Executive Summary

A Road Weather Information System, or RWIS, is a network of weather stations, forecasting services and the supporting infrastructure. In general, an RWIS contains the following components:

1. Roadside weather stations that collect road and atmospheric conditions

2. The communications system

3. One or more central computers to store and process collected data

4. A user interface to display processed data

5. Site-specific weather forecasts using the weather station data and the National Weather System forecasts

Transportation managers use the information to make maintenance and advisory decisions that help reduce the number of incidents during severe weather conditions. RWIS has been widely used in the United States and Canada starting in the late 1980's, when the development of accurate sensors made it possible to determine pavement surface temperatures and the maintenance community began using a more proactive approach to snow and ice removal. The systems are most commonly used to detect and aid in snow and ice removal efforts from roadways and to help alert motorists to dangerous driving conditions.

The California Department of Transportation (Caltrans) began implementing RWIS in 1990. Since then, ten of the twelve Caltrans Districts have installed sites. However, California is a large, diverse state and each District has unique transportation challenges and information needs. The goal of this project is to increase the use and improve the effectiveness of Caltrans RWIS. This final report contains the findings and recommendations of the project, including:

- State of the Practice – Current Use of RWIS by other states
- Current Use of RWIS by California
- Caltrans Goals for RWIS
- National Standards and Guidelines for RWIS
- Institutional Improvements for Caltrans
- Conclusions and Recommendations

The final report also contains an extensive Technical Appendix, with detailed research results and reference materials relative to the California RWIS project.

State of the Practice

Many states have had RWIS systems of some type in place since the late 1980's, and can provide valuable information regarding the state of the practice. Interviews were conducted with transportation officials from nine of these states: Nevada, Utah, Iowa, Montana, Washington, Oregon, Idaho, Virginia and Minnesota. The lessons learned by these states can be applied to the assessment of California RWIS.

Most states deploy RWIS for two purposes: to monitor current weather conditions at a specific location, and/or to forecast weather conditions in advance.

Currently, most states deploy RWIS for two purposes: to monitor current weather conditions at a specific location, and/or to forecast weather conditions in advance. When designing the system, transportation managers must make important decisions regarding data to be collected, site selection, and hardware. Data selection must be tailored to system goals and the site location. A typical sensor package measures air temperature, surface temperature, sub-surface temperature, wind speed and direction, precipitation and relative humidity. Site selection is best accomplished through input from both maintenance staff and vendors: maintenance staff to identify locations with perennial weather challenges and vendors to identify locations that will provide accurate readings. As for equipment, environmental system hardware is very similar in all states, while communications hardware varies widely, depending on the priority given cost, speed, and the need for back up systems.

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Once in place, RWIS systems that are most successful are those that have been embraced by maintenance personnel, the most common end-user. Maintenance staff members that have been involved in the planning process, and that receive adequate and ongoing training on the system, are most likely to use it on a regular basis. In addition, many agency officials are moving toward systems that promote ease of use For example, many states have chosen systems that provide automatic alerts to maintenance personnel when weather conditions change.

An important development in RWIS state of the practice is the presence of multiple vendors for products and services (as opposed to the early days when there was only one vendor). Competition has resulted in greater selection and cost savings. Depending on their needs and budgets, states can contract for assistance with many components of planning and implementation, including mapping and site location, system maintenance, and forecasting services.

Current Use of RWIS by Caltrans

Almost all of the Caltrans Districts and Headquarters use RWIS in some form. Currently, there are 81 operational sites, with approximately 170 in planning or under development. Most Districts use RWIS for snow and ice detection, although an increasing number are using it to monitor visibility and wind conditions, as well. The most common systems use Surface Systems Incorporated (SSI) products with ScanWeb, and ScanCast frequently included for forecasting services. Other products used in some Districts are Vaisala and Qualimetrics systems. Many Districts are upgrading their sites with improved computers and sensors and with additional components, such as Closed Circuit Television (CCTV). Districts also use forecasts from multiple sources (such as the National Weather Service (NWS) and Meteorlogix) to complement the information from RWIS. Districts are at different stages in developing partnerships with other agencies (NWS, emergency responders, etc.) to share information and improve the quality of services.

