The National Academies of
SCIENCES · ENGINEERING · MEDICINE

TRB
TRANSPORTATION RESEARCH BOARD

TRB WEBINAR PROGRAM

Springtime Damage to Roads and Seasonal Load Limits

Wednesday, February 22, 2017
2:00-3:30 PM ET

Note About Today's Webinar

Today's webinar discusses commercially available products. Inclusion in this webinar does not imply an endorsement by the Transportation Research Board or the National Academies of Sciences, Engineering, and Medicine.

Purpose

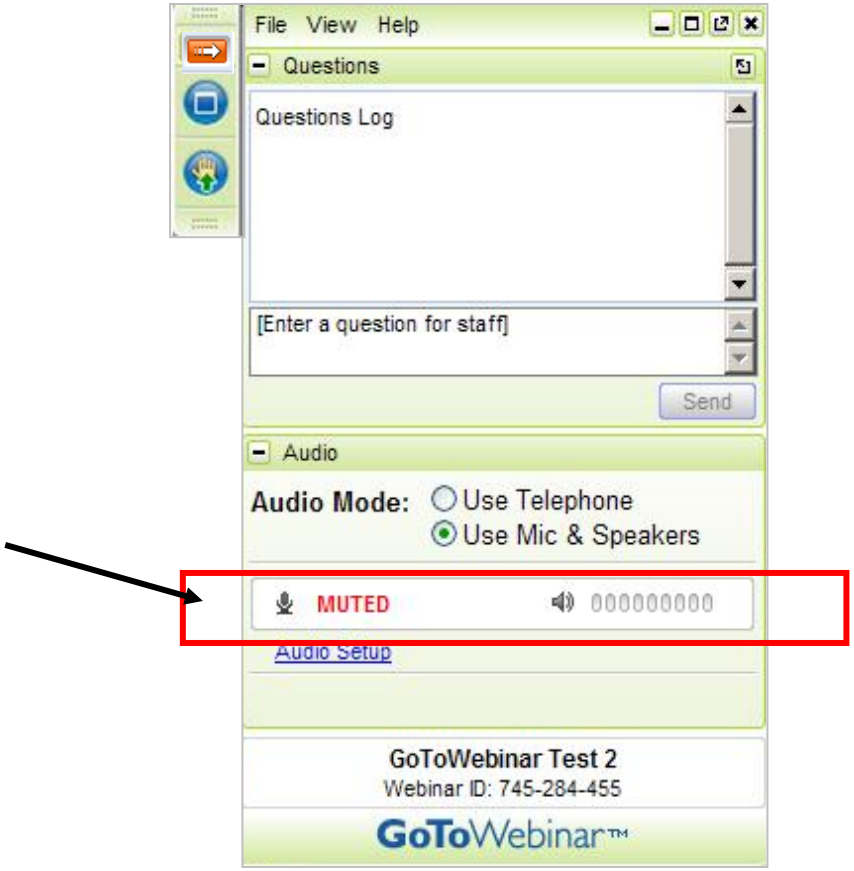
Discuss the background of seasonal thaw and load restrictions. The presenters will also demonstrate some of the websites transportation agencies use to allow users to check local road thawing conditions.

Learning Objectives

At the end of this webinar, you will be able to:

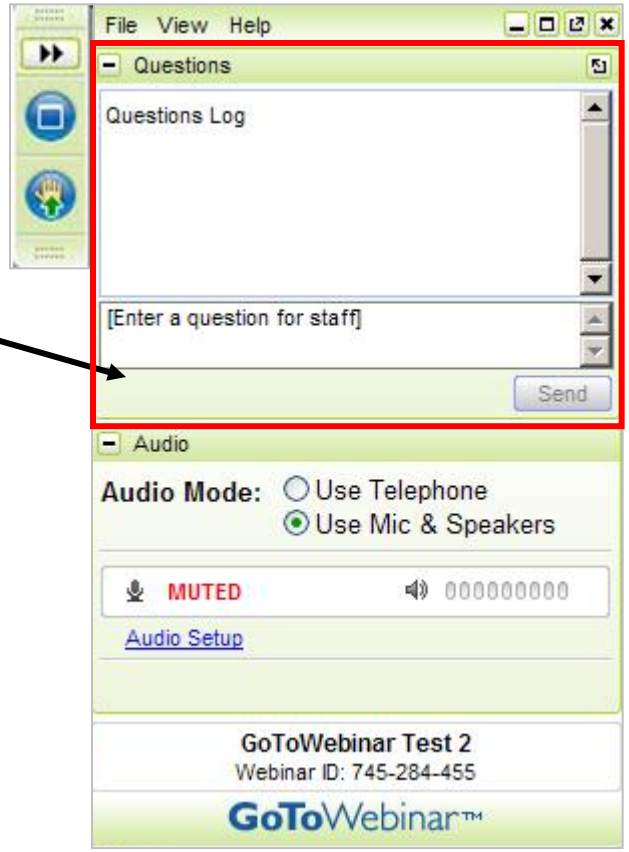
- Understand the reasons for thaw weakening
- Understand the need to predict a window in time during which the road will be most susceptible to damage from heavy loads.
- Understand how to predict when to restrict or limit heavy loads to reduce pavement damage to asphalt surfaced roads and to prevent resource damage caused by non-paved roads

All Attendees Are Muted



Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



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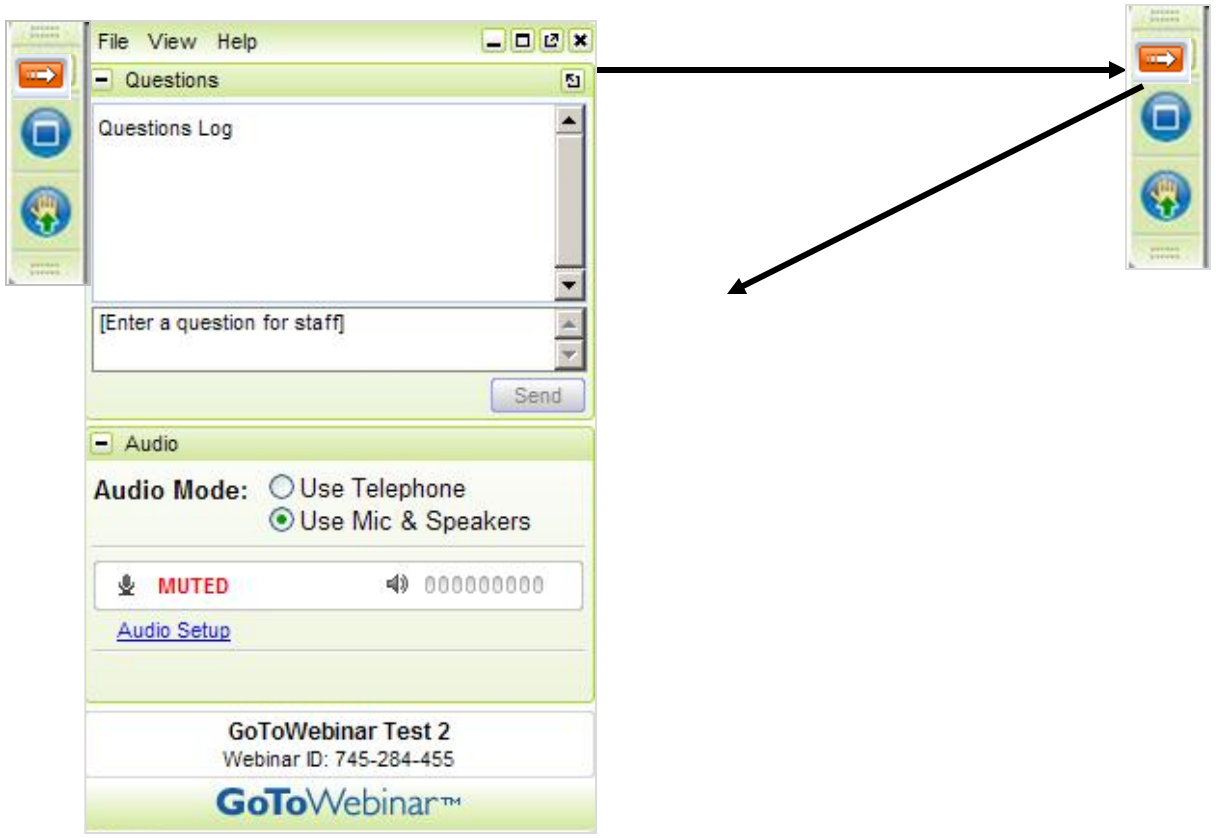

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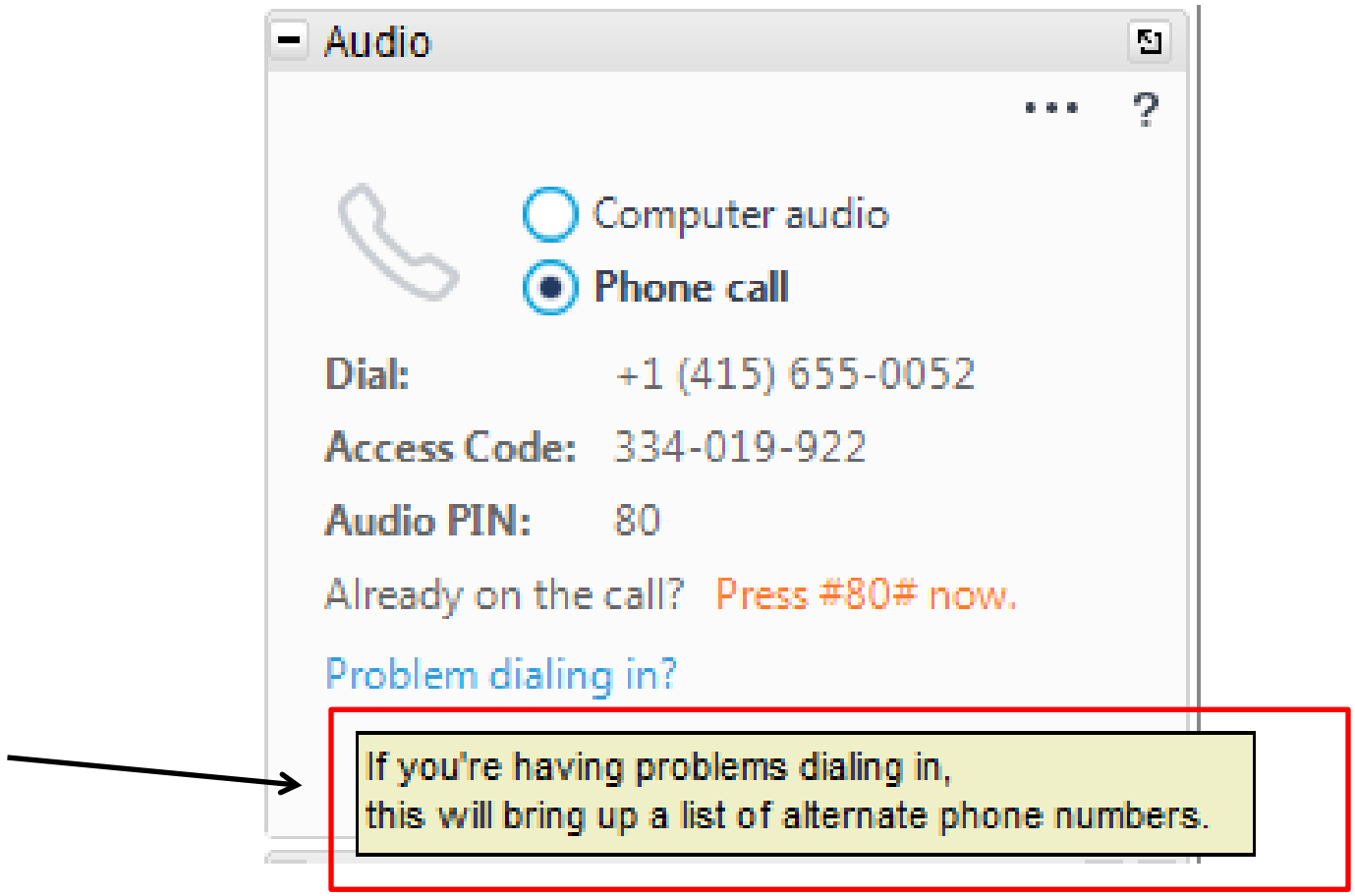

Panelists Presentations

http://onlinepubs.trb.org/onlinepubs/webinars/170222.pdf

After the webinar, you will receive a follow-up email containing a link to the recording

Today's Participants

- David Orr, *Cornell Local Roads Program – NYS LTAP Center*, david.orr@cornell.edu
- Maureen Kestler, USDA Forest Service, mkestler@fs.fed.us
- Tim Andersen, *Minnesota Department of Transportation*, timothy.lee.andersen@state.mn.us
- Gregg Larson, *Applied Research Associates,* glarson@ara.com

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  - AFP50 (Committee on Seasonal Climatic Effects on Transportation Infrastructure)
- Become a Friend of a Committee (http://bit.ly/TRBcommittees)
  - Best way to become a member
  - Ultimate networking opportunity
- For more information: www.mytrb.com
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97th TRB Annual Meeting: January 7-11, 2018

Seasonal Load Restrictions on Low-Volume Roads; A Toolkit of Practical Low-Cost Methods for Road Managers

Maureen A. Kestler – USDA Forest Service

Review a few diagnostic techniques for placing and removing seasonal load restrictions (SLRs)

Acknowledgments

- Gordon Hanek
- Mark Truebe
- Heather Miller
- Bob Eaton
- Dick Berg
- Chris Cabral
- Charlie Smith
- Edel Cortez
- Luke Johanneck
- Rebecca Embacher
- Bryan Steinert
- Dana Humphrey
- Gregg Larson
- David Orr
- Jo Daniel
- Rajib Mallick
- USDA Forest Service – National Forests, & National Technology & Development Program
- FHWA
- USACE-ERDC-CRREL
- Cornell Local Roads Program
- UMass-Dartmouth
- UNH
- WPI
- Univ. of Maine
- NH
- ME
- VT
- MA
- CT
- RI
- AK
- ID
- WA
- MT
- IA
- MI
- ND
- WI
- MN
- MN Local Roads Research Board
- Ontario, Canada

Outline

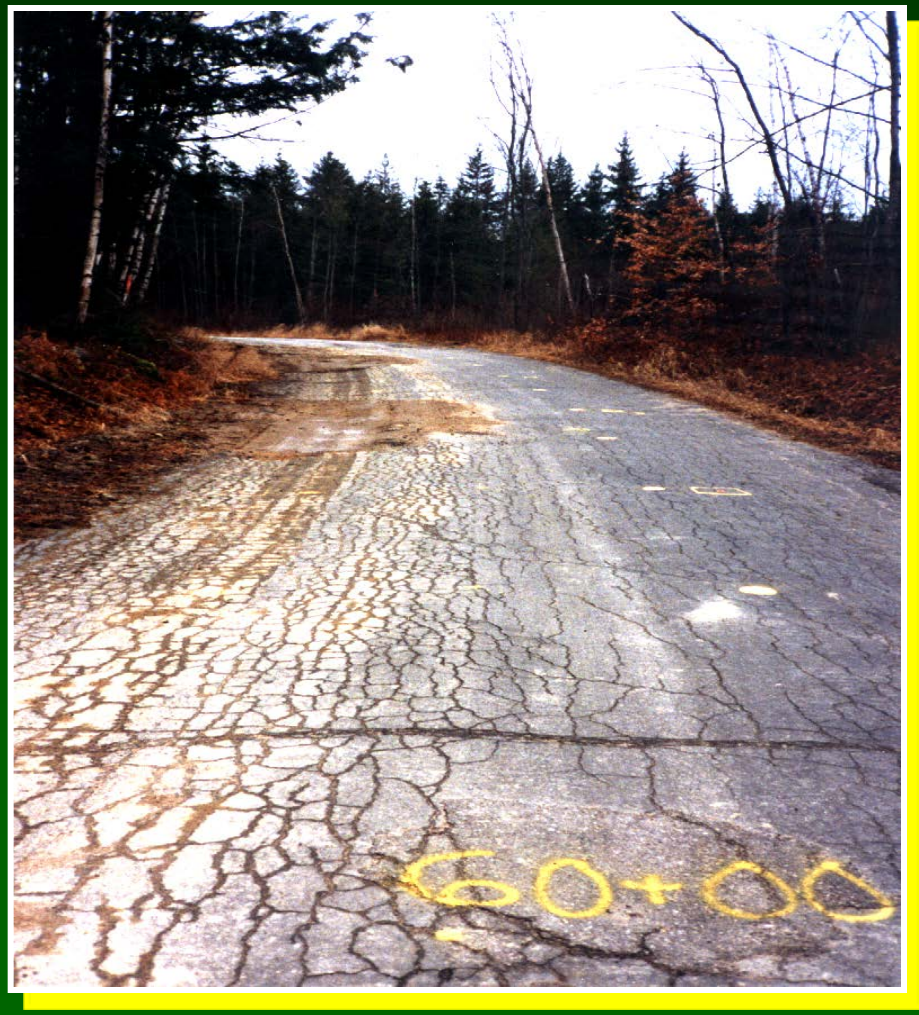
- Objectives
- Introduction / Background
- Methods for Determining Seasonal Load Restriction (SLR) Placement & Removal
  1. Subsurface Instrumentation
  2. Falling Weight and Lightweight Deflectometer (FWD, LWD)
  3. Mathematical Models – Degree days, thaw index, numerical
  4. Length of Time for Duration of SLR
  5. Combinations
- Summary

Introduction

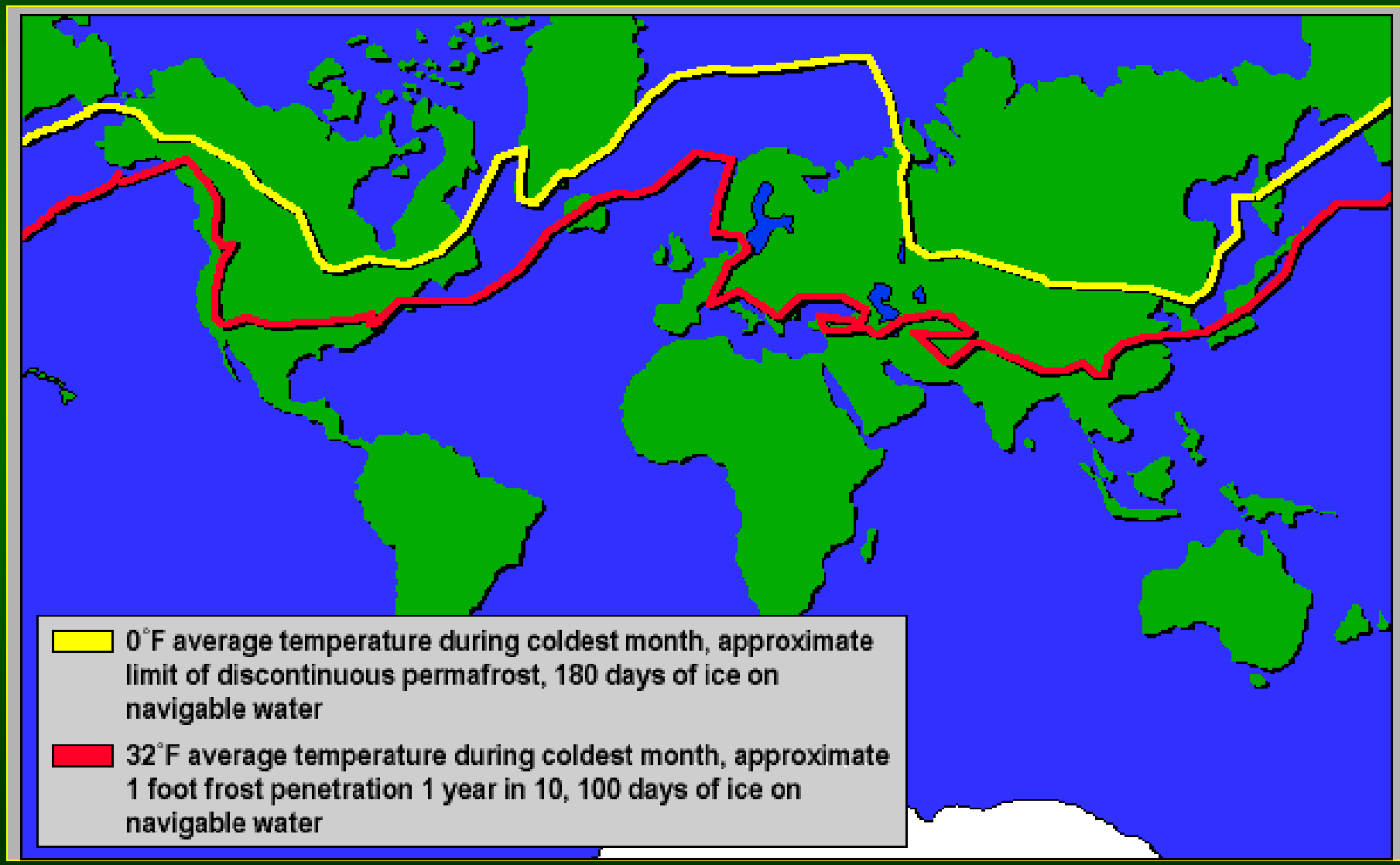
- Objectives of using SLRs
  - Asphalt-surfaced
    - Extend pavement life
    - Reduce maintenance cost
  - Gravel-surfaced and unsurfaced
    - Environmental: enhance stream quality / sediment reduction
    - Reduce maintenance cost
- Optimize timing of SLR placement and removal to strike a balance between reducing road damage and maximizing local economies

