1. Road Weather Information Systems

Instructor Notes: This module is the first part of a lesson that discusses Tools for Monitoring Road Weather. This presentation covers Road Weather Information Systems (RWIS), focusing on Environmental Sensing Stations (ESS) and how the sites compare to other surface observing stations (particularly ASOS). This presentation should take approximately 20 minutes.

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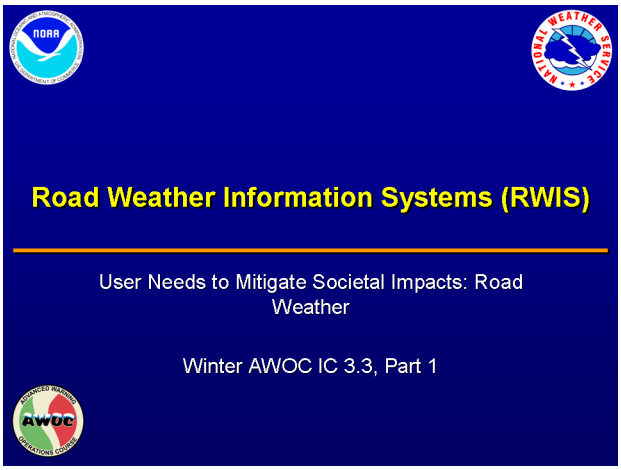

2. Learning Objectives

Instructor Notes: There are two learning objectives for this lesson: 1. Identify the components of an RWIS, the commonly collected data parameters, and the significance that siting has on the data parameters collected at a given location. 2. Identify the key differences between ESS and ASOS observing stations.

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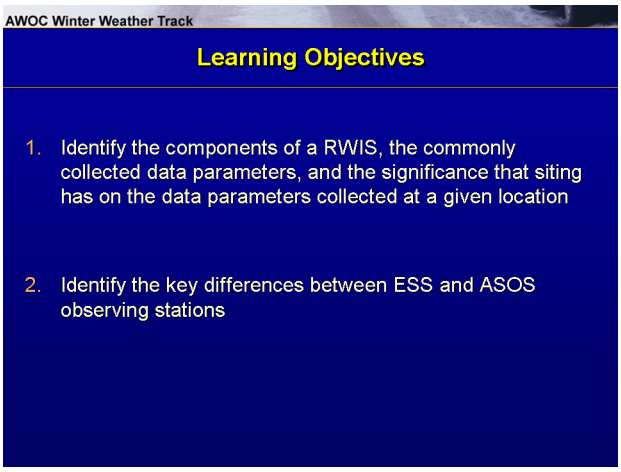

3. What Exactly Is a RWIS?

Instructor Notes: A Road Weather Information System is used by transportation operators to monitor road and weather conditions across their road network (Manfredi et al., 2005). While Close Circuit Television (CCTV) cameras and other surveillance tools help monitor traffic conditions, [CLICK] Environmental Sensing Stations are used at specific sites to monitor pavement, near-surface, and sub-surface environmental conditions. [CLICK] There are generally two reasons why transportation operators are interested in weather data: - To observe real-time weather conditions and - To gather data for traffic-related forecast models. [CLICK] CCTV and similar surveillance tools provide valuable information about weather conditions (e.g., visibility, occurrence of precipitation, and precipitation type), but RWIS data meets these two needs better. Still, some transportation departments are adding cameras to their RWIS networks. For instance, UDOT is adding a camera to all their sites that generates still images every 15 minutes for comparison purposes (Patterson, 2008).

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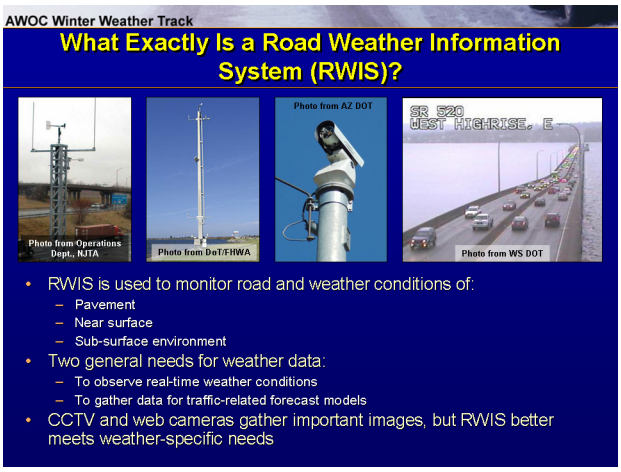

4. Three Individual Components of a RWIS

Instructor Notes: An RWIS is composed of three major components (Manfredi et al., 2005): [CLICK] 1. ESS sites, [CLICK] 2. Processing and display equipment at a TMC, TOC, maintenance garage, or off-site contractor, and [CLICK] 3. The communications infrastructure linking the observation sites, processing equipment, and display software together. [CLICK] Most of the subsequent discussion on RWIS focuses on ESS sites, the data these sites produce, and (where these data are available) how NWS forecasters can access them.

