Center for Environmentally Sustainable Transportation in Cold Climates

Long-term Stabilization of Disturbed Slopes Resulting from Construction Operations

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Highway construction disturbs soil, which must be stabilized to prevent migration of soil particles into water bodies. Stabilization is enforced by law, regulation, and a permit system. Stabilization is most efficiently attained by reestablishment of vegetation, and permits sometimes specify this method of stabilization. Revegetation is difficult in northern Alaska, and seeded grasses often die in a year or two, while reestablishment with native vegetation takes several years. A literature search and interviews with experts indicates that simply extending this "establishment period" has many practical difficulties. Field investigations and interviews indicate that in northern Alaska little erosion occurs at slopes with failed vegetation, which implies that vegetation was not critical to reducing contamination and the expense of revegetation was unnecessary. However, when revegetation is specified in standard permit language, and contractor, owner, and regulator must close out projects, grasses are utilized. This research supports the recommendation that the Alaska Department of Transportation and Public Facilities work with the Alaska Department of Natural Resources and the Alaska Department of Environmental Conservation to develop special standards for projects north of the Brooks Range and between the Brooks and Alaska ranges, that recognize the low erosion potential of clean road fill – embankments.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

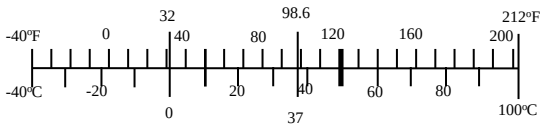
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4		mm
ft	feet	0.3048		m
yd	yards	0.914		m
mi	Miles (statute)	1.61		km
		AREA		
in^2	square inches	645.2	millimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.4046	hectares	ha
		MASS (weight)		
oz	Ounces (avdp)	28.35	grams	g
lb	Pounds (avdp)	0.454	kilograms	kg
T	Short tons (2000 lb)	0.907	megagrams	mg
		VOLUME		
fl oz	fluid ounces (US)	29.57	milliliters	mL
gal	Gallons (liq)	3.785	liters	liters
ft^3	cubic feet	0.0283	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
		TEMPERATURE (exact)		
ºF	Fahrenheit temperature	5/9 (ºF-32)	Celsius temperature	ºC
		ILLUMINATION		
fc	Foot-candles	10.76	lux	lx
fl	foot-lamberts	3.426	candela/m^2	cd/cm^2
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N
psi	pound-force per square inch	6.89	kilopascals	kPa

Note: Volumes greater than 1000 L shall be shown in m^3

These factors conform to the requirement of FHWA Order 5190.1A *SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	Miles (statute)	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2 m^2
meters squared		10.764	square feet	ft^2 km^2
kilometers squared		0.39	square miles	mi^2 ha
hectares (10,000 m^2)		2.471	acres	ac
		MASS (weight)		
g	grams	0.0353	Ounces (avdp)	oz
kg	kilograms	2.205	Pounds (avdp)	lb mg
megagrams (1000 kg)		1.103	short tons	T
		VOLUME		
mL	milliliters	0.034	fluid ounces (US)	fl oz
liters	liters	0.264	Gallons (liq)	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		TEMPERATURE (exact)		
ºC	Celsius temperature	9/5 ºC+32	Fahrenheit temperature	ºF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/cm^2	candela/m^2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	pound-force	lbf
kPa	kilopascals	0.145	pound-force per square inch	psi



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Executive Summary

One goal of long-term stabilization of disturbed slopes following construction activities is the maintenance of clean water. Erosion from disturbed slopes moves contaminants down-gradient towards water bodies. Most contaminants from highway construction are soil particles; in Alaska, these tend to be silts and uncharged clay-sized particles. Attainment of the stabilization goal is enforced by law, regulation, and a permit system. Stabilization is most efficiently attained by reestablishment of vegetation, and permits sometimes specify this method of stabilization. This research noted the difficulties of revegetation in northern Alaska. Seeded grasses often die in a year or two, while reestablishment with native vegetation takes several years—many years in some cases. Extending this "establishment period" by means of construction contractor maintenance or warranties, which sounds like a simple fix, has many practical difficulties.

In northern Alaska, little erosion occurs at slopes with failed vegetation, which suggests that revegetation was not critical to reducing contamination. For example, artificial riles or "tracking" commonly remain many years after the vegetation has died. Erosion would have obliterated the riles, but they remain intact. However, when revegetation is specified in standard permit language, and contractor, owner, and regulator need to close out projects, grasses are often utilized. If little or no erosion has taken place, the goal of clean water is met, but with unnecessary expense.

This research indicated that many road and transportation projects in northern Alaska could be permitted without revegetation or other stabilizing actions; however, standard Alaska Department of Transportation and Public Facilities (ADOT&PF) contracting language and permit stipulations make changes difficult. Since the Construction General Permit is the criteria

used, permit modifications should be developed based on data that demonstrate locations and situations where revegetation is not necessary to obtain the goal of clean water. We recommend that the ADOT&PF work with the Alaska Department of Natural Resources (DNR) and the Alaska Department of Environmental Conservation (ADEC) to develop special standards for projects north of the Brooks Range and in the region between the Brooks and Alaska ranges that recognize the low erosion potential of clean road fill – embankments.

Our review of practices used in other states reveals that simply extending the vegetation establishment period using a warranty or similar device has not worked well. However, we recommend that the ADOT&PF experiment with an additive bid item to explore the cost of extending the establishment period.

SECTION 1: LONG-TERM STABILIZATION OF DISTURBED SLOPES RESULTING FROM CONSTRUCTION OPERATIONS

Introduction

The research project, Long-term Stabilization of Disturbed Slopes Resulting from Construction Operations, was awarded by the Center for Environmentally Sustainable Transportation in Cold Climates (CESTiCC) on August 30, 2016. While the term "stabilization" has many meanings, the project focused on final stabilization of roadside embankments through revegetation, which is often the most economical and long-lasting of the common stabilization methods. Our research primarily regarded transportation, though we were informed by research on mining, which has similar ground disturbance and soil stabilization requirements. Revegetation in temperate semi-arid and arid environments is challenging, but revegetation has special challenges in the semi-arid and arid environments of cold regions. This report follows two lines of investigation, the first of which examines the revegetation practices currently employed following construction in northern Alaska, specifically north of the Alaska Range and north of the Brooks Range, and the second of which examines the administrative and contracting limitations on alternatives, especially regarding warranties. This second line of investigation proved so interesting, that we moved it to a separate section of the report, although we report the main results in this first section. For both lines of investigation, we queried other states and locations with harsh climates and report on their experiences.

Most transportation projects involve the creation of sloping ground, to some degree, whether already on the project site or built during the project. All slopes, but especially steep slopes, require some type of stabilization to prevent short- and long-term erosion. Steep slopes, defined as a slope exceeding 20 percent and having a length that exceeds 25 feet, are a feature of

many construction projects in Alaska. To meet construction specifications and regulatory permit requirements, contractors typically seed slopes and provide means for the growing vegetation to stabilize the ground, using hydraulically applied mulches, rolled erosion control products (erosion control blankets and turf reinforcement mats), geo-grids, and/or other proprietary soil amendment practices.

Heavy construction projects disturb the natural soil and lead to erosion and pollution of water due to soil particles (EPA 1995). Severe construction site erosion may result in gross soil movement and associated structural failures or may overwhelm existing or newly constructed infrastructure, for example, by blocking culverts and ditches. The Alaska Pollutant Discharge Elimination System (APDES) program requires all construction projects, both large and small (1 to 5 acres), to have a Storm Water Pollution Prevention Plan (SWPPP) that contains the Erosion and Sediment Control Plan (ESCP). The SWPPP provides details regarding how the contractor and owner will control erosion during the active construction process. At the conclusion of active construction, the owner of the project files a Notice of Termination (NOT) to "close" the SWPPP administratively. In order to file the NOT, the operator must certify that the site has achieved *final stabilization* (see Section 4.5 of the Construction General Permit [ADEC 2016]). In the context of the permit, final stabilization means that all disturbed soils are permanently covered with non-erodible materials, including pavement, fractured rock, structures and/or other low erodible materials, or vegetation.

The presumption of the NOT is that any revegetation similar to the native vegetation cover is permanent and will resist future erosion. Of course, if the native vegetation is trees, which require many years to grow, or even shrubs that take several years to mature, fast-growing vegetation, usually grasses, are needed to prevent erosion in the interim. Standard specifications

for highway construction in Alaska only envision a one-year follow-up on reseeding, as do many other states (see Section 2 of this report for many examples). Given that the growing season in Alaska and similar cold regions is half the length of the growing season in warmer climates, and that the most massive water flow is usually during breakup when the ground is partly frozen, how well does a one-year follow-up ensure future erosion resistance? A longer follow-up would seem in order; however, most federal project capital funding has a limited duration, and operations and maintenance (O&M) is funded with state general fund monies that are needed for many O&M needs. Remote locations are difficult to monitor for both the owner and the SWPPP agency, which in Alaska is the ADEC. Any stabilization method employed must be implemented by construction contracts via project management and must conform to standard procurement regulations and contracting methods. However, alternative contracting methods may deliver acceptable erosion control results, and an investigation of such methods seems warranted. Other northern regions as well as mountainous or arid regions in warmer states have similar issues.

The original objective of this project was to develop suggested contractual means, perhaps with several alternatives, including specification language, by which a public agency such as a state department of transportation can assure long-term upkeep of revegetated slopes. By “long term” we mean at least until the stabilizing vegetation has been reliably established. Necessary for that objective was a review of physical methods, products, and procedures that would affect those contracting decisions. As our investigations progressed, we noted many difficulties with simply changing contracting language and terms, and noted that changes to permit stipulations might be more appropriate. We discuss those permit stipulations, but providing data to support those changes is necessary and outside the scope of this project.

Background

Erosion Basics

Erosion involves the detachment and transport of soil particles. Vegetation inhibits the detachment of the particles, as does covering the soil with heavy material, such as riprap. In our context, inhibiting transport of soil particles to the waters of the United States is the key goal. Transport from a slope to a settling basin might be acceptable in a technical sense, but should be viewed as evidence of insufficient erosion control practices. In general, transport of some exogenous hazardous materials is a separate issue, and this study's concern is with the transport of soil and organic materials from the local land. Sedimentation effects might include the reduction of hydraulic capacity of mechanized conveyances and natural streams (the blockage of culverts, or filling of roadside ditches with sediment, deposition sediment in stream channels), smothering of downslope vegetation due to sediment deposition, and deleterious effects on aquatic life and habitat.

Unlike many other regions of the United States and southcentral, southeast, and southwest Alaska, where sediment deposition in downslope areas is undesirable but not necessarily a direct violation of the Clean Water Act, north of the Alaska Range, deposition sediment in downslope areas is often a direct violation of the Clean Water Act, as these areas meet the regulatory definition of wetlands. In Alaska, 176 million acres of land surface are classified as wetlands. Wetlands are the dominant ecotype on Alaska's North Slope and occupy an estimated 83 percent (93 million acres) of the land surface. Wetlands occupy approximately 44 percent (71 million acres) of the semi-arid valley bottoms of Interior Alaska (USACE 2007). Soil and organic material transported to waters, including palustrine wetlands with no visible

standing water, are defined as pollutants, despite their innocuous character in their original location.

The ADOT&PF Highway Drainage Manual (ADOT&PF 2006) provides a good summary of erosion, parts of which are included here. Inherent erosion potential of any area is determined by four principal factors: soil characteristics, vegetative cover, topography, and climate:

> Soil Characteristics: The properties of soil that influence erosion by rainfall and runoff are those affecting the infiltration capacity of a soil and those affecting the resistance of a soil to detachment and being carried away by falling or flowing water. Soils containing high percentages of fine sands and silt are normally the most erodible. As the clay and organic matter content of these soils increases, the erodibility decreases. True clays (alumino-silica clays, crystalline chain carbonate and sulfate minerals, amorphous clays, or sesquioxide clays) are charged and act as a binder to soil particles, thus reducing erodibility. However, while clays have a tendency to resist erosion, once eroded they are easily transported by water and notoriously difficult to remove from the water column. Soils high in organic matter have a more stable structure due to the charged organic acids resulting from decomposition, which improves their permeability. Such soils resist raindrop detachment and infiltrate more rainwater.
>
> Clear, well-drained and well-graded gravels and gravel-sand mixtures are usually the least erodible soils. Soils with high infiltration rates and permeability reduce the amount of runoff. (We note here that those are precisely the types of soils preferred for highway embankment.)
>
> Vegetative cover: plays an important role in controlling erosion in the following ways:
> - shields the soil surface from raindrop impact;
> - holds soil particles in place;
> - maintains the soil's capacity to absorb water;
> - slows the velocity of runoff; and
> - removes subsurface water between rainfalls through the process of evapotranspiration.
>
> By limiting and staging the removal of existing vegetation, and by decreasing the area and duration of exposure, soil erosion and sedimentation can be significantly reduced. Special consideration should be given to the maintenance of existing vegetative cover on areas of high erosion potential, such as erodible soils, steep slopes, drainage ways, permafrost areas, and stream banks. The corollary to this is that, once disturbed, the

procedural emphasis should be to stabilize these areas as soon as possible following disturbance.

Topography: The size, shape, and slope characteristics of a watershed influence the amount and rate of runoff. As both slope length and gradient increase, the rate of runoff increases and the potential for erosion is magnified. Empirical observation indicates that doubling the slope length increases erosion potential by 4 times while doubling the slope gradient will increase erosion potential by 5 times.

Climate: The frequency, intensity, and duration of rainfall are fundamental factors used for estimating the amounts of runoff produced in a given area. As both the volume and velocity of runoff increase, the capacity of runoff to detach and transport soil particles also increases.

A major factor in determining soil erodibility in northern Alaska is the presence or absence of permafrost. Between the Alaska and Brooks ranges, there are many areas of discontinuous permafrost, where slope orientation can be a significant factor in determining erosion potential. Relatively well-drained soils with low runoff potential are commonly present on south-facing slopes, while relatively poorly drained perennially frozen soils with high runoff potential tend to be present on north-facing slopes.

Laws and Regulations

The basic law sources are the federal Clean Water Act (CWA) of 1972 and parallel state laws. Here, we focus on the CWA.

The CWA governs discharges to the nation's navigable waters, which are broadly defined and include streams and wetlands. Originally, only "point sources" were regulated and these via NPDES (National Pollutant Discharge Elimination System) permits. The CWA and its regulations were later revised to cover "non-point sources," such as storm water runoff from construction sites and many other sources. In 1990, the U.S. Environmental Protection Agency (EPA) promulgated regulations regarding storm water from urban areas that entered water bodies

through storm sewers. Since storm water that entered via sanitary sewers was already regulated, the new regulations were specified as “Municipal Separate Storm Sewer Systems” (MS4). The rules came in two phases. Phase I in 1990 covered storm sewer systems in municipalities of over 100,000 in population. Since these and the ADOT&PF responsibilities that derive from that designation are clear, we will not spend any time here with Phase I, which in Alaska applies only to Anchorage. Phase II expanded the rule to construction sites greater than 5 acres, and then to sites greater than 1 acre.

