
Good Morning!!!

Gravel Preservation

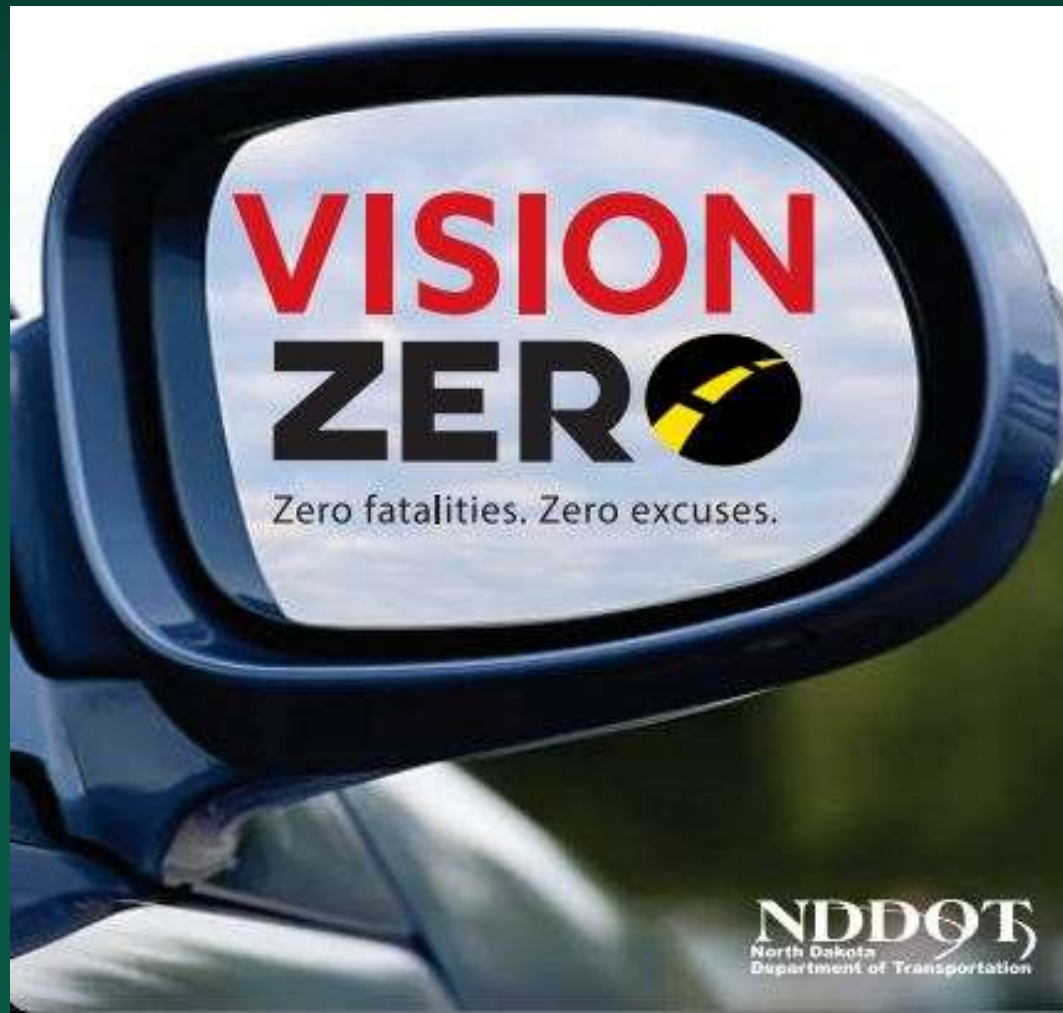
Newtown – May 19, 2021

Dale C. Heglund, North Dakota LTAP Director
701-318-6893 – dale.heglund@ndsu.edu

NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

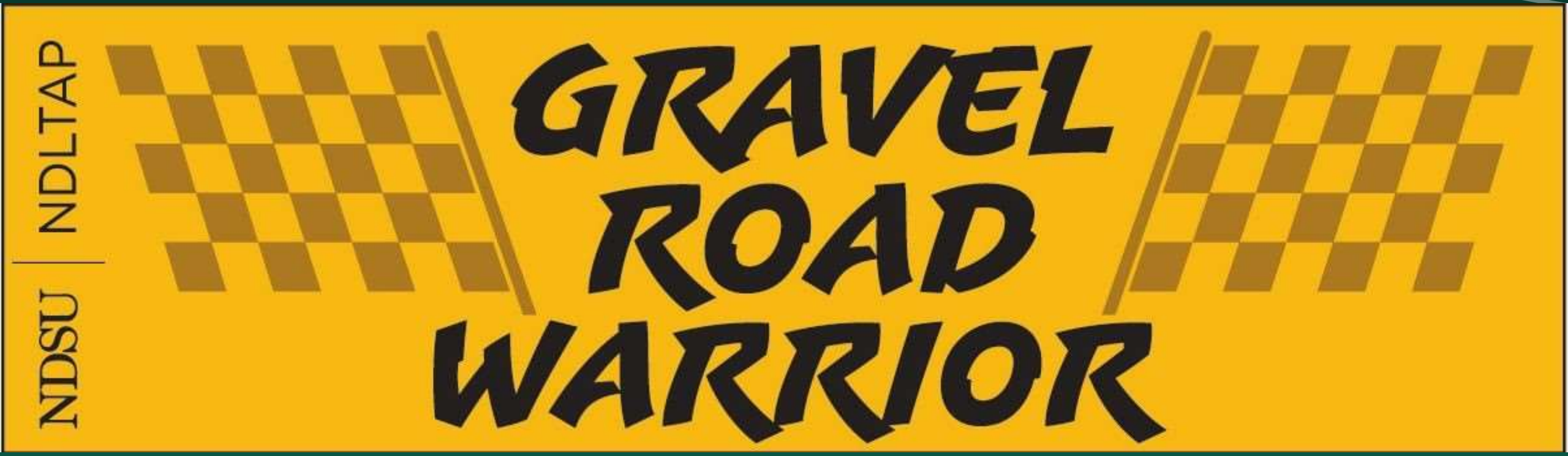
NORTH Dakota | Transportation
Be Legendary.™

Better Gravel – Better Roads
Better Roads – Safer Roads



North Dakota's County/Local Road Network: 97,600 miles

6,600 miles are paved
59,000 miles are gravel surfaced
32,000 miles are unsurfaced


NDSU | NDLTAP
GRAVEL ROAD WARRIOR


MUDDY
WHEN
WET
DUSTY
WHEN
DRY


CAT

The #1 problem with a gravel road:

It’s not a paved road!

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Float – Loose Rock

Gravel Road Problems & Consequences

Problem	Consequence of Problem		
	Gravel Loss & Budget	Road User Safety, Cost & Inconvenience	Public Health
Dusting	x	x	x
Wash Boarding	x	x	
Raveling	x	x	
Rutting	x	x	
Potholing		x	

NDSU

Gravel Road Problems & Consequences

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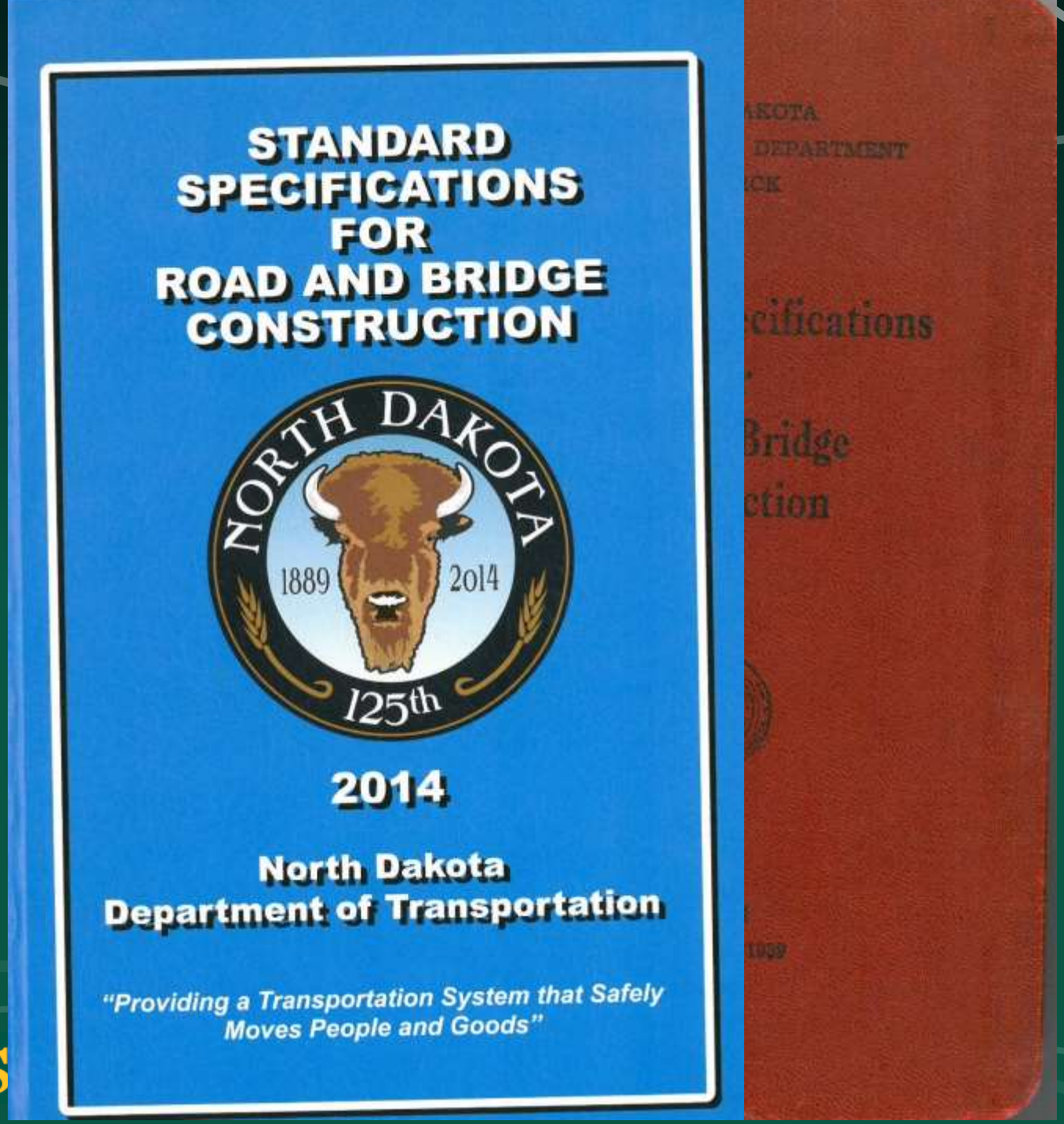
	Gravel Loss & Budget	Road User Safety, Cost & Inconvenience	Public Health
Dusting	x	x	x
Wash Boarding	x	x	
Raveling	x	x	
Rutting	x	x	
Potholing		x	


WANTED
Good
Gravel



Remember When…

Institutional Knowledge

NDS


Betty Crocker
Delights
SUPER MOIST
LEMON
CAKE MIX
PER 1/12 PACKAGE
160
NET WT 15.25 OZ (432g)


You will need:
1 Cup Water
1 Stick (½ Cup) Butter, Softened
3 Eggs
1 Heat oven to 350°F for shiny metal pan or 325°F for dark or nonstick pan. Grease bottom only of pan (use paper baking cups for cupcakes).
2 Beat cake mix, water, butter and eggs in large bowl on low speed 30 seconds, then on medium speed 2 minutes, scraping bowl occasionally. Pour into pan.
3 Bake as directed below or until toothpick inserted in center comes out clean. Cool completely before frosting.
Pan Size | 8" x 8" | 9" x 9" | 8" or 9" Round | 12 Cupcakes
Bake Time (in minutes) | 44-49 | 38-43 | 43-48 | 18-23
High Altitude (3500–6500 ft): Bake 8" square shiny pan 44-49 min; 8" square dark pan 46-51 min. Bake 9" square shiny pan 38-43 min; 9" square dark pan 40-45 min. Bake 18 cupcakes at 350°F 18-23 min (all pans).

Gravel

Material Assessment


CAT

Too much coarse rock, lacking coarse sands – will ravel badly

Too much coarse sand, too little rock, will washboard badly

Good gravel surfacing (good representation of sizes to fill voids, high enough minus #200 to create road crust, will hold chlorides well

8/29/2022

GLUE FOR GRAVEL ROADS

While even the best of gravels can't match the year-round qualities of asphalt, we can sweeten the mix and make them better with ***"That Little Something Extra" – Clay.***

Training

Preparation

Application

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NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

Plasticity Index - Clay

The glue that holds the rocks and sand together

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GRAVEL ROAD WARRIOR

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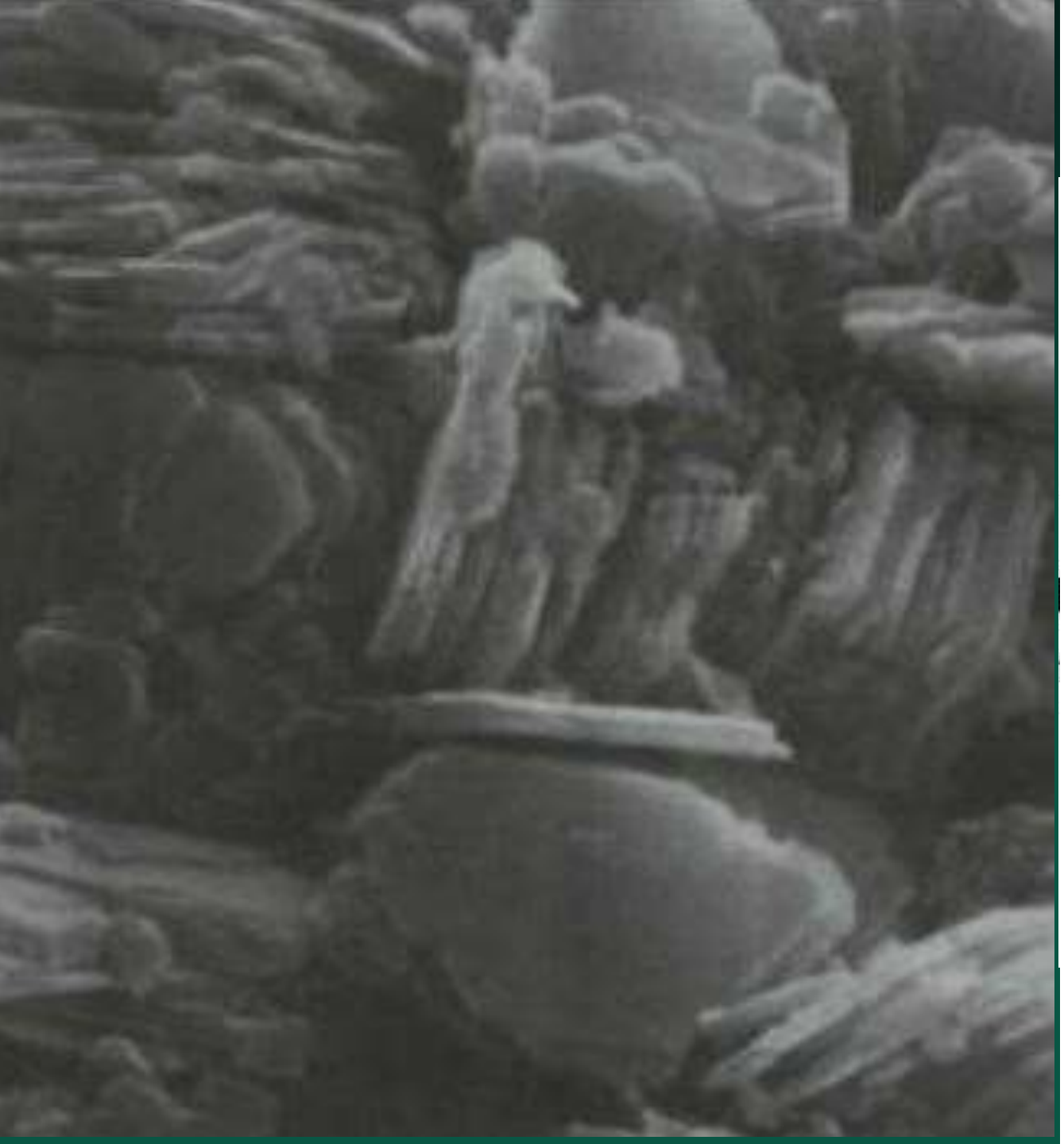
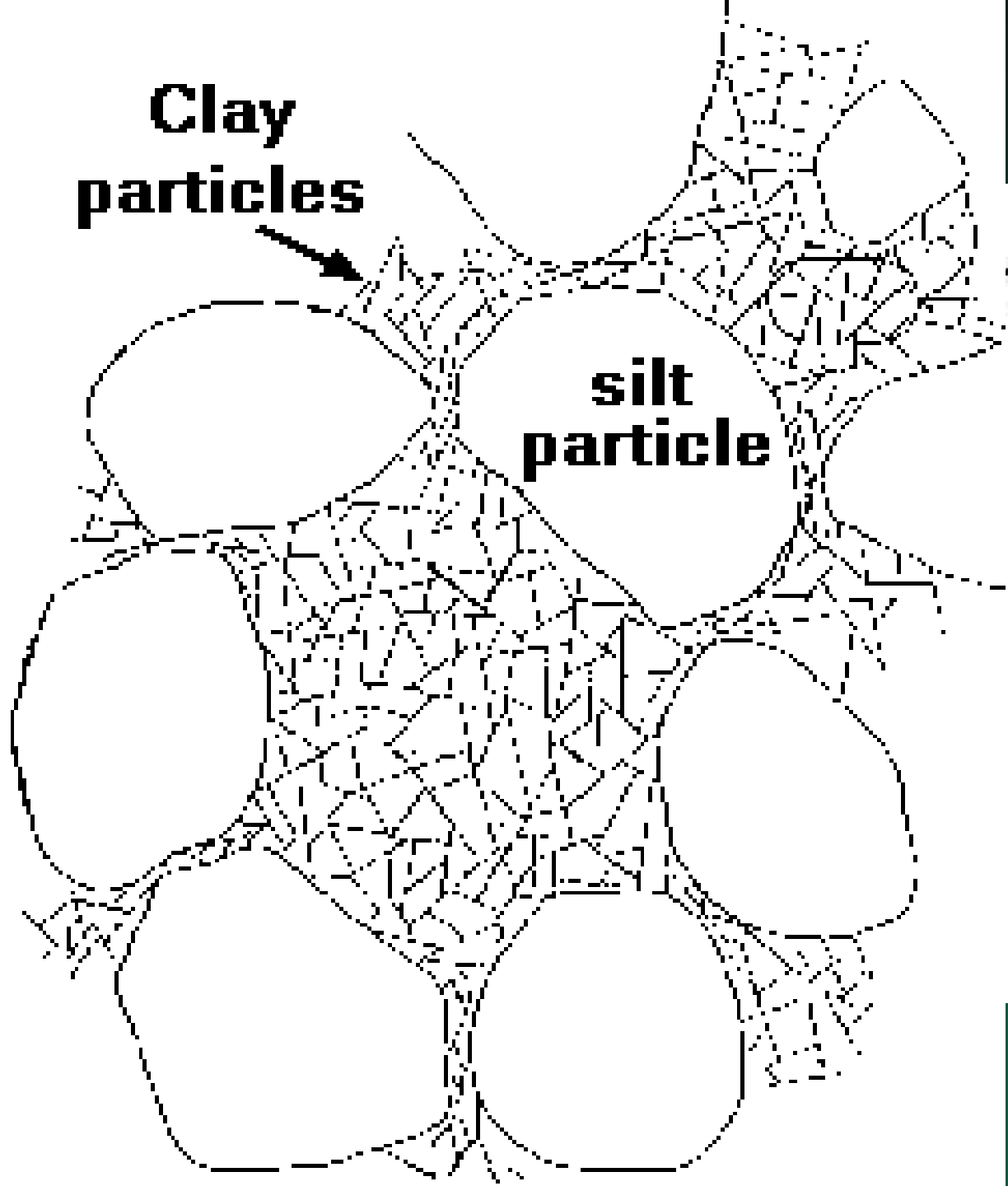



Clay particles
silt particle

1 vehicle

1 year

1 ton dust per mile

Each mile with 100 cars per day - 100 tons of fines per year!

NDSU

BURLEIGH COUNTY HIGHWAY DEPARTMENT

8100 43RD AVENUE NE
BISMARCK, ND 58503
701-204-7748
FAX 701-204-7749
www.burleighco.com

Dust Control Policy

Approved by the Burleigh County Commission
(February 3, 2014)

OVERVIEW

As the area around the City of Bismarck grows, residents on the township and county roadway system have experienced increases in traffic. It has long been the desire of the Burleigh County Board of Commissioners and the Highway Department to promote the paving of new subdivisions that are developed; however, in older subdivisions and on section line roadways in the growth area, that have not been paved, we are receiving more calls requesting some type of dust control.

The loss of fines (dust) from our gravel roads is not only a nuisance to residents, but it can also be a health hazard to individuals with emphysema or asthma. It also decreases the effectiveness of our gravel by creating greater segregation within our roadway surfacing. This requires us to gravel more often. Chemical treatment of gravel roads with either Calcium Chloride or Magnesium Chloride has been proven to reduce the loss of fines from gravel roadways. In general, Magnesium Chloride has been found most effective in our climate. Other types of chemical treatments have been tested but none have been found as effective as Magnesium Chloride.

It is the Highway Department's desire to implement a Dust Control Policy to help direct the use of chemical treatment of both township and county roadways. The following guidelines would be used in administering the application of dust control chemicals:

OPERATING PROCEDURES

On county roads:
Dust control will be applied to gravel roadways meeting the following criteria:

1) Roadways with Average Daily Traffic (ADT) counts of 200 or greater will receive solid application.

2) Roadways with ADT counts between 50 and 200 will receive application in front of homes and buildings.

3) Roadways with ADT counts less than 50 will receive application in front of homes if the resident of the home has health (breathing) issues, and provides us documentation of such.

4) Application in front of homes will only be done if the home is within 1,000 feet of the roadway. The application distance in front of homes will be for a maximum of 1,500 feet.

On township roads:

1) The township must request dust control application, and

2) The township agrees to pay all costs associated with application, and

3) The township agrees with the same application criteria as laid out for county roads.

