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PACKET RADIO USED IN A COST-EFFECTIVE AUTOMATED WEATHER MESO-NET

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The intent of TA 96-31 was to inform a meteorological audience about the technical aspects of an emergency-warning demonstration project. This addendum provides information on a pilot project using packet radio in automated weather nets. (A companion information sheet is under draft to offer a more detailed discussion of the broader scope of amateur radio requirements, capabilities, and restrictions with relation to weather information.) All radio aspects of the pilot project were sponsored under the local Ham radio club license. Those radio activities must adhere to rigorous FCC requirements. Any similar packet radio projects must be undertaken with the approval and cooperative participation of your local amateur radio club.

While the amateur radio regulations are exacting, they are also not broadly prohibitive to weather information dissemination or collection over amateur radio frequencies. The amateur radio TexNet makes a wide variety of NWS observational, forecast, and warning products available, including WSR-88D Radar Coded Messages (RCM). There are amateur associations that observe and collect daily weather information for state-wide weather summaries which are made available on Ham club sponsored packet systems and re-transmitted on AFOS. What is vital is the intimate involvement of the local amateur radio club in these efforts.

The Glasgow packet weather project was a short-term pilot project to examine and demonstrate the meteorological feasibility of an economical automated weather instrument for detection of emergency weather situations. The actual weather information was applied to a routine evaluation procedure of emergency conditions that placed the boating public at dangerous risk with no regular schedule, i.e., lake wind advisories. The pilot project has been successfully completed and the weather instruments configured inactive for NWS applications.

Judging from recent inquiries, a reminder for clarification is appropriate. Amateur radio networks are not established for non-amateur, non-emergency, exclusive meso-networks. Those interested in establishing emergency instruments to monitor weather warning parameters should thoughtfully discuss approval and coordinate license requirements with their local amateur radio organizations.

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Introduction

NWSO Glasgow has developed a prototype automated remote weather network using packet radio and Ultimeter II weather stations. These off-the-shelf weather units were installed at selected, critical analysis sites in the NWSO Glasgow County Warning Area (CWA) and configured to communicate over amateur radio frequencies to the NWSO Glasgow base station. Packet radio systems were installed and equipped with the Automatic Packet Reporting System (APRS) for data processing and graphic display. The APRS software has enabled packet radio technology to provide stand-alone or network display of real-time map and alphanumeric weather information.

The deployment of these economical weather stations has already proven useful to operational forecasters grappling with analysis questions and evaluation of wind advisory needs in the extensive Fort Peck Recreation Area. An expansion of the network to other data sparse locations within the NWSO Glasgow CWA will complement existing and planned NWS observational systems and greatly enhance the analysis, warning, and forecast program in northeast Montana.

Background

Weather observations are the keystone of operational meteorology. The National Weather Service (NWS) Modernization and Associated Restructuring (MAR) has brought vastly improved, state-of-the-art technological tools to the operational NWS Meteorologist and Hydro-Meteorological Technician (HMT) to observe, analyze, and forecast weather phenomena and fulfill the crucial NWS mission of protecting lives and property. Despite continuing national efforts to increase the spatial resolution of the observational network, many portions of the vast NWS Western Region remain data sparse. NWS offices throughout the country have been encouraged to incorporate previously untapped observational datasets available through other government agencies, public utilities companies, and private sources.

The NWS and amateur radio operators (Hams) have a long and established severe weather spotting relationship. Historically, Hams have provided supplementary/backup communications during local and regional emergencies through the Radio Amateur Civil Emergency Service/Amateur Radio Emergency Services (RACES/ARES) infrastructure. Additionally, Ham/Skywarn Spotters have been recruited to operate a supplementary observational network during weather emergencies or extensive severe weather events.

Thus, virtually all NWS Western Region forecast offices have some ham radio capabilities within their facility. Many forecast offices have also added packet radio capability to support alphanumeric text products. Currently, most of this additional communications capability is only activated during critical events. The NWS ham radio installations in most forecast offices represent an under-utilized resource and have potential for much broader routine applications.

A example of collaboration between the NWS and Hams has been the development of the TextNet packet radar network. For over two years, the WSR-88D Radar Coded Messages (RCMs) produced at the Tulsa WSFO have been routinely transmitted using the TULWX node (Piltz, 1995).