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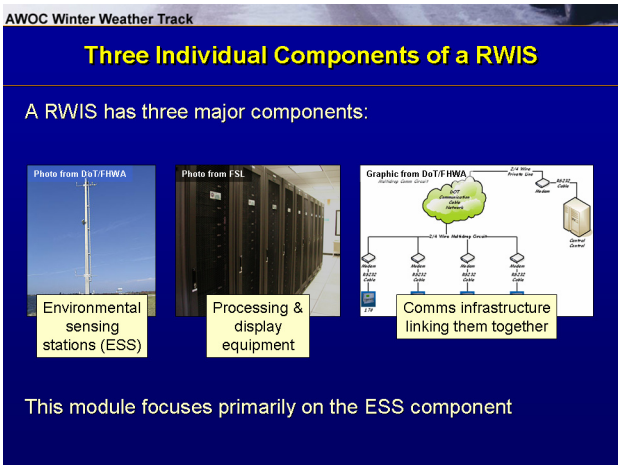

5. Factors in Determining an ESS Location

Instructor Notes: An Environmental Sensing Station site is a roadway location with one or more fixed sensors measuring atmospheric, pavement, and/or hydrologic conditions. Data from the sensors are stored temporarily in an on-site data logger and then transmitted to a central processor through the RWIS communications network. [CLICK] There are many reasons for choosing where to build an ESS site. [CLICK] One of the biggest considerations is communications infrastructure. Data collected at ESS sites need to be transmitted in real-time to be effective. Fortunately, newer communications technology has made this problem relatively easy to overcome. [CLICK] Other factors that go into choosing a site include (Patterson, 2008): - Does the location experience regular road maintenance problems during winter weather? - Would locating a site in a specific location fit road condition observation and forecasting needs? - Does the proposed site provide beneficial weather and road condition information to the traveling public? and - How far is the proposed site from the nearest maintenance garage?

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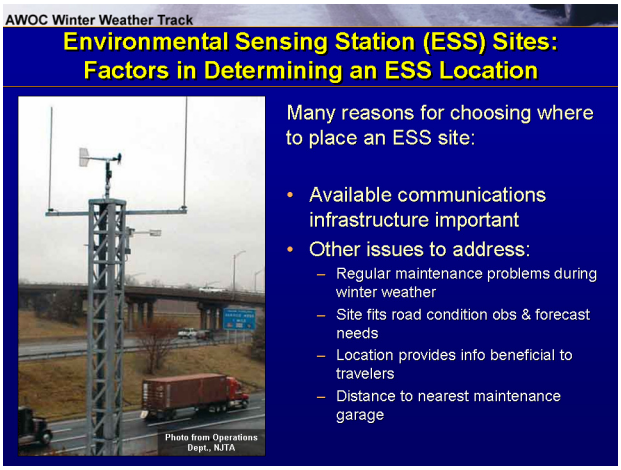

6. Other Factors in Choosing an ESS Site

Instructor Notes: While most ESS sites are selected to help observe road and weather conditions during winter weather operations, a smaller subset of sites are chosen to observe specific weather or hydrologic threats. [CLICK] ESS sites will vary from location to location depending on the purpose for the site, the number and type of data measurements collected, the vendor who builds the instruments and sites, and whether maintenance and calibration are performed in-house or by contract (Manfredi et al., 2005). [CLICK] Ideally, the sensors that are deployed at single location will complement each other. An example would be a pavement sensor collocated with a rain gauge, thermometer, and hygrometer to monitor road conditions and whether or not moisture on the road is from existing precipitation, previously frozen precipitation that's melting, or frost.

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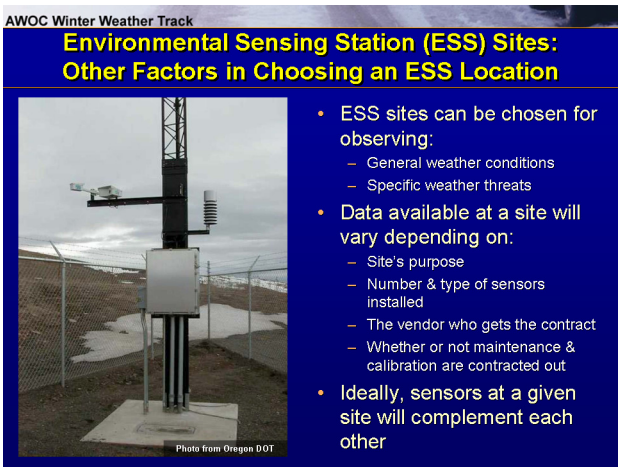

7. ESS Atmospheric Data Observations

Instructor Notes: Examples of atmospheric data collected at ESS locations include: [CLICK] - Air temperature, [CLICK] - Humidity, [CLICK] - Visibility distance, [CLICK] - Wind speed and direction, [CLICK] - Precipitation rate and type, and [CLICK] - Air quality. The instrumentation used to collect these data are generally similar to those used by other mesonet sites around the United States (FHWA, 2008).

