



# Saving Money and Reducing Environmental Impact Through Innovation: The Illinois Tollway Story

William R. Vavrik, Ph.D., P.E.  
Vice President & Principal Engineer

WAPA's 58th Annual Conference  
and Business Meeting

© 2017 Applied Research Associates, Inc. ARA Proprietary



NATIONAL SECURITY



ENERGY & ENVIRONMENT



INFRASTRUCTURE



HEALTH SOLUTIONS

# Illinois Tollway System

- 286-mile system comprised of four Tollways
  - Tri-State (I-94/I-294/I-80)
  - Jane Addams Memorial (I-90)
  - Reagan Memorial (I-88)
  - Veterans Memorial (I-355)
- Opened in 1958 as a bypass around Chicago to connect Indiana and Wisconsin
- Carries more than 1.4 million vehicles per day
- User-fee system – no state or federal gas tax dollars used for maintenance and operations



# TR NEWS

## Freight Planning

*Innovations, Scenarios,  
and Environmental Justice*

*Plus:*

**Safety Culture Lessons from  
the Offshore Oil Industry**

**Mileage-Based User Fees:  
What Does the Public Think?**

**Driverless Cars: The Need  
for Interdisciplinary Research**



## Implementing Sustainability Research Saves Illinois Tollway More Than \$200 Million

STEVEN GILLEN

The author is Deputy Program Manager of Materials, Illinois State Toll Highway Authority, Downs, Ill.

The Illinois Tollway has steadily increased the implementation of research findings over the past 12 years, producing new standards and policies for pavements, materials, and recycling. The tollway recently reviewed the documentation of construction costs and found that the adoption of more innovative and sustainable material specifications saved an estimated \$218.5 million between 2008 and the start of 2016. Normalized to 2013 dollar values, the cost savings demonstrate that sustainable recycling of aggregates, asphalt, and concrete materials have yielded substantial economic benefits, in addition to environmental and social benefits.

### Aggregates

In 2004, approximately \$4 billion of an \$18-billion, 25-year capital program were allocated to reconstruct and expand much of the Illinois Tollway (see Figure 1, below). Before then, the tollway did not use one of

FIGURE 1 Illinois Tollway system map.



### Asphalt

After realizing the economic benefits of adopting new materials for recycling or improving sustainability through aggregate production, the Illinois Tollway began investigating how similar savings could be achieved with more sustainable asphalt materials without sacrificing performance or durability. Through several recycling engine contracts, starting in 2006, researchers performed tests and reported the results. These activities resulted into an Illinois Tollway-sponsored research program in 2008, which established direct agreements with university research teams to produce formal studies (2).

### Good Tire Rubber—Modified Asphalt Binder

In 2008, the Illinois Tollway joint's task force initiated by the Cook County Highway Department to field-test high-performance stone matrix asphalt (HMA) mixes with asphalt binder modified at the asphalt plant to include recycled scrap tires at up to 32 percent of the mix. The mix samples were evaluated for long-term performance.

Results showed that the expected life of HMA mixes modified with good-tire rubber (GTR) would be equivalent to that of the standard polymer-modified HMA mixes used by the Illinois Department of

Transportation (DOT). Moreover, the mixes could be produced without the cellulose fibers needed to mix water the driveways or surface finishing of asphalt bound. Santral Corporation of the University of Illinois performed the informal research work.

GTR-modified SMA mixes save an estimated \$120 per ton by eliminating the need for fiber reinforcement. This equates to a savings of \$2.1 million for the 500,000 tons of SMA the Illinois Tollway produced from 2008 to 2014. The two choices for modified asphalt in SMA mixes allow for more compressive loading on the Illinois Tollway's SMA overlay projects and may reduce bid prices while maintaining production quality.

### Fractured-Reinforced Asphalt Pavement

The Illinois Tollway began investigating fractured reinforced asphalt pavement (FRAP) through research at the University of Illinois in 2007. Researchers found that asphalt mixes could contain an amount of 15 percent more RAP with fracture-tolerant and that the pavement could have the same high performance as RAP mixes used by the tollway and by Illinois DOT (3). The increased FRAP reduced the costs of the asphalt mixes by \$10 to \$15 per ton.

