PROJECT REPORT

ROAD WEATHER INFORMATION SYSTEM PHASE I
FEDERAL #ITS-9802(1)

iways

November 2004

Project Location:	Alaska
FY00 ITS Earmark Total:	$250,000 (50/30/20)
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OVERVIEW

The Alaska Department of Transportation & Public Facilities (ADOT&PF) initiated the first eight environmental sensor stations (ESS) in the Anchorage area, called the Road Weather Information System (RWIS) Phase I. The ESS are used to detect road weather conditions. ADOT&PF maintenance & operations (M&O) use RWIS information to make winter maintenance decisions on snowplowing, snow blowing, deicing and anti-icing. The RWIS information is also made available to the public via *roadweather.Alaska.gov* or *511.Alaska.gov*.

The ADOT&PF initiated RWIS Phase I by contracting a project manager to develop the project as part of the Alaska Iways Architecture Implementation. Iways is the name given to Alaska's Intelligent Transportation System program. ADOT&PF selected PB Farradyne as the vendor in October 1999 to complete the following tasks: define user needs; create concept of operations; draft a Request for Proposal to purchase and install ESS equipment; identify existing data sources; complete a vendor reconnaissance; conduct system and field site Plans Specification & Estimates (PS&E), and create a site selection plan. (Project Timeline, pg 3)

The ADOT&PF used a site selection plan as a starting point to select Phase I ESS locations (Appendix A). Matrix Management Group created the plan (June 2000) as a subcontractor to the project manager, PB Farradyne. Matrix Management selected sites based on: a reconnaissance of areas suggested by M&O personnel; an analysis of existing weather observation sites; and site analysis to determine the geography that allows for ideal road condition collection. The site selection plan generated a list of favorable sites. From this list and other determining factors such as power and communications, ADOT&PF RWIS managers chose the top priority locations based on available funding. The final RWIS Phase I ESS locations are listed in Table 1.

Table 1. RWIS Phase I – ESS locations

1	Seward Highway @ Portage Glacier Road
2	Seward Highway @ Bird Point MP 96
3	Seward Highway @ McHugh Creek MP 111
4	Seward Highway @ Huffman Road
5	Hillside Road @ Upper Huffman Road
6	Glenn Highway @ S Curves MP 10
7	Glenn Highway @ Eagle River Bridge
8	Glenn Highway @ 2^{nd} Knik River Bridge

The ADOT&PF purchased an extra set of equipment for future application. This set will later be used in RWIS Phase II on Portage Glacier Road near Whittier. All of the sites include sensors for surface, sub-surface and/or atmospheric data. In addition, some include fixed-zoom cameras or pan-tilt-zoom (PTZ). The fixed-zoom are stationary cameras that collect images from one view. The PTZ, however, have the ability to collect multiple views. The PTZ were introduced because the Federal Aviation Administration were interested in collecting views of the horizon from the ESS, especially those located in mountain passes. Two Phase I cameras were replaced with PTZ cameras in 2004. The ESS sensors are listed in Table 2.

Table 2. RWIS Phase I – Sensors

Surface	Surface Systems FP 2000 Chemical percent, ice percentage, depth, freeze point
Sub-Surface Temperature Probe	Surface Systems Model #S16UG-D 17" below roadway surface -22 to 176°F
Temperature Data Probe	Measurement Research Corp. Model #TP101 "SHRP" 72" below roadway surface
Wind Speed/Direction	RM Young Model #05103 0-134 MPH
Air Temperature/Relative Humidity	Thies Model #032202 10-100% relative humidity -31 to 158°F Ambient Temperature
Fixed-Zoom Camera	Cohu iView– Fixed Zoom Camera Color, low-light
Pan-Tilt-Zoom Camera	Cohu iDome – Pan Tilt Zoom Model #3920 Color, 360° rotation, 64 user-defined preset positions.
Precipitation Sensor	Hawk Eye or Price Yes/No detection, Optical Infra-red
Optical Weather Identifier – precipitation type, intensity and rate	Optical Scientific Inc.

The ADOT&PF chose Surface Systems Inc. (SSI) to purchase and install RWIS Phase I ESS. This deployment facilitated RWIS plans, specifications and estimates for additional ESS statewide, known as RWIS Phase II. ADOT&PF used lessons learned from Phase I to help alleviate issues in Phase II. Most notably, SSI completed a 3 month trial of pavement forecasting. The results of this trial were inconclusive and costly. Therefore, the ADOT&PF did not continue pavement forecasting in the future. This phase also heightened awareness of using RWIS to improve M&O winter operations statewide.

Matrix Management Group, subcontractor to PB Farradyne, completed an operational testing and analysis report of the Phase I ESS during the 2002 – 03' winter season. (Appendix B). The report consists of:

- brief conclusions related to the period of testing and an evaluation report of the findings by selected ADOT&PF maintenance decision makers on the utility of the RWIS equipment, SSI pavement forecasts, and first use of the system.
- An evaluation on the accuracy and utility of National Weather Service and SSI (ADOT&PF RWIS Contractor) forecasts
- an appendix of the performance criteria on which the evaluation was based, and the worksheet used by maintenance decision makers to report their experience.

Even though Phase I was completed in August 2002, the ADOT&PF has been addressing ongoing issues since their inception. These and other issues are addressed in this paper.

PROJECT TIMELINE

Request for Proposal --- September 1999
RWIS Phase I Project Coordination and Management

Vendor Selected (PB Farradyne) --- October 1999

Project Kickoff Meetings --- February 2000

User Needs --- June 2000

Identification of Existing Data Sources ----------------------------------- June 2000

RWIS Vendor Reconnaissance --- June 2000

RWIS Site Selection Plan (Matrix Mgmt Group) -------------------------- June 2000

RWIS Systems and Field Sites PS&E -- August 2000

Request for Proposal --- November 2000
Purchase & Install RWIS Phase I Equipment

Vendor Selected (Surface Systems, Inc.) ------------------------------------ December 2000

Project Begin -- December 2000

Project Completion --- August 2002

Operational Testing and Analysis Report ---------------------------------- Winter '02 – '03
Matrix Management Group

Maintenance & Operations --- Ongoing

Lessons Learned

Technical

The majority of technical issues in Phase I were communication related or faulty equipment. Cellular phone communications proved to be very costly. Three ESS sites were initially installed with cellular phone because there was no direct phone lines to the sites originally. The invoices were costly, approximately $300/mth/site, leading us to make changes in the communications right away. Two of these sites were converted over to Freewave Radio (spread spectrum). The cost of the equipment was expensive, but the technology proved reliable with very little operating costs. The third site was converted to plain old telephone (POTS) since it became available after the installation.

Other communication issues consist of M&O personnel using dial-up internet access to retrieve the data. Data retrieval with dial-up internet access is slow, especially when trying to view the camera images. In addition, some M&O stations still do not have internet access.

Lessons Learned – Technical:

1. Cellular phone is expensive to use as communication for the ESS. Freewave Radio is proving to be a reliable and inexpensive means to retrieve ESS data when POTS or other direct communication sources not available at the ESS.
2. Faster internet access for the M&O stations will help improve data retrieval from the central server.
3. Faster communication is necessary from the RPU to the Central Server in Anchorage, especially since the newer ESS will have PTZ cameras which can collect multiple images in one polling cycle. Freewave Radio from the RPU to a direct phone line is sufficient for our means. However, faster communication like fiber or DSL is preferred, if available from the RPU to the State WAN.

Other technical issues include faulty equipment. The McHugh ESS was reporting false wind direction until the contractor was able to repair it after weeks of trying to address the problem. In addition, the accuracy of many of the pavement sensors has been questionable since they were installed. When one sensor is not reporting correctly, it leads to questions about the integrity of the data from the other sensors. Last, the winch on the poles did not work smoothly initially. When lowering the pole to access the sensors the pole jerked. The contractor fixed the winch, but small issues like this have been ongoing.

Lessons Learned – Equipment:

1. Research more robust equipment for the ESS. New technology, such as radar can help alleviate the many problems of in-pavement sensors, including M&O paving projects that cover the pavement sensor. Once the sensor is paved over it must be replaced, costing approximately $5200 per site. The ADOT&PF is a member of AURORA is an Federal Highway Administration (FHWA) approved international pooled fund where members work together to perform joint research activities in the area of RWIS. Aurora membership helps the ADOT&PF to stay abreast of the latest and most beneficial ESS equipment.

2. Equipment issues arise continuously and must always be monitored for inaccuracies or complete failure. It's essential to keep additional funds in the budget for maintenance & operations of the equipment.

Institutional

Internal:

Internal issues include buy-in from M&O personnel, a high learning curve (understanding the data and using it for winter operations), integration of RWIS with other Intelligent Transportation System (ITS) projects and site maintenance issues. Buy-in from M&O personnel took time and patience. M&O used the data sparingly once Phase I was completed. Many continued normal winter operations without using the data. Although a formal survey was not conducted, a mix of assumptions can be made from various discussions with M&O personnel. One, M&O personnel were not accustomed to relying on technology to make winter maintenance decisions either because of the lack of experience with new technology, like PC use or because they didn't understand the need for it. M&O personnel were comfortable with analyzing NWS reports and/or driving the road to make maintenance decisions. Some were comfortable with the way they were making decisions and did not feel a need for the RWIS data. Sometimes this view was related to the location of the ESS where it wasn't necessary because they drove the road on the way to work. Two, the new technology requires training to learn and understand the data and how to incorporate it into everyday winter operations. Many M&O personnel did not feel comfortable making decisions based on reports coming from the station because of the lack of expertise on what to do with the RWIS data.

After deploying Phase I, the need for additional ESS statewide and integrating it with other ITS projects became more apparent. As the RWIS become more widely accepted by internal staff, they begin to make requests for new sites, site relocation, or questions about the ESS equipment and software. A contractor did evaluate M&O needs early in the process, but once the ESS were installed, it generated a whole new set of requests and needs once they could see and understand RWIS effectiveness.

Another internal issue includes appointing responsibility on maintaining the sites. Internal expertise on the sites is minimal. All of the technology requires technical training in order to maintain the sites. Even minor maintenance like cleaning the camera lenses or re-positioning the camera is a concern when the ADOT&PF doesn't have M&O trained to perform these procedures. It can be costly to send a contractor to perform these minor maintenance actions. Currently the ADOT&PF has purchased an extended warranty with the contractor to support and maintain the system, but eventually the ADOT&PF will need to be more self-sustaining.

Another internal issue is integrating other ITS projects. *511 Travel in the Know*, Alaska's travel information system, went online in April 2003. The RWIS information and camera images proved to be very valuable resource for travelers. The 511 contractor was able to access the RWIS data from the State FTP site and ingest it into the *511.Alaska.gov* web page directly. However, there were issues about providing surface temperatures because travelers might misinterpret the data. For example, if the surface temperature was 32 degrees, many travelers might interpret this as icy conditions when this might not be the case at all.

Lessons Learned – Internal:

1. User and on-site training is an essential part of bringing new technology into the ADOT&PF. M&O are expected to use the ESS and eventually maintain the system.
2. Conducting a follow-up user needs study with key M&O personnel on ESS location, equipment, usage, etc. after Phase I completion can help alleviate many changes to the scope of work in Phase II. Again, many M&O personnel did not fully comprehend the RWIS benefits until after the ADOT&PF completed Phase I.
3. Make the RWIS data available for easy integration with other ITS. The RWIS data provides very valuable traveler information. Integration will happen eventually, and this needs to be taken into consideration early in the design phase.

External:

One major external institutional issue included sharing the data with other agencies. The ADOT&PF must provide easy data access to agencies requesting the information. This proved to be a fairly easy task by providing an FTP site where the data can be accessed at no cost. The only issue raised is that the data being placed on the FTP site is vendor-supplied (raw format) that is not user friendly. The agencies accessing the data need to understand the raw data formats so they can convert it to a user friendly format. In order to alleviate this issue, the ADOT&PF provides agencies a document that explains the data formats.

Lessons Learned – External:

1. Take into consideration that other agencies will be interested in accessing the data and that interest outside the ADOT&PF will grow. Agencies such as the National Weather Service and the University of Alaska were interested in free access to the data. Pre-planning early in the design phase will help alleviate integration issues later on.

Financial

The cost of Phase I RWIS was fairly reasonable, $30 – 50, 000 per ESS site. However, ongoing changes and continuous upgrades have added to the costs significantly. Converting two sites to spread spectrum radio costs $11,700 total. Since Phase I deployment, the ADOT&PF replaced 4 pavement sensors at $5200 per site. Other expenses include training, warranty, power and communications. The ADOT&PF will need to budget for these costs each year. In any event, the ITS Earmark was not enough to continue these ongoing expenses. Additional funding is coming from the Statewide Transportation Improvement Program (STIP) where these costs are competing with other surface transportation projects.

Lessons Learned – Financial

1. When planning an RWIS budget, take into consideration additional expenses to cover ongoing changes, maintenance and operations of the ESS.

Procurement
The ADOT&PF used several procurement methods and types to complete RWIS Phase I:

1. RFP for the project manager – cost plus fixed fee
2. RFP for the construction of foundation – low bid
3. RFP for the design, purchase, installation and on-going support – cost plus fixed fee
4. Sole Source Contract for electrical engineer services

The ADOT&PF initiated RWIS Phase I by contracting a project manager to develop the project. The ADOT&PF selected PB Farradyne as the vendor in October 1999 to complete the following tasks: define user needs; create concept of operations; draft an RFP to purchase and install ESS equipment; identify existing data sources; complete a vendor reconnaissance; conduct system and field site Plans Specification & Estimates (PS&E), and create a site selection plan. (See Project Timeline, pg 3) The project manager was very useful in helping the ADOT&PF to organize the project scope of work and help us initiate our first ITS project.

Next, the ADOT&PF contracted the ESS site foundation using a low-bid construction contract. This included: construction of the foundation for the ESS equipment tower, provision for electrical and telephone service to the sites, additional underground conduit and junction boxes to enable subsequent installation of pavement sensors. This low-bid contract resulted in several issues. Mainly, the contractor did not have expertise in ESS site work. This resulted in incompatibility between the tower and foundation where the tower did not align with the base. Also, there were issues with the foundation work not located in the correct location in relation to the right-of-way.

Concurrent with the site preparation work, the ADOT&PF contracted out the provision and installation of all other elements to complete the deployment of a prototype RWIS. Work performed under this RFP addresses the design, purchase, installation and on-going support of RWIS Phase I. The ADOT&PF selected a contractor based on qualifications and cost for the site installation work. The ADOT&PF scored proposals using a 1-5 ranking system for each criteria: understanding of the project and credentials; hardware & installation; software; long term maintenance and operations; communications; technical support and extended warranty; contract cost evaluation. This selection method was a flexible approach in making sure an experienced and economical vendor was chosen.

The contractor for the ESS installation work negotiated a fixed fee for each RWIS site and equipment needed (i.e. computers, software, cabling, communications, etc) at the inception of the contract. In addition to the fixed fee, the ADOT&PF reimbursed costs for travel expenses and changes in the scope of work. This method proved to be very practical for this project since there were numerous unknown's and additional costs that were indeterminate early in the contract.

Initially, PB Farradyne hired an electrical engineer subcontractor to perform thorough site analysis on the exact placement of the ESS and to identify feasible power and communication resources. After PB Farradyne's contract ran out, the ADOT&PF continued the electrical engineers services through a sole source contract.

Lessons Learned – Procurement

1. Use procurement methods that are flexible for a project that has both construction and software.
2. Use procurement methods that take into consideration project unknown tasks. This method helps keep the procurement methods flexible when there are unknowns and additional costs that arise during installation.
3. Use selection methods that take into consideration both expertise and cost. Low-bid is not always the best solution for ITS projects since it doesn't take into consideration expertise and knowledge.
4. Outsource a project manager to help initiate a new technology. The RWIS Phase I was the first ITS project that the ADOT&PF deployed. Hiring a project manager helped prepare the ADOT&PF for something that was very new to the agency.
5. Use a single contract for all the construction work. Separating the construction work can cause issues such as those explained above.

ITS STANDARDS

RWIS Phase I equipment is fully compatible with the National Transportation Communications for ITS Protocols/Environmental Sensing Systems (NTCIP/ESS) standards as defined by AASHTO at the time of project completion. Appendix C contains a table of standards used in RWIS Phase I.

APPENDIX A

NEW (RWIS SENSOR) SITE SELECTION PLAN
AKDOT&PF ITS/RWIS PROJECT
June 5, 2000

TASK R6

1.0 Introduction

The first phase of the Alaska ITS/RWIS project is a prototype undertaking to focus on the Anchorage "Bowl". The siting analysis has two main objectives. The first is to determine the optimum number and locations for RWIS sensor stations. The second is to determine the desirable equipment for each location to achieve the most efficient use of RWIS hardware technology. The analysis for this prototype phase is limited by the time available for it. The intent to have some sensors in place by the winter of 2000-2001 (October 1) requires significant dependence on subjectivity, intuition and compromise. The highly variable nature of climatic effects in the Anchorage area creates a demand for increased density of weather observations to support tailoring of forecasts and tailoring of maintenance actions to localized requirements.

A total of 48 prospective sites were identified during the User Needs identification process, and each was given some evaluation. Each site was typically a composite of similar inputs; i.e., several people might have suggested specific places that were different, but within a few blocks of each other—one site was taken to represent all of the related inputs. The sites that were evaluated are listed in Appendix A. A brief description of the location, likely availability of power and communications, and rationale for inclusion is provided for each site. Because of the close fit between inputs from operations personnel and meteorological personnel, and the microclimates involved, it has been tentatively concluded that most sites should be "fully instrumented." Fully instrumented means they would include a Remote Processing Unit (RPU), pavement sensors (temperature, chemical presence), wind speed and direction sensors, air temperature sensor, humidity sensor, and precipitation sensor. Several locations (and further review could identify others) are near enough to existing atmospheric sensors as to be recommended for pavement sensors only.

