Data-rich, information-poor: First steps toward 10-year targets

Network-level analysis work by early adopters of TAM Plans Paul D. Thompson

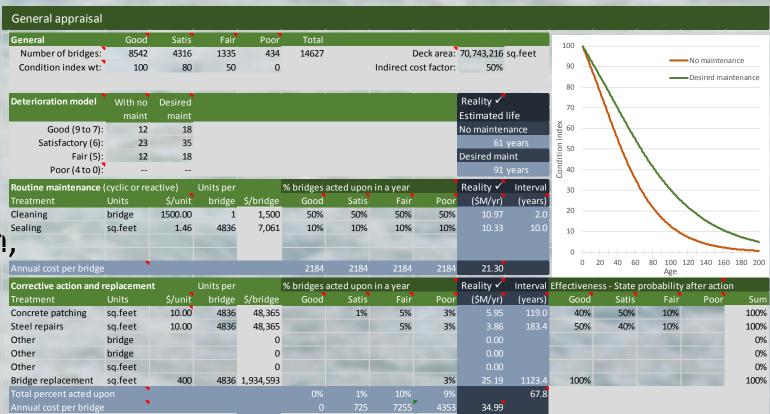
Background on TAM Plans

- Mandated by MAP-21 for pavements and bridges
- Among the required ingredients are:
 - Life cycle cost analysis
 - Risk analysis
 - Investment plan
- FHWA is developing guidance
 - About 15 states are early adopters
 - Some of them don't have fully-functional management systems

Life cycle cost and Return on investment

Life cycle cost analysis – Input data

- Quantity by condition state
- Deterioration rates
- Routine maintenance costs
- Corrective action application costs, and effects
- Replacement cost

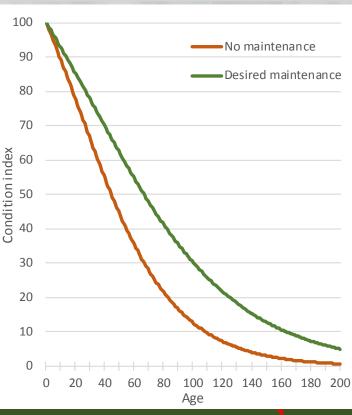


- Use NPRM definitions of Good and Poor for federal requirements
- Use element condition states for management

General	Good	Satis	Fair	Poor	Total						100	_
Number of bridges:	8542	4316	1335	434	14627		De	ck area:	70,743,216	sq.feet	100	
Condition index wt:	100	80	50	0		Ir	ndirect cost	t factor:	50%		90	
											80	
Deterioration model	With no	Desired							Reality 🗸		70	
	maint	maint							Estimated I	ife		
Good (9 to 7):	12	18							No mainten	ance	on dex	
Satisfactory (6):	23	35							61	years		
Fair (5):	12	18							Desired ma	int	ditio	
Poor (4 to 0):		-							91	years	Condition index 20 70 70 70 70 70 70 70 70 70 70 70 70 70	
Routine maintenance (cyclic or re		ner	ç	% bridges ac	ted upon ir	n a year		Reality 🗸	Interval	30	
Treatment	Units			∽⁄bridge	Good	Satis	Fair	Poor	(\$M/yr)	(years)		
Cleaning										20	20	
Sealing	niora	tion			modia	n tran		tim	00		10	

Deterioration expressed as median transition times

- Expert judgment informed by research
- Research often not in a form easily used for this purpose
- Element-level condition and deterioration would produce more reliable results



1	ffectiven	ess - State	probability	/ after actio	on
	Good	Satis	Fair	Poor	Sum
	40%	50%	10%		100%
I	50%	40%	10%		100%
	1000				0%
I					0%
I					0%
	100%				100%

