FINAL Close-Out Report

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Evaluation of the Benefits of Integrated Winter Road Weather Information in North Dakota

Prepared for:

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ITS Joint Program Office, HOIT-1
Washington, DC 20590

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EXECUTIVE SUMMARY

As part of the Intelligent Transportation Systems (ITS) Integration Program as authorized in the Transportation Equity Act for the 21st Century (TEA-21), the U.S. Federal Highway Administration (FHWA) funded the North Dakota Department of Transportation (NDDOT) and the University of North Dakota (UND) to implement improvements to the process by which they implement road restrictions during the winter-spring periods and to enhance the integration of road-weather information in transportation and emergency response agencies in both North and South Dakota. The Battelle Memorial Institute, teamed with Meyer, Mohaddes Associates, was contracted by the U.S. DOT's ITS Joint Program Office to conduct an independent evaluation of this earmark project in order to better determine and document the benefits of this rural ITS application.

NDDOT launched the Advanced Transportation Weather Information System (ATWIS) that became operational at the start of the winter of 1996/97 with private partner support in the development and deployment phases, and as part of a Field Operational Test (FOT). The purpose of the ATWIS program is to demonstrate how current technologies in weather forecasting, weather analysis, telecommunications and road condition monitoring can be integrated effectively to produce a safer and more efficient transportation system for both commercial and general travel in the states of North and South Dakota. NDDOT planned to extend the work of the ATWIS program under the FY2000 earmark project, which is intended to demonstrate how current technologies in mesoscale meteorological analysis and forecasting can be effectively used to produce precise spatial and temporal weather information that can be integrated into an Advanced Traveler Information System (ATIS) for safer and more efficient operations. It also seeks to better integrate the acquisition and sharing of road-weather information throughout the region.

This report presents the draft test plans for the earmark evaluation and a discussion of the baseline data collection and analysis. A decision was made, in consultation with the Project Manager and the FHWA evaluation Task Manager to terminate any further work on the post-deployment component of the evaluation and to prepare a close-out report to describe what had been learned and to provide a rationale for the close-out decision.

The Problem

North and South Dakota experience severe winters with prolonged low temperatures and dangerous driving conditions associated with blowing and drifting snow. The ground often freezes many feet below the surface, and with the spring thaw, road surface pavements are at high risk of damage from heavy vehicles. This presents the state DOTs with a challenge to make accurate decisions regarding the amount and timing of load restrictions on their road networks. In addition, the severe weather and visibility impairments create a major travel safety challenge to the state DOTs and the state emergency services. The DOTs, state patrols, and emergency service agencies need accurate road and weather information to better coordinate their operations, and travelers need information that can help them make better informed travel decisions.

The FY2000 earmark application specifically focused on two tasks that are independent in their objectives as they relate to this earmark, although eventually they are intended to be used together to provide more accurate weather and road condition information in addressing the problems noted above. These tasks include:

1. Deploy field sensors to support development and testing of a model designed to predict road surface and subsurface freezing and thawing that can cause damage to pavement integrity under heavy vehicle loads. The objectives of the model are to support more efficient and timely implementation of travel restrictions for heavy or commercial vehicles, to minimize the duration of imposed restrictions, and to minimize maintenance costs associated with repair of damaged pavement.
2. Integrate multiple transportation systems and agencies consistent with the National ITS Architecture. As weather and road conditions often change rapidly, a challenge is to coordinate information exchange between local and state agencies and to convey this information efficiently to the traveling public. Enhanced system integration of transportation information systems will result in the timely dissemination of decision support information to the traveler, Commercial Vehicle Operators (CVOs), highway patrol, freeway management, maintenance, incident management, and emergency management systems in North and South Dakota. The integration component will focus on ATWIS, Incident Reporting Systems, Emergency Management Systems, Metropolitan Planning Offices, Traffic Management Offices, Operations and Maintenance State Offices, Highway Patrol Dispatch Centers, and Traveler Information Systems.

Earmark Project Overview

The FY00 earmark project has the following key components:

- Improvements will be made to the existing road restriction decision-making process to base these politically sensitive decisions on more scientifically defensible information, including the ability to make load restriction decisions for specific road segments independently of other road segments, and the ability to forecast restrictions further in advance to assist CVOs in their planning. As part of this effort, a subsurface model will be developed to better understand the freeze-thaw dynamics of the soils under the road surface and the causal linkages between these variable conditions and changes in weather conditions. Model development will be based on six new subsurface probes collocated with Environmental Sensor Stations (ESS) that are part of the state's Road Weather Information System (RWIS). These RWIS-ESS and subsurface probe sites are illustrated in Figure ES-1.
- The integration of information acquisition and dissemination will be expanded both geographically, to cover urban and rural areas in both North and South Dakota, and institutionally, to involve more key stakeholder agencies than at present.

The implementation of each of these project components experienced significant delays and changes in scope over the course of the baseline component of the evaluation. The adoption of new, measurable improvements to the traditional road restriction decision-making process by the North Dakota District Engineers is expected to take several more years. The integration

component has been essentially overtaken by the recent introduction and deployment of a new 511 traveler information system throughout North and South Dakota.

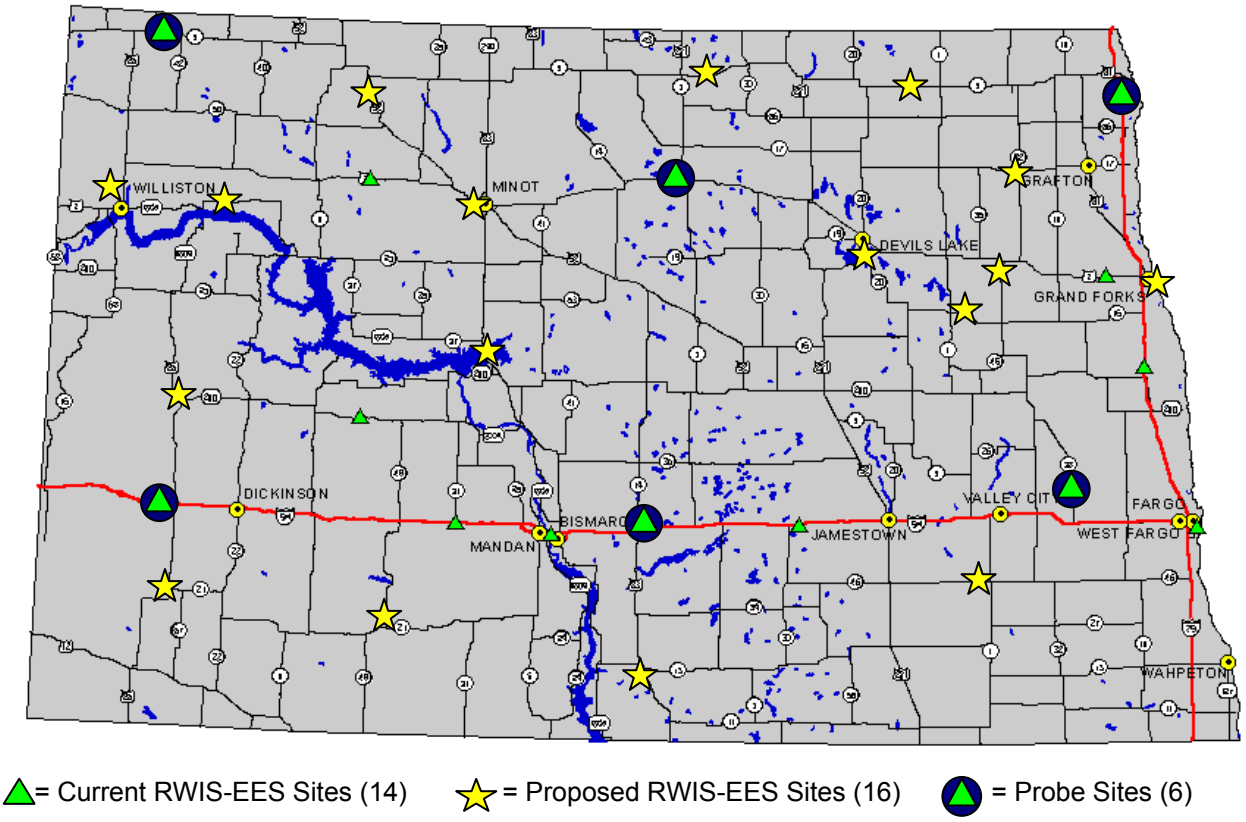

Figure ES-1. North Dakota RWIS-ESS and Sub-Surface Probe Location Map (2002)

Evaluation Approach

The objective of this evaluation has been to assess the effectiveness of North Dakota's ATWIS system to enhance the gathering and dissemination of traveler information, to support improvements in the timing and nature of road restriction decisions, given a better understanding of the relationship between weather and road conditions, and to further the integration of traveler information systems across key agencies in the states of North Dakota and South Dakota to support an efficient and safe transportation system in the project area.

Although a decision has been made to not continue with Phase III, the post-deployment component of the evaluation, and to close out this evaluation, a full discussion of the planned evaluation test plans is provided to document the work that was done up to the time a close-out decision was made. The test plans lay out the evaluation methods, hypotheses, and data collection methods and provide the details regarding data collection, analysis, and evaluation documentation for each of the focus areas. Test plans and the core hypotheses are provided in support of evaluation in the following three areas:

1. Improvements in system performance for the NDDOT District Engineers responsible for making annual road restriction decisions, based upon improved road-weather information that result from the ground probes and model development that is part of this earmark. Also improved efficiency of general system management, operations and maintenance.

   Hypothesis: Better road-weather condition information allows NDDOT to make more accurate, earlier, and better placed load restrictions during spring thaw.

2. Mobility, efficiency and productivity of CVOs, given improvements in the timeliness and quality of the road restriction process, and changes in the effects that an improved restriction process may have on CVO operations in North Dakota.

   Hypothesis: Improvements in load restriction decision-making results in better planning, increased mobility, reduced costs, and higher satisfaction for commercial operators.

3. Integration among key stakeholder agencies in both North and South Dakota, including the sharing and uses of road/weather data and information, given anticipated improvements in the content and mechanisms for exchanging data and information.

   Hypothesis: Improved road-weather data and information sharing and integration among key agencies in North and South Dakota enhance the management of the road systems, increasing operational efficiency, mobility, and safety.

Baseline Findings

Interviews were conducted with each of the North Dakota District Engineers to better understand how they currently make their annual road restriction decisions. Telephone interviews also were conducted with a representative sample of 77 commercial operators to learn how they obtain road restriction information and the impact that has on their business operations. Finally, a preliminary meeting was held with North and South Dakota representatives of the DOTs, state patrol and emergency service agencies to discuss strategies for improved integration of road-weather information in their operations. The data collected in each of these three goal areas are discussed in detail in the main close-out report. The baseline findings can be summarized as follows:

Road Restriction Decision-Making

- Road restrictions are placed as needed on road segments considered vulnerable to pavement damage from heavy vehicles during the spring thawing period. The decisions regarding when to place restrictions, which roads to restrict, and what level of load restriction to place are made by the District Engineers on a relatively ad hoc basis using a variety of different kinds of information.
- Better data are needed to ground these restriction decisions more scientifically and to help shield the decisions from political influence. The NDDOT desires to be able to notify affected commercial operators farther in advance and to confine restrictions only to those road segments that are known to be vulnerable to damage. Better data are expected

to provide better decisions, reduced economic impact, and reduced long-term road maintenance costs.

Impact on Commercial Operators

- Almost half of all the goods hauled by commercial operators in North Dakota are agricultural (46%). About 20% of all shipments reported in the survey occur during the potentially restricted travel periods. Some commercial operators can not easily adjust loads or otherwise avoid restricted roads and are therefore more severely impacted.
- Generally, the commercial operators prefer to have more advanced notification of the impending restrictions than they currently receive. On average they say they prefer one to two week's notification, but they actually get less than a week on average.
- Operators in the southwest corner of the state are usually the first to have their roads restricted, given the prevailing weather patterns. They also express a desire to have on average twice the amount of advance notification compared with operators in the rest of the state. The presumption is that the initial restrictions placed in the southwest districts serve as a "heads up" informal notice for the rest of the state that restrictions will soon be widespread. For that reason, perhaps, the usual formal NDDOT notice is more acceptable in the remaining districts, given that the commercial operators already know that restrictions will be placed soon after they are begun in the southwest districts.
- Almost two-thirds of the commercial operators interviewed (62%) said their companies experienced "some" or "severe" impacts from the imposed road restrictions. Also, those who say they are most impacted tend to most want longer advanced notification.
- Overall, 74% of the operators said they would value shorter restrictions, and 54% said they would value more selectively placed restrictions.
- Comments provided in the interviews with the operators suggest that, while they are adversely impacted by road restrictions, they understand the need for them. They feel the state is doing a good job of managing the process and keeping them informed. They also say that the decision process appears very subjective and the information provided is sometimes inconsistent. These are the kinds of issues directly addressed by this earmark.

Agency Coordination and Integration

- Results in this area are very limited, based largely on a single stakeholder meeting. Participants in the meeting said they wanted a centralized, integrated database that offered a single source for acquiring and disseminating road-weather information. This would help lend confidence to the information's validity and trustworthiness, and would enhance ease of access.
- A common, seamless set of terminology and communication protocol is needed for sharing road-weather information.
- It would be desirable to consolidate the many different sources of data and information to make it easier to achieve integration.
- Information Technology (IT) offices in both states were not represented at the stakeholder meeting, but are considered to be critical participants in the effort to achieve data reliability, security, and integration.

- Information integration faces many barriers that need to be overcome, including a lack of financial resources and staff skills. North and South Dakota have different institutional arrangements among their respective agencies and data systems that are not fully compatible. Also, responsibilities for achieving integration in both states are not clearly defined.

Close-Out Rationale

A decision to terminate this earmark evaluation at the end of Phase II was based on a careful assessment of the status of the project deployment, and an assessment of the risks of continuing with the evaluation versus the likely benefits to be derived from completing Phase III. Phase III of the evaluation would have implemented the test plans presented in this close-out report to assess the value of a more accurately modeled relationship between weather conditions, sub-surface freeze-thaw conditions, and road surface vulnerability to heavy vehicle traffic. This value or benefit of better road-weather information was expected to result in both improved decision making by the NDDOT District Engineers regarding the placement and lifting of road restrictions, and reduced impacts for the commercial operators on the state's roadways that are subject to these restrictions. In addition, the evaluation would have assessed the integration benefits to key stakeholder agencies in both North and South Dakota of improvements in the availability and coordination of road-weather data and information.

Some of the issues that have motivated the decision not to complete the post-deployment phase of the evaluation include the following:

- The earmark project per sé is now completed, making it awkward to continue to evaluate a project that has been delayed, modified, and for which funding has expired. Work on the activities initiated under the earmark, however, is continuing with leadership from the University of North Dakota and the active support of NDDOT on a longer-term timeframe.
- The processes of validating the predictive models based on the probe data are likely to take much longer than initially planned. Also, there is considerable uncertainty regarding how long it may take for the District Engineers to accept the new data as trustworthy enough to incorporate into changes in their traditional road restriction decision-making process. The evolution of this decision-making process bears directly on this evaluation's ability to detect measurable post-deployment changes that could benefit road maintenance operations or traveler behavior.
- The ability to detect benefits in the road-restriction component of this evaluation appears to depend on three elements: First, is the new, modeled information about the links between weather and road conditions going to be sufficiently different from the historical information, such that one would reasonably expect to see measurable differences? Second, even if there are significant differences, are the District Engineers likely to change their decision making based on a first year of new, unproven data? That is, will they be confident enough in the models to make these decisions differently in the initial year of new data? And third, even if the answer to these first two questions is "yes," is there a sound basis for anticipating changes that will be any less burdensome for travelers? These are important unanswered questions and uncertain benefit outcomes.

