UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Principal Facts and a Complete Bouguer Anomaly Map for a Gravity Study of the Proposed Mt. Henry Wilderness, Montana

by

Viki Bankey, M. Dean Kleinkopf, Mike Brickey, and Joe Mancinelli

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Table of Contents

List of Figures

Appendices

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal lands to determine their mineral resource potential. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geophysical survey of Mt. Henry Study Area in the Kootenai National Forest, Lincoln County, Montana. Mt. Henry was classified as a proposed wilderness during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

Introduction

The proposed Mt. Henry wilderness is located approximately 50 miles west of Glacier National Park and 5 miles south of the Canadian border. A gravity survey was conducted as part of the U.S. Geological Survey's (USGS) program to evaluate the mineral resource potential of proposed wilderness areas.

Gravity Data Collection

In July 1981 and July 1980, 33 gravity stations were established in and surrounding the proposed Mt. Henry wilderness. The principal facts of the gravity survey are included in Appendix 6. Gravity readings were made with a LaCoste-Romberg gravity meter (G-24). Stations were referenced to local USGS bases described in Appendices 4 and 5. These USGS bases were tied to the U.S. Department of Defense base in Kalispell, Montana (Appendix 3), which is part of the International Gravity Standardization Net (IGSN), 1971, established by the Defense Mapping Agency Aerospace Center (1974). Gravity loops were started and closed at these bases to give daily meter-drift corrections.

Elevation Control for Gravity Stations

Gravity station locations and elevations were obtained from benchmarks, spot elevations, and section corners found on 1:24,000 scale USGS topographic maps with a contour interval of 40 ft. However, a few station elevations were determined by altimeter readings taken by Jack Harrison (USGS, oral commun., July, 1981). These points are identified with a prefix "elb" rather than "lb" or "ks" in Appendices 1 and 6, and they are shown as open circles rather than solid dots on the complete Bouguer anomaly map. Specific elevation uncertainties for each station are included in Appendix 1.

Gravity Data Reduction

Computer programs existing on the USGS Honeywell Multics computer system were used to obtain principal facts and terrain-corrected gravity values. A program written by D. Dansereau and R. Wahl (USGS, unpublished program, 1979) was used to reduce gravity meter readings to observed gravity values by calculating and correcting for earth-tide and linear meter drift. The theoretical gravity value was calculated using the 1967 formula of the Geodetic Reference System (International Association of Geodesy, 1967).

Complete terrain corrections were computed using a program by R. H. Godson (USGS, unpublished program, 1978), correcting for the terrain from each station out to a radius of 166.7 km from the station using the method of Plouff (1977). These computed terrain corrections are based on mean elevation data digitized on a 15-second grid for corrections from 0 to 5 km; 1-minute terrain data for corrections from 5 to 21 km; and 3-minute terrain data for corrections from 21 to 166.7 km. An assumed density of 2.67 g/cm^3 was used to calculate terrain corrections. Godson's program also calculates earth curvature corrections and complete (terrain-corrected) Bouguer anomaly values. Two complete Bouguer anomaly values per station were obtained using average rock densities of 2.67 g/cm^3 and 2.57 g/cm^3. The corrections and anomaly values are listed in Appendix 6.

The points were projected with UTM co-ordinates. using program "prjrec" (M. Webring, unpub. data, 1978). Bouguer anomaly values calculated for a density of 2.67 g/cm^3 were contoured using programs "minc" (Webring, 1981) and "contour" (Godson and Webring, 1982). Data outside the study area were used to define contours near the edges of the complete Bouguer anomaly map. The contours were smoothed by hand for the final draft.

Physical Properties

Density and magnetic susceptibility measurements were made for the major rock types in the study area (Appendix 2). Rocks from adjoining areas were included in these measurements.

References cited

Defense Mapping Agency Aerospace Center, 1974, World Relative Gravity Reference Network, North America, Part 2: DMAAC Reference Publication 25, with supplement updating gravity values to the Internation Gravity Standardization Net 1971, 1635 p.