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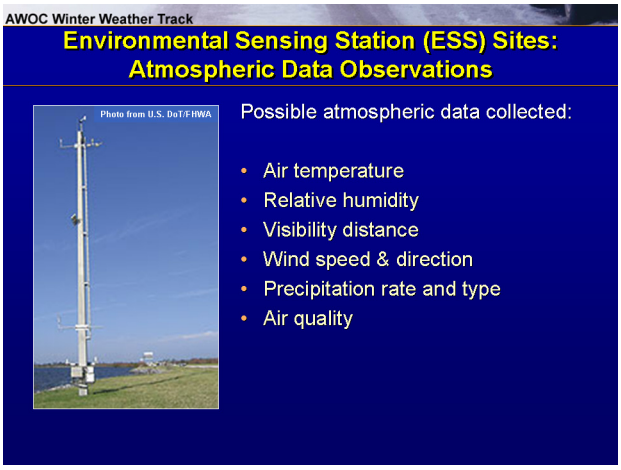

8. ESS Pavement Data Observations

Instructor Notes: Pavement data collected at an ESS location may include one or more of the following (FHWA, 2008): [CLICK] - Pavement temperature, [CLICK] - Pavement freezing point, [CLICK] - Pavement condition, [CLICK] - Pavement chemical concentration, and [CLICK] - Subsurface conditions. [CLICK] Pavement sensors (which look a lot like hockey pucks embedded in the road surface) usually include a pavement temperature and condition sensor to determine if the surface is dry, wet, or frozen. Chemical concentration sensors determine the freezing point of the road surface on a regular basis so maintenance departments can monitor how chemical applications are diluting. These sensors can either actively measure the freezing point by heating and cooling surface liquids or passively monitor changes in surface conductivity.

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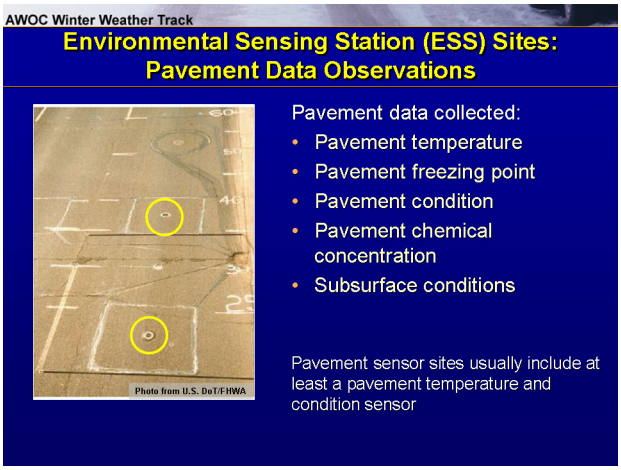

9. ESS Hydrologic Data Observations

Instructor Notes: Where pertinent, water level data may include: [CLICK] - Tide levels and - Stream, river, and lake levels near roads. [CLICK] These sensors are usually located near bridges that cross water bodies, road segments that run alongside lakes and oceans, or in low-lying areas that are prone to flash flooding (FHWA, 2008).

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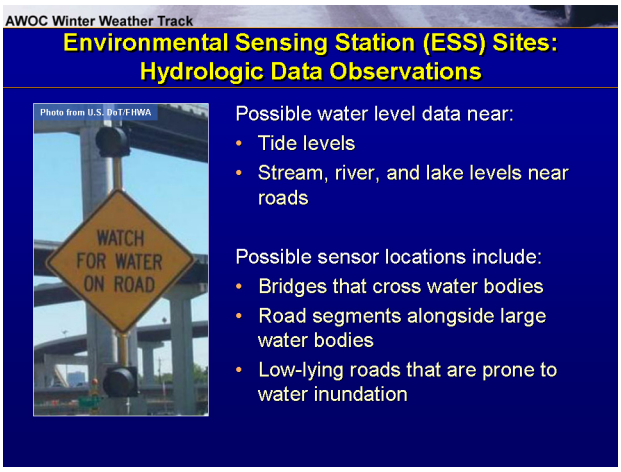

10. Regional & Local ESS Sites

Instructor Notes: In general, there are two different types of ESS sites: regional and local. In some cases, an ESS site may be classified as both. [CLICK] The parameters collected at any given site depend primarily on the site's purpose. [CLICK] Determining whether a specific site is either a regional or local site may not be trivial. Many DOTs and RWIS operators have metadata for their networks that indicate a site's purpose. Otherwise, you'll have to contact the RWIS owner directly. Each DOT is autonomous so the process isn't uniform. In some cases, it may take significant leg work to ascertain a given location's true siting purpose.

