GL009560

MONTANA TECH

Butte, Montana 59701
(406) 496-4101

Rec'd 7/5/88 HAR

June 29, 1988

Mr. H. Ross
Earth Science Laboratory,
UURI
391 Chipeta Way, Suite C
Salt Lake City, UT 84108

Dear Mr. Ross:

Enclosed is a copy of the Final Report Part II for Contract DE-FG07-84ID12425, "Geophysical Research on Geothermal Resources in Montana". Part I of the report was submitted previously on December 21, 1987.

Sincerely,

W. R. Sill, Professor
Department of Physics and Geophysical Engineering

WRS/rm
Enclosure (1)

DOE F 5[illegible]
(3-8[illegible])

U.S. DEPARTMENT OF ENERGY

NOTICE OF FINANCIAL ASSISTANCE AWARD

(See Instructions on Reverse)

File 4.M.2.33

Received @ ESL, 27 June '84

Under the authority of Public Law 93-410 and subject to legislation, regulations and policies applicable to *(cite legislative program title)*:
Geothermal Research, Development, and Demonstration Act of 1977

1. PROJECT TITLE
Geophysical Research on Geothermal Resources in Montana

2. INSTRUMENT TYPE
☒ GRANT ☐ COOPERATIVE AGREEMENT

4. INSTRUMENT NO.
DE-FG07-84ID12525

5. AMENDMENT NO.

3. RECIPIENT *(Name, address, zip code, area code and telephone no.)*
Montana College of Mineral Science and Technology
Butte, MT 59701

6. BUDGET PERIOD
FROM: 6/11/84 THRU: 12/11/85

7. PROJECT PERIOD
FROM: 6/11/84 THRU: 12/11/85

8. RECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*
Charles J. Wideman (406)496-4209
William R. Sill (406)496-4211

10. TYPE OF AWARD
☒ NEW ☐ CONTINUATION ☐ RENEWAL
☐ REVISION ☐ SUPPLEMENT

9. RECIPIENT BUSINESS OFFICER *(Name and telephone No.)*
John Dunston (406)496-4265

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*
Elizabeth M. Hyster, Contract Spec., R&DCB
U. S. Department of Energy (208)526-1229
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

11. DOE PROJECT OFFICER *(Name, address, zip code, telephone No.)*
R. Eldon Bray, Gen. Engr., ATD (208)526-0086
U.S.DOE, Idaho Operations Office
550 Second Street, Idaho Falls, ID 83401

13. RECIPIENT TYPE
☐ STATE GOV'T ☐ INDIAN TRIBAL GOV'T ☐ HOSPITAL ☐ FOR PROFIT ORGANIZATION ☐ INDIVIDUAL
☐ LOCAL GOV'T ☒ INSTITUTION OF HIGHER EDUCATION ☐ OTHER NONPROFIT ORGANIZATION ☐ C ☐ P ☐ SP ☐ OTHER *(Specify)*

14. ACCOUNTING AND APPROPRIATIONS DATA

a. Appropriation Symbol	b. B & R Number	c. FT/AFP/OC	d. CFA Number
89X0224.91	AM1510000	ID-44-91/250	

15. EMPLOYER I.D. NUMBER/SSN

16. BUDGET AND FUNDING INFORMATION

a. CURRENT BUDGET PERIOD INFORMATION

(1) DOE Funds Obligated This Action	$ 93,421
(2) DOE Funds Authorized for Carry Over	$ -0-
(3) DOE Funds Previously Obligated in this Budget Period	$ -0-
(4) DOE Share of Total Approved Budget	$ 93,421
(5) Recipient Share of Total Approved Budget	$ -0-
(6) Total Approved Budget	$ 93,421

b. CUMULATIVE DOE OBLIGATIONS

(1) This Budget Period *[Total of lines a.(1) and a.(3)]*	$ 93,421
(2) Prior Budget Periods	$ -0-
(3) Project Period to Date *[Total of lines b. (1) and b. (2)]*	$ 93,421

17. TOTAL ESTIMATED COST OF PROJECT $ _____

(This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this amount.)

18. AWARD/AGREEMENT TERMS AND CONDITIONS

This award/agreement consists of this form plus the following:

a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)

b. Applicable program regulations *(specify)* N/A *(Date)* _____

c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and ☒ B (Grants) or ☐ C (Cooperative Agreements).

d. Application/proposal dated 3/28/84, ☐ as submitted ☒ with changes as negotiated

19. REMARKS
This Grant consists of this NFAA, Part I - Budget Plan, Part II - Conditions and Part III - Statement of Work. The DOE Financial Assistance Rules (10CFR Part 600), OMB Circular A-110, and OMB Circular A-21 are incorporated by reference and attached hereto.

20. EVIDENCE OF RECIPIENT ACCEPTANCE
Edward C. Bingler 6/18/84
(Signature of Authorized Recipient Official) *(Date)*
Edward C. Bingler
(Name)
Director of Research
(Title)

21. AWARDED BY
William C. Drake 6/11/84
(Signature) *(Date)*
William C. Drake
(Name)
Contracting Officer
(Title)

INSTRUCTIONS

(This form shall be completed in accordance with the following instructions. For any clarification or additional information that might be needed, consult the appropriate section of the DOE Financial Assistance Procedures Manual (DOE-FAPM).

Insert in the space provided, in the line which begins, "Under the Authority of Public Law . . . ," the number and the name of the Public Law which authorizes this award. On the line below, enter the title of the pertinent program.

Block 1 - Enter the project title as it appears in the SF-424 or equivalent application/proposal face sheet.

Block 2 - Place a checkmark in the box beside the appropriate financial assistance instrument.

Block 3 - Enter the name, address and telephone number of the applicant/proposer as it appears in the SF-424 or equivalent application/proposal face sheet.

Block 4 - Enter the instrument number. (See DOE-FAPM.)

Block 5 - Enter the appropriate amendment number. (See DOE-FAPM for guidance.)

Block 6 - Enter the starting date and expiration date for the current budget period. If a budget period is being changed, enter the starting date and expiration date for the budget period, as changed.

Block 7 - Enter the starting date and anticipated completion date for the project. If a project period is being changed, enter the starting date and anticipated completion date for the project period, as changed.

Block 8 - Enter the name and telephone number of the individual designated by the applicant/proposer as the director of the project.

Block 9 - Enter the name and telephone number of the individual designated by the applicant/proposer as the contact for all business matters.

Block 10 - Place a checkmark in the box opposite the term which identifies the type of action being taken. (The terms are defined in the DOE-FAPM.)

Block 11 - Enter the name, address and telephone number of the individual designated by the DOE program office as the project officer.

Block 12 - Enter the name, address and telephone number of the individual/organization who will administer the agreement for DOE.

Block 13 - Place a checkmark in the box beside the applicable recipient type. If the recipient is a for-profit organization also check one of the lower boxes as follows: "C" for Corporation, "P" for Partnership and "SP" for Sole Proprietorship. If the recipient is of a type not indicated place a checkmark in the box beside "Other," and identify the recipient type in the space provided.

Block 14 - Enter where indicated, the appropriation symbol, B&R number, Fund Type (FT)/AFP Code (AFP)/Objective Class (OC) and CFA Number from the Procurement/Financial Assistance Request Authorization (DOE Form PR-799A). Completion of Block 14.d. is required only for awards made by Headquarters.

Block 15 - Enter the applicant's/proposer's Federal Employer Identification No. from the SF-424 or equivalent application/proposal face sheet, or if the applicant/proposer is an individual, enter his/her social security number.

•U.S. GOVERNMENT PRINTING OFFICE: 1981—522-056/4703

Block 16 - Entries should be made as follows: (If no dollar entry is appropriate a zero should be entered to indicate there was no error of omission.)

Line a.(1) - Enter the amount of DOE funds obligated by this action.

Line a.(2) - Enter the amount of DOE funds not expended in prior budget period(s), if any, authorized by DOE for expenditure in the current budget period.

Line a.(3) - Enter the amount of DOE funds previously obligated in the current budget period.

Line a.(4) - Enter DOE's share of the total approved budget shown on Line a.(6).

Line a.(5) - Enter the recipient's share of the total approved budget shown on Line a.(6).

Line a.(6) - Enter the total approved budget for the current budget period. (Add the amounts in lines a.(4) and a.(5).)

Line b.(1) - Enter the amount of DOE funds obligated in the current budget period. (Add the amounts in lines a.(1) and a.(3).)

Line b.(2) - Enter the amount obligated by DOE in prior budget periods.

Line b.(3) - Enter the amount obligated by DOE in the project period to date. (Add the amounts in lines b.(1) and b.(2).)

Block 17 - Must be completed for cooperative agreements. Contracting Officers may exercise discretion as to whether to complete it for grants. Enter in the blank provided, the amount which represents the current estimate of total funds and dollar value of in-kind contributions (both DOE and recipient shares) needed to carry out the entire project. Include all funds and contributions previously provided, those being provided by this action, and all anticipated future obligations and contributions of both parties.

Block 18 - Complete as follows:

Item a. - No entry necessary.

Item b. - Enter the legal citation from the Code of Federal Regulations or Federal Register and the effective date for the program regulations applicable to the program under which the award is made.

Item c. - Mark the box beside B for grants or C for cooperative agreements.

Item d. - In the blank provided, enter the date of the application/proposal. (If SF-424 is used, see block 23c on page 1.) Place a checkmark in the appropriate box to indicate whether the application/proposal was accepted as submitted or with negotiated changes.

Block 19 - Enter any explanation or advisory comments which are required for, or applicable to, this action.

Block 20 - Will be completed by the recipient.

Block 21 - The Contracting Officer shall sign and date the top line. His/her name and title should be entered on the next two lines. This box must be signed prior to forwarding to recipient.

Grantee - Montana College of Mineral Science and Technology

BUDGET PLAN

Salaries	$ 12,000
Benefits	$ 2,431
Research Fellowships	$ 20,000
Field Travel	$ 15,820
Supplies	$ 2,500
Publications	$ 2,000
Equipment	$ 30,855
Indirect Costs	$ 7,215
TOTAL	$ 93,421

PART II - CONDITIONS

This grant is subject to the following provisions:

1. General

The grantee is obligated to conduct such project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined herein.

2. Reporting Program Technical Performance

a. Copies. Copies of reports and all other related data and information generated under this grant shall be submitted in accordance with the attached Federal Assistance Reporting Checklist (DOE Form EIA-459A).

b. Publication of results. The Grantee may publish the results of its work. However, publications and reports prepared under this grant shall contain the following acknowledgment statement, "This (material) was prepared with the support of the U.S. Department of Energy (DOE) Grant No. DE-FG07-84ID12525. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of DOE."

c. The Federal assistance recipient shall prepare and submit (postage prepaid) the plans and reports indicated on the Federal Assistance Reporting Distribution List. Preparation of the specified plans and reports shall be in accordance with the DOE Uniform Reporting System for Federal Assistance Guidelines. The level of detail the recipient provides in the plans and reports shall be commensurate with the scope and complexity of the task and shall be as delineated in Block 4 - Reporting Requirements - and Block 5 - Special Instructions. The prime recipient shall be responsible for acquiring data from any subcontractors, or subrecipients to ensure that data submitted are compatible with the data elements which prime recipients submit to DOE. Plans and reports submitted in compliance with this provision are in addition to any other reporting requirements of the Federal assistance instrument.

d. All reports delivered to DOE shall be the sole property of the DOE. The Grantee shall not claim that any report contains any trade secrets or commercial or financial information deemed by the Grantee to be privileged or confidential, or that the Grantee has any proprietary interest in any report.

3. Travel

Domestic travel is an appropriate charge to this grant, and prior authorization for specific trips is not required. Foreign travel must be clearly essential to the grant effort and must, to be charged against this grant, have prior explicit approval of the Grants Officer regardless of its inclusion in the approved grant budget. The Grantee agrees to use U.S. Flag air carriers to the maximum extent practicable when international air transportation becomes necessary under this grant. The difference in cost between first-class air accommodations and economy class accommodations is unallowable.

4. Allowable Costs

Allowability of costs shall be determined in accordance with OMB Circular A-21 which is attached and hereby incorporated by reference.

5. Project Period

The project completion date is December 11, 1985, which includes 90 days for completion of the final report. All research effort must be completed by September 11, 1985. Only costs associated with preparation of the final report will be allowed during the 90 days from September 11, 1985 through December 11, 1985.

6. Payments

a. The Grantee may request advance payment of cost to be incurred. Such requests should not exceed the expected outlays by the Grantee in the succeeding 30-day period.

b. Payments to the Grantee shall equal the Federal share of actual allowable costs of performance of this grant, provided however, and notwithstanding any other provision of this grant, that the Government's monetary liability under this grant shall not exceed the Government share of the total approved budget or an amount equal to the Federal share of actual allowable costs, whichever is less. The Grantee shall be obligated to perform under this grant throughout the agreed-upon period of performance, and to bear all costs which DOE has not agreed to pay. However, the Grantee shall have the right to cease to perform when or after the Federal share of actual allowable costs equals or exceeds the Government share of the total approved budget and if prior written notice to that has been provided to DOE.

c. The Government obligations may be increased unilaterally by DOE by written notice to the Grantee and may be increased or decreased by written agreement of the parties.

6. Payments (Cont'd)

d. Upon termination or expiration of the total period of performance, the Grantee shall promptly refund to DOE (or make such disposition as DOE may in writing direct) any sums paid by DOE to the Grantee under this grant in excess of the cumulative Government allowable cost incurred in performance under the grant.

e. Applicable Credits. The Grantee agrees that any refunds, rebates, credits, or other amounts (including any interest thereon) accruing to or received by the Grantee or any assignee under this grant shall be paid by the Grantee to the Government, to the extent that they are properly allocable to costs for which the Grantee has been reimbursed by the Government under this grant. Reasonable expenses incurred by the Grantee for the purpose of securing such refunds, rebates, credits, or other amounts shall be allowable costs hereunder when approved by the Grant Officer.

f. Audit Adjustments. The Grant Officer may have invoices or vouchers and statements of cost submitted under this grant audited at any time prior to the end of the required retention period for the grant records. Each payment made shall be subject to reduction for amounts included in the related invoice or voucher which are found by the Grant Officer, on the basis of audit, not to constitute allowable cost. If a final audit of costs has not been performed prior to closeout of the grant, DOE or its successor agency, shall have the right to recover an appropriate amount after fully considering the recommendations on disallowed costs resulting from the final audit when conducted.

7. Financial Reporting Requirements

Three copies of the Grantee's Financial Status Report (prepared on an accrual basis) shall be submitted to the Grant Officer at the end of the project period. (The project period of this grant is inclusive of the 90 days stated in OMB Circular A-110, Attachment G.)

8. Retention and Custodial Requirements for Records

Grantees shall retain and permit examination of records as required by OMB Circular A-110, Attachment C.

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982)

a. Definitions

(1) "Invention" means any invention or discovery which is or may be patentable or otherwise protectable under Title 35 of the United States Code (USC).

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

(2) "Subject Invention" means any invention of the grantee conceived or first actually reduced to practice in the performance of work under this agreement.

(3) "Practical Application" means to manufacture in the case of a composition or product, to practice in the case of a process or method, or to operate in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

(4) "Made" when used in relation to any invention means the conception or first actual reduction to practice of such invention.

(5) "Small Business Firm" means a small business concern as defined at Section 2 of Public Law 85-536 (15 USC 632) and implementing regulations of the Administrator of the Small Business Administration. For the purpose of this clause, the size standard for small business concerns involved in Government procurement, contained in 13 CFR 121.3-8, and in subcontracting, contained in 13 CFR 121.3-12, will be used.

