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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Principal facts for gravity stations of the Broadwater,
Montana Geothermal Area

by

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On October 31, November 1 and 3, 1978, forty-eight gravity stations were established near Helena, in the Broadwater geothermal area, west-central Montana (fig. 1).

Elevations for the stations were determined by transit level (R. Leonard, U.S. Geological Survey, written communication, 1978), and by benchmark or spot elevations shown on the U.S. Geological Survey topographic map of Helena at a scale of 1:62,500.

The gravity observations were made with a LaCoste-Romberg¹ gravity meter (number g-235) having a scale factor of about one milligal per division.

A base station was located at the Helena Municipal Airport at the beginning and end of each day (fig. 2). The observed gravity was referenced to the base station at the Helena Municipal airport (fig. 2), having a value based on the International Gravity Standardization Net, 1971 (Defense Mapping Agency Aerospace Center, 1974).

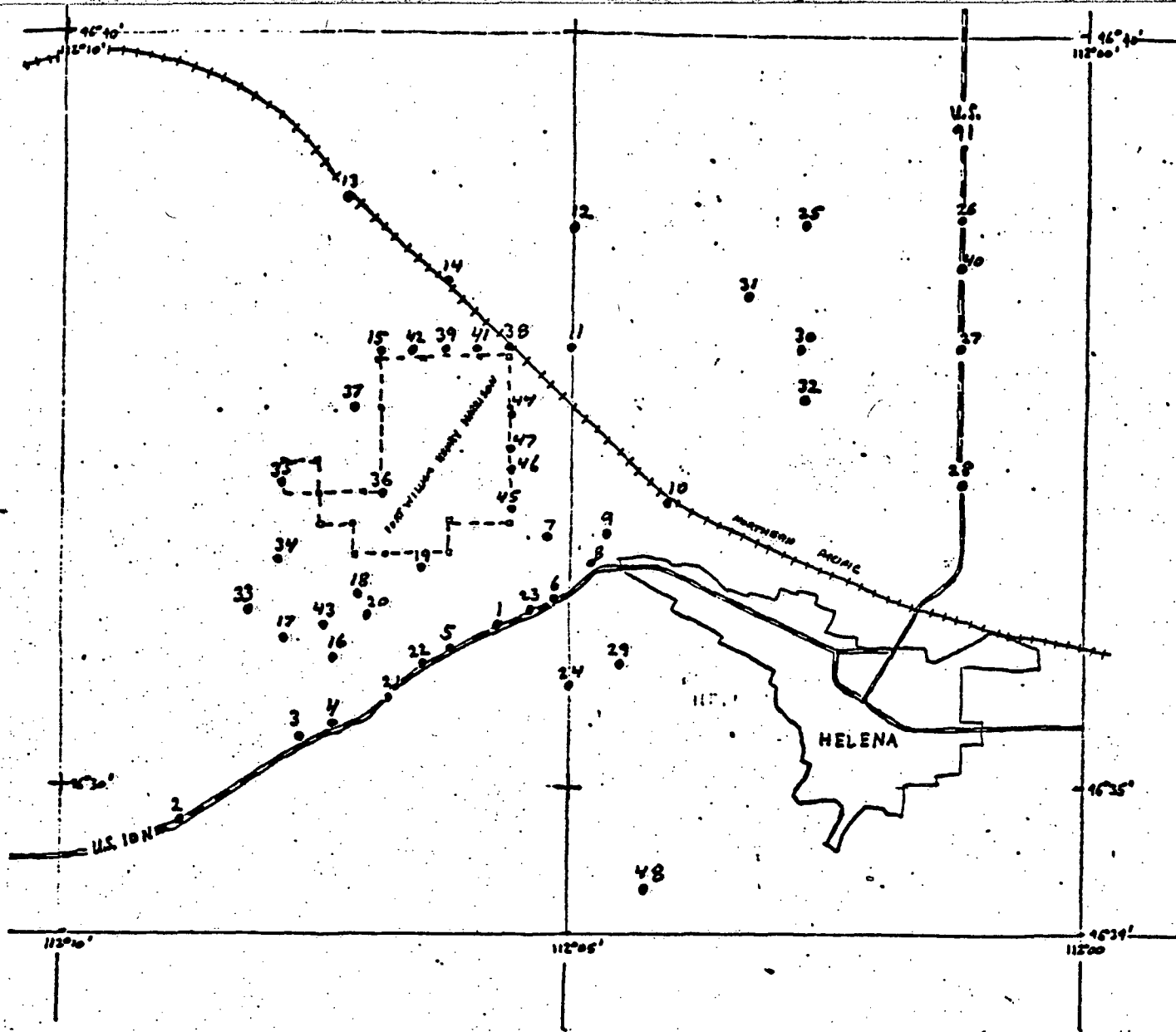
The Geodetic Reference System 1967 formula (International Association of Geodesy, 1967) was used to compute theoretical gravity.

