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SNOWY RANGE WATER RESOURCE OBSERVATORY
(A Progress Report)

Paul A. Rechard
Editor

September 1969

Abstract

The instrumentation within the Snowy Range Water Resource Observatory is described. Some of the problems of operating and maintaining the instruments are discussed. Methods of portraying the data collected are presented and the ADP card format and computer program for processing hygrothermograph records is given.

Resumés of single discipline research within the observatory during 1966-1969 are given, together with some conclusions as to interdisciplinary considerations.

Key Words: Instrumentation/ data processing/ watersheds/ operation and maintenance/

Identifiers: Anemometers, computers, evaporation pans, gages, hygrothermographs, observation wells, precipitation gages, pyrheliographs, pyrometers, soil moisture meters, theremometers

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George T. Baxter	-	Zoology
D. L. Blackstone	-	Geology
Robert D. Burman	-	Agri. Engineering
H. B. Eldridge	-	Physics
Dennis H. Knight	-	Botany
Robert L. Lang	-	Plant Science
Chairman - Paul A. Rechard	-	Civil Engineering

Students who have installed instruments, regularly visited the sites, maintained the instruments, changed charts or read the gages, and reduced the data to coding form for card punching are:

Louis E. Allen, a graduate student in Civil Engineering, installed or coordinated the installation of all of the streamflow gaging stations and the weather stations in the Medicine Bow and Pass Creek drainages. He has maintained or supervised the maintenance of the instruments since their installation. Undergraduate students working with him have been: Keith Fackrell, Doyl Fritz, Gary Geraud, Gene Gibson, Richard Goodschmidt, James Green, Douglas Hollingshead, Mike Ikua, Robert Kruse, Myron Leppke, Carl Lindberg, William Long, Frank Nelson, Ross Singleton, Pat Stevens, and Gerald Zimmerman.

F. Robert Gartner, a graduate student in Plant Science, installed, maintained, and submitted the data for the Elk Mountain Sites Nos. 1, 2, 3, and 4 (0301, 0302, 0303, and 0304) for water year 1966 and prior. Peter W. Jacoby, Jr., a graduate student in Plant Science, has taken over from Gartner and has continued to maintain the instruments. He reduced and submitted the water year 1967 and 1968 data for these sites.

John H. Lindsay, a graduate student in Botany, installed, maintained, and submitted the data for three of the sites on the Snowy Range: Ski Course Turnoff (0102), Knight Science Camp (0103) and Libby Flats (0104) for water year 1967 and prior. He was assisted in his work by William R. Good, James T. Nelson, and Neal J. Loken, graduate students in Zoology. James E. Stone, James F. Reynolds, and William R. Good have taken over the operation and maintenance of these instruments.

Paul J. Wicker, a graduate student in Civil Engineering, installed and maintained the instruments at the Little Brooklyn site.

Ronald C. Reichenbaugh, a graduate student in Water Resources, helped install streamflow gaging stations on Turpin Creek and Mill Creek in the Medicine Bow River drainage area. He also reduced most of the streamflow and weather data within the Medicine Bow River drainage area for use in his consumptive use study.

George J. Saulnier, a graduate student in Geology, located and supervised the installation of the 29 groundwater observation wells in the Medicine Bow River drainage area. He also observed water table fluctuations in these wells while developing material for his thesis.

William N. Embree, a graduate student in Water Resources, and Lee W. Larson, a graduate student in Civil Engineering, have coordinated the reduction, compilation, punching and processing of all of the data.

Reed W. Fautin, Professor of Zoology, assisted in the location of many of the instrument sites in the Snowy Range vicinity and has made valuable contributions in solving problems and suggesting interdisciplinary considerations for use of the instrumentations.

Others who have assisted in the reduction of data were Anton C. Munari, Associate Professor of General Engineering, and Sudhir S. Kulkarni and Ramnarayan B. Lahoti, graduate students in Civil Engineering.

The initial work on developing the card format and the computer program was accomplished by Robert D. Burman, Assistant Professor of Agricultural Engineering, and F. Robert Gartner. Roger A. Cole, programmer with the University of Wyoming computing center, put the program into its final form.

SNOWY RANGE WATER RESOURCE OBSERVATORY

(A Progress Report)

Introduction

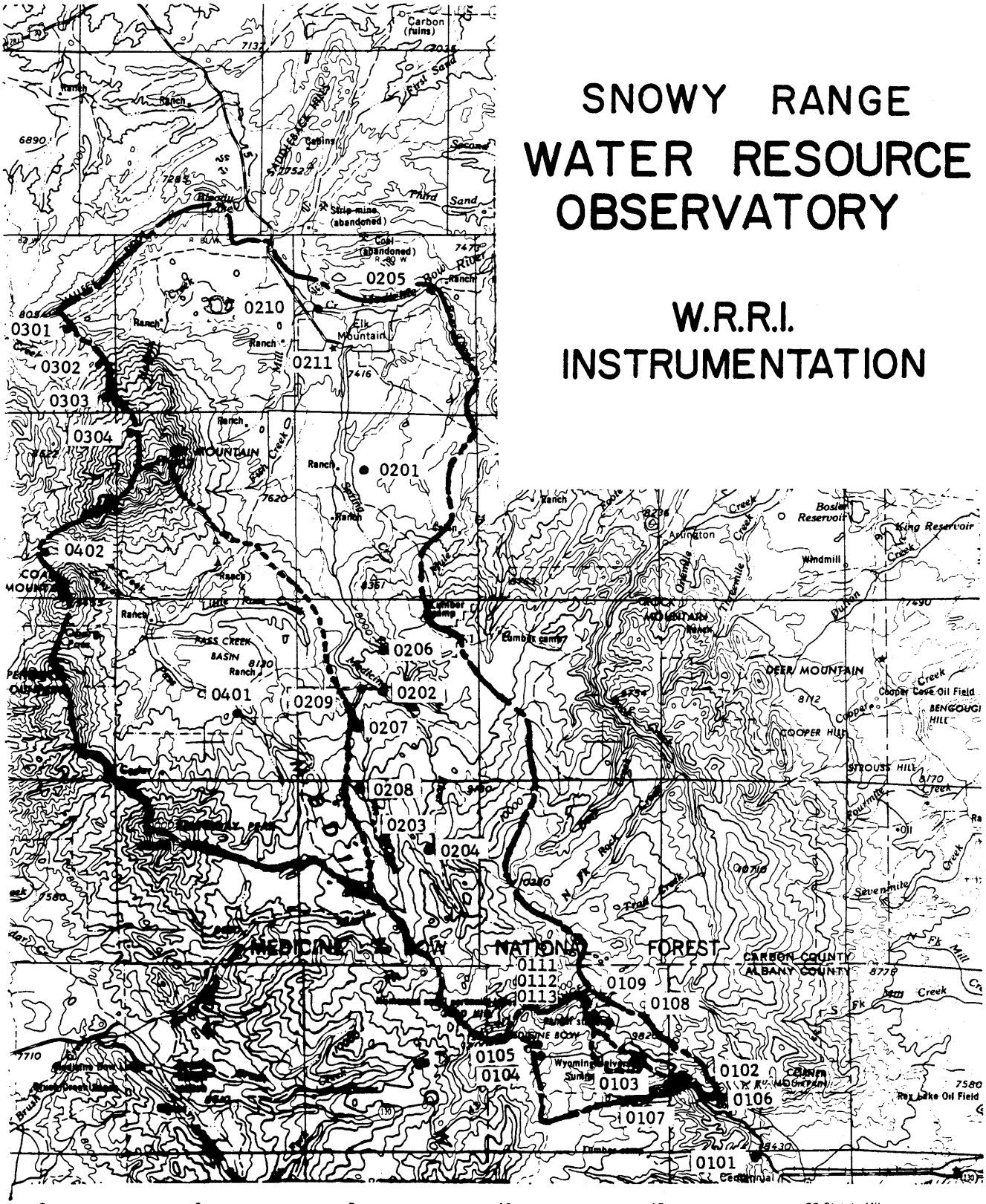
In the early summer of 1965 the Wyoming Water Resources Research Institute was faced with the sizable task of developing an outdoor water resource observatory. The area chosen for the observatory (Figure 1) includes: (1) the Snowy Range, an area previously utilized for biologic and geologic study due to its proximity to the University of Wyoming's Knight Science Summer Camp; (2) the headwaters of the Medicine Bow River; and (3) Elk Mountain, an isolated orographic feature used for weather modification research by the Natural Resources Research Institute.

A study group was formed with representatives from those disciplines on the Campus who were, or might be, interested in utilizing the results of hydrologic, meteorologic and ecologic observations concerning the biophysical relations in the hydrologic cycle. Because time was limited, it was decided to initially develop several single disciplinary studies within a close proximity of each other. This required each discipline to choose and install instruments with which they were familiar for the observance of parameters of known importance in their field.

The outline of the observatory and the instrumentation that has been installed is shown on Figure 1 and listed in Table I. As noted on the listing, there are several different types of instruments from several different manufacturers. It is not the intent of this paper to imply an endorsement of any product or to defame any product. The problems encountered are discussed in the hope that others with similar desires for watershed investigation might receive some benefit from the experience at the Snowy Range Observatory.

SNOWY RANGE WATER RESOURCE OBSERVATORY

W.R.R.I. INSTRUMENTATION



CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS
TRANSVERSE MERCATOR PROJECTION

SITE AND DESCRIPTION				INSTRUMENTATION			
CODE	NAME & LOC.	ELEV.	COVER	TYPE	MANUFACTURER	INSTALLED	REMARKS
0101 (AA)	Centennial Sec. 33 T. 16N R. 78W	8,400	Shrub	Anemometer Hygrothermograph Precipitation - Recording Gage	 Bendix-Friez Belfort 5-780	 February 1966	USFS USFS
0102 (AB)	Ski Course Turnoff Sec. 19 T. 16N R. 78W	9,400	Lodge-Pole Pine	Anemometer - Total Anemometer - Total Hygrothermograph Max-Min Thermometer Precipitation-Stge. Precipitation-Non R. 2-Pen Thermograph	Science Assoc. 403 (Mod.) Science Assoc. 403 Bendix-Friez Science Associates Linton Science Assoc. 503 Moeller	June 1967 October 1965 October 1965 October 1965 October 1966 October 1965 October 1965	 Low Level
0103 (AC)	Knight Science Camp Sec. 13 T. 16N R. 79W	10,000	Spruce Fir	Anemometer - Total Anemometer - Total Hygrothermograph Max-Min Thermometer Precipitation-Stge. Precipitation-Non R. 2-Pen Thermograph Streamflow	Science Assoc. 403 Science Assoc. 403 (Mod.) Bendix-Friez Science Associates Linton Science Assoc. 503 Moeller Stevens F-61 with 36" Parshall Flume	October 1965 July 1967 October 1965 October 1965 July 1967 October 1965 October 1965 July 1966	Low Level DA=0.8 sq.mi.
0104 (AD)	Libby Flats Sec. 20 T. 16N R. 79W	10,800	Alpine	Anemometer - Total Hygrothermograph Max-Min Thermometer Precipitation-Non R.	Belfort 5-349 Epic 252 Science Associates Science Associates	October 1965 August 1967 October 1965 October 1965	
0105 (AE)	Bellamy Lake Sec. 17 T. 16N R. 79W	10,800	Alpine Conifer	Precipitation-Stge. Snow Pillow	Linton	 October 1968	USFS
0106 (AF)	Nash Fork Below Ski Course Sec. 20 T. 16N R. 78W	9,100		Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	September 1966	DA=7.4 sq.mi.
0107 (AG)	Libby Creek Below Hair-pin Curve Sec. 19 T. 16N R. 78W	9,300		Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	July 1967	DA=8.9 sq.mi.
0108 (AH)	Little Brooklyn Sec. 11 T. 16N R. 79W	10,400	Conifer Brush	Anemometer and Direction-Recording Anemometer - Total Evaporation - Class A Pan Hygrothermograph Max-Min Thermometer Precipitation-Stge. Precipitation-Rec. Solar Radiation Solar Radiation 3-Pen Thermograph	Lambrecht 1482 (Epic) Belfort 5-349 Science Associates Bendix-Friez Science Associates Linton Belfort 5-780 Yellott Mark IV and Inverted Mark IV Belfort Pyrheliograph Kahlsico 22-WE-227	August 1967 October 1966 September 1967 October 1966 October 1966 October 1966 December 1967 October 1966 October 1967 October 1966	
0109 (AI)	Telephone Lakes Sec. 10 T. 16N R. 79W	10,700		Anemometer - Total Precipitation-Stge.	Belfort 5-349 Linton	October 1968 October 1966	
0110 (AJ)	Black Jack Lake Sec. 21 T. 16N R. 79W	10,520	Spotty Conifer	Precipitation-Rec.	Belfort 5-780 (Cannon Drive)	December 1967	Discontinued Sept. 1968
0111 (AK)	Nash Fork Above Brooklyn Lodge Sec. 14 T. 16N R. 79W	10,120		Streamflow	Stevens F-61 Recorder	August 1968	Heated Stilling Well DA=2.0 sq.mi.
0112 (AL)	Telephone Cr. Below Middle Pond Sec. 15 T. 16N R. 79W	10,325		Streamflow	Stevens F-61 Recorder 5-foot Parshall Flume	September 1968	Heated Stilling Well DA=1.8 sq.mi.
0113 (AM)	Telephone Cr. Above Towner Lake Sec. 15 T. 16N R. 79W	10,320		Streamflow	Stevens F-61 Recorder 5-foot Parshall Flume	September 1968	Heated Stilling Well DA=1.3 sq.mi.

