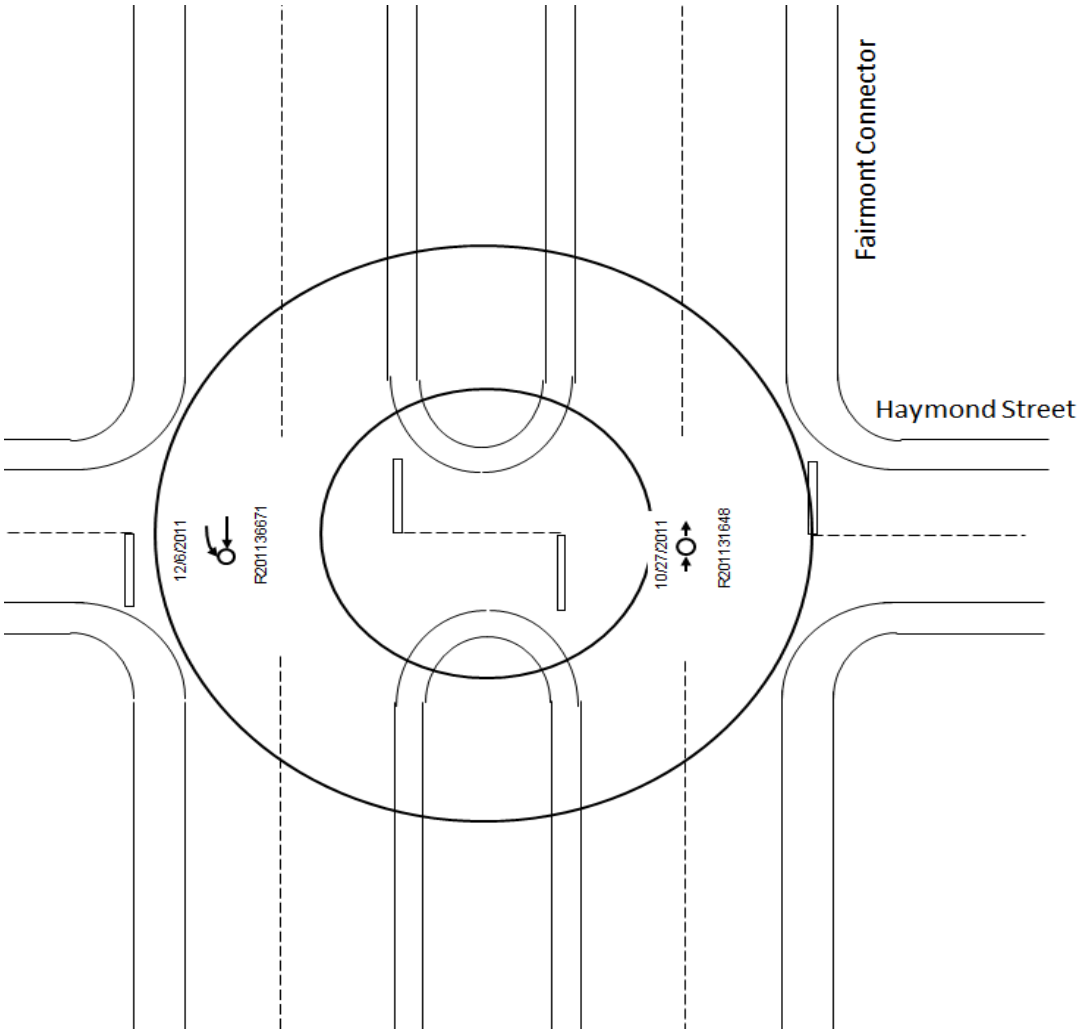
- Roundabout total fuel consumption= $ 951,794.43
- Signal total fuel consumption = $ 1,897,518.54