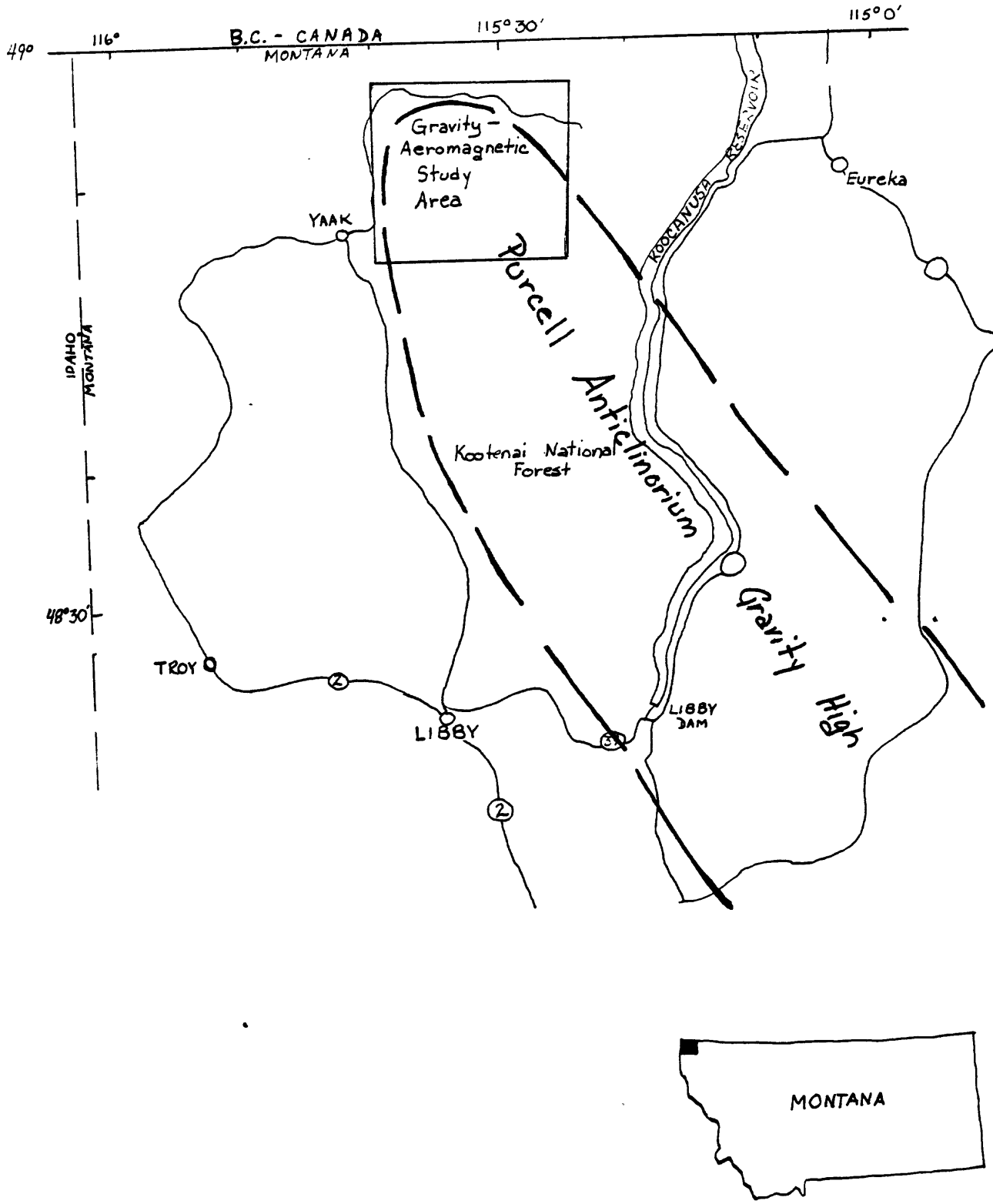
Godson, Richard H.; and Webring, Michael W., 1982, CONTOUR: a modification of G. I. Evenden's general purpose contouring program: U.S. Geological Survey Open-File Report 82-797.

International Association of Geodesy, 1967, Geodetic Reference System, 1967, International Association of Geodesy Special Publication 3, 74 p.