The Bouguer anomaly was computed by use of the following U.S.G.S. computer programs:

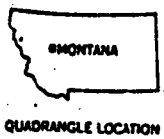
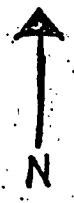
- 1.) U.S.G.S. Gravity Reduction System (R. H. Godson, D. Dansereau, and R. Sweeney, unpublished data, 1978)
- 2.) Program Bouguer (R. H. Godson, U.S.G.S. unpublished data, 1978)

¹ Use of brand names in this report is for descriptive purposes only, and in no way constitutes endorsement by the U.S. Geological Survey.

Terrain, tidal, and drift corrections were made with the above two programs. All corrections were made from each station to a distance of 167 kilometers. Densities of 2.67 g/cm^3 and 2.50 g/cm^3 were used in computing the Bouguer anomaly.

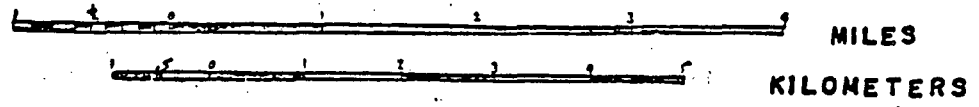


**Fig. 1 GRAVITY STATION LOCATION MAP
BROADWATER GEOTHERMAL AREA
HELENA, MONTANA**



- Gravity Station
- Railroad
- == Highway

SCALE



PRINCIPAL FACTS FOR GRAVITY STATIONS

Explanation of the headings of the accompanying table of principal facts:

STATION IDENTIFICATION	Gravity station number.
LATITUDE	North latitude in degrees, minutes and hundredths of minutes.
LONGITUDE	West longitude in degrees, minutes and hundredths of minutes.
ELE	Elevation in feet (to convert to meters, multiply by 0.3048).
ST	State identification (Montana).
OBSERVED	Observed gravity in milligals.
THEORETICAL	Theoretical gravity in milligals.
TERRAIN	Terrain correction in milligals.
BOUGUER	Bouguer correction in milligals.
CURV	Curvature correction in milligals.
FREE AIR	Free-air anomaly in milligals.
COMPLETE-BOUGUER	Bouguer anomaly in milligals, based on densities of 2.67 and 2.50.