- Net Benefit = ROUNDABOUT
- Saved $ 945,724.11

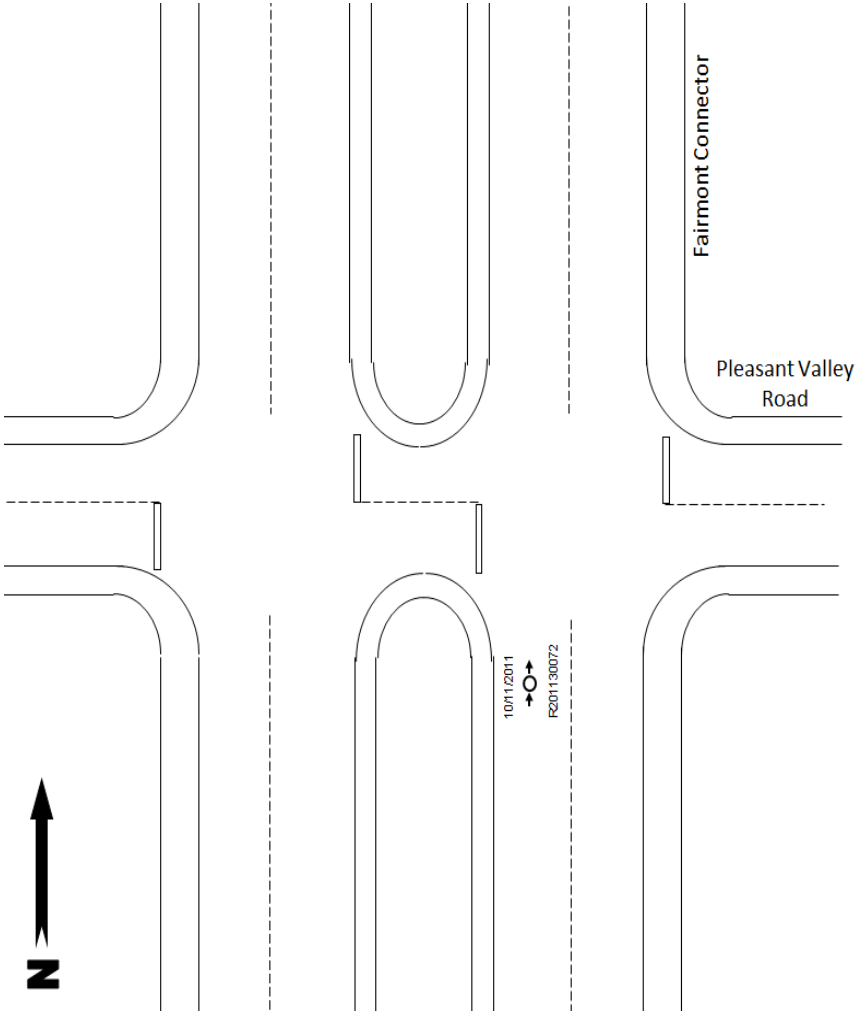
Crash Increase/Decrease

- 19 total accidents (Sept 2011 – Feb 2013)
- 8 accidents occurred at roundabouts
- 16 accidents involved two vehicles
- 17 accidents PDO

Crashes – Roundabout



Crashes – Signalized Intersection



Cutout of Roundabout Crash Spreadsheet

Injury Type	Average Cost (NSC, 2011)	Number of Accidents	Total Cost
Death	4,459,000	0	0
Incapacitating injury	225,100	0	0
Non-incapacitating injury	57,400	0	0
Possible injury	27,200	0	0
PDO	2,400	2	4,800

Cutout of Signal Crash Spreadsheet

Injury Type	Average Cost (NSC, 2011)	Number of Accidents	Total Cost
Death	4,459,000	0	0
Incapacitating injury	225,100	0	0
Non-incapacitating injury	57,400	0	0
Possible injury	27,200	0	0
PDO	2,400	1	2,400

Net Crash Increase

- Roundabout total cost of crashes=$ 175,004.46
- Signal total cost of crashes = $ 87,502.23

