IHRB TR-729

GRAMS

Granular Road Asset Management System

for Iowa County Engineers

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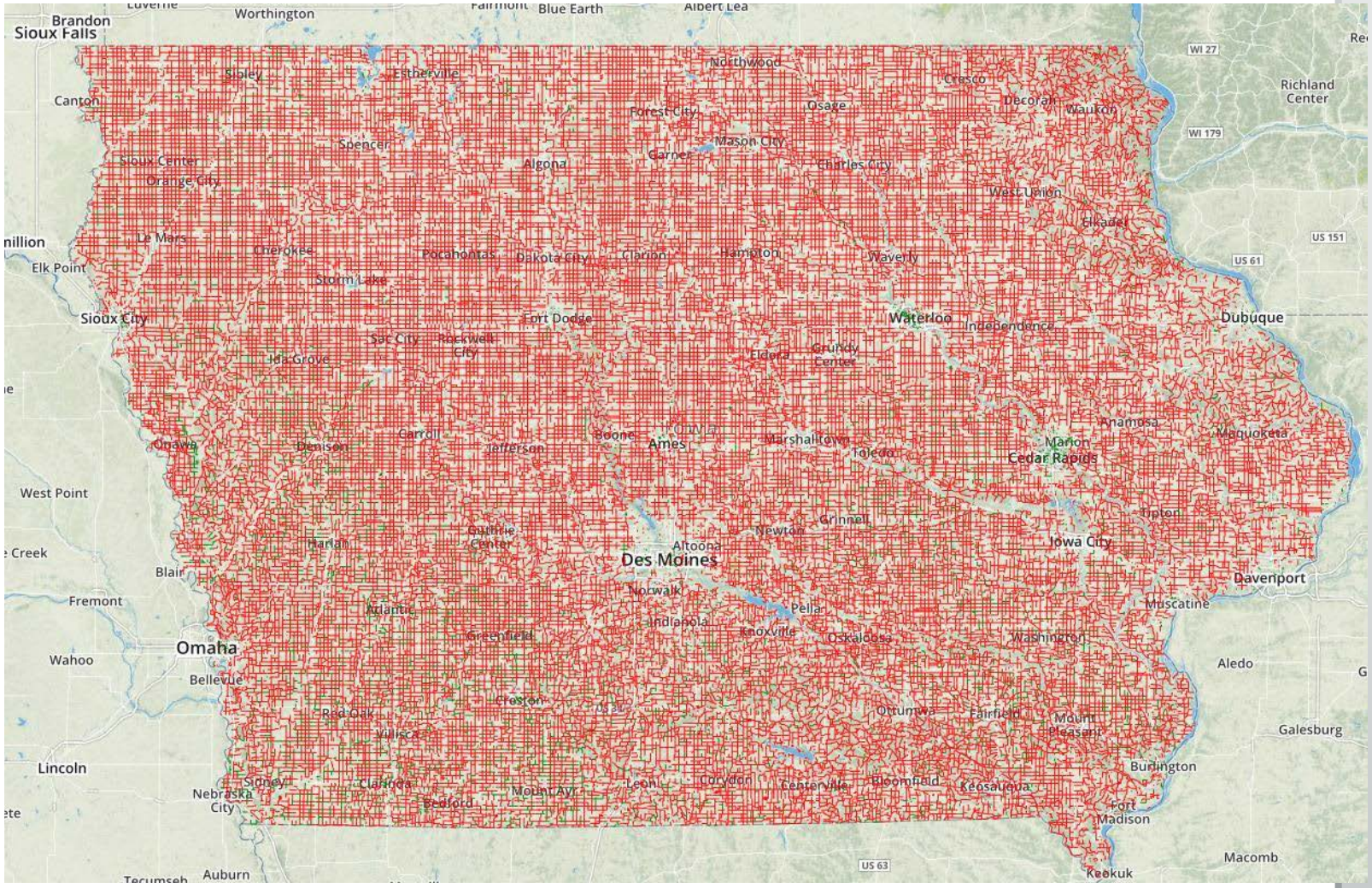
Iowa **Granular** Roads

- 60% of Iowa miles
- 66,243 miles
- $270 million/year

Contribution to:

- Economy:
  - 1st nationally in Pork, soybeans, corn (2.5 Billion bushels), & eggs
  - Renewable energy – 1st Ethanol, 3rd Wind, & 2nd biodiesel

- Use:
  - 2.96 M VMT/day
  - 119 times around earth
  - Over 6 times to moon & back
  - Not Insignificant



Previous IHRB Projects

- MLR-9007 – Crushed Stone Granular Surfacing Materials (1990)
- TR-632 – Low-Cost Rural Surface Alternatives: Phase I (2013)
- TR-664 – Low-Cost Rural Surface Alternatives: Demonstration Project, Phase II (2015)

Ongoing IHRB Projects

- TR-721 - Low-Cost Rural Surface Alternatives: Demonstration Project, Phase III (Treatments)
- TR-725 - Low-Cost Rural Surface Alternatives: Phase IV, Frost Depth Monitoring & Prediction
- TR-685 – Feasibility of Gravel Road and Shoulder Recycling (Gradations)
- TR-704 - Performance Based Evaluation of Cost Effective Aggregate Options (Quality & Econ)

Granular Roads Asset Management System (GRAMS)

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Project IHRB-TR 729

TAC Members

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- John Riherd, Butler County
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- Brad Skinner, Montgomery County
- Mark Nahra, Woodbury County
- Eric Cowles, Iowa DOT, Secondary Roads Engineer

National Efforts

- Other States: Wyoming, Utah, Michigan, South Dakota, & New Hampshire
  - Various methods of granular asset management or Best Management Practices
  - Data-Driven condition evaluation or Manuals
- Canada : Forest Engineering Research Institute
  - Condition based management