(6) "Nonprofit Organization" means universities and other institutions of higher education or an organization of the type described in section 501(c)(3) of the Internal Revenue Code of 1954 (26 USC 501a) and exempt from taxation under section 501(a) of the Internal Revenue Code (26 U.S.C. 501(a)) or any nonprofit scientific or educational organization qualified under a state nonprofit organization statute.

(7) "Patent Counsel" means the Department of Energy (DOE) patent counsel assisting the DOE contracting activity.

b. Allocation of Principal Rights

The Grantee may retain the entire right, title, and interest throughout the world to each subject invention subject to the provisions of this clause and 35 U.S.C. 203. With respect to any subject invention in which the Grantee retains title, the Federal Government shall have a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world.

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

c. Invention Disclosure, Election of Title and Filing of Patent Applications by the Grantee

(1) The Grantee will disclose each subject invention to the Patent Counsel (with notification by the Patent Counsel to the Contracting Officer) within two months after the inventor discloses it in writing to Grantee personnel responsible for the administration of patent matters. The disclosure to the Patent Counsel shall be in the form of a written report and shall identify the agreement under which the invention was made and the inventor(s). It shall be sufficiently complete in technical detail to convey a clear understanding, to the extent known at the time of the disclosure, of the nature, purpose, operation, and the physical, chemical, biological or electrical characteristics of the invention. The disclosure shall also identify any publication, on sale or public use of the invention and whether a manuscript describing the invention has been submitted for publication and, if so, whether it has been accepted for publication at the time of disclosure. In addition, after disclosure to Patent Counsel, the Grantee will promptly notify Patent Counsel of the acceptance of any manuscript describing the invention for publication or of any on sale or public use planned by the Grantee.

(2) The Grantee will elect in writing whether or not to retain title to any such invention by notifying Patent Counsel within twelve months of disclosure to the Grantee: provided that in any case where publication, on sale or public use has initiated the one year statutory period wherein valid patent protection can still be obtained in the United States, the period for election of title terminates sixty days prior to the end of the statutory period.

(3) The Grantee will file its initial patent application on an elected invention within two years after election or, if earlier, prior to the end of any statutory period wherein valid patent protection can be obtained in the United States after a publication, on sale, or public use. The Grantee will file patent applications in additional countries within either ten months of the corresponding initial patent application or six months from the date permission is granted by the Commissioner of Patents and Trademarks to file foreign patent applications where such filing has been prohibited by a Secrecy Order.

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

(4) Requests for extension of the time for disclosure to Patent Counsel, election, and filing may, at the discretion of the Patent Counsel, be granted.

d. Conditions When the Government May Obtain Title

(1) The Grantee will convey to DOE, upon written request, title to any subject invention:

(i) If the Grantee fails to disclose or elect the subject invention within the times specified in c. above, or elects not to retain title.

(ii) In those countries in which the Grantee fails to file patent application within the times specified in c. above: provided, however, that if the Grantee has filed a patent application in a country after the times specified in c. above, but prior to its receipt of the written request of Patent Counsel, the Grantee shall continue to retain title in that country; or

(iii) In any country in which the Grantee decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in a reexamination or opposition proceeding on, a patent on a subject invention.

e. Minimum Rights to Grantee

(1) The Grantee will retain a nonexeclusive, royalty-free license throughout the world in each subject invention to which the Government obtains title except if the Grantee fails to disclose the subject invention within the times specified in c. above. The Grantee's license extends to its domestic subsidiaries and affiliates, if any, within the corporate structure of which the Grantee is a part and includes the right to grant sublicenses of the same scope to the extent the Grantee was legally obligated to do so at the time the agreement was awarded. The license is transferable only with the approval of DOE except when transferred to the successor of that part of the Grantee's business to which the invention pertains.

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

(2) The Grantee's domestic license may be revoked or modified by DOE to the extent necessary to achieve expeditious practical application of the subject invention pursuant to an application for an exclusive license submitted in accordance with 10 CFR 781. This license will not be revoked in that field of use or the geographical areas in which the Grantee has achieved practical application and continues to make the benefits of the invention reasonably accessible to the public. The license in any foreign country may be revoked or modified at the discretion of DOE to the extent the Grantee, its licensees, or its domestic subsidiaries or affiliates have failed to achieve practical application in that foreign country.

(3) Before revocation or modification of the license, DOE will furnish the Grantee a written notice of its intention to revoke or modify the license, and the Grantee will be allowed thirty days (or such other time as may be authorized by DOE for good cause shown by the Grantee) after the notice to show cause why the license should not be revoked or modified. The Grantee has the right to appeal, in accordance with 10 CFR 781, any decision concerning the revocation or modification of its license.

f. Grantee Action to Protect Government's Interest

(1) The Grantee agrees to execute or to have executed and promptly deliver to Patent Counsel all instruments necessary to:

(i) Establish or confirm the rights the Government has throughout the world in those subject inventions for which the Grantee elects to retain title, and

(ii) Convey title to DOE when requested under d. above, and to enable the Government to obtain patent protection throughout the world in that subject invention.

(2) The Grantee agrees to require, by written agreement, its employees, other than clerical and nontechnical employees, to disclose promptly in writing to personnel identified as responsible for the administration of patent matters and in a format suggested by the Grantee each subject invention made under this agreement in order that the Grantee can comply with the disclosure provisions of c. above, and to execute

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

all papers necessary to file patent applications on subject inventions. The disclosure format should require, as a minimum, the information requested by subparagraph c.(1) above. The Grantee shall instruct such employees through the employee agreements or other suitable educational programs on the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to United States or foreign statutory bars.

(3) The Grantee will notify Patent Counsel of any decision not to continue prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceeding on a patent, in any country, not less than thirty days before the expiration of the response period required by the relevant patent office.

(4) The Grantee agrees to include, within the specification of any United States patent application and any patent issuing thereon covering a subject invention, the following statement, "This invention was made with Government support under (identify the agreement) awarded by the Department of Energy. The Government has certain rights in this invention."

(5) The Grantee agrees to:

(i) Provide a report prior to the close-out of the agreement listing all subject inventions;

(ii) Provide notification of all subcontracts for experimental, developmental, demonstration, or research work, the identity of the patent rights clause therein, and copy of each subcontract upon request;

(iii) Provide promptly a copy of the patent application, filing date, serial number, patent number and issue date for any subject invention in any country in which the Grantee has applied for patents.

g. Subcontracts

(1) The Grantee will include this clause, suitably modified to identify the parties, in all subcontracts, regardless of tier, for experimental, developmental or research work to be performed in the United States by a small business firm or domestic nonprofit organization. The subcontractor will

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

retain all rights provided for the Grantee in this clause, and the Grantee will not, as part of the consideration for awarding the subcontract, obtain rights in the subcontractor's subject inventions.

(2) The Grantee will include in all other subcontracts, regardless of tier, for experimental, developmental, demonstration, or research work the patent rights clause required by 41 CFR 9-9.107-5(a) or 41 CFR 9-9.107-6 as appropriate, modified to identify the parties.

(3) In the case of a subcontract, at any tier DOE, the subcontractor, and the Grantee agree that the mutual obligations of the parties created by this clause constitute a contract between the subcontractor and DOE with respect to those matters covered by this clause.

h. Reporting on Utilization of Subject Inventions

The Grantee agrees to submit on request periodic reports no more frequently than annually on the utilization of a subject invention or on efforts at obtaining such utilization that are being made by the Grantee or its licensees or assignees. Such reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the Grantee, and such other data and information as DOE may reasonably specify. The Grantee also agrees to provide additional reports as may be requested by DOE in connection with any march-in proceeding undertaken by DOE in accordance with paragraph j. of this clause. To the extent data or information supplied under this section is considered by the Grantee, its licensee or assignee to be privileged and confidential and is so marked, DOE agrees that, to the extent permitted by 35 USC 202(c)(5), it will not disclose such information to persons outside the Government.

i. Preference for United States Industry

Notwithstanding any other provision of this clause, the Grantee agrees that neither it nor any assignee will grant to any person the exclusive right to use or sell any subject invention in the United States unless such person agrees that any products embodying the subject invention or produced through the use of the subject invention will be manufactured substantially in the United States. However, in individual cases, the requirement for such an

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

agreement may be waived by DOE upon a showing by the Grantee or its assignee that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that under the circumstances domestic manufacture is not commercially feasible.

j. March-in Rights

The Grantee agrees that with respect to any subject invention in which it has acquired title, DOE has the right in accordance with the procedures in OMB Circular A-124 to require the Grantee, an assignee or exclusive licensee of a subject invention to grant a nonexclusive, partially exclusive, or exclusive license in any field of use to a responsible applicant or applicants, upon terms that are reasonable under the circumstances, and if the Grantee, assignee, or exclusive licensee refuses such a request, DOE has the right to grant such a license itself if DOE determines that:

(1) Such action is necessary because the Grantee or assignee has not taken, or is not expected to take within a reasonable time, effective steps to achieve practical application of the subject invention in such field of use;

(2) Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the Grantee, assignee, or their licensees;

(3) Such action is necessary to meet requirements for public use specified by federal regulations and such requirements are not reasonably satisfied by the Grantee, assignee, or licensees; or

(4) Such action is necessary because the agreement required by paragraph i. of this clause has not been obtained or waived or because a licensee of the exclusive right to use or sell any subject invention in the United States is in breach of such agreement.

k. Special Provisions for Agreements with Nonprofit Organizations

If the Grantee is a nonprofit organization, it agrees that:

9. Patent Rights - (Small Business Firms and Nonprofit Organizations) (March 1982) (Cont'd)

(1) Rights to a subject invention in the United States may not be assigned without the approval of DOE, except where such assignment is made to an organization which has as one of its primary functions the management of inventions and which is not, itself, engaged in or does not hold a substantial interest in other organizations engaged in the manufacture or sale of products or the use of processes that might utilize the invention or be in competition with embodiments of the invention (provided that such assignee will be subject to the same provisions as the Grantee);

(2) The Grantee may not grant exclusive licenses under United States patents or patent applications in subject inventions to persons other than small business firms for a period in excess of the earlier of:

(i) Five years from first commercial sale or use of the invention; or

(ii) Eight years from the date of the exclusive license excepting that time before regulatory agencies necessary to obtain premarket clearance, unless on a case-by-case basis, DOE approves a longer exclusive license. If exclusive field of use licenses are granted, commercial sale or use in one field of use will not be deemed commercial sale or use as to other fields of use, and a first commercial sale or use with respect to a product of the invention will not be deemed to end the exclusive period to different subsequent products covered by the invention.

(3) The Grantee will share any royalties collected on a subject invention with the inventor; and

(4) The balance of any royalties or income earned by the Grantee with respect to subject inventions, after payment of expenses (including payments to inventors) incidental to the administration subject inventions, will be utilized for the support of scientific research or education.

1. Communications

The DOE central point of contact for communications or matters relating to this clause is the Patent Counsel.

10. Rights in Technical Data - Short Form

a. Definitions. The definitions of terms set forth in 41 CFR 9-9.201 apply to the extent these terms are used herein.

b. Allocation of Rights.

(1) The Government shall have:

(i) Unlimited rights in technical data first produced or specifically used in the performance of this grant;

(ii) The right of the Grant Officer or his representatives to inspect at all reasonable times up to three (3) years after final payment under this grant all technical data first produced or specifically used in the grant (for which inspection the Grantee or its subcontractor shall afford proper facilities to DOE);

(iii) The right to have any technical data first produced or specifically used in the performance of this grant delivered to the Government as the Grant Officer may from time to time direct during the progress of the work or in any event as the Grant Officer shall direct upon completion or termination of this Grant.

(2) The Grantee shall have: The right to use for its private purposes, subject to patent, security or other provisions of this grant, technical data it first produces in the performance of this grant provided the data requirements of this grant have been met as of the date of the private use of such data. The Grantee agrees that to the extent it receives or is given access to proprietary data or other technical, business or financial data in the form of recorded information from DOE or a DOE contractor or subcontractor, the Grantee shall treat such data in accordance with any restrictive legend contained thereon, unless use is specifically authorized by prior written approval of the Grant Officer.

c. Copyrighted Material.

(1) The Grantee agrees to, and does hereby grant to the Government, and to its officers, agents, servants and employees acting within the scope of their duties:

10. Rights in Technical Data - Short Form (Cont'd)

(i) A royalty-free, nonexclusive, irrevocable license to reproduce, translate, publish, use, and dispose of and to authorize others so to do, all copyrightable material first produced or composed in the performance of this grant by the Grantee, its employees or any individual or concern specifically employed or assigned to originate and prepare such material; and

(ii) A license as aforesaid under any and all copyrighted or copyrightable works not first produced or composed by the Grantee in the performance of this grant but which are incorporated in the material furnished under the grant, provided that such license shall be only to the extent the Grantee now has, or prior to completion or final settlement of the grant may acquire, the right to grant such license without becoming liable to pay compensation to others solely because of such grant.

(2) The Grantee agrees that it will not knowingly include any material copyrighted by others in any written or copyrightable material furnished or delivered under this grant without a license as provided for in subparagraph c.(1)(ii) hereof, or without the consent of the copyright owner, unless it obtains specific written approval of the Grant Officer for the inclusion of such copyrighted material.

11. Authorization and Consent

The Government hereby gives its authorization and consent for all use and manufacture of any invention described in and covered by a patent of the United States in the performance of this grant or any part hereof or any amendment hereto or any grant hereunder (including any lower-tier subcontract).

12. Notice and Assistance Regarding Patent and Copyright Infringement

a. The Grantee shall report to the Grant Officer, promptly and in reasonable written detail, each notice or claim of patent or copyright infringement based on the performance of this grant of which the Grantee has knowledge.

b. In the event of any claim or suit against the Government on account of any alleged patent or copyright infringement arising out of the performance of this grant or out of the use of any supplies furnished or work or services performed hereunder, the Grantee shall furnish to the Government when requested by the Grant Officer, all evidence and information in possession of the Grantee pertaining to

12. Notice and Assistance Regarding Patent and Copyright Infringement (Cont'd)

such suit or claim. Such evidence and information shall be furnished at the expense of the Government except where the Grantee has agreed to indemnify the Government.

c. This clause shall be included in all lower-tier agreements and subcontracts.

13. Reporting of Royalties

If any royalty payments are directly involved in the grant or are reflected in the grant price to the Government, the Grantee agrees to report in writing to the Grant Officer or Patent Counsel during the performance of this grant and prior to its completion or final settlement the amount of any royalties or other payments paid by it directly to others in connection with the performance of this grant together with the names and addresses of licensors to whom such payments are made and either the patent numbers involved or such other information as will permit the identification of the patents or other basis on which the royalties are to be paid. The approval of DOE of any individual payments or royalties shall not stop the Government at any time from contesting the enforceability, validity or scope of, or title to, any patent under which a royalty or payments are made.

14. Procurement Standards

Grantee procurements are subject to the requirements of OMB Circular A-110, Attachment O. DOE prior approval is required for all sole source contracts or where only one bid or proposal is received and the aggregate expenditure is expected to exceed $5,000.

15. Revision of Financial Plans

Any revision to financial plans under this grant are subject to the requirements of OMB Circular A-110, Attachment J and paragraph 600.114 of the DOE Financial Assistance Rules (10 CFR Part 600). DOE approval is required for transfers of amounts budgeted between direct and indirect costs. Among direct cost catagories, DOE approval is required when the cumulative amounts of such transfers exceeds or is expected to exceed 5% of the total budget as last approved by DOE. The Grantee shall promptly notify DOE whenever the amount of Federal authorized funds is expected to exceed the needs of the recipient by more than $5,000 or five percent of the Federal award, whichever is greater. None of the substantive programmatic work may be subcontracted or transferred without the prior approval of DOE.