- Net Benefit = SIGNAL
- Cost 87,502.23

Net Present Value

- Using a 7% rate of return value, the net O&M, delay, and fuel consumption benefits and the net crash costs were brought to their present value

- NPV = $999,599.10

Benefit-Cost Analysis

- Total Cost of Roundabout: $651,678.40
- Total Benefit of Roundabout: $999,599.10

- Ratio: 1.53

Financial Analysis
Cost-Effectiveness Analysis

Cost-Effectiveness Analysis

- O&M, Delay, Fuel Consumption, and Crashes quantified the same way

- Difference – treat all values as “costs” and find the cost/vehicle served

CEA

	Roundabout	Signal
Capital Cost	587,776.58	617,091.44
Present Value of Annual Costs	1,732,638.71	2,732,237.807
Total Cost	2,320,415.29	3,349,329.247
Total Users	112,462,000	108,957,000
CER	0.021	0.031

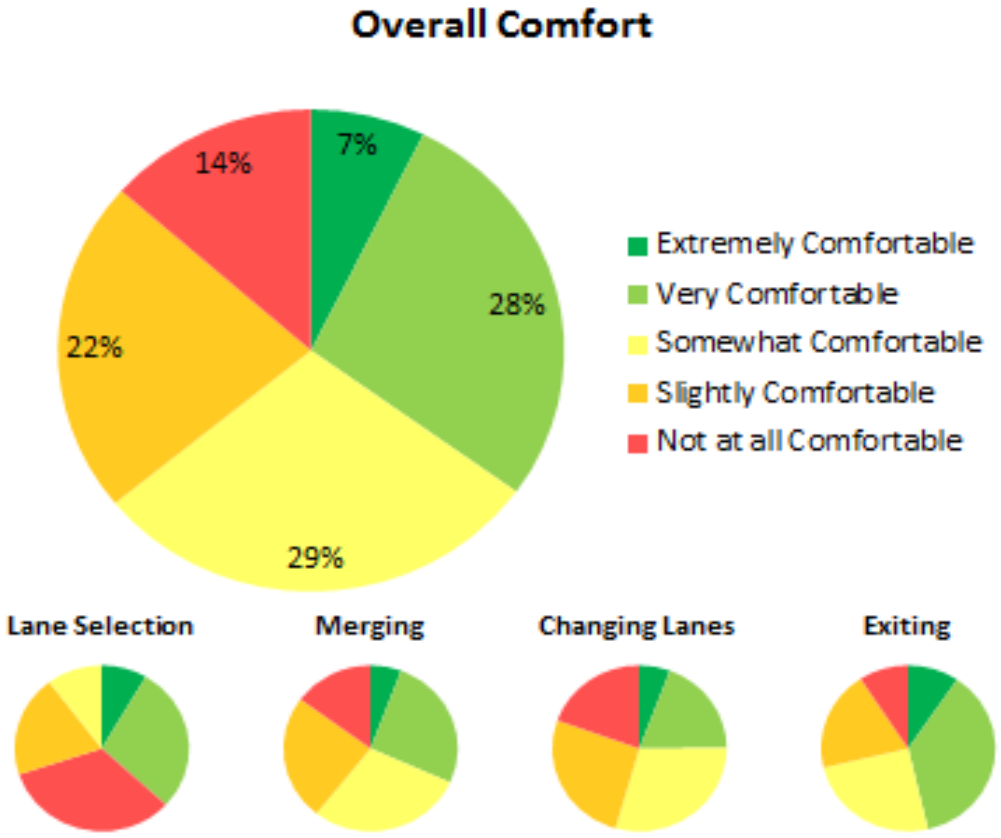
Public Perception of Roundabouts

Photo credit: AASHTO

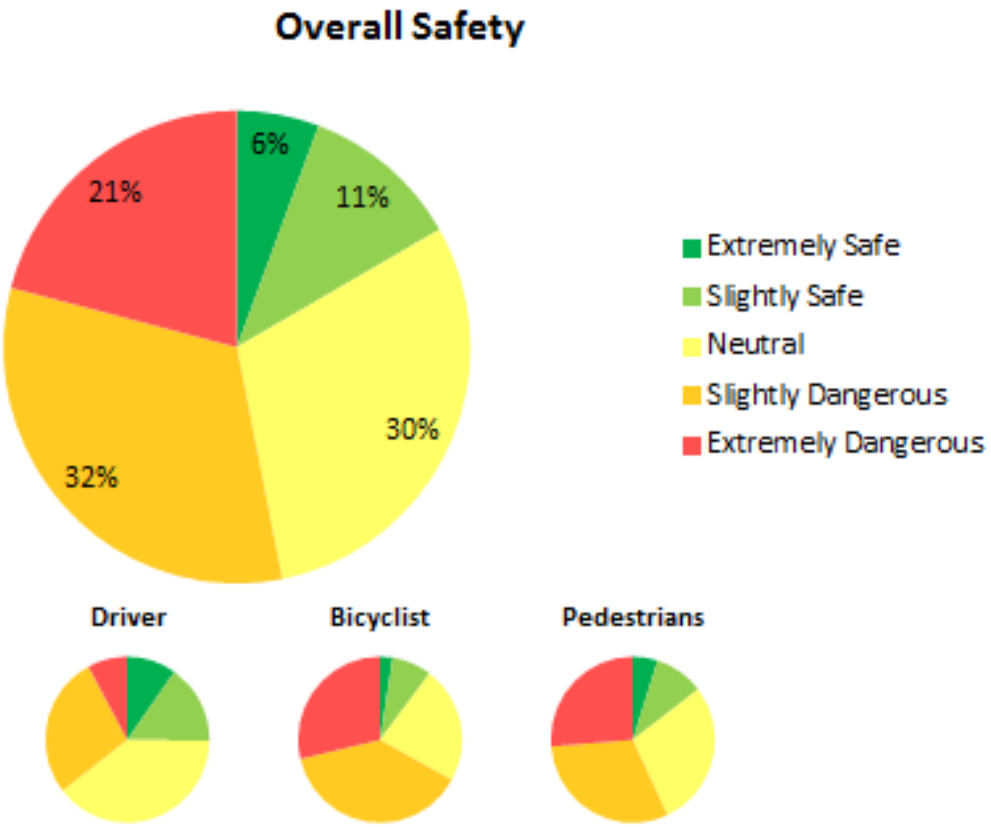
Public Perception Analysis

- Pre-Survey
  - Distributed between August 2010 and December 2010
  - 369 complete surveys
- Post-Survey
  - Distributed between November 2011 and December 2011
  - 297 complete surveys
- Comfort and safety opinions quantified