A reconstruction and widening project placed approximately 800,000 tons of high-FRAP asphalt mixes on the Jere Alderman Memorial Tollway (I-55-I-55) in 2008 and 2009, with an estimated

cost savings of \$10 million. These levels of savings have continued after implementing higher quantities of FRAP.

### Recycle Asphalt Shingles

In 2009, with the help of a grant from the U.S. Environmental Protection Agency, the Illinois Tollway teamed with Iowa State University and the University of Illinois to study the combination of recycled asphalt shingles (RAS) with high-FRAP to shoulder mixes (4). The up to 3 percent RAS allowable in asphalt mixes can reduce the need for virgin asphalt binder by approximately 20 percent.

The same year, a project placed polymer-modified SMA mixes that used RAS as a filler substitute on I-55 and I-55, and the University of Illinois conducted pavement tests on the pavement (5). In 2010, the University of Illinois studied SMA mixes installed with increased FRAP and RAS content and with high levels of asphalt binder replacement, using a variety of waste-free asphalt processes. The results from all studies confirmed the long-term durability of asphalt mixes with properly processed RAS (6).

The Illinois Tollway now permits RAS in all asphalt mixes at levels up to 3 percent. The savings with RAS depend on the asphalt mix but are estimated at \$5 to \$15 per ton. Approximately 2.6 million tons of asphalt mixes with RAS were produced in 2010 and 2013, yielding a savings of around \$2 million.



of Illinois recently completed a field test on samples of rigid SMA overlay mixes. The findings consist of asphalt binder replacement with high-performance SMA mixes along with the by-product mass processed (7).

High-level asphalt binder substitutes, or increased the use of recycled or the use of liquid asphalt, voided the trial success in all asphalt mix combinations tested. These

findings may change needed to save dollars for the tollway from 2007.

The second Strategic Highway

produced needs and technologies research systems (8). Building on work at the University of Illinois, developed specifications for concrete pavement to include the mix with higher levels of recycled alternative construction materials mixes (9, 10). The two-lane paved road (I-PC) on I-55 reduced cost \$5 compared with prices for other mixes that used I-PC. The estimated cost of I-PC would save nearly \$1 million in 2013 and 2014 was approximately \$1 million.

Additional research through the National Center for Sustainable Infrastructure (NCSI) Group led to increasing the research work optimized aggregate use improved the sustainability of standard pavements designs and costs. For the 841,205 square yards built on I-55 in 2013, the tollway savings of approximately \$4 million materials and labor.

### DOT

Industry research was practice, the tollway more than \$200 million per year (Table 1, above right) and methods of millions of dollars more, to include waste-free asphalt for asphalt mixes, the development of new concrete pavements and asphalt concrete paving mixes, of the design for continuously reinforced, and the development of

new, for accelerated bridge construction. These activities do not have large up-front

TABLE 1 Estimated Cost Savings, by Materials

Applications	Years	Total Cost Savings
Aggregates	2008-2016	\$118,000,000
Asphalt	2007-2011	\$74,000,000
Concrete	2010-2016	\$11,500,000
Total approximate savings		\$218,500,000

cost savings have an expected to yield substantial life-cycle savings by reducing maintenance needs and extending the service life of bridges and pavements.

For more information, contact Steven Gillen, Illinois State Toll Highway Authority, 2707 Ogden Avenue, Downs, Ill., 62423, 618-242-6883, gillen@stha.com.