16. Program Income

Program income is subject to the policy prescribed by OMB Circular A-110, Attachment D and paragraph 600.113 of the DOE Financial Assistance Rules (10 CFR Part 600). Program income other than interest, proceeds from the sale of real and personal property, and royalties shall be treated as specified in 600.113(e)(2)(i). That is they shall be deducted from the total approved budget to determine the net costs on which the DOE costs shall be calculated.

17. Liabilities and Losses

DOE assumes no liability with respect to any damages or loss arising out of any activities undertaken with the financial support of this grant.

18. Property

Property is subject to the requirements of OMB Circular A-110, Attachment N and paragraph 600.117 of the DOE Financial Assistance Rules (10 CFR Part 600). At the end of the project period or at the termination of DOE support for the project, the Grantee shall certify as to any property acquired under this grant.

The following property to be purchased with grant funds is designated as exempt equipment under the authority of Public Law 95-224:

GOP-12 Two-Channel Geophysical Receiver	$12,000
ZMG-20, 20 kw Motor Generator Set	$ 8,679
ANT/2 CSAMT Antenna	$ 4,736
XMT-12 Transmitter Controller	$ 2,440
FM Communications Radios	$ 2,500
Trailer for CSAMT System	$ 500

19. Suspension and Termination

a. DOE reserves the right to suspend this grant in accordance with the provisions of OMB Circular A-110, Attachment L, paragraph 3 and paragraph 600.122 of the DOE Financial Assistance Rules (10 CFR Part 600).

b. DOE reserves the right to terminate for cause, in addition to the right to terminate for convenience as provided in OMB Circular A-110, Attachment L, paragraph 4 and paragraph 600.122 of the DOE Financial Assistance Rules (10 CFR Part 600).

20. Quality Assurance

The Grantee will implement a Quality Program in accordance with ANSI Std. Z 1.8-1971 "Specification of General Requirements for a Quality Program" attached, except that paragraphs 3.3.2, 3.3.3, 3.3.4, 3.4, 3.5.2, 3.5.3, 3.6.2, and 3.6.3 are deleted.

SOW

STATEMENT OF WORK

MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY

1. All studies described below are to be performed in the area of Ennis, MT.

2. Collect sufficient Controlled Source Audio-Magnetotelluric (CSAMT) data to define anomalous areas. Model these data using appropriate one-dimensional inversion algorithims and two-dimensional forward modelling programs.

3. Integrate the data from the CSAMT study above with other available geological, hydrologic, geochemical, and geophysical data in order to select the most promising anomalous areas for further detailed work. In these selected areas, perform additional follow-up studies which may include CSAMT, gravity, self-potential, or dipole-dipole resistivity measurements.

4. Evaluate existing gravity data and collect additional data to help define anomalous regions. Integrate the gravity data with other geoscientific data as in Task 3 to select the best sites for further gravity surveys.

5. Perform detailed gravity surveys over the anomalous regions defined as a result of the work in Task 4 with adequate elevation control to allow the development of appropriate models of the results of the survey. Analyze the results of the gravity surveys and develop geophysical models based on gravity and other appropriate data.

6. Prepare a final report which will discuss the nature and occurrence of geothermal resources in the area of Ennis, MT. This report will include results of geophysical studies described in Tasks 2, 3, 4, and 5. The report will also evaluate the applicability and success of the geophysical techniques used. A model of geothermal resources, based on new data collected during this study, and existing data compiled in Tasks 3 and 4 will be developed and included in the report.

7. Provide overall project management and complete and report on tasks in a timely manner. Management reports shall be provided as defined by the attached DOE Form EIA 459A Reporting Requirements Checklist. The required reports are also summarized as follows:

a. Form DOE 538 Notice of Energy R&D	Due 30 days after award of grant
b. Quarterly Management Summary Report	Due 15 days after calendar quarter end
c. Quarterly Project Status Report	Due 15 days after calendar quarter end
d. Topical Report	Due prior to or accompanying final report in both draft and in final form including one camera-ready copy

e.	Final Report (Draft)	Due 45 days prior to completion date
f.	Final Report	Due on completion date
g.	Financial Status Report, OMB Form 269	Due on completion date and at the end of the first program year.

U.S DEPARTMENT OF ENERGY

FEDERAL ASSISTANCE REPORTING CHECKLIST

FORM EIA 459A
(10-80)

FORM APPROVED
OMB NO 1900-0127

1. Identification Number: DE-FG07-84ID12525	2. Program/Project Title: Geothermal
3. Recipient:	

4. Reporting Requirements:	Frequency	No. of Copies	Addressees
PROGRAM/PROJECT MANAGEMENT REPORTING			
☐ Federal Assistance Milestone Plan			
☐ Federal Assistance Budget Information Form			
☒ Federal Assistance Management Summary Report	Q		
☒ Federal Assistance Program/Project Status Report	Q		
☒ Financial Status Report, OMB Form 269	Y,F		
TECHNICAL INFORMATION REPORTING			
☒ Notice of Energy RD&D	O		
☐ Technical Progress Report			
☒ Topical Report	A		
☒ Final Technical Report	F		

FREQUENCY CODES AND DUE DATES:

A - As Necessary: within 5 calendar days after events.
F - Final: Upon completion date
Q - Quarterly: within 15 days after end of calendar quarter or portion thereof.
O - One time after project starts: within 30 days after award.
X - Required with proposals or with the application or with significant planning changes.
Y - Yearly: 30 days after the end of program year. (Financial Status Reports 90 days).
S - Semiannually: within 30 days after end of program fiscal half year.

5. Special Instructions:

6. Prepared by: (Signature and Date)	7. Reviewed by: (Signature and Date)

U.S. DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE

REPORT DISTRIBUTION LIST

DE-FG07-84ID12525

Addressees	Federal Assistance Management Plan	Federal Assistance Budget Initiation Form	Federal Assistance Program/Project Status Report	Federal Status Report	Report of Energy R&D OMB Form 269	Technical Progress Report	Final Technical Report	Topical Report	Number of Report Copies
U. S. Department of Energy Idaho Operations Office 550 Second Street Idaho Falls, ID 83401									
Attn: R. Eldon Bray, Program Mgr. Energy & Technology Division				2	2			8	8
Attn: Elizabeth M. Hyster Contracts Management Div.				1	1	1	1	1	1
Attn: E. G. Jones, Director Financial Management Div.				1					
U. S. Department of Energy Forrestal Bldg., CE-324 1000 Independence Ave, S.W. Washington, DC 20585 Attn: Ron Toms				1	1			6	6
University of Utah Research Institute Earth Science Laboratory 391 Chipeta Way, Suite C Salt Lake City, UT 84108 Attn: Duncan Foley				1	1			1	1
U. S. Department of Energy Technical Information Center P. O. Box 62 Oak Ridge, TN 37830						1			

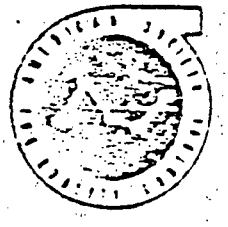
Special Instructions

ATTACHMENT B

ASQC STANDARD
C1 - 1968

ANSI Std. Z1.8-1971
Approved November 18, 1971
American National Standards Institute

Specification of General Requirements For A Quality Program



Approved 1968

AMERICAN SOCIETY FOR QUALITY CONTROL
161 West Wisconsin Avenue Milwaukee, Wisconsin 53203

ASQC STANDARD C1-1968

General Requirements For A Quality Program

1. DEFINITION OF TERMS

1.1 Quality Program. The system of activities established to provide a quality of product or service that meets the needs of users.

1.2 Contractor. A term used herein to designate the individual or organization on whom this Standard is imposed.

1.3 Buyer. A term used herein to designate the individual or organization that imposes this Standard on a contractor.

NOTE

When this Standard is used internally, the "contractor" may be a single shop or production group and the "buyer" may be a management or staff group empowered to specify the use of this Standard.

1.4 Inspection. The process of measuring, examining, testing, gaging, or otherwise comparing one or more units of product with the applicable requirements.

2. SCOPE

2.1 Applicability. When this Standard is prescribed or specified by contract or agreement, it provides a specification of the general requirements to be met by the quality program of a contractor or other organization. All the requirements apply to a given contract except to the extent that they are specifically deleted, supplemented, or amended in the contract.

2.2 General Purpose. This Standard requires the establishment and maintenance of a quality program by the contractor and his subcontractors to assure compliance with the requirements of the contract. The quality program including its procedures and operations, shall be documented by the contractor and shall be subject to review by the buyer's representative.

The program shall apply to the control of quality throughout all areas of contract performance including, as appropriate, the procurement, identification, stocking, and issue of material; the entire process of manufacture; and the packaging, storing, and shipping of material.

The program shall provide that, as early as possible, discrepancies (defects and program deficiencies) shall be discovered and corrective action taken.

3. REQUIREMENTS

3.1 Quality Management.

3.1.1 General. There shall be adequate planning, forceful direction, and control in the sense of measurement and evaluation of the effectiveness of the quality program.

3.1.2 Organization. Administration of the quality program shall be vested in a responsible, authoritative element of the organization, with a clear access to management. This organization shall be staffed by technically competent personnel with freedom to make decisions without hint of pressure or bias. It shall also have sufficient authority to assure that quality requirements are consistently maintained.

3.1.3 Procedures. Written quality control, test, and inspection procedures shall be used for all pertinent operations. These procedures shall be kept current and shall be available at all locations where they will be used.

3.2 Design Information.

3.2.1 General. Design information for a product (such as drawings, specifications, and standards) shall be maintained to ensure that items are fabricated, inspected, and tested to the latest applicable requirements. In like manner, task definitions for a service shall be maintained to ensure that the services are performed and inspected to the latest applicable requirements.

3.2.2 Change Control. All changes to design information or task definition shall be processed in a manner that will ensure accomplishment as specified, and a record of actual incorporation points (by date, batch, lot, unit, or other specific identification) shall be maintained.

3.3 Procurement.

3.3.1 General. Adequate control over procurement sources shall be maintained to ensure that services and supplies conform to specified requirements, including this specification. Purchase orders (or contracts) shall be controlled to ensure incorporation of pertinent technical and quality requirements, including authorized changes. Adequate records of inspections and tests performed on purchased material shall be maintained.

3.3.2 Source Inspection. The buyer and his authorized representatives reserve the right to inspect, at the source, any supplies furnished or services rendered under this contract. Inspection at the source shall not necessarily constitute acceptance, nor shall it relieve the seller of his responsibility to furnish acceptable product. When it is not practical or feasible to determine quality conformance of purchased items, inspection at the source is authorized.

3.3.3 Fabricated Material. All purchased material shall be evaluated to assure conformance with the requirements of applicable standards and specifications. When required, shipment of materials shall be accompanied by certified test reports that demonstrate the conformance of raw material, plating, etc., to the requirements stated in the purchase order or product specification. When submission of certified test reports is not specifically required, every shipment shall be accompanied by a certificate stating that conformance to all requirements has been ascertained, that quantitative data reports are on file, and that copies of test results will be furnished on request. The validity of certifications shall be verified periodically. Provisions will be made for withholding from use all incoming supplies pending completion of such required inspection and test or receipt of necessary test reports. The seller shall be notified whenever nonconforming materials are received, and corrective action shall be initiated when warranted.

3.3.4 Raw Materials. Raw material shall normally be tested to determine conformance to applicable specifications. Unless otherwise required by the purchase order or the product specification, certified test reports identifiable with the material may be accepted in lieu of such tests. When certifications are used as a basis for acceptance, the test results shall be compared with specification requirements. Furthermore, the validity of certifications shall be periodically verified by independent testing.

3.4 Material Control. Adequate methods and facilities shall be established for controlling the identification, handling, and storage of raw and fabricated material. The identification shall include indications of the inspection status of the material. These controls shall be maintained from the time of receipt of the material until delivery to the customer, in order to protect the material from damage, deterioration, loss, or substitution.

3.5 Manufacture.

3.5.1 General. Sufficient control shall be maintained over manufacturing processes to prevent excessive product defectiveness and variability, and to assure conformance of the characteristics of product, which can be verified only at the time and point of manufacture.

3.5.2 Process Control. Evaluations and controls shall be established and maintained at appropriately located points in the manufacturing process to assure continuous control of quality of parts, components, and assemblies.

3.5.3 Special Processes. Adequate methods and facilities shall be provided to assure conformance with requirements for special process specifications such as welding, plating, anodizing, nondestructive testing, heat-treating, soldering, and testing of materials. Certifications, such as those for personnel, procedures, and equipment, shall be maintained as required.

3.6 Acceptance.

3.6.1 General. Inspection and testing of completed material shall be performed as necessary to assure that contract requirements have been met. Sufficient surveillance shall be maintained over preservation, marking, packing and shipping operations to assure compliance with requirements and to prevent damage, deterioration, loss, or substitutions.

3.6.2 Sampling Inspection. Any acceptance sampling procedures that differ from those required by the contract shall afford adequate assurance that the quality meets acceptable levels, and shall be approved by the buyer.

3.6.3 Nonconforming Material. Procedures and facilities for the handling of nonconforming material shall require prominent identification of the material and prompt removal from the work area. Unless otherwise provided in the product specification, the seller may, at his option, scrap the material or request disposition instructions from the buyer.

3.7 Measuring Instruments. Validity of measurements and tests shall be assured through the use of suitable inspection measuring and test equipment of the range, validity, and type necessary to determine conformance of articles to contract requirements. At intervals established to ensure continued validity, measuring devices shall be verified or calibrated against certified standards that have a known, valid relationship to national standards. Tooling used as a media of inspection shall be included in this program. Furthermore, every device so verified shall bear an indication attesting to the current status and showing the date (or other basis) on which inspection or recalibration is next required.

3.8 Quality Information.

3.8.1 General. Information from control areas described in Paragraphs 3.1 through 3.7 of this specification shall be systematically utilized for the prevention, detection, and correction of deficiencies in the program that affect quality.

3.8.2 Quality Control Records. For all inspections and tests, records that include data on both conforming and nonconforming product shall be maintained. A continuing review of these records shall be made, and summary information shall be reported periodically to responsible management.

3.8.3 Corrective Action. Prompt action shall be taken to correct conditions that cause defective materials. Use shall be made of feedback data generated by the customer as well as data generated internally.

4. QUALITY PROGRAM AUDITS

Quality programs will be audited by the buyer for conformance to the intent of this specification. Disapproval of the program or major portions thereof may be cause for withholding acceptance of product.

MONTANA TECH
Butte, Montana 59701
(406) 496-4101

Rec 12/23/87
HPR

December 21, 1987

Mr. Howard P. Ross
University of Utah Research Institute
Earth Science Laboratory
391 Chipeta Way, Suite C
Salt Lake City, UT 84108

Dear Howard,

Enclosed is a copy of the Final Report (Part 1) for Contract DE-FG07-84ID 12525, "Geophysical Research on Geothermal Resources in Montana.

