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Operation

ROLLER COASTER

PROJECT OFFICERS REPORT—PROJECT 2.4

MICRO-METEOROLOGICAL MEASUREMENTS (U)

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R. W. Titus, Project Officer

United States Weather Bureau
Research Station
Las Vegas, Nevada

Issuance Date: July 6, 1965

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ABSTRACT

Documentation of meteorological parameters occurring just prior to, during, and for a period after each of the four events of the series was the primary object of Project 2.4 (Micro-meteorological measurements).

The meteorological parameters desired were wind speeds and directions from the surface to 3,000 feet above it, temperature profile in the same layer, and turbulence measurements. The wind data and temperature data were required to be continuously monitored at the control point during each event. This required various types of telemetering and communications.

Surface wind data were collected using sensors on 30-foot towers at locations in the downwind array. M-33 radars sited along the border of each array, with remote release points down the array centerlines, were used to obtain event winds-aloft profiles. Two 120-foot United Kingdom (UK) towers near each GZ supplied additional wind data at the 60-foot and 120-foot levels plus gustmeter data for turbulence evaluation. Pibal crews obtained gross scale wind features for use by event weather briefers.

A tethered United Kingdom balloon with sensors at 100-foot intervals obtained vertical temperature profiles. Also at each event shot time, United States Weather Bureau (USWB) personnel obtained a temperature sounding using modified rawinsonde equipment.

PREFACE

The requirement for U.S. Weather Bureau Project 2.4 participation in Operation Roller Coaster was one of documentation and not experimentation.

Therefore, the discussion and conclusions relating to project participation are with reference only to the documentation accomplished. Other projects and agencies will use the meteorological data as appended to present in support of their individual experimental conclusions and recommendations.

Acknowledgment is made of the fine supporting effort to Project 2.4 by the eleven-man U.S. Air Force contingent from 6th Weather Squadron (Mobile), Tinker Air Force Base, Oklahoma. This group, with Staff Sargeant Stephen A. Heinrichs in charge, working under adverse conditions, contributed materially to the success of the project. They are to be highly commended for their efforts; they did credit to themselves and to the U.S. Air Force.

Acknowledgment is also made of the excellent cooperation received from Mr. J.R. Schaeffer, resident Sandia Corporation meteorologist at the Tonopah Test Range. He placed his facilities and records at the disposal of project personnel, thus aiding materially in documentation for extra meteorological requirements placed upon the project.

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Chapter 1

INTRODUCTION

1.1 OBJECTIVES

Objectives for Project 2.4, Micro-Meteorological Measurements, were threefold.

Primary objective was to document, for each event, the immediate pre-event and sufficient post-event winds and temperatures both surface and aloft to provide sequential and spatial detail for correlation between cloud dimensions and particulate dispersion in relation to wind, temperature, and turbulence profiles.

Secondary objectives, which concerned pre-event phases of the operation were:

(1) To define meteorological parameters in the test area sufficiently to:

(a) Place technical equipment and structures for most effective use of probable weather patterns in cloud development, travel, and the fallout process

(b) Minimize weather delays for the events

(c) Provide an estimate of the meteorological problems for planning and forecasting

(2) To provide meteorological support, including observations and forecasts, for:

(a) Pre-event technical operations

(b) Implementation of the operational safety program.

1.2 BACKGROUND AND THEORY

It is logical to attempt to extrapolate surface-deposited particulate radiation patterns from one explosion to another explosion using only knowledge of the wind and other meteorological conditions affecting each.

In assessing the hazard from an explosively produced cloud laden with radioactive particles it is necessary to have as detailed a knowledge of the wind field and other meteorological variables as is possible to obtain. Such detail is required for construction of mathematical dispersion models which can be applied generally to any given meteorological situation. For example, low wind speed shortens the deposition pattern, shear in wind direction widens it, and thermal inversions can reduce cloud height and possibly shorten the pattern. It was important during this project that information be

collected in sufficient density to assure reasonable conclusions in extending the data to other conditions. Toward this end, since only small event clouds were in prospect for the operation, meteorological elements were measured in much greater detail through a thinner atmospheric layer and over a smaller area than is normally done at NTS. The detail is important not only for correlation but because local variations are frequent in the terrain of southern Nevada. Complete circulations are at times observed in about the same scale as those of the event clouds.

Measurements in sufficient detail to identify and fully describe the possible variations of this scale would involve an instrument grid spacing of approximately 500 feet horizontally and 50 feet vertically in the downwind direction over an area as far as the cloud might be of interest. Since enough instrumentation of all kinds was not available to have this close grid spacing, maximum effort was made to provide instruments for sufficient detail and attempts were made to insure that the event detonations occurred in conditions of relatively smooth and continuous flow without smaller perturbations than could be measured. U.S. Weather Bureau (USWB) measurements were supplemented with measurements in the micro-meteorological field by the United Kingdom (UK). Measurements consisted of temperature profile, turbulence profile, and the wind speed and direction profiles within the layer from the surface to 3,000 feet above it and in an area, surrounding ground zero, of sufficient dimension to encompass possible extremes in cloud formation and passage. Greatest instrumentation and meteorological effort was concentrated around ground zero and in the immediate downwind sector.

The operations needed to accomplish the project objectives may be divided into three phases. Phase I, Climatological, involved collection of data from the event areas primarily for statistical analysis to assist in the design of the experiments. Observing teams began this phase in October 1962 and continued through November. This was necessary since no data was available in the event areas, and this similar seasonal transition period best approximated the scheduled springtime meteorological conditions. Analysis of data led to a recommendation that arrays in the Cactus Flat area be aligned along a north-northwest south-southeast line, while in Stonewall Flat, because of dominant terrain features which appeared to induce a strong north-south channeling, it was recommended that the array be aligned north-south.

Phase II, Climatological-Support, involved a continuation of climatological observations with addition of observations in support of pre-event operations through March and

early April 1963. During this period United Kingdom observations from tethered balloons and fixed towers commenced. Weather forecasting studies during this phase were based upon the following desired shot weather conditions for the first 3,000 feet above the surface:

(1) Predictable winds of a persistent nature in the sector northwest through north-northeast at speeds between six and twelve knots. This speed limit was lowered to four to ten knots after Double Tracks.

(2) Directional wind shear in the 3,000-foot layer not to exceed 30 degrees.

(3) An inversion or isothermal temperature profile to reduce cloud rise within the layer.

(4) Conditions for minimal turbulence were added after Double Tracks (DT).

In general these conditions appeared to exist in forecastable sequence only after a cold front had passed over the test range with its trailing high-pressure cell or ridge moving from the west into the Pacific Northwest. A slight variation of this occurred when a moderate to strong high-pressure ridge approached the Pacific coast from the west after a low-pressure trough aloft passed over the test range with no apparent surface frontal system. In either case the dominant features were the moderate to strong high pressure building on the northwest coast with lower pressure south and southeast of the test areas to give the desired gradient wind flow of sufficient depth and persistence. From prior limited study, drainage wind flow during nighttime hours of cooled surface air, was not felt to affect a sufficiently deep layer or to be repeatable in time of formation to be dependable as the sole source of desired shot condition winds. An exception was for Double Tracks where the array direction had been chosen to use the effects of drainage flow and whose cloud height could be expected to remain within the drainage layer of the particular valley regime. On all of the Clean Slate (CS) series of events, therefore, drainage winds had to be replaced by general flow from the northwest quadrant both surface and aloft. On Clean Slate I and II (CS I and II) arrays where there were reverse or cross slopes, the drainage wind had to be overcome by gradient flow before shot conditions could be achieved.

The forecast problem was further complicated by general delays which shifted the entire program into late May and early June. This was toward the end of the spring transition period from northerly to southerly winds and the probability of southwest flow at the test range was greatly increased. Fortunately a late spring delayed and prolonged

the period of transition, allowing the series to be completed.

An added forecast problem was the requirement for meteorological conditions to be satisfactory for the inflation and flying of the tethered balloon array of Project 2.7 prior to each event. It was desired to obtain winds below 15 knots for the inflation period of six to twelve hours and winds of less than fifty knots during flying periods. In actual practice winds of 20 to 30 knots with gusts to 40 knots are found to be destructive to flying balloons. The above normal incidence of frontal passages during April and May with their attendant strong gusty winds made balloon flying hazardous.

Phase III, Events, encompassing the period from mid-April through the events, included installation and checkout of measurement systems and their operation through the event phase. The on-site observational program was enlarged to include radar winds-aloft observations, temperature soundings, and fixed-wind towers with data telemetered to the forward weather trailer in the control point (CP) complex.

During the period 1 April through the event phase, weather forecasts and briefings were provided for pre-event operations and for the events themselves. A base camp weather trailer was provided with reception equipment for weather facsimile, Service "A" and "C" Weather teletype circuits, and one special teletype link with weather facilities at the Nevada Test Site. Teams of forecasters manned the base camp weather trailer during this period and maintained twenty-four-hour weather coverage.

Chapter 2

PROCEDURE

2.1 ORGANIZATION

The Project Officer coordinated operational functions which were conveniently divided into the following:

(1) An observation section which operated the M-33 radars, temperature soundings, and pilot balloon stations and processed meteorological data.

(2) An equipment maintenance section which was responsible for both preventive and corrective maintenance on all major items of equipment.

(3) An analysis and forecasting section which operated in the base weather trailer preparing forecasts, warnings, and briefings as required.

2.2 OPERATIONS

2.2.1 Climatological Phase, (October 1962 to February 1963). Pilot balloon crews were sent to Stonewall Flat and Cactus Flat in October 1962 and remained in the field through November collecting upper air data. Their efforts were seriously hampered because the proposed event area in Stonewall Flat was a portion of the gunnery range for Nellis Air Force Base and was in almost daily use by aircraft. The Cactus Flat areas, as part of the Sandia Tonopah Test Range, had frequent rocket and other high-explosive experiments which precluded use by the U.S. Weather Bureau crews.

Surface wind data was collected from fixed anemometer towers in both areas during the period October through March.

2.2.2 Climatological, Support Phase, (March through April). Commencing in March climatological observations were augmented with meteorological observations in support of pre-event operations. These included radar winds-aloft in addition to pilot balloon runs. During this period test flying of the UK tethered balloons was started and construction of the UK 120-foot meteorological towers commenced. The 30-foot meteorological tower array for Double Tracks was completed in early April.

The base camp weather trailer was also completed in early April and weather

forecasting commenced during the first week of the month. Daily weather briefings were given from this time on through the end of the series in June.

Large tethered balloon operations began near mid-April. The first large balloon was flown several hundred feet above the filling beds at Cactus Flat to test its handling and flying characteristics in a high wind situation preceding a frontal passage. This ended in disaster when the strong winds caused collapse of the fin assembly and loss of stability. This and subsequent problems with balloon operations during high winds led to an AEC committee report on balloon operations (Reference 1).

During periods that balloons were airborne, weather briefings were given to supervisory balloon personnel at least twice a day. The twenty-four hour forecasting capability maintained at the base weather trailer insured notification of all cognizant departments and projects when high wind conditions were expected to endanger the balloons or when other weather phenomena would make such flying hazardous.

2.2.3 Event Phase (May through June). This phase covered the period from approximately the end of April through the end of the series in June.

During this time U.S. Weather Bureau Project 2.4 was at maximum staff, augmented by an eleven man contingent from the U.S. Air Force 6th Weather Squadron (Mobile), Tinker Air Force Base, Oklahoma.

Event weather briefings were added to the schedule; the frequency of these depended upon the proximity of a scheduled event. All events of the series were weather dependent and necessitated standby conditions until favorable shot weather situations were realized.

Once it was determined that favorable shot conditions were probable, necessary field operations by various projects commenced and were geared to a selected shot date and time. To complete the four events required only seven attempts in the field.

The unique nature of Project 2.4 participation in the Roller Coaster Series was best illustrated during the event phase. Prior to each event the weather briefings occupied the major portion of the Project Officer's effort, since he was in an advisory capacity to the decision-making personnel of Roller Coaster. This advisory function increased in importance as the field phase of each event moved to its climax. Meteorological conditions had to be monitored continuously to provide the necessary information upon which the final shot decision go, no-go could be made. This required that all available data be collected at the forward weather trailer where it was filtered by the Project

Officer/Briefer for presentation of applicable portions to the shot advisory panel and the Scientific Director's Staff. It was necessary that this meteorological data be available to the briefer on as nearly a continuous basis as possible.

2.3 OBSERVATIONAL PROCEDURE

2.3.1 Temperature Soundings. During event periods, thermal stability was determined at the control point by soundings taken using modified USWB free-balloon borne instruments which transmitted a steady temperature signal while rising. These flights, for data purposes, were terminated at 10,000 feet MSL.

In addition, during these periods, a large tethered balloon, flying 1,000 feet above the surface near ground zero, held ten thermistors affixed at 100-foot intervals which transmitted temperature difference to a recorder at the control point. This information was available to the briefer from UK representatives in the operations trailer.

2.3.2 Winds Aloft. Down-array winds were monitored during event periods by two or three M-33 radars. Helium-filled 100-gram balloons with radar reflectors were released from stations spaced along the array centerline to provide spatial wind detail to 3,000 feet above the surface. During nighttime, red flare-like fuzees were also attached to the balloon to provide visual tracking ability by the radar crews located along the edge of the array, outside the radiation hazard area. This permitted immediate tracking from the surface until the reflector cleared the electronic ground clutter and the radar shifted to automatic tracking. Winds were desired in detail for the first, 3,000 feet above the surface and runs near event times were required every 15 minutes to effectively monitor wind variations. Further support was provided by four off-site pilot balloon teams which took hourly winds-aloft observations at preselected locations consistent with expected wind patterns. All wind data was transmitted to the forward weather trailer immediately for plotting and display. This enabled the weather briefer to continuously monitor array and area winds and make forecasts and recommendations to the advisory panel and Scientific Director for their shot decision.

The radar winds aloft information from each of the M-33 radars was transmitted by field phone from each radar to a corresponding plotter in the forward weather trailer who made a hodograph on large size (20-by-20-inch) polar coordinate paper for a graphical planview display. The polar coordinate plot showed the position of the balloon every fifteen seconds, given as an azimuth and range from the balloon release point. Balloon heights were inscribed beside each plotted point. These radar hodographs gave a visual

display of wind profile, and in chronological order, gave an approximation of the time-variability of the wind field over the array.

2.3.3 Surface Winds. Winds aloft data were augmented by surface wind towers. Two United Kingdom 120-foot towers near each GZ were instrumented with anemometers and bi-vanes. In addition a maximum of five 30-foot towers with wind vanes and anemometers were placed in the array to provide spatial detail of the near-surface wind field. These tower winds were telemetered to recorders at the forward weather trailer for use by the weather briefer in his recommendations and forecasts to the advisory panel.

2.4 COMMUNICATIONS

2.4.1 Base Weather Trailer. Incoming weather information was received at a trailer in base camp via radio, teletype (Service A and C and 8GT26), facsimile, and telephone. Daily forecasts and briefings were prepared using this information.

2.4.2 Forward Weather Trailer. During each event a trailer at the control point was manned by project weather personnel. Incoming meso-scale weather information was received by radio from the off-site pibal stations, by field telephone from the M-33 radar crews, and by telemetering from various towers. The weather briefer was kept abreast of changes in the gross scale weather picture over the western United States by radio conversations with the duty forecaster at the base weather trailer.

2.5 ANALYSIS PROCEDURE-EVENT WEATHER BRIEFING

2.5.1 Event Data Input. In addition to data available to the weather briefer from the project observational program, national weather teletype circuits provided: (1) hourly station weather report sequences over the U.S., (2) area and air terminal forecasts, (3) more complete three and six-hourly weather reports from selected stations, (4) six-hourly upper wind data, and twelve hourly upper level pressure, temperature, and humidity reports from large portions of the northern hemisphere, and (5) state and regional forecasts and synopses for the U.S. The national weather facsimile circuit provided analyzed charts of the large scale weather systems, associated charts related to their make-up and probable movement, forecasts of major weather phenomena, and prognostic charts produced by numerical computer methods.

2.5.2 Event Data Utilization. Facsimile charts provided the major information required for general forecasting including constant level charts, synoptic weather

patterns, and charts to permit evaluation of advective processes such as thermal, vorticity, and pressure change. Teletype data supplemented the facsimile providing additional information for use in forecasting and briefing processes. Special time cross-sections of local winds aloft were maintained by the duty forecasters from the daily M-33 radar winds aloft runs which provided a micro-scale analysis within the main area of interest.

A detailed analysis of the 10,000-foot wind field over the western U.S. was prepared locally every six hours, occasionally for other levels when deemed necessary.

2.6 WEATHER BRIEFING PROCEDURE

2.6.1 Event Schedule. The event weather briefing was formally presented to the advisory panel by the briefing meteorologist. Briefing charts and forecasts used in the presentation were prepared by the briefing meteorologist. The final decision on the forecast and on the briefing charts to be used was the responsibility of the meteorologist giving the formal briefing. Normal briefing materials were graphical displays of the forecast elements, which included 10,000-foot prognostic streamlines for H-hour, clouds and weather for the period from H−4 to H + 8, winds aloft and surface wind forecasts for ground zero bracketing shot time, and an event temperature sounding and wind profile.

Although a daily forecasting service was maintained at the base weather trailer, event briefings were usually prepared separately by the briefing meteorologist. Because of balloon operations associated with every event, timing for each one was weather dependent. Approximately 30 to 40 hours lead time with low wind conditions was needed to complete balloon inflation and placing procedures with instrumentation of the balloon-borne curtain and of the array itself. Therefore when favorable shot conditions appeared probable within this time frame, informal briefings were scheduled as necessary, often 6 to 10 hours apart, with a continuous monitoring of all applicable weather data by duty forecasters and the briefers. A formal briefing was held 4 to 6 hours before each scheduled H-hour. H-hour was normally scheduled in the morning between midnight and dawn. The actual H-hour shot decision by the advisory panel was based upon the meteorological data flowing continuously into the forward weather trailer. H-hour would be delayed or canceled unless acceptable conditions were realized and predicted to remain reasonably persistent for several hours after a shot.

After detonation, all meteorological observations were continued for up to two hours to assure operational safety requirements were met and to obtain data for inclusion in

the scientific program.

In effect, after each event H-hour, the function of Project 2.4 data collection shifted from that of adjunct to decision making to one of documentation. The length of this post-shot definition of array meteorological conditions lasted through the time of debris cloud transport and deposition throughout the sampling array.

2.6.2 Daily Schedule. Weather briefings were presented daily at 1700 PDT in the conference trailer to all project officers, contractor department heads, Department of Defense personnel, and scientific staff. Briefings were presented by the duty forecasters using facsimile charts and special briefing charts. Present weather picture, together with forecast 24-hour patterns for the western U.S., were presented followed by a detailed 24-hour local area forecast and a general 72-hour outlook. In addition, around-the-clock forecast capability was maintained in the base weather trailer.

2.7 INSTRUMENTATION

2.7.1 Instrument Arrays. Shot documentation was accomplished using the instrument arrays shown in Figures 2.1 through 2.3.

2.7.2 Instrument Elevations. Locations and elevations of instruments in each array are outlined in Appendix A.

2.7.3 Instrument Descriptions. The meteorological instrumentation is grouped by events. Station ground heights are given in feet above MSL. Heights are not given for radar units because all releases were made at remote stations within each array.

Array heights were obtained from survey data. Off-site locations such as pilot balloon stations were obtained locally or from topographic maps.

Instrumentation was progressively shifted from one event to the next chronologically, so that records cover a period just prior to each event and for a short period after its completion.

2.7.4 Beckman & Whitley Wind Recording Systems WS-101. The Beckman and Whitley WS-101 wind recording system consisted of these major components: Model 1564 wind speed transmitter assembly; Model 1565 wind direction transmitter assembly; and Model 1567 wind speed direction translator with two recording milliammeters and connecting cables. These assemblies used solid-state components for stability and reliability of operation under severe environmental conditions.

The system could be operated on 115-volt 60-cycle ac power or from a self-contained 12-volt dc battery supply as was done during Operation Roller Coaster.

For remote transmission the sensors were designed for compatability with standard telephone transmission requirements without modification or addition of auxiliary telemetering equipment. Therefore, WD-8 wire was used with good results over distances up to ten miles (see array diagrams, Figures 2.1 through 2.3).

The Model 1564 wind speed transmitter had a range from 0.6 to 90 mph; accuracy 1 percent of true wind or ± 0.15 mph, whichever was greater within an operating temperature range of −40/140 degrees F. Signal to translator was 0.5 milliwatt audio input from a hole-in-disk light chopper with frequency proportional to wind speed; accuracy ± 0.3 percent.

The Model 1565 wind direction transmitter had a range of direction of 360 degrees continuous rotation; accuracy ± 3.0 percent. Direction signal was proportional to direction azimuth as measured on 0 to 10 k ohm potentiometer; accuracy ± 1.0 percent.

Three of the wind systems used on Operation Roller Coaster events were of the Beckman and Whitley WS-101 type.

2.7.5 K-100-A. The Beckman and Whitley K-100-A wind speed and wind direction recording system consisted of the same type components as the WS-101 system; Model 170-54 wind direction transmitter, Model 170-34 wind speed transmitter, translator unit, two recording milliammeters, and connecting cables. Power was supplied by a battery pack.

Specifications of the Model 170-34 wind speed transmitter assembly were: wind speed threshold, 0.75 mph; wind speed accuracy, ± 3 percent.

Specifications of the Model 170-54 wind direction transmitter were: wind direction threshold, 0.75 mph; accuracy, ± 5 degress azimuth.

Two of the wind systems on Operation Roller Coaster events were K-100-A systems.

Major differences between the WS-101 and the K-100-A systems were in the use of a 40-hole chopper in the WS-101 versus a 2-hole chopper in the K-100-A and in the use of a greater precision potentiometer on the WS-101 wind direction transmitter.

The wind speed circuit of each system produced a direct current proportional to the rate of rotation of the anemometer cup assembly. The anemometer cups rotated a light chopper which alternately exposed and masked a photo conductive cell. Amplifiers in the associated circuitry averaged the pulses; this average was carried through more circuitry and was indicated on the wind speed recorders as wind speed in mph. The 2-hole chopper at low wind speeds produced pulsing and painting through the wind speed

envelope on the recorder record rather than following small changes more smoothly and precisely as did the WS-101.

The difference between the 250-ohm precision potentiometer as used in the wind direction transmitter of the Model 170-54 of the K-100-A system and the 10,000 ohm potentiometer as used in the WS-101 accounted for the greater directional accuracy of the latter system.

2.7.6 Recorders, Esterline-Angus Milliammeter. The recorders used with the Beckman and Whitley wind systems were spring-clock driven chart, portable, recording milliammeters. Input to each recorder was 0 to 1 milliamp dc signal into a 1,400-ohm galvanometer movement. Accuracy was ± 0.5 percent full scale with response of 0.5 second to full scale. On the Roller Coaster recorder records, the wind direction scale covered 0 to 360 degrees with the changeover point at 090 degrees (except 60 and 120-foot levels of UK tower for each event). Wind speed scale used on all recorders was 0 to 60 mph.

2.7.7 M-33 Meteorological Radar (Balloon Tracking). Radar wind information was supplied by equipment in mobile vans located along the radial roads of the array (see array diagrams, Figures 2.1 through 2.3). All vans were equipped with a modified M-33 military radar of the anti-aircraft tracking and gun laying type. In general terms, modification was made in the data presentation sections of the equipment so that the incoming information could be assimilated, computed, and analyzed according to meteorological needs. For radar wind determination a 12-inch circular, 8-cornered, aluminum target was carried aloft by a free lift, 100-gm balloon. The target was of the passive type which did not originate a signal but reflected the incident energy of the pulse directed at it by the radar antenna. Direction finding and ranging was accomplished by sending out pulses of very short duration and very high power that had a wave length short enough to permit an exceedingly sharp beam to be directed by proper alignment of the parabolic antenna.

The tracking radar was used to follow a designated target in range, azimuth, and elevation and present accurate target-position data to the computer. The computer took the input polar coordinate data and converted it to rectangular coordinate information before passing it to the vertically mounted plotting board. The plotting board contained two vertical arms that ran left or right on tracks. On each arm was a pen assembly

geared to respond, by movement up or down, along the arm, to appropriate positioning signals from the computer. The plotting board, approximately 29 inches square, was covered by paper fed by hand from a continuous roll. The pen assemblies printed a dot at set intervals on the paper; the interval used in Roller Coaster was 15 seconds. One pen assembly made a pip trace of the XY or target planview position while the other pen moved upward along the other vertical arm, printing target height, H, at the same time. As the printout proceeded during tracking, the man at the plotting board used appropriate graphical means to obtain wind information over a 30-second interval, at every 15-second printout, using a 15-second increment either side of the desired print time. Balloon ascension rates were adjusted as near to 400 ft/min as possible, thus providing overlapping wind information every 200 feet.