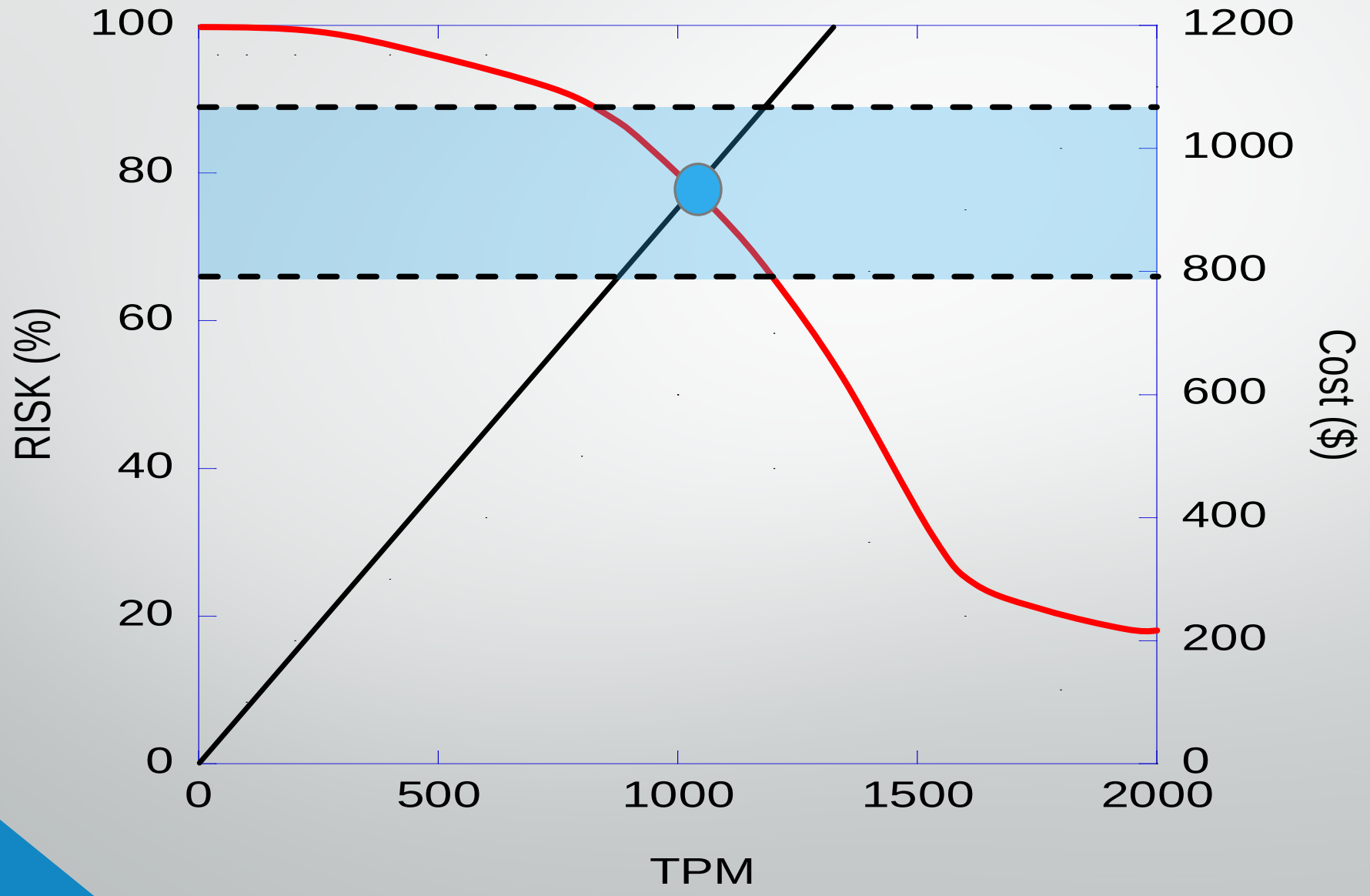
Objectives of the GRAMS effort

- Develop a user friendly Systemic Risk-Based Asset Management Tool to:
  - Tell the story
    - To identify new ways communicate the dynamics and needs of granular surfaced roads to the public and elected officials.
  - Perform technical analysis
    - Seeking to employ numeric modelling in a meaningful way.
  - Support decisions
    - Exploring to see if decisions can move from rule-of-thumb to evaluation of objective criteria.
  - Seek optimum
    - To explore whether or not one can build a model and use it to find the 'optimal' granular surfacing strategy for any given county.

GRAMS Concepts

1. Two structural components
   - Granular Surfacing – Effective "crust" Index or Rock-In-Service (RIS)
     - Gradation – Compactability
     - Material Quality – Type, hardness durability, plasticity
     - Physical conditions – width, crown, drainage, traffic, material loss, thickness
   - Subgrade – Wide range of embankment soils - many undesirable or unsuitable
     - Soil characteristics, drainage, freeze-thaw, seasonal variations
     - Likelihood of wet and weak subgrade conditions

Preliminary GRAMS Tool



GRAMS Concepts – Systemic Approach

1. Material Losses – MLR-9007 Crushed Stone Granular Surfacing Materials (1990)
   - Dust – 100 tons per 100 AADT / mile / year
   - Roll off – Vehicles and Blading – 15 tons per 100 AADT / mile / year
   - Water Runoff – variable amounts

2. Annual replacement is needed to sustain the system:
   - But, How much? Where? and How does it perform?

MLR-9007
Crushed Stone
Granular Surfacing
Material (1990)

Premise

- Develop a probabilistic model to predict system-wide risks and granular needs in TPM to manage the risk
  - Amount of Rock-In-Service (RIS) in the roadway crust, in Tons/Mile (TPM)
  - Reliability of roadway vs. its RIS level
    - Reliability = % chance of good performance under adverse subgrade conditions
    - Risk = % chance of impaired roadway use at times of weak subgrade conditions
- Premise: For any given effective TPM, there is a matching maximum risk of roadway failure during a freeze/thaw and high precipitation periods → Road Agency need to balance acceptable risk vs. budget needs

  and they can
- Implement a matching resurfacing program to optimize expected outcomes.