SITE AND DESCRIPTION				INSTRUMENTATION			
CODE	NAME & LOC.	ELEV.	COVER	TYPE	MANUFACTURER	INSTALLED	REMARKS
0201 (BA)	Flats Sec. 8 T. 19N R. 80W	7,720	Grass	Hygrothermograph	Kahlsico WE-24-01	October 1965	
				Max-Min Thermometer	Science Associates	October 1965	
				Precipitation-Rec.	Belfort 5-780 (Cannon Drive)	October 1965	
0202 (BB)	Bow Guard Station Sec. 21 T. 18N R. 80W	8,320	Aspen Conifer	Anemometer			USFS
				Hygrothermograph	Kahlsico WE-24-01	October 1965	
				Max-Min Thermometer	Science Associates	October 1965	
				Precipitation-Non R.	Western Fire Equipment Co.		USFS
				Precipitation-Stge.	Linton		USFS
				Precipitation-Rec.	Belfort 5-780 (Cannon Drive)		USFS
				Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	September 1965	DA=27.5 sq.mi
0203 (BC)	Turpin Sec. 16 T. 17N R. 80W	9,205	Conifer	Anemometer - Total	Belfort 5-349	July 1966	
				Hygrothermograph	Epic 252	October 1965	
				Max-Min Thermometer	Science Associates	October 1965	
				Precipitation-Non R.	Western Fire Equipment Co.	July 1966	
				Precipitation-Rec.	Belfort 5-780 (Cannon Drive)	September 1968	
				Solar Radiation	Yellott Mark VIII	July 1966	
				3-Pen Thermograph	Kahlsico 22-WE-227	September 1966	
				Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	September 1965	DA=5.5 sq.mi.
				Anemometer and Direction-Recording	Lambrecht 1482 (Epic)	October 1965	
0204 (BD)	Logging Camp Sec. 14 T. 17N R. 80W	9,380	Conifer	Anemometer - Total	Science Associates 403	October 1965	Discontinued 1969
				Hygrothermograph	Epic 252	October 1965	
				Max-Min Thermometer	Science Associates	October 1965	
				Precipitation-Non R.	Western Fire Equipment Co.	July 1966	
				3-Pen Thermograph	Kahlsico 22-WE-227	October 1965	
0205 (BE)	Medicine Bow River at Orton Ranch Sec. 11 T. 20N R. 80W	7,060		Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	October 1965	DA=177 sq.mi.
0206 (BF)	East Fork Medicine Bow River Sec. 9 T. 18N R. 80W	8,000		Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	September 1965	DA=18 sq.mi.
0207 (BG)	Elk Ditch Sec. 29 T. 18N R. 80W	8,500		Streamflow	Stevens A-35 Recorder and Parshall Flume	June 1968	Ditch Co.
0208 (BH)	Turpin Ditch Sec. 5 T. 17N R. 80W	8,900		Streamflow	Parshall Flume		Ditch Co.
0209 (BI)	Turpin Cr. at Mouth nr. Elk Mountain Sec. 20 T. 18N R. 80W	8,250		Streamflow	Stevens Manometer-Servo Model 63; Stevens A-35 Recorder	July 1968	DA=13.6 sq.mi.
0210 (BJ)	Mill Cr. at Larsen Ranch nr. Elk Mt. Sec. 18 T. 20N R. 80W	7,215		Streamflow	Stevens A-35 Recorder	July 1968	Heated Stilling Well
0211 (BK)	Elk Mountain Town Sec. 20 T. 20N R. 80W	7,270					ESSA USWB Weather Station No. 2995

SITE AND DESCRIPTION				INSTRUMENTATION			
CODE	NAME & LOC.	ELEV.	COVER	TYPE	MANUFACTURER	INSTALLED	REMARKS
0301	Elk Mtn. #1	7,600	Sage-	Anemometer - Total	Science Associates 403 (Mod.)	October 1965	
(CA)	Sec. 23		grass	Hygrothermograph	Epic 252	October 1965	
	T. 20N			Max-Min Thermometer	Science Associates	October 1965	
	R. 82W			Precipitation-Rec.	Belfort 5-780	October 1965	
0302	Elk Mtn. #2	8,000	Mixed	Anemometer - Total	Science Associates 403 (Mod.)	October 1965	
(CB)	Sec. 25		Shrub	Hygrothermograph	Epic 252	October 1965	
	T. 20N			Max-Min Thermometer	Science Associates	October 1965	
	R. 82W			Precipitation-Rec.	Belfort 5-780	October 1965	
0303	Elk Mtn. #3	8,600	Lower	Anemometer - Total	Science Associates 403 (Mod.)	October 1965	
(CC)	Sec. 31		Conifer	Hygrothermograph	Epic 252	October 1965	
	T. 20N			Max-Min Thermometer	Science Associates	October 1965	
	R. 81W			Precipitation-Rec.	Belfort 5-780	October 1965	
0304	Elk Mtn. #4	9,900	Upper	Anemometer - Total	Science Associates 403 (Mod.)	October 1965	
(CD)	Sec. 6		Conifer	Hygrothermograph	Epic 252	October 1965	
	T. 20N			Max-Min Thermometer	Science Associates	October 1965	
	R. 81W			Precipitation-Rec.	Belfort 5-780	October 1965	

SITE AND DESCRIPTION				INSTRUMENTATION			
CODE	NAME & LOC.	ELEV.	COVER	TYPE	MANUFACTURER	INSTALLED	REMARKS
0401	Palm Ranch	7,950	Ranch	Anemometer - Total		To be Installed	
(DA)	Sec. 22		Yard	Hygrothermograph	Epic 252	September 1966	
	T. 18N			Max-Min Thermometer	Science Associates	June 1966	
	R. 81W			Precipitation-Non R.	Science Associates 503	June 1966	

Present Instrumentation

The observatory was divided into four areas: (1) the Nash Fork and Libby Creek drainages tributary to the North Fork of the Little Laramie River; (2) the Upper Medicine Bow River drainage; (3) Elk Mountain; and (4) Pass Creek drainage. In addition to the map location and the listing of the instruments, a brief discussion of the reasoning behind the site selections is presented.

Area 1 - Nash Fork and Libby Creek Drainages

Four stations were initially installed to support ecologic studies by the Botany and Zoology Departments. These stations (0101, 0102, 0103, and 0104) represent an elevational transect up the eastern slope of the Snowy Range at elevations of 8,400, 9,400, 10,000 and 10,800 feet, respectively. The lowest site is located at the U. S. Forest Service District Ranger's headquarters and the upper three sites represent the lower median and upper range of the spruce-fir zone. The upper site is near the summit of Highway 130 and represents the maximum elevation of easy access on the range. The highest point in the observatory is Medicine Bow Peak at 12,005 feet.

Air temperature and relative humidity are recorded with Bendix-Frieze hygrothermographs located within standard ventilated weather shelters three feet above the ground. Maximum-minimum thermometers are also placed in the weather shelters. Wind run is recorded with totalizing anemometers located four feet and twelve feet above the ground. Amounts of precipitation are observed with a U. S. Weather Bureau type non-recording totalizing precipitation gage with the orifice two feet above the ground. Snow

accumulation is measured with a Mt. Rose Snow sampler. Two soil moisture tubes were located at each study site, and soil moisture is read with a Troxler neutron meter. Soil profile pits were dug at each site and the soil horizons were recorded.

The engineers were interested in streamflow, snowmelt runoff, evaporation, and the possibility of establishing a base of information from which to evaluate future weather modification activities. Six streamflow gaging stations were installed, three of these (0103, 0112, 0113) are Parshall flumes with heaters in the stilling wells and weekly Leupold-Stevens F-61 recorders. Two (0106, 0107) are standard gaging sections utilizing Leupold-Stevens Servo-manometers and Leupold-Stevens A-35 water level recorders. Site 0111 has a log control section with a heated stilling well and a weekly Leupold-Stevens F-61 water level recorder.

The study group has selected the Nash Fork basin as the study area to determine a hydrologic model of a mountain watershed ecosystem. This basin had the transect of weather stations established for Botany and Zoology and the streamflow gages installed for Engineering. To compliment these sites, it was decided to concentrate an instrumentation installation, approximately at the average elevation of the basin above the streamflow gaging station below the ski course. The site selected for the instrumentation is at Little Brooklyn Lake (0108).

A Class-A evaporation pan, a Belfort totalizing anemometer at pan level and at 12 feet, a non-recording precipitation gage, evaporation pan maximum and minimum water temperature, a Bendix-Frieze hygrothermograph, a Yellott pyrometer for insolation and reflected radiation, a Belfort pyrheliograph for a chart record of insolation, a weather measure micro-

barograph, a Belfort weighing recording precipitation gage with alter shield and height adjustable stand, an Epic anemometer recording wind direction and speed, a Kahlsico three-pen thermograph to record the ambient air temperation gradient, a Moeller two-pen thermograph for soil temperature, maximum-minimum thermometers and a Linton fiberglass storage precipitation gage with alter shield with orifice at 16 feet, were installed.

A 12-foot snow pillow was installed at the Bellamy Lake site (0105), where the U. S. Forest Service had installed a Linton storage precipitation gage with alter shield. It is planned to move this gage to the Brooklyn Lake site as soon as possible.

The Libby Flats site (0104) is at elevation 10,800 but outside the Nash Fork watershed. In order to have a high elevation site in the Nash Fork watershed, an amemometer and storage precipitation gage were installed at the Telephone Lakes site (0109).

Area 2 - Medicine Bow River Drainage

One of the studies planned was to utilize the upper Medicine Bow River area for an inflow-outflow determination of consumptive use by high elevation mountain meadow irrigation. Four streamflow gages were initially installed, three to measure the inflow by surface channels and the fourth to measure the outflow from the area. Subsequent observations indicated that two additional streamflow gages should be installed. Therefore, at the present time, there are five inflow stations (0202, 0206, 0207, 0209, 0210) and one outflow gaging station (0205).

In addition to the ESSA Weather Bureau station at the town of Elk Mountain, WRRI established two climatological stations in the area of water utilization. These are the Flats (0201) and the Bow Guard Station (0202). Instrumentation at the Flats consists of maximum-minimum thermometers, a Kahlsico hygrothermograph, a Belfort pyrheliograph for insolation, a Belfort weighing recording precipitation gage with alter shield and a Class-A evaporation pan with totalizing anemometer at pan height. The weather modification program of the Natural Resources Research Institute also installed at this site an MRI recording wind direction and velocity instrument.

The U. S. Forest Service had in existence a non-recording anemometer, a Belfort recording precipitation gage with alter shield, and a Linton storage precipitation gage with alter shield located at the Bow Guard Station. This instrumentation was supplemented with a Kahlsico hygrothermograph, and maximum-minimum thermometers.

Because the inflow gaging stations to the agricultural area were at the National Forest boundary and therefore representative of the outflow from a non-cultivated area, two climatological stations were established in the watershed above them. One of these was Turpin (0203), at elevation 9,200 feet. This site was selected, primarily because it represented about the upper limit of access during the winter months. The Turpin Station is similar to the Little Brooklyn Lake site in the types of instruments installed. At this site an Epic anemometer recording direction and velocity, a Belfort totalizing anemometer, an Epic hygrothermograph, maximum-minimum thermometers, a non-recording precipitation gage, a

Belfort weighing type recording precipitation gage mounted on a height adjustable stand with an alter shield, a Yellott net pyrometer, and a Kahlsico three-pen thermograph for ambient air temperature gradient have been installed.

In the watershed of the Medicine Bow River at the Logging Camp site (0204), a Belfort totalizing anemometer, Epic hygrothermograph, maximum-minimum thermometers, non-recording precipitation gage, and a three-pen thermograph for ambient air temperature gradient were installed. Subsequent analysis indicated that this station was difficult to visit during the winter and the observations were not significantly different from Turpin, so this site has been discontinued.

Twenty-nine groundwater observation wells were drilled within the Upper Medicine Bow River area. These wells are utilized to observe the ground water table fluctuations. A geology graduate student has prepared a groundwater analysis of the area. Observations of the water levels will be continued to establish a base for evaluating long-term variations in the ground water increment in the area.

Area 3 - Elk Mountain

Four weather stations were installed on the north slope of Elk Mountain along an elevational gradient ranging from 7,600 to 9,900 feet. These stations were installed for study by Range Management personnel and are used to study the variations in plant ecology as represented by elevational differences. Each site is identically instrumented with totalizing anemometer, Epic hygrothermograph, maximum-minimum thermometers, and Belfort weighing recording precipitation gages on moveable stands with alter shields. Soil moisture tubes were installed at each of the sites.

Area 4 - Pass Creek Drainage

The fourth area was the Pass Creek area with the site located at the foot of Kennaday Peak, in the upper reaches of Pass Creek. Palm Ranch was ideally located for the site and an Epic hygrothermograph, maximum-minimum thermometers and a non-recording precipitation gage were installed. A USGS streamflow gage has been in operation on Pass Creek for several years and provides the basic information on outflow from the area.

Operation and Maintenance of Instrumentation

Many problems have been encountered in the operation and maintenance of the meteorological instruments and these varied with study area location.