Plouff, D., 1977, Preliminary documentation for a FORTRAN program to compute gravity terrain corrections based on topography digitized on a geographic grid: U.S. Geological Survey Open-File Report 77-535.

Webring, Michael, 1981, MINC: A gridding program based on minimum curvature: U.S. Geological Survey Open-File Report 81-1224, 12 p.

FIGURE 1: Location of Mt. Henry Study Area



APPENDIX 1

Elevation Uncertainties for Gravity Stations

KEY:
- A: Benchmark
- B: Black spot elevation, road junctions
- C: Brown spot elevations (not field checked)
- D: Lake level
- E: Determined from altimeter (both elevation and position)

ACCURACIFS: Elevation and Bouguer Gravity (for 2.67 g/cm3 density)

- A: .5 ft accuracy , .028 mgals
- B: 5 ft accuracy, .28 mgal
- C: 13.3 ft accuracy, .76 mgal
- D: 5 ft accuracy, .28 mgal
- E: I assume 40 ft accuracy, 2.23 mgal

All stations are B (black spot elevations) EXCEPT the following:

A: lb194, lb196, lb205, lb599

C: ks155, lb182, lb183

D: lb 597

E: elb185, elb188, elb199, elb200, elb202, elb203

APPENDIX 2

Densities and Susceptibilities of Rock Samples

Sample i.d.	Formation	Density (g/cm3)	Susceptibility ($\times 10^{-6}$ emu/cm3)
1b2	Helena	2.73	14
1b59	Helena	2.68	18
1b5	Wallace	2.69	9
1b9	St. Regis	2.71	14
1b446	St. Regis	2.66	14
1b590	St. Regis	2.68	4
1b7	Revett	2.65	4
1b599	Revett	2.65	28
1b1	lower Burke	2.72	22
1b6	lower Burke	2.73	16
1b41	lower Burke	2.74	18
1b3	upper Burke	2.77	495
1b46	upper Burke	2.68	406
1b103	upper Burke	2.73	824
ks42	upper Burke	2.67	459
1b4	upper Prichard	2.75	22
1b88	upper Prichard	2.71	15
1b189	upper Prichard	2.74	16
1b8	Prichard	2.72	29