Targets were released remotely at points in the downwind array (see array diagram, Figures 2.1 through 2.3). For nighttime target acquisition, 15-minute red fuzees were carried aloft by the 100-gm balloons in addition to the aluminum radar reflectors. Thus, radar crews were able to track the targets optically at release, over distances in excess of five miles, until the target was free of ground clutter and the radar could be shifted into auto-track to track and follow automatically. This method enabled collection of downwind array winds-aloft information without placing equipment in a potentially hazardous fallout situation.

Remote balloon release trailers built to accomplish the balloon inflation and release automatically by means of radio-frequency tone triggers encountered considerable radio reception and operational problems and did not function as expected. This required manned release of balloons, targets, and fuzees by personnel suitably outfitted for radiological safety protection at these stations in the downwind array.

General electronic characteristics of the M-33 tracking radar:

Tracking Antenna

Metal plate; phase advance lens

Beam: horizontal and vertical dimensions, 20 mils at half power point; gain, 39 db; scan, conical, ± 9 mils

Minor lobes: conical scan, 26 db; polarization, vertical

Scanner: conical; scanning rate, variable 28 to 32 cps

RF line: circular wave guide

Drive: 2 phase 200-volt 400-cps variable speed motor

Tracking Radar Transmitting Group

Frequency: X band 8,500 to 9,600 mc

Transmitter: tunable magnetron

Peak RF power: 250 kw

Pulse repetition rate: 1,000 pps

Pulse duration: 0.25 microsecond

Pulse shape: trapezoidal

Modulator, type: hydrogen, line type

Tracking Radar Limits of Operation

Azimuth: 0 to 6,400 mils

Elevation: 180 to + 1,600 mils

Tracking Rates

Range: 600 yards per second

Azimuth: 700 mils per second

Elevation: 500 mils per second

Slewing Rate

Range: 6,000 yards per second

Resolution: can distinguish between targets separated by 18 mils in azimuth or elevation or 65 yards in range.

Periscope

Field of view: 100 mils

Magnification: 8 power

The M-33 radar was subject to certain range and angle errors. According to Reference 2, range errors are of three types: (1) static errors; (2) coordinate converter error; and (3) dynamic error. Reference 2 states that the maximum static error of the M-33 is ± 30 feet. The computer (coordinate converter) error even at maximum range is slightly more than one foot and as such can be neglected. Because of low velocity and acceleration values of balloon-borne targets, the M-33 is capable of tracking without objectionable lag, so the dynamic error is negligible.

Angle errors are also of three types: (1) tracking noise error; (2) data pickoff resolution; and (3) dynamic error. According to page 21 of Reference 3, the elevation and

azimuth angle errors from tracking noise and data pickoff resolution are near 0.25 milliradian each and the dynamic error, also because of low velocity and acceleration values of the balloon, is so small as to be negligible.

2.7.8 Pilot Balloon Observations. Pilot balloon observations using optical theodolites were used to relate the lower level wind structure to the gross profile of the winds aloft at greater heights and to add data to the lower level wind profiles.

A theodolite is an optical instrument resembling a surveyor's transit which is especially designed to enable visual tracking of a rising free-lift balloon. It is specifically designed to measure angles of elevation and azimuth in relation to the horizontal plane at the location of the instrument. The elevation and azimuth angle data are used with manual plotting and calculating methods to obtain wind speed and direction for height increments based upon mean sea level as a reference (see Appendix A for locations and elevations of theodolite stations used on Roller Coaster).

When using only one theodolite for an observation, the ascension rate of the released free-rising balloon must be assumed from standard rate-of-rise tables. This is inherently inaccurate because of changes aloft in the vertical velocities, stability, and other associated parameters in the atmosphere through which the balloon must rise. It is stated in Reference 4 that, apart from human errors caused by reading angles on the theodolites incorrectly, *even the best pilot balloon observations will not be more accurate* than ± 2 degrees in direction and ± 1 meter per second in speed. In Reference 4 no mention mention is made of the inherent height error from assumed ascension rates; however, local studies at NTS have found these to be considerable on occasion. Pilot balloon data was reduced by graphical means in the field, another inherently inaccurate process due to the nature of such conditions.

2.7.9 Temperature Profile Measurements. A standard radiosonde transmitter (AN/AMT-7) was modified to transmit only temperature and reference signals so that more detail in temperature was obtained in place of the usual relative humidity information. The radiosondes containing transmitter, barometric commutator switch, temperature sensor, and battery were carried aloft by free balloon. Data were transmitted on 403 Mc as an audio modulated signal to a receiver (AN-FMQ-2) and trace recorder (AN/TMQ-2) located in a trailer van near the CP. The antenna on top of the van was of a special type as modified by the Weather Bureau research station staff. The above components comprised what was essentially a slight modification of the standard GMD-1A upper-air measuring system.

Atmospheric temperature profile was measured to a height of 900 feet by means of a series of thermistors mounted at intervals of 100 feet on a captive balloon cable. This system was designed and operated by United Kingdom/Atomic Weapons Research Establishment (UK/AWRE) personnel.

The thermistors used had a linearized resistance-temperature characteristic with a five-minute response time. Each one was contained in an aluminum alloy radiation shield and ventilated by a fan driven by a small dc motor.

The thermistors were switched in turn into a bridge circuit and compared against a reference thermistor located at the surface. The output signal was measured, using a 12-channel potentiometric recorder. Channels 1 to 9 recorded the difference between the surface temperature and the temperature at each level up to 900 feet. Channel 11 recorded the surface temperature. Temperature differences measured were accurate to ± 0.3 degrees C.

2.7.10 Atmospheric Turbulence Measurements. Tower mounted vertical and lateral gustmeters, also designed and operated by UK/AWRE personnel, were used to measure turbulence. Each consisted of a light wind vane, free to move in the vertical or lateral plane, respectively, and controlling the position of the wiper arm of a micro-torque potentiometer. The potentiometer formed two arms of a bridge circuit, the out-of-balance current being recorded by means of a spark recorder having a 50-0-50 microamp movement. The recorder operated at a rate of 2 sparks per second, producing a trace on heat-sensitive chart paper, drawn at a rate of 3 inches per minute.

Full scale deflection was produced by ± 45 degrees for the vertical gustmeter and ± 90 degrees for the lateral one. The vertical gustmeter was maintained into the wind and gave zero output when the vane was horizontal. The lateral gustmeter was sighted to give zero output for some known reference direction.

One vertical gustmeter was mounted on a captive balloon cable. The arm supporting the potentiometer on this instrument was weighted to maintain it vertically in space.

Gustmeter data will be made available from United Kingdom sources and is not included with this report.

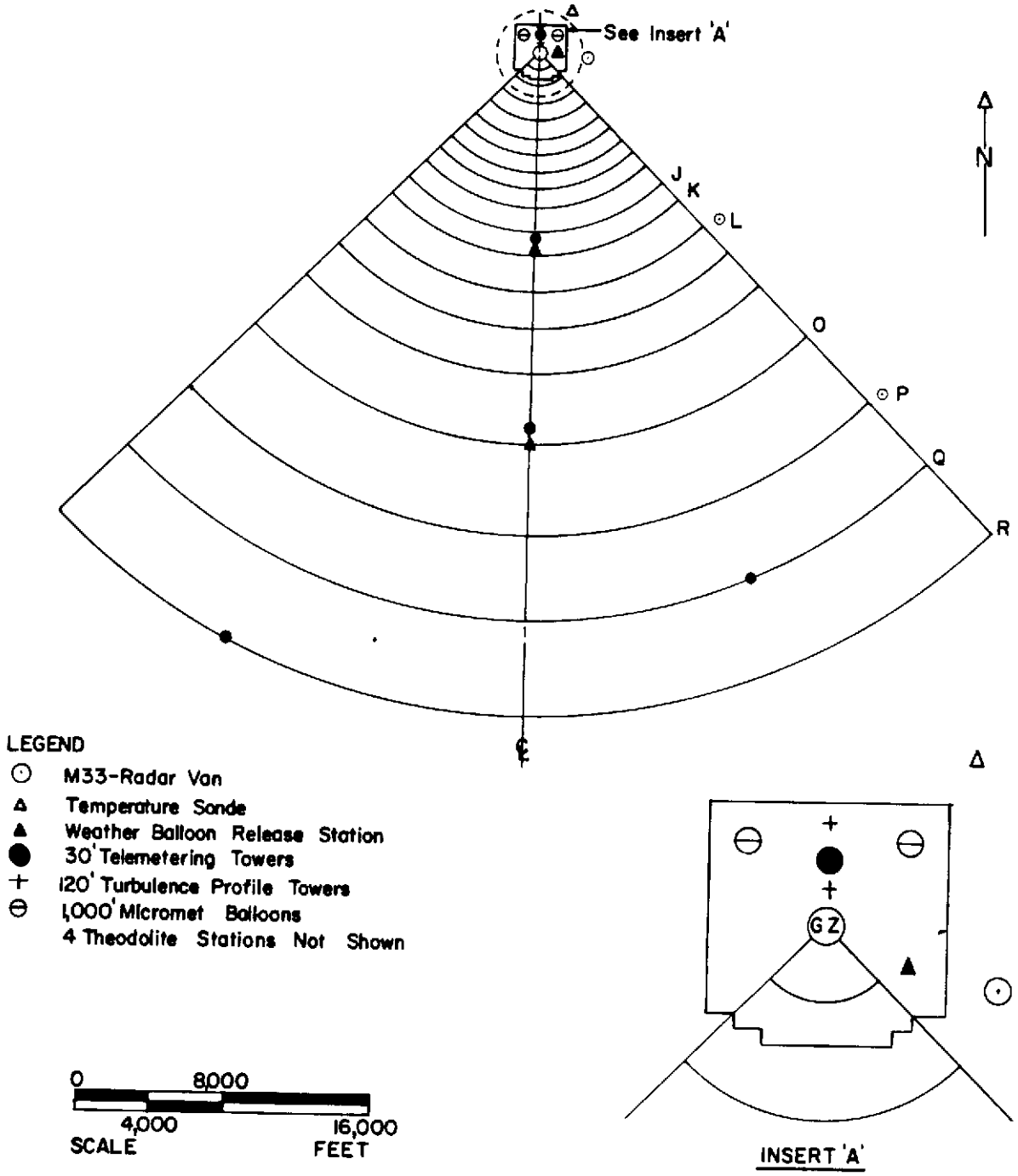


Figure 2.1 Double Tracks array diagram.

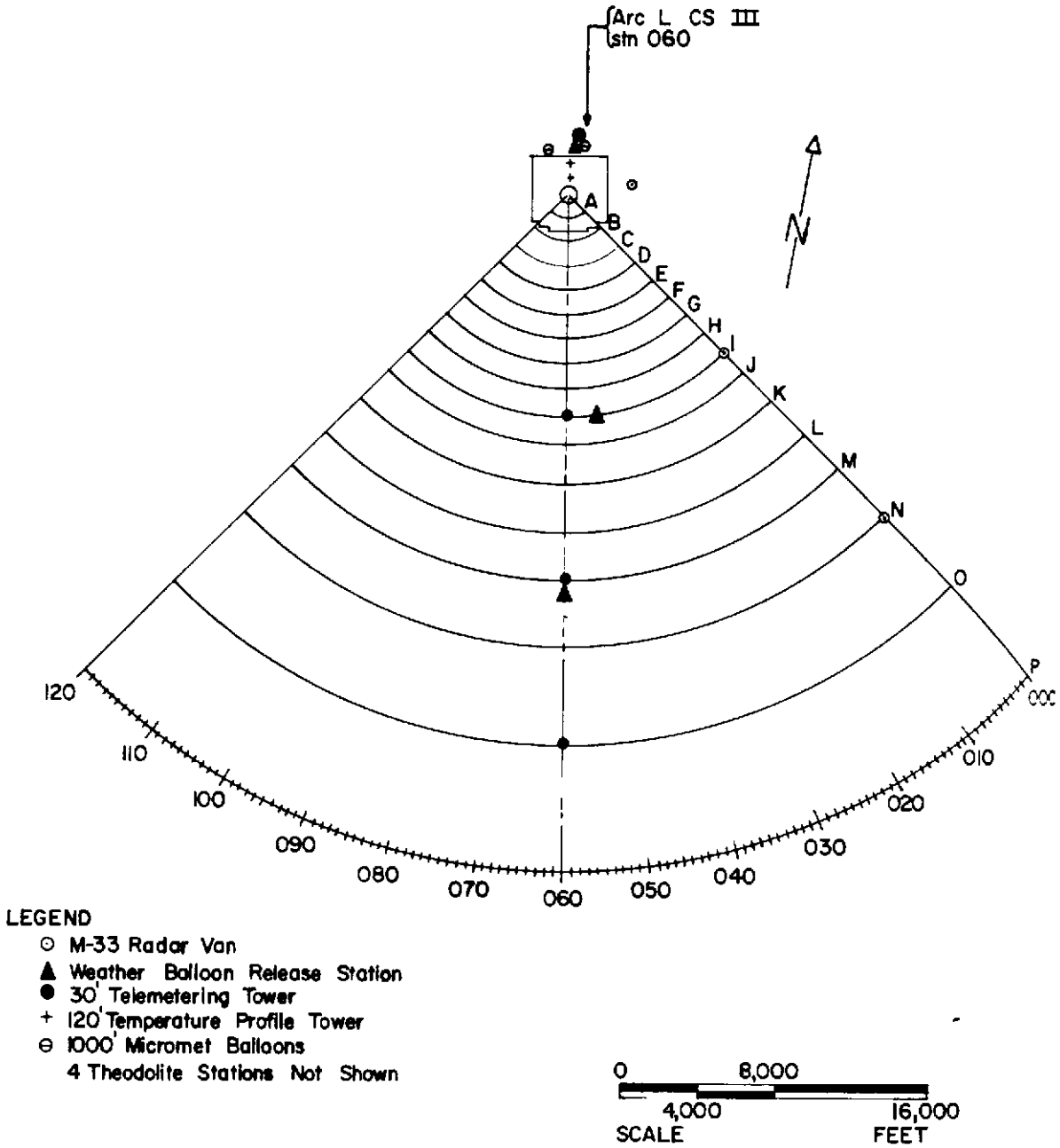


Figure 2.2 Clean Slate I array diagram.

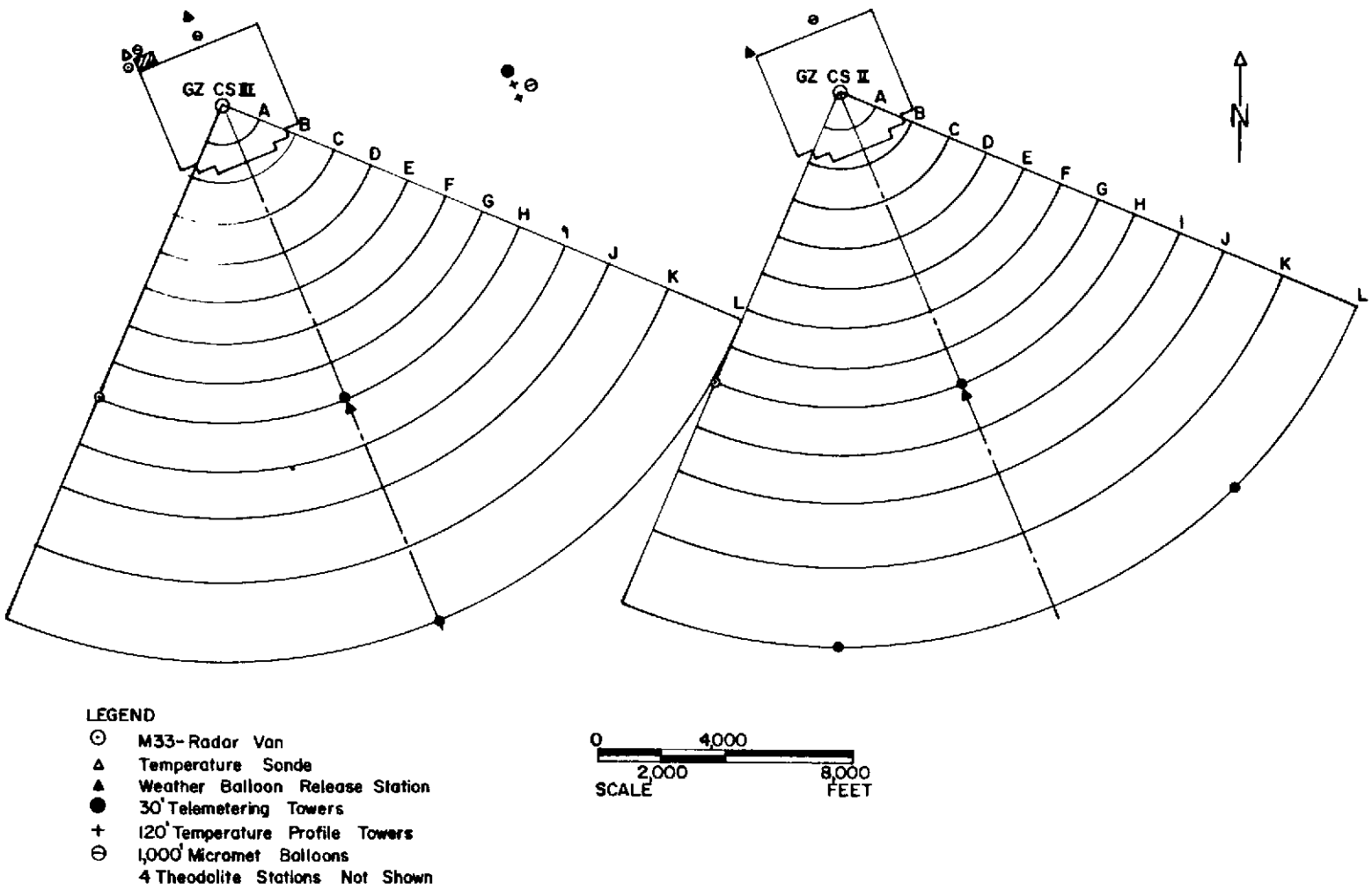


Figure 2.3 Clean Slate II and III array diagrams.

Chapter 3

RESULTS AND DISCUSSION

3.1 DATA PRESENTATION

Raw data is summarized in Appendixes B through F by event and type of instrumentation. The data is appended as documentation of the actual meteorological parameters during each event period.

3.2 DISCUSSION

Weather Synopsis, April 1 to June 10, 1963. The two words which best described April 1963 at the Tonopah Test Range were wet and cold. The month was one of the coldest on record and had an above normal amount of precipitation, some of which occurred as snow to a depth of several inches. Temperatures for the month over western Nevada ran six and more degrees below normal. As might be expected these conditions were associated with an increased frequency of frontal systems passing through the area. Tonopah Airport recorded eleven days with precipitation, Goldfield, Nevada, recorded nine, and Tonopah Test Range recorded five days. The average wind speed of 9 knots for the winds as recorded at the Sandia Weather Station on the Tonopah Test Range was indicative of the wind conditions for the month.

May continued the wet cycle started in April with scattered shower activity all month. The April through May period was one of the wettest of record for western Nevada. Temperatures moderated after mid-month, giving near normal readings for the period. Average wind speed as recorded at the Sandia Weather Station was 8 knots, only slightly below the April average.

June arrived with temperatures again below normal at the Tonopah Test Range and a continuation of shower activity. This was the pattern until June 9th and the end of the series. The summer regime was beginning to assert itself and winds in general moderated but strong gusty winds associated with shower and thundershower activity continued as a hazard to tethered balloon operations.

3.2.1 Event Weather. Surface weather maps and 10,000-foot MSL streamline charts for each event are contained in Appendix E.

3.2.2 Double Tracks (0255 PDT 15 May 1963). Winds as reported at the pilot balloon sites showed a light, occasionally moderate, northerly flow in the first few thousand feet above the surface prior to shot time. However, winds over Stonewall Flat remained in the 10 to 19 knot range all through the night. This can be attributed partly to channeling over the pass to the north of ground zero and the katabatic effect as the air descended into Stonewall Flat and partly to augmenting of the drainage flow by the prevailing synoptic situation. The moderate winds produced turbulent mixing which prevented any appreciable surface inversion from forming near ground zero; however, the first thousand feet above the surface was nearly isothermal for this same reason.

Stonewall Flat stations some 300 feet lower than ground zero showed the effects of the pooling of cold air as the night progressed and the air stabilized and stratified. Winds from the surface anemometers at Arcs O, Q, and R became quite light and variable, giving evidence of several eddies forming in the lowest layers over the dry lakes with cool air spilling out occasionally through the pass toward Lida Junction. The conditions persisted with the eddy layer increasing in depth until almost 0300, when winds in the layers near 6,000 feet MSL increased by several knots and the apparent coupling with the downward flux of momentum reduced the depth of this eddy layer which finally disappeared.

Wind direction shear at ground zero in the first 3,000 feet above the surface was approximately 20 to 30 degrees through the night.

3.2.3 Clean Slate I (0416 PDT 25 May 1963). Through the night the gross scale winds-aloft features, as shown by the off-site pilot balloon runs and radar wind soundings, exhibited a consistent north-northwesterly flow from approximately 330 degrees near the surface backing slightly to the northwest between 290 to 300 degrees at 8,000 feet MSL with a sharp shift above that level to a southwesterly flow. Wind shear in the layers of interest was about 10 to 20 degrees. Wind speeds ranged from 10 to 17 knots.

As cooling and stratification of the air mass progressed through the night, the drainage flow from the long alluvial slopes to the east of the event array produced a northeasterly wind in the lowest levels near the surface.

Cooling continued at all levels on the UK thermistor string until after shot time. An

inversion of almost five degrees Celsius through a layer approximately 600 feet deep existed at shot time.

Radar No. 1 near ground zero was knocked out by blast damage at shot time and no further runs were taken from it. Several runs from Radar No. 2 were aborted because the radar reflector passed too close to the balloon array and the radar jumped target to the array wires.

3.2.4 Clean Slate II (0347 PDT 31 May 1963). During this night, winds at all levels to 10,000-feet MSL were light. Near shot time winds to about 6,000 feet MSL were west-northwesterly with a sharp shift to northerly at that level and above to the 8,000-foot MSL level where the wind again backed into the northwest.

Surface winds responded to the drainage winds from the slopes to the east, producing northerly flow in the very lowest levels. Shear due to the light wind situation was highly variable from 30 to more than 60 degrees.

Cloudiness developed for a period during the night. This inhibited the radiational cooling, producing only a thin inversion of approximately one and a half degrees Celsius between the surface and 100 feet. A nearly isothermal layer existed above it to about 500 feet above the surface, with only a slight lapse in temperature through the remaining layer to 1,000 feet above the surface.

3.2.5 Clean Slate III (0330 PDT 9 June 1963). Below normal temperatures and a spring type regime persisted, even at this early summer date, giving the desired northerly flow over the Tonopah Test Range.

Pilot balloon and radar wind soundings showed strong northerly flow of 14 to 18 knots early in the evening. Near midnight, winds slowed and by shot time at 0330 PDT were quite light.

Shear in the first thousand feet above the surface was slightly less than 30 degrees with a backing wind from 330 degrees at the surface. Above 6,400 feet MSL, a sharp veering brought winds into the northeast near 010 degrees with shear in the next fifteen hundred feet of about 20 degrees. This upper shear zone had disappeared two hours after shot with winds at all levels from the northwest.

The wind shift zone was also the height of the inversion. Radiational cooling had affected a layer over one thousand feet deep by shot time with an inversion of about 5 degrees Celsius.

3.3 SUMMARY

Meteorological data of the detail required by the Roller Coaster events had never before been attempted at NTS. The requirement that this data be collected at night in a confined array and in a layer so near the surface and be presented continuously at the control point created sensing and communications problems not heretofore encountered.

With the exception of the remote release trailers which malfunctioned due to radio problems, all instruments operated satisfactorily. The M-33 radars, backbone of the documentation program, were required to operate continuously for long periods. This, combined with the ever-present dust which sifted into many of the electronic components, created critical maintenance problems especially during the latter stages of the series.

Seven field attempts, to finish the four Roller Coaster events, is considered near the minimal number which could be expected, considering the area of operation, the vagaries of weather in this area, the stringent shot meteorological conditions required, and the delays imposed by various factors which forced shots to be scheduled by other than meteorological conditions.