Introduction

Approximately half of the low volume roads in the U.S. are in seasonal frost areas

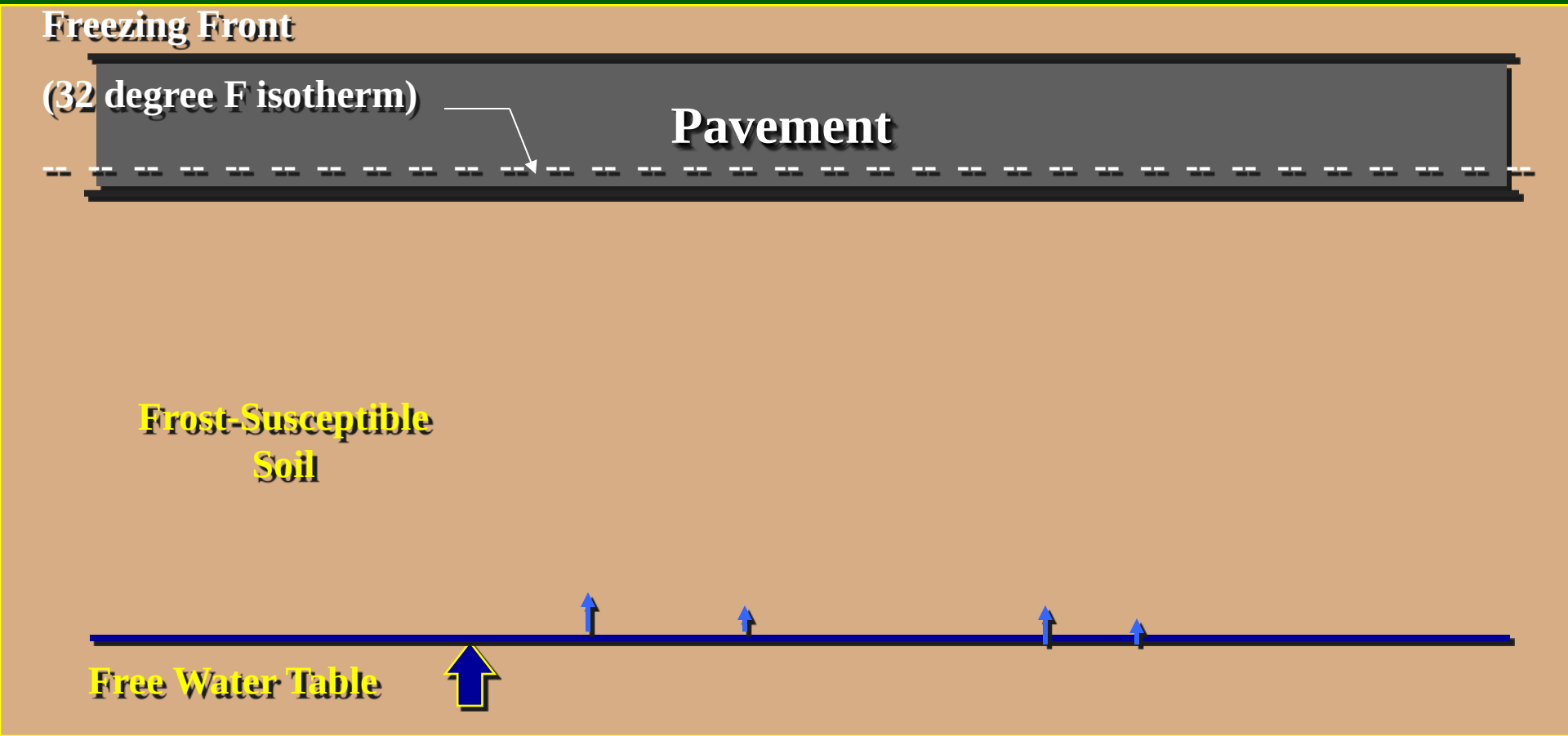


Introduction – Seasonal Frost Areas



Introduction

Mechanics of Freezing and Thawing



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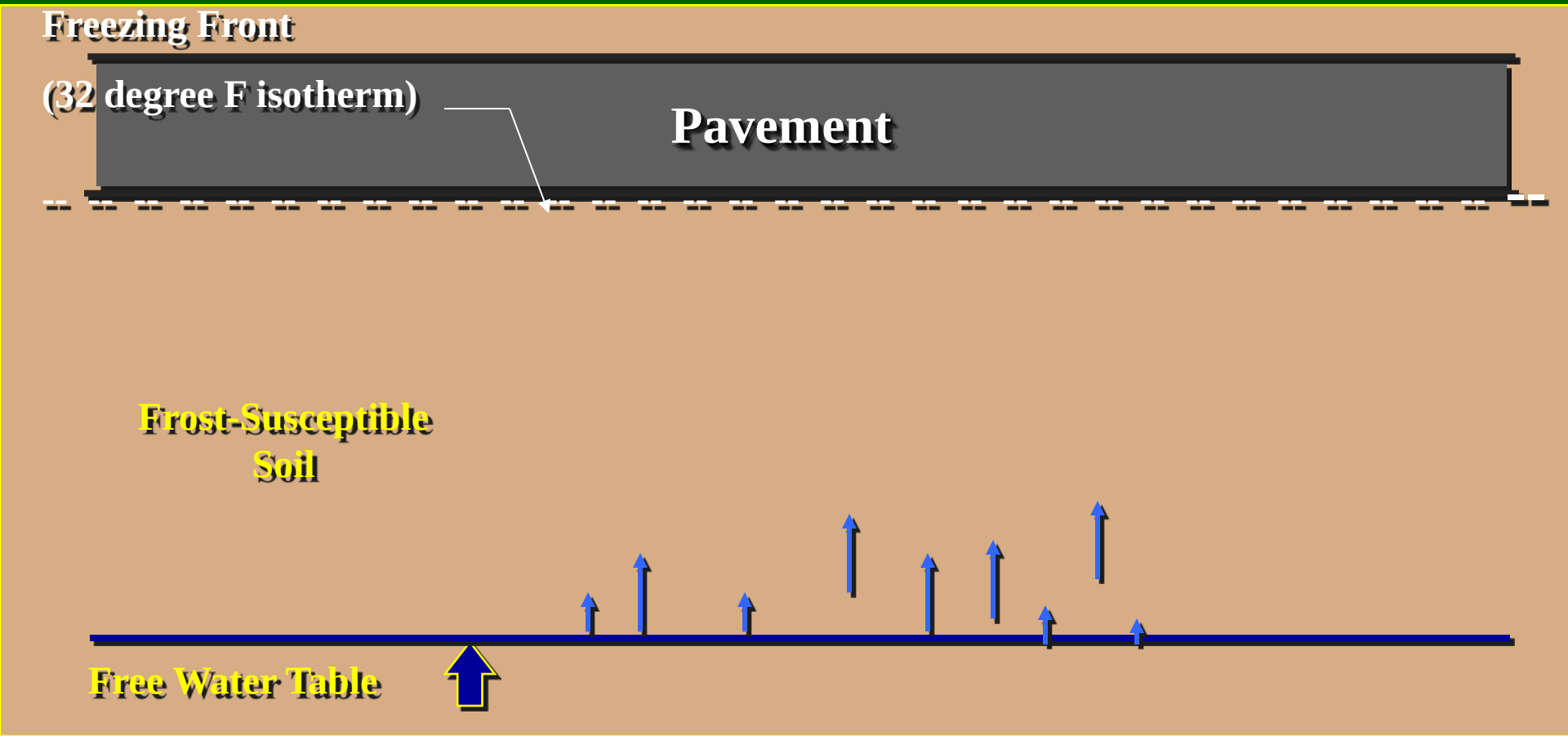

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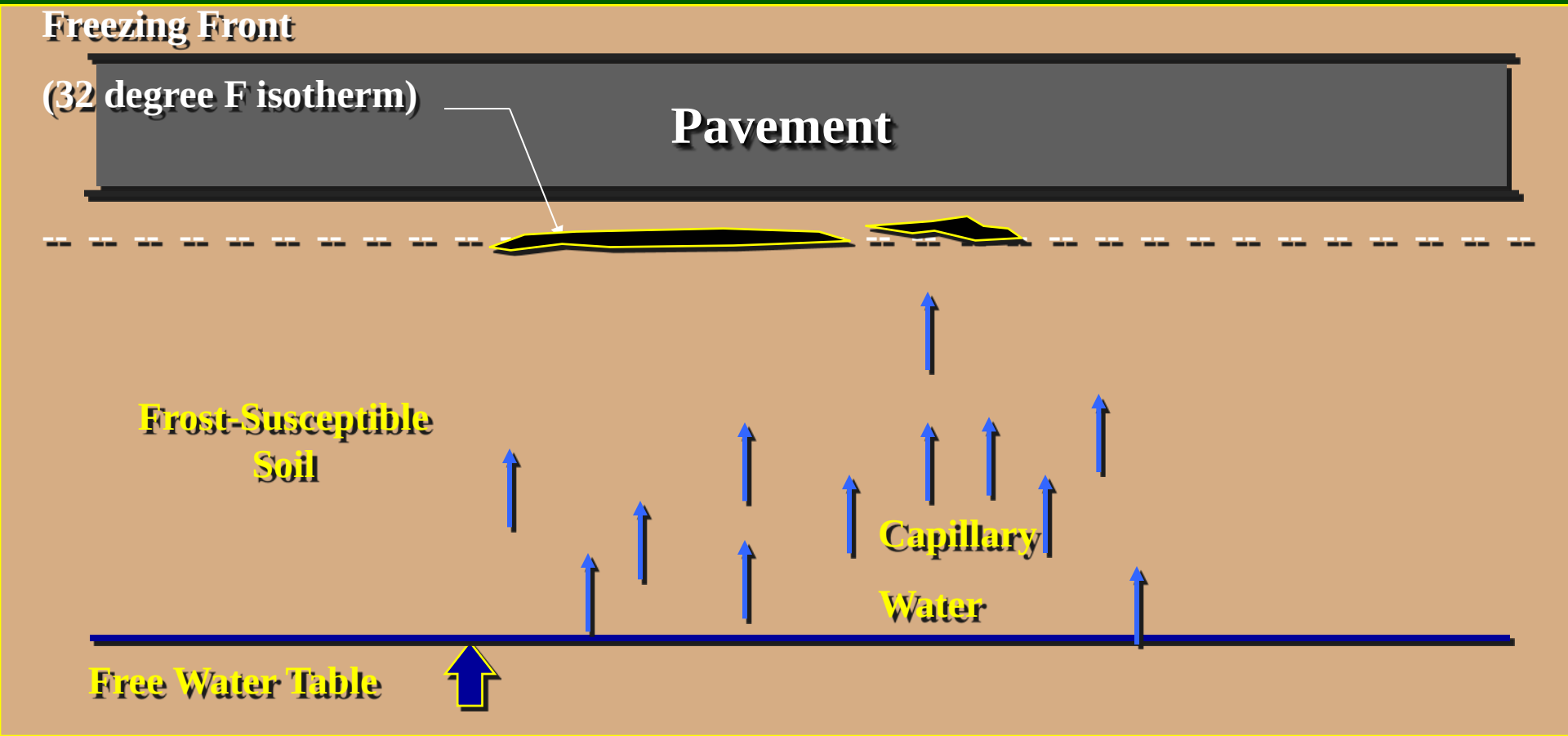

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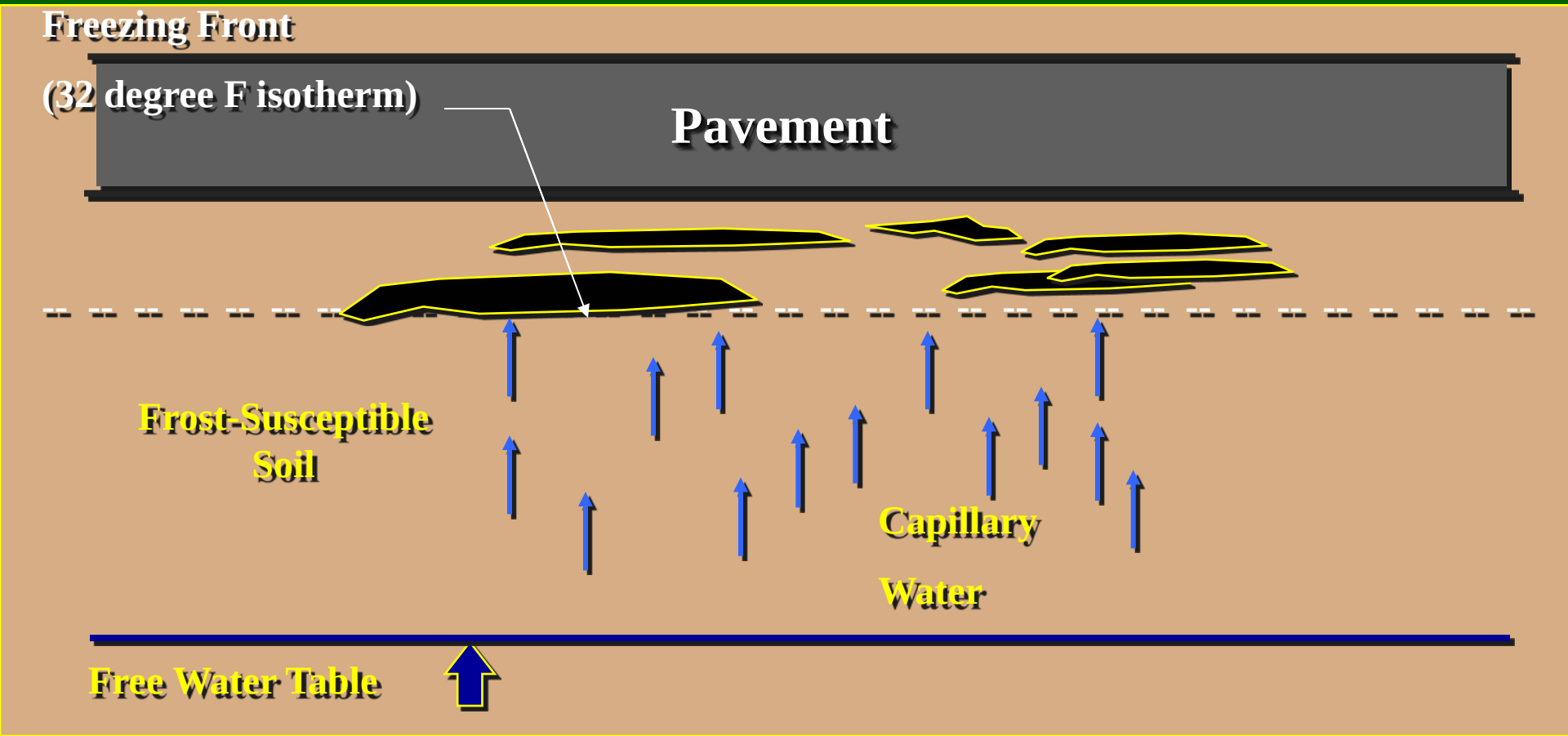

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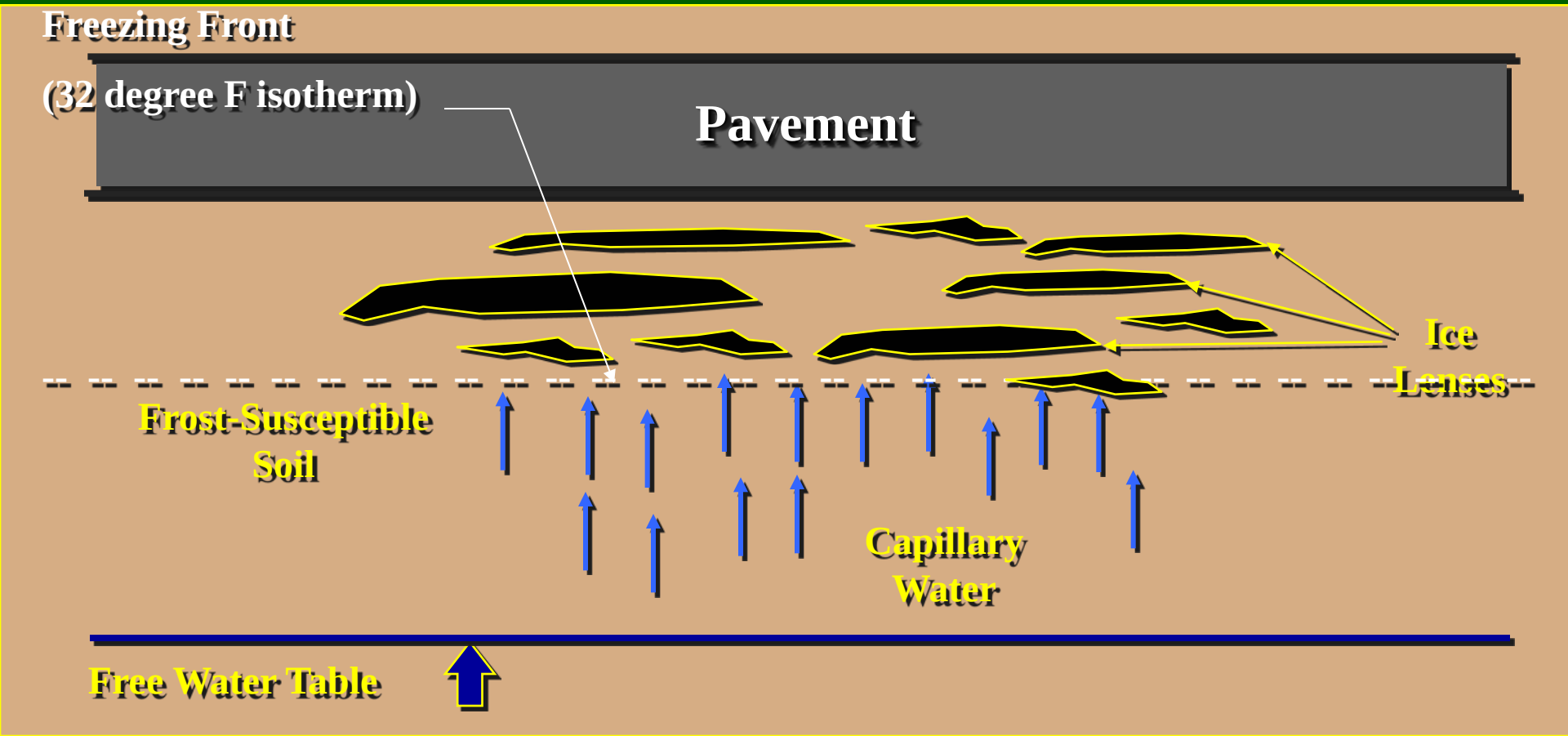
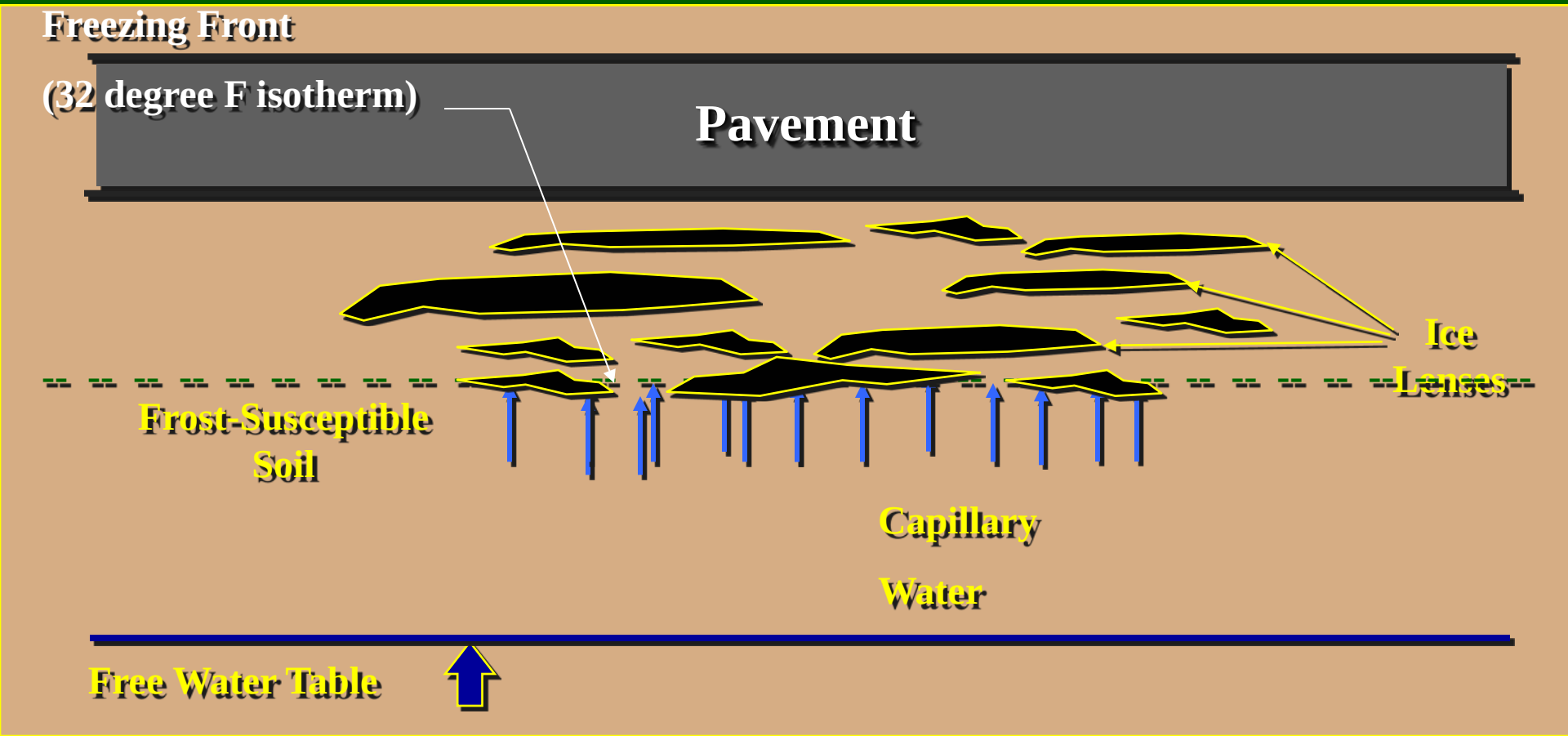
Mechanics of Freezing and Thawing