Student Notes:

11. More Information on Regional ESS Sites

Instructor Notes: Regional sites are chosen because they are considered to be representative of a larger, surrounding area. [CLICK] Regional sites generally include a standard suite of sensors and is located in a relatively unobstructed, roadside location. These sites are believed to be representative of the roadway for an area of approximately 20-30 miles (Manfredi et al., 2005). [CLICK] From a forecaster's point of view, transportation management would ideally chose to locate these sites where few (if any) other surface observations are available or in an area that benefits from more concentrated ground truth data. Of course, that isn't always the case. In areas where high-spatial weather data are desired (i.e., for traffic-related modeling), the sites would ideally be located relatively close to each other (i.e, about every 4 km). [CLICK] In reality, transportation management will have ESS sites located every 50-150 linear miles, depending on the weather threats in that particular area. [CLICK] Either way, data from regional sites should fit reasonably well with surrounding surface observations (Cambridge Systematics Inc., 2003).

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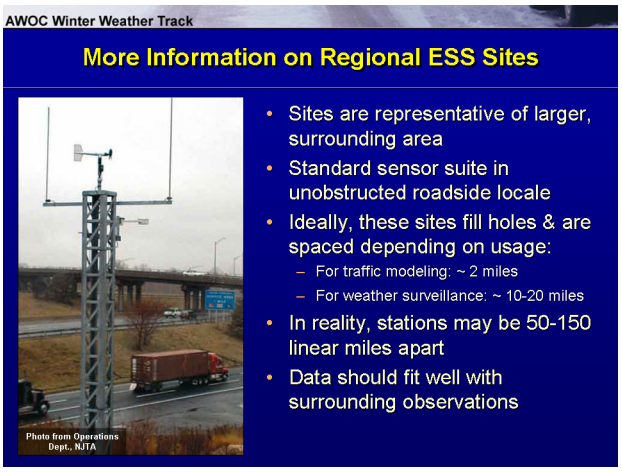

12. More Information on Local ESS Sites

Instructor Notes: Local sites are chosen because they are considered representative of a smaller area that is prone to a specific threat. These sites often include a specific set of sensors that are placed close to the road segment, traffic signal, or bridge where the recurring weather threat is most likely to occur. Examples of problems that could result in placing a local ESS site include: [CLICK] Slippery pavement – Such as spots where standing water, ice, frost, slush, or snow are prone to occur frequently; [CLICK] Low visibility conditions – Such as sites built in areas prone to fog, smoke, or dust events that significantly reduce local visibilities; [CLICK] Strong wind conditions – Such as exposed areas that either lack obstructions to wind or have natural barriers that channel and enhance the wind; and [CLICK] Water level conditions – Such as sites near roads relatively close to a permanent or intermittent water body. [CLICK] Because these sites were designed to observe a specific threat, their data may not match well with surrounding

sites. However, they provide important data on meso-to-microscale events that your regular surface observations may not identify.

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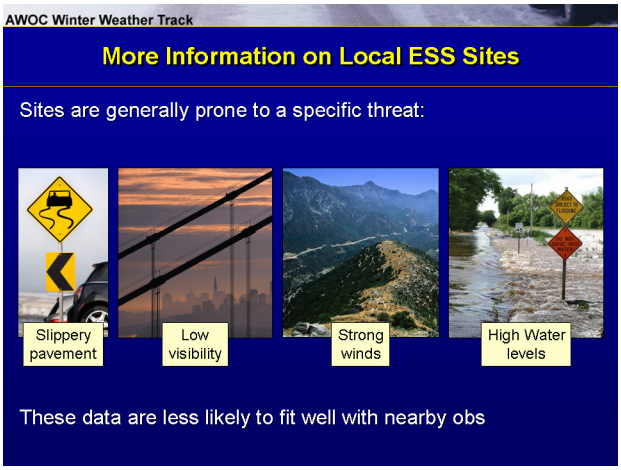

13. ESS Relationship to Management Strategies

Instructor Notes: Local ESS sites may be used in connection with a variety of advisory and control management strategies. [CLICK] Data from these sites may activate automated systems that warn the traveling public of hazardous conditions, [CLICK] or possibly limit or block access to a particular road segment. [CLICK] In some cases, these integrated systems have dramatically reduced instances of weather-related accidents in hazardous areas.