- The institutional integration of road-weather information into the transportation and emergency response activities of both North and South Dakota has headed in a substantially different direction than was anticipated earlier in this earmark project. The consolidation of the #SAFE program into the new 511 traveler information program has essentially co-opted the earlier intent to develop an integration work plan directly with these agencies under the earmark program.
- Even prior to the 511 program launch in North and South Dakota, the two states found themselves heading in somewhat different directions with regard to how they wanted to manage road-weather information. In both states, the DOTs, emergency management agencies, and state patrols had their own ideas about what was the best way to accomplish information integration. Differing information and system architectures in the two states, and different timetables for completing these architectures, coupled with different budgeting priorities, added to the difficulties of trying to get everyone on the same page.
- Other problems that occurred in the course of this earmark included the September 11th event and numerous wild fires. Two of the principal NDDOT staff who managed the earmark project were given new assignments and responsibilities by the Governor of North Dakota, primarily to help deal with the fires and also to help respond to the enhanced security situation. The involvement of key agency staff in both states in response to these events made it difficult to arrange for meetings to discuss the road-weather data integration and other aspects of the earmark evaluation.

Even though this evaluation is being terminated, it is apparent that the earmark project will provide significant benefits to both North and South Dakota operations, as well as to travelers in the region. The University of North Dakota is continuing to work closely with NDDOT, the subsurface probes are now operational, more RWIS-ESS facilities are planned, and the improved road-weather data provided by this ITS equipment will shortly be available to the District Engineers. The consolidation of North Dakota's pioneering #SAFE program into the recently implemented 511 systems in both North and South Dakota is already yielding significant benefits for the state DOTs and for travelers.

Hopefully the information obtained up to this point in the earmark evaluation will be helpful to the project partners, and perhaps in the future, once NDDOT has adjusted to the new subsurface data and the state agencies are more fully utilizing the improved road-weather information and sharing that with the public, evaluation of the benefits from these improvements could pick up where this evaluation has had to leave off.

1.0 INTRODUCTION

1.1 Background

The North Dakota Department of Transportation (NDDOT) launched the Advanced Transportation Weather Information System (ATWIS) at the start of the winter of 1996/97 as a public-private partnership and part of a Field Operational Test (FOT). The purpose of the ATWIS program is to demonstrate how current technologies in weather forecasting, weather analysis, telecommunications and road condition monitoring can be integrated effectively to produce a safer and more efficient transportation system for both commercial and general travel in the states of North and South Dakota. NDDOT is extending the work of the ATWIS program under the FY2000 earmark project, which is intended to demonstrate how current technologies in mesoscale meteorological analysis and forecasting can be effectively used to produce precise spatial and temporal weather information that can be integrated into an Advanced Traveler Information System (ATIS) for safer and more efficient operations. It also seeks to better integrate the acquisition and sharing of road-weather information throughout the region.

The FY2000 earmark application specifically focused on two tasks that are independent in their objectives as they relate to this earmark, although eventually they would be used together to provide more accurate weather and road condition information:

1. Deploy field sensors to support development and testing of a model designed to predict road surface and subsurface freezing and thawing that can cause damage to pavement integrity under heavy vehicle loads. The objectives of the model are to support more efficient and timely implementation of travel restrictions for heavy or commercial vehicles, to minimize the duration of imposed restrictions, and to minimize maintenance costs associated with repair of damaged pavement.
2. Integrate multiple transportation systems and agencies consistent with the National ITS Architecture. As weather and road conditions often change rapidly, a challenge is to coordinate information exchange between local and state agencies and to convey this information efficiently to the traveling public. Enhanced system integration of transportation information systems will result in the timely dissemination of decision support information to the traveler, Commercial Vehicle Operators (CVOs), highway patrol, freeway management, maintenance, incident management, and emergency management systems in North and South Dakota. The integration component will focus on ATWIS, Incident Reporting Systems, Emergency Management Systems, Metropolitan Planning Offices, Traffic Management Offices, Operations and Maintenance State Offices, Highway Patrol Dispatch Centers, and Traveler Information Systems.

The Battelle Memorial Institute, teamed with Meyer, Mohaddes Associates, was contracted by the U.S. DOT's Intelligent Transportation Systems (ITS) Joint Program Office to conduct an independent evaluation of this earmark project in order to better determine and document the benefits of such rural ITS deployments. The Project Partners who are implementing this earmark project include NDDOT, the South Dakota Department of transportation (SDDOT), and the Regional Weather Information Center of the University of North Dakota.

This independent evaluation was intended to be conducted in three phases. Phase I is completed and included a site visit and an initial project assessment that determined that this project had the potential to yield useful evaluation results. Phase II was only partially completed due to delays in the project development, along with changes in the scope of the project. The Phase II evaluation included the development of an Evaluation Plan[1] and detailed Test Plans, including updates to the Evaluation Plan included in the Test Plans. Additionally, "before" data were collected and analyzed to document the baseline conditions prior to the deployment of the ITS equipment. Phase III, if it had been approved, would have included conducting the post-implementation data collection and evaluation. However, due to the likelihood of further delays in the deployment of the ITS weather measuring equipment, along with significant changes in the plans for the institutional integration component in North and South Dakota, a decision was made to terminate the evaluation and prepare a close-out report of what has been learned to date. This report incorporates the information obtained during Phase II of the evaluation and provides the rationale for termination of the evaluation.

1.2 Project Overview

The FY00 earmark project has the following key components:

- Improvements will be made to the existing road restriction decision-making process to base these politically sensitive decisions on more scientifically defensible information, including the ability to make load restriction decisions for specific road segments independently of other road segments, and the ability to forecast restrictions further in advance to assist CVOs in their planning. As part of this effort, a subsurface model will be developed to better understand the freeze-thaw dynamics of the soils under the road surface and the causal linkages between these variable conditions and changes in weather conditions. Model development will be based on six new subsurface probes collocated with Environmental Sensor Stations (ESS) that are part of the state's Road Weather Information System (RWIS).
- The integration of information acquisition and dissemination will be expanded both geographically, to cover urban and rural areas in both North and South Dakota, and institutionally, to involve more key stakeholder agencies than at present.

Each of these earmark components is described separately below.

1.2.1 Improvements in Road Restriction Decision Making

The Project Partners have begun background work on the subsurface modeling. Preliminary research will be adopted and modified from previous work done by the U.S. Army Corps of Engineers. The model will support improved road restriction decision-making. Road restriction is different from road closure. The former refers to a decision to restrict access to selected roads for commercial vehicles exceeding specified weight limits. This is done to protect pavements from damage caused by heavy vehicles during periods when thawing creates subsurface conditions, such as frost heaving, that make pavement particularly vulnerable.

[1] Battelle Memorial Institute. 2001. *Grand Forks, ND FY00 Earmark Evaluation.* Draft Evaluation Plan prepared for U.S. Department of Transportation, ITS Joint Program Office. September 14.

1.2.1.1 History of the Road Restriction Decision-Making Process

In the past, NDDOT maintenance engineers made visual observations of pavement for evidence of water weeping out of cracks. They forced screwdrivers into the cracks to test the subsurface condition, to assess the risk to the pavement, and determine whether travel on that road should be restricted. The problem with this decision-making processes was that evidence of subsurface problems, such as water accumulation or freeze-thaw conditions, often was not detected in time or sufficiently accurately to protect pavement integrity from heavy vehicle traffic.

The current decision-making process is based on relatively shallow temperature probes coupled with an RWIS-ESS. The freezing and thawing of the subsurface is correlated with regional air temperatures, and this relationship is modeled and used for decision-making, based on average winter weather and road conditions (the "Freeze Tracks" program). The problem is that they usually don't have "average" winters, so the models have not proven to be very effective. Therefore, the partners want to move on to the proposed third generation model approach, using much more accurate data, covering more key indicators, and understood with more complex modeling tools.

Road restriction decisions are typically made twice a year: once in the first half of March to place restrictions, and then in late May to early June to lift the restrictions. The spring thaw conditions present higher risks for road surface damage than is the case when winter approaches in the fall. However, extensive agricultural crop transport occurring in the fall makes it politically infeasible to restrict CVO travel at that time. Although there are times in the spring period when the weather can change from cold to warm and back to cold again, there is rarely the need to lift restrictions soon after they are in place or to replace them once they are finally lifted.

NDDOT invokes the following five restriction levels (from not affected to maximum restriction) and disseminates this information to CVOs on a map using the Internet and fax media. A sample road restriction map, shown later in this report in Figure 3, illustrates each of these categories.

- Not Affected.
- Highways Restricted by Legal Weight
- Class A Restrictions (single axle=18,000 lbs, tandem axle=16,000 lbs/axle, 3 axles or more=14,000lbs/axle, Gross weight not to exceed 105,500 lbs)
- No. 1 Load Restriction (single axle=15,000 lbs, tandem axle=15,000 lbs/axle, 3 axles or more=12,000 lbs/axle, Gross weight not to exceed 80,000 lbs)
- No. 2 Load Restriction (single axle=12,000 lbs, tandem axle=12,000 lbs/axle, 3 axles or more=10,000 lbs/axle, Gross weight not to exceed 65,000 lbs)

It is important to note that, when a restriction is placed, each segment of road is assigned a restriction level based on the best information the NDDOT staff have at the time, and then the restriction is not changed until it is removed later in the spring. Although it can happen, very few exceptions are made to this policy.

1.2.1.2 Plans to Improve Road Restriction Decision-Making

The subsurface model was originally designed to incorporate as inputs a variety of indicators, including subsurface temperature (at 1 to 6 meters), soil characteristics, soil moisture content (at 1 to 6 meters), soil temperature (at 1 to 6 meters), the water table, pavement temperature provided by the RWIS-ESS, and regional weather forecasts, including precipitation, air temperature, wind speed, and solar radiation. The model is intended to help identify movement of the "frost front" up and down under the roadway and correlate that with measures of external weather conditions. The behavior of the frost front and the potential formation of ice lenses in the soil under the road surface are the two main factors that determine the probability of frost heaving. When these conditions create sufficient risk of road surface damage, the NDDOT will restrict heavy vehicle travel.

The period of greatest risk is when the weather begins to warm up and the soil under the pavement begins to melt. The general warming pattern is such that NDDOT first restricts heavy vehicle traffic in the southwest part of the state, and then progressively initiates road restrictions across the state moving toward the northeast. The actual decision-making process is as much art as science at this time, and varies from year to year under different weather patterns. The Project Partners want to support the decision-making process with quantitative damage risk data.

The subsurface probe design has undergone changes in the past several years. UND initially installed a pilot probe on campus in November 2002 to test the software and sensors, leading to changes in construction, testing procedures and calibration protocols. The next step was to install the first probe in early April 2003 in Emerado, west of Grand Forks, which also resulted in further modifications. The current model design primarily measures subsurface temperature and the frost profile, and no longer directly measures moisture content.

The models that take the subsurface, pavement, and atmospheric data as input also have been refined. The current model follows the Federal Highway Administration's 2002 design guidelines and is built off of their Enhanced Integrated Climatic Model (EICM). UND is now working to provide model output to NDDOT engineers over the Internet and have that ready for use by the District Engineers for the spring of 2004. The eventual plan is to fold the parameters of the road restriction model into the Maintenance Decision Support System (MDSS), which is being developed as part of a 5-state pooled fund study.

Road restrictions raise important institutional-political issues, because restrictions constrain the shipment of valuable agricultural commodities and other goods within and through the state. There is understandable concern on the part of the state's grain haulers and other commercial trucking companies that restrictions will interfere with their operations and cost them money. This results in significant political pressure being brought to bear on the road restriction decision-making process; hence, the NDDOT desires to base this process on damage risk information.

Each of NDDOT's eight maintenance districts has the decision authority to place and lift restrictions in their districts. However, from a practical standpoint, they confer closely on these decisions in order to coordinate the process, and the NDDOT central office has final authority.

The subsurface restriction model has a number of important objectives for NDDOT, as follows:

1. Limiting damage to road surfaces. This is the top priority.
2. Better, more scientifically based and justifiable decisions.
3. More accurate forecasts of when restrictions will need to be put in place.
4. Ability to forecast the onset of closures further in advance, thereby providing more timely and useful information on restrictions to CVOs and the public.
5. The ability to adjust road restrictions and load limits according to the conditions in smaller geographic units or particular road segments, rather than having to make one decision that covers a broad area or an entire district; ability to place restrictions selectively.
6. An overall shorter period of time during which road restrictions were in place, without jeopardizing the integrity of the pavement.
7. Reduce where possible the number and extent of restricted road segments to minimize the adverse impacts on the commercial operators.

There are six "climate regions" in the state, and NDDOT therefore wants to have at least six subsurface probes associated with the RWIS-ESS currently located in these regions. This would give them the range of weather and subsurface conditions that is optimal for validating the Road Restriction Model. The longer-term desire is to tie this new information into their regional weather forecasting model and to explore the subsurface condition response curve as driven by changes in atmospheric conditions.

Figure 1 illustrates the distribution of existing and proposed RWIS-ESS sites throughout the state of North Dakota, current as of 2002. In addition, the location of the subsurface probe sites is indicated on this map. There are still currently 14 RWIS-EES sites operational in North Dakota, and the 6 subsurface probes were installed in 2003 and are now operational and co-located with these RWIS-EES. NDDOT's RWIS vendor, Surface Systems, Inc. (SSI) has installed an additional subsurface probe of their own design outside of Grand Forks, and UND plans to do a comparative analysis of the data from the SSI probe with their own probes. There is now consideration of installing 21 additional probe sites in North Dakota to further enhance the geographic coverage. These monitoring sites are likely to be located independently of the RWIS sites.

1.2.2 Information Integration

The current ATWIS system has been very effective at providing weather information and forecasts to travelers. One of the next steps in the process of expanding the use of this information is to provide the information to other stakeholders. These other stakeholders include: highway patrol, freeway management and maintenance in North and South Dakota, incident management, emergency management systems, and local Metropolitan Planning Organizations. The key to successful integration is the support and cooperation of each of the stakeholders and an effective automated approach to make the transfer of information as seamless as possible. One of the key elements of the 2000 Earmark project has been to achieve this goal.

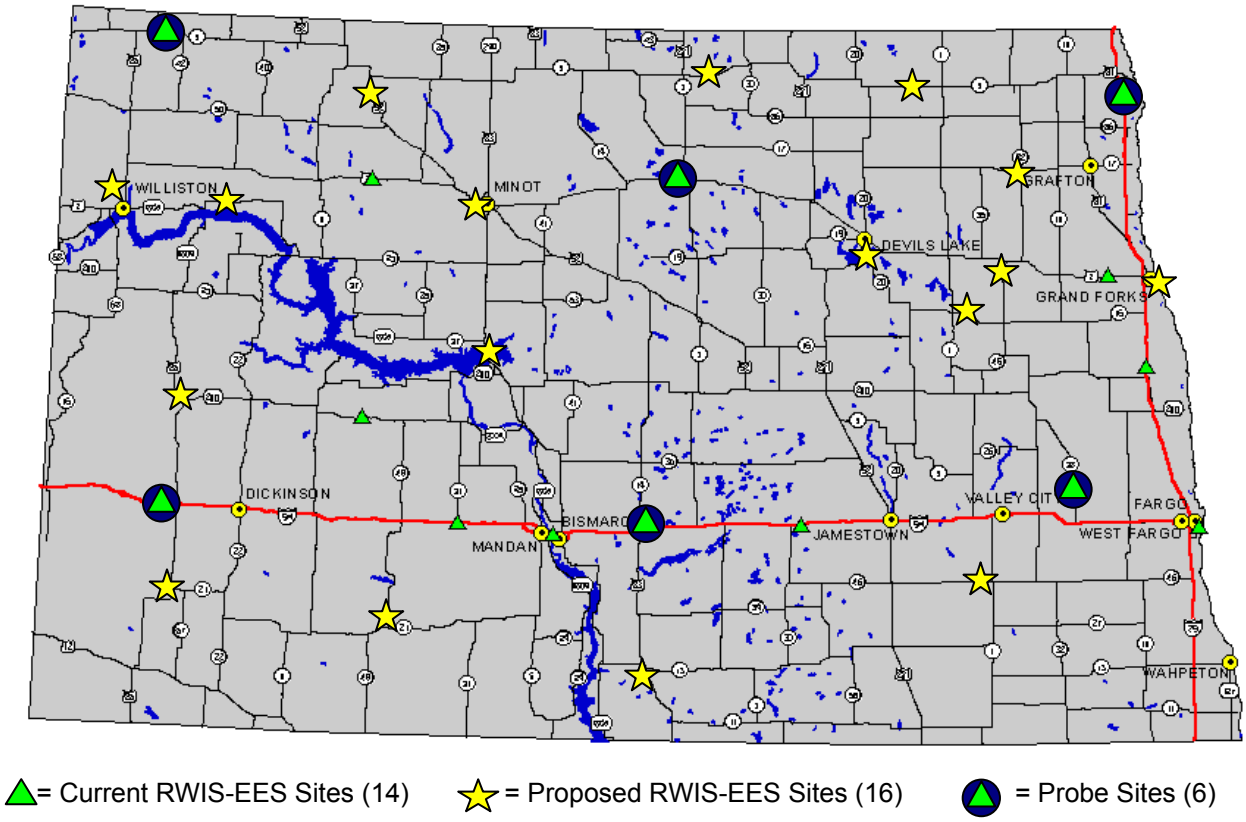

Figure 1. North Dakota RWIS-ESS and Sub-Surface Probe Location Map (2002)

The first step in this process was to bring together these stakeholders for two meetings. The first meeting, held May 9, 2002, focused on achieving consensus regarding the goals and objectives of the project, discussed the kinds of data that were available to be shared among the stakeholders, sought to provide a basis for developing a detailed integration plan, and offered support in helping the stakeholders move forward. The second meeting was intended to define an architecture and concept design of such an automated system to integrate the necessary information in a way that will help each organization conduct their mission. Early discussions indicated a strong interest by these stakeholders to make this a success. The second follow-up meeting was planned for the fall of 2002 but unfortunately, this second meeting never took place. Since that time, events such as the introduction of the 511 program in South Dakota in November 2002 and in North Dakota in February 2003 have overshadowed and essentially replaced the intended integration aspect of this earmark project.