Annual cost per bridge

Annual cost

Corrective a Treatment

Concrete pa

Steel repair

Bridge repla Total percent

Other Other Other

General	Good	Satis	Fair	Poor	Total						100				
Number of bridges:	8542	4316	1335	434	14627		De	ck area:	70,743,216	sq.feet	100			N	
Condition index wt:	100	80	50	0		1	ndirect cos	t factor:	50%		90 —			No maintena	nce
														Desired main	tenance
Deterioration model	With no	Desired				Actio	ns and		ts base	d on	agency				
Betenoration moder	maint	maint									~90110	y			
Good (9 to 7):	_	18				estim	estimation practice								
Satisfactory (6)		35				• Inc	liract	coct	s includ	4~4					
Fair (5):		18					inect	COSE	Sinciu	Jeu					
Poor (4 to 0)	-					• Ba	sed o	n tvr	oical pro	oiect	sizes				
Routine maintenance		activa)	Units por	c							0.200				
Treatment	Units	\$/unit	Units per bridge	\$/bridge	Good										
Cleaning	bridge	1500.00	bridge 1	1,500	50%	50%	50%	50%	10.97	2.0	20				
Sealing	sq.feet	1.46	4836	7,061	10%	10%	10%	10%	10.37	2.0 10.0					
Jeaning	34.1661	1.40	4030	7,001	1070	10/0	1070	1070	10.33	10.0	10				
											0		+ + + + +		
Annual cost per bridge					2184	2184	2184	2184	21.30		0 2	0 40 60	80 100 1 Age	20 140 160	180 200
			Unitspor	c		cted upon i			Reality 🗸	Intorval	Effectivenes	se State	0	oftoraction	
Corrective action and Treatment	Units	د \$/unit	Units per bridge	; \$/bridge	Good	Satis	Fair	Poor	· •	(years)	Good	Satis	Fair	Poor	Sum
Concrete patching	sq.feet	10.00	4836	48,365	G000	1%	5%	3%	(\$M/yr) 5.95	(years) 119.0	40%	50%	10%	PUUI	100%
Steel repairs	sq.feet	10.00	4836	48,365		170	5%	3%	3.86	119.0	50%	40%	10%		100%
Other	bridge	10.00	4030	-+0,505			570	370	0.00	103.4	5070	4070	1070		100%
Other	bridge			0					0.00						0%
Other	sq.feet			0					0.00						0%
Bridge replacement	sq.feet	400	4836	1,934,593				3%	25.19	1123.4	100%				100%
Total percent acted up		100	1000	_,	0%	1%	10%	9%		67.8	100/0				20070
Annual cost per bridge					0	725	7255	4353	34.99						

General	Good	Satis	Fair	Poor					<u></u>						
Number of bridges:	8542	4316	1335	434	Ap	plicati	ion rat	tes re	eflect c	urrer	nt			No maintena	nce
Condition index wt:	100	80	50	0	•	•									
					age	ency e	expend	aiture	es and	cona	itions			Desired mair	ntenance
Deterioration model	With no	Desired													
	maint	maint													
Good (9 to 7):		18		_					No mainten	ance	ě 60 —				
Satisfactory (6):		35								/ears	u.i.u				
Fair (5):		18							Desired mai						
Poor (4 to 0):										years	Condition index 20 40 40				
Routine maintenance	l (cyclic or rea	nctive)	Units per		% bridges a	cted unon i	n a vear		Reality 🗸	Interval	30				
Treatment	Units	\$/unit		\$/bridge	Good	Satis	Fair	Poor	(\$M/yr)	(years)	30				
Cleaning	bridge	1500.00	1	1,500	50%	50%	50%	50%	10.97	2.0	20				
Sealing	sq.feet	1.46	4836	7,061	10%	10%	10%	10%	10.33	10.0	10 ——				
		The second		,							10				
											0				
Annual cost per bridge					2184	2184	2184	2184	21.30		0 2	20 40 60	80 100 12 Age	20 140 160	180 200
Corrective action and	replacement	t	Units per		% bridges a	cted upon i	n a year		Reality 🗸	Interval	Effectivene	ss - State p	robability a	after action	า
Treatment	Units	\$/unit	bridge	\$/bridge	Good	Satis	Fair	Poor	(\$M/yr)	(years)	Good	Satis	Fair	Poor_	Sum
Concrete patching	sq.feet	10.00	4836	48,365		1%	5%	3%	5.95	119.0	40%	50%	10%		100%
Steel repairs	sq.feet	10.00	4836	48,365			5%	3%	3.86	183.4	50%	40%	10%		100%
Other	bridge			0				-	0.00		200 10				0%
Other	bridge			0					0.00		1100				0%
Other	sq.feet			0					0.00						0%
Bridge replacement	sq.feet	400	4836	1,934,593				3%	25.19	1123.4	100%				100%
Total percent acted up	on				0%	1%	10%	9%		67.8					
Annual cost per bridge	2				0	725	7255	4353	34.99						