APPENDIX 3

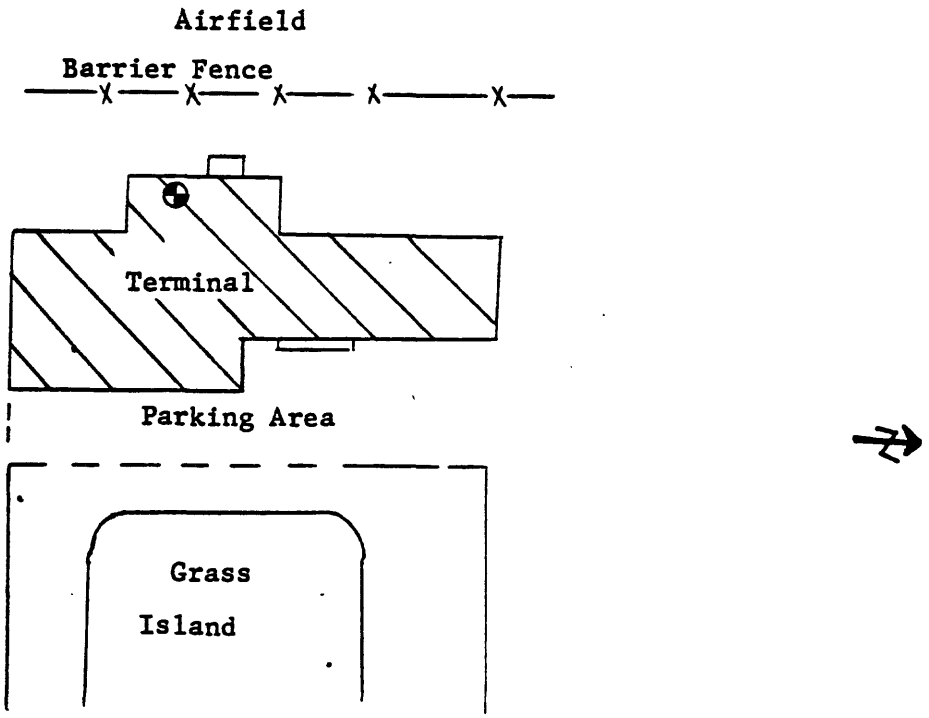
GRAVITY BASE STATION

LATITUDE: 48° 18.50' N (1)	STATION DESIGNATION: KALISPELL
LONGITUDE: 114° 15.00' W (1)	
ELEVATION: 905.6 METERS (1)	COUNTRY/STATE: USA/Montana

REFERENCE CODE NUMBERS		ADOPTED GRAVITY VALUE	
ACIC 0441-0		g= 980 567.39 mgals	
IGC 15684 J			
WA 32			
		ESTIMATED ACCURACY	DATE
		± 0.1 mgals	MONTH/YEAR 1971

DESCRIPTION AND/OR SKETCH

Station is located at the Flathead Airport, six miles north of Kalispell, Mont., on the west side of St.Hwy. #206, inside the airport lobby, on the floor, at the west side of the entrance to the apron and loading area. (1)



(2)

REFERENCE SOURCE

(1) 01355 (2) 05100

APPENDIX 4

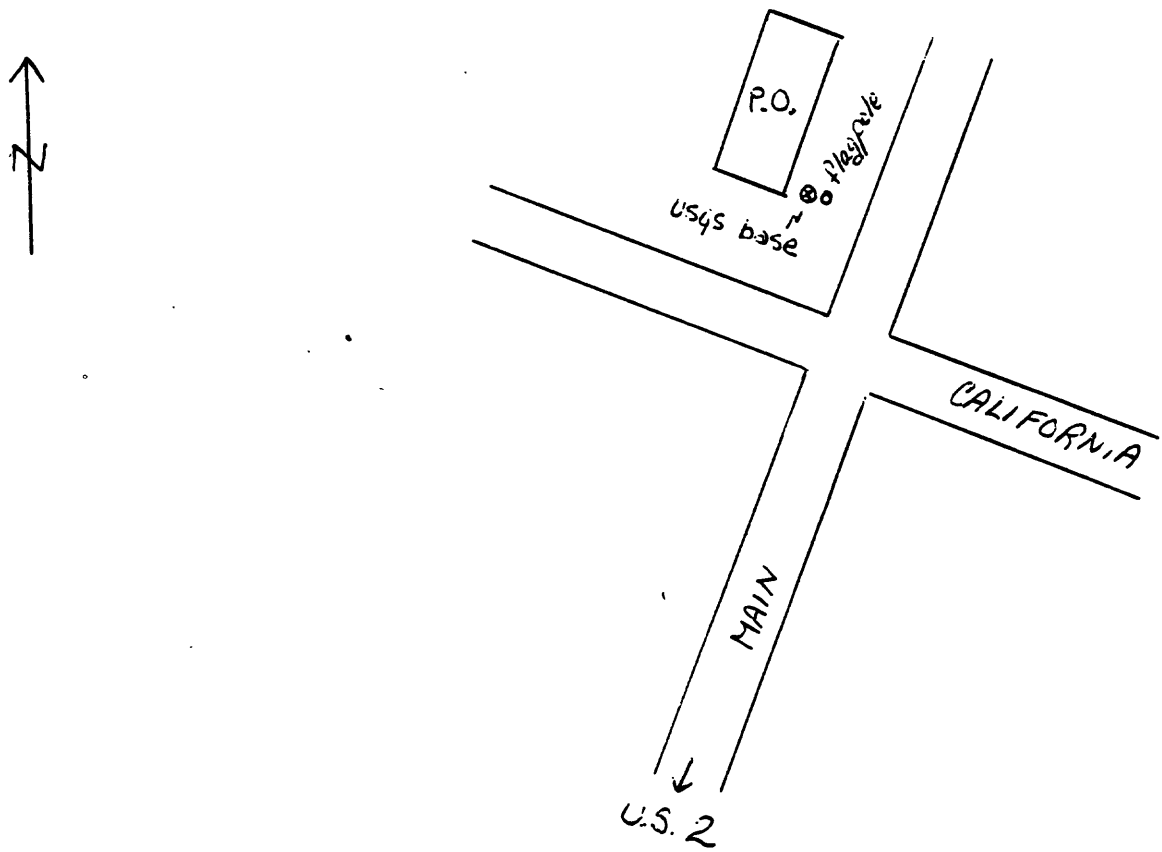
U.S. GEOLOGICAL SURVEY
GRAVITY BASE STATION