The state Department of Environmental Conservation (DEC) assumed responsibility for the CWA in Alaska in 2013. A permit, the APDES (Alaska Pollution Discharge Elimination System) is required. The DEC mandated that an APDES permit be obtained for all construction projects that encompass more than 1 acre—virtually all ADOT&PF highway projects. Rather than require an individual APDES permit for each construction project, the DEC issued a general permit for construction activities: the Construction General Permit for Storm Water Discharges for Large and Small Construction Activities (2016 CGP, AKR100000), effective in 2016.

Permits

On December 29, 2015, the DEC reissued the Construction General Permit for Storm Water Discharges for Large and Small Construction Activities (ADEC 2016). The 2016 Construction General Permit (CGP) became effective on February 1, 2016. The 2016 CGP authorizes storm water discharges from large and small construction-related activities that result in total land disturbance of equal to or greater than 1 acre and where those discharges enter waters of the U.S. (directly or through a storm water conveyance system) or a municipal separate storm sewer system (MS4) leading to waters of the U.S. subject to the conditions set forth in the

permit. The permit also authorizes storm water discharges from certain construction support activities and some non-storm water discharges commonly associated with construction sites.

The goal of the 2016 CGP is to minimize erosion and reduce or eliminate the discharge of pollutants, such as sediment carried in storm water runoff, from construction sites through implementation of appropriate control measures. Polluted storm water runoff can adversely affect fish, animals, plants, and humans. In order to ensure protection of water quality and human health, the permit describes control measures that must be used to manage storm water runoff during construction activities.

While it is possible to obtain a project-specific APDES permit (an "individual permit"), the CGP is almost always utilized because it is faster, significantly less expensive, and more certain than applying for an individual permit. Thus, some of the rigidities of the CGP are tolerated because of the perceived delays with obtaining an individual permit. Note that the State of Alaska is in the process of revising its anti-degradation policies and more fully developing a policy related to Tier II and Tier III waters (Outstanding National Resources Waters – ONRW); the requirements of the APDES CGP may be affected (ADECa 2017, ADECb 2017). The federal NPDES permit already contains divergent standards based on the receiving water's tier classification.

SWPPP and "Stabilization"

One of the key provisions of the CGP is the Stormwater Pollution Prevention Plan (SWPPP, usually pronounced "swip") that contains many details of planning and construction procedures related to stormwater pollution prevention.

The key to the APDES and the SWPPP is to keep the stormwater runoff that contains soil particles from entering the "waters of the United States." At the end of the construction process,

the site must be “stabilized.” That is, it must be left so that polluted runoff does not enter the waters in the future. As a practical matter, the project owner (or contractor) must “close” the SWPPP. Thus, at the conclusion of active construction, the owner of the project files a Notice of Termination (NOT) to administratively “close” the SWPPP. In order to file the NOT, the operator must certify that the site has achieved final stabilization. In the context of the permit, final stabilization means that all disturbed soils are permanently covered with non-erodible materials, including pavement, fractured rock, structures and/or other low erodible materials, or vegetation.

Here is the language from the CGP that pertains:

[DEFINITIONS]

Stabilization The use of vegetative and/or non-vegetative cover to prevent erosion and sediment loss in areas exposed by Construction Activities.

Final Stabilization

For the purposes of this permit, means that:

1. All soil disturbing activities at the site have been completed and either of the two following criteria shall be met:
    a. a uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 70 percent of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or
    b. equivalent non vegetative permanent stabilization measures have been employed (such as the use of riprap, gabions, porous backfill (ADOT&PF Specification 703-2.10) [in appendix], railroad ballast or subballast, ditch lining (ADOT&PF Specification 610-2.01) [in appendix], geotextiles, or fill material with low erodibility as determined by an engineer familiar with the site and documented in the SWPPP). [Note here that “porous backfill” is the standard highway prism.]
2. [beaches, etc.]
3. In arid and semi-arid areas only, all soil disturbing activities at the site have been completed and both of the following criteria have been met: Temporary erosion

control measures (e.g., degradable rolled erosion control product) are selected, designed, and installed along with an appropriate seed base to provide erosion control for at least three years without active maintenance by the permittee; The temporary erosion control measures are selected, designed, and installed to achieve 70 percent vegetative coverage within three years. [This part of the CGP is seldom used because of it would extend the project three years.]

4. [residential]

In practice, final stabilization Alternative 3 is used sparingly due to the additional expense incurred by the contractor. Other methods of stabilization include sediment basins, check dams, and riprap. Generally, revegetation with grass is a much cheaper method of stabilization than these other methods and is the preferred alternative.

Revegetation of disturbed soils is done for several reasons (Helm 2006), but primarily to prevent erosion and preserve water quality. Secondary reasons include blending with surrounding vegetation for aesthetics and for future land use, such as restoration of wildlife habitat. While the mining laws, envisioning a wide area restoration, require an attempt to replicate vegetation that was present before the disturbance, transportation laws, envisioning linear projects, seldom require “restoration.” Rather, the laws require preventing erosion and loss of water quality due to runoff-bearing soil particles entering waters. Wind could cause erosion as well, but in general, the preventive and stabilization concepts are the same. While aesthetics and surrounding land use may be a consideration, in Alaska, with its vast stretches of rural highways in low population areas, such considerations are generally subordinate to preventing erosion, and most well-functioning erosion prevention systems are not unsightly.

Revegetation 101

Basic Revegetation

a. If construction operations require removing topsoil —soil with organic content—from the surface, we refer to the remaining soil as "mineral" soil. In Interior Alaska, the mineral soil is commonly silt, but may be sand, gravel, rock, or some combination. Unlike the effects of a forest fire when a layer of organic material remains, mineral soils may lack nutrients, biologic moieties such as bacteria and fungi, and the capacity to retain moisture.

b. Mineral soils are very slow to revegetate naturally. Near Fox, Alaska, piles of dredge tailings (rocks, 2–4 inches in size) have been free of vegetation for over 50 years. Some locations in the tailings have revegetated, often with trees. These locations had fines material, and the progress of the revegetation was proportional to the amount of fines in the soil (Holmes 1981).

c. Following clearing, whether by fire, excavation, farming, or other means, revegetation follows a progression of stages, with a dominant form of vegetation in each state. Each defined stage may be called a *seral community* (Wikipedia 2017). Eventually, a climax community is reached. We are not interested in the ecological final stage, but in the progression to the point where erosion of the soil is no longer a threat. If aesthetics or moose browse were the issue, a latter-state seral community might be needed (Helm 2006).

d. For typical road excavation, the main seral communities are non-vascular plants (mosses and lichens), fibrous/herbaceous plants (grasses), and "woody" plants (typically willows and alder). These woody plants, which generally hold the soil and prevent erosion, end our inquiry. Empirically, evidence suggests that over time, the road embankment vegetation community becomes dominated by vascular plants that we call trees: poplar, birch, and finally spruce.

Revegetation on Mineral Soils

Even grasses will not grow on bare mineral soil. The current procedure (see Appendix A, DOT Specifications, Section 618) is to fertilize and water to establish grasses; sometimes continued watering is needed. Grasses may be seeded, hand-tilled, or hydroseeded; however, grasses on mineral soil will die out if not watered and fertilized.

a. Limitation of grasses

Grasses may delay or inhibit the transition to local vegetation or progression to woody plants. “Species, especially grasses, are frequently seeded to establish ground cover in the short term, but these may interfere with long term goals. Strategies are usually a balancing act of short term needs and long term goals.” This quotation is from a discussion of the Usibelli coal mine, which is at about latitude 64°N (Helm 1997). Regarding the Arctic, “tundra reveg to natural plants is slowed by application of fertilizer and grasses” (McKendrick 1997).

b. Limitation of adding topsoil

Installing topsoil over the mineral soil, or reinstalling removed overburden may have some benefit, and “many regulations suggest or require the use of surface soil. It frequently has many beneficial biological and organic characteristics: seeds, rhizomes, and soil microorganisms, although fine-grained (loams or finer) materials typical of surface soils are more likely to erode than coarse sands and gravels typical of sub-surface materials. There are situations when surface material is not the most appropriate media” (Helm 2006). Densmore (1987) notes, “the Alaska Power Authority documents recommending stockpiling overburden, but that may not be feasible, for example, existing sites for which stockpiles was not done, forested sites have stumps and, when they are removed, there is not much soil.” The topsoil layer in undisturbed areas in Alaska is often very thin, and therefore expensive and impractical to

salvage (Czapla and Wright 2012). Failure of vegetation to become established due to a lack of irrigation has been used as a basis for non-compliance under the APDES CGP.

c. Difficulties noted

From the Alaska DNR publication *Interior Alaska Revegetation and Erosion Control Guide* (Czapla and Wright 2012), construction and mining sites rarely have intact soil horizons. The preceding discussion on soil profiles does not apply to most disturbed land. Basic measures of soil particle size, elasticity, and water-holding capacity are usually applied to construction and mining sites. The uniform soil classification table is the best means of determining soil characteristics for revegetation purposes . Further, the discussion on "imprinting" is useful: [making] a depression in the soil surface, creating basins in the soil that reduce erosion, increases water infiltration and captures runoff (Dixon, 1997). Imprinting can be accomplished with heavy equipment such as a compactor with a "sheeps foot" attachment. A broadcast seeder is often attached to the back of an imprinter to apply seed. In Alaska, broadcast seeders are sometimes mounted on 4-wheelers. The most common method used is to hydromulch and seed at the same time.

When soil has been imprinted, uncovered seeds in the basin areas tend to be covered by natural processes such as wind and rain. Imprinting creates microclimates suitable for plant germination and growth. "Track walking" is a method of imprinting whereby the cleats on a tracked vehicle leave depressions on the soil surface. This technique is commonly used on sloping sites, before seeding. The equipment should be operated so that the depressions left will intercept runoff as it flows downslope. When using the track-walking technique, the surface area of the treated site is increased by approximately 25%; application rates of materials should be adjusted accordingly (Czapla and Wright 2012). Czapla and Wright have many definite

suggestions for seed types depending on soil, but all require fertilizer and watering on mineral soils.

Construction Practicalities

Because soil with high organic content is considered unsuitable for road foundations or embankments, it is removed from soils used for construction. Therefore, most road projects involve moving soil outside the roadway embankment, which often removes the existing vegetative layer from the soil and leaves bare or mineral soil. Organic or vegetative soils are sometimes sent to designated offsite disposal areas. The most common method employed is offsite disposal due to logistical and contractual constraints. The specification for roadside embankments is that the embankment material must be compacted and free draining. Fines, generally silts and clays, are limited in the upper course of the embankment. The net result of offsite disposal of "unsuitable" soil materials and the specified use of select borrow result in a final embankment surface that is drought prone, will not retain moisture, and is free of macro and micro nutrients. Might these embankment soils meet the definition of a final stabilized surface?

Conclusions

So far, we have noted the following:

- Heavy construction, such as roads and airports, exposes mineral soils, which are subject to erosion.
- Regulations, as expressed in the Construction General Permit (CGP), require stabilization for the project's permit to be closed.
    - Project practicalities dictate using the CGP, rather than an individual permit.
- Revegetation is often the most economical of the stabilization methods.

- Sustainable revegetation of mineral soils is not practical within project time constraints.
- Extending the time by warranties or extended maintenance by the construction contractor is not practical (see Section 2), but see recommendations that follow.
- The benefit of reduced particulate pollution of waters in the U.S. may be very small in many Alaska locations.
- In northern locations, enforcing growth of grasses with extended establishment periods may delay sustainable revegetation by natural vegetation.
- Two main paths forward to improve the current situation are (1) long-term maintenance with watering and fertilization until some organic layer is established, or (2) not revegetating, simply riling the low-erodibility mineral soils.

Recommendations

- We recommend that the CGP be modified to allow closure of the APDES SWPPP, without revegetation, in regions where sustainable revegetation with grasses is not practical and the erosion potential is low.
- We recommend that the proposed CGP modification be backed by data and observations, with this report a beginning.
- Since the CGP will expire in 2021, and presumably, the preparations for the renewal application will begin in 2019, it is not too soon to gather data for this process, and we recommend that data gathering begin.
    - The permit process is led by the ADEC, but would need to be supported by DNR, ADOT&PF, and possibly other owners of heavy construction projects.

- In regions where grasses are not likely to be sustainable but erosion potential is greater, the owner, ADOT&PF usually, has two options. The first option is to use riprap or other permanent ground cover, or settling basins or such. The second option is to maintain the grasses by extending the establishment period by several years. The costs of the first option are known, but usually expensive. The second option is generally unknown, but agencies could easily, and with little cost, determine the cost effect of different establishment periods for seeding and plantings by including alternates in their bid packages for different periods.
- Preliminary to such a bid, the ADOT&PF might hold an information session for contractors and bonding companies.

- We recommend that when the next CGP for Alaska is developed and re-issued, consideration be given to including a special condition that would allow interim closure of the SWPPP so that an extended period of establishment for seeding and plantings would not preclude closing other portions of the SWPPP. Likewise, the effect on bonding should be considered.

Photos and Field Notes

Figure 1.1 Dalton, MP 11–18 reconstruction, bid Jan. 2012, 1% for seeding. Tracked side slope, dead grass in tracks. Sparse grass in clumps.

Figure 1.2 Close up on tracks. Note grass is dead, but had roots.

Figure 1.3 Dalton Hwy., MP 19, may be different project. Sparse clumps on slide slope, but vegetated in pond. Note erosion control by ditch lining with rocks.

Figure 1.4 Slope failure. Could be permafrost or engineering failure, but note lack of revegetation on slope contrasted with lush growth above the cut.

Figure 1.5 Note lack of vegetation on embankment slope, some dead grass. This is rock riprap ditch with planned retention ponds, but slope of lobes has dead grass.

Figure 1.6a No data on when the next was done (near Dalton Hwy., MP 21). Note grass is still alive, but wood shrubs are evident. This may be example of good grass delaying woody plants.

Figure 1.6b Closer view.

Figure 1.7a (Next 3 photos) MP 100 Elliott Highway, no record of when work was done, seems recent. Tracked.

Figure 1.7b Some erosion, sediment in ditch.

Figure1.7c Some grass only in tracks.

Figure 1.8a MP 108, project opened October 2014, so work was done in 2015 and maybe 2016; riprap in ditch. Upslope side, presumably with organic soils, has grass; roadside, all mineral soils, has no grass.

Figure1.8b Same project, MP 108.

Figure 1.9 Some revegetation, green tinges.

Figure 1.10 Note slope erosion. This is on left/west side MP 108–109. Recent project.

Figure 1.11a Same project, as slope steepens, they go back to riprap the ditch**.**

Figure 1.11b Riprap in ditch.

