2014 Minnesota Fire Weather Annual Operating Plan

VII. Appendix

VII. APPENDICES (2014)

A. Glossary of Meteorological Terms
C. Smoke Management
D. Haines Index
E. Zones, Counties, Cities, and Weather Stations
F. NOAA Weather Radio Network
G. Spot Forecast Request Form
H. Fire-Weather Personal Directory

APPENDIX A

Glossary of Meteorological Terms

A

ADDS - Automated Digital Data Service. An interactive web site at the NWS's Aviation Weather Center. Hourly surface maps are available which allow fire personnel to assess and track wind shifts, temperature, and dew points in a region.

Adiabatic Process - A thermodynamic process in the atmosphere involving warming or cooling of air normally when a parcel or layer of air moves up or down. Cooling of the air parcel occurs as it moves up and expands. The parcel warms as it descends and as the surrounding air pressure increases. The dry lapse rate of 5.5^{o} F per 1000 feet of altitude describes how unsaturated air will cool. The moist adiabatic lapse rate of $3.0\ ^{o}$ F per 1000 feet describes a saturated air parcel movement.

Advection - The horizontal movement of air or of a specific component of air. Warm air advection or moisture advection that occurs may change the fire behavior.

AFD - Area Forecast Discussion. An unscheduled product from the NWS used to describe the weather features and trends for a forecast period. Although somewhat technical, it does list the features which the forecaster is following.

Air Mass - An extensive body of air having the same properties of temperature and moisture in the horizontal plane.

Anemometer - An instrument for measuring wind speed.

Anticyclone - An area of high pressure with closed, clockwise circulation. Its common name is simply a High. It is designated on a surface weather chart as a blue H.

Area Forecast Discussion (AFD) - See AFD

Atmospheric Pressure - The force exerted per unit area by the weight of the air above.

ASOS - Automated Surface Observing System **-** An automated weather system deployed at airports nationwide. They provide hourly reports called METARs which are plotted on surface weather maps.. These systems are primarily owned by the NWS and the Federal Aviation Administration (FAA)...

ATMU – Atmospheric Theodolite Meteorological Unit – portable equipment used by NWS Incident Meteorologists (IMET) to measure wind speed and direction aloft.

AWIPS -Advanced Weather Interactive Processing System- A powerful weather processing workstation used by forecasters at NWS Weather Forecast Offices.

AWOS - **Automated Weather Observing System** An automated weather system deployed at airports nationwide. They provide hourly reports called METARs which are plotted on surface weather maps.. Most systems are owned by state agencies. They are similar to ASOSs.

B

Backing Winds - Winds that change direction in a counter-clockwise direction with altitude in the vertical A south wind at the surface and an east wind at some point aloft would be an example of backing winds.

Barometer - An instrument for measuring atmospheric pressure.

Boundary Layer - The layer of air far enough above the surface to be free of frictional influences of the earth.

C

Chinook Wind - A foehn wind blowing down the eastern slopes of the Cascades, Rocky Mountains, and over the adjacent plains in the United States and Canada. In winter, this warm, dry wind causes snow to disappear with remarkable rapidity, and hence it has been nicknamed the “snow eater”. In hot dry weather, Chinook winds can quickly extend fire weather conditions to the ”extreme”.

Cirrus - A form of high cloud composed of ice crystals that do not obscure the sun to any great degree. They normally have a fibrous or wispy appearance.

Cold Front: The leading edge of a relatively cold air mass that displaces warmer air. The heavier cold air may cause some of the warm air to be lifted. If the lifted air contains enough moisture, the result may be cloudiness, precipitation, and thunderstorms. If both air masses are dry, no clouds may form. Following the passage of a cold front in the Northern Hemisphere, westerly or northwesterly winds of 15 to 30 or more miles per hour often continue for 12 to 24 hours.

Condensation - The atmospheric process by which water vapor changes into liquid form. This process releases heat.

Convection - As specialized in meteorology, atmospheric motions that are predominantly upward in the absence of wind (which distinguishes this process from advection), resulting in vertical mixing and transport of atmospheric properties. Convection is normally thought of as the process which initiates cumulus clouds and thunderstorms by heating the air from below.

Convergence - Net horizontal flow of air into an area associated with low pressure systems. If convergence occurs at the surface, upward vertical motion results. Consequently, areas of convergent winds are regions favorable to formation of clouds and development of rain.

Coriolis Force - An apparent force due to the rotation of the earth that causes a deflection of air to the right in the Northern Hemisphere as the air flows from high to low pressure. Aloft, the force balances the pressure gradient force resulting in winds flowing parallel to the height lines on an upper air chart.

Cumulonimbus - The ultimate growth of a cumulus cloud into an anvil shape, with considerable vertical growth, usually fibrous ice crystal tops, and probably accompanied by lightning, thunder, hail, and strong winds.

Cumulus - A principal, low cloud type in the form of individual cauliflower-like cells of sharp nonfiberous outline and less vertical development than cumulonimbus.

Cyclone - An area of low atmospheric pressure that has closed counter clockwise circulation. Cyclones usually bring about marked changes of weather and temperature during their passage. Other name given to cyclones are “low” or “depression”.

D

Derecho - A downburst straight line wind event from a mesoscale convective systems that produces widespread damage. The Boundary Waters Canoe Area blowdown of July 4, 1999 was a derecho.

Dew Point - The temperature to which air must be cooled at constant pressure and moisture content for saturation to occur.

Dispersion - The decrease in concentration of airborne pollutants as they spread throughout an increasing volume of the atmosphere.

Dispersion Index - A numerical value computed by multiplying the transport wind times the mixing depth or height of the mixing layer. Ranges of index values are assigned descriptive

terms indicating how well the atmosphere might function at spreading out or dispersing smoke. In Minnesota and Wisconsin the following values are used in the narrative fire weather forecasts.

<13,000	Poor
13,000 – 29,000	Fair
30,000 – 59,000	Good
60,000<	Excellent

Diurnal - Daily, especially pertaining to cyclic actions that are completed within a 24 hour period and which recur every 24 hours. The daily high and low temperature range is a diurnal cycle.

Divergence - The condition that exists when the distribution of winds within a given volume results in a net horizontal flow of air outward from the region. In divergence at lower levels, the resulting deficit is compensated by a downward movement of air from aloft. Divergence in upper levels of the atmosphere is often mentioned in Area Forecast Discussion products (AFD). Divergence in the wind flow aloft produces a compensating area of convergence near the surface resulting in the formation of low pressure centers or troughs. Divergence aloft can lead to the development of precipitation.

Dry bulb - An ordinary thermometer used to determine the ambient or existing air temperature. In a psychrometer both a dry bulb thermometer and a wet bulb thermometer are read in order to determine the relative humidity.

Dry Lightning Storm - A thunderstorm that produces little if any precipitation. Often virga is seen along with the lightning.

Drought Index: A number representing net effect of evaporation, transpiration, and precipitation in producing cumulative moisture depletion in deep duff or upper soil layers.

E

El Nino - An abnormal warming of the eastern Pacific Ocean along the west coast of South America. This pattern often disrupts normal weather cycle.