STATE/COUNTRY	STATION DESIGNATION	OBSERVED GRAVITY
Montana	Libby Post Office	980652.62 mgals
NEAREST TOWN	LONGITUDE	LATITUDE
Libby	115° 30.77'	48° 23.50'
ELEVATION	TOPOGRAPHIC MAP(S)	
634.1 m (2080')	Libby 1/24,000	

DATE	OBSERVER	METER	REFERENCE STATION	REFERENCE VALUE
8/26/78	Kleinkopf	G-235	Kalispell Airport (DOD)	980567.39 mgals

DESCRIPTION/SKETCH

Reading was at west base of flag pole, near the front door of the Post Office which is located at the corner of Main and California Ave. in Libby, Montana.



APPENDIX 5

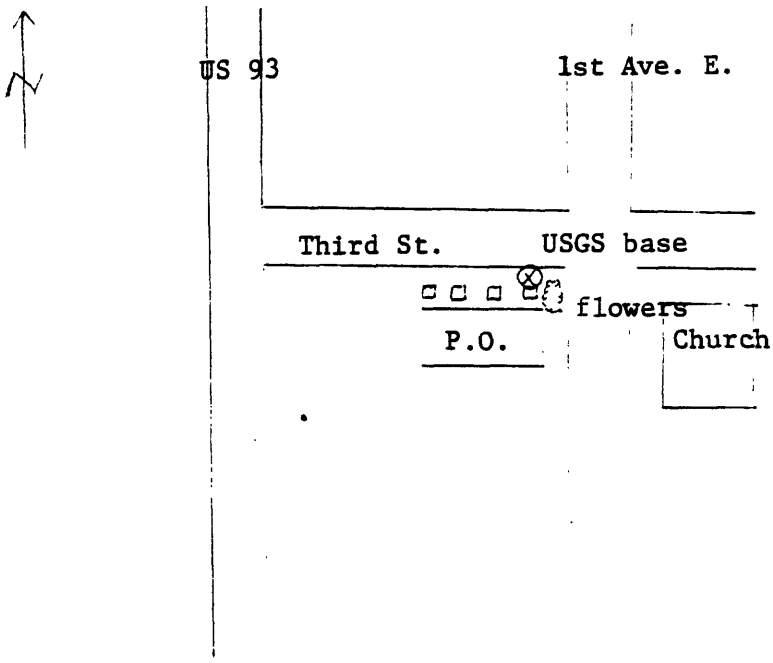
U.S. GEOLOGICAL SURVEY
GRAVITY BASE STATION

STATE/COUNTRY	STATION DESIGNATION	OBSERVED GRAVITY
Montana	Eureka Post Office	980660.70 mgals
NEAREST TOWN Eureka	LONGITUDE 115° 03.07'	LATITUDE 48° 52.85'
ELEVATION 634.1 m (2080')	TOPOGRAPHIC MAP(S) Eureka North 1/24000 Kalispell 1/250,000	

DATE	OBSERVER	METER	REFERENCE STATION	REFERENCE VALUE
8/25/78	Howard/Kleinkopf	G-235	Kalispell DOD	980567.39 mgals

DESCRIPTION/SKETCH

Meter read on concrete sidewalk in front of eastern-most of 4 brick pillars, in front of the Eureka Post Office, located on the corner of 1st Ave. E. and 3rd Street.