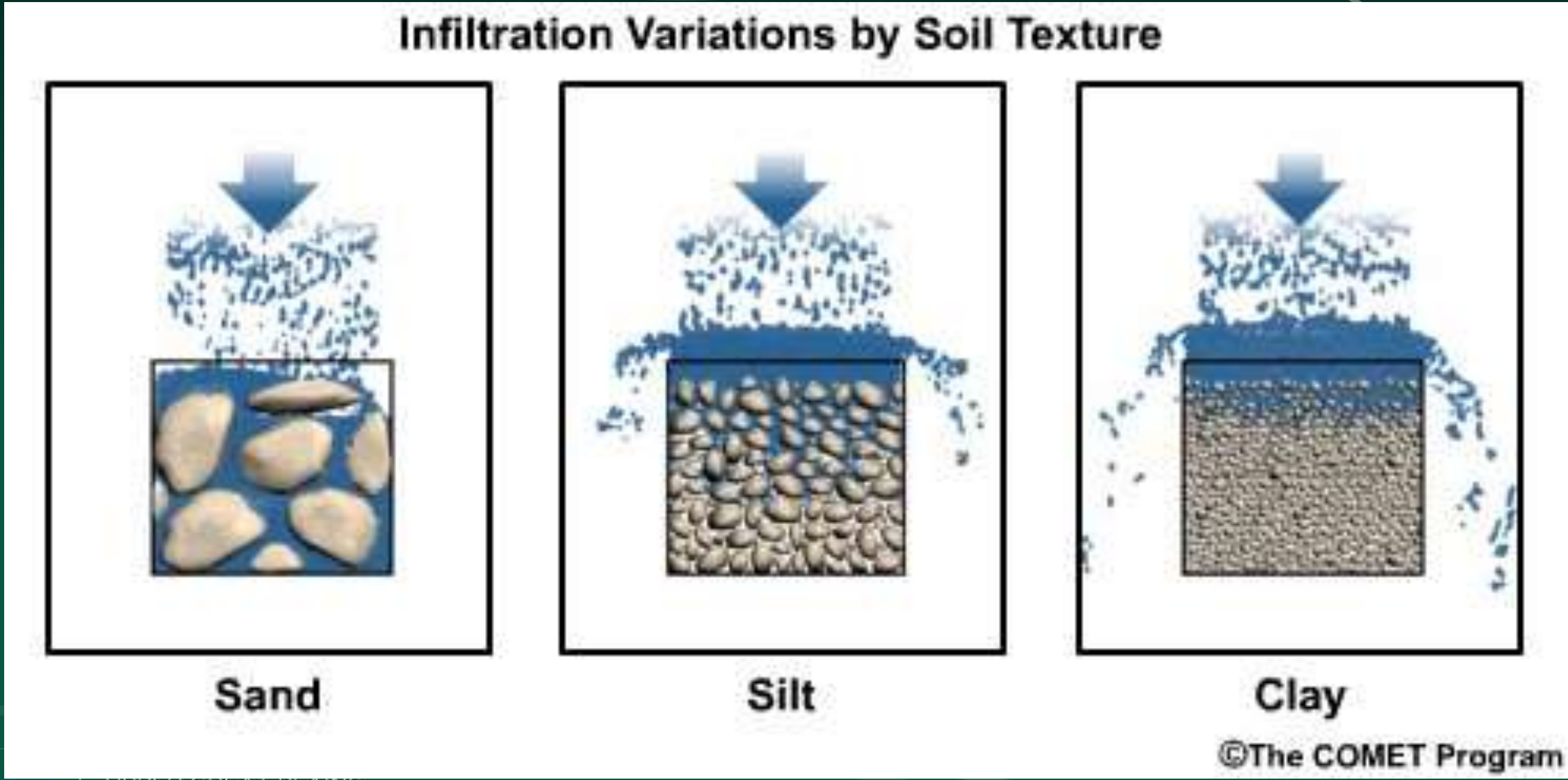
4) The County Commissioner holding the Highway Department portfolio will approve/deny all requests for dust control application on unorganized township roadways.

The County Highway Department will determine the application rates and the type of dust control chemical used on an annual basis.

INFORMATION

Questions or concerns regarding Burleigh County Dust Control Policy may be directed to the Burleigh County Highway Department in Bismarck at (701) 204 - 7748.

Gravel Quality – Gradation and Binder



Roadway Slope

NDSU


800
RPM
R3 F3
P
377.4
0.0
MPH


Gravel Road Surfacing

The North Dakota DOT maintains only PAVED ROADS. As such, the DOT uses gravel for pavement base and shoulder material. They typically specify:

Cl 5 Gravel – drainable base material that is placed beneath a paved surface. Water that passes through pavement cracks enters the Cl 5 base. Since the Cl 5 base has limited fine material, water easily drains to the outer edge of the roadway rather than progressing down into the subgrade. By keeping the subgrade (i.e., natural soil foundation) dry the NDDOT maximizes the roadway's load carrying capacity.

Cl 13 Gravel – shouldering material for highways. Cl 13 shoulder material is essentially a Cl 5 material with more fine material allowed (i.e., a dirty Cl 5). The fine material provides a reduction in water passage and allows sensible utilization of pit materials.

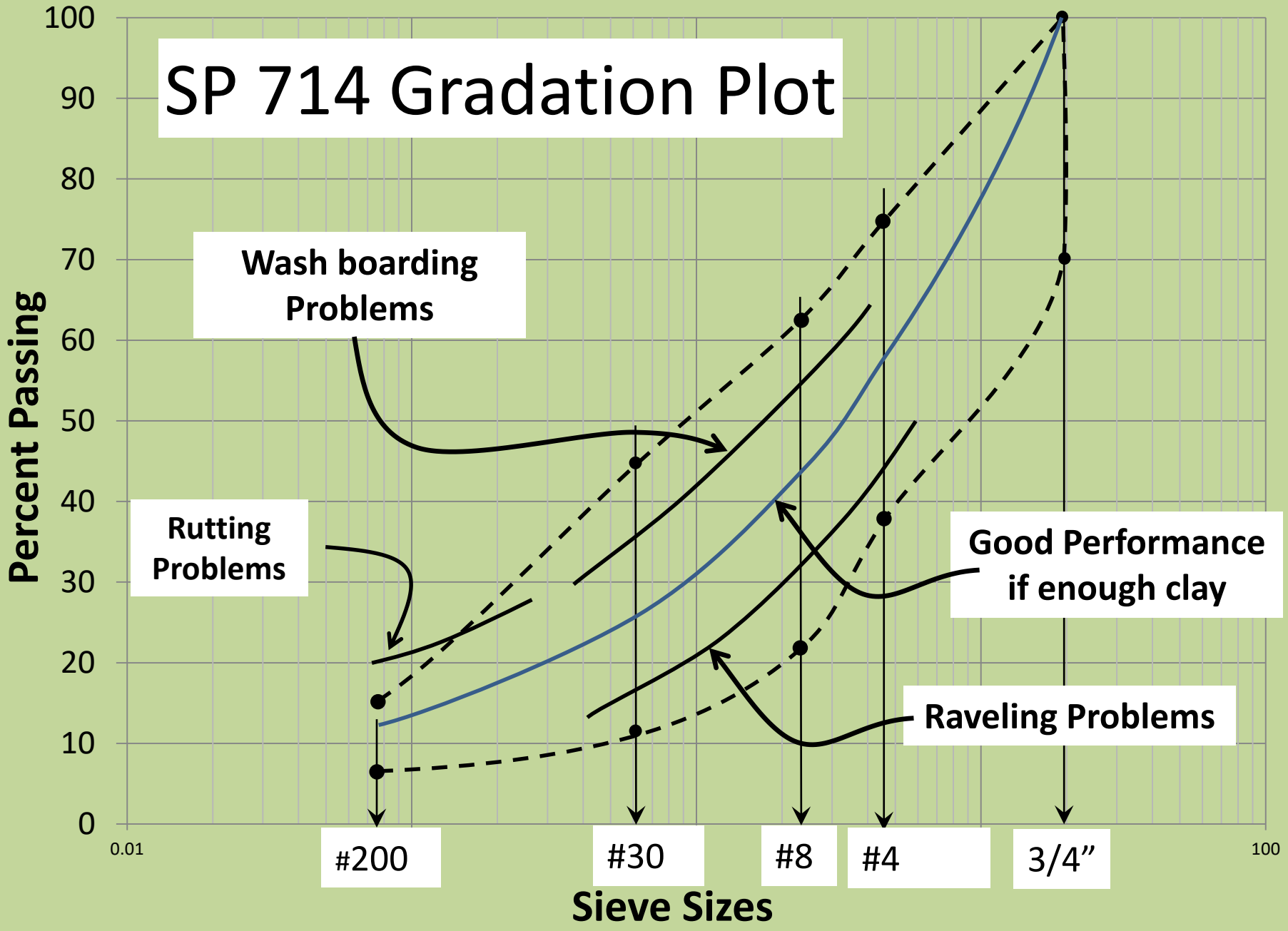
Modification of Class 13 Specification

Sieve Size	NDDOT Cl 13	Montana Gravel Surfacing	SD & FHWA Gravel Roads Manual	Sample County Spec	Proposed ND Gravel Surfacing
3"					
1-1/2"					
1"	100	100		100	100
3/4"	70-100	80-90	100	90-100	70-100
1/2"		60-80			
3/8"				50-90	
No. 4	38-75	50-70	38-75	35-80	38-75
No. 8	22-62	37-60	37-67		22-62
No. 10				20-70	
No. 30	12-45				12-45
No. 40		13-35	13-35	10-40	
No. 200	7-15	4-18	4-15	8-15	7-15
PI		4-12	4-12	4-12	4-12
Shale (max %)	12.0				12.0
LA Abrasion (max %)	50				50
NDDOT 4, Fractured Faces	10				10

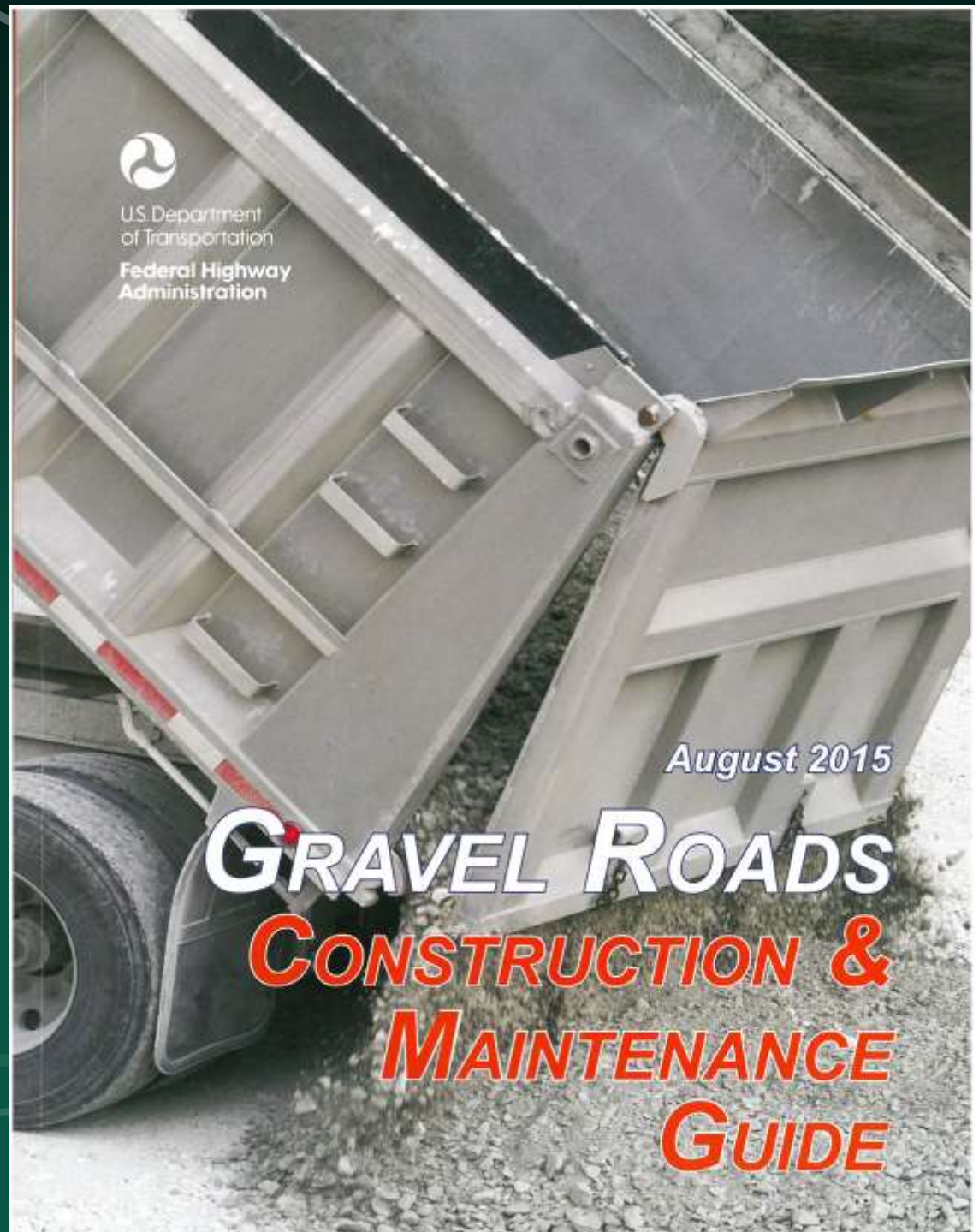
NDDOT Special Provision – Gravel Surfacing SP 714(14)

Sieve Size Or Testing Method	Aggregate Gravel Surfacing Percent passing or Test Limit
1"	100
¾"	70 – 100
No. 4	38 – 75
No. 8	22 – 62
No. 30	12 – 45
No. 200	7 - 15
Plasticity Index (PI)	3 - 9
ND T 113, Shale (max %)	12.0%
AASHTO T 96, L.A. Abrasion (max %)	50%
NDDOT 4, Fractured Faces[1]	10%

PI – Cohesiveness



NDSU



Gravel Roads

Part II

Back to the Basics

Local Technical Assistance Program
Department of Civil Engineering
Montana State University-Bozeman
Bozeman, MT

2000

ANSWERS FROM AN EXPERT

Application Rate of MagChloride Used for DUST Abatement

By Ken Skorseth, SD LTAP Special Projects Manager
Author: Gravel Roads Maintenance & Design Manual & Gravels Construction & Maintenance Guide

CO LTAP received the following technical assistance question. Gravel Roads expert, Ken Skorseth, submitted the following reply and supplemental photos.

What is the recommended amount and application rate of Magnesium Chloride used for DUST abatement for a second treatment applied about a year later?

[Ken] It is hard to give a concise answer due to these factors:

- The quality of the surface gravel has so much impact on this. Good surface gravel prepared well for MagChloride ($MgCl_2$) generally performs well, but ---
- The rate of application of *initial* treatment also has an impact on following treatments. We generally use between 0.45 and 0.6 gallons per square yard for the initial treatment.
- Thereafter, traffic volume and moisture received through the season will have some impact on the succeeding year as well.
- Having said all of the above, we often see second year treatment at the same rate as the first year, or 0.1 to 0.2 gallons per square yard ***less*** than the initial treatment.
- In succeeding years, we sometimes see treatments down to half of original application rates.
- The local agencies who do this very well nearly always say something like this, "there isn't a set rate for treatment; you have to observe the road and use field judgement to determine it."
- These photos show several different situations to demonstrate.

1/4
GOOD: 6-6-13 Just after treatment at 0.5 gal per sq yd. Commercial dairy road. Heavy truck traffic ^AADTT 30 - 40. Road looks good.

2/4
POOR: 7-16-13 Same road, already failing!

3/4
POOR: 7-16-13 Almost total dust control failure

4/4
POOR: 10-7-13 After another 0.3 gal per was applied same season still not performing well. This is such poor surface material it won't go into a bound state no matter how you maintain it. There is no way the $MgCl_2$ can work even with 0.8 gal per sq yd applied in one year!

Here's the critical issue: It was applied to poor material (reclaimed concrete) usually not compatible with chloride treatment.

GOOD: Residential road. Initial treatment 0.5 gal per sq yd. Same treatment Year 2. Gets 0.25 - 0.3 gal treatments in succeeding years. Treated annually 10 yrs. Performs very well.

GOOD: Treated with $MgCl_2$ continuously since 1988. Initial treatments of 0.5 gal per sq yd in first 2 years; 0.25 to 0.4 treatments since. Applied in May. 1,000 ADT

ROAD READY R3 RESEARCH

DEC 2020 NO. 2

RESEARCH REVIEW: Dust Control on Gravel Roads: Traditional Methods Using Magnesium and Calcium Choloride

by Curtis Glasoe, PE/PLS, NDLTAP Technical Support Representative

"Dust control for gravel roads has been practiced for many years now in our region and around the world. Dust generated by traffic on a gravel road creates many concerns including: safety issues for the traveling public by reducing visibility, degrading air quality, increasing road maintenance costs due to loss of fines in the gravel and reducing crop yields. Dust control products are a great tool to use for gravel preservation. The increased cost of mining, processing & hauling specified surfacing gravel plus the fact that its availability is limited are good reasons to have a policy on dust control that is connected to the average daily traffic counts for various road segments in your county or township. The reduction in re-graveling and blading costs should be considered as a savings when adding dust control projects into the road budget when planning widespread applications."

Kelly Bengtson PE, NDSU UGPTI LTAP Bridge & Pavement Engineer

Gravel roads are dusty. For many roadways, the dust creates unsafe driving conditions. Additionally, the loss of fine material degrades the ability of the driving surface aggregate to bond together and shed water.

Logically, increased traffic volumes result in increased dust. So what can we do to reduce the dust? As traffic volumes exceed 100 average daily traffic (ADT), consideration should be given to the application of dust control.

Your county should consider having a policy to follow that includes ADT, length of strip applications for rural homes or for road intersections susceptible to dust issues. A policy can reduce your liability and improve the safety of the traveling public. Several counties already have a policy and LTAP can help you develop one.

Spot applications in front of residences near roadways may suffice for some roadway segments. As traffic volumes increase, dust control for full roadway sections should be considered. According to various studies, the volume of gravel material that is blown away or lost from the surface can be estimated at 1 ton of material per mile/vehicle/year. To put it another way, consider a sample roadway with a traffic volume of 250 vehicles per day, we can estimate a loss of 250 tons of gravel per mile/year. That is 10 semi loads of gravel on a mile section of roadway!

In addition to the obvious safety problem of sight distance with dust, a bigger problem is that existing gravel sources are being depleted and not many new sites are being found to provide adequate aggregate to surface roads. Some counties in the state are already going outside county boundaries to secure aggregate surfacing. This serious situation must be addressed through changes in the way we do business.

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NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

NDLTAP – The Resource of Choice

2020 INNOVATIONS

Pipe Cleaner – 1st Place
Traill County Highway Department

Motor Grader Step
Golden Valley County Highway Dept.

Culvert Rack
Stark County Highway Department

Award

The 1st place winner will receive one paid trip to the North Central Regional Local Roads Conference in Sioux Falls, South Dakota. The award includes bus travel, conference registration and hotel (NDLTAP will reimburse costs to winner). This year the conference is on October 19-21, 2021. State and regional awards will be presented at the conference.

2020 State Winner

Traill County Highway Department

Corey Ackerman, Jay Showers—Innovators
(L. to R.)
(Award will be presented at the 2021 regional conference)

CONTACT:

Leanna Emmer
Office: (701) 220-4595
leanna.emmer@ndsu.edu

Upper Great Plains Transportation Institute
North Dakota State University

North Dakota Local Technical Assistance Program (NDLTAP)

www.ndltap.org

2021 INNOVATION CHAMPIONS

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

R.E.D. BOOK

Recognize
Eliminate
Discuss

NOBODY GETS HURT.

This book belongs to: _____

WHO IS RESPONSIBLE FOR SAFETY?

I AM!

"Create a safety culture every day, so that nobody gets hurt. Adopt a Safety Creed – No job is so important in maintenance or construction, and no service so urgent, that we cannot take time to perform our work safely. The Red Book and Safety Creed were adopted from MnDOT because safety knows no boundaries."

NDIRF

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Bee good

UGPTI - Tribal Outreach

MISSION: To improve safe transportation of people and goods on tribal reservations to enhance livability, community and cultural values through increased accessibility to employment, workforce development opportunities, education, healthcare and housing.

VISION: To be a leader in facilitating improvements in tribal transportation to enhance livability, community and cultural values for reservation residents.

Treasurer's Office, Kidder County.

No. 484

STEELE, North Dakota, JUN 29 1896

RECEIVED OF ... Woodlawn ... 88/100 DOLL.

In full for the following Taxes for the year 1895 upon ...

SUMMARY OF TAXES.

State Revenue,	4.	Mills
State Interest,	.5	"
General School	2.	"
Thistle Fund...	1.	"
Co. Gen'l...	6.	"
... Bonds..	5.8	"
... Bridge	.7	"
... Fund..	2.	"

Civil Township Levies.

Allen	11.	Mills
Woodlawn	5.6	"
Manning	2.6	"
Buckeye	.0	"
Sibley	.0	"
Pleasant Hill	1.7	"

School Township Levies.

Chestina	6.	Mills
Pleasant Hill	6.1	"
Allen	10.	"
Woodlawn	13.	"
Manning	5.	"
Vernon	6.4	"
Sibley	4.8	"
Liberty	12.	"
Union	13.	"
Fish...	9.1	"
Ta...	1.8	"
Qu...		
Cr...		
Buckeye	17.	
German	22.	

DESCRIPTION	Sec. or Lot	Town or Blo...	No. of Acres	Valuation Dollars	State and General Tax	City	Town	No. of School	Township School	Dog Tax	Sch...	Road	Road Warrants	Del... R...	Penalty	TOTAL TAX
Personal				590			26		348	00						13

ORIGINAL.

By ... Deputy.

... County Treas.