Chapter 4

CONCLUSIONS

Documentation was achieved for all essentially desired meteorological parameters. Data presented with this report is for each event of the series. However, much raw data, collected over the entire period of the project is available at the USWBRS, especially documentation of the surface wind patterns in the arrays.

As a by-product, much valuable information was gained on the problems to be encountered in micro-meteorological documentation of low-level winds and temperatures over remote desert valleys. This will prove useful for any future events under such similar conditions and weather regimes. Several new areas for instrument development and modification are now being explored by Weather Bureau Research Station, Las Vegas, in response to some of the problems encountered. For instance, the high cost of solid-wire telemetering has led to investigation of mobile radio-telemetered wind towers for use in such operations. The elements of mobility combined with those of ease of installation and maintenance are considered the most essential elements for any instrumentation used at remote locations.

Communications and visual display of data enabled the weather briefer to maintain constant contact with the weather situation as it pertained to the required shot contitions. This close watch on the meteorological situation enabled the event program to proceed on schedule.

Appendix A

EVENT INSTRUMENT LOCATIONS AND ELEVATIONS

(Elevations are feet MSL of ground at indicated locations.)

A.1 DOUBLE TRACKS

a. Location of M-33 Radar units:

(1) 3,000 feet east of GZ

(2) Arc L, Station 000

(3) Arc P, Station 000

b. Location of 30-foot telemetered towers:

(1) 525 feet north of GZ, 4,990 feet

(2) Midway between Arc J, Station 060 and Arc K, Station 060, 4,778 feet

(3) Arc O, Station 060, 4,647 feet

(4) Arc Q, Station 030, 4,742 feet

(5) Arc R, Station 096, 4,704 feet

c. Location of remote balloon release stations:

(1) 2,000 feet east of GZ, 5,050 feet

(2) Midway between Arc J, Station 060 and Arc K, Station 060, 4,778 feet

(3) Arc O, Station 060, 4,647 feet

d. Temperature sounding trailer was at the CP, located 3,000 feet northeast of ground zero, 5,050 feet

e. Location of pilot balloon sites

(1) Tonopah airport: 38° 04' N; 117° 04' W; 5,426 feet

(2) Lida Junction: 37° 30' N; 117° 11' W; 4,693 feet

(3) Sarcobatus Flat: 37° 16' N; 117° 02' W; 4,050 feet

(4) Cactus Flat: 37° 39' N; 116° 39' W; 5,400 feet

f. Meteorological towers: Two UK 120-foot towers located 225 feet (Tower 1) elevation 4,986 feet, and 825 feet (Tower 2) elevation 4,996 feet north of ground zero were mounted with UK instruments as follows:

Tower 1: lateral and vertical gustmeters at 30, 60, and 120-foot altitude

Tower 2: (1) lateral and vertical gustmeters at 30, 60, and 120-foot altitude;

(2) anemometers and wind vanes at 60- and 120-foot altitude.

g. Meteorological balloons: two UK balloons were located 3,000 feet from GZ on azimuths of 022° T and 338° T. One balloon was rigged with UK thermistors mounted every 100 feet to a height of 900 feet on the captive balloon cable. A vertical gustmeter was mounted at 250-foot altitude. Elevations of balloon trailers 5,075 feet and 5,030 feet.

A.2 CLEAN SLATE I

a. Location of M-33 Radar units:

(1) 3,000 feet east of GZ

(2) Arc I at Station 000

(3) Arc N at Station 000

b. Location of 30-foot telemetered towers:

(1) Arc O at Station 060: 5,384 feet

(2) Arc M at Station 060: 5,374 feet

(3) Arc I at Station 060: 5,350 feet

(4) Arc L at Station 060 of the Clean Slate III Array: 5,384 feet

c. Location of the radar balloon remote release stations:

(1) Arc M at Station 060: 5,374 feet

(2) Arc I at Station 049: 5,364 feet

(3) Arc L at Station 060 of the Clean Slate III Array: 5,384 feet

d. The temperature sonde trailer was at the CP located 3,000 feet northwest of the Clean Slate III ground zero: 5,380 feet

e. Location of pilot balloon sites:

(1) Base Camp, Operation Roller Coaster: 37° 43' N; 116° 44' W; 5,560 feet

(2) Wilson's Camp: 37° 32.5' N; 116° 40' W; 5,610 feet

(3) Highway 25 at: 37° 44' N; 116° 31' W; 5,680 feet

(4) Main Gate, Operation Roller Coaster: 37° 52' N; 116° 45' W; 5,350 feet

f. Meteorological towers: two UK-supplied 120-foot towers located 250 feet (Tower 1) and 850 feet (Tower 2) north of GZ along an extension of the array center

line were mounted with UK instruments as follows:

(1) Tower 1: elevation 5,381 feet. Lateral and vertical gustmeters were located at 30-, 60-, and 120-foot altitudes.

(2) Tower 2: elevation 5,381 feet. Lateral and vertical gustmeters were located at 30-, and 60-, and 120-foot altitudes. Anemometers and wind direction vanes were located at 60- and 120-foot altitudes.

(3) The gustmeter was a bridge-circuited potentiometer controlled by a wind vane and prepared to read the out-of-balance current depending upon the lateral or vertical wind deflection.

(4) The gustmeter on Tower 2 at 60-foot altitude failed to function.

g. Meteorological balloons: two United Kingdom balloons were located 2,500 feet from GZ on azimuth of 050° T and 315° T and one was rigged with UK thermistors mounted at the surface and every 100 feet to a height of 900 feet on the captive balloon cable. A vertical gustmeter was mounted at 250-foot altitude. Both balloons had ground elevations of 5,382 feet.

A.3 CLEAN SLATE II

a. Location of M-33 Radar units:

(1) CP complex, Clean Slate III

(2) Arc H, Station 120

b. Location of 30-foot telemetered towers:

(1) Arc L at Station 030; 5,538 feet

(2) Arc L at Station 090; 5,439 feet

(3) Arc H at Station 060; 5,489 feet

(4) A 30-foot level on the north 120-foot UK weather tower

(5) Arc L at Station 060 on Clean Slate III array 5,384 feet

c. Location of radar balloon remote release stations:

(1) 3,000 feet NW of ground zero: 5,509 feet

(2) Arc H at Station 060: 5,489 feet

d. The temperature sonde trailer was at the CP, located 3,000 feet northwest of the Clean Slate III ground zero.

e. Location of the pilot balloon sites:

(1) Roller Coaster Main Camp: 37° 43.8' N; 116° 44' W; 5,560 feet

(2) Wilson's Camp: 37° 32.5N; 116° 41' W; 5,610 feet

(3) Highway 25 at 47° 44' N; 116° 31' W; 5,680 feet

(4) Roller Coaster Main Gate: 37° 52' N; 116° 45' W; 5,350 feet

f. Meteorological towers: two UK-supplied 120-foot towers were located 500 feet apart on a north-south axis 37° 45.7' N and 116° 38.9' W and were mounted with UK instruments as follows:

(1) South tower: elevation 5,460 feet. Lateral and vertical gustmeters were located at 30-, 60-, and 120-foot altitudes.

(2) North tower: elevation 5,460 feet. Lateral and vertical gustmeters were located at 30-, 60-, and 120-foot altitudes. Anemometers and wind direction vanes were located at 60- and 120-foot altitudes.

g. Meteorological balloons: three UK-supplied balloons were flown. One was rigged with UK thermistors mounted every 100 feet to a height of 900 feet on the captive balloon cable. A vertical gustmeter was mounted at 250-foot altitude. Elevation of balloon trailers 5,376 feet for trailer at ground zero and 5,460 for trailers near UK towers.

A.4 CLEAN SLATE III

a. Location of M-33 Radar units:

(1) CP complex

(2) Arc H at Station 120

b. Location of the 30-foot telemetered towers:

(1) Arc H at Station 060; 5,390 feet

(2) Arc L at Station 060; 5,384 feet

(3) At 30-foot level on north 120-foot UK weather tower

c. Location of the radar balloon remote release stations:

(1) 300 feet, 338° T from ground zero; 5,380 feet

(2) Arc H at Station 060; 5,390 feet

d. The temperature sonde trailer was at the CP located 3,000 feet northwest of the Clean Slate III ground zero; 5,380 feet

e. Location of the pilot balloon sites:

(1) Roller Coaster Main Camp: 37° 43' N; 116° 44' W; 5,560 feet.

(2) Wilson's Camp: 37° 32.5' N; 116° 40' W; 5,610 feet

(3) Highway 25 at: 37° 44' N; 116° 31' W; 5,680 feet

(4) Roller Coaster Main Gate: 37° 52' N; 116° 45' W; 5,350 feet

f. Meteorological towers: two UK-supplied 120-foot towers were located 500 feet apart on a north-south axis at 37° 45.7' N and 116° 38.9' W and were mounted with UK instruments as follows:

(1) South tower: elevation 5,460 feet. Lateral and vertical gustmeters were located at 30-, 60-, and 120-foot altitudes.

(2) North tower: elevation 5,460 feet. Lateral and vertical gustmeters were located at 30-, 60-, and 120-foot altitudes. Anemometers and wind direction vanes were located at 60- and 120-foot altitudes.

g. Meteorological balloons: Two United Kingdom balloons were located at the Clean Slate II CP complex 3,000 feet northwest of ground zero and at 37° 45.7' N and 116° 38.9' W. The CP balloon was rigged with UK thermistors mounted every 100 feet to a height of 900 feet on the captive balloon cable. A vertical gustmeter was mounted at 250-foot altitude. Elevation of balloon trailers: 5,376 feet.

Appendix B

EVENT RADAR WIND PROFILES

Description: a. Intervals are given in minutes and seconds after balloon release. Nominal release times head each data column.

b. Mean layer winds are given from the surface to 6,000 feet MSL and from the surface to 8,000 feet MSL.

c. Balloon ascension rates are given in feet per minute for the radar nearest ground zero.

d. Heights are given above MSL.

e. Directions are in degrees True and speeds in knots.

OPERATION:

DATE: May 1

INTERVAL	
0:15	
0:30	
0:45	
1:00	
1:15	
1:30	
1:45	
2:00	
2:15	
2:30	
2:45	
3:00	
3:15	
3:30	
3:45	
4:00	
4:15	
4:30	
4:45	
M.S.W. FT.MSL	SFC- SFC-
ASC. RATES F.P.M.	

INTERVAL	H
0:15	
0:30	
0:45	
1:00	
1:15	
1:30	
1:45	
2:00	
2:15	
2:30	
2:45	
3:00	
3:15	
3:30	
3:45	
4:00	
4:15	
M.L.W. FT.MSL	SFC-6 SFC-7
ASC. RATES F.P.M.	

DOUBLE TRACES
RADAR UPPER AIR DATA

OPERATION: ROLLER COASTER PLACE: Stonewall Flat - Radar One

DATE: May 15, 1963 Remote Release 2000 Ft. East of G. Z. Height 5050 MSL

	0130 PDT			0200 PDT			0215 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5150	360	12	5200	357	15	5150	009	12
0:30	5290	356	16	5380	343	17	5300	350	16
0:45	5380	335	17	5520	342	16	5400	338	16
1:00	5490	321	20	5720	333	18	5550	339	16
1:15	5570	331	20	5860	332	20	5730	341	17
1:30	5710	333	16	5950	338	16	5840	333	17
1:45	5820	333	16	6060	339	16	5940	333	16
2:00	5920	333	16	6210	339	16	6070	337	16
2:15	6030	336	14	6330	340	15	6210	337	15
2:30	6130	342	15	6420	342	14	6320	334	15
2:45	6250	345	15	6560	346	15	6430	340	15
3:00	6370	348	14	6710	354	14	6600	345	15
3:15	6510	346	15	6880	003	14	6740	351	14
3:30	6600	347	16	7000	015	14	6900	356	13
3:45	6720	349	15				7050	008	10
4:00	6860	357	14						
4:15	7000	008	13						
4:30									
4:45									
M.S.W.	SFC-6000	338	17		340	17		344	16
FT.MSL	SFC-7000	342	15		346	16		344	15
ASC. RATES F.P.M.		470			591			580	

	0240 PDT			0300 PDT			0315 PDT			0330 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5350	356	13	5230	358	16	5240	003	15	5210	354	16
0:30	5480	350	14	5340	353	18	5360	347	16	5350	356	16
0:45	5590	348	16	5450	346	16	5470	345	16	5420	351	16
1:00	5730	343	18	5590	344	16	5600	343	17	5540	346	17
1:15	5890	338	18	5720	336	17	5740	346	22	5700	344	19
1:30	6080	339	20	5830	336	19	5910	343	20	5830	345	19
1:45	6220	338	20	5980	340	19	6010	345	16	5920	349	18
2:00	6330	340	18	6100	342	19	6170	353	15	6030	351	16
2:15	6510	346	16	6180	343	16	6320	358	14	6190	353	16
2:30	6650	346	15	6300	346	15	6420	005	13	6310	357	12
2:45	6790	354	14	6420	360	16	6570	007	15	6410	360	14
3:00	6910	006	12	6510	009	15	6680	005	15	6570	005	14
3:15	7100	009	14	6620	011	14	6810	005	15	6660	008	14
3:30				6720	010	15	6930	005	15	6780	011	14
3:45				6840	011	15	7100	011	10	6920	021	10
4:00				6980	010	15				7100	022	09
4:15				7120	010	15						
M.L.W.	SFC-6000	343	16		344	19		347	18		349	18
FT.MSL	SFC-7000	348	15		353	17		354	16		355	16
ASC. RATES F.P.M.		635			488			578			500	

DOUBLE TRACKS
RADAR UPPER AIR DATA

OPERATION: ROLLER COASTER PLACE: Stonewall Flat - Radar One

DATE: May 15, 1963 Remote Release 2000 Ft. East of G.Z. - Height 5050 MSL

	0345 PDT			0400 PDT			0430 PDT			0500 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5200	006	16	5230	010	18	5150	019	16	5200	020	13
0:30	5310	356	16	5380	355	17	5220	015	15	5410	005	12
0:45	5410	355	15	5500	349	15	5350	007	14	5540	344	14
1:00	5510	344	16	5630	347	14	5500	354	13	5720	335	15
1:15	5620	346	19	5800	348	16	5600	343	14	5850	338	14
1:30	5820	353	16	5940	348	16	5710	345	14	6000	341	14
1:45	5900	353	20	6030	355	16	5820	353	14	6100	348	14
2:00	6010	358	19	6180	360	16	5990	357	14	6280	354	15
2:15	6110	357	15	6320	003	14	6100	355	15	6410	358	14
2:30	6270	360	14	6400	010	14	6230	356	14	6550	360	12
2:45	6390	015	14	6510	016	15	6320	359	14	6640	003	10
3:00	6500	018	14	6660	022	15	6460	360	15	6780	002	09
3:15	6620	017	15	6740	021	14	6620	006	14	6900	004	10
3:30	6700	018	15	6870	020	14	6720	013	13	7100	014	10
3:45	6870	022	13	6990	027	14	6860	014	12			
4:00	7010	022	10	7200	030	10	6970	017	14			
M.L.W.	SFC-6000	355	18		357	17		001	14		352	13
FT.MSL	SFC-7000	002	15		003	15		360	14		353	13
ASC. RATES F.P.M.		478			525			468			606	

OPERATION: ROLLER COASTER PLACE: Stonewall Flat - Radar Two

DATE: May 15, 1963 Remote Release Midway Between Arc J Stn 060 and Arc K Stn 060
Height 4778 MSL

	0130 PDT			0200 PDT			0215 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	4860	352	08	4840	353	07	4920	357	08
0:30	4960	353	07	4980	353	11	5050	040	06
0:45	5050	355	09	5060	351	11	5220	025	07
1:00	5190	341	07	5180	353	11	5410	349	12
1:15	5350	317	09	5310	352	13	5530	344	12
1:30	5480	328	08	5420	343	12	5730	340	12
1:45	5680	336	08	5530	336	12	5870	339	13
2:00	5820	328	10	5640	337	09	6000	338	15
2:15	6020	333	12	5720	333	12	6120	336	16
2:30	6110	337	12	5900	332	13	6270	337	16
2:45	6250	327	13	6010	330	15	6350	341	17
3:00	6430	328	14	6160	332	17	6490	340	17
3:15	6610	335	15	6240	336	16	6620	339	16
3:30	6790	338	14	6360	332	14	6800	340	16
3:45	6910	343	12	6520	333	14	6900	340	15
4:00	7020	348	10	6700	336	14	7000	344	16
4:15				6830	335	14			
4:30				6940	336	13			
4:45				7110	336	12			

DOUBLE TRACKS
RADAR UPPER AIR DATA

OPERATION: ROLLER COASTER PLACE: Stonewall Flat - Radar Two

DATE: May 15, 1963 Remote Release Midway Between Arc J Stn 060 and Arc K Stn 060
Height 4778 MSL

	0400 PDT			0430 PDT			0500 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	4810	017	12	4860	007	10	4830	357	08
0:30	4870	012	13	5000	013	11	4920	013	08
0:45	4980	360	13	5150	016	12	4980	017	11
1:00	5030	006	13	5240	016	12	5090	009	11
1:15	5280	355	15	5370	010	10	5270	008	11
1:30	5380	346	13	5470	360	11	5370	004	12
1:45	5510	345	13	5580	353	09	5500	354	10
2:00	5630	343	13	5690	349	12	5630	339	09
2:15	5710	344	13	5840	350	13	5750	337	09
2:30	5890	348	14	5950	349	14	5870	336	13
2:45	6040	358	14	6080	351	14	5990	335	13
3:00	6170	356	15	6190	002	13	6090	350	13
3:15	6300	360	15	6320	001	13	6220	348	13
3:30	6470	006	13	6460	009	13	6310	346	13
3:45	6590	017	12	6570	017	10	6430	356	13
4:00	6790	022	12	6670	024	09	6530	005	14

	0230 PDT			0245 PDT			0330 PDT			0345 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	4850	357	08	4820	355	10	4840	003	10	4860	354	13
0:30	4980	006	07	4920	006	11	4910	006	09	4980	360	12
0:45	5110	009	10	5000	003	11	5010	354	11	5060	020	08
1:00	5200	354	13	5300	344	12	5070	347	11	5140	347	12
1:15	5330	336	11	5380	343	13	5180	336	12	5360	341	13
1:30	5450	336	12	5530	342	13	5300	331	09	5470	342	13
1:45	5560	340	12	5670	333	12	5410	329	08	5600	342	13
2:00	5660	328	13	5810	332	12	5570	330	10	5710	340	13
2:15	5800	329	13	5940	335	14	5660	344	13	5870	344	13
2:30	5880	335	13	6100	335	16	5800	345	14	5980	345	13
2:45	6010	335	15	6230	340	16	5860	345	13	6110	348	12
3:00	6150	338	17	6360	345	16	5910	343	12	6260	002	12
3:15	6270	340	17	6470	347	13	6010	344	14	6350	004	12
3:30	6380	344	16	6620	349	10	6100	344	13	6470	004	13
3:45	6510	344	13	6760	002	10	6190	341	11	6560	004	12
4:00	6700	348	13	6860	019	08	6260	352	12	6720	004	11
4:15	6820	350	13	7000	020	10						
4:30	6950	350	12									
4:45	7100	350	12									

DOUBLE TRACKS
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Stonewall Flat - Radar Three

DATE: May 15, 1963 Remote Release Point Arc 0 Stn 060 Height 4647 MSL

INTERVAL	0130 PDT HEIGHT	DIR	SPD	0200 PDT HEIGHT	DIR	SPD	0215 PDT HEIGHT	DIR	SPD
0:15	4780	CALM		4800	142	03	4750	CALM	
0:30	4850	CALM		4900	013	02	4920	351	04
0:45	4950	352	06	4980	356	04	5020	357	05
1:00	5100	349	07	5070	353	06	5100	356	05
1:15	5150	350	06	5180	356	06	5200	349	08
1:30	5250	334	05	5300	354	06	5300	344	07
1:45	5400	329	08	5400	343	08	5400	348	09
2:00	5450	328	09	5510	330	09	5500	335	09
2:15	5550	328	09	5680	328	08	5600	330	08
2:30	5650	329	11	5850	328	08	5700	325	07
2:45	5780	333	13	5980	329	08	5810	308	09
3:00	5900	332	14	6180	335	10	5920	318	07
3:15	6050	335	14	6380	340	13	6100	332	09
3:30	6100	337	14	6550	347	13	6280	331	11
3:45	6250	335	15	6700	349	13	6490	335	13
4:00	6400	336	14	6850	346	14	6590	341	15
4:15	6510	342	13	7000	345	09	6700	344	13
4:30	6620	344	13				6800	342	14
4:45	6780	343	13				6950	346	13
5:00	6890	343	12						
5:15	7000	344	12						

INTERVAL	0230 PDT HEIGHT	DIR	SPD	0245 PDT HEIGHT	DIR	SPD	0250 PDT HEIGHT	DIR	SPD	0305 PDT HEIGHT	DIR	SPD
0:15	4800	023	02	4760	360	06	4780	014	08	4760	017	03
0:30	4900	006	03	4870	357	07	4930	033	07	4840	027	06
0:45	4950	358	06	5000	357	08	4980	013	09	4900	031	08
1:00	5100	351	10	5100	360	09	5020	004	10	5000	025	08
1:15	5200	353	09	5200	356	08	5120	357	09	5080	007	08
1:30	5300	346	09	5300	342	09	5200	356	09	5140	357	08
1:45	5450	347	09	5420	323	08	5320	343	09	5200	353	08
2:00	5550	329	08	5590	304	05	5420	324	08	5250	344	07
2:15	5680	317	06	5680	314	06	5560	323	07	5320	328	08
2:30	5800	322	05	5880	343	08	5650	323	06	5400	331	09
2:45	5900	330	07	6040	339	08	5780	321	06	5500	327	10
3:00	6000	332	10	6250	341	12	5900	325	08	5600	324	09
3:15	6150	335	15	6400	340	12	6020	325	10	5700	328	08
3:30	6250	342	15	6600	342	13	6150	326	11	5800	318	09
3:45	6400	345	16	6800	343	16	6280	336	13	5900	324	12
4:00	6560	345	16	6950	349	15	6400	341	15	6000	330	12
4:15	6700	346	13									
4:30	6850	350	14									
4:45	6950	351	14									
5:00	7070	351	14									

DOUBLE TRACKS
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Stonewall Flat - Radar Three

DATE: May 15, 1963 Remote Release Point Arc 0 Stn 060 Height 4647 MSL

	0315 PDT			0400 PDT			0430 PDT			0500 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	4750	015	03	4780	027	06	4780	355	03	4740	041	02
0:30	4850	006	04	4880	029	05	4900	352	05	4840	004	05
0:45	5000	004	07	4970	023	07	5020	004	09	4960	347	07
1:00	5100	358	09	5090	018	09	5170	017	11	5080	337	12
1:15	5200	344	08	5200	010	09	5300	009	11	5170	346	11
1:30	5290	340	07	5310	349	09	5420	345	11	5260	004	12
1:45	5400	314	08	5410	330	07	5500	336	11	5360	349	11
2:00	5500	308	12	5510	333	08	5610	337	12	5470	338	12
2:15	5630	328	10	5630	336	09	5690	337	13	5630	342	13
2:30	5780	325	11	5740	336	09	5820	342	12	5740	336	12
2:45	5880	326	12	5900	341	10	5930	348	12	5860	335	13
3:00	6030	334	13	6020	347	12	6070	345	12	6000	340	12
3:15	6160	344	13	6120	350	12	6290	350	12	6100	340	11
3:30	6280	346	13	6240	351	12	6320	360	13	6210	345	16
3:45	6410	341	13	6400	346	13	6480	003	14	6360	345	13
4:00	6520	344	13	6510	355	13	6660	006	12	6510	350	12
4:15				6670	357	13	6770	006	11	6620	003	11
4:30				6760	002	13	6900	006	12	6760	002	12
4:45				6890	009	12	7030	008	13	6870	004	13
5:00				7060	010	12				7030	014	12

CLEAN SLATE ONE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: May 25, 1963 Remote Release Point CS3 Arc L Stn 060 Height 5384 MSL