### References

1. Recycling Concrete Aggregate, Recycled Concrete, Recycled Asphalt, Recycled, Illinois, 2010.
2. Construction and Engineering Partners. Roadway Design and High Input Materials. Illinois Tollway. <http://www.illinois-tollway.com/using/buyers-guide/construction-engineering/using-recycled-aggregate>. Accessed 10/22/13, 12:00 PM.
3. Werth, W. R., A. H. Caperton, S. Gillen, J. DeRube, and J. Carter. Evaluation of Field Produced Recycled Asphalt (RMA) Mixtures with Fractured Reinforced Asphalt Pavement (FRAP). 2008.
4. Williams, R. C., A. Caperton, D. S. Bauman, W. G. Farber, R. A. Brown, and J. DeRube. Characterization of High-Matrix Asphalt Containing Recycled Asphalt Shingles and Fractured Reinforced Asphalt Pavement. 2011.
5. Werth, W. R., S. Gillen, D. S. Bauman, J. DeRube, J. Carter, and A. H. Caperton. Evaluation of HMA Shoulder with Recycled Asphalt Shingle (RAS) Mixtures. 2010.
6. Al-Jabri, L. L., L. S. Liu, Z. Long, H. Wang, M. Stevens, J. Kim, and S. Gillen. Short-Term Performance of Modified Stone Matrix Asphalt (SMA) Produced with Waste Mix Asphalt. 2012.
7. Butler, W. G., and H. Wang. Laboratory Investigation of Stone Matrix Asphalt Mixtures with Recycled Asphalt Shingles. Illinois Tollway Authority, 2013.
8. Bao, S., M. O'Brien, D. S. Bauman, M. Stevens, L. Ruzarski, J. Spitzer, E. Clark, R. Wu, J. Harbo, and J. Netherstrom. Concrete Pavement Issues. Volume 2: RCPCC. Computer Research, NCHRP 2 Report 20-2(2)-2013. Transportation Research Board of the National Academies, Washington, D.C., 2013. <http://www.trb.org/Main/Reports/Papers/2013.aspx>.
9. Sand, A. S., J. B. Bostick, L. L. Al-Jabri, and P. Hangan. Fractured Reinforced Asphalt Pavement (FRAP) as a Concrete Aggregate Replacement in a Heavy Reinforced Concrete Pavement. 2011.
10. Sand, A. S., A. W. Amundson, and J. B. Bostick. Field Capacity of High Performance Concrete Slabs with Recycled Aggregate. 2013.

TERRON'S NEWS: Aggregates is sponsored by Nancy M. Whiting, Transportation Research Board, for her efforts in developing this article.

Suggestions for Research Pays Off papers are welcome. Contact Stephen Maltes, Transportation Research Board, Room 466, 500 Fifth Street, SW, Washington, DC 20001, 202-334-3393, smaltes@trb.com.



## Implementing Sustainability Research Saves Illinois Tollway More Than \$200 Million

STEVEN GILLEN

The Illinois Tollway has recently increased the implementation of research findings on the

use of recycled aggregates, although other agencies had developed

Transportation (DOT) Materials, the mixes could be produced without the additional flows needed to mix water the downflow or surface flooding of asphalt based. Several Corporates of the University of Illinois performed the relevant research work.

GTR modified SMA mixes cost an estimated \$120 per ton by eliminating the need for fiber reinforcement. This equates to a savings of \$2.2 million for the 180,000 tons of SMA the Illinois Tollway

cost savings of \$20 million. These levels of savings have continued after implementing higher quantities of DRAP.

### Recycled Asphalt Shingles

In 2009, with the help of a grant from the U.S. Environmental Protection Agency, the Illinois Tollway teamed with Iowa State University and the University of Illinois to study the reuse of recycled asphalt

of Illinois recently completed a field scale analysis of aged SMA mixtures. The findings con-

TABLE 1 Estimated Cost Savings, by Materials

Applications	Years	Total Cost Savings
Aggregate	2004-2010	\$113,000,000
Asphalt	2004-2010	\$87,000,000

RESEARCH PAYS OFF



# Implementing Sustainability Research Saves Illinois Tollway More Than \$200 Million

up to 12 percent of the mix. The mix samples were evaluated for long-term performance.