Following these initial activities, the project team intended to begin development of the system integration software (and perhaps necessary hardware) to achieve the project goals. They anticipated that an initial version would be tested before a final version was developed and installed.

Initial discussions with the stakeholders in the first meeting revealed some key issues that would need to be addressed during subsequent stakeholder meetings and as part of the system

integration program development. These included: 1) how to cross firewall barriers, 2) common phrasing to be used by all agencies, and 3) methodology of delivery of information (will it be provided in a format for easy decision making?). The firewall issue between multiple agencies appeared to be the primary issue to be addressed.

The results of the first stakeholder integration meeting that was held May 9, 2002 in Bismarck, ND are described in Section 3.4 of this report.

1.3 Project Implementation Schedule

Each of the major components of this project experienced significant delays. Two sets of events appear to be responsible for these delays. First, the events of 9/11 and the shift of emphasis onto homeland security placed new responsibilities on NDDOT, safety, and emergency personnel that significantly sidetracked attention to the day-to-day needs of this earmark. Second, North Dakota experienced over 200 wild fires in early May 2002, and the Governor assigned the two key NDDOT people on this earmark project to coordinate emergency response teams. The stakeholders in both North and South Dakota who were part of the project's integration team were sidetracked by these events as well. Finally, the Project Manager for the partners changed jobs and was replaced by the Principle Investigator from the University of North Dakota during the Summer 2002. Although the intent of the project team was to have both the road restriction model and system integration components functional in time for the 2002-2003 winter and spring, this did not occur.

Overall, the probe procurement, deployment, model development, and model validation have been delayed about two years since the inception of the earmark evaluation. An Internet-based approach to integrating the new atmospheric, pavement surface, and subsurface probe data into the road restriction decision processes employed by the North Dakota District Engineers remains on-going. The current decision process is essentially ad hoc, and it changes from year to year. The objective of this earmark has been to refine this decision process and ground it in much better, more accurate data. The steps to accomplish this include how best to communicate the new data to the DEs, and how to build confidence over time in a new basis for making the restriction decisions. This is a long-term evolutionary process, expected to take up to five years.

The system integration component of the earmark has proven even more difficult to keep on schedule. This has been due to institutional impediments identified in the first stakeholder meeting held in May 2002, and to the subsequent introduction and deployment of the 511 program in North and South Dakota in late 2002 and early 2003. The #SAFE system, created under the ATWIS program, actually provided a national model after which the 511 systems of several of the early adopter states were designed. The 511 road-weather information system essentially operates outside of the usual state Information Technology (IT) networks and thereby avoids some of the institutional constraints that were hindering the development of the integration component of this earmark project.

1.4 Close-out Report Contents

This Close-out report documents progress to date on the evaluation of the North Dakota ATWIS 2000 earmark project. The report includes discussion of the test plans that were prepared to guide Phase III of the evaluation, the collection and analysis of baseline data, and a rationale for

the eventual decision to terminate of the evaluation. This report defines the measures, hypotheses, and methods that had been proposed for the main areas of evaluation that included:

- Improvements in system performance
- Mobility, efficiency and productivity of CVOs
- Efficiency, productivity and overall integration among key stakeholders in North and South Dakota

Each Test Plan contains the approach, data collection instruments, and analysis techniques that were applied in this evaluation or had been planned. The format follows Federal Highway Administration (FHWA) guidelines to assist in the detailed data collection and analysis.

2.0 EVALUATION APPROACH

2.1 Introduction

The objective of this evaluation has been to assess the effectiveness of North Dakota's ATWIS system to enhance the gathering and dissemination of traveler information, to support improvements in the timing and nature of road restriction decisions, given a better understanding of the relationship between weather and road conditions, and to further the integration of traveler information systems across key agencies in the states of North Dakota and South Dakota to support an efficient and safe transportation system in the project area.

Although a decision has been made to not continue with Phase III, the post-deployment component of the evaluation, and to close out this evaluation, a full discussion of the planned evaluation test plans is provided to document the work that was done up to the time a close-out decision was made.

This chapter presents detailed test plans for each of the three main evaluation goal areas. The test plans expand on the evaluation methods, hypotheses, and data collection methods described in the Evaluation Plan submitted in September 2001. The purpose of these test plans is to provide the details regarding data collection, analysis, and evaluation documentation for each of the focus areas. Test plans are provided in support of evaluation in the following three areas:

1. Improvements in system performance for the NDDOT District Engineers responsible for making annual road restriction decisions, based upon improved road-weather information that result from the ground probes and model development that is part of this earmark. Also improved efficiency of general system management, operations and maintenance.
2. Mobility, efficiency and productivity of CVOs, given improvements in the timeliness and quality of the road restriction process, and changes in the effects that an improved restriction process may have on CVO operations in North Dakota.
3. Integration among key stakeholder agencies in both North and South Dakota, including the sharing and uses of road/weather data and information, given anticipated improvements in the content and mechanisms for exchanging data and information.

2.2 Evaluation Schedule

The evaluation schedule, current as of the summer of 2002, is illustrated in Figure 2. The Phase II activities to define the evaluation procedures and establish baseline conditions were completed in October 2002. Based on the analysis of the Phase II baseline data, the potential risks and benefits of continuing with a Phase III post-deployment evaluation of earmark project benefits were assessed. Subsequent delays in the project deployments led to a decision made by the FHWA over a year later not to proceed with Phase III, but instead to prepare a close-out report.

Phase III post-deployment evaluation activities were originally proposed to be accomplished from the fall of 2003 through the end of 2004. The development of the subsurface model, based on the six installed probes, was to have taken place from the fall and into the spring of 2003.

This would have allowed for post-implementation evaluation (data collection and analysis) during the winter of 2003 and spring of 2004, with the final evaluation results projected to be available by the end of 2004. However, because the project milestones were not met, the evaluation schedule could not be met.

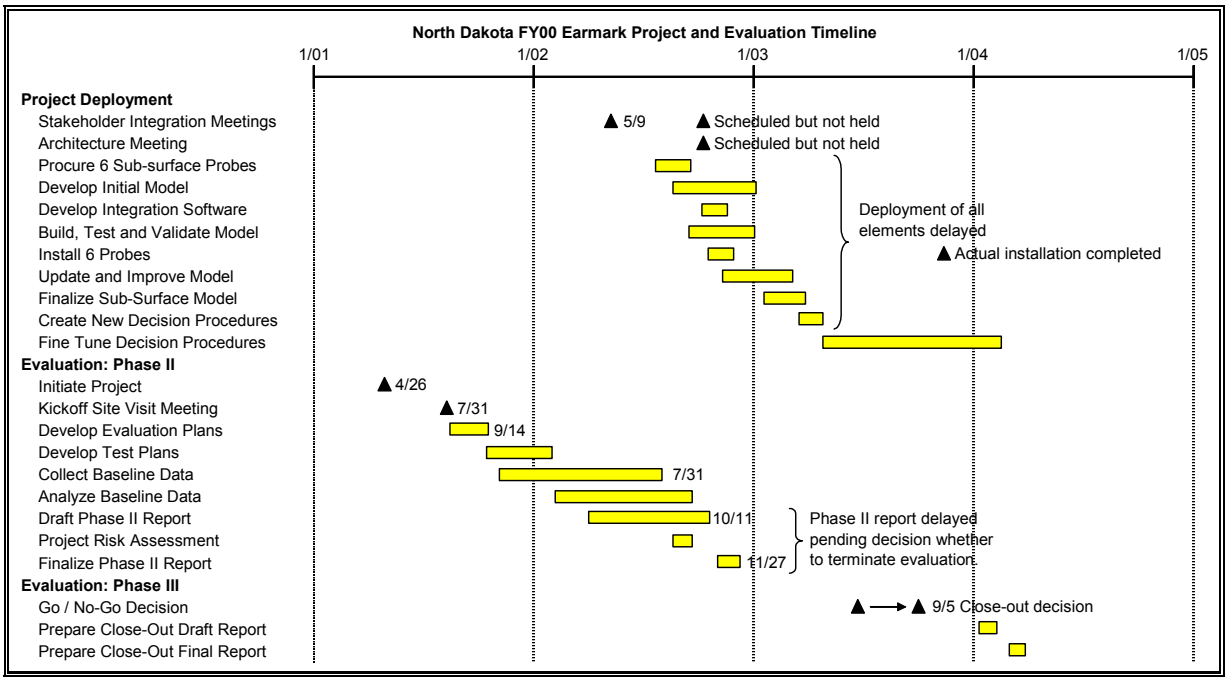

Figure 2. North Dakota Project and Evaluation Schedule, as of Summer 2002

2.3 General Methods of Evaluation

The general strategy for evaluating each of the project components is to identify the goal area in which project-related effects can be anticipated, and then to specify measures of project-induced changes or impacts, along with available data sources and methods for collecting the data. Hypotheses have been framed that express desired outcomes or beneficial effects from elements of the project in a straightforward way that is suggestive of data analysis strategies that can be used to test whether or not the project in fact is having the desired effects or outcomes. For each goal area covered, measures, hypotheses, data collection methods, and analytic methods are discussed in this report.

The overall evaluation design for each of the goal areas included two data collection periods, one before any of the ITS project improvements have been implemented, and another after implementation and a period of operations. Data collected in the "before" period describe current conditions at the project site and provide a benchmark against which to judge any changes that may be attributable to the project. A challenge in this kind of field evaluation is to be able to disentangle the presumed effects of the project from change effects that are due to other, often unmeasured, factors that are operating in the project environment. A related challenge is to account for changes in baseline conditions that may occur between the time data were collected until the time when the post-implementation data are collected. The most appropriate baseline describes how conditions will be at the time the "after" data are collected, if

there had been no project-related effects occurring. Generally, the assumption is made that the "before" data adequately describe those conditions. Other factors that could also account for changes in the measures of interest should be acknowledged, even though they are likely to remain unmeasured. Finally, the difference between the "before" and "after" condition is the change or impact.

Depending on the measures identified as appropriate for each goal area, data collection methods are selected that may include the collection of objectively measured data such as accident statistics, or subjectively measured data such as the perceptions and opinions of drivers. A variety of such methods were identified for use in this evaluation and are described as they apply in each of the goal areas.

Test plans for each of the goal areas describe the following topics:

- Background and test objectives
- Approach, including a discussion of anticipated impacts, measures, and hypotheses;
- Pre-test activities, including a discussion of data requirements, development of data collection strategies and instruments, interview protocols, and data recording formats;
- Test activities, such as baseline and post-deployment data collection;
- Post-test activities, focusing on data analysis, interpretation, and presentation of results.

The Phase II report included a suggested Phase III report format and expected contents, and also would have included estimated resources required to complete all test activities across all the goal areas. The outline of what the Phase III report would have presented is included in this report to illustrate the intended coverage, but the estimated resource requirements are not provided in this close-out report, given the decision not to proceed with a Phase III.

2.4 Test Plan: Improvements in System Performance

2.4.1 Background and Test Objectives

The State of North Dakota currently has 14 RWIS-ESS sites, and 16 more sites are proposed (as of mid-2002). While there remain a few gaps across the state, these will be largely filled when the new RWIS-ESS facilities are installed. The installation of the six subsurface probes will lead to a new level of understanding about how to best interpret and use the data flowing from these RWIS-ESS, which measure road surface and atmospheric conditions. With refinements from the new models, the NDDOT will be armed with a quality and understanding of data about road-weather conditions that should significantly enhance the efficiency of their operations activities, and most specifically their ability to make better, more scientifically based road restriction decisions.

Coupled with the data and information integration component of this earmark project, better data will be made available in both North and South Dakota to NDDOT operational personnel, emergency response personnel, and NDDOT road maintenance personnel that are expected to greatly improve the overall management and operational efficiency of the system. More

specifically, for the purposes of this evaluation, a better understanding of how changes in external weather are linked to the dynamics of sub-surface soil conditions under the state's roadways, particularly during freezing and thawing cycles, will give North Dakota DOT's District Engineers an improved ability to make wise road restriction decisions. This is expected to mean more precise timing of these decisions, an ability to forecast further ahead, more micro-level road segment restrictions rather than broad global restrictions, and potentially less restrictive load constraints on the CVO community than has historically been needed to assure adequate protection of the state's road surfaces from heavy vehicle damage.

2.4.2 Approach

The anticipated impacts and measures that are guiding this assessment are summarized in Table 1.

Table 1. Anticipated Impacts and Measures for System Performance

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Improve the quality of road restriction decisions	- Perceived accuracy of road restriction decision-making - Ability to forecast restrictions further ahead - Ability to more precisely target restrictions to road segments - Reduced magnitude and duration of restrictions	- Roads are restricted more efficiently and accurately using the new models and information on subsurface conditions - District Engineers (DEs) have more confidence in their decisions as scientifically grounded - NDDOT receives fewer complaints regarding restrictions - Extent and duration of restrictions are reduced - NDDOT can forecast the placement of restrictions farther ahead, offering affected CVOs more time to plan and respond.

2.4.2.1 Pre-Test Activities: Baseline

The pre-test baseline activities included gaining a broad understanding of how NDDOT is currently making decisions regarding road restrictions, then designing and implementing a telephone interview protocol, assembling the appropriate list of District contacts and receiving permission to follow-up and make the telephone interview calls. The findings from these interviews are presented in Chapter 3 on baseline results.

Information regarding NDDOT's road restriction decision-making processes is being obtained through discussions primarily with the District Engineers (DEs). The State of North Dakota is divided into 8 Districts, and telephone interviews have been conducted with maintenance personnel in each of these districts. In addition, the Assistant Maintenance Engineer for the Central Office of NDDOT is also being interviewed. He provided the evaluation team with a contact list for the 8 DE offices, with addresses and phone numbers. He also provided a general overview of the state-wide road restriction process as it currently exists. Based on this understanding of the general process, a list of questions was developed to gather additional details and to understand the differences that may exist across each of the Districts in how they make these critical restriction decisions. These questions were refined into a telephone interview

guide, and then representatives from each of the Districts were interviewed. One knowledgeable individual from each District was contacted, and included the District Engineer, or if that person was not available at the time of the call, then the Maintenance Coordinator or Maintenance Foreman was interviewed. The information gathered included the following topics:

- What kinds of information do you use to make road restriction decisions?
- How do you go about setting the level of the restrictions?
- Are changes made to the level of restrictions after they are initially set?
- Is there coordination with the other Districts and, if so, please describe.
- How many and what kinds of complaints do you receive regarding road restrictions?
- Do you have adequate information now to make good restriction decisions?
- Would you like additional information? Please describe.
- Do you have any recommendations for improving the restriction decision-making process?