Introduction

Mechanics of Freezing and Thawing



Introduction

Frost Action

Introduction
Frost Action

- Frost Action Video
  - Original: USACE-ERDC-CRREL
  - Revised: MN Local Roads Research Board, AK DOT&PF, ASCE, USACE-ERDC-CRREL, FHWA, Forest Service, etc.
  - Video shows techniques for new construction; first portion describes frost action

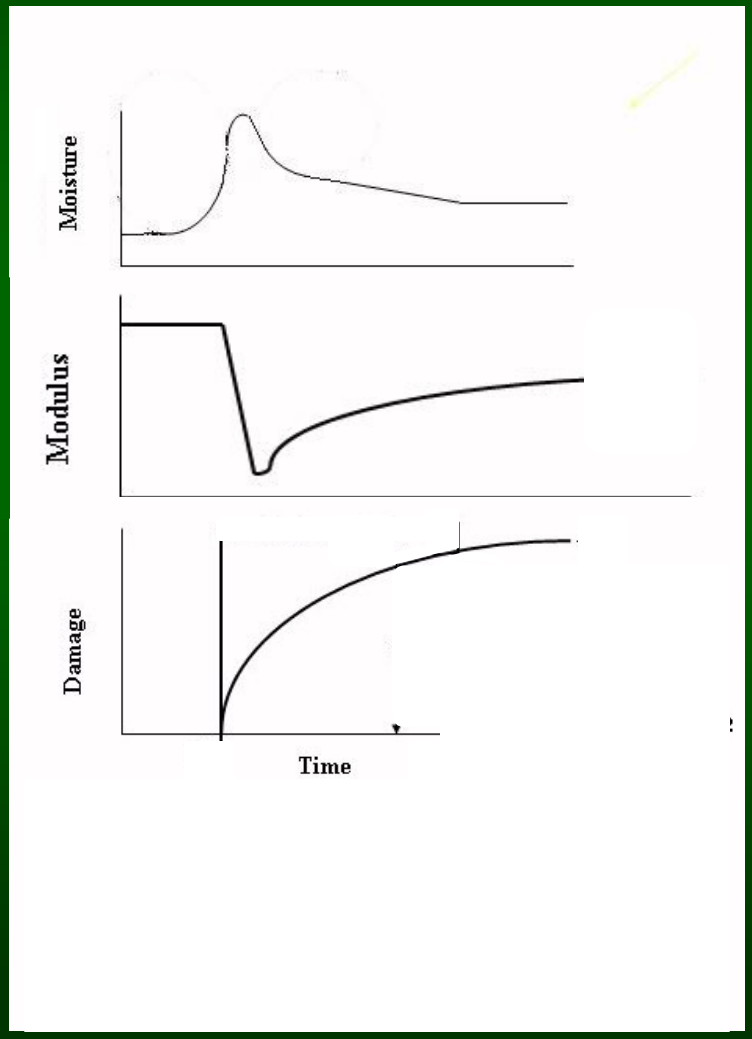
http://www.youtube.com/watch?v=fkrrSys03qQ

Introduction

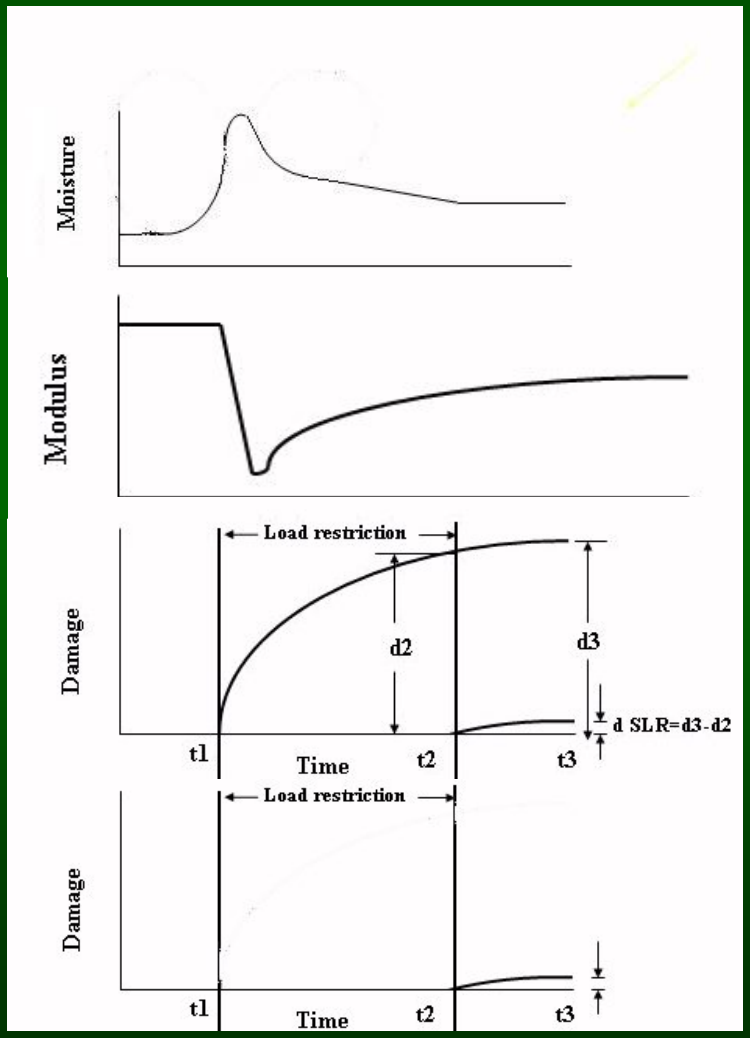
Seasonal Load Restrictions

Introduction

Load Restrictions



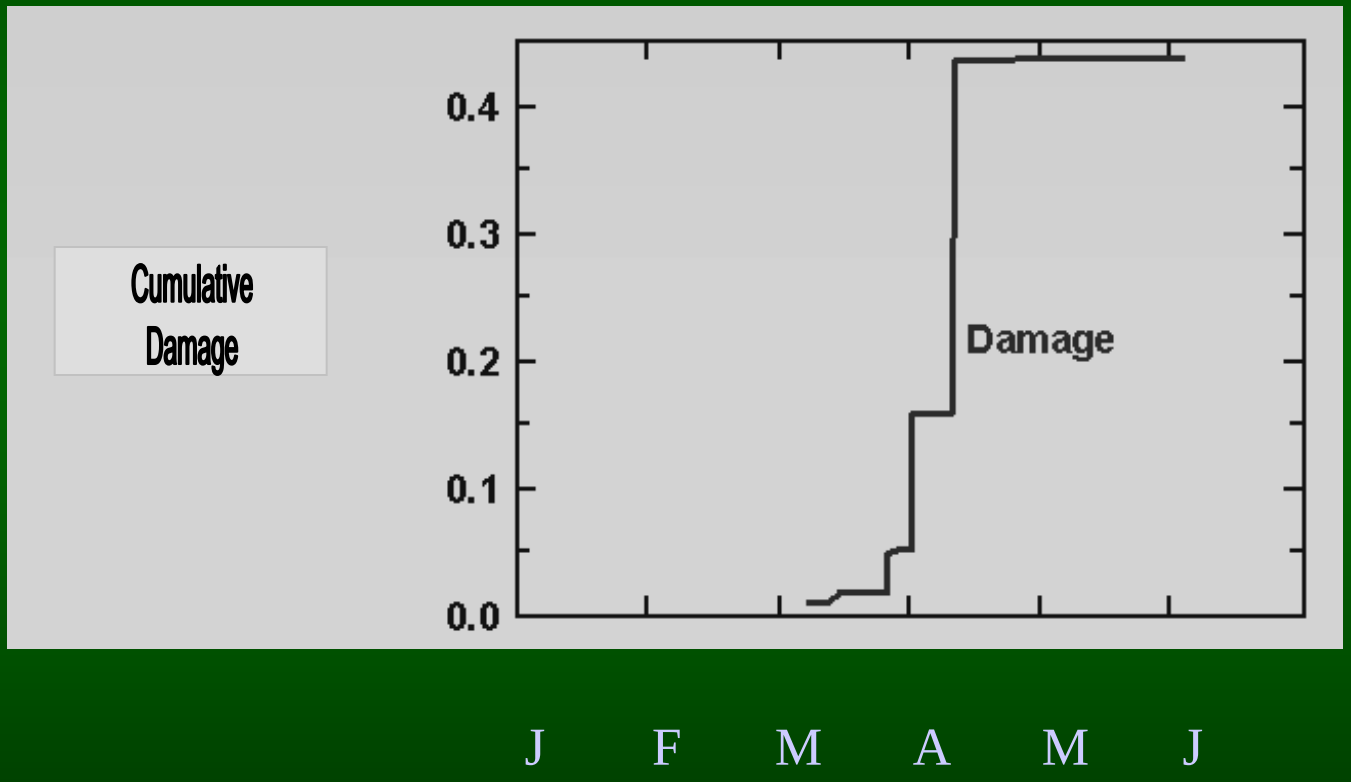
Introduction
Load Restrictions



Introduction

- SLRs do keep damage to a minimum, but adversely affect companies whose livelihoods depend on trucking
- Optimize SLR placement & removal to strike a balance between reducing road damage & maximizing local economies
- Numerous studies & publications – MN, AK, UMass-Dartmouth, Waterloo, Lakehead Univ., WA, Forest Service, etc.
- The Forest Service is currently compiling a toolkit of low-cost methods for determining when to place & remove SLRs
  - Past and current projects typically conducted in partnership with one or more other agencies with mutual interests

Introduction



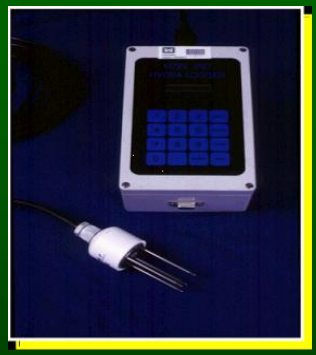
Outline

- Objectives
- Introduction / Background
- Methods for Determining SLR Placement & Removal
  1. Subsurface Instrumentation
  2. Falling Weight & Lightweight Deflectometer (FWD & LWD)
  3. Mathematical Models
  4. Length of Time for Duration of SLR
  5. Combinations
- Summary

1) Subsurface Temperature and Moisture Sensors

- Temperature is most commonly measured by thermistors or thermocouples. These aid in SLR placement, but not removal.

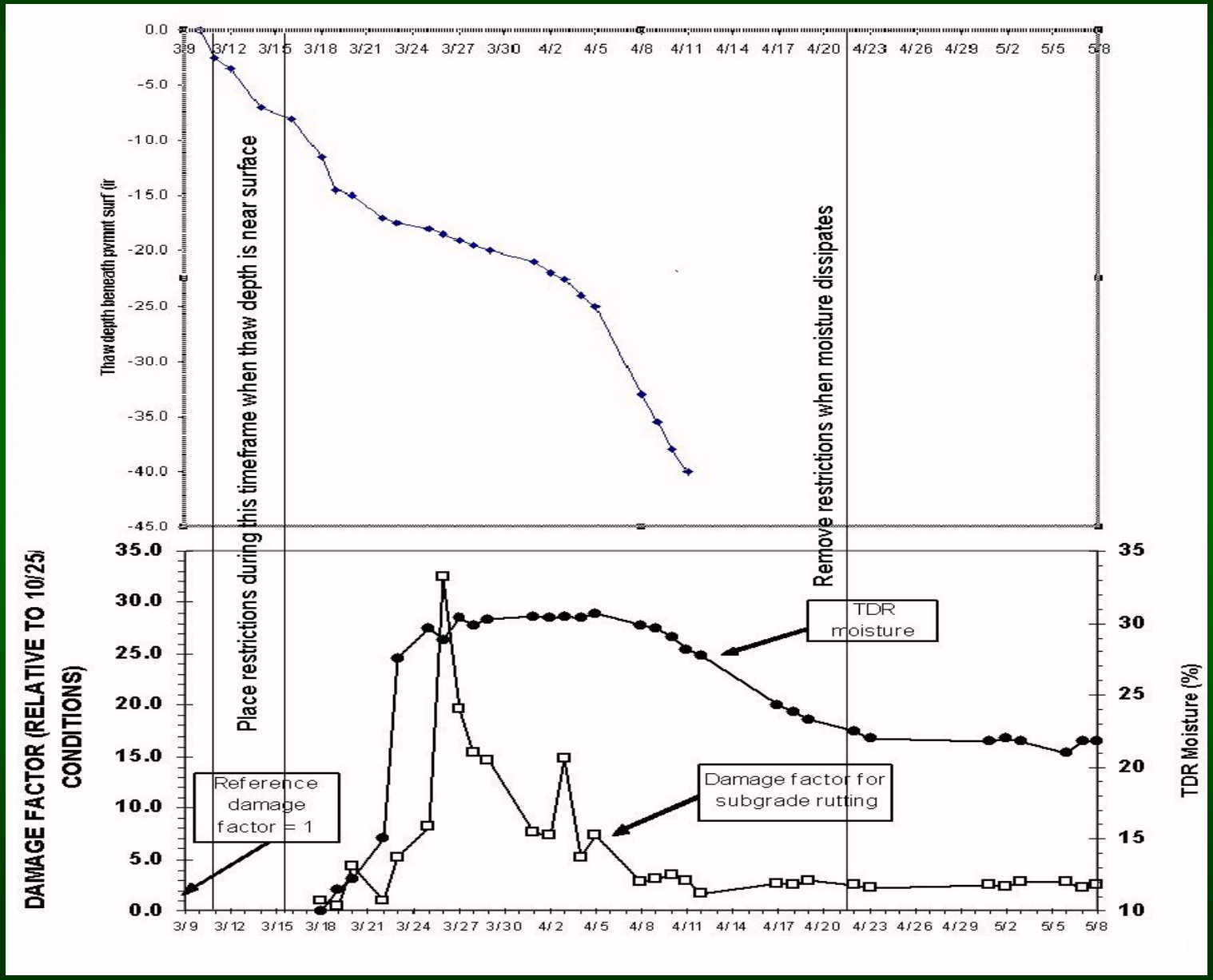
- Soil moisture sensors can serve as a surrogate measurement of pavement stiffness, so can aid in SLR removal.



1) Subsurface Temperature and Moisture Sensors

- Data acquisition
  - Manually read at discrete times
  - Automated datalogger
- Transmittal of data
  - Manual collection/downloading – not transmitted
  - Telemetric
    - Satellite
    - Cell
    - Radio

1) Subsurface Temperature and Moisture Sensors



1) Subsurface Temperature and Moisture Sensors

- Observations from project for which results were just shown
  - Moisture Peaks when Drainage Impeded by Frozen Layers
  - Subgrade Min. Modulus → 18 in. Thaw Depth
  - Moisture Content: Surrogate Road Strength Indicator

- System to Minimize LVR Damage
  - Thermistors → Determine Start of Thaw
  - Moisture Sensors → Determine Recovery

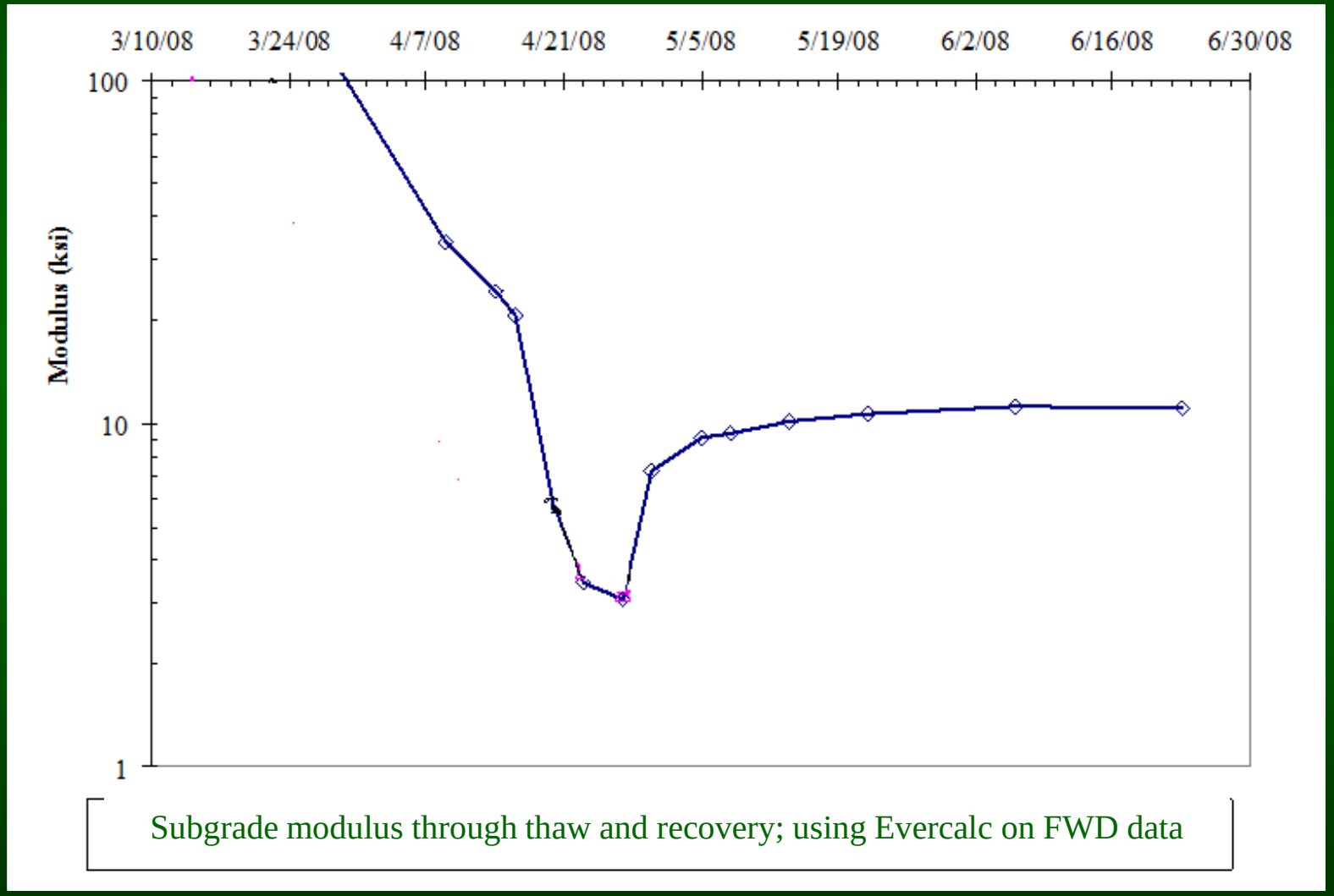
- Drawback: Site specific

2. Falling Weight & Lightweight Deflectometer

Conventional Falling Weight Deflectometer (FWD)