	0305 PDT			0325 PDT			0345 PDT			0400 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5490	337	12	5460	310	09	5500	300	10	5510	301	08
0:30	5640	335	14	5500	304	10	5610	297	09	5590	315	09
0:45	5720	335	14	5640	320	10	5660	315	10	5670	334	10
1:00	5820	336	14	5710	331	12	5770	324	12	5740	337	12
1:15	5900	336	14	5800	332	14	5850	329	14	5810	335	14
1:30	6000	336	15	5880	330	14	5950	332	14	5910	336	13
1:45	6120	330	15	5950	330	15	6060	328	14	6000	335	15
2:00	6260	328	16	6050	327	15	6150	328	15	6110	334	15
2:15	6370	330	16	6160	333	15	6280	330	16	6240	331	16
2:30	6470	330	16	6260	334	15	6360	328	16	6350	330	16
2:45	6600	331	15	6360	336	16	6490	328	16	6430	332	16
3:00	6760	329	15	6460	335	15	6590	330	15	6580	332	16
3:15	6870	328	15	6560	330	15	6730	330	15	6700	329	16
3:30	6990	325	14	6700	330	14	6840	328	15	6840	329	16
3:45	7100	325	14	6810	329	14	6920	325	14	6920	329	15
4:00	7200	323	14	6930	328	14	7020	324	14	7020	331	14
4:15	7340	316	14	7040	329	14	7120	324	15	7130	332	14
4:30	7440	309	14	7140	329	14	7240	324	15	7260	331	14
4:45	7580	300	12	7240	328	15	7350	323	14	7380	328	14
5:00	7720	288	12	7360	327	15	7460	324	14	7480	328	13
5:15	7890	278	10	7490	318	14	7590	327	14	7610	327	12
5:30	8040	274	10	7610	305	12	7700	325	14	7740	327	12
5:45				7750	300	10	7820	304	14	7870	319	10
6:00				7890	298	10	7940	299	12	8000	301	10
6:15				8040	279	10	8090	298	09	8120	297	08
6:30				8150	275	10	8210	293	10	8260	283	10
6:45				8270	279	10	8380	281	10	8400	283	10
7:00				8310	278	10						
M.L.W.	SFC-6000	335	13		324	11		320	11		328	11
FT.MSL	SFC-8000	323	13		324	13		325	13		327	13
ASC. RATES F.P.M.		484			419			441			444	

CLEAN SLATE ONE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: May 24, 1963 Remote Release Point Arc L Stn 060 Height 5384 MSL

INTERVAL	0415 PDT HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5420	313	06									
0:30	5550	314	10									
0:45	5700	325	11									
1:00	5760	331	10									
1:15	5850	330	12									
1:30	5940	330	14									
1:45	6040	331	14									
2:00	6170	333	15									
2:15	6300	331	15									
2:30	6410	324	16									
2:45	6920	322	16									
(Radar Failure)												
M.L.W.	SFC-6000	326	10									
FT.MSL	SFC-8000	—	—									
ASC RATES F.P.M.		404										

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Two

DATE: May 25, 1963 Remote Release Point Arc I Stn 049 Height 5364 MSL

INTERVAL	0400 PDT HEIGHT	DIR	SPD	0415 PDT HEIGHT	DIR	SPD	0445 PDT HEIGHT	DIR	SPD	0505 PDT HEIGHT	DIR	SPD
0:15	5490	299	07	5500	329	07				5440	004	03
0:30	5590	311	08	5590	329	08	Range			5570	325	03
0:45	5710	333	10	5700	327	10				5680	314	04
1:00	5780	342	12	5820	327	12	not set			5800	317	06
1:15	5860	335	14	5930	328	13				5870	328	09
1:30	6000	335	14	6090	327	15				6010	328	10
1:45	6090	336	14	6190	328	15	5980			6100	328	10
2:00	6200	340	15	6300	328	16	6060	333	12	6220	327	11
2:15	6300	339	16	6400	326	16	6160	327	12	6320	321	12
2:30	6410	334	15	6520	326	17	6270	322	14	6400	324	12
2:45	6500	334	18	6650	325	17	6370	324	12	6500	323	10
3:00	6600	335	16	6720	325	17	6440	321	12	6600	318	11
3:15	6700	336	14	6850	328	16	6560	316	14	6710	331	09
3:30	6830	335	15	7000	328	14	6650	321	13	6810	323	10
3:45	6910	335	13	7100	331	14	6770	322	10	6920	315	10
4:00	7080	335	13	7210	329	13	6880	328	11	7030	315	10
4:15	7180	338	13	7330	331	12	6990	325	10	7140	316	13
4:30	7300	339	12	7460	332	12	7130	310	08	7260	313	12
4:45	7390	338	12	7580	334	12	7240	289	08	7360	314	11
5:00	7510	335	12	7700	323	11	7400	308	08	7510	308	10
5:15	7610	328	10	7810	308	08	7490	304	08	7590	307	10
5:30	7730	315	09	7990	306	07	7600	305	08	7710	308	09
5:45	7880	305	09	8090	300	07	7770	286	08	7840	296	07
6:00	7970	291	08	8200	292	05	7890	274	07	8000	290	05
6:15	8100	280	07	8330	285	04	8060	272	06	8110	280	05
6:30	8220	277	06	8500	280	04	8200	262	05	8250	278	05
6:45	8360	268	05				8320	255	05	8350	264	05
7:00	8490	250	05				8510	252	05	8490	253	05
7:15										8600	250	05

CLEAN SLATE ONE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Two

DATE: May 25, 1963 Remote Release Point Arc I Stn 049 Height 5364 MSL

	0530 PDT			0600 PDT								
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5510	334	03	5550	327	03						
0:30	5590	314	04	5710	331	06						
0:45	5700	308	04	5910	332	07						
1:00	5810	341	06	6070	336	08						
1:15	5910	337	08	6240	332	10						
1:30	6050	335	08	6380	334	10						
1:45	6140	334	10	6530	337	12						
2:00	6250	329	12	6690	329	12						
2:15	6370	331	11	6890	335	08						
2:30	6500	330	09	7020	334	09						
2:45	6580	333	08	7200	310	08						
3:00	6700	335	10	7400	290	05						
3:15	6810	335	10	7550	303	05						
3:30	6910	336	09	7740	300	05						
3:45	7040	338	09	7890	285	06						
4:00	7150	325	10	8020	256	05						
4:15	7290	325	09	8200	236	04						
4:30	7400	323	09	8370	225	04						
4:45	7530	308	08	8540	222	05						
5:00	7610	298	07									
5:15	7800	321	04									
5:30	7910	315	04									
5:45	8080	309	04									
6:00	8190	304	03									
6:15	8340	282	03									
6:30	8490	280	03									

CLEAN SLATE ONE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Three

DATE: May 25, 1963 Remote Release Point Arc M Stn 060 Height 5374 MSL

CLEAN SLATE ONE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Three

DATE: May 25, 1963 Remote Release Point Arc M Stn 060 Height 5374 MSL

	0305 PDT			0325 PDT			0345 PDT			0400 PDT			0415 PDT SHOT			0430 PDT			0530 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5610	339	08	5620	348	08	5610	335	09	5620	340	08	5650	346	09	5650	343	07	5610	335	05
0:30	5700	335	08	5700	338	11	5700	324	10	5700	340	09	5800	333	08	5720	330	08	5670	335	05
0:45	5800	334	08	5900	328	13	5800	309	10	5790	340	10	5900	310	08	5800	332	09	5720	335	05
1:00	5920	308	09	6000	333	13	5850	314	11	5900	340	10	6000	326	11	5900	339	11	5800	326	05
1:15	5980	314	12	6100	330	14	6000	322	13	6000	340	12	6100	331	14	6000	336	13	5900	316	06
1:30	6050	333	14	6200	332	14	6100	328	14	6120	340	13	6200	331	15	6090	335	13	5920	338	07
1:45	6120	336	15	6300	333	16	6200	330	16	6220	340	15	6350	331	16	6190	335	14	6000	351	08
2:00	6200	339	16	6400	336	18	6300	333	16	6330	340	15	6500	331	18	6300	327	15	6100	337	09
2:15	6250	341	16	6520	336	17	6390	337	16	6480	340	17	6600	331	18	6400	335	16	6200	337	09
2:30	6300	339	16	6620	337	16	6500	340	17	6590	340	17	6700	331	17	6500	334	16	6250	337	09
2:45	6400	340	16	6750	337	15	6600	338	18	6680	340	16	6800	331	17	6600	325	15	6300	337	10
3:00	6480	335	17	6850	337	14	6690	335	17	6800	340	15	6950	342	16	6700	336	15	6400	333	11
3:15	6520	335	15	6950	336	14	6800	331	16	6900	340	15	7050	343	14	6800	337	14	6500	334	10
3:30	6600	338	15	7060	336	14	6900	329	15	7050	340	14	7150	340	13	6940	338	13	6600	344	10
3:45	6670	344	16	7200	335	13	7000	336	15	7120	340	13	7300	333	14	7050	339	12	6700	345	10
4:00	6720	337	16	7300	328	13	7100	334	15	7220	340	14	7400	332	13	7150	346	11	6800	336	10
4:15	6800	337	15	7450	320	12	7200	328	13	7450	335	13	7530	340	13	7300	348	10	6900	336	10
4:30	6890	333	15	7550	315	10	7300	330	13	7550	333	12	7620	332	11	7400	330	09	6980	336	10
4:45	6980	336	16	7720	295	10	7400	325	13	7680	332	12	7730	319	11	7520	310	09	7050	336	11
5:00	7050	333	14	7830	280	10	7500	317	11	7790	316	11	7480	328	09	7620	303	09	7150	328	10
5:15	7100	339	14	8000	292	09	7680	309	10	7900	308	10	8030	310	08	7740	295	08	7220	317	11
5:30	7200	332	14	8130	291	07	7800	305	09	8050	297	09	8190	282	07	7850	285	09	7300	327	10
5:45	7280	316	15	8290	268	07	7900	299	09	8220	281	08	8320	275	07	8030	274	08	7450	322	09
6:00	7380	314	11	8420	258	06	8050	293	09	8330	281	08	8500	274	06	8160	276	08	7550	322	09
6:15	7500	306	12	8530	261	05	8170	286	08	8450	274	08				8300	267	07	7600	320	08
6:30	7550	305	12				8300	280	08							8450	255	05	7700	315	07
6:45	7620	305	11				8400	277	08										7800	316	07
7:00	7730	299	10				8550	278	08										7900	311	07
7:15	7800	300	11																8000	311	07
7:30	7900	298	12																8100	311	06
7:45	8020	300	10																8200	284	05
8:00	8100	292	09																8300	269	03
8:15	8250	293	09																8400	266	02
8:30	8300	287	08																8500	251	03
8:45	8400	280	07																		
9:00	8520	268	06																		

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: May 31, 1963 Remote Release - 3000' NW of G.Z. Height 5509 MSL

INTERVAL	0215 PDT HEIGHT	DIR	SPD	0235 PDT HEIGHT	DIR	SPD	0330 PDT HEIGHT	DIR	SPD	0345 PDT HEIGHT	DIR	SPD	0400 PDT HEIGHT	DIR	SPD	0415 PDT HEIGHT	DIR	SPD	0430 PDT HEIGHT	DIR	SPD
0:15	5650	040	05	5690	CALM		5660	316	05	5700	395	06	5710	332	05	5740	CALM		5680	306	06
0:30	5740	062	06	5780	325	04	5730	315	05	5780	338	06	5830	322	06	5860	335	08	5760	358	05
0:45	5830	020	05	5990	302	06	5810	313	06	5870	323	08	5930	319	14	5980	317	12	5950	340	06
1:00	5920	355	04	6120	311	05	5950	303	14	6050	293	14	6050	304	14	6110	294	12	6100	300	10
1:15	6050	357	05	6250	313	06	6100	304	14	6150	292	14	6100	290	14	6200	297	10	6190	293	12
1:30	6200	305	06	6300	296	08	6300	306	12	6220	297	13	6180	303	10	6350	317	08	6250	302	10
1:45	6290	280	08	6350	298	10	6350	303	12	6250	300	10	6250	302	06	6480	309	05	6310	295	06
2:00	6390	303	06	6500	314	06	6430	302	08	6330	306	09	6300	303	05	6580	329	04	6430	305	05
2:15	6520	319	06	6550	326	05	6540	319	05	6420	306	06	6400	301	05	6690	007	03	6520	312	05
2:30	6580	330	06	6690	318	06	6680	322	04	6540	297	04	6500	291	04	6800	008	02	6600	324	05
2:45	6680	330	06	6800	352	05	6730	334	03	6650	318	04	6600	301	02	6900	010	02	6740	320	05
3:00	6750	349	05	6900	001	05	6830	335	04	6750	343	03	6690	020	04	7000	001	02	6820	311	03
3:15	6890	351	06	6970	351	05	6920	332	06	6800	003	04	6790	004	05	7080	344	04	6920	316	03
3:30	6940	334	08	7080	342	06	7020	332	06	6890	345	04	6890	343	05	7230	360	04	6990	338	03
3:45	7030	335	06	7210	339	06	7150	320	05	6950	345	04	6980	341	04	7300	008	02	7100	350	02
4:00	7150	328	08	7300	333	05	7250	319	04	7050	348	03	7060	325	04	7430	002	02	7200	343	02
4:15	7240	333	06	7410	340	04	7390	323	04	7100	344	03	7200	340	04	7540	004	04	7310	353	02
4:30	7370	346	06	7500	334	06	7490	348	05	7200	359	04	7290	360	03	7630	007	04	7410	360	02
4:45	7460	344	06	7600	322	06	7590	360	04	7290	357	04	7400	012	03	7740	007	04	7500	350	02
5:00	7550	330	07	7720	316	05	7720	357	04	7330	360	03	7450	010	03	7850	357	04	7610	340	02
5:15	7680	334	07	7820	277	05	7810	349	04	7420	305	04	7580	007	04	7960	353	04	7770	348	03
5:30	7780	324	10	7910	277	06	7950	349	05	7500	352	04	7650	010	03	8110	330	04	7860	344	03
5:45	7850	313	10	8000	288	06	8040	356	04	7550	355	04	7790	004	03	8210	314	06	7990	342	05
6:00	7960	311	09	8190	290	06	8170	348	05	7690	341	06	7920	346	03	8370	321	04	8100	332	03
6:15	8050	308	07	8240	283	06	8250	331	04	7750	344	06	8080	337	04	8500	313	04	8180	334	05
6:30	8180	321	05	8330	275	06	8400	326	06	7860	338	06	8190	328	04				8290	327	05
6:45	8290	298	04	8480	276	08	8490	325	06	7960	329	05	8350	331	04				8400	307	05
7:00	8410	298	04	8600	276	06	8600	324	06	8050	337	06	8480	336	05				8540	309	05
7:15	8510	298	04							8160	321	06	8650	336	04						
7:30										8250	305	06									
7:45										8400	316	04									
8:00										8480	318	04									
M.L.W.	SFC-6000	029	05		313	04		314	07		311	09		322	09		323	09		320	05
FT.MSL	SFC-8000	336	07		319	06		320	06		321	05		321	04		331	04		320	04
ASC. RATES F.P.M.		418			442			442			372			435			481			434	

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: May 31, 1963 Remote Release - 3000' NW of G.Z. Height 5509 MSL

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: May 31, 1963 Remote Release - 3000' NW of G.Z. Height 5509 MSL

	0445 PDT			0515 PDT			0545 PDT					
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5700	305	06	5690	351	04	5650	332	04			
0:30	5760	329	07	5780	335	05	5700	280	06			
0:45	5820	320	06	5820	323	06	5800	294	04			
1:00	5930	298	14	5920	339	07	5900	026	04			
1:15	6100	298	14	6070	338	10	5970	355	05			
1:30	6200	306	11	6190	331	12	6070	355	06			
1:45	6270	300	14	6280	335	10	6170	337	08			
2:00	6400	304	08	6400	328	10	6250	314	10			
2:15	6500	310	05	6550	330	08	6320	321	10			
2:30	6600	313	05	6620	315	05	6470	315	10			
2:45	6700	300	06	6730	312	05	6580	310	09			
3:00	6790	319	04	6830	338	06	6620	325	05			
3:15	6890	334	03	6960	329	06	6720	325	05			
3:30	7010	322	05	7040	333	05	6850	322	06			
3:45	7040	334	04	7150	329	05	6940	322	08			
4:00	7200	360	04	7300	338	04	7020	323	07			
4:15	7290	360	03	7380	360	02	7150	322	07			
4:30	7380	360	02	7490	345	02	7270	311	06			
4:45	7480	003	02	7590	330	04	7370	295	06			
5:00	7590	002	02	7720	343	04	7480	293	05			
5:15	7700	345	04	7810	345	03	7580	290	05			
5:30	7790	330	06	7900	355	05	7690	305	04			
5:45	7890	322	06	8090	347	05	7780	327	04			
6:00	8020	313	05	8160	325	06	7900	287	04			
6:15	8150	300	06	8270	323	06	8020	288	03			
6:30	8250	291	06	8380	322	05	8130	301	03			
6:45	8360	292	06	8500	322	04	8180	302	02			
7:00	8470	303	06				8340	305	01			
7:15	8630	292	05				8510	305	01			
M.L.W.	SFC-6000	310	08		340	06		322	03			
FT.MSL	SFC-8000	319	05		333	06		318	06			
ASC. RATES F.P.M.		430			443			415				

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Two

DATE: May 31, 1963 Remote Release Arc H - Stn 060 Height 5490 MSL

	0215 PDT			0230 PDT			0245 PDT			0300 PDT			0315 PDT			0330 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5640	027	04	5610	350	04	5610	350	01	5640	317	03	5640	296	04	5600	327	09
0:30	5790	350	06	5770	320	07	5710	309	06	5790	310	07	5760	298	09	5720	308	10
0:45	5910	328	08	5900	316	08	5820	308	07	5910	312	10	5860	310	10	5840	307	10
1:00	6100	318	10	6050	315	08	5990	312	07	6080	315	10	6000	309	10	5960	312	10
1:15	6220	318	10	6180	310	11	6100	311	08	6190	323	08	6120	311	08	6080	318	12
1:30	6350	322	09	6310	307	12	6210	310	10	6310	335	05	6240	314	05	6200	311	11
1:45	6490	328	08	6430	314	09	6330	310	09	6460	352	05	6380	322	05	6320	310	08
2:00	6650	334	08	6600	325	07	6450	314	08	6600	360	06	6540	340	05	6490	312	07
2:15	6780	346	08	6710	337	07	6600	328	06	6730	347	07	6670	338	06	6620	325	06
2:30	6890	343	08	6820	342	07	6720	348	07	6860	341	07	6790	333	06	6740	346	06
2:45	7020	341	09	6930	338	08	6840	347	08	6990	339	06	6890	330	06	6860	344	07
3:00	7150	335	11	7050	332	08	6990	336	08	7100	328	07	7030	331	06	7000	334	05
3:15	7290	333	10	7170	335	07	7100	335	07	7210	325	07	7130	320	07	7100	334	03
3:30	7400	334	10	7290	338	07	7200	329	07	7320	340	06	7250	319	07	7210	338	03
3:45	7520	334	09	7400	341	08	7330	322	07	7450	330	06	7370	320	05	7330	341	04
4:00	7640	328	09	7500	335	08	7450	328	08	7580	314	07	7490	330	05	7450	335	04
4:15	7780	320	10	7620	320	09	7560	333	09	7700	293	08	7600	328	05	7570	334	04
4:30	7910	315	08	7780	315	08	7690	328	08	7860	286	07	7700	323	07	7690	334	05
4:45	8050	298	06	7910	306	07	7810	324	07	8010	282	06	7810	320	08	7810	336	05
5:00	8200	277	04	8090	297	06	7950	311	06	8180	276	05	7960	317	08	7920	340	05
5:15	8330	273	05	8250	283	05	8090	305	06	8330	274	07	8080	315	06	8030	338	06
5:30	8500	269	05	8400	273	05	8230	294	05	8530	272	07	8210	314	07	8140	337	07
5:45				8580	245	05	8380	274	05				8320	316	07	8250	336	08
6:00							8580	265	05				8470	298	08	8370	329	08
6:15													8620	287	08	8510	322	07

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Two

DATE: May 31, 1963 Remote Release Arc H Stn 060 Height 5490 MSL

*First Minute Doubtful

CLEAN SLATE TWO
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar Two

DATE: May 31, 1963 Remote Release Arc H Stn 060 Height 5490 MSL

*First Minute Doubtful

	0345 PDT			0400 PDT			0415 PDT			0445 PDT			0520 PDT			0545 PDT		
INTERVAL	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD	HEIGHT	DIR	SPD
0:15	5650	308	02	5630	295	03	5630	012	07*	5640	040	02	5620	347	07	5610	062	02
0:30	5810	295	08	5720	313	07	5790	306	11*	5780	320	08	5780	327	06	5700	037	01
0:45	5980	305	12	5810	304	10	5980	292	20*	5890	303	11	5880	315	08	5770	006	02
1:00	6120	306	13	5900	297	13	6110	299	15*	6000	306	11	6000	321	10	5850	345	03
1:15	6290	304	11	5990	302	12	6220	316	08	6100	305	12	6120	325	10	5950	337	06
1:30	6460	324	10	6080	303	08	6330	315	05	6200	307	10	6260	328	09	6050	332	08
1:45	6640	338	06	6170	304	07	6440	317	04	6300	309	09	6400	329	08	6150	321	08
2:00	6800	329	05	6260	303	08	6560	343	04	6400	308	08	6560	318	05	6250	320	07
2:15	6980	325	05	6350	308	07	6690	340	04	6520	310	07	6680	330	03	6350	317	09
2:30	7110	342	05	6430	308	06	6800	354	04	6650	310	06	6780	334	03	6450	312	10
2:45	7290	343	04	6520	312	06	6900	360	04	6760	314	05	6890	332	04	6550	317	10
3:00	7420	360	04	6620	354	06	7020	350	04	6870	327	04	7030	333	04	6660	323	10
3:15	7600	353	03	6710	332	04	7150	353	05	7000	347	04	7140	328	03	6750	317	10
3:30	7760	343	03	6800	332	03	7250	351	04	7100	328	05	7250	336	03	6860	310	09
3:45	7910	338	05	6890	020	03	7380	360	05	7210	337	04	7360	334	03	6970	306	08
4:00	8090	328	06	7000	359	03	7490	360	04	7330	007	03	7500	329	03	7080	304	07
4:15	8230	318	07	7080	008	04	7600	327	06	7430	345	04	7640	334	02	7170	305	04
4:30	8410	306	07	7150	357	04	7710	328	05	7550	347	04	7800	336	04	7260	302	04
4:45	8600	285	06	7240	345	03	7820	327	05	7650	007	03	7920	333	04	7360	300	04
5:00				7330	008	03	7950	320	05	7760	350	03	8050	330	04	7450	297	03
5:15				7420	006	03	8070	317	05	7860	340	04	8200	320	06	7550	284	03
5:30				7510	344	04	8200	315	04	7980	335	05	8310	314	06	7640	281	02
5:45				7580	344	05	8310	300	04	8090	328	06	8480	315	07	7730	290	02
6:00				7690	342	05	8480	280	04	8200	324	07	8620	314	07	7830	294	03
6:15				7780	340	06	8610	280	04	8300	321	07				7920	310	05
6:30				7880	328	07				8400	311	08				8010	313	06
6:45				7970	323	06				8500	308	07				8100	309	06
7:00				8060	318	06										8220	292	05
7:15				8160	311	06										8260	286	05
7:30				8260	287	04										8340	293	06
7:45				8360	261	05										8510	294	06
8:00				8500	259	05												

CLEAN SLATE THREE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: June 9, 1963 Remote Release - 3000' 338° True from G.Z. Height MSL