Caltrans staff identified as the most common users of RWIS were surveyed to determine their assessment of the current RWIS system. Results were sorted by region and by main RWIS usage (i.e. snow/ice, wind/visibility) to allow for more detailed interpretation of the responses.

Caltrans survey respondents believe the system would be more effective if there were more sites, if some of the current sites were in different locations and maintained better, if the information was easier to interpret, and if staff received more training on the system.

A majority of the respondents stated that RWIS information is generally accurate and current, and that the system has great potential for alerting motorists to both snow and ice conditions, and low visibility conditions. However, the responses also identified factors that may help explain under utilization of RWIS, including:

- 36% of Caltrans district staff rarely or never use RWIS,
- 29% of respondents are not encouraged to use RWIS, and
- Caltrans staff use televised weather reports and non-Caltrans websites more often than they use their RWIS systems to obtain future weather condition information.

The survey also generated many suggestions for how the system could be improved, including:

- 67% of respondents believe the system would be more effective if there were more sites,
- 41% believe the some of the current sites would be more effective if they were in different locations and maintained better,
- 69% stated that the amount of training needs to be increased, and
- 83% stated that RWIS data must be easier to read and interpret.

Caltrans' Goals for RWIS

Through this project, the Technical Advisory Committee (TAC) has agreed upon a vision for RWIS at Caltrans:

Create and maintain a statewide linked road weather information system for road maintenance, traffic operations, and traveler information utilizing the best practices from around the world.

- Procure flexible, cost effective road weather information systems that meet the needs for the designed use and consider the needs of partners

- Work with vendors and partners to provide quality, cost effective forecasting services

- Create the best possible return on investment through

    o proper system maintenance and training

    o knowledge and data sharing between districts and with partners

This vision is depicted in FIGURE ES-1.

A substantial effort was also made to identify RWIS goals at the District level. To determine how the statewide Technical Advisory Committee vision can be reached and to help determine direction at the districts, researchers interviewed, met, and surveyed District staff to learn their goals for RWIS. They were asked to prioritize a list of objectives for the District itself, as well as objectives for the entire system statewide. At the District level, staff expressed a strong desire to make RWIS services more efficient, less costly, and more accessible. Specifically, most districts selected the following as goals that should receive the highest priority:

- Caltrans should develop capabilities to allow districts to access RWIS data from the field

- Caltrans should incorporate weather information into Advanced Transportation Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS), such as a statewide traveler information page.

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District priorities for goals at the state level were remarkably consistent. Almost every District chose the implementation of a standard RWIS communications