Student Notes:

14. RWIS/ESS Data Availability

Instructor Notes: The availability of RWIS data varies from state to state, with some significant variations seen within a state. Availability depends on how aggressive a particular DOT, or other transportation operator, has implemented a RWIS in their area. [CLICK] In some states, there are hundreds of ESS locations; [CLICK] in others; there

are less than 10. In some cases, transportation operators rely on outside data providers who already have a significant surface observing network in place (Pisano et al., 2007). [CLICK] Even if a transportation operator manages numerous ESS sites and collect data on several atmospheric, pavement, and hydrologic parameters, the data may not be accessible. When I say accessible, I mean that all of the data are available in real-time for government, research, educational, or public consumption through a web site, ftp, or other data feed. After all, that is what your office needs for RWIS data to be operationally useful.

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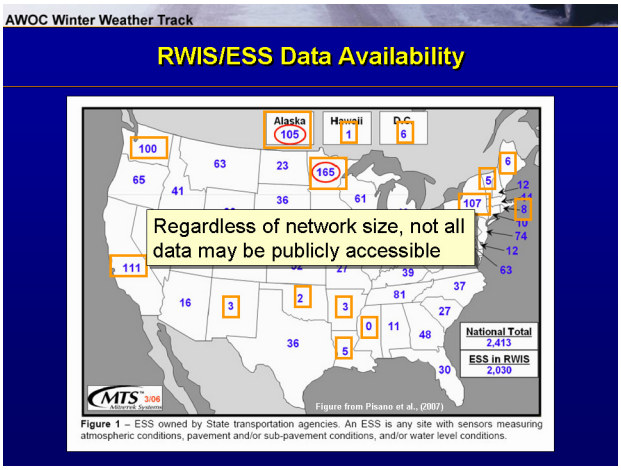

15. Current RWIS Data Availability (MADIS, LDAD, & the Internet) & the Near Future (Clarus)

Instructor Notes: Currently, approximately half of the states in the U.S. make their RWIS data accessible through some means. [CLICK] Just about all of these states have their data available on-line via a public web site in real-time with minimal delay. [CLICK] Many of these agencies also make their data available for download for a variety of purposes through the Meteorological Assimilation Data Ingest System (MADIS). The benefit of MADIS access for NWS forecasters is the data can be ingested into AWIPS using LDAD. [CLICK] In a similar effort, NOAA and the U.S. Department of Transportation are collaborating on a project called Clarus. [CLICK] The goal of Clarus is to develop and demonstrate an integrated data management system for surface observations and forecasts related to road weather. All of the surface data available through Clarus would be thoroughly quality controlled and available in a common data format. [CLICK] Clarus, which has already demonstrated the concept of operations on a small scale, hopes to have every state participate and make their RWIS data available in the next few years. [CLICK] In addition to providing the observational data, the Clarus web site also has extensive metadata for each participating RWIS network.

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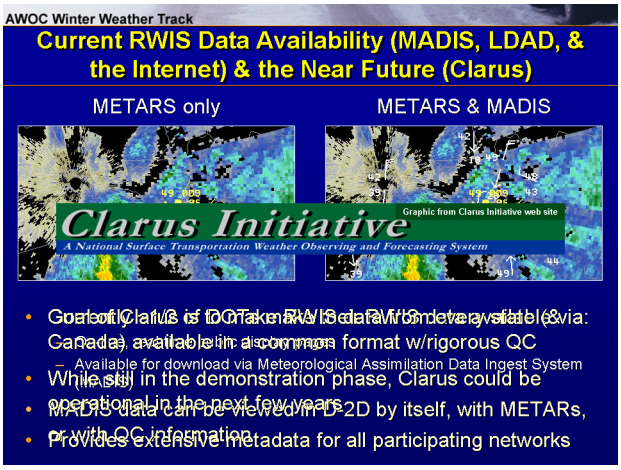

16. Learning Interaction

Instructor Notes: Please take a few moments to read the question on the slide. Use your mouse to position the cursor over your answer and press the mouse button to proceed to the feedback slide.

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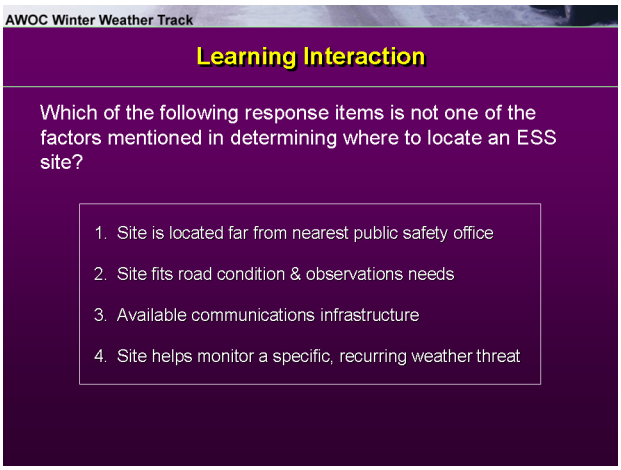