Instrument Shelter and Hygrothermograph

One of the major problems encountered early in the operation of the observatory was that of wind blowing snow into the instrument shelters. This is a common occurrence when the ground is snow-covered. Periodically snow is also blown into the hygrothermographs which are in the shelters. This snow dilutes the ink in the pens as well as that on the charts, making the record difficult to read and in some instances completely clogging the mechanism resulting in no record. This problem is less serious in the forested study areas than in the open areas.

Two possible solutions for the snow problem have been attempted. These are (1) to raise the instrument shelter so that it is above the major portion of the blowing snow, or (2) to improve the design of the shelter.

Where snow accumulates to some depths, towers were designed such that the shelter was raised ten feet above the ground. An alternate would be to design[4] a movable tower on which the shelter could be raised or lowered in order to maintain instruments at any desired level above the ground or snow.

A possible modification of shelter design has been tested during the winter of 1968-69 at Libby Flats. The design is to have no floor to the shelter, using only wooden strips to support the instruments, a shield to protect the instruments from reflected radiation and radiation from the ground is suspended about 12 inches below the shelter. This "dropped floor" not only provides a shield against radiation, it lets the wind provide a venturi action to clean the shelter of snow that blows in through the louvers. Preliminary results appear to be promising.

Usually, the monthly hygrothermograph mechanical chart drives are accurate within two hours or less at the end of 30 days of operation. The weekly clock drives are within the tolerances of accuracy but, of course, have to be visited once a week. When the instruments are frequently checked in summer (even the monthly chart drives), adjustments are made when necessary so that correct time is maintained on all instruments. Generally, the clock drives for the Bendix-Frieze and the Epic hygrothermographs have proven to be the most reliable.

One of the problems associated with attempting to obtain measurements of air temperature at the various sites that reflect the differences in selected parameters. As an example, if the shelter at one site is shaded and at another it is in the open, there could be an effect on

the air temperature recorded inside the shelter. Even though the louvered shelter protects the instruments, the effect of solar radiation on the instrument shelter and subsequently on the temperature recording devices inside has been studied only to a limited extent.[1]

Precipitation Gages

The amounts of precipitation collected in gages located in areas subjected to wind is probably less than actual, even though the gages are equipped with alter windshields. It is believed that much of the winter precipitation in mountainous areas is accompanied by strong winds. While windshields unquestionably aid in reducing the distortion of wind currents around the gage, they are not perfect. The selection of the site is critical; in some instances, one can find a natural barrier of tall vegetation, i.e. shrubs or trees, near which the gage could be installed to provide a measure of wind protection. However, all of the literature indicates that there is little known regarding a firm determination of "true catch" and its relationship to what is caught.

When using standard gages along with storage precipitation gages, the variations in catch due to the orifices being at different heights above the ground can become significant. Many authors have worked on the problem; however, the relationships developed probably should be confirmed at any instrument location because the major cause of the differences is wind.

Wind, especially at exposed locations, also subjects the recording weighing-type precipitation gages to severe vibration. The effect is not on the gage itself, but on the trace on the charts. The net result is a recorded trace in the form of a ragged line which was difficult to interpret.

This problem occurs almost daily in the exposed locations and less frequently in the forested study areas.

On a few occasions, wind-blown snow collects inside the gage around and beneath the bucket. Upon melting, the water moves downward through the scale mechanism and collects in the dash pot or clock. Then, when freezing temperatures occur, ice forms in the dash pot or clock and obstructs the weighing mechanism or stops the clock. Possibly the design of the upper portion of the gage could be altered to prevent this occurrence.

Following a few heavy snowstorms, the inked record on the charts appears to indicate a loss of precipitation as though caused by extreme sublimation or wind action. It is believed that the indicated loss occurs when snow accumulates in the collection bucket too rapidly to be melted by the antifreeze solution. Some of the snow freezes to the sides of the neck, reducing the weight. Then, after the sun hits the gage, the ice melts and the apparent loss is recovered. The losses generally occur after 1200 hours. In remote areas, especially at high elevations, it might help to paint the precipitation gages black. The increased radiation absorbed by a black surface may assist in more rapid melting of accumulated snow.

Anemometers

Dial-Totalizing anemometers (Science Associates, Inc. Model No. 403) were installed in the spring of 1966. The totalizing dials registered to only 999 miles (even though the catalog indicated 9,999 miles) and total wind between visits to the study areas was almost always greater than that amount. Therefore, some method of recording total wind over long periods was essential. The anemometers were modified to record every ten miles of wind on a mechanical counter (Veeder-Root, Inc.) activated by a six-volt

DC solenoid (Allied Electronics, Inc.). The power was supplied by a 7.5-volt dry cell battery.

This arrangement was found to be unsatisfactory for two reasons. First, the battery would not operate at temperatures below freezing. Secondly, since the batteries were wired directly to the solenoid, they were drained of their power whenever the wind subsided with the anemometer contacts in a closed position. Thus, further modification was necessary.

The dry cell batteries were replaced by three, 3.0-volt manganese-alkaline batteries (in series). A capacitor was needed to activate the solenoid in order to prevent direct drain of current from the batteries when the anemometer contacts remained closed. A low voltage electrical circuit was devised and the power supply, circuit, solenoid and counter were all enclosed in a watertight metal container. A length of wire connected this unit with the anemometer contacts. These units are being replaced with Belfort totalizing anemometers as these have been found to be more reliable.

Snow and rime frequently collect in the cups of the anemometers especially at the high elevations. On one instrument, the cups were painted black so that they might absorb more solar radiation, but this did not remedy the problem. Accumulations of snow and rime in the cups has an effect on recorded wind totals (or velocities), but a solution has not been found.

Epic recording anemometers were installed at two sites within the observatory. The instruments appear to be so sensitive to changes in wind direction that many times the data are difficult to reduce in a meaningful manner. The data are recorded on pressure-sensitive paper

tape and, if the clock stops or the chart paper jams so that it does not move or, if the instrument is not serviced at the end of one month and the tape runs out, the ridges on the instrument have metal-to-metal contact and tend to wear, causing costly replacement items.

Soil Moisture Determination

Soil moisture access tubes are difficult to install in the rough, mountainous terrain. Mechanical drilling rigs many times cannot be used, so the tubes are driven into the soil or a hole is drilled by hand. Because of differences in hardness and depth of the underlying parent materials, the depths at which soil moisture can be determined differs between study areas.

Soil moisture determination with a neutron probe underneath snow cover presents problems: (1) The use of neutron equipment in winter causes compaction of the snow in the vicinity of each access tube; (2) The snow has to be shovelled away from each tube every time the measurements are to be made because the tubes usually extend only about eight inches above the ground surface. An alternate to this is to use an extension tube whose length is about equivalent to the depth of snow expected before the next visit; (3) The scaler and radioactive probe have to be transported on over-snow vehicles with increased radiation exposure to the operator, as well as greater wear and tear on the instruments.

Thermographs

The three-pen-three-probe thermographs from Kahl Scientific Instrument Company were plagued with the problem of maintaining the clocks in

an operating condition during the cold weather. The temperature probes seemed to operate satisfactorily with the pens indicating the correct temperature when the instrument was serviced. Some difficulty was experienced with the ink fading on the chart. This problem was corrected by utilizing a black ink rather than the ink furnished with the instrument.

Solar Radiation

The Yellott net pyrometers installed are sometimes affected by an accumulation of snow and ice on the glass cover. This snow and ice prevents the recording of incoming radiation even though the albedo is still being subtracted. Due to the fact that the instruments are visited once a week at most, there are times when negative net radiation results. The positioning of the instrument is also difficult due to the fact that the reflective radiation at the site of installation is not necessarily at a spot that would be indicative of the reflective conditions on the watershed.

In applying the results of the observations, it has been the experience of the Institute that incoming solar radiation would be a more valuable reading to obtain than a net reading. Also, for many uses, the daily radiation would be important rather than periodic readings covering a week or a month. When applying the solar radiation observations to snowmelt equations, it becomes very difficult to utilize the totalized readings as obtained. If net radiation is desired, the Institute's experience indicates that it is better to observe both the insolation and albedo and manually subtract the results than to mechanically observe the net.

Streamflow Measurements in Mountain Streams

It is desirable, in establishing a streamflow gaging station, to have a good measurement section as well as a good rating section. That is, there must be a "control" to obtain a relationship between gage height and discharge, while, in the same vicinity, conditions must permit making a stream discharge measurement. In steep, rocky, mountainous streams, it is difficult to find adequate rating and measuring sections near each other to obtain accurate observations of discharge. It therefore becomes necessary to utilize either an artificially constructed measuring section or to develop new techniques of stream discharge measurements.

It is not as difficult to find a natural rating section as a measuring section, so the Institute has done considerable work on the use of fluorescent dye in making the streamflow measurement. It appears that the rating developed in this manner can be quite accurate, usually within the "excellent" classification established by the USGS.

For small streams, the use of Parshall flumes or H-flumes seems to be satisfactory. The biggest difficulty with flumes being that, for small discharges, which might occur during the winter period, a small flume is desirable; whereas, when the spring snowmelt season occurs, the flume adequate for measuring small discharges becomes inundated. A V-notch weir might be used successfully to overcome this particular problem, however the well,the stilling pond, and the notch must be heated during the winter to prevent freezing. Heating this much space can be a problem in remote locations and these types of installations can become very expensive.

The Institute does have both Parshall flumes and natural control types of streamflow measuring sections in the observatory. The use of small propane heaters in the stilling wells for the Parshall flumes is necessary. The flumes themselves should be covered with slabs during the winter so that the snow does not plug the flume and also so that the insulating property of the snow can assist in maintaining an open water condition. At one site, where electric power was available, heat tape was used to keep the stilling well open. After two winters of operation, it has been found that there is not enough heat produced unless a heavy blanket of snow provides protection from the low temperatures experienced in the observatory. For the natural gaging sections, the use of servo-manometer equipment is the most satisfactory as this type of installation precludes the difficult task of digging in rock and boulders to install a stilling well and also does away with the necessity for heating the stilling wells.

Winter Evaporation Measurements

The usual procedure for estimating the rate of water surface evaporation is to install a U. S. Weather Bureau Class-A Pan, observe the evaporation from this instrument and by coefficient relate the pan loss to lake evaporation. Because the water in the pan freezes, it is not feasible to operate it during the winter period even though some evaporation or sublimation undoubtedly occurs from the ice surface of lakes and from the snow. In an effort to obtain an estimate of the amount of evaporation or sublimation that takes place during the winter, a modified weighing Belfort precipitation recorder has been used. The receiving cone of the recorder was removed and a plastic bucket utilized to prevent damage from the ice formation. As evaporation occurs, the chart records what would appear to be negative precipitation. Because the

graduations on the chart are representative of an 8-inch opening, it is necessary to correct the apparent evaporation by a factor representing the ratio of 64 to the square of the diameter of the ice to obtain meaningful readings. It is believed that the modified gage has considerable potential for estimating winter evaporation. The evaporation data obtained by such a procedure are obviously applicable only to a solid ice surface. The problem of estimating evaporation or sublimation from blowing snow is yet to be solved.

Groundwater Observation Wells

The location of an observation well is of significant importance. It is advisable to utilize the services of a geologist when locating observation wells. While possibly not all of the wells would need to be developed, it appears advisable to have at least part of them constructed and developed so that pump tests may be made and water samples collected. To facilitate measurement of water level, the casings should be cut off at a uniform height above the ground and the elevation determined by a level net so that water table-elevation above mean sea level might accurately be determined.

Winter Access to Instrument Sites

Snow accumulation in the mountains precludes visiting almost all of the instrument sites within the Water Resource Observatory by automobile or even 4-wheel drive vehicles during the winter period. Over-snow vehicles have to be utilized so the Institute purchased two alpine model Ski-Doos for winter access. These machines have, in most instances, been completely satisfactory. They are, however, not without their difficulties.

The maintenance cost for these machines is considerable. There are times during the year when snow drifts block the road well below the main snow-pack area and it is necessary to run the Ski-Doos on dry ground. The machines are not equipped to operate for any great distance without snow, so such conditions cause considerable maintenance problems. At some times during the year, the snow conditions are not the best and this causes difficulty in operating the equipment.

Portrayal of Data

The Study Group has given considerable thought to the manner in which the data obtained from the charts should be portrayed. It was decided that the data from various instruments should be considered separately. A detailed description of the automatic data processing of the hygrothermograph information is included in Appendix A.

The charts obtained from the hygrothermographs present a continuous picture of ambient air temperature and relative humidity. Because most users of these data do not require readings by minutes or even hours, it was decided to publish the temperature information at six-hour intervals, i.e. 0600, 1200, 1800 and 2400 hours, and to record the daily maximum and minimum temperatures with the times of their occurrence. The mean daily temperature is computed as the average of the maximum and minimum temperature for that day so that the recorded mean is comparable with published mean values at Weather Bureau stations.

Relative humidity values are likewise published at the same six hourly intervals but instead of the maximum-minimum values, the relative humidity at the times of maximum and minimum temperatures are presented.

It is possible by using the temperature and relative humidity values with psycrometric tables[2] to determine the dewpoint or frost point and the vapor pressure deficit. These latter forms are common in application equations.

Non-recording precipitation data are presented as daily or period quantities, depending on the frequency of visit.

Recording precipitation charts are reduced to tabular values at hourly increments.

Wind data obtained from totalizing anemometers are presented as total miles of travel and average wind speed during the periods between observations. The data from recording wind velocity and direction instruments are presented as the mean hourly velocity and direction. Where recording precipitation data are available at the same sites, the occurrances of rain during the day are indicated.