General	Good	Satis	Fair	Poor	Total						100				
Number of bridges:	8542	4316	1335	434	14627		Ľ	eck area:	70,743,216 s	sq.feet	100			Ne maintanar	
Condition index wt:	100	80	50	0			Indirect co	ost factor:	50%		90 —			No maintenan	
											80 —			Desired maint	enance
Deterioration model	With no	Desired							Reality 🗸		00				
		Desired							Estimated I	:fo	70 —				— I
Good (9 to 7):	maint	maint 18									а Ко				
Satisfactory (6):		35							No mainten		ind				
, , ,		35 18							Desired mai	years int	50		<u> </u>		— I
Fair (5): Poor (4 to 0):	-	10								years	Condition index Condition index Condition index		\		
											U U				
Routine maintenance		· · · ·	Units p						Reality ✓	Interval	30				— I
Treatment	Units	\$/unit	bri Et	ffectiv	veness	base	don		(\$M/yr)	(years)	20				/
Cleaning	bridge	1500.00						6	10.97	2.0	20				
Sealing	sq.feet	1.46	e	xpert	judgm	ent		6	10.33	10.0	10 —				
											0				
											0	20 40 60	80 100 12	20 140 160	180 200
Annual cost per bridge								84	21.50				Age		
Corrective action and r			Units per		% bridges ac				Reality 🗸			ess - State p		fter action	
Treatment	Units	\$/unit	bridge	\$/bridge	Good	Satis	Fair	Poor		(years)	Good	Satis	Fair	Poor	Sum
	sq.feet	10.00	4836	48,365		1%	5%	3%		119.0	40%	50%	10%		100%
	sq.feet	10.00	4836	48,365			5%	3%		183.4	50%	40%	10%		100%
Other	bridge			0					0.00						0%
Other	bridge			0					0.00						0%
Other	sq.feet			0					0.00						0%
	sq.feet	400	4836	1,934,593				3%	25.19	1123.4	100%				100%
Total percent acted up	on				0%	1%	10%	9%		67.8					
Annual cost per bridge	4				0	725	7255	4353	34.99						

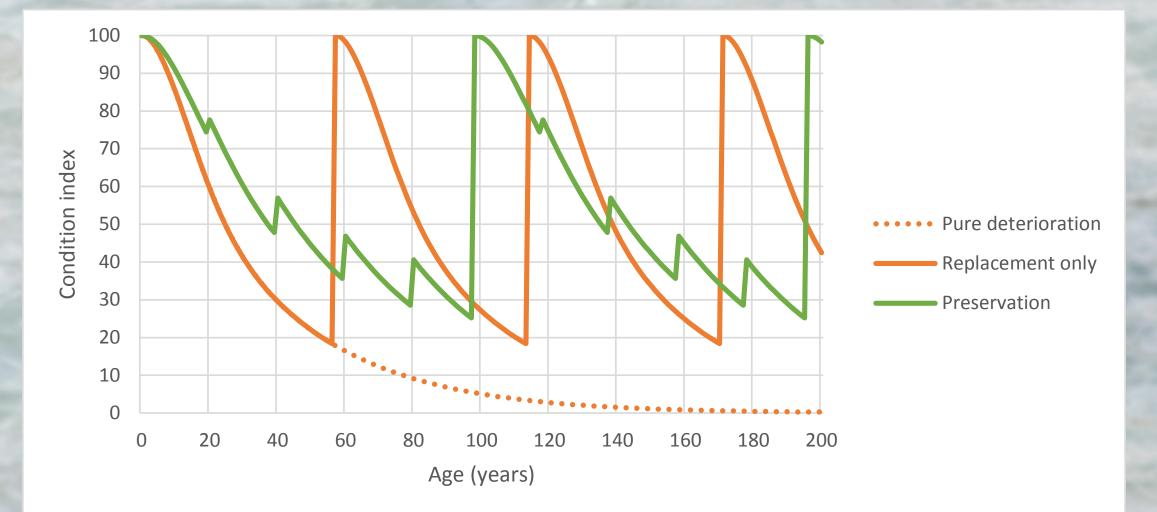
Bridge LCCA – Life cycle activity profile

- Compares preservation strategy with replacement-only, for a typical bridge over its life cycle
- Pro-forma analysis to show life extension benefit of preservation
- A bridge management system would be able to do this routinely as a decision support tool
- In Ohio, for example, Replacement-only found to cost 1.47 times as much as preservation