BROADWATER GRAVITY STATIONS
 GATHERED BY M. SENICOFF 1978
 Meter ID: g-235 Date: 08/13/79

Table 1. -- Bouguer Gravity Data for the Broadwater, Montana geothermal area

STATION IDENTIFICATION	L O C A T I O N S				ELEVATION (in ft)	ST	GRAVITY		CORRECTIONS			ANOMALIES				
	proj	sta-id	LATITUDE deg min	LONGITUDE deg min			OBSERVED	THEORETICAL	TERRAIN	BOUGUER	CURV	SPECIAL	FREE AIR	COMPLETE BOUGUER		
Broadwater																
00350: UAST STA	46	36.50	-111	59.50	3872.0	mt	980363.26	980764.56	0.54	-132.06	-1.24	0.00	-37.27	-170.03	-161.58	
00350:	1	46	36.03	-112	5.64	3992.0	mt	980354.58	980763.85	1.69	-136.16	-1.26	0.00	-33.90	-169.09	-161.05
00350:	2	46	34.74	-112	8.02	4162.0	mt	980339.99	980761.94	2.90	-141.95	-1.29	0.00	-30.66	-171.00	-162.06
00350:	3	46	35.27	-112	7.63	4099.0	mt	980347.22	980762.70	2.70	-139.81	-1.28	0.00	-30.12	-168.50	-159.69
00350:	4	46	35.35	-112	7.28	4080.2	mt	980347.23	980762.83	3.38	-139.16	-1.27	0.00	-31.99	-169.05	-160.33
00350:	5	46	35.80	-112	6.15	4072.0	mt	980351.37	980763.51	2.37	-137.18	-1.26	0.00	-34.01	-170.08	-161.42
00350:	6	46	30.27	-112	5.12	3972.0	mt	980358.43	980764.14	1.40	-135.47	-1.25	0.00	-32.28	-167.60	-158.99
00350:	7	46	36.65	-112	5.20	3941.0	mt	980359.75	980764.79	1.06	-134.42	-1.25	0.00	-34.52	-169.12	-160.55
00350:	8	46	36.44	-112	4.77	3941.0	mt	980360.59	980764.53	1.26	-134.42	-1.25	0.00	-33.42	-167.82	-159.27
00350:	9	46	36.69	-112	4.64	3930.0	mt	980361.21	980764.84	0.97	-134.04	-1.25	0.00	-34.15	-168.47	-159.92
00350:	10	46	36.87	-112	3.04	3896.0	mt	980364.49	980765.12	0.75	-132.88	-1.24	0.00	-34.34	-167.71	-159.22
00350:	11	46	37.83	-112	5.02	3913.0	mt	980365.76	980766.56	0.73	-133.46	-1.24	0.00	-32.92	-166.90	-158.36
00350:	12	46	38.75	-112	5.00	3995.0	mt	980362.73	980767.95	0.62	-136.26	-1.26	0.00	-29.62	-166.52	-157.80
00350:	13	46	38.92	-112	7.24	4085.0	mt	980359.44	980768.20	0.93	-139.33	-1.28	0.00	-24.72	-164.39	-155.50
00350:	14	46	38.28	-112	6.20	4009.0	mt	980362.31	980767.24	0.70	-136.74	-1.26	0.00	-28.02	-165.32	-158.58
00350:	15	46	37.84	-112	6.89	4040.0	mt	980357.60	980766.58	0.86	-138.07	-1.27	0.00	-28.40	-166.88	-159.06
00350:	16	46	36.80	-112	7.33	4721.0	mt	980309.71	980765.02	5.24	-161.02	-1.38	0.00	-11.48	-168.63	-158.63
00350:	17	46	35.95	-112	7.80	4650.0	mt	980314.62	980763.73	1.83	-158.60	-1.37	0.00	-11.96	-170.09	-160.03
00350:	18	46	39.51	-112	7.05	4570.0	mt	980317.83	980764.58	2.19	-155.87	-1.35	0.00	-17.11	-172.15	-162.27
00350:	19	46	36.40	-112	6.42	4470.0	mt	980326.51	980764.41	2.39	-152.46	-1.34	0.00	-17.66	-169.07	-159.43
00350:	20	46	36.08	-112	7.97	4218.0	mt	980340.55	980763.93	2.30	-143.86	-1.30	0.00	-26.83	-169.09	-160.59
00350:	21	46	35.58	-112	6.80	4047.0	mt	980347.42	980763.17	3.30	-138.03	-1.27	0.00	-35.27	-171.27	-162.61
