IOWA STATE UNIVERSITY
Dept. of Civil, Construction & Envr. Engineering

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON
Dept. of Civil & Envr. Engineering

Determining Pavement Design Criteria for Recycled Aggregate Base and Large Stone Subbase

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MnDOT Project TPF-5(341)

Kick of Meeting

February 1st 2018

RESEARCH TEAM

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  - Assistant Professor – Department of Civil & Environmental Engineering
- Co-Principal Investigator – Halil Ceylan
  - Professor– Department of Civil, Construction & Environmental Engineering
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  - PhD Student – Department of Civil, Construction & Environmental Engineering

University of Wisconsin-Madison

- Co-Principal Investigator – William Likos
  - Professor – Department of Civil and Environmental Engineering
- Co-Principal Investigator – Tuncer B. Edil
  - Professor Emeritus – Department of Civil and Environmental Engineering

NRRA Members (Agency Partners)

- MnDOT
- Caltrans
- MDOT
- Illinois DOT
- LRRB
- MoDOT
- WiscDOT

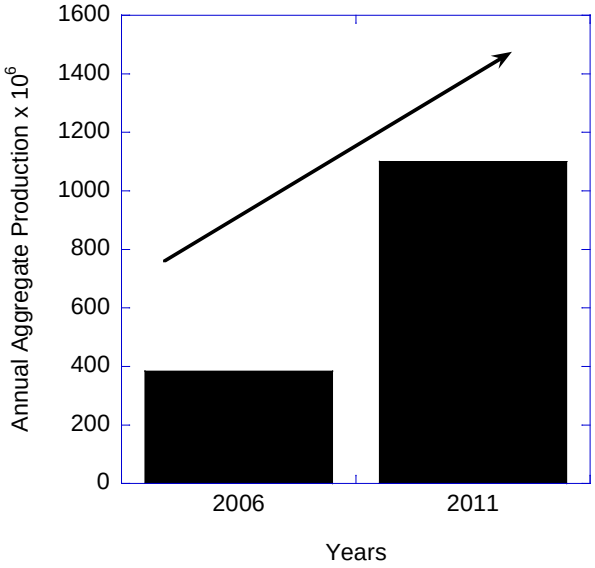
NRRA Members (Industry Partners)

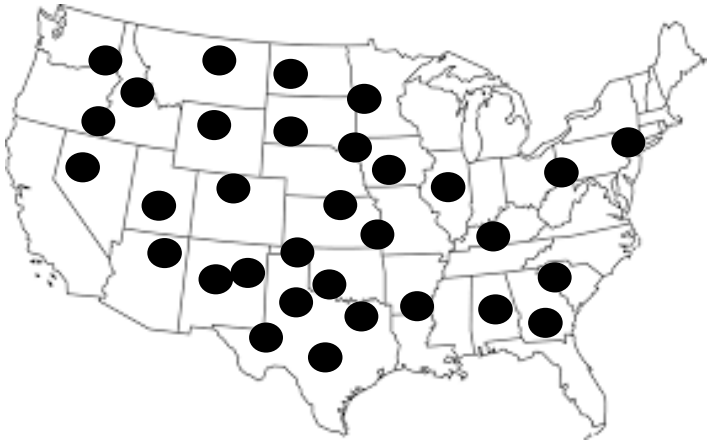
- Aggregate and Ready Mix (Association of MN)
- APA
- Braun Intertec
- CPAM
- Diamond Surface Inc
- Flint Hills Resources
- IGGA
- MIDSTATE (Reclamation and Trucking)
- MN Asphalt Pavement Association
- Minnesota State University
- NCP Tech Center
- Road Scanners
- University of Minnesota-Duluth
- University of New Hampshire
- MATHY
- 3M
- Paviasystems
- Michigan Tech
- University of Minnesota
- NCAT
- GSE Environmental
- HELIX
- Ingios
- WSB
- Cargill
- PITT Swanson Engineering
- INFRASENSE
- Collaborative Aggregates LLC
- American Engineering Testing, Inc.
- CTIS
- ARRA
- 1st
- O-BASF
- North Dakota State University
- All States Materials Group