Appendix 6: Principal Facts of Gravity Data

Explanation of headings

Identification	
proj	Project name.
sta id	Gravity station identification number.
Location	
latitude	North latitude in degrees, minutes, and hundredths of minutes.
longitude	West longitude in degrees, minutes, and hundredths of minutes.
ele	Station elevation in feet.
st	State where station is located.
Gravity	
observed	Observed gravity in milligals.
theoretical	Theoretical gravity in milligals.
Corrections	
terrain	Terrain correction out to 166.7km in milligals.
Bouguer	Elevation correction in milligals.
curv	Curvature correction in milligals.
special	Not used.
Anomalies	
free-air	Free-air anomaly in milligals.
complete-Bouguer	Complete Bouguer anomaly in milligals for designated densities.
spec fields	Not used.

Mt. Henry Proposed Wilderness Gravity Stations
V.Rankey, J.Mancinelli and M. Brickey 1980-1981
Meter ID: a-24 Date: 01/28/82

STATION IDENTIFICATION proj	sta-id	LOCATIONS LATITUDE deg	min	LONGITUDE deg	min	ELE (in ft)	ST	GRAVITY OBSERVED	THEORETICAL	CORRECTIONS TERRAIN	BOUGUER	CURV	SPECIAL	ANOMALIES FREE AIR	COMPLETE-BOUGUER d1=2.67	d2=2.57	SPEC FIELDS
n :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
n :	lb182	48	48.86	-115	39.61	3310.0	mt	980634.21	980963.37	2.28	-112.89	-1.12	0.00	-17.96	-129.70	-125.51	
n :	lb183	48	49.22	-115	38.25	3452.0	mt	980625.84	980963.91	3.09	-117.74	-1.15	0.00	-13.52	-129.32	-124.98	
n :	elb185	48	50.55	-115	36.00	3992.0		980595.73	980965.89	5.55	-136.16	-1.26	0.00	5.13	-126.73	-121.80	
n :	elb188	48	50.17	-115	33.47	5220.0		980527.56	980965.33	3.76	-178.04	-1.44	0.00	52.93	-122.78	-116.20	
n :	lb189	48	50.99	-115	34.69	5402.0	mt	980511.24	980966.55	9.73	-184.25	-1.45	0.00	52.48	-123.49	-116.90	
n :	lb191	48	52.11	-115	39.91	3042.0	mt	980655.35	980968.23	5.10	-103.75	-1.05	0.00	-26.88	-126.59	-122.85	
n :	lb192	48	54.15	-115	39.81	2983.0	mt	980660.93	980971.28	4.78	-101.74	-1.04	0.00	-29.90	-127.90	-124.23	
n :	lb193	48	55.42	-115	39.23	3004.0	mt	980662.23	980973.18	5.01	-102.46	-1.04	0.00	-28.52	-127.01	-123.32	
n :	lb194	48	56.19	-115	38.64	3051.0	mt	980660.10	980974.33	5.38	-104.06	-1.06	0.00	-27.38	-127.12	-123.38	
n :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
n :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
n :	lb196	48	56.89	-115	34.35	3364.0	mt	980643.91	980975.38	3.46	-114.74	-1.13	0.00	-15.20	-127.60	-123.39	
n :	lb197	48	56.60	-115	31.72	3918.0	mt	980609.73	980974.95	3.70	-133.63	-1.24	0.00	3.13	-128.05	-123.14	
n :	elb199	48	54.73	-115	32.00	5680.0	mt	980499.06	980972.15	9.09	-193.73	-1.48	0.00	60.83	-125.28	-118.31	
n :	elb200	48	53.71	-115	32.46	5200.0	mt	980530.53	980970.62	6.66	-177.36	-1.43	0.00	48.72	-123.41	-116.96	
n :	elb202	48	54.46	-115	33.49	4655.0	mt	980563.92	980971.74	3.27	-158.77	-1.37	0.00	29.78	-127.09	-121.21	
n :	elb203	48	55.12	-115	31.30	4360.0	mt	980580.12	980972.73	5.84	-148.71	-1.32	0.00	17.26	-126.93	-121.53	