RIS* – or 'how thick is the crust'

Miles of granular surfaced road:		**473.754**	**miles**	**24.1**	**Avg. width**
Rock density (worked into grade)		**115**	← lbs/cf		
TPM for 1 in x 24 ft wide x 1 mile:		**607**	Tons/mile	**609**	TPM @ average width

	Scenario 1			Scenario 2		
A C T U A L	**Top condition achieved currently**	**[Actual]**	A C T U A L	**Lowest condition level to which roads are allowed to reach**	**[Actual]**	A C T U A L
	Layer	**Pct rock**		**Layer**	**Pct rock**	
	Top inch	**75%**	←	Top inch	**45%**	←
	2nd inch	**55%**	←	2nd inch	**15%**	←
	3rd inch	**20%**	←	3rd inch	**10%**	←
	4th inch	**10%**	←	4th inch	**4%**	←
	5th inch	**0%**	←	5th inch	**0%**	←
	6th inch	**0%**	←	6th inch	**0%**	←
	Equivalent inches of granular	1.60		**Equivalent inches of granular**	0.74	
	TPM @ 24 ft	971		**TPM @ 24 ft**	449	
	TPM @ avg width	**974**		**TPM @ avg width**	**450**	

Need to know (as best as one can) how many tons of granular are "in service"

TR-685
TR-704
Gradations and Aggregate Quality

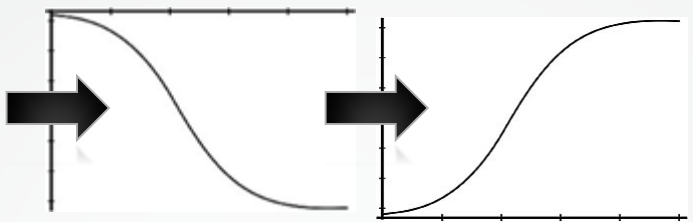
"*ROCK IN SERVICE" -- in Tons per Mile

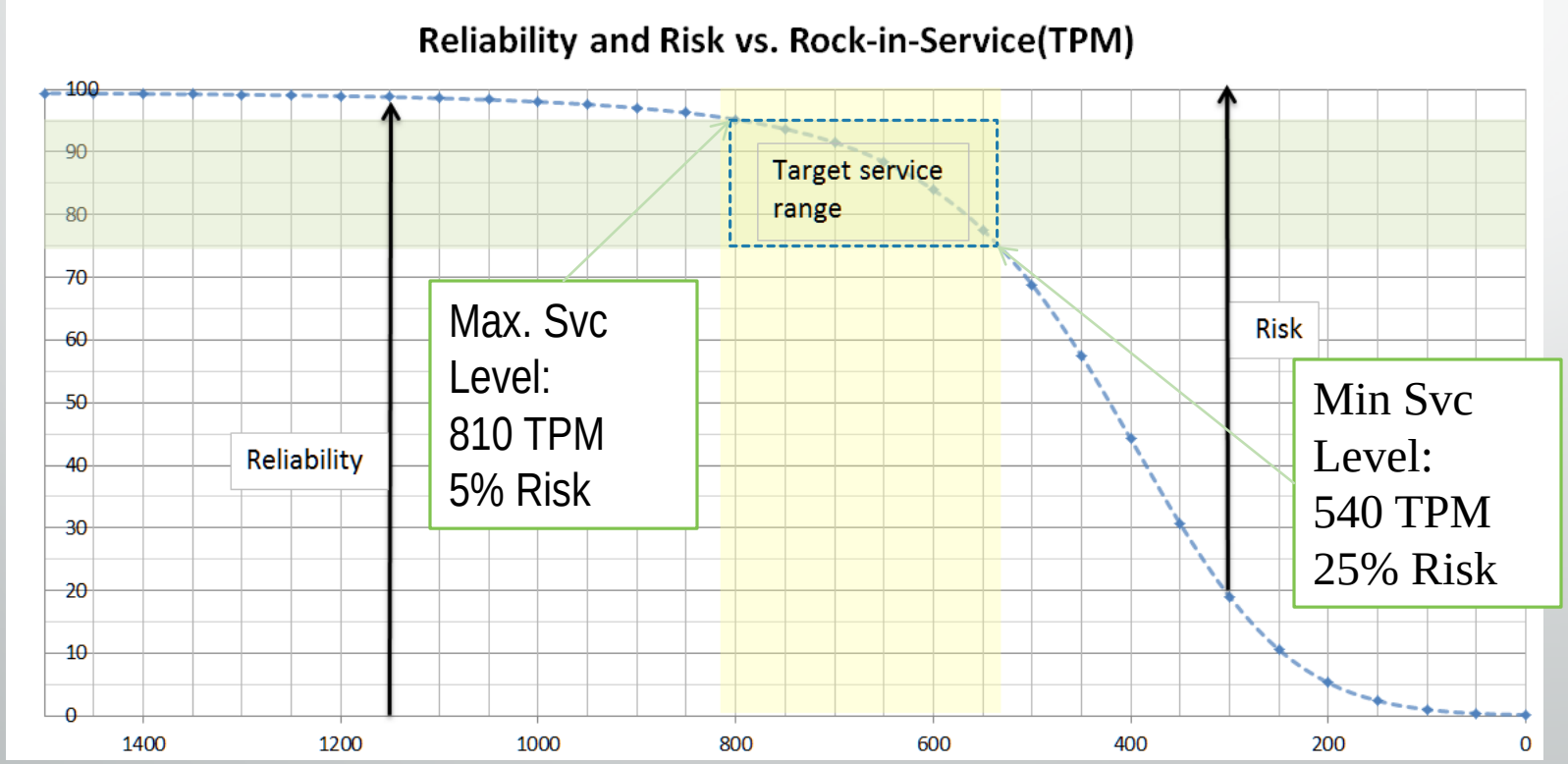
Method for estimation of RIS

Reliability vs. crust RIS

Service quality vs. quantity

Tune a 'logistics' curve to model the relationship between RIS(TPM) and Reliability/Risk of the system. Similar to pavement deterioration curve.