OUTLINE

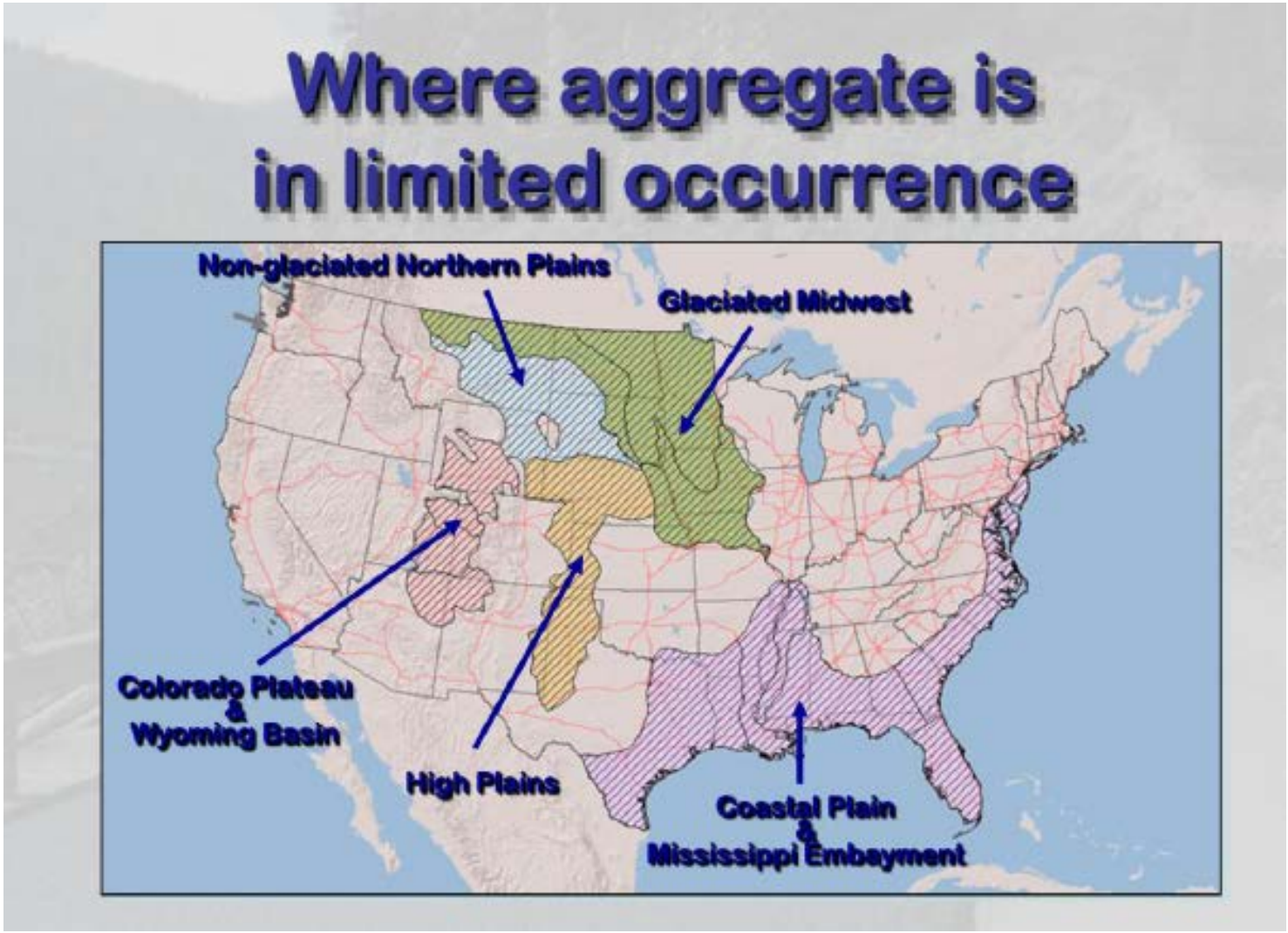
- Problem Statement
- Background
- Objectives
- Research Plan
- Products and Deliverables
- Agency Assistance

PROBLEM STATEMENT





PROBLEM STATEMENT



PROBLEM STATEMENT

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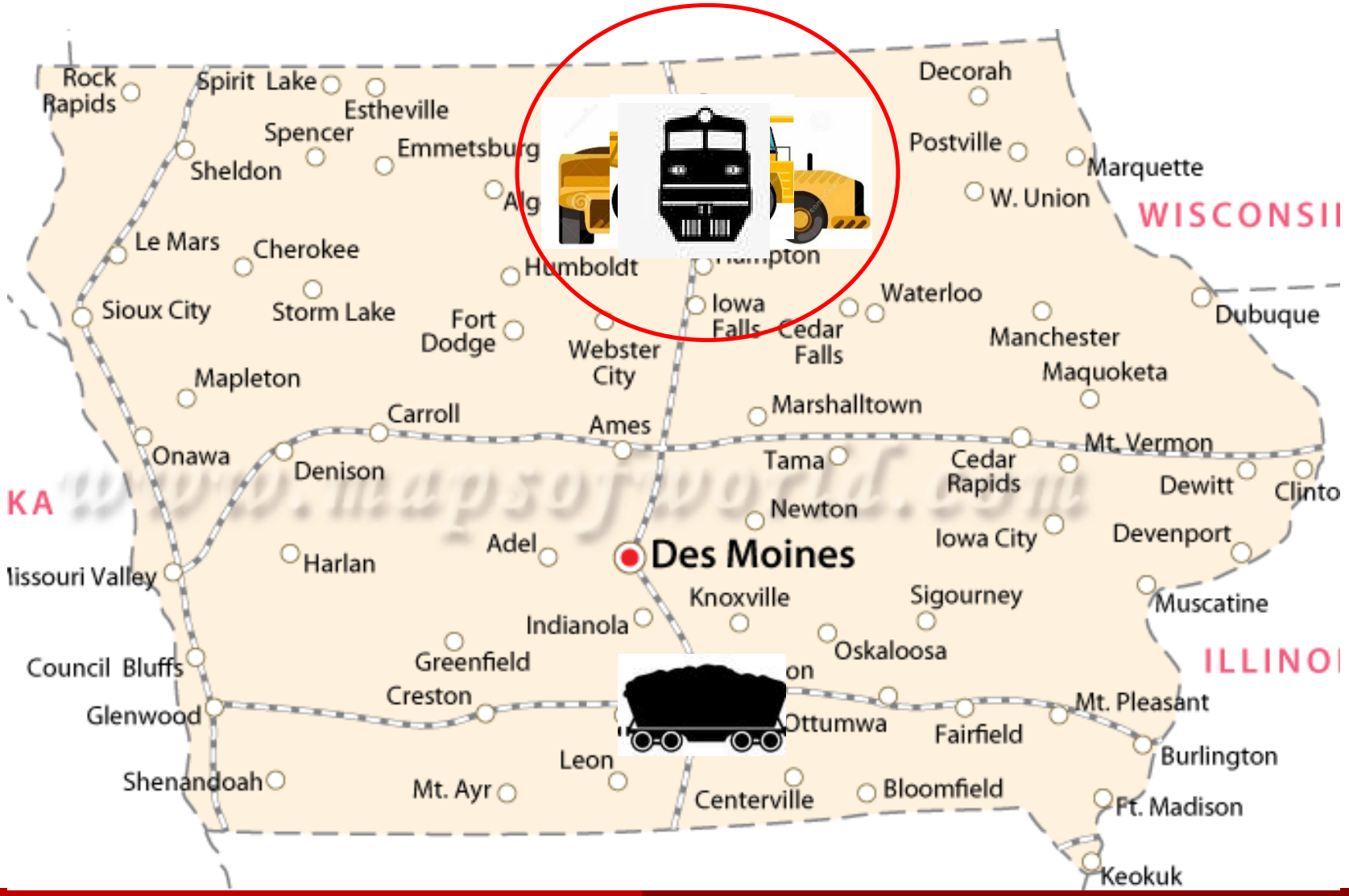