Yours,

W. R. Sill, Chair
Department of Physics and Geophysical Engineering

WRS/rm
Enclosure

Rec 11/09/87

DOE F 4200.33
(10-85)

U.S. Department of Energy

Procurement Request-Authorization

Formerly PR-799A
(Previous editions are obsolete)

1. To Awarding Office: CMD

2. From Initiating Office: AMD

3. PR Number — •

4. Change/Correction to a PR in Process? ☐ Yes ☐ No

5. If Item 4 is Yes, Enter PR Correction Letter

6. ☐ Acquisition ☐ Assistance

7. Consistent with Principal Purpose of Program? ☐ Yes ☐ No

8. Description of Work/Purpose of Assistance (180 Characters Maximum)

NCTE for Mont Tech DE-FG07-84ID12525

Has List of Sources Been Attached? ☐ Yes ☐ No

9. Name: Montana Tech

10. Division: Attn Dr Sill

11. Address: Butte MT 59701

For Acquisition Actions Only: 12. Product or Service Code

For Assistance Actions Only: 13. CFDA Number

Proposed Instrument: 14. Cooperative Agreement ☐ 15. Grant ☐

16. OSTI Deliverable For All Actions	17. (Reserved)	18. Master BIN	19. Desired Award Date Mo Day Year

20. Unsolicited Proposal Number

21. Project Number

22. Government Property _____ F-Furnished, P-Purchased, B-Both, N-Not Involved

FINANCIAL DATA

23. Government Share	24. Awardee Share	25. Total

FY FUNDS COMMITTED

26. Approp. Symbol	27. B&R Number	28. Dollar Amt.	29. Allotment	30. Object Class	31. AFP	32. CFA

33. From Continuation Sheet

34. Total Funds This PR —0—

35. Project Period from _____ thru _____

36. Budget Period from _____ thru _____

PROJECT MANAGER/INITIATOR

37. Name	38. Signature	39. Date	40. Office Code / 41. FTS Telephone Number
SM Prestwich	SM Prestwich	10/29/87	6-1147

PROGRAM REVIEWING OFFICIAL

42. Name	43. Signature	44. Date
CE Gilmore		

PROGRAM OFFICE BUDGET OFFICIAL

45. Name	46. Signature	47. Date
D Bell		

CERTIFYING OFFICIAL. I hereby certify that the funds cited in item 34 are available

48. Name	49. Signature	50. Date
E Miles		

51. Initiating Office/Local Office Use

Contracting Office (White)

MONTANA TECH
Butte, Montana 59701
(406) 496-4101

October 13, 1987

Ms. Peggy Brookshier
Energy & Technology Division
U.S. Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

Re: Grant No. 1-DE-FG07-84ID12525

Dear Ms. Brookshier:

This letter is a request for a no-cost time extension for the geothermal project at Montana Tech. The reason for the requested extension is the final revision of the thesis by Gunnar Emilson, which will constitute the second portion of the final report. I would anticipate that the final report completion time of December 31, 1987, will be adequate.

Yours truly,

William R. Sill, Head
Dept. of Physics and Geophysical
Engineering

WRS/rm

xc: Ron King
Howard Ross
John Dunstan

MONTANA TECH
Butte, Montana 59701
(406) 496-4101

October 13, 1987

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Yours truly,

William R. Sill

William R. Sill, Head
Dept. of Physics and Geophysical
Engineering

WRS/rm

xc: Ron King
✓Howard Ross
John Dunstan

found PR was already in system by me (how soon we forget) You should be receiving copy PR if not all ready

11/6/87

MONTANA TECH
Butte, Montana 59701
(406) 496-4101

October 13, 1987

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Yours truly,

William R. Sill

William R. Sill, Head
Dept. of Physics and Geophysical Engineering

WRS/rm

xc: Ron King
✓Howard Ross
John Dunstan

NOTICE OF FINANCIAL ASSISTANCE AWARD

(See Instructions on Reverse)

Brookshier Rec 6/15/87

Under the authority of Public Law 93-410 and

Subject to legislation, regulations and policies applicable to *(cite legislative program title)*:

Geothermal Research, Development, and Demonstration Act of 1977

PROJECT TITLE
Geophysical Research on Geothermal Resources in Montana

2. INSTRUMENT TYPE
☒ GRANT ☐ COOPERATIVE AGREEMENT

4. INSTRUMENT NO.
DE-FG07-841D12525

5. AMENDMENT NO.
M004

RECIPIENT *(Name, address, zip code, area code and telephone no.)*
Montana College of Mineral Science and Technology
Butte, Montana 59701

6. BUDGET PERIOD
FROM: 12/11/85 THRU: 6/30/87

7. PROJECT PERIOD
FROM: 6/11/84 THRU: 6/30/87

RECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*
Charles Widman (406) 496-4209
William R. Sill (406) 496-4211

10. TYPE OF AWARD
☐ NEW ☐ CONTINUATION ☐ RENEWAL
☒ REVISION ☐ SUPPLEMENT

RECIPIENT BUSINESS OFFICER *(Name and telephone No.)*
John Dunston (406) 496-4265

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*
R. Jeffrey Hoyles (208) 526-0790
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, ID 83402
Howard Ross

1. DOE PROJECT OFFICER *(Name, address, zip code, telephone No.)*
Peggy Brookshier (208) 526-1403
U.S. DOE, Idaho Operations Office
785 DOE Place, Idaho Falls, ID 83402

3. RECIPIENT TYPE
☐ STATE GOV'T ☐ INDIAN TRIBAL GOV'T ☐ HOSPITAL ☐ FOR PROFIT ORGANIZATION
☐ LOCAL GOV'T ☒ INSTITUTION OF HIGHER EDUCATION ☐ OTHER NONPROFIT ORGANIZATION ☐ C ☐ P ☐ SP ☐ OTHER *(Specify)*

14. ACCOUNTING AND APPROPRIATIONS DATA

a. Appropriation Symbol	b. B & R Number	c. FT/AFP/OC	d. CFA Number
N/A			

15. EMPLOYER I.D. NUMBER/SSN

16. BUDGET AND FUNDING INFORMATION

a. CURRENT BUDGET PERIOD INFORMATION		b. CUMULATIVE DOE OBLIGATIONS	
(1) DOE Funds Obligated This Action	$ -0-	(1) This Budget Period *[Total of lines a.(1) and a.(3)]*	$ 93,421
(2) DOE Funds Authorized for Carry Over	$ -0-	(2) Prior Budget Periods	$ -0-
(3) DOE Funds Previously Obligated in this Budget Period	$ 93,421		
(4) DOE Share of Total Approved Budget	$ 93,421		
(5) Recipient Share of Total Approved Budget	$ -0-	(3) Project Period to Date *[Total of lines b. (1) and b. (2)]*	$ 93,421
(6) Total Approved Budget	$ 93,421		

17. TOTAL ESTIMATED COST OF PROJECT $ 93,421

(This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this amount.)

18. AWARD/AGREEMENT TERMS AND CONDITIONS

This award/agreement consists of this form plus the following:

a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)

b. Applicable program regulations *(specify)* n/a *(Date)* _____

c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and ☒ B (Grants) or ☐ C (Cooperative Agreements).

d. Application/proposal dated 9/11/86, ☐ as submitted ☒ with changes as negotiated

19. REMARKS

This document is a no cost time extension to allow participants time to complete project reports.

20. EVIDENCE OF RECIPIENT ACCEPTANCE

(Signature of Authorized Recipient Official) *(Date)* 5/19/87

Henry McClernan
(Name)

Dean of Research
(Title)

21. AWARDED BY

R. Jeffrey Hoyles R. Jeffrey Hoyles
(Signature) *(Date)* 6/5/87

Contracting Officer
(Name)

(Title)

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

M E M O R A N D U M

TO: Peggy Brookshier

FROM: Howard Ross HR

SUBJECT: Review of Draft Final Report by Montana Team, "Geophysical Research on Geothermal Resources in Montana"

DATE: February 13, 1987

The subject draft report is an excellent summary of preexisting geologic, geophysical and drilling studies, and presents previous and new gravity data in good detail. The computer modeling approach to gravity interpretation is certainly state-of-the-art in the use of inversion techniques. The mathematics and computer programs and modeling output are presented in detail in appendicies. Thus the report fulfills Tasks 4 and 5 in good fashion.

The section on geothermometry and fluid geochemistry has been reviewed in some detail by Dr. Joe Moore and Mike Adams of our Geochemistry Section, both of whom have considerable expertise in these areas. They have noted some interpretational and understanding problems in these areas which they feel should be corrected to maintain accuracy and the overall report quality. Their comments are attached and in the report margins.

Although the technical content of most of the report is excellent, the organization of the report reflects its draft status and hence could be improved. At its present stage of completion the report does not have: Table of Contents; Abstract; Acknowledgement of DOE funding; List of Illustrations; pagination. There is almost no hierarchy of topic titles. The report should be organized into chapters and subsections. The reproduction of some illustrations is poor, for example Figure 13, and many words cannot be read. Paragraph indentation varies from two to five spaces.

This report includes five appendicies totaling about 124 pages. I consider Appendicies A, B, and C to be appropriate for they document the gravity data in detail (A), present computer

programs developed in part with DOE funding (B), and describe their usage (C). These appendicies total about 47 pages. Appendicies D and E are basically computer input and output perhaps essential to the documentation of the student's thesis but of no practical use to those reading the final report to DOE. I recommend that appendicies D and E be deleted except for a title page with the notation that the full appendix is on file at MCMS&T. This would reduce the total appendicies from 124 to 49 pages without detracting from the report.

Notations have been made in the text which question statements, may improve some grammatical usage and clarity, and some inconsistancies in referencing. The authorship of those portions of the report written in the first person, generally by the student, should be clearly indicated. Most of these are minor problems in the report which should be easily corrected for the final, thanks to word processor technology. Perhaps the most serious revisions will be in the geothermometry and fluid geochemistry sections.

The results of the CSAMT survey (Task 2) and the modeling, interpretation, and integration of the CSAMT (Tasks 2 and 3) are not included in this report but are still forthcomming as another thesis, currently in a rough draft stage with format problems, at MCMS&T. Dr. Wideman expects a completed first draft soon, but it appears that the final report of this work will be received some time after the Febrauary 28 grant ending date.

REVIEW BY GEOCHEMISTS

1. Chemical geothermometers can be applied to any geothermal water, not just surface or near-surface waters.

2. The Na-K-Ca(-Mg) should be included since it is one of the most useful. Even though the magnesium is not abundant in many of the samples it should be included for completeness.

3. Fig. 6. It is not clear from the figure what the authors are trying to show. It would help to clarify the figure by labeling the reservoir, and giving us an idea of the scale of the features they are discussing. What are the rock types? Do the small arrows with the crooked shafts represent heat or fluids? What do the dashed arrows in the upper part of Model B represent? In places permeability appears to be controlled by faults and horizontal aquifers, in other places near the top of Model B the fluids appear to move vertically through a unit that is not an aquifer. What does this represent? I believe that this figure is illustrative and is taken from a paper by Fournier. If so it should be deleted.

4. The source of data for Fig. 7 should be identified.

5. No distinction is made between the aquifers and the reservoir. Re-equilibration may or may not take place. The amount of re-equilibration that takes place depends on the rate of fluid movement and the temperature. In addition, some geothermometers may be frozen while others are not.

6. The choice is between silica polymorphs, not silica minerals.

7. Although pages 5-11 discuss many of the geothermometers in detail, the information has little relevance to the work that was done. The effect of pH on the calculated silica temperatures is not discussed (p. 5); no evidence of boiling is ever presented for the Ennis Hot Spring geothermal system (p. 6); the methods of calculating the various geothermometers are readily available and need not be reviewed in detail (p. 7); the van't Hoff equation is missing and is irrelevant (p. 7); the Mg correction is never applied and the effect of Mg on the calculated temperatures is never discussed (p. 8); no data on oxygen isotopes at Ennis is presented (p. 9). These pages should be summarized in one or two paragraphs.

8. Fig. 8 has no bearing on the present study. The vertical and the upper horizontal axes are incorrectly labeled. The figure should be deleted.

9. The effects of mixing on the various geothermometers should be briefly summarized and inappropriate sections deleted (i.e. effect of steam loss, application of sulfate-water geothermometer).

10. Despite the extensive review of the effects of various processes on the chemistry of geothermal fluids, only mixing is considered. Each of these processes (boiling, mixing, and conductive cooling) should be addressed after discussing the data, even if the discussion consists of stating that there is no possibility of boiling. However, the fact that two of the springs are above 90°C indicates that the possibility should be explored. The variation of pH from neutral up to >8 indicates that some boiling may have occurred.

11. Table 5 should also include the downhole temperatures of the waters. A statement regarding the quality of the analyses should be given (i.e. charge balance and calculated vs. measured TDS). In addition, the data should be plotted on a Piper plot or other suitable diagram to illustrate the relationships between the samples.

12. Fig. 10 is redundant since it is also given as Fig. 3. For illustration and discussion, the conservative components, either singly or as ratios, should be plotted and compared to measured temperatures. These plots may provide additional information on fluid movement and mixing.

13. The graph of Cl/B ratios should be changed to a histogram format. This would provide a basis for discussing populations. It may be possible to obtain additional information from these data by relating them to well location and temperature (see comment 13).

14. The discussion of Fig. 11 should be expanded. Although the authors recognize two different trends, no explanation is given for the trend defined by constant chloride and decreasing temperature. This trend suggests conductive cooling. Also, enthalpy should be used because it is a conservative quantity, and the vertical axis should be enthalpy, rather than the horizontal axis, in order to follow convention.

15. No evidence is presented for the fluids having a long residence time in a high-temperature environment. Although many scientists use intuition, it is not considered proof.

16. If only the highest temperature waters are used, then the plot of temperature vs. chloride content would suggest that little mixing of these waters with groundwaters has occurred and that cooling of the fluids has occurred mainly by conduction. The calculated temperatures are equally consistent with a model that does not require mixing. The

geothermometers can then be examined with respect to simple processes. For instance, the internal consistency of the cation and the silica geothermometers indicate a homogeneous source of the water, and no interferences with the geothermometers. The silica polymorph is probably quartz, as indicated by the high cation temperature, and the fact that the quartz temperature is lower. The difference in predicted temperatures between the cation and quartz geothermometers indicate that the silica has precipitated out of solution during a slow ascent, which is consistent with the more rapid rate of equilibration of silica than cations shown by Fournier and several other researchers. All this implies that little mixing is taking place, and that the deep temperature is between 160° and 170°C, but that an aquifer of 140° to 150°C may be the most accessible.

UNIVERSITY OF UTAH RESEARCH INSTITUTE

UURI

EARTH SCIENCE LABORATORY
391 CHIPETA WAY, SUITE C
SALT LAKE CITY, UTAH 84108—1295
TELEPHONE 801-524-3422

February 13, 1986

Dr. C. J. Wideman
Dr. W. R. Sill
Dept. of Physics and Geophysical Engineering
Montana College of Mineral Science and Technology
West Park Street
Butte, Montana 59701

Gentlemen:

Transmitted herewith is the draft final report (Volume I ?) for the gravity studies at Ennis Hot Springs, MT. Also enclosed is a copy of my memo to Peggy Brookshier, DOE-ID, with my general comments on the draft report.

I enjoyed reading the report and appreciate the quality of the gravity study, numerical modeling, and integration with other data. I think that the technical work is excellent, with the possible exception of the geothemometry section. I must admit that I didn't take the time to review my linear algebra and check all the matrix equations- I trust that you have.

Please address the format, organization, grammatical usage, wording and other nitpicking comments I have noted in the memo to Peggy and in the report margins. Please call me if any of these are unclear or present a real problem to you. Peggy Brookshier agrees with my recommendation to delete Appendicies D and E, except for a cover page with a notation that the full appendix is on file at MCMS&T.

Please feel free to call Dr. Joe Moore or Mike Adams of our Geochemistry Section at (801) 524-3428 to discuss their comments on the geothermometry or fluid geochemistry.

I look forward to reviewing the CSAMT study as soon as possible so that we may all wind up the old business and get on to some new studies.

Sincerely,

Howard Ross

Howard P. Ross
Section Head/Geophysics

VHR
encl.