2. Falling Weight & Lightweight Deflectometer

Conventional Falling Weight Deflectometer (FWD)



Subgrade modulus through thaw and recovery; using Evercalc on FWD data

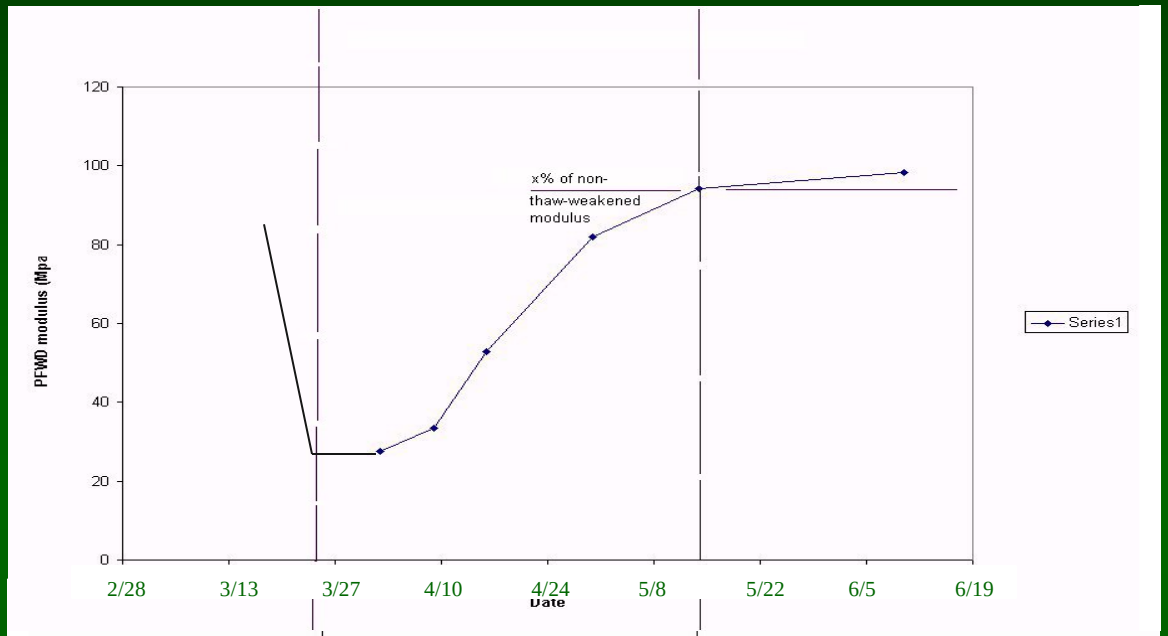
2. Falling Weight & Lightweight Deflectometer

Lightweight Deflectometer (LWD)

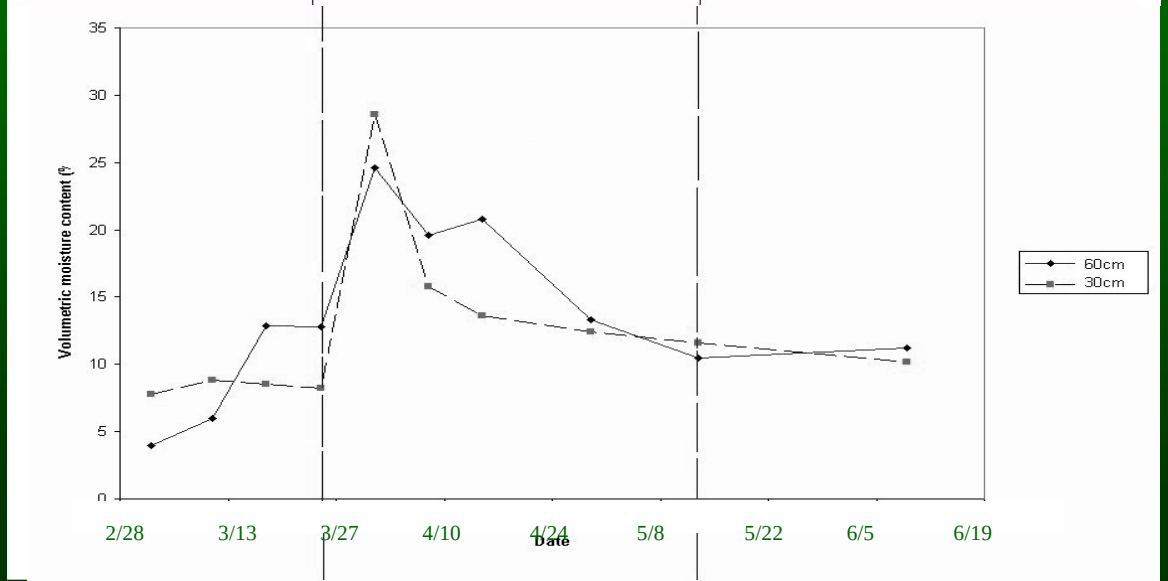
2. Falling Weight & Lightweight Deflectometer

Lightweight Deflectometer (LWD)

Modulus from LWD

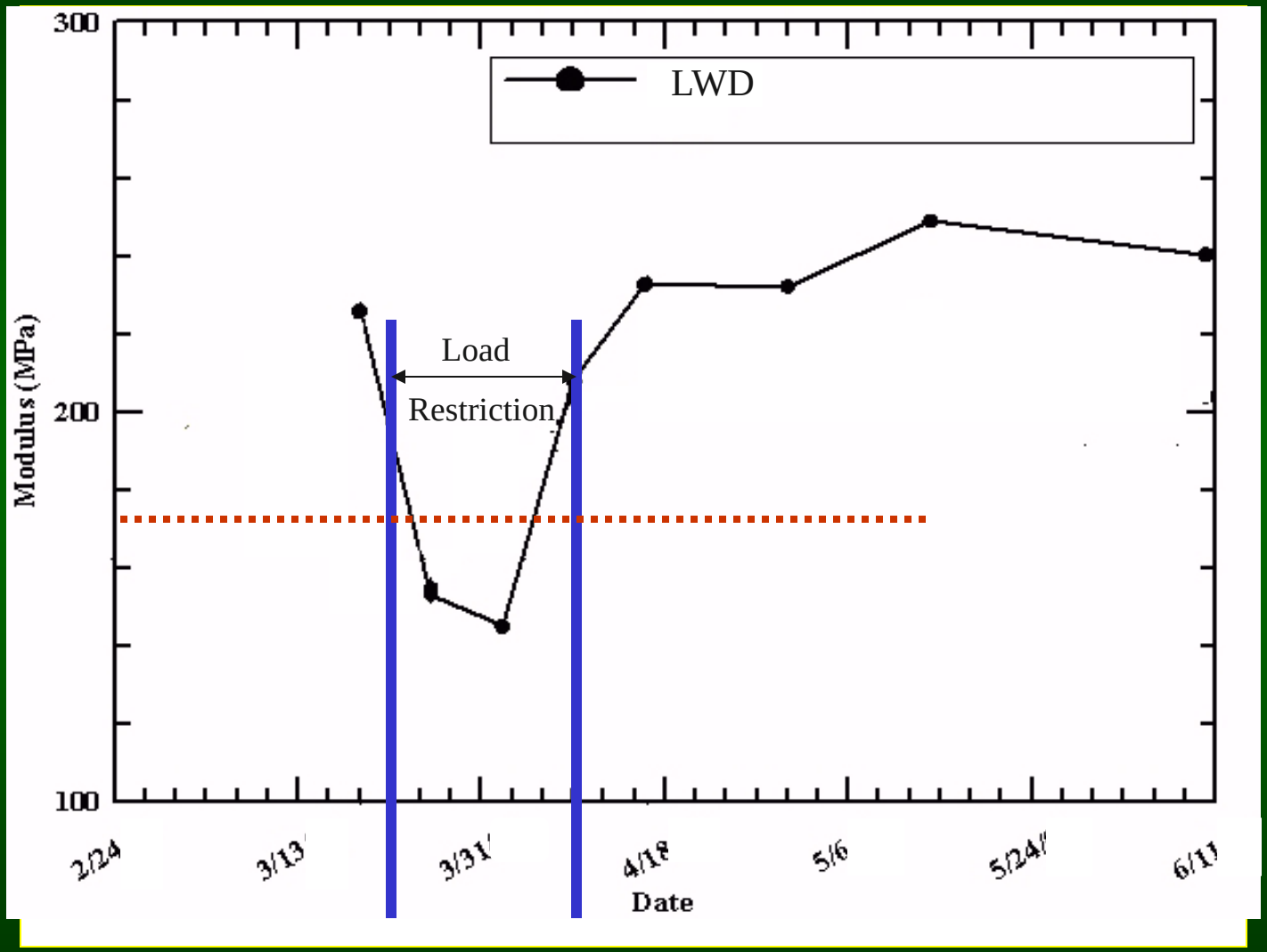


Moisture Content



2. Falling Weight & Lightweight Deflectometer

Lightweight Deflectometer (LWD)



Not site specific, and can be used to place or remove SLRs

2. Falling Weight & Lightweight Deflectometer

Lightweight Deflectometer (LWD)

- LWDs being increasingly accepted in US
- There are ASTM standards for LWD
- Cost: Approx. $10K-$20K
- Can track seasonal stiffness variations
- Correlations improve with decreasing asphalt thickness
  - Reasonable comparison for up to 5 in asphalt thickness

3. Models

3. Models

a. Thaw Index

- Past Studies
  - State of Washington
  - Minnesota
  - Canada
- Determine Dates for Load Restrictions by a Simple Index
  - No special skills or equipment
  - Anywhere, not site specific
  - Parameters - Daily Air Temperature
  - WA and MN – use specific reference temp
  - FROST Assoc. - Dick Berg - Sinusoidal pavement temp with season
  - Etc.
- Works well for placing restrictions. Not as good for removal.

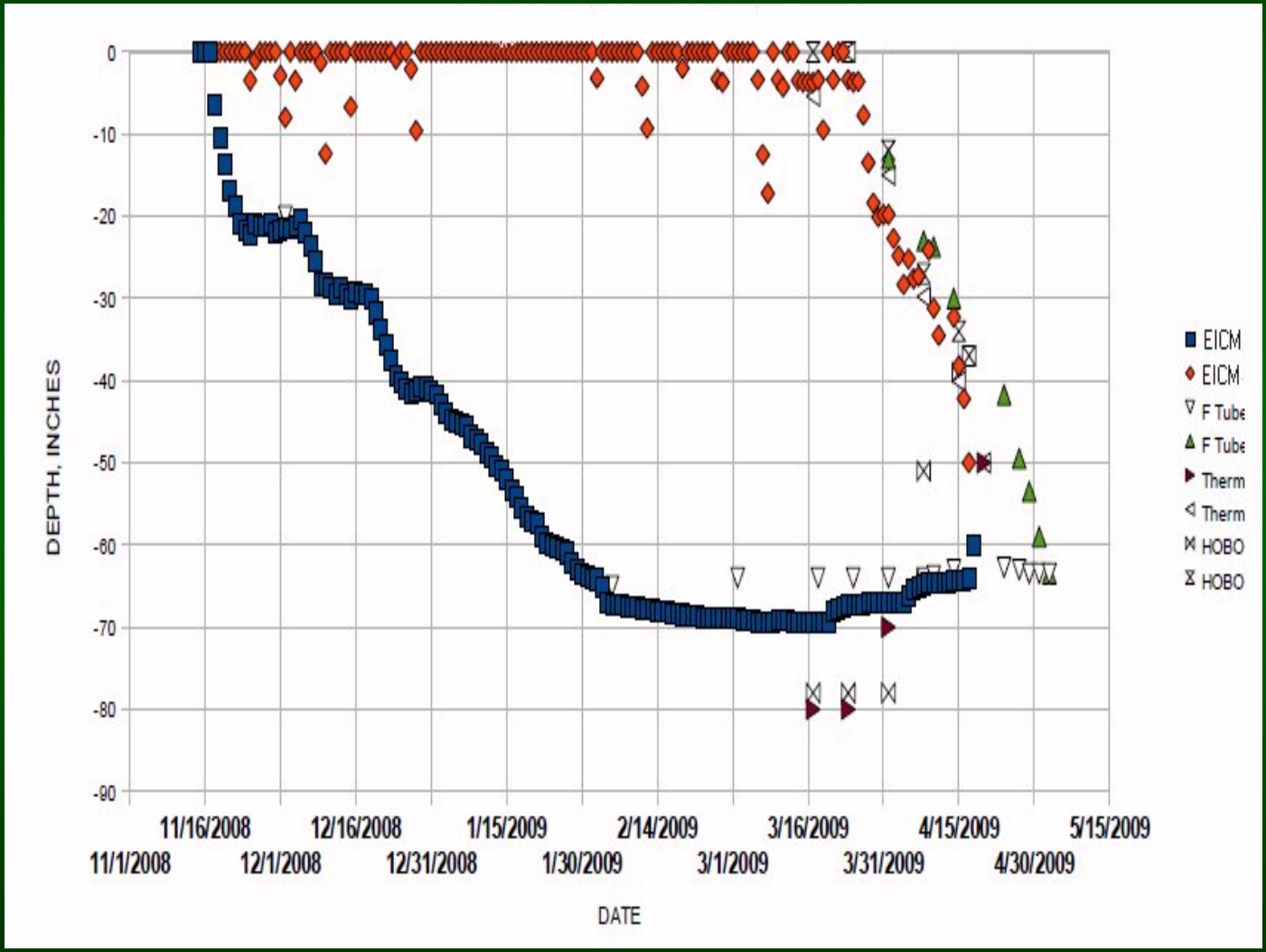
3. Models

b. Numerical

- Enhanced Integrated Climatic Model – Thaw Forecast Model
  - 1-D heat and moisture flow climatic model incorporated in the current AASHTO pavement design procedure
  - Computes changes in behavior and characteristics of unbound materials as a function of environmental conditions over time (temp, pore water pressure, frost & thaw depth, frost heave, etc.)
  - A few thaw predictor variations
    - ARA – EICM vRWIS – frost, thaw (& icing)
    - FHWA/Clarus, SLR tool – frost, thaw
- Other numerical models

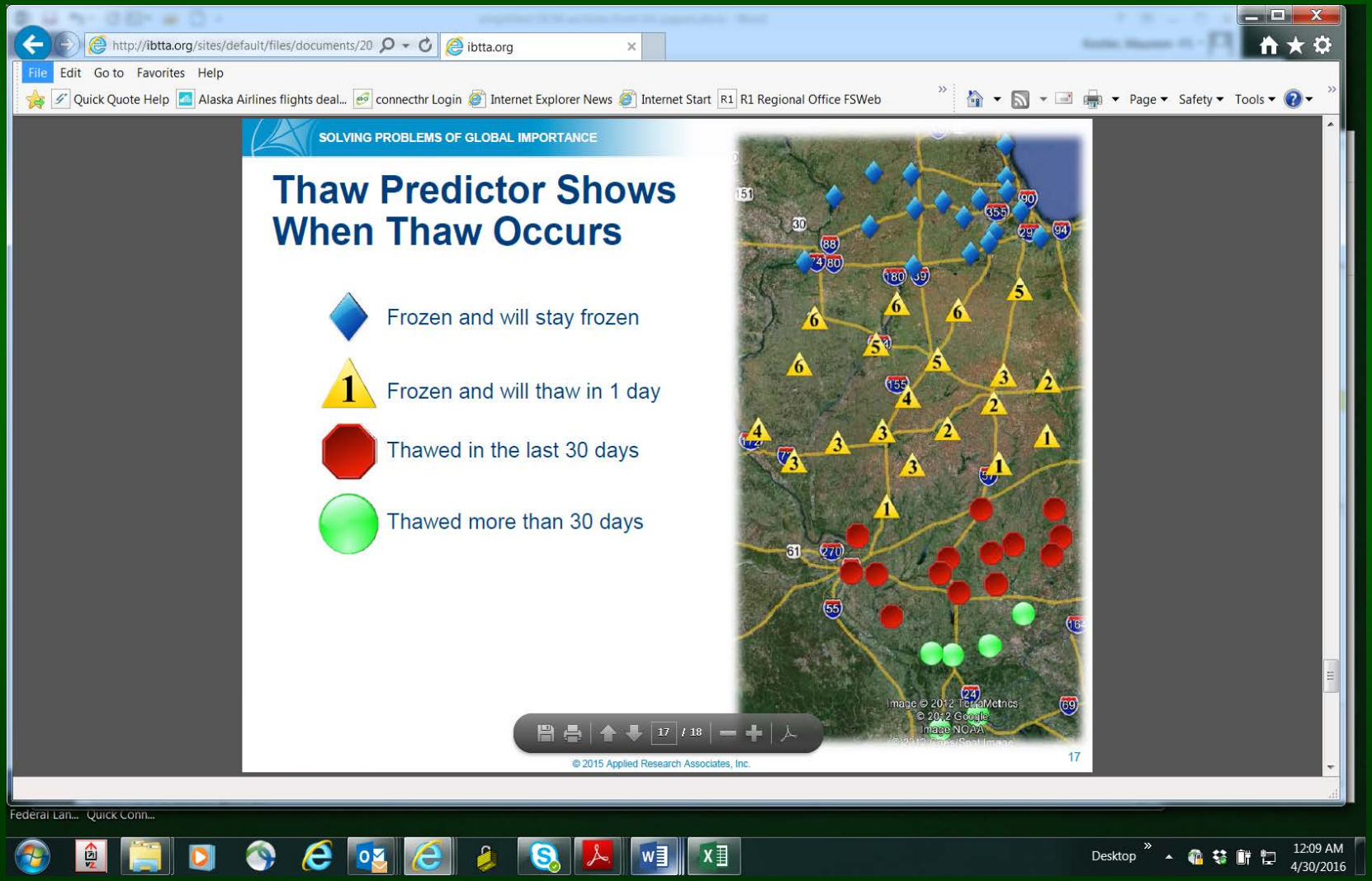
3. Models

b. Numerical

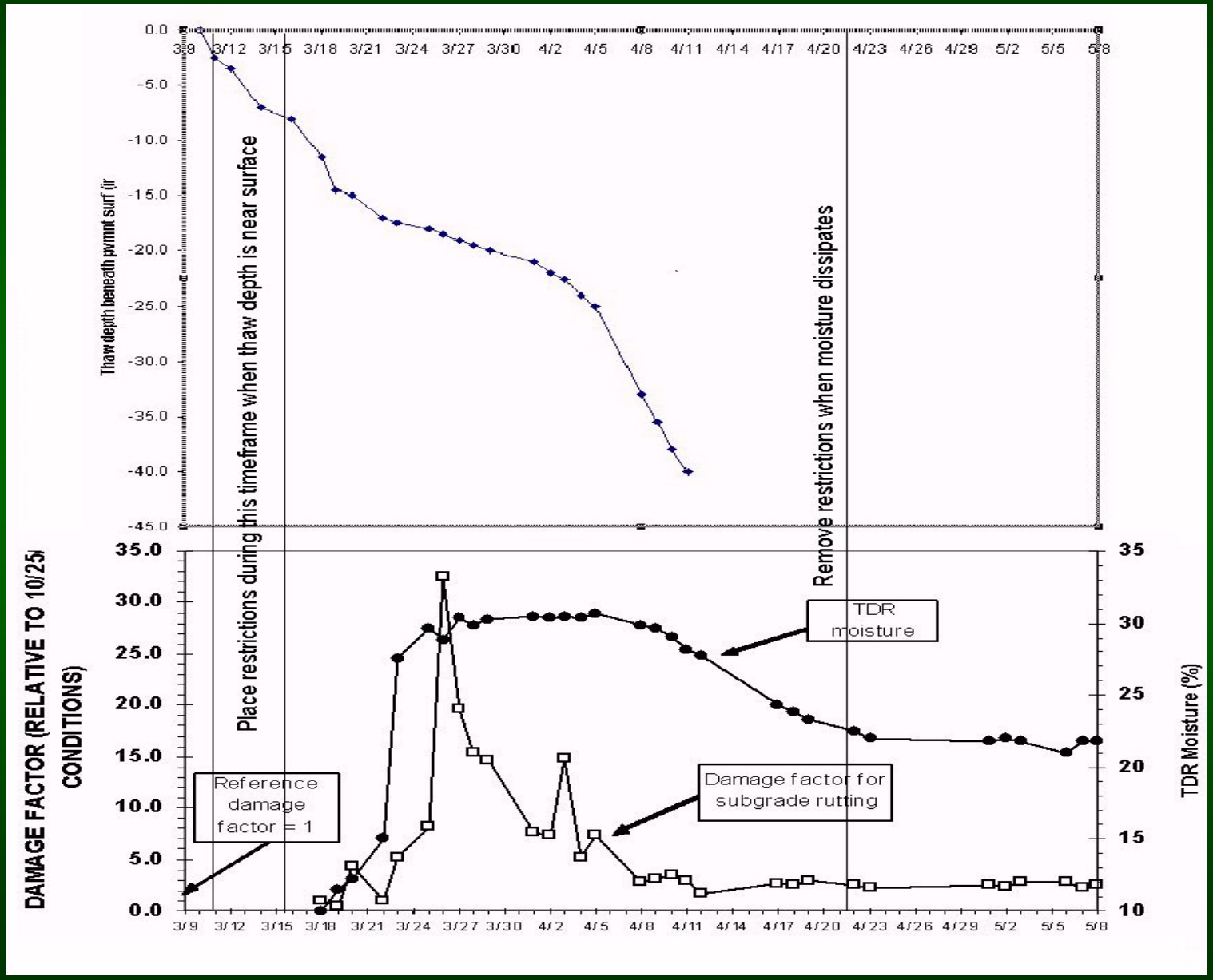


3. Models

b. Numerical



4) Length of Time for Removal



4) Length of Time for Removal

- Sites analyzed by the Forest Service have shown in the range of 5-8 weeks for recovery, but data is too limited.