protocol as their highest priority for Caltrans. The other goal that staff frequently listed as a high priority is the development of statewide standards and recommendations for RWIS field equipment.
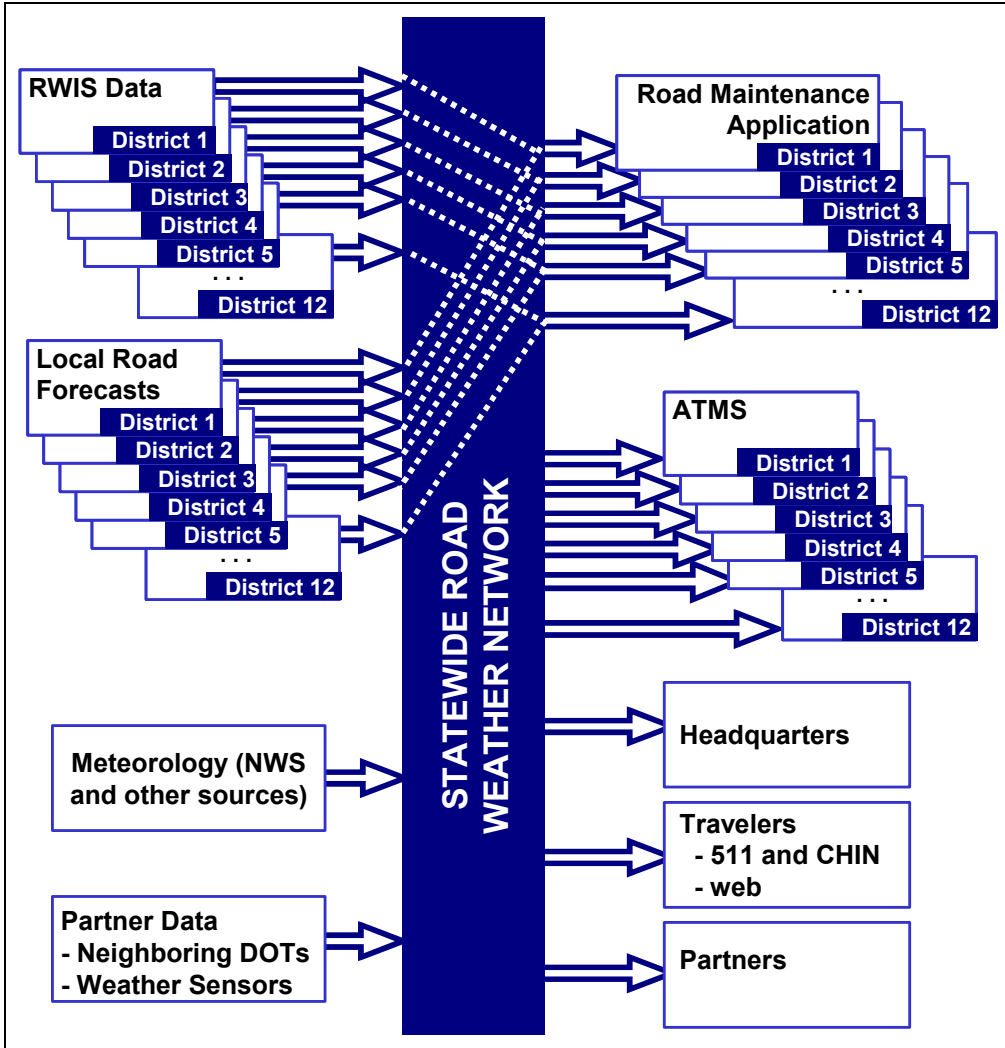

FIGURE ES-1 Statewide linked RWIS vision.

National Standards and Guidelines for RWIS

Project staff conducted extensive research to identify existing national standards and guidelines that can be applied to the assessment of and recommendations for California RWIS. This report strongly recommends that Caltrans move toward an RWIS system that is compliant with standards developed by the National Transportation Communications for Intelligent Transportation Systems (ITS) Protocol (NTCIP). NTCIP guidelines represent a collection of communication protocols and data definitions that address communication modes between various

subsystems of the ITS National Architecture. These standards have also been carefully developed to employ and build on other important guidelines, such as those established by the International Standards Organization (ISO). NTCIP standards enable RWIS systems to achieve interchangeability and interoperability of system components, which has many benefits including:

NTCIP standards enable RWIS systems to achieve interchangeability and interoperability of system components

- Decreased early obsolescence of hardware and software
- Increased choice of vendors
- Increased interagency coordination through easy sharing of information
- Use of one communication network for all purposes

This report also recommends the use of national meteorological standards, particularly those established by the Office of the Federal Coordinator for Meteorology (OFCM) and the Strategic Highway Research Program (SHRP). The benefits of designing RWIS systems that meet these standards include:

- Increased ability to obtain meteorologically accurate data
- Obtaining data that has high value and usability to multiple users
- Increased potential for data dissemination and exchange with other agencies
- Increased ability to install sensors built on proven methods

This report summarizes the most relevant standards, and identifies additional resources available for further study.