Operations personnel typically want to have sensors in the locations that are particularly troublesome, and/or are representative of the micro-climates they perceive to exist and to create localized maintenance problems, and/or are representative pavements where observations could be used to make judgements for a larger area. Weather analysts and forecasters typically want to have information from existing data-sparse areas in order to better appraise atmospheric conditions and to make more refined forecasts, especially if snow and ice control decision makers are going to be looking for more specific information. Especially, forecasters would like to see more information "upstream" and at higher elevations. Most observations are now being taken near sea level. There is considerable agreement between both groups on the locales where RWIS sites would ideally be located.

2.0 Methodology

Developing the Siting Plan for the "Prototype Phase" has been essentially a six step, somewhat overlapping, process. Each step has provided feedback and informed the other concurrent steps. However, the overlapping process has been mostly necessitated by a schedule requiring a somewhat truncated process with abbreviated documentation and significant subjectivity and intuition. We are moving fairly quickly to merge operation and forecaster needs in some cases, but mostly, there is good agreement on the needs.

The six steps have been:

1. Needs identification through interviews among highway operations personnel, meteorologists experienced in the Anchorage area, and third parties with important perspectives.
2. Determination of existing weather observations to avoid duplication in siting, and to integrate them with RWIS generated information during deployment.
3. Reconnaissance of areas suggested by interviewees, and follow-up for clarification.
4. Identifying specific sites, in terms of “siting considerations,” within the locales suggested.
5. Preliminary evaluation of sites against the evaluative criteria arising out of the needs identification process.
6. Documentation of the “best” sites, a short list of 14 from which 10-12 could hopefully survive the practicality tests of power, communications, and right of way availability. (This list is Appendix C, and is an extract from Appendix A.)

2.1 **User Needs** – Maintenance decision-maker information requirements were appraised. The kinds of weather that triggers their particular actions, the clues they use in discerning weather that is about to or is occurring, their service levels, practices and decision thresholds, and the kinds of weather and pavement condition information they wished they had were noted. Similarly, after explaining the particular activities and decision thresholds of highway operations to meteorologists, the weaknesses in existing data to enable tailored forecasts were identified by them. Finally, the consultant “stirred” experiences from other places with established RWIS and anti-icing programs “into the pot.” From these multiple sources, the information that provided a basis for characterizing the RWIS sensor sites included:

- The types of weather and road conditions in the Anchorage area that require snow and ice control,
- Snow and ice control routes, priorities, areas of responsibility,
- Snow and ice control equipment in use, spreader calibration procedures and schedules,
- Extent of and circumstances for anti-icing measures,
- Anti-icing, deicing, abrasive materials in use,
- Sources of local weather information used by decision makers,
- The particular weather patterns that generate the weather effects that trigger maintenance actions,
- Current practice and possibilities relative to decision thresholds that should be embedded in forecast products,
- Communications used to monitor approaching storms and weather in progress,
- Known roadway weather impact trouble spots,
- Impact of roadway elevation changes, terrain shadows, and other effects on snow and ice control practices,
- Functional classification of roads, types and volumes of traffic, relative priority of routes and services.

Particular decision thresholds, practices and service levels are contained in the Task R2 User Needs Interim Report.

Keeping these kinds of needs in mind, interviewees were also asked what kinds of information from what particular areas is needed to make better decisions and to achieve more effective practices. And in the case of meteorologists, what data from what particular places would support more localized analysis and tailored forecasts. This process generated a "raw" list of about three dozen locations.

In preparing to evaluate the list, it was recognized that both maintenance managers and meteorologists have essential needs that must be integrated to develop the most responsive RWIS information network. A prime consideration was to develop criteria for selection of sites that would provide the most effective network of timely and accurate weather and pavement information for use by decision makers. The ranking of prospective sites would need to be in terms of their relative value to the basic functions of an RWIS site, which were evident in the stated needs of the potential users. These evaluative criteria would be:

- **DETECTING:** A function of sensors is to detect existing or changing weather, or roadway surface conditions, on a real-time basis. Typical sites emphasizing detection would include known trouble spots, frost and ice formation areas, fog prone areas, and strong wind areas; and some sites would complete a suitable grid for the reliable characterization of significant weather events. A strong subset of DETECT is VERIFY. Maintenance decision makers, in particular, feel a need to "see" that the sensors are reporting conditions that are actually occurring and verify the extent of those conditions. An expected source of cost and time savings from RWIS is to negate maintenance personnel driving out to see what is happening. The need to verify is the source of a strong interest in co-locating video cameras with the weather sensor sites. Detection serves both maintenance decision makers and weather forecasters.

- **FORECASTING:** Sensors are also sited to provide local information to supplement NWS or other weather observations. This information is used to develop site-specific forecasts of weather and road conditions. Since the benefit of using weather information is to make timely decisions through the use of forecasts, acquiring specific local information should be considered a primary reason for siting sensors. Sites selected to support forecasting should be meteorologically representative of an area. Maintenance decision makers, ideally in conjunction with a weather forecaster dedicated to their support, make "nowcasts" in accomplishing their work. A "nowcast" is essentially the assumption that is made about what the immediate future weather will be and therefore the basis for the maintenance action undertaken. Thus, forecasting is of interest to both the meteorologists and the maintenance decision makers.

- **MONITORING:** Sensors are also sited to provide a monitoring function, to check the onset, ongoing, and conclusion of weather compared to the predicted conditions in order to make mid-course corrections. Monitoring sites are most useful if selected to provide information "upstream" of the area, i.e. first indications of change where the weather is "coming from." Monitoring sites serve both the operational decision makers and the weather forecasters.

It is worth noting that thermal mapping would be very useful in a siting analysis, but is not a practical consideration in the time available for this prototype phase.

Ideally, sites that serve all three aims—detect and verify, forecast, monitor—would be most favorable.

2.2 **Existing Data Sources** - Existing weather observation sites with some proximity to the Anchorage prototype phase area were identified. This will help to maximize the RWIS investment by avoiding duplicative sites and provide an opportunity to eventually fuse data from all useful sources into the road weather information system. Existing observations are fairly abundant in the immediate Anchorage area already. However, there are few reporting on a 24 hour basis above near sea-level elevation; and only Portage and Girdwood in the "upstream" direction. There are no pavement temperature observations being reported and used by maintenance personnel on an operational basis.

Approximately 30 NWS Cooperative Observers in the Anchorage area take limited observations once per day. These have archival and planning value, but are of limited use for operational decision making.

The nine hourly reporting NWS and FAA observation sites and some of the 20 MesoNet system of weather observing sites are important considerations in prioritizing new sites for RWIS.

2.3 **Reconnaissance** – All areas suggested for sites were visited to familiarize with the topographical conditions, and to make an initial survey of sites that might have the necessary attributes for proper operation of weather sensors and representative pavements for surface condition sensors.

2.4 **Identify Specific Possible Sites** – Considerations for the tentative selection of RWIS sites for the prototype phase in the Anchorage area were set down based on the inputs of the User Needs process and established good practice elsewhere. Particular locations were identified which seemed to satisfy those siting considerations. Notes were taken and Polaroid photos documented the most encouraging sites for recurring reference during site evaluation.

2.5 **Preliminary Evaluation** – All sites were subjectively scored in terms of their Detection, Forecasting, and Monitoring value to the identified user needs, and the siting considerations. Site consideration was essentially a screening process: yes, no, or maybe. It generally took a Yes to move to the "short list."

For a site to be included in the list of prospects it had to pass the "fatal flaw test," and meet either, or ideally both, the meteorology criterion and the decision-maker criterion.

Fatal flaw test: the site must have a favorable aspect, and be free of obstructions to the flow of air, i.e. be representative of ambient atmospheric conditions.

Meteorology criterion: Provides meteorologically important information.

Decision-maker criterion: Provides operationally important information to decision-makers.

The prospective sites listed in Appendix A derived from an initial consideration of these criteria, and were then evaluated through a methodical application of more detailed considerations. The methodology is described in Appendix B. A spreadsheet displaying the rating process is in Exhibit B-1.

2.6 **"Best Sites"** – The sites that scored best in the preliminary evaluation are included at Appendix C. In general, the highest scoring sites combined the Detection, Forecasting and Monitoring aims of both the decision-makers and the meteorologists. Several of the highest scoring sites serve as alternates to other sites in the list, because both would not be implemented due to proximity.

APPENDIX A: Prospective List of Suggested RWIS Sensor Sites

NO PRIORITY OR RELATIVE IMPORTANCE IS DENOTED BY THE NUMBERS ASSIGNED OR BY SEQUENCE. NUMBERING GENERALLY FOLLOWS A SEQUENCE GEOGRAPHICALLY SOUTH TO NORTH AROUND THE ANCHORAGE REGION, BUT ADDITIONAL SITES WERE ADDED IN AND NUMBERED AS THEY OCCURRED.

AS A POINT OF DEPARTURE FOR THE PHASE 1 PROTOTYPE PROJECT, ALL SITES ARE INITIALLY ASSUMED TO HAVE A REMOTE PROCESSING UNIT (RPU), STANDARD SET OF WEATHER SENSORS AND A VIDEO CAMERA. A "MET SET" HERE INCLUDES: WIND SPEED AND DIRECTION, AIR TEMPERATURE, HUMIDITY, AND PRECIPITATION SENSORS. "PAVEMENT SENSORS" INCLUDES PAVEMENT TEMPERATURE AND CHEMICAL PRESENCE SENSORS.

1. Summit Lake, Seward Highway, MP approx. 46.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place RPU and Met Set on west side of highway approaching Summit Lake Lodge southbound (SB). Place pavement sensors just outside of outside ("curb") wheel track of SB lane. Trees may affect wind observations.

c. *Services:* Power: electrical line crosses overhead near the site, power is assumed to be available. Telephone seemingly available to the Lodge.

d. *Rationale:* Offsets absence of weather observations between Portage and Kenai-Soldotna, and lack of observations at higher elevations. Provides "upstream" weather observation for Anchorage, i.e. detection and monitoring of weather approaching from the Gulf of Alaska. Representative, altitude and "upstream" location for pavement conditions for Silvertip Maintenance station. This site serves a section of the NHS.

2. Silvertip, Seward Highway @ Hope Junction.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on knoll between roads. Place RPU in NE corner of intersection, or on Met Set mast, whichever is most cost effective considering pavement sensor distribution. Place pavement sensors just outside of the wheel track of the outside ("curb") lane in NB lane of Seward Highway, say 400' south of intersection, and in WB lane of Hope Highway, along with a sub-surface sensor, say 200' west of intersection, and one on the center line of Canyon Creek Bridge. Terrain may affect representativeness of wind observations, but testing during prototype phase will evaluate this. If invalid, wind sensors can be moved to a Phase 2 location.

c. *Services:* Lighting poles suggest power available; may switch to solar when lighting turned off for summer. Place solar panel high on light pole out of reach of vandals. Telephone not fully determined: ACS says telephone service is 10 miles away; telephone service exists at Silvertip Maintenance Office, approximately .5 mi away on Hope Highway.

d. *Rationale:* Offsets absence of weather observations between Portage and Kenai-Soldotna, and lack of observations at higher elevations. Provides "upstream" weather observation for Anchorage, i.e. weather approaching from the Gulf of Alaska. Representative pavement condition location for Silvertip Maintenance area. Provides bridge deck pavement condition information. Location is an important section of the National Highway System (NHS).

2A. Turnagain Pass, Seward Highway @ West Side Visitors Parking Lot

a. *Sensors:* Met Set. Video Camera. Pavement Sensors.

b. *Location:* RPU co-located with restroom building, perhaps within or adjoining in enclosure, or on emergency telephone pole. Met Sensors share emergency telephone pole and solar panel, or adjoining pad with fence enclosure. Pavement sensors in both NB and SB divided roadways.

c. *Services:* Power appears to require solar; share or emulate solar power to emergency telephone. High voltage transmission line adjoins site, but cost of stepping down presumably very high. Future shared interests of multiple users could make case for mutual investment in transformer. Telephone assumed to require cellular, again emulating emergency telephone available at site.

d. *Rationale:* Offsets absence of weather observations between Portage and Kenai-Soldotna, and lack of observations at higher elevations. Provides "upstream" weather observation for Anchorage, i.e. weather approaching from the Gulf of Alaska. Weather detection and monitoring for high-use recreation area, and proximity to active avalanche zone. Pavement condition negates long drive from Silvertip to determine conditions in a critical area. This site serves a much visited section of the NHS.

2B. Pete's Creek, Seward Highway @ MP approx. 64.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors.

b. *Location:* RPU and Met Set in clearest area west side of highway in between stream crossing and transmission line over-crossing. Pavement sensors adjoining RPU. Trees may degrade wind readings.

c. *Services:* Power probably requires solar. Telephone assumed to require cellular.

d. *Rationale:* Offsets absence of weather observations between Portage and ' Kenai-Soldotna, and lack of observations at higher elevations. Provides "upstream" weather observations for Anchorage, i.e. weather approaching from the Gulf of Alaska. Pavement condition detection negates long drive from Silvertip to determine conditions in a critical area. This site is on the NHS.

3. Portage, Seward Highway @ Junction with Visitors Center Road.

a. *Sensors:* Met Set. Video Camera. Pavement sensors. Sub-surface sensor.

b. *Location:* Place RPU in any convenient space at the Seward Highway – Portage Visitors Center road junction (southeast corner?) and pavement sensors just outside of wheel track along with a sub-surface sensor on SB side approximately 200' north of the RPU and on NB side as far to the "south" into the Placer Overflow area as is practical (.25-.5 mi.?)

c. *Services:* Power and telephone appear to be available to adjoining business locations.

d. *Rationale:* Meteorological observations are provided for this critical area by the NWS ASOS site near the Portage Glacier Visitors Center, but the conditions there are considered to be highly localized and likely not representative of conditions on the Seward Highway. Also, some observations at the Visitors Center ASOS are considered unreliable. For example, snow driven by vertical wind is reported as rain. Wind blowing snow during even clear sky conditions is reported as precipitation. This is essentially a problem of automated observation, but a site at the junction, albeit some five miles away, will provide a comparison. And the Portage location is key to detecting changing weather conditions for the region. The ASOS site atmospheric pressure observations have often been unreliable. Detection and monitoring of pavement temperature and surface condition information is needed for maintenance. Additional pavement condition sensors at some distance into the Placer Overflow area should be considered, transmitting to this same RPU. Site serves a section of the NHS.

4. Portage – Ingram Creek, Seward Highway @ (typically) MP 79 (See # 6).

5. Seward Highway @ MP approximately 87.5.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors.

b. *Location:* Just north of largest pond in this area, at avalanche cannon platform on south side of highway at approximately MP 87.5. Wind readings may be degraded by 10'-15' tall trees south side and approx. 25' tall trees north side. Clearing between trees and near platform about 150' across. Rocky hill to right of platform looking south, about 150' from highway is a prospect for RPU and Met Set tower. Pavement sensors in SB lanes 500' north and NB lanes 500' south to get representative coverage in the area.

c. *Services:* No apparent source of power, solar probably required. High voltage transmission line across the highway. Landline telephone not available; cellular?

d. *Rationale:* Provides monitoring of the progression of weather westward along Turnagain Arm. Responds to maintenance interest in pavement and weather conditions in the vicinity of accident prone "Deadman's Curve," MP 88. This site serves a section of the NHS.

6. Seward Highway, Placer Overflow area MP approximately 75-79.

a. *Sensors:* Video Camera. Pavement Sensors.

b. *Location:* No suitable, cost effective location has been identified. Parking area @ approximately MP 77.8 on southwest side of Placer River Overflow bridge a possible but marginal option.

c. *Services:* No apparent source of power, solar probably required. Landline telephone not available; cellular signal seems good.

d. *Rationale:* Most meteorological observations are provided for this critical area by the NWS ASOS site at Portage, although the addition of wind speed and direction here, in this drifting prone area, would be good. Video camera would provide information on visibility and a visual scanning of this unique area. Lack of site largely precludes further consideration. Pavement temperature/condition information can be sought by extending sensors as far as possible into the Placer Overflow area from Portage. This is a section of the NHS.

7. Seward Highway @ MP approximately 88.4.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on brushy knoll on south (east) side of small parking area next to old once paved road, on north side of Seward Highway. Place pavement sensor and a sub-surface sensor just outside of wheel track of outside lane in NB lane 500' south of RPU, and pavement sensor in SB lane 300' north of RPU.

c. *Services:* No apparent source of power, solar probably required. Telephone is available 2.2 miles west (north). Good cellular signal.

d. *Rationale:* Provides monitoring of the progression of weather westward along Turnagain Arm. Responds to maintenance interest in pavement and weather conditions in the vicinity of accident prone "Deadman's Curve," the next curve to the south. Site serves a section of the NHS.

8. Seward Highway, MP 84 to MP 91, Peterson Creek Area (See #5, #7)

9. Seward Highway @ Girdwood, MP 90

a. *Sensors:* Pavement sensors only, and a sub-surface sensor.

b. *Location:* Place RPU in the most cost effective place relative to power supply at the junction of Seward Highway and Aleyeska Highway. Place pavement sensor and sub-surface sensor just outside of wheel track on NB lane adjoining the RPU, and a pavement sensor just outside of wheel track of Aleyeska Highway lane nearest to the RPU, 300' from the RPU.

c. *Services:* Power and telephone are available to adjoining business locations.

d. *Rationale:* Meteorological observations are adequately provided for this busy area by the MesoNet site at Girdwood. Detection and monitoring of pavement temperature and surface condition information is needed for maintenance. This site serves a section of the NHS.

10. Skipped

11. Seward Highway, "Leaving Girdwood", MP 93.3 Wayside.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Subsurface Sensor.

b. *Location:* Only marginal site prospects. One possibility is just beyond guardrail on south side of Seward Highway at southeast corner of the wayside parking area entrance.

c. *Services:* Power may be available on top of est. 100' bluff north of RR tracks across the Highway. Telephone undetermined.

d. *Rationale:* Responds to interest of some users, especially meteorologists, for information in this area characterized by some "the seven waterfalls area". Would monitor movement of weather westward along Turnagain Arm and provide highway level information in this avalanche prone area. It is on the NHS. However, it is a marginal site for siting weather sensors. Girdwood pavement sensors, Girdwood MesoNet site and recommended site #12 at Bird Point probably provide comparable coverage.