Solar radiation is published as langleys per day or for the period between visits to the site.

Stream gage height charts are translated to mean daily discharge in cubic feet per second with annual maximum and minimum instantaneous values noted. The data are included in the computerized system for Wyoming's surface water.[3]

Multiple Use of the Observatory

The Water Resources Research Institute is attempting to develop a hydrologic model of a mountain watershed ecosystem. Prior to the development of the framework of the model, the Study Group concluded that each discipline should define the uses it might make of the instrumentation

installed in the observatory and the unit within the observatory which should be studied in detail to define the model.

In approaching the task set forth above, the study group requested each of the disciplines of agricultural engineering, botany, civil engineering, geology, and zoology to design a specifically single-disciplinary research program which would utilize the observation of events which make up a portion of the hydrologic cycle. Requirements for instrumentation reflected each investigator's best thinking as to the parameters necessary for observation and the instruments best suited to their individual needs. As would be expected, the several investigators generally agreed on the parameters to be measured but differed considerably in the selection of the instrumentation and location of observation. Summaries of the research which has been accomplished within this study group are given below.

Agricultural Engineering

To refine the instrumentation for microclimatic measurements, the agricultural engineering department has engaged in evapotranspiration research using the University's experimental farm near Farson, Wyoming. Results of this research were directly applicable to the instrumentation of the Elk Mountain Water Resources Observatory. A brief description of that project follows:

In 1961, a study was undertaken by the agricultural engineering section to make field measurements of evapotranspiration rates and irrigation efficiency on the University of Wyoming Farson Pilot Farm. The

farm is a unit on the Eden Reclamation Project and water shortages shortly after settlement on the project emphasized the need for information concerning water requirements. The program was expanded to include a study of the vertical energy balance over two irrigated pastures.

Continuous measurements of evapotranspiration were made during most of the 1962 and the entire 1963 irrigation seasons by measuring changes in soil moisture content using the neutron scatter method. These were made on three different irrigation borders 50 feet wide and 800 to 1,000 feet long. The plots consisted of (1) alfalfa and Russian wildrye grass pasture, (2) alfalfa and intermediate wheatgrass pasture and (3) pure alfalfa which was cut for hay. During each irrigation, amounts of water applied to and lost as surface waste from these plots were also measured.

Results of these studies indicate the alfalfa-wildrye pasture used consistently more moisture than did the alfalfa-wheatgrass pasture.

In an attempt to further document the fact these two pasture mixtures use different amounts of moisture, it was decided to make detailed measurements of the vertical energy balance over these two borders. Measurements of incoming solar radiation, reflected solar radiation, net long and short wave radiation, soil heat flow, and wet and dry-bulb temperature gradients have been made over both borders. Measurements of the vertical wind profile have also been made to a height of 320 centimeters.

No consistent difference of appreciable magnitude in the radiation balance of the two crops was discovered. However, hourly and daily evaporation calculated from radiation and temperature gradient did

indicate more moisture requirements for the alfalfa-wildrye pasture. It was also found there is a relationship between evapotranspiration rate and minimum temperature.

A study was also conducted to determine the effect of chemical control of big sagebrush on the evapotranspiration and vertical energy balance of the range. Information was sought concerning the relation of the environmental factors to moisture depletion and retention.

A site of typical big sagebrush, Artamisia tridentata, range was selected in southcentral Wyoming. The site was fenced and divided into 15 plots. Five were treated with 2,4-D, an accepted practice of range improvement, to kill sagebrush. Five other plots were treated with Dalapon to kill the grass and leave the sagebrush. The remaining five plots were left untreated for control.

Continuous measurements were made of precipitation, temperature, humidity, and wind, while periodic measurements of vegetation and soil moisture were made. Soil moisture was sampled at 25 randomly selected times during the five-year study period. Measurements were taken at two points in each plot to a maximum depth of nine feet with a neutron scatter soil moisture probe. The greatest differences in soil moisture occurred in the 0-1, 1-2 ft. depths, as a result of 2,4-D treatment.

Vegetation was sampled at the beginning of the study and once each year for a five-year period. The big sagebrush had an initial cover density of 17.2 percent and was reduced to about 2 percent with the 2,4-D treatment. The grass in the 2,4-D treated plots increased from 6 to almost 12 percent basal cover. The Dalapon treatment resulted

in the undesirable effect of severely damaging the sagebrush as well as reducing the grass. For this reason little consideration should be given to findings in relation to the Dalapon treatment.

Evapotranspiration from the 2,4-D treated plots was reduced for the first two growing seasons following treatment. The maximum evapotranspiration from the untreated control plots was 0.10-inch per day and 0.06-inch per day for the 2,4-D treated plots during the same period. Later in the study, evapotranspiration was similar from treated and untreated plots.

The vertical energy balance component study indicated that only about one-fourth to one-fifth of the energy available for evapotranspiration and heating of the air is actually used for evapotranspiration. There tends to be more energy available for evapotranspiration and heating of the air over the 2,4-D treated plots than over the untreated.

The reflective character (albedo) of the 2,4-D treated plots, tends to be less than for the untreated. This condition is consistent with the higher energy for evapotranspiration and air heating.

The increase of grass as a result of reducing the competition for soil moisture was quite evident. It appears that the increase in grass following 2,4-D treatment will eventually adjust itself until all available moisture will be used during the year.

Botany

Personnel of the department of botany have been participating in the WRRI research program also. Their emphasis has been on water stress within the leaves of coniferous trees, the dominant component of

the observatory vegetation. Lindsay (1967) related leaf water stress to various environmental factors along a broad altitudinal gradient, and Stone (1969) studied the relationships of leaf water stress to tree growth and seasonal moisture conditions, using different topographic positions at about the same elevation for the source of variability. The results of both studies have been accepted as M.S. theses and have been the basis for two reports at the annual meeting of the American Association for the Advancement of Science, Southwestern Division. Both students are currently involved in Ph.D. research on the water relations of trees.

There are three principle ways in which these studies on leaf water stress are pertinent to the objectives of the Institute. First, numerous plant processes are partly controlled by leaf water stress; one process especially important for understanding the hydrologic cycle is transpiration. Secondly, leaf water balance is a function of several environmental factors, and therefore tends to integrate the environment in a way no instrument can; in the future we may be able to use leaf water balance for detecting conditions pertinent to the hydrologic cycle. And thirdly, the studies have provided data for several environmental factors at different locations on the observatory for a four-year period.

Civil Engineering

The engineering phase of the program has involved snow hydrology studies, consumptive use analysis, and the gathering and presentating of data.

Wicker (1966) utilized the instrumentation in the observatory to predict the timing and amount of runoff from the Nash Fork watershed.

His estimate will be refined and the critical parameters defined, such that the predictive model may be improved for the conditions prevailing in the high elevations of Wyoming.

Two other graduate students in Civil Engineering, Whittenberg (1967) and Fisher (1968) have used the predictive equation to compare estimates with measured runoff from a snow drift which accumulated behind an artificial barrier. Each of these studies indicated that the coefficients developed by the Corps of Engineers for the Central Sierra Snow Laboratory in California need to be modified before the equation can be used at the higher elevations experienced in Wyoming.

In addition to their usefulness in measuring the pattern of runoff from high mountain watersheds, the streamflow gages also provide inflow measurements for an inflow-outflow study of agricultural consumptive use.

Reichenbaugh (1969) prepared a thesis entitled "Selected Methods of Estimating Consumptive Use from Mountain Meadows in Wyoming", which provided a first look at what might be some new information on consumptive uses in high elevation irrigated mountain meadow conditions.

Based on Reichenbaugh's study, the inflow-outflow procedure indicated consumptive use is considerably higher than would be estimated by the three emperical methods (Blaney-Criddle, Lowry-Johnson and Modified Jensen-Haise) he selected for study. Because the data were available for only three irrigation seasons, it is planned to continue and expand the work as started.

Geology

Saulnier (1968) conducted an investigation of the groundwater resources and geomorphology of the Pass Creek Basin. The area is a part of the Snowy

Range Water Resources Observatory and encompasses the upper drainage basins of Pass Creek and the Medicine Bow River in southeastern Wyoming on the north flank of the Medicine Bow Mountains. Twenty-nine groundwater observation wells were drilled and cased. The average depth of the wells was 20 to 25 feet. The formations in which the wells were located are:

Quarternary Undifferentiated.....	15 wells
Mesaverde Formation.....	4 wells
Tertiary Undifferentiated.....	6 wells
Glacial Till.....	4 wells

Pass Creek Basin is an eroded, north-plunging syncline bordered by north-plunging, asymmetrical, faulted anticlines. Outcropping stratigraph units range in age from Mississippian to Late Cretaceous, and Ecocene deposits unconformably overlie all older rocks in the southern part of the area.

Complex geomorphic features control the movement of free ground water. A succession of erosion surfaces and stream terraces are developed in the basin and along the Medicine Bow River. Depositional valley-side surfaces grade off the flanks of the mountains on the west edge of the basin. Glacial moraines ranging from Bull Lake (?) to Late Pinedale (?) occur above 8700 feet in the southern part of the area.

Ground water occurs in pre-Cenozoic, Cenozoic and Quarternary units. Water in the alluvial, terrace, and valleyside deposits is of fair to poor quality and the aquifers have low porosity and permeability. The Ecocene deposits have fair to good hydrologic properties and good quality water. The major sources of recharge are precipitation, irrigation water,

and streamflow. The Medicine Bow River is influent from April through July, in equilibrium from August through fall, and effluent from late fall through March. The best source for extensive confined groundwater development is the basal Cloverly Formation.

Physics

The Physics Department is attempting to design and develop a low level tritium counter for use in dating water samples. A commercial counting system costs about $18,000 and, in the absence of such funds, Mr. Anup Bhowmik, a graduate student in Physics, has been attempting to design a revolutionary new type of tritium counter. This counter would greatly ease the measurement of the tritium content of water and would enable a start to be made on water dating. The major problem encountered in the measurement of tritium is the very low concentration - the usual method used to count the tritium involves first a substantial "concentration" phase. The tritium in the water vapor is then counted by conventional counters. The work of Bhowmik was directed along the lines of taking a water vapor counter in which the vapor itself would be used as a scintillator - in lay terms, the tritium would then detect and count itself. Such a counter had been suggested by Japanese works but, while Bhowmik has demonstrated that, with development, such a counter is feasible, no working counter has been successfully produced.

Range Management

At each of four sites on an elevational gradient on the northwest exposure of Elk Mountain, special treatments were applied to determine soil moisture use and recharge under varying conditions. These sites

were located from bottom to top in vegetational types designated: (1) Sagebrush-Grassland (elevation 7,580 feet); (2) Mixed Shrub (elevation 8,060 feet); (3) Lower Conifer (elevation 8,700 feet); and (4) Upper Conifer (elevation 9,900). At each site a weather station was located to gather microclimatic data on precipitation, temperature, relative humidity, and wind.

Three plots were located at each of the above sites, each containing three soil moisture neutron probe access tubes. Two of the plots were fenced, one of which was completely denuded of vegetation by chemical means and the other undisturbed, while the third plot was left accessible to grazing by livestock and wild game.

Zoology

A study of the possible relationship of snow cover and summer soil moisture to soil displacement by the pocket gopher was conducted from June 1967 to June 1968.

Four different study areas were selected, within which 21 circular 0.1-acre plots were established on representative types of different slopes, exposures and soil conditions. The study areas were designated as Park A, Park B, Park C, and Libby Flats.

Snow cover depths were measured on 17 of these plots on March 11, 1966, at which time the depths at the centers of the plots varied from no snow on three of the plots on wind-swept Libby Flats to a maximum of 82 inches in Plot 1 of Park C. Regression of the snow cover was studied on several of the plots and in one case (Plot 9 of Park B), the snow did not completely melt until July 10, although in most cases the snow had completely melted by June 30.

Soil moisture measurements were made with a Troxler neutron probe and scaler during the period from June 28 to October 8, 1967, within seven of the plots located in three different study areas. No soil moisture measurements were made in study area Park B because the equipment necessary for installing the soil moisture tubes and for making soil moisture measurements could not be transported to the area. Two to three soil moisture tubes were installed in each of seven different plots. Soil moisture measurements were made at depths of 6, 12, and 18 inches in all seven plots and at depths of 24, 30, and 36 inches in certain plots where the soil moisture tubes could be installed at such depths. A total of 500 soil moisture measurements were made at approximately two-week intervals from June 28 to October 8, 1967.

There was a general seasonal decrease in soil moisture at levels about 24 inches until late August, at which time an increase occurred in response to increased seasonal precipitation rates. Ranges of soil moisture values at the 12-inch level were from 7.5 to 56 volume percent.

The amounts of soil displaced by pocket gophers during the winter and summer months were measured on 13 plots in the four different study areas. Winter displacement varied from 104 pounds (dry weight) to 8,408 pounds per acre. Soil displacement during the summer months varied from 106 to 19,490 pounds per acre with an average of 6,192.9 pounds or 3.96 tons per acre for those plots where burrowing activities occurred.

No soil displacement occurred on four of the plots. Although the greatest amount of winter soil displacement occurred on the plots where the greatest amounts of snow had accumulated, there was no evident corre-

lation between the amounts of soil displaced during the summer and the soil moisture conditions. There was no evident increase or decrease in soil moisture as a result of the burrowing activities of the gophers.