The full interview guide is contained in Appendix A.

2.4.2.2 Pre-Test Activities: Post-Deployment

Based on the pre-test interviews, the interview protocol will be revisited and refined as needed to more fully capture the impacts of the ITS deployments on the road restriction decision-making process. Most of the questions are expected to remain in order to provide for a direct comparison of responses over time as one way to measure changes that may be caused by improvements in the underlying information that drives these important decisions. In addition to using the baseline interviews as a basis for assessing changes in procedures and outcomes, the intended test methodology includes asking the District Engineers to consider retrospectively how they would have made their restriction placements in the absence of the new model-based information. That is, they will describe in the post-deployment interviews how they made their current restriction decisions. Then they will be asked how they *would have* made those same decisions if they had access to only the kinds of information available in prior years. Because weather conditions change considerably and unpredictably from year to year, this methodology will help control for those environmental conditions to better isolate the direct effects of the improvements in information, if any. With this approach in mind, guidelines and questions will be prepared so that each of the Districts is presented with a common approach to both how they decide now versus how they would have decided in prior years *given exactly the weather conditions at the time of the post-deployment interview.* Therefore, the post-deployment interviews will likely include the following kinds of questions, keyed to the effects of now having improved information available for decision making:

- Please take me through your current decision-making process step by step, describing what information you use, with whom you consult, what factors you weigh, how long the process takes, and anything else you think is relevant to an understanding of how you make the restriction decisions.

- Now take me through the same process with today's conditions, the only difference being that you are to assume you would only have the kinds of information that were available to you last year. This is a hypothetical exercise to see whether the new modeled road-weather information changes your decision making in any way.
- Are you now able to more precisely apply restrictions to fewer or smaller road segments? If so, describe how you are able to do that.
- Are you now able to provide information about upcoming restrictions farther in advance to those most affected, such as the CVO community? If so, how much more notice can you provide now than you could previously? Is that just for the initial restriction (Order #1) or does it apply to all restriction orders?
- On average, can restrictions be placed later and/or lifted earlier than was previously possible?
- On balance, are the current restrictions either less severe (in terms of the load level of the restriction) or shorter in duration than before?
- Do you believe that the new road-weather information will lead to decisions that are of more benefit or less impact to commercial vehicle operators than before?
- Do you believe the information assisted you to more precisely select and restrict specific road segments?

These are just some of the kinds of questions that should allow us to get a good measure of the impact of the new sub-surface modeling and resulting anticipated improvements in the decision-making processes. This will all be discussed in more detail with NDDOT officials to arrive at the best ways to collect data from each of the Districts to evaluate the benefits of the improvements in road/weather information.

2.4.2.3 Test Activities: Data Collection

The data will be collected from phone interviews with the appropriate NDDOT district representatives and stored in a database and analyzed in order to explore the hypotheses laid out in Table 1. The analysis will compare the post-deployment conditions with the baseline conditions in order to assess changes that may be attributable to the increased availability of ITS information in the region from this project. It will also compare the respondents' actual decision-making process with a self-reconstructed process based on the pre-test information they would have been limited to in the absence of the new and improved information. This is a before-after research design with a comparison of the use of real and hypothetical road-weather information and data under the "after" conditions.

2.4.2.4 Post-Test Activities: Data Analysis and Interpretation

Data analysis will focus on addressing the hypotheses presented in Table 1. As indicated earlier, post-deployment interview data will be compared with the pre-deployment baseline interviews. In addition, hypothetical restriction decisions, based on "old" information will be compared with actual decisions based on "new" information under current conditions, and the differences will be examined.

In this first year of restriction decision-making, the District Engineers who make these decisions are likely to be feeling their way cautiously with new kinds of data with which they are unfamiliar and with which they may lack full confidence. It is reasonable to anticipate that they may be reluctant to change the way they have always used information to make these kinds of decisions. Therefore we will want to use caution in analyzing and interpreting the results from these interviews. The new, modeled data will likely need to be proven over time, and that proof will ultimately come from observing how well the state's roadways are holding up under any changes in how these decisions are being made, and from evidence that the adverse impacts of the restrictions on CVOs are reduced.

It is a fundamental reality of this evaluation and the measurement of the impact of improved road-weather data that the ultimate efficacy of changes in restriction decisions is likely to take years to play out. Road surfaces are typically not likely to experience measurable degradation in a single winter season cycle. It may take years before heavy truckloads take their toll. Since it will not be feasible to directly measure changes in road surface conditions that are associated with any changes in how road restrictions are placed and removed, at least in the short timeframe of this earmark evaluation, the interpretation of the potential effectiveness of the new data will be based on qualitative data received from interviews with experts—namely, the District Engineers, along with discussions with representatives of the CVO community.

The analysis will look at a two-step process.

1. Do the engineers report differences in how they are placing restrictions now compared with before?
2. Do they perceive that the new restriction process is better than the old, more defensible, and likely to preserve road conditions longer while also reducing the burden on road users, especially the CVOs?

Finally, users' suggestions will be collected regarding further improvements to the road restriction decision-making process and the information that informs that process to better achieve the program's objectives.

2.5 Test Plan: Travel and Mobility for Commercial Vehicles

2.5.1 Background and Test Objectives

The commercial transport of agricultural and other goods throughout the state of North Dakota and the surrounding region is an important component of the region's economy. When the State issues road and load restrictions, this can have a major impact on both the individual commercial shippers and the economy at large. The intent of this project is to create a sound scientific basis for making these restriction decisions, and the expectation is that an improved decision-making process will be reflected in direct mobility benefits for commercial operations. There are several mechanisms by which these mobility benefits are expected to occur.

- NDDOT will be able to forecast the date they will need to place roads under restriction further in advance, potentially up to two weeks or more. This will allow CVOs to plan in

advance for necessary shipments that require at least a week or more advance notice to set up.

- NDDOT will be able to restrict road segments with greater precision, adjusting load requirements depending on specific road segment conditions. Previously, restrictions have been sweeping, covering relatively large geographic portions of a district, regardless of differences in the structure and condition of roads covered. This will aid CVOs in planning linked contiguous routes for loads of a given size, thereby enhancing their mobility and reducing travel time and distances. This will have direct economic benefits as well.
- NDDOT restriction decisions are expected to be more accurate than in the past, hopefully resulting is shorter durations of road restrictions without risking road surface damage. Significant benefits to the CVO community could result.
- In situations where road closure decisions need to be made, a sounder basis for those decisions, coupled with more advance notice and shorter durations of closures will benefit all travelers over those road segments, not just the CVO community.

2.5.2 Approach

The anticipated impacts and measures guiding this assessment are summarized in Table 2. The approach to measuring the impacts of an improved road restriction decision-making process on CVOs is to conduct telephone interviews with a sample of all companies that operate commercial vehicles in the State of North Dakota. The approach is discussed in detail in Section 2.5.2.1.

Table 2. Anticipated Impacts and Measures for Commercial Operations

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Increase mobility of truck travel	- Perceived impact of road restrictions on CVO operations - Value of more advanced restriction information - Value of segment-specific information	- Better trip planning leads to more timely, reliable trips - Use of information alters trip decisions/behaviors, leading to enhanced mobility - Reduced load level restrictions means fewer Over Size/Over Weight (OS/OW) permit requests and enhanced mobility of CVOs.
Increase efficiency of CVO operations	- Management of shipment timing/routing - Costs of operations	- More advanced, accurate information makes trip planning more efficient - The overall costs of operations are reduced
Increase satisfaction of commercial operators	- Awareness of information - Use of information - Reported satisfaction with and acceptance of the NDDOT decision-making process	- CVOs are more satisfied with the improved road restriction process

2.5.2.1 Pre-Test Activities: Baseline

The first step in this assessment was to create a comprehensive list of all the CVO companies that have active operations in the State of North Dakota providing goods or services requiring

transport in or through the state. While most of these companies are based in North Dakota, an effort was made to identify commercial operators based in neighboring states who have operations in North Dakota. In this way, all operators who could potentially be affected by NDDOT's road restrictions would be included in the list of companies from which the telephone interview sample would be drawn.

In order to begin compiling this comprehensive population of CVOs, a list of 279 companies was obtained from NDDOT. This list of companies, with fax numbers, was printed from the State's database of CVOs who, on a yearly basis, request load restriction information to be faxed to them prior to the spring restriction season. This list was known to cover only a portion of all the CVOs, because many of them obtain information about the load restrictions from other sources than by fax from NDDOT. In addition, CVOs had to pay a small fee for this fax service, and many elected not to incur that cost. Therefore, another list of CVOs was obtained covering all oversize/overweight (OS/OW) permit requests made to the highway patrol from companies operating in North Dakota. This list included 266 companies, including individual farming businesses and larger CVOs seeking OS/OW permits. A final source of company names was the North Dakota Motor Carrier Association (MCA), which provided a current year 2000 directory of their membership. This source provided an additional 417 listings to be included.

The three sources yielded 962 companies that included many duplicate entries; therefore, the complete list was sorted by company name, multiple entries for the same company eliminated, and a final composite master list of 876 unique commercial operators remained. The original data source was retained in the database.

Tracking down all the CVOs with operations in the State of North Dakota would be a very time and resource intensive activity, but after examining the three main sources and discussing this with local experts, it was determined that most of the operators, and likely all of the major operators within the consolidated set of 876 companies, were on the list. This set of CVOs was judged more than adequate from which to draw a representative working sample of companies to interview. The comprehensive listings represented companies having office locations within the State's eight Districts as well as 136 companies with office locations outside the State, but who transported goods in or through North Dakota.

The objective was to generate a sample for interviewing that was representative of both the types and sizes of companies included in the CVO master list and of the geographic distribution of these companies across the state. To accomplish this, companies in the master list were sorted by District and out-of-state location. Each of the three sources used to compile the master list provided different pieces of information about each CVO, such as fax number, phone number, number of employees, and other related information that was preserved for each unique CVO entry in the database. Fortunately, each source provided a contact address, including a Zip Code. The third digit of the Zip Code corresponds with the District location of the CVO, and this was used to classify the CVOs into each of the 9 categories shown in Table 3. A sampling quota was then set equal to the proportionate distribution of CVOs in each of these geographic categories. Since a sample of 100 CVOs was targeted, the number to be selected from each geographic group was equal to its percent of the master total.

Table 3. CVO Interview Sample Selection

Company Location by District (#)	3rd Digit of CVO Zip Code	Number of CVOs by Location	Percent of Total	Number Randomly Selected
Out-of-state	n/a	136	15.5	16
Bismarck (1)	5	114	13.0	13
Valley City (2)	4	86	9.8	10
Devils Lake (3)	3	74	8.5	9
Minot (4)	7	97	11.1	11
Dickinson (5)	6	65	7.4	7
Grand Forks (6)	2	95	10.8	11
Williston (7)	8	45	5.1	5
Fargo (8)	0-1	164	18.7	18
Totals:		**876**	**100**	**100**

A sampling procedure was desired that could be implemented efficiently and that would produce a representative selection of company interviewees from each geographic group. In order to randomly select about 100 companies from within the geographic sample quotas, the companies in each quota were sorted alphabetically. The ninth CVO entry in each quota group was selected first into the sample, and from there every ninth company was selected until the number of companies listed in Table 3 was reached. This produced a sample of 100 companies. For any of these companies that lacked a telephone number in the consolidated database, their number was located based on the address provided. Finally, a representative of each of these companies was contacted by telephone.

In preparation for conducting these interviews with the CVO representatives, a detailed CVO interview guide was prepared to provide a consistent and uniform set of questions to ask each of the CVO contacts. These questions were developed to elicit information from the CVOs about how motor carriers operating in North Dakota respond to road restrictions, what their information needs are, and what the implications of the road restrictions are for their business. A list of questions was drafted, reviewed by NDDOT, and finalized into the interview guide (see Appendix B). The questions explore the hypotheses outlined in Table 2 in order to assess the mobility and efficiency implications for the CVO community of improved road restriction decision making. The information gathered during the baseline data collection included the following:

- Type of goods hauled
- Number of trucks operated in ND
- Awareness/familiarity with road restriction process
- Sources of restriction information
- Major shipping routes

- Effect of restrictions on CVO operations
- CVO responses to restrictions
- Advanced notice received regarding upcoming restrictions
- Preferences for notification
- Costs of restrictions
- Value to CVO of reduced or shorter restrictions, or more road segment selectivity

The interview guide was given a limited in-house review and pretest, a few modifications were made, and the interviewing was begun. The telephone interviews were conducted during business hours using the interview guide form. Since these were cold calls to these companies, the purpose of the survey was briefly explained and an interviewee was identified who would be most knowledgeable about load restrictions and their impact on the company. The overall response rate was quite high, with 77 successfully completed interviews out of the 100 phone calls attempted. Persons interviewed included the following company positions:

- President or Vice-president
- Owner
- Dispatch coordinator
- Cargo coordinator
- Safety coordinator
- Driver support service coordinator
- Terminal manager
- Regional operations manager

The interviewer recorded responses from the interviews on the guide form, and these written responses were compiled and entered into an Excel database. Analyses of these baseline data are presented in Chapter 3. The experience gained in talking with these respondents will lead to further refinements of the interview guide, both to take advantage of what was learned about CVO operations in the baseline and to focus more directly on the impacts due to the new road-weather information that were anticipated to be available during Phase III. Had the evaluation progressed to Phase III, an attempt would have been made to contact the same companies and individuals that were contacted during the baseline data collection to facilitate a comparative before and after evaluation.

2.5.2.2 Pre-Test Activities: Post-Deployment

After establishing a baseline understanding of how the current road restriction process is affecting commercial operations in North Dakota, the next step would be to evaluate the effects of any changes in the process and outcome of restriction decisions in the spring following full deployment of the new systems, based on the new models and road-weather information. The post-deployment telephone surveys with the sample of commercial operators were to be conducted in the Spring of 2004 (see Figure 2), using a telephone interview guide very similar to

that used in the baseline collection effort and using the contact list prepared for the baseline interviews with updates as needed[2]. The process of refining the interview guide will include examining the preliminary guide and analysis to date to ensure that the following issues are addressed:

- Are the questions clear and do they elicit appropriate responses?
- Does the interview guide adequately address the specific hypotheses the survey is designed to test?
- Were any key questions overlooked in the baseline survey that should be asked post-deployment?
- Do the Project Partners suggest any changes in questions or question wording?

It was not expected that changes in the format or content would require additional pretesting. Information from the CVO phone interviews would be supplemented with interviews with key stakeholders.

Phase III data collected concerning mobility of commercial vehicle operations would be used for comparative purposes with the baseline data. The comparison would indicate what effects, if any, the enhanced road-weather information, and resultant changes in the nature of the restrictions imposed upon the operators, if any, were having on those operators.

2.5.2.3 Test Activities: Data Collection

The data will be collected from phone interviews with the CVO representatives, stored in a database, and analyzed in order to explore the hypotheses laid out in Table 2. The analysis would compare the post-deployment conditions with the baseline conditions in order to assess changes that may be attributable to the enhanced road-weather information, and hypothesized reductions in road restriction burden for commercial operators in the region from this project.

2.5.2.4 Post-Test Activities: Data Analysis and Interpretation

The analyses would include a descriptive presentation of values on all the measured variables under both baseline and post-deployment conditions. In addition, it would include an exploration of pertinent relationships in the data that would examine changes between "before" and "after" conditions by geographic location, and by characteristics of the CVO operators, such as number and type of trucks, typical exposure to restricted roadways, and other variables of interest. The analysis is essentially a two-step process. First, any observable changes in how restrictions are placed on the CVOs would be measured. This includes how much advance warning is provided, the length of time between placing and lifting restrictions, the levels of the restrictions put in place, and the coverage in terms of road segments affected by restrictions. Then, data that reflect the reactions of the commercial operators to these changes would be analyzed and interpreted. This could include changes in shipping schedules based on advanced notice of restrictions, alternate route selections, applications for OS/OW permits, load dividing, and other strategies.