Results showed that the expected life of SMA mixes modified with ground tire rubber (GTR) would be equivalent to that of the standard polymer-modified SMA mixes used by the Illinois Department of



highways of approximately 30 and 40-year-old mixtures.

Illinois Tollway research was practice, the research saved more than \$200 million on just one lane (see Table 1, above right) and methods of millions of dollars more.

It includes water mix asphalt for asphalt pavements, the development of porous concrete pavements and other high-strength paving materials, all the design for continuously reinforced concrete, and the development of

concrete for accelerated bridge construction. These innovations do not have large up-front

Illinois Tollway Research Department, 2011; Gillen, S., M. S. Gillen, D. S. Gillen, M. S. Gillen, L. K. Gillen, J. Gillen, F. Gillen, R. Gillen, J. Gillen, and J. Gillen. "Concrete Pavement Systems: A Review of R.C.C., Concrete Pavement, W.P.P. C. Report 2002-2011." Transportation Research Board of the National Academies, Washington, D.C., 2011. <http://www.nhtsa.gov/ncfrts/2011/11-11-11>

10. Gillen, S. S., J. S. Gillen, L. S. Gillen, and J. S. Gillen. "Pavement Research Asphalt Research (PRAR) as a Case Study." Transportation Research Board of the National Academies, Washington, D.C., 2011. <http://www.nhtsa.gov/ncfrts/2011/11-11-11>

11. Gillen, S. S., J. S. Gillen, L. S. Gillen, and J. S. Gillen. "Capacity of High Performance Concrete Slabs with Recycled Aggregate." 2011.

Terrace News: Aggregates is sponsored by Nancy M. Whiting Transportation Research Board, for her efforts in developing this article.

Suggestions for Research Pays Off topics are welcome. Contact Stephen Malzer, Transportation Research Board, Room 406, 500 Park Street, SW, Washington, DC 20004, 202-334-3393; [smalzer@trb.com](mailto:smalzer@trb.com)

# Aggregate Initiatives in Recycling

**Cost savings started from the bottom up using established methods of recycling**

- Existing aggregate subbases re-used
- Existing concrete recycled by rubblization
- Existing concrete recycled as new porous base
- Existing asphalt recycled for many applications



# Research opened the door or the Tollway to reach sustainability goals

## Pavement initiatives started with asphalt

- Ground tire rubber mixes tested and analyzed
- Hot & warm asphalt mixes with varied levels of FRAP produced & tested for performance
- Roof shingle and high FRAP mixes studied
- Early age rutting potential of high ABR SMA mixes with various warm mix processes studied
- In place SMA surface mixes with low, medium, and high ABR content studied to show performance being maintained.

# Asphalt Research Continues

- Other options for ground tire rubber modifications being explored
- Research to find the best lab test methods to use with performance based specifications for asphalt mix designs





# Summary of Asphalt Mix Savings

- Higher levels of FRAP reduces virgin aggregate needs and liquid asphalt quantities
- Option for grounded tire rubber modified asphalt in high performance SMA mixes eliminated the need for fiber reinforcement in the mixes and competes with SBS modifiers to reduce prices further
- Use of RAS allowed for asphalt binder replacement (ABR) levels to go higher and reduced need for fibers in SMA
- Total savings since these initiatives were introduced in 2006 has saved the Tollway approximately \$74,000,000

# Concrete also included...

- NCHRP study on quietest pavement textures
- Development of specs for performance engineered concrete mixes for patching, HPC decks, & new pavements, most all designs fully optimized and ternary
- SHRP2 R05 project on precast pavements
- SHRP2 R21 project on composite pavements
- U of I evaluation of black rock concrete mixes for composite pavements
- Performance related specifications for concrete pavement construction developed and implemented