12A. Seward Highway @ MP 96.3, Bird Point.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on south side of highway adjoining Wayside under construction at approximately the SB point of curve, outside the west end of guardrail. Place pavement sensor and a sub-surface sensor just outside of wheel track in NB outside lane of bridge over-crossing of RR approximately 300’ south; and pavement sensors in SB lane adjoining Met Set/RPU, and in SB lane 2500’ of RPU.

c. *Services:* Power apparently available across highway to the south, and could be cabled through the bicycle path under-crossing. Telephone is available 300’ west on south side. R/W is available.

d. *Rationale:* Provides detection and monitoring of the progression of weather westward along Turnagain Arm, is on “leading edge” of southeast winds from Whittier-Portage area. Site is at western edge of Bird to Girdwood avalanche zone. Pavement temperatures would likely be representative of the region. Good open airflow site. Site serves a section of the NHS. Sites number 12 and 13 are alternatives for the same area. Number 12 is preferred. If achievability or cost argue against it, choose number 13. The visual impact of the atmospheric sensors and mast could be a concern at this highly scenic location (and that is exactly why Beluga Point was avoided). However, the RPU with an approximate 30” X 21” silhouette could be placed on the surface at this location, leaving a very slender silhouette for high speed traffic to see through. Most people enjoying the scenery will have stopped in the wayside and be outside and below the sensor installation “impact.”

12B. Seward Highway @ MP 96, Bird Point Alternate.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place Met Set/RPU on north side of highway approximately .3mi south of Bird Point Wayside under construction (April 2000), in grassy area just north of divided highway (up/down arrows) warning sign. Place pavement sensor and a sub-surface sensor just outside of wheel track in NB lane of bridge over-crossing of RR about 700’ north of RPU; and pavement sensor just outside of outside wheel track in SB lane opposite the RPU.

c. *Services:* Power is apparently available approximately 800’ north near pedestrian under-crossing. Telephone is available approximately 1000’ northbound (west) on south side. R/W is likely available.

d. *Rationale:* Same as site 12A. However, 12A is preferable because of access to pavement observation around Bird Point to the north, and is in a more open air flow location.

13. Seward Highway @ MP 101.4, Bird Creek.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Attach Met Set/RPU to west (south) side of bridge structure at approximately mid-span at Bird Creek on Seward Highway. Place pavement sensors just outside of wheel track of outside SB lane on adjoining bridge deck, and along with sub-surface sensor on NB lane 500’ north of bridge.

c. *Services:* Residential/commercial development estimated .5 mi. south of bridge suggests power may be available. Telephone is available 500’ east on south side. R/W is available.

d. *Rationale:* Provides monitoring of the progression of weather westward along Turnagain Arm, and detection of flow of air down Bird Creek Valley. "Bird Flats" area believed to be a different microclimate than areas north and south, i.e. outside the valley effects. Obtaining pavement temperatures of both bridge deck and approach roadways provide contrast. The approach sensor is placed north to get more representation of the area out of the "flats." The site is on the NHS. Sites number 12 and 13 are alternatives for the same area. Number 12 is preferred. If achievability or cost argue against it, choose number 13.

14. **Seward Highway @ Indian Road, MP 104.**

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Perhaps place Met Set in flat space west of Indian Road on north side of Seward Highway, with pavement sensors in adjoining sections of Highway. However, it is a marginal location for weather sensors due to likely terrain and vegetation interference with air flow.

c. *Services:* Telephone likely within one-half mile (not determined), and nearby highway lighting suggests availability of power.

d. *Rationale:* Jurisdiction for highway maintenance changes here. This stretch of Turnagain Arm is somewhat of a bay or indentation in the coastline and appears to not be representative of prevailing conditions along the Arm. However, it is thought to be a distinctive climatic area before reaching (NB) the sharp change in climate believed to prevail in the McHugh Creek to MP 113 area.

15. **Seward Highway @ MP 111.8, McHugh Creek (Point).**

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set/RPU on west (south) side of road at the point just north of the McHugh Creek Wayside, either between roadway (outside of guardrail) and railroad, or across the tracks on the rocky promontory near the micro wave tower. Place pavement sensors just outside of outside wheel track in NB lane 2500' south of RPU and in SB lane 2500' north (or sufficient distance to get around corner to different environment) of the RPU. Place sub-surface sensor at either one. The site adjoining the road may be preferred to minimize maintenance difficulties.

c. *Services:* Power and telephone not apparently available. Will require solar and cellular or radio communications.

d. *Rationale:* Provides detection and monitoring of the progression of weather westward along Turnagain Arm, and in the vicinity of microclimate change described by maintenance personnel as a "curtain" where Girdwood area weather changes to Anchorage area weather. Good open air flow site. The curve provides opportunity to observe pavement temperature/condition in potentially contrasting south facing and north facing aspects. This site is on the NHS.

16. Seward Highway @ MP 113.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors.

b. *Location:* No suitable site found.

c. *Services:* N/A

d. *Rationale:* Same as #15, area of great interest to maintenance personnel, but replaced by #15 for lack of more suitable site.

17. Seward Highway @ MP 114.8, Potter Scale House.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors.

b. *Location:* Place Met Set/RPU on west (south) side of road across from weigh station and pavement sensor in NB lane adjoining.

c. *Services:* Power and telephone available.

d. *Rationale:* Similar # 15. Also, representative of Potter Marsh area, an area of interest to both maintenance and weather forecaster personnel. However, this location is somewhat duplicative and adequately served by #15 and the existing Potter Marsh site, especially if the latter is moved to the Chugach State Park Headquarters.

18. Seward Highway @ Potter Marsh

a. *Sensors:* Met Set. *Video Camera.* Pavement Sensors. Sub-surface Sensor.

b. *Location*: This site already exists with a Met Set on the marsh side of the Seward Highway on a highway lighting pole adjacent to the bird viewing boardwalk. NWS meteorologists have suggested the Chugach Park Headquarters at the south end of the marsh would be a preferable location.

c. *Services:* Power and telephone communications are in use.

d. *Rationale:* Provides detection and monitoring of weather entering the City from the southeast, and representative conditions for a stretch of the NHS.

19. Seward Highway @ Huffman Road

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Mount Met Set 10m above Seward Highway roadway on tall highway lighting pole, near over-crossing of Huffman, with RPU either also mounted on the pole or in or near traffic control cabinet in NE quadrant of interchange. Place pavement sensors just inside of NB outside (curb) wheel track of bridge deck. Also, in inside of outside wheel track along with sub-surface sensor of NB lane of Seward Highway near the merge of Huffman to Seward Highway NB on-ramp. On the east side of Huffman overpass, place pavement sensors just outside of outside wheel track of WB lane of Huffman, and in center of Huffman EB left turn pocket in the first car-length.

c. *Services:* Power and telephone are available. Site is within the R/W.

d. *Rationale:* This is an area of interest to both maintenance and weather forecast personnel. It provides detection and monitoring at the "leading edge" of weather entering the City from the south. Pavement conditions on the high standard approach and structure of Seward Highway and the local arterial of Huffman below should be representative of a wide cross-section of similar roadways at a similar elevation in the southern section of the City. The sensor in the turning lane is to gather data that could enable development of anti-icing procedures that would discourage build-up of ice in such locations. This site is on the NHS. One drawback is that it is less than 3 miles from an existing MesoNet station.

20. Ingra Street @ 15th Ave.

a. *Sensors:* Pavement Sensors and a sub-surface sensor.

b. *Location:* Place pavement sensors just inside of outside wheel track of outside (curb) lane of 15th Ave. EB and Ingra St. SB (utilizing an adjoining traffic cabinet for the RPU), or in the same relationship to an existing cabinet on the NE corner if preferred. Place sensors approximately 100' from the intersection or as advantageous to the current construction project (#50624). Place a sub-surface sensor at either location.

c. *Services:* Power and telephone are available. R/W is available.

d. *Rationale:* This is an ideal and representative in-city location, in an area of interest to both City and State maintenance personnel and provides detection and forecasting information for roadways of comparable elevation and traffic exposure in the mid-town area. This would also be an excellent site for a MetSet and video camera, but the Merrill Field continuous observing and reporting station, ASOS, is only about a mile away, so the duplication is not justified. On the other hand, the nearby Merrill Field observation makes this pavement site relatively co-located with an existing weather observation.

21. Hillside Road @ Upper Huffman Road

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. Location: Place Met Set/RPU approximately midway between Upper Huffman Road and 12500 Hillside Road on the west side of road. Place pavement sensors just outside of wheel track on curb side SB adjoining the RPU along with a sub-surface sensor, and in front of 12640 Hillside. Road.

c. *Services:* Power and telephone are available. R/W is available to 40' from centerline.

d. *Rationale:* This site provides a representative location with good open airflow, at a higher elevation of the City. No other site was identified on the hillside with such good siting characteristics. It responds to weather forecasters' desire for more observations at higher elevations, and is at an elevation between the highest MesoNet site (Glen Alps) and most of the other sites within the City. It provides information for snow and ice control operations on the hillside. Although sensors are suggested for the same side of the pavement to minimize cost, the two pavement sensors provide north and south facing aspects respectively, and thus, potentially different representative information.

22. Sand Lake Road – W. Dimond Blvd.

a. *Sensors:* Pavement sensors, and a sub-surface sensor.

b. *Location:* Place RPU 200' east of Sand Lake Road on north side of Dimond Blvd. Met Set could be placed at this location also. Place pavement sensor and sub-surface sensor just inside of outside wheel track of WB Dimond adjoining the RPU, and pavement sensor just outside of outside wheel track of NB Sand Lake 300' from Dimond.

c. *Services:* Power and telephone are available. R/W is available to 40' from centerline of Dimond Blvd.

d. *Rationale:* This region of the City is regarded by maintenance personnel as a distinctive micro-climate with drifting snow a frequent problem. Meteorological observations are provided for this area by the NWS MesoNet station about 1.5 mi. away on Sand Lake Road. Condition of the pavements suggest investment in pavement sensors here would not have permanence. Site #23 can perhaps provide somewhat representative pavement observations.

23. Raspberry Road @ Jewel Lake Road

a. *Sensors:* Pavement Sensors and a sub-surface sensor.

b. *Location:* Place RPU in existing cabinet at NE or NW quadrant of intersection if possible; otherwise in an RWIS cabinet at best available location. Place pavement sensors just inside of the outside (curb) wheel track of the outside lanes of the adjoining Raspberry Road and Jewel Lake Road along with a sub-surface sensor at about 100' from the intersection and in the center of the turning lane adjoining the RPU, in the first car-length.

c. *Services:* Power and telephone are available. R/W is available.

d. *Rationale:* Provides representative pavement information for the general "Sand Lake area," a distinctive area of concern to maintenance personnel. This area is also regarded to be representative of one of the Anchorage micro-climates, but a Meso Net site at the NWS Forecast Office is only about .75 mi. away, so duplication is not needed. On the other hand, the nearby weather observation makes this pavement site relatively co-located with an associated weather observation. The sensor in the turning lane is to gather data that could enable development of anti-icing procedures that would discourage build-up of ice in such locations.

24A. Minnesota Drive Bypass @ Raspberry Road

a. *Sensors:* Pavement sensors and a sub-surface sensor.
b. *Location:* Place RPU in infield of southeast quadrant of interchange (Met Set could go on light pole), with pavement sensors on Minnesota NB approach and over-crossing of Raspberry, and on Raspberry EB and in left turn pocket to Minnesota NB on the east side of the interchange.

c. *Services:* Power and telephone and R/W are available.

d. *Rationale:* This site is representative of a large area of interest, and with its multiple roadways, provides opportunities to detect conditions under varying circumstances. However, the meteorological observations are adequately provided by the NWS MesoNet site less than 3 miles away on Sand Lake Road. Site #24B is a preferred alternative for pavement sensors because of current construction.

24B. Minnesota Drive Bypass @ Strawberry Road (projected).

a. *Sensors:* Pavement sensors and a sub-surface sensor.

b. *Location:* Place RPU wherever advantageous within the WIM site now under construction, with a pavement sensor and a sub-surface sensor placed just outside of outside wheel track of the SB passing lane adjoining the RPU, and a pavement sensor just inside of the outside wheel track of the NB through lane across from the RPU on Minnesota Drive.

c. *Services:* Power, telephone, and R/W are available.

d. *Rationale:* This site is representative of a large area of interest and provides opportunity to provide pavement information in support of prediction and monitoring in one lane, and detection in another lane. This replaces site #24A. to take advantage of current construction.

24C. Minnesota Drive @ International Airport Road

a. *Sensors:* Pavement sensors and a sub-surface sensor.

b. Location: Place RPU wherever advantageous within the current construction project (#56283), with a pavement sensor and a sub-surface sensor placed just outside of outside wheel track of the passing lane adjoining the RPU, and a pavement sensor just inside of the outside wheel track of the through lane across from the RPU.

c. *Services:* Power, telephone, and R/W are available.

d. *Rationale:* This site is representative of a large area of interest, and provides opportunity to provide pavement information in support of prediction and monitoring in one lane, and detection in another lane. This is an alternative to replace site #24A to take advantage of current construction.

25. "Mid-town," Seward Highway @ Northern Lights Blvd, for example.

a. *Sensors:* Met Set. Video Camera. Pavement Sensor. Sub-surface Sensor.

b. *Location:* Pavement sensors in representative lanes and turning lanes, with corresponding weather observations, somewhere in the mid-town area have been suggested by maintenance personnel dealing with this busy area.

c. *Services:* Power, telephone and R/W available.

d. *Rationale:* This is a high service level area. Information that would support increased practice of anti-icing, and improved NOWCASTING would be highly useful. However, site #20 and others that can be incorporated with current construction projects, and at least three MesoNet sites less than three miles away (Merrill Field, Lake Otis Parkway, Airport Heights) would make this location duplicative. Also, no site free of air-flow obstructions was identified.

26. Glen Highway @ Muldoon Road Overpass.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place Met Set/RPU in southwest quadrant of interchange, somewhat north of the Municipal Light & Power meter cabinet, in the open location. However, use taller than usual pole to place anemometer 10m above grade on adjoining roadway fill sections. Place pavement sensor and a sub-surface sensor just outside of outside wheel track of SB lane of Muldoon just north of Boundary Avenue; and place pavement sensors just inside of outside wheel tracks on both EB ("NB") and WB Glen Highway 300' west of bridge over Muldoon, and on bridge itself.

c. *Services:* Power, telephone, and R/W are available.

d. *Rationale:* Provides information for prediction and monitoring in the Muldoon area, regarded as a boundary of windier area east of there, pavement conditions on a representative busy City arterial, and detection of pavement conditions under am-pm shifts in prevailing traffic direction on both approach and bridge deck conditions. This is a NHS location. However, this site is somewhat duplicative of weather observations at Elmendorf

AFB and the Muldoon @ 36th Ave. MesoNet site. Pavement sensors would be somewhat duplicative of those at site # 27 if implemented.

27. Glenn Highway @ Approximately 1.0 mile south of Weigh Station

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU in clear area between east side of Glenn Highway and Fort Richardson Firing Range Road, about one mile south of the Weigh Station entrance, and about 100' north of a Municipal Light and Power Meter box and a load center box. Place pavement sensors just inside of the outside (curb) wheel track of the NB lane 1000' south of the RPU along with a sub-surface sensor, and of the SB lane 1000' north of the RPU.

c. *Services:* Power is available; telephone undetermined. R/W is available.

d. *Rationale:* This location will provide information for meteorologists in an area that experiences strong winds, and air drainage from Arctic Valley. It is a very problematical, yet representative area for maintenance personnel. It is a high volume, high priority section of the NHS. There would appear to be a prospect for co-locating a pavement sensor in the adjoining Fort Richardson Firing Range Road, providing information of value to them, but also providing another reading representative of lighter pavements and more lightly traveled roads in the area using the same RPU.

28. Glenn Highway @ Arctic Valley Road. (See # 27)

Rationale: This location responds to the same interest in Arctic Valley air drainage as that addressed by #27.

29. Glenn Highway @ Weigh Station. (See # 27)

Rationale: This location responds to the same interest in Arctic Valley air drainage and windy conditions as that addressed by #27.

30A. Glenn Highway @ Eagle River Hill and Bridges

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU in the "infield" where the SB lanes of the Glenn Highway diverge from the NB lanes south of the Artillery Road over-crossing in Eagle River. Keep the sensors far enough "north" (east) to be beyond the effects of trees. Place four pavement sensors: One each just inside of the outside wheel track of the outside (curb) lane on the NB and SB Eagle River bridges, one just outside of the wheel track of the NB passing lane half way up the hill along with a sub-surface sensor, and one just outside of the wheel track of the SB passing lane at the "top of the hill" near Artillery Road, but in an unshaded location.

c. *Services:* Power is available. Telephone is probable, but undetermined. R/W is available.

d. *Rationale:* This site is a favorite on the list of practically every interested party. It provides weather information in an area affected by valley effects of the Eagle River Valley. This is an operationally demanding area for maintenance with frequent icing and accident problems on both the grades and the bridges. Sensing pavement temperature over the variety of conditions, bridge decks, approaches on grade, and significant differences in elevation will provide data for future analysis as well as input to current operations. This is a high volume, important section of the NHS.

30B. Glenn Highway @ Artillery Road Over-crossing.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set/RPU on east side of Glenn Highway just north of Artillery Road over-crossing, in relatively clear area near the Eagle River Mortuary. Place a pavement sensor and a sub-surface sensor just outside of the outside wheel track of the NB lane adjoining the RPU, and a pavement sensor just outside of the outside wheel track of the SB lane 300' north of Artillery Road.

c. *Services:* Power, telephone, and R/W presumed to be available by observation.

d. *Rationale:* This site is an alternative to #30A, should that be unachievable. The rationale is the same, except that it loses the advantages of bridge deck and on-grade observations. This site is on the NHS.