Technical Description

The prototype NWSO Glasgow Packet Radio Weather System (Fig. 1), fielded in the spring of 1995, included a network of packet radio systems, a base station, and various field weather instruments:

- A packet radio system typically consisted of a PC (8088 as a minimum), VHF radio transceiver, terminal node controller (TNC), power supply, and an antenna. The TNC accepts information from the computer and breaks the data up into small pieces called "Packets". Along with information from the computer, each packet contains addressing, error checking, and control information that is sent over the VHF radio frequency.

- The packet radio base-station consisted of a 286 PC, dual-band transceiver, TNC, 50 watt power supply, and antenna.

- The field weather instruments selected for testing were the Ultimeter II weather station, compatible with APRS and AutoWx, and a Kantronics KTU. The Ultimeter II provided wind velocity, temperature, and precipitation sensors. The Kantronics KTU configuration supplied wind velocity and temperature information with independent telemetering capabilities and a DC power option. The Ultimeter II systems allow for automatic data updates through the APRS while the Kantronics units require the user to request data updates.

The NWSO Glasgow Packet Radio Weather System was designed to provide analysis information to the duty forecasters with an emphasis on short-term warning requirements. There are data archival capabilities with the Ultimeter II units, at the field site IBM PC units, and at the base station. A full data archival protocol has not yet been established and was not considered a priority in fielding this prototype system.

Meso-Network Application

NWSO Glasgow issues lake wind advisories for sustained winds of 25 kts or greater, persisting for greater than 3 hours, for area lakes within the Glasgow CWA including Fort Peck Lake. Fort Peck Lake is a manmade reservoir impounded behind the largest hydraulically filled, earthen dam in the world. The lake extends westward from the damsite for 135 miles and has a shoreline of approximately 1,600 miles, more than the general coastline of California. There are over 500,000 recreational visitors to the lake each year, nearly the entire population of Montana.

There were no routine observations available from the lake before the packet radio weather instruments were installed. The closest observational site was 20 miles to the northwest at Glasgow International Airport (GGW). For many years forecasters have issued lake wind advisories having no capability to reliably assess observed conditions. The packet radio weather instruments offered the promise of reducing uncertainty and achieving an improvement in the warning record and contributing to overall boating safety.

The first instruments were installed adjacent to the GGW ASOS in the spring of 1995 for comparative purposes. In the late summer of 1995, and after several months of calibration testing, these instruments were moved to a local packet radio node on Signal Hill, elevation 2900 ft, near Fort Peck Lake (Fig. 2). A second station was added along the lake at Duck Creek in the late fall of the same year. Two additional stations were added to the network in the spring of 1996. The site selection requirements were unobstructed radio communications, availability of AC power, road accessibility, and locations representative of local meteorological conditions.

The packet radio base-station was located in the NWSO operations area, adjacent to the NOAA Weather Radio (NWR) Interalia. The alphanumeric and graphic displays were set to update network information every five minutes. A short archive of information from each individual station could be also be reviewed if increased temporal detail was necessary.

The entire system was installed and maintained primarily by the NWSO GGW Packet Radio Systems Operator, Matt Moorman. Members of the local Ham Radio club and numerous NWSO GGW office personnel assisted in system procurement, configuration and weather station establishment. Site visits were performed on a rotating schedule and/or on-demand for inspection, calibration, and maintenance.

Once reliability and system confidence was established, the automated packet radio weather information from the four sites was included in the hourly NWR broadcasts for northeast Montana. In June of 1996, the Glasgow NWR transmitter site was relocated to Signal Hill. This greatly expanded NWR broadcast reception to include most of the Fort Peck Recreation Area. Based on the improved reception and recreational utility of NWR, the United States Army Corps of Engineers (USCE) installed specially designed NWR receiver units at all campgrounds, marinas, and boat ramps at Fort Peck Lake.

The near real-time display of packet radio weather information was also made available to NWSO GGW operational personnel for meso-scale surface analyses. While each packet radio field site possessed the capability to archive 30 days of data, the base-station was configured to only hold about a two hour information archive. This information was routinely incorporated into analyses which the GGW forecasters used when evaluating the need for lake wind advisories. NMC model guidance, radar and satellite imagery, and additional meteorological information was also employed by the forecasters when deciding on actual issuance of lake wind advisories.