[2] For example, where a phone number has been disconnected, a replacement will be made from the same quota of the master list of CVOs.

An objective is to learn *how* commercial operators obtain information about road restrictions and *what* steps they take in response to the placement of restrictions on road segments they typically use. The potential value of obtaining accurate advance notice of when, where, and at what level restrictions will be placed would be explored. Specifically, any changes in the ability of the District Engineers to provide more advance warning would be measured between baseline and post-deployment, and the effects of these changes, if any, on the CVOs examined. It remains an empirical question in this evaluation whether in fact the District Engineers are likely to make *any* changes in their decision-making process in the near term. In fact, while the evaluation hypotheses are couched in terms of positive effects of the better road-weather information on restriction decisions (i.e., earlier notice, shorter durations, less restrictive load limits, fewer road segments impacted), it is certainly possible that none of these outcomes would occur within the timeframe of this evaluation. It is even possible that the NDDOT will discover from the new data that they need to be even *more* restrictive to protect their road surfaces over the long term. If this outcome were to occur, the consequences for the commercial operators could be worse than under the current process. Another possibility, that was noted earlier, is that the new data could support a more relaxed restriction process, the NDDOT District Engineers would be reluctant to change their tried-and-true way of making these annual decisions, thereby resulting in few if any measurable differences in the decision-making process in the short timeframe of this evaluation. Therefore, the data analysis and interpretation must be approached with these possibilities in mind.

Another possible outcome is that the restriction decision outcomes do not measurably change in this test period, but the District Engineers and the affected commercial operators feel more confident in and satisfied with the data and information that the new models yield. Traditional political tensions that surround these annual decisions could be reduced, and all involved may find the data more trustworthy and hence more acceptable. In this sense, the objectively measured outcomes may be little changed but the subjectively measured benefits could be significant. This also was intended to be explored in the data.

Finally, suggestions would be solicited from the District Engineers and the commercial operators regarding further steps that could be made to provide greater benefit for NDDOT and the CVOs.

2.6 Test Plan: Stakeholder Agency Coordination and Integration

2.6.1 Background and Test Objectives

The evaluation of the integration component of this earmark will look to the institutional participants (stakeholders) to understand how the network of participants may be expanding or changing and how they are collaborating in the sharing of road-weather data and information. Through participation in stakeholder meetings and individual stakeholder interviews, the evaluation will examine institutional issues, solutions, and outcome benefits attributable to this earmark project.

2.6.2 Approach

The anticipated impacts and measures guiding this assessment are summarized in Table 4. The approach to evaluating the anticipated improvements and benefits of integration is to participate in several meetings with the agency stakeholder representatives as they discuss and plan for the coordination and integration of road-weather information in North and South Dakota. Interviews also will be conducted with various stakeholders to get their qualitative perspective on the anticipated and actual benefits of better coordination and integration. The University of North Dakota is planning to implement new integration software that will be used by these agencies to enhance the exchange of data and information among these agencies, and the evaluation will track the development, installation, and use of that software to assess its role in facilitating the desired integration. This approach is discussed in more detail in this report.

Table 4. Anticipated Impacts and Measures for Agency Coordination and Integration

Objectives and Anticipated Impacts	Evaluation Measures	Hypotheses
Increase data and information sharing across key agencies	- Agency adoption and use of new integration software - Creation of common database(s) - Time it takes to obtain and/or exchange data and information - Number of individuals and agencies provided access to data and information - Agreements reached in support of better integration - Stakeholders' perceptions of benefits derived from improved integration	- Road/weather data and information are shared more frequently across ND and SD agencies - Key data are maintained in common databases and made more accessible to more agencies and individuals - Time-sensitive road/weather data are exchanged and made available more quickly than before this program - New institutional arrangements are made that facilitate the exchange of data and information - The number of individuals with access to the expanded database and information is increasing - Decision making is improved by better access to the data and information
Improve agency service delivery due to more-better-faster data and information acquisition	- Speed and effectiveness of emergency response - Access of Highway Patrol to data on road-weather conditions	- Better information has improved the effectiveness of emergency response in both ND and SD - Highway Patrols in both states feel they are providing better, faster service
Manage information more effectively	- Amount of duplication of data in state systems - Clarity of understanding about what data are available where and when	- Agencies no longer feel they are besieged by too much information coming from too many places with too much overlap - Everyone knows how to get the road-weather information they need

2.6.2.1 Pre-Test Activities: Baseline

The first stakeholder integration meeting was held in Bismarck, ND on May 9, 2002. The purposes of this meeting were to: 1) discuss ways to better integrate road-weather information across agency and jurisdictional boundaries as an extension or enhancement of the Advanced Rural Transportation Information System (ARTIS) within North and South Dakota, 2) to identify the institutional issues and data requirements that must be addressed, and 3) to lay the groundwork for development of a strategic and tactical integration work plan. Participants in

this meeting represented North and South Dakota DOTs, Emergency Management, regional FHWA, Highway Patrol, the Regional Weather Information Center of the University of North Dakota, and the Battelle evaluation team. Ultimately, integration is being sought to link a number of related systems, including freeway management, emergency management, advanced weather information, road-weather information, sub-surface data, traveler information, and accident reporting. This effort will consolidate similar shared information and data, enhance management and support decision-making, increase timeliness and availability of data, and encourage inter- and intra-agency cooperation.

The following questions were posed to the meeting participants:

- What road/weather information do you currently use?
- How do you currently access or share road/weather information?
- How is this information used and by whom?
- Is this information centrally collected and managed? Is it currently shared with others?
- What type of improved road/weather information would you like to have?
- Would route-specific, timely road/weather information be used in your agency's operations, and if so, how?
- What are some benefits, if any, you would expect from the better integration of information?
- Are there institutional barriers that interfere with the use and integration of data and information?
- Are you aware of any state/agency policies or procedures that may need changing to facilitate this data sharing?
- Any suggestions on how to best integrate into your existing systems?

Results of the discussion prompted by these kinds of questions are included in Section 3.4.

Another baseline meeting was planned to discuss the system architecture requirements for exchanging data and information among these stakeholder agencies, but this meeting was postponed, and now is not planned to take place.

The Project Manager at the University of North Dakota (UND) has been seeking input from the stakeholders regarding their needs and perspectives on integration as a basis for drafting a work plan. This work plan would then be presented at another stakeholder integration meeting with the objective of refining it and reaching consensus on a strategy for proceeding to develop and implement the integration software and procedures that will achieve the program's objectives outlined earlier. In light of the other demands on the participants' time, it has not been possible to schedule this follow-on meeting, so it was decided to try to obtain input for this work plan on an individual interview basis. Unfortunately, to date these interviews have not been able to be scheduled.

The proposed work plan was considered essential not only as a driver for reaching consensus on a workable plan for integration, but also as a basis for the test plan for evaluating integration outcomes. A test plan can only be developed once the specific steps the stakeholders plan to implement are known.

2.6.2.2 Pre-Test Activities: Post-Deployment

Based on the experience of participating in the baseline integration meetings with the stakeholders, a next step would be to refine the questions that would be posed to the stakeholders to measure and understand the benefits they are getting from the hardware and software, and the integration agreements, that are components of the integration deployment. The evaluation team was anticipating two strategies for assessing the benefits of integration. The first would be to continue to participate in post-deployment stakeholder meetings as a way to understand how the stakeholders are responding to the integration initiative. A second strategy would be individual interviews with each of the stakeholder agency representatives, including site visits to their respective agencies where feasible, to see first hand the extent to which, and how, they are using the ARTIS data and information in their own agency programs, how they access those data, what differences they see as a result of the deployment compared with how they used to operate, and how their agency is contributing their own agency's information and data into the ARTIS system to benefit the other participant stakeholders. It is likely a combination of these strategies would need to be implemented to fully understand and evaluate the effects of the new system integration components and procedures.

The evaluation team would plan to work closely with the Project Manager to develop meeting materials and to frame probing questions in order to effectively guide the stakeholder discussions to elicit information on the integration benefits. Included in these questions would be an understanding of any barriers the stakeholders may have encountered as they sought to work more closely with other agencies or acquire needed data from the ARTIS system. It would be important to know specifically what procedures may have changed, and what specific benefits they believe they are deriving from improved integration. The integration links would include within-agency improvements, between-agency and within state improvements, and between state improvements.

One of the issues that would need to be addressed in the pre-test post-deployment planning is how well each agency and their representative stakeholders are adapting to new procedures and new ways of working together and sharing information and data. It would be important to know what specific adjustments or changes in procedure are being made, and how extensively the stakeholders are "buying-in" to the new integrated system.

2.6.2.3 Test Activities: Data Collection

As noted earlier, data would be collected through direct participation in stakeholder meetings and individual interviews. Further delineation of data that could be collected would depend on reviewing the work plans, on which these test plans depend. Once it is known more precisely what procedures are to be implemented and what data would be covered by these procedures and made available both *to* these agencies through ARTIS, and *by* these agencies into ARTIS, then it would be possible to determine additional data that could be collected from the agencies that serve to document the changes that have taken place, both institutionally (procedures,

agreements, working arrangements) and with respect to the actual data types that are being exchanged.

2.6.2.4 Post-Test Activities: Data Analysis and Interpretation

The data analysis related to changes in agency coordination and integration would be guided by the evaluation measures and hypotheses listed in Table 4. As noted above the data would be collected primarily through stakeholder discussions and interviews, but would be supplemented where possible with performance and efficiency measures that can be clearly tied to better access to data and better integration and coordination across agencies and between states. Further details on this topic also depend on a clearly defined work plan that would specify the kinds of data to be integrated and the procedures for doing that. Much of the data and analysis in this regard was anticipated to be qualitative and descriptive.

3.0 BASELINE EVALUATION RESULTS

3.1 Introduction

This chapter describes the results of the baseline analyses performed in Phase II of the earmark evaluation process for the following three goal areas:

- Improvements in system performance
- Mobility and efficiency for commercial operators
- Agency coordination and integration

Discussions of measures and hypotheses, along with the procedures used to collect the data, were presented earlier in the discussions of the test plans for each of the goal areas.

3.2 System Performance

This section addresses system performance in terms of the current (baseline) process by which NDDOT decides when and where to place, and later remove, the road restrictions that specify truck load limits on the state's road segments. It provides an overview of the five year period from 1998 to 2002 of experience with restrictions, and it then addresses the potential ways in which the approach to placing and removing restrictions might change, given the anticipated improvements in road-weather data.

There are some common elements across all eight of North Dakota's Districts in the road restriction decision-making process; however, some aspects of this process are unique in particular Districts or "climate" regions that may cover several Districts. As a generalization, weather systems move across the state of North Dakota from the southwest to the northeast following the pattern of the jet stream. As a result, winter ground freezing and spring thawing tends to follow this same pattern. Therefore, the Districts in the southwestern portion of the state tend to be the first to place road restrictions in the late winter, early spring period, and the first to remove those restrictions in the late spring, early summer period. This pattern tends to be repeated from year to year, and it influences the timing of the road restriction decision-making process District-by-District throughout the state.

The responsibility to implement road restrictions rests primarily with the District Engineers (DEs) in each of the eight North Dakota DOT Districts. Although the DEs are vested with this responsibility, they share in the decision making process with other District, and NDDOT officials have the final authority for these decisions. Depending on the particular conditions and their location, they may confer with one or more of the following people before making the final decision:

- Maintenance Coordinators
- Maintenance Superintendents
- Section Workers
- Neighboring Districts

- Sign Placement Personnel
- County Highway Personnel
- City Personnel
- Section Supervisors

There are at least three major decisions to be made when *placing* load restrictions: 1) when to place road restrictions, 2) which roadways or road segments to restrict, and 3) what level of load restrictions to place on individual roadways or road segments.

Road restrictions typically are placed after cold winter months as the ground thaws and potential pavement damage increases. Based on interview discussions with the DEs, this typically occurs as early as mid-February. Removal of the restrictions usually happens during the month of June. The NDDOT records and keeps on file load restriction placements from year to year. Thus, DEs have access to previous years' times, locations and load restriction levels. Previous load restriction records guide the DEs in the road restriction decision-making process from year-to-year. Typically, in February NDDOT will make available a proposed restriction map to alert the DEs, CVOs and other interested people. This advance notice is based on historical experience. However, as the time for placing the initial restrictions approaches, the DEs fine tune their decision making with data from the RWIS-ESS, Falling Weight Deflectometer (FWD) readings[3], and visual inspection of vulnerable road sections.

Figure 3 shows an example of the peak period load restrictions that were placed March 26, 2001. This is Order Number 6 in a series of 23 orders that were issued during the spring of 2001, spanning a period from March 9th to July 10th of that year. Actually, Order Number 22 on July 12th indicated the end of the main restriction period, except for one short segment of roadway for which the restriction was removed a month later.

One thing that is made clear on this map (Figure 3) is that the restrictions present a complex maze for CVOs who need to figure out how to most efficiently move loads of various weights and configurations throughout the state of North Dakota. It is important to note that Interstate Route 94, running East-West across the lower third of the state, and Interstate Route 29, running North-South just inside the Eastern border of the state, are not subject to any restrictions at any time.

During the 2001 road restriction period, 17 mapped orders were initiated by NDDOT. In addition, 6 one-page written orders were issued, without a map, regarding placing, changing, or removing restrictions on only one or two road segments. All but one of these orders was effective as of 7:00 a.m. on the day issued. The issue days between March and July 2001 are shown in Figure 4 (highlighted bold dates).

[3] This measurement of pavement vulnerability is obtained by dropping a standard weight onto the pavement and measuring the pavement deflection.

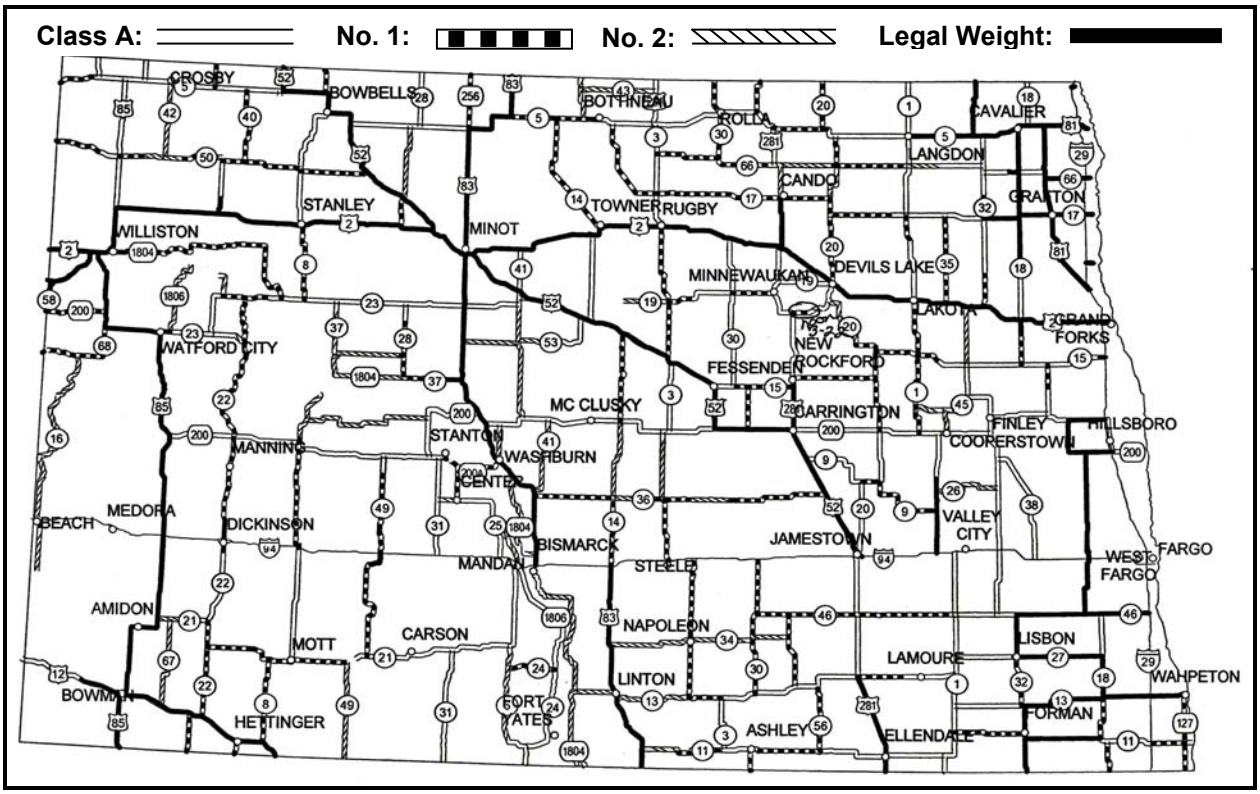

Figure 3. NDDOT Load Restrictions, Order No. 6 Effective 03/26/2001, 7:00 a.m.