NDSU

SIGN WARRIOR

SAVE OUR SIGNS

Sign Warrior Calendar Drawing Submission Guidelines

Drawings should:

- Be on letter-size paper (11 X 8 ½)
- Drawn in landscape orientation (wider than they are tall)
- Be drawn in bold and vibrant colors for quality reproduction
  - Previous years calendars can be viewed online at www.ndltap.org/programs/signwarrior.php
- NOT include guns or excessive violence
- Include an aspect of **"RESPECT"** into your drawing

On the back of the drawing, include:

- Student's name
- Teacher's name, teacher's email
- School and school address

Drawings (do not fold) must be submitted to NDLTAP, 608 East Boulevard Avenue, Bismarck, ND, 58505, by no later than Friday, April 30, 2021. Alternatively: Drawings may be scanned or digitally photographed at a resolution of at least 300 dpi and emailed to ndltap@ugpti.org

waohola awiiteerat
respect
manaaji'idiwin waohoda
waohona ga'cahcee

Joy Anne Annette, UGPTI Tribal Liaison

The Good Life =>Mino-Bi-Maa-dizi-win

The Seven Grandfather Teachings, Anishinabi

Wisdom – beaver, blue

Love – eagle, gold

Respect – buffalo, white

Courage – bear, purple

Honesty – bigfoot, tan

Humility – wolf, rose

Truth – turtle, green


ROUGH-T


Vintage


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RESERVE FUND
For North Dakota. For Local Government. For You.
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GRAVEL
WINDROW
AHEAD




Gravel Preservation

- Road Structure
- Gravel Specs and Testing
- Options to Improve Gravel Quality
- Prediction Models
- Test Sections
- Gravel Production
- Safer Roads

Spec Gravel

NDSU | NDLTAP

GRAVEL ROAD WARRIOR

Test Gravel

CUBIC YARDS PER MILE

Width of the roadway in feet

Compacted depth of material in	12	14	16	18	20	22	24	26	28	30
1	244.44	285.19	325.93	366.67	407.41	448.15	48	89	529.63	570.37	611.11
1.5	366.67	427.78	488.89	550	611.11	672.22	73	33	794.44	855.56	916.67
2	488.89	570.37	651.85	733.33	814.81	896.3	97	78	1059.3	1140.7	1222.2
2.5	611.11	712.96	814.81	916.67	1018.5	1120.4	12	.2	1324.1	1425.9	1527.8
3	733.33	855.56	977.78	1100	1222.2	1344.4	14	.7	1588.9	1711.1	1833.3
3.5	855.56	998.15	1140.7	1283.3	1425.9	1568.5	17	.1	1853.7	1996.3	2138.9
4	977.78	1140.7	1303.7	1466.7	1629.6	1792.6	19	.6	2118.5	2281.5	2444.4
4.5	1100	1283.3	1466.7	1650	1833.3	2016.7		00	2383.3	2566.7	2750
5	1222.2	1425.9	1629.6	1833.3	2037	2240.7	24	.4	2648.1	2851.9	3055.6
5.5	1344.4	1568.5	1792.6	2016.7	2240.7	2464.8	26	.9	2913	3137	3361.1
6	1466.7	1711.1	1955.6	2200	2444.4	2688.9	29	.3	3177.8	3422.2	3666.7
6.5	1588.9	1853.7	2118.5	2383.3	2648.1	2913	31	.8	3442.6	3707.4	3972.2
7	1711.1	1996.3	2281.5	2566.7	2851.9	3137	34	.2	3707.4	3992.6	4277.8
7.5	1833.3	2138.9	2444.4	2750	3055.6	3361.1	36	.7	3972.2	4277.8	4583.3
8	1955.6	2281.5	2607.4	2933.3	3259.3	3585.2	39	.1	4237	4563	4888.9
8.5	2						4155.6	4501.9	4848.1	5194.4
9	2200	2566.7	2933.3	3300	3666.7	403	44	00	4766.7	5133.3	5500
9.5	2322.2	2709.3	3096.3	3483.3	3870.4	4257.4	4644.4	5031.5	5418.5	5805.6
10	2444.4	2851.9	3259.3	3666.7	4074.1	4481.5	4888.9	5296.3	5703.7	6111.1
10.5	2566.7	2994.4	3422.2	3850	4277.8	4705.6	5133.3	5561.1	5988.9	6416.7
11	2688.9	3137	3585.2	4033.3	4481.5	4929.6	5377.8	5825.9	6274.1	6722.2
11.5	2811.1	3279.6	3748.1	4216.7	4685.2	5153.7	5622.2	6090.7	6559.3	7027.8
12	2933.3	3422.2	3911.1	4400	4888.9	5377.8	5866.7	6355.6	6844.4	7333.3

Note: To convert cubic yards to tons multiply the yards by 1.4 (this is approximate)

This chart uses a compaction factor of 25%.


DEERE

Gravel Roads Maintenance Cost

Potential Savings Per Mile

$8,077.50

	DustGard	Untreated
Aggregate Replacement Cost	$2,340.00	$5,827.50
Maintenance Cost	$3,720.00	$10,560.00
Cost of DustGard	$2,250.00	$0.00
Total	$8,310.00	$16,387.50

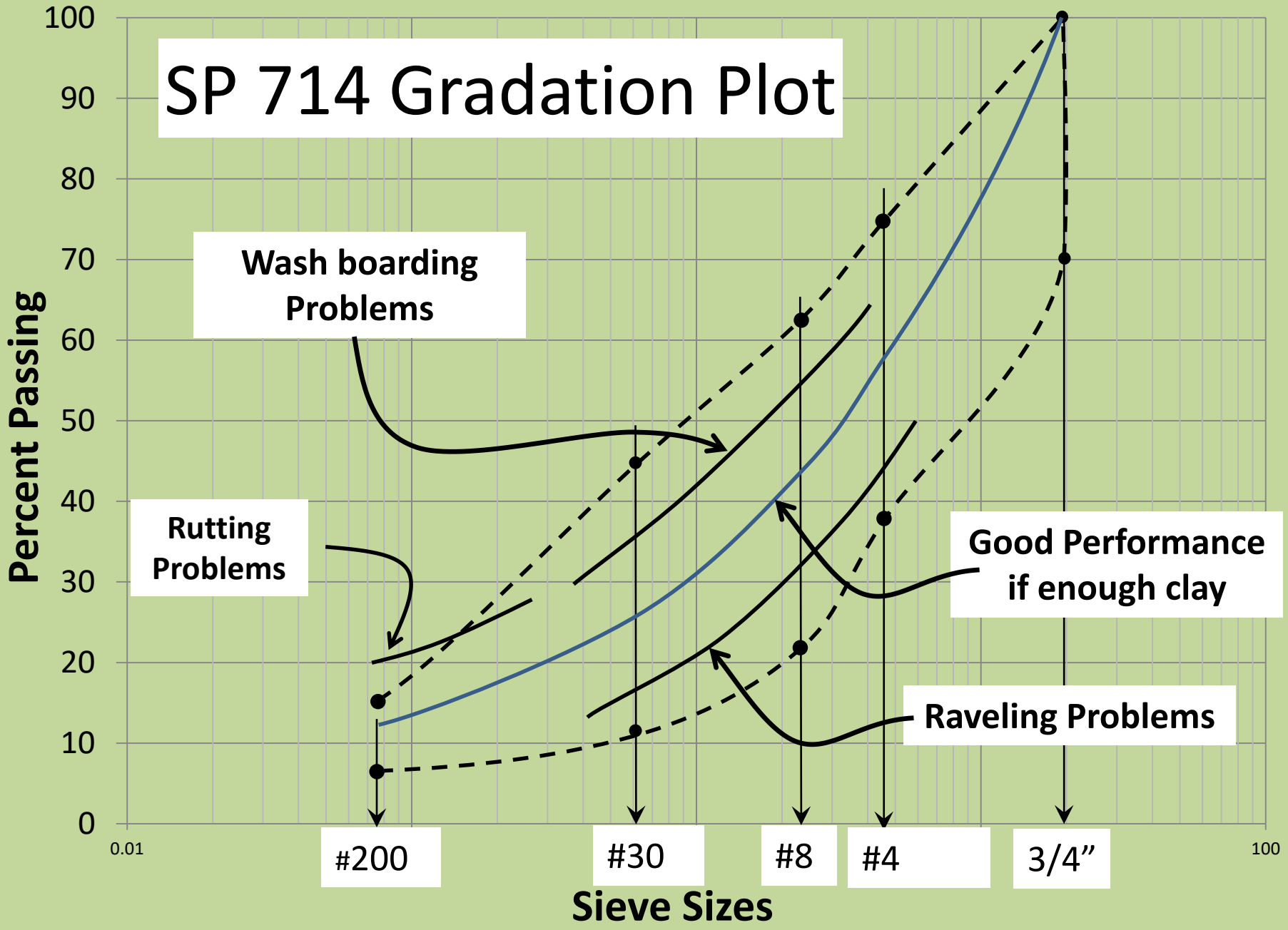
3/25/15 From Neil Bowman

2014 DUST CONTROL TOTAL COST PER MILE

EQUIPMENT	HOURLY RATE	HOURS	COST
BLADE	$ 130.00	8	$1,040.00
BLADE	$ 130.00	8	$1,040.00
PACKER	$ 100.00	8	$ 800.00
PILOT CAR	$ 90.00	9	$ 810.00
2 FLAGGERS	$ 50.00	9	$ 450.00
WATER TRUCK	$ 110.00	8	$ 880.00
DISTRIBUTOR	$ 175.00	8	$1,400.00
SANDER	$ 120.00	8	$ 960.00

PRODUCT	COST/MILE	APPLICATION	TOTAL COST
TRAILBOS	$ 13,938.00	$ 6,420.00	$ 20,358.00
ROAD GENESIS	$ 16,460.00	$ 6,420.00	$ 22,880.00
MEG CRYSTALS	$ 5,302.00	$ 4,130.00	$ 9,432.00
STABILOCK	$ 24,500.00	$ 4,940.00	$ 29,440.00
CALCIUM CHLORIDE	$ 4,800.00	$ 480.00	$ 5,280.00
MAGNESIUM CHLORIDE	$ 5,800.00	$ 480.00	$ 6,280.00

Dirt is complicated



Gravel Road Surfacing Stabilization Testing

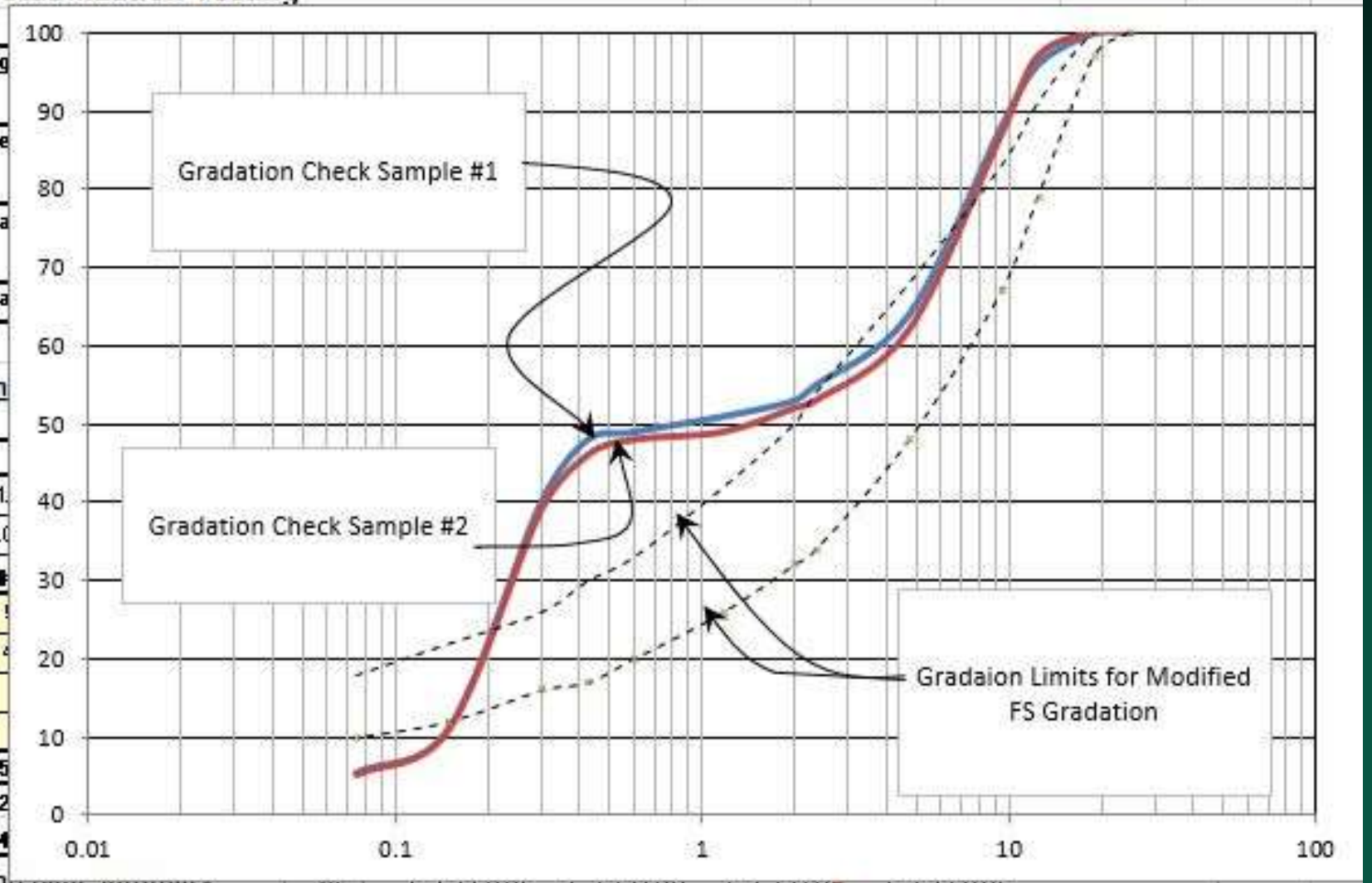
Client :	Richland County
	201 W. Holly St.
	Sidney, Mt. 59270
Project:	Gravel Roads
	5/8 inch reject

Ag
Be
Ca
Da

Preliminary Testin

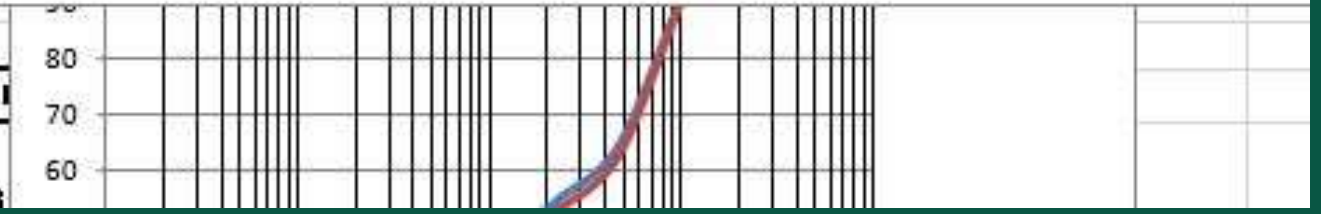
Sieve Analysis

Sieve Size									
	mm	25	19	12.5	9.5	4.75	2.36	2	1.
	0.45 P	4.257	3.762	3.116	2.754	2.016	1.472	1.366	1.0
	Std	**1**	**3/4**	**1/2**	**3/8**	**#4**	**#8**	**#10**	**#**
sample #1		100	100	96	88	64	55	53	
sample #2		100	100	97	87	62	53	52	
sample #3									
sample #4									
AVERAGE		**100**	**100**	**97**	**88**	**63**	**54**	**53**	**5**
Mod FS Spec	Low	**100**	**97**	79	**67**	**48**	34	32	**2**
	High	**100**	**100**	91	**83**	**68**	54	50	**4**



Mix Design Trial Blend Data Summary

Test No.	% Bentonite	% Calcium Chloride	AASHTO T180		CBR Specimen I		
			Optimum Moisture	Maximum Dry Density	% Mois	% of	CBR



UNPAVED ROAD CHEMICAL TREATMENT SELECTION TOOL

UCPRC City and County Pavement Improvement Center

Home | Instructions | Treatment Selection | Results Interpretation | About

WELCOME TO THE UCPRC'S UNPAVED ROAD CHEMICAL SELECTION TOOL SITE

Language & Units
(•) English ( ) Spanish
(•) US ( ) SI

There are millions of kilometers/miles of unpaved roads around the world managed by numerous authorities, land owners, and public and private organizations. Common to all of these roads are unacceptable levels of dust, poor riding quality and/or impassability in wet weather, and expensive maintenance and gravel replacement activities. Over the last 100+ years, a range of different chemical treatments have been developed to overcome these issues. Most of these are proprietary, which can complicate selection of an appropriate treatment for a specific set of conditions. There is also no single product that will solve all problems under all conditions.

Loss of fines (as dust) on an untreated road

A procedure has therefore been developed to guide practitioners in the selection of an appropriate treatment. This procedure, based on the 1999 US Forest Service Guide (*Dust Palliative Selection and Application Guide*), and updated with new research and experience, factors traffic, climate, material properties, and road geometry into the most appropriate treatment selections for a given set of input values. The procedure is based on the philosophy of using chemical treatments to keep good roads in good condition, rather than attempting to use chemical treatments to "fix" bad roads. This unpaved road chemical treatment selection tool and information related to it is fully described in the UCPRC guideline entitled "Guidelines for the Selection, Specification, and Application of Chemical Dust Control and Stabilization Treatments on Unpaved Roads." This web-based chemical treatment selection tool can be considered as a companion to the guideline.

The photo on the left shows loss of fines on an untreated road while the photo on the right shows the results of applying a fines preservation treatment.

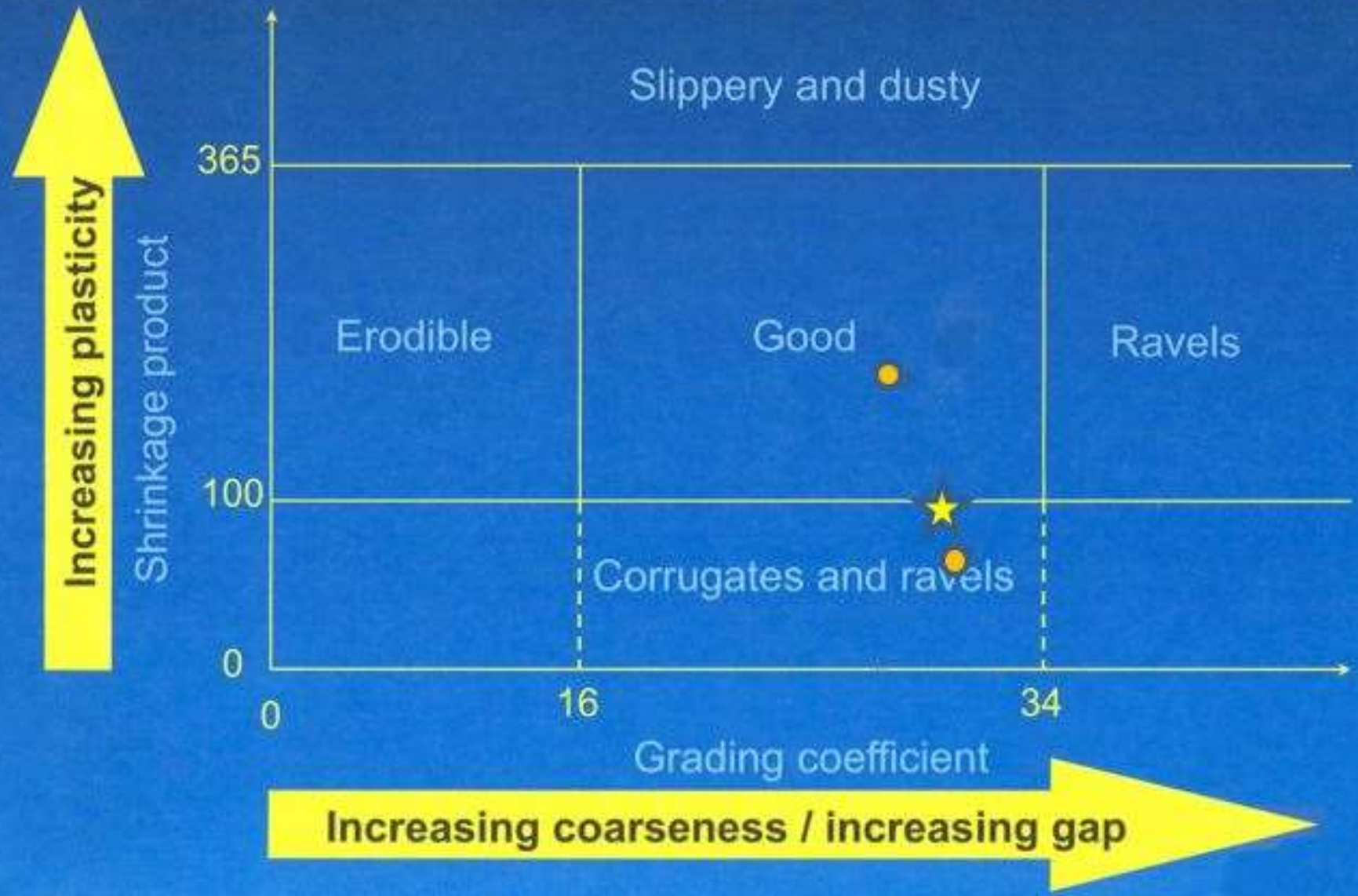
Stable fines preservation on a treated road

Disclaimer

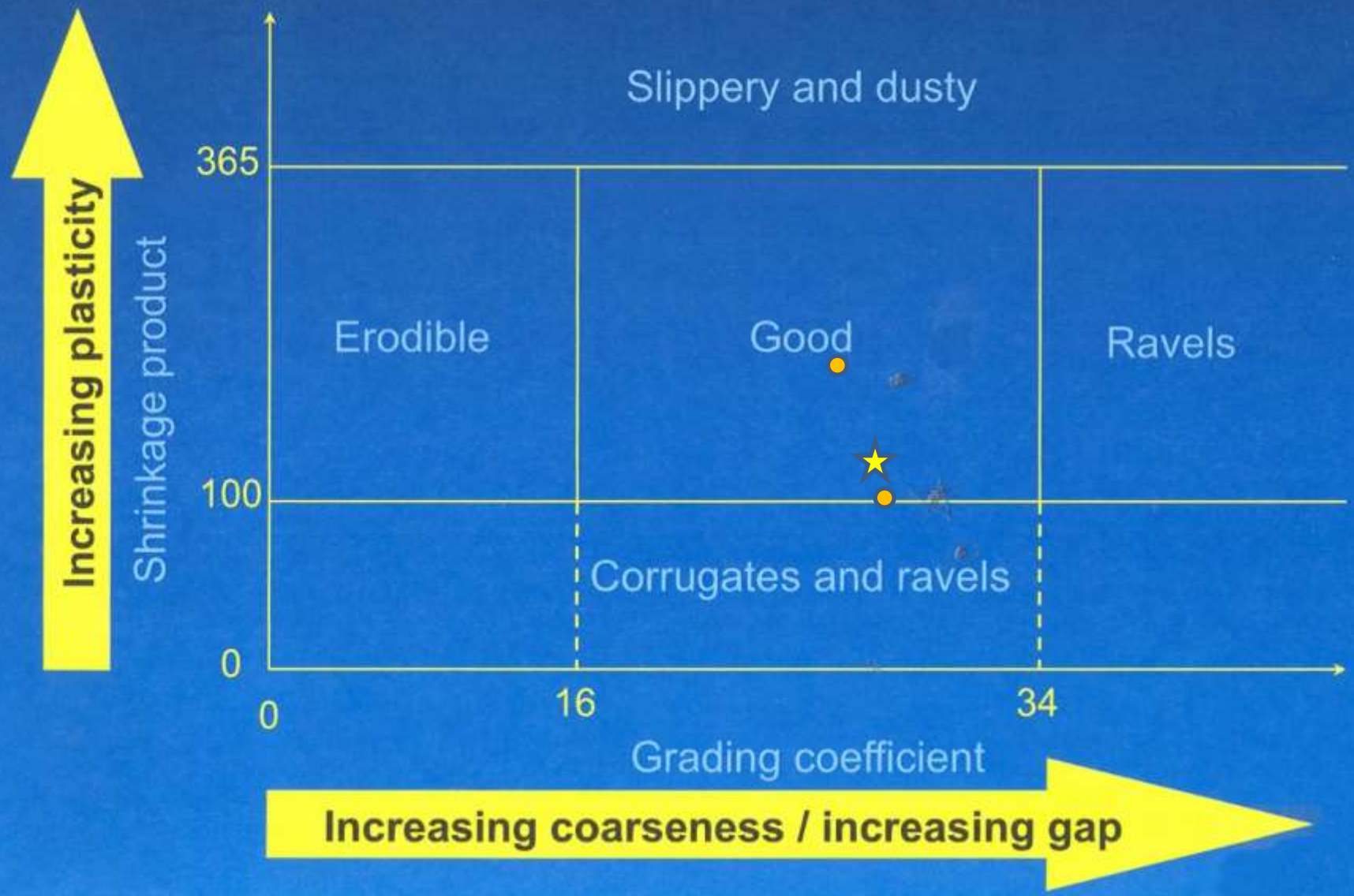
This unpaved road chemical treatment selection procedure has been developed to guide selection of an appropriate treatment. It is based on the experience of practitioners and documented field experiment results. It is a guide only and does not replace engineering practice and judgment. Before initiating a treatment program, users should check actual performance for their particular materials and conditions with appropriate laboratory performance tests and/or short field experiments and/or seek guidance from other experienced practitioners and treatment suppliers. The University of California does not endorse the use of any specific product for dust control and stabilization of unpaved roads. In no event shall the University of California be liable to any party for

