

ANNEX O

GRAVITY CONTROL FORMULAS DEPARTMENT OF DEFENSE GRAVITY LIBRARY

Formulas Used in Computing Free-Air and Bouguer Anomalies

1. Symbology

Symbol	Definition	Units
ξ	Free-Air Anomaly	milligals
ζ	Bouguer Anomaly	milligals
ϕ	Latitude of Observation	degrees, minutes
γ	Theoretical Gravity	milligals
g	Observed Gravity	milligals
h	Elevation (Col 23-29) of surface of land, ice or water; depth of ocean, (positive downward) elevation types 3, 4, and 5. + = above SL; - = below SL.	meters
d	Supplemental Elevation (Col 31-35) = Depth of Ocean, lake, ice or instrument (positive downward)	meters

2. Theoretical Gravity Computation

Using the International Gravity Formula 1967

$$\gamma = C_1 (1 + C_2 \sin^2 \phi + C_3 \sin^4 \phi)$$

where: $C_1 = 978031.85$ mgals

$$C_2 = 0.005278895$$

$$C_3 = 0.000023462$$

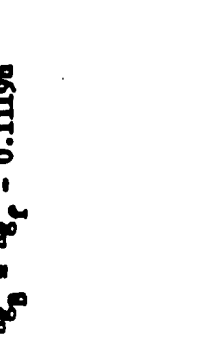
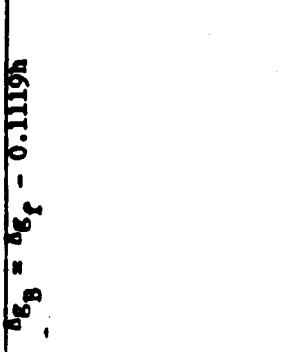
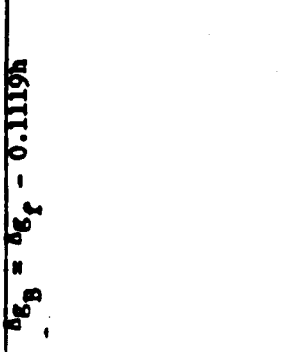
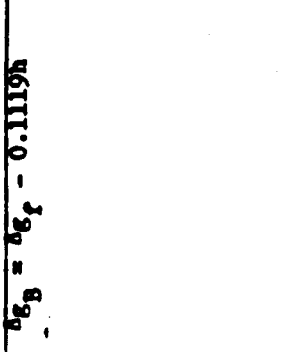
3. Anomaly Computations

$$b = \text{Bouguer Correction Factor}$$
$$= 2 \pi \kappa \rho = 0.04191 \rho$$

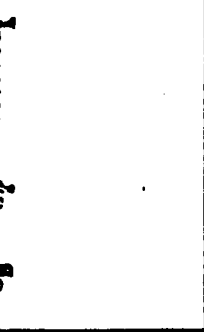
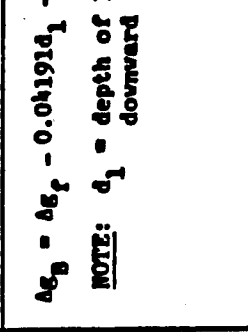
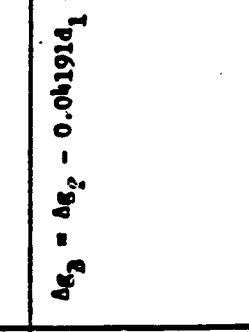
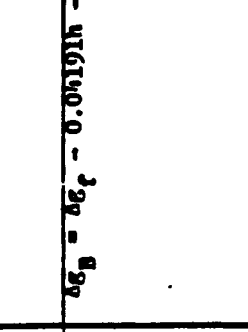
ρ = Density Used in Computations

Substance	ρ	$b = 2 \pi \kappa \rho$
Fresh Water	1.0	0.04191
Salt Water	1.027	0.04304
Ice	0.917	0.03843
Land	2.67	0.1119
Land-Fresh Water	1.67	0.06999
Land-Salt Water	1.643	0.06886
Land and Ice	1.753	0.07347