The Zoology Department is now studying stream drift of invertebrates and fish in the Nash Fork Creek. The relationships of drift with streamflow and climatological parameters is being investigated.

Interdisciplinary Considerations

From the studies undertaken within the WyoWRRI to date, the following items appear:

It is important to all disciplines to have climatic data recorded on a continuous basis. Periodic or short term data might be valuable for a particular study, but for generalized use, the data must be available without breaks. Also, the levels at which the sensing elements are placed should be standarized for all locations.

For specialized ecologic studies, it is desirable to observe the parameters within the community being studied. For example, this might entail temperatures at one-foot above the ground, at ground level and at desired depths within the ground. Some of these detailed measurements must be made by the discipline and not included in a network.

The ecologist or microclimatologist must make an early decision with regard to "clustering" a set of instruments or spreading them apart. If instruments are to be installed in two different kinds of vegetation, for example, all of them may be located on one rather small site. Otherwise, they could be located several hundred feet apart with precipitation gages near a natural barrier, and other instruments in exposed positions, if desired.

Snow is not only an important form of moisture which is vital to all living organisms, but the patterns of its distribution, due to drifting, is also an important feature of the winter environment of both plants and animals. The winter environments of areas blown free of snow are drastically different from those where heavy accumulations of snow occur. In order to properly interpret and evaluate the spatial distribution patterns and quantitative aspects of plant and animal populations, it is important to the ecologist and engineer to have as much data as possible on the distributional patterns of the snow.

The Study Group is also searching for improved methods of recording, storing, and utilizing the mass of data being gathered. This is truly interdisciplinary in nature, because the types of data desired by one discipline may vary slightly from those desired by another. Therefore, while the gathering of mutually advantageous data is a goal, it is equally important to store data in some form and in some place so they are usable and readily available for all disciplines. It is desirable to keep in mind the utility for all those outside the University as well as disciplines represented on the Study Group.

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APPENDIX A

APPENDIX A

ADP CARD FORMATS FOR CLIMATOLOGICAL DATA

TITLE CARD

Columns	Contents
1-4	Code Number. The code number can be any combination of letters and/or numbers. The code number is used to identify the data cards for a particular station and month.
5-6	Month (01 = January, 11 = November, etc.)
7-8	Calendar Year (65 = 1965, etc.)
9-80	Heading (name of station and brief description) centered in field. The heading can contain up to 72 alphanumeric characters. Spaces are printed as spaces. A slash (/) in Column 9 results in the printing of the last preceding heading.

DATA CARDS

Columns	Contents
1-4	Code Number. (Corresponds to code number on title card.)
5-6	Day (01 = first day of month, etc.)
7-43	Data for the day in Columns 5-6. (A breakdown of this format is set forth on page 13.)
44-80	Data for the following day (as defined on page 13). (When day in Columns 5-6 = 31, Columns 44-80 are blank.)

The number of the day of the month for the data on the first half of the card is used to provide sequencing of the cards and to fix the date for the two sets of data on the card.

DATA CARDS (Continued)

Columns	Contents
7-9, 44-46	Temperature at 0600 hours.
10-12, 47-49	Temperature at 1200 hours.
13-15, 50-52	Temperature at 1800 hours.
16-18, 53-55	Temperature at 2400 hours.
19-21, 56-58	Maximum Temperature.
22-23, 59-60	Time of Maximum Temperature to Nearest Hour.
24-26, 61-63	Minimum Temperature.
27-28, 64-65	Time of Minimum Temperature to Nearest Hour.
29-30, 66-67	0600 Relative Humidity.
31-32, 68-69	1200 Relative Humidity.
33-34, 70-71	1800 Relative Humidity.
35-36, 72-73	2400 Relative Humidity.
37-38, 74-75	Relative Humidity at Time of Maximum Temperature.
39-40, 76-77	Relative Humidity at Time of Minimum Temperature.
41-43, 78-80	Precipitation in Inches and Hundredths.

Temperatures are in degrees Fahrenheit to the nearest whole degree. Use Minus Sign (-) for temperatures below zero.

Times are based on a 24-hour clock. Times a few minutes after midnight must be recorded as 01.

Relative humidities are in percent to the whole percent. Use 99 to represent 100%.

Precipitation is in hundredths of an inch.

No decimal points should appear in the data.

Missing and cumulated data:

-99 indicates a missing temperature or precipitation value.

00 indicates a missing value for humidity or time.

-01 for precipitation indicates that that value is included in the next meaningful one.

DATA DECK MAKE-UP

Each month's data should be preceded by a title card and followed by a blank card. After the initial month's data for a particular heading subsequent months need not have anything but the code, month, year, and a slash in Column 9.

Following the blank card of the last month to be processed, place a card with end△data in Columns 1-8. (△ = space.)

TOTAL DECK MAKE-UP

Job Card	
Load Card	LOAD - in Columns 17-20
Binary Deck	
Go Card	GO - in Columns 17-20
Data Deck	
End Data Card	END△DATA - in Columns 1-8

Running time is less than 3 minutes for 12 months on Philco 211.

PROGRAM OUTPUT

PRIMARY OUTPUT

The output consists of a plot of the daily mean and extreme temperatures and a printed table.

Table

The mean daily temperatures are the means of the minimum and maximum temperatures, rounded to integers.

The monthly mean is found by summing the unrounded daily means and dividing them by the number of them.

The six most frequent times in each time column are listed with the number of times they occurred.

Notes are printed when necessary to explain missing or cumulated values.

Plot

The maximum, mean, and minimum temperatures are plotted with an accuracy of about 3 degrees.

The mean is always plotted as an 0. The extremes are plotted as dots, except on days divisible by 5 when they are plotted as X's.

When any of the temperature values are within 3 degrees of each other, they will be plotted as the same point, in which case that point is identified as the mean. Missing data are not plotted.

Punch (Optional)

This program is easily modified to punch any of the printed information onto cards, with the exception of the frequency of the times.

To do this, the dummy subroutine CUM is replaced by one which does the desired punching.

SECONDARY OUTPUT

A subroutine called CUM has been written to further process the data in the table and present the results in a second table.

Table

An analysis table presents the following data for each day:

Maximum, Mean, and Minimum Temperatures.

Mean Relative Humidity as an average of the humidities at 0600, 1200, 1800, and 2400 hours.

Dewpoint - at 0600, 1200, 1800, 2400 hours, at times of maximum and minimum temperatures, and mean dewpoint computed as an average of the dewpoints at 0600, 1200, 1800, and 2400 hours. Dewpoints are based on the saturation vapor pressure table in WyoWRRI Water Resources Series No. 6.

Vapor Pressure Deficit - at times noted for dewpoint, and mean vapor pressure deficit computed as an average of the deficit at 0600, 1200, 1800, and 2400 hours. Deficits are based on the saturation vapor pressure table in WyoWRRI Water Resources Series No. 6.

These data are summarized on a weekly basis. For standardization purpose, the weeks used are based on Week Number 1 beginning on March 1. The weekly summary is continuous between months for a particular site.

Definitions are:

```
Subroutine CUM (A, B, C, D, E).
Dimension A (40, 15), B (40).
Integer A, C, D, E.
```

The columns of "A" correspond with the columns of the table, beginning with 0600 temperature. The values of time in "A" are the values in the table plus 10,000. The column of "B" contains precipitation.

Rows 1-31 of "A" and "B" correspond to the days of the month. 32-36 are, respectively, minimum, maximum, mean, total, N. Only the last two are significant for "B".

"C" is the month.
"D" is the year.
"E" is the code.

One call is made to CUM after the processing and output for a month is completed.