Figure 1.12a Example of grass in rills (tracks), about MP 109 Elliott Hwy.; recent project. Slope here is quite green. This is new revegetation from recent project. Note woody shrubs, probably from former road, and native trees in background**.**

Figure 1.12b Same location. Note green is only in rills.

Figure 1.12c Same location, but close look indicates grass is only in clumps in tracks**.**

Figure 1.13 Elliott Hwy., recent project. Note erosion on slope and general lack of revegetation. This project has ditch dams (checks) at intervals to inhibit transfer of fines downstream.

Figure 2.14 Example of an old project, MP 120–127 Elliott Hwy., probably 1994. Note the woody plants are sparse. This ROW has surely been cut down. Note contrast with taller plants on right. Some grass is evident.

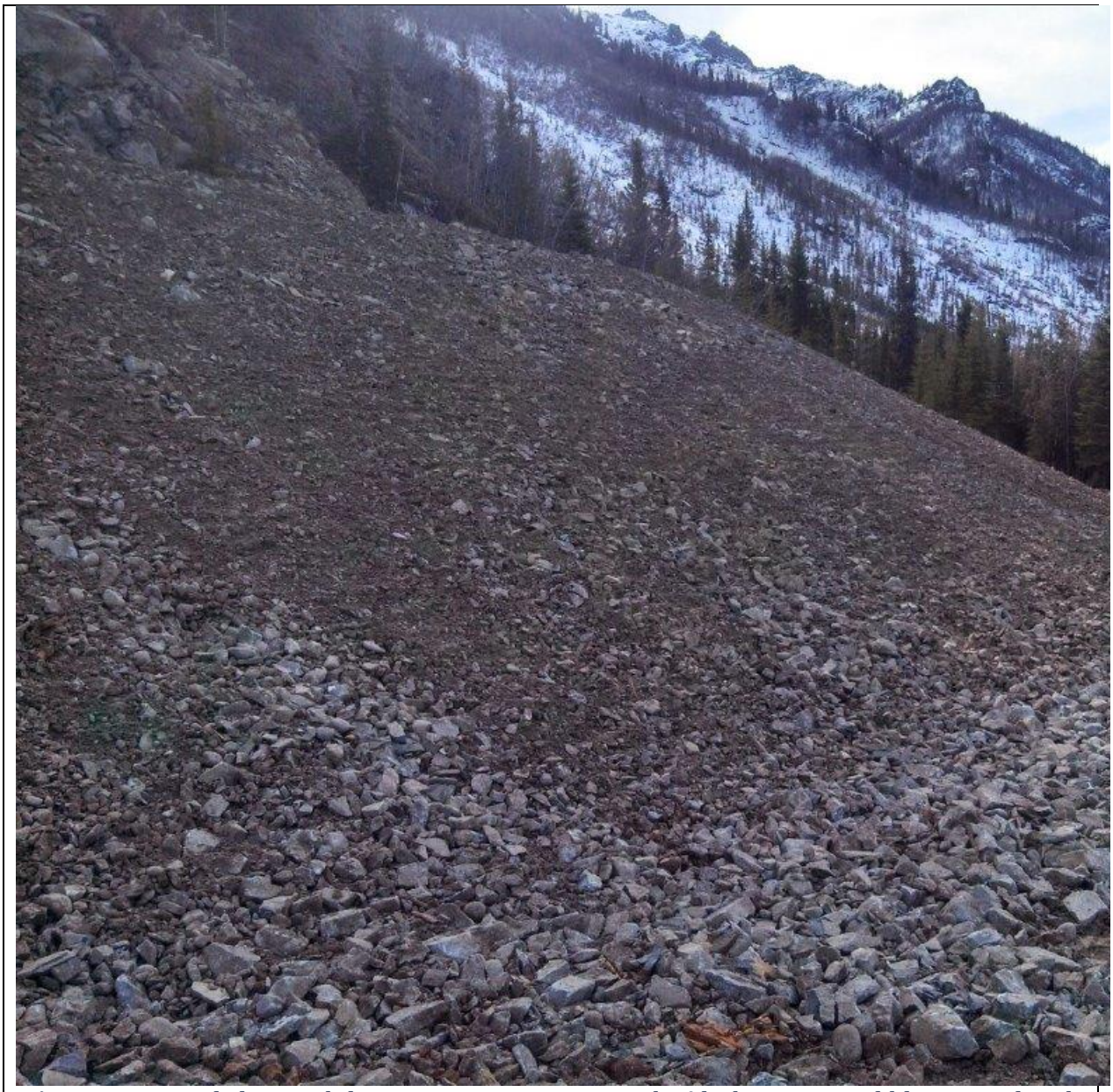

Figure 1.15 Final slope stabilization at a quarry near Tok, Alaska. Low erodible material with surface roughening (track walked).

Figure 1.16 Quarry reclamation along Tok Cutoff. Low erodible material with recovered growth media, surface roughening (track walked) prior to application of seed and mulch.

Figure 1.17 Bridge replacement project near Gakona, Alaska. Riprap around stream. Track walking (surface roughening) prior to seed and mulch application.

Figure 1.18 Road construction project near Fairbanks, Alaska. Temporary erosion and sediment controls in a conveyance, with surface roughening (grooving on embankments, track walking in ditch bottom) with velocity dissipation (rock check dams).

Figure 1.19 Construction project near Fairbanks showing final stabilization (riprap/stone mulch) and temporary perimeter sediment control (silt fence) and surface roughening (grooving) on embankment above placed rock.

Figure 1.20 Utility line construction showing fiber roll used as velocity dissipation device and hydromulch/seed.

Figure 1.21 Temporary soil stabilization during construction using brush mulch consisting of hydro-ax slash.

Figure 1.22 Temporary soil stabilization during construction using brush mulch consisting of hydro-ax slash**.**

Figure 1.23 Trail rehabilitation using native vegetation and organics as seed source for native plants, brush mulch, and seeding with “rehabilitation seed mix.”

Figure 1.24 Trail rehabilitation near stream crossing using straw mulch, rolled erosion control products (erosion control blanket), perimeter sediment control (silt fence), and seeding with "rehabilitation seed mix."

SECTION 2: MANAGING THE MAINTENANCE OF HIGHWAY ROADSIDES

Introduction

This project focused on two aspects of the stabilization of disturbed slopes. The first aspect, discussed in Section 1 of this report, deals with selection of methods and materials for initial construction and the regulations governing those choices and activities. In Section 2, we consider possible approaches to the long-term maintenance of disturbed slopes.

We present three alternative approaches to the management of these highway assets, review the interesting history of warranty contracting in the United States highway construction industry, and look at some common definitions and generally understood advantages and limitations of warranty contracting, We then report on the experiences had by several states in the U.S. when implementing warranties on highway projects, summarize a series of interviews with members of the (mostly) Alaska construction community, describe the current status of warranty contracting, and finally, return to the central question of whether warranty contracting or another approach is more practical for maintaining disturbed and stabilized slopes.

Like the earlier part of the report, the emphasis here is on vegetation and revegetation as the primary method of stabilization, although many of the findings apply equally to other methods.

Three Basic Approaches to Roadside Vegetation Management

Briefly, here are the three primary means by which the maintenance of roadside vegetation management is accomplished. Each is discussed, with emphasis on the third method: maintenance by the highway contractor.

In-House Maintenance by the Highway Agency

In-house maintenance by the highway agency is probably the most prevalent method of roadside vegetation management, although there is some indication that contracting with outside maintenance contractors is becoming more common. Understandably, transportation agency maintenance departments tend to protect their interests by advocating for this in-house approach.

Contract or Other Agreement with Separate Entity

In a contract or other agreement with a separate entity, roadside vegetation maintenance is performed by a separate contractor or by another governmental entity. If by a contractor, the contractor could be the one that built the project, but maintenance would be under a separate contract. Gharaibeh and Miron (2008) express a preference for this method, as opposed to using the same contractor under the original contract, as described next). It is more likely to be a different contractor who specializes in maintenance work. Rural airports in Alaska are maintained in this manner. Another option is to use agreements with local jurisdictions, such as in Wisconsin, where the ninety-nine counties are responsible for maintaining their own roadways.

Maintenance by the Highway Contractor

The original highway [construction] contractor can supply long-term roadside vegetation maintenance, providing some measure of guarantee for that work. Because consideration of this approach rapidly points to the inclusion of warranty provisions in the construction contract, we delve rather deeply into an exhaustive (and exhausting) study of warranty contracting, its history, advantages, limitations, and current status, and experiences with using this method.

Information Sources

Literature Review

We have drawn from a seemingly overwhelming amount of literature, both printed and digital. Much of it relates to construction warranties, which have been extensively described, studied, and evaluated. A bibliography is included at the end of the report.

Interviews

We conducted a series of interviews, face-to-face and telephonic, with persons knowledgeable about construction and who have experience with construction warranties. These sessions set the tone for many of the report's conclusions and led, in one case, to the development of a case study describing the use of a performance warranty in Alaska. A complication compilation of information about several warranty projects also resulted from the interviews.

Highway Construction Specification Review

A review of the standard specifications for highway construction used by fourteen states in the U.S. and by British Columbia, plus some related documentation, formed the basis for two discussions in this report: (1) a summary of warranty practices and (2) information on required establishment periods for seeding and plantings in various jurisdictions.

Other Expert Contacts

Direct contact with two Federal Highway Administration (FHWA) employees who have worked closely with the agency's warranty program provided valuable insights into the current status of highway construction warranties.

History of Highway Construction Warranties

The early history of using warranties in U.S. highway construction begins in 1889 in Bellefontaine, Ohio, when George W. Bartholomew installed the first Portland cement concrete pavement; his contract required him to donate all the road material, to post a $5,000 performance bond, and to guarantee that the pavement would last for 5 years. Reports indicate the pavement met the performance requirements (Hancher 1994).

In 1890, Warren Brothers Paving began warrantying their hot mix asphalt pavements (D'Angelo et al. 2003, Gallivan 2011, Scott et al. n.d.). Their product was patented in 1901. For their Warrenite-Bitulithic pavement, they provided a 15-year warranty that covered both materials and workmanship. Their patent expired in 1921, at which time competition was opened, and the warranty program was discontinued.

Figure 2.1 Brass seal used by Warren Brothers to identify warranted pavement; from pavement in New York City area used from 1919 to early 1960s (D'Angelo et al. 2003).

By 1910, the essential need for the contractor to cover risks in pricing warranty contracts was already apparent (Patil and Mollenaar 2011). Asphalt Paving & Contracting Company lost a case in the Supreme Court of New York. The company had a 15-year contract with the City of New York for paving and repair, and was unable to keep up with repairs in the contract's final years. The court denied the contractor's excuses for non-performance, such as traffic conditions

and underlying soil conditions, which the court said were “open and obvious to the contractor at the time the contract was made.”

With interesting foresight into the next century of warranty contracting, *Engineering News Record* opined on July 23, 1898, that “the guarantee clauses of paving contracts are the source of endless litigation” (Hancher 1994).

Stepping ahead to 1930, we find a report that only New Jersey required maintenance guarantees on state highway work. At that time, several U.S. cities did require some form of maintenance guarantee (Hancher 1994).

With the advent of the Interstate Highway system in the 1950s, the use of warranties on federal-aid highway projects was explicitly disallowed (Federal Highway Administration 2014, Gallivan 2011). The rationale was that at least a portion of a highway’s warranty work was considered routine maintenance, and such work was the responsibility of the states, not the federal government. Over the next 40 years, there was little use of warranties on state or federal highway projects.

In the late 1980s, North Carolina instituted a warranty program for highway pavement markings (Cui et al. 2003). Since then, there has been a surge of applications for many types of highway construction elements, followed by a lessening of interest. In the wake of increased interest, warranties have also been extensively studied, investigated, championed, criticized, and reported upon. For this part of our report, we have selected what appear to be some of the most relevant and interesting nuggets from that 30-year history.

A proposed amendment to the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) would have removed the prohibition of warranties in federal-aid highway construction contracts. At that time, engineering and construction organizations were solidly opposed to the

amendment, and it failed (Hancher 1994, Scott et al. n.d.) A consequence of that failure was used by the FHWA under its Special Experimental Project No. 4 (SEP-14), created to study promising innovative contracting techniques, to establish an initiative to test the effectiveness of warranty contracting on selected federal-aid projects. This trial program was to "encourage a better quality of construction and contractor accountability while not shifting the maintenance burden to the contractor" (Hancher 1994, Sees et al. 2009). Eleven states took part in that experiment; subsequent evaluations indicated mixed success.

In 1996, the FHWA revised its policy to allow warranties under certain conditions. The current version of the regulation has important qualifiers: The warranty must apply to a specific product or feature, it must exclude routine maintenance items or features outside the contractor's control, and general warranties for an entire project are not acceptable unless the project is designed and constructed by a single entity designer-builder (Government Publishing Office 2011, Zlatkovic et al. 2015). Federal regulations now allow flexibility in warranties for public-private partnership agreements and for projects utilizing best-value selection procedures.

A significant stimulus for increasing interest in the use of warranties in U.S. highway construction was a 2003 report by a study team that visited several European countries using various kinds of warranties (Hancher 1994, D'Angelo et al. 2003, Scott et al. 2011). The study team reported warranty durations as great as 30 years for some design-build-finance-operate projects. Although the European highway construction industry differs from that in the U.S. in several respects—broader-based specifications that give greater leeway to contractors to select materials and designs, a preponderance of best-value selection methods instead of low-bid, smaller number of contractors but larger-sized companies, and a less litigious contracting

atmosphere—the report urged serious consideration of expanding the use of warranties in U.S. highway construction.

After we define and discuss the three basic types of construction contract warranties, set forth the advantages and limitations of performance warranties that were expected based on early studies, and list several highway elements that have been the subject of such warranties, we shall reflect on the experiences encountered in a sampling of states as they sought to implement warranties.

Warranty Definitions

What is a warranty? Hancher (1994) says a warranty is a "guarantee of the integrity of a product and of the maker's responsibility for the repair or replacement of deficiencies." Sees et al. (2009) suggest the same, but they emphasize the time element: "A warranty in highway construction, like the warranty for a manufactured product, is a guarantee that holds the contractor accountable for the repair and replacement of deficiencies under his control for a given period of time."

Warranties in highway construction were first used to guarantee only the project's materials and workmanship. Later practice expanded the use of warranties to the performance of the finished product. Here is a helpful distinction among the types of warranties as applied to pavement construction, taken from the FHWA website on pavement warranties (U.S. Department of Transportation 2017):

- ***Materials and Workmanship Warranties***

  Materials and workmanship type warranties require the contractor to correct defects in the pavement caused by elements within their control and assume no contractor responsibility for the design. The warranties are generally related to preventive maintenance treatments such as crack sealing and chip and seal coats and range from 2–4

years in duration, depending on the specific treatment. Materials and workmanship warranties follow an agency's current standard specifications for the specific treatment.