DOE F 4600.1
(7-81)

U.S. DEPARTMENT OF ENERGY

NOTICE OF FINANCIAL ASSISTANCE AWARD

(See Instructions on Reverse)

Under the authority of Public Law 93-410 and subject to legislation, regulations and policies applicable to *(cite legislative program title)*:
Geothermal Research, Development, and Demonstration Act of 1977

1. PROJECT TITLE
Geophysical Research on Geothermal Resources in Montana

2. INSTRUMENT TYPE
☒ GRANT ☐ COOPERATIVE AGREEMENT

3. RECIPIENT *(Name, address, zip code, area code and telephone no.)*
Montana College of Mineral Science and Technology
Butte, Montana 59701

4. INSTRUMENT NO.
DE-FG07-84ID12525

5. AMENDMENT NO.
M003

6. BUDGET PERIOD
FROM: 12/11/85 THRU: 2/28/87

7. PROJECT PERIOD
FROM: 6/11/84 THRU: 2/28/87

8. RECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*
Charles Wideman (406) 496-4209
William R. Sill (406) 496-4211

10. TYPE OF AWARD
☐ NEW ☐ CONTINUATION ☐ RENEWAL
☒ REVISION ☐ SUPPLEMENT

9. RECIPIENT BUSINESS OFFICER *(Name and telephone No.)*
John Dunston (406) 496-4265

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*
Ronald A. King (208) 526-0790
U.S. Department of Energy
Idaho Operations Office
785 DOE Place
Idaho Falls, Idaho 83402

11. DOE PROJECT OFFICER *(Name, address, zip code, telephone No.)*
Peggy Brookshier (208) 526-1403
U.S. DOE, 785 DOE Place
Idaho Falls, Idaho 83402

13. RECIPIENT TYPE
☐ STATE GOV'T ☐ INDIAN TRIBAL GOV'T ☐ HOSPITAL ☐ FOR PROFIT ORGANIZATION ☐ INDIVIDUAL
☐ LOCAL GOV'T ☒ INSTITUTION OF HIGHER EDUCATION ☐ OTHER NONPROFIT ORGANIZATION ☐ C ☐ P ☐ SP ☐ OTHER *(Specify)*

14. ACCOUNTING AND APPROPRIATIONS DATA

a. Appropriation Symbol	b. B & R Number	c. FT/AFP/OC	d. CFA Number
N/A			

15. EMPLOYER I.D. NUMBER/SSN

16. BUDGET AND FUNDING INFORMATION

a. CURRENT BUDGET PERIOD INFORMATION

(1) DOE Funds Obligated This Action	$ -0-
(2) DOE Funds Authorized for Carry Over	$ -0-
(3) DOE Funds Previously Obligated in this Budget Period	$ 93,421
(4) DOE Share of Total Approved Budget	$ 93,421
(5) Recipient Share of Total Approved Budget	$ -0-
(6) Total Approved Budget	$ 93,421

b. CUMULATIVE DOE OBLIGATIONS

(1) This Budget Period *[Total of lines a.(1) and a.(3)]*	$ 93,421
(2) Prior Budget Periods	$ -0-
(3) Project Period to Date *[Total of lines b. (1) and b. (2)]*	$ 93,421

17. TOTAL ESTIMATED COST OF PROJECT $ 93,421
(This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this

Send to Howard Ross

18. AWARD/AGREEMENT TERMS AND CONDITIONS

This award/agreement consists of this form plus the following:

a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)

b. Applicable program regulations *(specify)* n/a

c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and ☒ B (Grants) or ☐ C (Coop

d. Application/proposal dated 9/11/86, ☐ as submitted ☒ with changes as negotiated

19. REMARKS

This document is a no cost time extension to allow participants time to complete project reports.

20. EVIDENCE OF RECIPIENT ACCEPTANCE

(Signature of Authorized Recipient Official) *(Date)*

(Name)

(Title)

21. AWARDED BY

William C. Drake 9/12/86
(Signature) *(Date)*

William C. Drake
(Name)

Contracting Officer
(Title)

rev. Sept. 15, '86

MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY

BUTTE, MONTANA 59701

406/496-4101

September 11, 1986

Peggy Brookshier
Energy & Technology Division
U.S. Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

Re: Grant No. 1-DE-FG07-84ID12525

As a follow-up to our telephone conversation of September 9, 1986, this letter is a request for a no cost time extension for the geothermal project at Montana Tech. The reason for the requested extension is that we anticipate the completion of Master's thesis by Gunnar Emilsson and Dave Semmens during the present academic semester and we wish to make these theses the final technical report for the project. We believe that a final report completion time of February 28, 1987 will allow for adequate review and comment for the report.

Thank you for your attention to this matter.

Sincerely,

Charles D. Wideman
Professor
Department of Physics and
Geophysical Engineering

cc: Ron King
Howard Ross
John Dunstan

CJW:wi

NOTICE OF FINANCIAL ASSISTANCE AWARD

(See Instructions on Reverse)

93-410

er the authority of Public Law _____ and

ct to legislation, regulations and policies applicable to *(cite legislative program title)*:

Geothermal Research, Development, and Demonstration Act of 1977

ROJECT TITLE

eor sical Research on Geothermal
esu ces in Montana

2. INSTRUMENT TYPE

☒ GRANT ☐ COOPERATIVE AGREEMENT

4. INSTRUMENT NO.: DE-FG07-84ID12525

5. AMENDMENT NO.: M001

6. BUDGET PERIOD: FROM: 12/11/85 THRU: 6/30/86

7. PROJECT PERIOD: FROM: 6/11/84 THRU: 6/30/86

ECIPIENT *(Name, address, zip code, area code and telephone no.)*

ontana College of Mineral Science
id Technology
itte, MT 59701

10. TYPE OF AWARD

☐ NEW ☐ CONTINUATION ☐ RENEWAL

☒ REVISION ☐ SUPPLEMENT

ECIPIENT PROJECT DIRECTOR *(Name and telephone No.)*

harles J. Wideman (406) 496-4209
illiam R. Sill (406) 496-4211

ECIPIENT BUSINESS OFFICER *(Name and telephone No.)*

ohn Dunston (406) 496-4265

12. ADMINISTERED FOR DOE BY *(Name, address, zip code, telephone No.)*

Ronald A. King (208) 526-0790
U. S. Department of Energy
Idaho Operations Office
550 Second Street
Idaho Falls, ID 83401

OE PROJECT OFFICER *(Name, address, zip code, telephone No.)*

eggy A. M. Brookshier (208) 526-1403
S. DOE, Idaho Operations Office
50 Second Street, Idaho Falls, ID 83401

ECIPIENT TYPE

☐ STATE GOV'T ☐ INDIAN TRIBAL GOV'T ☐ HOSPITAL ☐ FOR PROFIT ORGANIZATION ☐ INDIVIDUAL

☐ LOCAL GOV'T ☒ INSTITUTION OF HIGHER EDUCATION ☐ OTHER NONPROFIT ORGANIZATION ☐ C ☐ P ☐ SP ☐ OTHER *(Specify)*

CCOUNTING AND APPROPRIATIONS DATA

a. Appropriation Symbol	b. B & R Number	c. FT/AFP/OC	d. CFA Number
N/A			

15. EMPLOYER I.D. NUMBER/SSN

UDGET AND FUNDING INFORMATION

a. CURRENT BUDGET PERIOD INFORMATION		b. CUMULATIVE DOE OBLIGATIONS	
OE Funds Obligated This Action	$ -0-	(1) This Budget Period *[Total of lines a.(1) and a.(3)]*	$ 93,421
OE Funds Authorized for Carry Over	$ -0-	(2) Prior Budget Periods	$ -0-
OE Funds Previously Obligated in this Budget Period	$ 93,421		
OE Share of Total Approved Budget	$ 93,421		
ecipient Share of Total Approved Budget	$ -0-	(3) Project Period to Date *[Total of lines b. (1) and b. (2)]*	$ 93,421
otal Approved Budget	$ 93,421		

OTAL ESTIMATED COST OF PROJECT $ 93,421

This is the current estimated cost of the project. It is not a promise to award nor an authorization to expend funds in this amount.)

WARD/AGREEMENT TERMS AND CONDITIONS

This award/agreement consists of this form plus the following:

a. Special terms and conditions (if grant) or schedule, general provisions, special provisions (if cooperative agreement)

b. Applicable program regulations *(specify)* N/A *(Date)* _____

c. DOE Assistance Regulations, 10 CFR Part 600, as amended, Subparts A and ☒ B (Grants) or ☐ C (Cooperative Agreements).

d. Application/proposal dated 7/1/85, ☐ as submitted ☒ with changes as negotiated

EMARKS

This document is a no cost time extension to allow participants time to mplete projects delayed by weather. The DOE Project Officer and Contract Administrator e also changed. Budget plans have been revised, within existing budgeted dollar ceiling attached.

VIDENCE OF RECIPIENT ACCEPTANCE

_____
ignature of Authorized Recipient Official) *(Date)*

(Name)

(Title)

21. AWARDED BY

William C. Drake 8/8/85
(Signature) *(Date)*

William C. Drake
(Name)

Contracting Officer
(Title)

Grantee - Montana College of Mineral Science and Technology

BUDGET PLAN

	Old Budget	(+/-)	New Budget
Salaries	$ 12,600	+ 345.	$ 12,945.00
Benefits	$ 2,431	+ 106.	2,537.00
Research Fellowships	$ 20,000	+6532.	26,532.00
Field Travel	$ 15,820	-7200.	8,620.00
Supplies	$ 2,500	---	2,500.00
Publications	$ 2,000	---	2,000.00
Equipment	$ 30,855	---	30,855.00
Indirect Costs	$ 7,215	+ 217.	7,432.00
	$ 93,421	0.0	$ 93,421.00

No FTS for Montana
use UNIV. Phone –

Montana

Voucher	1 Amt.	2 Σ $	3 $ Avail	4 $ left	5 billed thru	6 comments	7	8 updated	9	
1	42,882.47		93,421							
2	3785.00	46,667.47								
3	2,514.93	49,182.40								
4	16,096.95	65,279.35								
5	14,794.46	80,073.81	13,347.19		8-31-85			11-6-85		
6	6,056.34	86,130.15	7,290.85	7,290.85	12-31-85			23-1-86		
7	[7,290.85]	93,421.00		2,290.85				huh @ ID Apr 21, 86		
8	5000.00	signed off by PB		$2,290.85				will be 2.2k retained 'til final, 5k ok'd Apr 23 86		
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APPENDIX B

CODE FOR PROGRAMS

GRAVBL

AND

GINDEP

AND

3D

PROGRAM GRAVBL:

A 3-D FOWARD GRAVITY MODELING PROGRAM
USING BLOCKS (MAX=100) OF EARTH

```
C
C... GRAVBL IS A FORWARD GRAVITY PROGRAM THAT MODELS THE EARTH
C... BY USING BLOCKS (UP TO 500) OF VARIABLE DENSITY.
C
C
C*****************************************************************
C
C..                 VARIABLE LIST
C
C
C..     GEOMETRY VARIABLES  ** ALL DISTANCE UNITS IN METERS **
C       ------------------------------------------------------
C
C.. NBLKS = NUMBER OF BLOCKS IN MODEL J=1,NBLKS
C.. XL(J) = LEFT (OR MIN. X) EDGE OF BLOCK J
C.. XR(J) = RIGHT (OR MAX. X) EDGE OF BLOCK J
C.. ZU(J) = TOP (OR MIN. Z, Z POS. DOWN) EDGE OF BLOCK J
C.. ZD(J) = BOTTOM (OR MAX. Z, Z POS. DOWN) EDGE OF BLOCK J
C           -WHERE ZU AND ZD ARE THE POSITIVE DISTANCE DOWN FROM THE
C            DATUM ELEVATION CONSIDERING THE DATUM ELEVATION ZERO
C
C.. LAMNUM(J) = NUMBER OF LAMINAE USED TO FORM BLOCK J
C.. Y(I,J) = Y POSITION OF LAMINAE I ON BLOCK J
C..          I=1,LAMNUM(J)
C.. DEN(J) = DENSITY OF BLOCK J
C
C
C..     GRID VARIABLES (PREDICTED GRAVITY AS OBSERVED FROM GRID)
C       --------------------------------------------------------
C
C.. XSIZE = SIZE OF GRID IN X-DIRECTION
C.. YSIZE = SIZE OF GRID IN Y-DIRECTION
C.. COLS = NUMBER OF COLUMNS IN GRID
C.. ROWS = NUMBER OF ROWS IN GRID
C.. ELEV(I) = ELEVATION OF GRID POINT I -- READ IN FROM SURFII SAVED FILE
C.. DATELV  = DATUM ELEVATION
C.. XPOS,YPOS - CURRENT X,Y POSITION OF OBSERVATION ON GRID
C
C
C..     CALCULATION VARIABLES
C       ---------------------
C
C.. ANOM(I,J) = ANOMALY CALCULATED FOR LAMINAE I OF BLOCK J
C.. V(J) = ANOMALY OF BLOCK J RESULTING FROM A QUADRITURE FORMULA
C          SUMMATION OF THE CONTRIBUTIONS OF EACH LAMINAE IN BLOCK J
C
C.. TANOM(J) = VARIABLE USED FOR THE SUMMATION OF THE CONTRIBUTIONS
C              OF EACH BLOCK IN THE MODEL AT OBERSERVATION POINT
C              XPOS,YPOS ON THE GRID.  TANOM(NBLKS) IS THEREFORE
C              THE TOTAL ANOMALY OF THE PRESENT MODEL AT OBSERVATION
C              POINT XPOS,YPOS ON THE GRID.
C
C
C..     MISCELLANEOUS VARIABLES
C       -----------------------
C
C.. MP = PERCENTAGE VALUE THE CONTROLS HOW MANY LAMINAE WILL
C        BE USED TO DEFINE A BLOCK.  FOR EXAMPLE IF MP=5 THEN
```

```
C        ENOUGH LAMINAE WILL BE INSERTED SUCH THAT THE GRAVITATIONAL
C        ANOMALY BETWEEN ADJACENT LAMIAE IS NOT GREATER THEN 5
C        PERCENT.
C

        COMMON /GRAV/MP,XSIZE,YSIZE,COLS,ROWS,XL(500),XR(500),
     &ZD(500),ZU(500),DEN(500),Y(500,500),ELEV(500),LAMNUM(500),
     &V(500),ANOM(500,500),NBLKS,XPOS,YPOS,TANOM(500),
     &M1,YMAX(500)
C
        REAL*8 ANOM,XL,XR,ZU,ZD,Y
        CHARACTER*20 FILENAME
C
C...  MODEL INPUT
C
        OPEN(22,FILE='GRAVBL.DAT',STATUS='OLD')
        OPEN(23,FILE='GBL.DAT',STATUS='NEW')
        OPEN(24,FILE='GEOM.DAT',STATUS='NEW')
C
        WRITE(24,'('' BLOCK     XL          XR           ZU       ZD
     &     YMIN       YMAX         DEN'')')
        WRITE(24,'(''-------------------------------------------------
     &--------------------------------'')')
        READ(22,*)NBLKS
        DO J=1,NBLKS
        READ(22,*)XL(J),XR(J),ZU(J),ZD(J),Y(1,J),Y(2,J),
     &DEN(J)
C
        YMAX(J)=Y(2,J)
        WRITE(24,'(I4,7F10.1)')J,XL(J),XR(J),ZU(J),ZD(J),Y(1,J),Y(2,J),
     &DEN(J)
        END DO
C
        READ(22,*)XSIZE,YSIZE,COLS,ROWS
        READ(22,*)MP
C
C... INPUT FOR TOPOGRAPHY: IF WANT TOPOGRAPHY SET LL=1
C...                       ELSE SET LL .NE. 1
C
        READ(22,*)LL
        IF(LL.EQ.1)THEN
C
C... READ DATUM ELEVATION
C
        READ(22,*)DATELV
C
C... ENTER FILENAME OF SAVED SURFII DATA FILE CONTAINING GRID
C... LOCATIONS AND GRID POINT ELEVATIONS
C
C
        READ(22,'(A20)')FILENAME
C
        OPEN(27,FILE=FILENAME,STATUS='OLD',FORM='UNFORMATTED',
     &ACCESS='SEQUENTIAL')
C
C
C... READ IN FIRST RECORD
C
```

```
        READ(27)NCOLS,NROWS,IZERO
C
C
C... READ IN SECOND RECORD
C
        READ(27)IROWS,JCOLS,DIFY,DIFX,XMN,XMX,YMN,YMX,DUMMY
C
C... READ IN ELELVATIONS (METERS)
C
        DO I=NROWS,1,-1
        IBEG=(I-1)*NCOLS+1
        IEND=IBEG+NCOLS-1
        READ(27)(ELEV(J),J=IBEG,IEND)
        END DO
C
        DO I=1,NROWS*NCOLS
        ELEV(I)=ELEV(I)-DATELV
        END DO
C
C
        DO J=1,NBLKS
        ZU(J)=ZU(J)+ELEV(1)
        ZD(J)=ZD(J)+ELEV(1)
        END DO
C
        END IF
C
        DO I=1,NBLKS
        CALL REORDER(I)
C
C...  MAKE SURE LAMNUM(I) IS AN ODD NUMBER SO THAT QUADRITURE
C...  FORMULA WILL WORK
C
        L1=LAMNUM(I)/2
        T1=(LAMNUM(I)/2.)-L1
        IF(LAMNUM(I).GT.2)THEN
                IF(T1.EQ.0.0)THEN
                Y(LAMNUM(I)+1,I)=Y(LAMNUM(I),I)
                Y(LAMNUM(I),I)=Y(LAMNUM(I),I)-1.
                CALL FORWARD(LAMNUM(I),I)
                LAMNUM(I)=LAMNUM(I)+1
                END IF
        END IF
        PRINT *,I,' LAMNUM=',LAMNUM(I)
        END DO
C
        M1=0
        M=1
        CHECK=0.0
        XDELTA=XSIZE/(COLS-1)
        YDELTA=YSIZE/(ROWS-1)
        PRINT *,'   '
        PRINT *,'GRID INFORMATION (UNITS=METERS)'
        PRINT *,'-------------------------------------------------'
        PRINT *,'XSIZE=',XSIZE,'YSIZE=',YSIZE
        PRINT *,COLS,'COLUMNS',',',ROWS,'ROWS'
        PRINT *,'DIST. BETWN. COLS.=',XDELTA
        PRINT *,'DIST. BETWN. ROWS =',YDELTA
```

```
        PRINT *,'  '
C
10      IF(M.EQ.1)THEN
                XPOS=0.0
                YPOS=0.0
                TANOM(1)=0.0
C
                DO J=2,NBLKS+1
C
                        CALL QUAD(J-1)
                        TANOM(J)=TANOM(J-1)+V(((LAMNUM(J-1)-1)/2)+1)
                END DO
                WRITE(23,'(3F12.4)')XPOS,YPOS,TANOM(NBLKS+1)
                M=M+1
                GO TO 10
        ELSE
                DO I=1,COLS*ROWS-1
                        CALL GRID(I,CHECK,XDELTA,YDELTA)
                        DO J=2,NBLKS+1
C
C... IF CHOSE TOPOGRAPHY LL=1
C
                        IF(LL.EQ.1)THEN
                                ZU(J-1)=ZU(J-1)+ELEV(I+1)-ELEV(I)
                                ZD(J-1)=ZD(J-1)+ELEV(I+1)-ELEV(I)
                        END IF
C
                        CALL FORWARD(1,J-1)
                        DO K=2,LAMNUM(J-1)
                                CALL FORWARD(K,J-1)
                        END DO
                        CALL QUAD(J-1)
                        TANOM(J)=TANOM(J-1)+V(((LAMNUM(J-1)-1)/2)+1)
                        END DO
                WRITE(23,'(3F12.4)')XPOS,YPOS
     &,TANOM(NBLKS+1)
                END DO
        END IF
C
        CLOSE(22)
        CLOSE(23)
C
        PRINT *,'          '
        PRINT *,' OUTPUT IN FILE GBL.DAT!'
        PRINT *,'          '
        CALL EXIT
        END
C
C
C**********************************************************************
C
C...            SUBROUTINES
C
C
C.. SUBROUTINE REORDER DETERMINES HOW EACH BLOCK WILL BE CUT UP
C.. IN THE Y-DIRECTION.  ENOUGH LAMINAE WILL BE INSERTED SO THAT
C.. THE GRAVITATION ATTRACTION BETWEEN ADJACENT LAMINAE DOES NOT VARY
C.. BY MORE THEN AN INPUT PERCENTAGE (DEFINED BY VARIABLE MP).
```

```
C
      SUBROUTINE REORDER(I)
C
      COMMON /GRAV/MP,XSIZE,YSIZE,COLS,ROWS,XL(500),XR(500),
     &ZD(500),ZU(500),DEN(500),Y(500,500),ELEV(500),LAMNUM(500),
     &V(500),ANOM(500,500),NBLKS,XPOS,YPOS,TANOM(500),
     &M1,YMAX(500)
C
      REAL*8 ANOM,XL,XR,ZU,ZD,Y
C
C.. CUT UP EACH BLOCK LAMNUM(I) TIMES
C
            K1=DABS(Y(2,I)-Y(1,I))
            K2=DABS(XR(I)-XL(I))
            LAMNUM(I)=(K1*MP*(JMAX0(K1,K2)/JMIN0(K1,K2)))/100
            IF(LAMNUM(I).LT.10)LAMNUM(I)=10
C
            IF(LAMNUM(I).GT.500)THEN
            PRINT *,' MAXIMUM NUMBER OF LAMINA (500) '
            PRINT *,'FOR BLOCK ',I,' EXCEEDED.'
            CALL EXIT
            END IF
C
            YDIST=K1/FLOAT(LAMNUM(I))
            CALL FORWARD(1,I)
            LAMNUM(I)=LAMNUM(I)+1
            DO K=2,LAMNUM(I)+1
            Y(K,I)=Y(K-1,I)+YDIST
            CALL FORWARD(K,I)
            END DO
C
      RETURN
      END
C
C
C... SUBROUTINE FORWARD CALCULATES THE GRAVITY ANOMALY/UNIT WIDTH FOR
C... EACH LAMINAE I IN BLOCK J
C
      SUBROUTINE FORWARD(I,J)
C
      COMMON /GRAV/MP,XSIZE,YSIZE,COLS,ROWS,XL(500),XR(500),
     &ZD(500),ZU(500),DEN(500),Y(500,500),ELEV(500),LAMNUM(500),
     &V(500),ANOM(500,500),NBLKS,XPOS,YPOS,TANOM(500),
     &M1,YMAX(500)
C
      REAL*8 ANOM,XL,XR,ZU,ZD,PER,A0,B,A1,B1,A2,B2,Y
C
      G0=6.67E-8
C
C... START CALCULATIN'
C
C... PREVENT DIVIDE BY ZERO
C
      IF(XR(J).EQ.0.0)XR(J)=1E-20
      IF(XL(J).EQ.0.0)XL(J)=1E-20
      IF(Y(I,J).EQ.0.0)Y(I,J)=1E-20
C
      A0=(ZD(J)*ZD(J))+(Y(I,J)*Y(I,J))
```

```
        B=(ZU(J)*ZU(J))+(Y(I,J)*Y(I,J))
        A1=XL(J)+SQRT((XL(J)*XL(J))+B)
        A2=XR(J)+SQRT((XR(J)*XR(J))+B)
        B1=XR(J)+SQRT((XR(J)*XR(J))+A0)
        B2=XL(J)+SQRT((XL(J)*XL(J))+A0)
C
        IF((A1.EQ.0.0).OR.(A2.EQ.0.0).OR.(B1.EQ.0.0)
     &.OR.(B2.EQ.0.0))M1=M1+1
C
C... PREVENT TAKING LOG OF 0.0 OR NEGATIVE NUMBER
C
        IF(A1.LE.0.0)A1=.001
        IF(A2.LE.0.0)A2=.001
        IF(B1.LE.0.0)B1=.001
        IF(B2.LE.0.0)B2=.001
        IF((A1.EQ.0.001).OR.(A2.EQ.0.001).OR.(B1.EQ.0.001)
     &.OR.(B2.EQ.0.001))THEN
        PRINT *,'HAVE HIT A ZERO OR NEGATIVE NUMBER; THIS NUMBER HAS BEEN'
        PRINT *,'CHANGED TO  .001 SO THAT TAKING ITS LOG IS POSSIBLE.'
        PRINT *,'YOU MAY WANT TO CHANGE THE GEOMETRY OF BLOCK :',J
        END IF
C
C... THE 100000 IS TO GET THE ANOMALY IN UNITS OF MGALS
C
        ANOM(I,J)=-100000.*GO*DEN(J)*(DLOG(A1)+DLOG(B1)-DLOG(A2)-DLOG(B2))
C
        RETURN
        END
C
C
C...  SUBROUTINE GRID GIVES X,Y GRID POSITIONS
C
C
        SUBROUTINE GRID(KOUNT,CHECK,XDELTA,YDELTA)
C
        COMMON /GRAV/MP,XSIZE,YSIZE,COLS,ROWS,XL(500),XR(500),
     &ZD(500),ZU(500),DEN(500),Y(500,500),ELEV(500),LAMNUM(500),
     &V(500),ANOM(500,500),NBLKS,XPOS,YPOS,TANOM(500),
     &M1,YMAX(500)
C
        REAL*8 ANOM,XL,XR,ZU,ZD,Y
        NI=KOUNT/COLS
        XPOS=KOUNT*XDELTA-(NI*XSIZE+XDELTA*NI)
        IF(ABS(XPOS).LE.1.0E-01)XPOS=0.00E+00
        YPOS=NI*YDELTA
        IF(XSIZE.GT.CHECK)THEN
                CHECK=CHECK+XDELTA
                DO J=1,NBLKS
                XL(J)=XL(J)-XDELTA
                XR(J)=XR(J)-XDELTA
                END DO
        ELSE
                CHECK=0.0
                DO J=1,NBLKS
C
                XL(J)=XL(J)+XDELTA*(COLS-1)
                XR(J)=XR(J)+XDELTA*(COLS-1)
C
```

```
                DO I=1,LAMNUM(J)
                Y(I,J)=Y(I,J)-YDELTA
                END DO
                END DO
        END IF
        RETURN
        END
C
C
C...  SUBROUTINE QUAD CALCULATES THE ANOMALY ASSOCIATED WITH EACH BLOCK
C...  K BY DOING THE INTEGRATION IN THE Y-DIRECTION USING THE QUADRATURE
C...  FORMULA TALWANI USED.
C
C
        SUBROUTINE QUAD(K)
C
        COMMON /GRAV/MP,XSIZE,YSIZE,COLS,ROWS,XL(500),XR(500),
     &ZD(500),ZU(500),DEN(500),Y(500,500),ELEV(500),LAMNUM(500),
     &V(500),ANOM(500,500),NBLKS,XPOS,YPOS,TANOM(500),
     &M1,YMAX(500)
C
        REAL*8 ANOM,XL,XR,ZU,ZD,Y
        DIMENSION TEMP(500)
C
C...  FIND THE ANOMALY
C
        IF(LAMNUM(K)-1.GT.1)THEN
                I=1
                V(1)=0.0
        DO J=2,((LAMNUM(K)-1)/2)+1
C
        A0=ANOM(I,K)*((Y(I,K)-Y(I+2,K))/(Y(I,K)-Y(I+1,K)))
     &*(3.0*Y(I+1,K)-Y(I+2,K)-2.0*Y(I,K))
C
        B=ANOM(I+1,K)*((Y(I,K)-Y(I+2,K))**3)/((Y(I+1,K)-
     &Y(I+2,K))*(Y(I+1,K)-Y(I,K)))
C
        C=ANOM(I+2,K)*((Y(I,K)-Y(I+2,K))/(Y(I+2,K)-Y(I+1,K)))
     &*(3.0*Y(I+1,K)-Y(I,K)-2.*Y(I+2,K))
C
        TEMP(J-1)=(A0+B+C)/6.0
C
        V(J)=V(J-1)+TEMP(J-1)
        I=I+2
        END DO
C
        ELSE
C
C...  TRAPEZOIDAL RULE FOR ONE AREA
C
        V(((LAMNUM(K)-1)/2)+1)=(Y(2,K)-Y(1,K))*.5*(ANOM(1,K)+ANOM(2,K))
        END IF
C
        RETURN
        END
```

PROGRAM GINDEP:

A 3-D GRAVITY MODELING PROGRAM THAT INVERTS ON MAXIMUM DEPTHS OF BLOCKS INPUT AS OUTPUT FROM

PROGRAM GRAVBL

```
C
C... PROGRAM GINDEP IS AN INVERSE GRAVITY MODELING PROGRAM
C... THAT PREDICTS LOWER BLOCK DEPTHS THAT WILL GIVE A BEST FIT
C... TO OBSERVED GRAVITY DATA BASED ON FORWARD MODELING THAT
C... USES UP TO 100 RECTANGULAR BLOCKS OF EARTH. RIDGE REGRESSION,
C... WEIGHTING AND SCALING ARE USED
C
C*****************************************************************
C
C..                  VARIABLE LIST
C
C
C..     GEOMETRY VARIABLES  ** ALL DISTANCE UNITS IN METERS **
C       ------------------------------------------------------
C
C.. NBLKS = NUMBER OF BLOCKS IN MODEL J=1,NBLKS
C.. XL(J) = LEFT (OR MIN. X) EDGE OF BLOCK J
C.. XR(J) = RIGHT (OR MAX. X) EDGE OF BLOCK J
C.. ZU(J) = TOP (OR MIN. Z, Z POS. DOWN) EDGE OF BLOCK J
C.. ZD(J) = BOTTOM (OR MAX. Z, Z POS. DOWN) EDGE OF BLOCK J
C           -WHERE ZU AND ZD ARE THE POSITIVE DISTANCE DOWN FROM THE
C            DATUM ELEVATION CONSIDERING THE DATUM ELEVATION ZERO
C
C.. LAMNUM(J) = NUMBER OF LAMINAE USED TO FORM BLOCK J
C.. Y(I,J) = Y POSITION OF LAMINAE I ON BLOCK J
C..          I=1,LAMNUM(J)
C.. DEN(J) = DENSITY OF BLOCK J
C
C
C..     GRID VARIABLES (PREDICTED GRAVITY AS OBSERVED FROM GRID)
C       --------------------------------------------------------
C
C.. XSIZE = SIZE OF GRID IN X-DIRECTION
C.. YSIZE = SIZE OF GRID IN Y-DIRECTION
C.. COLS = NUMBER OF COLUMNS IN GRID
C.. ROWS = NUMBER OF ROWS IN GRID
C.. ELEV(I) = ELEVATION OF GRID POINT I -- READ IN FROM SURFII SAVED FILE
C.. DATELV  = DATUM ELEVATION
C.. XPOS,YPOS - CURRENT X,Y POSITION OF OBSERVATION ON GRID
C
C
C..     CALCULATION VARIABLES
C       ---------------------
C
C.. ANOM(I,J) = ANOMALY CALCULATED FOR LAMINAE I OF BLOCK J
C.. V(J) = ANOMALY OF BLOCK J RESULTING FROM A QUADRITURE FORMULA
C          SUMMATION OF THE CONTRIBUTIONS OF EACH LAMINAE IN BLOCK J
C
C.. TANOM(J) = VARIABLE USED FOR THE SUMMATION OF THE CONTRIBUTIONS
C              OF EACH BLOCK IN THE MODEL AT OBERSERVATION POINT
C              XPOS,YPOS ON THE GRID.  TANOM(NBLKS) IS THEREFORE
C              THE TOTAL ANOMALY OF THE PRESENT MODEL AT OBSERVATION
C              POINT XPOS,YPOS ON THE GRID.
C
C
C..     MISCELLANEOUS VARIABLES
C       -----------------------
C
```

```
C.. MAXPER =  VALUE THAT CONTROLS HOW MANY LAMINAE WILL
C             BE USED TO DEFINE A BLOCK.
C
        COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
        COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
        CHARACTER CHAR*1
C
        DIMENSION A(500,500),DPRED(500,500),DAMP(100)
C
        DIMENSION WDEP(250,250),DELT(400,1),DOBS(400),SQE(20,1),
     &WS(250,250),WKAREA(10500),C(250,250),GINV(250,250),DELTM(250,1),
     &DELTN(250,1),SQEN(20,1),ERR(20,1),COVM(250,250),SIGMAM(250)
     &,CA(250,250),D(250,250),WSS(250,250),WERR(250,250)
C
        CHARACTER*20 FILENAME,FILNAM
C*********************************************************************
C
C               INPUT MODEL DATA FOR FORWARD PROGRAM
C                  DATA IN COMAND FILE G.DAT
C
        OPEN(26,FILE='G.DAT',STATUS='OLD')
C
C... READ FILENAME OF SAVED SURFII GRIDFILE
C
        READ(26,'(A20)')FILENAME
        READ(26,*)TDEPL
        READ(26,*)TDEPH
C
        READ(26,*)NBLKS
        DO J=1,NBLKS
        READ(26,*)XL(J),XR(J),ZU(J),ZD(J,1),Y(1,J),Y(2,J),DEN(J)
        YMIN(J)=Y(1,J)
        YMAX(J)=Y(2,J)
        END DO
        READ(26,*)MAXPER
C
C               INPUT DATA FOR INVERSION
C
        READ(26,*)RATIO
        READ(26,*)STDDEV
        READ(26,*)ITMAX
C
C... IF WANT TOPOGRAPHY SET LL=1, ELSE SET LL .NE. 1
C
        READ(26,*)LL
        IF(LL.EQ.1)THEN
C
C
C*********************************************************************
C
C                INPUT FOR TOPOGRAPHY
C
C... INPUT DATAUM ELEVATION FOR SURVEY
```

```
C
      READ(26,*)DATELV
C
C*********************************************************************
C
C
C              INPUT - ELEVATION OF OBSERVATION POINTS (GRAVITY
C                      STATIONS) FROM SAVED SURFII GRIDFILE
C
C... ENTER FILENAME OF SAVED SURFII GRIDFILE
C
      READ(26,'(A20)')FILNAM
C
      OPEN(28,FILE=FILNAM,STATUS='OLD',FORM='UNFORMATTED'
     &,ACCESS='SEQUENTIAL')
C
C
C... READ IN FIRST RECORD
C
      READ(28)NCOLS,NROWS,IZERO
C
C... READ IN SECOND RECORD
C
      READ(28)IROWS,JCOLS,DIFY,DIFX,XMN,XMX,YMN,YMX,DUMMY
C
C... READ IN ELEVATIONS
C
      DO I=NROWS,1,-1
      IBEG=(I-1)*NCOLS+1
      IEND=IBEG+NCOLS-1
      READ(28)(ELEV(J),J=IBEG,IEND)
      END DO
C
      DO I=1,NCOLS*NROWS
      ELEV(I)=ELEV(I)-DATELV
      END DO
C
      END IF
C
C
C*********************************************************************
C
C               INPUT-OBSERVED GRAVITY DATA
C                FROM SAVED SURFII GRIDFILE
C
C
C... ENTER FILENAME OF SAVED SURFII DATA FILE IN FILE G.DAT
C
      OPEN(27,FILE=FILENAME,STATUS='OLD',FORM='UNFORMATTED'
     &,ACCESS='SEQUENTIAL')
C
C
C... READ IN FIRST RECORD
C
      READ(27)NCOLS,NROWS,IZERO
C
C... READ IN SECOND RECORD
C
```

```
      READ(27)IROWS,JCOLS,DIFY,DIFX,XMN,XMX,YMN,YMX,DUMMY
C
C... READ IN OBS DATA
C
      DO I=NROWS,1,-1
      IBEG=(I-1)*NCOLS+1
      IEND=IBEG+NCOLS-1
      READ(27)(DOBS(J),J=IBEG,IEND)
      END DO
C
      XSIZE=ABS(XMX-XMN)
      YSIZE=ABS(YMX-YMN)
C
      CLOSE(27)
      NDAT=NCOLS*NROWS
      NPARMS=NBLKS
C
C
      OPEN(16,FILE='GINDEP.OUT',STATUS='NEW')
      WRITE(16,'(''                    '')')
      WRITE(16,'(''****************************************
     &************************************'')')
      WRITE(16,'(''                    '')')
      WRITE(16,'(''                  GRID INFO'')')
      WRITE(16,'(''                    '')')
      WRITE(16,'(''----------------------------------------
     &------------------------------------'')')
      WRITE(16,'(''$GRID SIZE IN X DIRECTION
     &(METERS)='',E12.4)')XSIZE
      WRITE(16,'(''$GRID SIZE IN Y DIRECTION
     &(METERS)='',E12.4)')YSIZE
      WRITE(16,'(''$NUMBER OF COLUMNS='',I3)')NCOLS
      WRITE(16,'(''$NUMBER OF ROWS='',I3)')NROWS
      WRITE(16,'(''----------------------------------------
     &------------------------------------'')')
      WRITE(16,'(''                    '')')
      WRITE(16,'(''----------------------------------------
     &------------------------------------'')')
      WRITE(16,'(''                    '')')
      WRITE(16,'(''                       INPUT MODEL'')')
      WRITE(16,'(''                     '')')
      WRITE(16,'(''----------------------------------------
     &------------------------------------'')')
      WRITE(16,'(''  BLOCK #   XMIN    XMAX
     &YMIN     YMAX       ZMIN     ZMAX      DENSITY'')')
      DO J=1,NPARMS
      WRITE(16,'(3X,I3,2X,F7.1,2X,F7.1,2X,F7.1,2X,F7.1,2X,F7.1,
     &2X,F7.1,2X,F7.1)')
     &J,XL(J),XR(J),Y(1,J),Y(2,J),ZU(J),ZD(J,1),DEN(J)
      END DO
      WRITE(16,'(''****************************************
     &************************************'')')
      WRITE(16,'(''                               '')')
C
      WRITE(16,'(''                    '')')
      WRITE(16,'(''****************************************
     &************************************'')')
      WRITE(16,'(''                    '')')
```

```
      WRITE(16,'(''   TABLE OF CONVERGENCE'')')
      WRITE(16,'(''                 '')')
      WRITE(16,'(''-------------------------------------
     &-----------------------------------''')')
C
      CLOSE(28)
C
      IF(LL.EQ.1)THEN
      DO J=1,NBLKS
      ZU(J)=ZU(J)+ELEV(1)
      ZD(J,1)=ZD(J,1)+ELEV(1)
      END DO
      END IF
C
C
      IA=250
      IB=250
      IC=250
      CDAMP=.001
C
      KEPTRK=1
      KOUNT=0
      KVAR=0
C
      CALL FWRD(A,DPRED)
C
5     KOUNT=KOUNT+1
      IF(KOUNT.GT.ITMAX)THEN
      PRINT *,'MAXIMUM NUMBER OF ITERATIONS EXCEEDED -
     & CONVERGENCE NOT OBTAINED'
      GO TO 20
      END IF
C
C... FIND A MATRIX
C
      CALL DERIV(A)
C
C... FIND DEPTH WEIGHTING MATRIX
C
      IF(RATIO.EQ.0.0)RATIO=1E-04
      DO I=1,NPARMS
      DO J=1,NPARMS
      IF(I.EQ.J)THEN
      WDEP(I,J)=(1./(ABS(ZD(J,KEPTRK))+10E-12))+1.
              IF(ZD(J,KEPTRK).LT.TDEPL)THEN
              ZD(J,KEPTRK)=TDEPL
              DAMP(I)=15E+1
C     WDEP(I,J)=10E+18*((1./(ABS(ZD(J,KEPTRK))+10E-12))+1.)
              ELSE IF(ZD(J,KEPTRK).GT.TDEPH)THEN
              ZD(J,KEPTRK)=TDEPH
              DAMP(I)=15E+1
C     WDEP(I,J)=10E+18*((1./(ABS(ZD(J,KEPTRK))+10E-12))+1.)
C             ELSE
              END IF
      ELSE
              WDEP(I,J)=0.0
      END IF
      END DO
```

```
        END DO
C
C... FIND A*WDEP*A(TRANSPOSE) MATRIX FOR NOISE WEIGHTING
C
        CALL VMULFF(A,WDEP,NDAT,NPARMS,NPARMS,500,IB,C,IC,IER)
        CALL VMULFP(C,A,NDAT,NPARMS,NDAT,IA,500,WERR,IC,IER)
C
        DO I=1,NDAT
        DO J=1,NDAT
                IF(I.NE.J)WERR(I,J)=0.0
        END DO
        END DO
C
        CALL VMULFM(A,WERR,NDAT,NPARMS,NDAT,500,IB,C,IC,IER)
        CALL VMULFF(C,A,NPARMS,NDAT,NPARMS,IA,500,WS,IC,IER)
C
C... SCALE THE A(TRANSPOSE)WA MATRIX FOR ONES ON THE DIAGONAL
C
        DO I=1,NPARMS
        DO J=1,NPARMS
                IF(I.EQ.J)THEN
                D(I,J)=1./(SQRT(WS(I,I)))
                ELSE
                D(I,J)=0.0
                END IF
        END DO
        END DO
C
        CALL VMULFF(D,WS,NPARMS,NPARMS,NPARMS,IA,IB,CA,IC,IER)
        CALL VMULFF(CA,D,NPARMS,NPARMS,NPARMS,IA,IB,WSS,IC,IER)
C
C... ADD THE "NOISE/SIGNAL" RATIO
C
        DO I=1,NPARMS
        WSS(I,I)=WSS(I,I)+RATIO*RATIO
        END DO
C
        DO I=1,NDAT
        DELT(I,1)=DOBS(I)-DPRED(I,KEPTRK)
        END DO
C
C... FIND ERROR
C
        CALL VMULFM(DELT,DELT,NDAT,1,1,400,400,SQE,20,IER)
        WRITE(16,'(''$ITERATION #'',I3)')KOUNT
        WRITE(16,'(''$STARTING DATA ERROR='',E12.4)')
     &SQRT(SQE(1,1)/(NDAT-NPARMS))
C
C********** MARQUARDT LOOP **********************************
C
10      IF(CDAMP.GE.100000)THEN
        WRITE(16,'(''DAMPING FACTOR HAS REACHED 100000 - WILL NOT CONVERGE
     &TO PRESENT INPUT DATA STD. DEV.'')')
        CALL EXIT
        END IF
C
        DO I=1,NPARMS
C
```

```
        IF(DAMP(I).NE.15E+1)DAMP(I)=CDAMP
        WSS(I,I)=WSS(I,I)+DAMP(I)
C
                IF(ZD(I,KEPTRK).LT.TDEPL)THEN
                ZD(I,KEPTRK)=TDEPL
                DAMP(I)=15E+1
                ELSE IF(ZD(J,KEPTRK).GT.TDEPH)THEN
                ZD(I,KEPTRK)=TDEPH
                DAMP(I)=15E+1
                END IF
        END DO
C
C... FIND INVERSE OF WS
C
        CALL LINV2F(WSS,NPARMS,IA,C,1,WKAREA,IER)
C
C...  FIND GENERALIZED INVERSE GINV
C
        CALL VMULFF(D,C,NPARMS,NPARMS,NPARMS,IA,IB,CA,IC,IER)
        CALL VMULFF(CA,D,NPARMS,NPARMS,NPARMS,IA,IB,C,IC,IER)
        CALL VMULFP(C,A,NPARMS,NPARMS,NDAT,IA,500,CA,IC,IER)
        CALL VMULFF(CA,WERR,NPARMS,NDAT,NDAT,IA,IB,GINV,IC,IER)
C
C... DELTM IS THE JUMP HOPEFULLY TOWARD A SOLUTION
C
        CALL VMULFF(GINV,DELT,NPARMS,NDAT,1,IA,400,DELTM,250,IER)
C
        WRITE(16,'('' '')')
        WRITE(16,'('' BLOCK    PARM. JUMP.  NEW PARMS.'')')
C
        DO I=1,NPARMS
45      ZD(I,KEPTRK+1)=DELTM(I,1)+ZD(I,KEPTRK)
C
C...  PRVENT FLAKY MODELS
C
C
        IF(ZD(I,KEPTRK+1).LE.ZU(I))THEN
        DELTM(I,1)=DELTM(I,1)/10
        GO TO 45
        END IF
C
        IF(ZD(I,KEPTRK).EQ.TDEPL.AND.DAMP(I).EQ.15E+1)THEN
        IF(DELTM(I,1).GT.0.0)DAMP(I)=CDAMP
C
       ELSE IF(ZD(I,KEPTRK).EQ.TDEPH.AND.DAMP(I).EQ.15E+1)THEN
        IF(DELTM(I,1).LT.0.0)DAMP(I)=CDAMP
        END IF
C
        WRITE(16,'(1X,I3,3X,E12.4,1X,E12.4)')I,DELTM(I,1),ZD(I,KEPTRK+1)
        END DO
C
        WRITE(16,'(''$DAMPING (MARQUARDT) VALUE='',E12.4)')
     &CDAMP
C
C... NOW HAVE NEW PARAMS.
C
        KEPTRK=KEPTRK+1
        CALL FWRD(A,DPRED)
```

```
C
        DO I=1,NDAT
        DELTN(I,1)=DOBS(I)-DPRED(I,KEPTRK)
        END DO
C
C... DO NEW PARAMS REDUCE ERROR?
C
        CALL VMULFM(DELTN,DELTN,NDAT,1,1,IA,IB,SQEN,20,IER)
        WRITE(16,'(''$NEW DATA ERROR='',E12.4)')
