

# Wyoming Department of Transportation



## Statewide Transportation Management Center (TMC)



## WEATHER INTEGRATION PLAN

December 15, 2010

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## **ABBREVIATIONS AND ACRONYMS**

ASOS	Automated Surface Observing Systems
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
AWOS	Automated Weather Observing Systems
DMS	Dynamic Message Signs
ECAR	Enhanced Citizen-Assisted Reporting
EOC	Emergency Operations Center
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
ITS	Intelligent Transportation Systems
MDC	Mobile Data Computer
MDSS	Maintenance Decision Support System
OEM	Office of Emergency Management
RWIS	Road Weather Information System
RWMP	Road Weather Management Program
SALECS	State Law Enforcement Communications System
TMC	Transportation Management Center
VSL	Variable Speed Limit
WHP	Wyoming Highway Patrol
WIM	Weather Information Manager
Wx	Weather
WYDOT	Wyoming Department of Transportation

## **1. Introduction**

### **1.1 Background**

The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has established a programmatic road map that identifies the integration of weather information into the operations of Transportation Management Centers (TMCs) across the country as a key objective. Integrating weather information supports the capability of state and local transportation agencies to better manage their traffic, dispatch maintenance crews and respond appropriately and in a timely way to weather-induced problems affecting the transportation system. Well-integrated weather information allows TMC operators to make effective and timely management and operational decisions based on quality information related to weather forecasts, the anticipated timing and intensity of weather events, and the interaction of weather conditions with the road surface. Integrated weather information positions a TMC to be proactive rather than reactive with regard to the operations and maintenance of their transportation infrastructure. The FHWA has prepared a detailed self-evaluation "Guide" that assists TMCs in identifying appropriate weather integration strategies, given their current level of weather integration and where they would like to be with regard to enhanced integration and to prepare a weather integration plan based on strategies suggested by the self-evaluation.

### **1.2 Purpose**

The WYDOT Statewide Transportation Management Center (TMC) was chosen by the FHWA to conduct a weather information integration self-evaluation and planning process (using a provided Guide) and provide feedback. The Guide was prepared in an electronic form (Microsoft Access) that walks the user through several sections to eventually result in the identification of potential weather information integration strategies that a TMC may consider for future enhancements to their operations. The WYDOT Statewide TMC was chosen because of their strong interest in improving their use of weather information in support of their operations and to better manage the extreme weather events experienced throughout the state. The TMC was asked to review the Guide and provide feedback that will be used to improve the Guide. As part of this activity, WYDOT was asked to develop a weather integration plan. This document is that plan.

Since the jurisdiction for WYDOT's TMC is statewide, this plan was undertaken as part of an effort to develop a weather integration strategy for the entire state of Wyoming. In addition, this effort was to aid developers with the final design of the FHWA's Weather Integration Self-Evaluation and Planning Guide.

### **1.3 TMC Overview**

WYDOT's statewide TMC became operational in the Fall of 2008. The TMC is housed in the basement of the Qwest building at 6101 Yellowstone Road in Cheyenne, Wyoming, approximately a mile north of the WYDOT headquarters complex. The TMC houses both the emerging Intelligent Transportation Systems (ITS) operations function and a new dispatch center for the Wyoming Highway Patrol.



Source: Courtesy C. Cluett, Battelle

**Figure 1 – TMC Building Exterior**



Source: Courtesy WYDOT Public Affairs Office

**Figure 2 – TMC Operations Room**

While numerous states already have similar TMCs in operation to deal with urban traffic congestion, Wyoming's center is geared almost exclusively toward rural travel management and information needs that result from extreme weather conditions. Additionally, it is one of the few TMCs where communication services for DOT construction, traffic, and maintenance functions are co-located with law enforcement.

## 1.4 Key Functions of WYDOT's TMC

The functions of the TMC have expanded over time, but the core functions can be grouped into the following four main areas:

- **Monitoring and control of roadside ITS devices** such as web cameras, road weather information systems (RWIS), variable speed limit (VSL) signs, dynamic message signs (DMS), highway advisory radios (HAR), flashing beacons, and road closure gates;
- **Serving as a law enforcement communications hub** for state and federal agencies by maintaining frequent contact with Highway Patrol troopers and other personnel via the State Law Enforcement Communications Systems (SALECS);
- **Managing communication with the traveling public** via the 511 Travel Information Service (telephone and internet components) and direct contact with media outlets, visitor centers, and truck stops;
- **Receiving and relaying road and weather reports** from volunteers participating in the Enhanced Citizen-Assisted Reporting (ECAR) program, as well as, dispatching WYDOT construction and maintenance crews throughout the state.

## **1.5 Weather Integration Self-Evaluation Process**

WYDOT was first introduced to the Weather Information Integration Self-Evaluation and Planning Guide on April 22<sup>nd</sup>, 2009. On May 18<sup>th</sup>, 2009, WYDOT conducted a meeting to work through the Guide with a team of stakeholders from WYDOT Maintenance, Winter Research Services, the Transportation Management Center, Highway Patrol Dispatch, and the National Weather Service. During this two-hour meeting, the stakeholders worked their way through the Guide, answering the questions collectively as a group. The stakeholders included the following individuals:

Chad Hahn, Senior Forecaster, National Weather Service, Cheyenne  
Ken Shultz, P.E., State Maintenance Engineer, WYDOT, Cheyenne  
Tim McGary, P.E., District Maintenance Engineer, WYDOT, Laramie  
Captain Bill Morse, Patrol Dispatch Supervisor, WYDOT, Cheyenne  
Cliff Spoonemore, P.E., Winter Research Services, WYDOT, Cheyenne  
Vince Garcia, P.E., GIS/ITS Program Manager, WYDOT, Cheyenne  
Kevin Cox, P.E., ITS-Systems Engineer, WYDOT, Cheyenne

Selected output from the Guide is included in the appendices.

## **1.6 Relationship to Other Plan Documents**

This section lists current and proposed documents that help guide the TMC's practices and operations. Along with the name of each document is a brief description of its relationship to this Weather Integration Plan.

***Wyoming Statewide Intelligent Transportation (ITS) Architecture*** - This document produced by WYDOT was published in April 2006. It updated the previous ITS Strategic Plan that WYDOT had been operating under since 2002. This document serves as a high-level guide for ITS infrastructure deployment, compliance with ITS standards, and multi-jurisdictional coordination. It relates to TMC weather integration by providing a good planning reference for future ITS deployments, and guidance on how WYDOT communicates with surrounding states during storm events.