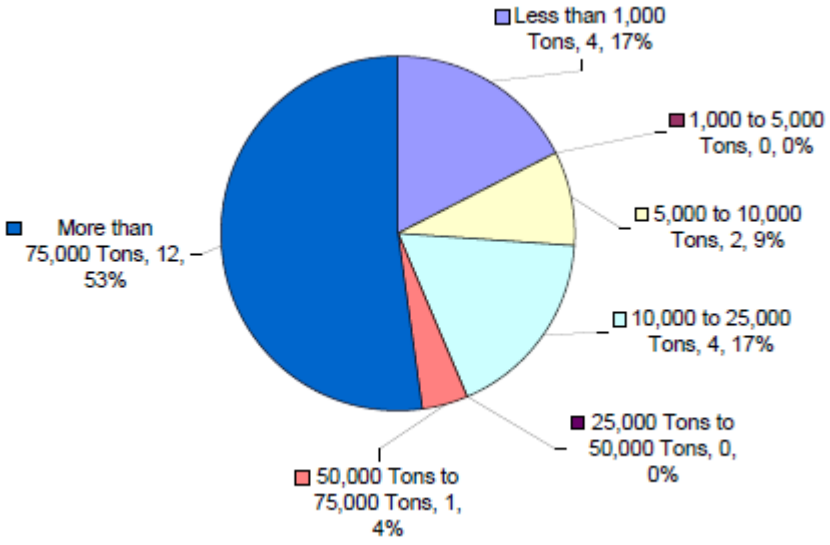
PROBLEM STATEMENT

- 2 billion tons/year aggregate produced (FWHA 2004)
- 200 million tons/year of RCA and 90 million tons/year of RAP generated (FHWA 2011)

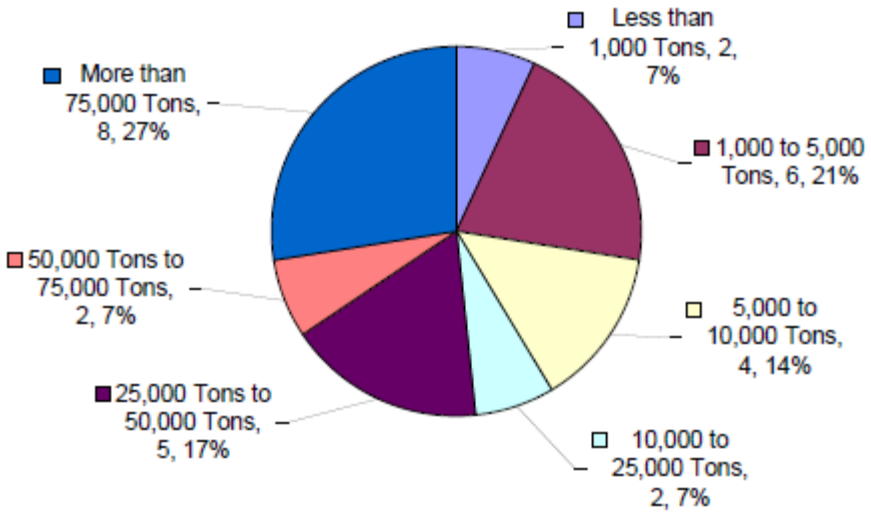
http://www.gratechcompanyltd.com/aggregate.htm

PROBLEM STATEMENT

Annual Quantity Used



RAP



RCA

From Edil et al. (2012)

PROBLEMS WITH USE OF RECYCLED BASE MATERIAL AND LARGE STONE SUBBASE

- Limited information about the performance of RCA and RAP built on LSSB.
  - Different mixtures of RCA-RAP
  - Freeze-thaw durability
  - Frost heave-thaw weakening settlement
  - Stiffness
- No pavement design guideline for pavements built with RCA, RAP on LSSB.
- Verify available methods to predict stiffness and strength of these materials with simple index properties.