March 2001

Su	Mo	Tu	We	Th	Fr	Sa
				1	2	3
4	5	6	7	8	**9**	10
11	**12**	**13**	14	15	16	17
18	**19**	20	21	**22**	23	24
25	**26**	27	28	29	30	31

April 2001

Su	Mo	Tu	We	Th	Fr	Sa
1	**2**	**3**	4	5	6	7
8	9	**10**	11	**12**	13	14
15	16	17	18	19	20	21
22	**23**	24	25	**26**	27	28
29	**30**					

May 2001

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	**3**	**4**	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	**21**	22	23	**24**	25	26
27	28	**29**	30	31		

June 2001

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	**4**	5	6	7	8	9
10	11	**12**	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

July 2001

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	**16**	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

August 2001

Su	Mo	Tu	We	Th	Fr	Sa
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Figure 4. Effective Dates of NDDOT's Restriction Orders, 2001

NDDOT makes these orders available via Fax, phone, in hard copy (maps and written orders), posting on roadside signs, and on their web site at www.DiscoverND.com/dot/load_restrict.html. While the web site may only show the two most recent orders, NDDOT maintains a database of

their maps, currently from 1997 to the present. The DEs are assisted in their decisions regarding when, where, and how to place road restrictions on specific roadways in their Districts by having access to the previous years' restriction times and levels, conferencing with the district personnel noted earlier, and accessing weather data. Historic information guides DEs in knowing at *what level* to place the restrictions on particular roadways, and current weather, probe data, and road surface observations aid in the *timing* of these decisions.

The broad outline of the 5 years of road restrictions from 1998 to 2002 is illustrated in Table 5.

Table 5. Restriction Timing and Duration, 1999 - 2002

Year	Start	Peak	End 1*	End 2*	Duration (days) Start to End 1
2002	02-19-02	04-01-02	06-03-02	06-03-02	104 days
2001	03-09-01	03-26-01	06-12-01	07-10-01	78 days
2000	02-24-00	03-02-00	05-22-00	06-08-00	81 days
1999	02-25-99	03-22-99	unknown	07-19-99	n/a
1998	02-13-98	03-09-98	unknown	09-22-98	n/a

*NOTE: "End 1" reflects removal of 95% of all road restrictions. "End 2" is the date the last restriction was removed.

While the procedure that the DEs follow in making their restriction decisions each year varies from District-to-District and year-to-year in some respects, basically they go about making these determinations in a similar and consistent way. The basic drivers for these decisions include information about evolving weather conditions, as determined from the RWIS-ESS, ground probe, and national weather service readings, and knowledge of current road conditions, particularly any changes related to NDDOT maintenance work on those roads that may make them more resistant to truck impacts. DEs check for restriction consistency and timing of neighboring Districts and observe the restrictions imposed by neighboring Districts as the spring ground thawing process progresses in a roughly southwest to northeast direction across the State. Thus, referring to the NDDOT District map in Figure 5, the first District to typically place road restrictions will be Dickinson District (#5). In the weeks following the initial restrictions in Dickinson, the neighboring Districts will initiate their restrictions. In this way restrictions will be placed in a wave from the Southwest toward the Northeast, typically with Devils Lake and Grand Forks being the last to impose restrictions. Likewise, as restrictions are removed in the late spring and early summer, Devils Lake and Grand Forks will be the last to remove them.

As has been noted, the RWIS-ESS information provided by NDDOT is a primary source for the DEs to understand changing road and weather conditions (see Figure 1 for current and proposed locations of the RWIS-ESS throughout the state, as of summer 2002). Some RWIS-ESS are linked to subsurface temperature probes that give below-grade and road surface temperatures in the Districts where they are located. As has been discussed, it is the intent of this earmark project to install additional probes that will provide deeper and more complete subsurface data in support of these restrictions decisions.

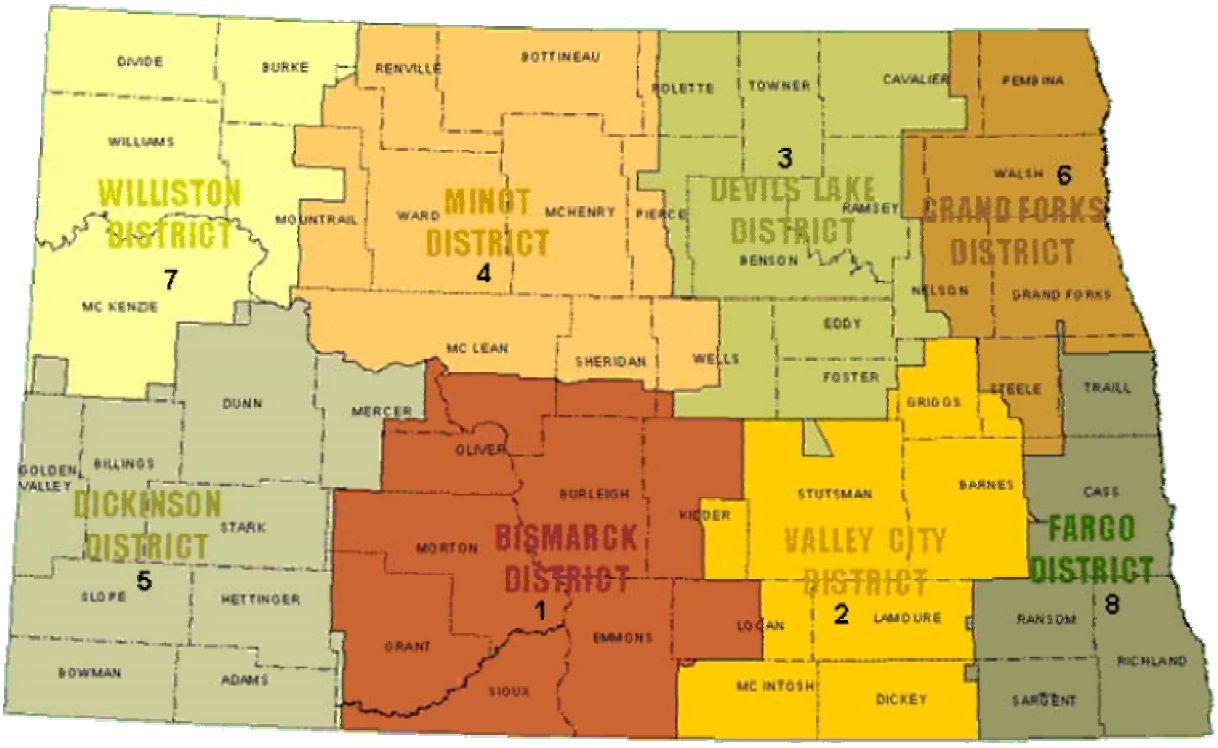

Figure 5. North Dakota DOT District Map

The North Dakota DOT also conducts bi-monthly falling weight deflectometer (FWD) tests throughout the state and sends them to each of the DEs to indicate pavement strengths and conditions in their Districts. Also, DEs and their personnel access weather and road information from media sources, including the North Dakota University web site, Data Transmission Network (DTN) weather system information, the State's web site, local and University radio stations, and the degrees heating days above 32^{o} records provided by the North Dakota State University Agricultural Weather Information Network (NDAWN). The following are other sources on which the DEs rely to make their road restriction decisions:

- Surveillance by field, sign and other maintenance workers; visual inspection of water seepage in cracks in the road surface;
- Discussions with County and City personnel; evidence that local and gravel roads are softening or breaking up;
- Results from piles driven into the ground by signing personnel along roadways, and checks of frost depths;
- Results from the Freeze Track System[4]; and,

[4] FrezTrax™ was developed to support improved road restriction decisions to increase pavement life. A recent South Dakota DOT study on modeling sub-surface conditions comprises the core of FrezTrax™. Based upon both observed and forecast data, Meridian calculates "freezing" and "thawing" indices across the state of North Dakota. These indices are coupled with soil moisture data on a daily basis to arrive at current and one week forecast road restriction recommendations.

- Access information of the structural numbers (SN) of roadways from the State's Roadway Information Management System (RIMS) database of pavement history and condition.[5]

Determining the level of road restriction is done using the same information sources as used to determine when to restrict, with emphasis on reviewing past records. Conversations with other Districts also influence decisions regarding the level of the restrictions, because the DEs want to maintain a consistent restriction level on roadways that are connected from District to District. Consistency helps avoids situations that might "trap" commercial vehicles. Based on interviews with the DEs and records of past road restrictions, typically the Districts do not increase or decrease the extent or level of road restrictions once they are placed. This helps avoid District restriction inconsistency and load restriction notification problems. The following are exceptions for increasing or decreasing the restriction level:

- Observed intense pavement condition breakdown (deterioration);
- Overlay (road coatings or layers) or some form of pavement thickness change;
- Special commitment to a particular industry, City, or County, or exceptions granted by NDDOT or the State; and,
- Avoidance of any restriction inconsistency on specific roadways.

Initial timing and level of road restrictions, as well as any changes during the season are put on the NDDOT web site and sent out to the subscribing industries and agencies immediately. It is important for enforcement reasons to provide timely and clear notification of all changes in restriction status. In North Dakota, however, the timing and duration of restrictions is not governed by law, as it is in some other states.

Restrictions are lifted (decreased to the normal road standards that are in place throughout the rest of the year) at the end of the spring thaw season according to a reversed plan of how load restrictions were placed. The same information that was used when deciding when and how to place load restrictions is employed in the decision to remove load restrictions. However, the information source hierarchy or the order in which Districts use and rely on sources is different. Districts rely heavily on field workers to closely watch the road conditions (visual seepage and pavement breakup) when considering the removal of the load restrictions. Once again, the FWD readings are carefully analyzed to judge moisture content and pavement strength. Also RWIS-ESS, subsurface and surface probes, and media sources are used to understand the relation between external weather trends and pavement conditions. The Districts remove load restrictions following the same southwest to northeast pattern over the State, and they collaborate frequently in this process with their neighboring Districts.

[5] Information contained in the RIMS database includes how roads were constructed, when they were completed, and resources spent on road improvements. RIMS has a Geographic Information Systems (GIS) component that is used to map information such as when seal coats are needed on various road segments. The DEs provide update information to RIMS that is accessible by NDDOT throughout the state.

3.3 Mobility and Efficiency for Commercial Operators

This section presents the results of the analysis of baseline data collected from telephone interviews with 77 Commercial Vehicle Operators (CVO) who report that they operate one or more trucks in the study region. The baseline methods and procedures for gathering the interview data are described in Section 2.5 of this report.

The CVOs included in these interviews represent a cross-section of the kinds and sizes of businesses that generate truck traffic in and through the study region. Figure 6 shows the distribution among the CVO respondents by the type of goods they haul. Companies hauling

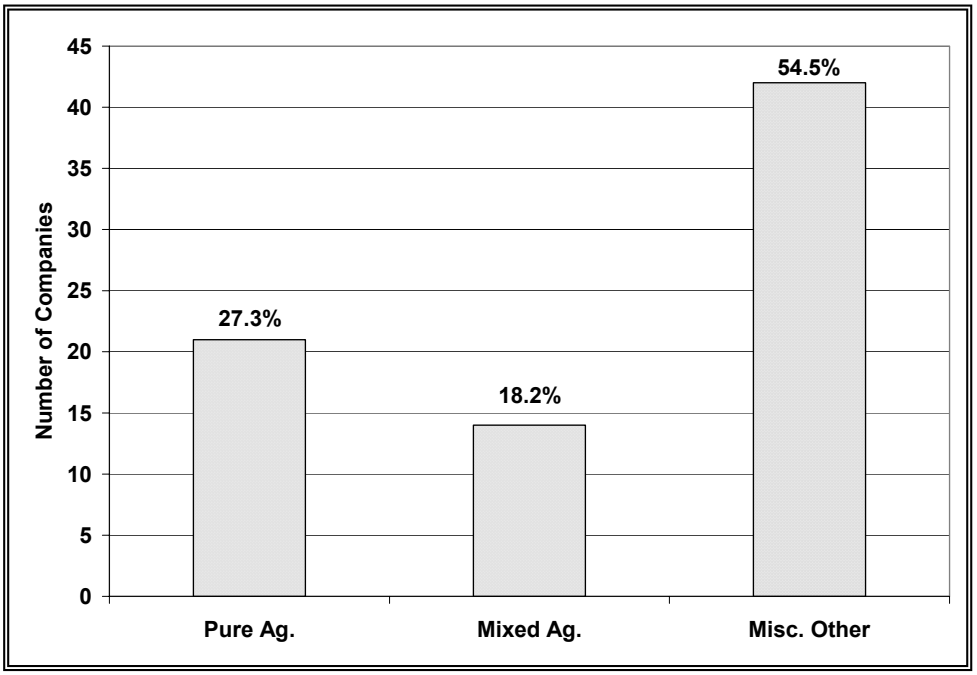

Figure 6. Type of Goods Hauled by CVOs

agricultural products, either solely or combined with other types of goods, constitute 45.5% of the sample of CVOs. Agricultural goods include grain, cattle feed, fertilizer, produce, and refrigerated items. Each of these companies, on average, operates about 17 trucks, but the range of company sizes as indicated by number of trucks per CVO is substantial.

As shown in Figure 7, over 40 percent of the CVOs in this survey reported operating one or two trucks each, and only 25 percent of the CVOs reported operating 10 or more trucks, with the largest company reporting 269 trucks. Clearly, the average is skewed up by a very few CVOs that report a very large number of trucks. The median number (half operate fewer and half operate more) is only three trucks.

During the interviews respondents were asked to report what information sources they used, if any, to learn about the status of road restrictions. They were specifically asked about the NDDOT web site, information faxed to them by the NDDOT (CVOs can register for this if they want), signs posted on restricted roadway segments, other truckers or word of mouth, or any other sources they may rely upon. The average number of sources reported by all respondents

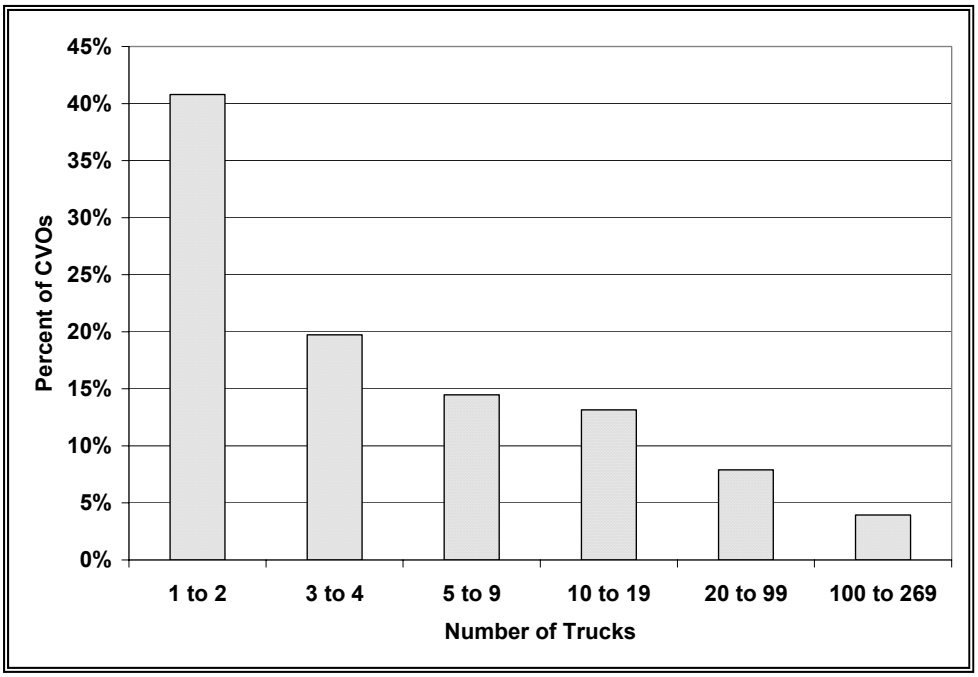

Figure 7. Range of Size of CVOs by Number of Trucks

was 1.9, with a range from one to five. Just over half of the CVOs (51.9%) said they received road restriction information via Fax from NDDOT; 37.7% said they got their information from the NDDOT web site over the Internet, and 29.9% said they got their information from signs posted by NDDOT on the road segments where the restrictions applied. The smallest number, 22.1%, reported obtaining restriction information from other truckers, or by word of mouth. About 40 percent of the CVOs reported using other sources, mostly in addition to the sources listed, and these included notices in the newspaper, notices on radio or TV, calling in to the Highway Patrol, or information posted at border crossing or checkpoints.