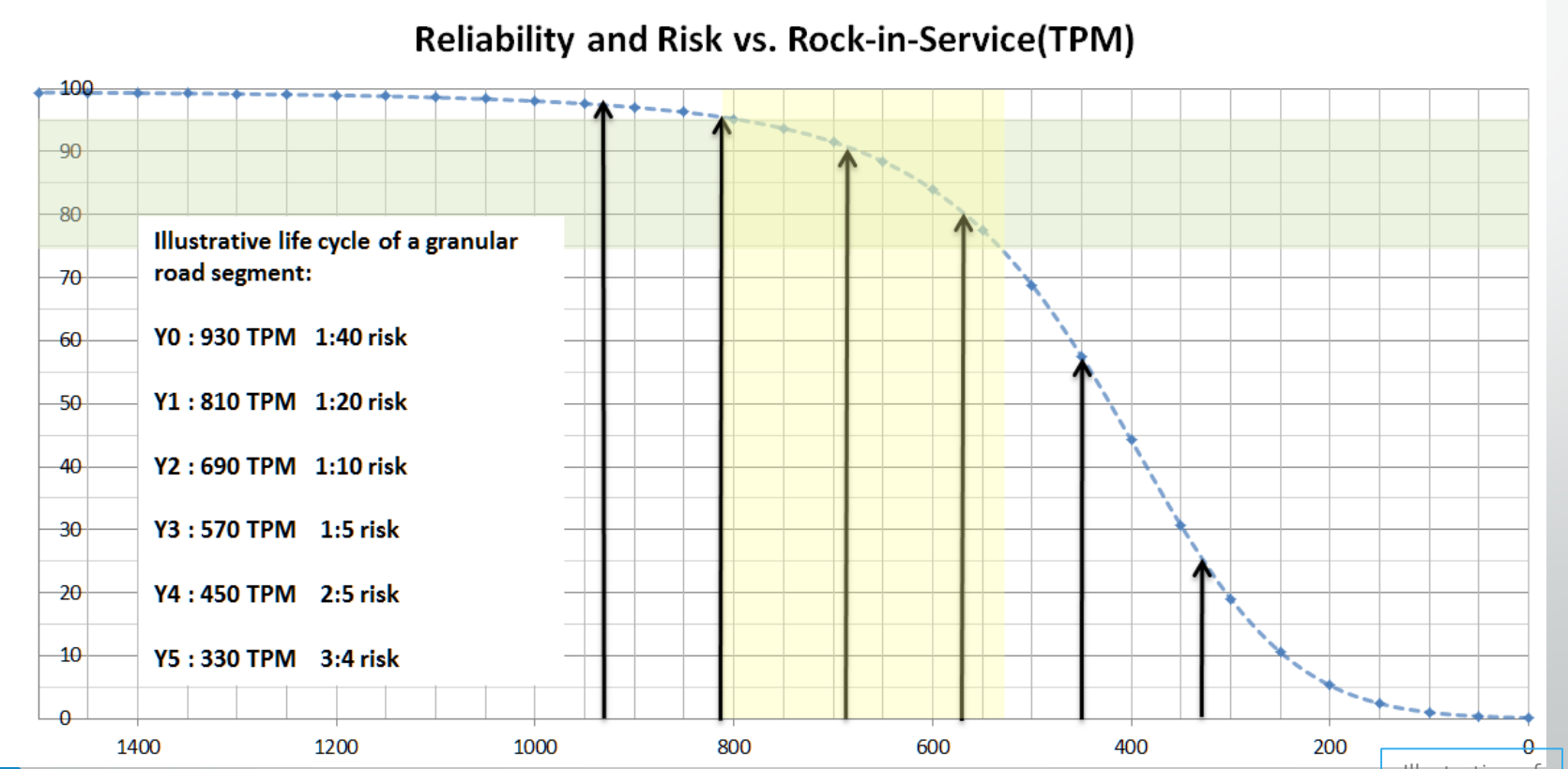




"Maximum risk of road impairment during a period of subgrade weakness."

Single roadway over time

- Risk, although small at first, grows exponentially as the tons per mile of Rock-in-Service declines



Y0 Y1 Y2 Y3 Y4 Y5

Illustration of life cycle

TR-664
TR-721
Granular
Surfacing
Stabilizing
Treatments

Condition of the system

- System status is a composite of the individual statuses of all the encompassed road segments. (∑ mi x risk)/Total miles