Evaporation - The transformation of a liquid into a gaseous state. Heat is lost by the liquid during the process.

F

Fire Weather - Weather conditions that influence fire ignition, behavior and suppression.

Fire Weather Watch: A term used by fire weather forecasters to notify land management agencies, usually 18 to 72 hours ahead of a situation where fire weather parameters would create dangerous fire conditions.

Foehn Wind - Pronounced “Fern” A type of general wind that occurs when stable, high pressure air is forced across and then down the lee slopes of a mountain range. The descending air is warmed and dried due to adiabatic compression. In that process, wind flowing down hill warms at the rate of 5.5^{o} per 1,000 feet. Some local names for a foehn wind are: Santa Ana, Chinook, or Mono.

Fog - A cloud at the earth’s surface. Fog consists of numerous droplets of water which individually are so small that they cannot readily be distinguished by the naked eye. Three of the most common types of fog are: advection fog, radiation fog, and upslope fog.

Free Air - That portion of the atmosphere that is not modified by local surface frictional affects.

Friction Layer - The layer of the atmosphere in which the frictional force of the earth’s surface exercises an appreciable influence on winds. This is generally the air within about 1500 feet of the ground.

Front - The transition zone between two air masses of different density and temperature. Fronts

emerge from a low pressure center. A cold front is the lead edge for colder and more dense air. A warm front marks the northern or eastern edge of a warmer and less dense air mass. `
Frontal Inversion - An increase in temperature with height, normally near and ahead of an advancing warm front. Warm, less dense air rides up and over the retreating colder air to the north.

G

General Winds - Large scale winds caused by the pressure gradient between high and low pressure systems but generally influenced and modified in the lower atmosphere by terrain.
GOES - Geostationary Operational Environmental Satellite. Weather satellites that remain at a fixed location 22,500 miles above the earth. East GOES is at 75° W, and West GOES is at 135° W GOES satellites provide a variety of weather imagery but also handle uplink and downlink communication with various observing technologies such as RAWS.
GPS Winds - Winds aloft measured by GPS navigation equipment in an aircraft.
Gradient - The change in a property between two locations. Pressure gradient is the difference in air pressure between areas of high and low pressure.
Gradient Winds - winds that flow parallel to the contours on upper air charts. This usually occurs above 1500 feet above ground level. Below that point winds cross the isobars at an angle.
Gust - A sudden, brief increase in the speed of the wind.
Gust Front - The leading edge of cold dense air flowing outward from a thunderstorm. The boundary is marked by rising air above it and downward motion behind it. Winds can be quite strong and gusty. Gust fronts are sometimes visible on Doppler radar as thin circular arcs around a thunderstorm cell or complex.

H

Haines Index: An atmospheric index used to indicate the potential for wildfire growth by measuring the stability and dryness of the air over a fire.
Hazardous Weather Outlook (HWO) - An alerting tool issued by the NWS at least every morning by 730 a.m. The HWO briefly explains potential weather hazards in the seven days ahead.

Heat Index - A discomfort index used to described the combined effects of temperature and humidity on the body's ability to cool itself.
High Clouds - Thin clouds, generally above 20,000 feet. The clouds are thin and wispy and comprised of ice crystals. Clouds in this ground include: cirrus, cirrostratus, and cirrocumulus. They are often indications of an approaching low pressure area, particularly a warm front.
High Pressure (Ridge) - An area on the surface map where atmospheric pressure measured by barometers is higher than the surrounding air. High pressure results from air descending into a region. On weather maps, highs are designated with a blue H and have closed isobars surrounding them. High pressure ridges usually are areas of cooler, subsiding air associated with quiet weather. Circulation around a high is in a clockwise direction. Over time, a subsidence inversion often forms.
HPC - Hydrometeorological Prediction Center. A part of the National Center for Environmental Prediction. The HPC is responsible for producing surface maps every three hours, forecast surface maps for every six hours, and the quantitative precipitation forecast (QPF).
Hudson Bay High - High Pressure centered near Hudson Bay, Canada. The Hudson Bay High is a contributor to fire weather problems. The air flowing clockwise around the high emerges from a cold region. As it moves south and warms, the relative humidity falls significantly. The resulting northeast winds that flow into Minnesota and Wisconsin are dry and can increase fire behavior.

Humidity - The measure of water vapor content in the air.

I

Infrared (IR) - Radiation emitted from objects in the spectrum between visible light and microwaves. Weather satellites detect levels of IR radiation and display the data in a manner such that darker grey shades represent warm temperatures and whiter colors represent cooler temperatures. In that way satellites can locate clouds and storms at various levels as well as lakes and rivers. IR imagery can also be used to detect fires.

Insolation - Radiation received from the sun at the earth's surface.

Instability - The state of the atmosphere in which the vertical distribution of temperature is such that an independent air parcel rising through the surrounding air, will become warmer than the surrounding air and will continue to rise. Unstable air contributes to increased fire behavior and better smoke dispersion.

Inversion - A condition in the atmosphere where temperature increases with increasing altitude rather than decreasing like it normally does. Inversions are of four types: Subsidence, Frontal, Radiation (nighttime), and Marine**.** Inversions inhibit smoke dispersal if low enough, and can increase fire behavior when they dissipate.

Isobar - A line of equal pressure surrounding areas of high and low pressure.

J

Jet Stream - A narrow meandering stream of high speed winds embedded in the normal prevailing westerly wind flow aloft. The jet stream is normally at about 30,000 feet but varies with seasons. Diverging air at the jet stream level often results in converging air near the earth's surface, leading to upward motion, formation clouds, and possible precipitation. There are two jet streams that cross the U.S., the polar jet, near the Canadian border, and the subtropical jet that crosses the southern tier of states.

K

Keech Byram Drought Index (KBDI): Commonly-used drought index adapted for fire management applications, with a numerical range from 0 (no moisture deficiency) to 800 (maximum drought).

L

La Nina' - The opposite of El Nino' in which abnormally cold Pacific Ocean water exists along the west coast of South America.

Lake Effect - Precipitation that occurs along the shores of the Great Lakes. The precipitation is not necessarily associated to a low pressure system but is produced by cold air moving across a relatively warmer and open lake. This unstable condition produces clouds over the relatively warmer open water. The instability can lead to precipitation, particularly snowfall.

Lapse Rate - The change of temperature with height. Normally temperature decreases with height, but it sometimes increases. This latter condition is called a temperature inversion. Lapse rates are normally expressed in negative values for temperatures that decrease with height and as positive values for inversions. The ambient lapse rate refers to the existing temperature structure of the atmosphere. The dry adiabatic lapse rate of
-5.5^{o}F per 1,000 feet is the rate at which a rising parcel of air would cool if lifted. The moist

adiabatic lapse rate of -3.0^{o}F per 1,000 feet is the rate at which a saturated air parcel would cool as it rises. The normal lapse rate of -3.5^{o}F per 1,000 feet is an average atmosphere lapse rate.
Lifted Index (LI) - An index used by the NWS to forecast thunderstorm development and severity.
Lightning - A sudden visible flash of energy and light caused by electrical discharges from thunderstorms**.**
Lightning Activity Level (LAL): A number, on a scale of 1 to 6, that reflects frequency and character of cloud-to-ground lightning. An LAL of 6 refers to dry thunderstorms. The LAL is not forecast in Minnesota.
Local Winds - Small scale convective winds of local origin cause by temperature differences. Upslope winds during the day are examples of local winds.
Low Pressure Trough - An elongated area of relatively low atmospheric pressure, usually extending from the center of a low pressure system. Troughs are areas of converging and upward-moving air.