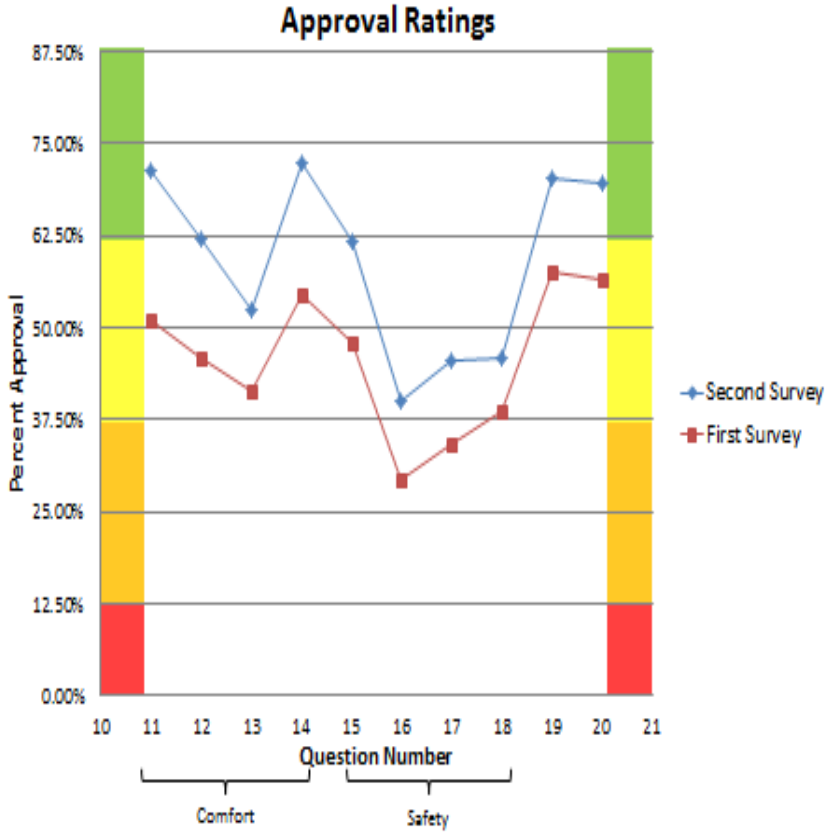
Pre-Survey :: Comfort Perception

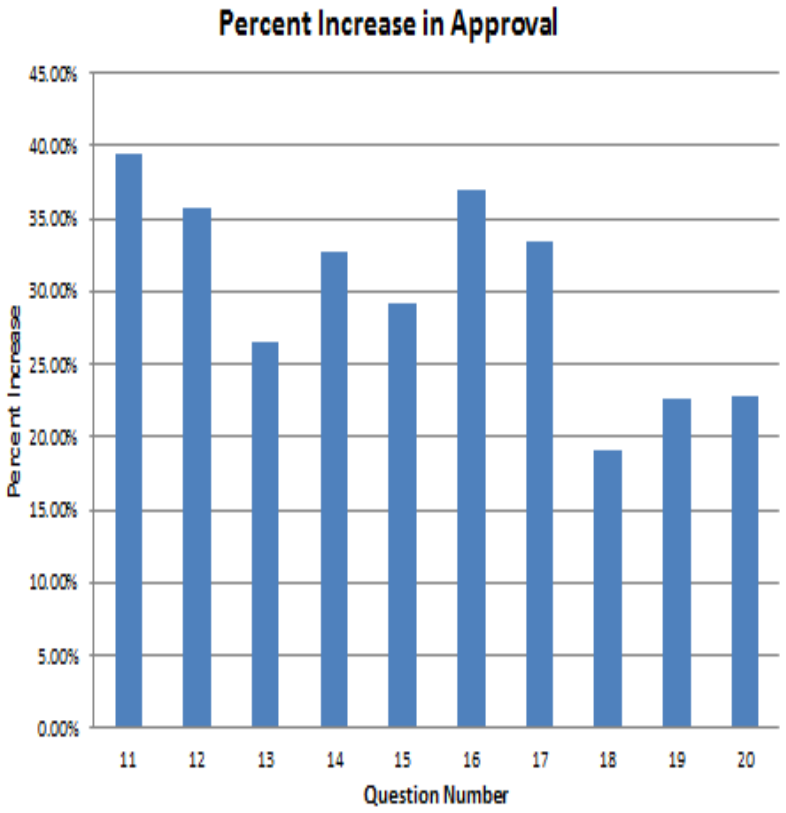


Pre-Survey :: Safety Perception