INTERVAL	0200 PDT HEIGHT	DIR	SPD	0215 PDT HEIGHT	DIR	SPD	0230 HEIGHT	DIR	SPD	0245 PDT HEIGHT	DIR	SPD	0300 PDT HEIGHT	DIR	SPD	0315 PDT HEIGHT	DIR	SPD	SHOT RUN 0327 PDT HEIGHT	DIR	SPD
0:15	5490	335	06	5480	327	05	5480	314	06	5470	325	05	5500	343	04	5500	325	04	5460	330	06
0:30	5610	329	07	5540	325	06	5560	325	08	5580	316	06	5600	329	05	5600	331	05	5570	320	06
0:45	5770	291	07	5660	320	06	5700	320	08	5700	309	06	5750	327	06	5710	323	06	5660	326	06
1:00	5890	273	06	5810	281	04	5790	310	06	5820	316	06	5830	328	07	5810	314	06	5780	320	08
1:15	6010	270	05	5920	267	03	5900	283	05	5900	315	08	5910	329	07	5880	315	07	5900	309	09
1:30	6110	261	05	6030	288	03	6030	267	05	6000	301	05	6050	323	03	6000	330	05	6020	306	05
1:45	6230	267	05	6120	272	03	6130	274	04	6110	290	05	6130	300	02	6100	335	04	6130	310	04
2:00	6360	302	04	6230	270	03	6240	348	02	6200	286	04	6260	340	03	6210	337	03	6220	326	01
2:15	6560	347	04	6350	341	04	6400	035	03	6300	258	01	6350	022	04	6340	037	03	6320	328	01
2:30	6720	345	04	6460	358	03	6510	029	03	6410	CALM		6430	022	04	6450	035	04	6490	028	03
2:45	6940	018	07	6590	019	05	6640	029	04	6530	010	04	6570	017	04	6590	030	05	6590	014	04
3:00	7020	020	08	6660	029	06	6720	030	06	6610	020	04	6670	026	05	6710	015	05	6700	013	05
3:15	7160	034	07	6790	023	06	6880	025	06	6720	012	04	6790	018	05	6850	017	04	6800	013	05
3:30	7250	034	06	6930	021	06	6980	021	06	6850	007	05	6930	012	05	6950	031	04	6960	011	04
3:45	7370	022	09	7090	021	06	7100	023	06	6950	015	05	7010	027	05	7100	037	05	7030	011	04
4:00	7510	010	09	Locked			7230	020	04	7040	018	06	7130	027	06	7210	029	06	7200	021	04
4:15							7330	030	04	7190	020	06	7220	022	08	7380	025	06	7300	030	06
4:30				on			7420	024	04	7290	022	06	7340	012	08	7480	031	07	7400	030	06
4:45							7510	024	04	7370	020	08	7450	018	09	7600	015	08	7500	023	06
5:00				U K Balloon						7510	022	07	7600	019	09						
M.L.W.	SFC-6000	306	07		311	05		310	06		318	06		332	05		320	05		318	06
ASC. RATES F.P.M.		524			457			450			427			444			464			446	

CLEAN SLATE THREE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: June 9, 1963 Remote Release - 3000' 338° True from G.Z. Height 5380 MSL

CLEAN SLATE THREE
RADAR UPPER AIR DATA

OPERATION: ROLLERCOASTER PLACE: Cactus Flat - Radar One

DATE: June 9, 1963 Remote Release - 3000' 338° True from G.Z. Height 5380 MSL

INTERVAL	0337 PDT HEIGHT	DIR	SPD	0352 PDT HEIGHT	DIR	SPD	0415 PDT HEIGHT	DIR	SPD	0430 PDT HEIGHT	DIR	SPD	0500 PDT HEIGHT	DIR	SPD	0530 PDT HEIGHT	DIR	SPD
0:15	5450	328	06	5440	332	06	5450	324	05	5450	330	06	5490	342	05	5500	337	05
0:30	5550	330	06	5580	345	06	5540	324	06	5490	334	06	5560	342	06	5600	341	06
0:45	5690	331	06	5680	339	06	5640	337	08	5590	338	08	5650	344	06	5700	333	06
1:00	5790	317	08	5790	330	07	5790	329	07	5650	350	07	5690	345	06	5780	334	06
1:15	5900	316	08	5860	327	08	5860	305	06	5740	342	10	5730	350	06	5900	351	06
1:30	5960	322	06	5930	310	06	5970	313	07	5830	320	10	5800	352	09	5980	360	07
1:45	6090	307	04	6090	297	05	6060	323	07	5890	310	09	5880	345	12	6080	348	06
2:00	6200	309	01	6140	317	04	6160	319	05	5990	321	08	5930	335	09	6180	318	06
2:15	6310	349	03	6230	347	03	6250	343	03	6050	331	06	6040	320	06	6250	314	05
2:30	6400	008	03	6350	347	03	6350	356	03	6130	321	05	6120	332	06	6350	322	05
2:45	6500	013	04	6460	353	04	6450	356	04	6210	324	03	6190	330	06	6470	341	05
3:00	6630	016	04	6540	002	04	6590	357	04	6320	360	02	6290	317	05	6600	360	03
3:15	6720	005	04	6660	356	05	6670	355	04	6410	352	03	6390	335	04	6650	293	03
3:30	6850	004	05	6740	360	04	6800	031	04	6480	339	04	6480	347	05	6800	274	03
3:45	6970	017	04	6880	015	05	6920	034	03	6610	350	05	6500	330	05	6950	318	03
4:00	7040	029	05	7000	020	04	7000	022	04	6690	344	04	6650	338	05	7030	347	04
4:15	7190	032	05	7080	024	04	7120	025	05	6900	349	03	6700	343	05	7170	343	04
4:30	7250	027	05	7210	020	05	7210	012	05	6930	045	01	6840	340	05	7300	341	04
4:45	7400	007	06	7300	019	05	7360	009	05	7010	034	02	6950	CALM		7410	330	04
5:00	7500	001	06	7420	011	06	7410	005	04	7140	018	04	7030	CALM		7500	311	04
5:15				7530	010	07	7610	005	04	7240	010	06	7110	348	03			
5:30										7330	012	05	7280	345	04			
5:45										7420	002	05	7350	343	06			
6:00										7550	353	06	7440	355	06			
6:15													7510	360	06			
M.L.W.	SFC-6000	323	06		330	06		323	07		332	08		342	07		343	05
ASC. RATES F.P.M.		425			428			439			361			331			425	

Appendix C

EVENT TOWER WIND PROFILES

DOUBLE TRACKS

May 14 through 15, 1963

Wind data whole degrees and miles per hour
Wind speeds: average wind and high gust for previous 15 minutes

Meteorological tower data, 30-foot towers

PDT	G.Z.		STN 060 ARC J&K		STN 090 ARC 'R'		STN 060 ARC 'OH'		STN 030 ARC 'QUE'	
TIME	DIR	SPD	DIR	SPD	DIR	SPD	DIR	SPD	DIR	SPD
0200	355	13/16	360	06/09	250	03/05	230	02/05	170	03/05
0215	355	13/15	035	04/15	280	03/05	090	02/05	255	04/06
0230	360	12/14	045	08/15	280	04/06	270	03/04	250	05/07
0245	360	12/14	015	07/11	315	02/07	320	04/06	245	07/09
0300	350	12/15	360	05/10	080	02/05	110	05/08	300	03/06
0315	340	13/16	015	06/10	100	03/05	090	02/05	270	01/03
0330	350	12/15	025	04/09	125	02/05	315	02/03	205	02/04
0345	355	14/18	015	07/10	070	03/07	090	02/05	240	02/03
0400	355	15/19	025	09/14	090	03/08	035	03/05	240	03/06
0415	360	15/18	035	09/14	090	04/07	100	03/06	300	02/04
0430	005	13/18	025	05/08	090	08/10	135	01/03	190	01/03
0445	350	11/15	350	08/10	085	06/08	280	02/05	225	03/05
0500	355	11/14	360	08/10	090	03/05	290	02/04	300	02/05
0255	**Shot Data 2 Min Avg 0254 - 0256 PDT**									
0255	355	12/14	350	05/09	080	02/05	110	05/07	320	02/03

	UK Tower 60 feet		UK Tower 120 feet	
0200	015	16/19	010	17/20
0215	015	16/19	010	16/18
0230	010	15/18	010	14/16
0245	010	14/16	005	14/17
0300	015	14/17	005	15/17
0315	020	16/20	015	17/20
0330	010	17/20	010	17/19
0345	015	18/20	010	18/20
0400	015	19/21	005	19/21
0415	005	19/22	360	20/22
0430	005	19/21	355	18/20
0445	010	18/22	355	15/18
0500	010	17/21	355	14/16

CLEAN SLATE ONE

May 24 through 25, 1963

Wind data degrees/miles per hour
Wind speeds: average wind and high gust for previous 15 minutes

Meteorological tower data, 30-foot towers

PDT TIME	CS#3 ARC 'L' 060 G. Z. DIR	SPD	STN 060 ARC 'I' DIR	SPD	STN 060 ARC 'M' DIR	SPD	STN 060 ARC 'O' DIR	SPD
0300	030	02/04	360	04/06	355	05/11	010	05/07
0315	015	03/05	025	03/07	030	04/05	015	05/08
0330	020	03/05	045	04/05	030	04/05	045	04/05
0345	025	02/04	020	05/05	030	03/05	050	03/05
0400	025	03/05	005	04/05	040	03/05	080	04/05
0415	020	03/05	025	05/05	045	04/05	065	04/05
0430	055	04/07	030	05/06	045	03/05	065	03/06
0445	060	05/07	030	06/06	060	03/05	080	04/05
0500	060	05/06	050	06/06	060	03/05	090	04/05
0515	055	04/06	055	05/06	110	02/03	085	03/05
0530	055	04/05	060	03/04	180	02/03	085	02/03
0545	060	04/04	070	02/04	195	02/02	155	02/03
0600	050	02/04	240	01/03	215	02/03	190	03/03
0416 SHOT DATA 2 Min Avg 0415 - 0417 PDT								
0416	055	03/05	020	05/05	015	05/05	055	03/04

	UK Tower 60 feet		UK Tower 120 feet	
0300	345	05/07	315	05/08
0315	320	06/07	310	07/09
0330	335	05/07	315	07/08
0345	335	05/06	305	07/08
0400	330	05/06	310	06/08
0415	355	05/07	320	07/08
0430	020	05/07	340	05/06
0445	035	06/07	360	04/05
0500	025	05/07	355	04/05
0515	035	05/06	005	03/04
0530	020	05/06	005	03/04
0545	010	05/06	355	03/04
0600	360	04/05	335	03/03
0615	020	03/04	320	03/04
0630	050	03/04	360	02/03
0645	VAR	02/03	VAR	02/02
0700	VAR	02/03	VAR	02/03

CLEAN SLATE TWO

May 30 through 31, 1963

Wind data degrees/miles per hour
Wind speeds: average wind and high gust for previous 15 minutes

Meteorological tower data, 30-foot towers

PDT TIME	U.K. TOWER DIR	U.K. TOWER SPD	STN 060 ARC 'H' DIR	STN 060 ARC 'H' SPD	STN 030 ARC 'L' DIR	STN 030 ARC 'L' SPD	STN 090 ARC 'L' DIR	STN 090 ARC 'L' SPD	STN 060-CS#3 ARC 'L' DIR	STN 060-CS#3 ARC 'L' SPD
0300	320	03/05	034	03/05	010	03/05	020	03/05	025	05/07
0315	345	02/04	040	03/04	055	03/04	325	05/06	360	03/04
0330	010	04/06	025	02/03	050	04/05	320	05/07	330	04/06
0345	335	04/07	360	04/05	050	04/05	320	05/06	335	05/07
0400	345	04/05	050	04/06	075	05/07	030	05/06	330	05/06
0415	340	04/05	060	05/07	080	05/06	055	06/08	330	05/07
0430	010	03/05	080	05/06	075	05/06	040	05/06	340	05/07
0445	360	05/09	085	04/07	090	03/05	050	04/05	325	05/07
0500	345	06/08	090	04/07	225	02/05	045	04/06	045	03/05
0515	050	03/05	050	03/05	055	05/09	345	05/09	015	05/08
0530	035	05/08	045	05/07	090	04/08	015	04/08	340	05/08
0545	355	05/06	060	03/05	145	04/05	320	03/06	035	04/06
0348	SHOT DATA Three Min Avg 0345 - 0348									
0348	340	04/05	360	04/04	070	05/06	005	04/05	335	04/05

	UK Tower 60 feet		UK Tower 120 feet	
0300	295	04/05	305	05/06
0315	320	05/06	320	06/06
0330	330	04/07	320	06/08
0345	320	06/07	310	08/08
0400	325	05/07	315	08/09
0415	325	05/07	315	08/09
0430	325	06/07	315	08/09
0445	330	07/08	315	09/10
0500	335	08/09	320	11/12
0515	020	06/08	355	07/10
0530	005	07/08	340	08/10
0545	340	07/08	325	08/10
0600	005	07/08	340	06/08
0615	025	06/07	025	06/07
0630	045	05/06	025	06/07
0645	030	05/06	005	05/06
0700	045	04/05	010	05/06

CLEAN SLATE THREE

June 8 through 9, 1963

Wind data degrees/miles per hour
Wind speeds: average wind and high gust for previous 15 minutes

Meteorological tower data, 30-foot towers

PDT TIME	U.K. TOWER DIR	U.K. TOWER SPD	STN 060 ARC 'H' DIR	STN 060 ARC 'H' SPD	STN 060 ARC 'L' DIR	STN 060 ARC 'L' SPD
0300	015	03/05	025	04/07	045	05/06
0315	005	04/06	040	03/06	055	04/05
0330	355	03/05	020	03/05	030	04/05
0345	330	04/06	015	04/06	020	05/07
0400	320	04/05	360	05/05	355	06/07
0415	325	04/05	330	04/05	345	03/06
0430	030	02/04	035	03/04	020	02/04
0445	345	02/04	360	04/06	350	04/06
0500	345	04/07	340	06/07	345	05/07
0515	010	05/08	340	06/07	345	05/07
0530	030	04/07	355	06/07	350	05/07

0330 SHOT DATA Three Min Avg

0330	355	03/05	020	03/05	030	04/05

	UK tower 60 feet		UK Tower 120 feet	
0300	357	03/04	335	04/06
0315	352	05/06	330	05/06
0330	360	05/06	345	05/05
0345	329	05/06	315	05/06
0400	320	05/06	320	05/06
0415	322	05/06	325	04/06
0430	315	04/06	305	05/06
0445	325	04/05	317	05/05
0500	342	04/05	337	04/05
0515	357	06/07	344	05/05
0530	015	04/06	330	04/05
0545	010	03/05	330	03/04
0600	005	03/03	332	03/04

Appendix D

H-HOUR TEMPERATURE SOUNDINGS (USWB) BY EVENT AND EVENT UK TEMPERATURE PROFILES

TEMPERATURE SOUNDINGS-GMD-1A

Each Event H-Hour

Height (MSL)	Pressure (mb)	Temperature (°C)
DOUBLE TRACKS (H-5 min)		
Sfc 5050	844	7.0
5410	832	7.3
6526	793	6.9
8627	738	3.8
9900	703	-0.7
CLEAN SLATE ONE (H-hour)		
Sfc 5380	835	5.6
5770	824	6.8
7280	777	5.3
8037	754	5.0
8694	736	3.2
9835	706	1.7
CLEAN SLATE TWO (H-hour)		
Sfc 5380	834	11.7
5625	826	14.7
8040	768	13.9
10,230	702	7.0
CLEAN SLATE THREE (H+15 min)		
Sfc 5380	833	6.4
5870	820	9.8
6000	804	10.2
6560	798	10.6
7000	774	9.0
8000	747	6.7

TEMPERATURE PROFILES UK BALLOON

BORNE THERMISTORS - DEGREES CELSIUS

EVENT: DOUBLE TRACKS

Height Feet Abv Sfc	Time - PDT 2320	0000	0030	0100	0130	0200	0215	0230	0300	0310	0340
Sfc	7.5	7.4	7.6	7.8	7.7	7.2	7.4	7.0	7.2	6.9	6.3
100	9.2	10.2	9.8	9.5	9.0	9.0	9.0	8.8	8.3	8.1	7.8
200	10.2	10.4	10.1	9.6	9.3	9.4	9.2	9.2	8.6	8.5	8.4
300	9.9	10.0	9.9	9.3	9.1	9.3	9.1	8.8	8.3	8.3	8.4
400	10.4	10.3	10.2	9.6	9.5	9.6	9.5	9.4	8.7	9.0	8.9
500	10.4	10.3	10.1	9.5	9.6	9.7	9.5	9.4	8.8	9.1	9.2
600	10.4	10.3	10.0	9.4	9.6	9.6	9.4	9.2	8.9	9.3	9.3
700	10.4	10.1	9.8	9.3	9.7	9.4	9.3	9.0	8.9	9.4	9.2
800	10.3	10.0	9.6	9.4	9.9	9.5	9.4	9.4	9.1	9.5	9.3
900	10.0	9.8	9.3	9.3	9.7	9.3	9.3	9.1	9.0	9.3	9.2

TEMPERATURE PROFILES UK BALLOON

BORNE THERMISTORS - DEGREES CELSIUS

EVENT: CLEAN SLATE ONE

Height Feet Abv Sfc	TIME - PDT 2100	2140	2200	2230	2300	2330	0020	0030
Sfc	14.8	13.2	12.6	11.5	10.7	11.0	10.1	10.1
100	15.0	13.6	13.4	12.9	11.7	11.3	11.2	10.9
200	14.9	13.8	13.5	13.2	11.9	11.7	11.5	11.4
300	14.6	13.9	13.6	13.3	11.9	12.2	11.6	11.5
400	14.8	14.2	13.9	13.6	12.5	12.9	11.9	11.8
500	14.4	13.7	13.3	13.0	12.1	12.7	11.4	11.2
600	14.4	13.6	13.4	12.8	12.3	12.8	12.9	11.5
700	14.2	13.2	12.9	12.5	12.1	12.5	12.9	11.7
800	13.9	13.0	12.7	12.2	12.0	12.2	12.0	11.9
900	13.7	12.5	12.2	11.7	11.5	11.6	11.7	11.6

	0100	0130	0140	0230	0300	0330	0345	0400
Sfc	10.0	10.0	10.0	9.5	8.0	6.7	6.7	6.5
100	10.9	10.6	10.5	10.1	9.5	9.3	8.9	8.9
200	11.1	10.8	10.6	10.3	9.5	9.6	9.1	9.1
300	11.3	11.1	11.0	10.6	9.7	9.9	9.7	9.9
400	11.8	12.1	11.9	11.6	10.4	10.9	10.7	10.6
500	11.2	11.3	11.5	11.2	10.5	10.6	10.3	10.3
600	11.4	11.8	11.5	11.1	10.6	10.6	10.6	10.6
700	11.5	11.5	11.3	11.0	10.5	10.4	10.4	10.3
800	11.5	11.4	11.1	10.8	10.3	10.2	10.3	10.2
900	11.1	10.8	10.5	10.2	9.8	9.2	9.7	9.7

TEMPERATURE PROFILES UK BALLOON

BORNE THERMISTORS - DEGREES CELSIUS

EVENT: CLEAN SLATE TWO

Height Feet Abv Sfc	Time - PDT 2230	2300	2330	0030	0100	0130	0215	0230	0245	0300 & 0330	0345
	16.2	15.2	15.5	16.5	15.5	15.0	13.5	14.5	14.0	14.0	13.5
100	19.2	18.7	17.0	16.5	16.0	16.0	15.0		15.5	15.5	15.0
200	22.7	22.2	19.0	17.0	17.0	16.5	16.5		17.0	17.0	17.0
300	25.7	25.7	22.0	17.5	17.5	18.0	18.0	Malfunction	18.5	18.5	19.0
400	29.2	29.2	25.5	18.3	18.5	19.5	20.0		20.5	20.5	21.0
500	32.9	32.9	29.0	19.0	19.5	21.0	21.5		22.5	22.5	23.0
600	37.4	32.9	29.0	19.5	20.0	22.0	23.0		24.0	24.0	24.5
700	40.9	36.9	32.5	19.5	20.5	23.0	25.0		25.5	25.5	26.0
800	43.9	40.6	35.5	19.5	20.5	23.5	26.5		27.0	27.0	27.5
900	46.9	44.3	38.3	19.5	20.5	24.0	28.0		28.5	28.5	29.0

TEMPERATURE PROFILES UK BALLOON

BORNE THERMISTORS - DEGREES CELSIUS

EVENT: CLEAN SLATE THREE

Height Feet Abv Surface	TIME - PDT 0315*
0	7.5
100	8.5
300	10.0
400	11.0
500	10.5
600	11.5
700	11.5
900	13.0

* NOTE: Only data available at this time

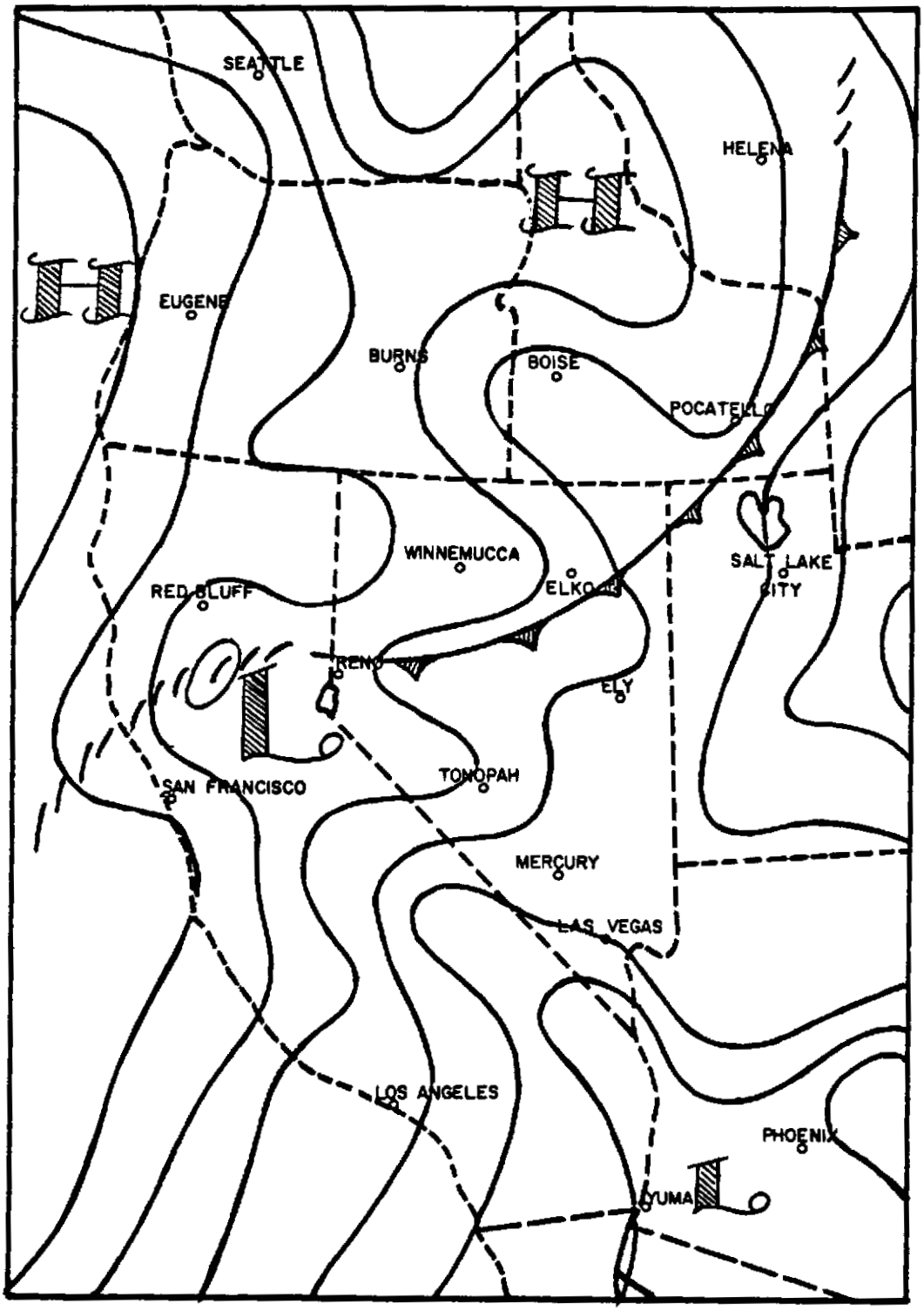
Appendix E

EVENT—V

SURFACE A
1000Z - 0
15 MAY 196

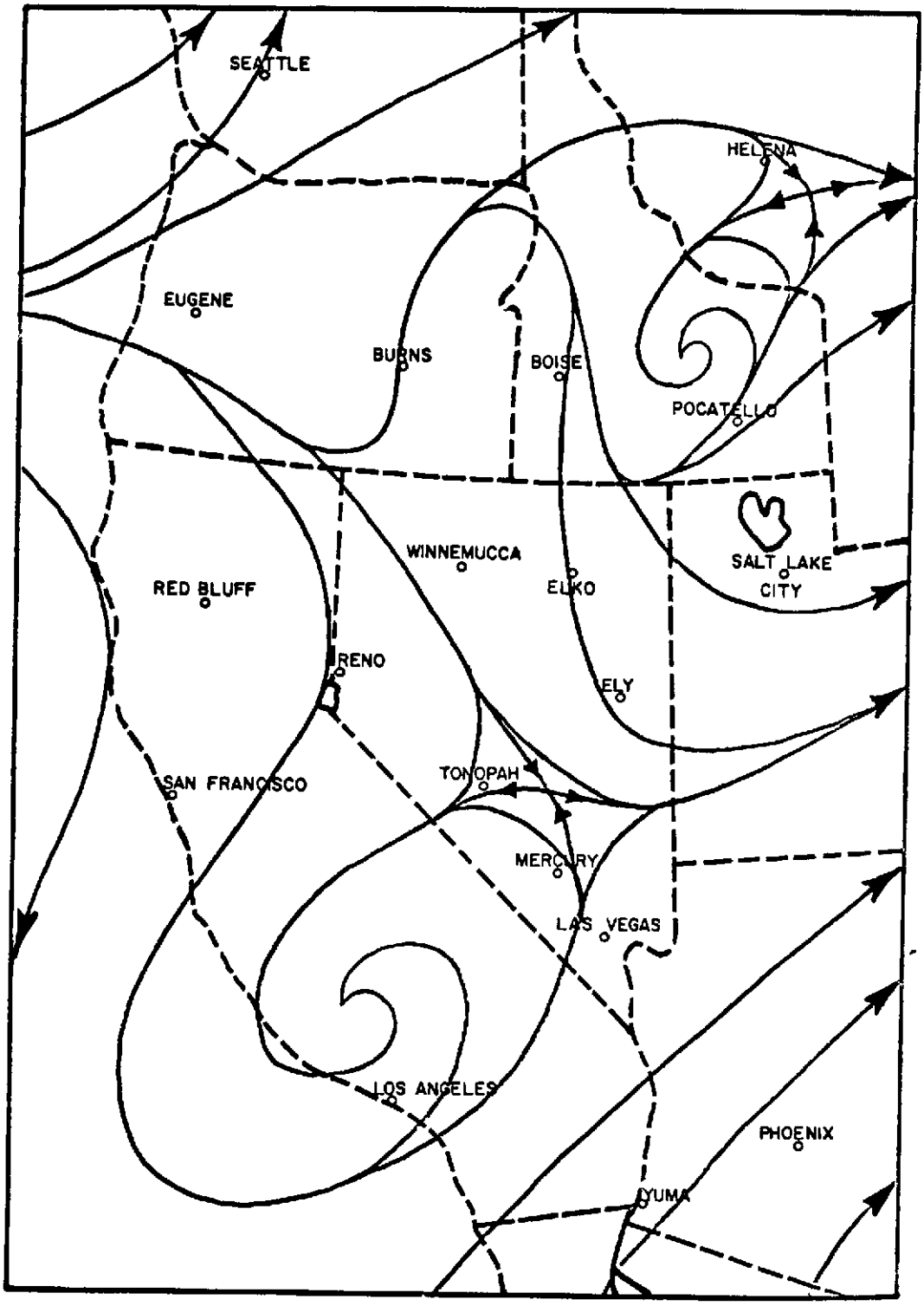
Appendix E

EVENT—WEATHER AND STREAMLINF MAPS



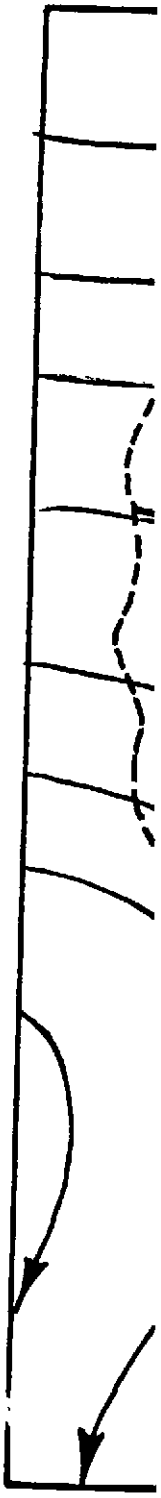
SURFACE ANALYSIS
1000Z - 0300PDT H hr.
15 MAY 1963