- ***Performance Warranties***

Performance warranties require the contractor to assume additional responsibility for the actual pavement performance over a specified length of time. Performance warranties are generally grouped into two classifications of short-term or long-term warranties.

  - ***Short-Term Performance Warranties***

    The warranty period for short-term performance warranties generally ranges from 5 years to 10 years depending on the pavement type and the design of the project. These warranties include specific agency pavement performance criteria to be achieved. Project specifications for short-term warranties include the minimum materials and construction requirements acceptable to the agency.

    Typically, for short-term warranties, the agency is responsible for the structural design requirements of the pavement and the contractor is responsible for the mixture design. The warranty program utilizes the contractor's Quality Control Plan (QCP) and procedures to address construction details. The agency is responsible for the evaluation of the pavement over the warranty period. Final acceptance of short-term warranty projects is not until the specified warranty period has been completed.

  - ***Long-Term Performance Warranties***

    The warranty period for long-term performance warranties generally ranges from 10 years to 20 years. For long-term warranties, the contractor has additional responsibility to meet the minimum materials, structural, and mixture design requirements for the pavement. The contractor's QCP and procedures are used to address the construction details. The agency is responsible for the evaluation of the pavement over the warranty period. Final acceptance of long-term warranties is not until the specified warranty period has been completed.

The distinction between these two basic types of warranties is important. Materials and workmanship warranties hold the contractor responsible for “meeting the specs” as they apply to the quality of the materials and the way in which those materials are incorporated into the project. Performance warranties go well beyond that, shifting the ultimate responsibility for the project and how it performs (notwithstanding that its materials and methods may have been fully compliant) from the owner (government agency in the case of highway contracting) to the

private contractor. The test of time has shown several challenges in the application of that idea to the real world of construction contracting.

Advantages and Limitations – Initial Expectations

The early literature on warranties set forth both prospective advantages and potential limitations in their use (Johnson 1999, Anderson and Russell 2001). Among the prospective advantages were the following:

- Increased product quality.
- Lower life-cycle cost.
- Shifting risk from the owner to the contractor.
- Increased contractor involvement in planning and execution, leading to fewer claims and disputes, better bids, and reduced risk of liability losses for everyone.
- Development of better testing equipment and construction techniques
- Predominance of larger, qualified, stable firms to do all tasks for major transportation projects, lessening the risk to both owners and sureties for large projects.
- Reduction in agency staff.

Among the "concerns" were the following:

- Potential higher life-cycle costs despite maintenance cost savings.
- Enforcement over extended periods.
- Selection of appropriate warranty periods.
- Obtaining recourse in case of contractor business failure.
- Uncertainty of whether surety companies will provide long-term bonding guarantees.
- Elimination of small or minority contractors unable to acquire bonding.

Types of Highway Components Subject to Warranty

Gallivan (2009) reported that, by 2006, thirty-four U.S. states had used some kind of warranty specifications in their highway contracts. The most prevalent use was for hot mix asphalt pavements; twenty-two states had used them for over 700 such projects. The following list was compiled from studies by Anderson et al. (2011), Bayraktar et al. (2006a), Johnson (2008), Markow (2010), Russell et al. (1999), and Scott (n.d.). The list identifies the wide variety

of highway components covered by some kind of warranty in at least one project up to about 2006:

- Asphaltic crack treatment
- Bridge components (deck overlays, coatings, deck joints, granite (pier protection, lighting and electrical components, waterproofing membranes, parapets and approaches, bearing devices, drainage systems)
- Bridge painting
- Chip seals
- Concrete joint sealant
- Concrete pavement patching
- Culverts
- Dowel bar retrofit
- Drainage
- Hot mix asphalt pavements
- Intelligent transportation system components
- Landscape and irrigation systems
- Lighting
- Micro-surfacing
- Pavement marking (methyl methacrylate, reflective raised markers, high performance marking tape, paint with glass beads, other painting, [plus others])
- Pavement preservation
- Pavement settlement/cracking
- Plant establishment
- Portland cement concrete pavement
- Roadside facilities
- Roofs
- Rubberized asphalt pavements
- Traffic signals

In relation to our present study, note in this list that the categories “landscape and irrigation systems” and “plant establishment” might somehow have to do with slope stabilization. While that possible connection is not discernable from the literature, it is known that the number of warranty projects in these categories is very small.

The U.S. Army Corps of Engineers (2012) uses an Army Reserve Construction Warranty Implementation Plan for its Louisville District that makes the contractor responsible for providing “a minimum One Year Warranty Period of all equipment, material, design furnished,

or workmanship or as proposed by the contractor as a betterment." The plan involves conferences, training, inspections, identification tags, an ombudsman, and other requirements. It even includes a furniture warranty reference sheet, giving warranty durations, by manufacturer, for several types of furniture.

State Experience and Evaluations

In an earlier section, we noted that states' experiences with highway construction warranties have been extensively studied and evaluated. In this section, we summarize some of those findings. The impetus for these studies was the rapid increase in warranty use in the late 1990s and into the early 21st century. One statistic is representative: Russell et al. (1999) reported that the number of warranty project completions in U.S. highway construction rose from 10 in 1995 to 119 in 1997.

Experience with highway construction warranties has resulted in mixed success. We shall describe a representative sampling of the many reports, with the reminder that there is a dearth of reports from the very recent past, since the decline in popularity of this approach to construction has made writing about it less popular. To start, the following general comment by Sees et al. (2009) seems appropriate: "These projects have met with varying degrees of success, causing some states to broaden the use of warranties, whereas others have abandoned them completely."

Wisconsin's early experience was positive. A major reconstruction project of a rural highway was one example of a result considered positive. The project required a 5-year performance warranty (Udelhofen 2006). Anderson et al. (2005/2006) reported the following at about the same time: "WisDOT believes that warranty contracting is a positive direction for both contractors and themselves." Later studies concluded that non-warranted and warranted hot-mix asphalt pavements had approximately equal total cost, pavement distress, and anticipated

rehabilitation requirements. The staff time was greater for warranted projects, but the ride quality was better for warranted pavements (Scott et al. 2014).

In 2012, the Wisconsin DOT suspended the use of warranties until it was able to "revise the current specification to address concerns …" (Scott et al. 2014). Apparently, this was the death knell for the performance warranty program in Wisconsin, because it no longer exists. Bonding was a major issue. Warranties began to be used on inappropriate projects, such as those over which the contractor could not have control. Contracting companies' attitudes changed, and they became less cooperative. Contention arose between the agency and its contractors over condition assessment methods and the enforcement of warranty repair work. The result—no more performance warranty projects in Wisconsin, and none likely in the foreseeable future (Whited 2017).

In Colorado, as reported by Shuler et al. (2014), experience with warranty and non-warranty projects led to the conclusion that there was no significant difference in competition, performance, or cost between the two types. Further, no tangible benefit was apparent from shifting the risks and responsibilities between contractor and agency. Thus, at the time of the study, "there was no strong cost-benefit evidence to suggest that either continuation or stoppage of the 3-year warranty program will be beneficial." Scott et al. (2014) reported a similar conclusion from a 2007 report: "the implementation of short term warranties of HMA [*hot mix asphalt*] was not a cost-effective tool for the Colorado DOT."

Goldbaum (2006, 2012, 2017), who has tracked the cost aspects of warranty highway contracting in Colorado over many years, described a recent study in which ten pairs of warranted and non-warranted projects were compared after ten years of service life. His primary conclusion mirrors those from earlier investigations: "… the implementation of short-term

warranties of HMA is currently not a cost-effective tool for CDOT to implement" (Goldbaum 2012). An even later Goldbaum study on a hot mix asphalt and a Portland cement concrete project reported that neither was cost effective (Goldbaum 2017).

Michigan has been at the forefront of warranty contracting for highways. Its Department of Transportation claims to be the most experienced agency, having completed over 1000 warranty projects from 1997 to 2006 (Michigan Department of Transportation 2015). A 2002 project was threatened with a lawsuit (later withdrawn) by four trade organizations concerned with some of the warranty provisions (Czurak 2002). An analyst for the Michigan House Fiscal Agency provided a prophetic caution regarding the limitations of such an approach:

> If MDOT wishes to expand the use of performance warranties, it will have to allow contractors a say in design decisions. As long as MDOT continues to do the design work, specifies the material properties, and prescribes construction specifications, it is unlikely that contractors would be willing to warrant the actual performance of the road. In effect, the contractors would be asked to warrant something they had no control over. (Hamilton 2001)

Michigan's early experience was positive. Bid prices did not increase for warranty projects. The agency saved money by having contractors perform repair work within their contracts, and had further cost savings through reduction in numbers of agency personnel (Anderson et al. 2005/2006).

Indiana's experience has been more positive than that of some states, although the warranty program was recently suspended after an attempt to increase the warranty period to 10 years (McDaniel et al. 2017). A 2007 report on Indiana's pavement warranty program expressed a "general air of guarded optimism" (Singh et al. 2007). That optimism was based on comparatively better performance over non-warranty projects and better cost effectiveness in the long term. A more recent study (Sadeghi et al. 2016) offered similar results and estimated service

lives 10 to 14 years longer, on average, for warranted asphalt pavement projects, compared with similar non-warranted projects.

Other evaluations led to similarly mixed results. In Mississippi, a statistical analysis of both asphalt and Portland cement concrete pavement projects completed between 2003 and 2010 (Qi et al. 0213) showed that the deterioration rate for warranted projects was slower and the performance of warranted pavements was superior for equal lengths of service. On that basis, the report suggests, rather tentatively, "it could be concluded that the pavement warranty program in Mississippi can effectively improve the pavement performance for the state." Zlatkovic et al. (2015) discussed the disadvantages of highway pavement marking warranties in Utah, including higher initial costs, a more complex bidding process, and difficulties in risk assessments; however, they concluded that advantages identified in their study outweighed the disadvantages.

Alaska's experience with actual true performance warranties is very limited. Except for maintenance warranties on various electrical products and pavement markings, under which the supplier is responsible for "performance" of such systems for a stated period, the only other experience has been the use of product performance warranties for dust palliatives, on a 3-year trial basis, for rural airport gravel runway dust control. We append to this report a case study about that effort (Appendix 2.E), including the rationale for starting the trial program, lessons learned, and reasons why the program was terminated.

Of all the experience reported above and elsewhere, only a few projects have utilized long-term (greater than, say, 10 years) performance warranties (Scott et al. n.d.). Bolling (2012) reported that, of more than 2000 highway warranty projects in the U.S. highway system, most utilized materials and workmanship warranties, while about 100 utilized short-term performance warranties, leaving a "handful" in the long-term category. All the long-term performance

warranty projects, and most of those in the short-term category, wherein the contractor was responsible for the performance of the work put in place (such as pavement, rather than purchased products such as traffic controllers or pavement striping), have been built using design-build or public private partnership contracting methods. Contractors are not willing to guarantee the performance of projects in whose designs they have not been involved.

At this point in the report, with respect to our initial hypothesis that long-term or even short-term warranty contracts might be appropriate for maintaining stabilized slopes over time, it could be concluded that little experience is available to evaluate the practicality of that approach and that evaluations made have set forth mixed results.

Five years ago, the FHWA was still encouraging the use of warranties (Federal Highway Administration 2012). Its guidance paper, which offered ideas to assist states in managing their warranty programs, listed some states that were still utilizing highway construction warranties, whether materials and workmanship or short-term or long-term performance types. The paper made it clear that "(t)he Federal Highway Administration (FHWA) intends to continue supporting and encouraging the use of pavement warranties throughout the United States." As we shall see, much has changed in the years since that statement was made.

Construction Community Attitudes about Construction Warranties and Maintenance Management -- Interview Results

To ascertain the attitudes of Alaska's construction community and others about construction warranty-related issues and the way these issues might relate to the maintenance of stabilized slopes and other aspects of roadside maintenance, we interviewed thirteen contractors, engineers, and engineering managers. A list of those interviewees is contained in Appendix B, and a summary of warranty examples discussed in the interviews is included as Appendix C.

We asked about experience with construction warranties, the potential for including warranty provisions in specifications related to maintaining stabilized slopes, the use of "establishment periods" in specifications related to roadside vegetation, experience with or interest in various contractual/management approaches to maintenance of roadside vegetation including stabilized slopes, and other comments or suggestions. Nearly all of the responses relate to highway or other horizontal construction. The following comments are summaries of the responses to each of these topics:

Experience with Construction Warranties

Appendix D contains short descriptions of warranty uses on projects that were discussed during the interviews.

Nearly every construction contract has some materials and workmanship warranty provisions. Many contractors have had no "warranty issues" with these types of warranties over many years of contracting experience.

Whatever the type of warranty, many owners have difficulty understanding the difference between maintenance and warranty work. Owners are expected to keep up on maintenance, but they often neglect it. The customer owner on a military performance warranty project to install a boiler tended to think it was an O&M contract, and frequently requested routine operation or maintenance that was really a customer owner's responsibility. The contract required a response to warranty calls within a given period or the contractor risked forfeiture of retainage, so the contractor responded to all calls, even if the ultimate resolution was for the customer owner to perform routine maintenance per procedure.

Every job should require a good maintenance manual that indicates what the owner must do for maintenance and should require maintenance training of the owner's personnel. This, in

part, is for contractors' protection, so they are not called back to "fix" every issue that could have been avoided (or made less bad) by proper maintenance.

Contractors are generally not in favor of performance warranties. Such contracts tend to reduce competition because fewer firms are eligible for the required bonding, especially smaller firms. In a contract that includes subcontractors, such as landscaping on slopes, the warranty provision would apply to the subcontractor; but the subcontractor does not want to take on that responsibility.

It is difficult to identify the cause(s) of construction failures and thus decide whether the contractor is at fault for poor performance. Higher than expected traffic counts and poor maintenance by DOT forces can lead to failures that are not the contractor's fault. Performance standards are often vague and difficult to establish, interpret, and enforce.

In some cases, performance warranties, even though included in the contract, are not enforced because of the difficulty of determining the cause/fault.

Conditions that can influence performance during the performance period can include weather, other seasonality issues, wildfires, wayward ATVs, accidents, and other hard uses. Those causes might be stated as exceptions, but they may be difficult to interpret and enforce.

Highway elements for which performance warranties have been used (pavements, electrical, pavement markings) have something in common: they are typically not subject to weather influences and thus would not need weather as an exception in deciding if performance is satisfactory.

The availability of bonding for performance-warranty contracts is a major issue. Sureties do not like bonds that go much beyond 12 months (24-month maximum). Leaving the contract open during the performance warranty period means bonding is still in effect.

There has been little to no experience with performance warranty construction on Alaska DOT&PF projects. The attitude is that the contractor did not have responsibility for the design, and therefore cannot be responsible for its performance. Other issues with DOT&PF projects and performance warranties include the difficulty or impossibility of keeping the bond open for 5 or so years, and hard to determine causes of failure. A challenge is how to keep the contract open just for the warranty phase, and the extent to which FHWA would participate in the maintenance phase.