***WYDOT Transportation Management Center Concept of Operations*** – This document produced by WYDOT was adopted in March 2005. It was the primary planning document used to design, build and staff WYDOT's TMC. This document represented the culmination of several years work to identify the TMC requirements and the entire systems engineering process. This document is relevant to the TMC weather integration because it provides several examples of operational scenarios that involve winter weather maintenance and traveler information.

***Variable Speed Limit (VSL) Policy Memorandum*** – This policy has been developed over the past two years to provide WYDOT with an interim process by which appropriate speeds can be determined and posted on VSL signs. The current policy relies heavily on speed sensor data for determining speed, but the TMC operators, Highway Patrol, and maintenance personnel also use whatever weather information is available to assist in establishing an appropriate speed for conditions.

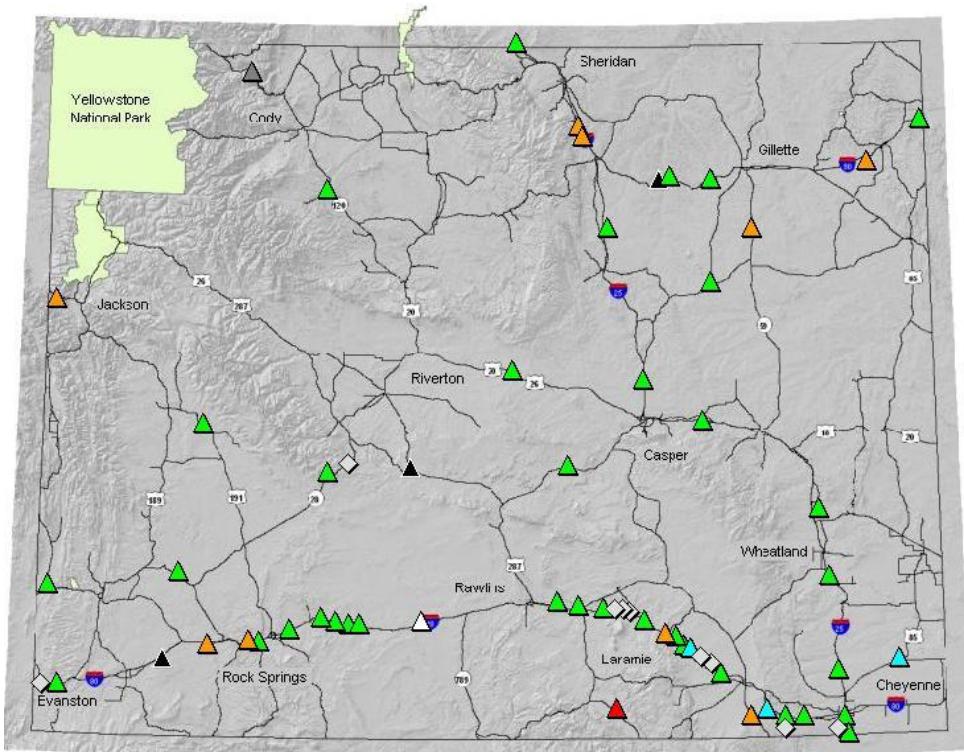
***Proposed VSL Control Strategy*** – This document and process is still being developed by the University of Wyoming. When complete, this document will provide the necessary documentation to implement a sound practice for WYDOT to use to post speed limits on VSL signs. Preliminary reports indicate that this control strategy will require input from both speed sensors and RWIS stations to determine appropriate speed limits. The way in which WYDOT manages weather information within the TMC will be fundamental to the development of this process and this document.

***High Wind/No Light Trailer Alerting Policy*** – This is a policy established by the TMC and district maintenance personnel simply to establish definitive, consistent thresholds for posting either high wind conditions, or advising no light trailers.

## 2 Existing Road Weather Management Systems

### 2.1 RWIS Infrastructure

Currently, WYDOT has a network of 62 RWIS stations located throughout the state. They are managed by a central software system known as SCAN Web. The two figures that follow are screen shots from that software, showing the statewide network, followed by a more detailed map of southeast Wyoming where WYDOT has deployed greater density of RWIS for a 52-mile VSL corridor between Laramie and Rawlins. Between the two figures is a table listing the RWIS locations statewide.