M

METAR- **Meteorological Terminal Air Report** - A coded weather report from ASOS and AWOS automated airport weather stations. Reports are sent at least every hour or more often if conditions change significantly. The reports are decoded and plotted on surface maps.
Middle Clouds - Clouds ranging in altitude from 6,500 to near 20,000 feet.
Millibar (Mb)- a unit of measure for atmospheric pressure. Multiplying millibars times 0.02953 yields inches of mercury. Multiplying inches of mercury times 33.86 yields millibars. Another more universal name for a millibar is a HectaPascal (HPa).
Mixed Layer - The lowest layer of the atmosphere from the surface to the base of any temperature inversion that may exist aloft. A well mixed layer has a lapse rate close to the dry adiabatic lapse rate of -5.5^{o} F per 1,000 feet.
Mixing - The process of upward and downward motion in the atmosphere, particularly near the surface of the earth.
Mixing Height - The layer in the atmosphere from the surface to the first inversion layer. It is in this layer where vigorous mixing occurs due to convection.
NWS Spot - A web-based program for requesting and receiving spot weather forecasts.

O

Occluded Front - The front that is formed when and where a cold front overtakes a warm front or a stationary front.
Outflow - Cold, denser air that descends from the base of a thunderstorm and then spreads out in all directions. Outflow can travel several miles ahead of the thunderstorm and create gusty erratic winds unexpectedly.
Outflow Boundary - The leading edge of thunderstorm outflow. If these boundaries meet boundaries from other thunderstorms, new thunderstorm development is possible. Outflow boundaries are sometimes visible on weather radar as thin, curved lines surrounding a thunderstorm.

P

Palmer Drought Severity Index - An index used to gage the severity of drought conditions by using a water balance equation to track water supply and demand. This index is calculated weekly by the NWS.

Pibal - Pilot balloon. A method used by an Incident Meteorologist (IMET) at a fire to measure the winds aloft. The IMET tracks the ascending balloon with a theodolite noting azimuth and elevation every minute. He later uses these angles to calculate the winds. Launched with equipment contained in the ATMU.
Pressure Gradient - The difference between the air pressure in one area and the air pressure in another. The difference between High and Low pressure areas can be very small and result in light winds. Or the air pressure differences can be large, resulting in strong winds flowing from the High to the Low.
Profiler - A sampling device used to measure wind speeds aloft. A network of profilers is in the Midwest. The most northern installation is at Wood Lake, Minnesota. Profiler data maps are available on the internet.

Q

QPF - Quantitative Precipitation Forecast - A forecast of the rainfall amount that might be measured in a rain gage randomly placed in an area.

R

Radiational Cooling - The net loss of heat due to infrared radiation. Radiational cooling cools the ground and the air immediately above. Over time, radiational cooling helps to develop a nocturnal inversion, and that leads to poor smoke dispersion.
Radiosonde - an instrument carried aloft by balloon and tracked by ground equipment. The instrument sends back temperature, humidity, and pressure. Ground equipment helps to calculate wind speeds.
RAOB - Radiosonde Observation. A collection of information sent back from a radiosonde instrument. The data are used to create a plotted sounding which shows the temperature, humidity, and wind structure of the air aloft. RAOBs are used as basic information for the atmospheric forecast models and for determining smoke management parameters.
Red Flag Warning - Term used by fire weather forecasters to alert forecast users to an ongoing or imminent critical fire weather pattern.
Reflectivity - The ability of a radar target to return energy; used to estimate precipitation intensity and rainfall rates. Reflectivity imagery this that most often display on NWS web sites and on TV weathercasts. Cooler blue shades usually indicate light precipitation while warmer, red hues imply stronger thunderstorms.
Relative Humidity (RH) - The ratio of the amount of moisture in the air, to the maximum amount of moisture that air would contain if it were saturated. The ratio of the actual vapor pressure to the saturated vapor pressure.
Remote Automatic Weather Station (RAWS) - An apparatus that automatically acquires, processes, and stores local weather data for later transmission to the GOES Satellite, from which the data is re-transmitted to an earth-receiving station for use in the National Fire Danger Rating System.
Ridge - An elongated area of High Pressure.
Roll Cloud.- A horizontal, tubular cloud that may be seen on the leading edge of an outflow from a thunderstorm.
RUC - Rapid Update Cycle. A short term atmospheric forecast model that uses recent surface observations (METARs), satellite-calculated winds and temperatures, Doppler radar winds, and other information from commercial aircraft.

S

Severe Weather Statement (SVS) - A text product issued by the local NWS office during severe weather as an update to a Severe Thunderstorm Warning or Tornado Warning. The SVS gives detailed information about when the leading edge of severe weather, gusty winds, hail, and rain will pass designated locations.

Sea Breeze - A local wind that flows from a large body of water toward land. The sea breeze results from the land heating up, causing the air to rise convectively. As this happens, air from the cooler water flows inland. Sea breezes are often noted along Lake Superior, especially in the spring. Sea breezes can be opposite to the established flow in the area, or it can enhance the local wind if blowing in the same direction as the local winds.

Security Weather Watch - Observers are posted at one or more strategic locations in the proximity of a fire to detect critical weather changes that might significantly affect the fire and to report those changes to fire personnel.

Short Term Forecast - Sometimes called a NOWCAST. A short text product issued by the local NWS office to supply detail on weather such as non-severe thunderstorms that is or soon will be occurring at designated locations.

Short Wave - A kink in the broad scale upper flow. The east side of short waves area areas of rising motion, while the west side are areas of downward motion. Forecasters track short waves since short waves can often help to initiate or strengthen storms.

SkewT - A special graph for plotting upper air soundings or RAOBS. Forecasters use SkewTs to determine atmospheric instability as well as to calculate smoke management parameters. The temperature axis is shifted or skewed at an angle rather than being at right angles to the other axis as is normally done. *See also Stuve.*

Slope Winds - Small scale convective winds that occur due to local heating and cooling of a natural incline of the ground.

Smoke Management: **-** Application of fire intensities and meteorological processes to minimize degradation of air quality during prescribed fires.

Sounding - See RAOB

SPC - Storm Prediction Center - The office that issues Severe Thunderstorm and Tornado Watches. SPC also issues a daily fire weather related message on the potential for severe fire weather conditions.

Spot Weather Forecast: **-** A special forecast issued to fit the time, topography, and weather of each specific fire. These forecasts are issued upon request of the user agency and are more detailed, timely, and specific than zone forecasts.

Squall line - Any non-frontal line or narrow band of active thunderstorms extending across the horizon. It is of importance to fire behavior due to accompanying strong gusty winds and the possibility of such a line passing between regular weather observation stations without being reported.