Performance warranties are more appropriate for design-build projects; there has been little experience with these in the DOT&PF Northern Region.

Stated another way, performance warranties can be successful if all parties are in it as one entity. Risk must be carried out within the single-entity team, which has an advantage to the owner by not being involved in this part of risk sharing. The risk sharing must be spelled out in the team agreement.

An advantage of a performance warranty might be a reduction in the number of state agency personnel needed on a project.

Use of Warranties for Roadside Vegetation Including Stabilized Slopes

With one exception, there was no experience with, nor support for, the use of performance warranties for roadside vegetation including stabilized slopes. For highway projects in Alaska, everything about slope stability is designed and specified by DOT&PF, thus making such warranties inappropriate. For vegetation design, especially for stabilized slopes, the design

may not be fully appropriate for actual conditions; expecting the contractor to take responsibility for performance assigns undue risk to the contractor. As stated in the previous section, the landscape subcontractor has little interest in taking responsibility for warranty work.

In the case of vegetated slopes, performance is highly dependent on weather and other similar conditions; it is difficult to determine an equitable sharing of risk. Other slope stabilization methods rely more on workmanship, thus making it somewhat easier to evaluate risk.

Since there are many variables outside the contractor's control, it is difficult to prove that the contractor was responsible for poor performance.

Performance warranty provisions for vegetated slopes might work in the case of a design-build contract.

The one exception mentioned in one interview was the City of Anchorage. In the case of seeding and other plantings, there is a 1-year performance-type warranty. The contractor is paid 30% upon completion of the seeding/planting. If satisfactory after 1 year, the 70% balance is paid. Otherwise, reseeding and/or re-planting is required.

Establishment Periods

The Alaska DOT&PF Northern Region uses a special provision related to seeding (Section 618): establishment period is that length of time needed to achieve 70% cover, rather than a specified length of time. The rationale is that insufficient control is given to the contractor to warrant performance. The contract is kept open until seeding/planting is accepted; everything else can be accepted.

Most interviewees believe that the Alaska DOT&PF 1-year-establishment period (for plantings statewide and seeding, except in the Northern Region) is reasonable. Comments and cautions included the following:

- Reasonable, provided planting is done at the proper time of year.
- The intent is to get through the first growing season.
- Maybe the 1 year could be made more flexible, making it project-by-project.
- "Employ all possible means…" could be interpreted to be very severe on contractor (greenhouse? Heat and light?)
- Reasonable except for the pitfalls – stacking snow, grader trims shoulder, four wheelers; dry weather.
- Extending beyond 1 year would have to include bonding considerations. Would a bond be available?

One approach might be just to stabilize the slope in the fall and then seed it in the spring (maybe under a separate contract).

With regard to bonding, there were two related ideas: (1) If seeding is left until the next spring, perhaps all the other work could be closed and bond coverage carried just for the remaining seeding; (2) bond coverage might be extended just for vegetation during the establishment period.

One approach might be to make all of the vegetation, including the establishment period, a separate contract. Thus, the main construction contract could be closed out earlier.

The Washington DOT interviewee reported that Washington uses establishment periods of up to 3 years, but that 7 to 10 years may be needed in some cases.

Maintenance Management Approaches

The only real options for highway maintenance, including vegetation, are the following:

- Extended construction contract, over a several-year warranty period – discussed at length in the first section above.
- State maintenance – as happens now in Alaska, except in a few municipalities.
- Separate maintenance contract (private or an agreement with the local government).

This section deals with the third option and focuses on private maintenance contracting.

An out-of-state interviewee noted that, across the country, most such work is done in-house, but there is a trend toward more contracted-out maintenance work (with some resistance from M&O departments, whose role becomes diminished).

The varying opinions on this issue were not surprising. Public agency personnel tend to prefer in-house (DOT&PF) maintenance forces, and private contractors suggest that the private sector might be well suited to perform such maintenance in some cases.

The following are comments we received on the topic.

- Alaska DOT&PF Maintenance and Operations typically does this work cheaper, and does an excellent job. Attitudes might be different if M&O were not so good. Local DOT&PF M&O personnel know best; are motivated and close to the situation; have pride in their work; would likely resent an outside contractor. Thus, DOT&PF managers tend not to favor private contracts for this task.

- There would have to be a long-term fiscal plan for contracting roadway vegetation management. The contractor may have to acquire special equipment, and it would be unfair to tie the contractor to a 1-year-only contract. It would be inefficient to have a maintenance contractor

for vegetation for several locations far apart from each other, when DOT&PF maintenance stations can handle all maintenance including vegetation.

- A maintenance contract likely would still require bonding. The duration of the contract might preclude bonding, but there could be renewable bonds, each of which was for, say, 2 years.

On the other hand, several contractors believe that privatizing such work is a good idea, with one comment that it is unfortunate that Davis-Bacon makes wages for this kind of work so high. Many contractors would be interested. A suggested approach is a term contract to take care of several locations; a payment bond covering seed, fertilizer, etc., would probably have to be purchased by the contractor.

A maintenance contract separate from construction might work, especially if it involves locals who have authority and interest in doing a good job of maintenance. Mechanisms do exist, under such programs as LRSA (Local Road Service Areas), which allow local "participation in government."

Alaska DOT&PF uses maintenance contracts for rural airports; the contractor must maintain vegetation control within a certain distance of the runway edge lights.

A contractor reported having a maintenance contract with Alyeska Pipeline Service Company and suggested contractors would be interested in similar arrangements with DOT&PF.

Contractors and DOT&PF personnel observed that DOT&PF M&O does not do much to maintain remote vegetated slopes. After the end of the establishment period, M&O does not work toward long-term establishment (seeding, fertilizer, watering).

There are similarities between vegetation management and snow removal with respect to contracting out or doing in-house. Several interviewees reminded us that such private contracts

would have to be state funded, since federal funds cannot cover maintenance. Maintenance contractors should not be expected to warrant performance, since many conditions are not under the contractor's control.

In Alaska, the Anchorage municipality and some other borough/city governments sometimes assume maintenance responsibilities for roadsides. In some states, such maintenance is the responsibility of county governments.

Other Comments/Suggestions

- Bonding agencies are hesitant to cover work done under long-term warranty contracts.
- Vertical construction is more amenable to performance warranties (HVAC systems, etc.).
- Alaska DOT&PF finds it difficult to close a contract that includes seeding and planting; the Notice of Termination (SWPPP) and contract close tend to be delayed. The usual goal is to finish a project within one construction season. But with seeding and planting, unless the project finishes well before cold weather (which usually does not happen), the contractor must wait until the following year to get sufficient stabilization/establishment.
- Whatever the approach to maintenance management, the state has fiscal responsibility for long-term maintenance on federal aid projects.
- Extremely severe weather may be offered as an exclusion in performance warranty contracting. The Army Corps of Engineers has developed contract language that tries to determine these effects on project schedules. Such an approach may be appropriate for finding if weather is a legitimate excuse for non-performance of the finished product.

Current Warranty Status in U.S. Construction

In this half of our report, we have traced the history of warranties in U.S. highway construction, listed anticipated advantages and limitations and the components that have been warrantied, reported some evaluation results, and summarized the current attitudes toward warranties and the management of roadside maintenance as expressed by a representative group

in the Alaska construction community. It is important to try to ascertain the status of warranty use, because some major trends can be identified during the past 5 years or so.

We ascertain the status of warranty use by reviewing some representative highway construction specifications, looking at a few projects currently underway, reporting the surety industry's current position on warranty contracting, and summarizing information from two experts in the field who were once actively involved in warranty contracting with the FHWA.

Specification Review

Due to declining emphasis at the federal level, and in many states, on performance warranties for highway construction, recent literature contains little on the subject. Furthermore, even those publications dated since 2016 rely on data considerably older than the publication date. Thus, it seemed important to conduct a review of representative state highway construction specifications to learn the extent to which contracts contain any type of warranty provisions.

We selected 14 states, plus British Columbia. Most were known to have had considerable interest in warranties during the heyday of highway construction warranties. The documents consulted are listed in Appendix 2.A. The results of the review are included in Table 2.1.

Table 2.1 Sampling of state highway specification warranty provisions

State	Element	Warranty Type	Other Information
Alabama	Nuclear Density Testing Device	"Service Warranty"	
	LED Traffic Signal Lamps	Materials and Workmanship	5 years
	Lighting system electrical and mechanical equipment	Equipment and workmanship	1 year
	Overhead sign structures; traffic control devices;		"Manufacturers' guarantees or warranties customarily provided"

State	Element	Warranty Type	Other Information
	traffic counting devices		
Alaska	Standard signs reflective sheeting	Performance	10 years
	Seeding; planting	Workmanship and materials	During period of establishment
	Control modules; pedestrian signals	Materials, workmanship, and compliance with ITE spec	5 years
Arizona	All non-maintained elements	Materials and workmanship	Meet "all of the requirements in the contract documents" *
British Columbia	Crack sealing	Materials and workmanship	1 year; "... /contractor shall rectify any defect ... resulting from work done or material supplied ..."
	Trees, shrubs, and ground cover	Materials and workmanship; performance	1 year; requires replacing any that die; this provision found only in D-B specs
California	Pre-fabricated detectable warning surface	Performance	5-year "manufacturer's replacement warranty"
Colorado	LED luminaires	Performance	Manufacturer's 10-year warranty
	Traffic signal vehicle detector amplifier	Performance	Manufacturer's standard warranty
	Irrigation system	Performance	... warranty the system "for the duration for the landscape establishment period"
	Preformed plastic pavement marking	Performance, materials and workmanship	... secure from the manufacturer "all warranties and guarantees with respect to materials, workmanship, performance, or combination thereof"
	Traffic signals	Repair or replacement guarantee	5 years; covering all but accidental damage
Florida	Value-added asphalt pavement	Performance	3 years' "... the Responsible Party ... is responsible for performance ..."
	Value-added Portland cement concrete pavement	Performance	5 years; "... continued responsibility for performing all remedial work associated with pavement distresses exceeding threshold values ..."
	Traffic control signals and devices	Materials and workmanship	"... for at least the duration specified ..."

State	Element	Warranty Type	Other Information
	Coating systems for galvanized steel; poles, mast arms, monotube assemblies	Performance	Ensure adhesion and color retention requirements are met for 5 years; responsible for performing all remedial work;
	Pull, splice and junction boxes; equipment shelter	Manufacturer's warranty covering defects	1 year
	Fiber optic cable; midblock crosswalk enhancement assembly; vehicle detection system; traffic cabinets	Manufacturer's warranty covering defects	2 years
	Pole mounting assemblies; signal assembly components; system control equipment; CCTV cameras; (list incomplete)	Manufacturer's warranty covering defects	3 years
	LED signal modules; pedestrian detection system; internally illuminated signs; dynamic message signs; (list incomplete)	Manufacturer's warranty covering defects	5 years
Idaho	Luminaire assembly	Materials, workmanship, and performance	"The entire luminaire assembly including material, workmanship, finish, photometrics, power supply(ies), and LED modules ... minimum 10-year manufacturer's warranty ..."
	Composite junction boxes	Manufacturer's warranty	1 year
	Chip seal coat	Materials and workmanship	Through April 1 of the following year
	Painting	Performance (?)	1 year
	Silicone sealant (furnished for owner's later use)	"Manufacturer's shelf life warranty"	
Indiana	Micro-surface course	Performance	3 years
	Ultra-thin bonded wearing course	Performance	3 years

State	Element	Warranty Type	Other Information
	Highway illumination components (luminaires, lamps, poles, wire, cable, etc.)	Performance, materials and workmanship	"...against loss of performance, defects in materials and defects in workmanship ...;" 5–10 years depending on type of device
	Durable pavement marking material	Materials and workmanship	"... failure resulting from material defects or method of application, or the result of snow plowing and deicing activities;" 180 days
	Seeding and sodding	Performance	Through June 15, for seeding performed between October 16 and January 31.
	Traffic signal controller cabinet, sunshields, doors, and other exterior surfaces	Materials	5 years
	Traffic signal cabinet electrical components and wiring	Materials and workmanship	3 years
	Field office and laboratory equipment	"Normal manufacturer's warranties"	
Michigan	Permanent traffic signal materials	Materials and workmanship	"specified period"
Minnesota	Lighting systems	Performance	"Warrant and guarantee in-service operation of all materials and electrical equipment for 1 year ..."
	Traffic management system	Performance	6 months; "During the warranty period, make repairs to all equipment and devices provided and installed during the project."
	Traffic control signals	Performance	Similar to lighting systems, with added proviso: does not apply to equipment subject to misuse, negligence or accident and not the fault of the contractor.
	Reflective sheeting for signs	Performance	12 years – 1st 7 years – provide materials and installation; balance – materials only
Mississippi	"All work"	Performance	"All work shall be warranted for a period of one (1) year following final acceptance. Any defective or nonconforming work, or latent defects, shall be corrected by the

State	Element	Warranty Type	Other Information
			Contractor, at no cost to the Department."
	Roadway lighting equipment and related components	Performance	6 months; "... intent (is) ... to provide for equipment that performs as intended by the manufacturer."
	Lighting LED luminaire assembly	Performance	5 years
	Signal radar detection sensor, video detection sensor, dynamic message sign, radio interconnect system	Materials and workmanship	1 year
	Uninterruptable power supply,	"Minimum 2-year warranty"	
	Blank out signs	Materials and workmanship	2 years
	Traffic signal LED modules	Materials and workmanship	5 years
	Magnetometer detection system	"Limited 5-year warranty"	
Washington	"Purchase of any equipment, materials or items incorporated into the project"		"... furnish ... any guarantee or warranty furnished as a customary trade practice ..."
	Solid state controller assemblies		"... furnish ... all guarantees and warranties furnished as a normal trade practice ..."
West Virginia	Interim traffic control signs; temporary pavement markings	Performance	30 days
	Permanent traffic zone paint	Performance	Through October 31
	Fast dry paint; preformed intersection traffic markings	Performance	1 year
	Channelization and delineation devices; roll-up signs; auxiliary traffic signal equipment electronic components	Performance	3 years

State	Element	Warranty Type	Other Information
	Detectable warning surfaces	Material	5 years
	Skid resistant preformed thermoplastic traffic markings	Performance	Transverse – 3 years; longitudinal – 4; "when applied according to the manufacturer's recommendations"
	Supplemental flashing beacons and mountings	Materials, workmanship, and performance	"12 months with respect to parts, workmanship and performance of product"
	LED signal module	Materials and workmanship	5 years
Wisconsin	Pavement markings – paint	"Proving period"	
	Pavement markings – other	"Proving period"	
	High mast lighting lowering device	Performance	10-year warranty "against failure of its components"
	Luminaire ring centering system	Performance	10-year warranty "against failure of its components"

* See Appendix E, "Bonding Arizona's South Mountain Freeway" as part of this report

In the case of various equipment or parts, such as luminaires or traffic signals, we have chosen to label the "manufacturer's warranty" as a performance warranty, our rationale being that the manufacturer guarantees the performance of that equipment or part. Such a guarantee might be labeled a material warranty, although the specification is typically for performance characteristics, rather than a "recipe" for how the element must be made.