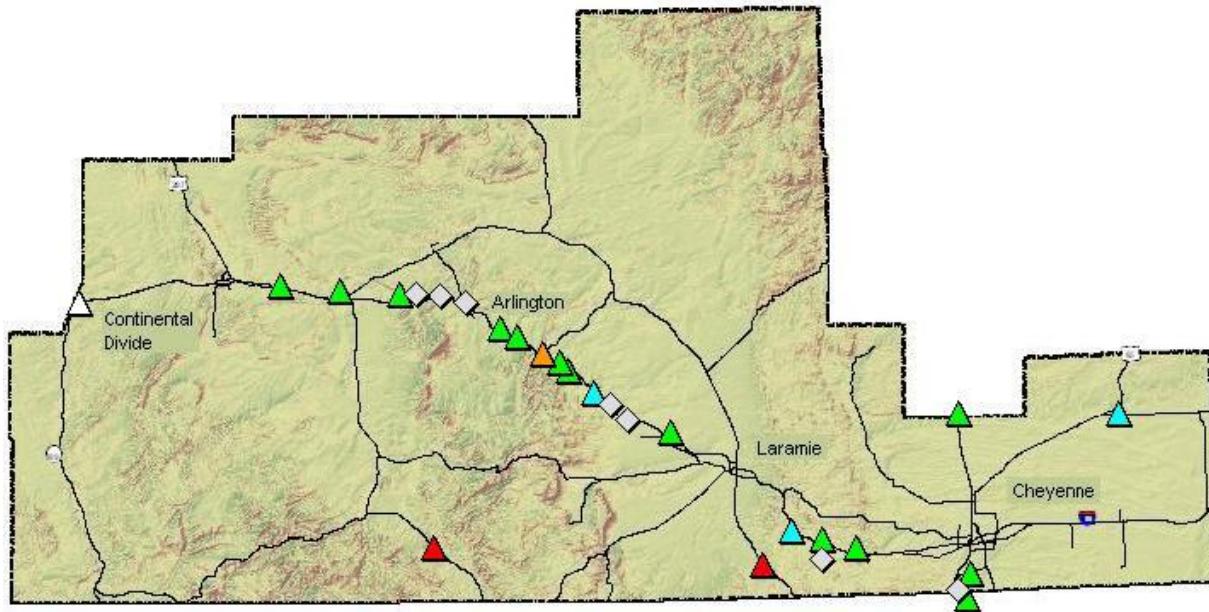
Source: Screenshot of ScanWeb Map Image

**Figure 3 – RWIS locations statewide**

**Table 1 – List of RWIS Locations**

RWIS No.	SITENAME	Highway	MILEPOST
1	Wyo Hill	I - 25	3.52
2	Whitaker	I - 25	30.2
3	Bordeaux Interchange	I - 25	70.8
4	Coleman	I - 25	98.7
5	Deer Creek	I - 25	164.2
6	Twenty Mile Hill	I - 25	207.2
7	I-25 Divide	I - 25	267.3
8	Evanston	I - 80	4.2
9	First Divide	I - 80	13.86
10	Church Butte	I - 80	52.65
11	Peru Hill	I - 80	82.31
12	Green River Tunnel East	I - 80	90.5
13	Rock Springs West	I - 80	97.9
14	Baxter Road	I - 80	111.5
15	Superior	I - 80	124.5
16	Point of Rocks	I - 80	129.8
17	Bitter Creek	I - 80	141.83
18	Tipton	I - 80	156.72
19	Continental Divide	I - 80	184.3
20	Sinclair	I - 80	221.7
21	Walcott Junction	I - 80	234.66
22	Dana Ridge	I - 80	244.8
23	Mile Marker 249.1	I - 80	249.1
24	Halleck Ridge	I - 80	252.16
25	Elk Mountain	I - 80	256.17
26	County Road 402	I - 80	262
27	Wagonhound	I - 80	266.58
28	Foote Creek	I - 80	269.5
29	Arlington	I - 80	271.8
30	Arlington East	I - 80	273.85
31	Cooper Cove	I - 80	279.36
32	Strouss Hill	I - 80	283.75
33	Quealy Dome	I - 80	289.5
34	Herrick Lane	I - 80	297.66
35	Summit East	I - 80	325.8
36	Vedauwoo	I - 80	329.4
37	Vedauwoo	I - 80	329.4
38	Remount	I - 80	340.5
39	Montana Line	I - 90	0.1
40	Piney Creek North	I - 90	43.7
41	Piney Creek Interchange	I - 90	44.7
42	Indian Creek Rd	I - 90	83.3
43	Dead Horse	I - 90	91.5
44	Mile Marker 108	I - 90	108
45	Inyan Kara	I - 90	170.5
46	Beulah Interchange	I - 90	205.9
47	Rim	US - 191	127
48	Hiland	US - 20/26	57.4
49	Pumpkin Vine	US - 287	420.4
50	Beaver Rim	US - 287 / WY 789	48.1
51	Sage Junction	US - 30	34
52	Gun Barrel	US - 85	46.8
53	Meeteetse Rim	WY - 120	61.5
54	Teton Pass	WY - 22	11.2
55	Pathfinder	WY - 220	80.1
56	Skyline	WY - 230	113.2
57	South Pass	WY - 28	41.4
58	Red Canyon	WY - 28	59.5
59	Chief Joseph	WY - 296	32.96
60	Shute Creek	WY - 372	36
61	Pine Tree Junction	WY - 387	131.79

The VSL corridor is the first of its kind in Wyoming. It consists of a 52-mile stretch of Interstate 80 from Walcott Junction (20 miles east of Rawlins) to Quealy Dome Interchange (17 miles west of Laramie). In that 52-mile corridor, WYDOT now has 13 RWIS stations. This project represents the first corridor-level RWIS deployment in WYDOT's history.



Source: Screenshot of ScanWeb Map Image

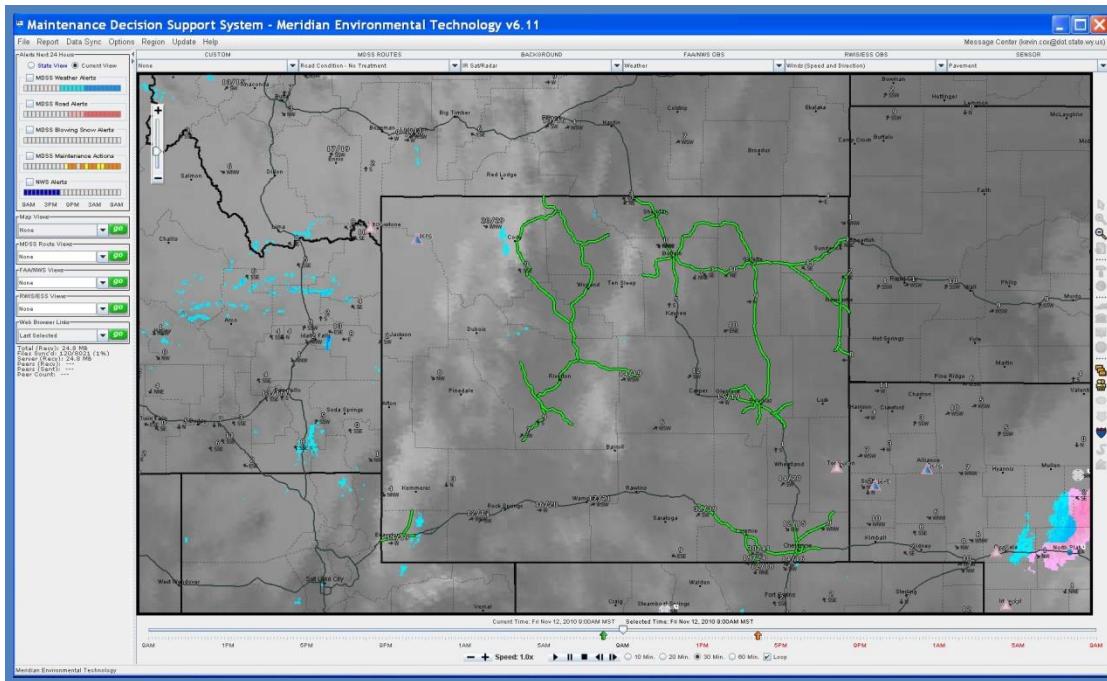
**Figure 4 – RWIS in southeast Wyoming**

RWIS maintenance statewide is primarily conducted by WYDOT forces with the exception of an annual maintenance contract to assist WYDOT forces with the annual preventive maintenance. Annual maintenance costs for WYDOT RWIS are estimated at about \$4,000 per site for WYDOT.

## 2.2 Maintenance Decision Support System

Over the past several years, WYDOT has participated in the FHWA pooled-fund study to deploy a maintenance decision support system (MDSS). That product is currently being used by WYDOT as provided by Meridian Environmental Technologies. The extent to which it is used within the TMC has been somewhat limited, but is beginning to emerge as a useful tool for the TMC operators in road weather condition status and forecasting.

There is no formal guideline in place for using MDSS in WYDOT's day-to-day operations. Several maintenance crews use the system. However, there is no coordinated effort within WYDOT for how best to use this tool either within the TMC or between the TMC and maintenance. The TMC intends to put this system to better use in the future. Figure 5 below is an image of the MDSS graphical user interface.