NDSU

Material Design



Material Design



Unpaved Road Chemical Treatment Selection Tool

UCPRC City and County Pavement Improvement Center

Home | Instructions | Treatment Selection | Results Interpretation | About

Road ID 57 **Details** Good County North Dakota

Material Test Results

%Passing 1"	100	%Passing #40	30
%Passing #4	70	%Passing #200	18
%Passing #8	56	PI (or BLSx2)	3

Objective

- Short-term dust control (spray-on)
- Long-term fines preservation (spray-on)
- Long-term fines preservation (mix-in)
- Long-term stabilization (mix-in)

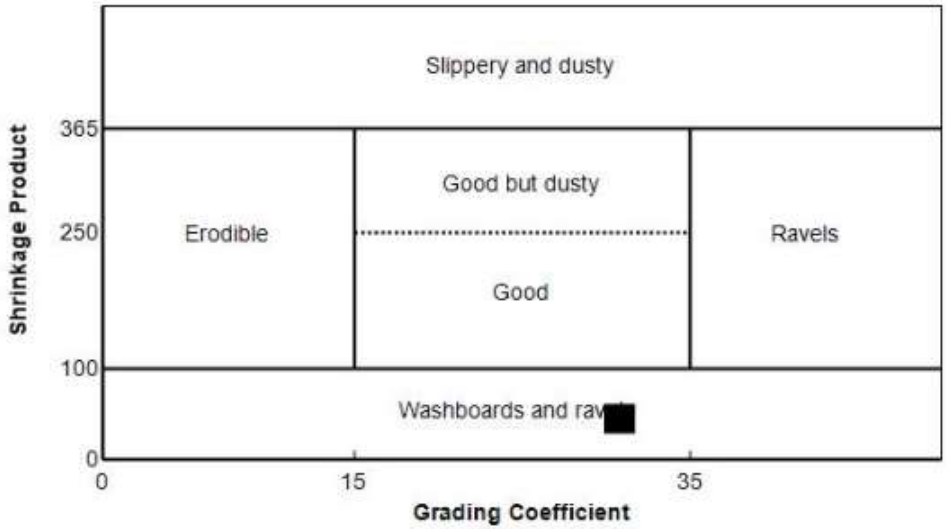
Roadway Parameters

Traffic (AADT): < 100 | Climate: Dry

- [x] More Than 10% Trucks
- [ ] Steep Grades
- [ ] Sharp Curves

Compute Ratings | Environmental & Other Influences

Predicted Material Performance for Untreated Road



Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Synthetic Fluid + Binder	1	1	1	1	1	0	0	1.0
Petroleum Resin	1	1	1	1	2	0	0	2.0
Synthetic Polymer	1	1	1	1	2	0	0	2.0
Asphalt Emulsion	1	1	1	2	2	0	0	2.2
Magnesium Choride	2	2	2	2	1	0	0	2.4
Lignosulfonate	2	1	2	2	2	0	0	2.4
Tall Oil	2	1	2	2	2	0	0	2.4
Concentrated Liquid Stabilizer	1	1	3	2	1	0	0	3.0
Clay Additive	1	1	2	3	2	0	0	3.0
Calcium Chloride	2	3	2	2	2	0	0	3.1
Sodium Chloride Brine	2	3	2	2	2	0	0	3.1
Water	3	3	3	3	3	0	0	NA
Water + Surfactant	3	3	3	3	3	0	0	NA
Glycerin Based	3	3	3	3	3	0	0	NA
Molasses/Sugar	3	3	3	3	3	0	0	NA
Plant Oil	3	3	3	3	3	0	0	NA
Base Oil	3	3	3	3	3	0	0	NA
Synthetic Fluid	3	3	3	3	3	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

Suppliers | Print

Unpaved Road Chemical Treatment Selection Tool

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Home | Instructions | Treatment Selection | Results Interpretation | About

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%Passing 1"	100	%Passing #40	30
%Passing #4	70	%Passing #200	18
%Passing #8	56	PI (or BLSx2)	9

Objective

- (•) Short-term dust control (spray-on)
- ( ) Long-term fines preservation (spray-on)
- ( ) Long-term fines preservation (mix-in)
- ( ) Long-term stabilization (mix-in)

Roadway Parameters

Traffic (AADT): < 100 ▼ Climate: Dry ▼

- [x] More Than 10% Trucks
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- [ ] Sharp Curves

Compute Ratings | Environmental & Other Influences

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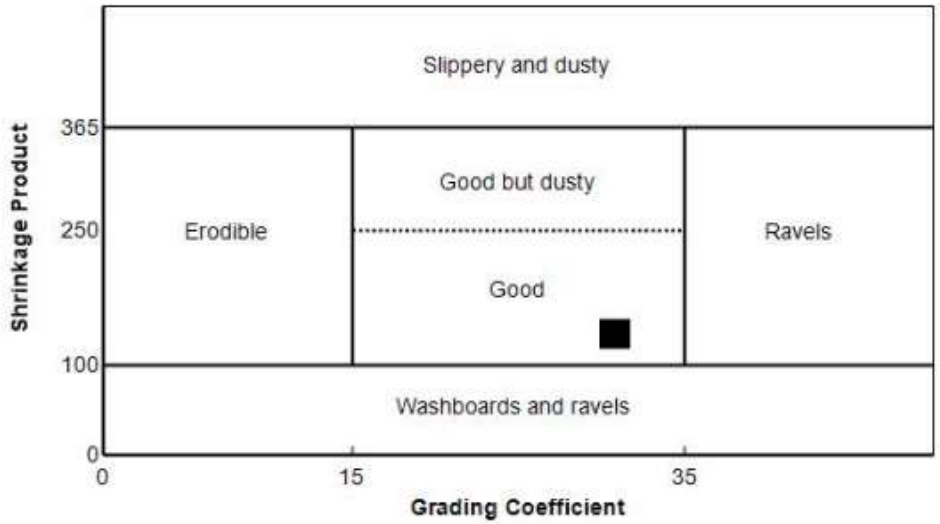


Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Glycerin Based	1	1	1	1	1	0	0	1.0
Lignosulfonate	1	1	1	1	1	0	0	1.0
Tall Oil	1	1	1	1	1	0	0	1.0
Petroleum Resin	1	1	1	1	1	0	0	1.0
Synthetic Fluid	1	1	1	1	1	0	0	1.0
Synthetic Fluid + Binder	1	1	1	1	1	0	0	1.0
Magnesium Choride	1	2	1	1	1	0	0	2.0
Molasses/Sugar	1	1	1	1	2	0	0	2.0
Plant Oil	1	1	1	1	2	0	0	2.0
Base Oil	1	1	1	1	2	0	0	2.0
Synthetic Polymer	2	2	2	2	2	0	0	2.6
Calcium Chloride	1	3	1	1	1	0	0	3.0
Sodium Chloride Brine	1	3	1	1	1	0	0	3.0
Water	2	3	1	1	2	0	0	3.0
Water + Surfactant	2	3	1	1	2	0	0	3.0
Asphalt Emulsion	1	1	2	2	3	0	0	3.0
Concentrated Liquid Stabilizer	3	3	3	3	3	0	0	NA
Clay Additive	3	3	3	3	3	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

Suppliers | Print

NDSU

Permazyme ---------- ----- $12,000- $16,000/ mile

Base One ---------- $0.28-$0.55/sy yd/inch of depth

Corn Oil Acrylic Resins ----- $0.14-$0.15sy yd, $16,000/ mile

Calcium Chloride ---------- - $455/ton, 1.5-2lb/sq yd; $1.26/gallon

Magnesium Chloride -------- $8,000/mile (1st trmt)
$4,900/mile (addl trmt)

Oil Field Salt Brine ---------- Product is free,
$135-$500/hr to apply

Cement ---------- $60,000-$250,000/mile (depending on depth)

Stabilock ---------- $15,000/mile

Dust Control North Dakota
Schwindt 2012

Investment Strategies - Alternatives

Agency Cost Parameters Setup

HMA | AST | Gravel | Dust Control | Stabilized Gravel

HMA

INITIAL COST

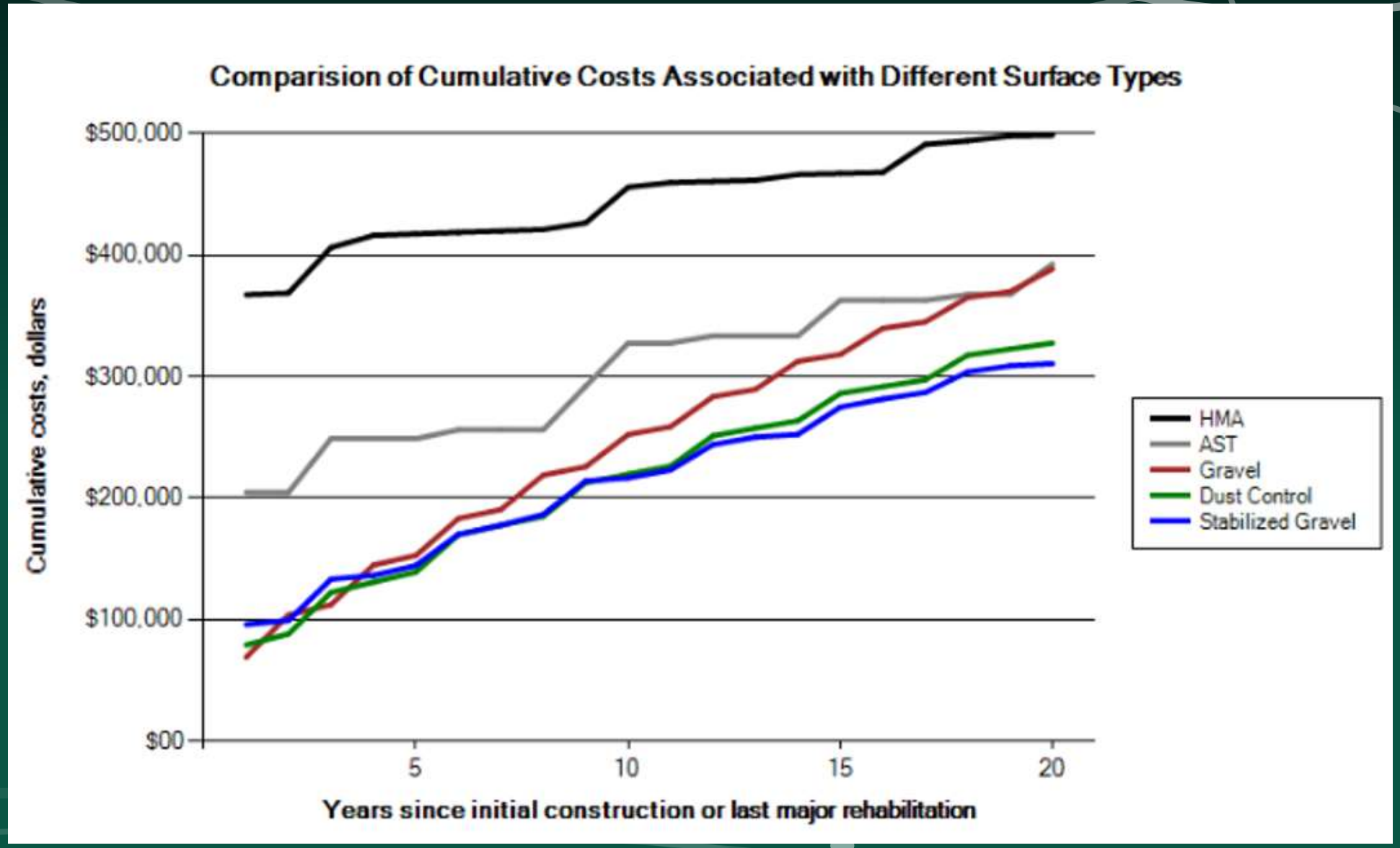
Total Initial Cost ($/mile): $ 725,115 [Initial Costs Calculator]

MAINTENANCE COST

Treatment Selection	Treatment Name	Application Times Per Year	Year Interval Between Applications	Application Start Year	Unit Cost (dollars)	Unit Selection
☑	Crack Sealing	1	4	6	10000	per mile
☑	Seal Coat	1	7	3	20000	per mile
☑	Thin Lift OverLay	1	20	20	250000	per mile
☑	Striping and Marking	1	3	3	2000	per mile
☑	Patching/Maintenance	1	3	3	3000	per mile
☐	Other	1	1	1	0	per mile

[Reset]

[Next Surface] [Back to Common Parameters Setup] [View Analysis Summary] [Help]


Comparision of Cumulative Costs Associated with Different Surface Types
Cumulative costs, dollars
$500,000
$400,000
$300,000
$200,000
$100,000
$00
5
10
15
20
Years since initial construction or last major rehabilitation
HMA
AST
Gravel
Dust Control
Stabilized Gravel

Dr David Jones – University of California Davis
stab/dust – break even at 75-125 vpd

INNOVATIONS in TRANSPORTATION

brought to you by the Soybean Checkoff and UGPTI/NDLTAP

DUST CONTROL — SOY INNOVATIONS

Webinar hosted by UGPTI/NDLTAP

May 11, 2021

9:00 — 10:00 A.M. (CT)

Moderator: Dale Heglund, UGPTI/NDLTAP

9:00	Dale Heglund, NDLTAP	Introduction and history
9:07	Jim Bahr, NDSU	Story of development and future of BioBlend's Epic EL
9:27	Kelly Bengston, NDLTAP	Testing on township roads
9:31	Todd Allison, BioBlend	Product information, specifications, and procurement
9:46	Jason Benson, Cass County Engineer	Cass County testimonial
9:49	Chris Brossart, NDSC	Checkoff story and it's impact here
9:58	Dale Heglund, NDLTAP	Wrap-up
10:00	Conclude	

North Dakota Soybean Council — Our World is Growing

NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE — NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

INNOVATIONS in TRANSPORTATION

brought to you by the Soybean Checkoff and UGPTI/NDLTAP

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North Dakota Soybean Council — Our World is Growing

NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE — NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

North Dakota Local Technical Assistance Program

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North Dakota Local Technical Assistance Program
@ndltap

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Liked | Following | Share | ...

North Dakota Local Technical Assistance Program added 2 new photos.

Published by Dale Heglund · June 13, 2017

North Dakota soy beans are poised to enhance rural road safety. How? Jim Bahr, NDSU Researcher, is helping the ND Soybean Council develop soy-based roadway dust control agents. Reduced dust on gravel roads means safer roads. In 2015 NDLTAP linked up with Jim to assist with Health Department process review and application approval, finding county test site options and planning, specifying dust control measuring equipment, and developing a process to evaluate the product. ... See More

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE


07/27/2017

NDSU

PERMA-ZYME®

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

NDSU


160H


160H


TEAM LAB
BASE ONE®
AGGREGATE BASE STABILIZER

Iowa Study

7-15 PI

4-6% bentonite

$270/mile to pave vs $15k/mile to gravel

Steel smooth vibratory roller laydown

5x dust with normal gravel

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	ROM-0300(130)	6	1

ÞTES

302-P04 AGGREGATE SURFACE COURSE CL 13: Provide a Class 13 Aggregate with a Plasticity Index (PI) ranging from 4 to 9 and meets the requirements of Section 816.02, "Miscellaneous Aggregates". The PI is to be determined in accordance with test ND T 90, "Determining the Plastic Limit and Plasticity Index.

A contract adjustment will be administered if the PI is not within the specified range. The Engineer will determine the PI adjustment factor if the limits for PI are exceeded, as calculated:

PI Adjustment Factor = 5 percent x (Average of 3 Samples – Allowable PI)

If the PI is determined to be greater than 12, the material will be rejected.

STATE	PROJECT NO.	PCN	SECTION NO.	SHEET NO.
ND	ROM-0300(130)	21282	1	1

JOB #

NORTH DAKOTA

'MENT OF TRANSPORTATION

ROM-0300(130)

au, Burke, Mclean, Mountrail, & Renville Counties

Minot Minuteman Complex Regraveling

GOVERNING SPECIFICATIONS:

2014 Standard Specifications adopted by the North Dakota Department of Transportation and the Supplemental Specifications effective on the date the project is advertised.

PROJECT NUMBER \ DESCRIPTION	NET MILES	GROSS MILES
ROM-0300(130) Minot Minuteman Complex Regraveling	34.6	34.6

DESIGNERS

STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND	ROM-0300(130)	6	1

ÐTES

302-P04 AGGREGATE SURFACE COURSE CL 13: Provide a Class 13 Aggregate with a Plasticity Index (PI) ranging from 4 to 9 and meets the requirements of Section 816.02, "Miscellaneous Aggregates". The PI is to be determined in accordance with test ND T 90, "Determining the Plastic Limit and Plasticity Index.

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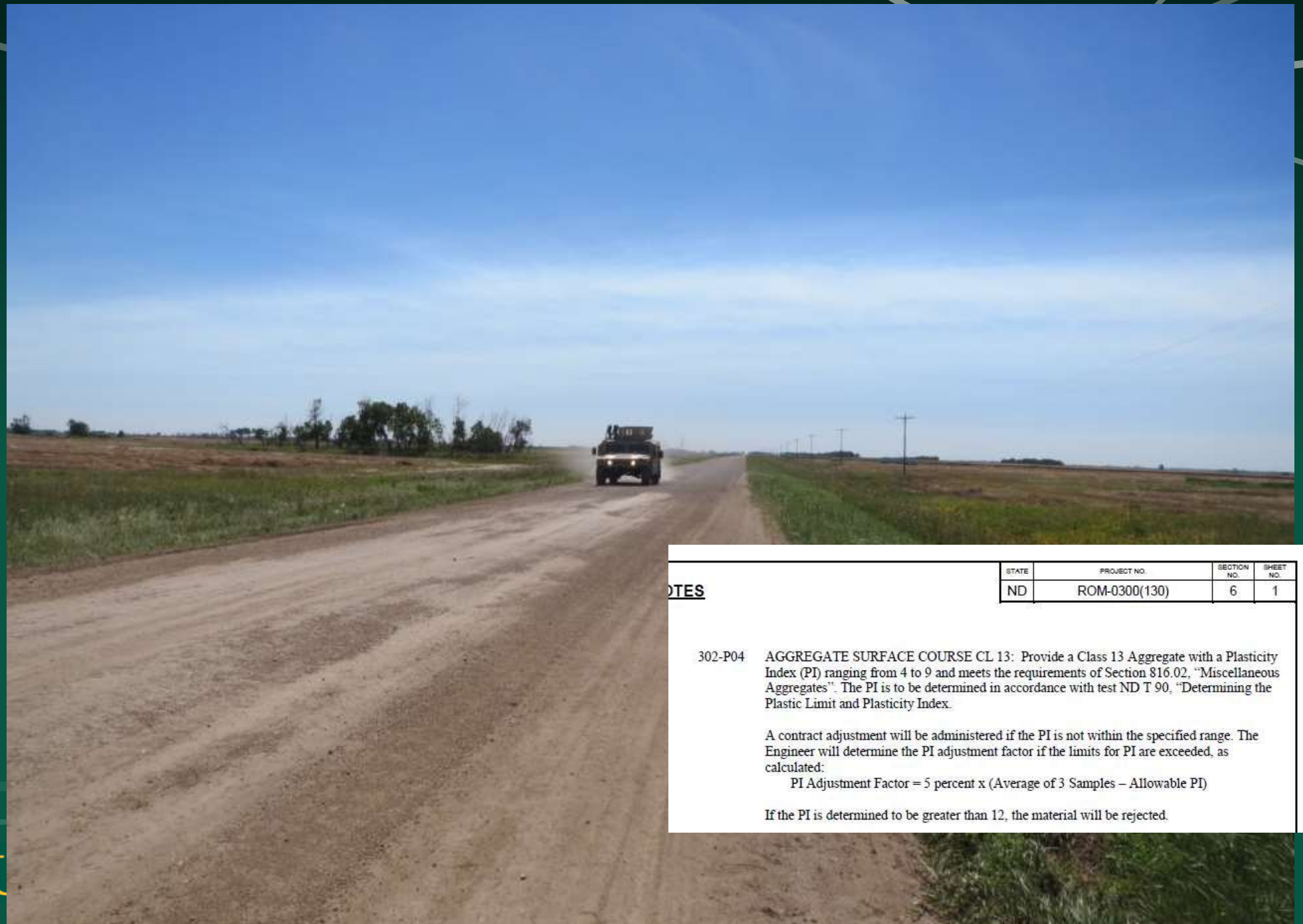