In Table 2.1, performance warranties of the type that make the contractor, not the "manufacturer," responsible for repairs in the case of failure of performance (the classic or traditional sense in which "performance" is used) are limited in the following listing:

Florida

- Value-added asphalt pavement
- Value-added Portland cement concrete pavement

Indiana

- Micro-surface course
- Ultra-thin bonded wearing course

- Seeding and sodding

Mississippi

- All work

Three other comments are noteworthy regarding the data in Table 2.1. First, should those states with pavement marking "performance warranties" be in the preceding short list? We left them off, because the supplier/manufacturer is typically held responsible for performance. They could be included, if we make the general contractor responsible. Second, Wisconsin now uses the term "proving period," rather than warranty period, for its pavement markings, in line with that state's much reduced attraction to the whole warranty concept. Finally, only Alaska, Indiana, and British Columbia have anything about seeding/sodding that uses the term warranty, although the establishment periods in other specs assure some degree of performance guarantee during this period.

Two Current Projects

In Appendix E, we give a thumbnail sketch of a large project currently underway in Arizona—the design, construction, and maintenance of the Phoenix-area South Mountain Freeway. This P3 (Public-Private Partnership) project utilizes a single entity consortium for the entire design, construction, and 30-year maintenance period. The maintenance part of the contract negates the need for a performance warranty, but some items are not in the maintenance agreement. Those items will be covered by a material and workmanship warranty.

The other example is a project familiar to many Alaskans: Seattle's Alaskan Way Viaduct Bored Tunnel. Awarded in December 2010 to a consortium called Seattle Tunnel Partners, this design-build project is currently (as of October 1, 2017) scheduled for substantial completion in February 2019. Its accepted bid price was $1.09 billion; the current price is $2.10 billion. The contract's design-build character makes it suitable for the use of warranties, and they

are included. We quote the specification section related to project warranties in its entirety (Washington State Department of Transportation 2010).

22.1.1 Project Warranties

> Design-Builder warrants that:
>
> (a) all design Work performed pursuant to the Contract Documents shall conform to all professional engineering principles generally accepted as standards of the industry in the State;
>
> (b) the Project shall be free of defects, including design defects, deficiencies, errors and omissions, except to the extent that such defects are inherent in prescriptive specifications included in the Technical Requirements;
>
> (c) materials and equipment incorporated into the Work shall be of good quality and, when installed, shall be new;
>
> (d) Equipment provided by Design-Builder shall be of modern design and in good working condition;
>
> (e) the Work shall meet all of the requirements of the Contract Documents;
>
> (f) the specifications and/or drawings selected or prepared for use during construction are appropriate for their intended use; and
>
> (g) the Project shall be fit for use for the intended function.

"Fit for use for the intended function" may be a bit vague, but it sounds close to the performance warranties we have considered herein. The contract specifies a 2-year warranty period for "the tunnel structure, the tunnel approach structure and all systems, equipment, fixtures and other appurtenances of the tunnel structure and tunnel approach structure." All other work is warranted until the later of (1) one year from the physical completion date, or (2) the final completion date.

These two examples are symbolic of the notion that the traditional design-bid-build approach to construction contracting, wherein the eventual contractor is not part of the design process, is poorly suited to the use of any sort of performance warranties.

The Matter of Bonding

The reluctance of the surety industry to provide long-term bonding for construction contracts, and the resulting difficulty that contractors experience in acquiring such, was noted previously. That difficulty is a major element in the situation today.

On warranty projects, state DOTs typically require long-term maintenance bonds, also called warranty bonds. Since the contractor is responsible for "performance" of the project during the warranty period, the bonding company is expected to guarantee the contractor's operational and financial viability during that period.

As stated by Bayraktar et al. (2006b), "The main difficulty for sureties is predicting the contractor's financial position in the future. According to the underwriters, regardless of the current financial strength of the client, predicting its position beyond two years becomes a game of Russian roulette; and as the duration of the warranty period increases, the stakes in the Russian roulette game increase accordingly."

The surety industry has made clear its position on this matter. From Canada, we find the following summary of the association's position: "…The Surety Association of Canada (SAC) believes that it is inappropriate to impose extended warranty obligations upon both a contractor and a surety … will continue to suggest to the contract surety community that while surety bonds provide the best protection against contractor default, they are neither priced nor designed to provide a solution to long-term warranty requirements (Surety Association of Canada/Association Canadienne de Caution. 2014).

The Surety & Fidelity Association of America (2017), after stating concerns about reduced competition, increased risks and increased costs, offers a somewhat more hopeful attitude, as follows:

> The SFAA believes that a workable bond requirement can be established which provides effective protection to state DOTs, presents a reasonable risk to the sureties and enhances competition among responsible contractors. SFAA recommends that the warranty be limited to three years. With adequate design, engineering and inspection this length of time protects the owner but does not subject a contracting company to financial hardship for defects which are out of its control…
>
> SFAA invites dialogue with contractors and state DOTs to develop a bond requirement that would be more widely available than a long-term warranty bond and would enhance competition.

Even in this statement, however, there is opposition to bonding long-term warranty projects.

Current Status of U.S. Warranty Contracting – Reports from Two Experts

To conclude our investigation of the current status of warranty use in U.S. highway construction contracts, we contacted two experts in the field. Both have long-term associations with the Federal Highway Administration (FHWA) and in that role have worked with Alaska DOT&PF personnel. Victor "Lee" Gallivan has retired from FHWA and now works as a consultant in Indiana. Dennis Dvorak is still employed by the agency. Our information came from an extensive and helpful series of e-mail exchanges (Gallivan 2017, Dvorak 2017). The following summarizes those exchanges:

The decline in interest in highway construction warranties is real. Except for P3 projects, there is little current interest. Probably fewer than a dozen states are using them. Except for P3 and design-build projects, the only states using performance warranties are those required to do so by legislation. A large number of pavement preservation projects do use materials and workmanship warranties, but they are mainly for materials, not workmanship. The reduction in interest in warranties is due to many factors, including:

- Reduction in service life of projects compared with non-warranty projects.

- Unsatisfactory (for state agencies) results of disputes and lawsuits, when projects suffered from lack of good material test results and contractors had results showing otherwise.
- Protracted and expensive disputes and lawsuits, even when pavements did not meet warranty requirements.
- Little or no reduction in agency staffing, contrary to predictions.
- Difficulty in developing warranty acceptance criteria.
- Significant extra charges from sureties for warranty bonds that extend more than 3 to 5 years.
- Reduced ability of contractors to bid, since warranty bonds count against their total bonding capacity.
- FHWA's elimination of support for the warranty program, due to reduced funding and changing priorities

Regarding the possibility of applying performance warranties to stabilized slopes, there is no known experience among the states in this area. The development of acceptance criteria would be a major challenge. For example, deciding whether erosion is due to normal conditions or to contractor performance failure would often be controversial. Large P3 projects, wherein everything is warranted, do include warranties for slopes and other parts of the roadside.

On the topic of whether to perform roadside maintenance, including stabilized slopes, with agency forces or by contract, most states use their own crews, although several states maintain these assets under contract with the private sector. Large slope failures are often repaired under contract.

Possible approaches Alaska might take regarding maintenance of these slopes include:

- Development of materials and workmanship warranty criteria for construction contracts on a project-by-project basis for maximum periods of 5-year guarantees. Some states call these warranties "M&W guarantees," in order to avoid contractual issues surrounding the term "warranty." It would take considerable effort to develop suitable criteria for such.
- Small maintenance contracts with the local population (similar to what is done at Alaska's rural airports), or larger contracts on a more regional basis.

Warranties and Stabilized Slopes

After our extensive investigation of warranty contracting in U.S. highway construction, we returned to the central question addressed in this portion of the project: Are warranties of any sort appropriate in dealing with the maintenance of stabilized slopes in remote cold regions such as rural Alaska? If the question relates to performance warranties, the answer is decidedly "no." If the question relates to materials and workmanship warranties, the answer is "maybe."

Period of Establishment

Many states include a "period of establishment" in their construction specifications for seeding and plantings. The common understanding of "establishment period" is the period that "encompass(es) the time required by the planting to become acclimated to the growing conditions at the planting site" (Alaska Department of Transportation 2016).

During this period, the contractor is responsible for assuring that the planted material attains a specified level of survival and growth. Although the term *warranty* is not used, the requirement has the same purpose—a guarantee by the contractor of a certain level of "performance" over a specified time frame. We reviewed several state construction specifications (the same set used to review warranty provisions), to determine what types of establishment period provisions were included. The results are shown in Table 2.2

Table 2.2 Sampling of state highway specifications establishment periods for seeding and planting

	Establishment Period		
State	Seeding	Plants	Comments
Alabama	When 80% cover is achieved	Provide a minimum of one growing season	One-year vegetation bond required
Alaska	1 year (except Northern Region)	1 year	Northern Region seeding: "until a uniform perennial living vegetative cover with a 70% density ... is achieved"
Arizona	Per Special Provisions	Per Special Provisions	Depends on local conditions, climate, and type of plant materials
British Columbia	1 year materials, workmanship, and performance warranty	1 year materials, workmanship, and performance warranty	Only in D-B specs
California	Examples: 125 working days; 250 working days; 3 years	Examples: 125 days; 250 working days; 3 years	Project specific
Colorado	For spring planting: 12 months after completion; other times: 12 months after start of next planting season		
Florida	Until turf is established in accordance with specification		
Idaho	1 year	1 year	
Indiana		from the end of the specified planting period to the fall inspection	If the initial planting and spring replacements are not completed within the specified time, the completion date may be extended 1 year
Michigan		From completion of planting through following two growing seasons (June, July, August)	
Minnesota		Usually 2 years	Replacement plants require 1 year establishment period
Mississippi	Minimum 45 days after completion of seeding	Between 90 and 240 days, depending on date	

	Establishment Period		
		of completion of installation	
Washington	4 mowings or 20 working days, whichever is longer	1 year	
West Virginia	Maintain all seeded areas until final acceptance of the project	Maintain the plants in a healthy, living condition during the life of the contract	
Wisconsin	During growing season after applying seed	2 years (unless 1 year is specified in the contract)	

Although there are some gaps in these findings, the considerable variety in the way states approach the time requirement for seeding and planting establishment is clear. Some states specify a number of years (one or two is common) or even days. Some states are more flexible, allowing for project-specific periods. Some (like for Alaska's Northern Region) define the end of the period by the percent cover that must be achieved. British Columbia, in its design-build specifications, requires what is essentially a 1-year performance warranty for both seeding and plantings.

Alaska's *Standard Specifications for Highway Construction* (Alaska Department of Transportation and Public Facilities 2016) provide for a 1-year establishment period for roadside seeding and plantings, except in the Northern Region, where the contractor is responsible for maintaining the seeding until a vegetative cover of 70% is achieved. (Alaska Department of Transportation 2016). One approach for assigning to the contractor greater responsibility for establishing vegetation growth would be to extend that establishment period.

In the case of remote cold regions such as in rural Alaska, where there are challenges in keeping vegetated slopes sufficiently maintained, a possible remedy might be to extend the

establishment period to, say, 2 years or 2 growing seasons. To test the cost of this approach, contractors could be asked to bid an alternate with such a provision.

Other Warranty Approaches

If the contract requires compliance with a "period of establishment" specification, such a requirement might be considered a performance warranty over a very short period. (It could also be called a materials and workmanship-type warranty, but there is no need to argue that distinction here.) Beyond that period of establishment, it seems impractical to invoke any sort of warranty.

Especially when dealing with planted materials, and especially on sloping ground, the disadvantages of short-term and long-term performance warranties cited *ad infinitum* in this report become apparent. Except for design-build contracts, the contractor has no participation in the design. Setting and enforcing performance criteria can be problematic. Obtaining reasonably priced bonding may be impossible. And then, exclusions, for which the contractor cannot be held responsible, would need to be anticipated and stated: weather (too much precipitation or too little, gnarly breakup, glaciering due to unexpected temperature conditions), errant ATVs and snow machines, animal damage, and traffic accidents. The use of these types of warranties is simply not practical for the kind of work that is the subject of this research study.

CONCLUSIONS AND RECOMMENDATIONS

Our conclusions are summarized as follows:

- The popularity of warranties in highway construction contracts has reached its zenith and is declining.
- This decline in popularity is due to many factors, including the difficulty of developing and enforcing appropriate performance criteria, disputes over interpretation of those criteria, lack of timely response to identified deficiencies, problems with obtaining reasonably priced bonding, mixed results with respect to quality and cost of warranted work, and agency staff levels that did not decline as expected.
- Performance warranties, especially long-term versions, are appropriate only when the contractor is involved in the design phase.
- Design-build (DB) project delivery systems, private-public partnerships (P3), and variants thereof provide the only practical means for including performance warranties.
- Material and workmanship warranties, or at least some sort of assurance for the owner that the materials and methods meet the project requirements, are still an important part of construction contracting.
- The most prevalent method for performing long-term maintenance for stabilized slopes is by highway agency in-house forces, although there is a trend toward more private-contractor maintenance.
- Establishment periods contained in highway construction specifications for seeding and planting often provide sufficient “warranty” protection for the owner, in the short term.

Our recommendations for consideration by highway system owners and contractors include the following:

- In the short run, continuing to perform roadside maintenance with in-house forces, at least in Alaska, is most appropriate, rather than pursuing performance warranty contracting for this work.
- A more comprehensive study of methods by which maintenance work is performed in all U.S. states and overseas, especially for roadside assets including slopes, would yield valuable findings.
- Agencies could easily and with little cost determine the cost effect of different establishment periods for seeding and plantings by including alternates in their bid packages for different periods.
- For future design-build and public-private partnership projects, consideration should be given to including roadside maintenance among the items to be warranted.
- Close collaboration among agencies, contractors, and the surety industry may result in some innovative ways to provide less expensive bonding strategies for warranty projects.

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APPENDIX A: DOT SPECIFICATIONS

SECTION 618 SEEDING

618-1.01 DESCRIPTION. Establish a perennial stand of grass or other specified living vegetative cover, by seeding, in the areas indicated on the Plans. Maintain the cover for the term of the Contract.

618-2.01 MATERIALS. Use materials that conform to the Special Provisions and the following:

- Seed Section 724
- Fertilizer (20-20-10) Section 725
- Water Subsection 712-2.01

CONSTRUCTION REQUIREMENTS

618-3.01 SOIL PREPARATION. Clear all areas to be seeded of stones 4 inches in diameter and larger and of all weeds, plant growth, sticks, stumps, and other debris or irregularities that might interfere with the seeding operation, growth of grass, or subsequent maintenance of the grass- covered areas.

Make areas to be seeded reasonably free of ruts, holes, and humps. When specified, apply topsoil according to Section 620.