It was important to know how extensively CVO operations are affected by road restrictions, so they were asked to indicate what percent of their annual shipments occur during the months of March through June when the restrictions are typically in place in North Dakota. About one-fifth or 19.5% of shipments reportedly occur during this period and therefore would be at risk of being impacted by restrictions. This vulnerable period of time represents four months out of the year, or 33% of the time. Therefore, on average, for these CVOs a higher portion of their shipping activity apparently occurs during those months when restrictions are not likely to be in place.

Following on that question, respondents were asked to indicate in their own words how road restrictions affect their operations. There was a wide range of responses, from no effect at all to very significant impact. Those who replied that impacts were minimal said they are able to stay under the weight limits most of the time, or they avoid restrictions by using the Interstates, or they alter their freight schedules to minimize exposure to restrictions, or they rearrange their loads to be sure to stay under the limits. Those who experience the greatest impacts ship heavy equipment that can't be easily divided into smaller loads, or otherwise report that restrictions severely limit their operations. Finally, those in the middle report that they are impacted but they

make adjustments, even though that is costly to them and to their customers. Typically, they have to haul more small loads, travel greater than normal distances, postpone business opportunities, or apply for OS/OW permits. For some this means lost business, extra planning costs, or postponed shipments.

CVOs were asked how they typically respond when they are faced with restrictions. The majority of CVOs say they have two primary strategies: 76.6% alter their route to avoid or minimize exposure to restricted roads, and 70.1% alter their loads by dividing large loads that would exceed restrictions into several smaller loads that will not be subject to restrictions. Other strategies include altering the timing of their shipments (35.1%), applying for Over Size Over Weight (OS/OW) permits that, for a fee, will allow their shipments to travel on restricted roads up to specified limits (23.4%). Very few CVOs (9.1%) reported that they seek special permission from NDDOT or the County for a restriction waver. These are the main strategies used, and few other alternatives were offered in response to this question. A couple of CVOs say they simply avoid shipments in the northern tier states during this period, preferring to concentrate their business in the warmer states.

The CVO respondents were asked how much advanced notification they usually receive before road restrictions are imposed. Responses from 74 CVOs ranged between zero and 30 days, with an average of 5.8 days. This reported notification as experienced by the CVOs was compared with the number of days the CVOs said they would prefer to have, but more than half of them (67.1%) didn't say what they would prefer to have, with a few saying "as much as possible" or "the more the better." The assumption was that those who didn't respond to the question about their preferred notification were probably satisfied with the actual number of days notice they said they are actually receiving. With that assumption, the average of the preferred number of day's notification is 8.7, or on average 2.9 more days' notification over what they receive now (8.7 preferred versus 5.8 currently).

The 26 respondents who specified the number of days they would prefer to have on average preferred 13.1 days advance notice, versus an average of 3.1 days these 26 CVOs said they currently get on average. This represents a difference of 10 days (13.1 preferred minus 3.1 currently). Those 26 CVOs who specified the advanced notice they wished they could get were indicating fewer days' current notice than the 51 CVOs who didn't express a preference, namely, 3.1 days versus 7.0 days.

Thus, if the assumption in this regard is close to correct, the 51 CVOs who say they are getting an average of 7.0 days advanced notice are reasonably satisfied with that (assumed because they didn't express a preference for any more than what they say they get currently). The remaining 26 CVOs who say they currently get 3.1 days notice would prefer to get 13.1 days. Arguably then, somewhere between 7 and 13 days seems to be perceived as adequate notification for most of these CVOs, though some say they want up to a month's advance notice.

As has been explained, the placement of restriction orders occurs progressively across the state. Because of this pattern, it is reasonable to anticipate that advanced notice would be of greatest value to those CVOs operating in Dickinson District, and that those CVOs would prefer the most advanced notice. CVOs primarily operating in the other districts to the northeast have the benefit

of knowing that they will experience restrictions soon after the first restrictions are placed in Dickinson. In effect, they have the benefit of longer advance notice, equal to the notice given initially by NDDOT plus the anticipated delay before their district's roads are restricted. Figure 8 looks at the reported current notice in days, the CVOs' preferred notice, and the difference between these two that could be interpreted as a measure of satisfaction with the

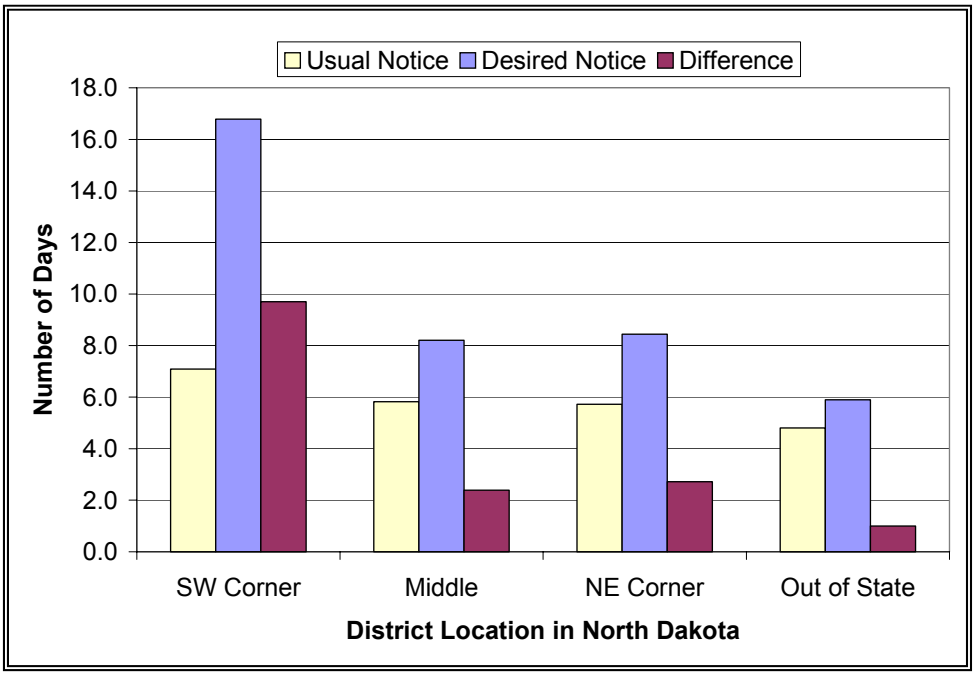

Figure 8. CVO Advance Restriction Notification by Location

current restrictions. While the current or usual notification in days is about the same for CVOs throughout the state, the preferred or desired notice is much greater for the CVOs in Dickinson District in the SW corner of the state. Their average preference is almost 17 days, somewhat over twice the preferred notification expressed by CVOs in the rest of the state, and almost three times the out-of-state CVO preference.

As has been pointed out earlier, one of the objectives of the road-weather information enhancements is to provide better data on which to base earlier notification. The post-deployment data were expected to provide an opportunity to see whether more advanced notice is in fact possible with the improvements in sub-surface and road condition data, and forecasting models based on those data.

The reported effects of road restrictions on CVO operations were examined in connection with other characteristics and perspectives of these respondents, as shown in Table 6. Every one of the CVOs located in District #5 (Dickinson) where restrictions usually are imposed first in the state said that those restrictions had at least some impact; whereas 44% of the CVOs in the other districts said they experienced no serious impacts. Those CVOs who said they were not impacted also indicated the greatest satisfaction with their usual amount of advanced notification. That is, the average difference between the number of days they said they preferred and the usual notification they received was only 0.4 days, indicating that what they got and what

they wanted were virtually the same. Overall, 61.8% of the CVO respondents said their company experienced "some" to "severe" impacts from the restrictions. While smaller operations, measured in terms of the number of trucks they reported, are expected to be more likely to be affected than larger companies, this was not the case. CVOs of all sizes reported almost equal impacts. Those who said they weren't impacted significantly by the restrictions were much more likely to say that having a shorter restriction period would not be of value to them. And finally, those same CVOs reporting little or no impacts of restrictions also were much more likely to say having restrictions that are more selective of which roadway segments are affected would be of no value.

Table 6. CVO Reported Impact of Restrictions on their Operations

Restriction Impact	Location in State (District Number)				Preferred - Usual Notification	Shorter Restriction Period of Value?		More Selective of Road Segment of Value?	
	SW (5)	Mid	NE (3,6)	Outside	Days	Yes	No	Yes	No
None	0	20	6	4	0.4	13	17	6	22
Some	7	16	12	6	4.8	40	0	28	9
High	0	5	0	1	3.2	5	1	4	2

One of the objectives of seeking improvements in weather and road condition data and models is to improve road restriction decision making both in terms of reducing the level and shortening the amount of time highly restrictive load limits have to be in place, and to be able to target these restrictions to smaller segments of roadway. Improvements in both of these areas should be of benefit to CVOs and would be feasible as long as the District Engineers and Maintenance Supervisors could be assured that the roads would not be subject to further deterioration. As has been noted, the CVOs were asked two questions in this regard. Would a shorter restriction season be of value, and would a more selective placement of restrictions on road segments be of value? All but seven of the CVOs gave a clear "yes" or "no" answer to each of these questions. Overall, 74.3% said they would value shorter restrictions, and 54.3% said they would value more selectively placed restrictions.

Table 7. Value of Shorter Restrictions versus More Selective Restrictions

Q13: Value Shorter Restrictions?	Q14: Value Selective Restrictions?		
	Yes	No	Total
Yes	37 (71.2%)	15 (28.8%)	52 (100.0%)
No	1 (5.6%)	17 (94.4%)	18 (100.0%)
Total	38 (54.3%)	32 (45.7%)	70 (100.0%)

While a majority of the CVOs who say they value shorter restrictions also say they value more selective placement of restrictions (71.2%), as shown in Table 7, only one interviewee (5.6%) who placed no value in shorter restrictions thought selective restrictions would be of any benefit. Virtually all of those who said shorter restrictions were of no value also said more selective placement was of no value as well (94.4%).

It is understandable that travelers would very much like to have shorter restrictions, all things equal. But the NDDOT and traffic engineers are primarily concerned with road surface preservation, and it is not at all clear that a better understanding of subsurface freeze-thaw conditions and road-weather modeling would yield shorter restriction periods. It is equally plausible that better data would support a need for longer restrictions. These data and models may however be able to offer more precise restriction placement than has been possible up to now, and selective restrictions are a stated goal of this program. Therefore, it will be important to understand why the CVOs are split almost 50-50 on their sense of the value of being able to accomplish this (38 said "Yes" and 32 said "No" in answering question #14: *If the road restrictions could be more selective in which highway segments are affected, would that be of value to your company? How (What would you do differently)?*).

At the end of each interview the CVO respondents were asked if they had any comments to offer, and 30 of the 77 CVOs interviewed (39%) did. Their comments are grouped and paraphrased below:

- Just have to cope with it. We understand that the roads need to be protected. The state is doing a good job.
- Without better notice of when they go on and especially when they come off, it's hard to plan.
- Restrictions are hard on our small business. It doesn't pay to haul half-sized loads.
- Wouldn't speed reductions offset some of the need for restrictions? Would help keep us in business.
- Need exceptions to the restrictions under special or emergency situations.
- Restriction decisions seem very subjective. The information provided is often inconsistent. For example, road signs don't match other notifications. The restriction classifications should be simplified with fewer categories. It would be easier for everyone to understand. Restrictions and the decision criteria should be standardized nation-wide.
- Changing restrictions mid-term, even while trucks are en route, is a big problem.

3.4 Agency Coordination and Integration

Baseline results are very limited in this goal area, for the reasons that have been discussed previously. Essentially all the baseline data available at this time come from the first stakeholder meeting held May 9, 2002 and discussions with the project partners. The meeting discussions centered on how data currently are acquired, shared, and reported out to other agencies and the public. The information reported here precedes the implementation of the 511 system that is now operational in both North and South Dakota. Issues of data security and barriers to greater

integration were also discussed at the May 9th meeting. Baseline data related both to the current level of coordination and integration and to what these stakeholder agencies would like to see include the following:

Data acquisition and distribution. The stakeholder agencies generally derive weather and road information from the National Weather Service and their state DOT respectively. These data are typically passed through the state Emergency Operations Center (EOC) and on to recipient agencies listed in the state Emergency Operations Plan. The mode of information transfer is through phone and computer (Internet), with daily briefings. This information system is coordinated through Meridian Environmental Technology, Inc., a subcontractor to the University of North Dakota. The state EOC thinks of integration in terms of the ability to marshal information in a way that communicates clearly to all recipients, avoiding the current "hit or miss" approach. The Highway Patrol is looking to the integration function to channel all the varieties of information through a single medium other than the Internet. The NDDOT would like to see a single information source, data repository and a distribution system based on each agency's individual requirements. Both North and South Dakota would like information acquisition and dissemination to be streamlined through a single point as an aid to decision-making. There is a common desire across these agencies to see that accurate road and weather information is made available to the public on a need-to-know basis, and that public awareness of this information is enhanced. A centralized, integrated database of such information would provide a single source of information for broadband distribution to the public via web, phone, am/fm radio, and other media.

Communication Terminology. One aspect of integration discussed was the need to create and use a more consistent set of terminology in communicating road and weather information across agencies and with the traveling public. This should provide a seamless communication protocol that travelers can understand across the country, and it should be an element in all integration plans.

Road and weather information sources. There is concern that data currently come from a variety of different sources and are in different forms, and this makes it difficult to integrate road and weather data. These sources include MET, NWS and DTN, and information dissemination is through the #SAFE system, websites, and DTN radar displays. There is a desire to reduce the number of separate data sources to make it easier to integrate the information. The stakeholders discussed the value of getting more information on road conditions directly from commuters (perhaps as probe vehicles), in addition to receiving real-time road condition reports from the Highway Patrol. It was suggested that commuters could be trained to provide reliable site-specific traffic and road conditions reports. A tighter linking of information on weather and road conditions is desired.

Inter- and Intra-agency information sharing. Information shared within and between agencies is sent via email, phone, fax, manual teletype, the Internet, and a system called INLETS. The stakeholders expressed a desire to create a common information database as one way to lend confidence to the information's validity and trustworthiness, and to enhance ease of access. Another strategy for enhancing information integration is to implement the 511 system.

Information management and security. A substantial amount of discussion among the stakeholders centered on issues of firewalls and restricted access servers. Questions were raised about how a centralized server would be operated and serviced, and where it would be located. Issues included what information could be released and to whom, the timing of release, and the protocols that should be used. In addition to issues of single-source servers, security, and state guidelines that would have to be met, there remained the underlying reality of multiple, non-conforming systems currently in use that would have to be addressed in any integration strategy. There was an acknowledgement in this meeting that Information Technology (IT) was a critical missing stakeholder (from both North and South Dakota) in the discussions, and they must be included henceforth. The various agencies in each state currently have different policies regarding what data can be released and to whom. Any integration scheme will need to understand these current policies and procedures and seek consensus on common approaches. Another strategy discussed was automation of various information management and dissemination procedures, but while automation can help streamline various systems, there will remain a need for key personnel in such areas as data reliability, system maintenance and security.