Stability - The state of the atmosphere in which the vertical distribution of temperature is such that an air parcel will resist vertical displacement from its level.

State of Weather - A brief description of current weather that expresses the amount of cloud cover, kind of precipitation, and/or restrictions to visibility being observed at a weather observation site.

Stratosphere - The layer of the atmosphere between the troposphere and the mesosphere where the air is usually stable.

Stuve Diagram - (Pronounced STOO vee) A type of graph used to plot upper air soundings or RAOBs and from which smoke management parameters can be calculated. *See also SkewT.*

Subsidence - An extensive sinking motion of air in the atmosphere, most frequently occurring in high pressure areas of polar origin. The subsiding air is warmed by compression and becomes more stable as a subsidence inversion develops. Of particular importance is the heating and drying of the air.
Subsidence Inversion - A temperature inversion that forms under high pressure. The inversion lowers with time.
Subtropical High - The semi-permanent area of high pressure centered in the south Atlantic and Caribbean areas.
Surface Wind - The wind measured at 20 feet above the average top of the local vegetation. It is often a combination of the local and general winds.

T

Thermal Belt - An area of mountainous slope (characteristically the middle third), where the top of the radiation inversion intersects the slope. That area typically experiences the least variation in diurnal temperature variation and has the highest average temperature, and thus the lowest relative humidity. Its presence is most evident during clear weather with light wind.
Thunderstorm - Localized storm characterized by one or more electrical discharges.
Transport Winds - The average wind speed and direction of the horizontal wind within the mixing layer.
Troposphere - The layer of the atmosphere from the earth's surface up to the tropopause, characterized by decreasing temperature with height (except, perhaps in thin layers, called inversions), vertical wind motion, appreciable water vapor content, and sensible weather (clouds, rain, etc.)
Trough - An elongated area of low pressure. Troughs are regions of converging air at low levels which in turn results in upward vertical motion. See also Upper level disturbance, short wave.
Turbulence - Irregular motion of the atmosphere usually produced when air flows over a comparatively uneven surface such as the surface of the earth; or when two currents of air flow past or over each other in different directions or at different speeds.

U

Upper Level Disturbance - See Short Wave. A general term for any large scale or mesoscale disturbance capable of producing upward motion (lift) in the middle or upper parts of the atmosphere. Such disturbances can help initiate vertical motion or enhance existing vertical motion.

V

Vorticity - A measure of the local rotation in a fluid flow. In weather analysis and forecasting, it usually refers to the vertical component of rotation (i.e. rotation about a vertical axis) and is used most often in reference to synoptic scale or mesoscale weather systems. By convention, positive values indicate cyclonic rotation.
Veering Winds - Winds which shift in a clockwise direction with time at a given location (e.g. from southerly to westerly), or which change direction in a clockwise sense with height (e.g. southeasterly at the surface, turning to southwesterly aloft). The latter example is a form of directional shear which is important for tornado formation. Contrast with backing winds.
Virga - Streaks or wisps of precipitation falling from a cloud but evaporating before reaching the ground. In certain cases, shafts of virga may precede a microburst. Virga may also be present in

dry thunderstorms which produce “dry lightning”.

W

Warm Front - The leading edge of a relatively warm air mass which moves in such a way so that warm air displaces colder air. Winds associated with warm frontal activity are usually light, and mixing is limited. The atmosphere is relatively stable near a warm front when compared to the air near a cold front.

Weather Information and Management System (WIMS): An interactive computer system designed to accommodate the weather information needs of all federal and state natural resource management agencies. Provides timely access to weather forecasts, current and historical weather data, the National Fire Danger Rating System (NFDRS), and the National Interagency Fire Management Integrated Database (NIFMID).

Wet Bulb Depression - The difference between the wet-bulb and dry-bulb temperatures as measured by a psychrometer. The greater the web bulb depression, the drier the air. **Wet Bulb Temperature -** The lowest temperature to which air can be cooled by evaporating water into it at a constant pressure when the heat required for evaporation is supplied by the cooling of the air. It is measured by the wet-bulb thermometer, which usually employs a wetted wick on the bulb as a cooling devise through the process of evaporation. The drier the air, the more evaporation from the wet bulb of a psychrometer can occur. The wet bulb temperature is an indicator of the water vapor in the air. Relative humidity and dew point are calculated from tables into which the dry bulb and wet bulb temperatures are used an inputs.

WSR-88D - The identifier for National Weather Service Doppler radar. Weather Surveillance Radar deployed in 1988 with Doppler capability.

APPENDIX B

SMOKE MANAGEMENT

The Clean Air Act requires land management agencies to address the issue of smoke management in its prescribed burns. The goal is to burn in atmospheric conditions that would encourage smoke to rise to such a level that the smoke is dispersed as much as possible to reduce a number of health and safety risks near the fire.

A Minnesota Smoke Management Plan (SMP) was created in the year 2000 and should be considered the source document for any questions regarding the requirements or practices of smoke management in Minnesota. The Plan was updated in 2008.

The National Weather Service will support the smoke management efforts of federal, state, and local agencies as well as organizations involved in such burning. The NWS will provide three (3) parameters used in smoke management in its Fire Weather Planning Forecasts. The NWS will also include these parameters, upon request of the land agency, in spot forecasts.

The three weather parameters of smoke management forecasts are mixing layer (or depth), transport winds, and dispersion index. For smoke management purposes, the mixing layer is usually considered the lowest layers of the atmosphere bounded by the earth's surface and the bottom of any temperature inversion which may exist aloft. If a temperature inversion is based at the surface, then there is little if any mixed layer. A temperature inversion would serve to trap smoke at low levels or would prevent sufficient lofting of smoke to a level where winds would dilute or transport it away from the area. See Figure 16 below.

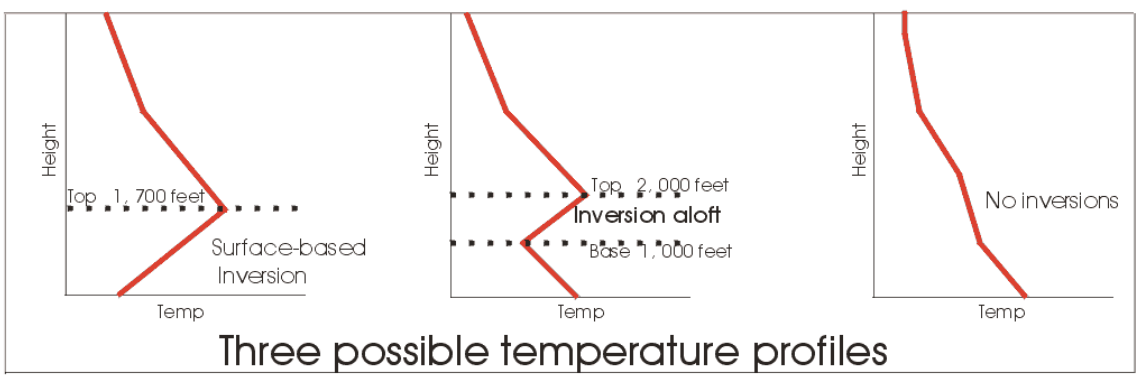


Figure 16. Three upper air temperature profiles which affect smoke dispersal differently.

a) a surface-based inversion is an absolutely stable condition that traps smoke and prevents lofting. b) An elevated inversion is unstable or neutral and allows limited smoke rise, but the smoke will stop rising at the base of the inversion aloft. c) When no inversions are present, smoke is free to rise. However, the existing (ambient) lapse rate will determine the rate of rise and the plume characteristics.