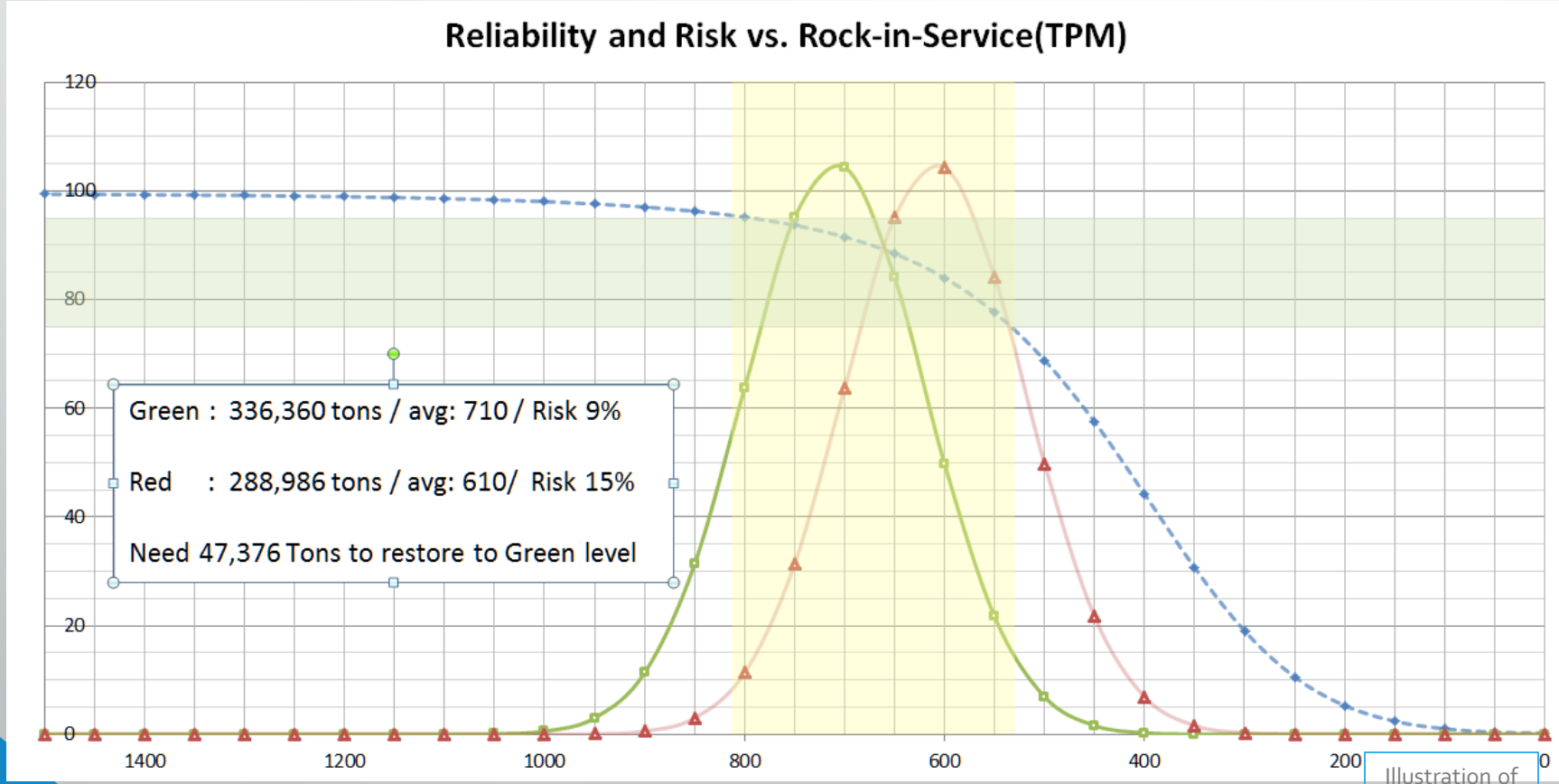
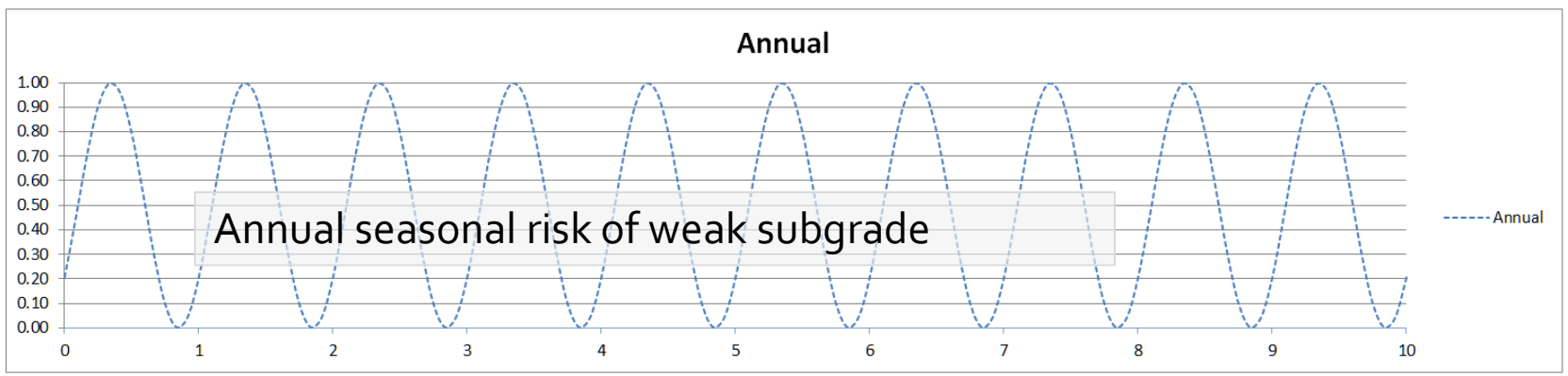