							1000		
					-				
							-		
							_		
							1000		
							1.000		
							1000		
							1000		
							100	9	
							1000	9	
							1000		

Bridge LCCA – Life cycle activity profile



Development of unit costs

Total by treatm	Total by treatment (all in 2015 dollars)												
		Average	Report	Cost per	Compare								
	Cost (\$)	annual \$	count	report	with								
Routine	12,153,084	3,238,126	4557	2,842									
Deck repair	2,858,845	761,724	176	17,312	25,122 MN								
Rail repair	964,937	257,102	145	7,092	23,800 TX								
Joint repair	1,541,495	410,723	310	5,300	5,590 TX								
Super repair	2,493,739	664,444	204	13,028	40,000 MN								
Bearing repair	1,145,145	305,118	136	8,974	40,000 NV								
Sub repair	1,069,709	285,018	270	4,222	20,637 TX								
Slope repair	748,419	199,412	122	6,538	5,300 TX								
Culvert repair	576,243	153,537	44	13,958	12,100 MN								

 The exercise quickly shows strengths, weaknesses of cost information

Painting costs from other states: TxDOT had about 300,000/bridge for painting Ohio had about 200,000/bridge MnDOT had 377,500/bridge

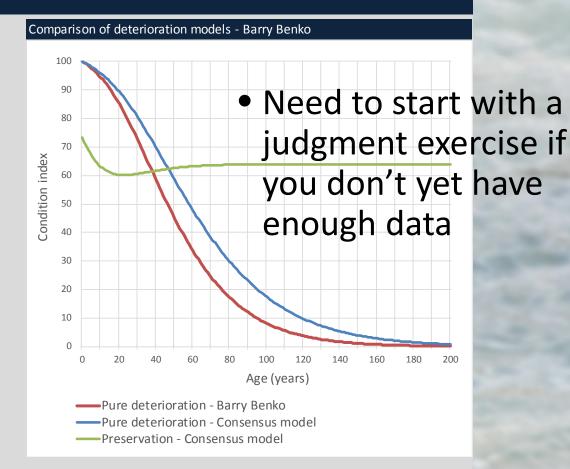
Deterioration modeling

Deterioration model - Soil slopes

Current conditions													
	State 1	State 2	State 3	State 4	State 5	Sum							
Sq.ft by state	55,987	19,342	186,467	93,161	46,229	354,957							
Transition time - media	an years to the	next state											
	State 1	State 2	State 3	State 4		Life							
Consensus model	19.3	15.5	10.3	6.3		69							
Darren Beckstrand	20.0	15.0	10.0	5.0		67							
Barry Benko	15.0	12.0	9.0	5.0		55							
Bob Kimmerling	20.0	17.0	9.0	7.0		71							
Aine Mines	15.0	15.0	12.0	7.0		66							
Paul Thompson	25.0	20.0	15.0	10.0		94							
Mark Vessely	21.0	14.0	7.0	4.0		61							
Other													
Other													
Other													
Treatment frequency a	Treatment frequency and cost \$/sq.ft												
Unit cost per state improved:													

			Unit cos	st per state	improved:	1328	50%
	% acted upor	n per year				Cost	Cost
Treatment	State 1	State 2	State 3	State 4	State 5	\$/sq.ft	\$k/year
Maintain same state						0	0.0
Improve by 1 state			0.50%			1328	1238.1
Improve by 2 states			1.00%	1.50%	0.50%	2656	9278.0
Improve by 3 states				1.50%	1.00%	3984	7409.1
Improve by 4 states					1.00%	5312	2455.7
Total acted upon	0.00%	0.00%	1.50%	3.00%	2.50%		20380.9

OH%



Preservation model starts with current condition; others with new condition

Investment analysis

Additional inputs for investment analysis

- Fiscal forecast
- Inflation rate
- Real growth rate
- Recapitalization rate
- Primary source: Agency revenue forecasts and pro-forma financial statements