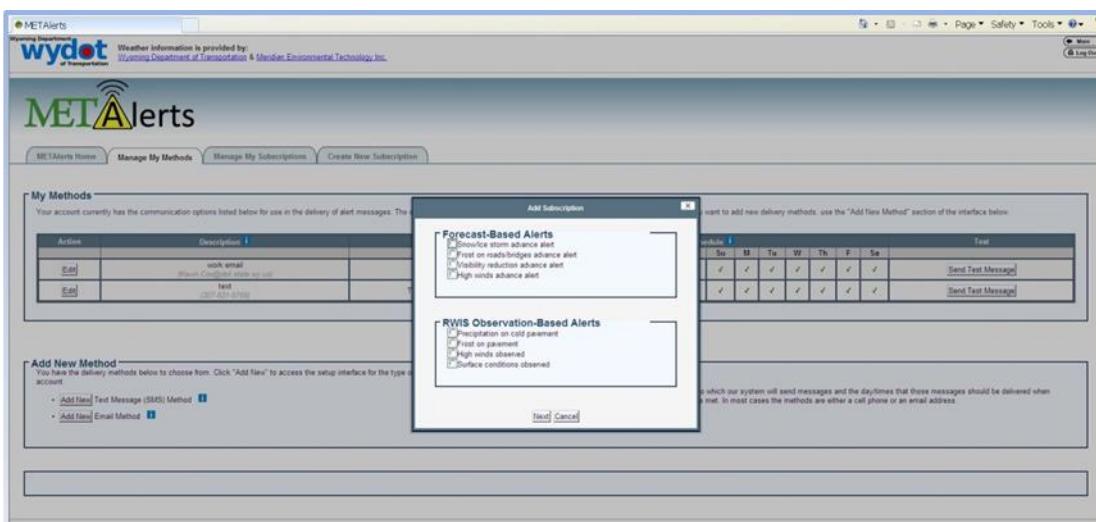
Source: Screenshot of MDSS, Meridian Environmental Technology

**Figure 5 – MDSS User Interface**

## 2.3 Alert Notifications

Another product of the MDSS system is known as METalert. It provides current and forecast weather alerts based on individual user-defined thresholds for counties, cities, or individual RWIS stations. WYDOT has just deployed this system, and made it available to TMC operators and maintenance personnel. Below is a screen shot from the application showing the types of alert notifications available.

The alerting system provides for either e-mail or text message notifications, and has quite a few variables for criteria threshold selection. However, the limitation of this system is that it doesn't provide pop-up alerts on the TMC operators' computer screens.



Source: Screenshot of WYDOT METAlerts System

## Figure 6 – Weather Alerting System

In the past, WYDOT had used SCAN Sentry alerting system which is part of the overall SCAN Web RWIS management package used to monitor WYDOT's RWIS. There has not been much success in implementing that into the TMC due to configuration issues with setting reasonable thresholds. The complaint from the TMC operators has been that it sends repetitive alerts for the same condition. Further investigation will be conducted to see if appropriate parameters can be established for that alerting system.

## 2.4 NorthWest Weathernet

NorthWest Weathernet is the forecasting service WYDOT maintenance forces have used for several years. The service consists of a text-based twice daily forecast hosted on a website. It provides forecasts based on WYDOT's maintenance shop locations. This format has proven to be very useful for the maintenance foremen and plow operators because they can easily scroll down to their shop location, and get an up-to-date forecast for their area. The format has proven to be more cumbersome from the TMC's statewide or even sometimes district-wide perspective.

Below is a sample screen shot of the product provided by NorthWest Weathernet, Inc.

The screenshot shows a Microsoft Internet Explorer window with the title bar "Wyoming Department of Transportation - Windows Internet Explorer provided by GISITS". The address bar shows the URL "http://www.nw-weathernet.com/wydot.htm". The page content is a weather forecast for "DISTRICT 1".  
**Weather Discussion:**  
A "Clipper" event out of Alberta will move quickly N to S will impact the district from 02/0300 Sat through 17/1800 Sat. Very light snowfall will be developing and becoming widespread. NW winds of up to 35 mph are expected with this event. Most valley routes including I-25 eastward will see a dusting to 1" of road snow through 10/1100 then roads trending wet. Up to 1-2" is expected in the Laramie range and around the SW Dist 1 mtns, including Elk Mtn and Arlington. Ice becomes a high impact concern in most areas after sunset Sat. Some blow and drift is expected, largely in the Laramie range and Arlington/Elk Mtn.  
There will continue to be on and off light blowing snow showers on all mtn routes over 7,800 ft Sat night and Sun. Road snow accumulations there will be light and sporadic with the peak period being Sun afternoon. All valley/basin routes look to stay dry but it is a close call. Watch for updates.  
**BAGGS**  
FRI NIGHT ... Snow showers E 70 after 01/0200. Snow showers 789 mainly after 0300. Areas of drift/minor blow. Lower teens Battle to upper teens 789. 1" Battle, dustings to ½" 789.  
SNOW Concern = 6, ICE = 3, FROST = 0, HIGH WIND = 4  
SAT ... Snow showers E 70. Snow showers 789, mainly before 1500. Areas of drift/minor blow. Lower 20s Battle, upper 20s 789. 2" Battle, dustings 789 before 1100.  
SNOW Concern = 7, ICE = 4, FROST = 0, HIGH WIND = 4  
**RAWLINS**  
FRI NIGHT ... Snow showers after 0300. Areas of drift/minor blow. Upper teens. Dustings to ½".  
SNOW Concern = 6, ICE = 2, FROST = 0, HIGH WIND = 4  
SAT ... Snow showers mainly before 1500. Areas of drift/minor blow. Upper 20s. Dustings before 1100.  
SNOW Concern = 2, ICE = 1, FROST = 0, HIGH WIND = 4  
**SARATOGA**  
FRI NIGHT ... Snow showers mtns/Skyline after 0200. Snow showers Sara mainly after 03/0400. Areas of drift/minor blow. Lower teens Battle to upper teens Sara. 1" Battle, ½-1" Ryan/Skyline, dustings to ½" Sara.  
SNOW Concern = 7, ICE = 3, FROST = 0, HIGH WIND = 4  
SAT ... Snow showers mtns/Skyline. Snow showers Sara, ending after 16/1700. Areas of drift/minor blow. Lower 20s Battle, near 30 Sara. 2" Battle, 1-2" Ryan/Skyline, dustings Sara before 1100.  
SNOW Concern = 6, ICE = 4, FROST = 0, HIGH WIND = 4  
**EEL MOUNTAIN**  
FRI NIGHT ... Snow showers mainly after 02/0300. Drift/minor blow. Mid teens. Dustings to ½".  
SNOW Concern = 6, ICE = 2, FROST = 0, HIGH WIND = 4  
SAT ... Snow showers, ending after 17/1800. Drift/blow. Upper 20s. 1" or so summit, 1/2" Hanna.  
SNOW Concern = 6, ICE = 4, FROST = 0, HIGH WIND = 4  
**MEDICINE BOW**  
FRI NIGHT ... Snow showers mainly after 0300. Drift/minor blow. Mid teens. Dustings to ½".  
SNOW Concern = 6, ICE = 2, FROST = 0, HIGH WIND = 4  
SAT ... Snow showers, ending after 1600. Drift/blow. Upper 20s. Dustings to ½".  
SNOW Concern = 6, ICE = 4, FROST = 0, HIGH WIND = 4