To use subroutine CUM, it should be preceded by a FORTRAN order and placed before the "load" card of the binary deck. The four cards identified as CUM must also be removed from the binary deck. (These four cards must be present if a fortran version of CUM is not present).

```
      I       CLIMAT. DATA
C     NRRI CLIMATOLOGICAL DATA PROGRAM.                                  CLIM0010
C     R.A. COLE     JUNE, 1967                                           CLIM0020
C     TABLE KEY                                                          CLIM0030
C     ROWS   1-31, DAYS OF MONTH,  32 MINIMUM VALUE OF COLUMN,  33 MAXIMCLIM0040
C     UM VALUE OF OLUMN,  34 MEAN VALUE OF COLUMN,  35  TOTAL OF COLUMN CLIM0050
C     36 COUNT OF COLUMN                                                 CLIM0060
C     COLUMNS   IN ORDER   4 TEMPERATURE READINGS  MAX TEMP AND TIME     CLIM0070
C     MIN TEMP AND TIME  MEAN TEMP  4 HUMID READINGS  RH AT MAX TEMP     CLIM0080
C     RH AT MIN TEMP  PRECIPITATION IN TABLE2                            CLIM0090
C     THERE SHOULD BE A TITLE CARD FOR EACH MONTHS DATA                  CLIM0100
C     1-4  CODE NUMBER,5-6  MONTH,  7-8 YEAR,  9-80 TABLE HEADING       CLIM0110
C     A SLASH IN COLUMN 9 CAUSES THE PRECEDING TABLE TITLE TO BE USED    CLIM0120
C     DATA CARD KEY                                                      CLIM0130
C     1-4 CODE NUMBER,5-6 DAY,7-9 0600 TEMP, 10-12 1200 TEMP,            CLIM0140
C     13-15 1800 TEMP, 16-18 2400 TEMP, 19-21 MAX TEMP, 22-23 TIME AT    CLIM0150
C     MAX TEMP, 24-26 MIN TEMP, 27-28 TIME AT MIN TEMP, 29-30 0600 REL   CLIM0160
C     HUMID, 31-32 1200 RH, 33-34 1800 RH, 35-36 2400 RH, 37-38 RH AT    CLIM0170
C     MAX TEMP, 39-40 RH AT MIN TEMP, 41-43 PRECIPITATION, 1/100 IN.     CLIM0180
C     COLUMNS 44-80 CONTAIN THE SAME FORMAT AS COLUMNS 7-43              CLIM0190
C     MISSING DATA INDICATORS ARE -99 FOR TEMP,PRECIP, 00 FOR RH,TIME    CLIM0200
C     -01 INDICATES THAT PRECIP. READING IS INCLUDED IN LATER VALUE      CLIM0210
C     LAST CARD EACH MONTH SHOULD BE BLANK                               CLIM0220
C     LAST CARD OF ENTIRE DATA DECK SHOULD CONTAIN THE WORDS             CLIM0230
C     END DATA IN COLUMNS 1-8                                            CLIM0240
C     ERROR INDICATORS                                                   CLIM0250
C     INDICATION IS GIVEN FOR   WRONG CODE NUMBERS IN A MONTH DECK  TOO  CLIM0260
C     LARGE OF A DATE  AN INSUFFICIENT NUMBER OF CARDS FOR A MINTH       CLIM0270
C     TOO MANY CARDS FOR A MONTH                                         CLIM0280
C     THE ABOVE ERRORS CAUSE PROCESSING TO BE DELETED, AND A SEARCH FOR  CLIM0290
C     THE NEXT MONTHS DATA IS MADE                                       CLIM0300
C     INDICATION OF OUT OF SEQUENCE CARDS IS GIVEN, BUT PROCESSING IS    CLIM0310
C     NOT DELETED                                                        CLIM0320
C     THE CODE NUMBER 0000 IS UNACCEPTABLE, BUT ALPHAMERIC ONES ARE      CLIM0330
C     ACCEPTABLE, SO LONG AS THEY ARE NOT ALL BLANKS                     CLIM0340
C     A CALL TO A DUMMY SUBROUTINE--CUM--HAS BEEN INCLUDED IN THE        CLIM0350
C     OBJECT DECK.  THIS DUMMY MAY BE REPLACED TO FACILITATE ACCUMU-     CLIM0360
C     LATION OF SUMMARY DATA BY PUNCHING CERTAIN RESULTS                 CLIM0370
      DIMENSION LIST1%31¤,LIST2%31¤                                      CLIM0371
      REAL TABLE2%40¤,TITLE1%72¤,TITLE2%72¤,FORM1%18¤,FORM %2,18¤,PPTIN%CLIM0380
     12¤,SLASH,TRMEAN,RMEAN                                              CLIM0390
      INTEGER TABLE1%40,15¤,CARDID%2¤,X%2,14¤,MODMIN%6,2¤,MODMAX%6,2¤,   CLIM0400
     1NAME%2,12¤,CODE, MONTH,YEAR,MO,PROCES,ERR1,ERR2,BLANK             CLIM0410
      LOGICAL NOTE,NOTE2                                                 CLIM0420
      COMMON TITLE2,MO,YEAR,TABLE1                                       CLIM0430
      COMMON/A/TITLE1
      DATA AS1,IAS1,AS2/2*4H  * ,4H ** /                                 CLIM0440
C     SET UP FORMAT ARRAY FOR PRINT TABLE WITH POSSIBLE ALPHAMERIC INFO  CLIM0441
      DATA %FORM1%J¤,J#1,18¤/                                            CLIM0450
     1            6H6X,I2,,15*3HI4,,5HF5.2,,1H¤/,%FORM%1,J¤,J#1,18¤/5H%1CLIM0460
     1H ,,3H3X,,4*3H2X,,3H3X,,3H2X,,3H4X,,3H2X,,3H6X,,4*3H2X,,3H3X,,    CLIM0470
     23H5X,,1H /,AISPEC/3HI4,/,FSPEC/5HF5.2,/,ASPEC/3HA4,/,FASPEC/3HA5,/CLIM0480
      DATA BLANK/4H    /                                                 CLIM0490
      DATA SLASH/1H//                                                    CLIM0500
      DATA %NAME%1,J¤,J#1,12¤          /12H  JANUARY, 1,12H FEBRUARY, 1,1CLIM0510
     12H    MARCH, 1,12H    APRIL, 1,12H      MAY, 1,12H     JUNE, 1,12HCLIM0520
     2     JULY, 1,12H   AUGUST, 1,12HSEPTEMBER, 1,12H  OCTOBER, 1,12H NCLIM0530
     3OVEMBER, 1,12H DECEMBER, 1/                                        CLIM0540
        DO 101 I#1,19                                                    CLIM0550
```

```
  101  FORM%2,I¤#FORM1%I¤                                                    CLIM0560
C       INITIALIZE PROCESSING FOR MONTH                                     CLIM0561
11111 READ 1001,CODE,MONTH,YEAR,TITLE1                                      CLIM0570
 1001 FORMAT%A4,2I2,72A1¤                                                   CLIM0580
      IF%CODE.EQ.BLANK¤ GO TO 11111                                         CLIM0590
      IF%TITLE1%1¤.EQ.SLASH¤ GO TO 1                                        CLIM0600
      DO 2 I#1,72                                                           CLIM0610
    2  TITLE2%I¤#TITLE1%I¤                                                  CLIM0620
    1 GO TO %3,5,3,4,3,4,3,3,4,3,4,3¤,MONTH                                 CLIM0630
    3 MC#31                                                                 CLIM0640
      GO TO 6                                                               CLIM0650
    4 MC#30                                                                 CLIM0660
      GO TO 6                                                               CLIM0670
    5 IF%MOD %YEAR,4¤.NE.0¤ GO TO 7                                         CLIM0680
      MC#29                                                                 CLIM0690
      GO TO 6                                                               CLIM0700
    7 MC#28                                                                 CLIM0710
    6 ERR1#1                                                                CLIM0720
      ERR2#0                                                                CLIM0730
      PROCES#0                                                              CLIM0740
      ICOUNT#0                                                              CLIM0741
      NOTE#.FALSE.                                                          CLIM0750
      NOTE2#.FALSE.                                                         CLIM0760
      TABLE2%35¤#0                                                          CLIM0770
      TABLE2%36¤#0                                                          CLIM0771
      DO 601 I#1,15                                                         CLIM0780
      TABLE1%32,I¤#10000                                                    CLIM0790
      TABLE1%33,I¤#-10000                                                   CLIM0800
      DO 601 J#34,36                                                        CLIM0810
  601 TABLE1%J,I¤#0                                                         CLIM0820
      YEAR#YEAR&900                                                         CLIM0830
C     READ AND TEST DATA FOR MONTH                                          CLIM0831
      IND1#2**%%MO&1¤/2¤&1                                                  CLIM0840
      DO 8 I8#1,IND1,2                                                      CLIM0850
      READ 1002,CARDID,%%%X%I,J¤,J#1,14¤,PPTIN%I¤¤,I#1,2¤                   CLIM0860
 1002 FORMAT%A4,I2,2%4I3,2%I3,I2¤,6I2,F3.2¤¤                               CLIM0870
      IF%CARDID%2¤.NE.0.AND.IABS%CARDID%2¤-I8¤.GE.2¤ ERR1#2                 CLIM0880
      IF%CARDID%1¤.NE.CODE¤ GO TO 3001                                      CLIM0890
      IF%CARDID%2¤.LE.MO¤ GO TO 901                                         CLIM0900
      ERR2#3                                                                CLIM0910
      GO TO 3003                                                            CLIM0920
C     STORE CARD DATA IN TABLES                                             CLIM0921
  901 DO 9 I9#1,2                                                           CLIM0930
      IND2#CARDID%2¤&I9-1                                                   CLIM0940
      IF%IND2.GT.31¤ GO TO 902                                              CLIM0941
      ICOUNT#ICOUNT&1                                                       CLIM0942
      DO 10 I10#1,5                                                         CLIM0950
   10 TABLE1%IND2,I10¤#X%I9,I10¤                                            CLIM0960
      TABLE1%IND2,6¤#X%I9,6¤*100&10000                                      CLIM0970
      TABLE1%IND2,7¤#X%I9,7¤                                                CLIM0980
      TABLE1%IND2,8¤#X%I9,8¤*100&10000                                      CLIM0990
      DO 11 I11#10,15                                                       CLIM1000
   11 TABLE1%IND2,I11¤#X%I9,I11-1¤                                          CLIM1010
    9 TABLE2%IND2¤#PPTIN%I9¤                                                CLIM1020
  902 ID1#CARDID%1¤                                                         CLIM1021
      ID2#CARDID%2¤                                                         CLIM1022
    8 CONTINUE                                                              CLIM1030
      ERR2#1                                                                CLIM1040
      GO TO 3003                                                            CLIM1050
```

```
 3001 IF%CARDID%1¤.EQ.BLANK¤ GO TO %50,3002¤,ERR1                          CLIM1060
C     IF HERE, ERROR%S¤ EXIST@ PRINT OUT AND CONTINUE                     CLIM1061
      ERR2#2                                                              CLIM1070
 3003  PRINT 3100,ID1 ,     %NAME%J,MONTH¤,J#1,2¤,YEAR                     CLIM1080
      IF %ERR2.EQ.1¤ PRINT 3102                                           CLIM1090
      IF%ERR2.EQ.2¤ PRINT 3107                                            CLIM1100
      IF%ERR2.EQ.3¤ PRINT 3103 ,CARDID%2¤                                 CLIM1110
      PRINT 3105                                                          CLIM1120
      PROCES#1                                                            CLIM1130
      GO TO %3500,3002¤,ERR1                                              CLIM1140
 3002 PRINT 3101,ID1       ,%NAME%J,MONTH¤,J#1, 2¤,YEAR                   CLIM1150
      PRINT 3104                                                          CLIM1160
      IF%PROCES.EQ.1¤ GO TO 3500                                          CLIM1170
      PRINT 3106                                                          CLIM1180
      GO TO 50                                                            CLIM1190
 3500 IF%CARDID%1¤.EQ.BLANK¤ GO TO 11111                                  CLIM1200
      READ 1002,CARDID%1¤                                                 CLIM1210
      GO TO 3500                                                          CLIM1220
 3100 FORMAT%1H1,48X,23H*****ERROR MESSAGE*****/1H0,23HDECK ID     CODE CLIM1230
     INUMBER,4X,A4,5X,2A6,I3/////¤                                        CLIM1240
 3101 FORMAT%1H1,48X,24H*****POSSIBLE ERROR*****/1H0,23HDECK ID     CODECLIM1250
     1 NUMBER,4X,A4,5X,2A6,I3/////¤                                       CLIM1260
 3102 FORMAT%1H ,22HTOO MANY CARDS IN DECK¤                               CLIM1270
 3103 FORMAT%1H ,26HDATE PUNCHED IS TOO LARGE ,I2¤                        CLIM1280
 3104 FORMAT%1H ,33HONE OR MORE CARDS OUT OF SEQUENCE¤                    CLIM1290
 3105 FORMAT%1H0,47X,28H*****PROCESSING DELETED*****¤                     CLIM1300
 3106 FORMAT%1H0,45X,32H*****PROCESSING NOT DELETED*****¤                 CLIM1310
 3107 FORMAT%1H ,19HFOREIGN CODE NUMBER¤                                  CLIM1320
 3108 FORMAT%1H ,33HINSUFFICIENT CARDS FOR THIS MONTH¤                    CLIM1330
   50  IF%ID2.GE.%MO-1¤.AND.ICOUNT.GE.MO¤ GO TO 501                       CLIM1340
      PRINT 3100,ID1,%NAME%J,MONTH¤,J#1,2¤,YEAR                           CLIM1350
      PRINT 3108                                                          CLIM1360
      PRINT 3105                                                          CLIM1370
      GO TO 3500                                                          CLIM1380
C     BEGIN PROCESSING                                                    CLIM1381
  501 TRMEAN#0                                                            CLIM1390
C     FIND MEAN, PROCESS MIN AND MAX COLUMNS, CHECK FOR MSSING DATA       CLIM1391
      DO 51 I51#1,MO                                                      CLIM1400
      IF%TABLE1%I51,5¤.EQ.-99.OR.TABLE1%I51,7¤.EQ.-99¤ GO TO 52           CLIM1410
      RMEAN#FLOAT%TABLE1%I51,5¤&TABLE1%I51,7¤¤/2.                         CLIM1420
      TABLE1%I51,9¤#RMEAN&.5                                              CLIM1430
      TRMEAN#TRMEAN&RMEAN                                                 CLIM1440
      TABLE1%36,9¤#TABLE1%36,9¤&1                                         CLIM1450
      TABLE1%32,9¤#MIN0%TABLE1%32,9¤,TABLE1%I51,9¤¤                       CLIM1460
      TABLE1%33,9¤#MAX0%TABLE1%33,9¤,TABLE1%I51,9¤¤                       CLIM1470
      GO TO 51                                                            CLIM1480
   52 TABLE1%I51,9¤#-99                                                   CLIM1490
      NOTE#.TRUE.                                                         CLIM1500
   51 CONTINUE                                                            CLIM1510
      TABLE1%34,9¤#TRMEAN/FLOAT%TABLE1%36,9¤¤&.5                          CLIM1520
      TABLE1%35,9¤#TRMEAN&.5                                              CLIM1530
C     PROCESS REMAINDER OF TABLE1                                         CLIM1531
      DO 53 I53#1,15                                                      CLIM1540
      IF%I53.EQ.9.OR.I53.EQ.6.OR.I53.EQ.8¤ GO TO 53                       CLIM1550
      DO 54 J53#1,MO                                                      CLIM1560
       IF%I53.LE.7.AND.TABLE1%J53,I53¤.EQ.-99¤ GO TO 55                   CLIM1570
      IF%I53.GE.10.AND.TABLE1%J53,I53¤.EQ.00¤ GO TO 56                    CLIM1580
      TABLE1%32,I53¤#MIN0%TABLE1%32,I53¤,TABLE1%J53,I53¤¤                 CLIM1590
      TABLE1%33,I53¤#MAX0%TABLE1%33,I53¤,TABLE1%J53,I53¤¤                 CLIM1600