17. I'm Sorry, That's Incorrect

Instructor Notes:

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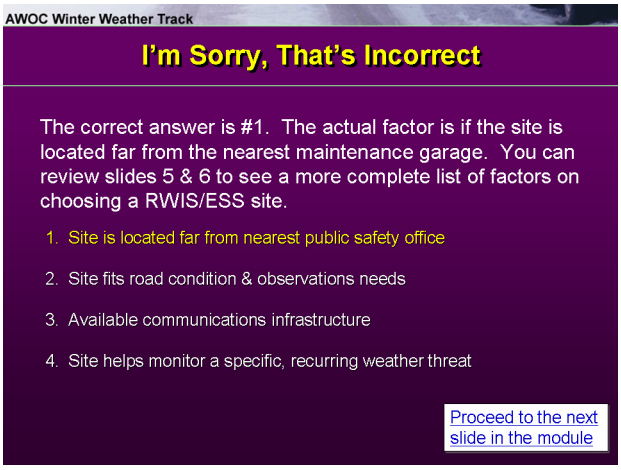

18. That's Correct!

Instructor Notes:

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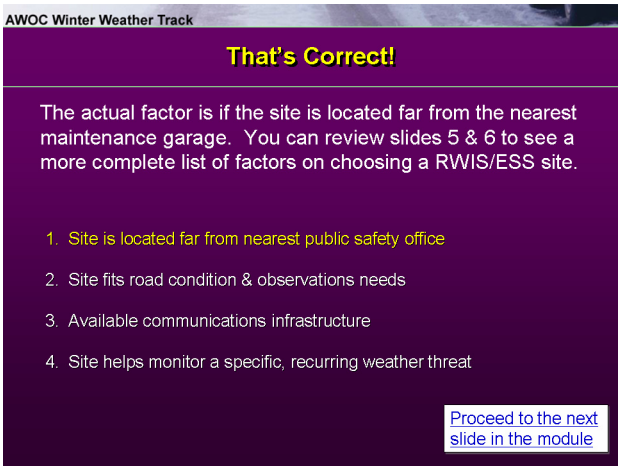

19. ESS Instrumentation Accuracy & Biases

Instructor Notes: In general, RWIS sites do not have the same accuracy specifications as similar ASOS and research mesonetwork sites. [CLICK] However, the accuracy of the instrumentation are generally sufficient for most operational forecasting needs. [CLICK] For instance, most temperature sensors at RWIS sites will have an accuracy range of +/- 2 degrees C (when functioning properly; Manfredi et al., 2005). For reference, ASOS temperature sensors have an accuracy range of +/- 0.5-1.0 degrees C (NOAA, 1998). [CLICK] Biases with specific sensors and measurements is a trickier situation. Often, you will need to peruse the data yourself for a sufficient time period before clearly identifying small, significant biases. [CLICK] Since several vendors provide different instruments to all of these different RWIS networks, a variety of biases is likely from WFO to WFO, state to state, or sometimes within the same local area.

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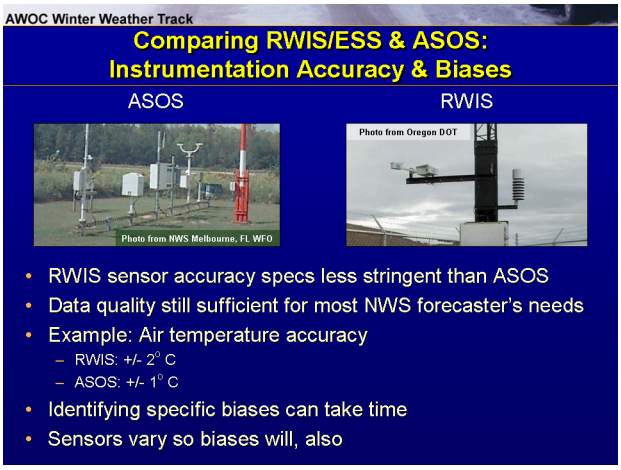

20. ESS Acceptable Deviations & Biases

Instructor Notes: Here are a few examples of documented biases that you may or may not observe in your CWA: [CLICK] - In general, ASOS and ESS sites will have relatively close agreements between temperatures, but any given site could have a ~2-4 deg F bias as compared to a nearby ASOS and still be operating within specifications. - Since ESS sites often use non-aspirated shelters, then air temperature measurements will generally exhibit a warm bias of ~1-3 deg F on sunny, relatively calm days (Pisano et al., 2003). [CLICK] - Humidity sensors tend to be very sensitive and require more frequent calibration than other instruments commonly found at ESS sites. As a result, biases and other accuracy issues may be most recognizable in these measurements. In general, relative humidity measurements at nearby ASOS and ESS sites should be within 10% of each other. An analysis of nearby ASOS and ESS sites found ESS dew point measurements to be lower during the day, and higher during the night time (Pisano et al., 2003). This pattern may vary depending on the instrument manufacturer. [CLICK] - At lower wind speeds (<12 kts), ESS wind speed measurements may have a low bias when compare to ASOS due to differences in siting requirements. In general, wind speeds are usually within 4 kts of each other at nearby ESS and ASOS sites (Pisano et al., 2003).