The transport wind is defined as the average wind speed and direction through the mixing layer.

In forecasts provided by the NWS, the transport wind will be provided in mph and the height of the mixed layer will be in feet agl.

The transport wind may suggest the need for surveillance or resource location at downstream areas for the purpose of minimizing the danger posed by spotting due to firebrands and to determine the impacts of smoke on a sensitive area.

The Dispersion Index is detailed in the Minnesota Smoke Management Plan (SMP) in section 4.2.2. The index is intended to serve as a single adjective index which describes how smoke will disperse on that day. The Dispersion Rate is given by the following formula as defined in the Minnesota Smoke Management Plan:

Dispersion Index = (Mixing Height in feet) x (Transport Wind in knots)

The Minnesota Smoke Management Plan (SMP) suggests the following interpretation of the values:

Dispersion Index	**Dispersion Rate**
< 13,000	Poor
13,000 - 29,999	Fair
30,000 - 59,999	Good
60,000 or greater	Excellent

The SMP contains guidelines for using the index and should be consulted for those details.

Most smoke management inputs to software programs and nomograms are in metric units.
A table for conversion among various units is provided.

The National Weather Service uses a variety of units of measure for wind and height. To minimize confusion and to make the conversion of units easier, the following conversion factors will prove helpful.

Multiply	**By**	**To get**
Feet	0.308	Meters
Feet	0.0152	Chains
Statute Miles	1609.34	Meters
Statute Miles	1.60934	Kilometers
Statute Miles	0.8684	Nautical Miles
Statute Miles	80	Chains
Nautical Miles	0.6080	Feet
Nautical Miles	1.152	Statute Miles
Nautical Miles	1853.25	Meters
Nautical Miles	1.85325	Kilometers
Chains	66	Feet
Chains	20.12	Meters
Chains	0.0125	Statute Miles
Meters	3.281	Feet
Meters	0.0497	Chains
Meters	0.0006 2	Statute Miles
Meters	0.00054	Nautical Miles
Kilometers	3280.84	Feet
Kilometers	0.6214	Statute Miles
Kilometers	0.5396	Nautical Miles
Knots	1	Nautical Miles Per Hour
Knots	1.152	Statute MPH
Knots	1.689	Feet Per Second
Knots	0.515	Meters Per Second
Knots	1.853	Kilometers Per Hour
Statute MPH	0.868	Knots
Statute MPH	1.467	Feet Per Second
Statute MPH	0.447	Meters Per Second
Statute MPH	1.609	Kilometers Per Hour
Statute MPH	88	Feet Per Minute
Kilometers Per Hour	0.278	Meters Per Second
Kilometers Per Hour	0.540	Knots
Kilometers Per Hour	0.621	Miles Per Hour
Kilometers Per Hour	0.911	Feet Per Second
Meters Per Second	3.6	Kilometers Per Hour
Meters Per Second	1.943	Knots
Meters Per Second	2.237	Miles Per Hour
Meters Per Second	3.281	Feet Per Second
Meters Per Second	196.85	Feet Per Minute

APPENDIX C

HAINES INDEX

The NWS will provide the Haines Index in Fire Weather Planning Forecasts.

What is the Haines Index?

The Haines Index combines the effects of dry air and instability to determine the potential for large fire growth. Its purpose is to identify weather conditions that may allow an existing fire to spread rapidly or exhibit extreme fire behavior. It should NOT be used to predict the potential or probability for wildfires to ignite. The Haines Index is most applicable to plume-dominated fires. The Haines Index does not account for wind.

The Haines Index contains two components, one to assess the dry air, and the other to measure the instability. Dry air affects fire behavior by lowering fuel moisture, which increases the amount of fuel available to the fire. Instability is caused by warming the lower levels of the atmosphere, cooling the higher levels, or by a combination of the two processes. An unstable air mass promotes the formation of rising currents of air and thus increases the vertical extent of a smoke column. Wildfires that burn in a dry, unstable environment can become plume-dominated and are often able to generate their own strong surface winds. Ground elevation will determine which of three levels in the atmosphere will be used to compute the Haines Index. In Minnesota, the mid-level layer between 850 mb (around 5000 feet agl) and 700 mb (around 9000 feet agl) will be used.

Computing the Haines Index

Haines Index = Stability + Moisture = A + B

Stability Term (A) = 850 MB Temperature - 700 MB Temperature
Let A equal the following values according to the temperature differences

A = 1	when stability term is 5 degrees C or less
A = 2	when stability term is 6 to 10 degrees C
A = 3	when stability term is 11 degrees C or more

Large positive values of the stability term indicate an unstable layer of the atmosphere near the earth's surface. Negative values indicate a temperature inversion.

Moisture Term (B) = 850 MB Temperature - 850 MB Dew Point Temperature

B = 1 when moisture term is 5 degrees C or less
B = 2 when moisture term is 6 to 12 degrees C
B = 3 when moisture term is 13 degrees C or more
The greater the value of this term, the drier the air is.

An example calculation

850 MB Temperature = 20 degrees C
850 MB Dew Point = 15 degrees C
700 MB Temperature = 12 degrees C
Haines Index = Stability (A) + Moisture (B)
From the tables above
850 MB Temp - 700 MB Temp = 20 - 12 = 8 Stability is between 6 and 10, so let A = 2
850 MB Temp - 850 MB Dew point = 20 - 15 = 5 Moisture is less than 6, so let B = 1

A + B = 2 + 1 = 3.

An Index value of 3 corresponds to a "Very Low" category. The conclusion is that extreme fire behavior would not be expected on this day.