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OTES

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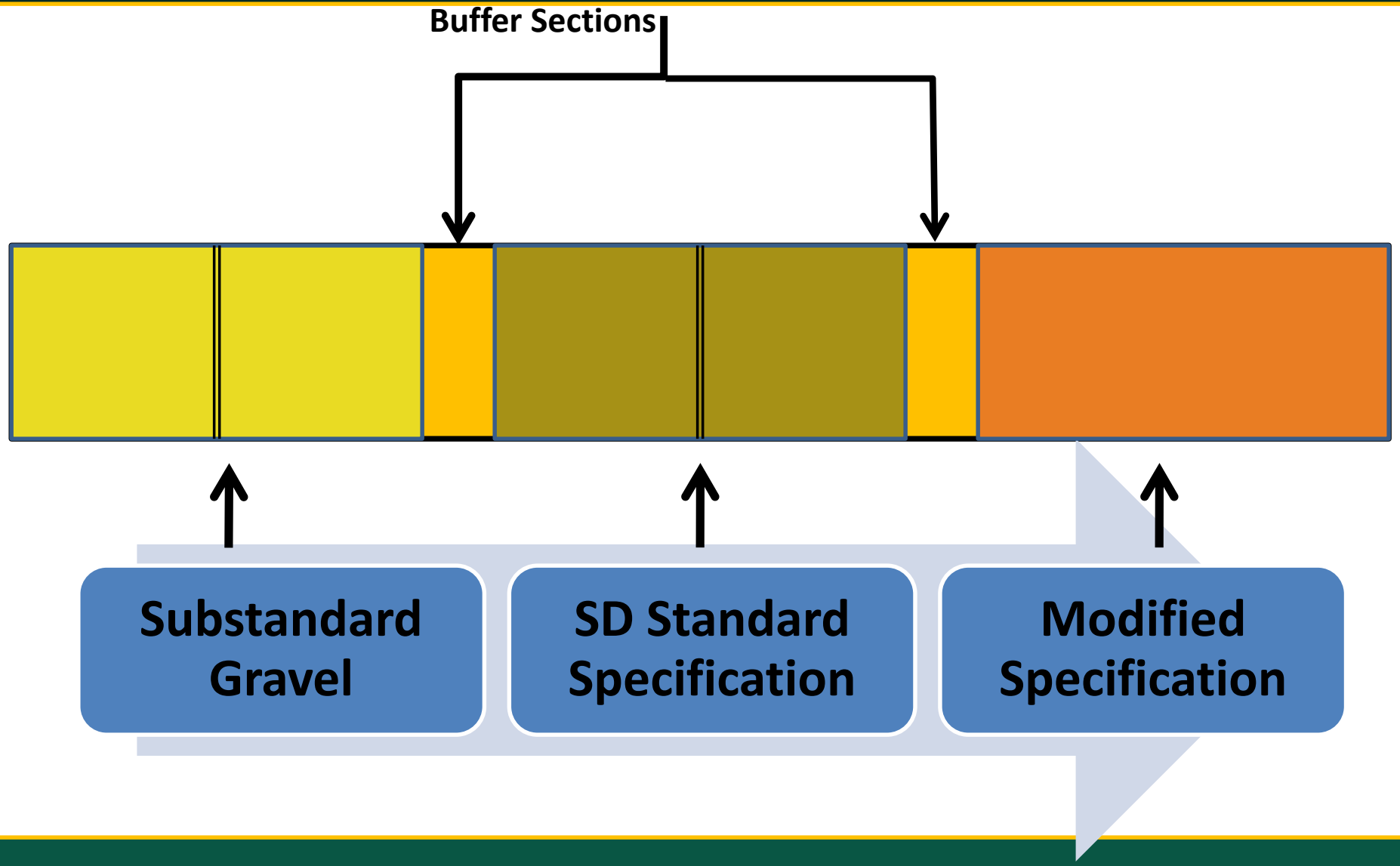
NDSU

NDSU UPPER TRANS

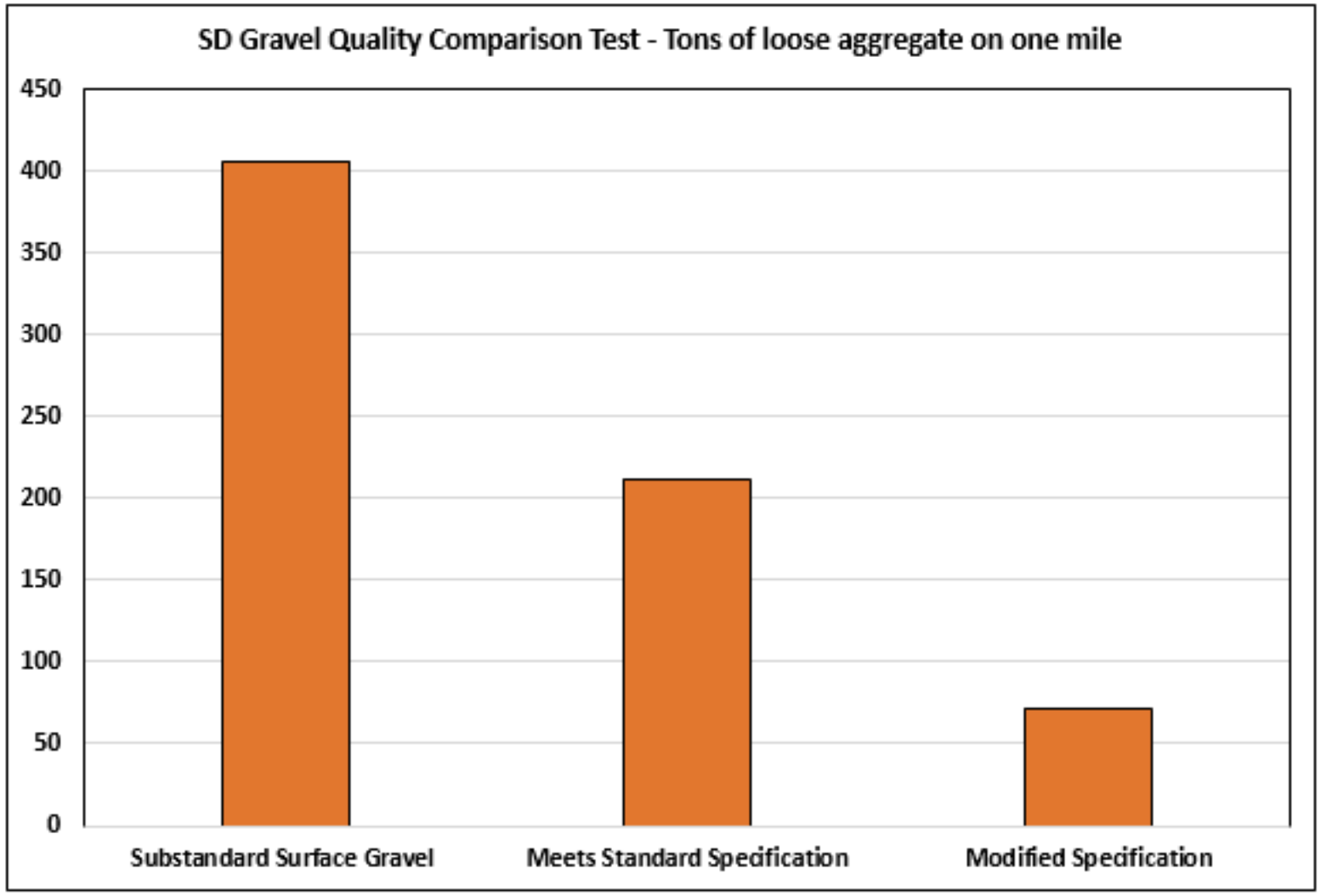
South Dakota Gravel Study



The float test (loose aggregate)

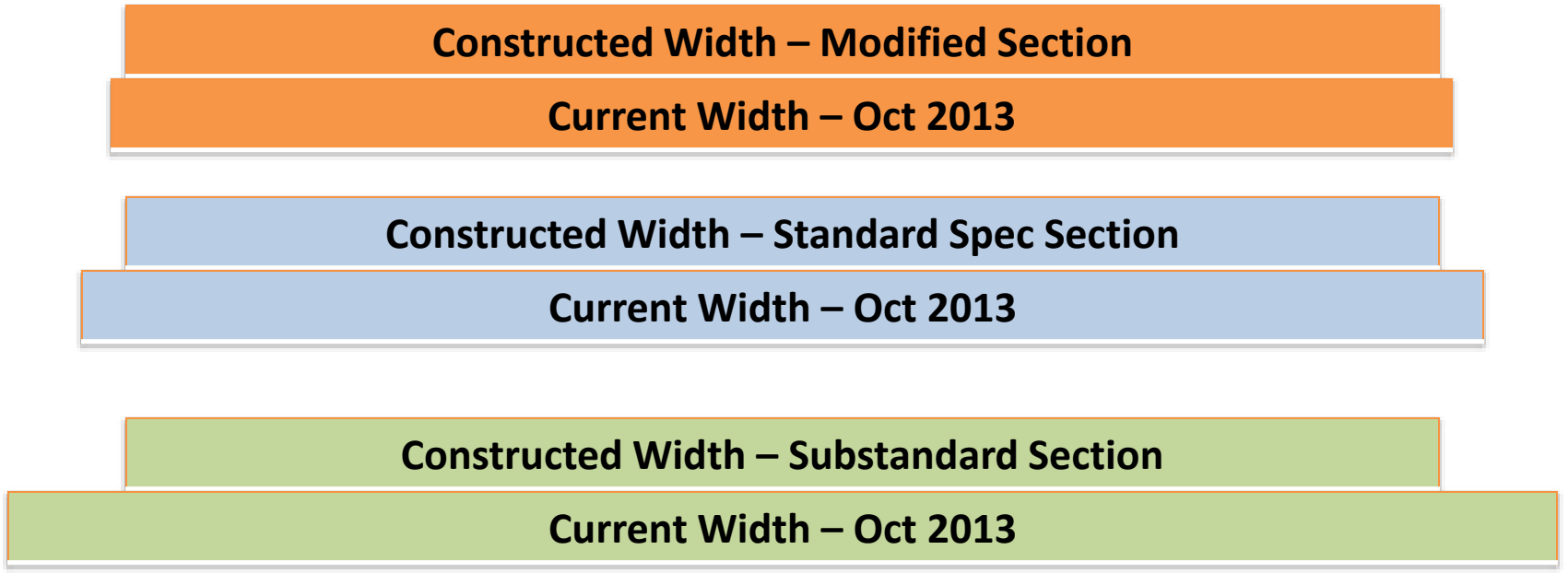
Corrugations = Wash Boarding

Volume of loose aggregate measured in a dry season was the biggest difference in the test sections.



Substandard section – aggregate has moved outward over 4 ft since construction

Change in Roadway Surface Width
Constructed Width – 21.5 ft on all sections



Current width ranges from 22 ft on modified section (top bar) to 25.25 ft on substandard section (bottom bar)

The modified section in the spring after construction

One way to meet modified spec – blend different material from separate sources

2020 INNOVATIONS

Pipe Cleaner – 1st Place
Traill County Highway Department

Motor Grader Step
Golden Valley County Highway Dept.

Culvert Rack
Stark County Highway Department

Award

The 1st place winner will receive one paid trip to the North Central Regional Local Roads Conference in Sioux Falls, South Dakota. The award includes bus travel, conference registration and hotel (NDLTAP will reimburse costs to winner). This year the conference is on October 19-21, 2021. State and regional awards will be presented at the conference.

2020 State Winner

Traill County Highway Department

Corey Ackerman, Jay Showers—Innovators
(L. to R.)
(Award will be presented at the 2021 regional conference)

CONTACT:

Leanna Emmer
Office: (701) 220-4595
leanna.emmer@ndsu.edu

Upper Great Plains Transportation Institute
North Dakota State University

North Dakota Local Technical Assistance Program (NDLTAP)

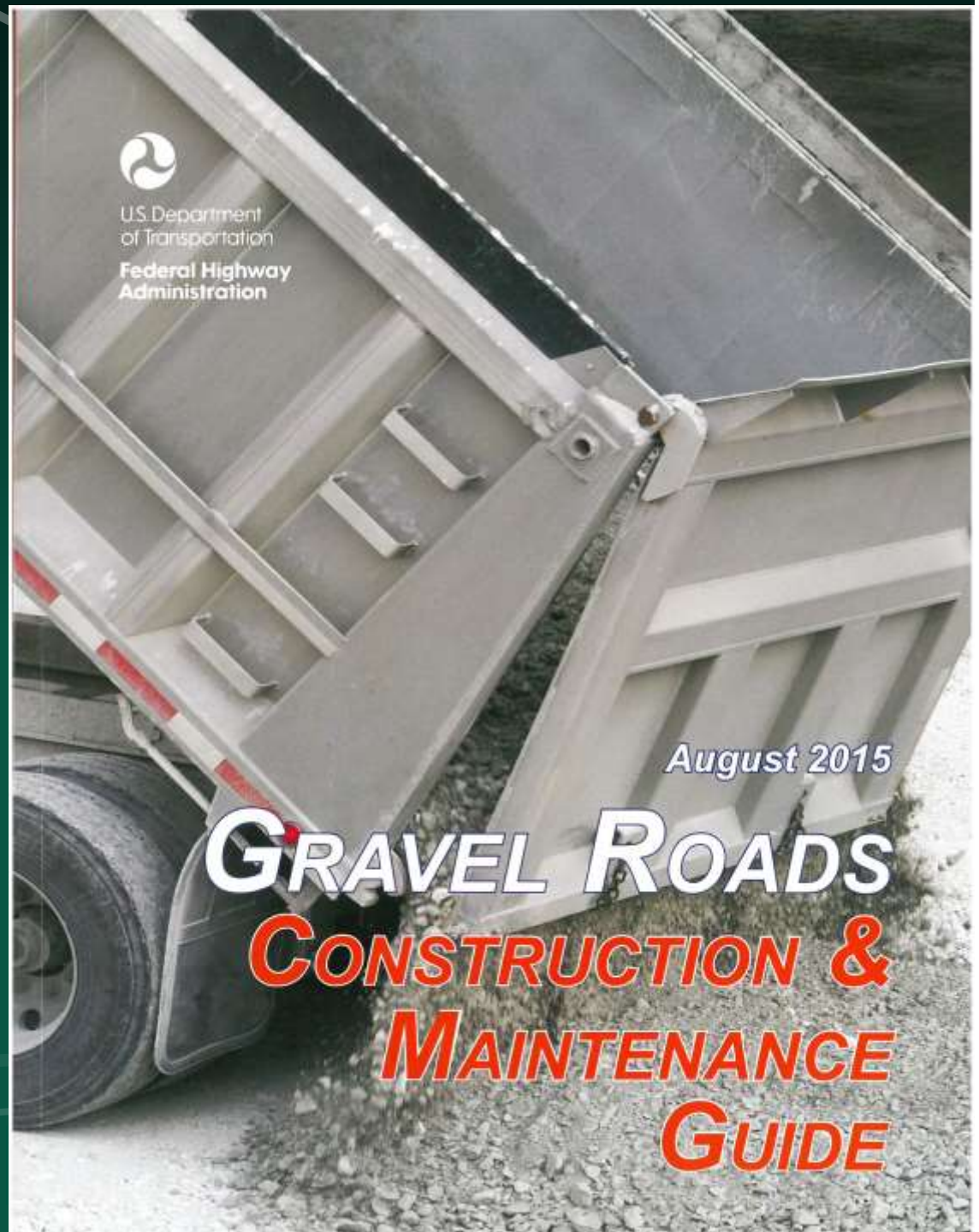
www.ndltap.org

2021 INNOVATION CHAMPIONS

NDSU UPPER GREAT PLAINS TRANSPORTATION INSTITUTE

National Winner – LaMoure County

Spring Load Arm for Gravel Saver Disc



Gravel Roads

Part II

Back to the Basics

Local Technical Assistance Program
Department of Civil Engineering
Montana State University-Bozeman
Bozeman, MT

2000


ROUGH-T


Vintage

NDLTAP – The Resource of Choice

ANSWERS FROM AN EXPERT

Application Rate of MagChloride Used for DUST Abatement

By Ken Skorseth, SD LTAP Special Projects Manager
Author: Gravel Roads Maintenance & Design Manual & Gravels Construction & Maintenance Guide

CO LTAP received the following technical assistance question. Gravel Roads expert, Ken Skorseth, submitted the following reply and supplemental photos.

What is the recommended amount and application rate of Magnesium Chloride used for DUST abatement for a second treatment applied about a year later?

[Ken] It is hard to give a concise answer due to these factors:

- The quality of the surface gravel has so much impact on this. Good surface gravel prepared well for MagChloride ($MgCl_2$) generally performs well, but ---
- The rate of application of *initial* treatment also has an impact on following treatments. We generally use between 0.45 and 0.6 gallons per square yard for the initial treatment.
- Thereafter, traffic volume and moisture received through the season will have some impact on the succeeding year as well.
- Having said all of the above, we often see second year treatment at the same rate as the first year, or 0.1 to 0.2 gallons per square yard ***less*** than the initial treatment.
- In succeeding years, we sometimes see treatments down to half of original application rates.
- The local agencies who do this very well nearly always say something like this, "there isn't a set rate for treatment; you have to observe the road and use field judgement to determine it."
- These photos show several different situations to demonstrate.

1/4
GOOD: 6-6-13 Just after treatment at 0.5 gal per sq yd. Commercial dairy road. Heavy truck traffic ^AADTT 30 - 40. Road looks good.

2/4
POOR: 7-16-13 Same road, already failing!

3/4
POOR: 7-16-13 Almost total dust control failure

4/4
POOR: 10-7-13 After another 0.3 gal per was applied same season still not performing well. This is such poor surface material it won't go into a bound state no matter how you maintain it. There is no way the $MgCl_2$ can work even with 0.8 gal per sq yd applied in one year!

Here's the critical issue: It was applied to poor material (reclaimed concrete) usually not compatible with chloride treatment.

GOOD: Residential road. Initial treatment 0.5 gal per sq yd. Same treatment Year 2. Gets 0.25 - 0.3 gal treatments in succeeding years. Treated annually 10 yrs. Performs very well.

GOOD: Treated with $MgCl_2$ continuously since 1988. Initial treatments of 0.5 gal per sq yd in first 2 years; 0.25 to 0.4 treatments since. Applied in May. 1,000 ADT

ROAD READY R3 RESEARCH

DEC 2020 NO. 2

RESEARCH REVIEW: Dust Control on Gravel Roads: Traditional Methods Using Magnesium and Calcium Choloride

by Curtis Glasoe, PE/PLS, NDLTAP Technical Support Representative

"Dust control for gravel roads has been practiced for many years now in our region and around the world. Dust generated by traffic on a gravel road creates many concerns including: safety issues for the traveling public by reducing visibility, degrading air quality, increasing road maintenance costs due to loss of fines in the gravel and reducing crop yields. Dust control products are a great tool to use for gravel preservation. The increased cost of mining, processing & hauling specified surfacing gravel plus the fact that its availability is limited are good reasons to have a policy on dust control that is connected to the average daily traffic counts for various road segments in your county or township. The reduction in re-graveling and blading costs should be considered as a savings when adding dust control projects into the road budget when planning widespread applications."

Kelly Bengtson PE, NDSU UGPTI LTAP Bridge & Pavement Engineer

Gravel roads are dusty. For many roadways, the dust creates unsafe driving conditions. Additionally, the loss of fine material degrades the ability of the driving surface aggregate to bond together and shed water.

Logically, increased traffic volumes result in increased dust. So what can we do to reduce the dust? As traffic volumes exceed 100 average daily traffic (ADT), consideration should be given to the application of dust control.

Your county should consider having a policy to follow that includes ADT, length of strip applications for rural homes or for road intersections susceptible to dust issues. A policy can reduce your liability and improve the safety of the traveling public. Several counties already have a policy and LTAP can help you develop one.

Spot applications in front of residences near roadways may suffice for some roadway segments. As traffic volumes increase, dust control for full roadway sections should be considered. According to various studies, the volume of gravel material that is blown away or lost from the surface can be estimated at 1 ton of material per mile/vehicle/year. To put it another way, consider a sample roadway with a traffic volume of 250 vehicles per day, we can estimate a loss of 250 tons of gravel per mile/year. That is 10 semi loads of gravel on a mile section of roadway!

In addition to the obvious safety problem of sight distance with dust, a bigger problem is that existing gravel sources are being depleted and not many new sites are being found to provide adequate aggregate to surface roads. Some counties in the state are already going outside county boundaries to secure aggregate surfacing. This serious situation must be addressed through changes in the way we do business.

NDSU | UPPER GREAT PLAINS TRANSPORTATION INSTITUTE
NORTH DAKOTA LOCAL TECHNICAL ASSISTANCE PROGRAM

BURLEIGH COUNTY HIGHWAY DEPARTMENT

8100 43RD AVENUE NE
BISMARCK, ND 58503
701-204-7748
FAX 701-204-7749
www.burleighco.com

Dust Control Policy

Approved by the Burleigh County Commission
(February 3, 2014)

OVERVIEW

As the area around the City of Bismarck grows, residents on the township and county roadway system have experienced increases in traffic. It has long been the desire of the Burleigh County Board of Commissioners and the Highway Department to promote the paving of new subdivisions that are developed; however, in older subdivisions and on section line roadways in the growth area, that have not been paved, we are receiving more calls requesting some type of dust control.

The loss of fines (dust) from our gravel roads is not only a nuisance to residents, but it can also be a health hazard to individuals with emphysema or asthma. It also decreases the effectiveness of our gravel by creating greater segregation within our roadway surfacing. This requires us to gravel more often. Chemical treatment of gravel roads with either Calcium Chloride or Magnesium Chloride has been proven to reduce the loss of fines from gravel roadways. In general, Magnesium Chloride has been found most effective in our climate. Other types of chemical treatments have been tested but none have been found as effective as Magnesium Chloride.

It is the Highway Department's desire to implement a Dust Control Policy to help direct the use of chemical treatment of both township and county roadways. The following guidelines would be used in administering the application of dust control chemicals:

OPERATING PROCEDURES

On county roads:
Dust control will be applied to gravel roadways meeting the following criteria:

1) Roadways with Average Daily Traffic (ADT) counts of 200 or greater will receive solid application.

2) Roadways with ADT counts between 50 and 200 will receive application in front of homes and buildings.

3) Roadways with ADT counts less than 50 will receive application in front of homes if the resident of the home has health (breathing) issues, and provides us documentation of such.

4) Application in front of homes will only be done if the home is within 1,000 feet of the roadway. The application distance in front of homes will be for a maximum of 1,500 feet.

On township roads:

1) The township must request dust control application, and

2) The township agrees to pay all costs associated with application, and

3) The township agrees with the same application criteria as laid out for county roads.

4) The County Commissioner holding the Highway Department portfolio will approve/deny all requests for dust control application on unorganized township roadways.

The County Highway Department will determine the application rates and the type of dust control chemical used on an annual basis.

INFORMATION

Questions or concerns regarding Burleigh County Dust Control Policy may be directed to the Burleigh County Highway Department in Bismarck at (701) 204 - 7748.