Evaluation

There have been automated packet radio weather units located at the Fort Peck Lake Recreation Area for a test period of over one year. During this time these units maintained their reliability through an extremely cold winter season and continued to provide reliable weather data in support of an active summer boating season. Temperature extremes ranged from -40 to +104 degrees F during the 1995-1996 test year. Winds in excess of 70 kts were encountered. The mesoscale network appears to have accurately described the highly variable wind regimes around the lake and in doing so, it has enhanced forecaster understanding and contributed to improved analyses throughout the year.

The maintenance effort of the four-station network was modest. Each site required at least one visit for unscheduled maintenance to correct a unit failure. Failures were largely due to lightning strikes or power outages. An IBM PC reset would usually restart weather information transmission. There was one failure due to a loose antenna wire. The Pines remote site required antenna relocation when it was discovered that the packet transmission interfered with a collocated USCE recording system. A mesoscale network of more than four units would have likely crossed the threshold into the realm of a dedicated maintenance program beyond the capability and intent of this prototype project.

A preliminary assessment of the temperature and wind data quality firmly suggests that the meso-network weather information was descriptive, reliable, and consistent with existing meteorological conditions and the climatology of the sites. Precipitation data quality is less certain. The rain gauges used were tipping rain gauge units with a .10 inch resolution. And, while precipitation detection appeared generally reliable, a systematic

evaluation of the overall amounts, using standard field gauge units, remains to be accomplished. Once calibrated, it is hoped that the packet gauges can be used to provide verification for WSR-88D precipitation estimation algorithms.

The Ultimeter II wind velocity was obtained from an instantaneous reading and did not provide maximum gust information during the sample period. FMH-1 wind algorithms require a longer time period of measurement. The instantaneously measured wind data certainly appears to have operational utility, but lacks rigorous quality control and may have limited research applications. A sampling strategy consistent with the FMH-1 would facilitate data interpretation and comparison with NWS wind systems.

Additional Considerations

During this test period, an IBM PC was placed at the field sites. While overall PC reliability was quite acceptable, the PC was the most common point of failure. Need for a PC at the site also limited site selection by restricting site suitability to locations with A/C power. Updated TNCs and Ultimeter 2000 field units have been recently released. These field units use a firmware upgrade that eliminates the PC, resulting in improved reliability and the liberating option of D/C power. Solar power is a commodity that is consistently available to much of the West. NWSO Glasgow plans to field test a solar powered packet radio weather station as soon as we can get the time to put the units together. One of our planned network sites would require such a truly independent system.

Packet radio architecture falls into three broad configurations. The complexity and capability increases from Node to Star and to Rose packet radio networks. The Node system in northeast Montana is the most basic packet radio network. Each digipeater node must be manually addressed when communicating to more distant sites. Although packet radio traffic in northeast Montana is comparatively modest, and would have permitted a largely unobstructed communication schedule, it was decided to install a dedicated weather node to eliminate any frequency saturation. In a more saturated packet radio environment, this approach would be a definite necessity.

The NWSO GGW amateur radio license requirements were initially fulfilled with the system operators license. This restricted base station transmissions to times when the systems operator was present. The local amateur radio club license is commonly used by many NWS ham radio installations. The amateur club licensing arrangement is generally robust enough to fulfill FCC requirements for packet radio weather stations.

The APRS software continues to evolve since updated versions are frequently issued by system developer, Robert Bruninga. Another APRS Windows version is being written by a different author which features peak gusts, daily temperature extremes, and total rainfall amounts. The Ultimeter firmware updates provide for binary file storage for up to one year

on the supporting unit. However, at this time, the annual Ultimeter binary file is not compatible with an APRS base station for remote storage.

Conclusion

The lake wind advisories issued during the 1996 summer season for the Fort Peck Lake Recreation Area were highly dependent on the analyses made possible by the automated packet radio stations. These packet stations contributed significantly to improvements in local boating safety. While the other five USCE Missouri River recreation areas experienced record numbers of boating fatalities, there were none in the Fort Peck Recreation Area within the NWR reception area. This record was in no small part due to timely lake wind advisories and the automated packet radio weather station information that was broadcast over NWR.

There are undoubtedly numerous "problem sites" that pose observation and forecast challenges to all NWS forecast offices. Forecasters in virtually every NWS office can identify at least one location where the addition of real-time weather information would result in improved weather forecasts and warnings. Many such sites are in heavily used recreational areas that lack adequate telecommunications capability. The adaption of existing packet radio systems to transmit continuous weather information from crucial locations is easily and economically achieved. While packet units lack the robust engineering of the primary NWS observational systems, the low-cost, low maintenance, and data integrity offered by such systems are an attractive solution to the many remote and data-sparse areas served by the NWS Western Region.