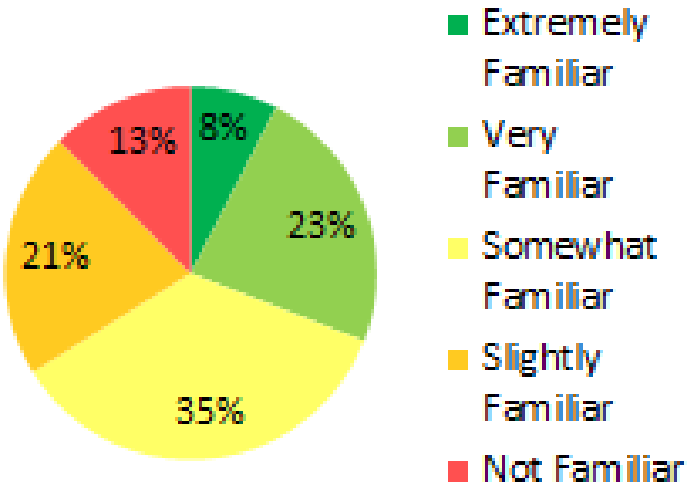


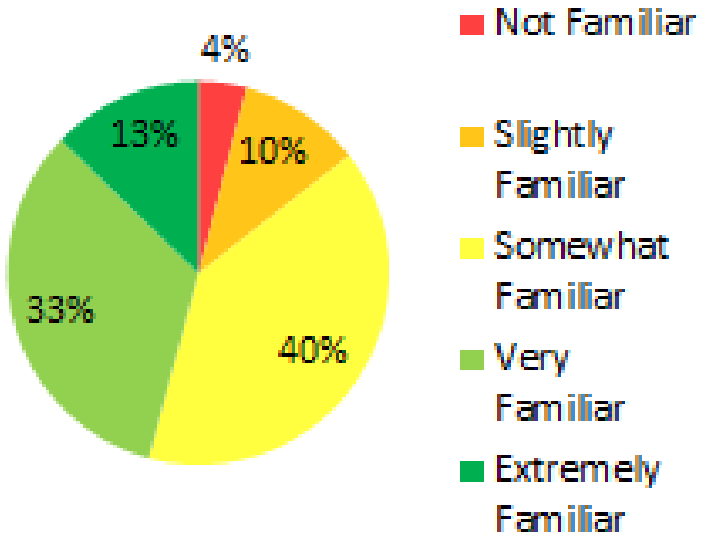
Significant Changes in Public Opinion Observed