- MN's recommendations are based on a larger database than FS, so recommendation is to use MN's 8 or so weeks for asphalt, and approx. 10 weeks for gravel.

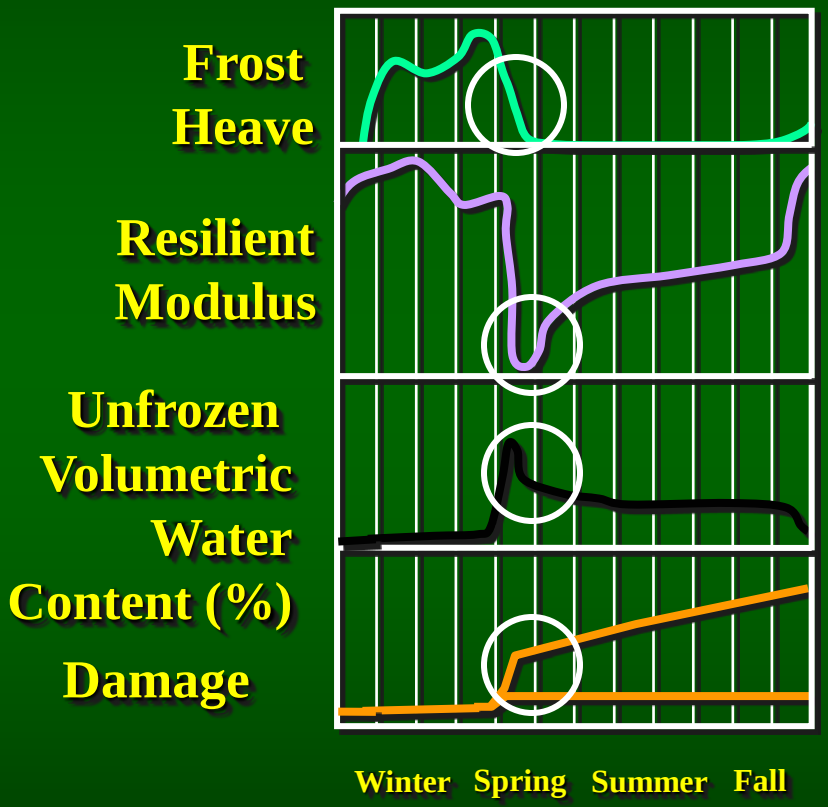
5) Combinations of Techniques for Placing and Removing SLRs

If Spring Load Restriction is *Placed* Using this Method:	**Recommended method(s) for *Removing* Spring Load Restriction, in order of recommendation:**
Subsurface temperature sensors	Subsurface moisture sensors
	Lightweight Deflectometer
	Length of time
Lightweight Deflectometer	Lightweight Deflectometer
	Length of time
Thaw Index	Lightweight Deflectometer
	Length of time
EICM Thaw Predictor	Lightweight Deflectometer
	Length of time

Summary

Summary

- Existing Pavements:
  - Reduce damage by limiting hauling during damage susceptible period



  - Timing of SLR placement & removal can be determined via any one or combination of methods

Summary

1. Subsurface Instrumentation
2. Falling Weight & Lightweight Deflectometers
3. Mathematical Models
4. Length of Time for Duration of SLR
5. Combinations

Technique	Strengths/Advantages	Weaknesses / Disadvantages
Subsurface sensors	• Can be fairly simple. • Coupling of temp & moisture sensors predict when to place & remove SLRs.	• Site specific. • Requires field visits unless a remote automated data acquisition system. • Difficult to install (drill) if rocky.
FWD or LWD	• Anywhere – not site specific. • Good for placement & removal.	•FWD: $$$. Agencies have limited no. •FWD: Travel required, not near all sites. •LWD: Modulus is for just near-surface. • LWD: 4-5 in. max asphalt thickness. • LWD: Composite modulus; near surface.
Thaw Index	• Does not require field visit; can be used from office. • Simple to use.	• Initial setup may require additional time. • Mountainous location issues. • Better for SLR placement than removal.
EICM Thaw Predictor	• Does not require ongoing field visits. • Accounts for materials/road structure.	• Better w/ temp sensor in road for calibration. • Good for determining start, needs work for predicting completion of thaw. • Requires a lot of input for good output.
Length of Time	• Very simple to use.	• Good for standard season, but not for out-of-the-ordinary seasons.

Thank You

Seasonal Load Limits

Tim Andersen

Minnesota Department of Transportation

April 22, 2017

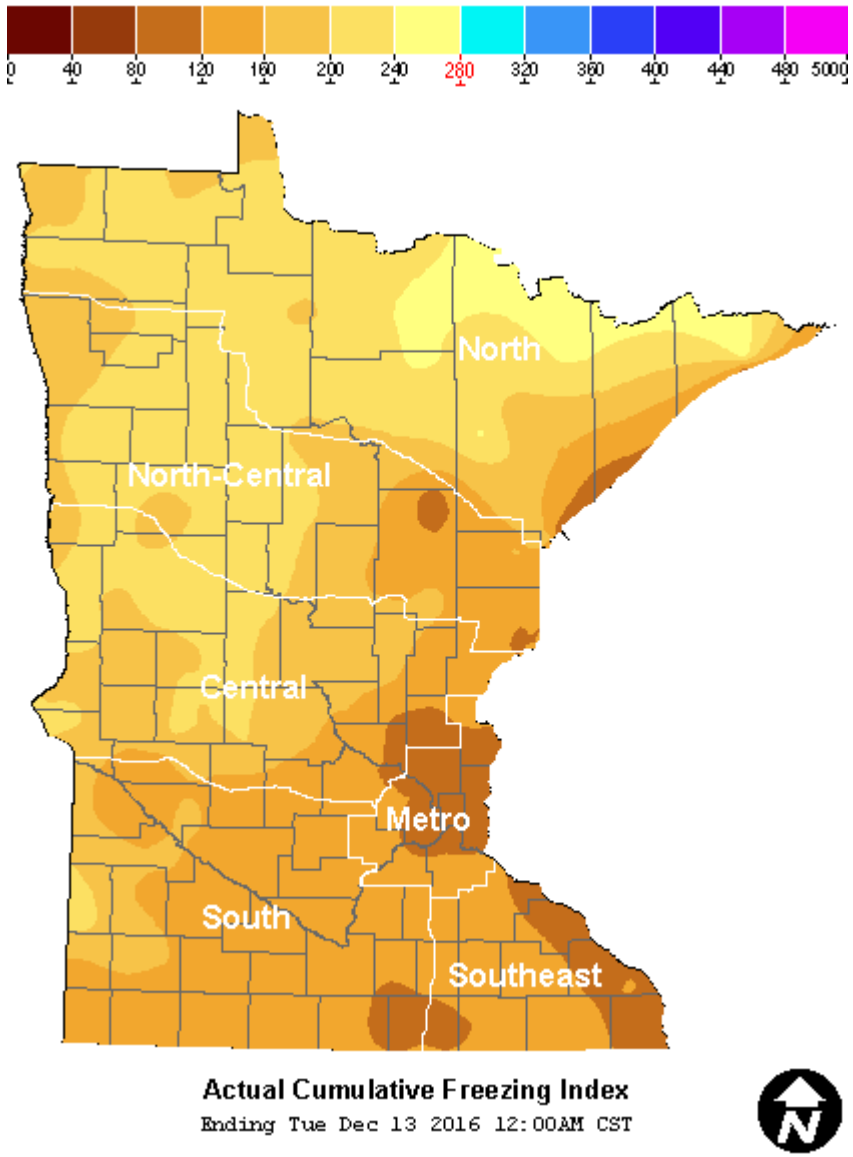
Seasonal Load Limits (SLL)

- What is Seasonal Load Limits?
  - Setting load limits for the winter and spring months
- Tech Memo: 14-10-MAT-02 Process for Seasonal Load Limit Starting and Ending Dates
  - https://techmemos.dot.state.mn.us/techmemo.aspx
- Winter Load Increases (WLI)
  - Increase GVW by ten percent for each frost zone based on freezing index model each winter
  - When the 3-day weather forecast indicates a cumulative freezing index (CFI) for a frost zone will exceed 280°F-days and the extended forecast predicts continued freezing temperatures

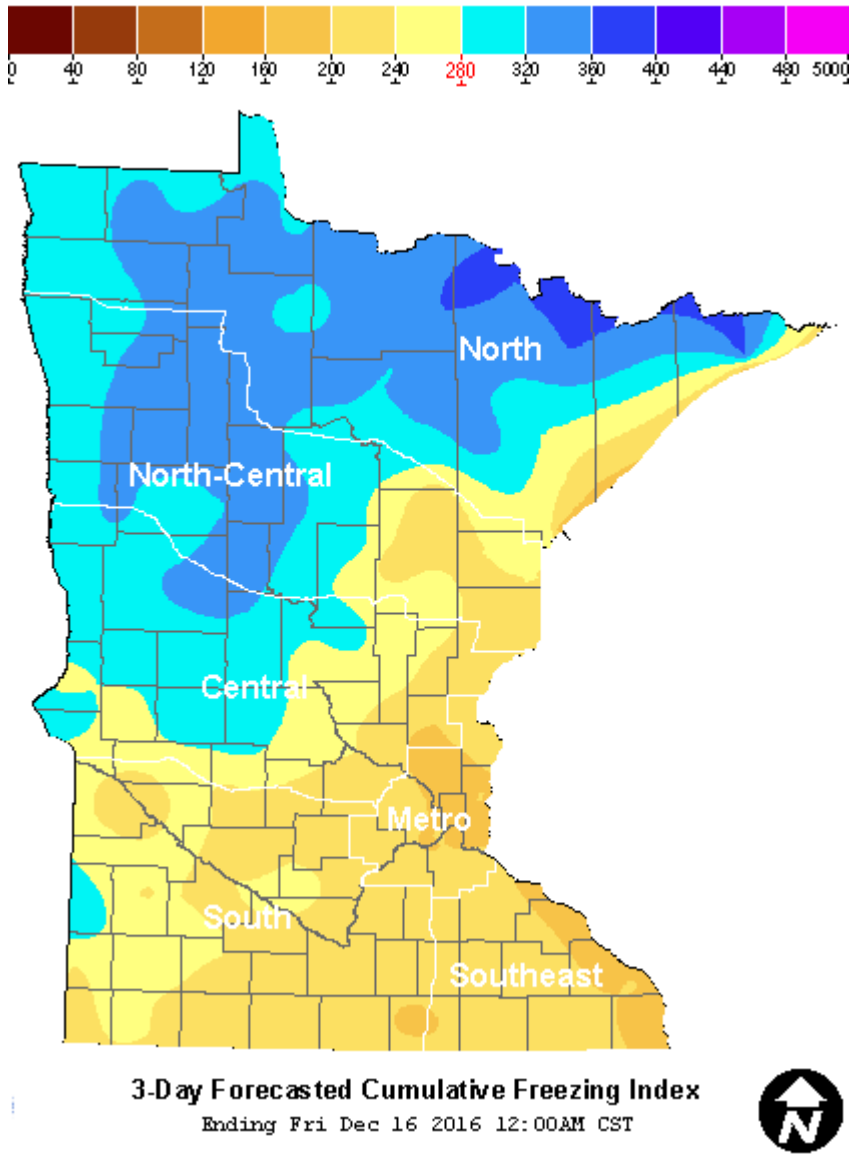
Winter Load Increases (WLI)

- $CFI_n = \sum_{i=1}^{n} \left(32°F - \frac{T_{maximum} + T_{minimum}}{2} \right)$
- CFI_n = cumulative freezing index calculated over ‘n’ days (°F-day)
- $T_{maximum}$ = Maximum daily air temperature (°F)
- $T_{minimum}$ = Minimum daily air temperature (°F)

Winter Load Increases (WLI)

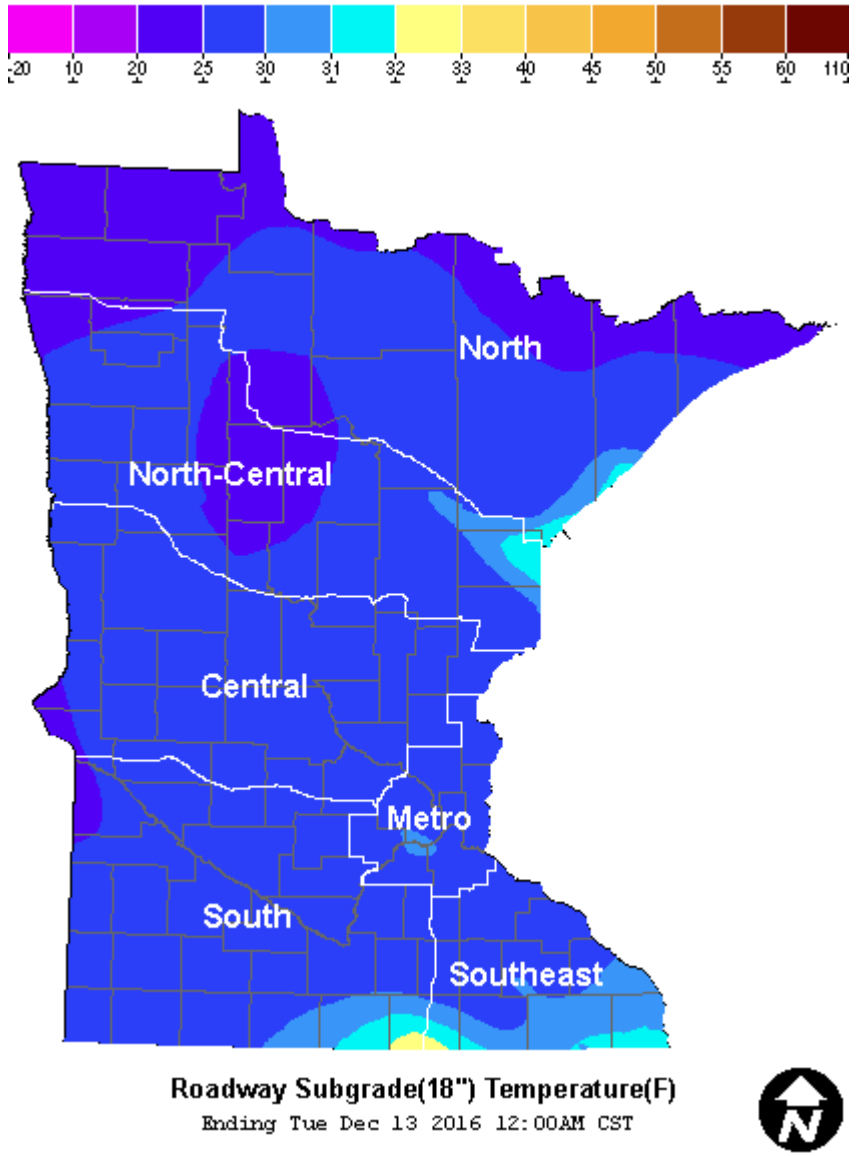


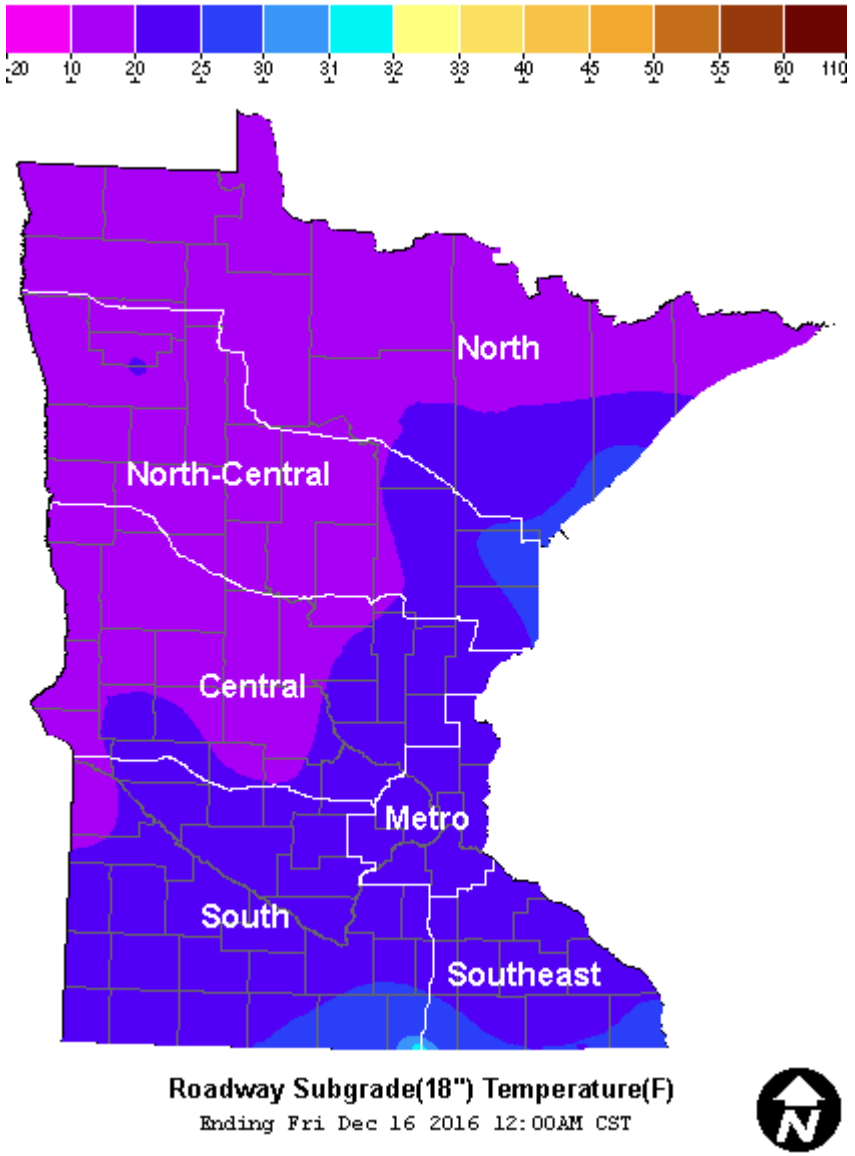
Actual Cumulative Freezing Index
Ending Tue Dec 13 2016 12:00AM CST



3-Day Forecasted Cumulative Freezing Index
Ending Fri Dec 16 2016 12:00AM CST

Winter Load Increases (WLI)



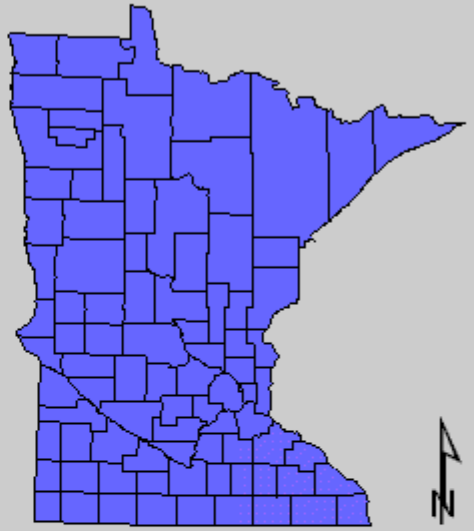


Winter Load Increases (WLI)