30C. Glenn Highway @ N. Eagle River Access Over-crossing.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place Met Set/RPU approximately 400-500' west of access over-crossing on north side of highway. Place pavement sensor and sub-surface sensor just outside of the outside wheel track of the SB lane, and just outside of the outside wheel track of the NB lane adjoining the RPU.

c. *Services:* Power and telephone availability are undetermined. R/W is probably available.

d. *Rationale:* This site is an alternative to #30A, should that be unachievable. The rationale is similar, except that it loses the advantages of bridge deck and on-grade observations. This site is on the NHS.

31. Glenn Highway @ Birchwood.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* No suitable location identified.

c. *Services:* Undetermined.

d. *Rationale:* This location would provide information for a representative stretch of the NHS; and it would be at a somewhat higher elevation than the AWOS at the Birchwood Airport. However, it is somewhat duplicative of the AWOS and with no unobstructed location identified, it was not evaluated further.

32. Glenn Highway in Mirror Lake-Peters Creek Area.

Rationale: No suitable site was located, and site #33 would be somewhat of a duplication. So search for a representative site was abandoned. See site #33.

33. Glenn Highway in Vicinity of Eklutna River Bridge

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on south side of Glenn Highway at the Thunderbird Falls off ramp, between the off ramp and the NB lanes of the Glenn Highway. Place pavement sensors just inside of the outside (curb) wheel track of the NB through lanes, along with a sub-surface sensor, adjoining the Met Set, and just inside of the outside wheel track of the SB Eklutna River Bridge. The RPU can be placed on the Met Set tower or in a separate location beside the road part way toward the Eklutna River Bridges, whichever is most cost effective.

c. *Services:* Power and telephone availability is undetermined. R/W is available.

d. *Rationale:* This is regarded by some as a climatically distinctive area and is at a higher elevation than the AWOS approximately four miles away at the Birchwood Airport. Icing is a problem for maintenance personnel on the Eklutna River bridges and the grade to the south. No suitable sites, free of air flow obstructions, could be identified other than in this off ramp location. This proposed site will need to be reviewed by traffic engineers because it is within the clear zone. Pavement sensor locations provide representative information for both bridges and approaches on a north facing grade. This is a high volume section of the NHS.

34. Old Glenn Highway @ Old Knik River Road.

Rationale: This location is off the higher priority NHS, and the concerns are also addressed by site #35. Siting at this particular location was not pursued.

35. Glenn Highway at (Second) Knik River Bridge

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU on the west side of Glenn Highway approximately 300’ north of last light pole beyond the SB off ramp to Knik River Access. This is almost directly across from the last light pole on the NB side of the highway, beyond the Knik River Access, and just south of the secondary Knik River Bridge. Place pavement sensors just outside of either wheel track in the passing lane on the SB bridge along with a sub-surface sensor, just inside of the outside wheel track of the SB outside lane 500’ south of the bridge, and just outside of either wheel track in the passing lane on the NB side 250’ south of the NB bridge.

c. *Services:* Power is presumed available because of the presence of street lighting; telephone is undetermined. DOT R/W is available if stay on the fill section.

d. *Rationale:* This location is ranked number one among all alternatives. The Knik and Matanuska River flats represent a singular micro-climate. The Knik Valley air drainage, in particular, is a source region for Anchorage and Anchorage International Airport fog. Dangerous winds impact traffic. The abundant moisture sources contribute to roadway icing, especially during the shoulder seasons of temperature variations in and out of the freezing zone. Drifting snow is a problem. This is a high volume, important section of the NHS.

36. Glenn Highway @ Matanuska River Bridge.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place Met Set and RPU near the Matanuska River Bridge, with pavement sensors in both directions of the Glenn Highway.

c. *Services:* Neither power nor telephone available. R/W undetermined.

d. *Rationale:* Justification for this site is similar to that of the Knik River Bridge, site #35. However, meteorological effects are more distinctive during winter at the Knik River location. Absence of power and telephone makes #36 problematical and it is at the margin of the "Anchorage Bowl" focus of Phase 1. Therefore, siting was not evaluated in this area.

37. Eagle River Road, Midway up Valley.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface Sensor.

b. *Location:* Place Met Set/RPU on west side of Eagle River Road, just north of Crystal Creek Drive, approximately 4.5 miles south of Eagle River Loop Road. Place pavement sensors just outside of wheel track in SB lane 500' north of and 500' south of the RPU, and a sub-surface sensor with one of them.

c. *Services:* Power and telephone availability undetermined. Nearby residential development makes it likely.

d. *Rationale:* Will provide weather observation at significantly higher elevation than others available, a value to tailored weather forecasts. Will provide representative weather and pavement condition information in a distinctive valley micro-climate and with telemetry, reduce need to "go look" to see what snow & ice control requirements are. Pavement condition may make the sensor in-pavement relatively short lived.

38. Peters Creek Valley

Rationale: Weather sensors in this area would help to address now unexplained local wind effects. Suitable sites not easily identified, and likely relatively low priority for Phase 1 led to no sites identified or evaluated.

39. Tudor Road at C Street

a. *Sensors:* Pavement sensors and a sub-surface sensor.

b. *Location:* Place RPU wherever advantageous within the current construction project (#52512), with a pavement sensor and a sub-surface sensor placed just outside of the outside wheel track of the C street passing lane adjoining the RPU, and a pavement sensor just inside of the outside wheel track of the curb lane on Tudor Road 300' from the RPU.

c. *Services:* Power, telephone, and R/W are available.

d. *Rationale:* This site is representative of the midtown area of interest, and provides opportunity to provide pavement information in support of prediction and monitoring in one of the crossing arterials, and detection in the other arterial.

40. Old Seward Highway @ Dimond Boulevard

a. *Sensors:* Pavement sensors and a sub-surface sensor.

b. *Location:* Place RPU wherever advantageous within the current construction project (#53569), with a pavement sensor and a sub-surface sensor placed just outside of the outside wheel track of the Old Seward Highway passing lane adjoining the RPU, and a pavement sensor just inside of the outside wheel track of the curb lane on Dimond Boulevard 300' from the RPU.

c. *Services:* Power, telephone, and R/w are available.

d. *Rationale:* This site is contributes to a grid of detection sites, and provides opportunity to provide pavement information in support of prediction and monitoring in one of the crossing arterials, and detection in the other arterial.

41. Bragaw Street @ 20th Avenue

a. *Sensors:* Pavement sensors and a sub-surface sensor.

b. *Location:* Place RPU wherever advantageous within the current construction project (#51681), probably in the NE corner of the intersection and possibly sharing an existing cabinet. Place a pavement sensor and a sub-surface sensor just outside of the outside wheel track of the Bragaw Street lane adjoining the RPU, and outside of the outside wheel track of the adjoining 20th Street lane 300' from the RPU.

c. *Services:* Power, telephone, and R/W are available.

d. *Rationale:* This site is representative of a large area of interest and seeks to use a current construction project to advantage. It provides opportunity to provide surface condition information in support of prediction and monitoring in one of the intersecting streets, and detection in the other. It is well located to be correlated with at least three MesoNet sites less than three miles away.

APPENDIX B: Selection Criteria for Anchorage "Bowl" RWIS Sites (Phase 1), and Rating of Sites

The following are criteria used in selecting prospective RWIS sites to benefit operations and forecasts in support of operations in the Anchorage Bowl. The sites were initially identified during interviews and document review of the user needs identification process (Task R2). Most sites are intended to be representative of a larger area or a transition zone between microclimates.

Overall Criterion ("fatal flaw" test):
Does the site have an informative aspect (orientation to the sun), free of obstructions by trees, cuts, embankments, and buildings? YES? NO? MAYBE?

Meteorology Criterion: The location provides meteorologically important information to:

a) Meteorologists in order to develop accurate and timely forecasts of weather conditions, pavement temperature, and road conditions;

b) Meteorologists on the actual type, intensity, and progress of a storm in order to evaluate and update forecasts, as required;

c) Decision-makers on the actual weather and road condition in order to evaluate forecast information in conjunction with their meteorologist.

Decision-maker Criterion: The location provides operationally important information to decision-makers by detecting:

a) Actual road condition (dry, wet, frozen, etc.); in order to evaluate interactively with the forecasters actual storm characteristics and timing compared to forecasts, and therefore, any need for action;

b) Actual weather conditions (especially precipitation or no precipitation, type and intensity of precipitation, wind direction and speed, visibility, and amount of precipitation) in order to determine the appropriate maintenance action or the appropriateness of current maintenance operations;

c) Pavement temperature in order to determine the mix of, or need for, deicing materials;

d) Pavement temperature in order to determine the timing of the application of deicing materials, including anti-icing strategies;

e) The existence and amount of deicing chemicals on the surface, or the temperature at which liquid on the surface will freeze, in order to determine if applications of deicing materials are required.

Rating of Sites

Sites that met the Selection Criteria were methodically rated against evaluative criteria to narrow the list to those that would be recommended. The evaluation process was largely subjective and intuitive but used consistent **considerations** applied to the same **mindsets** from two **perspectives**.

There are three **mindsets** or purposes served in the placement of sensors:

FORECASTING: Sensors are sited to provide local information to supplement NWS and other weather observations to develop site-specific *forecasts* of weather and road conditions. Since the benefit of using weather information is to make timely decision through the use of forecasts, acquiring specific local information should be considered a primary reason for siting sensors. Sites selected primarily in support of forecasting should be meteorologically representative of an area.

Embedded in this consideration is the concept of *NOWCASTING*, which is the process whereby a decision-maker, ideally in consultation with a weather forecaster, uses all available information (weather forecasts, advisories, warnings, RWIS road and weather observations, road reports, and other sources of weather and road condition information) to make near-term decisions about the conditions that will prevail. These are the assumptions that underlie the actions to be taken.

DETECTING: Sensors are sited to *detect* existing or changing weather or roadway surface conditions on a real-time basis. Typical sites would include known trouble spots, fog and frost source areas, bridge decks, elevated roadways, as well as sufficient sites to provide a suitable grid for the reliable reporting of snow accumulation or other precipitation events.

MONITORING: Sensors are also sited to provide a *monitoring* function to check the onset or existence of predicted conditions. Ideal monitoring sites provide information "upstream" of an area. For example, if weather usually comes from the southeast, sensors are placed to the southeast for monitoring; or where temperature inversions are common, sensors would be placed at several elevations.

In the case of a RWIS, there are two important **perspectives**. There is the perspective of the *meteorologists* who analyze current and expected weather conditions to provide forecasts tailored specifically to the operationally significant weather thresholds of certain decision-makers. Their focus is on the atmosphere and what its effects are likely to be—where and when. Also, there is the perspective of the *decision-makers*, who are responsible for maintaining safety and efficiency in the transportation system. Their focus is on the procedures that will maintain intended service levels, and therefore, on the current and predicted weather. The weather effects expected to prevail significantly drive the equipment, materials and personnel assignments selected.

Each prospective site was methodically evaluated in terms of the following **considerations** with the foregoing mindsets and perspectives in mind. The ratings are summarized in the matrix at Exhibit B-1. Inasmuch as each rating was subjectively and intuitively applied by a single individual, as necessitated by the Phase 1 schedule, certainly the value assigned could arguably be somewhat high or low. However, with so many determinations across the matrix, it is believed the composite scores, the totals, should be fairly representative of relative merit for the Phase 1, Anchorage Bowl project.

Considerations methodically applied were as follows:

Road Perspective:

10 points – Roadway is a high weather impact area where road data is of the highest importance in providing the capability to forecast the onset, duration, and monitoring of road conditions. And multiple maintenance & operations interviewees suggested the approximate location, and the rater favors it.

7-9 points – Roadway is a dangerous ice formation area where road data is very important to providing the capability to forecast the onset, duration, and monitoring of road conditions. And one maintainer suggested the approximate location and the rater favors it; or it is particularly representative for pavement temperature.

4-6 points – Roadway is important, but road data is primarily needed for detecting changes in road conditions in an area; also, the site may only require monitoring of road conditions under certain weather patterns. Also, either the rater favors it or a "third party" suggested it.

0-3 points* – Roadway is of lesser importance in terms of overall snow and ice control, but still would benefit from monitoring of road conditions for a specific area; or sensors are too costly for the expected benefits in forecast capability.
Also, interviewees were indifferent to the location, or their views are unknown.

Two points were added to the initial rating if the site was on the National Highway System to give higher priority to high volume, high priority routes. (Thus, on the "10 point scale," a site could score 12.)

Meteorology Perspective:

Special considerations:
1. Representative of a forecast problem area.
2. "Upstream" weather location.

Other important considerations:

3. Elevation.
4. Geographic location.
5. Relation to highway grade.
6. Greater than 3 miles from another observation. (arbitrary)
7. Supports forecaster need for forecast studies.

10 points – Weather data at this location is of the highest importance to forecasting the onset, duration, timing, and for monitoring of severe winter storm events. Existing area weather reporting sites are not representative of this location. All special considerations (above) apply. And multiple meteorologists suggest the approximate location, and the rater favors it.

7-9 points – Weather data at this location is important to forecasting the onset, duration, timing and for monitoring of severe storm events; but topography or proximity of other reporting sites make this site less than a top priority. At least five of the special considerations apply. And one meteorologist suggests the approximate location, and the rater favors it.

4-6 points – Weather data at this location is essential to provide snow pack and icing forecasting capability. At least three of the special considerations apply. And either the rater favors it, or maintenance personnel implied weather information from this location would be used in NOWCASTING.

0-3* points – Weather data at this location would provide added information for enhancing snow and ice control decisions but is not essential for the capability to forecast onset, duration, timing, or monitoring of severe winter storms. Or placement of weather sensors is too costly for the expected benefits in forecast capability. And meteorologists were indifferent to this location or their views are unknown.

*Actually, sites that would have fallen into this range never made it to the list to be evaluated.

In the Ratings Summary of Projected Sites (Exhibit B-1), pavement-sensor only sites are separated out. In some cases, they were initially conceived as full-complement sites, but during the rating process converted to pavement-sensor only. After compiling the ratings, the totals that were high enough to be in the **"top group"** were printed **in bold**.

EXHIBIT B-1: Rating Process Results

PROSPECTIVE LIST OF SUGGESTED RWIS SITES (1 - 22) (See Appendix A)																									
SELECTION CRITERIA (See Appendix B)																									
SITE NUMBER	**1**	**2**	**2A**	**2B**	**3***	**4***	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**12A**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Meteorological Siting Requirements																									
<u>Y</u>es <u>N</u>o <u>M</u>aybe	Y	M	Y	M	-	-	Y	M	Y	Y	Y	M	M	Y	Y	Y	Y	Y	M	M	Y	Y	Y	Y	M
DETECTING																									
Road Perspective	8	10	9	7	12	12	10	10	10	8	8	4	4	12	10	10	9	8	8	8	8	12	12	10	10
Meteorology Perspective	8	10	9	7	-	-	8	4	9	4	7	5	5	6	5	10	9	10	10	9	7	9	8	10	4
FORECASTING																									
Road Perspective (Nowcasting)	7	10	9	7	12	12	10	10	10	8	7	4	4	10	8	9	8	10	10	10	10	10	12	9	10
Meteorology Perspective	10	10	10	8	-	-	9	4	10	4	5	8	8	6	5	10	9	10	10	9	7	9	7	10	4
MONITORING																									
Road Perspective	8	10	10	8	12	12	10	10	10	8	8	6	6	12	10	9	8	8	8	8	8	10	12	10	10
Meteorology Perspective	6	10	10	7	-	-	9	4	9	4	7	5	5	8	7	10	9	10	10	9	7	9	8	10	6
Total Points	**47**	**60**	**57**	**44**	**36***	**36***	**56**	**42**	**58**	**36**	**42**	**32**	**32**	**54**	**45**	**58**	**52**	**56**	**56**	**53**	**47**	**59**	**59**	**59**	**44**
Rank (top 20)		**3**	**11**				**15**		**10**					**16**		**9**	**20**	**13**	**14**	**18**		**5**	****	**6**	

*Pavement/Subsurface only--36 points possible)
**Good site, but duplicative of mesonet sites, so not included in final rating.
xDesirable site, but no place to put sensors.

PROSPECTIVE LIST OF SUGGESTED RWIS SITES (23 - 41)
(See Appendix A)

SELECTION CRITERIA (See Appendix B)																								
SITE NUMBER	**23**	**24A**	**24B***	**24C***	**25**	**26**	**27**	**28**	**29**	**30A**	**30B**	**30C**	**31**	**32**	**33**	**34**	**34A**	**35**	**36**	**37**	**38**	**39***	**40***	**41***
Meteorological Siting Requirements																								
Yes No Maybe	Y	Y	-	-	N	Y	Y	Y	Y	Y	Y	Y	N	M	Y	N	M	Y	M	Y	M	-	-	-
DETECTING																								
Road Perspective	10	11	10	10	12	12	10	10	9	12	8	8	5	10	12	-	9	12	11	8	6	9	10	8
Meteorology Perspective	4	5	-	-	8	6	10	10	10	10	8	8	8	8	7	-	7	10	9	5	5	-	-	-
FORECASTING																								
Road Perspective (Nowcasting)	10	12	11	11	12	12	9	9	9	12	8	8	5	10	10	-	8	12	11	8	6	10	11	9
Meteorology Perspective	4	5	-	-	7	5	10	10	10	8	8	8	8	8	5	-	7	10	9	7	7	-	-	-
MONITORING																								
Road Perspective	10		11	11	12	12	10	10	9	12	8	8	5	10	12	-	8	12	11	8	6	10	10	8
Meteorology Perspective	6	5	-	-	8	6	10	10	10	10	8	8	6	6	7	-	6	10	9	7	7	-	-	-
Total Points	**44**	**49**	**32***	**32***	**59**	**53**	**59**	**59**	**57**	**64**	**48**	**48**	**37**	**52**	**53**	**-**	**45**	**66**	**60**	**43**	**37**	**29***	**31***	**25***
Rank (top 20)					**x**	**19**	**7**	**8**	**12**	**2**					**17**			**1**	**4**					

*Pavement/Subsurface only--36 points possible)
**Good site, but duplicative of mesonet sites, so not included in final rating.
xDesirable site, but no place to put sensors.