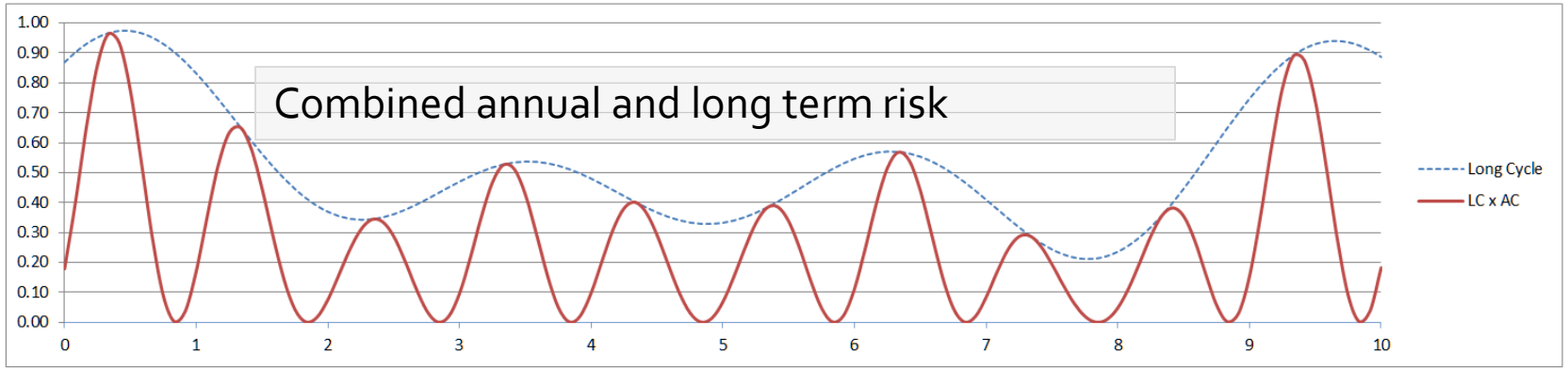
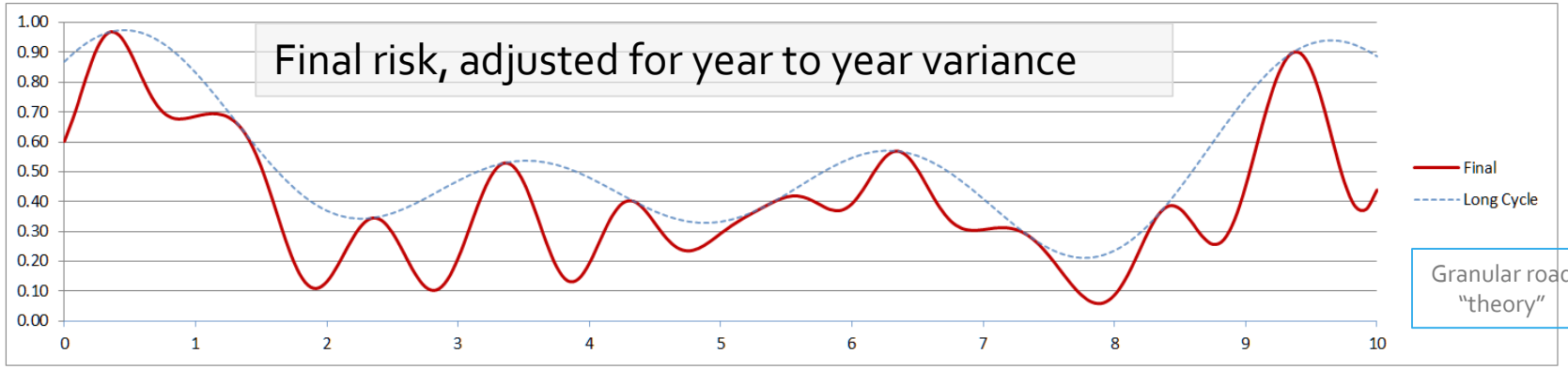