OBJECTIVES

1st Goal – Determine the field and laboratory performance

- FWD, LWD, DCP, Intelligent compaction (IC) data
- Unsaturated characteristics, index properties

2nd Goal – Develop a method to estimate the stiffness and permeability

- Percent crushing of recycled aggregates and LSSB
- Sphericity, angularity, and surface texture of aggregates
- Gravel, sand, fines content, gravel-to-sand ratio, D_{10}, D_{30}, D_{50}, D_{60}

3rd Goal – Prepare a pavement design and construction specification

- Performance
- Cost benefits
- Life cycle cost

Overview of Research Plan

- **Task 1 –** Literature Review and Recommendations
- **Task 2 –** Tech Transfer “State of Practice”
- **Task 3 –** Construction Monitoring and Reporting
- **Task 4 –** Laboratory Testing
- **Task 5 –** Performance Monitoring and Reporting and Climatic Effects
- **Task 6 –** Instrumentation
- **Task 7 –** Pavement Design Criteria
- **Task 8&9 –** Draft/Final Report

Task 1

Task 1 – Literature Review and Recommendations

Conduct a comprehensive literature review on:

- Current recycling practices of State DOTs from different climatic regions
- Previous laboratory and field investigations on the use of RCA, RAP, and LSSB
- In depth review on a recently published FHWA report (Edil 2012)

Task 2

Task 2 – Tech Transfer “State of Practice”

Prepare a report:

- To guide local county engineers and state DOTs on how to apply recommended methods and designs to built highway pavement foundation systems with recycled materials and LSSB.
- Specific information will be provided about the mixtures of RCA-RAP-VA, RCA-VA, and LSSB built with different thickness and geosynthetics.
- CP Tech Center will assist to the research team