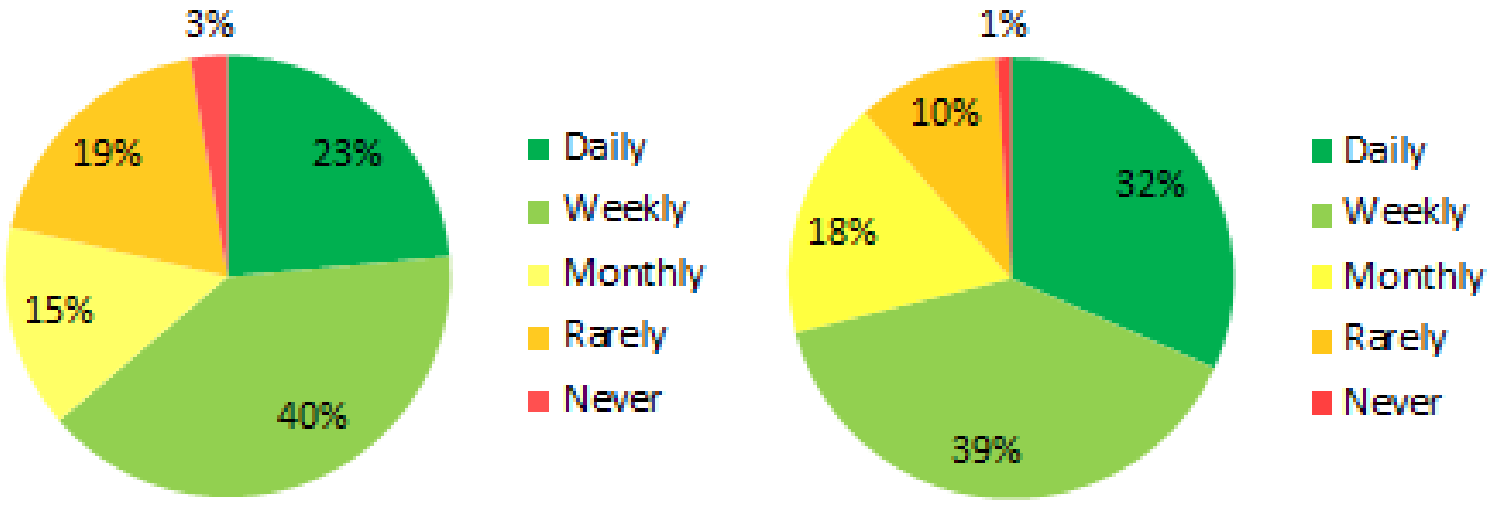


Familiarity with Roundabouts





Use of Roundabout



Significance of Perception Improvement?

- Chi Squared Test for Contingency were preformed on questions 11-20 (comfort, safety, and efficiency questions)
- ALL perception improvements were found to be statistically significant at the 1% significance level.

Question 11: How comfortable do you feel about selecting the proper lane prior to entering roundabout?

		Pre-Survey	Post-Survey	Total
Extremely Comfortable	O	31	92	123
	E	68.15	54.85	123
	(O-E)	-37.15	37.15	0
	$(O-E)^2$	1380.12	1380.12	0
	$(O-E)^2/E$	20.25	25.16	
Very Comfortable	O	105	114	219
	E	121.34	97.66	219
	(O-E)	-16.34	16.34	0
	$(O-E)^2$	266.996	266.996	0
	$(O-E)^2/E$	2.2	2.73	
Somewhat Comfortable	O	122	56	178
	E	98.62	79.38	178
	(O-E)	23.38	-23.38	0
	$(O-E)^2$	546.624	546.624	0
	$(O-E)^2/E$	5.54	6.89	
Slightly Comfortable	O	73	27	100
	E	55.41	44.59	100
	(O-E)	17.59	-17.59	0
	$(O-E)^2$	309.408	309.408	0
	$(O-E)^2/E$	5.58	6.94	
Not-at-All Comfortable	O	38	8	46
	E	25.49	20.51	46
	(O-E)	12.51	-12.51	0
	$(O-E)^2$	156.5	156.5	0
	$(O-E)^2/E$	6.14	7.63	
Totals		369	297	666

H_0	The public did not change their minds in between the survey distribution.
H_1	The public did change their minds in between the survey distribution.