```

```
      TABLE1%35,I53¤#TABLE1%35,I53¤&TABLE1%J53,I53¤                    CLIM1610
      TABLE1%36,I53¤#TABLE1%36,I53¤&1                                  CLIM1620
      GO TO 54                                                         CLIM1630
   56 TABLE1%J53,I53¤#-99                                              CLIM1640
   55 NOTE#.TRUE.                                                      CLIM1650
   54 CONTINUE                                                         CLIM1660
  533 TABLE1%34,I53¤#FLOAT%TABLE1%35,I53¤¤/FLOAT%TABLE1%36,I53¤¤&.5    CLIM1670
   53 CONTINUE                                                         CLIM1671
C     PROCESS TABLE2                                                   CLIM1672
      DO 57 I57#1,MO                                                   CLIM1680
      IF%TABLE2%I57¤.EQ.-.99¤ GO TO 571                                CLIM1690
      IF%TABLE2%I57¤.EQ.-.01¤ GO TO 572                                CLIM1700
       TABLE2%35¤#TABLE2%35¤&TABLE2%I57¤                               CLIM1710
      IF%TABLE2%I57¤.EQ.0.0¤  GO TO 57                                 CLIM1711
      TABLE2%36¤#TABLE2%36¤&1.                                         CLIM1712
       GO TO 57                                                        CLIM1720
  572 TABLE2%I57¤#-1                                                   CLIM1730
      NOTE2#.TRUE.                                                     CLIM1740
      GO TO 57                                                         CLIM1750
  571  TABLE2%I57¤#-99                                                 CLIM1760
       NOTE#.TRUE.                                                     CLIM1770
   57  CONTINUE                                                        CLIM1780
      DO 58 I58#1,MO                                                   CLIM1790
      IF%TABLE1%I58,6¤.EQ.10000¤ TABLE1%I58,6¤#-99                     CLIM1800
   58 IF%TABLE1%I58,8¤.EQ.10000¤ TABLE1%I58,8¤#-99                     CLIM1810
      CALL CUM%TABLE1,TABLE2,MONTH,YEAR,CODE¤                          CLIM1811
      DO 95 I#1,MO                                                     CLIM1820
      LIST1%I¤#TABLE1%I,6¤                                             CLIM1830
   95 LIST2%I¤#TABLE1%I,8¤                                             CLIM1831
      CALL FREQNC%LIST1,31,MO,6,MODMAX,24¤                             CLIM1832
      CALL FREQNC%LIST2,31,MO,6,MODMIN,24¤                             CLIM1833
      CALL PLOT%NAME%1,MONTH¤,NAME%2,MONTH¤¤                           CLIM1834
C     PRINT TITLE AND HEADINGS                                         CLIM1835
 2000 IF%TITLE1%1¤.EQ.SLASH¤ GO TO 2001                                CLIM1840
      PRINT 2002,TITLE1                                                CLIM1850
      GO TO 2003                                                       CLIM1860
 2001 PRINT 2002,TITLE2                                                CLIM1870
 2002 FORMAT%1H1,24X,72A1¤                                             CLIM1880
 2003 PRINT 2004,%NAME%J,MONTH¤,J#1,2¤,YEAR                            CLIM1890
 2004 FORMAT%1HO,54X,2A6,I3//¤                                         CLIM1900
      PRINT 2005                                                       CLIM1910
 2005 FORMAT%1HO,6X,3HDAY,15X,32HTEMPERATURE - DEGREES FAHRENHEIT,20X,  CLIM1920
     I27HRELATIVE HUMIDITY - PERCENT,8X,9HPRECIP.- ¤                   CLIM1921
      PRINT 20051                                                      CLIM1922
20051 FORMAT%1H ,112X,6HINCHES¤                                        CLIM1923
      PRINT 2006                                                       CLIM1930
 2006 FORMAT%1H ,43X,4HTIME,9X,4HTIME,36X,13HAT MAX AT MIN¤            CLIM1940
      PRINT 2007                                                       CLIM1950
 2007 FORMAT%1H ,12X,         4H0600,2X,4H1200,2X,4H1800,2X,4H2400,3X,3HMCLIM1960
     1AX,2X,6HOF MAX,2X,3HMIN,2X,6HOF MIN,2X,4HMEAN,6X,4H0600,2X,4H1200,CLIM1970
     22X,4H1800,2X,4H2400,2X,4HTEMP,3X,4HTEMP//¤                       CLIM1980
C     PRINT OUT TABLE, USING SUITABLE FORMAT                           CLIM1981
      DO 20080 K#1,MO                                                  CLIM1990
      IF%.NOT.%NOTE.OR.NOTE2¤¤ GO TO 20081                             CLIM2000
      DO 20082 M#1,15                                                  CLIM2010
      IF%TABLE1%K,M¤.NE.-99¤ GO TO 20082                               CLIM2020
       TABLE1%K,M¤#IAS1                                                CLIM2030
       FORM%2,M&1¤#ASPEC                                               CLIM2040
20082  CONTINUE                                                        CLIM2050
```

```
      IF%TABLE2%K¤.GE.0.¤ GO TO 20086                                   CLIM2060
      IF%TABLE2%K¤.EQ.-1.¤GO TO 20084                                   CLIM2061
      IF%TABLE2%K¤.EQ.-99.¤ GO TO 20083                                 CLIM2062
20083  TABLE2%K¤#AS1                                                    CLIM2070
       GO TO 20085                                                      CLIM2080
20084  TABLE2%K¤#AS2                                                    CLIM2090
20085  FORM%2,17¤#FASPEC                                                CLIM2100
20086  PRINT FORM,K,%TABLE1%K,J¤,J#1,15¤,TABLE2%K¤                      CLIM2110
       DO 20087 I#2,17                                                  CLIM2120
20087  FORM%2,I¤#FORM1%I¤                                               CLIM2130
      GO TO 20080                                                       CLIM2140
20081  PRINT FORM,K,%TABLE1%K,J¤,J#1,15¤,TABLE2%K¤                      CLIM2150
20080  CONTINUE                                                         CLIM2160
 2009 FORMAT%1H ,6X,I2,1X,4%3X,I3¤,1X,2%3X,I3,3X,I4¤,3X,I3,4X,5%3X,I3¤,4CLIM2170
     1X,I5,5X,F5.2¤                                                     CLIM2180
      PRINT 2010,%TABLE1%35,J¤,J#1,5¤,TABLE1%35,7¤,%TABLE1%35,J¤,J#9,15¤CLIM2190
     1,TABLE2%35¤                                                       CLIM2200
 2010 FORMAT%1H0,3X,8HTOTALS  ,                                         CLIM2210
     1#%I4,2X¤,I4,9X,I4,10X,I4,6X,5%I4,2X¤,1X,I4,6X,F4.2¤               CLIM2211
      PRINT 2011,%TABLE1%36,J¤,J#1,5¤,TABLE1%36,7¤,%TABLE1%36,J¤,J#9,15¤CLIM2212
 2011 FORMAT%1H 3X,8HN       ,                                          CLIM2213
     1#%I4,2X¤,I4,9X,I4,10X,I4,6X,5%I4,2X¤,1X,I4,6X,F4.2¤               CLIM2214
      IF%.NOT.NOTE2¤ PRINT 2012,TABLE2%36¤                              CLIM2215
 2012 FORMAT%1H&,112X,F4.0¤                                             CLIM2216
      PRINT 2013,%TABLE1%34,J¤,J#1,5¤,TABLE1%34,7¤,%TABLE1%34,J¤,J#9,15¤CLIM2217
 2013 FORMAT%1H0,3X,8HMEAN    ,                                         CLIM2218
     1#%I4,2X¤,I4,9X,I4,10X,I4,6X,5%I4,2X¤,1X,I4,6X,F4.2¤               CLIM2219
      PRINT 2014,%TABLE1%33,J¤,J#1,5¤,TABLE1%33,7¤,%TABLE1%33,J¤,J#9,15¤CLIM2220
 2014 FORMAT%1H ,3X,8HMAXIMUM ,                                         CLIM2221
     1#%I4,2X¤,I4,9X,I4,10X,I4,6X,5%I4,2X¤,1X,I4,6X,F4.2¤               CLIM2222
      PRINT 2015,%TABLE1%32,J¤,J#1,5¤,TABLE1%32,7¤,%TABLE1%32,J¤,J#9,15¤CLIM2223
 2015 FORMAT%1H ,3X,8HMINIMUM ,                                         CLIM2224
     1#%I4,2X¤,I4,9X,I4,10X,I4,6X,5%I4,2X¤,1X,I4,6X,F4.2¤               CLIM2225
      PRINT 2016,MODMAX                                                 CLIM2226
 2016 FORMAT%1H0,3X,18HTIME OF MAX. TEMP.,4X,6%2X,I4¤/                  CLIM2227
     1H ,8X,9HFREQUENCY,7X,6%2X,I4¤¤                                   CLIM2228
      PRINT 2017,MODMIN                                                 CLIM2229
 2017 FORMAT%1H0,3X,18HTIME OF MIN. TEMP.,4X,6%2X,I4¤/                  CLIM2230
     1H ,8X,9HFREQUENCY,7X,6%2X,I4¤¤                                   CLIM2231
      IF%NOTE.OR.NOTE2¤ PRINT 2020                                      CLIM2400
      IF%NOTE¤ PRINT 2018                                               CLIM2410
      IF%NOTE2¤ PRINT 2019                                              CLIM2420
 2018 FORMAT%1H ,60X,25H *  THIS VALUE IS MISSING¤                      CLIM2430
 2019 FORMAT%1H ,60X,53H**  PRECIPITATION FOR THIS DAY INCLUDED IN NEXT CLIM2440
     1VALUE¤                                                            CLIM2450
 2020 FORMAT%1H0¤                                                       CLIM2460
      GO TO 11111                                                       CLIM2480
      END                                                               CLIM2490
      SUBROUTINE FREQNC%LIST,DIM,SIG,NN,STORE,RANGE¤                    FREQ0010
      INTEGER DIM,RANGE,SIG,NN,LIST%DIM¤,STORE%NN,2¤                    FREQ0020
      INTEGER ITABLE%24,2¤                                              FREQ0030
      DO 11 I#1,RANGE                                                   FREQ0040
      ITABLE%I,1¤#I*100&10000                                           FREQ0050
   11 ITABLE%I,2¤#0                                                     FREQ0060
      DO 22 I#1,SIG                                                     FREQ0070
      IND#%LIST%I¤-10000¤/100                                           FREQ0080
      IF%IND.LE.0.OR.IND.GT.RANGE¤ GO TO 22                             FREQ0081
      ITABLE%IND,2¤#ITABLE%IND,2¤&1                                     FREQ0090
   22 CONTINUE                                                          FREQ0091
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      K#2                                                                    FREQ0100
      N#RANGE                                                                FREQ0110
      M#2                                                                    FREQ0120
      L#N                                                                    FREQ0130
    3 L#L/2                                                                  FREQ0140
      IF%L.EQ.0¤ GO TO 111                                                   FREQ0150
      KDO#N-L                                                                FREQ0160
      JDO#1                                                                  FREQ0170
    4 IDO#JDO                                                                FREQ0180
    5 I#IDO&L                                                                FREQ0190
      IF%ITABLE%IDO,K¤.GE.ITABLE%I,K¤¤ GO TO 10                              FREQ0200
      DO 20 NDX#1,M                                                          FREQ0210
      IDUM#ITABLE%IDO,NDX¤                                                   FREQ0220
      ITABLE%IDO,NDX¤#ITABLE%I,NDX¤                                          FREQ0230
   20 ITABLE%I,NDX¤#IDUM                                                     FREQ0240
      IDO#IDO-L                                                              FREQ0250
      IF%IDO.GE.1¤ GO TO 5                                                   FREQ0260
   10 JDO#JDO&1                                                              FREQ0270
      IF%JDO-KDO¤4,4,3                                                       FREQ0280
  111 DO 33 I#1,NN                                                           FREQ0290
      STORE%I,1¤#ITABLE%I,1¤                                                 FREQ0300
   33 STORE%I,2¤#ITABLE%I,2¤                                                 FREQ0310
      RETURN                                                                 FREQ0320
      END                                                                    FREQ0330
      SUBROUTINE PLOT%NAME¤                                                  PLOT0000
      INTEGER TITLE2,YEAR,TABLE1,SIDE                                        PLOT0010
      COMMON TITLE2%72¤,MO    ,YEAR,TABLE1%40,15¤                            PLOT0020
      DIMENSION PAGE%44,97¤   ,NAME%2¤                                       PLOT0030
      DATA STAR,DOT,X/1H*,1H.,1HX/                                           PLOT0040
      DATA BLANK/1H /,0H/1H0/                                                PLOT0041
      DO 11 I#1,44                                                           PLOT0042
      DO 11 J#1,97                                                           PLOT0043
   11 PAGE%I,J¤#BLANK                                                        PLOT0044
      PRINT 2001,TITLE2,NAME,YEAR                                            PLOT0050
 2001 FORMAT%1H1,35X,72A1/1H0,58X,2A6,I3/1H0,49X,35HDAILY MEAN AND EXTREPLOT0060
     1ME TEMPERATURES//¤                                                     PLOT0070
      DO 1 I#1,97                                                            PLOT0080
      PAGE%44,I¤#STAR                                                        PLOT0090
    1 PAGE%2,I¤#STAR                                                         PLOT0100
      DO 2 I#16,91,15                                                        PLOT0110
    2 PAGE%1,I¤#STAR                                                         PLOT0120
      DO 3 I#2,44                                                            PLOT0130
      PAGE%I,1¤#STAR                                                         PLOT0140
    3 PAGE%I,97¤#STAR                                                        PLOT0150
      DO 4 I#1,MO                                                            PLOT0160
      IF%MOD%I,5¤.EQ.0¤ POINT#X                                              PLOT0170
      IF%MOD%I,5¤.NE.0¤  POINT#DOT                                           PLOT0180
      I5#%3*TABLE1%I,5¤¤/10&14                                               PLOT0190
      I7#%3*TABLE1%I,7¤¤/10&14                                               PLOT0200
      I9#%3*TABLE1%I,9¤¤/10&14                                               PLOT0210
      IF%I5.GT.0¤ PAGE%I5,3*I&1¤#POINT
      IF%I7.GT.0¤ PAGE%I7,3*I&1¤#POINT
    4 IF%I9.GT.0¤ PAGE%I9,3*I&1¤#OH
      SIDE#120                                                               PLOT0250
      DO 5 I#1,44                                                            PLOT0260
      IND#45-I                                                               PLOT0270
      PRINT 2002,%PAGE%IND,J¤,J#1,97¤                                        PLOT0280
 2002 FORMAT%1H ,19X,97A1¤                                                   PLOT0290
      IF%MOD%I-1,6¤.NE.0¤ GO TO 5                                            PLOT0300
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      SIDE#SIDE-20                                                          PLOT0310
      PRINT 2003,SIDE                                                       PLOT0320
 2003 FORMAT%1H&,12X,I4,3H  *¤                                              PLOT0330
    5 CONTINUE                                                             PLOT0340