n :	lb204	48	55.00	-115	30.41	5338.0	mt	980522.63	980972.55	6.63	-182.06	-1.45	0.00	51.86	-125.02	-118.39	
n :	lb205	48	56.61	-115	29.39	3703.0	mt	980619.32	980974.95	5.09	-126.30	-1.20	0.00	-7.51	-129.92	-125.38	
n :	lb206	48	53.41	-115	27.68	5105.0	mt	980534.87	980970.17	7.17	-174.12	-1.42	0.00	44.58	-123.79	-117.48	
n :	lb208	48	51.43	-115	25.83	5767.0	mt	980493.47	980967.21	3.36	-196.70	-1.48	0.00	68.35	-126.47	-119.17	
n :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
n :	eureka	48	52.85	-115	3.07	2580.0	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-149.51	
n :	lb597	48	56.25	-115	35.35	3312.0	mt	980644.65	980974.42	3.58	-112.96	-1.12	0.00	-18.39	-128.89	-124.75	
n :	lb598	48	56.41	-115	35.01	3373.0	mt	980644.18	980974.66	3.10	-115.04	-1.13	0.00	-13.37	-126.44	-122.21	
n :	lb599	48	53.00	-115	31.06	7243.0	mt	980385.01	980969.56	30.02	-247.04	-1.51	0.00	96.21	-122.32	-114.13	
n :	eureka	48	52.85	-115	3.07	2580.0	mt	980660.70	980969.34	2.23	-88.00	-0.93	0.00	-66.06	-152.76	-149.51	
North :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
North :	ks102	48	51.31	-115	39.94	3019.0	mt	980656.04	980967.03	3.54	-102.97	-1.05	0.00	-27.15	-127.63	-123.87	
North:	ks103	48	52.90	-115	39.88	3045.0	mt	980657.48	980969.41	3.11	-103.86	-1.05	0.00	-25.64	-127.44	-123.63	
North :	ks109	48	56.58	-115	38.25	3063.0	mt	980660.63	980974.91	4.79	-104.47	-1.06	0.00	-26.31	-127.05	-123.27	
North :	ks110	48	57.07	-115	35.50	3339.0	mt	980645.57	980975.65	2.83	-113.88	-1.12	0.00	-16.16	-128.34	-124.14	
North :	ks111	48	57.03	-115	32.48	3457.0	mt	980635.68	980975.59	5.80	-117.91	-1.15	0.00	-14.90	-128.16	-123.92	
North :	ks112	48	55.43	-115	32.32	4010.0	mt	980600.56	980973.20	8.16	-136.77	-1.26	0.00	4.35	-125.52	-120.66	
North :	ks113	48	56.90	-115	30.56	3714.0	mt	980621.20	980975.39	3.72	-126.67	-1.20	0.00	-5.03	-129.18	-124.53	
North :	ks114	48	56.01	-115	28.12	3852.0	mt	980607.32	980974.06	5.03	-131.38	-1.23	0.00	-4.61	-132.19	-127.41	
North :	ks115	48	55.90	-115	26.10	4089.0	mt	980591.67	980973.90	6.70	-139.46	-1.28	0.00	2.18	-131.86	-126.84	
North :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
North :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	
North :	ks149	48	48.54	-115	25.26	5225.0	mt	980521.94	980962.89	3.24	-178.21	-1.44	0.00	50.21	-126.19	-119.59	

Mt. Henry Proposed Wilderness Gravity Stations
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Meter ID: g-24 Date: 01/28/82

STATION IDENTIFICATION proj	sta-id	LOCATIONS LATITUDE deg	min	LONGITUDE deg	min	ELE (in ft)	ST	GRAVITY OBSERVED	THEORETICAL	CORRECTIONS TERRAIN	BOUGUER	CURV	SPECIAL	ANOMALIES FREE AIR	COMPLETE-BOUGUER d1=2.67	d2=2.57	SPEC FIELDS
North :	ks155	48	49.02	-115	31.36	5492.0	mt	980508.84	980963.61	5.30	-187.32	-1.46	0.00	61.49	-121.99	-115.12	
North :	libby	48	23.50	-115	30.77	2080.0	mt	980652.62	980925.39	7.99	-70.94	-0.79	0.00	-77.21	-140.94	-138.56	