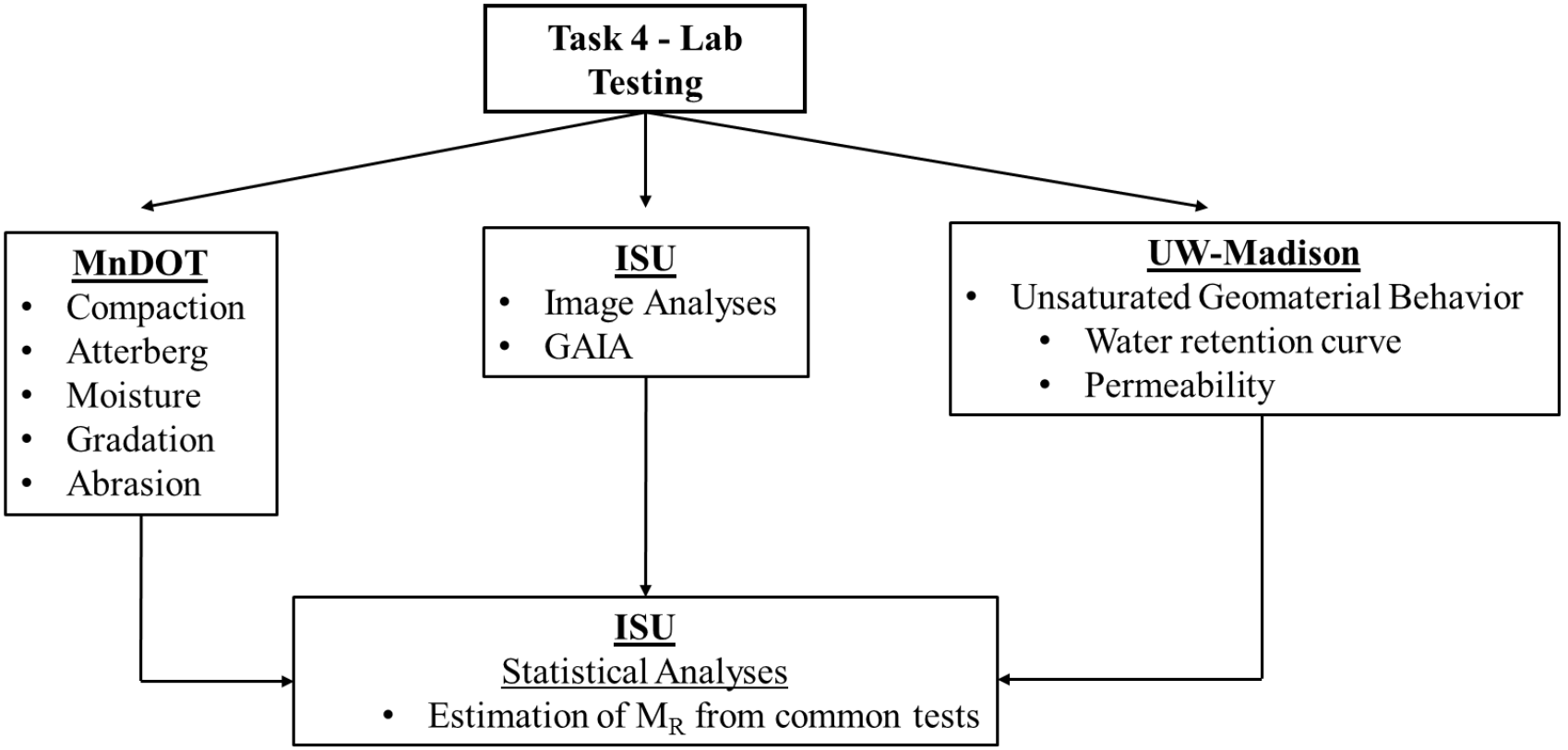
Task 3

Task 3 – Construction Monitoring and Reporting

South Side Cells (West to East)											
Recycled Unbound Base					Large Subbase		Large Subbase and Geogrid Cells				
185	186	87	188	189	127	227	328	428	528	628	728
3.5" HMA	3.5" HMA	4" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA	3.5" HMA
12" Coarse RCA	12" Fine RCA	4" Mesabi Ballast	12" Recycled Aggregate Base Class 6	12" Recycled Aggregate Base Class 6	6" Class 6	6" Class 6	6" Class 6	6" Class 5Q	6" Class 5Q	6" Class 5Q	6" Class 5Q
3.5" Select Granular Borrow	3.5" Select Granular Borrow	CA-15	3.5" Select Granular Borrow	3.5" Select Granular Borrow	18" Large Subbase 1 Lift	18" Large Subbase 2 Lift	9" Large Subbase	Grid 1 9" Large Subbase	Fabric Grid 1 9" Large Subbase	Fabric Grid 2 9" Large Subbase	Grid 2 9" Large Subbase
Sand	Sand	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay

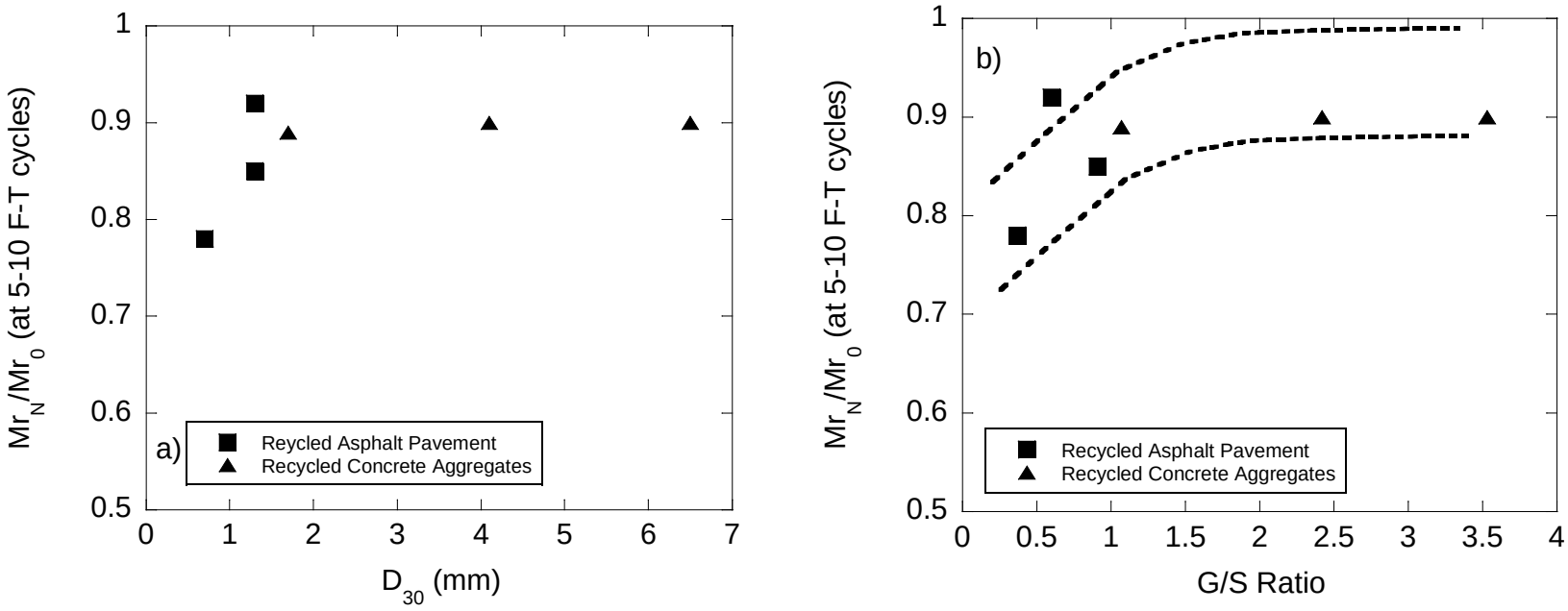
Task 4

Task 4 – Laboratory Testing



Task 4

Task 4 – Example of Freeze-Thaw Behavior of Recycled Materials



Normalized resilient modulus of recycled concrete aggregate and recycled asphalt pavement at 5-10 F-T cycles (a) vs D_{30}, (b) vs G/S ratio (from Rosa et al. 2017).