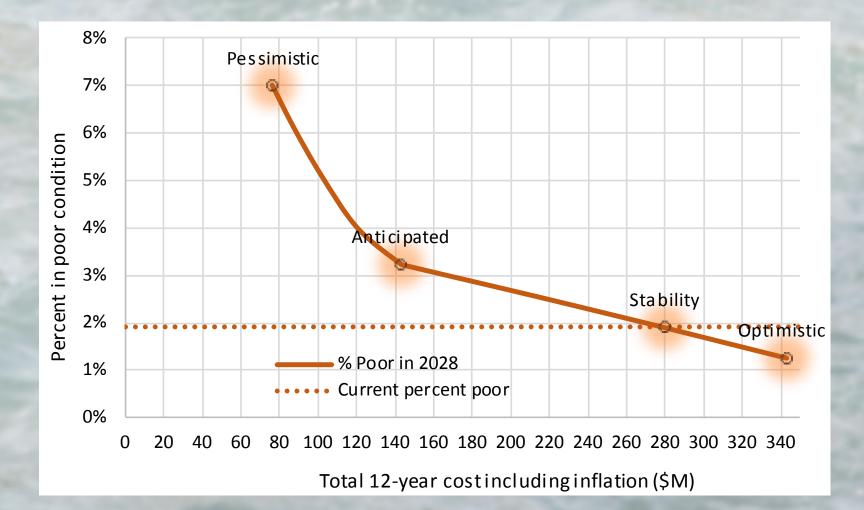
TRANSPORTATION FUNDING AN	ID PROG	DAM FOR	ECAST	in Million	40			
Tables Coulter 20, 201	-	1911	-	-		- 1	-	
1 Die Brook Comits/s Subse Toppes	-		_					
1 Sector for the state"	2.00	100	4.00	4.00	4.10	1.00	4.00	1.87
Contraction of the second seco			- 16	- 6	-	-	1	-
THE REPORT OF THE PARTY AND ADDRESS OF THE PARTY AND ADDRESS OF THE PARTY ADDRESS OF THE PART	- 1	, i	and a	1	1	1	-1	
11 STORE RELATIONATION AND A	1.50	1.91	1.00	1.50	1.12	1.50	19	1.50
1 be to a law boot a law boot a law and and the law of	-	211	-	-	-		-	
1 Top has not a set of a set of the	10		-	-	1418	-	10.00	100
 De Der Gersten Gerstelle Gerstelle Frank Der seine Bulleten gerstellten. Der Statigen Gerstellten Ge	- A.M.	1.00 2.00	104	1.00	1.5. 1.11	1.00	1.0	A.T.
A Day for the Besse Brid Schele	1.14	1.70	81.04	81,000	8,04	8, 80	81,987	8,79
The second secon	-16			- 42	- 2	- 2	12	- 14
A DECEMBER OF THE OWNER		- 14			_			-
The second secon	1	- 24		1.60		100		10
A DECEMBER OF A	1.00	8.75	1.10	1.15	1.1	1.0	1.4	0.00
[2] Sa Lid ha ad label house	100	8.78	81.10*	BLAR	61.00	8,81	86,000	\$5,000
A long has been as a long has been				-		_	-	_
C Visual Car The Sec.	_	-			-	-	-	_
To Same Line at Line and Same		_	_					
W Marine Long and LLN No. And Annual Street		_	_		_		_	_
A Decision Star Section Case						-	-	
* Idente attrate forme	1. A.	8.75	11.10	10.000	11.77	8,87	12.77	80,917
The state function of the second seco			-	-		-	-	
Traction and States and Single Tool		100		-	10,000	100	1.11	10.00
With Table Street Stree	32	20	100	20	-	223	- 21	- 2
a structure of the second s	-	- 25	- 2	20	1	2	22	- F.
Construction of the second secon	-		- D	- 11		- 11	- 17	- E
Contrast of the second se				ų,		17	- 84	
A Collector	-15	-15	- 12	- 10	15	100	-	-
	- 6	- 64	ę.	the second	the second	- 61	-6	- 6
·····································			-	- 8	- 8		- 21	- 2
Sandy Arthr. See	-11	1		-13	- 18	- 21	10	-21
A ID AN AN AN AND A DATE			-	-	-	100		-
C 2010/10/10/10/	100	- 12	1	1 A	- Party	10	虚	- 12
A Tochia have	10	10.	32.5	201	2.01	1.00	100	100
6 THE CR. LOW CO. NO. INC. INC. INC. INC. INC. INC.	40	-4			- Martin	-1	- House	
WEATHER FOR THE PARTY OF THE PA			de la constante	- 175	-		- 10+	
A CONTRACT OF A	- 5	- 21		- 11		ų	- 8	- 8
A BUCKET AND A THE AND A STREET		- 1	- 9	- 2	- 2	- 91	-3	- 2
A BOARD MAN AND AND AND AND AND	1	- ĉ	address of	1000	- 1	- 1	1	1
	- 21	- 1	- 1		ALC: N	4	- 1	
A DATE OF			- 5	- 21	- 5	- 51	-3	- 5
A Design of the second second	- 6	- 2	- 2	- 2	- 2	- 21	2	- 2
A DESCRIPTION OF AN ADDRESS OF A DESCRIPTION OF A DESCRIP	-16	18	100	10	101	10	100	100
A DESCRIPTION OF A DESC		- 10		- 10	-10	10	12	- 10
Lot in the owner of				- 90	-	- 20		
Contract of the second se			1	2	3	- 7	- 21	
A CONTRACTOR OF A CONTRACTOR OFTA CONTRACTOR O	- 1	1	- 2	-	-		1	-
a second s	-				- 6	- 12	1	
The second		-	100	-	111	110	100	1117
The party of the local data was a second to be a se	-	1 A	4144	100	atta Lan		- 41	4
State Statement		111	E Denie	1	-	-	4	-
		_	- 61	- 11			-	-
Test Bar Re Trans	Line .	100	100	100	10	ALC: NOT	ALC: N	E.E.
28 Log 2007 Constantion Programs		8.0		3001	1.00		34.75	
The second second second second	-	- 2	長	1	内内		10	10
The Distance of the local distance of the lo	-			The second	-	100	-	
CONTRACTOR OF THE PARTY NAMES AND ADDRESS OF	-		-			-		-
THE REAL PROPERTY AND ADDRESS OF THE OWNER OF THE PARTY AND ADDRESS OF THE PARTY AND ADDRESS OF THE PARTY ADDRESS	-	- 10	-	10	西日	10	费	唐
Share a start and the second start and the second	100	375	- 1871-	353	0	1975	85	85
A REAL PROPERTY OF A REAL PROPER			1	- N	- 24	- 10		X
A REAL PROPERTY AND A REAL	<i>ii</i>		-	-				
小学校の教育的などのないない	-	-	-			-		
The second		-	- 20,00	-	-		The state	- 10
No. 10 (2010)	-		india in		11		11 10	-
The stand of address of organ have be in ching in 118		-	17.	1	1.1	12	-	-
Provide No. 14 Marco Provide	_	_	-				1000	1000