"Investigation of Methodologies to Control Dust on County Roads in Western North Dakota"
Francis Schwindt 2012.

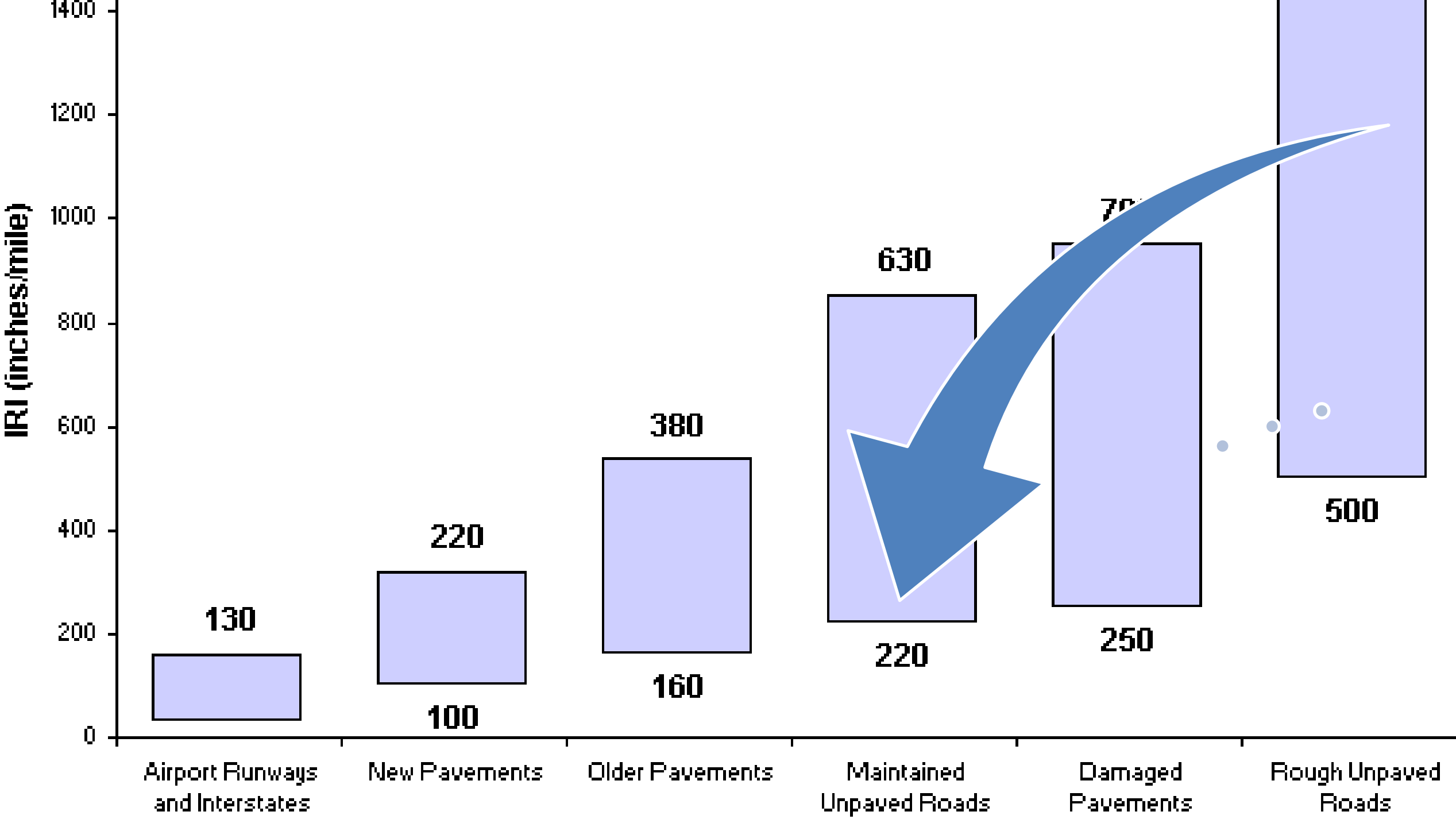
Find links to his reports at http://www.ndltap.org/resources/dust.php

Gravel Roads Maintenance Cost

Potential Savings Per Mile

$8,077.50

	DustGard	Untreated
Aggregate Replacement Cost	$2,340.00	$5,827.50
Maintenance Cost	$3,720.00	$10,560.00
Cost of DustGard	$2,250.00	$0.00
Total	$8,310.00	$16,387.50


IRI (inches/mile)
1400
1200
1000
800
600
400
200
0
130
100
220
160
380
220
630
250
500
Airport Runways and Interstates
New Pavements
Older Pavements
Maintained Unpaved Roads
Damaged Pavements
Rough Unpaved Roads

302-P01 AGGREGATE SURFACE COURSE CL 13 (MODIFIED): This item shall be modified as follows:

Class 13 (Modified)	
Sieve Size or Testing Method	Percent Passing or Testing Requirement
1"	100
3/4"	90-100
3/8"	50-90
No. 4	35-65
No. 8	22-55
No. 30	12-45
No. 200	8-15*
% Shale and Soft Rock	Max. 15%
L.A. Abrasion Loss	Max. 15%
Plasticity Index	7-13%
Fractured Faces	10%

*The material passing the #200 sieve should be able to be rolled into a ribbon when moistened, indicating adequate clay material in the fines.

NDDOT Gravel Spec (Special Provision 714)

Sieve Size Or Testing Method	Aggregate Gravel Surfacing Percent passing or Test Limit
1"	100
¾"	70 – 100
No. 4	38 – 75
No. 8	22 – 62
No. 30	12 – 45
No. 200	7 - 15
Plasticity Index (PI)	3 - 9
ND T 113, Shale (max %)	12.0%
AASHTO T 96, L.A. Abrasion (max %)	50%
NDDOT 4, Fractured Faces[1]	10%

[1]Minimum weight percentage allowable for the portion of the aggregate retained on a No. 4 sieve having at least 1 fractured face.

"Binder" Clay Requirement

"Gradation" Requirement

a. Liquid Limit test

b. Plastic Limit test

Too much coarse rock, lacking coarse sands – will ravel badly

Too much coarse sand, too little rock, will washboard badly

Good gravel surfacing (good representation of sizes to fill voids, high enough minus #200 to create road crust, will hold chlorides well

8/29/2022

NDSU UPPER TRANS

Bringing Ideas to Life

Road Blading Task List

1	Restore drainage in ditches
2	Remove road shoulder vegetation
3	Blade when road surface moisture is high
4	Cut out potholes and washboards
5	Salvage loose gravel & remix, remove large rock
6	Maintain a straight shoulder line
7	Rebuild a consistent crown that is centered
8	Compact the bladed surface at correct moisture
9	Develop a tough road surface crust
10	Reduce surface erosion & sedimentation
11	Reduce gravel loss
12	Improve road user safety
13	Avoid accidents with idiot drivers
14	Limit time talking with road users
15	Blade as many miles per day as possible
16	Adjust blading methods based on variable road conditions, window of time for proper moisture and total miles in your area.
17	Return home safely


Betty Crocker
Delights
SUPER MOIST
LEMON
CAKE MIX
PER 1/12 PACKAGE
160
NET WT 15.25 OZ (432g)


You will need:
1 Cup Water
1 Stick (½ Cup) Butter, Softened
3 Eggs
1 Heat oven to 350°F for shiny metal pan or 325°F for dark or nonstick pan. Grease bottom only of pan (use paper baking cups for cupcakes).
2 Beat cake mix, water, butter and eggs in large bowl on low speed 30 seconds, then on medium speed 2 minutes, scraping bowl occasionally. Pour into pan.
3 Bake as directed below or until toothpick inserted in center comes out clean. Cool completely before frosting.
Pan Size | 8" x 8" | 9" x 9" | 8" or 9" Round | 12 Cupcakes
Bake Time (in minutes) | 44-49 | 38-43 | 43-48 | 18-23
High Altitude (3500–6500 ft): Bake 8" square shiny pan 44-49 min; 8" square dark pan 46-51 min. Bake 9" square shiny pan 38-43 min; 9" square dark pan 40-45 min. Bake 18 cupcakes at 350°F 18-23 min (all pans).

NDSU UPPER GREAT PLAINS TRANSPORTATION INST

The float test (loose aggregate)

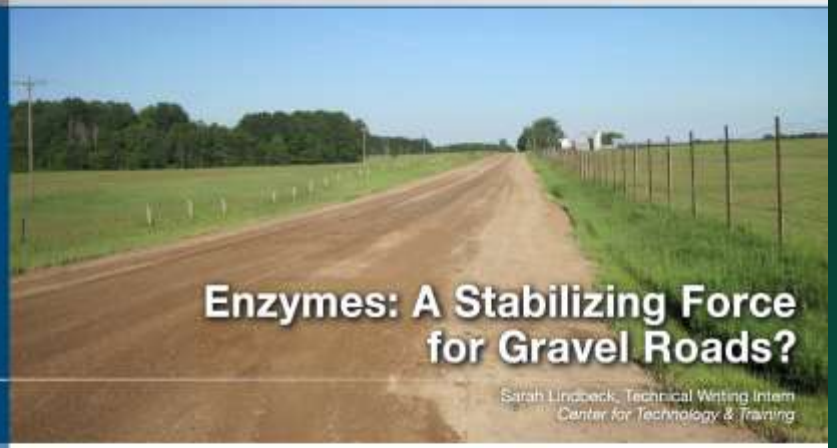

DEERE
RM
07/27/2017

Vol. 32, No. 4 – Spring 2020

The Bridge

A quarterly newsletter from Michigan's Local Technical Assistance Program

Enzymes may drastically decrease the need for preventive maintenance on unpaved roads. Learn more about this intriguing innovation.



Enzymes: A Stabilizing Force for Gravel Roads?

Sarah Lindbeck, Technical Writing Intern
Center for Technology & Training

Inside

Michigan's Local Technical Assistance Program

The people who built the pyramids, Parthenon, and Empire State Building believed they were engineering something that would stand the test of time. Arguably even more admirable than that are the people who build gravel roads, knowing that they are engineering something that will require constant maintenance until the end of its time. Building a road is a binding commitment. It commits a road owner to contending with freeze-thaw cycles, drought, Labor-Day weekend traffic, and varying gravel and soil qualities over the road's entire service life. But, what if gravel roads did not have to consume so much money, calcium chloride, and time for upkeep? A brighter future for gravel road maintenance may lie ahead with enzymes used to stabilize the gravel.

Enzymes are a relatively new method for stabilizing gravel roads, originating in the 1990s. Eric Seagren, professor of Civil and Environmental Engineering at Michigan Technological University, provided a timeline of unpaved road design, explaining, "Early on, geotechnical and pavement engineers were focused on physical and mechanical things they could do to soil, such as compacting it and adding geosynthetics." He says that, years later, it was discovered soil had a chemistry of its own and was teeming with life. Seagren not only studies soils but also a process called "bio-cementation", in which "microorganisms or enzymes are used to facilitate reactions that create an environment where calcium carbonate can precipitate and cement soil particles together". His work with bio-cementation is part of a gradual movement toward inter-disciplinary collaboration between science experts to develop better, cheaper, more environmentally-friendly solutions that consider different aspects of road construction and maintenance.

Enzyme History and Science

Enzymes first found their way into agricultural applications after a family of farmers noticed the ground around their animal feeder became compacted.[1] The farmers determined that enzymes in the feed reacted with the soil to harden the ground. After that, the enzymes were used to harden the surface of farm roads as well as repair leaks and eliminate vegetation growth in ponds. Variations that contained additional nutrients to fertilize soil were developed, but the enzymes in the fertilizer also retained their original water attraction properties, which helped improve the soil quality for crops.

Since those initial uses, manufacturers began selling enzyme products for stabilization of soils in gravel roads because they worked so well on the farm roads. Although many components that make up these enzyme products are proprietary, the company Perma-zyme discloses that their enzyme consists of "food by-products that are created through a fermentation process".

An enzyme is an organic catalyst that can be used in gravel road stabilization. Once it is in contact with the soil, the positively-charged enzyme merges with the soil's organic molecules to form a reactant intermediary, which exchanges ions with the negatively-charged clay structure of the soil. As a result, the clay particles become

► Enzymes, page 10

Dust Control Policy

One way to meet modified spec – blend different material from separate sources

Road mixing natural clay to get a high quality surface gravel

The modified section in the spring after construction

Corrugation was a problem on the substandard section. No corrugation on the modified section.

Concluding Points

- **Meeting basic SDDOT standard surface gravel specification reduces loose aggregate by 1/3 to 1/2.**
- **2012: 405 tons of loose aggregate on substandard section and only 71 tons on modified section.**
- **No corrugation ever observed on standard or modified material.**

Concluding Points (Con't)

- **Blade maintenance <u>four times on substandard section</u> and <u>once on modified</u>!**
- **Some aggregate producers have resisted change - prefer to produce as they always have – no close control of % passing the #200 sieve and plasticity index.**

NDDOT Special Provision – Gravel Surfacing SP 714(14)

Sieve Size Or Testing Method	Aggregate Gravel Surfacing Percent passing or Test Limit
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¾”	70 – 100
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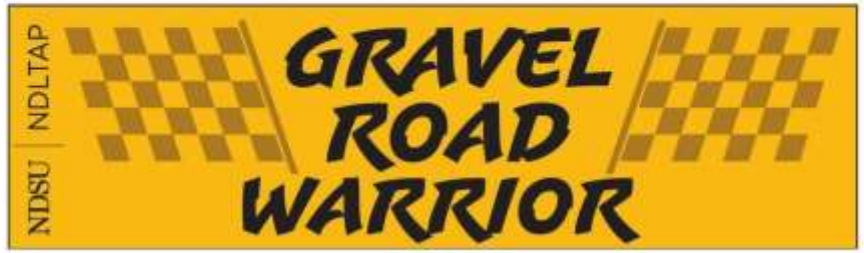
NDDOT 4, Fractured Faces[1]	10%


Z&S
Dust
Control

Gravel Surfacing – New Specification

By Dale C. Heglund, NDLTAP



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Continuous improvement, a way of life for local leaders.

October 1, 2018

Learn tips on how to find and evaluate gravel sources, making realistic specifications, how owners and suppliers working together provide quality results, and adding clay (nature's glue) to gravel surfacing. Participants from the class will leave with the working knowledge on how to improve gravel performance and life.

Crushing good gravel can be a challenge, but how can we make existing poor and tired gravel perform better? While even the best of gravels can't match the year-round qualities of asphalt, we can sweeten the mix and make them better with a small percentage of clay.

- Hands-on review of sand, silt and clay.
- Identify the causes of gravel road deficiencies – wash boarding, dust, float, rutting, etc.
- The value of gravel testing.
- Clay is the glue. Review test for fine materials in gravel.
- Ways to lower bids for gravel.
- Best practices for gravel road maintenance.
- Best practices for gravel sampling, testing and acceptance.
- Develop options to improve existing gravel quality – production, stockpiles and road surfaces.
- Better gravel – better roads. Better roads – safer roads. Safer roads – save lives. With nearly 60,000 miles of gravel roads, the class is meant to help us create better, safer roads.

Learn how to "Make Gravel Roads Great Again!"

More Clay needed on Deving Township Roads

Curt Glasoe, Technical Support Representative recently met with Charlie Sorenson, Deving Township Supervisor – Mountrail County to discuss township road issues. Charlie is looking for innovative ways to improve the roads in Deving Township. Sorenson stated there is good spec gravel, on the roads, but with no or little plasticity index (PI).

Good surface gravel needs a percentage of plastic material, usually natural clays, which will give the gravel a "binding" characteristic and hence a smooth driving surface.

Binder for gravel:

- Improves road crust durability
- Can reduce dust & subgrade soft spots
- Improves life of chloride salt dust abatement
- Improves performance of some proprietary dust abatement and stabilization products

Some other benefits of Clay binder is it fills voids in gravel, forms road crust, sheds rain, retains chloride and chloride keeps clay from dusting.

More information on Clay binder can be found in several resources on the NDLTAP website.
https://www.ndltap.org/resources/motorgrader.php

What does your gravel spec look like now?

Sieve Size	NDDOT Cl 13	MT Gravel Surfacing	SD/FHWA Gravel Roads Manual	Proposed Gravel Surfacing
1”	100	100		100
3/4”	70-100	80-90	100	70-100
1/2”		60-80		
3/8”				
No. 4	38-75	50-70	50-78	38-75
No. 8	22-62	37-60	37-67	22-62
No. 10				
No. 30	12-45			12-45
No. 40		13-35	13-35	
No. 200	7-15	4-18	4-15	7-15
PI		4-12	4-12	4-12
Shale (max %)	12.0			12.0
LA Abrasion (max %)	50		40	50
NDDOT 4, Fractured Faces	10			10

NDDOT
North Dakota
Department of Transportation

How do you make the Transition to good gravel?

- Change your specification and start using it, or
- Need to try it first
  - Get someone else to pay for it
    - Like the Air Force

NDDOT
North Dakota
Department of Transportation

Trial Project

- Defense Access Road Program
  - Funding for maintenance of TE Routes
  - 300 miles of gravel roads in 8 Counties in ND
  - FHWA works with the Air Force
  - NDDOT typically manages the projects
- 2016 Graveling project
  - 40 miles in 5 counties
  - Modified Cl 13 specified
    - PI requirement of 4-9
  - FHWA and the Air Force will monitor the project

NDDOT
North Dakota
Department of Transportation

How do you make the Transition to good gravel?

- Changing the specification?
  - Get NDDOT to change the Cl 13 spec (add PI), or
  - Get NDDOT to add new Spec (Cl ?) specifically for gravel surfacing, or
  - Add a plan note in your plans to modify the spec, or
  - Modify the gravel spec in each county to what works for each county?
- Do some training on blading/maintenance with the different material!

NDDOT
North Dakota
Department of Transportation


Plasticity
Index
“PI”

Gravel Road Surfacing Stabilization Testing

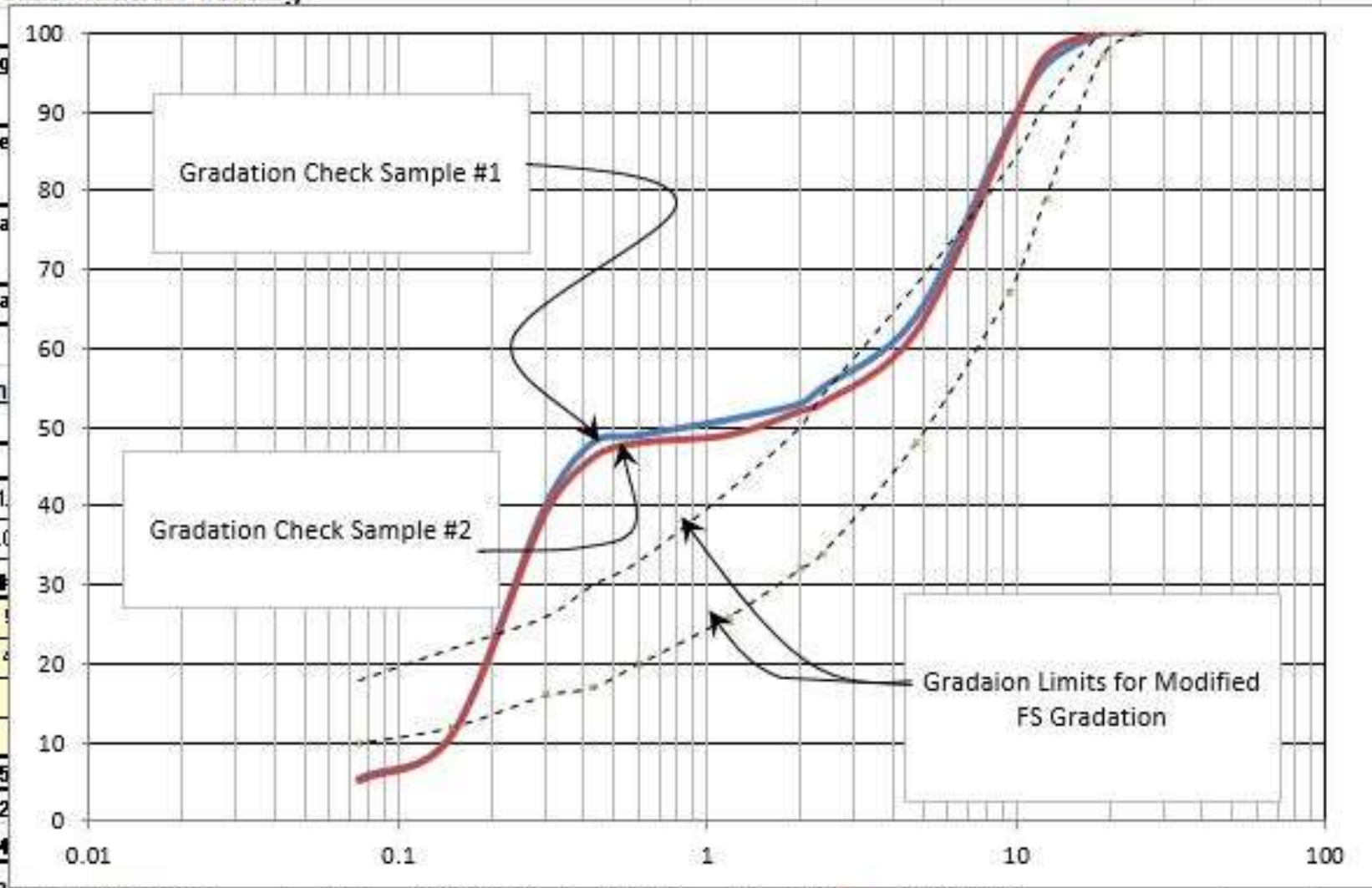
Client :	Richland County
	201 W. Holly St.
	Sidney, Mt. 59270
Project:	Gravel Roads
	5/8 inch reject

Ag
Be
Ca
Da

Preliminary Testin

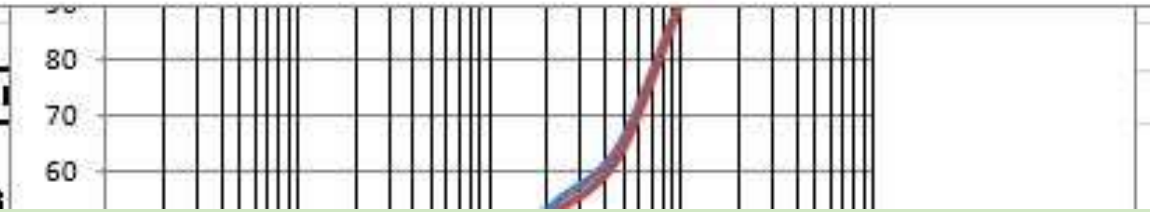
Sieve Analysis

Sieve Size									
	mm	25	19	12.5	9.5	4.75	2.36	2	1.
	0.45 P	4.257	3.762	3.116	2.754	2.016	1.472	1.366	1.0
	Std	**1**	**3/4**	**1/2**	**3/8**	**#4**	**#8**	**#10**	**#**
sample #1		100	100	96	88	64	55	53	
sample #2		100	100	97	87	62	53	52	
sample #3									
sample #4									
AVERAGE		**100**	**100**	**97**	**88**	**63**	**54**	**53**	**5**
Mod FS Spec	Low	**100**	**97**	79	**67**	**48**	34	32	**2**
	High	**100**	**100**	91	**83**	**68**	54	50	**4**