APPENDIX C: Suggested RWIS Sensor Sites to Serve the Anchorage "Bowl" (Phase 1)

The following list of suggested sensor sites has been extracted from a longer list considered in the Task R6 Site Selection process. The composition and rationale for each site is suggested. Within the general scope set down for Phase 1, these prospective sites seem to best meet the user needs identified during the earlier and overlapping Task 2 User Needs process.

No priority or relative importance is denoted by the numbers assigned or by sequence. Numbering generally follows a sequence geographically south to north around the Anchorage region, but additional sites were added in and numbered as they occurred.

As a point of departure for the Phase 1 Prototype project, all sites are initially assumed to have a remote processing unit (RPU), standard set of weather sensors and a video camera. A "Met Set" here includes: wind speed and direction, air temperature, humidity, and precipitation sensors. Generally, atmospheric sensors are placed close to the roadway, but not so close as to be affected by the road environment—splash, vehicle-induced winds, traffic heat, etc. "Pavement Sensors" includes pavement surface temperature, concentration of deicing chemicals present on the road, and whether the surface is wet or icy, and a co-located sub-surface temperature sensor at one pavement sensor per site. Generally, pavement sensors are placed 8"-12" from a wheel track center.

2. Silvertip, Seward Highway @ Hope Junction.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on knoll between roads. Place RPU in NE corner of intersection, or on Met Set mast, whichever is most cost effective considering pavement sensor distribution. Place pavement sensors just outside of the wheel track of the outside ("curb") lane in NB lane of Seward Highway, say 400' south of intersection, and in WB lane of Hope Highway, along with a sub-surface sensor, say 200' west of intersection, and one on the center line of Canyon Creek Bridge. Terrain may affect representativeness of wind observations, but testing during prototype phase will evaluate this. If invalid, wind sensors can be moved to a Phase 2 location.

c. *Services:* Lighting poles suggest power available; may switch to solar when lighting turned off for summer. Place solar panel high on light pole out of reach of vandals. Telephone not fully determined: ACS says telephone service is 10 miles away; telephone service exists at Silvertip Maintenance Office, approximately .5 mi away on Hope Highway.

d. *Rationale:* Offsets absence of weather observations between Portage and Kenai-Soldotna, and lack of observations at higher elevations. Provides "upstream" weather observation for Anchorage, i.e. detection and monitoring of weather approaching from the

Gulf of Alaska. Representative pavement condition location for Silvertip Maintenance area. Provides bridge deck pavement condition information. Location is an important section of the National Highway System (NHS).

3. Portage, Seward Highway @ Junction with Visitors Center Road.

a. *Sensors:* Met Set. Video Camera. Pavement sensors. Sub-surface sensor.

b. *Location:* Place RPU in any convenient space at the Seward Highway – Portage Visitors Center road junction (southeast corner?) and pavement sensors just outside of wheel track along with a sub-surface sensor on SB side approximately 200' north of the RPU, and on NB side as far to the "south" into the Placer Overflow area as is practical (.25-.5 mi.?)

c. *Services:* Power and telephone appear to be available to adjoining business locations.

d. *Rationale:* Meteorological observations are provided for this critical area by the NWS ASOS site near the Portage Glacier Visitors Center, but the conditions there are considered be highly localized and likely not representative of conditions on the Seward Highway. Also, some observations at the Visitors Center ASOS site are considered unreliable. For example, snow driven by vertical wind is reported as rain. Wind blowing snow during even clear sky conditions is reported as precipitation. This is essentially a problem of automated observation, but a site at the junction, albeit some five miles away, will provide a comparison. And the Portage area is key to detecting changing weather conditions for the region. The ASOS site pressure observations have often been unreliable; it may be desirable to also add a pressure sensor to the RWIS set at this location. Detection and monitoring of pavement temperature and surface condition information is needed for maintenance. Additional pavement condition sensors at some distance into the Placer Overflow area should be considered, transmitting to this same RPU. Site serves a section of the NHS.

7. Seward Highway @ MP approximately 88.4.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on brushy knoll on south (east) side of small parking area next to old once paved road, on north side of Seward Highway. Place pavement sensor and a sub-surface sensor just outside of wheel track of outside lane in NB lane 500' south of RPU, and pavement sensor in SB lane 300' north of RPU.

c. *Services:* No apparent source of power, solar probably required. Telephone is available 2.2 miles west (north). Good cellular signal.

d. *Rationale:* Provides monitoring of the progression of weather westward along Turnagain Arm. Responds to maintenance interest in pavement and weather conditions in the vicinity of accident prone "Deadman's Curve," the next curve to the south. Site serves a section of the NHS.

12A. Seward Highway @ MP 96.3, Bird Point.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set on south side of highway adjoining Wayside under construction at approximately the SB point of curve, outside the west end of guardrail. Place pavement sensor and a sub-surface sensor just outside of wheel track in NB outside lane of bridge over-crossing of RR approximately

300’ south; and pavement sensors in SB lane adjoining Met Set/RPU, and in SB lane 2500’ of RPU.

c. *Services:* Power apparently available across highway to the south, and could be cabled through the bicycle path under-crossing. Telephone is available 300’ west on south side. R/W is available..

d. *Rationale:* Provides detection and monitoring of the progression of weather westward along Turnagain Arm, is on “leading edge” of southeast winds from Whittier-Portage area. Site is at western edge of Bird to Girdwood avalanche zone. Pavement temperatures would likely be representative of the region. Good open airflow site. Site serves a section of the NHS. Sites number 12 and 13 are alternatives for the same area. Number 12 is preferred. If achievability or cost argue against it, choose number 13. The visual impact of the atmospheric sensors and mast could be a concern at this highly scenic location (and that is exactly why Beluga Point was avoided). However, the RPU with an approximate 30” X 21” silhouette could be placed on the surface at this location, leaving a very slender silhouette for high speed traffic to see through. Most people enjoying the scenery will have stopped in the wayside and be outside and below the sensor installation “impact.”

13. Seward Highway @ MP 101.4, Bird Creek.

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Attach Met Set/RPU to west (south) side of bridge structure at approximately mid-span at Bird Creek on Seward Highway. Place pavement sensors just outside of wheel track of outside SB lane on adjoining bridge deck, and along with sub-surface sensor on NB lane 500’ north of bridge.

c. *Services:* Residential/commercial development estimated .5 mi. south of bridge suggests power may be available. Telephone is available 500’ east on south side. R/W is available.

d. *Rationale:* Provides monitoring of the progression of weather westward along Turnagain Arm, and detection of flow of air down Bird Creek Valley. “Bird Flats” area believed to be a different microclimate than areas north and south, i.e. outside the valley effects. Obtaining pavement temperatures of both bridge deck and approach roadways provide contrast. The approach sensor is placed north to get more representation of the area out of the “flats.” The site is on the NHS. Sites number 12 and 13 are alternatives for the same area. Number 12 is preferred. If achievability or cost argue against it, choose number 13.

15. Seward Highway @ MP 111.8, McHugh Creek (Point).

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set/RPU on west (south) side of road at the point just north of the McHugh Creek Wayside, either between roadway (outside of guardrail) and railroad, or across the tracks on the rocky promontory near the micro wave tower. Place pavement sensors just outside of outside wheel track in NB lane 2500’ south of RPU and in SB lane 2500’ north (or sufficient distance to get around corner to different environment) of the RPU. Place sub-surface sensor at either one. The site adjoining the road may be preferred to minimize maintenance difficulties.

c. *Services:* Power and telephone not apparently available. Will require solar and cellular or radio communications.

d. *Rationale:* Provides detection and monitoring of the progression of weather westward along Turnagain Arm, and in the vicinity of microclimate change described by maintenance personnel as a "curtain" where Girdwood area weather changes to Anchorage area weather. Good open air flow site. The curve provides opportunity to observe pavement temperature/condition in potentially contrasting south facing and north facing aspects. This site is on the NHS.

19. Seward Highway @ Huffman Road

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Mount Met Set 10m above Seward Highway roadway on tall highway lighting pole, near over-crossing of Huffman, with RPU either also mounted on the pole or in or near traffic control cabinet in NE quadrant of interchange. Place pavement sensors just inside of NB outside (curb) wheel track of bridge deck. Also, in inside of outside wheel track along with sub -surface sensor of NB lane of Seward Highway near the merge of Huffman to Seward Highway NB on-ramp. On the east side of the Huffman overpass, place pavement sensors just outside of outside wheel track of WB lane of Huffman, and in center of Huffman EB left turn pocket in the first car-length.

c. *Services:* Power and telephone are available. Site is within the R/W.

d. *Rationale:* This is an area of interest to both maintenance and weather Forecast personnel. It provides detection and monitoring at the "leading edge" of weather entering the City from the south. Pavement conditions on the high standard approach and structure of Seward Highway and the local arterial of Huffman below should be representative of a wide cross-section of similar roadways at a similar elevation in the southern section of the City. The sensor in the turning lane is to gather data that could enable development of anti-icing procedures that would discourage build-up of ice in such locations. This site is on the NHS. One drawback is that it is less than 3 miles from an existing MesoNet station.

20. Ingra Street @ 15th Ave.

a. *Sensors:* Pavement Sensors, and a sub-surface sensor.

b. *Location:* Place pavement sensors just inside of outside wheel track of outside (curb) lane of 15th Ave. EB and Ingra St. SB (utilizing an adjoining traffic cabinet for the RPU), or in the same relationship to an existing cabinet on the NE corner if preferred. Place sensors approximately 100' from the intersection or as advantageous to the current construction project (50624). Place a sub-surface sensor at either location.

c. *Services:* Power and telephone are available. R/W is available.

d. *Rationale:* This is an ideal and representative in-city location, in an area of interest to both City and State maintenance personnel and provides detection and forecasting information for roadways of comparable elevation and traffic exposure in the mid-town area. This would also be an excellent site for a MetSet and video camera, but the Merrill Field continuous observing and reporting station, ASOS, is only about a mile away, so the duplication is not justified. On the other hand, the nearby Merrill Field observation makes this pavement site relatively co-located with an associated weather observation.

21. Hillside Road @ Upper Huffman Road

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set/RPU approximately midway between Upper Huffman Road and 12500 Hillside Road on the west side of road. Place pavement sensors just outside of wheel track on curb side SB adjoining the RPU along with a sub-surface sensor, and in front of 12640 Hillside Road.

c. *Services:* Power and telephone are available. R/W is available to 40' from centerline.

d. *Rationale:* This site provides a representative location with good open airflow, at a higher elevation of the City. No other site was identified on the hillside with such good siting characteristics. It responds to weather forecasters' desire for more observations at higher elevations, and is at an elevation between the highest MesoNet site (Glen Alps) and most of the other sites within the City. It provides information for snow and ice control operations on the hillside. Although sensors are suggested for the same side of the pavement to minimize cost, the two pavement sensors provide north and south facing aspects respectively, and thus, potentially different representative information.

23. Raspberry Road @ Jewel Lake Road

a. *Sensors:* Pavement Sensors and a sub-surface sensor.

b. *Location:* Place RPU in existing cabinet at NE or NW quadrant of intersection, if possible; otherwise in an RWIS cabinet at best available location. Place pavement sensors just inside of the outside (curb) wheel track of the outside lanes of the adjoining Raspberry Road, and Jewel Lake Road along with a sub-surface sensor at about 100' from the intersection, and in the center of the turning lane adjoining the RPU, in the first car-length.

c. *Services:* Power and telephone are available. R/W is available.

d. *Rationale:* Provides representative pavement information for the general "Sand Lake area," a distinctive area of concern to maintenance personnel. This area is also regarded to be representative of one of the Anchorage micro-climates, but a Meso Net site at the NWS Forecast Office is only about .75 mi. away, so duplication is not needed. On the other hand, the nearby weather observation makes this pavement site relatively co-located with an associated weather observation. The sensor in the turning lane is to gather data that could enable development of anti-icing procedures that would discourage build-up of ice in such locations.

27. Glenn Highway @ Approximately 1.0 mile south of Weigh Station

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU in clear area between east side of Glenn

Highway and Fort Richardson Firing Range Road, about one mile south of the Weigh Station entrance, and about 100' north of a Municipal Light and Power Meter box and a load center box. Place pavement sensors just inside of the outside (curb) wheel track of the NB lane 1000' south of the RPU along with a sub-surface sensor, and of the SB lane 1000' north of the RPU.

c. *Services:* Power is available; telephone undetermined. R/W is available.

d. *Rationale:* This location will provide information for meteorologists in an area that experiences strong winds, and air drainage from Arctic Valley. It is a very problematical, yet representative area for maintenance personnel. It is a high volume, high priority section of the National Highway System (NHS). There would appear to be a prospect for co-locating a pavement sensor in the adjoining Fort Richardson Firing Range Road, providing information of value to them, but also providing another reading representative of lighter pavements and more lightly traveled roads in the area using the same RPU.

30A. Glenn Highway @ Eagle River Hill and Bridges

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU in the "infield" where the SB lanes of the Glenn Highway diverge from the NB lanes south of the Artillery Road over-crossing in Eagle River. Keep the sensors far enough "north" (east) to be beyond the effects of trees. Place four pavement sensors: One each just inside of the outside wheel track of the outside (curb) lane on the NB and SB Eagle River bridges, one just outside of the wheel track of the NB passing lane half way up the hill along with a sub-surface sensor, and one just outside of the wheel track of the SB passing lane at the "top of the hill" near Artillery Road, but in an unshaded location.

c. *Services:* Power is available. Telephone is probable, but undetermined. R/W is available.

d. *Rationale:* This site is a favorite on the list of practically every interested party. It provides weather information in an area affected by valley effects of the Eagle River Valley. This is an operationally demanding area for maintenance with frequent icing and accident problems on both the grades and the bridges. Sensing pavement temperature over the variety of conditions, bridge decks, approaches on grade, and significant differences in elevation will provide data for future analysis as well as input to current operations. This is a high volume, important section of the NHS.

33. Glenn Highway in Vicinity of Eklutna River Bridge

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. Location: Place Met Set on south side of Glenn Highway at the Thunderbird Falls off ramp, between the off ramp and the NB lanes of the Glenn Highway. Place pavement sensors just inside of the outside (curb) wheel track of the NB through lanes, along with a sub-surface sensor, adjoining the Met Set, and just inside of the outside wheel track of the SB Eklutna River Bridge. The RPU can be placed on the Met Set tower or in a separate location beside the road part way toward the Eklutna River Bridges, whichever is most cost effective.

c. *Services:* Power and telephone availability is undetermined. R/W is available.

d. *Rationale:* This is regarded by some as a climatically distinctive area and is at a higher elevation than the AWOS approximately four miles away at the Birchwood Airport. Icing is a problem for maintenance personnel on the Eklutna River bridges and the grade to the south. No suitable sites, free of air flow obstructions, could be identified other than in this off ramp location. This proposed site will need to be reviewed by traffic engineers because it is within the clear zone. Pavement sensor locations provide representative information for both bridges and approaches on a north-facing grade. This is a high volume section of the NHS.

35. Glenn Highway at (Second) Knik River Bridge

a. *Sensors:* Met Set. Video Camera. Pavement Sensors. Sub-surface sensor.

b. *Location:* Place Met Set and RPU on the west side of Glenn Highway approximately 300' north of last light pole beyond the SB off ramp to Knik River Access. This is almost directly across from the last light pole on the NB side of the highway, beyond the Knik River Access, and just south of the secondary Knik River Bridge. Place pavement sensors just outside of either wheel track in the passing lane on the SB bridge along with a sub-surface sensor, just inside of the outside wheel track of the SB outside lane 500' south of the bridge, and just outside of either wheel track in the passing lane on the NB side 250' south of the NB bridge.

c. *Services:* Power is presumed available because of the presence of street lighting; telephone is undetermined. DOT R/W is available if stay on the fill section.

d. *Rationale:* This location is ranked number one among all alternatives. The Knik and Matanuska River flats represent a singular micro-climate. The Knik Valley air drainage, in particular, is a source region for Anchorage and Anchorage International Airport fog. Dangerous winds impact traffic. The abundant moisture sources contribute to roadway icing, especially during the shoulder seasons of temperature variations in and out of the freezing zone. Drifting snow is a problem. This is a high volume, important section of the NHS.

APPENDIX D: Sensor Summary

Recommended Sites	Pavement Sensors								Power		Communications	
Location	**Approach**	**Deck**	Sub Surface	**Temp**	**RH**	**Wind**	**Precip**	**Camera**	**Electric**	**Solar**	**Phone**	**Other**
2. Silvertip, Seward Highway @ Hope Junction	2	1	1	1	1	1	1	1	1	1	?	?
3. Portage, Seward Highway @ Junction with Visitors Center Road	2		1	1	1	1	1	1	1		1	
7. Seward Highway @ MP approximately 88.4	2		1	1	1	1	1	1		1	?	?
12. Seward Highway @ MP 96.3, Bird Point	2	1	1	1	1	1	1	1	1		1	
13. Seward Highway @ MP 101.4, Bird Creek	1	1	1	1	1	1	1	1	1		1	
15. Seward Highway @ MP 111.8, McHugh Creek (Point)	2		1	1	1	1	1	1		1		1
19. Seward Highway @ Huffman Road	3	1	1	1	1	1	1	1	1		1	
20. Ingra Street @ 15th Ave	2		1						1		1	
21. Hillside Road @ Upper Huffman Road	2		1	1	1	1	1	1	1		1	
23. Raspberry Road @ Jewel Lake Road	3		1						1		1	
27. Glenn Highway @ Approximately 1.0 mile south of Weigh Station	2		1	1	1	1	1	1	1		?	?
30A. Glenn Highway @ Eagle River Hill and Bridges	2	2	1	1	1	1	1	1	1		?	?
33. Glenn Highway in Vicinity of Eklutna River Bridge	2		1	1	1	1	1	1	?	?	?	?
35. Glenn Highway @ (Second) Knik River Bridge	2	1	1	1	1	1	1	1	1		?	?
TOTALS	**29**	**7**	**14**	**12**	**12**	**12**	**12**	**12**	**11**	**3**	**7**	**1**
Pavement Sensor Sites, Current Construction												
Location												
24C. Minnesota Drive @ International Airport Road	2		1									
39. Tudor Road @ "C" Street	2		1									

40. Old Seward Highway @ Dimond Boulevard	2		1									
41. Bragaw Street @ 20th Avenue	2		1									
TOTALS	**8**		**4**									

ALASKA DOT&PF INTELLIGENT TRANSPORTATION SYSTEM
ROAD WEATHER INFORMATION SYSTEM (RWIS)

Phase I Task R12
Operational Testing and Evaluation

July 11, 2002

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Alaska Road Weather Information System
Phase I
Test and Evaluation

INTRODUCTION

During the winter season of 2001-02, the Alaska Department of Transportation & Public Facilities (ADOT&PF) began incorporating the use of a Road Weather Information System (RWIS) into its winter maintenance operations. Eight new remote weather stations were installed in and near the Anchorage area. These sites provide much data not previously available to the maintenance decision-maker. Such data as pavement temperature and pavement status (wet, dry, ice, snow, wet, etc.) gave the managers an additional tool to aid in fighting winter storms.