Task 5 & 6

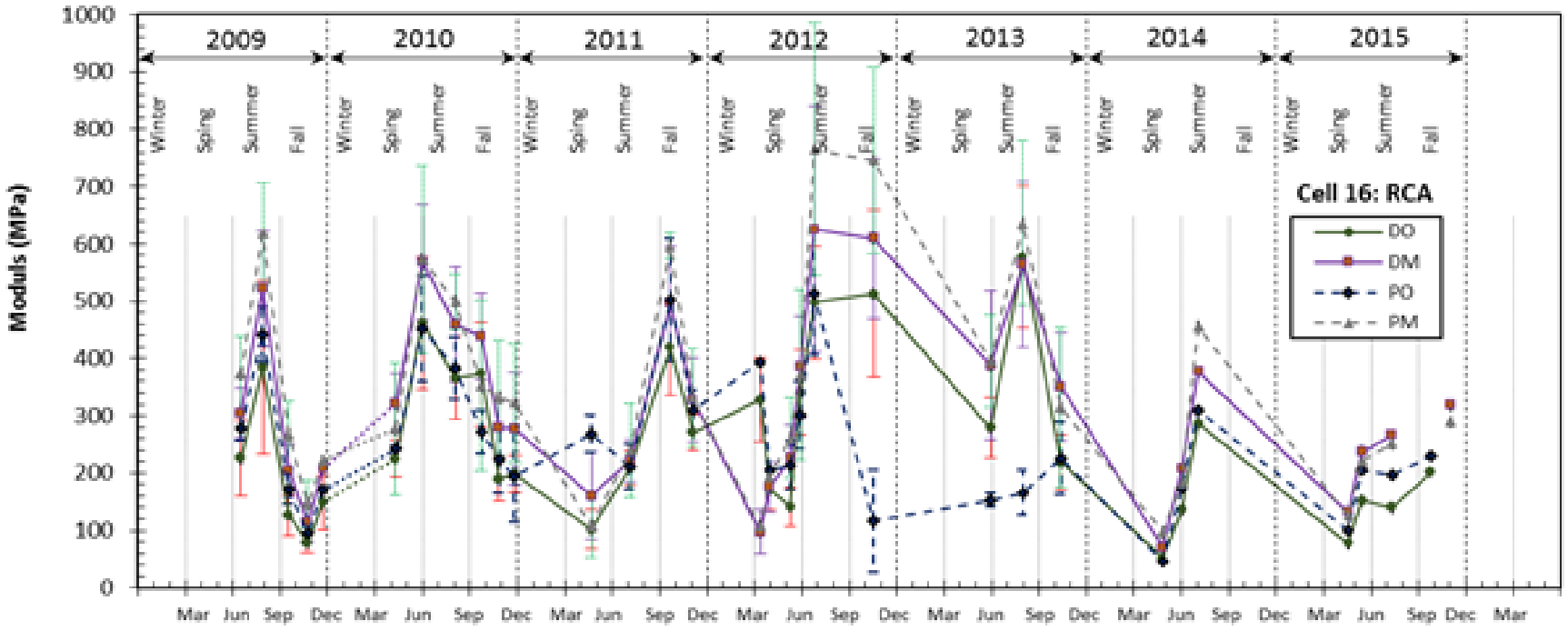
Task 5 & 6 – Performance Monitoring and Reporting, and Climatic Effects

Analyze the following data that will be collecting throughout the project

- FWD, frost heave-thaw settlement, IRI, rutting, surface survey.
- Temperature, moisture, matric suction, strain.
  - Determine freeze-thaw cycle numbers and its impact on pavement performance
  - Determine impact of frost heave and thaw settlements on pavement performance
  - Predict frost/thaw depth

Task 5 & 6

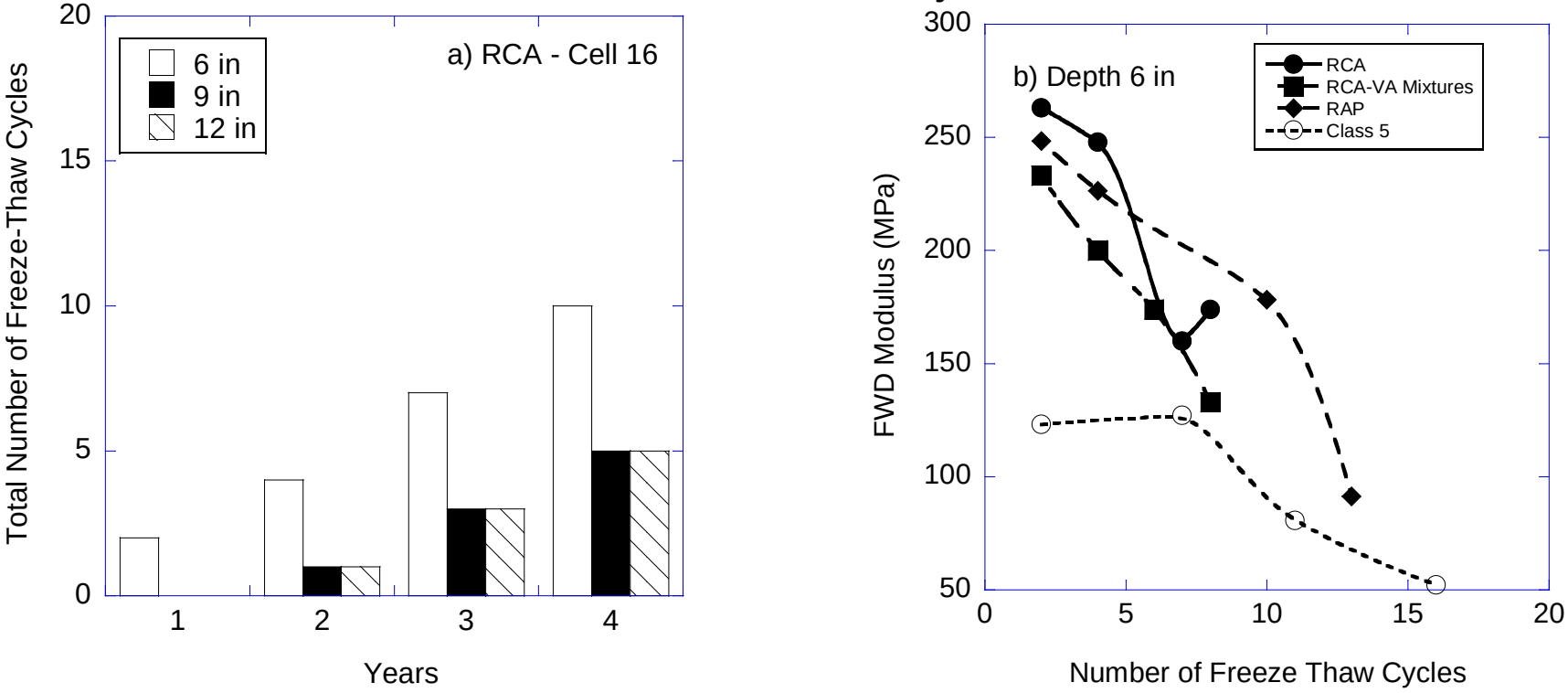
Task 5 & 6 – FWD variation over long period of time