Barriers to integration. The stakeholders recognize that they face a number of challenges in their efforts to achieve improved integration. Some of the potential barriers that need to be addressed include:

- Providing integrated information is costly, and it is a constant struggle to marshal the needed resources within the public sector. While the private sector has a role to play, they have had trouble identifying a viable market for their information products. All the while, public demand for service improvements continues to rise and place pressure on the public agencies.
- New, integrated information systems call for new skills and approaches, at a time when these agencies are downsizing. Managing large amounts of information in integrated databases is not in anyone's job description at this time, so organizational adjustments will be needed. Automation may help in certain tasks, and outsourcing is a possibility, but it too is not cost-free.
- Road and weather information will need to be stored and integrated in a Geographic Information System (GIS) database. The situation now is that these GIS systems are being built application by application, resulting in different incompatible systems in the different agencies. This creates issues of data standardization and data quality. Given the presence of a number of GIS legacy systems, integration will be a challenge. This is one of the reasons it is so critical to involve IT in these integration discussions.
- North and South Dakota are at different stages in the build-out of wireless communication systems. This calls for better coordination in order to support an integrated approach to information management.
- Both states face an organizational environment in which responsibilities for these matters are not clearly defined. Roles and responsibilities need to be clearly spelled out to support smooth integration of these complex information systems.

More work is clearly needed to be able to develop a complete and coherent set of baseline information to support an evaluation of the integration component. An important next step would be to prepare an integration work plan, then the stakeholders could be interviewed individually with a prepared set of questions in order to obtain a consistent understanding of road-weather information uses and procedures in place in each agency that could be affected by actions or procedures described in the plan. In addition the evaluators would need to participate in future stakeholder meetings where possible to round out an understanding of stakeholders' procedures, perspectives and concerns regarding integration.

The participants in the May 9th integration meeting expressed concern that not all the intended agencies were represented. Also, as noted, involvement from the information technology agencies of each state (ND ITD and SD BIT) was considered essential.

A next step action recommended at this stakeholder meeting was for UND to construct and distribute to participants an action document based on the information gathered at this meeting. This would then be discussed in a subsequent meeting to lay the ground work for an integration implementation plan. Unfortunately, to date it has not been possible to get all the stakeholders together for another meeting, given homeland security demands on the time of the key players, and other constraints. UND feels they can't develop an action plan without further understanding of the needs of the stakeholders. Their strategy, in lieu of having another meeting, has been to try to work with the participants individually to gather the information they need to develop this preliminary plan.

The integration process turned out to be slow and tedious. While the stakeholders in the first meeting expressed a commitment to move forward to achieve meaningful and productive integration, this did not occur as envisioned. Instead, events overtook the earmark. The #SAFE traveler information program transitioned into the newly established 511 road-weather information phone number, and this provided a new mechanism for integrating road-weather information within NDDOT and the Highway Patrol. Both North and South Dakota adopted the integrated #SAFE and 511 independently of any prior efforts to achieve information integration through the earmark. This approach operates externally to North and South Dakota's standard IT networks, providing for a smooth and rapid diffusion of a well integrated road-weather information system.

4.0 PROPOSED PHASE III EVALUATION REPORT OUTLINE

The Phase III report outline describes the intended presentation of the evaluation's final results from the analysis of the post-deployment data, making comparisons with the previously collected baseline data, as well as examining these data independently across the three major goal areas as presented in this close-out report. This offers an outline of what had been intended for the post-deployment analysis component of the evaluation. The suggested format for this report and an outline description of the topics that would have been covered are presented in Table 8 below:

Table 8. Evaluation Report Format and Contents

Section	Suggested Topic Contents
Executive Summary	- Report summary focused on evaluation findings and lessons learned
Introduction and Background	- Brief background on FHWA earmark evaluation goals and objectives - History of this project, NDDOT's objectives, coordination with Project Partner's evaluation, connection with other programs in state, baseline evaluation from Phase II, overall focus for Phase III
System Description	- System components, operations, objectives - Project schedule and accomplishments - Map of project elements
Evaluation Goals, Measures and Hypotheses	- Summarize 3 goal areas, plus sub-objectives, for this evaluation - Discuss overall ITS integration objectives - Distinguish primary and secondary evaluation objectives by goal area - Present in table form
Technical Approach	- Discuss each of the tests applied in each of the evaluation goal areas (data, methods, analytic procedures) - Discuss "before" and "after" research design
Results	- Present and interpret findings in each of the goal area tests - Provide descriptive results and analysis of relationships in the data - Present findings in both tabular and graphic form to maximize communication of results to the reader - Highlight ITS benefits identified (integration and other benefits) - Acknowledge assumptions and limitations of the analysis and conclusions
Conclusions	- Present insights and conclusions from the analysis and interpretation of results - Highlight common conclusions across the goal areas - Identify how findings and conclusions do or do not fit with the existing body of research - Discuss practical implications of results and lessons learned that may apply to other States and DOTs
Recommendations	- Recommend how best to capitalize on the findings - Recommend additional research that may be appropriate to more adequately understand key issues, supplement inadequacies in the data, or examine related issues

5.0 RATIONALE FOR CLOSE-OUT

A decision to terminate this earmark evaluation at the end of Phase II was based on a careful assessment of the status of the project deployment, and an assessment of the risks of continuing with the evaluation versus the likely benefits to be derived from completing Phase III. Phase III of the evaluation would have implemented the test plans presented in this close-out report to assess the value of a more accurately modeled relationship between weather conditions, sub-surface freeze-thaw conditions, and road surface vulnerability to heavy vehicle traffic. This value or benefit of better road-weather information was expected to result in both improved decision making by the NDDOT District Engineers regarding the placement and lifting of road restrictions, and reduced impacts for the commercial operators on the state's roadways that are subject to these restrictions. In addition, the evaluation would have assessed the integration benefits to key stakeholder agencies in both North and South Dakota of improvements in the availability and coordination of road-weather data and information.

By way of summarizing the key issues that have already been touched on in this report, the following have motivated the decision not to proceed with Phase III of the evaluation:

- In order to complete their report, the Project Manager had requested a no-cost time extension of the period of performance for the earmark project to the end of calendar year 2003. Beyond that time the intent has been to subsume the subsurface program as part of the activity of the University of North Dakota. The earmark project per sé is now completed, making it awkward to continue to evaluate a project that has been delayed, modified, and for which funding has expired. Work on the activities initiated under the earmark, however, is continuing with leadership from the University of North Dakota and the active support of NDDOT on a longer-term timeframe.
- The road restriction modeling and decision-making aspect of the original earmark project has been significantly delayed. The deployments of the subsurface probes are well behind the original schedule for several reasons: 1) the procurement of commercially manufactured probes turned out to be much more costly than originally anticipated, exceeding the available budget; 2) about 18 months of project time was taken up by a search for temperature and moisture probes, and even now a suitable moisture probe has not be found; and, 3) given costs and the need to modify the probe design, a decision was made to have UND design and build custom probes for this purpose. From that point the project moved more quickly forward. Also, custom probes have apparently sparked an interest on the part of other state DOTs who are looking for low-cost, reliable and accurate subsurface probes. Thus, although the delays have adversely affected the evaluation, they are yielding unanticipated benefits in terms of probe design improvements, increased regional usage, and renewed interest on the part of instrument vendors, such as SSI to support further commercial applications.
- The processes of validating the predictive models based on the probe data is taking longer than initially planned, due to the probe development delays. Also, there is uncertainty regarding how long it may take for the District Engineers to accept the new data as trustworthy enough to incorporate into changes in their traditional road restriction decision-making process. The evolution of this decision-making process bears directly on this

evaluation's ability to detect measurable post-deployment changes that could benefit road maintenance operations or traveler behavior.

- The ability to detect benefits in the road-restriction component of this evaluation appears to depend on three elements: First, is the new, modeled information about the links between weather and road conditions going to be sufficiently different from the historical information, such that one would reasonably expect to see measurable differences? Second, even if there are significant differences, are the District Engineers likely to change their decision making based on a first year of new, unproven data? That is, will they be confident enough in the models to make these decisions differently? And third, even if the answer to these first two questions is "yes," is there a sound basis for anticipating changes that will be any less burdensome for travelers? These are important unanswered questions and uncertain benefit outcomes.
- The institutional integration of road-weather information into the transportation and emergency response activities of both North and South Dakota has headed in a substantially different direction than was anticipated earlier in this earmark project. The consolidation of NDDOT's #SAFE program into the new 511 traveler information program has essentially co-opted the earlier intent to develop an integration work plan directly with these agencies under the earmark program.
- Even prior to the 511 program launch in North and South Dakota, the two states found themselves heading in somewhat different directions with regard to how they wanted to manage road-weather information. In both states, the DOTs, emergency management agencies, and state patrols had their own ideas about what was the best way to accomplish information integration. Differing information and system architectures in the two states, and different timetables for completing these architectures, coupled with different budgeting priorities, added to the difficulties of trying to get everyone on the same page.
- Other problems that occurred in the course of this earmark included the September 11th event and numerous wild fires. Two of the principal NDDOT staff who managed the earmark project were given new assignments and responsibilities by the Governor of North Dakota, primarily to help deal with the fires and also to help respond to the enhanced security situation. The involvement of key agency staff in both states in response to these events made it difficult to arrange for meetings to discuss the road-weather data integration and other aspects of the earmark evaluation.

Notwithstanding the decision to terminate the evaluation of this earmark, significant progress has been made under the earmark toward expanding on the early work under #SAFE, enhancing awareness of the value of integrating ATIS across states and agencies, and building the 511 program on this foundation. Winter road-weather information applications in North and South Dakota and the creative use and dissemination of ATIS for both travelers and operators has set a model for other states to emulate.

APPENDIX A

DISTRICT ENGINEERS INTERVIEW GUIDE

Contact Name: _____ Title: _____

District Number: _____ Office Location: _____

Date/Time: _____

Introduction for discussion:

- My name is _____, and I am with Meyer Mohaddes, Associates in Boise, ID.
- We are assisting Battelle Memorial Institute to conduct an FHWA-sponsored independent evaluation of the North Dakota Road Restriction Process.
- The project is part of an effort to improve the Road Restriction decision-making process. We are working closely with the state, Ed Ryen and Jerry Horner of the Districts' Central Office, and the University, Leon Osborn and Mark Owens, to gather baseline information about how the road restriction decision-making process throughout the state is conducted.
- This interview will provide baseline information for how the state's restrictions are currently placed on roadways and highways.

Be assured that your information will be kept confidential. The following information will be used for the purpose of this survey only.

This will take 15-20 minutes. Are you the person in the office with whom I should speak and is this a good time to speak to you?

1. Do you make decisions to place Spring Road Restrictions to limit truck weights on certain Highways/Roadways?

   ❒ Yes ❒ No

   If not, who makes the decisions? _____

2. What information/data do you have access to when making an initial decision to place a Road Restriction? _____

3. What is the process that you use to determine the initial level of Road Restrictions in your jurisdiction? _____

4. After the first Road Restriction is placed, what additional information is used to increase or decrease the Road Restrictions?_____

5. After the first Road Restriction is placed, what is the process that you use to determine what level of Road Restrictions to use? _____

6. Do you coordinate your Road Restriction levels with other Districts?

   ❒ Yes ❒ No

   And if so, how?_____

7. How many problems/complaints does your District receive in a season related to Road Restrictions?

   _____Number of reported problems/complaints

8. What are the typical complaints received?

9. Do you feel that you have adequate information to place Road Restrictions?

   ❒ Yes ❒ No

10. Is there any information you don't currently have available that would be helpful to you in supporting better road restriction decisions?

11. What recommendations would you offer to improve the Road Restriction placement process?

Thank you for being willing to participate in the evaluation of the Road Restriction decisions process. We would like to contact you again later, in the late Spring or early Summer of 2003, to ask some follow up questions.

APPENDIX B

COMMERCIAL VEHICLE OPERATORS INTERVIEW GUIDE

Introduction for discussion:

- My name is _____, and I am with Meyer Mohaddes, Associates in Boise, ID.
- We are assisting Battelle Memorial Institute to conduct an FHWA-sponsored independent evaluation of the North Dakota Road Restriction Process.
- The project is part of an effort to improve the Road Restriction decision-making process. We are working with the state (Ed Ryen and Jerry Horner of the NDDOT's Central Office), the University (Leon Osborn and Mark Owens), and Commercial Vehicle Operation personnel to gather baseline information about how the road restriction decision-making process throughout the state is presently conducted and how it affects the operations of trucking companies like yours.

  Be assured that your information will be kept confidential. The following information will be used for the purpose of this survey only.

This will take 15-20 minutes. Who in your company would be the most knowledgeable about road restrictions on traveled roadways of your company and the affect they have on your operations?

Company Name:_____ Contact Name:_____
Date/Time:_____ Title: _____
Office Location:_____ Telephone No:_____

1. What type of goods does your company haul (typical cargo)?_____
   _____

2. How many tractors/trailers/trucks does your company own and operate within or through North Dakota?
   Tractors_____ Trailers_____ Trucks_____

3. Are you familiar with the 5 different road restriction levels (If no, I'll briefly explain)?
   ❒ Yes ❒ No

4. What information sources do you use primarily to get road restriction information?
   ❒ Internet (Web site): _____
   ❒ DOT (Faxed information)
   ❒ Signs posted on the roadway
   ❒ Other Truckers
   ❒ Other (Specify):_____

5. Name the three most frequent shipping routes by origin and destination:

	Origin	Destination
1-	_____	_____
2-	_____	_____
3-	_____	_____

6. A) What percent (%) of your annual shipments occur during the road restriction season (April – June)? % of Trips _____

   B) When road restrictions are placed on some roads lowering the maximum weight limits, how does it affect your operation? _____

7. A) What actions are taken in response to the North Dakota placed road restrictions (check)?
   - ❒ Petition/apply for oversize/overweight (OS/OW) permits to exceed roadway restrictions
   - ❒ Alter loads to meet the restrictions
   - ❒ Seek special permission to traverse restricted area
   - ❒ Choose a different route for hauling your goods/services
   - ❒ Wait or choose a different time to haul your goods/services
   - ❒ Other (Specify):_____

   B) How frequently does your company take these actions that affect your operations?_____

8. A) How much advance notice do you usually receive about road restrictions before they happen? Days _____(look at question 4 for correlation)

   B) How does your company plan in response/anticipation of the placement of these road restrictions?_____

9. A) If earlier notice could be provided to you regarding upcoming road restrictions, would that be of value to you?

   ❒ Yes ❒ No

   B) How (What would you do differently)?_____

10. A) Do you divide your loads in response to a road restriction placements?

❒ Yes ❒ No

B) How often do you divide loads to stay within a particular load category?
% of Trips/Loads _____(Flexibility/Choose to do?)

11. Do the restrictions on the roadway cost your company? Person-hours _____hrs
(Tell me the affects on your operations –Cost) Cost $ _____
Other _____

12. How much advance notice would your company like to have? _____Days

13. A) If the road restrictions could be shortened, would that be of value to your company?

❒ Yes ❒ No

B) How would it affect your operations and your response to road restriction placements? ___
_____
_____
_____

14. A) If the road restrictions could be more selective in which highway segments are affected, would that be of value to your company?

❒ Yes ❒ No

B) How (What would you do differently)? _____
_____
_____
_____

15. A) Would you be interested in participating in this on-going study of the affects of road restriction next winter to help us evaluate the impacts of possible changes in road restriction implementation on your operation?

❒ Yes ❒ No

B) May we call you again next winter/spring to ask some follow-up questions?

❒ Yes ❒ No

Any other Questions or Comments?

_____
_____
_____
_____
_____

Thank you for being willing to participate in this evaluation.