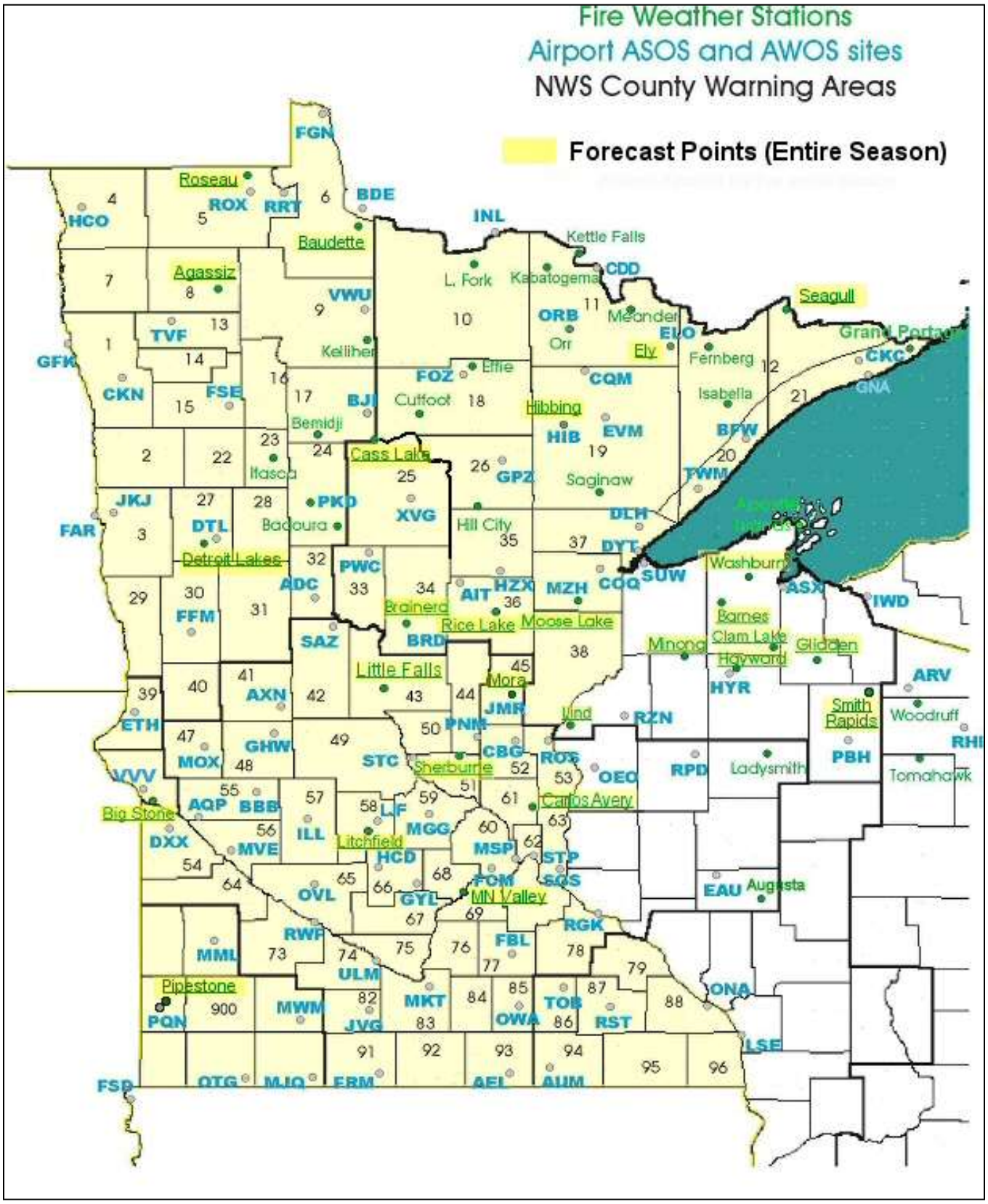
A weakness of using the Haines Index is that the stability and moisture terms are calculated at two fixed levels (850 and 700 MB). At times, making the calculations at slightly different levels could lead to a significantly different Haines Index.

Significance of Haines Values

2 or 3	Very Low
4	Low
5	Moderate
6	High

APPENDIX D

Zones, Counties, Cities, and Weather Stations
Zones, County Warning Areas, Fire Weather Stations and Airport ASOS and AWOS Weather Observation sites. A list of stations, zone names, and zone numbers is on the next page.