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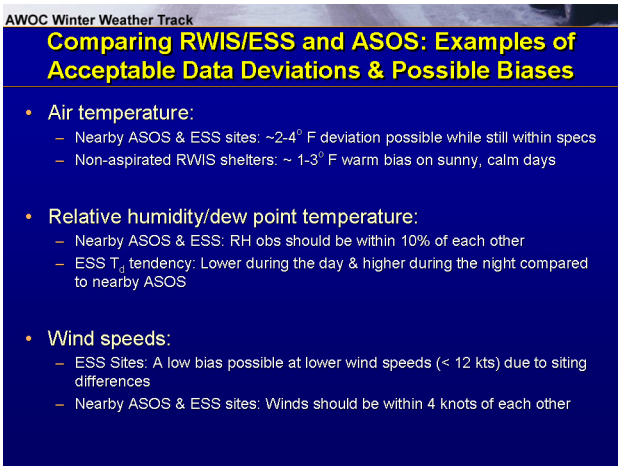

21. ASOS & ESS Support Different Systems

Instructor Notes: A key difference between RWIS and ASOS sites is that their weather observations support different modes of transportation. [CLICK] ASOS sites were designed and built to support aviation and airport operations, particularly takeoffs and landings. As a result, almost all ASOS observations are located at or near airfields with many observations taken near the most common landing point on the primary runway. The specs for ASOS sensors and sites were designed to produce the most representative observations for those areas and limit measurement contamination as much as possible (NOAA, 1998). [CLICK] In contrast, ESS sites are designed to support surface transportation. Remember that ground transportation cares primarily about the weather at or near the road surface. So, the specs for ESS sites were written to allow for instrument locations near roadways. The road environment is often less standardized (e.g., less flat, more trees and bodies of water) than what's found at an airfield. [CLICK] Many environmental parameters measured at ESS sites follow specs similar to those at ASOS sites. When they do deviate, it's often to measure the parameters in the same environment that cars and trucks experience (Cambridge Systematics Inc., 2003). [CLICK] ESS locations, when well sited, sample the environment of drivers very well and provide transportation operators an excellent picture of the roadway environment. Some differences observed between ESS and ASOS data parameters may have more to do with the differences in location and measurement height than with any differences in instrumentation that may exist between the two sites.

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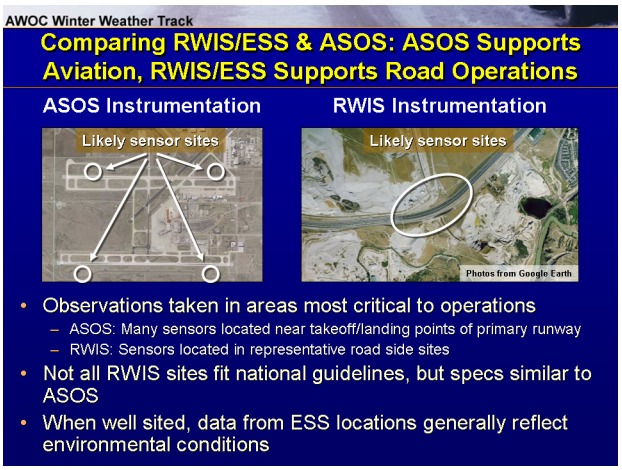

22. RWIS & ASOS Site Specifications

Instructor Notes: This page contains an interactive flash application that shows all of the different sensors that might be found at both an ASOS and ESS site. While ESS guidelines exist, they were written after many networks were established. As a result, ESS sites may or may not have been installed following these guidelines at a particular site. Please take a few minutes to view the information on each tab before moving on to the next slide.