      PRINT 2004                                                            PLOT0350
 2004 FORMAT%1H0,34X,1H5,13X,2H10,13X,2H15,13X,2H20,13X,2H25,13X,2H30/      PLOT0360
     11H0,55X,12HDAY OF MONTH¤                                              PLOT0370
      RETURN                                                                PLOT0380
      END                                                                   PLOT0390
      SUBROUTINE DEWDEF%DEWPT,DEF,TEMP,RH¤                                  DEW 0010
      DIMENSION TABLE%130,2¤                                                DEW 0020
      INTEGER DEWPT,TEMP,RH                                                 DEW 0030
      DATA%%TABLE%I,J¤,J#1,2¤,I#1,65¤/                                      DEW 0040
     A0.004,0.005,0.005,0.005,0.005,0.005,0.005,0.005,0.006,0.006,          DEW 0050
     B0.006,0.006,0.006,0.006,0.007,0.007,0.007,0.007,0.007,0.008,          DEW 0060
     C0.008,0.008,0.008,0.008,0.009,0.009,0.009,0.009,0.010,0.010,          DEW 0070
     D0.010,0.010,0.011,0.011,0.011,0.012,0.012,0.012,0.013,0.013,          DEW 0080
     E0.013,0.014,0.014,0.015,0.015,0.015,0.016,0.016,0.017,0.017,          DEW 0090
     F0.018,0.018,0.019,0.019,0.020,0.020,0.021,0.021,0.022,0.023,          DEW 0100
     G0.023,0.024,0.024,0.025,0.026,0.026,0.027,0.028,0.029,0.029,          DEW 0110
     H0.030,0.031,0.032,0.033,0.033,0.034,0.035,0.036,0.037,0.038,          DEW 0120
     I0.039,0.040,0.041,0.042,0.043,0.044,0.046,0.047,0.048,0.049,          DEW 0130
     J0.051,0.052,0.053,0.055,0.056,0.057,0.059,0.060,0.062,0.063,          DEW 0140
     K0.065,0.067,0.068,0.070,0.072,0.073,0.075,0.077,0.079,0.081,          DEW 0150
     L0.083,0.085,0.087,0.089,0.092,0.094,0.096,0.098,0.101,0.103,          DEW 0160
     M0.106,0.108,0.111,0.113,0.116,0.119,0.122,0.125,0.128,0.131/          DEW 0170
      DATA%%TABLE%I,J¤,J#1,2¤,I#66,130¤/                                    DEW 0180
     A0.134,0.137,0.140,0.144,0.147,0.150,0.154,0.158,0.161,0.165,          DEW 0190
     B0.169,0.173,0.177,0.181,0.185,0.188,0.192,0.196,0.200,0.204,          DEW 0200
     C0.208,0.212,0.216,0.221,0.225,0.230,0.234,0.239,0.243,0.248,          DEW 0210
     D0.253,0.258,0.263,0.268,0.273,0.279,0.284,0.289,0.295,0.301,          DEW 0220
     E0.306,0.312,0.318,0.324,0.331,0.337,0.343,0.350,0.356,0.363,          DEW 0230
     F0.370,0.377,0.384,0.391,0.398,0.405,0.413,0.421,0.428,0.436,          DEW 0240
     G0.444,0.452,0.461,0.469,0.477,0.486,0.495,0.504,0.513,0.522,          DEW 0250
     H0.531,0.541,0.551,0.560,0.570,0.581,0.591,0.601,0.612,0.623,          DEW 0260
     I0.634,0.645,0.656,0.667,0.679,0.691,0.703,0.715,0.727,0.740,          DEW 0270
     J0.752,0.765,0.778,0.792,0.805,0.819,0.833,0.847,0.861,0.876,          DEW 0280
     K0.890,0.905,0.920,0.936,0.951,0.967,0.983,1.000,1.016,1.033,          DEW 0290
     L1.050,1.067,1.084,1.102,1.120,1.138,1.157,1.176,1.195,1.214,          DEW 0300
     M1.234,1.255,1.274,1.294,1.315,1.336,1.357,1.378,1.400,1.422/          DEW 0310
      IF%TEMP.GE.-39.AND.TEMP.LE.90¤ GO TO 1                                DEW 0320
      DEWPT#-99                                                             DEW 0330
      DEF#-.99                                                              DEW 0340
      RETURN                                                                DEW 0350
    1 ED#TABLE%TEMP&40,2¤                                                   DEW 0360
      E#FLOAT%RH¤*ED/100.                                                   DEW 0370
      DEF#ED-E                                                              DEW 0380
      DO 2 I#1,130                                                          DEW 0390
    2 IF%TABLE%I,1¤.GE.E¤ GO TO 3                                           DEW 0400
      DEWPT#90                                                              DEW 0410
      RETURN                                                                DEW 0420
    3 DEWPT#I-41                                                            DEW 0430
      RETURN                                                                DEW 0440
      END                                                                   DEW 0450
      SUBROUTINE CUM%TABLE1,TABLE2,MONTH,YEAR,CODE¤                         CUM00000
      INTEGER TABLE1                                                        CUM   10
      DIMENSION  NUM%18¤                                                    CUM   20
      DIMENSION TITLE1%72¤,TITLE2%72¤,TABLE1%40,15¤,INT%11¤,IWEEK%11¤,      CUM   30
     1DEF%7¤,RWEEK%7¤,IONE%12¤,TABLE2%40¤                                   CUM   40
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      COMMON TITLE2,MO,YEAR,TABLE1                                          CUM   50
      COMMON/A/TITLE1                                                       CUM   60
      DATA%IONE%J¤,J#1,12¤/3,7,1,5,3,7,5,2,6,4,1,6/,SLASH/1H//              CUM   70
      IF%TITLE1%1¤.EQ.SLASH.AND.MONTH.NE.3¤ GO TO 21                        CUM   80
      DO 17 I#1,11                                                          CUM   90
      NUM%I¤#0                                                              CUM  100
   17 IWEEK%I¤#0                                                            CUM  110
      DO 18 I#1,7                                                           CUM  120
      NUM%I&11¤#0                                                           CUM  130
   18 RWEEK%I¤#0                                                            CUM  140
      IND#1-IONE%MONTH¤                                                     CUM  150
   21 PRINT 100,TITLE2,MONTH,YEAR                                           CUM  160
  100 FORMAT%1H1,24X,72A1/1HO,56X,I2,2H/1,I3/1HO,5H  DAY,4X,13HTEMP.-DEG    CUM  170
     1. F.,2X,9HREL HUM- ,7X,27HDEWPOINT-DEGREES FAHRENHEIT,17X,29HVAPORC   CUM  180
     2 PRESSURE DEFICIT-IN.HG./1HO,25X,2%31X,13HAT MAX AT MIN¤/1H ,10X,2C   CUM  190
     31HMAX  MIN MEAN    MEAN,2%4X,40H0600 1200 1800 2400   TEMP   TEMP C   CUM  200
     4  MEAN¤//¤                                                           CUM  210
      IMO#0                                                                 CUM  220
   22 IMO#IMO&1                                                             CUM  230
      IF%IMO.GT.MO¤ GO TO 1111                                              CUM  240
      IF%TABLE1%IMO,5¤.EQ.-99¤ GO TO 33                                     CUM  250
      INT%1¤#TABLE1%IMO,5¤                                                  CUM  260
      NUM%1¤#NUM%1¤&1                                                       CUM  270
      GO TO 3                                                               CUM  280
   33 INT%1¤#-99                                                            CUM  290
    3 IF%TABLE1%IMO,7¤.EQ.-99¤ GO TO 44                                     CUM  300
      INT%2¤#TABLE1%IMO,7¤                                                  CUM  310
      NUM%2¤#NUM%2¤&1                                                       CUM  320
      GO TO 4                                                               CUM  330
   44 INT%2¤#-99                                                            CUM  340
    4 IF%TABLE1%IMO,9¤.EQ.-99¤ GO TO 55                                     CUM  350
      INT%3¤#TABLE1%IMO,9¤                                                  CUM  360
      NUM%3¤#NUM%3¤&1                                                       CUM  370
      GO TO 5                                                               CUM  380
   55 INT%3¤#-99                                                            CUM  390
    5 IF%TABLE1%IMO,10¤.EQ.-99.OR.TABLE1%IMO,11¤.EQ.-99.OR.TABLE1%IMO,12C   CUM  400
     1¤.EQ.-99.OR.TABLE1%IMO,13¤.EQ.-99¤ GO TO 66                           CUM  410
      INT%4¤#FLOAT%TABLE1%IMO,10¤&TABLE1%IMO,11¤&TABLE1%IMO,12¤&TABLE1%IC   CUM  420
     1MO,13¤¤/4.&.5                                                         CUM  430
      NUM%4¤#NUM%4¤&1                                                       CUM  440
      GO TO 7                                                               CUM  450
   66 INT%4¤#-99                                                            CUM  460
    7 DO 2 J#1,4                                                            CUM  470
      IF%TABLE1%IMO,J¤.EQ.-99.OR.TABLE1%IMO,J&9¤.EQ.-99¤ GO TO 8            CUM  480
      CALL DEWDEF%INT%J&4¤,DEF%J¤,TABLE1%IMO,J¤,TABLE1%IMO,J&9¤¤            CUM  490
      NUM%J&4¤#NUM%J&4¤&1                                                   CUM  500
      NUM%J&11¤#NUM%J&11¤&1                                                 CUM  510
      GO TO 2                                                               CUM  520
    8 INT%J&4¤#-99                                                          CUM  530
      DEF%J¤#-.99                                                           CUM  540
    2 CONTINUE                                                              CUM  550
      IF%TABLE1%IMO,5¤.EQ.-99.OR.TABLE1%IMO,14¤.EQ.-99¤ GO TO 9             CUM  560
      CALL DEWDEF%INT%9¤,DEF%5¤,TABLE1%IMO,5¤,TABLE1%IMO,14¤¤               CUM  570
      NUM%9¤#NUM%9¤&1                                                       CUM  580
      NUM%16¤#NUM%16¤&1                                                     CUM  590
      GO TO 10                                                              CUM  600
    9 INT%9¤#-99                                                            CUM  610
      DEF%5¤#-.99                                                           CUM  620
   10 IF%TABLE1%IMO,7¤.EQ.-99.OR.TABLE1%IMO,15¤.EQ.-99 ¤ GO TO 11           CUM  630
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      CALL DEWDEF%INT%10¤,DEF%6¤,TABLE1%IMO,7¤,TABLE1%IMO,15¤¤          CUM  640
      NUM%10¤#NUM%10¤&1                                                 CUM  650
      NUM%17¤#NUM%17¤&1                                                 CUM  660
      GO TO 12                                                          CUM  670
   11 INT%10¤#-99                                                       CUM  680
      DEF%6¤#-.99                                                       CUM  690
   12 IF%INT%5¤.EQ.-99.OR.INT%6¤.EQ.-99.OR.INT%7¤.EQ.-99.OR.INT%8¤.EQ.-9CUM  700
     19¤ GO TO 13                                                       CUM  710
      INT%11¤#FLOAT%INT%5¤&INT%6¤&INT%7¤&INT%8¤¤/4.&.5                  CUM  720
      NUM%11¤#NUM%11¤&1                                                 CUM  730
      GO TO 14                                                          CUM  740
   13 INT%11¤#-99                                                       CUM  750
   14 IF%DEF%1¤.EQ.-.99.OR.DEF%2¤.EQ.-.99.OR.DEF%3¤.EQ.-.99.OR.DEF%4¤.EQCUM  760
     1.-.99¤ GO TO 15                                                   CUM  770
      DEF%7¤#%DEF%1¤&DEF%2¤&DEF%3¤&DEF%4¤¤/4.                           CUM  780
      NUM%18¤#NUM%18¤&1                                                 CUM  790
      GO TO 16                                                          CUM  800
   15 DEF%7¤#-.99                                                       CUM  810
   16 PRINT 101,IMO                                                     CUM  820
  101 FORMAT%1H ,3X,I2¤                                                 CUM  830
      PRINT 102,INT,DEF                                                 CUM  840
  102 FORMAT%1H&,7X,3I5,3X,I5,3X,4I5,3%2X,I5¤,4X,4F5.2,3%2X,F5.2¤¤      CUM  850
      IND#IND&1                                                         CUM  860
      IF%IND.LE.0¤ GO TO 22                                             CUM  870
      DO 23 I#1,11                                                      CUM  880
      IF%INT%I¤.EQ.-99¤ GO TO 23                                        CUM  890
      IWEEK%I¤#INT%I¤&IWEEK%I¤                                          CUM  900
   23 CONTINUE                                                          CUM  910
      DO 24 I#1,7                                                       CUM  920
      IF%DEF%I¤.EQ.-.99¤ GO TO 24                                       CUM  930
      RWEEK%I¤#DEF%I¤&RWEEK%I¤                                          CUM  940
   24 CONTINUE                                                          CUM  950
      IF%IND.LT.7¤ GO TO 22                                             CUM  960
      DO 25 I#1,11                                                      CUM  970
      IF%NUM%I¤.EQ.0¤ GO TO 251                                         CUM  980
      IWEEK%I¤#FLOAT%IWEEK%I¤¤/FLOAT%NUM%I¤¤&.5                         CUM  990
      GO TO 25                                                          CUM 1000
  251 IWEEK%I¤#-99                                                      CUM 1010
   25 CONTINUE                                                          CUM 1020
      DO 26 I#1,7                                                       CUM 1030
      IF%NUM%I&11¤,EQ.0¤ GO TO 261                                      CUM 1040
      RWEEK%I¤#RWEEK%I¤/FLOAT%NUM%I&11¤¤                                CUM 1050
      GO TO 26                                                          CUM 1060
  261 RWEEK%I¤#-.99                                                     CUM 1070
   26 CONTINUE                                                          CUM 1080
      PRINT 103                                                         CUM 1090
  103 FORMAT%7H0     ••¤                                               CUM 1100
      PRINT 102,IWEEK,RWEEK                                             CUM 1110
      PRINT 105                                                         CUM 1120
  105 FORMAT%1H ¤                                                       CUM 1130
      DO 27 I#1,11                                                      CUM 1140
      NUM%I¤#0                                                          CUM 1150
   27 IWEEK%I¤#0                                                        CUM 1160
      DO 28 I#1,7                                                       CUM 1170
      NUM%I&11¤#0                                                       CUM 1180
   28 RWEEK%I¤#0                                                        CUM 1190
      IND#0                                                             CUM 1200
      GO TO 22                                                          CUM 1210
 1111 PRINT 104                                                         CUM 1220
  104 FORMAT%1H0,50X,30H••  MEANS OF COLUMNS FOR PRECEDING WEEK/1H ,50X,CUM 1230
     1H2HNOTE  -99 AND -.99 INDICATE MISSING VALUES¤                    CUM 1240
      RETURN                                                            CUM 1250
      END                                                               CUM 1260
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