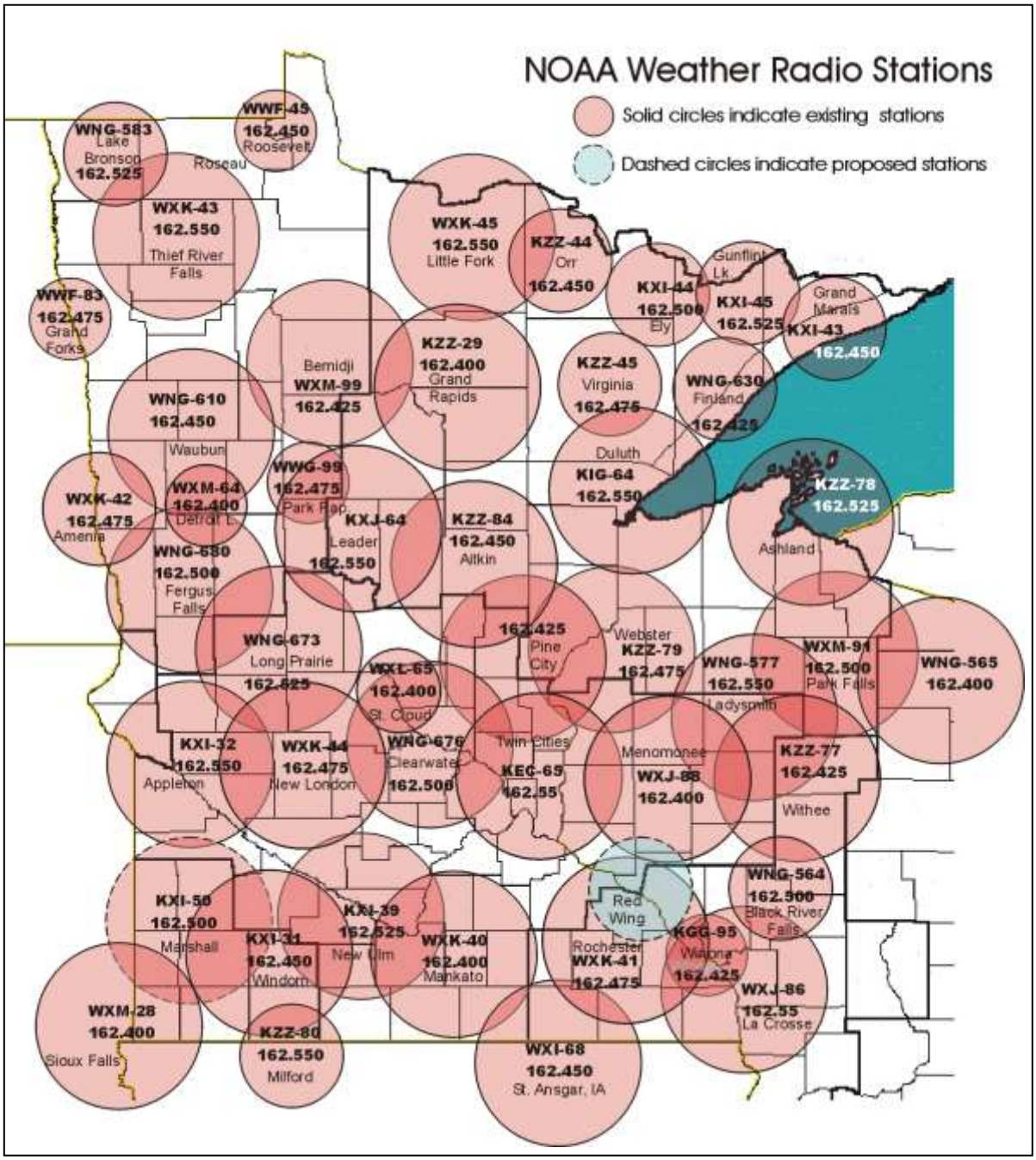


Zones, Counties, Cities, and Weather Stations

ZONE	City	Zone Name
1	Crookston	West Polk
2	Ada	Norman
3	Moorhead	Clay
4	Hallock	Kittson
5	Roseau/Greenbush	Roseau
6	Baudette	Lake of the Woods
7	Argyle	W. Marshall
8	Grygla	E. Marshall
9	Waskish	N. Beltrami
10	International Falls	Koochiching
11	Ely	N. St. Louis
12	BWCAW	N. Cook/Lake
13	Thief River Falls	Pennington
14	Red Lake Falls	Red Lake
15	Erskine	E. Polk
16	Clearbrook	N. Clearwater
17	Bemidji	S. Beltrami
18	Effie	N. Itasca
19	Hibbing	C. St. Louis
20	Finland/Two Harbors	Northshore/S. Lake
21	Grand Marais/ Grand Portage	Northshore/S. Cook
22	Mahnomen	Mahnomen
23	Bagley	S. Clearwater
24	Park Rapids	Hubbard
25	Cass Lake	N. Cass
26	Grand Rapids	S. Itasca
27	Detroit Lakes	W. Becker
28	Osage	E. Becker
29	Breckenridge	Wilkin
30	Fergus Falls	W. Otter Tail
31	Ottertail	E. Otter Tail
32	Wadena	Wadena
33	Leech Lake	S. Cass
34	Brainerd	Crow Wing
35	Hill City	N. Aitkin
36	Aitkin	S. Aitkin
37	Duluth/Cloquet	Carlton/S. St. Louis
38	Hinckley	Pine
39	Wheaton	Traverse
40	Elbow Lake	Grant
41	Alexandria	Douglas
42	Long Prairie	Todd
43	Little Falls	Morrison
44	Onamia	Mille Lacs
45	Mora	Kanabec
46	Ortonville	Big Stone
47	Morris	Stevens
48	Glenwood	Pope
49	St. Cloud	Stearns
50	Sauk Rapids	Benton
51	Elk River	Sherburne
52	Cambridge	Isanti
53	Taylors Falls	Chisago
54	Madison	Lac Qui Parle
55	Benson	Swift
56	Montevideo	Chippewa
57	Willmar	Kandiyohi
58	Litchfield	Meeker
59	Buffalo	Wright
60	Minneapolis	Hennepin
61	Anoka	Anoka
62	St. Paul	Ramsey
63	Stillwater	Washington
64	Granite Falls	Yellow Medicine
65	Renville	Renville
66	Glencoe	McLeod
67	Gaylord	Sibley
68	Waconia	Carver
69	Shakopee	Scott
70	Hastings	Dakota
71	Lake Benton	Lincoln
72	Marshall	Lyon
73	Redwood Falls	Redwood
74	New Ulm	Brown
75	St. Peter	Nicollet
76	Montgomery	Le Sueur
77	Faribault	Rice
78	Zumbrota	Goodhue
79	Wabasha	Wabasha
80	Slayton	Murray
81	Windom	Cottonwood
82	St. James	Watonwan
83	Mankato	Blue Earth
84	Waseca	Waseca
85	Owatonna	Steele
86	Dodge Center	Dodge
87	Rochester	Olmsted
88	Winona	Winona
89	Worthington	Nobles
90	Jackson	Jackson
91	Fairmont	Martin
92	Blue Earth	Faribault
93	Albert Lea	Freeborn
94	Austin	Mower
95	Preston	Fillmore
96	Caledonia	Houston
97	Pipestone	Pipestone
98	Luverne	Rock

APPENDIX F

NOAA WEATHER RADIO STATIONS



NOAA Weather Radio transmitter sites. The circles indicate a radius within which the tone alert should be available. Actual availability may vary due to terrain, weather conditions, or other reasons. Smaller circles indicate lower-powered transmitters. Red, or blue colored circles indicate existing stations or those which should be available in the near future. Frequencies are shown in megahertz.

Appendix G

MINNEAPOLIS SPOT FORECAST REQUEST

Required Elements in RED

PROJECT NAME

Project Name:

○ Wildfire ○ WFU ○ HAZMAT

◉ Prescribed Fire ○ SAR

Ignition Time: 1245 ◉ Central Local Time

Date: 5/3/04

REQUESTING AGENCY

NOTE: **Do not use commas in this section.**

Requesting Agency: NWS Chanhassen Tes

Requesting Official:

Phone Number: (952) 361-6670 Ext.

FAX Number: (952) 361-6668

Contact Person: DNR Guy

REASON FOR SPOT FORECAST REQUEST

Must choose either Wildfire or one of the Non-Wildfire reasons

○ **Wildfire**

Non-Wildfire

○ Under the Interagency Agreement for Meteorological Services (USFS, BLM, NPS, USFWS, BIA).

○ State, tribal or local fire agency working in coordination with a federal participant in the Interagency Agreement for Meteorological Services.

○ Essential to public safety, e.g. due to the proximity of population centers or critical infrastructure.

For NWS Spot forecast policy, see section 4.0 in NWS Instruction 10-401 at
http://www.nws.noaa.gov/directives/010/010.htm

LOCATION

Lat:

Lon:

7.5' Quad:

Legal (T/R): ◉ MN ○ WI

Elevation: Top Bottom

Drainage:

Aspect:

Size: (Acres)

*Enter Lat/Lon, Legal(T/R) also acceptable
*Legal(T/R) is for WI **only**.

FUEL

Type:

Sheltering
○ Full
○ Partial
○ Unsheltered

OBSERVATIONS

Place	Elev	Time	Wind	Temp	Wetbulb	RH	Dewpt	Sky/Weather

PRIMARY FORECAST ELEMENTS

TDA TNT TMR (Today, Tonight, Tomorrow)

☐ ☐ ☐ Sky / Weather
☐ ☐ ☐ Temperature
☐ ☐ ☐ Relative Humidity
☐ ☐ ☐ 20 Foot Wind
☐ ☐ ☐ Haines Index

REMARKS

Submit Request | Cancel Request | Clear Form

NOTICE: Information provided on this form may be used by the National Weather Service (NWS) for official purposes in any way, including public release and publication in NWS products. False statements on this form may be subject to prosecution under the False Statement Accountability Act of 1996 (18 U.S.C. § 1001) or other statutes.

National Weather Service, NOAA
Page last updated at 11:23 am MDT 4/14/04

Instructions on How to Use the Internet Spot Forecast Request Form

From the Fire Weather Main Page on any National Weather Service web site, click **on Internet Request Spot Form**. The Spot Forecast Request form will appear. This page auto-updates every minute, so as new spot forecasts are requested or their status changes, you immediately see the changes on the page. We call this the monitoring page. It should be noted that Spot Forecasts on this Web Page are viewable by the public.

A nice feature available now is that Spot Forecasts can be viewed in a KML file in Google Earth from the following NWS webpage http://www.wrh.noaa.gov/tfx/php/firekml.php. Simply click on the Spot Forecast Request KML link on the right side of page to access a National Map of Spot Forecasts.

Some of the features on the Internet Spot Forecast Request Form Page include:

A) The current date with arrow keys allowing you to step back or forward to a particular date. A calendar is also available, which will allow you to see how many spot forecasts were issued on a certain date.