These systems were installed by Surface Systems, Inc. (SSI). One part of the package provided by SSI was a weather and pavement temperature forecast service known as SCANCAST. The SCANCAST is a site-specific forecast for each Environmental Sensor Station (ESS) location. It provides the "standard" weather forecast information such as temperature, winds, and precipitation. But it also gives the user additional information not available elsewhere, such as pavement temperature and hour-by-hour forecasts of other criteria.

A test and evaluation process was undertaken for the final month of winter, April 2002, in accordance with the Phase I work plan. The system and participants were not accepted and prepared to do so earlier. The weather during the month was mostly benign. So the results are not definitive and the experience not particularly representative for a full winter's experience. Nevertheless, the process did provide insights to use, reliability, and performance of the system, and to utility and accuracy of the forecasts.

This report consists of the following:

- Brief conclusions related to the brief period of the test and evaluation (T&E).
- Report of the findings by selected ADOT&PF maintenance decision makers on the utility of the RWIS equipment, SSI pavement forecasts, and first use of the system.
- Report on the accuracy and utility of National Weather Service (NWS) and SSI forecasts.
- Report on the automated SSI forecast verification process.
- Appendix of the performance criteria on which the evaluation was based, and the worksheet used by maintenance decision makers to report their experience.

CONCLUSIONS

Field Test

The field test centered on daily reporting from four maintenance activities, with trained personnel monitoring reliability, utility, and value of the RWIS during the period of April 2002.

Field equipment was found to be very reliable during the brief period of this test and evaluation. Utility of the field equipment was also found to be good, i.e. observations representative of the surrounding area, and indicative of the nature of the weather and surface conditions at the reporting location.

The ScanWeb system was fully operational the vast majority of the time. The time taken to access ScanWeb was mostly acceptable, although there were exceptions to this that primarily stemmed from difficulty accessing the State WAN. However, the ScanWeb was deemed useful or highly useful for the day's conditions only about half the time. This finding seems to have been influenced by the relatively benign weather experienced during April 2002, the T&E period.

It is a little unclear whether evaluators always recognized that evaluation of the ScanCast product was a focus on the pavement temperature forecast primarily, and secondarily, on the weather forecast assumptions on which the pavement forecasts were based. On the face of it, however, evaluator reports indicated ScanCast delivery was very reliable, useful 77% of the time, with the pavement temperature forecast being the element having the greatest bearing on decisions made.

Pavement temperature forecasts were impressively good; yet, occasions where they missed the mark are instructive to forecasters for the future.

There was no contact between users (decision makers) and providers (forecasters) of the weather and pavement temperature forecasts. This is unfortunate because feedback among the parties would synergistically raise the effectiveness of the RWIS; a period of more severe weather might change this practice.

The lack of weather impacts mostly precluded a meaningful appraisal of whether use of the RWIS led to savings through better decision-making.

Weather and Pavement Forecasts

The Matrix Management Group conducted a subjective analysis of RWIS weather and pavement temperature forecasts for the T&E period. Both SSI and NWS forecast accuracy was acceptable in this benign weather regime. There were very few large errors in the forecasts. Air temperature forecasts were generally accurate. Both organizations had more trouble forecasting the winds in this difficult terrain. There were probably too few precipitation events upon which to draw solid conclusions, but both appeared to be reasonably accurate.

The tailored SSI forecast, by definition, was always more precise, i.e. more differentiated conditions site-by-site than the NWS forecast. It provided the user much more detail, both site by site and timing-wise, as to where and when changes would occur. However, further study is needed to determine if this leads to increased accuracy.

SSI Automated Verification

An automated process of forecast verification maintained by SSI confirms the high accuracy of the pavement forecasts during this period.

FIELD TEST and EVALUATION RESULTS

A "low impact methodology" was established, involving a small cadre of evaluators addressing a limited range of questions, and only a sampling of the environmental sensor station (ESS) locations on a regular basis. This was sufficient to get a sense of the system's performance during the limited period from roughly mid-March through April 2002 (evaluators did not start and stop on exactly the same dates). Five reporting stations, involving seven people (two were backups), were invited to participate. In the end, reports steadily monitored four ESS locations and the utility of the information to operations in those areas (Portage, Bird Point, Seward Highway at Huffman, Knik).

Performance of Field Equipment

The equipment was found to be generally very reliable. Out off 56 reports: surface (pavement) temperature, sub-surface temperature, air temperature, relative humidity, wind speed and direction were reported out of service only once, or **98% in-service.** (However, reported wind speed and direction at Bird Point and McHugh Creek often seemed incongruous with conditions being experienced by personnel—see Utility of Field Equipment and of Scan Web below.)

Precipitation sensors were reported out of service (or unclear) 4 times, or **93% in-service**.

Out of 40 reports (among the T&E stations, Knik camera was not available) the cameras were reported out of service 3 times, or **93% in-service**.

Four system outages were recorded, but only one reported to SSI. The reported outage was 9 hours 12 minutes in duration, but the system was back in service 1.5 hours after being reported to SSI by email. The outage was "no camera images."

Three times during the individual 59 daily reports, evaluators were unable to connect to the system, or 5% of the attempts. However, there were other times when connecting took so long as to be unsatisfactory. This is a reflection on State Internet connectivity rather than SSI RWIS equipment.

Utility of Field Equipment

89% of the daily reports found observations from the particular ESS being monitored to be **representative** of the surrounding area for that day; **and** the collection of instruments and observations at the site to **fully indicate the nature** of weather and surface conditions there.

The exceptions to that general picture primarily consisted of concerns due to indicated Ice Warning conditions that were confusing or unexplainable for the surrounding conditions at Bird Point; and a couple of times when the precipitation report seemed low. Anecdotally (because the McHugh Creek ESS was not among the sites daily monitored by the T&E) the McHugh Creek ESS was very often reported to be showing northerly winds when people were experiencing easterly or westerly winds.

71% of the time weather factors were believed **useful** to the decisions for the day's conditions. The primary shortfall was the Knik ESS location, which the Palmer maintenance supervisor thought was not useful for the weather and operations of April.

Performance of ScanWeb

ScanWeb is the SSI Internet based presentation of RWIS observations.

The ScanWeb service was reported **fully operational 87% of the time**; but there were also 4 times when the system could not be accessed and 2 when the evaluator's report was left blank. When the system was reported "not accessible," it was accessed from other stations, suggesting a local problem. The primary reason for the "not fully operational" reports were that camera images were not available at Seward/Huffman, Bird Point, or Portage. The camera at Knik was never available because it was turned off to avoid cellular phone charges.

Time of access was 78% acceptable. When evaluators accessed the system in times that ranged from "instantly" to 5 minutes, they found it acceptable. Of the acceptable times, 33% were 1 minute or less, and 17% were blank as to time, but reported as acceptable, and could have been in a similar range. However, when the time to access ran beyond five minutes, evaluators found the time unacceptable. These times ran from 5 minutes to 2 hours, and (as noted above) four times, they were unable to connect at all.

Seemingly, all unacceptable times were related to difficulty accessing the State WAN; and virtually all of the slow times were at Girdwood—mostly the avalanche office. So the deficiencies needing correction seem not to be related to ScanWeb per se.

Utility of Scan Web

Air temperature, surface (pavement) temperature, wind speed, and wind direction reports were most often (and almost always when anything at all was cited) noted as having the greatest bearing on decisions made that day, with camera images also scoring highly (or triggering negative comments when missing).

ScanWeb was deemed **useful or highly useful** for the day's conditions in **50%** of the reports, but in **44%**of the reports, the ScanWeb information was categorized as **indifferent** for the conditions of the day. This is very reflective of the benign weather experienced during most of April. In **6%** of the reports, ScanWeb was reported as not particularly useful or even counterproductive due to missing camera image, or a precipitation report not consistent with actual weather. The latter reports stem primarily from Palmer where, on March 27, it was snowing and packing on roads and conditions were "treacherous." Although the NWS forecast called for snow showers, and the SSI forecast for accumulations of perhaps 2", taken together with a seemingly inaccurate Knik ESS precipitation observation, the system did not adequately address the situation. It was recognized that the supplemental sites of Phase II might combine with the Knik site to better characterize the entire Palmer area.

Utility of ScanWeb in both the Bird Point and Portage areas was weakened by reported wind speed that seemed incongruous for the reported direction (north) on a couple of reported occasions. "Ice Warning" at Bird Point when all other sites had the same conditions but were reported "Dry" created consternation in at least four reports.

Performance of ScanCast (SSI forecasts)

This element of the T&E was focused on the pavement temperature forecasts acquired from SSI. The ScanCasts also included the underlying SSI weather forecasts that were part of the premise on which the pavement forecasts were made. This evaluation represents the perceptions of the participating ADOT&PF maintenance evaluators. A more systematic verification of both SSI and NWS forecasts is presented in the next section of this report.

The results of this item are presented here as reported in the worksheets. However, there was evidence that "ScanCast" was not consistently recognized by some evaluators as focused on SSI **forecasts.** Some of the responses were repetitious of Worksheet question 3 that was focused on the sensor and camera readings (ScanWeb). This will need to be made clearer in Phase II.

ScanCast delivery was very reliable. Virtually all reports said the daily ScanCast was received, and on time. The two "no"s were apparently related to problems accessing the State WAN system, or that one element of the ScanCast did not respond (although other evaluators at the same time did get it).

Evaluators found the ScanCast **useful** that day **77%** of the time. However, 23% of the time, they did not. Again, at least two of those instances were related to difficulty accessing the system. There were 13 reports of "not useful," almost all of which were from Palmer where the Knik ESS site was either deemed not relevant to the operations appropriate for the April weather being experienced, or the forecasts seemed contrary to the actual weather being experienced.

The ScanCast element having the greatest bearing on decisions made was the pavement temperature forecast. Fully half of all responses noted this, even though for many reporting periods of April the icing threat was low.

Air temperature, wind speed, and wind direction (especially for avalanche) were also rated very important. The general weather forecast (to anticipate the air mass remaining stable, for example), precipitation forecast (especially of none anticipated, and the probability), and camera observations (though not seemingly forecast related) were also mentioned often.

Only one element of the ScanCast was significantly mentioned as seemingly contradictory to the weather being experienced: wind direction was cited on 10 out of 50 reports, or more exactly, on almost all reports from the Avalanche Office at Girdwood. Quote: "the forecasters have no handle on wind direction." This seems to be focused primarily on Bird Point and McHugh stations.

Pavement temperature forecast results as recorded by evaluators were impressively good. Yet, the few inaccurate forecasts identify situations on which to direct attention in the future, to determine whether forecast lessons are implied, or whether system access issues are in play.

The focus of the evaluation was on the times at which the surface temperature was forecast to cross the freeze-point, which was several times per day. The actual crossing of that critical threshold was within an hour or less of the forecast time 68 times; and 17 of those times, the forecast was perfect—the actual time the same as the forecast time. The other variances: 15 min., 8 times; 30 min., 15 times; 45-60 min., 21 times. Eight times the pavement temperature was forecast to cross the 32°F line, but never did.

Pavement temperature forecasts that missed by over an hour included four that missed by 90 minutes, two by 1 hour 45 minutes (still quite commendable); and twelve* by 2 to 5 hours. Some of this latter group may reflect reporting problems—how the worksheet was completed at the change in day, etc. It would be useful for the forecasters to review what was the difficulty at those particular times.* There were also four instances when the pavement temperature was forecast not to cross 32°F, but did—the most dangerous situation, and eight instances when it was forecast to cross freezing, but didn't.

Some comments by evaluators are interesting. It was noted that although the freeze intercepts were right on target, the actual pavement temperatures at the warmest time of the day were often much higher than forecast (11°F higher noted). Several examples of usefulness of these forecasts in conjunction with video cams were given: When the forecast projected warm, dry pavements, but a lot of water could be seen in shoulders by video cam: "Go thaw culverts." From the ScanCast, (we) would have guessed snow would melt off in the afternoon, but the video cam showed otherwise.

With regard to usefulness of the ScanCasts, 22 reports found them useful or highly useful; 19 reported indifference to them—typically conveying it was due to the relatively benign weather and dry roads, and didn't matter. Five reports found them not particularly useful or even counter-productive. Reasons for these included: the information was not received timely that day; or especially regarding the Knik site for Palmer, readings that were different than the prevailing weather being experienced, and/or disappointment of a camera image not being available.

RWIS "Teamwork"

The point of this evaluation item was to gauge the degree to which the users and providers of the weather and pavement forecasts interacted to make them better—additional insights from the field to the forecasters, and updating explanations to the users. With the exception of one emailed notice of outage to SSI, there were no contacts.

In the case of SSI forecasts, this is disappointing because this kind of interaction is part of the service purchased. Heightened mutual understanding can only make the products more tailored and more accurate. However, the non-threatening weather during this short period is undoubtedly a part of the explanation.

In the case of the NWS forecasts, the lack of contact is not surprising. The NWS is not now encouraging such contacts because of concerns about work overloads during inclement weather.

Early Value of RWIS

Evaluators were prepared to appraise their actions taken during storms with RWIS information available, and whether it made any difference—either leading to savings or advantageously redirected effort, or unnecessarily triggered into unwarranted action. However, there were virtually no storm events during the T&E period.

* 3/26/02, no forecast, 0100 and 0300 crossings, Bird Point; 3/26, 1900 and 1800 forecasts, Huffman; 3/27, 2030 forecast, Bird point; 3/27, 0900 and 2100, Knik; 4/10, 0815, Portage; 4/15, 2200, Knik; 4/16, 2200, Portage; 4/22, 2330 no forecast, Portage; 4/25, 1030 and 0100, Knik.

There was one wet snow event with pavement temperature just below freezing, but the supervisor believed the situation was fairly obvious and that the RWIS information resulted in no change from what would have been done anyway—no effect on budgeted resources. In another case of wet snow, with RWIS information showing, after the fact, the event was only 5 hours long, had an initially below freezing pavement, but warming to 35°F, it was recognized that crews and equipment could have been re-dispatched to other work. There was no effect on budgeted activities in this instance.

ANALYSIS OF WEATHER and PAVEMENT TEMPERATURE FORECASTS AVAILABLE TO ALASKA DOT&PF

Introduction and Background

The Matrix Management Group conducted a brief analysis of the two primary sources of forecast information available to the winter maintenance decision-maker. This study covers the period of March 15, 2002 to April 30, 2002. Unfortunately, this encompassed only the tail end of the winter season, and very few winter weather events occurred during the period. At the very start of the period, a record-setting snowfall was underway in the Anchorage area. But because it was already underway, it was difficult to assess forecast performance related to this event. During the period of the study, only a couple of minor events occurred, making it difficult to assess performance related to precipitation forecasting.

It must be stated up front that the intent of this report is **not** to directly compare the SCANCAST with NWS forecasts. The two products are designed with different purposes in mind. The NWS forecast is not site-specific, nor is it prepared with ADOT&PF operational criteria in mind. The SCANCAST, on the other hand, is. As SSI becomes more familiar with ADOT&PF operational criteria, they should be able to increase the utility of the forecast.

Rather than directly comparing the two products, this study aims to examine some basic measures of accuracy and utility. The forecasts, as this report will show, are not directly comparable, due to the factors stated in the previous paragraph. However, both sources are intended to be part of the weather information base used by ADOT&PF decision makers under the concept of operations.

Methodology

Location Selection. The first step in the process was to select appropriate locations for which forecast verification could be conducted. It was decided that three locations would provide a representative cross-section of forecast quality. All locations are ESS sites in the Anchorage area. The locations selected were:

- Glenn Highway at Eagle River. This site is northeast of Anchorage on the southern side of the Knik Arm, with higher terrain to the east.
- Seward Highway at Huffman Road. This site is in Anchorage.
- Seward Highway at Milepost 96.3 (Bird Point). This site is southeast of Anchorage between Bird Creek and Girdwood. It is along the Turnagain Arm, with steeply sloping terrain to the north and east.

Data Selection. Next, all available data was examined in order to determine which information would be verified. The primary criteria used in this decision were the importance of the data to the maintenance manager. In the end, it was decided to examine forecast accuracy for four elements of each forecast:

Air temperature
Pavement temperature (SCANCAST only)
Wind speed and direction
Precipitation

Data Gathering. Beginning with the afternoon forecasts on March 16, most weekday SCANCAST's and NWS forecasts issued in the morning were collected. Some forecast information was downloaded for afternoon forecasts when the morning forecast was missed to provide completeness, but it was decided to eliminate the few afternoon forecasts collected that were available for reasons of consistency.