# Design practices contribute

**Jointed concrete built on asphalt base with asphalt shoulders.**

**Pavement ME to optimize designs for actual conditions and expected future traffic**

# Savings through 2015

## Savings indirectly related to research by others

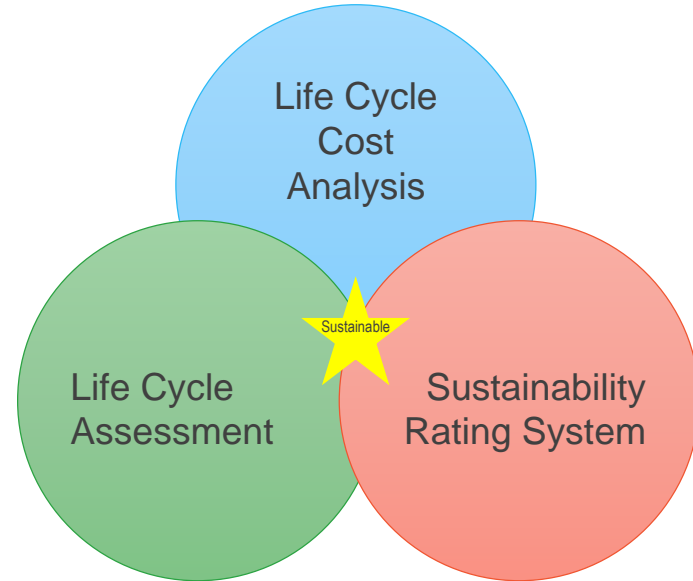
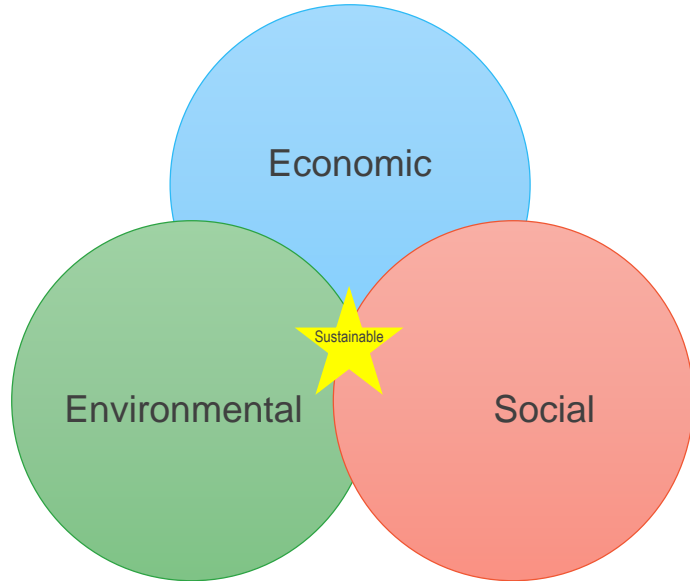
- Aggregate related initiatives - \$113,000,000
- Pavement design initiatives - \$29,000,000

## Savings directly related to recent Tollway research

- Asphalt related initiatives - \$74,000,000
- Concrete related initiatives - \$31,500,000