FWD elastic modulus of RCA base layer during 7 years (Data collected from MnDOT 2008 project).

Task 5 & 6

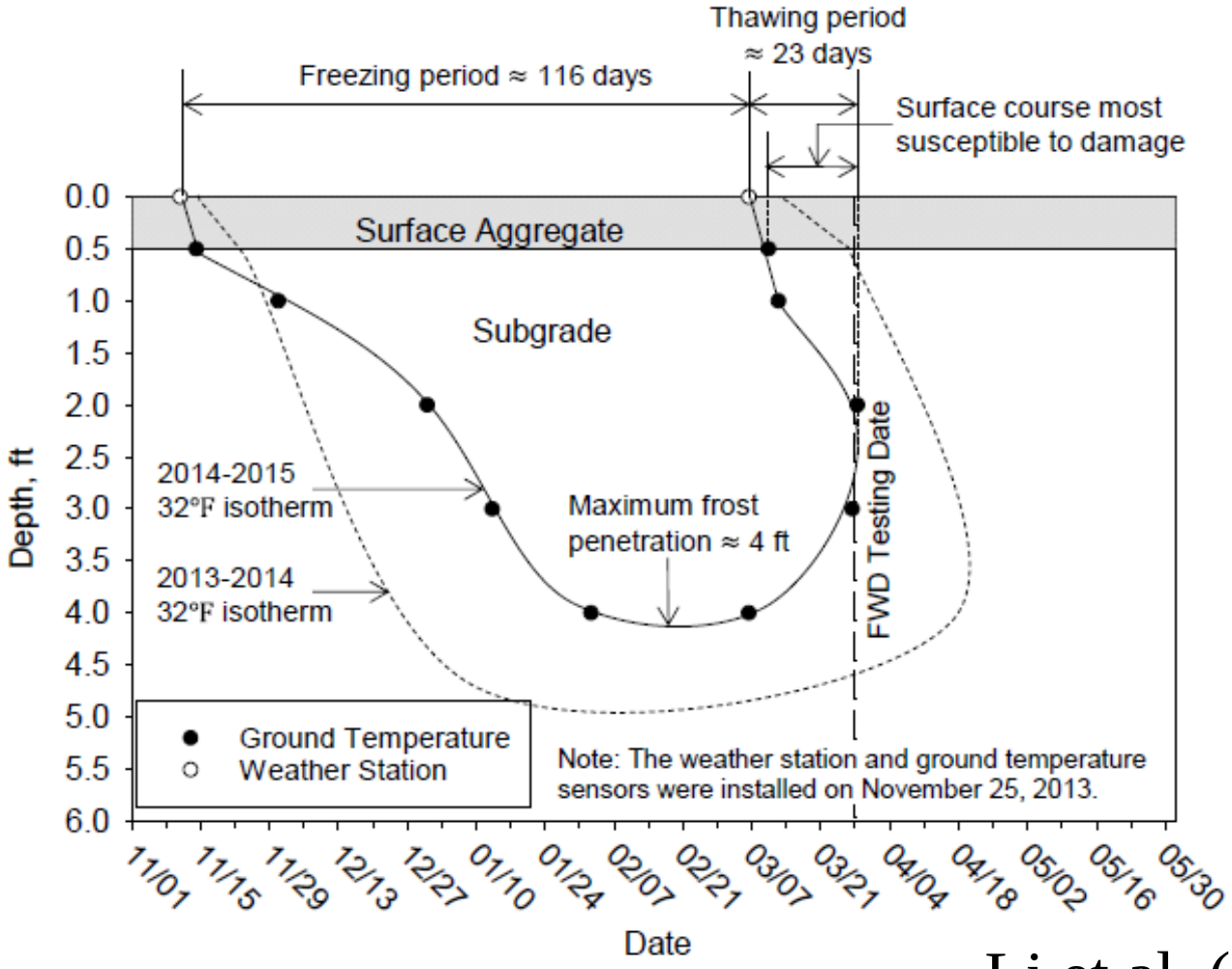
Task 5 & 6 – FWD variation with freeze-thaw cycles



a) Cumulative number of F-T cycles since 2008 in RCA base layer and b) field elastic modulus of RCA, RCA-VA blend, RAP, and Class 5 aggregate field test sections with F-T cycles (Edil et al. 2017).