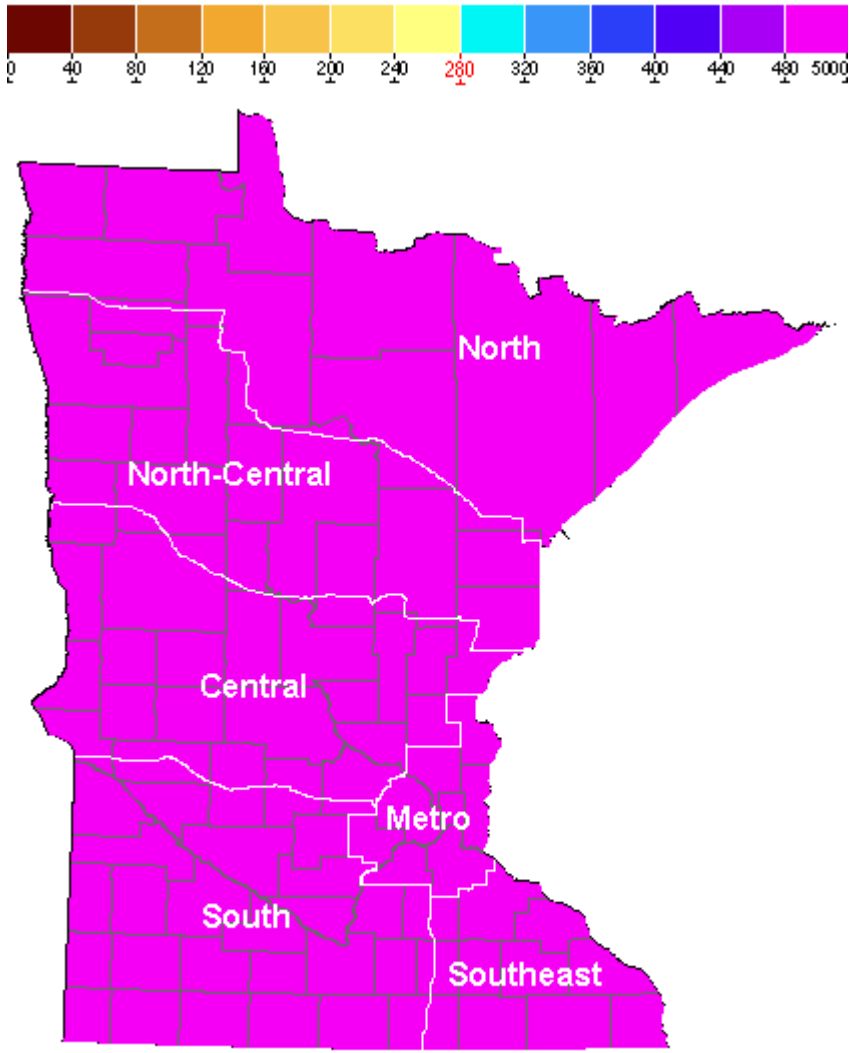
SLL Update 2016-2017

Frost Zone	Starting Date	Ending Date
Winter Load Increases (WLI)		
North	Dec 16, 2016	
North-Central	Dec 16, 2016	
Central	Dec 22, 2016	
Metro	Dec 22, 2016	Feb 17, 2017
South	Dec 22, 2016	Feb 17, 2017
Southeast	Dec 22, 2016	Feb 17, 2017
Spring Load Restrictions (SLR)		
North		
North-Central		
Central		
Metro	Feb 17, 2017	
South	Feb 17, 2017	
Southeast	Feb 17, 2017	
Middle-Range Overweight Permits		
North	May 04, 2016	
North-Central	May 03, 2016	
Central	Apr 15, 2016	
Metro	Apr 15, 2016	Feb 17, 2017
South	Apr 15, 2016	Feb 17, 2017
Southeast	Apr 15, 2016	Feb 17, 2017
Full-Summer Overweight Permits		
North	May 25, 2016	
North-Central	May 24, 2016	
Central	May 06, 2016	
Metro	May 06, 2016	Feb 17, 2017
South	May 06, 2016	Feb 17, 2017
Southeast	May 06, 2016	Feb 17, 2017

Visual Status



- Normal Legal Loads, Winter Load Increases, Middle-Range and Full-Summer Overweight Permits Available
- Normal Legal Loads, Spring Load Restrictions Imminent
- Spring Load Restrictions Enforced
- Normal Legal Loads, Middle-Range Overweight Permits Available
- Normal Legal Loads, Middle-Range and Full-Summer Overweight Permits Available



Actual Cumulative Freezing Index

Ending Tue Feb 14 2017 12:00AM CST

Spring Load Restrictions (SLR)

- MN used SLR since 1937
- A preservation strategy for weak roads in the spring
- Allows trapped water to drain and allow the pavement to recover

Spring Load Restrictions (SLR)

- Improved Spring Load Restriction Guidelines using Mechanistic Analysis
  - http://dotapp7.dot.state.mn.us/research/pdf/200018.pdf

- Found SLR were being placed 7 to 10 days to late under current method

- Found by adjusting the reference temperature in the Washington State Department of Transportation (WSDOT) thawing index equation based on air temperatures to fit Minnesota conditions.

Spring Load Restrictions (SLR)

- $CTI_n = \sum_{i=1}^{n} \ (Daily\ Thawing\ Index - 0.5 \ * Daily\ Freezing\ Index)$
- $CTI_n = \sum_{i=1}^{n} \left(\left[\frac{T_{maximum} + Tmi_{nimum}}{2} - Tre_{ference} \right] - 0.5 \ * [32°F \ - \frac{T_{maximum} + Tmi_{nimum}}{2}] \right)$
- CTI_n = cumulative thawing index calculated over ‘n’ days (°F-day)
- $T_{maximum}$ = Maximum daily air temperature (°F)
- $T_{minimum}$ = Minimum daily air temperature (°F)
- $T_{reference}$ = Reference air temperature (°F)

Spring Load Restrictions (SLR)

Date*	Reference Temperature (°F)
January 1 – January 31	32.0
February 1 – February 7	29.3
February 8 – February 14	28.4
February 15 – February 21	27.5
February 22 – February 28	26.6
March 1 – March 7	25.7
March 8 – March 14	24.8
March 15 – March 21	23.9
March 22 – March 28	23.0
March 29 – April 4	22.1
April 5 – April 11	21.2
April 12 – April 18	20.3
April 19 – April 25	19.4
April 26 – May 2	18.5
May 3 – May 9	17.6
May 10 – May 16	16.7
May 17 – May 23	15.8
May 24 – May 30	14.9
June 1 – December 31	32.0

Spring Load Restrictions (SLR)

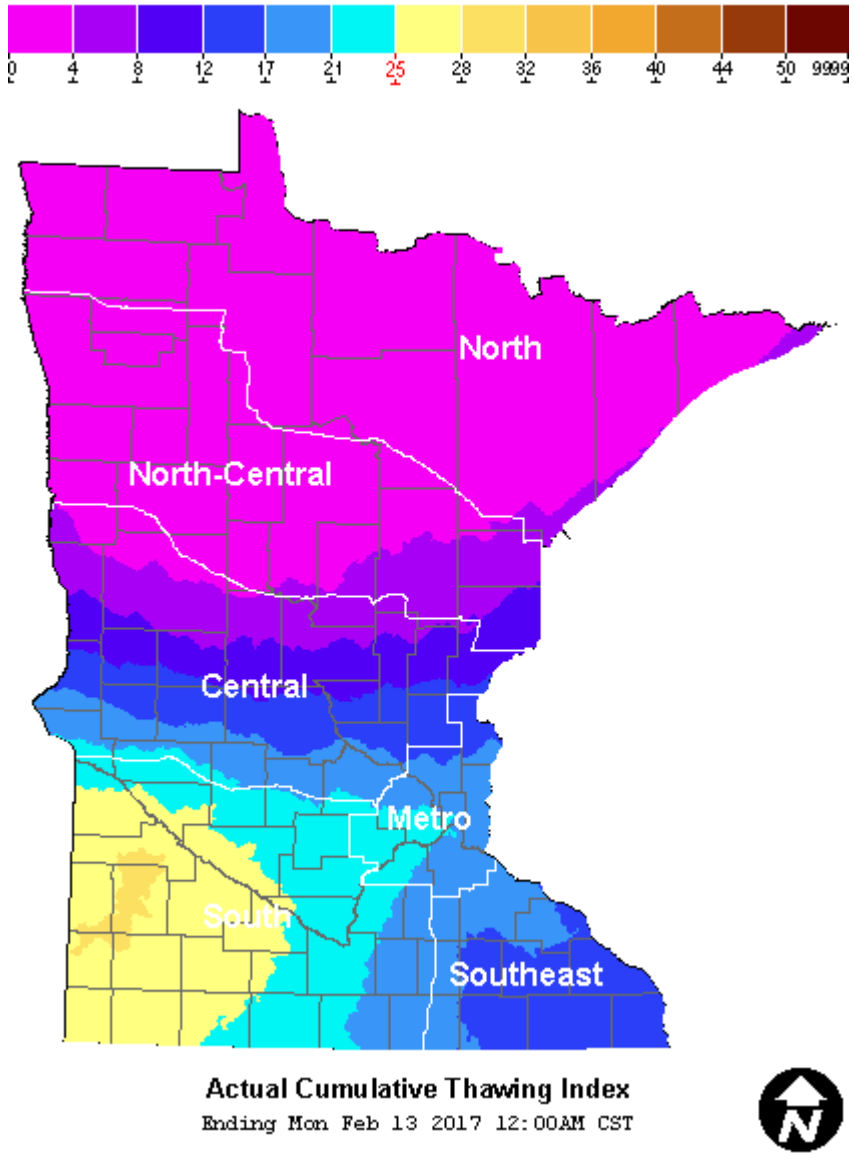
- When the 3-day weather forecast indicates a cumulative thawing index (CTI) for a frost zone will exceed 25°F-days and longer-range forecasts predict continued warmth

- Based on FWD testing across the state, a typical period for the pavement base and subgrade layers to regain sufficient strength to support heavy truck loads was eight weeks.

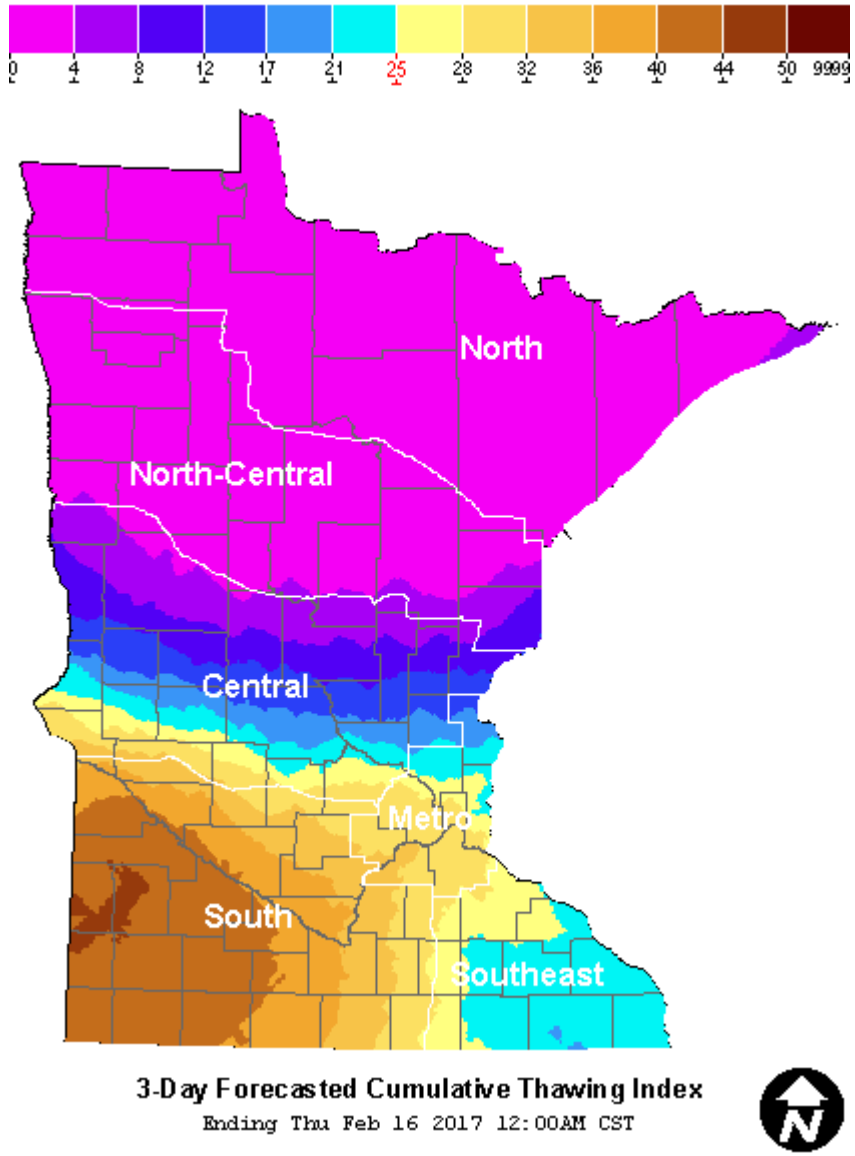
Spring Load Restrictions (SLR)

- Adopted in the spring of 1999
- Starting in spring of 2000 the state statue specified that local government will begin and end SLR in common with MnDOT, unless the roads are posted otherwise.
- In 1999 it was estimated that a 10 percent reduction in roadway life cost the Minnesota taxpayers $10,000,000 a year.

Spring Load Restrictions (SLR)

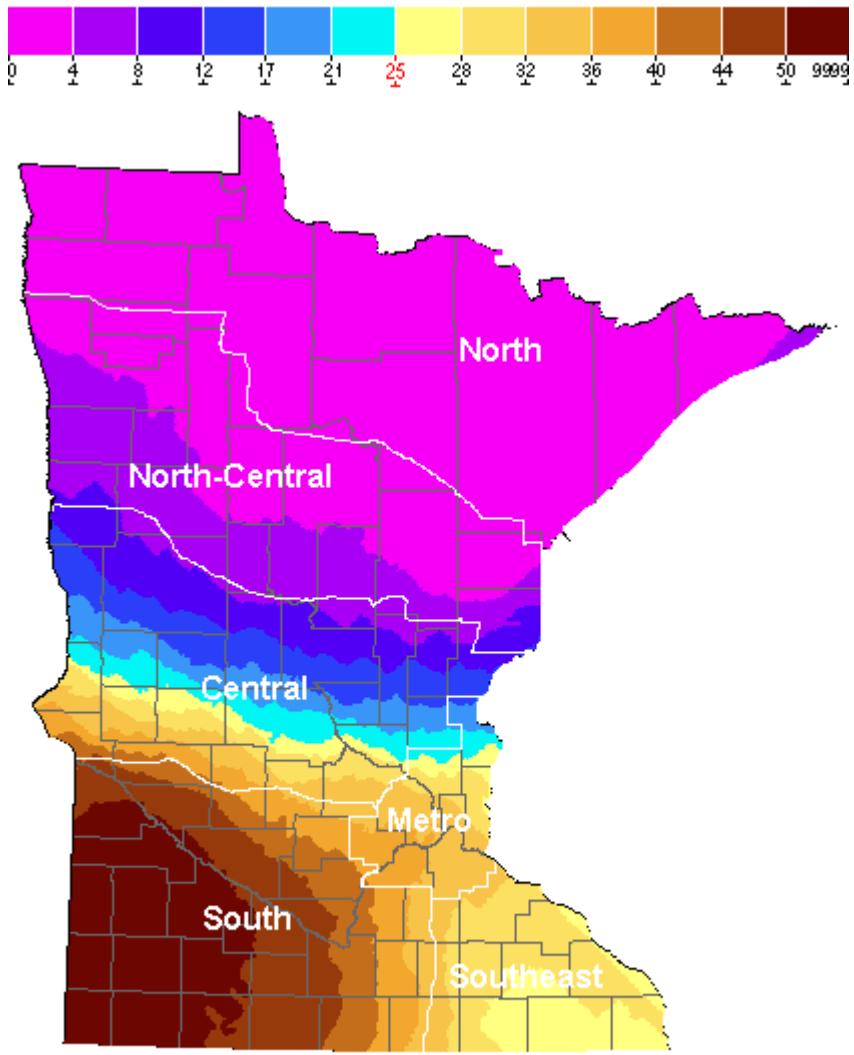


Actual Cumulative Thawing Index
Ending Mon Feb 13 2017 12:00AM CST

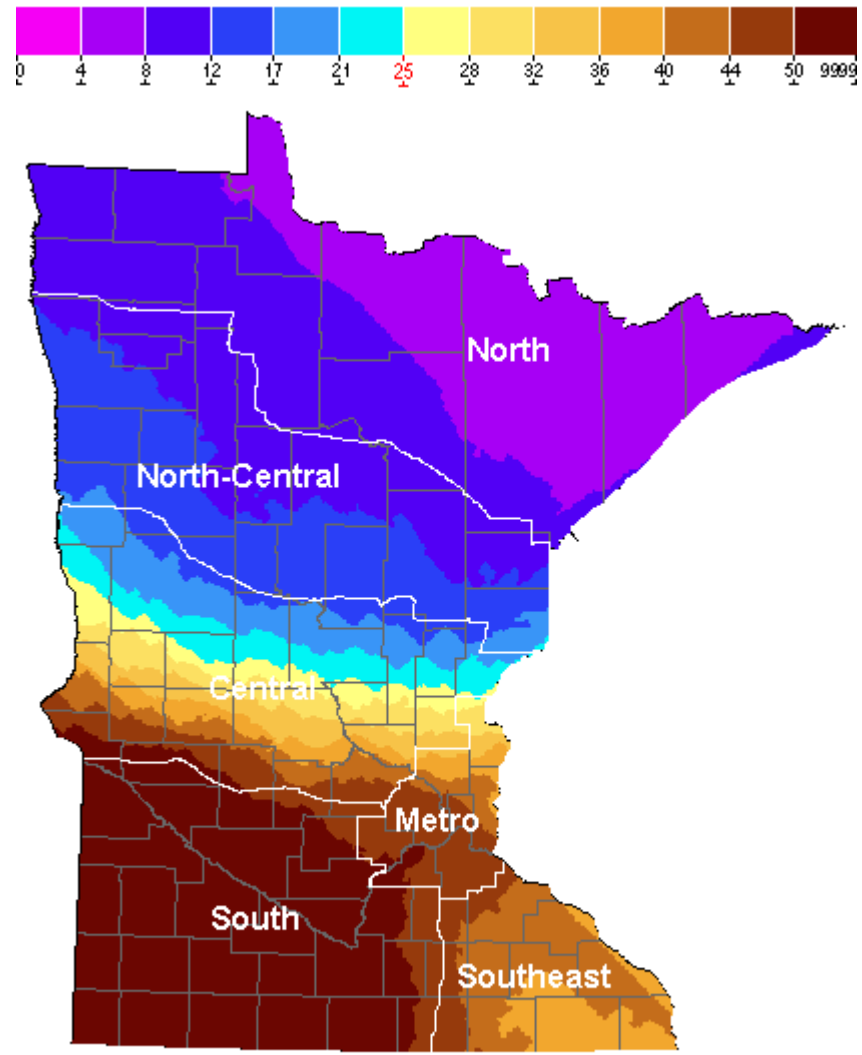


3-Day Forecasted Cumulative Thawing Index
Ending Thu Feb 16 2017 12:00AM CST

Spring Load Restrictions (SLR)