DOUBLE TRACKS
ROLLER COASTER

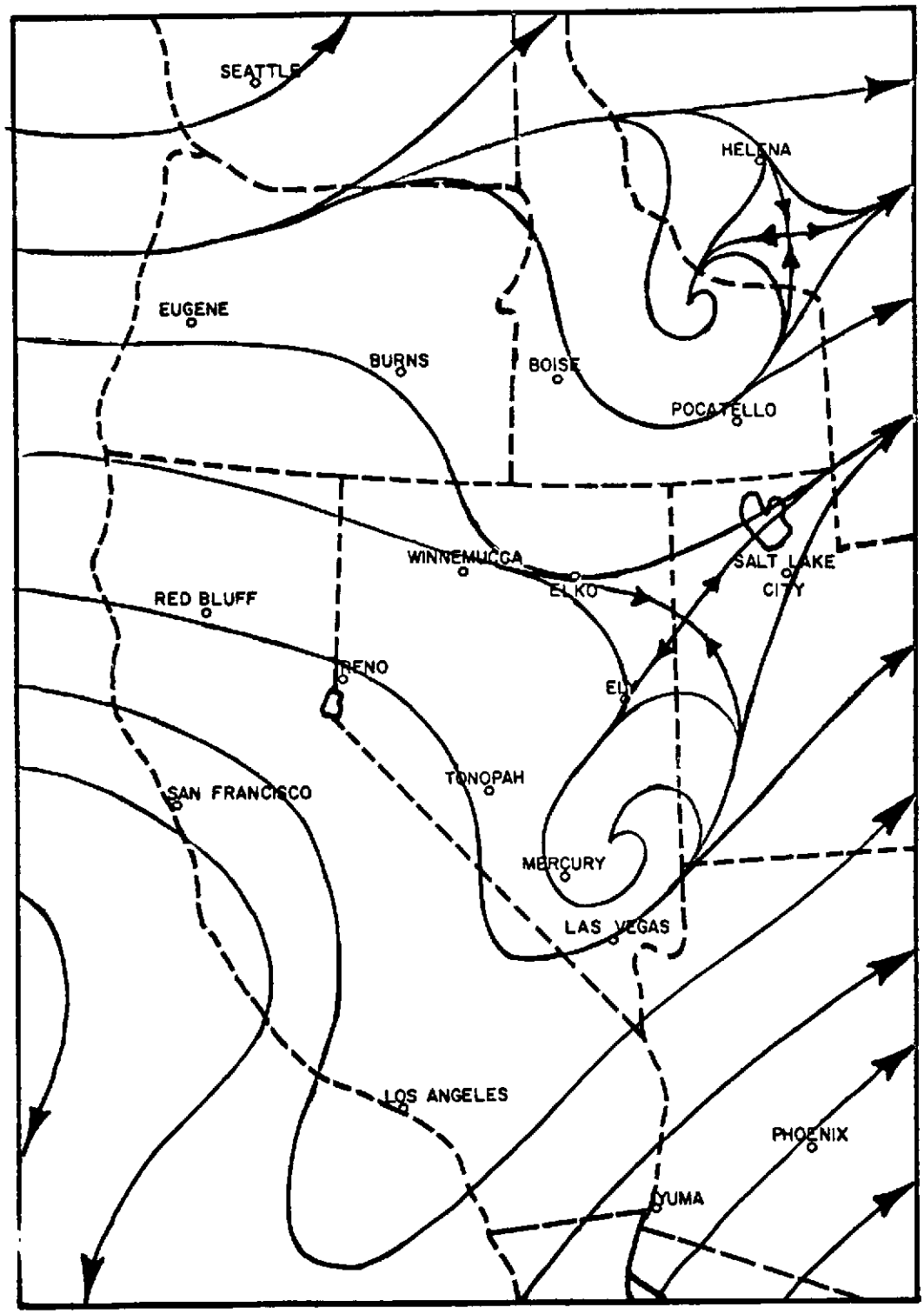


10,000 Ft. STREAMLINE ANALYSIS
0600Z - 2300PDT (14May) H-4
15 MAY 1963

DOUBLE TRACKS
ROLLER COASTER

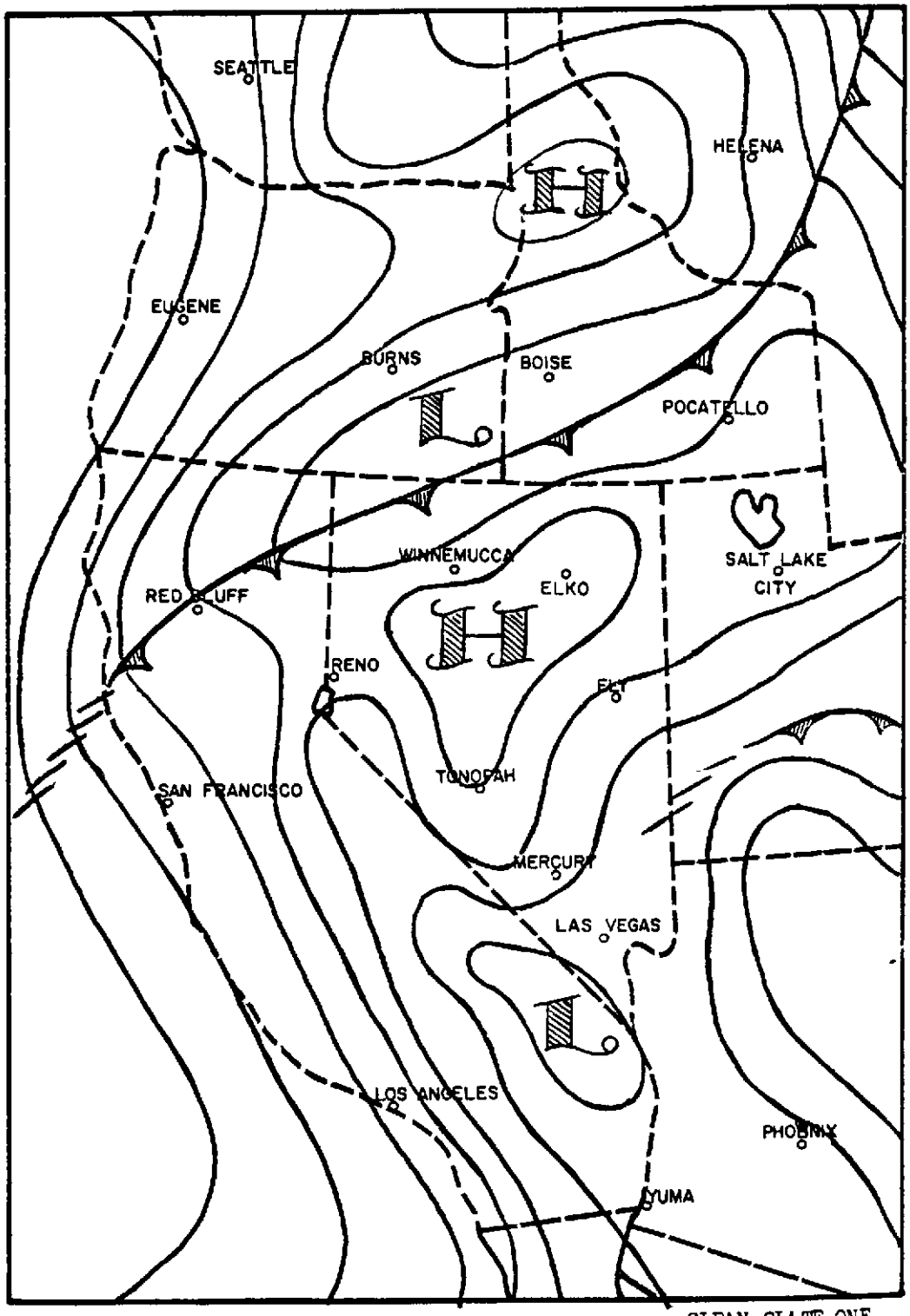


10,000 Ft.
1200Z - 050
15 MAY 1963



10,000 Ft. STREAMLINE ANALYSIS
1200Z - 0500PDT H+2
15 MAY 1963

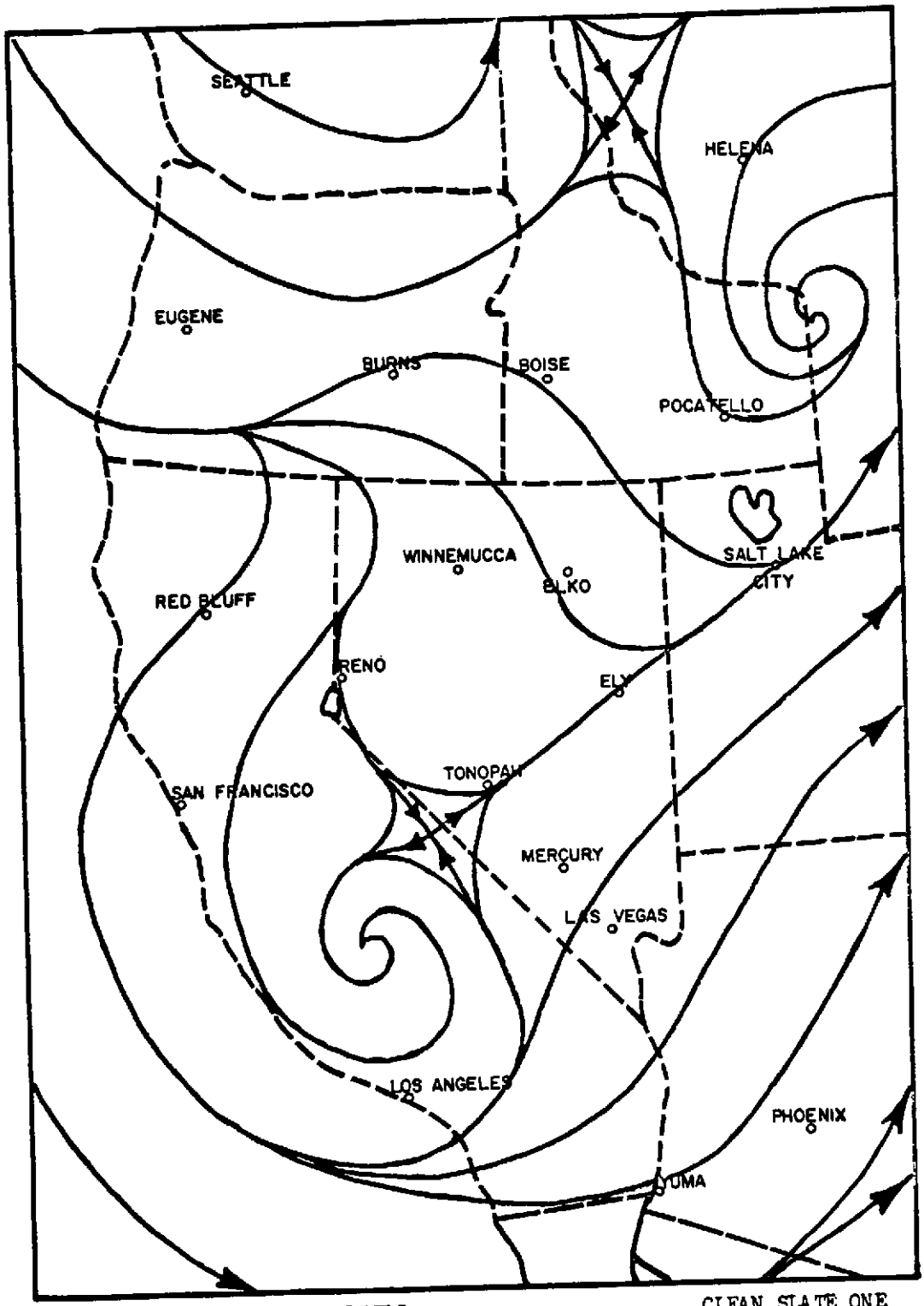
DOUBLE TRACKS
ROLLER COASTER



SURFACE ANALYSIS
1100Z - 0400PDT H-$\frac{1}{4}$
25 MAY 1963

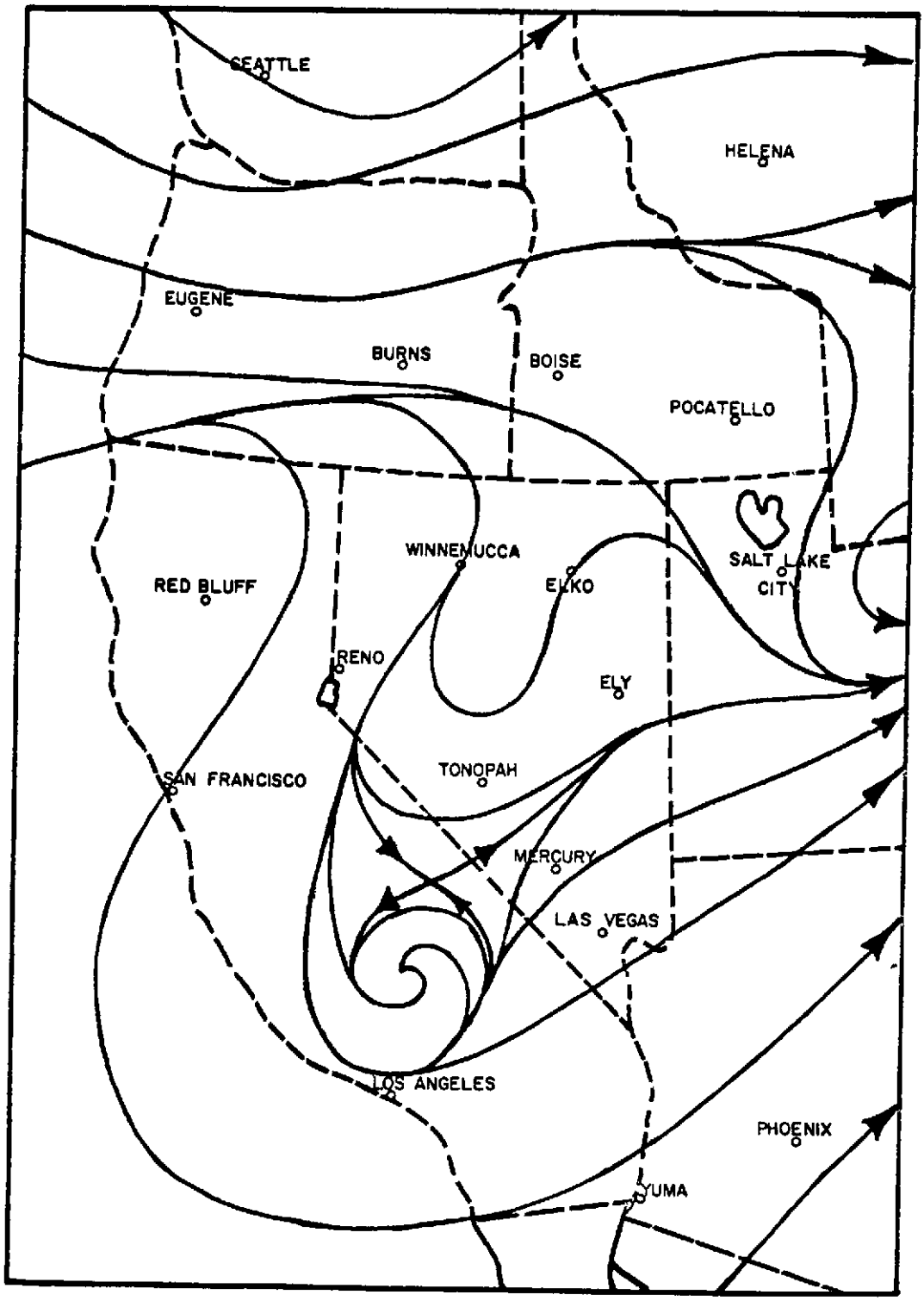
CLEAN SLATE ONE
ROLLER COASTER

10,000 Ft.
0600Z - 2
25 MAY 19



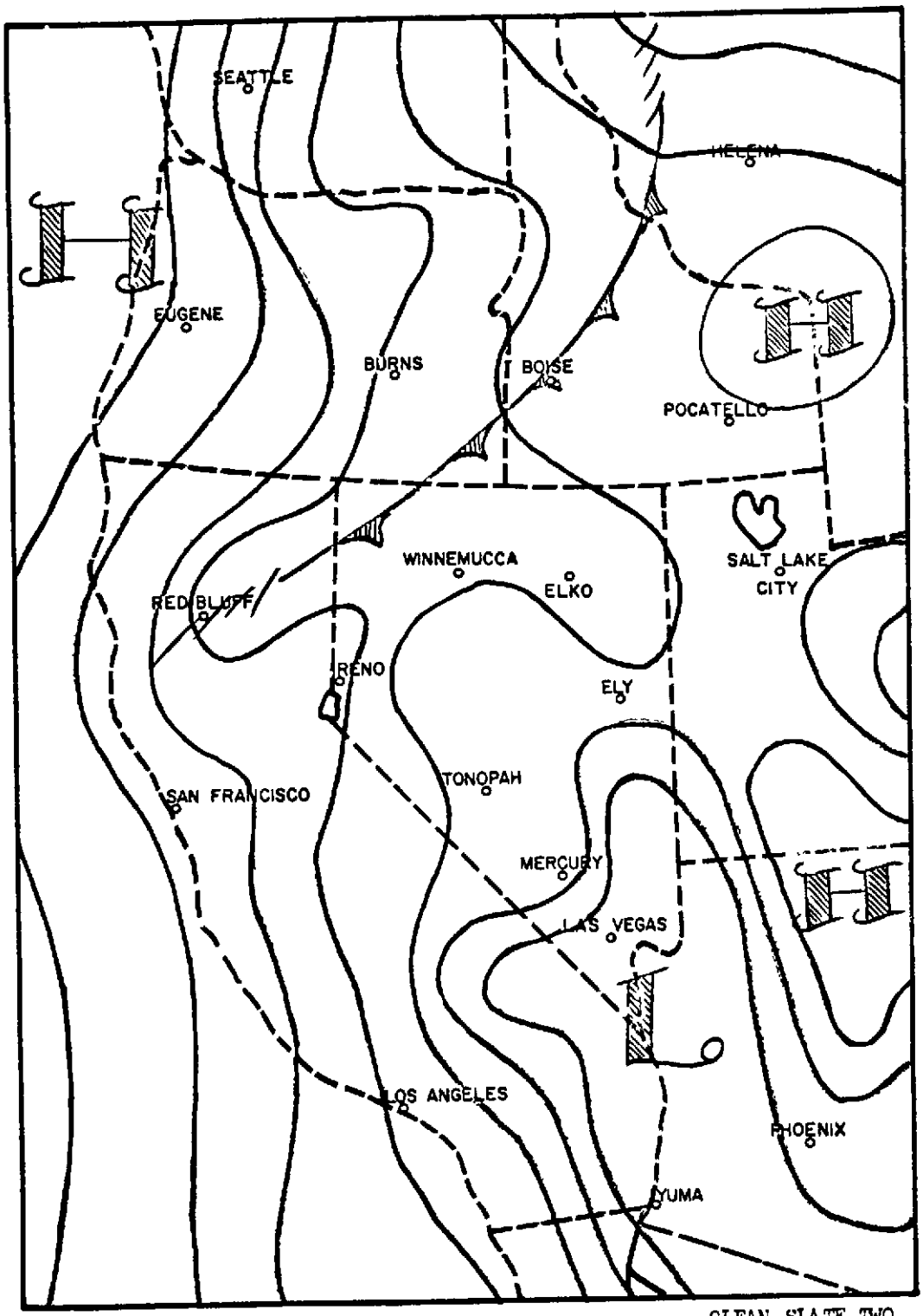
10,000 Ft. STREAMLINE ANALYSIS
0600Z - 2300PDT (24May) H-5¼
25 MAY 1963