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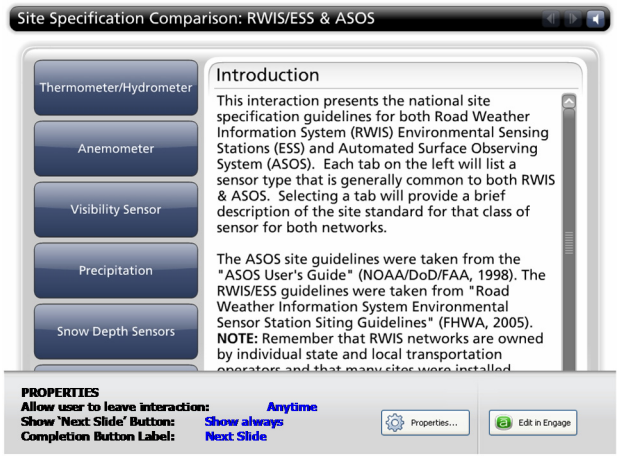

23. Visibility & Precipitation Sensor Differences

Instructor Notes: From the previous slide, you should have noticed the key differences in site specs between ASOS and ESS were the height of the visibility sensor and the types of sensors used to measure precipitation accumulation. [CLICK] ESS sites measure visibility ideally around 7-8 ft. AGL, compared to approximately 10 ft. AGL at ASOS sites. While this difference may not seem like much, it may be significant during some low visibility situations. The driver of an SUV is only sitting a few feet higher than the driver of a car, but that few feet seems to make a big difference for many drivers (Cambridge Systematics Inc., 2003). [CLICK] Many ESS sites use a standard tipping bucket gauge sensor to measure precipitation accumulation. Other sites have a single, combined optical sensor for measuring precipitation rate, type and accumulation. Optical sensors that measure precipitation rate and amount are relatively new technology that can require extensive calibration. Because of their accumulation measurement technique, they may overestimate accumulations during light events and underestimate accumulations during heavier events when compared to standard tipping bucket gauges (Cambridge Systematics Inc., 2003).

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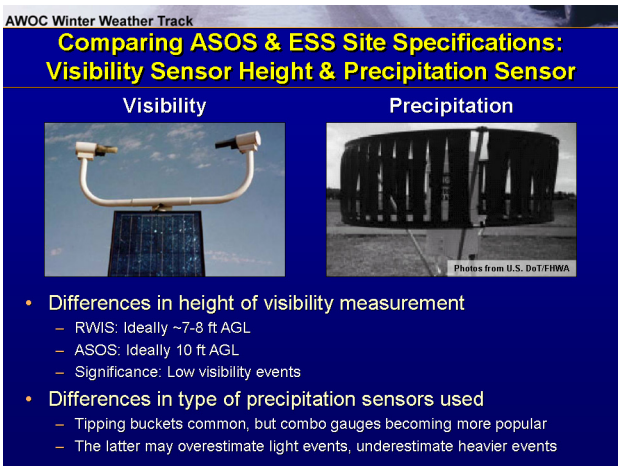
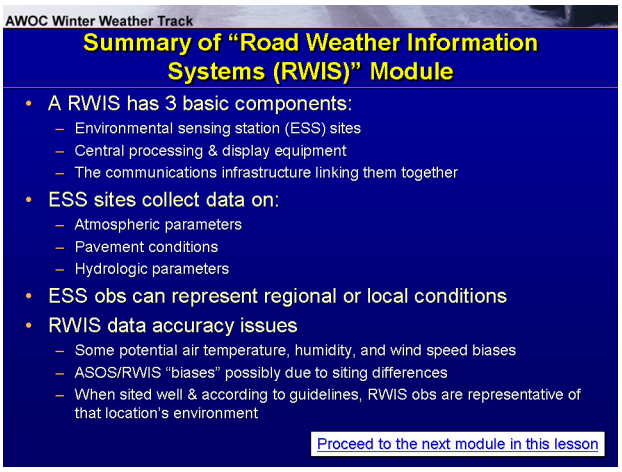


24. Summary of “Road Weather Information Systems (RWIS)” Module

Instructor Notes: In summary, this lesson provided a basic overview of Road Weather Information Systems. [CLICK] An RWIS has three basic components: - Environmental Sensing Stations, - Central processing and display equipment, and - The communication infrastructure that links it all together. [CLICK] Individual ESS sites collect data from several atmospheric, pavement, and/or hydrologic sensors. The instrumentation at a specific site is usually complementary to the site’s purpose (i.e., whether it is a regional or local site). [CLICK] Regional sites produce data that should be representative of the surrounding roadway environment. Local sites are chosen to observe particular, recurring hazardous conditions and may produce observations that deviate significantly from nearby surface observations. [CLICK] Some general RWIS data issues were also discussed. When comparing ASOS and RWIS data, it’s important to remember that RWIS sites are often located in environments different than ASOS and other mesonetwork sites. Some data biases may be related more to the ESS location than to any problem with the sensors themselves. In general, when ESS sites are well chosen and follow national siting guidelines, the data from these sites are representative of the nearby environment and can be useful for operational forecasters. [CLICK] To proceed to the next section of this lesson, click on the link at the bottom of the slide or use the navigation in the NWS Learning Center’s course page.

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