00350:	22	46	35.79	-112	6.42	4020.0	mt	980351.24	980763.49	2.58	-137.11	-1.26	0.00	-34.30	-170.10	-161.45
00350:	23	46	36.13	-112	5.35	3975.0	mt	980357.77	980764.00	1.55	-135.58	-1.26	0.00	-32.52	-167.80	-159.18
00350:	24	46	35.68	-112	5.06	4245.0	mt	980339.92	980763.33	1.42	-144.79	-1.30	0.00	-24.31	-168.98	-159.77
00350:	25	46	38.75	-112	2.70	3795.0	mt	980379.16	980767.95	0.58	-129.44	-1.22	0.00	-31.99	-162.07	-153.79
00350:	26	46	38.07	-112	1.15	3749.0	mt	980377.02	980768.13	0.46	-127.87	-1.21	0.00	-38.63	-167.25	-159.07
00350:	27	46	37.89	-112	1.15	3781.0	mt	980371.96	980766.66	0.49	-128.96	-1.22	0.00	-39.21	-168.90	-160.64
00350:	28	46	37.00	-112	1.15	3845.0	mt	980367.34	980765.31	0.58	-131.14	-1.23	0.00	-36.47	-168.27	-159.88
00350:	29	46	35.08	-112	4.52	4237.0	mt	980342.31	980763.63	1.43	-144.51	-1.30	0.00	-22.97	-167.36	-158.17
00350:	30	46	37.89	-112	2.75	3815.0	mt	980373.51	980766.66	0.59	-130.12	-1.22	0.00	-34.47	-165.23	-158.90
00350:	31	46	38.27	-112	3.54	3638.0	mt	980372.74	980767.23	0.63	-130.90	-1.23	0.00	-33.65	-165.15	-158.78
00350:	32	46	37.57	-112	2.75	3820.0	mt	980371.35	980766.17	0.64	-130.29	-1.23	0.00	-35.67	-166.55	-158.22
00350:	33	46	36.14	-112	8.15	4485.0	mt	980326.03	980764.02	0.87	-152.97	-1.34	0.00	-16.34	-169.78	-160.01
00350:	34	46	36.44	-112	7.94	4520.0	mt	980326.92	980764.47	0.81	-154.16	-1.35	0.00	-12.61	-167.31	-157.46
00350:	35	46	36.93	-112	7.84	4270.0	mt	980341.62	980765.21	1.26	-145.64	-1.31	0.00	-22.15	-167.83	-158.56
00350:	36	46	36.93	-112	6.86	4091.0	mt	980352.98	980765.21	1.03	-139.53	-1.28	0.00	-27.61	-167.39	-158.49
00350:	37	46	37.53	-112	7.15	4113.0	mt	980353.67	980766.11	0.86	-140.28	-1.28	0.00	-25.76	-166.46	-157.50
00350:	38	46	37.84	-112	5.62	3949.0	mt	980353.87	980766.58	0.74	-134.69	-1.25	0.00	-31.44	-166.64	-158.03
00350:	39	46	37.84	-112	6.27	3991.0	mt	980359.75	980766.58	0.79	-136.12	-1.26	0.00	-31.61	-168.20	-159.50
00350:	40	46	38.40	-112	1.15	3764.0	mt	980375.63	980767.42	0.47	-128.38	-1.21	0.00	-37.91	-167.03	-158.81
00350:	41	46	37.84	-112	5.95	3968.0	mt	980362.34	980766.58	0.76	-135.34	-1.25	0.00	-31.18	-167.01	-158.36
00350:	42	46	37.84	-112	6.52	4016.0	mt	980358.09	980766.58	0.79	-136.97	-1.26	0.00	-30.92	-168.36	-159.01
00350:	44	46	37.37	-112	5.60	3945.0	mt	980363.18	980765.87	0.83	-134.55	-1.25	0.00	-31.80	-166.77	-158.18
00350:	45	46	36.88	-112	5.62	3946.0	mt	980359.38	980765.13	1.04	-134.65	-1.25	0.00	-34.57	-169.44	-160.65
00350:	46	46	37.10	-112	5.60	3951.0	mt	980360.21	980765.46	0.89	-134.76	-1.25	0.00	-33.80	-168.91	-160.31
00350:	47	46	37.23	-112	5.60	3947.0	mt	980362.37	980765.66	0.66	-134.62	-1.25	0.00	-32.21	-167.22	-158.63
00350:	48	46	34.26	-112	4.32	4414.0	mt	980326.91	980761.19	2.77	-150.55	-1.33	0.00	-19.30	-168.41	-158.91