Source: Screenshot of WYDOT NorthWest Weathernet

## Figure 7 – NorthWest Weathernet WYDOT page

## **2.5 Other TMC Weather Resources**

Numerous other sources of weather information are currently being used within the TMC. Most of these are in the form of websites such as Intellicast, the Weather Channel, or the National Weather Service. Additionally, there is a television in the TMC which is oftentimes tuned to the Weather Channel, or a national or local news channel which occasionally show weather information.

## **3 Concepts of Operations**

In terms of operational concepts for using weather within the TMC, very few formal guidelines or written policies exist. There are some established thresholds from RWIS stations that require action in terms of notifying maintenance or the public of conditions.

Conceptually, the TMC attempts to manage weather at two levels, statewide and/or corridor.

### **3.1 Statewide Weather Management**

The TMC is the only entity at WYDOT that attempts to, or has the responsibility to manage weather from a statewide perspective. Although there are many weather information resources, no single group or person within the TMC is tasked with managing weather information and providing a strategy to handle it statewide. In effect, the TMC still has a WYDOT legacy tendency to operate as five separate maintenance districts. However, the TMC offers WYDOT's best promise for strategic management of weather events.

### **3.2 Laramie to Cheyenne (The Summit) Commuter Corridor**

This corridor along Interstate 80 was WYDOT's first corridor-level deployment of ITS equipment back in 2003. Additional equipment has been deployed in this corridor since 2003. Today, the ITS equipment in this 20-mile stretch includes: six cameras, ten dynamic message signs, three RWIS stations, and twelve speed sensors. With the density of DMS signs in this corridor, the TMC is able to provide traveler information in a slightly different manner. Essentially, information can be provided in a more location-specific manner as to road and weather conditions. The treacherous nature of this corridor has made it a candidate for one of the next three VSL corridors in the state.

### **3.3 Variable Speed Limit Corridor**

WYDOT's first VSL corridor is a 52-mile stretch of Interstate 80 located in the south central part of the state between the towns of Rawlins and Laramie. The VSL signs for the corridor became operational February 13<sup>th</sup>, 2009. In their first 14 months of use, they have proven to offer some very positive results in terms of number and severity of accidents, and number and length of closures.

The corridor consists of 14 VSL locations (seven in each direction). Vehicle speeds are monitored by side-fire radar detectors at 18 locations, and central control software provides average speeds for all vehicles every 30 seconds. The speeds are displayed on a map using color-coded icons and highway segments that change color based on the average observed speeds. Additionally, 13 RWIS sensors provide real-time weather information, including surface status, visibility, wind, humidity, air temperature and surface temperature.

### **3.3.1 Current Policy/Procedure**

The current policy for posting speed limits was developed in a cooperative effort amongst the TMC, Highway Patrol, and the District Maintenance personnel. The policy is lengthy, and describes the procedures for posting speeds based on the situation, and the personnel available at the time of posting a speed limit change.

The policy does allow TMC operators to reduce the speed based on a sustained speed reduction of at least 10 MPH for at least 15 minutes. The TMC operators primarily use speed data to make this decision, but also refer to RWIS data as supporting information.

### **3.3.2 Draft Control Strategy**

WYDOT's ITS Program is currently working with the University of Wyoming's Civil Engineering Department to come up with a control strategy that would automate, and make better use of the speed and weather data to provide TMC operators with a quality recommended speed based on the information available from these sensors. The control strategy is in its early phases of development, and the draft version will begin to be tested this Fall.

## 4 Integration Needs

After completing the self-evaluation “interview” process, 11 high priority needs were identified as shown in Table 2 below. There were also seven medium priority needs, and two low priority needs. As the group evaluated the needs and their levels, it became apparent that by addressing the high priority needs, most of the medium and low priority needs would be addressed. (See Appendix D)

The sections below describe the 11 high priority needs, and group them into four main “need” areas.

**Table 2 – High Priority Needs**

Need Areas	Definition of Need
<b>Advisory Operations</b>	
Weather Information Dissemination	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
<b>Institutional Coordination</b>	
Written Policy Development	Develop and implement clear, written policies and procedures for handling weather events.
Coordination within TMC	Improve coordination within the TMC
Coordination with Adjacent Jurisdictions	More coordinated responses and information with adjacent jurisdictions/regions
<b>Treatment Operations</b>	
Level of Service Restoration	Reduce the time required to restore pre-event level of service operations after a weather event
Weather Management Response	Improve the timeliness of weather management response including deployment of field personnel and equipment
<b>Weather Information Processing and Gathering</b>	
Interpreting Weather Information	Assistance in interpreting weather information and how best to adjust operations in light of that information.
Improving Weather Information Coverage	Improve the coverage and granularity of weather information in the region.
Better Real-Time Information On Road Conditions	Better real-time information on road conditions during weather events.
Better Prediction of Weather Event Impacts	Better prediction of impact of weather events including assessment of reduction in capacity.
Better Short-Term Forecasts	Better short-term forecasts of arrival time, duration, and intensity of specific weather events at specific locations.

## **5 Integration Solutions**

The “Levels of Integration” matrix (see Figure 8 on the following page) shows where WYDOT’s TMC is today (highlighted in yellow), and where it needs to be following integration (highlighted in pink). This matrix represents recommendations directly from the Self-Evaluation Guide.

The six items of integration shown in gray are the six broad areas where WYDOT’s TMC needs to improve from its current level of integration to a proposed level of integration in order to effectively integrate weather into its operations. The sections below give more detail on each of these integration areas, and offer proposed solutions on how that integration might be accomplished.

### **5.1 Frequency of Road Weather Observations**

This integration item can best be addressed by expanding the frequency of real-time reports from individuals traveling on Wyoming highways, including, but not limited to plow drivers, the commercial trucking community, and other members of the traveling public.