**Total estimated savings = \$247,500,000**

# Goal is to be sustainable



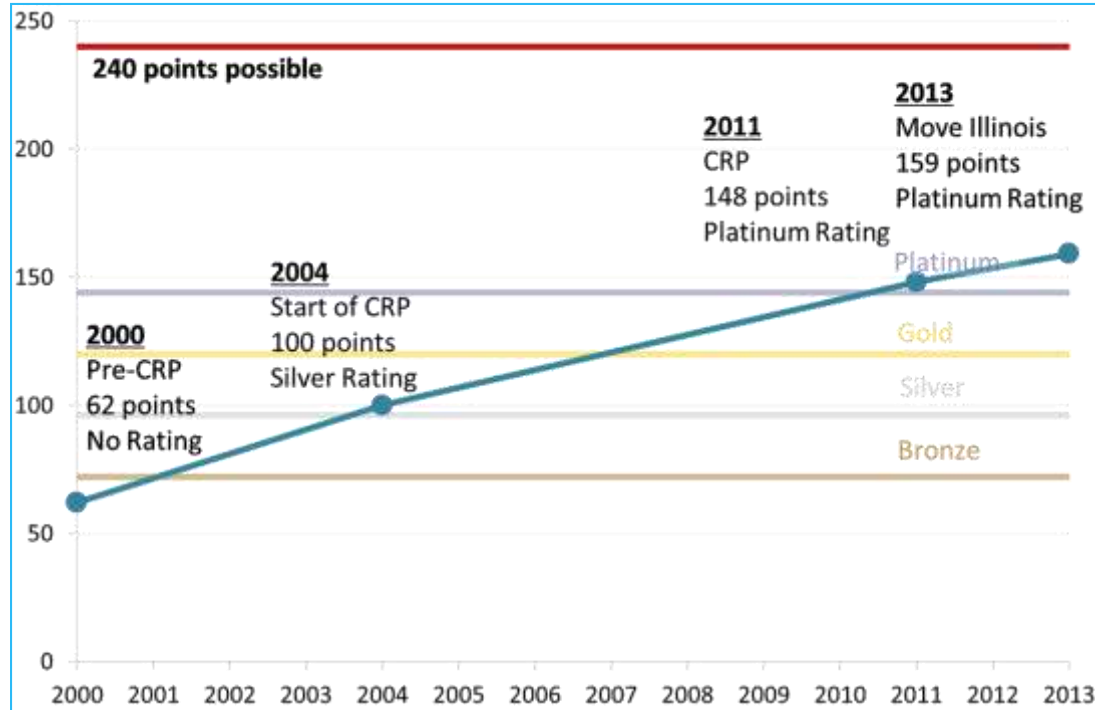
# Rating system for qualitative measurement



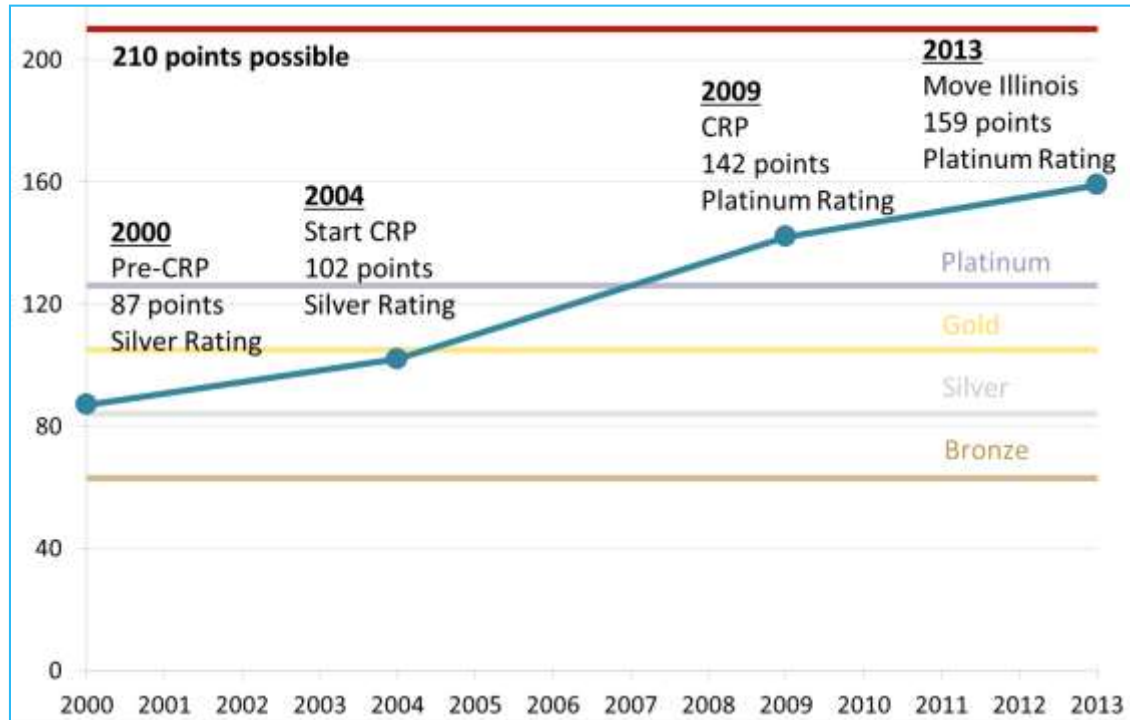
*Infrastructure Voluntary Evaluation Sustainability Tool (INVEST)*