All NWS forecasts were downloaded from their web site, which is available to the general public. Some copies of early forecasts that were not downloaded were requested directly from NWSFO Anchorage, who graciously provided them.

All SCANCAST's were downloaded from the ADOT&PF SCANWeb site, which also contains all current and historical information generated by the ESS sites.

At the same time as SCANCASTs were downloaded, detailed historical information for the three sites was also saved. This data includes the following:

Air temperature
Relative humidity
Dew point
Wind speed and direction
Wind gust
Precipitation (Yes/No)
Pavement temperature

These data were all available in tabular form. In addition, the air and pavement temperatures were available and saved in a graphic format that showed plots of both forecast and actual conditions. The trends available in this format were extremely useful in determining accuracy and utility of forecasts.

ADOT&PF has set the polling frequency for its ESS sites at 15 minutes. Thus, 15 minutes is the interval between successive lines of historical data. This resolution is more than sufficient for this study.

Mesh datasets. The next step was to mesh the available datasets. As stated earlier, since very few afternoon forecasts were available, it was decided not to use any of these in the analysis. All forecasts for which no or an insufficient number of verifying observations were available were also eliminated. Finally, any forecast for which either the NWS forecast or the SCANCAST was not available was also eliminated. While direct comparison of forecast verification results is not advised, consistency requires use of as similar of datasets as possible.

Next, the forecasts were separated into two valid periods, each consisting of 12 hours. Essentially, the first 12-hour period measured forecast quality during the day, while the second 12-hour period examined accuracy during the night.

Develop verification criteria. The key decision centered on how to perform the verification. One method was required, yet two dissimilar products were being examined. For this reason, it was decided that a fairly "general" scheme was required. Thus, a simple 1 through 5 rating scheme was used for each element being examined, with 5 being the best and 1 the worst. Points were awarded to each element for each forecast as follows.

a. Air temperature. The NWS uses categories to state air temperature forecasts. For instance, "high in the low 30's" is a category. "High near 40" would be another. The SSI forecast was adjusted to agree with these categories. High temperature forecasts were verified for daytime hours; low temperature forecast were used for nighttime forecasts. Points were awarded as follows:

5: 0 categories off on high temperature for the day/low for night
4: 1 category off
3: 2 categories off
2: 3 categories off
1: 4 or more categories off

b. Pavement temperature (SCANCAST only)

5: crossed 32°F within 1 hour of forecast
4: crossed 32°F within 2 hours of forecast
3: crossed 32°F within 3 hours of forecast
2: crossed 32°F within 4 hours of forecast
1: crossed 32°F more than 4 hours from forecast

In the event that the pavement temperature crossed 32°F more than once (perhaps rising then falling), typically hovering around 32°F, an average of the two or more times was used to determine the rating. This infrequently occurred, however.

c. Wind speed. In order to verify NWS wind speed forecasts, the middle of their forecast wind speed range was used. Fore instance, if the forecast was for winds of 5 to 15 mph, 10 mph was used as the forecast wind speed. SSI forecasts used specific speeds.

5. speed within 2 mph
4: speed within 4 mph
3: speed within 6 mph
2: speed within 8 mph
1: speed within 10 mph
0: Speed not within 10 mph

d. Wind direction. As with speed, in some cases NWS used ranges of directions. In these cases, the middle of the range was used as the forecast.

5: Direction within 30°
4: Direction within 60°
3: Direction within 90°
2: Direction within 120°
1: Direction within 150°

0: Direction missed by 180°

e. Precipitation. Start and stop times were used. No historical information on observed precipitation type was available. Like the system user, it would have to have been inferred from the yes/no sensor and air temperature. However, it is not felt that this is an accurate enough method to draw conclusions from this study. It might be acceptable for the user to make such inferences when additional information is available.

5: Start/stop time within 2 hours
4: Start/stop time within 3 hours
3: Start/stop time within 4 hours
2: Start/stop time within 5 hours
1: Start/stop time more than 5 hours off

It must be noted that there were really no occurrences of sustained precipitation during the study period at the three sites monitored. The precipitation events that did occur were generally cases of showery precipitation in which air temperatures were above freezing. This report will present statistics drawn from the precipitation verification, but no conclusions should be drawn from this due to the lack of data.

RESULTS

0-12 Hour Forecasts

SCANCAST

	Air Temperature	Pavement Temperature	Wind Speed	Wind Direction	Precipitation
Glenn Highway @ Eagle River	4.2	4.1	3.7	2.5	3.8
Seward Highway @ Huffman Rd.	4.2	4.2	3.7	3.0	3.8
Seward Highway (Bird Point)	4.6	4.0	3.9	3.0	4.3
Average	**4.3**	**4.1**	**3.8**	**2.8**	**4.0**

Direct comparison of the above numbers for each parameter to each other is not advised, due to the differences in verification methodology for each. For instance, the air temperature criteria were based on somewhat broad categories, while the pavement temperature was based on the much more specific 32°threshold. Thus, observations regarding each element are presented.

Air temperature forecasts were generally very accurate. There were very few instances where the forecast was two or more categories (i.e., forecast for upper 30's observed in the low 30's) off. Timing of when the high temperature occurred was not examined, but there were several instances where the high actually occurred during the morning hours. This is not the usual situation, where a high is normally reached in late afternoon.

Pavement temperature forecast performance at all locations was very impressive. In the vast majority of cases, the time when the pavement temperature was forecast to rise above 32° was forecast within 1 hour. Generally, when a forecast was missed at one location, it was missed at all three. This indicates that a general cloud cover pattern was misforecast. Most of these cases occurred when cloud cover was forecast but did not occur, as evidenced by the pavement temperature forecasts being far too low compared to what actually occurred. Nevertheless, in all instances, SI did correctly predict the trend, even if timing or magnitude was slightly off on occasion.

Wind forecasts were more of a mixed bag. Speed forecasts were generally accurate, despite the somewhat stringent criteria. However, wind direction forecasts were not good. Eagle River was of particular interest. On 11 separate occasions, early morning winds were from the southeast, then shifted to another direction (presumed to be the prevailing direction) by about 1100L. However, it did not occur every day. This would appear to be a terrain-induced phenomenon. This was not well forecast by SSI, as indicated by the poor overall score for wind direction. However, wind direction forecasts for the other two locations were not appreciably better.

At Bird Point, winds were generally westerly even when the other locations reported winds from a different direction. Again, this was not picked up by SSI. This could possibly be due to lack of knowledge of the terrain. There is a sharp rise in elevation just north of the site, and it might be causing some sort of eddies at this location. At Huffman Road, there wasn't a distinct pattern to the inaccuracy. The forecasts were generally more accurate, but on three days, they issued forecasts that were 180 degrees off. In a small sample size of 15 cases, this greatly influenced the final average.

It is worthy of note that, with the criteria used here, the tailored forecasts of SSI for wind speed at these three stations appear more accurate than the zone-wide forecasts of the NWS.

Precipitation forecasts were reasonably accurate, using the defined criteria, being typically within three hours on start/stop time. However, there were very few events and no conclusions should be drawn from those few that did occur. It did appear as though the SCANCAST tended to "broad brush" the precipitation in the area, but it is unlikely to be known whether this would prove prudent over the course of an entire winter season. Anecdotal evidence suggests that it might not be the optimum course to take. Because the ESS as configured during this T&E reported only the presence of precipitation, this study was unable to ascertain whether the precipitation type forecasts were accurate. In an area with such widely varying terrain, verification of precipitation type forecasts is very important; so, ADOT&PF will want to develop a method for accomplishing this over the long run, for its primary source of precipitation forecasts. In the future, there needs to be a method of accomplishing this.

NWS FORECASTS

	Air Temperature	Wind Speed	Wind Direction	Precipitation
Glenn Highway @ Eagle River	4.6	3.1	3.9	4.7
Seward Highway @ Huffman Rd.	4.7	2.8	3.3	4.3
Seward Highway (Bird Point)	4.4	3.3	2.7	3.9
Average	**4.5**	**3.1**	**3.3**	**4.7**

Air temperature forecasts were very accurate. However, they tended to be less precise than the SCANCAST, giving NWS an advantage in verification. For instance, while SSI would always forecast a specific temperature, NWS would often make a forecast like "highs in the 30's." With nothing else to go on, this was considered a correct forecast if the temperature verified in the 30's. On the other hand, SSI might have been charged with an incorrect forecast if they forecast, say, 32, and the high hit 38.

Wind speed forecasts were slightly less accurate than direction forecasts. As with the SSI forecasts, the NWS forecasts tended to miss the early morning wind shift at Eagle River. They also failed to forecast the prevailing westerly winds at Bird Point. Interestingly, the NWS direction forecasts were most accurate for Eagle River, which was the location where the SSI direction forecasts were the least accurate. If there was any tendency on the speed forecasts, it was for NWS to over forecast wind speeds.

As with the SSI forecasts, it was difficult to draw any conclusions regarding precipitation since there were so few events, and those that did occur were of the showery variety. The high accuracy numbers reflect the vast majority of cases where nothing was forecast and nothing happened.

12-24 Hour Forecasts

SCANCAST

	Air Temperature	Pavement Temperature	Wind Speed	Wind Direction	Precipitation
Glenn Highway @ Eagle River	4.3	4.0	3.3	2.4	4.0
Seward Highway @ Huffman Rd.	4.2	4.2	3.5	2.6	4.3
Seward Highway (Bird Point)	3.9	4.1	3.0	3.1	4.0
Average	**4.1**	**4.1**	**3.3**	**2.8**	**4.1**

Air temperature forecasts were generally accurate, though slightly less so than in the first 12-hour period. Accuracy was consistent between locations. There were very few large temperature forecast errors. In most cases, forecasts were within one NWS category.

Pavement temperature forecasts were also very accurate. In fact, the overall accuracy was the same as for the first 12 hours. Unlike air temperatures, accuracy here was a case of "all or nothing." Of course, a different verification methodology causes some of this. But it can be said that SSI's forecasts were excellent at predicting the time the pavement temperature would drop below freezing. Most of the errors noted were when they forecast such a drop, but the pavement temperature remained above freezing all night.

As with the initial 12-hour period, the area of most concern is wind direction forecasts. They again failed to forecast the prevailing westerly winds at Bird Point. They also did not predict what seems to be the diurnal shift to southeast winds after sunset at Eagle River. Only on occasions where winds were strong (i.e., strong low pressure area) did this shift fail to occur. Wind speed forecasts were slightly less accurate than for the daytime period. There was no readily apparent pattern. If anything, they tended to over forecast wind speeds.

Precipitation forecasts were very accurate, with little difference compared to the daytime forecasts. Most of the errors occurred on April 19, when they failed to forecast precipitation at all sites.

It is worthy of note again, that for the 12-24 hour forecasts using these criteria, the tailored forecasts of SSI earned a higher score than the NWS zone forecasts for both air temperature and wind speed.

NWS FORECASTS

	Air Temperature	Wind Speed	Wind Direction	Precipitation
Glenn Highway @ Eagle River	3.4	2.4	2.3	4.7
Seward Highway @ Huffman Rd.	3.2	2.9	4.4	4.4
Seward Highway (Bird Point)	3.0	3.6	2.9	5.0
Average	**3.2**	**2.9**	**3.0**	**4.7**

The NWS forecasts for nighttime lows were not particularly accurate. In may instances, it was impossible to determine what the low temperature forecast was. They used ranges of as much as 20°F (for instance, "low tonight 0 to 20). Such a forecast is of limited value to maintenance authorities responsible for specific stretches of road. Thus, in any cases where there was more than a 10°F range in the forecast lows, these forecasts were eliminated. For those forecasts used, the NWS tendency was to forecast low temperatures that were lower than what actually occurred.

Similarly, wind speed and direction were also not particularly good. Most errors on speed forecast resulted from them over forecasting the winds. They experienced some of the same problems, as did SSI in direction forecasts. They often failed to forecast the prevailing westerly winds at Bird Point. At Eagle River, they generally missed the transition to southeast winds after sunset.

On the other hand, precipitation forecasts were excellent. Other than twice forecasting precipitation that did not occur at the Huffman Road location and doing so once at Eagle River, they hit every precipitation forecast.

Forecast Precision

Forecast precision is defined here as the ability to differentiate conditions site-by-site. This is very important in an area such as Anchorage, where tremendous differences in weather conditions can exist across very small areas.

On air temperature, the SCANCAST did attempt to specify different air temperatures at each location, though the forecasts were generally no more than a degree or two different. Further study during periods of inclement weather is needed to determine if the forecasts would exhibit greater differences. The forecast also provides hour-by-hour readings, and this is important, especially when making decisions on when freezing conditions might occur. Of course, the NWS forecast was the same for all locations and only forecast high and low temperatures. In addition, as noted above, they often forecast very wide ranges for the overnight low temperatures. While it is indeed likely that lows will vary tremendously due to the varied terrain, the forecasts do not specify the cold and warm areas.

The SCANCAST wind forecasts attempted even greater precision. There was usually a difference in both speed and direction between the sites, and in some cases, the difference was large. For instance, on March 25, they issued the following wind forecasts:

Location	Forecast Speed and Direction
Eagle River	North at 3-8 mph
Huffman Rd.	North and Northeast at 3-11 mph
Bird Point	North and Northeast at 25-28 mph

However, the NWS forecast was usually the same for all locations. In general, SSI tended to forecast stronger winds at Bird Point, though usually by not as large of margin as above. The NWS forecast would occasionally specify higher winds along the hillsides, but this should not have applied to any of the sites in question. The NWS forecast often used terms like “winds to 20 mph.” Again, this is probably valid given the terrain, but it is too general of wording to be of much use to maintenance personnel.

In the few events where snow was forecast, the SSI SCANCAST did vary from site to site. They generally adjusted the accumulations, and even changed precipitation types a couple times. On the other hand, the NWS precipitation forecasts used the “broad-brush” approach, with little, if any, differentiation. They also did not mention snow amounts in several cases, whereas the SCANCAST did.

The SSI pavement temperature forecasts also varied slightly by site.

Thus, in general, it can be stated that the SSI forecasts did indeed tend to be more precise. This can be an important factor for maintenance personnel, who depend on knowledge of specific conditions at specific times to make accurate decisions. However, as with all previous conclusions, one must temper this with the knowledge that very little winter weather occurred. A full winter of monitoring the forecasts is required to draw any definitive conclusions. One needs to examine a large number of storm events to decide whether the SSI forecasts are more precise, and more importantly, whether that precision leads to increased accuracy. The assumption is that this would be the case, but the small number of events examined for this study does not allow a definitive conclusion.

SSI AUTOMATED VERIFICATION

SSI also maintains an automated verification process. Whereas the standard SSI forecast verification process involves human intervention and judgment to purge extraneous effects, the automated process cannot adjust for such things as false sensor reports. Results of the automated verification process are in the following tables.

This verification confirms the high accuracy of pavement temperature forecasts noted by ADOT&PF evaluators, and the foregoing Matrix Management Group analysis. However, the precipitation forecasts judged by the MMG analysis as "reasonably accurate" and by evaluators as "not too good", are seen here as a very mixed bag—as many forecasts missed as hit, many events missed, and so on. However, the automated report seems to have been impacted by false sensor reports—which suggests a different problem than forecast accuracy. Yet, evaluators found the sensors generally reliable. The precipitation sensor reliability and forecast accuracy interface deserves more attention during Phase II.

Forecast Accuracy Report							
Surface Temperature Average Temperature Variance							
		Operational (1 - 6 hours)			**Planning (7 - 24 hours)**		
Fcst	**Sensor**	**Average**	**Bias**	**Data Points**	**Average**	**Bias**	**Data Points**
Seward Hwy @ MP 96.3	Bird Point	2.8 deg.	-1.8 deg.	1574 points	3.5 deg.	-2.4 deg.	5683 points
Glen Hwy @ Eagle River	Eagle River	3.2 deg.	-2.2 deg.	1700 points	4.5 deg.	-2.4 deg.	6099 points
Hillside Rd@Upper Huffman	Upper Huffman	3.5 deg.	-2 deg.	1648 points	3.5 deg.	-1 deg.	5939 points
Seward Hwy @ Huffman	Huffman Rd	2.9 deg.	-1.7 deg.	1454 points	3.7 deg.	-1.8 deg.	5197 points
Seward Highway @ Portage	Portage Glasier	4.7 deg.	-4.1 deg.	1539 points	5.5 deg.	-4.3 deg.	5584 points
Glen Hwy @ 2nd Knik River	Knik River	3 deg.	-1.5 deg.	1786 points	3.7 deg.	-1.1 deg.	6355 points
Glen Hwy 1 from Weigh Station	Weigh Station	2.8 deg.	-1.3 deg.	1692 points	3.4 deg.	-1 deg.	6130 points
Totals		**3.3 deg.**	**-2.1 deg.**	**11393 points**	**4 deg.**	**-2 deg.**	**40987 points**

Definitions:
Average Temperature Variance: The average of the difference between the forecasted temperature and the actual temperature for all data points in the selected period. This is measured in degrees fahrenheit. The lower the average temperature variance, the more accurate the forecast.

Data Points: The number of data points is determined by the number of forecast times at which an actual surface temperature is available to compare to the forecasted temperature. An actual temperature with a time within plus/minus 20 minutes of the forecast time is considered a match.

Forecast Accuracy Report										
Precipitation Event Metrics										
Rpu	**Operational (1 - 6 hours)**					**Planning (7 - 24 hours)**				
	Fcst Hit	**Hit Avg. Start Error**	**Hit Avg. End Error**	**Fcst Missed**	**Events Missed**	**Fcst Hit**	**Hit Avg. Start Error**	**Hit Avg. End Error**	**Fcst Missed**	**Events Missed**
Seward Hwy @ MP 96.3	11	4 min.	472 min.	4	4	1	0 min.		5	8
Glen Hwy @ Eagle Riv	10	33 min.	343 min.	11	5	0			6	23
Hillside Rd@Upper Hu	7	11 min.	385 min.	11	8	0			6	25
Seward Hwy @ Huffman	4	27 min.	499 min.	9	8	0			6	15
Seward Hwy @ McHugh	0			14	0	0			6	1
Seward Highway @ Por	8	13 min.	724 min.	5	6	1	0 min.		4	7
Glen Hwy @ 2nd Kwik	10	13 min.	430 min.	10	6	0			7	13
Glen Hwy 1 from Weig	11	35 min.	394 min.	7	5	0			6	12
Totals	**61**	**19.4 min.**	**463.9 min.**	**71**	**42**	**2**			**46**	**104**

Definitions:
Fcst Hit: The number of precipitation events that were forecasted and an actual event occurred within +/- 3 hours of the forecasted time.