Presently, snow plow operators call the TMC when either conditions change, or two hours have passed. The TMC could benefit from the implementation of a system that notifies when each currently active plow has passed the two-hour report timeframe.

Additional reporting could come from other travelers on WYDOT’s highways, assuming that they have been properly trained to identify conditions, and how to pass that information to the TMC.

### **5.2 Weather Information Coordination**

As can be seen from the levels of integrations matrix, this item of integration has the biggest gap in terms of where WYDOT currently is (highlighted in yellow), and where WYDOT would ultimately like to be in terms of TMC weather integration. Consequently, most of the initial implementation efforts of this plan will focus in this broad area of weather information coordination.

WYDOT plans to at least partially address this need immediately by contracting with a part-time local meteorologist (DayWeather, Inc.) to perform weather information management tasks in the TMC. This initial contract began in early December 2010 and will extend for a trial period through May 31<sup>st</sup>, 2011.

### **5.3 Extent of Coverage**

Until this past year, WYDOT had a scattered network of approximately 32 RWIS stations throughout the state. With the implementation of the first VSL project, WYDOT found it necessary to increase the coverage of real-time weather information, and implemented its first corridor-level RWIS deployment, installing 13 RWIS in a 52-mile stretch of interstate.

Item of Integration (Broad Requirement)	Levels of Integration					
	None	Level 1	Level 2	Level 3	Level 4	Level 5
Use of Internal Weather Information Resources	None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	<b>Level 2 data plus data from RWIS and related networks</b>	Level 3 data plus data from AVL/MDC sources and internal radio communications	Level 4 data with addition of analyzed fields & transformed data parameters (frost index, wind chill, snow, ice, water depth)
Use of External Weather Information Sources	None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	<b>Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies</b>	Direct connection between private weather information service providers and traffic management software
Availability of Weather Information	None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall	Field observers or ESS network providing scheduled road or driving condition reports	<b>Vendor provided daily surface transportation weather forecasts and observed weather conditions incl Level 3</b>	Meteorologist, located within TMC, forecasting and interpreting weather
Frequency of Weather Forecasts	None	Receive weather forecast information on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	<b>Receive hourly weather forecasts several times a day</b>	Receive continuous updates of weather forecasts in real-time
Frequency of Weather/Road Weather Observations	None	Receive information of weather conditions on a request basis	<b>Receive weather observations once hourly</b>	<b>Level 2 plus receive weather/road weather observations when predefined threshold has been exceeded</b>	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted
Weather Information Coordination	<b>None</b>	Intra-TMC committee tasked with weather information coordination	Identified TMC or member tasked w/ coordinating weather information at TMC	<b>Dedicated weather operations supervisor</b>	Meteorology staff located within the TMC forecasting and interpreting weather info.	Co-location of the EOC/OEM
Extent of Coverage	None	Sparse set of isolated locations	<b>Network of scattered locations</b>	Corridor-level	<b>Multiple-corridor/sub-regional</b>	Regional/statewide
Interaction with Meteorologists	None	<b>Focus group or informal gatherings of local professionals from the transportation management and weather communities</b>	Develop check list of routine weather awareness activities	<b>Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses</b>	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	None	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	<b>Manual email/paging system</b>	<b>TMC road weather system (RWIS / ALERT / FEWS) generated specific notification</b>	Automatic notification through Center-to-Center communications
Decision Support	None	<b>Ad-hoc implementation of weather management strategies</b>	Use quick-reference flip cards on operator's workstation to implement predefined response	<b>Response scenarios through software-supplied solutions w/ projected outcomes based on weather / traffic modeling</b>	Automated condition recognition & advisory/control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention
Weather/Road Weather Data Acquisition	None	Media reports	Internet and/or satellite data sources	Across agency intranet and dedicated phone acquisition	<b>Dedicated communications link to state, federal, private data sources</b>	Dedicated communications link to state, federal, private data sources incl vehicle weather data

Figure 8 – Integration Levels Matrix

This deployment is likely the beginning of many more of its kind in Wyoming. Presently, there are three more VSL projects in the design phase for WYDOT, and one currently under construction.

The TMC is struggling to manage this corridor-level information, and needs to improve its ability to effectively use this more granular information to identify problems, and help establish appropriate speed limits.

## **5.4 Interaction with Meteorologists**

The TMC currently has two very good resources that allow for direct communication with a meteorologist. The first is provided by a direct telephone number to a staff meteorologist at NorthWest WeatherNet, Inc., and the second is either by phone or radio to the National Weather Service meteorologist located in Cheyenne. Both of these resources are currently under-utilized by the TMC. With the addition of a Weather Information Manager on the floor of the TMC, coordination with these resources should improve greatly.

## **5.5 Alert Notifications**

Although WYDOT is presently at integration level 4 on this item, work still remains to enhance our current MetAlert system. Work also remains to attempt redeployment of SCAN Sentry on the TMC operator workstations. Lastly, WYDOT is also going to pursue the development of its own weather information tool that can be tailored to include current and forecast road weather conditions. Part of that tool will include a system to provide alert notifications.

## **5.6 Decision Support**

Two of the biggest decisions TMC operators face on a minute-by-minute basis are determining appropriate DMS messaging and VSL speed postings. Through the use of weather and traffic information, a decision model integrated into WYDOT's advance traffic management system (ATMS) could prove to be an effective means of providing timely, accurate, and consistent messaging and posted speeds on WYDOT's DMS and VSL, respectively.

## 6 Implementation of Integration Plan

### 6.1 Summary of Integration Strategies

Shown below (Table 3) is a summary of WYDOT's integration strategies. The table shows WYDOT's current level for each integration item, the recommendation from the self-evaluation guide, the integration level selected by WYDOT for both the current (C) timeframe, and future (F) timeframe, and comments for each integration item.

**Table 3 – Summary of Integration Strategies**

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level (C/F)*	Rationale/Comments
1: Use of Internal Weather Information Resources	3	3	3/4	C=expand RWIS locations; F=outfit & receive data from plows & other vehicles
2: Use of External Weather Information Resources	4	4	4/4	Build integrated weather information tool to assist TMC operators
3: Availability of Weather Information	4	4	4/4	Availability meets current needs
4: Frequency of Weather Forecasts	4	4	4/4	Frequency meets current needs
5: Frequency of Weather/Road Weather Observations	2	3	3/3	Expand coverage and frequency of plow driver reports
6: Weather Information Coordination	None	3	3/3	Contracting with a part-time local meteorologist to perform weather information management tasks in TMC.
7: Extent of Coverage	2	4	4/5	C=Adding four more VSL corridors throughout the state; F=continued expansion of RWIS sites.
8: Interaction with Meteorologists	1	3	4/5	See item 6 above.
9: Alert Notification	4	4	4/4	Enhance alert notification in phases (use SCAN Sentry, expand METalert , build new alert system w/ new Wx info tool).
10: Decision Support	1	3	3/4	C=automated recommendations for VSL system; F=expand to DMS recommendations.
11: Weather and Road Weather Data Acquisition	4	4	4/5	C=continue current acquisition; F=automated data collection from DOT vehicles.