CLEAN SLATE ONE
ROLLER COASTER



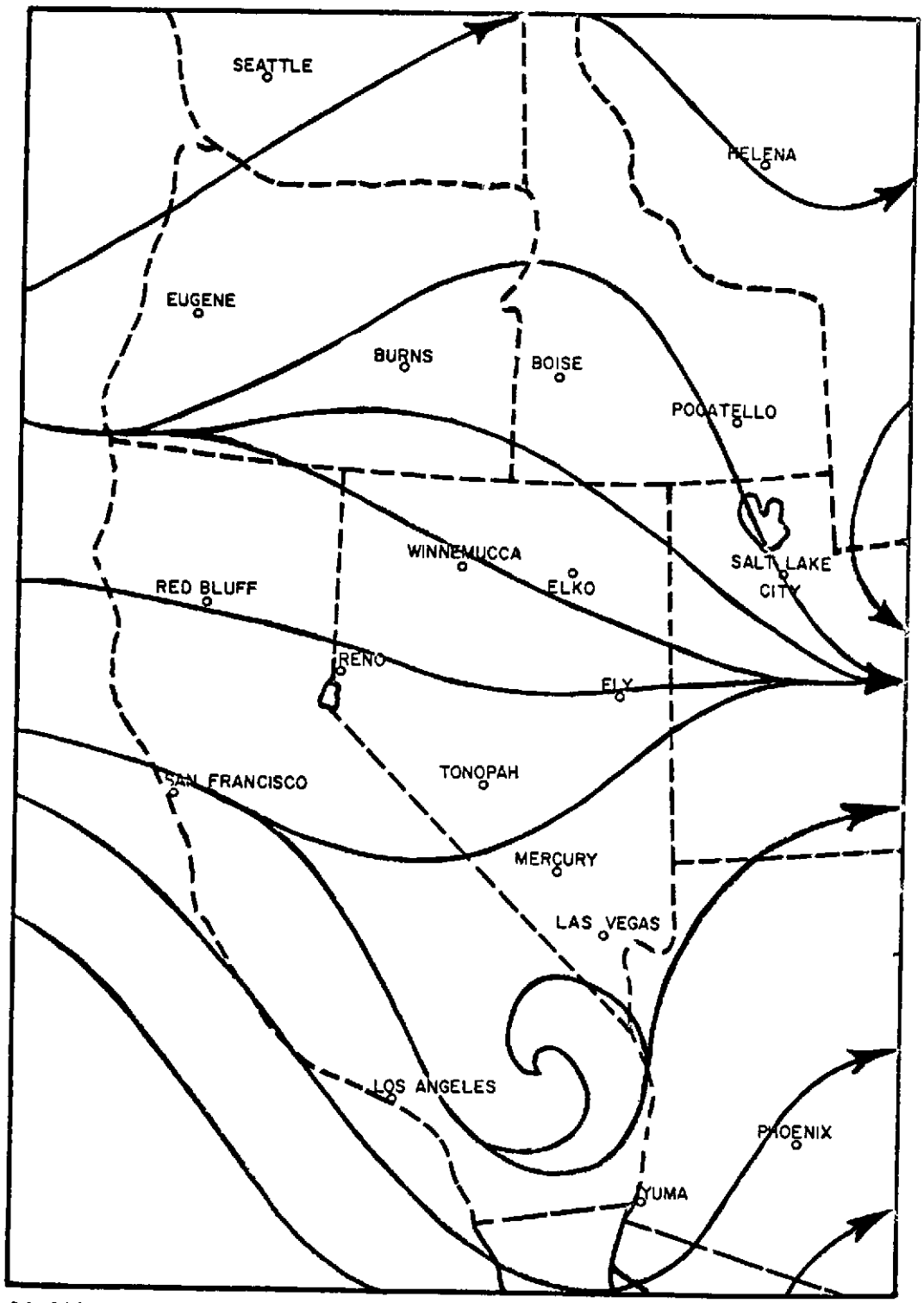
10,000 Ft. STREAMLINE ANALYSIS
1200Z - 0500PDT H/3/4
25 MAY 1963

CLEAN SLATE ONE
ROLLER COASTER



SURFACE ANALYSIS
1100Z - 0400PDT H/4
31 MAY 1963

CLEAN SLATE TWO
ROLLER COASTER



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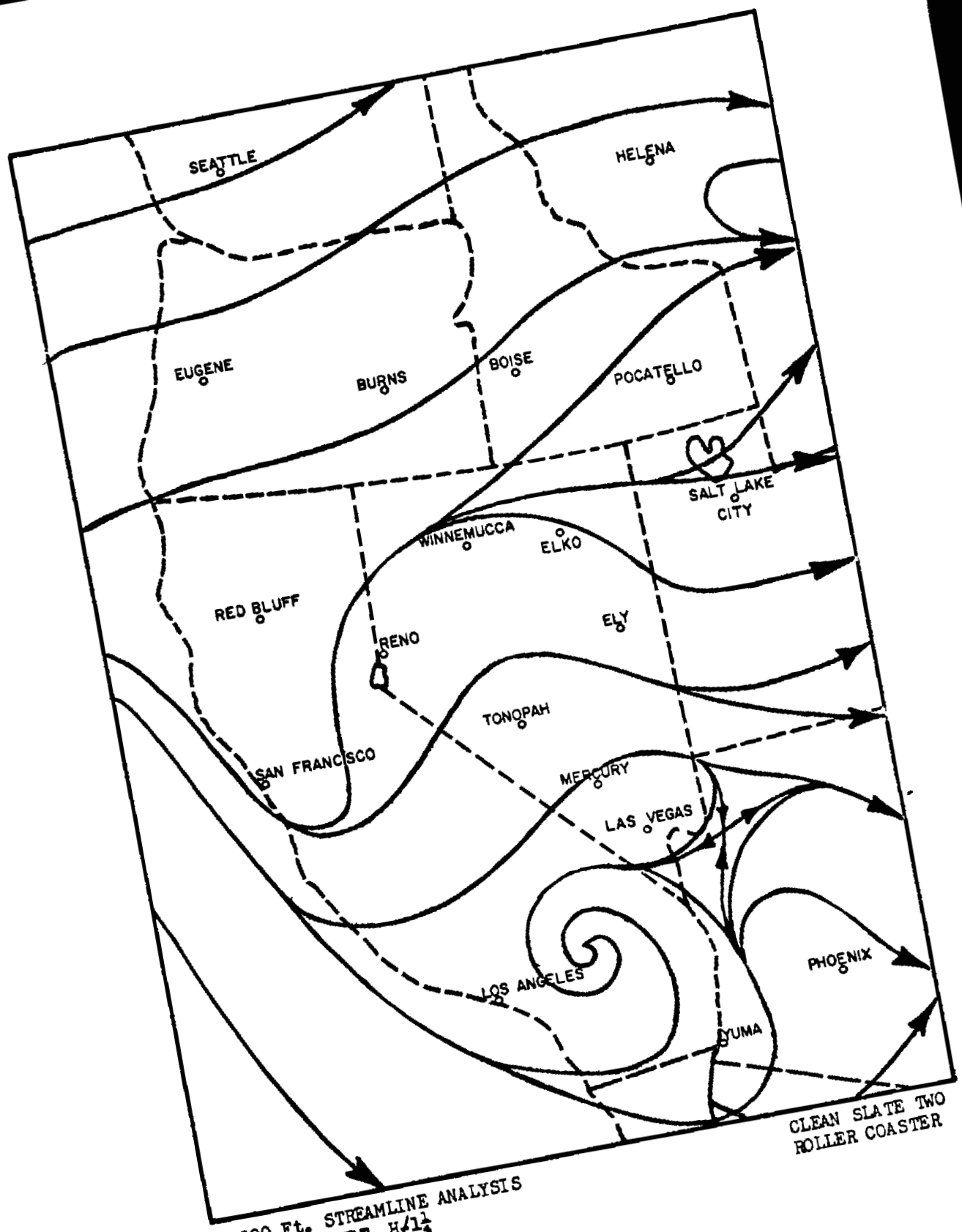
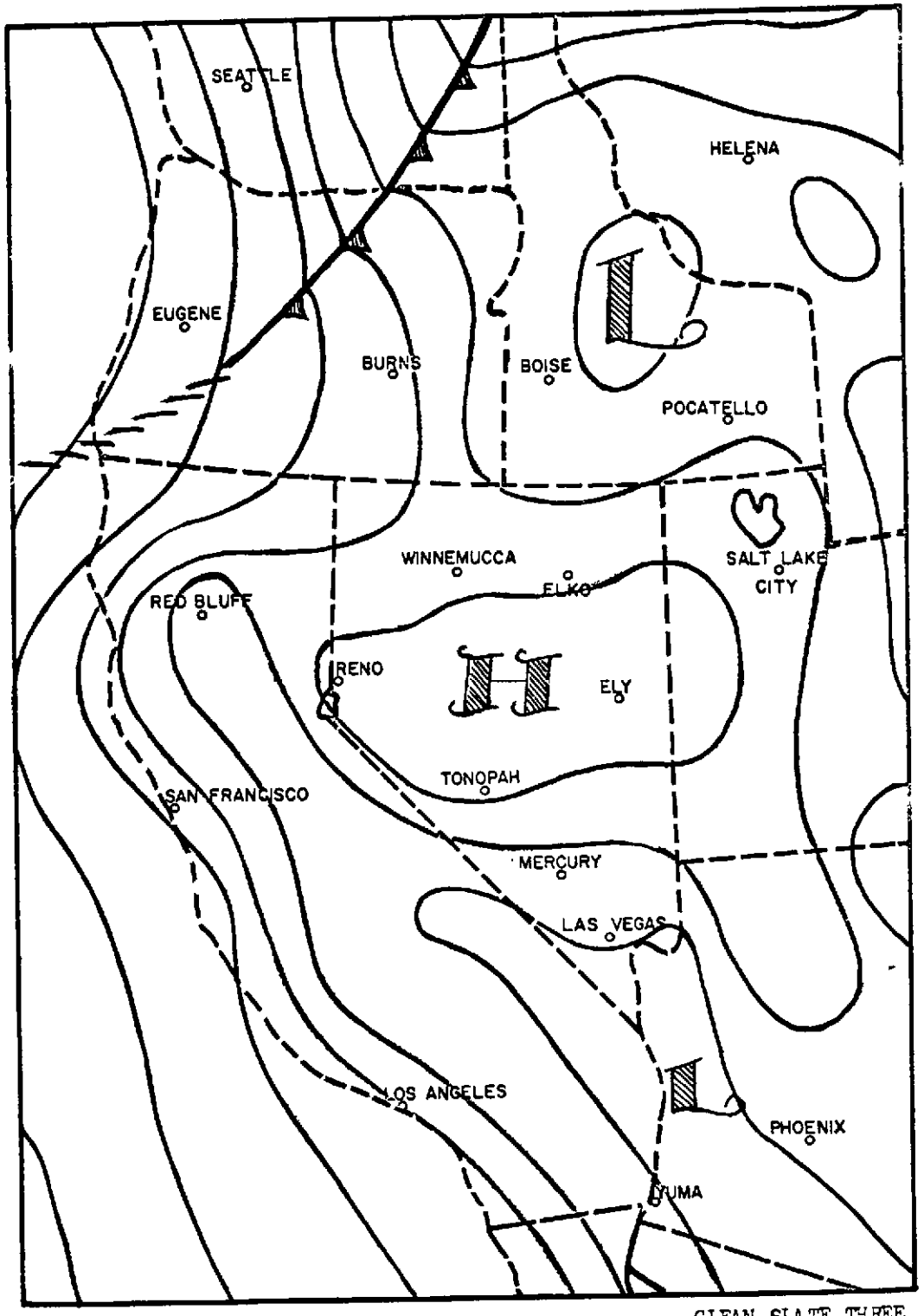
0600Z - 2300PDT (30May) H-4 3/4
31 MAY 1963

CLEAN SLATE TWO
ROLLER COASTER



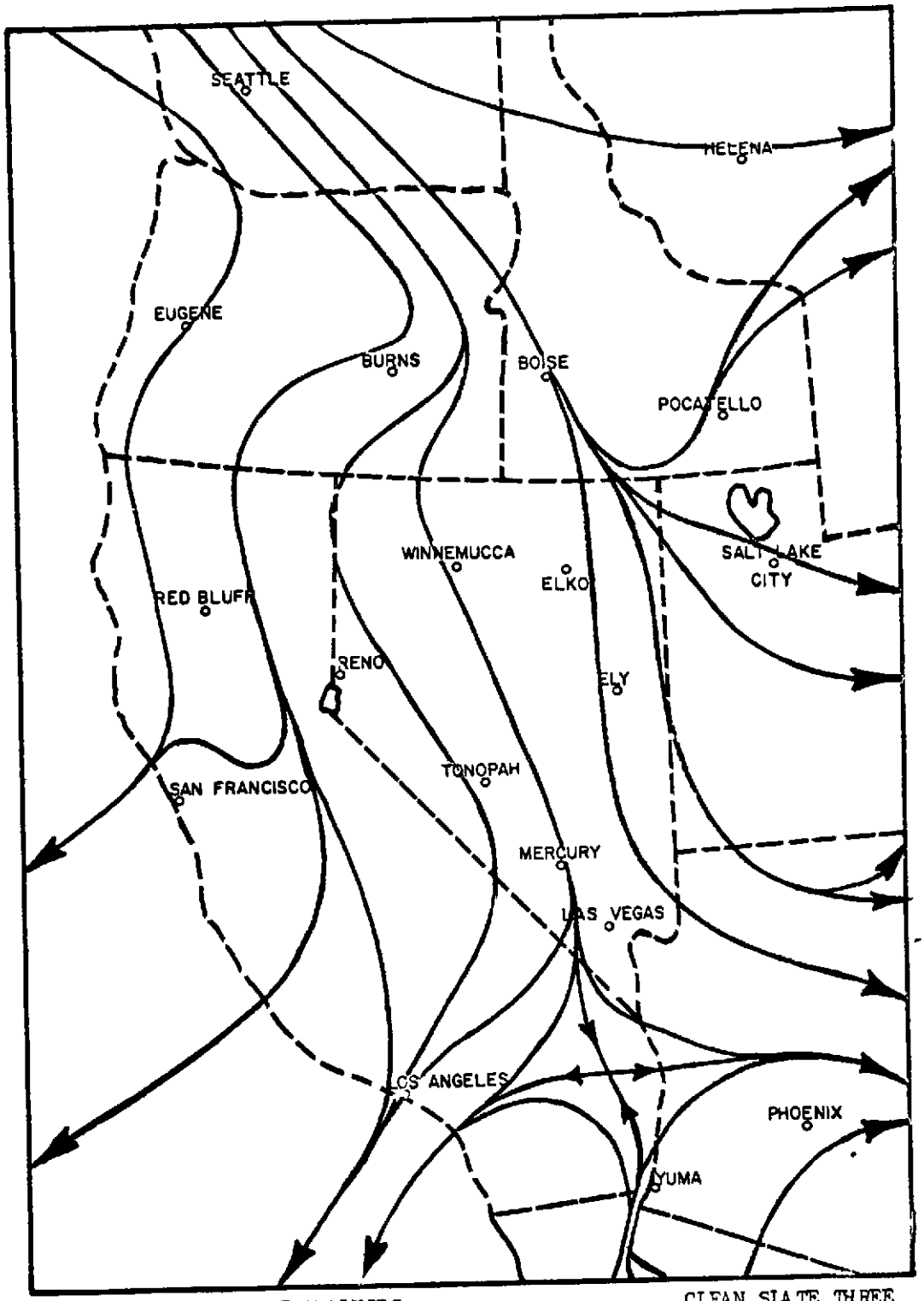
CLEAN SLATE TWO
ROLLER COASTER

10,000 Ft. STREAMLINE ANALYSIS
1200Z-- 0500PDT H/1¼
31 MAY 1963



SURFACE ANALYSIS
1100Z - 0400PDT H/½
9 JUNE 1963

CLEAN SLATE THREE
ROLLER COASTER



10,000 Ft. STREAMLINE ANALYSIS
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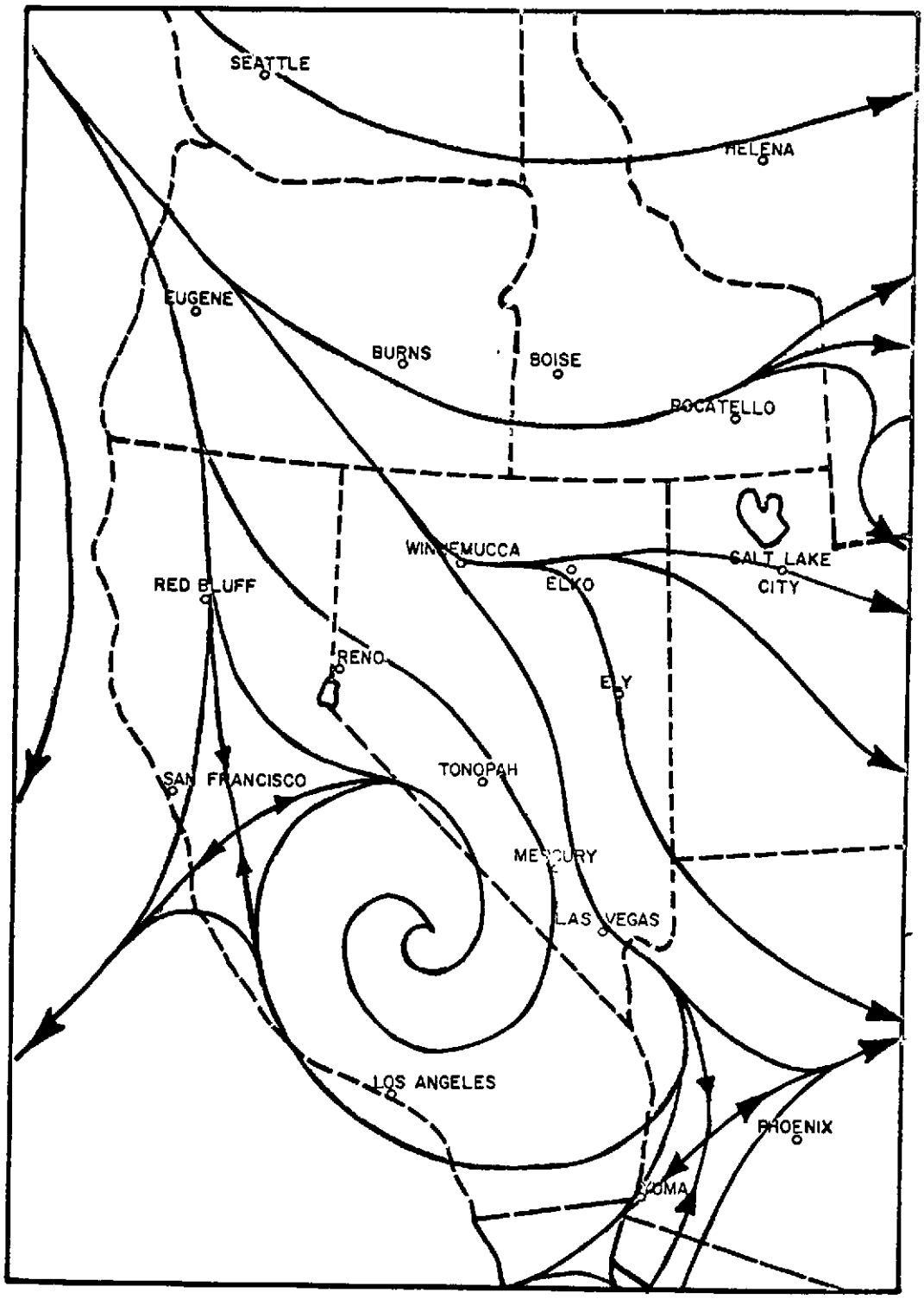
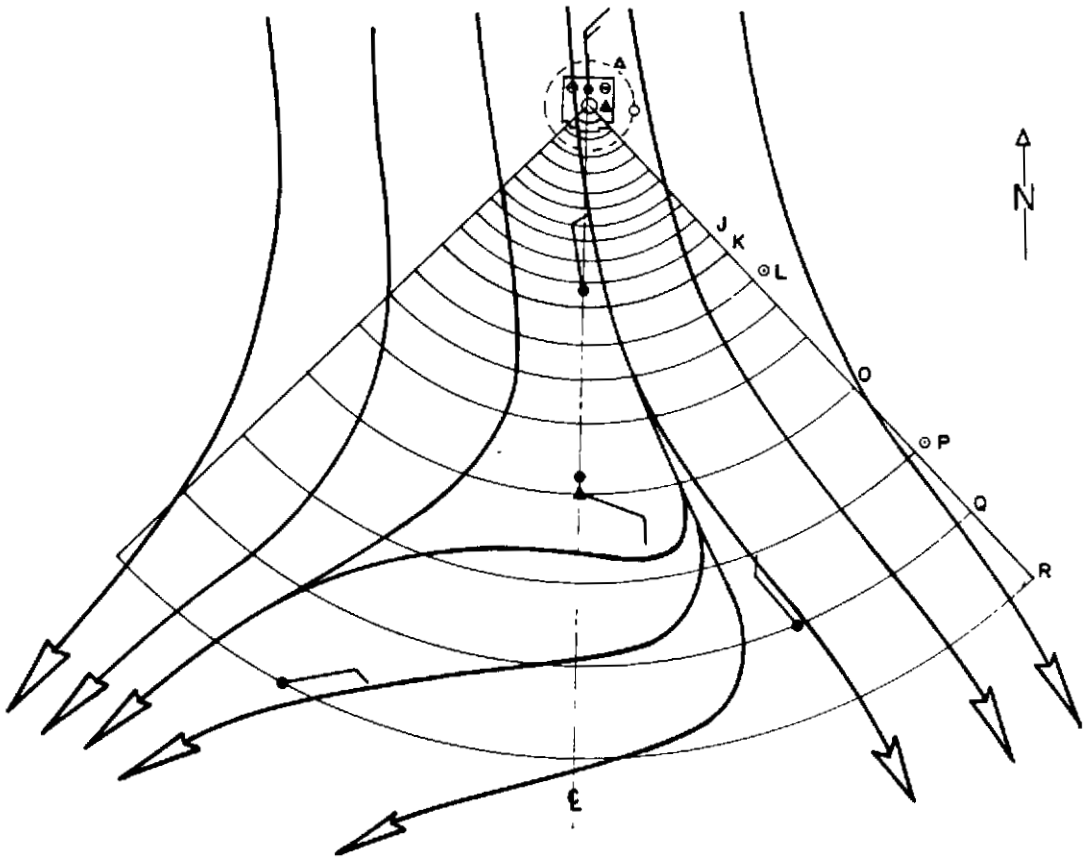
9 JUNE 1963