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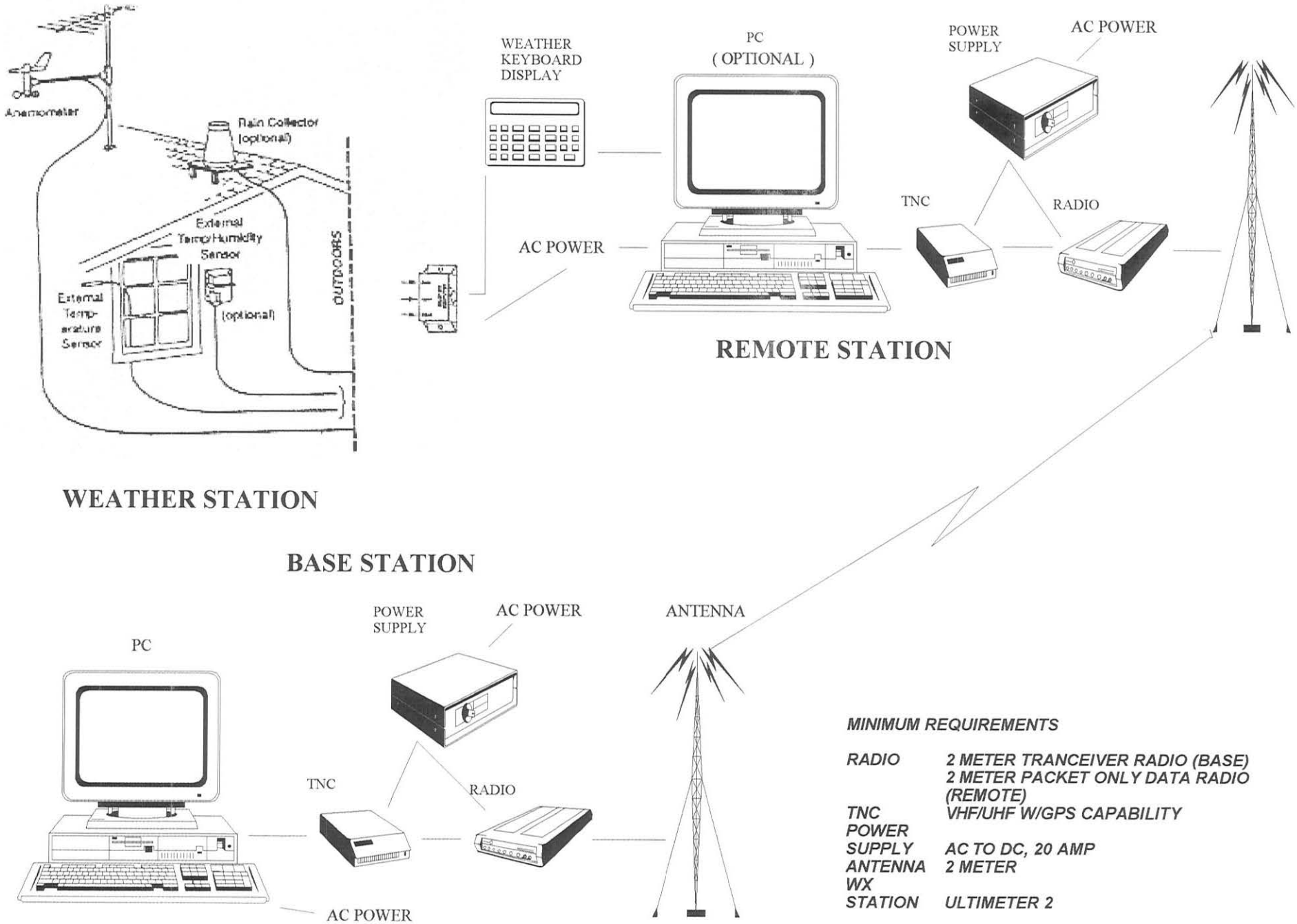
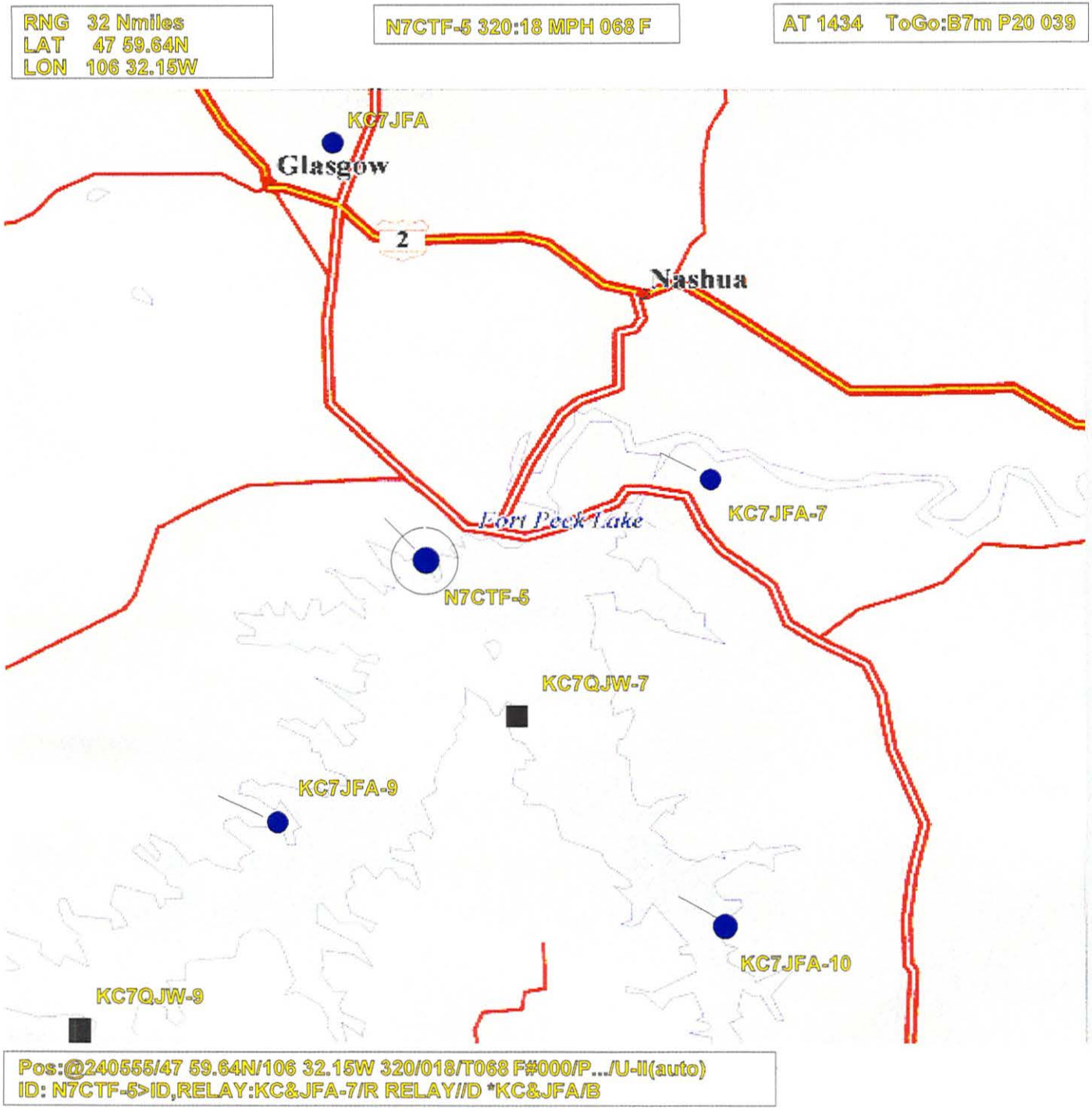


Figure 1. The typical packet radio weather station consists of various weather instruments connected to the packet radio TNC and transceiver through an IBM PC. The packet radio transceiver then communicates to the base station transceiver and TNC for display through the host computer.



APRS MAP DISPLAY OF FORT PECK RECREATION AREA

CURRENT PACKET WEATHER STATIONS

FUTURE PACKET WEATHER STATIONS

Figure 2. The Glasgow Packet Radio Weather Meso-Net covering most of the Fort Peck Recreation Area. Packet stations were established at Signal Hill (KC7JFA-7), Duck Creek (N7CTF-5), The Pines (KC7JFA-9), and Rock Creek (KC7JFA-10). Two additional sites are planned at Haxby Point (KC7QJW-7) and the Hell Creek Recreation Area (KC7QJW-9). The display as viewed at the Glasgow base station is indicating the current temperature, wind direction, and speed at Duck Creek.