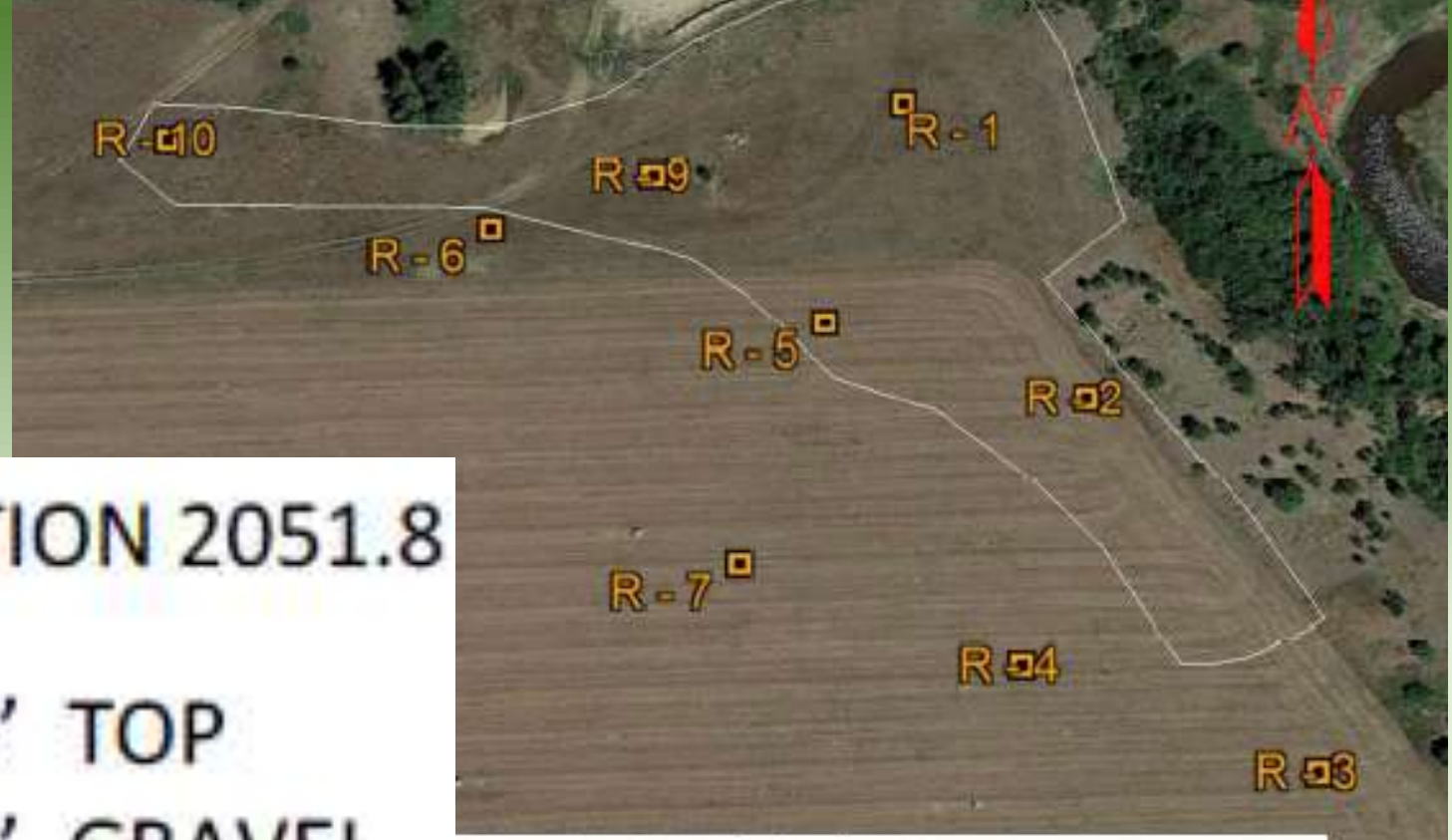


Mix Design Trial Blend Data Summary

Test No.	% Bentonite	% Calcium Chloride	AASHTO T180		CBR Specimen I		
			Optimum Moisture	Maximum Dry Density	% Mois	% of	CBR



Grant County Sample



R – 1 ELEVATION 2051.8

0’ – 1.5’ TOP
1.5’ – 5’ GRAVEL
5’+ SAND

Jay Ruscheinsky Pit
NW1/4 Section 35, T132N, R87W

AREA = 167,000 SF
AVERAGE DEPTH = 3’
ESTIMATED GRAVEL = 18,555 CY

R – 1	ELEVATION 2051.8	R – 2	ELEVATION 2052.2	R – 3	ELEVATION 2055.5
	0’ – 1.5’ TOP		0’ – 2’ TOP		0’ – 1’ TOP
	1.5’ – 5’ GRAVEL		2’ – 5’ GRAVEL		1’ – 6 NO GRAVEL
	5’+ SAND		5’+ SAND		6’+ SAND
R – 4	ELEVATION 2057.3	R – 5	ELEVATION 2052.3	R – 6	ELEVATION 2052.1

SOURCE: J. Ruschienski

erracon
Hancock Dr, PO Box 2084
arck, ND 58501
258-2833

71

MECHANICAL ANALYSIS:

Passing	
4”	100%
3	89
2	86
1 1/2	84
1	81
3/4	78
5/8	77
1/2	74
3/8	71
#4	58
8	46
16	36
30	28
50	20
100	9.3
200	6.0

ATTERBERG LIMITS:

Liquid Limit	NP
Plastic Limit	NP
Plasticity Index	NP

Material testing

Stockpile measurement

Payment

Reclamation

Gra

The North Dakota DOT ma
and shoulder material. They

CI 5 Gravel – drainable base
pavement cracks enters the
outer edge of the roadway ra
natural soil foundation) dry th

CI 13 Gravel – shouldering
more fine material allowed (i
allows sensible utilization of

Gravel Surfacing – New Specification

By Dale C. Heglund, NDLTAP

NDSU | NDLTAP GRAVEL ROAD WARRIOR

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Continuous improvement, a way of life for local leaders.

October 1, 2018

Dale C. Heglund

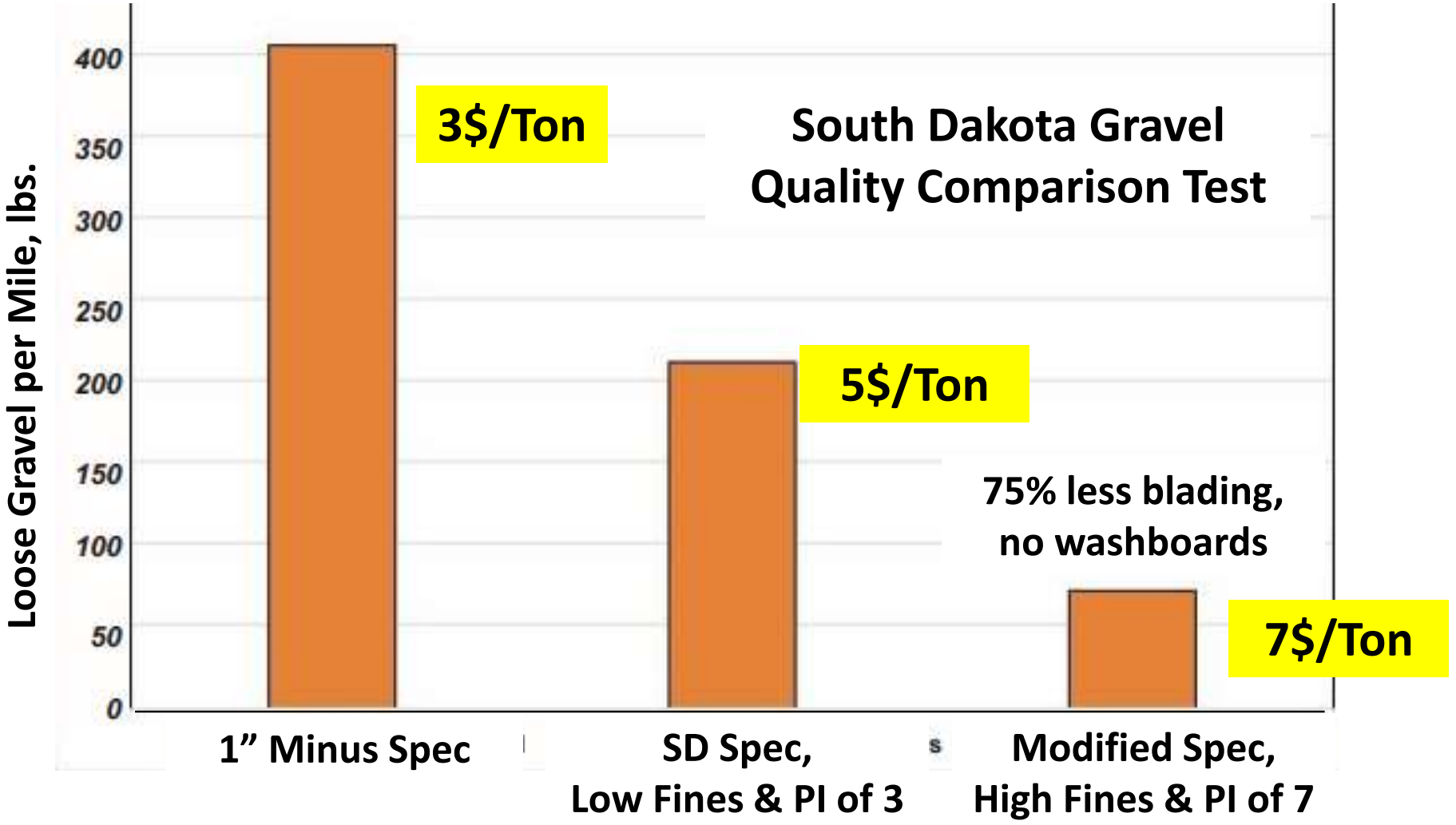
cing

s gravel for pavement base

ater that passes through
al, water easily drains to the
eping the subgrade (i.e.,
pacity.

ntially a CI 5 material with
on in water passage and

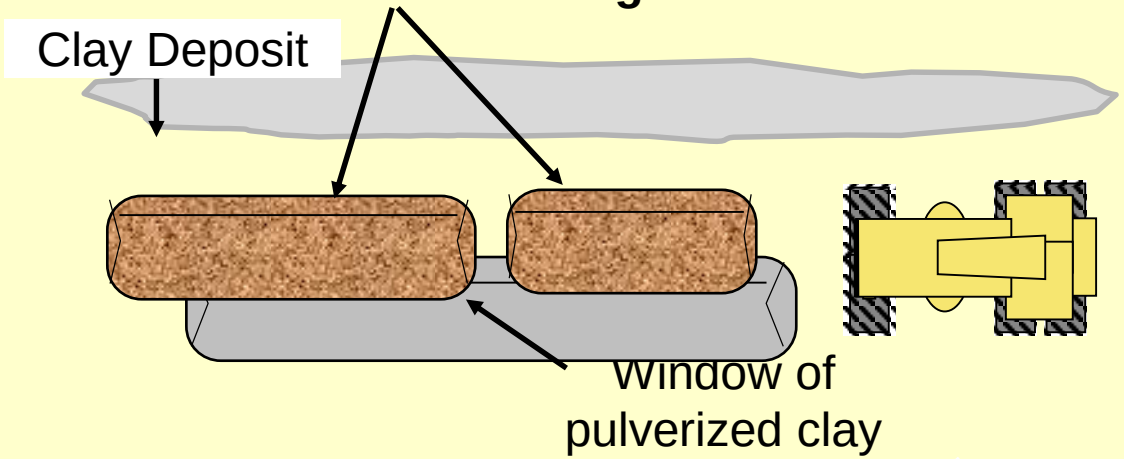
Better Gravel = Less Blading, Gravel Replacement, etc.



Belly Dump Clay Spreading

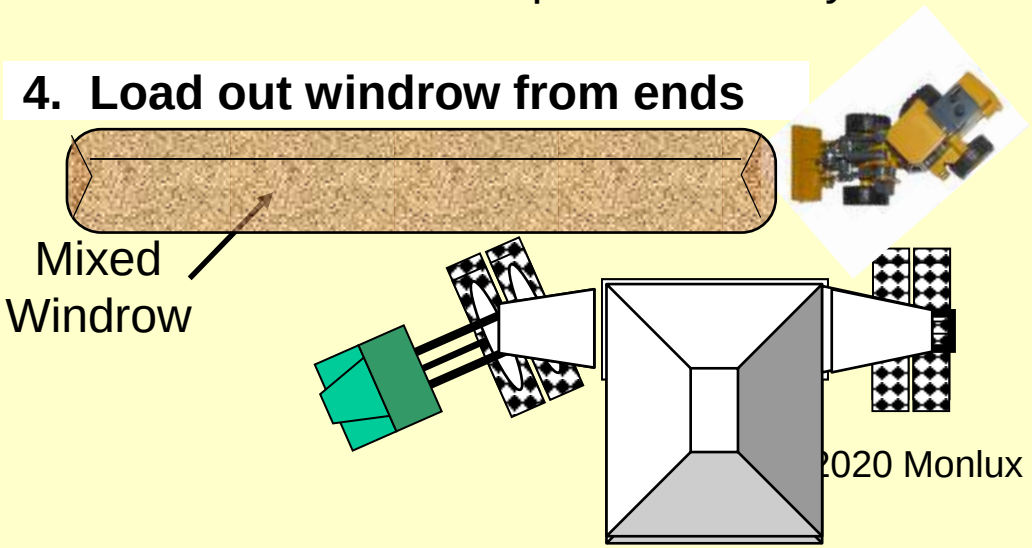
1. Excavate & pulverize clay deposit

2. Haul in gravel and windrow



3. Mix 1:1 Clay:Gravel – one pass

4. Load out windrow from ends



5. Spread on 300 to 500 ft of road

6. Water, Blade Mix and Compact

Spread Bank Run Clay with Belly Dump

Concept: Add bank run clay and gravel to belly dump to help clay flow and spread uniformly during high speed spreading

Details: Refer to one page guide

Note: If spread is poor, lower clay moisture or add more gravel

General Process:

1. Locate bank run clay source, dig holes to check moisture
2. Pulverize clay with blade, rotary mixer, disc, etc. & windrow with blade
3. Spread gravel windrow next to clay windrow and blade together
4. Reload belly dump with gravel clay mixture
5. Spread on 300 to 500 feet of road surface → If uneven spread, use more gravel on next load
6. Blade mixture into existing gravel

Gravel Road Surfacing Stabilization Testing

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	201 W. Holly St.
	Sidney, Mt. 59270
Project:	Gravel Roads
	5/8 inch reject

Ag
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Preliminary Testin

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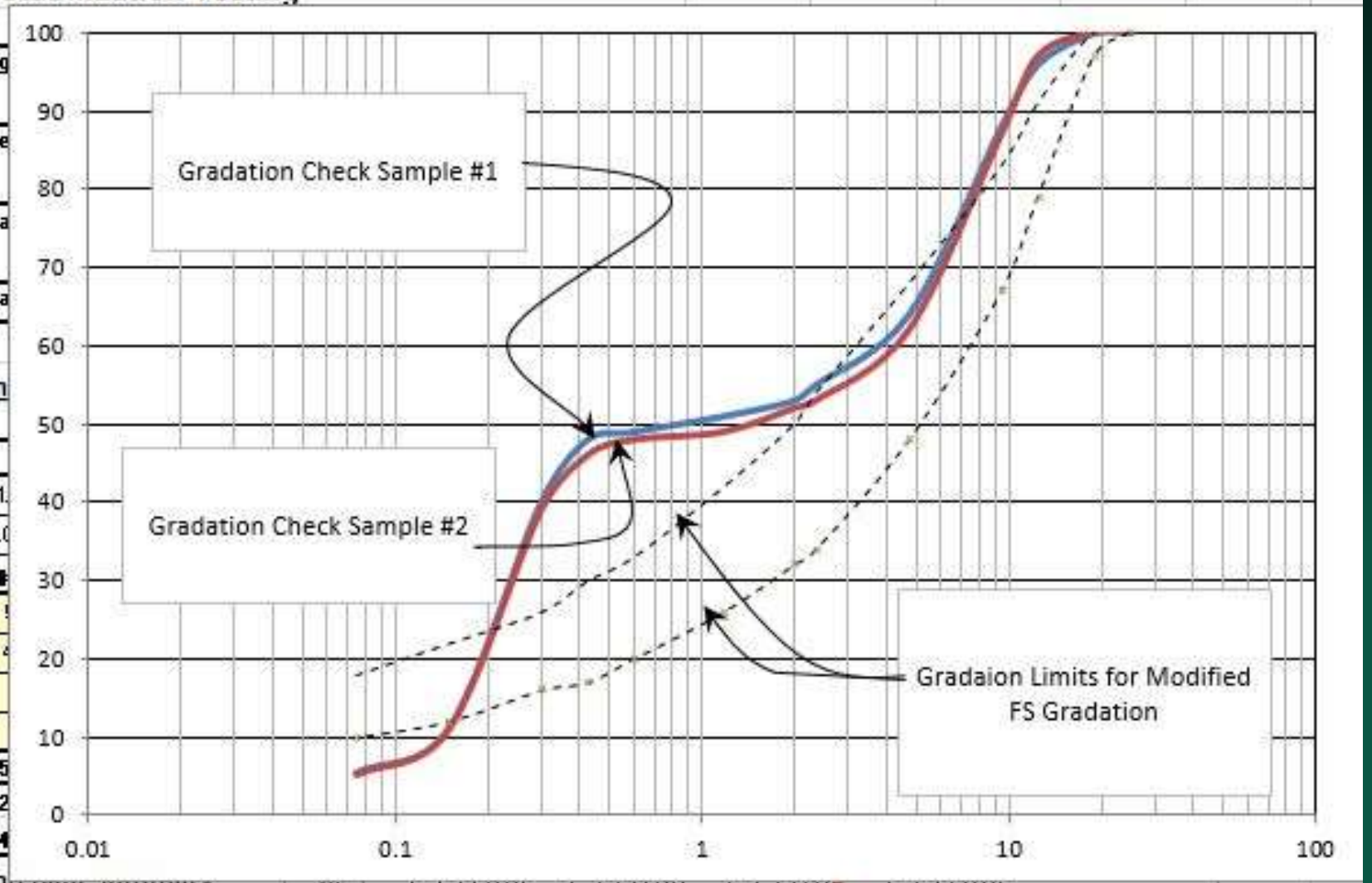
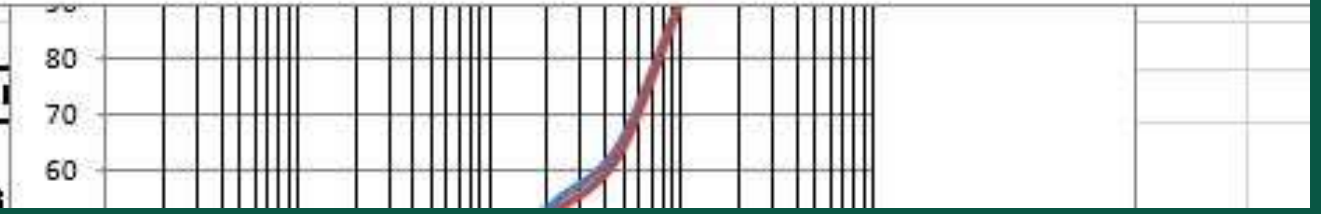
Mod FS Spec	Low	**100**	**97**	79	**67**	**48**	34	32	**2**
	High	**100**	**100**	91	**83**	**68**	54	50	**4**



Mix Design Trial Blend Data Summary

Test No.	% Bentonite	% Calcium Chloride	AASHTO T180		CBR Specimen I		
			Optimum Moisture	Maximum Dry Density	% Mois	% of	CBR



UNPAVED ROAD CHEMICAL TREATMENT SELECTION TOOL

UCPRC City and County Pavement Improvement Center

Home | Instructions | Treatment Selection | Results Interpretation | About

WELCOME TO THE UCPRC'S UNPAVED ROAD CHEMICAL SELECTION TOOL SITE

Language & Units
(•) English ( ) Spanish
(•) US ( ) SI

There are millions of kilometers/miles of unpaved roads around the world managed by numerous authorities, land owners, and public and private organizations. Common to all of these roads are unacceptable levels of dust, poor riding quality and/or impassability in wet weather, and expensive maintenance and gravel replacement activities. Over the last 100+ years, a range of different chemical treatments have been developed to overcome these issues. Most of these are proprietary, which can complicate selection of an appropriate treatment for a specific set of conditions. There is also no single product that will solve all problems under all conditions.

Loss of fines (as dust) on an untreated road

A procedure has therefore been developed to guide practitioners in the selection of an appropriate treatment. This procedure, based on the 1999 US Forest Service Guide (*Dust Palliative Selection and Application Guide*), and updated with new research and experience, factors traffic, climate, material properties, and road geometry into the most appropriate treatment selections for a given set of input values. The procedure is based on the philosophy of using chemical treatments to keep good roads in good condition, rather than attempting to use chemical treatments to "fix" bad roads. This unpaved road chemical treatment selection tool and information related to it is fully described in the UCPRC guideline entitled "Guidelines for the Selection, Specification, and Application of Chemical Dust Control and Stabilization Treatments on Unpaved Roads." This web-based chemical treatment selection tool can be considered as a companion to the guideline.

The photo on the left shows loss of fines on an untreated road while the photo on the right shows the results of applying a fines preservation treatment.