Institutional Improvements

There are numerous institutional issues that prevent Caltrans from moving towards its goal of a fully realized, linked RWIS. These issues can be grouped into the categories of cost and quality, system utilization, isolated systems, varied users, and liability. This report describes these issues in detail, and presents solutions for Caltrans to consider.

Quality and Cost

- Resources and Funding: Increased funding will be needed to pursue the report's recommendations such as proper system maintenance, dedicated staff, system training and implementing standards-compliant systems. Caltrans should pursue a Budget Change Proposal for RWIS, as well as a cost benefits study for use of RWIS in each District.

- Siting and Coverage: Costs for RWIS equipment and maintenance can be controlled through careful selection of the quantity of sites, by consulting a meteorologist to determine sensor needs and placement and by weighting the benefit of accuracy versus coverage.

- Maintenance: Maintenance is of extreme importance to system success. A maintenance plan should be developed, and maintenance staff must receive sufficient and ongoing training.

- Appropriate Technologies: Technologies must be chosen to coordinate with intended uses of the system. Consultants and cost-benefit studies of specific technologies such as sensors can assist in technology selection.

- Procurement and Contracting: Procurement contracts must be specific as to equipment needs, desired services, and requiring standards compliant specifications.

Utilization

- Training: Caltrans should develop users' conferences, in-District hands-on training, and technical sessions to train maintenance staff.

- Trust of Forecasts: To improve everyone's confidence if forecasts, Caltrans should look at an expanded selection of providers, provide feedback to forecast providers, and improve measurements provided to forecasters.

- Reaching System Potential: Caltrans can move towards reaching RWIS' full potential by considering improved application designs, such as new decision support systems (DSS).

- Coordination and Partnerships: Caltrans needs to develop a shared vision on RWIS architecture between Districts, and actively seek out partners that can assist in system development.

Isolated Systems

- Proprietary and Non-Standard Systems: Caltrans should make an effort to develop inter/intra-District consistent systems,

which are also consistent with the systems of external partners. Purchasing officials should be educated to the broad choice of RWIS vendors, and to the importance of selecting NTCIP compliant systems and components.

- Dedicated Staff: Caltrans should dedicate someone at the state level for RWIS coordination to champion implementation of recommendations and assist District staff.

- Access to Data: To facilitate sharing of data, partners and vendors should be allowed some access to the Caltrans RWIS network for weather information.

Varied Users

- District Diversity: As Caltrans integrates data across the state, it should examine the differences between districts and standardize definitions within geographic regions.

- Types of Users: Improvements need to recognize and respect the three primary users of RWIS: maintenance, traffic operations, and travelers.

Liability

To minimize exposure to liability, Caltrans needs to recognize potential liability issues. Caltrans could conceivably face claims based on the:

- Availability of RWIS data and subsequent corrective measures

- Accuracy of hazard warnings

- Accuracy of data shared with other parties

- Failure to deploy RWIS, (i.e., if previously deployed in similar situations)

- Malfunctions

- Shared liability with partners and vendors

- Patent and copyright infringement from use of proprietary technologies.

It is recommended that Caltrans seek legal advice if they need further information or guidance.

Conclusions and Recommendations

The fundamental conclusion of this report is that RWIS provides many benefits and has great potential. Therefore, Caltrans should continue to pursue and develop its system and other weather-related features for managing California roadways. The report also includes numerous specific recommendations, which can be grouped into the categories of General, Maintenance Decision Support, Traveler Information, Traffic Management Systems, Statewide Coordination and Assistance, Product Selection, Partnerships, and Access to Data from the field.

General

- Assess sensor capabilities to address trade offs of cost, accuracy, and reliability; develop performance specifications for sensors

- Conduct benefit-cost analysis of RWIS development

- Update headquarters electrical maintenance inventory with RWIS stations

- Identify deployment locations based on safety and relevant other criteria

Maintenance Decision Support

- Identify Caltrans representative to participate in and track national Maintenance Decision Support System efforts.