Illustration of rock vs. risk

Sample wave patterns over time



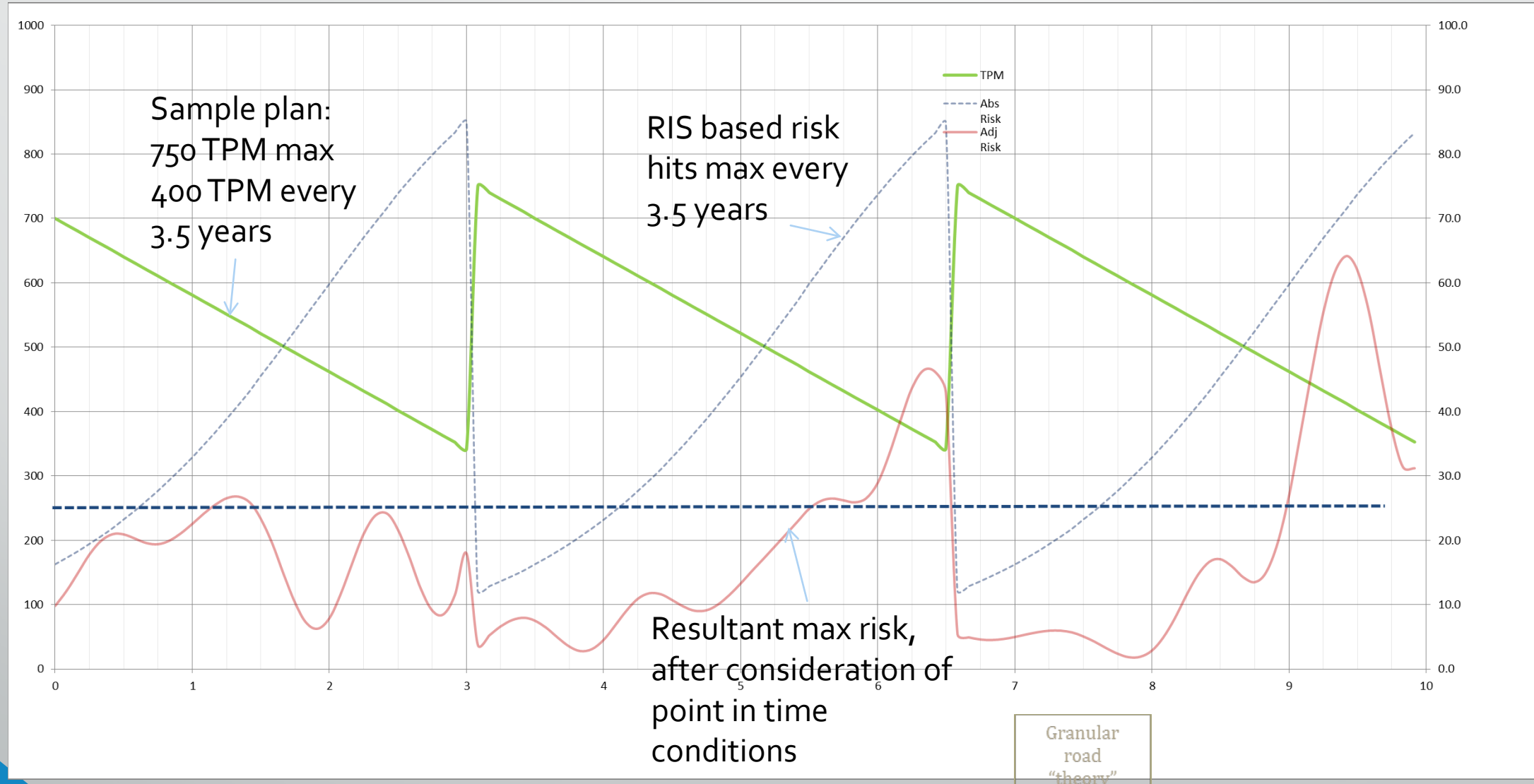




Granular road "theory"

TR-725
Frost Prediction
Model

Single roadway dynamics



Granular road "theory"

System level optimization

- Criteria
  - Minimize the maximum risk
  - Minimize length of time that risk exceeds target threshold
  - Set risk allowances to fit traffic levels
    - Perhaps a different TPM target for low, medium, high AADT
- Tradeoff between cost and achievement
  - More 'rock-in-service' equals less risk – up to a point
  - More RIS requires a higher total investment in material
  - Budget limits may require prioritization

Granular road "theory"

Sample of possible summary sheet

GRANULAR ROAD SNAPSHOT: **Average County, Iowa (0)** May 6, 2015

Basics 1

System overview

System size	718.575	miles
Average width	24.3	ft
Average traffic level	45	VPD
Total travel carried	32575	Miles/day

High/Low maintenance and risk levels

Range	TPM	Thickness	Risk Lvl
Max	1050	1.65 in.	1:33
Avg	795	1.25 in.	1:10
Min	540	0.85 in.	1:2

Average crown : 3.4% - vs. 4% optimal

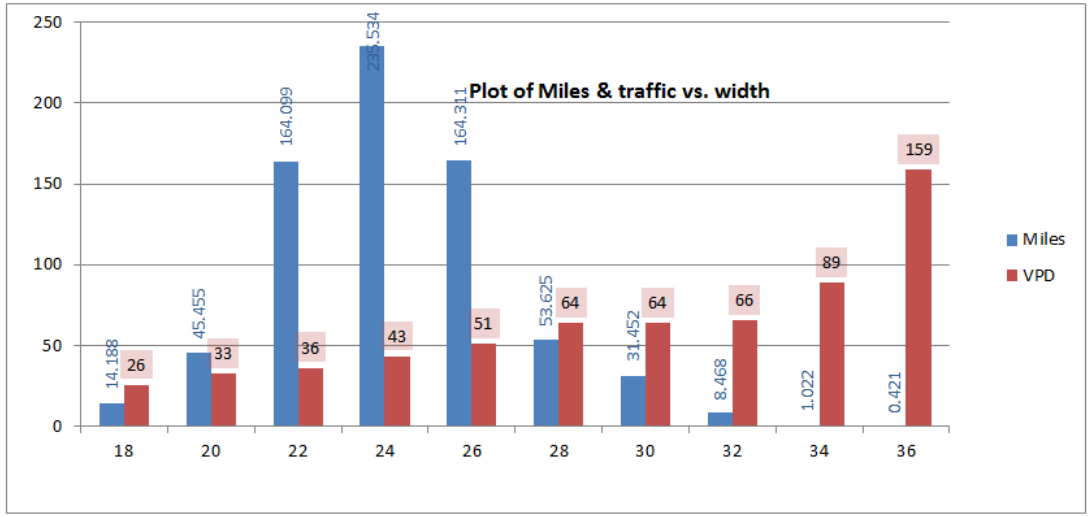
Cost of new material

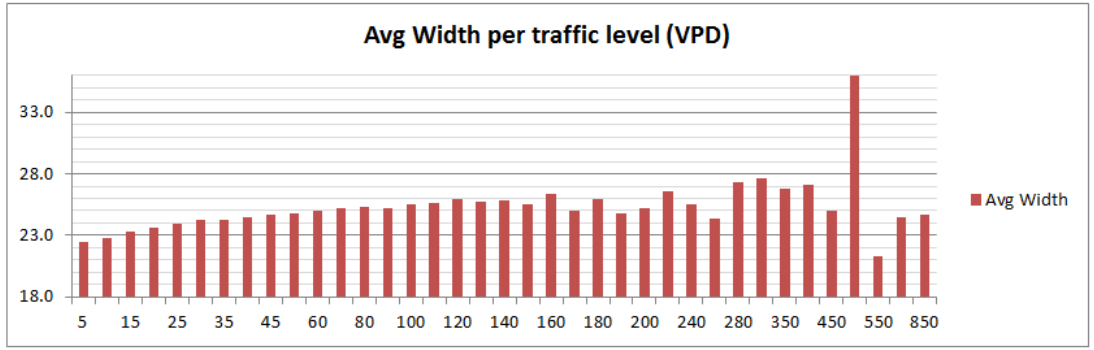
Cost per ton FOB @ source	$7.33
Cost to transport ton per mile	$0.30
Average miles of transport	13
Cost to place and grade $/Tn	$0.37
Total cost per ton	$11.60