[www.sustainablehighways.org](http://www.sustainablehighways.org)

# System Planning Scores



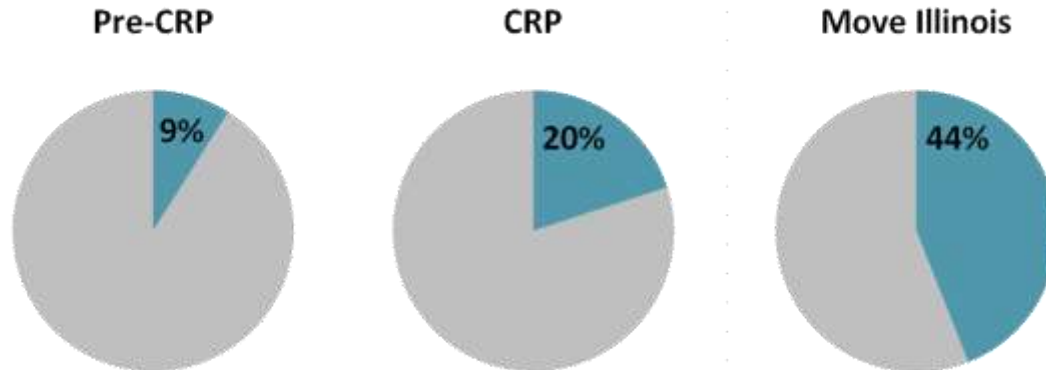
# Operations and Maintenance Scores





# Project Development Scores

Capital Program	Number of Projects Scored	Avg. % Total Points Achieved per Project
Pre-CRP	1	9%
CRP	21	20%
<i>Move Illinois</i>	15	44%



# LCA is next step

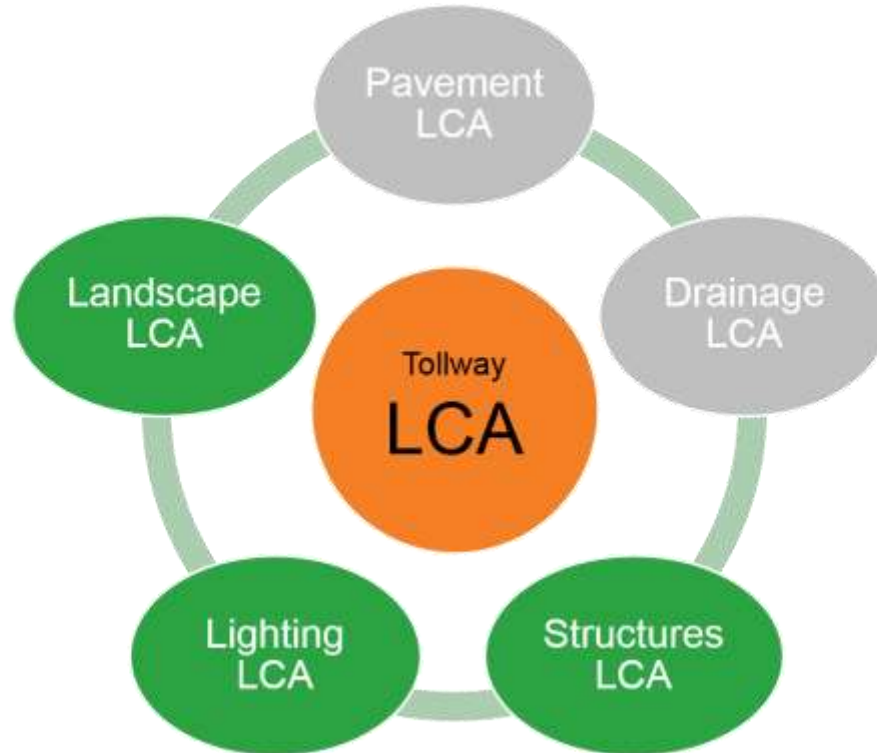
## Why must we quantify?