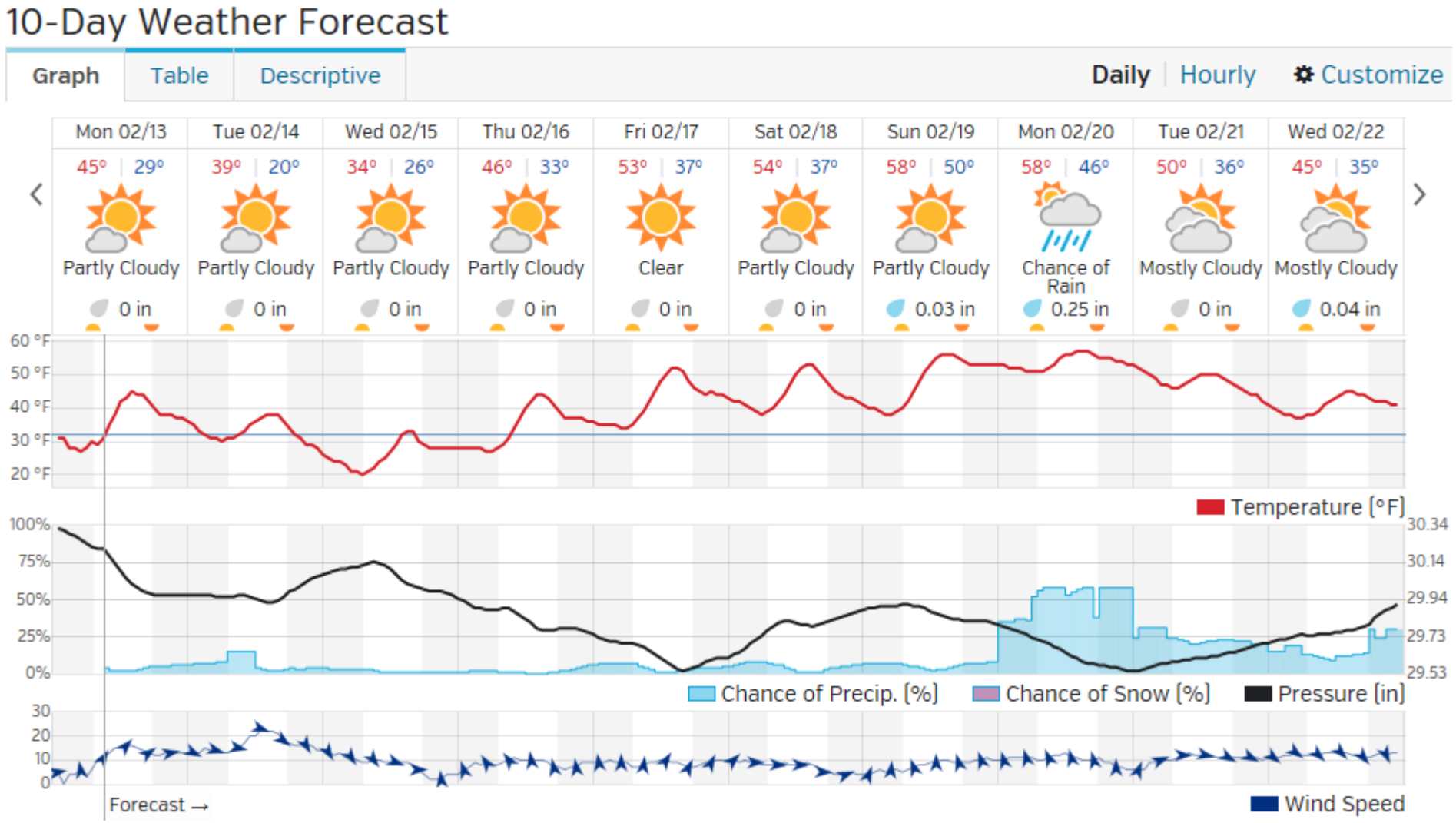
4-Day Forecasted Cumulative Thawing Index
Ending Fri Feb 17 2017 12:00AM CST



5-Day Forecasted Cumulative Thawing Index
Ending Sat Feb 18 2017 12:00AM CST

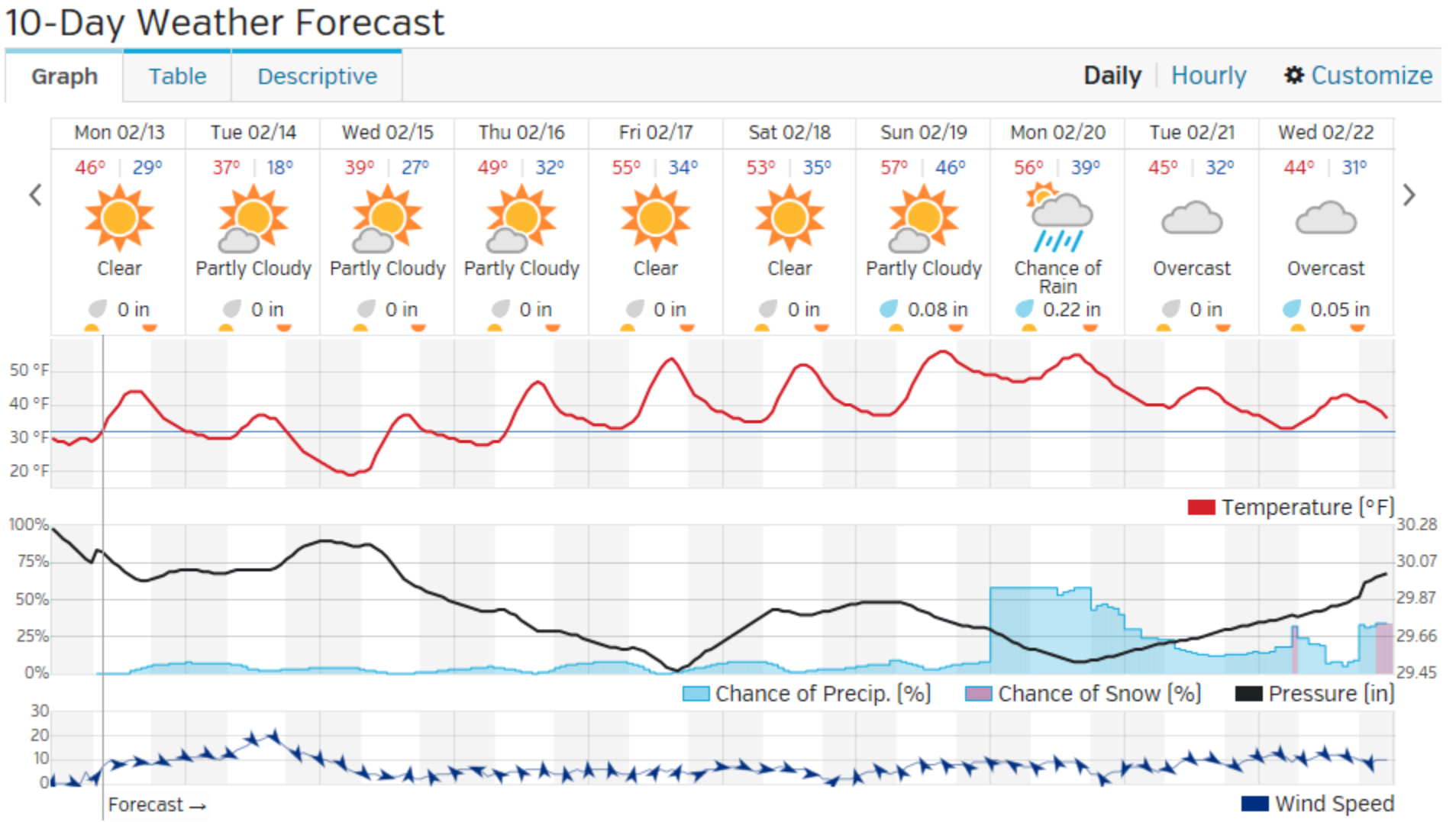
Spring Load Restrictions (SLR)

- Rochester, MN



Spring Load Restrictions (SLR)

- Willmar, MN

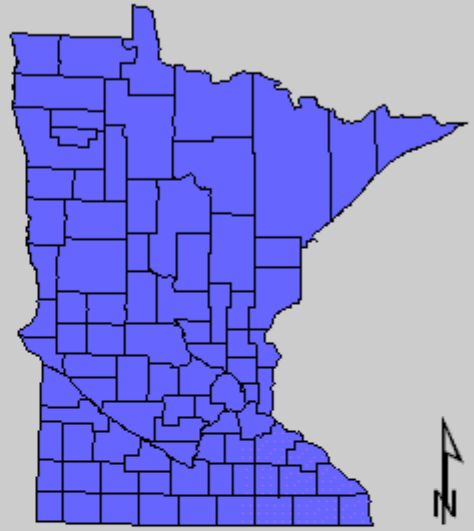


Spring Load Restrictions (SLR)

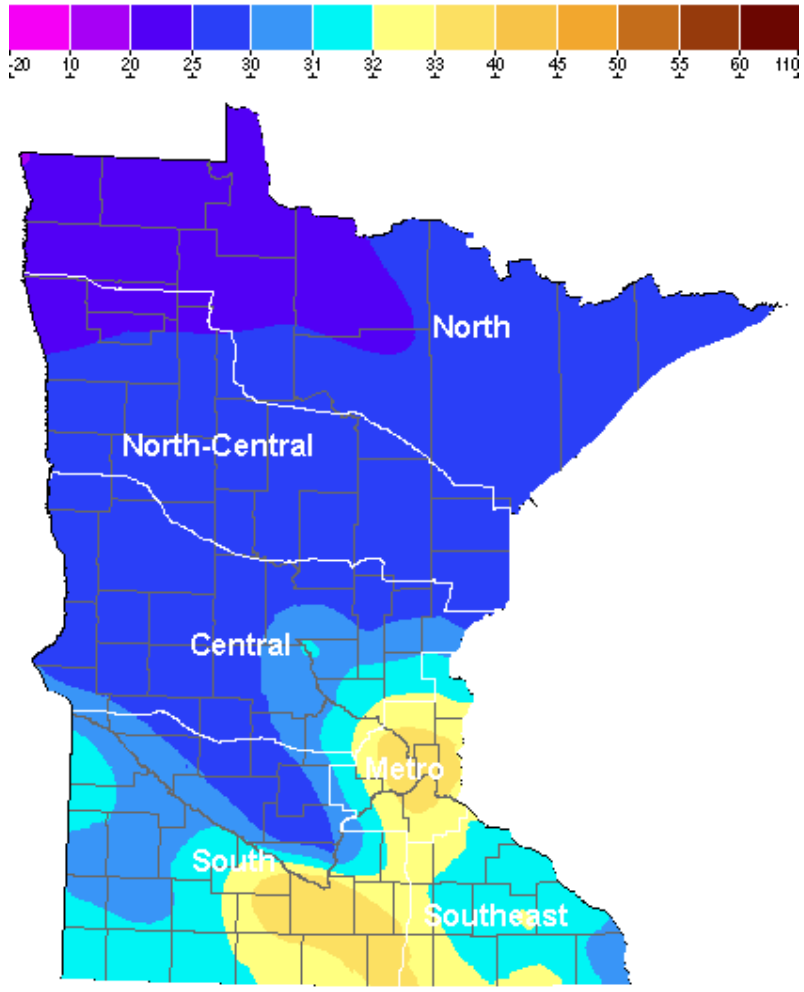
SLL Update 2016-2017

Frost Zone	Starting Date	Ending Date
Winter Load Increases (WLI)		
North	Dec 16, 2016	
North-Central	Dec 16, 2016	
Central	Dec 22, 2016	
Metro	Dec 22, 2016	Feb 17, 2017
South	Dec 22, 2016	Feb 17, 2017
Southeast	Dec 22, 2016	Feb 17, 2017
Spring Load Restrictions (SLR)		
North		
North-Central		
Central		
Metro	Feb 17, 2017	
South	Feb 17, 2017	
Southeast	Feb 17, 2017	
Middle-Range Overweight Permits		
North	May 04, 2016	
North-Central	May 03, 2016	
Central	Apr 15, 2016	
Metro	Apr 15, 2016	Feb 17, 2017
South	Apr 15, 2016	Feb 17, 2017
Southeast	Apr 15, 2016	Feb 17, 2017
Full-Summer Overweight Permits		
North	May 25, 2016	
North-Central	May 24, 2016	
Central	May 06, 2016	
Metro	May 06, 2016	Feb 17, 2017
South	May 06, 2016	Feb 17, 2017
Southeast	May 06, 2016	Feb 17, 2017

Visual Status



- Normal Legal Loads, Winter Load Increases, Middle-Range and Full-Summer Overweight Permits Available
- Normal Legal Loads, Spring Load Restrictions Imminent
- Spring Load Restrictions Enforced
- Normal Legal Loads, Middle-Range Overweight Permits Available
- Normal Legal Loads, Middle-Range and Full-Summer Overweight Permits Available



Roadway Subgrade(18") Temperature(F)

Ending Mon Feb 13 2017 12:00AM CST

Spring Load Restrictions (SLR)

- In 2002, Spring Load Restrictions were placed in late February in most of the state. March was really cold that year. The North Zone didn't get restricted until over 4 weeks later.

	2006		2005		2004		2003		2002	
	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
North	25-Mar	15-May	26-Mar	20-May	8-Mar	3-May	15-Mar	10-May	27-Mar	22-May
North-Central	24-Mar	15-May	26-Mar	20-May	8-Mar	3-May				
Central	10-Mar	5-May	25-Mar	12-May	1-Mar	26-Apr	15-Mar	10-May	19-Feb	16-Apr
Metro	8-Mar	22-Apr	23-Mar	4-May	27-Feb	19-Apr	15-Mar	2-May	18-Feb	15-Apr
South	8-Mar	22-Apr	23-Mar	4-May	27-Feb	19-Apr	15-Mar	2-May	18-Feb	15-Apr
Southeast	8-Mar	22-Apr	23-Mar	4-May	27-Feb	19-Apr	15-Mar	2-May	18-Feb	15-Apr

Seasonal Load Limits (SLL)

- http://dotapp7.dot.state.mn.us/research/seasonal_load_limits/sllindex.asp

- Use browser to search for “seasonal load limits mn”

VIRTUAL ROADWAY WEATHER INFORMATION SYSTEM FOR SPRING THAW AND WINTER ICING PREDICTIONS

TRB WEBINAR: SPRINGTIME DAMAGE TO ROADS AND SEASONAL LOAD LIMITS

FEBRUARY 22,2017

GREGG LARSON
PRINCIPAL ENGINEER, APPLIED RESEARCH ASSOCIATES

PAVEMENT CLIMATE MODELING BACKGROUND

- DEVELOPER OF THE INTEGRATED CLIMATIC MODEL AT UNIVERSITY OF ILLINOIS IN THE 1980S.
- DEVELOPER OF THE NCHRP MECHANISTIC EMPIRICAL PAVEMENT DESIGN GUIDE.
- DEVELOPER OF AASHTOWARE ME-DESIGN SOFTWARE
- DEVELOPER OF THE ARA'S VRWIS SOFTWARE

WHAT IS VRWIS

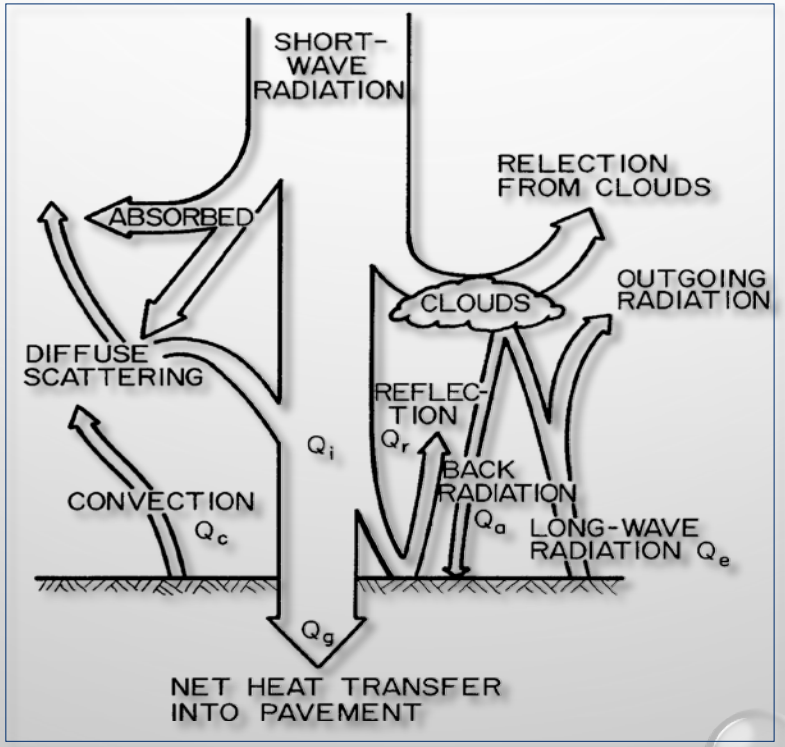
- VIRTUAL ROADWAY WEATHER INFORMATION SYSTEM (VRWIS) IS A WEB-BASED SYSTEM THAT TELLS YOU THE PAVEMENT TEMPERATURE AND FROST CONDITIONS IN REAL TIME AND IN THE NEAR FUTURE.
- VRWIS DOES NOT USE IN-PAVEMENT SENSORS, RATHER USES PAVEMENT PROPERTIES AND WEATHER DATA TO MODEL THE TEMPERATURES THROUGHOUT THE ENTIRE PAVEMENT SECTION
- THE VRWIS FREEZE-THAW FEATURE PROVIDES THE FROST PENETRATION AND THAWING IN THE PAVEMENT SECTION, WHICH IS USEFUL INFORMATION FOR DETERMINING LOAD RESTRICTIONS DURING SPRING THAWS
- THE VRWIS SYSTEM USES THE SAME INTEGRATED CLIMATIC MODEL FOR TEMPERATURE AND MOISTURE PREDICTIONS AS THE AASHTOWARE ME-DESIGN SOFTWARE.

VRWIS FEATURES

- ONLY COMMERCIALLY AVAILABLE PROGRAM TO PROVIDE **ROADWAY ICING** AND **SUBGRADE FREEZE-THAW** PREDICTIONS.
- **INTUITIVE GRAPHICS** TO SIGNAL THE NEXT ICING OR FREEZE-THAW EVENT
- POWERFUL ZOOM AND VISUALIZATION FEATURES USING **GOOGLE EARTH®** AND **GOOGLE MAPS**
- CURRENT AND FORECASTED WEATHER DATA FROM WEATHER UNDERGROUND, A FORECASTING SYSTEM THAT LEVERAGES DATA FROM **42,000 WEATHER STATIONS** FROM ACROSS THE COUNTRY
- **HOURLY UPDATES** OF ALL DATA, INCLUDING FORECASTS OF PAVEMENT SURFACE TEMPERATURES, ROADWAY ICING EVENTS, AND SUBGRADE FROST AND THAW DEPTHS.

INTEGRATED CLIMATIC MODEL (ICM)

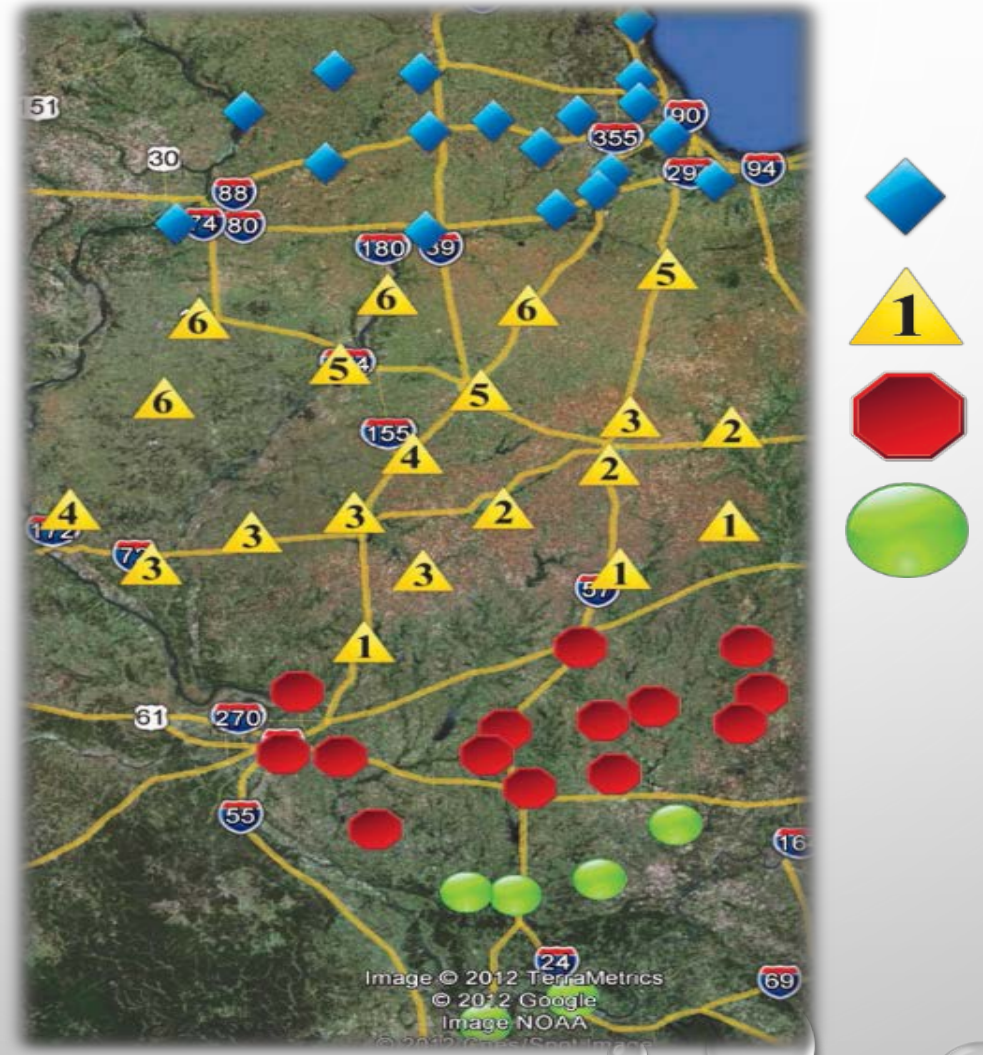
The EICM is a one-dimensional forward finite difference heat and moisture flow model that simulates changes in pavement and subgrade properties. At the pavement surface it incorporates patterns of rainfall, solar radiation, cloud cover, wind speed, and air temperature.