Task 5 & 6

Task 5 & 6 – Frost depth prediction over the years



Li et al. (2016)

Task 7

Task 7 – Determine Pavement Design Criteria

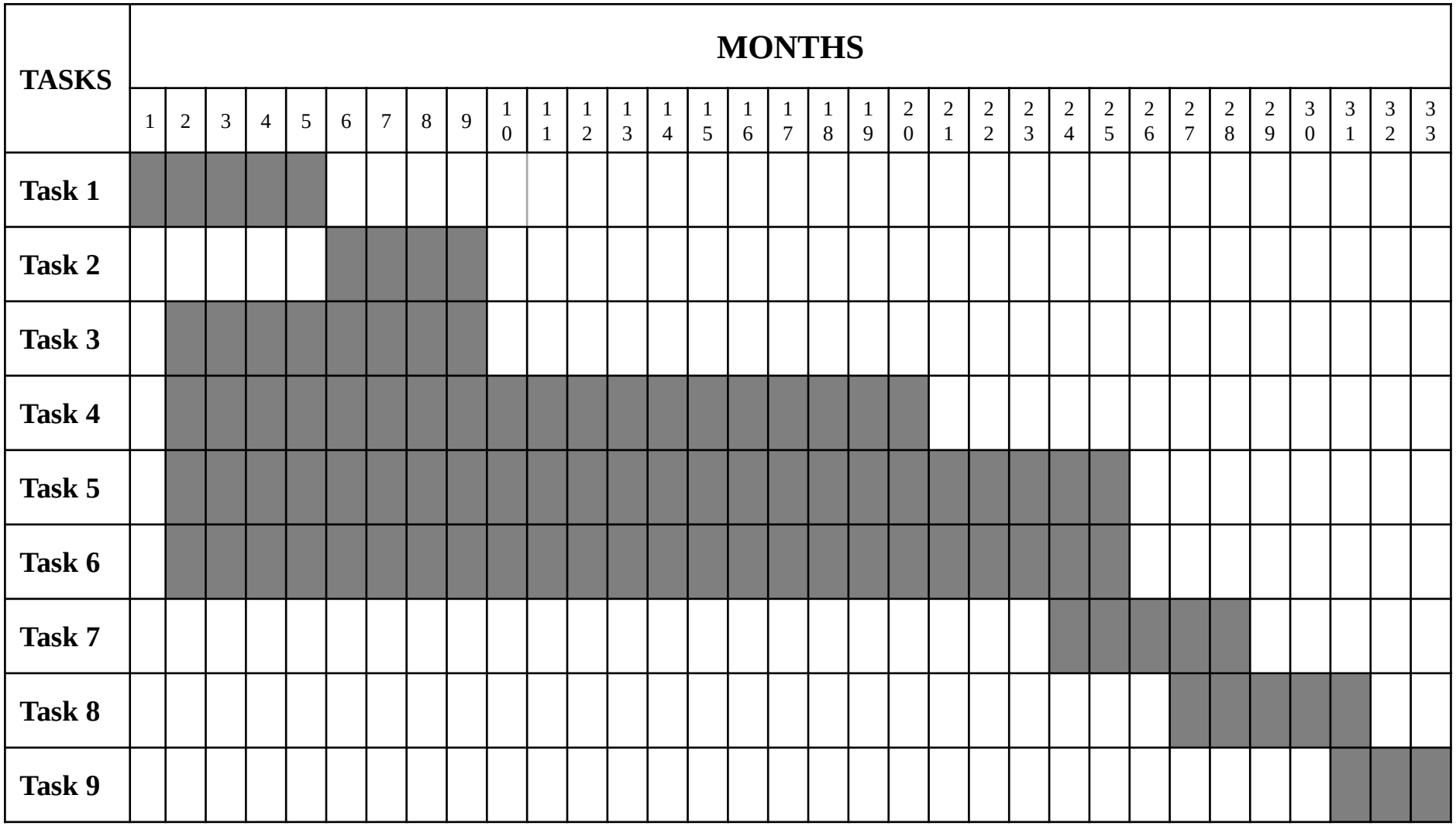
Prepare a report that:

- Summarizes the findings from the laboratory and field tests
- Provides detailed review on pavement design inputs in terms of benefits and costs
- Analyzes the cost effectiveness of using recycled materials and LSSB
- Shows correlations between the index properties and stiffness/permeability of geomaterials tested
- Provides the results of sustainability assessment analyses

Task 8&9

Task 8&9 – Draft/Final Report

Schedule


TASKS
MONTHS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
Task 1
Task 2
Task 3
Task 4
Task 5
Task 6
Task 7
Task 8
Task 9

PRODUCTS & DELIVERABLES

- Quarterly progress reports as required
- Draft final report
- Final report
- Technology transfer brief
- A copy of the executive final presentation

AGENCY ASSISTANCE

- Access to data collected during construction
- Access to data being collected throughout the project
- Assistance with installation of matric suction sensors

Thank You!

QUESTIONS??