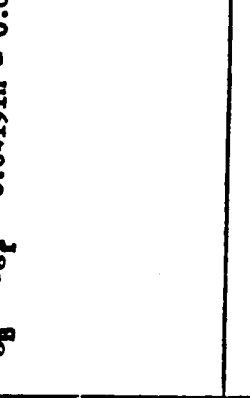
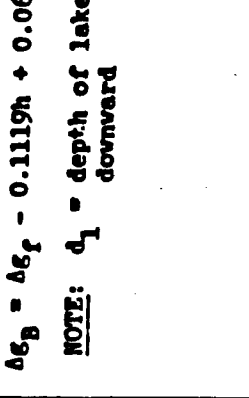
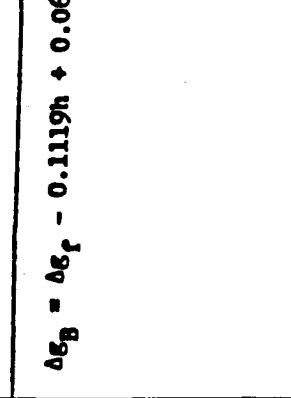
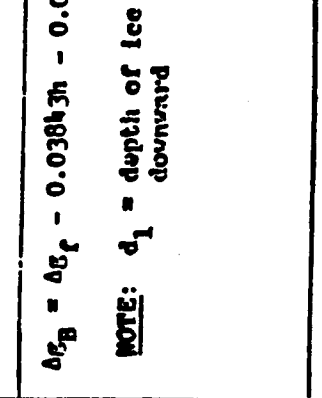
ANOMALY COMPUTATION CHART (p. 1)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
1	<p>LAND OBSERVATION</p> 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h$
2	<p>SUBSURFACE</p> 	$\Delta g_f = g + 0.223d_2 + 0.3086(h-d_2) - \gamma$ <p>NOTE: d_2 = depth of instrument</p>	$\Delta g_B = \Delta g_f - 0.1119h$
3	<p>OCEAN SURFACE</p> 	$\Delta g_f = g - \gamma$	$\Delta g_B = \Delta g_f + 0.06886h$ <p>NOTE: h = depth of ocean positive downward from surface</p>
h	<p>OCEAN SUBMERGED</p> 	$\Delta g_f = g - 0.223d_2 - \gamma$ <p>NOTE: d_2 = depth of instrument positive downward</p>	$\Delta g_B = \Delta g_f + 0.06886h$ <p>NOTE: h = depth of ocean positive downward</p>

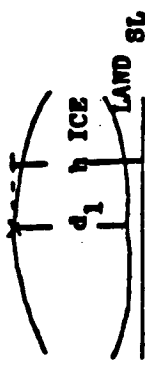
ANOMALY COMPUTATION CHART (p. 2)

Elev. Type Col. 1, 2)	SITUATION	FREE-AIR ANOMALY COMPUTATION	LONGUER ANOMALY COMPUTATION
5	<p>OCEAN BOTTOM</p> 	$\Delta G_f = g - 0.2225d_1 - \gamma$ <p>NOTE: d_1 = depth of ocean positive downward</p>	$\Delta G_B = \Delta G_f + 0.0686d_1$
6	<p>LAKE SURFACE (above sea level)</p> 	$\Delta G_f = g + 0.3086h - \gamma$	$\Delta G_B = \Delta G_f - 0.04191d_1 - 0.1119(h-d_1)$ <p>NOTE: d_1 = depth of lake positive downward</p>
7	<p>LAKE BOTTOM (above sea level)</p> 	$\Delta G_f = g + 0.08382d_1 + 0.3086(h-d_1) - \gamma$	$\Delta G_B = \Delta G_f - 0.04191d_1 - 0.1119(h-d_1)$
8	<p>LAKE BOTTOM (below sea level)</p> 	$\Delta G_f = g + 0.08382d_1 + 0.3086(h-d_1) - \gamma$	$\Delta G_B = \Delta G_f - 0.04191h - 0.06999(h-d_1)$

ANOMALY COMPUTATION CHART (p. 3)

Elev. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
9	<p>LAKE SURFACE (above sea level)</p> <p>with bottom below sea level</p> 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.04191h - 0.06999(h-d_1)$
A	<p>LAKE SURFACE (below sea level)</p> 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$ <p>NOTE: d_1 = depth of lake positive downward</p>
B	<p>LAKE BOTTOM (surface below sea level)</p> 	$\Delta g_f = g + 0.3086h - 0.2248d_1 - \gamma$ <p>NOTE: d_1 = depth of lake positive downward</p>	$\Delta g_B = \Delta g_f - 0.1119h + 0.06999d_1$
C	<p>ICE CAP (bottom below sea level)</p> 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.03843h - 0.07347(h-d_1)$ <p>NOTE: d_1 = depth of ice positive downward</p>

ANOMALY COMPUTATION CHART (p. 4)

Fig. Type Col. 21	SITUATION	FREE-AIR ANOMALY COMPUTATION	BOUGUER ANOMALY COMPUTATION
D	ICE CAP (bottom above sea level) 	$\Delta g_f = g + 0.3086h - \gamma$	$\Delta g_B = \Delta g_f - 0.03863d_1 - 0.1119(h-d_1)$ NOTE: d_1 = depth of ice