Alternative fiscal scenarios

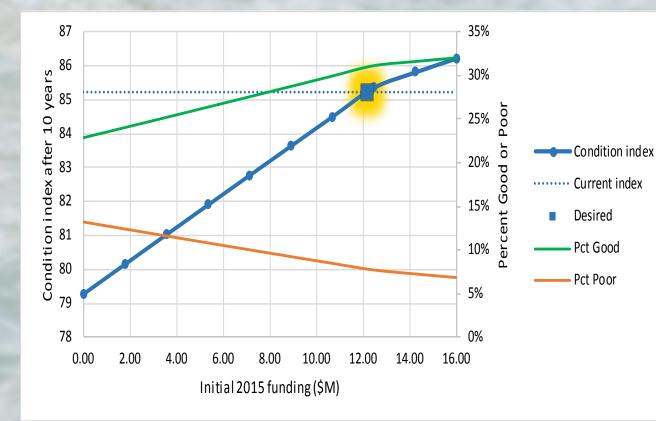
- For minimum scenario, we used either current funding or agency conservative forecast (for Ohio, \$351 million/year for bridges)
- For maximum scenario, we used a typical recapitalization rate
 - Recapitalization rate = annual expenditure ÷ replacement cost
 - Both in current dollars, assuming no backlog and optimal preservation
 - Includes replacement in-kind and all indirect costs
 - Typically 0.5% to 1.5% depending on climate
- For ODOT on-system bridges this works out to \$424.5M for the maximum scenario



Funding vs condition – bridge example



Funding vs condition - slopes



This works for many asset classes:

- Pavements & bridges
- Culverts
- Geotechnical slopes, embankments, walls
- Signals and ITS
- Signs
- Sidewalks, bikeways

Conclusions

- Simplified spreadsheet methods can help you get started with analysis
- Not a substitute for good systems in the long run
- Can help you prioritize system improvements

Conclusions

All models are wrong; Some models are useful

Thank you!