\* C/F=Current plans (within next 1-2 years)/Future plans (beyond 2 years)

## 6.2 Implementation Tasks

The integration strategies can be grouped into the following seven implementation tasks or projects:

- 1) **RWIS Expansion** - Expand RWIS coverage throughout state, and multiple corridor RWIS projects. We will start by doing a gap analysis, and seek input from District Maintenance offices to determine desired locations. With that, WYDOT can develop an RWIS expansion plan, and budget for new RWIS on an annual basis to complete the desired expansion in approximately the next five years.
- 2) **AVL/MDC** - Expand vehicle weather data transmission to TMC from plows with AVL/MDC. This will include continued deployment of our current AVL system statewide. For the MDC component, WYDOT will use its systems engineering process to ensure all requirements are met, including integration with the current AVL system.
- 3) **Weather Information Manager (WIM)** - Employ part time, contracted meteorologist as weather information manager. This individual will help implement much of this plan, assist the TMC operators in managing and utilizing current and future weather information, and provide a primary point of contact for all weather information resources within WYDOT.
- 4) **VSL Expansion** - Add VSL in four locations and continue to expand in statewide corridors. One of these four new corridors is currently under construction and scheduled to be complete by January 2011. Two more of these four will be operational by October 2011, and the fourth corridor is currently schedule to be constructed in 2012.
- 5) **Weather Information Tool** - Build integrated weather information tool to assist operators. Deploy portions of this for commercial vehicle and general public use. The weather information manager will be instrumental in developing this system. They will also be the one responsible for keeping the information in this tool timely and accurate.
- 6) **Weather Alert Notification** - Expand/enhance alert notification system in phases: 1) using SCAN Sentry 2) expanding METalert system 3) using the new integrated weather integration tool/database. SCAN Sentry is presently available to the TMC, it just needs some fine tuning on the configuration and some additional training for the operators. METalert is also available, but additional features (e.g. visibility alerts) could be very useful for the TMC operators.
- 7) **ATMS Decision Support** - Expand decision support tools, starting with VSL and moving to DMS recommendations. This will include some software development work for our existing ATMS to provide such recommendations based on weather and traffic information.

## 6.3 Integration Timeline and Cost Estimates

The table below shows the seven projects identified in the previous section, an estimated start time and end time for each, an estimated implementation cost, and an estimated operations and maintenance cost.

**Table 4 – Project Timeline and Costs**

<b>Project</b>	<b>Start</b>	<b>Completion</b>	<b>Initial Cost</b>	<b>O&amp;M Cost</b>
<b>RWIS Expansion</b>	Ongoing	2015	\$ 2,000,000	\$ 400,000/year
<b>AVL/MDC</b>	2011	2017	\$ 800,000	\$ 100,000/year
<b>WIM</b>	Ongoing	N/A	N/A	\$ 100,000/year
<b>VSL Expansion</b>	Ongoing	2014	\$ 3,000,000	\$ 200,000/year
<b>Wx Info Tool</b>	2011	2013	\$300,000	\$15,000/year
<b>Wx Alert Notification</b>	Ongoing	2013	\$20,000	\$3,000/year
<b>ATMS Decision Support</b>	2011	2013	\$150,000	\$15,000/year

The good news is that most of these projects are underway and at least partially funded. At this point, the scopes of these projects may need to be slightly re-defined to meet the needs identified in this plan.

#### **6.4 Anticipated Challenges and Constraints**

As shown in Table 4 above, four of the seven projects are already ongoing, and reasonably funded. The AVL project is also underway, but there is no clear direction yet on the mobile data computer (MDC) aspect of that project. Integrating an MDC with the AVL system WYDOT is currently in the process of deploying could prove to be challenging.

The weather information tool will be a fairly challenging undertaking, but many of the components are already in-place to facilitate some of that system. Again, integration of multiple information resources will be the challenge with this project.

Lastly, WYDOT currently has an off-the-shelf ATMS. Tailoring this system to meet the needs of our VSL and DMS decision support could prove to be a difficult task. This software is provided by a third party vendor and their ability to tailor the software to the TMC's needs remains an unknown at this point.

## **Appendix A - Summary Report of Weather Events**

# **Summary report of weather events experienced by your TMC (Section 1 Report)**

<b>Weather Event</b>	<b>Frequency</b>	<b>Extent</b>	<b>Impact</b>
Tornadoes	Seldom	Local/Isolated Spots	Significant Impact
Blowing Sand or Dust	Occasional	Areawide	Significant Impact
Flooding	Occasional	Statewide	Significant Impact
Sleet, and Freezing Rain	Occasional	Areawide	Significant Impact
Blizzard or White-out	Regular	Statewide	Significant Impact
Blowing Snow	Regular	Statewide	Significant Impact
Bridge Frost, Road Frost	Regular	Statewide	Significant Impact
Drizzle and Light Rain	Regular	Statewide	Little Impact
Flurries and Light Snow	Regular	Statewide	Little Impact
High Winds	Regular	Regional	Significant Impact
Moderate to Heavy Rain	Regular	Statewide	Little Impact
Moderate to Heavy Snow	Regular	Statewide	Moderate Impact
Severe Thunderstorms	Regular	Regional	Significant Impact
Smoke, Mist, Fog, Smog or Haze	Regular	Regional	Significant Impact

## **Appendix B – Summary Report of Impacts Due to Weather Events**

# **Summary report of impacts due to your weather events (Section 2 Report)**

Weather often impacts the activities of transportation system operators working to maintain safety and mobility. Making sense of weather information along with recognizing the benefits of its application beyond the simplest case is not a trivial task. As a generalization, TMC operators tend to be more responsive and take action based on their observations of traffic impacts rather than responding directly to weather information. It is important to understand the nature of weather impacts on capacity and speed reductions, impacts on safety (e.g., crash risk/frequency, incident management including Safety Service Patrols that are often dispatched from or coordinated with TMCs), and impacts on institutional coordination (i.e., need for communication between traffic managers and maintenance personnel, traffic managers and emergency management personnel, traffic managers and law enforcement personnel) to ensure that the self-evaluation and the integration solutions address the right concerns. The ability to estimate impacts could presumably lead to managing freeway systems and arterial signal systems using advisory, control and treatment strategies efficiently.