Traveler Information

- Include RWIS information and road conditions in Caltrans-designed traveler information sources, such as a Web page, phone systems (including 511), and the California Highway Information Network

- Design systems to provide information in a manner most useful to the traveling public

Traffic Management Systems

- Include RWIS in requirements for upgrades to ATMS

- Include user-settable operational alarms

Statewide Coordination and Assistance

- Establish a statewide RWIS coordinator

- Encourage each District to utilize existing headquarters staff and experts in other Districts

- Hold an RWIS user group meeting (including partners) every other year for training purposes

- Require roadside equipment to be NTCIP compliant; require software to be compliant with National ITS Architecture

- Validate NTCIP compliance through independent contractor

- Require that data from RWIS and forecasts be owned by Caltrans and housed on Caltrans servers

Product Selection

- Procure through competitive bid process

Partnerships

- Provide Caltrans RWIS data to Mesowest

- Develop relationships with local agencies, the National Weather Service, and other identified potential partners

- Initiate an effort to form or join a California meteorological consortium

Access to Data from the Field

- Interested Districts should pursue products that provide access to data via pager, Internet, or cell phone

- Create opportunities to develop and deploy "push" technology (e.g., email alerts) to assisted partner organizations

Furthermore, based on suggestions and recommendations expressed in district visits, surveys, phone interviews, and literature review, the research group highlighted some additional recommendations and suggestions to improve the effectiveness of RWIS by Caltrans. Recommendations are as follows:

Quality and Cost

- Strive to achieve quality along with cost. Do not simply select a contract based on the lowest bid. Foremost consider required functionality and reliability for the intended use and then balance with cost.
- Be informed of RWIS maintenance requirements.
  - ➡ Consider developing a maintenance plan or program, which includes a statewide vision that blends with each individual Districts needs.
  - ➡ Recognize an agency's preventive and recurring maintenance needs for those with RWIS in place, or those acquiring RWIS.
  - ➡ Determine most cost-effective method for maintenance services: in-house or vendor-provided
  - ➡ Develop state level financial support for RWIS maintenance; pursue a Budget Change Proposal
- Identify meteorological data, siting and sensor requirements at the District level. Review potential sites with a professional meteorologist and the National Weather Service to better determine specific sensor needs and placement.
- Identify appropriate RWIS technology through careful definition of the intended use of the system. Coordinate with qualified internal staff, external vender-independent professionals, and meteorologists regarding placement, needed hardware, and functionality of the system.
- Consider University-based resources, a cost-effective source for research and evaluation.
- Create a state level RWIS specialist to champion coordination and provide staff support. Consider incorporating into the BCP a request for funding for staff dedicated to RWIS.
- Conduct and utilize cost benefit studies:
  - ➡ Consider conducting a cost benefits study on the use of RWIS in different Districts in California to determine return on investment
  - ➡ Use cost benefit studies to determine equipment needs, such as for selecting number and type of sensors needed
- Conduct a thorough vendor selection and contract process:

➡ Look at all potential providers for each service
➡ Investigate an open bid/Request for Proposal process
➡ Consider teaming on contracts with other Districts to negotiate bulk discounts
➡ Do not automatically accept a vendor's standard contract
➡ Write performance criteria for vendor tasks, e.g. forecast accuracy, service response times, etc.