Tons and cost per mile per year

Traffic	TPM/yr	Cost: Mi/Yr	Cycle (yrs)
Low	60	$694	4.7
Medium	211	$2,448	2.7
High	363	$4,210	0.8

Material quality index - 0.97 (119 PCF)





Sample of possible summary sheet

GRANULAR ROAD SNAPSHOT: **Average County, Iowa (0)** May 6, 2015

Service levels and reliability 2

Annual replacement needs

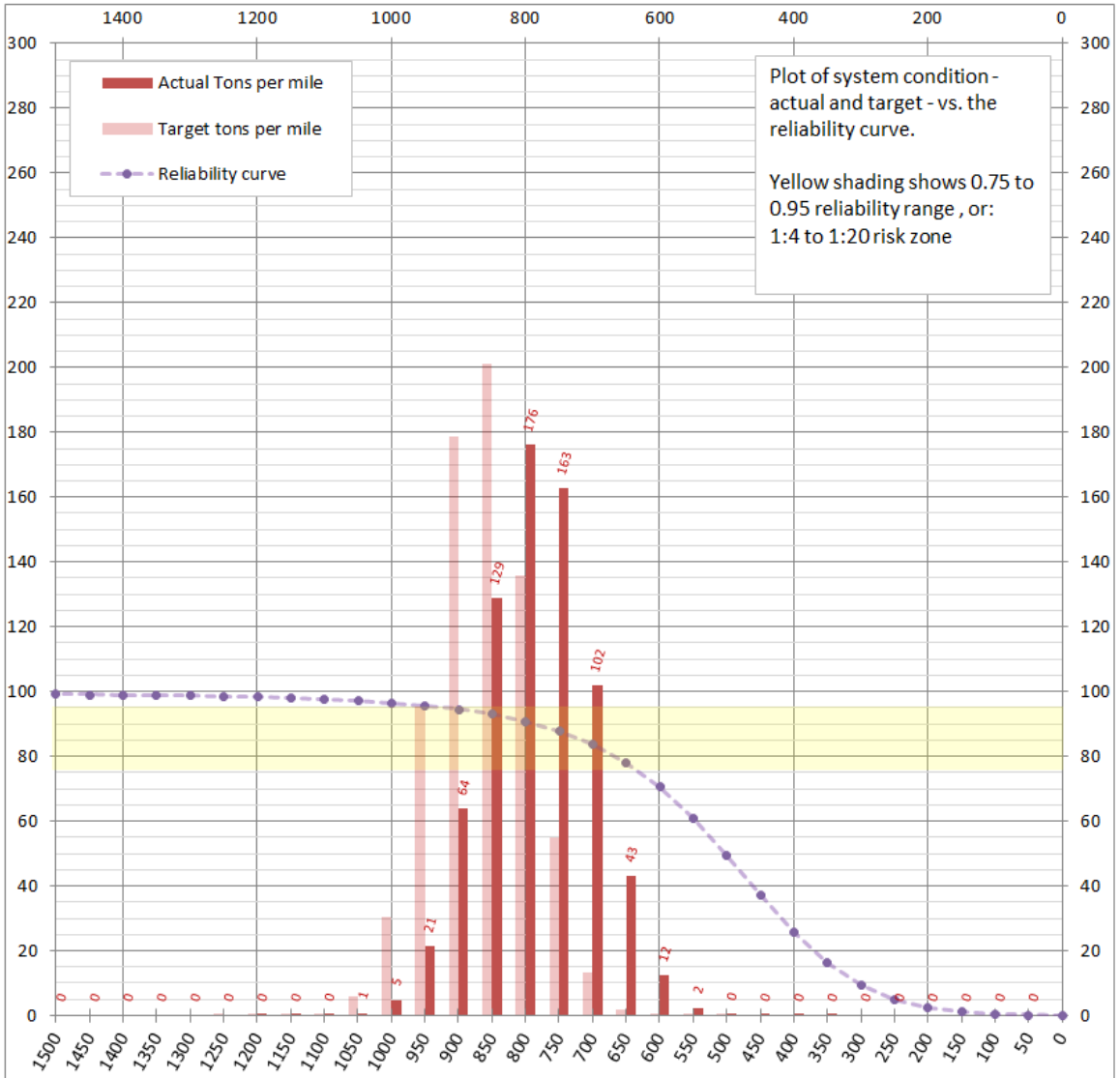
Items	Tons/Yr	$/Yr
Current replacement	79,336	$920,296
Actual annual loss	84,331	$978,244
Surplus(+)/Shortfall(-)	-4,995	($57,948)

* Positve = catching up
* Negative = losing ground

Total tons in service & Systemic risk

Items	Total tons	Value	Risk level
Current	571,268	$6.63 M	1:9
Target	628,394	$7.29 M	1:14
	-57,127	$0.66 M	← Catchup cost

* Positive = system in excellent condition
* Negative = system with excess risk



Products & Deliverables

- A spreadsheet-based GRAMS for county engineers to perform local construction and maintenance optimization analyses.
- Validated formulas to predict and estimate the material quality, need for material replacement, and performance of existing aged materials, risk potential for methods applied, and system-wide risk performance over multiple years.
- A web-based GRAMS for state wide assessment and communication of granular roads management needs. This will provide a foundation for building a web-based GIS map and mobile app.

THANK YOU

- QUESTIONS – COMMENTS – CRITQUE