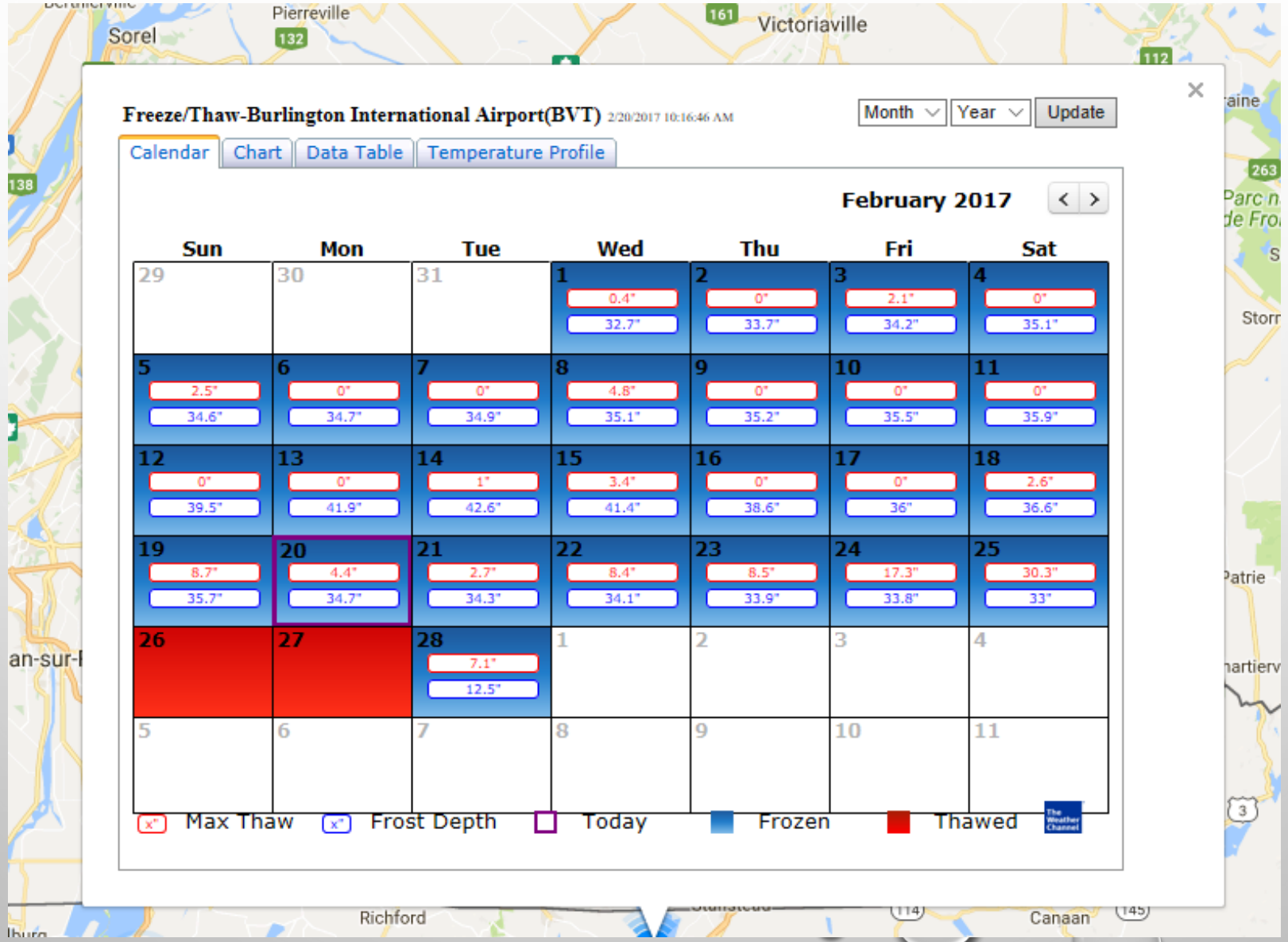
WHAT TURNS THE ICM INTO VRWIS

- USE OF THE WEATHER UNDERGROUND DATABASE OF HISTORICAL AND FORECAST DATA.
- HOURLY WEATHER FORECAST FOR 3, 7 AND 14 DAYS.
- ABILITY TO RUN 1000S OF ICM ANALYSES ON AN HOURLY BASIS.

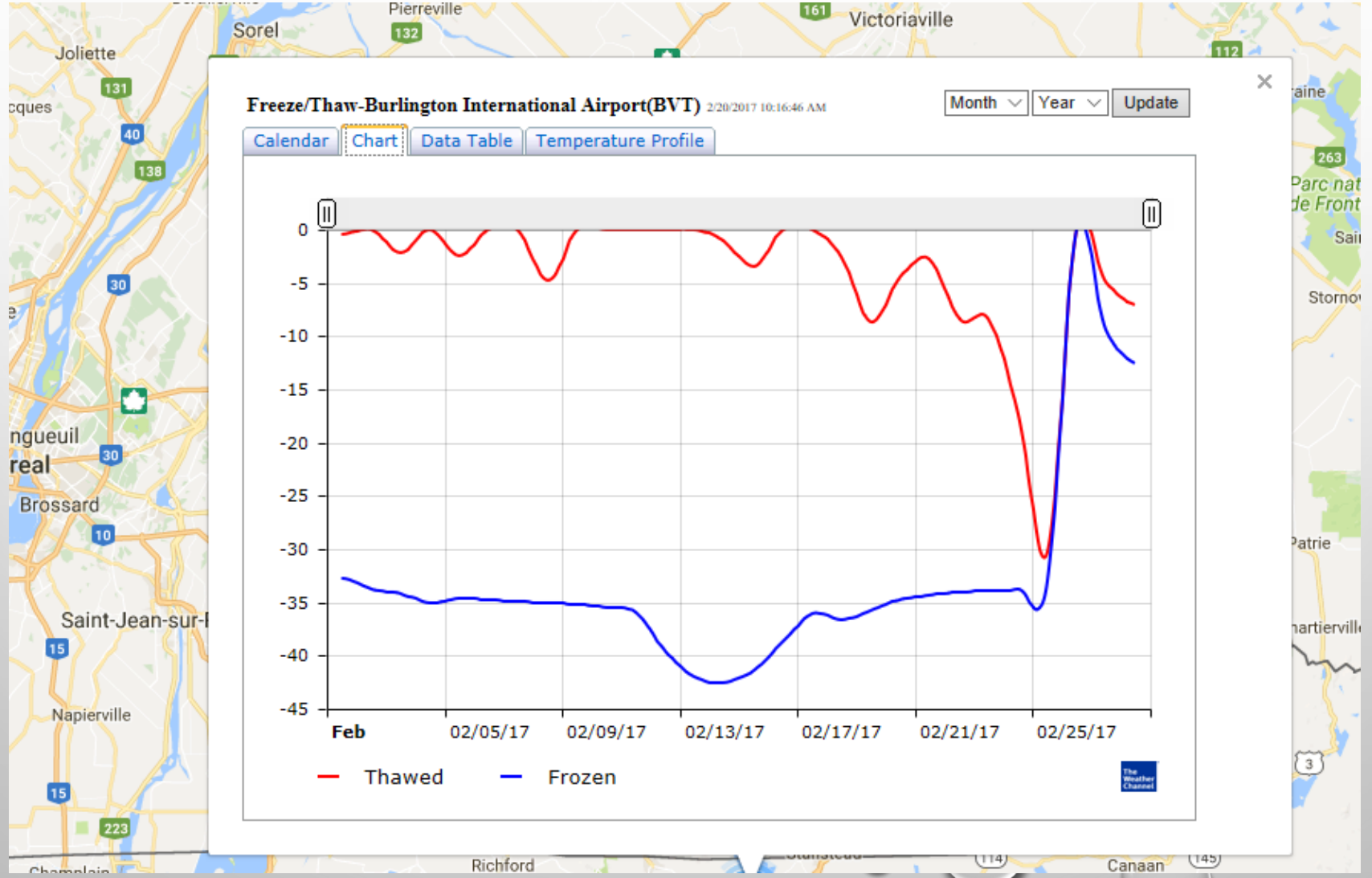
VRWIS THAW PREDICTIONS



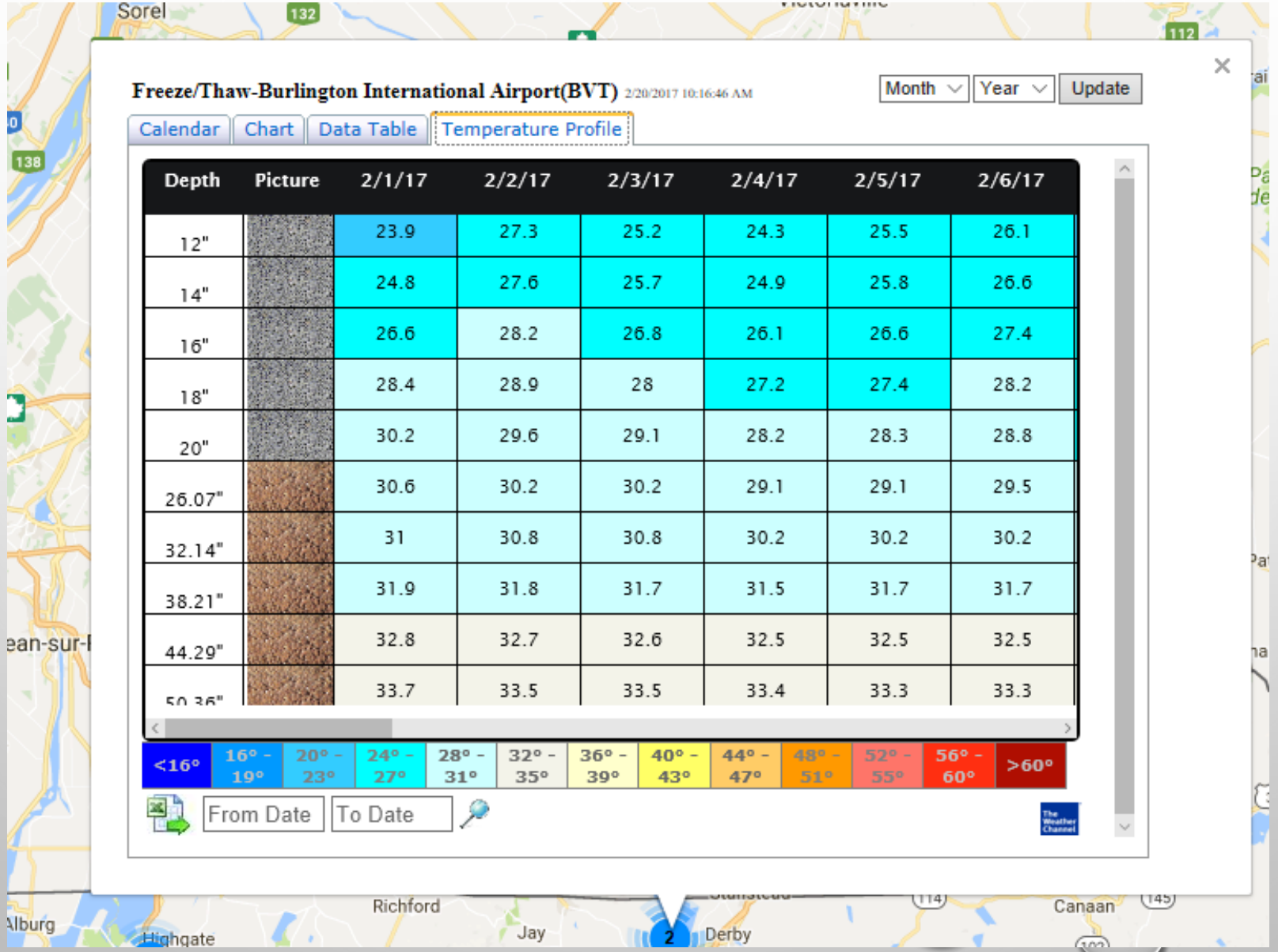
VRWIS THAW PREDICTIONS



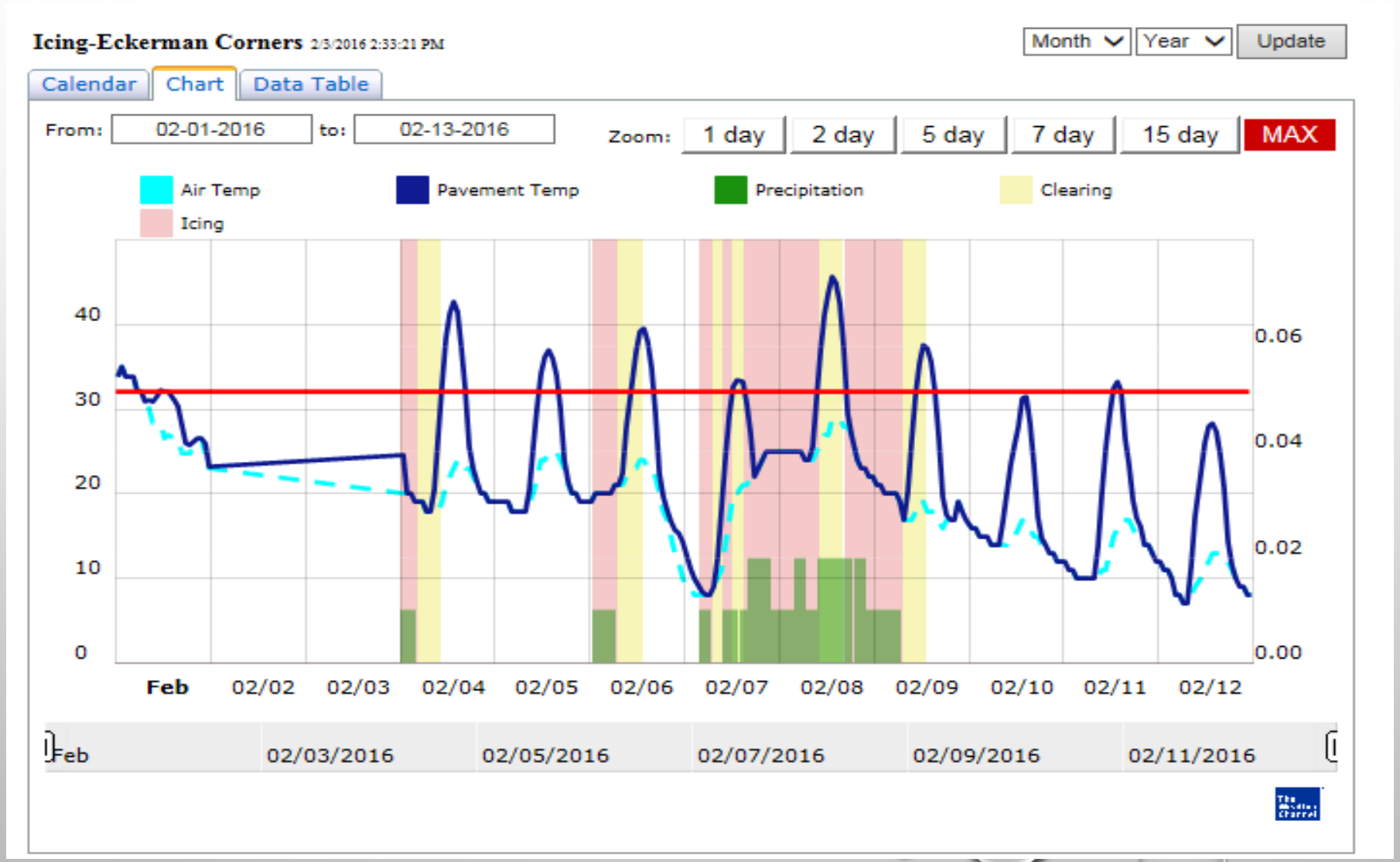
VRWIS THAW PREDICTIONS



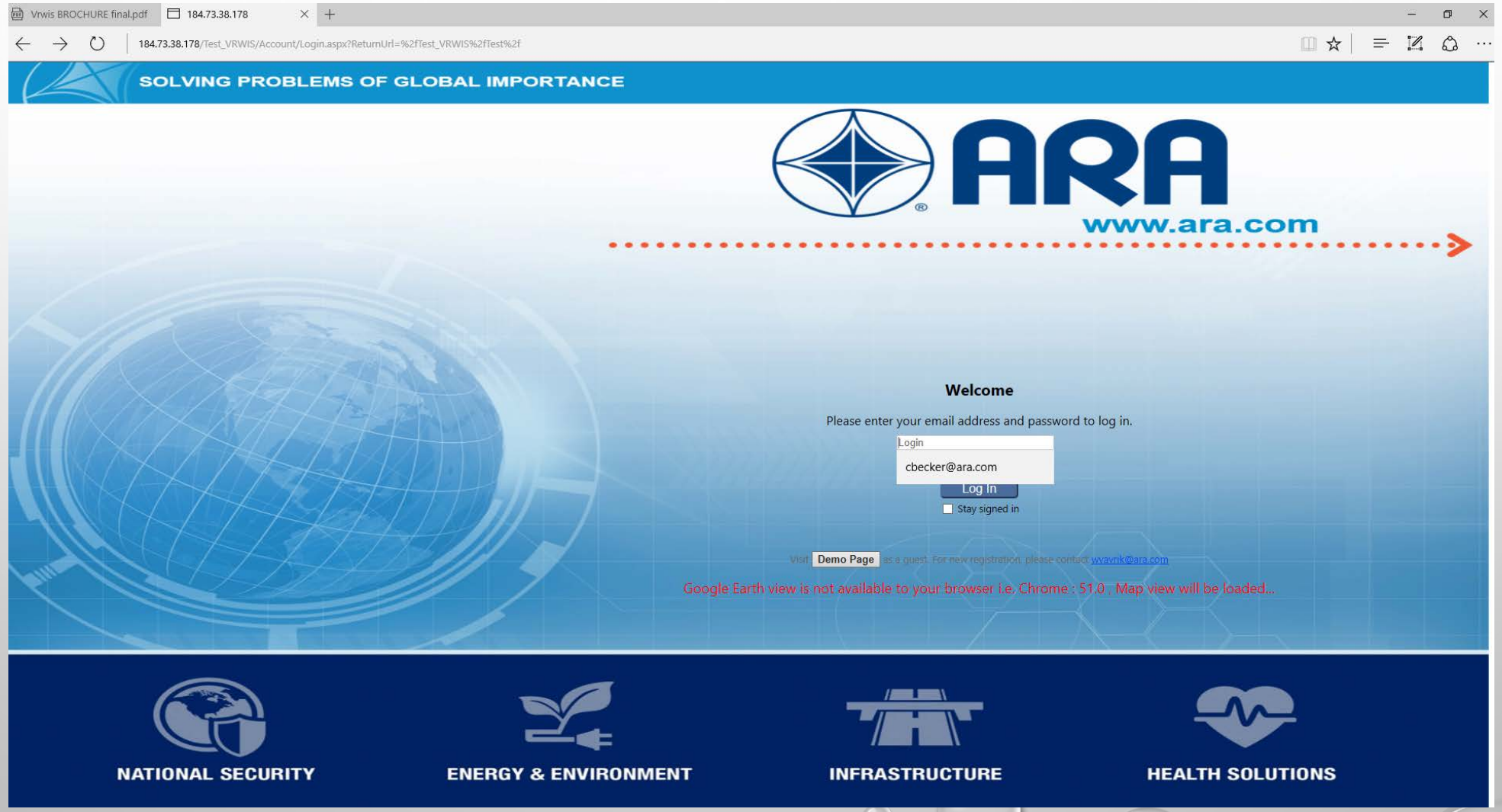
VRWIS THAW PREDICTIONS



VRWIS ICING PREDICTIONS



LIVE SOFTWARE DEMONSTRATION



VISIT THE VRWIS DEMONSTRATION PAGE

CLICK THE DEMO BUTTON AT

HTTP://V-RWIS.COM/TEST_VRWIS/TEST/