Utilization

- Know (determine ahead of time) what RWIS goals the District desires. Develop a plan as to how RWIS will be used and where sites will be located in the future.
- Expand training opportunities to build expertise:
  ➡ Develop and initiate a semi-annual statewide RWIS user's conference including a train the trainer workshop. The conference would allow Districts to share lessons learned and review advances within and outside of Caltrans. The training workshop would focus on a continuing education approach to train District educators on RWIS technologies, operation, maintenance, and available value added services.
  ➡ Conduct in-District hands-on training each fall for all involved staff levels. Training should provide skills to allow fully integrated RWIS technologies and corresponding road/weather information into the snow and ice control decision process and traffic operations.
  ➡ Develop a technical session at existing statewide and District meetings to train maintenance staff.
  ➡ Encourage employee attendance at national conferences and workshops regarding RWIS technologies operation and service.
- Involve road maintenance and traffic operations personnel at all levels of the implementation/deployment process to instill a feeling of ownership. Involve them in site/data selection, station maintenance and service, and evaluations/change decisions.
- Promote data ownership, sharing and use of advanced tools:
  ➡ A District should require full ownership of its RWIS data with the freedom to disseminate as it pleases.
  ➡ Be informed of the FHWA Maintenance Decision Support System. While the initial product of this effort may not be directly useable by Caltrans, headquarters and maintenance should track this endeavor, participate in steering the product and look for opportunities to use this and other next generation RWIS tools.

Isolated Systems

- Consider using existing or developing statewide communication systems for the dissemination of RWIS data.
- Make an effort to realize the potential of developing inter/intra-District consistent systems as well as consistency with external partnering agencies.
- Promote compliancy with national standards:
    - New systems should be compliant with TCPIP standards as identified in the TMS Standardization Plan.
    - Push towards NTCIP compliant systems to help avoid early obsolescence of software and hardware, provide choice of vendor, enable interagency coordination, facilitate use of single communications network for all purposes, and ensure access to federal funding.
    - Follow meteorological weather standards when developing partnerships
- Work with Information Services to revisit their blanket policy of no vendor access within the firewall in the Caltrans Intranet. Information Services should explore innovative technologies to allow limited, secure Intranet access by vendors.

Varied Users

- Develop regional standards for defining road weather incidents for the traveler, e.g., The Central Valley should have a consistent definition of heavy fog; the Sierra Nevada should have consistent snow-related regulations and warnings. When information goes to the traveler via the Internet, Caltrans should provide access to explanations of differing regional criteria for warnings to minimize risk of claims.
- Form ongoing relationships with partners, users and other states to access their expertise:
    - Look to partners to develop a network of stations and add worth to system. Potential partners include the National Weather Service, Bureau of Land Management, Department of Forestry, as well as representatives of the meteorological, emergency response and transportation communities.
    - Form a statewide user group. The user group could be an inter-District group of people interested in advancing RWIS and utility. The group could facilitate technology transfer, share goals, objectives and needs, reach agreements for coordination, identify issues and establish mechanisms to address them, assess agency participation with the larger meteorological community and possible

corresponding weather support, and establish a between meeting support network for RWIS.

➡ Investigate and consider involvement in consortiums such as Aurora. Members are state agencies that have a long history with RWIS, and can provide good information.

- Weigh the pro's and con's of state information custody versus vendor custody/management. Putting appropriate RWIS data in the public domain can facilitate the widest distribution and use.

- Post weather-related traveler information on the web page in the most user-friendly manner possible. Review Washington State DOT rWeather web site (http://www.wsdot.wa.gov/rweather/) as a potential model.

Liability

- Include appropriate written disclaimers, limitations on liability, indemnity provisions, and warnings when posting data. If possible, the receiving parties should be required to formally agree to such terms before receiving the data.

- RWIS technologies should be thoroughly tested, and once deployed, they should be subject to appropriate monitoring and control. Generally, RWIS devices should not be deployed as substitutes for traditional safety measures.

- Be informed of claims arising from partnerships. An agency should incorporate indemnification provisions and insurance requirements into all agreements.

- Be aware of proprietary liabilities. Accordingly, agencies should sign license agreements to avoid claims of misappropriation and liability for patent and copyright infringement.

- Weigh your options for deployment. When assessing potential liabilities, it should be remembered that the deployment of RWIS may increase safety and reduce the occurrence of accidents and fatalities, which may help agencies avoid certain liabilities. These potential benefits should be weighed against the risk of liabilities.

- Caltrans should seek legal advice from a licensed California attorney with expertise in the field, prior to the deployment of cutting-edge RWIS projects.