Roughen the surface to be seeded by grooving the soil in a uniform pattern that is perpendicular to the fall of the slope. Use one or more of the following grooving methods prior to the application of seed:

- Manual raking with landscaping rakes;
- Mechanical track walking with track equipment; or
- Mechanical raking with a scarifying slope board. Form one inch wide grooves spaced no more than six inches apart.

You may round the top and bottom of slopes to facilitate tracking or raking and to create a pleasant appearance, but you may not disrupt drainage flow lines.

618-3.02 SEEDING SEASONS. Seed and fertilize during the local growing season.

Do not seed during windy conditions or when climatic conditions or ground conditions would hinder placement or proper growth.

Seed disturbed areas that require seeding within fourteen days of the permanent cessation of ground-disturbing activities in that area.

Seed between May 15 and August 15, or obtain written approval from the Engineer to seed at a different date.

618-3.03 APPLICATION. Apply seed mix, fertilizer, and mulch (if required) at the rate specified in the special provisions. If no seed mix, seed mix application rate, or fertilizer rate are specified in the special provisions, use the recommendations of the Alaska Department of Natural Resources (DNR) and the Revegetation Manual for Alaska.

Do not seed areas of bedrock, plant beds, and areas indicated on the plans as "no seeding". Water and fertilizer required for application are subsidiary to the Seeding bid item.

Use any of the following methods:

- Hydraulic Method.
    - Furnish and place a slurry made of seed, fertilizer, water, and other components as required by the Special Provisions.
    - Use hydraulic seeding equipment that will maintain a continuous agitation and apply a homogeneous mixture through a spray nozzle. The pump must produce enough pressure to maintain a continuous, nonfluctuating spray that will reach the extremities of the seeding area with the pump unit located on the roadbed. Provide enough hose to reach areas not practical to seed from the nozzle unit situated on the roadbed.
    - If mulch material is required, it may be added to the water slurry in the hydraulic seeder after adding the proportionate amounts of seed and fertilizer. Add seed to the slurry mixture no more than 30 minutes before application.
    - Mix the slurry and apply it evenly.
- Dry Methods.
    - Use mechanical spreaders, seed drills, landscape seeders, aircraft, cultipacker seeders, fertilizer spreaders, or other approved mechanical spreading equipment when seed and fertilizer are to be applied in dry form.
    - Spread fertilizer separately at the specified rate.

618-3.04 MAINTENANCE AND WATERING. Protect seeded areas against traffic by approved warning signs or barricades. Repair surfaces gullied or otherwise damaged following seeding. Maintain seeded areas in a satisfactory condition until final acceptance of work.

Water and maintain seeded areas. Water applied by this Subsection is a paid contract item. If, in the opinion of the Engineer, too much water is being applied, reduce amount of water as directed.

Reseed areas not showing evidence of satisfactory growth within 3 weeks of seeding. Bare patches of soil more than 10 square feet in area must be reseeded. Erosion gullies over 4 inches deep must be filled and reseeded. Fill the entire erosion gully to surrounding grade, even the portions less than 4 inch deep.

Contact DNR for advice or corrective measures, when seeded areas are not showing evidence of satisfactory growth. You are responsible for retracking, reseeding, refertilizing and remulching areas that do not show satisfactory growth, and those actions are subsidiary.

618-3.05 ACCEPTANCE. The Engineer will perform a visual inspection of seeding to determine final stabilization. During the visual inspection each station and each side of the road will be considered a separate area. The Engineer will accept seeding that has become a vegetative matt with 70% cover density in the inspection area.

Reseed areas that are not acceptable to the Engineer.

618-3.06 PERIOD OF ESTABLISHMENT. Establishment periods extend for one complete growing season following acceptable seeding. Employ all possible means to preserve the new vegetative matt in a healthy and vigorous condition to ensure successful establishment. Reseed areas that do not meet the specifications. Watering and reseeding after the final inspection are subsidiary.

The Engineer may, but is not required to, determine the Project is complete except for the period of establishment, and issue a letter of final acceptance. After final acceptance, work or materials due under this subsection during any remaining period of establishment are considered warranty obligations that continue to be due following final acceptance in accordance with Subsection 105- 1.16.

618-4.01 METHOD OF MEASUREMENT. See Section 109 and as follows:

Seeding by the Acre. By the area of ground surface acceptably seeded and maintained.

Seeding by the Pound. By the weight of dry seed acceptably seeded and maintained.

Water for Seeding. If weighed, a conversion factor of 8.34 pounds per gallon will be used to convert weights to gallons.

618-5.01 BASIS OF PAYMENT. Mulching will be paid for under Section 619.

Seeding by the Acre. Payment is for established vegetative matt. Soil preparation, fertilizer, and water required for hydraulic method are subsidiary.

Seeding by the Pound. Payment is for established vegetative matt. Soil preparation, fertilizer, and water required for hydraulic method are subsidiary.

Water for Seeding. Water applied for growth of vegetative matt. Water for hydraulic seeding, fertilizing or mulching is subsidiary. Water after project completion is subsidiary.

Payment will be made under:

Pay Item	**Pay Unit**
618(1) Seeding	Acre
618(2) Seeding	Pound
618(3) Water for Seeding	M Gal.

SECTION 610 DITCH LINING

610-1.01 DESCRIPTION. Construct ditch lining at the locations on the Plans or as staked.

610-2.01 MATERIALS. Use stones that are sound and durable, are no larger than 8 inches in greatest dimension, and not more than 50% by weight passing a 3-inch sieve as determined by ATM 304.

610-3.01 CONSTRUCTION REQUIREMENTS. Excavate to the dimensions shown on the Plans. Place and spread ditch lining materials so that the finished face is reasonably uniform and conforms with the lines and slope shown on the Plans or as directed.

610-4.01 METHOD OF MEASUREMENT. Section 109.

610-5.01 BASIS OF PAYMENT. Excavation required below normal ditch grade is subsidiary. Payment will be made under:

Pay Item	**Pay Unit**
610(1) Ditch Lining	Cubic Yard
610(2) Ditch Lining	Ton
610(3) Ditch Lining	Station

703-2.08 FILTER BLANKET. Meet AASHTO M 80, Class A. Meet the following gradation: AASHTO M 43, size No. 467.

703-2.09 SUBBASE. Hard, durable particles or fragments of stone or gravel. Do not use materials that break up when alternately frozen and thawed or wetted and dried. Do not include muck, frozen material, roots, sod, or other deleterious matter. Meet Table 703-8.

TABLE 703-8: **QUALITY PROPERTIES FOR SUBBASE**

L.A. Wear,%	AASHTO T 96	50, max.
Liquid Limit	ATM 204	25, max.
Plasticity Index	ATM 205	6, max.
Degradation Value	ATM 313	40, min.

Meet the grading requirements of Table 703-9 (ATM 304).

Grading C and Grading D: Crushed aggregate with at least 50% by weight of the particles retained on the No. 4 sieve having at least one fractured face as tested by ATM 305.

TABLE 703-9: **AGGREGATE GRADATION FOR SUBBASE**

Percent Passing by Weight

	GRADING				
	A	B	C	D	E
4 in.	100	--	--	--	--
2 in.	85-100	100	--	--	--
1 in.	--	--	100	--	--
3/4 in.	--	--	--	100	--
No. 4	15-60	15-60	40-75	45-80	--
No. 16	--	--	20-43	23-50	--
No. 200 *	10 Max.	0-6	4-10	4-12	0-6

** Gradation shall be determined on that portion passing the 3-inch screen.*

703-2.10 POROUS BACKFILL MATERIAL. Gravel consisting of crushed or naturally occurring granular material containing not more than 1% clay lumps or other readily decomposed material (AASHTO T 112). Meet the grading requirements of Table 703-10 (ATM 304).

TABLE 703-10: **AGGREGATE GRADATION FOR POROUS BACKFILL MATERIAL**

SIEVE	PERCENT PASSING BY WEIGHT
3 in.	100
1 in.	0-10
No. 200	0-5

703-2.11 GABION BACKFILL. Stone and gravel, uniformly graded from 4 to 12 inches in least dimension and having no more than 60% wear (AASHTO T 96).

703-2.12 SAND BLANKET. Sand containing no muck, frozen material, roots, sod or other deleterious matter and with a plasticity index not greater than 6 as determined by ATM 204 and ATM 205. Meet the grading requirements of Table 703-11 as determined by ATM 304. **TABLE 703-11**

SAND BLANKET MATERIAL GRADATION

SIEVE	PERCENT PASSING BY WEIGHT
3/8 in.	100
No. 4	95-100
No. 200	0-6

703-2.13 STRUCTURAL FILL. Aggregate containing no muck, frozen material, roots, sod or other deleterious matter and with a plasticity index not greater than 6 as determined by ATM 204 and ATM 205. Meet the grading requirements of Table 703-12 as determined by ATM 304.

TABLE 703-12: **AGGREGATE GRADATION FOR STRUCTURAL FILL**

SIEVE	PERCENT PASSING BY WEIGHT
3 in.	100
3/4 in.	75-100
No. 4	15-60
No. 16	10-30
No. 200	0-6

703-2.14 AGGREGATE FOR ABRASIVE FINISH. Crushed silica sand, oven dried, and stored in moisture-proof bags. Free from clay balls, vegetative matter, or other deleterious matters (AASHTO T 112). Not coated with dirt or other finely divided mineral matter. Meet the grading requirements of Table 703-13 as determined by ATM 304.

TABLE 703-13: **GRADATION FOR SAND FOR ABRASIVE FINISH**

SIEVE	PERCENT PASSING BY WEIGHT
No. 12	100
No. 40	0-5

703-2.15 CRUSHED GLASS. Up to 10% by weight crushed glass (cullet) smaller than 3/8-inch may be uniformly blended with natural soil-aggregate material prior to project delivery and placement. Glass cullet must be free of soil, paper, plastic, metals, organic material and other deleterious and hazardous substances. No more than 2.0% debris should be present as determined by Section X3 of AASHTO M318.

Eligible glass products from which glass cullet might be produced include: food and beverage container glass; plain ceramic or china dinnerware; or building window glass.

Prohibited glass products include: automobile windshields or other glass from automobiles; light bulbs of any type; porcelain products; laboratory glass; television, computer or other cathode ray monitor tubes.

Provide documentation identifying the origin of the glass products and certifying the glass cullet:

- Does not contain prohibited materials,
- Meets debris content requirement.

Uniformly blend glass cullet and natural soil-aggregate and meet the gradation requirements of Table 703-14.

APPENDIX B: SPECIFICATIONS AND OTHER DOCUMENTS REVIEWED FOR WARRANTY AND PLANT ESTABLISHMENT PROVISIONS

2009 Design Build Standard Specifications for Highway Construction, Volume 2 of 2, British Columbia Ministry of Transportation and Infrastructure,

2012 Standard Specifications for Construction, Michigan Department of Transportation,

2016 Standard Specifications for Highway Construction, British Columbia Ministry of Transportation and Infrastructure,

2017 Standard Specifications for Highway Construction, Idaho Transportation Department.

Alabama Department of Transportation, *Standard Specifications for Highway Construction*, 2012 Edition.

Alaska Department of Transportation and Public Facilities, *Standard Specifications for Highway Construction*, 2016 Edition.

Arizona Department of Transportation, *ADOT Construction Manual.* https://www.azdot.gov/business/engineering-and-construction/construction-and-materials/manuals/ConstructionManual, accessed 30 October 2017.

Arizona Department of Transportation, *Standard Specifications for Road and Bridge Construction*, 2008.

Colorado Department of Transportation, *Standard Specifications for Road and Bridge Construction*, 2017

Florida Department of Transportation, *Standard Specifications for Road and Bridge Construction*, July 2017.

Indiana Department of Transportation, *Standard Specifications*, 2018.

Minnesota Department of Transportation, Inspection and Contract Administration Manual for MnDOT Landscape Projects, 2017 Edition.

Minnesota Department of Transportation, *Standard Specifications for Construction*, 2016 Edition.

Mississippi Standard Specifications for Road and Bridge Construction, Mississippi Department of Transportation Jackson, 2017 Edition

Public Private Partnership (P3) Design-Build-Maintain Agreement for 202 MA 054 H882701C SR 202L (South Mountain Freeway) between Arizona Department of Transportation and Connect 202L Partners LLC, February 26, 2016.

Standard Specifications for Road, Bridge, and Municipal Construction 2016, **Amended August 7, 2017,** Washington State Department of Transportation.

Standard Specifications State of California, California State Transportation Agency, Department of Transportation, 2015.

State of Wisconsin Department of Transportation, *Standard Specifications for Highway and Bridge Construction*, 2018 Edition.

West Virginia Department of Transportation Division of Highways, 2017 Edition, *Standard Specifications Roads and Bridges*.

APPENDIX C: CONSTRUCTION WARRANTY INTERVIEWEES

Name	Affiliation	Date (all 2017)
Jake Allen, P.E.	Alaska DOTPF*, Northern Region	September 27
Jeff Alling, Matt Brockman	Alcan Builders Inc.	September 14
Bert Bell, P.E.	Ghemm Company Contractors (ret)	September 19
Frank Ganley, P.E.	Alaska DOTPF, Northern Region	September 7
Tony Johansen, P.E.	Great Northwest, Inc.	September 15
Marc Luiken	Alaska DOTPF, Commissioner	September 11
Clark Milne, P.E.	DOWL	September 11
Jason Sakalaskas, P.E.	Alaska DOTPF, Northern Region	September 18
Doug Smith, Mark Erickson	Haskell Corporation / Mass X, Inc.	September 15
Marcus Trivette, P.E.	Brice, Inc.	September 21
Al Vezey	Lakloey, Inc.	September 6
Gary Whited, P.E.	University of Wisconsin/ Wisc DOT	September 6
Ray Willard	Washington DOT	September 7

*DOTPF = Department of Transportation and Public Facilities

APPENDIX D: WARRANTY EXAMPLES RELATED DURING INTERVIEW

Project	Warranty Type	Description
Vehicle scale project	Materials & workmanship; maintenance	Initial contract had M & W warranty; Maintenance contract separate but by same contractor with 2 to 3-year maintenance warranty
Baked-on paint	Performance	Bubbles formed after 15 years; difficult to determine cause; warranty not enforced. Owner paid for warranty in contractor's price.
Sports rrena roof	Performance	Warranted for 20± years; needed repair after 10± years. General passed responsibility to roofing sub; resolved satisfactorily.
Dormitory-type building	Performance	Redesign suggested by contractor: thick (16"±) concrete floor in lieu of waffle system. Bad soil. After 2 years bubbles under vinyl flooring due to continuing presence of moisture. Builders risk insurance covered the cost of replacement
Heap leaching & sanitary landfills	Materials & workmanship	HDPE liners; crucial that they work correctly; such warranties are appropriate & successful.
Dust control palliatives	Performance	For rural airport gravel runways; warranty used on trial basis; see sidebar for more detailed case study.
Military facility boiler	Performance	Owner thought of it as an operations and maintenance contract; contractor had to respond to requests or risk losing retainage.
Cell tower installation	Performance	Specs called for landscape bond; instead, contractor posted $3000 deposit in lieu of bond. Sub guaranteed the plantings. Contractor did not recover deposit at end.
Wind farm (wind turbines)	Performance	2-year performance warranty; designer part of team; design-build type called EPC – Engineer-Procure-Construct; problem with permafrost soils; some warranty re-work.
Seeding on saline soil (Kotzebue)	Materials & workmanship	Contractor used proper seed and methods; seed did not grow; owner agreed it was not contractor's fault.