This report identifies the impacts of these weather events on your TMC's traffic operations considering both impacts to users as well as operators

## **Traffic impacts commonly associated with the weather events in your region.**

Weather Event	Increased Travel Times	Increased Crash Risk	Reduced Roadway Capacity	Traffic Management Device Impairment	Disruption of CVO or specialized vehicle operations	Road Closures
Drizzle and Light Rain	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate to Heavy Rain	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Severe Thunderstorms	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Flooding	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Flurries and Light Snow	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Moderate to Heavy Snow	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Blizzard or White-out	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Sleet, and Freezing Rain	■	■	■	■	■	■	■
High Winds	■	■	■	□	■	■	□
Blowing Snow	■	■	■	■	■	■	■
Blowing Sand or Dust	■	■	□	■	■	□	□
Smoke, Mist, Fog, Smog or Haze	■	■	■	■	■	■	■
Tornadoes	■	■	■	■	■	■	■
Bridge Frost, Road Frost	■	■	■	□	■	■	□

## Roadway impacts commonly associated with the weather events in the region

Weather Event	Slick Roads	Road Obstruction	Structural deterioration	Presence of debris	Low visibility	Others (Please specify)
Drizzle and Light Rain	■	□	□	□	□	
Moderate to Heavy Rain	■	■	□	□	■	
Severe Thunderstorms	■	■	■	■	■	
Flooding	■	■	■	■	□	
Flurries and Light Snow	■	□	□	□	□	
Moderate to Heavy Snow	■	■	□	□	■	
Blizzard or White-out	■	■	□	□	■	
Sleet, and Freezing Rain	■	□	□	□	■	
High Winds	□	□	■	■	■	
Blowing Snow	■	■	□	□	■	

Blowing Sand or Dust	■	□	□	■	■
Smoke, Mist, Fog, Smog or Haze	□	□	□	□	■
Tornadoes	□	■	■	■	□
Bridge Frost, Road Frost	■	□	□	□	□

## Specific impacts of weather events in your region on TMC operations

Weather Event	Increased use of equipment and labor	Increased in-house labor	Increased contractor labor	Loss of communications /power	Changes in traffic control operations	Others Significant Impacts
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### LEGEND

4 - Significant Impact, 3 - Moderate Impact, 2- Little Impact, 1 - No Impact

Drizzle and Light Rain	1	1	1	1	1
Moderate to Heavy Rain	2	2	1	1	2
Severe Thunderstorms	3	2	1	3	3
Flooding	2	2	1	1	2
Flurries and Light Snow	2	2	1	1	2
Moderate to Heavy Snow	3	3	1	2	3
Blizzard or White-out	4	4	1	2	4
Sleet, and Freezing Rain	3	3	1	2	2
High Winds	3	2	1	2	3
Blowing Snow	4	4	1	2	4
Blowing Sand or Dust	2	1	1	1	2
Smoke, Mist, Fog, Smog or	3	3	1	1	3
Tornadoes	2	1	1	3	2
Bridge Frost, Road Frost	2	1	1	1	3

## **Appendix C – Summary Report on Current Integration Level**

# Summary report on your TMC's current level of weather integration (Section 3 Report)

## Item of Integration I1 Use of Internal Weather Information Resources

<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	Level 2 data plus data from RWIS and related networks	Level 3 data plus data from AVL/MDC sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)

## Item of Integration I2 Use of External Weather Information Sources

<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software

<b>Item of Integration I3 Availability of Weather Information</b>					
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall or computer screen	Field observers or ESS network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including level 3.	Meteorologist, located within TMC, forecasting and interpreting weather
<b>Item of Integration I4 Frequency of Weather Forecasts</b>					
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
None	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time
<b>Item of Integration I5 Frequency of Weather/Road Weather</b>					
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted

**Item of Integration I6 Weather Information Coordination**

	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC or virtually linked to the TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the EOC/OEM

**Item of Integration I7 Extent of Coverage**

	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide	

**Item of Integration I8 Interaction with Meteorologists**

	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC	

**Item of Integration I9 Alert Notification**

	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system (RWIS / ALERT / FEWS) generated specific notifications (Email or page)	Automatic notification through Center-to-Center communications	

**Item of Integration II10 Decision Support**

	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
None	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention	

**Item of Integration II11 Weather/Road Weather Data Acquisition**

	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
None	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communications link to state, federal, private data sources including vehicle-derived weather data	

## **Appendix D – Summary Report on TMC Operational Needs to Be Addressed by Better Weather Integration**

## **Summary report on your TMC Operational Needs that could be addressed by better weather integration (Section 4 Report)**

### **Rating Legend: 3 - High, 2- Medium, 1-Low, 0 - No Need**

#### **Need Area**

<b>Rating</b>	<b>Need Statement</b>
Advisory Operations	
3-High	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
2-Medium	Improve targeting of weather messages (site-specific; user group specific) to more effectively convey road weather information.
2-Medium	Provide better pre-trip weather condition information to aid travelers in their decision-making
2-Medium	Provide better en-route information on weather conditions to aid travelers in their decision-making
2-Medium	Improve message content (for DMS, 511, HAR, Web sites, etc.)
Institutional Coordination	
3-High	Develop and implement clear, written policies and procedures for handling weather events.
3-High	Improve coordination within the TMC
3-High	More coordinated responses and information with adjacent jurisdictions/regions
2-Medium	Improve coordination with local public safety and emergency agencies
1-Low	More opportunities and mechanisms for communications and exchange with others in the weather community and those with experience dealing with weather events.
Traffic Control Operations	
2-Medium	Improve management of emergency routing and evacuation for large-scale weather events
2-Medium	Improve traffic diversion and alternate routing capabilities
0-No Need	Improve traffic signal timing during weather events to facilitate traffic movement
0-No Need	Improve safety at intersections during weather events
Treatment Operations	
3-High	Reduce the time required to restore pre-event level of service operations after a weather event
3-High	Improve the timeliness of weather management response including deployment of field personnel and equipment
2-Medium	Reduce costs of roadway treatment options
1-Low	Need to assist maintenance in determining the optimal treatment materials, application rates, and timing of treatments.

**Need Area****Rating   Need Statement**

## Weather Information Processing and Gathering

3-High	Assistance in interpreting weather information and how best to adjust operations in light of that information.
3-High	Improve the coverage and granularity of weather information in the region
3-High	Better real-time information on road conditions during weather events
3-High	Better prediction of impact of weather events including assessment of reductions in capacity
3-High	Better short-term forecasts of arrival time, duration, and intensity of specific weather events at specific locations