### If it is not quantified, it is not valued

- Without value, it won't get done
- Without value, it cannot be improved upon
- Without value, there is no incentive



# Tollway LCA is full roadway system



# Soon we will be showing environmental improvements

## 2000 Mixes

- No recycle content
- SBS-modified binder

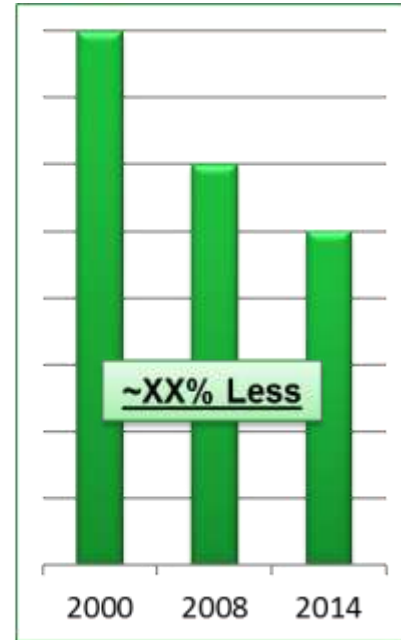
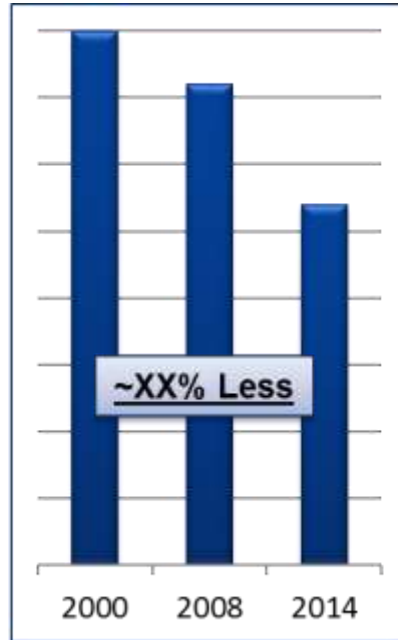
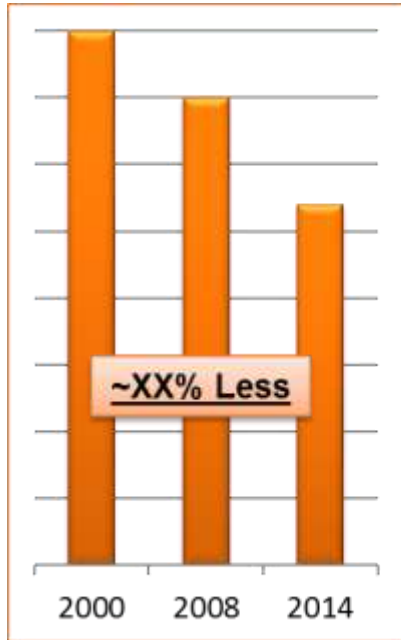
## 2008 Mixes (as constructed)

- SMA surface and binder for mainline
- ABR content ranging from 15 to 47 percent
- GTR binder

## 2014 Mixes (similar projects)

- Warm-Mix Asphalt (WMA)
- ABR content ranging from 24 to 53 percent
- Includes RAS

# Expecting remarkable results



# In summary...

**Research leads to innovation...**

**Innovation facilitates doing more with less**

**Measurement allows good management**

**Managing facilitates sustainable success**

# Questions



**Bill Vavrik**, Ph.D., P.E.

V.P. – Transportation

Office: 217.356.4500

Cell: 217.778.0041

[wwavrik@ara.com](mailto:wwavrik@ara.com)