Stable fines preservation on a treated road

Disclaimer

This unpaved road chemical treatment selection procedure has been developed to guide selection of an appropriate treatment. It is based on the experience of practitioners and documented field experiment results. It is a guide only and does not replace engineering practice and judgment. Before initiating a treatment program, users should check actual performance for their particular materials and conditions with appropriate laboratory performance tests and/or short field experiments and/or seek guidance from other experienced practitioners and treatment suppliers. The University of California does not endorse the use of any specific product for dust control and stabilization of unpaved roads. In no event shall the University of California be liable to any party for

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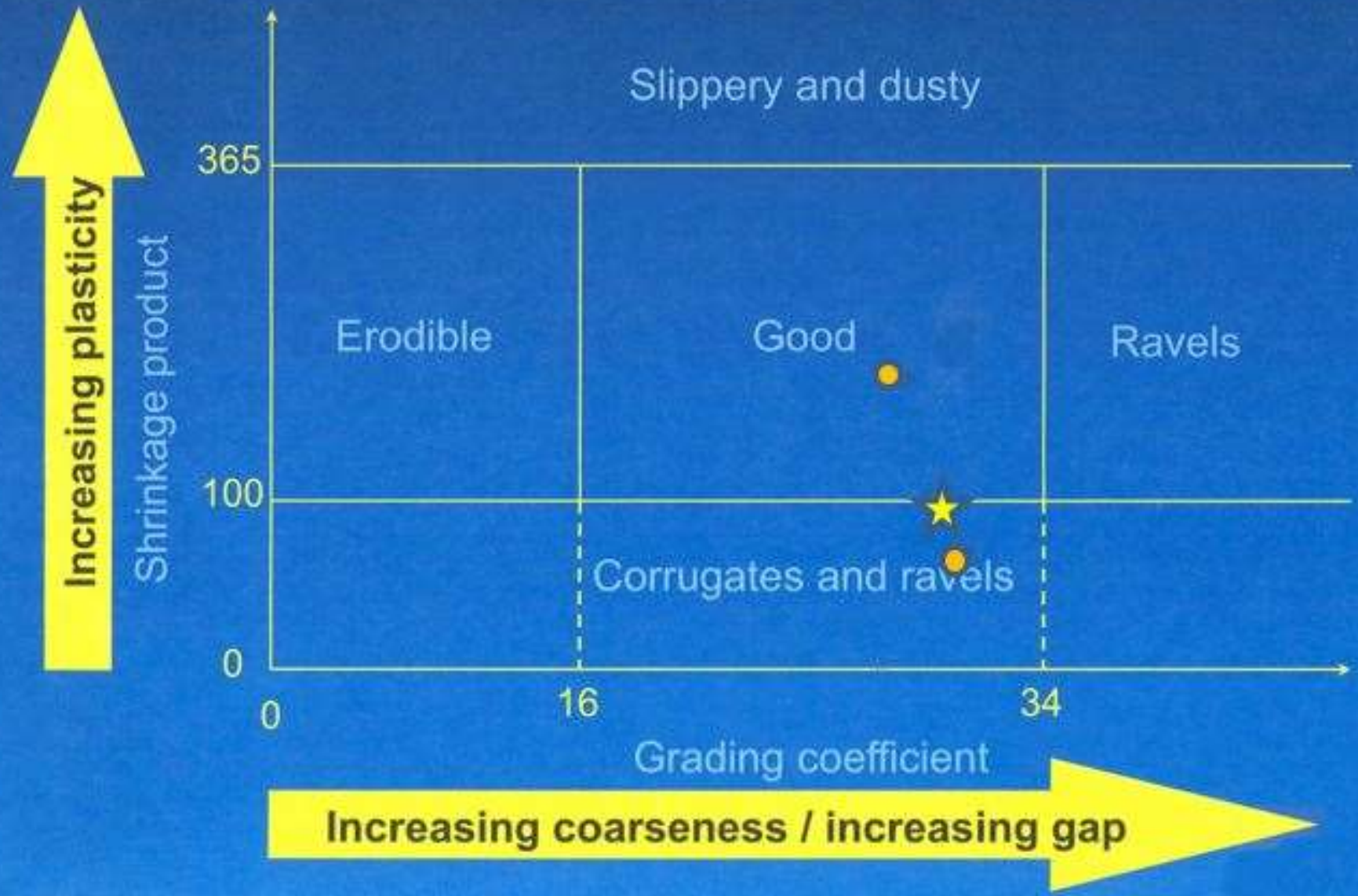
Material Design



Source of Aggregates: SW SEC 11, T141N, R96W Burin County, ND

Specifications		SIEVE SIZES AND PERCENTS PASS								
		1"	3/4"	#4	#8	#30	#200		P.I.	
	Spec. Limit	100	70-100	38-75	22-62	12-45	7.0-18.0		3.0-6.0	
	*Target Range									

TEST DATA	DATE/TIME SAMPLED	LOCATION SAMPLED	TEST NO.	PERCENTS PASSING								
	10/8/18	Belt	18-SCG01	100	99	66	55	39	14.4		2.6	
	10/11/18	Belt	18-SCG02	100	99	64	53	38	14.0		3.4	
	10/12/18	Belt	18-SCG03	100	97	66	53	39	13.6		4.0	
	10/15/18	Belt	18-SCG04	100	97	68	58	44	14.6		2.0	
	10/16/18	Belt	18-SCG05	100	98	68	58	43	13.8		2.4	
	10/17/18	Belt	18-SCG06	100	98	62	51	36	12.3		2.1	
	10/18/18	Belt	18-SCG07	100	99	68	56	39	12.4		2.9	
	10/22/18	Belt	18-SCG08	100	97	63	52	38	13.9		2.5	
	10/23/18	Belt	18-SCG09	100	99	64	52	35	12.3		3.9	
	10/24/18	Belt	18-SCG10	100	97	62	50	35	12.2		3.2	
	10/25/18	Belt	18-SCG11	100	96	63	51	36	13.4		6.0	
	10/29/18	Belt	18-SCG12	100	97	64	52	36	12.3		5.2	
	10/30/18	Belt	18-SCG13	100	98	58	48	35	11.5		3.8	
	10/31/18	Belt	18-SCG14	100	98	68	56	40	12.5		2.2	
	11/1/18	Belt	18-SCG15	100	98	63	53	38	12.5		3.1	
	11/19/18	Belt	18-SCG16	100	96	69	58	44	14.3		5.5	
	11/20/18	Belt	18-SCG17	100	97	66	56	41	15.1		6.4	
	11/26/18	Belt	18-SCG18	100	98	68	56	41	14.7		7.4	

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Unpaved Road Chemical Treatment Selection Tool

UCPRC City and County Pavement Improvement Center

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Road ID 57 **Details** Good County North Dakota

Material Test Results

%Passing 1"	100	%Passing #40	30
%Passing #4	70	%Passing #200	18
%Passing #8	56	PI (or BLSx2)	3

Objective

- Short-term dust control (spray-on)
- Long-term fines preservation (spray-on)
- Long-term fines preservation (mix-in)
- Long-term stabilization (mix-in)

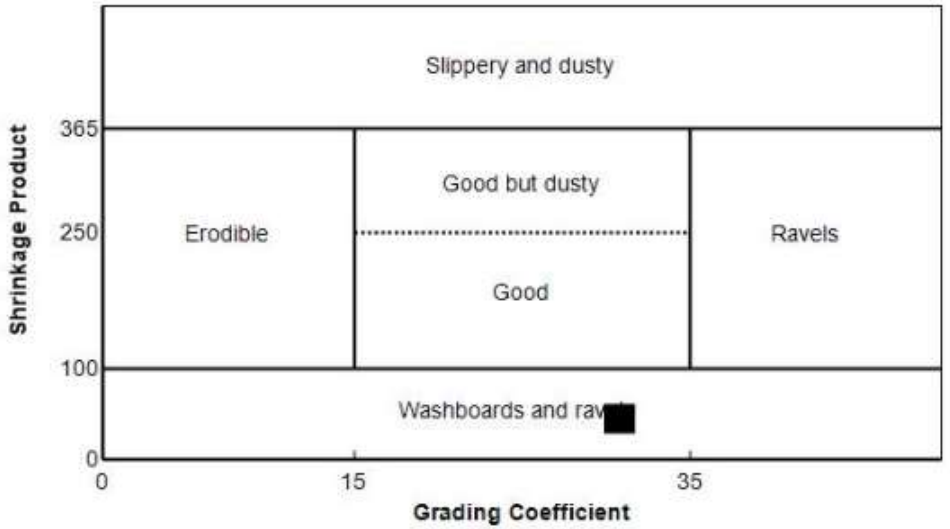
Roadway Parameters

Traffic (AADT): < 100 | Climate: Dry

- [x] More Than 10% Trucks
- [ ] Steep Grades
- [ ] Sharp Curves

Compute Ratings | Environmental & Other Influences

Predicted Material Performance for Untreated Road



Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Synthetic Fluid + Binder	1	1	1	1	1	0	0	1.0
Petroleum Resin	1	1	1	1	2	0	0	2.0
Synthetic Polymer	1	1	1	1	2	0	0	2.0
Asphalt Emulsion	1	1	1	2	2	0	0	2.2
Magnesium Choride	2	2	2	2	1	0	0	2.4
Lignosulfonate	2	1	2	2	2	0	0	2.4
Tall Oil	2	1	2	2	2	0	0	2.4
Concentrated Liquid Stabilizer	1	1	3	2	1	0	0	3.0
Clay Additive	1	1	2	3	2	0	0	3.0
Calcium Chloride	2	3	2	2	2	0	0	3.1
Sodium Chloride Brine	2	3	2	2	2	0	0	3.1
Water	3	3	3	3	3	0	0	NA
Water + Surfactant	3	3	3	3	3	0	0	NA
Glycerin Based	3	3	3	3	3	0	0	NA
Molasses/Sugar	3	3	3	3	3	0	0	NA
Plant Oil	3	3	3	3	3	0	0	NA
Base Oil	3	3	3	3	3	0	0	NA
Synthetic Fluid	3	3	3	3	3	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

Suppliers | Print

Unpaved Road Chemical Treatment Selection Tool

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Road ID 57 **Details** Good County North Dakota

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%Passing 1"	100	%Passing #40	30
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%Passing #8	56	PI (or BLSx2)	9

Objective

- (•) Short-term dust control (spray-on)
- ( ) Long-term fines preservation (spray-on)
- ( ) Long-term fines preservation (mix-in)
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Roadway Parameters

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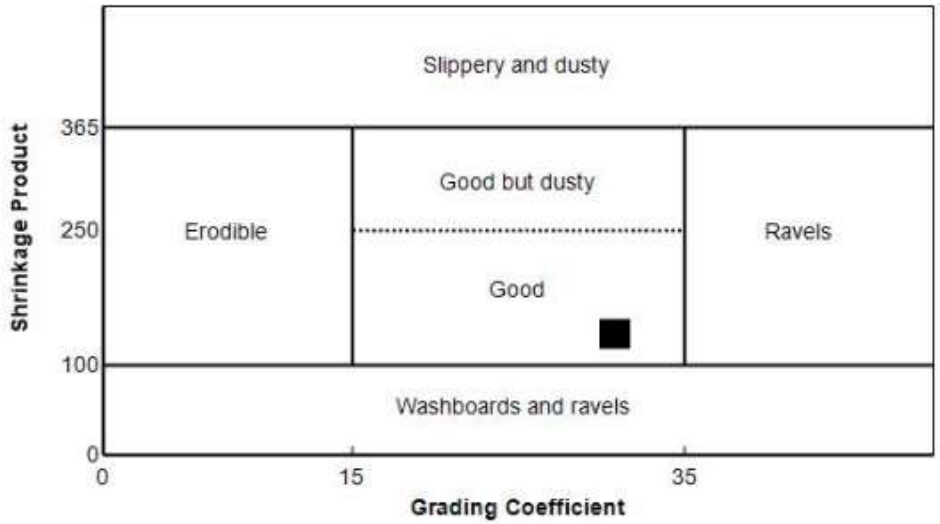
Compute Ratings | Environmental & Other Influences

Predicted Material Performance for Untreated Road



Treatment Ratings

Treatment	TR	CL	PI	FC	HV	SG	SC	Rating
Glycerin Based	1	1	1	1	1	0	0	1.0
Lignosulfonate	1	1	1	1	1	0	0	1.0
Tall Oil	1	1	1	1	1	0	0	1.0
Petroleum Resin	1	1	1	1	1	0	0	1.0
Synthetic Fluid	1	1	1	1	1	0	0	1.0
Synthetic Fluid + Binder	1	1	1	1	1	0	0	1.0
Magnesium Choride	1	2	1	1	1	0	0	2.0
Molasses/Sugar	1	1	1	1	2	0	0	2.0
Plant Oil	1	1	1	1	2	0	0	2.0
Base Oil	1	1	1	1	2	0	0	2.0
Synthetic Polymer	2	2	2	2	2	0	0	2.6
Calcium Chloride	1	3	1	1	1	0	0	3.0
Sodium Chloride Brine	1	3	1	1	1	0	0	3.0
Water	2	3	1	1	2	0	0	3.0
Water + Surfactant	2	3	1	1	2	0	0	3.0
Asphalt Emulsion	1	1	2	2	3	0	0	3.0
Concentrated Liquid Stabilizer	3	3	3	3	3	0	0	NA
Clay Additive	3	3	3	3	3	0	0	NA

TR: Traffic; **CL:** Climate; **PI:** Plasticity; **FC:** Fines Content; **HV:** More Than 10% Trucks
SG: Steep Grades; **SC:** Sharp Curves; **Rating:** Treatment Performance Ratings

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SPECIAL PROVISIONS

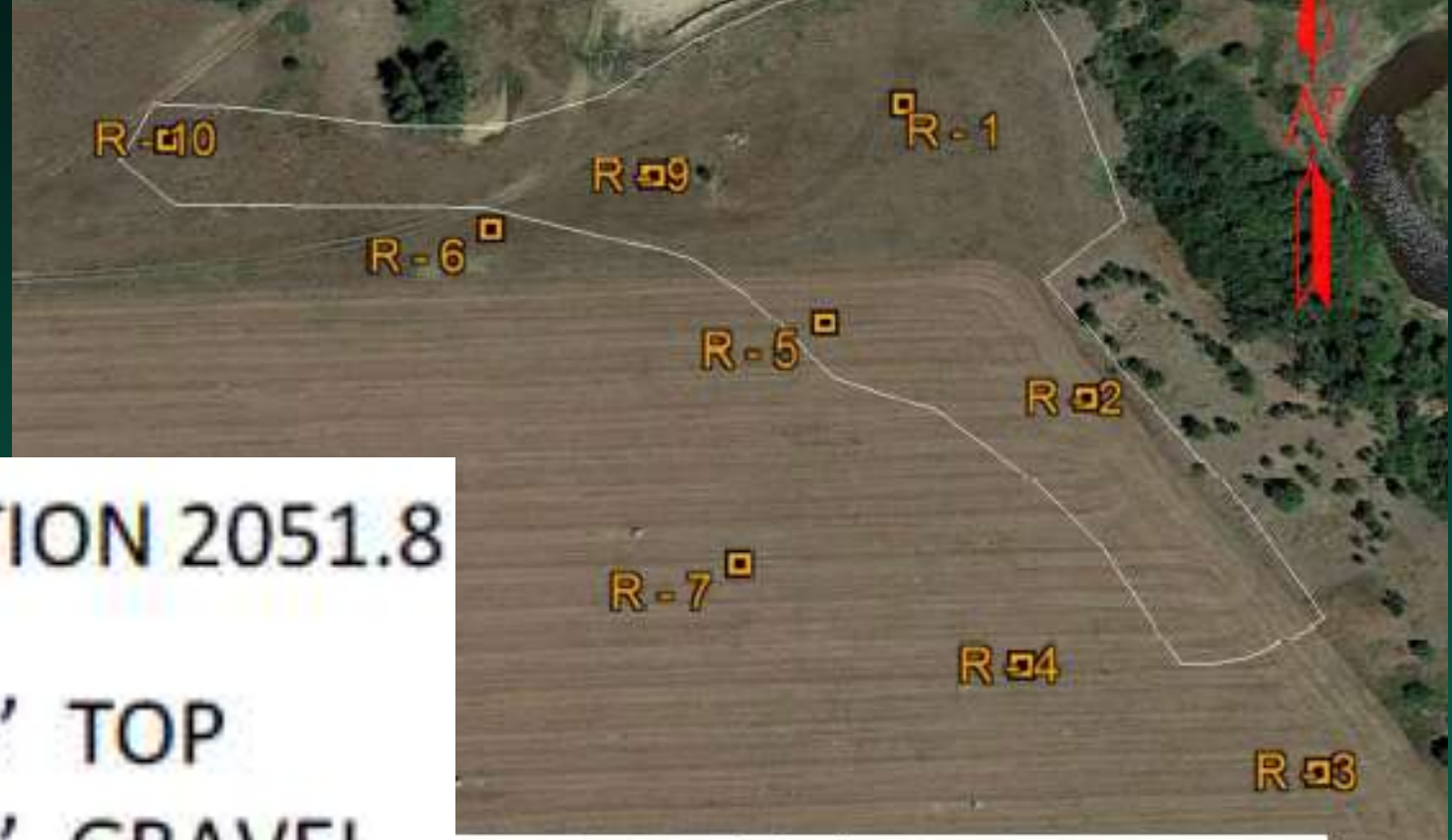
GRANT COUNTY

2019 GRAVEL CRUSHING & STOCKPILING

1. **Governing Specifications** – 2014 Standard Specifications adopted by the North Dakota Department of Transportation.

2. **Surface Gravel** – The Contractor shall supply aggregate that meets the following requirements:

	Surface Gravel
Sieve Size	% Passing
3/4"	100
No. 4	50-78
No. 8	37-67
No. 40	13-35
No. 200	4-15
Shale (max %)	12.0
LA Abrasion (max %)	50
Fractured Faces **	10



R – 1 ELEVATION 2051.8

0’ – 1.5’ TOP
1.5’ – 5’ GRAVEL
5’+ SAND

Jay Ruscheinsky Pit
W1/4 Section 35, T132N, R87W

AREA = 167,000 SF
AVERAGE DEPTH = 3’
ESTIMATED GRAVEL = 18,555 CY

R – 1	ELEVATION 2051.8	R – 2	ELEVATION 2052.2	R – 3	ELEVATION 2055.5
	0’ – 1.5’ TOP		0’ – 2’ TOP		0’ – 1’ TOP
	1.5’ – 5’ GRAVEL		2’ – 5’ GRAVEL		1’ – 6 NO GRAVEL
	5’+ SAND		5’+ SAND		6’+ SAND
R – 4	ELEVATION 2057.3	R – 5	ELEVATION 2052.3	R – 6	ELEVATION 2052.1

SOURCE: J. Ruschienski

erracon
Hancock Dr, PO Box 2084
arck, ND 58501
258-2833

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MECHANICAL ANALYSIS:

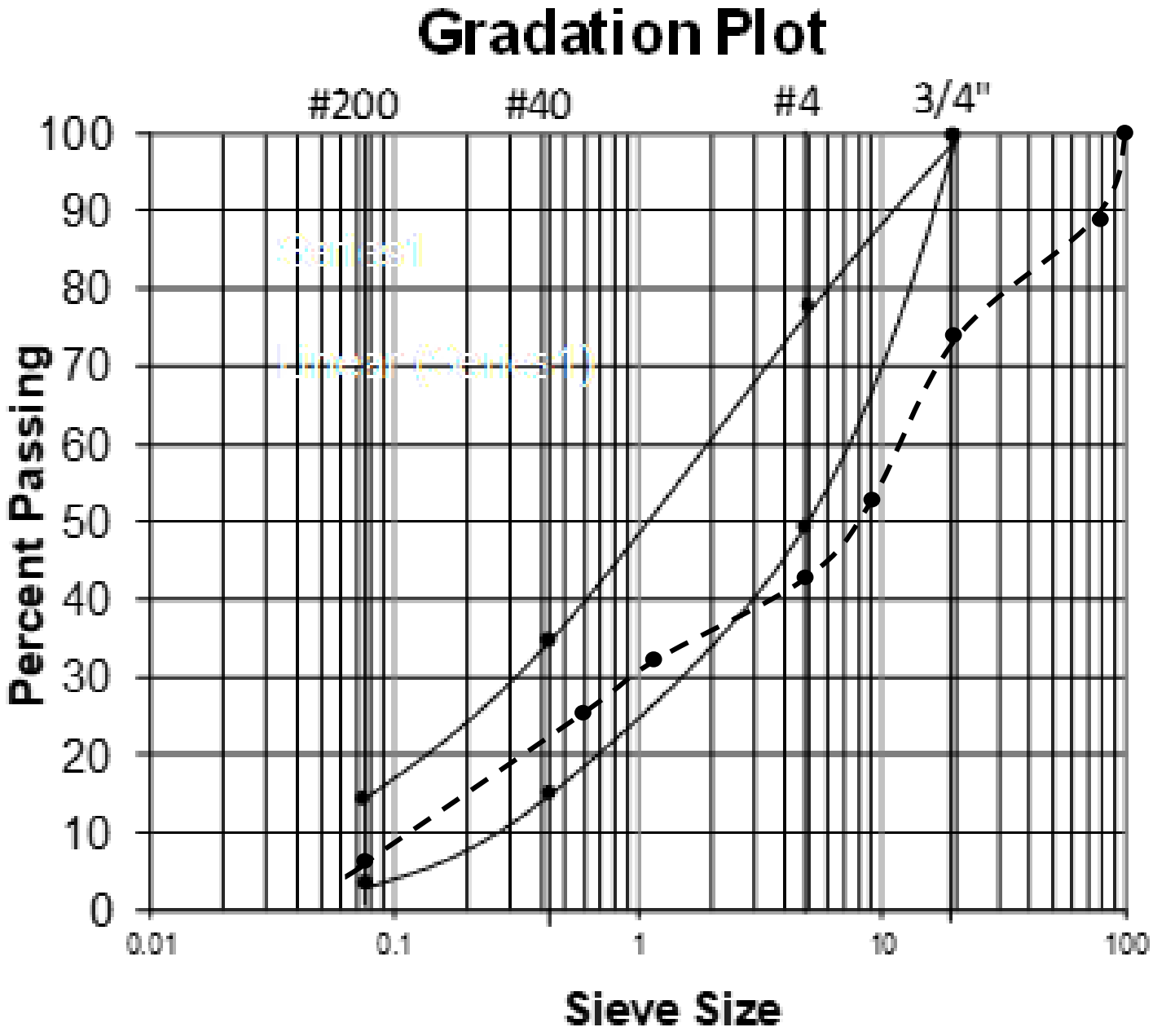
Passing	4”	100%
	3	89
	2	86
	1 1/2	84
	1	81
	3/4	78
	5/8	77
	1/2	74
	3/8	71
	#4	58
	8	46
	16	36
	30	28
	50	20
	100	9.3
	200	6.0

ATTERBERG LIMITS:

Liquid Limit	NP
Plastic Limit	NP
Plasticity Index	NP

Ruscheinsky Pit Tests

Sieve Size	Ruschienski Pit		
	R-2	R-9	Average
4"	100	100	100
3"	89	88	89
3/4"	78	69	74
3/8"	58.0	47	53
#4	46	39	43
#30	28	25	27
#200	6.0	7.1	6.6



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