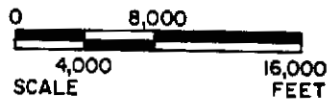
CLEAN SLATE THREE
ROLLER COASTER



10,000 Ft. STREAMLINE ANALYSIS
1200Z - 0500PDT H/1½
9 JUNE 1963

CLEAN SLATE THREE
ROLLER COASTER

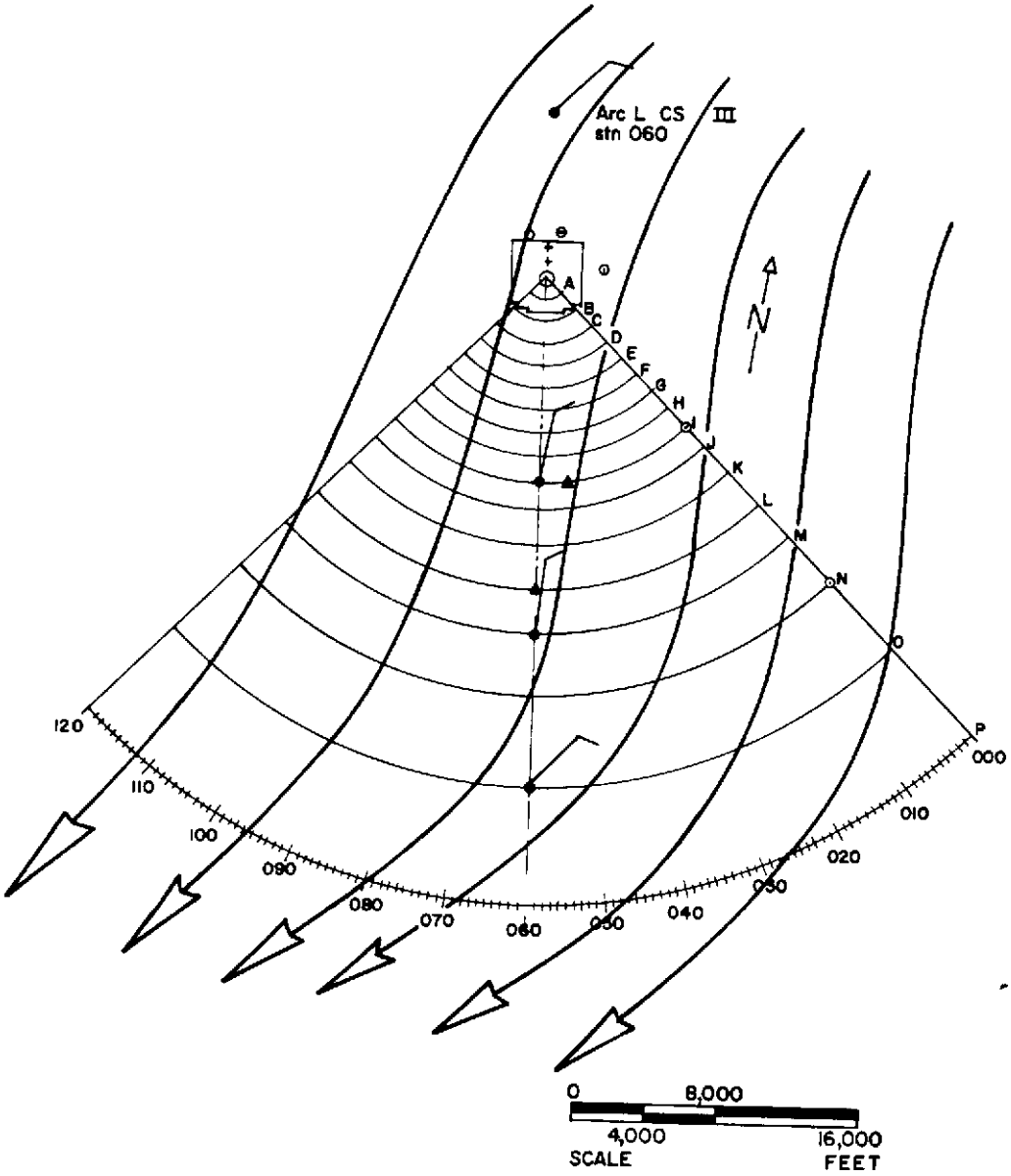




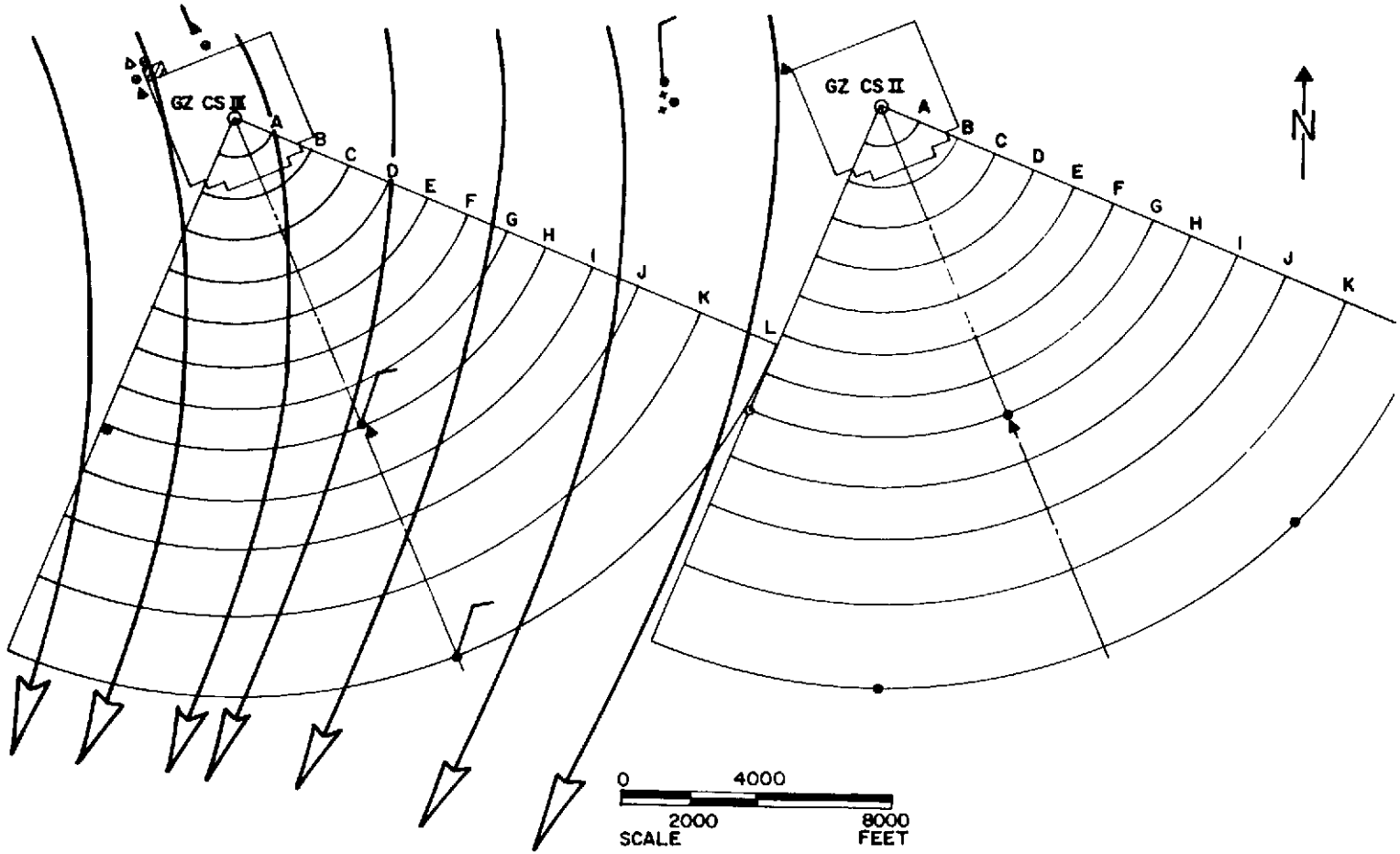
DOUBLE TRACKS

Shot Time

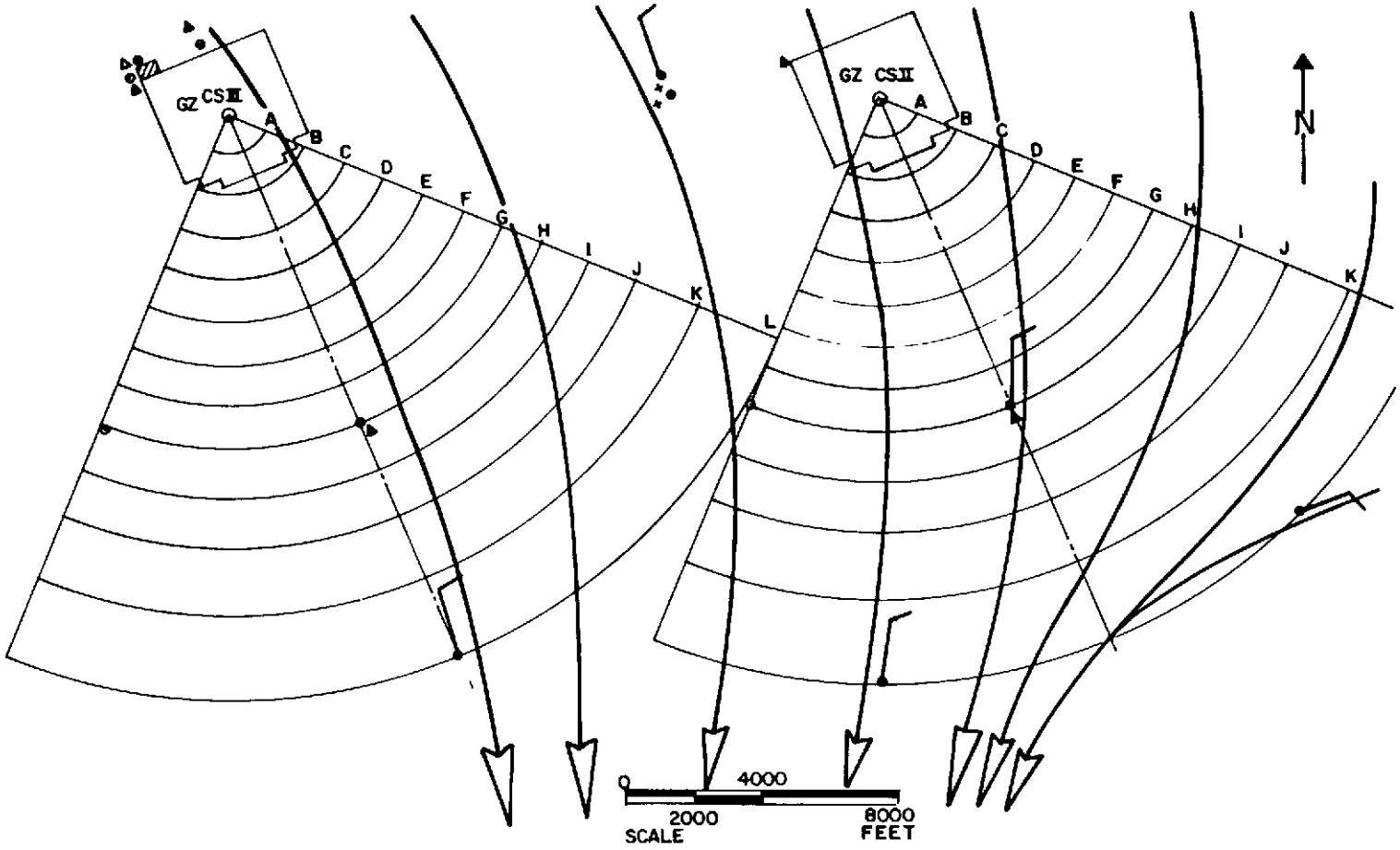
30 Ft. Streamlines



CLEAN SLATE I
30 Ft. Streamlines



CLEAN SLATE III
30 Ft. Streamlines



CLEAN SLATE II
30 Ft. Streamlines

Appendix F

EVENT PILOT BALLOON SOUNDINGS

SUPPLEMENTARY WINDS ALOFT DATA
PILOT BALLOON OBSERVATIONS

Appendix F

EVENT PILOT BALLOON SOUNDINGS

SUPPLEMENTARY WINDS ALOFT DATA
PILOT BALLOON OBSERVATIONS
(Degrees/Knots)

EVENT DOUBLE TRACKS DATE May 15, 1963

Observation Point		TPH AIRPORT	LIDA JUNCTION	SARCOBATUS FLATS	CACTUS FLATS
Time PDT		0200	0200	0200	0200
Height MSL Feet	Surface	340/10	020/06	020/04	CALM
	5000		020/08	020/08	
	6000	340/10	350/11	350/12	340/03
	7000	360/07	340/16	350/18	360/06
	8000	010/02	350/15	020/10	070/03
	9000	020/05	360/12	040/05	140/01
	10000	040/06	010/06	330/05	120/02
	11000	050/05	340/03	310/07	120/03
	12000	160/02	280/06	320/06	230/01
	13000	100/05	270/05	240/02	290/06
	14000	080/04	240/08	250/01	270/06
	15000	040/04	270/08	280/04	250/04
Time PDT		0300	0300	0300	0300
Height MSL Feet	Surface	340/08	360/08	350/03	CALM
	5000		360/10	350/07	
	6000	340/15	350/13	350/12	310/04
	7000	350/16	350/12	340/14	340/09
	8000	350/15	010/12	350/08	040/07
	9000	350/16	010/12	340/04	040/06
	10000	010/06	360/10	320/03	130/04
	11000	030/07	360/06	360/03	160/09
	12000	050/07	310/03	320/04	330/06
	13000	050/05	290/05	260/02	300/10
	14000	070/06	260/06	270/05	270/09
	15000	060/06	260/07	290/04	260/09

EVENT CLEAN SLATE #1 DATE May 25, 1964

Observation Point		WILSON'S CAMP	HIGHWAY 25	BASE CAMP	TTR MAIN GATE
Time PDT		0400	0400	0400	0400
Height MSL Feet	Surface	360/10	340/04	330/04	290/02
	6000	360/12	340/06	330/11	320/11
	7000	350/15	320/12	320/16	310/15
	8000	330/11	310/10	290/08	300/10
	9000	250/04	240/04	210/06	250/07
	10000	210/09	230/10	200/12	200/10
	11000	220/14	200/13	200/16	200/15
	12000	210/15	200/15	200/16	200/17
	13000	200/15	210/12	190/16	200/17
	14000	190/15	180/14	190/14	200/16
	15000	190/12	180/13	200/14	210/16
Time PDT		0500	0500	0500	0500
Height MSL Feet	Surface	360/08	330/04	330/04	CALM
	6000	360/12	330/06	330/07	330/08
	7000	350/16	320/12	320/11	310/11
	8000	330/11	320/08	290/06	290/12
	9000	270/04	250/04	220/08	250/07
	10000	220/11	210/08	220/14	210/11
	11000	230/14	210/15	210/16	210/17
	12000	210/13	200/15	190/15	210/22
	13000	*	190/15	190/13	210/23
	14000	*	180/12	200/13	200/21
	15000	*	200/11	210/12	190/20

* Lost Balloon

EVENT CLEAN SLATE #3 DATE June 9, 1963

Observation Point		BASE CAMP	WILSON'S CAMP	HIGHWAY 25	TTR MAIN GATE
Time PDT		0300	0300	0300	0300
Height MSL Feet	Surface	310/10	360/02	360/03	360/02
	6000	320/09	010/04	020/02	010/06
	7000	350/07	030/08	050/03	030/05
	8000	360/08	010/11	020/11	360/07
	9000	350/09	360/08	010/11	350/08
	10000	350/10	350/09	360/10	360/10
	11000	340/11	340/12	340/10	350/10
	12000	330/11	340/13	340/10	340/13
	13000	320/10	330/12	340/09	320/15
	14000	320/07	330/12	340/10	310/10
	15000	MOON LIGHT	340/15	350/11	310/10
Time PDT		0400	0400	0400	0400
Height MSL Feet	Surface	310/10	360/02	010/03	360/04
	6000	320/10	010/03	030/01	010/06
	7000	360/05	040/06	030/02	020/04
	8000	360/06	360/09	010/06	010/05
	9000	350/08	350/08	010/09	360/07
	10000	340/06	350/08	360/10	360/09
	11000	330/12	330/11	340/09	350/10
	12000	330/12	330/12	320/13	340/13
	13000	320/11	320/12	320/11	340/12
	14000	320/11	330/10	340/11	320/11
	15000	330/11	340/15	340/15	320/09

EVENT CLEAN SLATE #2 DATE May 31, 1964

Observation Point		HIGHWAY 25	TTR MAIN GATE	WILSON'S CAMP	BASE CAMP
Time PDT		0400	0400	0400	0400
Height MSL Feet	Surface	320/04	360/02	CALM	310/04
	6000	300/05	360/07	340/05	320/13
	7000	300/03	350/07	340/07	330/07
	8000	300/04	320/06	280/03	350/08
	9000	270/05	300/05	220/03	330/06
	10000	230/06	250/02	200/04	270/04
	11000	240/05	240/06	200/04	220/05
	12000	250/06	240/08	260/06	210/05
	13000	270/09	250/11	260/09	230/07
	14000	280/08	250/11		250/11
	15000	280/07	270/10		260/12
Time PDT		0500	0500	0500	0500
Height MSL Feet	Surface	RECALLED	010/02	220/02	240/02
	6000		330/04	230/02	360/02
	7000		330/05	330/03	030/05
	8000		320/04	310/04	080/04
	9000		290/05	280/03	100/05
	10000		240/04	240/03	170/07
	11000		240/06	230/03	210/14
	12000		240/08	240/05	220/20
	13000		240/10	240/07	220/22
	14000		240/09	250/11	220/21

Appendix

PHOTOG

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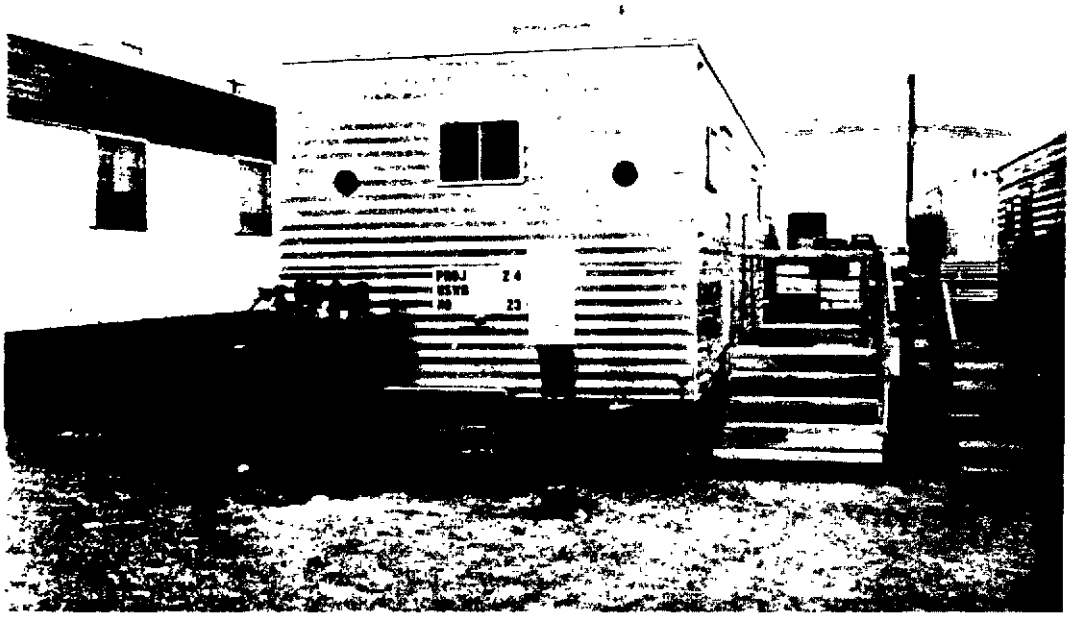
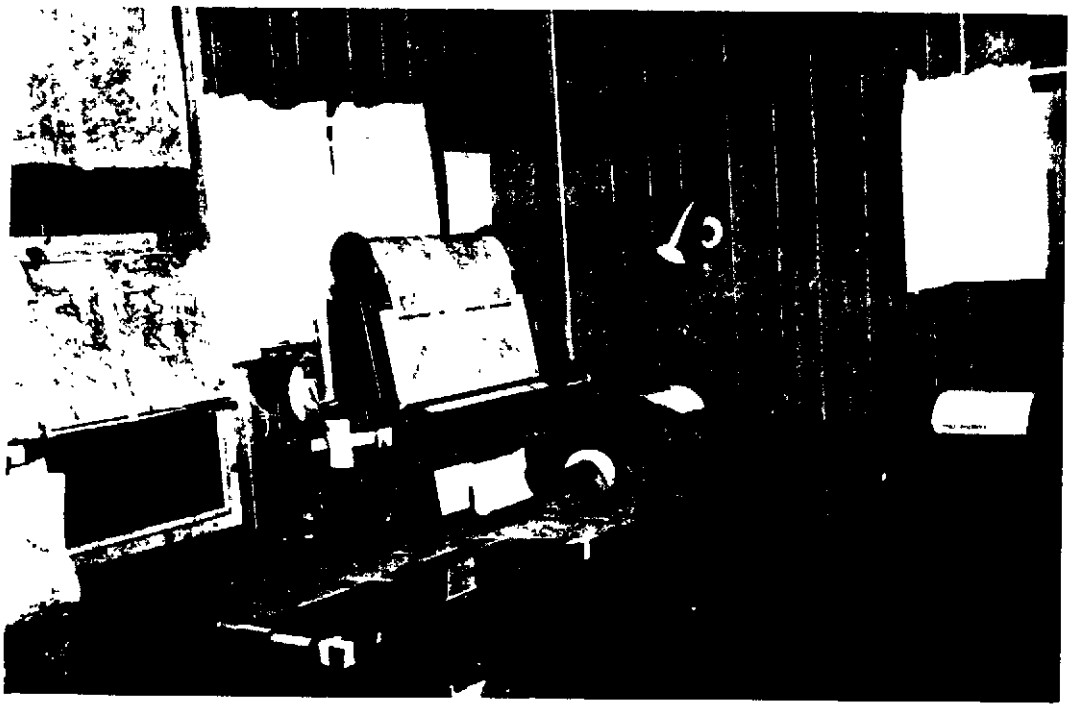
Appendix G

PHOTOGRAPHS OF USWB ACTIVITIES DURING ROLLER COASTER



Project 2.4 base camp weather trailer. (FCWT DASA 137-02-TTR-63)



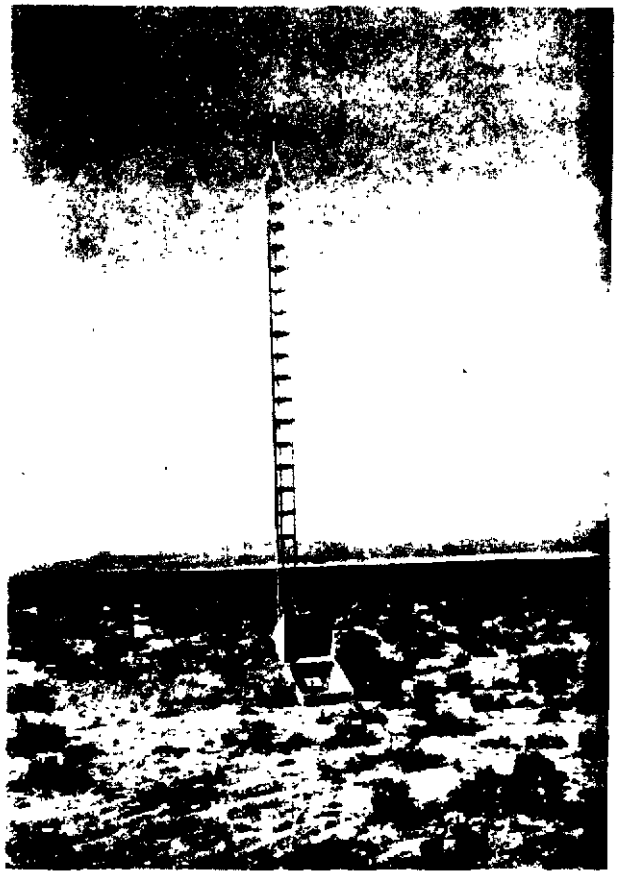
Interior view of teletype room, base camp weather trailer showing teletypes, facsimile, and display board. (FCWT DASA 103-18-TTR-63)

M-33 Radar on station with two 30KS/400-cycle generators in foreground. (FCWT DASA 137-04-TTR-63)

Inflated 100-gm balloon carrying radar reflector and lighted fuzee. (FCWT DASA 137-01-TTR-63)

Field pilot balloon station crewman inflating 30-gm balloon; theodolite and plotting boards in foreground. (FCWT DASA 103-17-TTR-63)

30-foot wind tower in downwind array with translator unit at base of tower. (FCWT DASA 110-49-TTR-63)



Interior view M-33 Radar, crew members at plotting board and console. (FCWT DASA 110-46-TTR-62)

Plotting room in forward CP weather trailer showing two of hodograph plotting boards with polar coordinate charts in place and field phone headsets for communications with radar. (FCWT DASA 110-50-TTR-63)

Remote balloon release trailer with balloon cannister in place. (FCWT 137-03-TTR-63)

Maintenance crewman rigging balloon in cannister, (note radar target and fuzee in exterior mount). (FCWT DASA 122-20-TTR-63)

Interior view T-sonde trailer showing crew member making calibration check of modified radiosonde instrument on TMQ-5 Recorder. (FCWT DASA 110-45-TTR-63)

REFERE

1. "A

July 1963

2. "I

6093-1, J

3. Te

4. "N

Universi t

REFERENCES

1. "Ad Hoc Committee Report on Balloon Activities"; T.S. D'Agostino, Chairman; July 1963.

2. "Introduction and Theory of Operations of Anti-Aircraft M-33 Radar"; TM-9-6093-1, July 1965; Department of the Army.

3. Technical Report 0130A; Sierra Research Corporation; February 1961.

4. "Meteorological Instruments"; 3rd Ed Rev; W.E.K. Middleton and A.F. Spilhaus, Universi ty of Toronto Press, 1953.

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1	CHIEF OF RFSE
1	ASST.CHIEF OF
2	CHIEF OF ENGI
3	THE SURGEON C
2	COMD. GEN. US
1	COMD. OFFICER
2	COMD. OFFICER
1	CHIEF,US ARMY
3	COMD.GEN. US
1	COMD.OFFICER,
3	COMD.GEN. US

NAVY ACTIVITI

1	CHIEF OF NAVAL
1	CHIEF OF NAVAL
1	CHIEF,BUREAU
1	CHIEF,BUREAU
1	CHIEF,BUREAU
3	CHIEF,BUREAU
1	COMD.OFFICER
2	COMD. OFFICER
1	COMD. OFFICER
1	COMMANDANT HD
1	COMD.-IN-CHIEF
1	COMD.-IN-CHIEF
1	COMD.-IN-CHIEF

AIR FORCE ACTI

1	HDQ.,US AIR FO
1	HDQ.,US AIR FO
1	HDQ.,US AIR FO
1	HDQ.,US AIR FO
1	HDQ.,US AIR FO
1	COMD. AIR FORC
1	COMD. BOLLING
1	HDQ. AIR DEFE
1	COMD. AIR FORC
1	COMD.AIR TRAIN
1	COMD.STRATEGIC
1	COMD.TACTICAL
5	AIR FORCE WEAP
1	AIR FORCE WEAP
1	AIR FORCE WEAP
2	COMD.OGDEN AIR
2	COMD.SAN ANTON

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