GRAVITY BASE STATION

LATITUDE $46^{\circ} 36.5' N$ (1)	STATION DESIGNATION <p style="text-align: center;">HELENA</p>	
LONGITUDE $111^{\circ} 59.5' W$ (1)		
ELEVATION 1180.5 METERS (1)	COUNTRY/STATE <p style="text-align: center;">USA/Montana</p>	
REFERENCE CODE NUMBERS		ADOPTED GRAVITY VALUE
ACIC 0175-0 IGC 15661J WA 31	$g = 980\ 363.50$ mgals	
		ESTIMATED ACCURACY
		DATE
		MONTH/YEAR
		Aug/1968
		± 0.1 mgals

DESCRIPTION AND/OR SKETCH

Station is located at Helena, Mont., Municipal Airport, at the gate of the barrier, on the ramp side of the terminal building, opposite the terminal exit to planes, on the asphalt. (1)

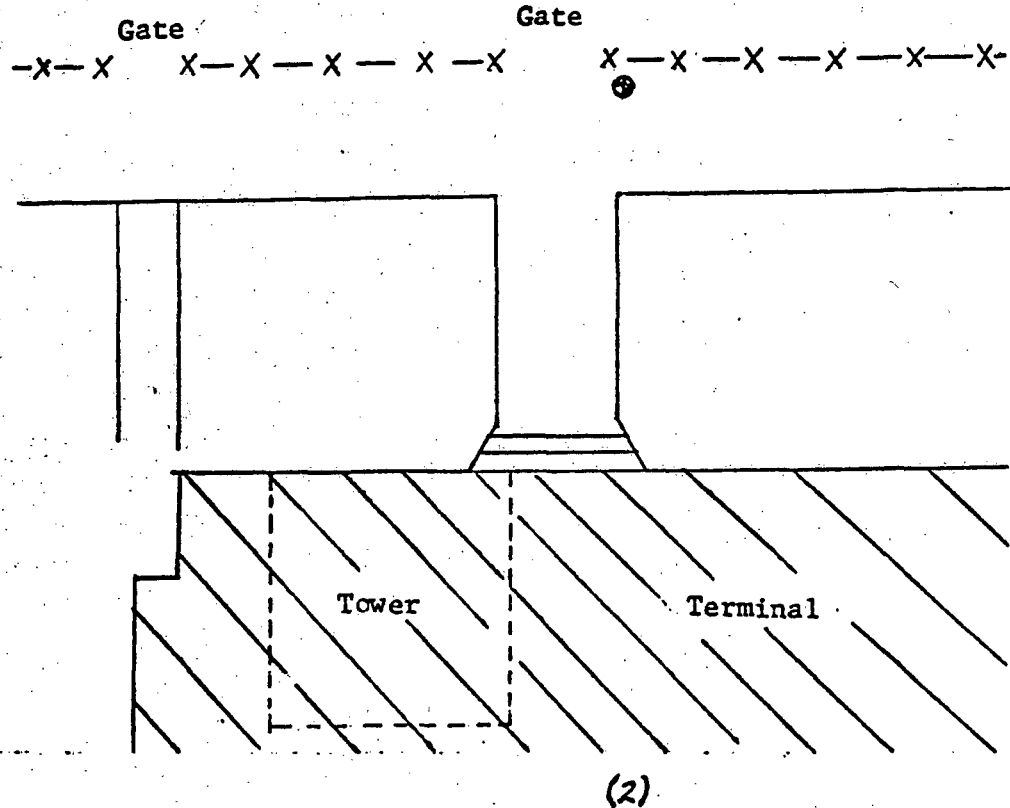


Figure 2.--Helena Municipal Airport base station statistics.

REFERENCE SOURCE

(1) 01355 (2) 05100

References

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

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