B) A map of the NWS office's fire weather area of responsibility. A small box will appear indicating the location of any spot requests. The box is colored coded to indicate if the spot forecast is pending (green), which means you have submitted the request and the NWS is working on the forecast. A purple box indicates the NWS has sent you a question with respect to the spot forecast. A red box on the map means the spot forecast is complete and you can either click on the red box or in the Name/Ignition Time/Status Box to see the forecast.

C) A link at the top of the monitoring page will take you back to the NWS Fire Weather Page. So to submit a spot request online, simply click on SUBMIT A NEW SPOT REQUEST. You will now be taken to the NWS SPOT FORECAST REQUEST page.

Information Page You Will Be Filling In

***** It is important to note that the elements colored in red are required fields! *****

Let's look at the information fields on this page...

1 _ Project Name: If your fire has a name, go ahead and put it in. Otherwise, let's say the fire is 5 miles west of Litchfield, MN. Go ahead and enter in 5W of Litchfield, MN. Put in something that you will be able to reference on the Spot Request Page because this is a required field.

* select the type of project. If it is a prescribed burn, please enter in the Ignition Time (using the 24 hour clock) and Date. The form defaults to an ignition time about ½ hour into the future. If it is a wildfire, remove the default ignition time.

2 _ Requesting Agency: The Requesting Agency name and phone number are required. Fax number and contact person are optional, but we consider those very important if we have any questions or a breakdown in dissemination capabilities. You will only need to enter your agency name, phone/fax

numbers, and your name the first time you request a spot forecast. After that, it will be filled in with the same information as your last request, assuming you use the same computer. Please note that no other people other than you and the NWS will see this information. Only the name of the requesting agency is shown.

You will also have to choose the Reason for the Spot Forecast Request Wildfire or Non-wildfire. If a non-wildfire, you must also click on one of the three justifications. See Page 14 of the Minnesota Fire Weather AOP for more details.

3 _ Location: You have a couple of options on this one, but they are important with respect to having the location appear on the map. Proper location data will give us detailed map information on the location of the fire and the terrain in the area.

* Enter the Latitude and Longitude of the fire (you can either specify degrees like 45.1486 or degrees/minutes/seconds like 45 13 34).

4 _ Elevation: The top and bottom elevations of the fire are required. You can just enter the numbers and do not need to mention the word feet. If the burn or fire is on flat ground, you can enter a value in only one of the boxes, preferably the one labeled Top.

* Drainage is optional and once again references the river drainage basin the fire is in. If you do not know it, go ahead and just submit the request anyway.

5 _ Aspect:. Use direction references such as N, NE, E, SE, S, SW, W, NW. If the fire or burn is in flat terrain, you can type in FLAT.

6 _ Size: Enter the acreage if known, but it is an optional field.

7 _ Fuel: Please indicate the type of fuel, either using fuel model numbers, or better yet a description of the fuel such as grass, slash, timber, etc. Also, if you can indicate the amount of fuel sheltering, it helps us in providing accurate wind forecasts.

8 _ Observations: Current weather observations can improve the quality of a spot forecast. Please enter in the information with respect to the observation. For each observation we need to know where it is in relation to the burn, the elevation in feet, and the time (preferably using a 24 hour clock). The wind (in mph) can be specified as N12 Gust 25 or North at 10 for example. You must specify if the wind is a 20 foot wind or an eye-level wind. The temperature and wet bulb values (in degrees F) should be entered and the RH (in percent) and dew point (in degrees F) can also be entered if known. If you enter a temperature and wet bulb, the RH and dew point will be calculated for you. Finally, any remarks about clouds, weather, or other important information should be entered in the final box.

9 _ Primary Forecast Elements: Tell us what the forecast elements you need, or are particularly important to the burn. There are six parameters listed for you. Select which ones you want a forecast for, and the time period(s) you would like as well (available times are Today, Tonight, and Tomorrow).

10 _ Remarks: Information such as wind direction or change in wind direction or speed which would adversely affect the burn is very useful. Any other information which you feel would be of use to the forecaster preparing the forecast is helpful. It is here where you would make a request for Hysplit trajectory parcel forecasts, which may be of value for smoke management. To obtain this information,

simply add to the REMARKS block of the request Hysplit<space>your email address. An example would be Hysplit jack.pine@state.mn.us. The Hysplit run will then be emailed to you. At this time, the lowest trajectory level available is 500 meters with others at 1000 and 3000 meters. Hysplit may be of more value in larger burns when impacts would extend beyond 6 miles. It may also not be appropriate in situations with low mixing heights – under an inversion.

11 _ Action: You now have three options. You can Submit Request, Cancel Request, or Clear Form. When you hit Submit Request, various checks are performed on the data you have entered. Some problems make it impossible for your request to be accepted (for example, if you forget to enter a name for the burn), while others will produce warnings and messages for your information. For example, even though drainage name is not required, it will still ask you if you know what it is. You do not have to answer this question. If an error is found, you will be taken to a page that describes the errors or minor problems. You can click on Go Back and Fix and have the opportunity to make the necessary changes. You can click on Submit Request Anyway, but we may send back a question or call you. You do have one more option and that is to Cancel Request.

Other Important Information

* After you have submitted a spot forecast request, an individualized spot forecast web page becomes available for that burn. The page automatically updates every minute so that as new information becomes available for the burn, you see it immediately. Detailed maps of the area around the burn are generated and displayed when they become available.

* Once the forecast is COMPLETED and made available to you, the page will not update anymore. Thus, if we update the forecast, we would have to call you to inform you of the upcoming change, since the page no longer updates or has a way to inform you that a change has been sent. When you go back into the forecast, the only way you might pick up on the changed forecast is at the top of the page it shows the time that the spot was requested and the time it was issued. The issue time will have changed. Keep in mind that "sensitive" information like your name, phone number, and the exact location of the burn are NOT visible to others - only to you and the NWS.

* If we have questions about your request, we may send you back a question about it. If this happens, the Status Box will show the word QUESTION and the box on the map will turn purple. Click on this and you will see a big red box in the forecast page with our question. Usually there is some problem with the request that you can probably fix (use the CHANGE REQUEST link to do this, make your changes if necessary, then submit the request once again. The purple box will return to green and the word QUESTION will change back to PENDING) or you can call us.

* When your forecast is complete, it will show up in the spot forecast web page (clicking on the red box in the map or COMPLETED in the Status Box can access the spot). On the forecast page a Feedback box will appear where you can provide us information with respect to how the forecast worked out, perhaps later in the day or several days down the road. This feedback helps us to improve. Simply type in your feedback into the box and click on Send Feedback.

* At the bottom of the forecast page are links for actions that you can take. For example, you can go "Back to Spot List" to return to the monitor page. If you need to delete a request, simply click on "Delete Request".

* You can also click on "Copy Info to New Spot Request". This is helpful for burns that last over several days. Rather than having to re-enter the data in the form to get a new forecast, you can view the previous spot request and then copy all the location parameters to a new request using this link. This will save you some time when filling out the request form.

*Remember, you can also call the servicing NWS office in you have any questions.