	Chi-Square	89.06
	df	4
10%	0.1	7.779
5%	0.05	9.488
1%	**0.01**	**11.14**

χ^2 ? $c_{(1-\alpha, df)}$

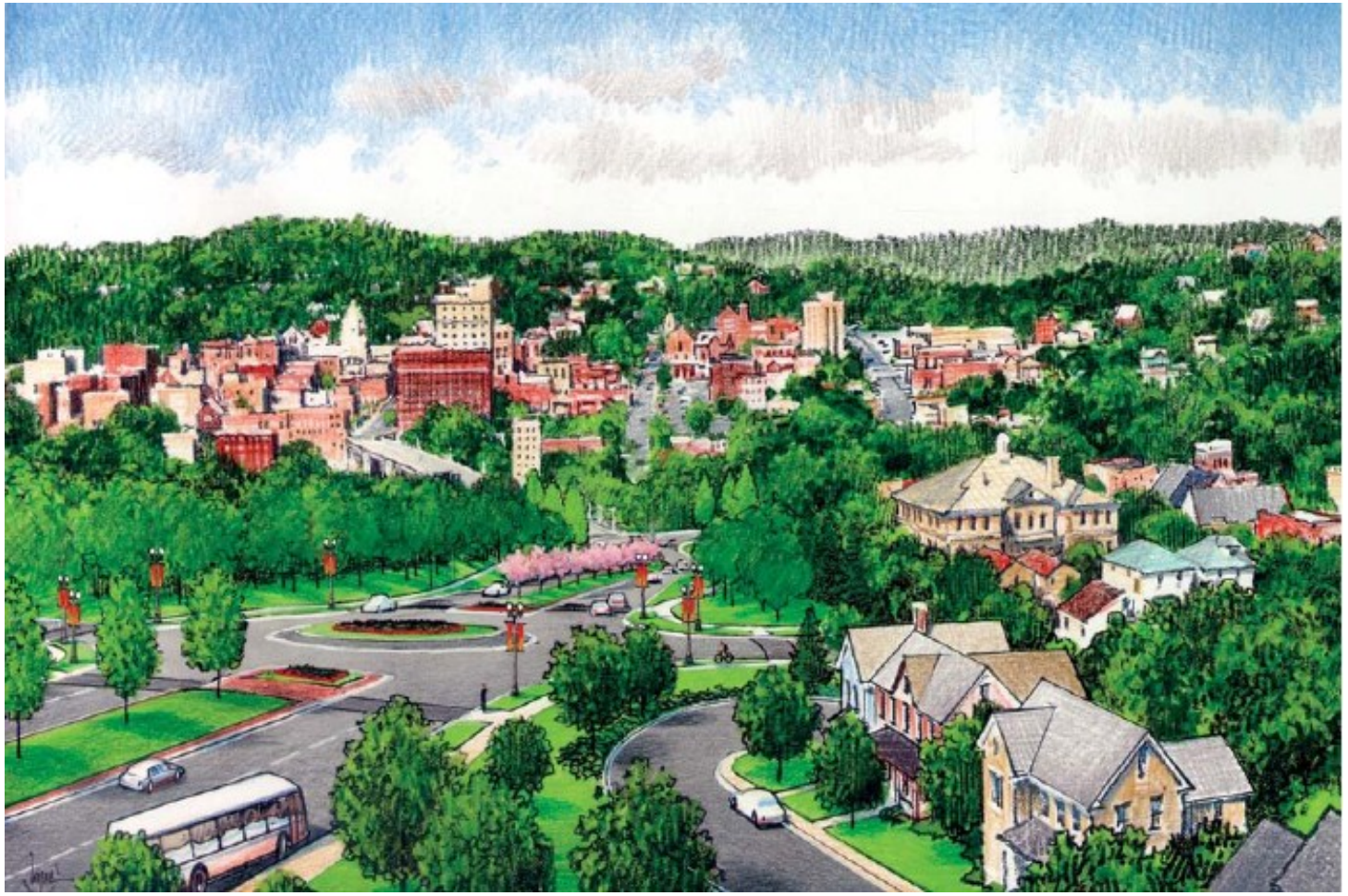
89.06 > 11.14

Therefore, we reject the null hypothesis at the 1% significance level.

Conclusions

- Roundabout implementation is success
  - Cost Effective
    - BCR >1
    - $CER_{roundabout} < CER_{signal}$
  - Accepted by public
    - Public opinion has increased by more than 20%
    - Results statistically significant

Thank you for your attention!
Any questions?



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References

Belenky, Peter. *Revised Departmental Guidance on Valuation of Travel Time in Economic Analysis*. U.S. Department of Transportation, 2011. Web.<*http://www.dot.gov/sites/dot.dev/files/docs/vot_guidance_092811c.pdf*>.

National Safety Council. *The Cost of Injuries: How Much Do You Really Pay?*, 2013. Web <*http://www.nsc.org/news_resources/injury_and_death_statistics/Pages/EstimatingtheCostsofUnintentionalInjuries.aspx* >.

California Energy Commission. *Energy Myths and Fallacies*, 2013. Web. <http://www.consumerenergycenter.org/myths/idling.html>.

U.S. Energy Information Administration. *2011 Brief: U.S. Average Gasoline and Diesel prices over $3.00 per gallon throughout 2011*, 2012. Web. <*http://www.eia.gov/todayinenergy/detail.cfm?id=4570*>.

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