Hit Avg. Start Error: The average of the absolute value of the difference between the forecasted start time and the actual start time for all forecasted events in the selected period. This is measured in minutes. The lower the average start error, the more accurate the forecast.

Hit Avg. End Error: The average of the absolute value of the difference between the forecasted end time and the actual end time for all forecasted events in the selected period. This is measured in minutes. The lower the average end error, the more accurate the forecast.

Fcst Missed: The number of precipitation events that were forecasted but an actual event did not occur within +/- 3 hours of the forecasted time.

Event Missed: The number of actual precipitation events that occurred which did not have a forecasted event within +/- 3 hours of the forecasted time.

APPENDIX

1. Performance Criteria on which the evaluation methodology was based.
2. Worksheets—embodying the data gathering methodology.

ADOT&PF RWIS

Task R12 – Operational Testing & Evaluation
Assumptions/Situation at February 2002

1. Phase I installation/acceptance, and evaluation period will start in March 2002.
2. Not much winter is left.
3. Should use evaluation period and remainder of winter to the fullest beneficial extent possible.
4. To achieve low impact on operations, yet a representative sample, 2 managers and 5 maintenance foremen will be requested to participate; additional volunteers welcomed (but for all days, not spontaneously).
5. Only surface (pavement) temperature forecasts are being purchased during March-April 2002, so only those will be evaluated. (However, SSI does provide additional forecast parameters—precipitation, air temperature, winds, and other atmospheric conditions—showing the basis for the pavement temperature forecasts.) Other than a general review of weather forecasts, weather forecast evaluation/verification will be deferred to Phase II.
6. This Operational Test & Evaluation provides for evaluation by users. Taken with the SSI Acceptance Test Plan, a reasonably comprehensive picture of early system performance and use during the remainder of the 2002 winter will be obtained.
7. It will take several years for personnel to accept and learn how to fully benefit from the RWIS.

Performance Criteria

1. Performance of field equipment—objective, each site, each instrument.
    a. Whether each instrument is operational/in-service. Yes/No
        1) Time at which outage reported to Dimond Electric.
        2) Time at which back in service.
    b. Whether observation seems valid.

→Explanatory comments welcomed.

2. Utility of field equipment—subjective, each site, each instrument.
    a. Representativeness of site. Parameters observed seem indicative of area served?
    b. Utility of site. Parameters observed are useful to snow & ice control in the area served?

→Explanatory comments welcomed.

3. Performance of ScanWeb
    a. Whether operational/in-service—each day, as a whole. Yes/No
    b. List elements missing (each day).

→ Explanatory comments welcomed.

4. Utility of Scan Web

   For sites designated for the rater, daily:
   On a scale of 1 to 5, where 1=highly useful, 2=useful, 3=indifferent, 4=not particularly useful, and 5=counterproductive.

   a. Is the ScanWeb information useful today?

[NOTE: This is not a measure of the severity of the weather. Benign weather well portrayed, leading to a wise decision to expend few resources, is as valuable as severe weather graphically portrayed and leading to actions that apply resources that provide safe travel. The question is whether the information being provided, and the way it is accessed and displayed, provides what is needed to make effective decisions for today's circumstances.]

   b. Elements of ScanWeb having the greatest bearing on the decisions made.
   c. Elements of ScanWeb, if any, that seemed contradictory or confusing, and therefore a hindrance to making a timely, effective snow & ice control decision.

→*Explanatory comments encouraged; required for 5 rating.*

5. Performance of ScanCast
   a. Whether operational, received—each scheduled time.   Yes/No
   b. Is the ScanCast information useful today?
   c. What element of the ScanCast had the greatest bearing on the decisions you made?
   d. What elements of ScanCast, if any, seemed contradictory or confusing, and were therefore a hindrance to making a timely, effective snow & ice control decision?
   e. For the ScanCast surface temperature forecast, at the beginning of the work day:
      (1) List the times during the past 24 hours, on the 0300AST forecast, at which the surface temperature is forecast to cross 32°F.
      (2) List the times during the past 24 hours on the 1600AST history graph at which the surface temperature actually crossed 32°F.
      (3) Record each variance (actual time minus forecasted time in minutes) for each 32°F intercept.

   f. Rate the usefulness of the ScanCast (daily), on a scale of 1 to 5, where: 1=highly useful, 2=useful, 3=indifferent, 4=not particularly useful, 5=counterproductive.

→ Explanatory comments encouraged; required for 5 rating.

6. RWIS Teamwork
   a. Record the number of times you (rater, or first-hand knowledge of other ADOT personnel) contacted SSI to report conditions that seemed different than SSI ScanCast forecasters were expecting.

b. Record the number of times you contacted the NWS to report conditions different than forecast products seemed to be expecting.
c. Record the number of times SSI ScanCast forecasters contacted ADOT to coordinate or update use of the ScanCast product.
d. Record the number of times the NWS Anchorage Forecast Office contacted ADOT to clarify forecast products or to solicit input.
e. List issues and/or ScanWeb elements that created consternation because training seemingly did not address them, or did so inadequately.

7. Early value of RWIS (highly subjective) for particular/selected weather events.
   a. Compare the difference between understanding of the weather and surface condition prevailing at the start of the workday, given the RWIS information in hand, with what you believe you would have had to go on without it (as objectively as possible).
   b. Estimate the amount of materials, person-hours, and equipment hours used, having considered RWIS information; and compare them to what would they would have been without it.

With:		Without RWIS:	
	Tons materials used =		Tons materials used =
	Person-hours redirected =		Person-hours redirected =
	Equipment hours saved =		Equipment hours saved =

→Explanatory comments encouraged; required for 5 rating.

Alaska Department of Transportation & Public Facilities
Road Weather Information System Deployment
PHASE I TEST & EVALUATION

Data Gathering Worksheet

Name:____________________________ Date:______________
Site(s):____________________________

1. Performance of field equipment

a. Is each instrument in service? **Y**es/**N**o

Sfc Temp	SubSfc Temp	Air Temp	RH	Wind Speed	Wind Dir	Precip	Camera	Date/Time Outage Reported	Date/Time Back in Service

b. Does the observation seem valid?

Explanatory comments welcomed:
____
____
____

2. Utility of field equipment

a. In your opinion, is the location of the Environmental Sensor Station (ESS) representative of the area surrounding it for today's conditions? **Y**es **N**o

b. In your opinion, does the collection of instruments/observations at the site fully indicate the nature of weather and surface conditions existing at the site? **Y**es **N**o
If not, what is missing? ____

c. Are the weather factors being observed —air temperature, wind, etc.-- useful to snow & ice control decisions for today's conditions? **Y**es **N**o

Explanatory comments welcomed:
____
____
____

3. Performance of Scan Web

a. Is ScanWeb fully operational today? **Y**es **N**o
b. If not, what parts of the ScanWeb product are missing?
____

c. How long did it take ScanWeb to load, to be accessible to you? ______________
Was that acceptable? **Y**es **N**o

Explanatory comments welcomed:
____

____
____

4. Utility of ScanWeb

NOTE: This is **not** a measure of the severity of the weather. Benign weather well portrayed, leading to a wise decision to expend few resources, is as valuable as severe weather graphically portrayed. The question is whether the information being provided, and the way it is accessed and displayed, provides what is needed to make effective decisions for safe travel under today's circumstances.

On a scale of 1 to 5, where 1 = highly useful, 2 = useful, 3 = indifferent, 4 = not particularly useful, and 5 = counterproductive.

a. How useful is the ScanWeb information today? __________

b. What elements of ScanWeb, i.e. the various reports, types of observations, graphs, etc., have the greatest bearing on the decisions to be made today?
____

c. What elements of ScanWeb, if any, seemed contradictory or confusing, and therefore hindered making a timely, effective snow & ice control decision?
____
____

Explanatory comments encouraged; required for 5 rating.
____
____
____

5. Performance of ScanCast

a. Was each scheduled ScanCast received? **Y**es **N**o
On time? **Y**es **N**o

b. Is the ScanCast information useful today? **Y**es **N**o

c. What element of the ScanCast had the greatest bearing on the decisions you made?
____

d. What elements of ScanCast, if any, seemed contradictory or confusing, and were therefore a hindrance to making a timely, effective snow & ice control decision?
____

e. For the ScanCast surface temperature forecast, at the beginning of the work day:

List the times during the past 24 hours, at which the surface temperature was forecast to cross 32°F. (0300AST Historical Temperature graph.)

Time of forecast 32°F intercept	Time of forecast 32°F intercept	Time of forecast 32°F intercept	Time of forecast 32°F intercept	Time of forecast 32°F intercept

List the times during the past 24 hours at which the surface temperature actually crossed 32°F. (0300AST Historical Temperature graph with Actual checked and updated.)

Time of actual 32°F intercept	Time of actual 32°F intercept	Time of actual 32°F intercept	Time of actual 32°F intercept	Time of actual 32°F intercept

Record variance (actual time minus forecasted time in minutes) for each 32°F intercept.

Rate the usefulness of the ScanCast today on a scale of 1 to 5, where:
1 = highly useful, 2 = useful, 3 = indifferent, 4 = not particularly useful,
5 = counterproductive. _______________

Explanatory comments encouraged; required for 5 rating.
____
____
____

6. RWIS Teamwork

In the past 24 hour period:
a. Record the number of times you (rater, or first-hand knowledge of other ADOT personnel) contacted SSI to report conditions that seemed different than SSI ScanCast forecasters were expecting.
____

b. Record the number of times you contacted the NWS to report conditions different than forecast products seemed to be expecting. _______________

c. Record the number of times SSI ScanCast forecasters contacted ADOT to coordinate or update use of the ScanCast product. ____________

d. Record the number of times the NWS Anchorage Forecast Office contacted ADOT to clarify forecast products or to solicit input. _______________

e. List issues and/or ScanWeb elements that created consternation because training seemingly did not address them, or did so inadequately.
____
____
____
____
____
__

7. Early Value of RWIS

This item is necessarily highly subjective, and applies to the duration of a weather event, a "storm."

The goal is to gauge whether RWIS information allowed less materials to be used and labor and equipment time saved or redirected to other productive uses during selected storm events.

Use the Worksheet on the next page to document a "storm."

Consider your understanding of the weather and surface condition prevailing at the onset and during a storm with RWIS information in hand, with what you would have known without it (in the past).

Estimate the amount of materials, person-hours, and equipment hours used each day during the storm. It is understood that work demands during the storm may make it necessary for you to do this after the fact, after the storm demands settle down. Perhaps you can keep "cuff notes" to facilitate this.

Estimate what it would have been without the RWIS information. Compare.
If you avoided use, or re-directed it to another beneficial use, the difference would be a "**Savings**." If the information caused you to expend resources unnecessarily, it would be a "**Loss**."

See Attachment 1 for definitions.

Item 7 Worksheet.

Day	S		S		M		T		W		T		F	
Date														
Storm Start														
Pvmt Temp														
Crew Out														
Crew In														
Storm End														
Pvmt Temp														
Pvmt Bare														
Type Precip.*														
Snow Amount														
Temp(min/max)														
Wind Dir/Speed														
Material Saved(S), Lost (L)	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Sand (tons)														
$NaCl_2$ (tons)														
$MgCl_2$ (gal.)														
$CaCl_2$ (gal.)														
Labor S/L	S	L	S	L	S	L	S	L	S	L	S	L	S	L
Normal (hrs)														

Overtime (hrs)														
Equipment (hrs)														

*WS=wet snow; DS=dry snow; FR=freezing rain/drizzle; SL=sleet; DR=drifting snow; I=ice; F=frost; R=refreeze.

REMARKS:

ATTACHMENT 1

Worksheet, Item 6, Definitions

1. Date: Write in the date under the day (M, T, W, etc.).

2. Storm Start: Enter the time the storm started to the nearest 1/2 hour. The definition of "Storm Start" will be the time it was decided to undertake snow and ice control actions.

3. Pavement Temperature: Record the pavement temperature from this site at start of the storm.

4. Crew Out: Enter the time the first equipment operator went out to the nearest 1/2 hour.

5. Crew In: Enter the time the last equipment operator returned with the intended service level achieved, to the nearest 1/2 hour.

6. Storm End: Enter the time the storm ended to the nearest 1/2-hour. This will be the time the weather condition causing the problem stops. Work will continue to clean up, i.e. Crew In. If a storm keeps going through a particular day into the next, put a dash to indicate the storm was continuing.

7. Pavement Temperature: Enter the pavement temperature from the RPU nearest the storm area at the time the storm ended.

8. Pavement Bare: Enter the time the pavement was bare to the nearest 1/2 hour.

9. Type Precipitation: Enter the types of precipitation and/or conditions that occurred each day during the storm. Abbreviations are listed at the bottom of the documentation form.

10. Snow Amount: Enter the minimum **and** maximum amount for each day. This can be estimated by measuring with a ruler on a flat, open spot around the maintenance shop

11. Temperature: Enter the minimum and maximum **air** temperature for each day from the start to ending of the storm.

12. Wind Direction/Speed: Enter both the direction and minimum and maximum wind speed for each day during the storm.

13. Materials Saved (or Lost): Enter the **estimated** tons of mixture/sand/salt and gallons of liquid chemicals saved or lost during the storm. If a daily tally is impossible, make the tally as accurate as possible at the end of the storm.

14. Labor Saved (or Lost): Enter the number of hours saved or lost. Overtime hours saved or lost is self-explanatory. Hours re-directed to other productive work counts as saved.

NTCIP-ESS IMPLEMENTATION

ADOT&PF is presently compliant for NTCIP ESS, having been tested by an independent testing agency funded by the Virginia DOT and FHWA.

ADOT&PF's NTCIP ESS implementation is compliant with the standards specified below. ADOT&PF's compliance has been tested by an independent testing agency funded by the Virginia DOT. Surface Systems, Inc. (ADOT&PF RWIS Contractor) was also an active participant in the standards testing conducted by Battelle Corporation and the Minnesota DOT. In addition, SSI recently contracted with Trevilon Corp. to perform an independent conformance test of the SSI NTCIP ESS implementation. The Trevilon test results are available upon request.

- *NTCIP Document 1204 NTCIP Object Definitions for Environment Sensor Stations (ESS) Version 98.01.12, Status: Approved by 3 SDOs and amended*
- *NTCIP Document 1201 NTCIP Global Object Definitions, Status: Approved by 3 SDOs and amended*
- *NTCIP Document 1101 NTCIP Simple Transportation Management Framework (STMF) Level 1. Status: Approved by 3 SDOs and amended.*
- *NTCIP Document 2202 NTCIP TP-Internet (TCP/IP and UDP/IP), Status: Recommended Standard.*
- *NTCIP Document 2103 NTCIP Point to Point Protocol (PPP), Status: Recommended Standard.*
- *NTCIP Document 2104 NTCIP Ethernet, Status: Recommended Standard.*

SSI is also currently compliant with the following NTCIP Standards of Compliance:

- NTCIP 1201: 1997
  SSI complies with all mandatory conformance groups and several optional conformance groups.
- NTCIP 1204: 1998
  SSI complies with all mandatory conformance groups and several optional conformance groups.
- NTCIP 1101: 1997
  SSI complies with STMF Level 1

SSI is compliant with the following NTCIP Application Levels, for Required NTCIP Functions:

- Application Level: SSI complies with STMF Level 1
- Transport Level:
  - SSI complies with NTCIP Document 2201 TP-Null when the subnet level profile is PMPP.
  - SSI complies with NTCIP Document 2202 NTCIP TP-Internet (UDP/IP) transport profile when the subnet level profile is PPP, SLIP, or Ethernet.

- Subnet Level
- SSI complies with the NTCIP Document 2103 NTCIP, Point to Point Protocol except PPP authentication. It supports data rates of 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 bits per second.
- SSI complies with the NTCIP Document 2101 SP-PMPP/RS232 standard. It supports data rates of 1200, 2400, 4800, 9600, and 19200 bits per second.
- SSI complies with the NTCIP Document 2104, NTCIP Ethernet.
- SSI supports SLIP for RS-232 router interface connections.

- *NTCIP Document 2202 NTCIP TP-Internet (TCP/IP and UDP/IP), Status: Recommended Standard.*
- *NTCIP Document 2103 NTCIP Point-to-Point Protocol, Status: Recommended Standard.*
- *NTCIP Document 2104 NTCIP Ethernet, Status: Recommended Standard.*
  Information Level
- The NTCIP-ESS RPU supports all mandatory objects of all mandatory conformance groups as defined in 1201 and 1204

Optional NTCIP Function Supported:

- Global Configuration Conformance Group
- Global Time Management Conformance Group
- Global PMPP (when PMPP is the sub network profile)
- ESS Configuration
- ESS Location
- Pressure
- Wind Data
- Basic and Enhanced Temperature Data – SSI currently supports 1 Air Temp sensor
- Basic Precipitation Data
- Standard Precipitation Data
- Enhanced Precipitation Data
- Solar Radiation
- Visibility Data – SSI does not presently support the full range of the visibility situation object.
- Standard and Enhanced Pavement Sensor Data
- The NTCIP-ESS RPU supports up to 16 surface sensors (8 wired and 8 wireless)
- Standard and Enhanced Sub-Surface Sensor Data
- The NTCIP-ESS RPU supports up to 16 sub surface sensors (8 wired and 8 wireless)
- MIB files - SSI will supply the following MIB files:
- Standard Device MIB files and Manufacturer specific MIB files as necessary.