APPENDIX E: BONDING ARIZONA'S $1.77 BILLION SOUTH MOUNTAIN FREEWAY DESIGN-BUILD-MAINTAIN PROJECT

The Loop 202 (South Mountain Freeway) is adding 22 miles of freeway to the existing Phoenix metropolitan transportation system. The freeway will connect the east and west valley while providing much needed relief to existing freeway corridors and local streets.

Connect 202 Partners, LLC (Fluor Enterprises, Granite Construction, Ames Construction and DBI Services) was awarded a design-build and maintain contract by the Arizona Department of Transportation (ADOT) to complete work on the largest highway project in the state's history. Connect 202 Partners will provide design, construction and 30 years of maintenance services for the Loop 202 South Mountain Freeway.

This project is the first freeway project procured under Arizona's public-private-partnership (P3) statute and ADOT's first design-build-maintain project. The $1.77 billion project is funded by a combination of Regional Area Road Fund revenues, Highway User Revenue Fund revenues and federal funds dedicated to the Maricopa County region and ADOT.

Many of the project's elements will be maintained under the separate maintenance agreement with Connect 202 Partners, which will be covered by its own payment and performance bonds.

One-year material and workmanship warranties for non-maintained items are required, with a separate warranty bond to protect the owner for this work.

Thus, the total bond package includes D&C (Design and Construction) Payment Bond, D&C Performance Bond, Warranty Bond, Maintenance Payment Bond, and Maintenance Performance Bond.

Construction began in September 2016, with its four individual segments being constructed simultaneously. Project completion is scheduled for late 2019.

Information from

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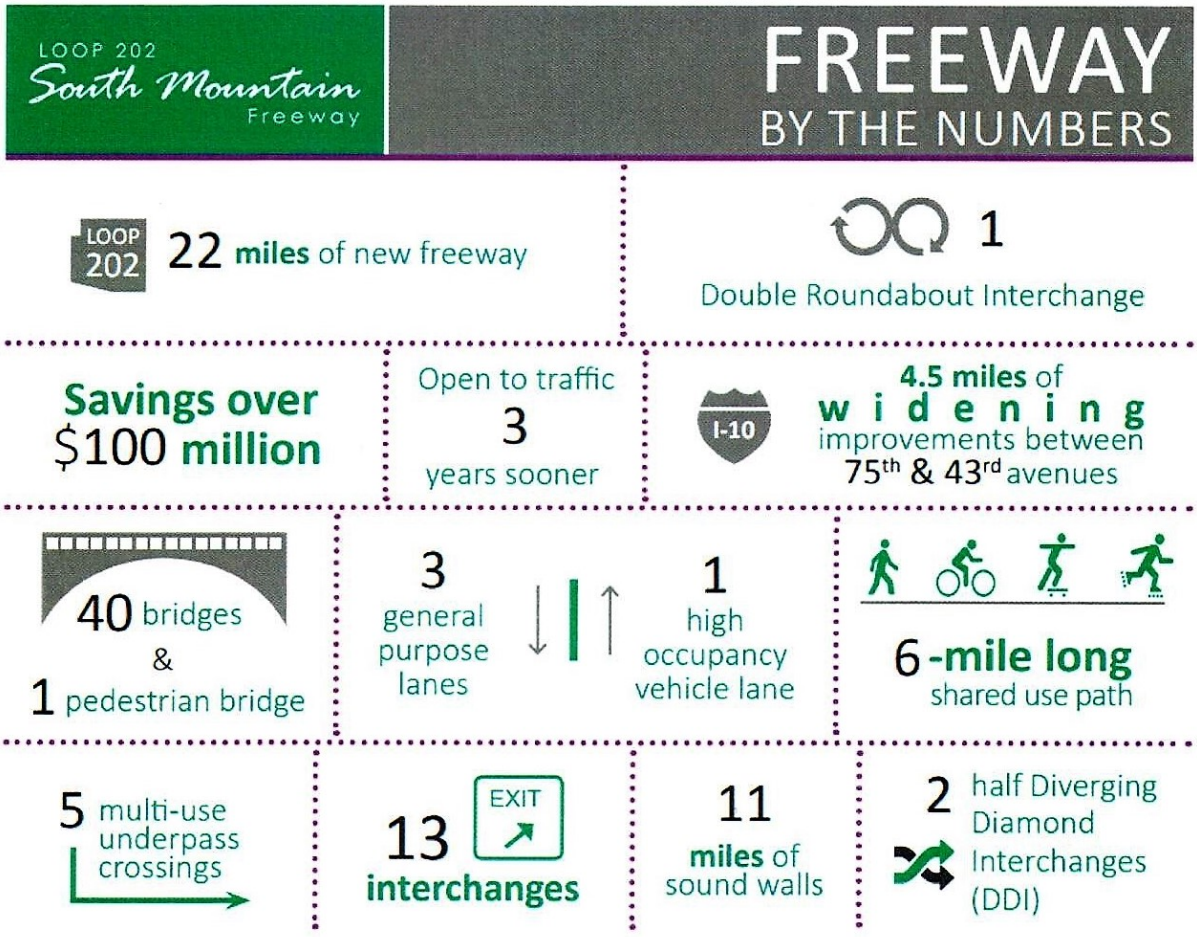
LOOP 202
South Mountain
Freeway
FREEWAY
BY THE NUMBERS
LOOP 202
22 miles of new freeway
1
Double Roundabout Interchange
Savings over
$100 million
Open to traffic
3
years sooner
I-10
4.5 miles of
widening
improvements between
75th & 43rd avenues
40 bridges
&
1 pedestrian bridge
3
general
purpose
lanes
1
high
occupancy
vehicle lane
6-mile long
shared use path
5 multi-use
underpass
crossings
13
interchanges
EXIT
11
miles of
sound walls
2 half Diverging
Diamond
Interchanges
(DDI)

APPENDIX F: AN ALASKAN PERFORMANCE-TYPE WARRANTY CONTRACT CASE STUDY

The construction and maintenance of gravel runways at Alaska's rural airports poses special challenges for the Alaska Department of Transportation and Public Facilities. With few exceptions, these airports are located in rural communities that are not connected to Alaska's road system, serving villages with populations ranging from 25 to 300 and more. Thus, rural, gravel-surfaced airports, some 200+ in number, provide vital links to the rest of world for these small and otherwise isolated places.

One of the especially significant challenges to operating rural airports is dust control. Risks to human and animal health, safety and the environment are well-documented problems associated with airborne dust. Several types of products have been used as dust palliatives on gravel roads and runways, including water, salts and brines (e.g., calcium chloride and magnesium chloride), non-petroleum palliatives such as lignosulfonates, synthetic fluids with proprietary formulas produced by several manufacturers with such product names as EK-35, Enviroclean, and Durasoil, and polymer powders, such as vinyl acrylics, polyvinyl acrylics, and blends thereof. (Barnes & Connor 2014).

The palliative is applied to the prepared gravel surface by spraying or dropping. Proper preparation of the surface includes the right aggregate material, proper cross-section profile, and adequate drainage. For effective performance, sieve-size gradation of the surface course material must include sufficient fine material. Uniform application is important. Depending on the type of palliative, it is mixed into the surface or allowed to seep into the surface without further processing.

An important consideration in these remote villages is that any specialized application and monitoring equipment not available in the community must be compact and light weight enough to be easily transported to the village by air.

In 2009, the Alaska Department of Transportation and Public Facilities (DOT&PF), in cooperation with the Alaska University Transportation Center at the University of Alaska Fairbanks, undertook a program to reduce fugitive dust at many of the state's rural airports. Dust problems had been studied for a number of years, with several projects conducted at UAF and sponsored by the Alaska DOT&PF and others. (Barnes 2013, McHattie 2015a & 2015b, Succarieh 1992). This research resulted, among other outcomes, in the invention, development and testing of a device, known as DUSTM, intended for the measurement of fugitive road and runway dust in remote rural communities. (Eckhoff 2012) This mobile monitoring device is mounted on a small all-terrain vehicle and collects air samples as it traverses the gravel surface.

As part of its airfield dust control effort, the Alaska DOT&PF published, in 2008, a set of specifications for dust palliative applications at nine, individual-lot airport dust suppression projects to be carried out in summer 2009.

Of significance to this report on construction contract warranties, the specification prescribed a performance warranty-type of requirement for the eventual supplier of the palliative material. It provided that the supplier would be responsible for the product's dust reduction performance, and it set forth a simple performance measurement standard, to be based on samples collected by the DUSTM device before and after application of the palliative. Application of the palliative

was performed by Alaska DOT&PF personnel, as was subsequent airfield surface maintenance and snow removal.

The following are quotations from the material supply specifications:

> *An effective and long-term dust palliative result (substantial diminishment of fugitive dust release) for at least two full years after ADOT&PF personnel complete the application of the palliative product. …. Within the time period of from 2 days to 30 days after final placement of the dust palliative product, measurements will be made with the University of Alaska Fairbanks' DUSTM device (see discussion on page 5, below), and an average reduction of no less than 80% in the fugitive dust amount must be measured by the instrument on the palliative treated runway, in comparison to the adjacent, untreated area of runway, or else the fugitive dust suppression result will be considered to be inadequate. One year (plus or minus 20 days) after the final placement of the dust palliative product at each airport, measurements will again be made with the UAF DUSTM device, and an average reduction of no less than 55% in the fugitive dust amount must be measured by this instrument on the palliative treated runway, in comparison to the adjacent, untreated area of runway, or else the fugitive dust suppression result will be considered to be inadequate….*
>
> *If the initial dust reduction measurement, made soon after the application procedure is completed, does not indicate at least an 80% reduction in dust release, no payment will be provided to the product supplier until this dust suppression failure is rectified. The dust palliative supplier will be expected to provide additional palliative product and deliver it to the airport at no cost to the AKDOT&PF, to re-treat the airport's aggregate surfaces if either of the two dust measurements do not meet the dust release reduction levels specified.*

The specifications also included exclusions, as follows:

> *Any weather or vehicle-related damage to aggregate surfaces treated with the supplier's dust palliative product is the responsibility of the AKDOT&PF. Repairing such damage is also the responsibility of the AKDOT&PF. Repairs may include grading, compacting at near-optimum moisture content and possible replacement of dust palliative product. The dust palliative supplier will not be held responsible for the performance of any repaired surfaces that have been treated with dust palliative product as specified herein if the supplier's guidelines for maintenance have not been followed during the DOT&PF's application program.*

Other information included in the specifications included a list of equipment likely to be used for applying the palliative at each airport (by Alaska DOT&PF personnel), non-corrosivity and other environmental requirements, a list of the nine airports and their runway dimensions, a description of the DUSTM device, and a bid schedule for each airport.

Reasons for initiating a performance warranty-type specification were the following:

1. Palliative suppliers, despite advertising claims, did not have a standardized way to measure (with repeatable results) or evaluate, scientifically, how much dust control was actually provided by their products. Thus, the relative value and longevity of their palliative applications was difficult for the purchaser to establish.

2. The palliative suppliers seldom differentiated how much of their product was necessary or desirable in order to accomplish substantial dust release reduction results. The DOT&PF performance specification made it their decision about how much product would be needed per square foot, to meet the dust reduction requirements.

3. Lastly, the performance specification openly stated the constraints and potential complications of the dust palliative process. DOT&PF was to do the installation, and then airport maintenance contractors graded and snowplowed the runway and apron surfaces, so normal usage and surface deterioration was to be expected. The palliative suppliers were thus "forewarned" about what to plan for.

DOT&PF's experience in working through the bid process for remote airport dust palliative applications was an adventure in itself. The performance specification was complex enough, and detailed enough, that it promptly discouraged almost all of the wide array of less-qualified palliative suppliers. Only a handful of bidders provided quotes, and the low bidders were all very experienced and confident in the likely performance of their products. The level of detail indicated in the specification write-up led to an impression by the palliative suppliers that the department was intending to be fair in doing the application, properly maintaining the aggregate surfaces and taking responsibility if aspects of the project caused failure of the dust control process, when it was not caused by the supplier's product lack of performance.

This performance warranty-type approach was used from 2009 to about 2011, when the DOT&PF Northern Region shifted to purchasing specified amounts (in 280 gallon totes) of EK-35 and Durasoil, delivered to the remote airport aprons. During that time period (approximately 2012 to 2014), DOT&PF experienced a string of generally positive airfield dust control results, affecting twenty more small airports during those three years.

At the same time, some limitations became apparent: it was difficult to agree on whether some failures fell within the suppliers' warranty responsibilities, and there were disagreements over the performance evaluation standards. Some of the suppliers filed appeals, but no formal claims or lawsuits resulted.

Currently (2017), the performance warranty specification is not used for this dust palliative program. Reasons cited are 1) other initiatives within the department have been given higher priority; 2) there is no longer a champion to spearhead the program, and 3) despite the positive effects of performance standards noted below, difficulties in setting and enforcing those criteria made it difficult to administer.

Lessons learned from this performance warranty-type specification program can be listed as follows:

1. The establishment of a measurable, verifiable dust-release and dust control standard dramatically affected the attention of the palliative suppliers to the provable (or not) success of their product while bringing proper focus to the various aspects of the process that could cause dust control failure, and result in extra costs for the supplier. Thus, in general, product quality improved.

2. The standard of performance tended to lead to more realistic and data-based evaluations by DOT&PF and its client villages as to whether or not dust control was worthwhile and sufficient to continue, instead of shifting to other useful airfield expenditures. Having a better grasp of

what it cost to do dust control and for how long the palliative accomplished that dust reduction, given various other factors that altered the results, made the work more accurately evaluated fiscally.

3. The clear definition of what was expected, and how it would be measured, strongly discouraged the involvement of sub-quality suppliers. It annoyed the capable suppliers too, but that was primarily because both UAF and DOT&PF were out on the edge of normal practice, developing a repeatable measurement method which was not part of the suppliers' previous experiences. The department's honesty and good-faith execution of contracts over the first few years kept the good suppliers returning to bid cost-effectively on airport dust control projects. Over 50 Alaska airports had dust palliatives applied from 2005 to 2015.

Dust at a rural Alaska airport

Dr. David Barnes and his DUST-M dust analyzer

Palliative application at Boundary, Alaska

The authors appreciate the contributions of Clark Milne, P.E., former Alaska DOT&PF Northern Region Maintenance Engineer, to this case study.

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