     &SQRT(SQEN(1,1)/(NDAT-NPARMS))
C
        IF(SQEN(1,1).GE.SQE(1,1))THEN
C
        DO I=1,NPARMS
        ZD(I,KEPTRK)=ZD(I,KEPTRK-1)
        END DO
        CDAMP=10.*CDAMP
        GO TO 10
        ELSE
12      PERCENT=((SQRT(SQE(1,1)/(NDAT-NPARMS))-SQRT(SQEN(1,1)
     &/(NDAT-NPARMS)))/SQRT(SQE(1,1)/(NDAT-NPARMS)))*100.
C
C... ERROR MUST BE IMPROVED BY AT LEAST ONE PERCENT FOR
C... NEW ITERATION
C
        IF(PERCENT.LT.1.)THEN
                CDAMP=10.*CDAMP
                GO TO 10
        END IF
C
        SQE(1,1)=SQEN(1,1)
        CDAMP=CDAMP/10.
        DO I=1,NDAT
        DELT(I,1)=DELTN(I,1)
        END DO
        END IF
C
C... CHECK TO SEE IF SOLN. IS WITHIN STD. DEV. OF DATA
C
        CALL VMULFM(DELT,DELT,NDAT,1,1,400,400,ERR,20,IER)
        CHIERR=(1./(NDAT-NPARMS))*ERR(1,1)
C
C
C
        IF(SQRT(CHIERR).LE.STDDEV)GO TO 20
        WRITE(16,'(''      '')')
        GO TO 5
C
C********** OUTPUT ****************************************************
C
20      WRITE(16,'(''----------------------------------------
     &-----------------------------------''')')
        WRITE(16,'(''                          '')')
        WRITE(16,'(''**************************************************
     &**********''')')
        WRITE(16,'(''                          '')')
        WRITE(16,'(''**************************************************
     &**********''')')
```

```
      WRITE(16,'('' '')')
      WRITE(16,'('' OUTPUT-PROGRAM GINDEP'')')
      WRITE(16,'('' '')')
      CALL VMULFP(GINV,GINV,NPARMS,NDAT,NPARMS,IA,IB,C,IC,IER)
      DO I=1,NPARMS
      DO J=1,NPARMS
      COVM(I,J)=CHIERR*C(I,J)
      END DO
      END DO
C
      DO I=1,NPARMS
      SIGMAM(I)=SQRT(COVM(I,I))
      END DO
C
      WRITE(16,'('' ----------------------------------------
     &--------------'')')
      WRITE(16,'('' '
     &                              '')')
      WRITE(16,'('' I     ZD(I) +/- STD.DEV.'')')
      WRITE(16,'('' ----------------------------------------
     &------------'')')
      DO I=1,NPARMS
      WRITE(16,'(1X,I2,3X,E10.3,2X,E10.3)')
     &I,ZD(I,KEPTRK),SIGMAM(I)
      END DO
      WRITE(16,'('' ----------------------------------------
     &-----------'')')
C
      WRITE(16,'('' ----------------------------------------
     &-----------'')')
      WRITE(16,'('' $INPUT STD. DEV. = '',E12.4)')STDDEV
      WRITE(16,'('' $CALC. DATA STD. DEV. = '',E12.4)')SQRT(CHIERR)
      WRITE(16,'('' $NUMBER OF ITERATIONS FOR SOLUTION = '',I3)')KOUNT
      WRITE(16,'('' ----------------------------------------
     &----------'')')
C
      WRITE(16,'('' ----------------------------------------
     &-----------'')')
      WRITE(16,'('' MODEL RESOLUTION MATRIX'')')
      CALL VMULFF(GINV,A,NPARMS,NDAT,NPARMS,IA,500,C,IC,IER)
      WRITE(16,'('' '')')
C
      IF(NPARMS.GT.15)THEN
      WRITE(16,'(1X,A1,11X,A10,7X,A5,7X,A10)')'I','...(I,I-2)...',
     &'(I,I)','(I,I+2)...'
      WRITE(16,'(1X,I3,1X,A1,22X,3F6.2,10X,A1)')
     &1,'|',(C(1,J),J=1,3),'|'
      WRITE(16,'(1X,I3,1X,A1,16X,4F6.2,10X,A1)')
     &2,'|',(C(2,J),J=1,4),'|'
      DO I=3,NPARMS
      WRITE(16,'(1X,I3,1X,A1,10X,5F6.2,10X,A1)')I,'|',
     &(C(I,J),J=I-2,I+2),'|'
      IF(I+2.EQ.NPARMS)THEN
      WRITE(16,'(1X,I3,1X,A1,10X,4F6.2,16X,A1)')
     &NPARMS-1,'|',(C(NPARMS-1,J),J=NPARMS-3,NPARMS),'|'
      WRITE(16,'(1X,I3,1X,A1,10X,3F6.2,22X,A1)')
     &NPARMS,'|',(C(NPARMS,J),J=NPARMS-2,NPARMS),'|'
      GO TO 21
```

```
        END IF
        END DO
C
        ELSE
C
        DO I=1,NPARMS
        WRITE(16,'(1X,A1,<NPARMS>F6.2,2X,A1)')'|',(C(I,J)
     &,J=1,NPARMS),'|'
        END DO
C
        END IF
C
21      WRITE(16,'(''-----------------------------------------
     &------------'')')
        WRITE(16,'(''-----------------------------------------
     &------------'')')
        WRITE(16,'('' DATA RESOLUTION MATRIX'')')
        WRITE(16,'(''                                    '')')
        CALL VMULFF(A,GINV,NDAT,NPARMS,NDAT,500,IB,C,IC,IER)
C
        IF(NDAT.GT.15)THEN
        WRITE(16,'(1X,A1,11X,A10,7X,A5,7X,A10)')'I','...(I,I-2)...',
     &'(I,I)','(I,I+2)...'
        WRITE(16,'(1X,I3,1X,A1,22X,3F6.2,10X,A1)')
     &1,'|',(C(1,J),J=1,3),'|'
        WRITE(16,'(1X,I3,1X,A1,16X,4F6.2,10X,A1)')
     &2,'|',(C(2,J),J=1,4),'|'
        DO I=3,NDAT
        WRITE(16,'(1X,I3,1X,A1,10X,5F6.2,10X,A1)')I,'|',
     &(C(I,J),J=I-2,I+2),'|'
        IF(I+2.EQ.NDAT)THEN
        WRITE(16,'(1X,I3,1X,A1,10X,4F6.2,16X,A1)')
     &NDAT-1,'|',(C(NDAT-1,J),J=NDAT-3,NDAT),'|'
        WRITE(16,'(1X,I3,1X,A1,10X,3F6.2,22X,A1)')
     &NDAT,'|',(C(NDAT,J),J=NDAT-2,NDAT),'|'
        GO TO 22
        END IF
        END DO
C
        ELSE
C
        DO I=1,NDAT
        WRITE(16,'(1X,A1,<NDAT>F6.2,2X,A1)')'|',(C(I,J)
     &,J=1,NDAT),'|'
        END DO
C
        END IF
C
22      WRITE(16,'(''-----------------------------------------
     &------------'')')
C
        WRITE(16,'(''-----------------------------------------
     &------------'')')
        WRITE(16,'('' COVARIANCE MATRIX'')')
        WRITE(16,'(''                                    '')')
        IF(NPARMS.GT.15)THEN
        WRITE(16,'(1X,A1,12X,A10,13X,A5,19X,A10)')'I','...(I,I-2)...',
     &'(I,I)','(I,I+2)...'
```

```
      WRITE(16,'(1X,I3,1X,A1,30X,3E10.2,10X,A1)')
     &1,'|',(COVM(1,J),J=1,3),'|'
      WRITE(16,'(1X,I3,1X,A1,20X,4E10.2,10X,A1)')
     &2,'|',(COVM(2,J),J=1,4),'|'
      DO I=3,NPARMS
      WRITE(16,'(1X,I3,1X,A1,10X,5E10.2,10X,A1)')I,'|',
     &(COVM(I,J),J=I-2,I+2),'|'
      IF(I+2.EQ.NPARMS)THEN
      WRITE(16,'(1X,I3,1X,A1,10X,4E10.2,20X,A1)')
     &NPARMS-1,'|',(COVM(NPARMS-1,J),J=NPARMS-3,NPARMS),'|'
      WRITE(16,'(1X,I3,1X,A1,10X,3E10.2,30X,A1)')
     &NPARMS,'|',(COVM(NPARMS,J),J=NPARMS-2,NPARMS),'|'
      GO TO 23
      END IF
      END DO
      ELSE
C
      DO I=1,NPARMS
      WRITE(16,'(1X,A1,<NPARMS>E10.2,2X,A1)')'|',(COVM(I,J)
     &,J=1,NPARMS),'|'
      END DO
C
      END IF
C
23    WRITE(16,'(''-------------------------------------------
     &------------'')')
C
      WRITE(16,'(''-------------------------------------------
     &------------'')')
      WRITE(16,'('' CORRELATION MATRIX'')')
      WRITE(16,'('' '')')
      DO I=1,NPARMS
      DO J=1,NPARMS
      C(I,J)=COVM(I,J)/(SQRT(COVM(I,I))*SQRT(COVM(J,J)))
      END DO
      END DO
C
      IF(NPARMS.GT.15)THEN
      WRITE(16,'(1X,A1,11X,A10,7X,A5,7X,A10)')'I','...(I,I-2)...',
     &'(I,I)','(I,I+2)...'
      WRITE(16,'(1X,I3,1X,A1,22X,3F6.2,10X,A1)')
     &1,'|',(C(1,J),J=1,3),'|'
      WRITE(16,'(1X,I3,1X,A1,16X,4F6.2,10X,A1)')
     &2,'|',(C(2,J),J=1,4),'|'
      DO I=3,NPARMS
      WRITE(16,'(1X,I3,1X,A1,10X,5F6.2,10X,A1)')I,'|',
     &(C(I,J),J=I-2,I+2),'|'
      IF(I+2.EQ.NPARMS)THEN
      WRITE(16,'(1X,I3,1X,A1,10X,4F6.2,16X,A1)')
     &NPARMS-1,'|',(C(NPARMS-1,J),J=NPARMS-3,NPARMS),'|'
      WRITE(16,'(1X,I3,1X,A1,10X,3F6.2,22X,A1)')
     &NPARMS,'|',(C(NPARMS,J),J=NPARMS-2,NPARMS),'|'
      GO TO 24
      END IF
      END DO
C
      ELSE
C
```

```
        DO I=1,NPARMS
        WRITE(16,'(1X,A1,<NPARMS>F6.2,2X,A1)')'|',(C(I,J)
     &,J=1,NPARMS),'|'
        END DO
C
        END IF
24      WRITE(16,'(''**********************************************
     &***************''')')
        CLOSE(16)
        PRINT *,' OUTPUT IN FILE GINDEP.OUT.'
50      CALL EXIT
        END
C
C*************************************************************************
C     SUBROUTINES
C
C... SUBROUTINE FWRD IS A FORWARD GRAVITY PROGRAM THAT MODELS THE EARTH
C... BY USING BLOCKS (UP TO 100) OF VARIABLE DENSITY.
C
        SUBROUTINE FWRD(A,DPRED)
C
        COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
        COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
        DIMENSION A(500,500),DPRED(500,500),B(250,1),G(500,500)
C
        M1=0
        M=1
        CHECK=0.0
        XDELTA=XSIZE/(NCOLS-1)
        YDELTA=YSIZE/(NROWS-1)
C
        IF(KEPTRK.EQ.1.AND.KVAR.NE.20)THEN
        DO I=1,NBLKS
        CALL REORDER(I)
C
C...  MAKE SURE LAMNUM(I) IS AN ODD NUMBER SO THAT QUADRITURE
C...  FORMULA WILL WORK
C
        L1=LAMNUM(I)/2
        T1=(LAMNUM(I)/2.)-L1
        IF(LAMNUM(I).GT.2)THEN
                IF(T1.EQ.0.0)THEN
                Y(LAMNUM(I)+1,I)=Y(LAMNUM(I),I)
                Y(LAMNUM(I),I)=Y(LAMNUM(I),I)-1.
                CALL FORWARD(LAMNUM(I),I)
                LAMNUM(I)=LAMNUM(I)+1
                END IF
        END IF
        END DO
C
10      IF(M.EQ.1)THEN
        XPOS=0.0
        YPOS=0.0
C
```

```
        DO J=2,NBLKS+1
                CALL QUAD(J-1)
                        G(1,J-1)=V(((LAMNUM(J-1)-1)/2)+1)
                END DO
                M=2
                GO TO 10
        ELSE
30              DO I=1,NCOLS*NROWS-1
                        CALL GRID(I,CHECK,XDELTA,YDELTA)
                        DO J=2,NBLKS+1
C
        IF(LL.EQ.1)THEN
        ZU(J-1)=ZU(J-1)+ELEV(I+1)-ELEV(I)
        ZD(J-1,KEPTRK)=ZD(J-1,KEPTRK)+ELEV(I+1)-ELEV(I)
        END IF
C
                        CALL FORWARD(1,J-1)
                        DO K=2,LAMNUM(J-1)
                                CALL FORWARD(K,J-1)
                        END DO
                        CALL QUAD(J-1)
                        G(I+1,J-1)=V(((LAMNUM(J-1)-1)/2)+1)
                        END DO
                END DO
C
C..  FIND THE A MATRIX IK KVAR=20
C
        IF(KVAR.EQ.20)THEN
        DO I=1,NDAT
        DO J=1,NPARMS
                A(I,J)=G(I,J)*DEN(J)
                IF(A(I,J).EQ.0.0)A(I,J)=1E-10
        END DO
        END DO
        GO TO 7
        END IF
C
        DO I=1,NPARMS
        B(I,1)=DEN(I)
        END DO
C
        CALL VMULFF(G,B,NDAT,NPARMS,1,500,IB,DPRED,500,IER)
C
        DO I=1,NDAT
        DPRED(I,KEPTRK)=DPRED(I,1)
        END DO
C
7       IF(KEPTRK.EQ.1)THEN
        OPEN(29,FILE='A.DAT',STATUS='NEW')
        DO I=1,NDAT
        DO J=1,NPARMS
        WRITE(29,'(E12.4)')A(I,J)
        END DO
        END DO
        CLOSE(29)
        GO TO 40
        END IF
        IF(KK.EQ.2)GO TO 40
```

```
        END IF
C
        ELSE
C
        KK=1
20      IF(KK.EQ.1)THEN
        XPOS=0.0
        YPOS=0.0
        DO J=2,NBLKS+1
C
                IF(LL.EQ.1)THEN
                ZU(J-1)=ZU(J-1)+ELEV(1)
                ZD(J-1,KEPTRK)=ZD(J-1,KEPTRK)+ELEV(1)
                END IF
C
        CALL FORWARD(1,J-1)
        DO K=2,LAMNUM(J-1)
                CALL FORWARD(K,J-1)
        END DO
        CALL QUAD(J-1)
        G(1,J-1)=V(((LAMNUM(J-1)-1)/2)+1)
        END DO
        KK=2
        GO TO 20
        ELSE
        GO TO 30
        END IF
        END IF
C
40      DO J=1,NBLKS
        XL(J)=XL(J)+XSIZE
        XR(J)=XR(J)+XSIZE
        IF(LL.EQ.1)THEN
        ZU(J)=ZU(J)-ELEV(NROWS*NCOLS)
        ZD(J,KEPTRK)=ZD(J,KEPTRK)-ELEV(NROWS*NCOLS)
        END IF
        DO K=1,LAMNUM(J)
        Y(K,J)=Y(K,J)+YSIZE
        END DO
        END DO
C
        RETURN
        END
C
C
C...  SUBROUTINES
C
C
        SUBROUTINE REORDER(I)
C
        COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
        COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
        K1=ABS(Y(2,I)-Y(1,I))
```

```
      K2=ABS(XR(I)-XL(I))
      LAMNUM(I)=(K1*MAXPER*(JMAX0(K1,K2)/JMIN0(K1,K2)))/100
C
      IF(LAMNUM(I).LT.10)LAMNUM(I)=10
C
      IF(LAMNUM(I).GE.500)THEN
      PRINT *,' MAXIMUM NUMBER OF LAMINAE (500) '
      PRINT *,'FOR BLOCK ',I,' EXCEEDED.'
      CALL EXIT
      END IF
C
      YDIST=K1/FLOAT(LAMNUM(I))
      CALL FORWARD(1,I)
      LAMNUM(I)=LAMNUM(I)+1
      DO K=2,LAMNUM(I)+1
      Y(K,I)=Y(K-1,I)+YDIST
      CALL FORWARD(K,I)
      END DO
C
      RETURN
      END
C
C
C... SUBROUTINE FORWARD CALCULATES THE GRAVITY ANOMALY/UNIT WIDTH FOR
C... EACH LAMINAE
C
      SUBROUTINE FORWARD(I,J)
C
      COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
      COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
      G0=0.0000000667
C
C... START CALCULATIN'
C
C... PREVENT INSTABILITIES
C
      IF(XR(J).EQ.0.0)XR(J)=1E-10
      IF(XL(J).EQ.0.0)XL(J)=1E-10
      IF(Y(I,J).EQ.0.0)Y(I,J)=1E-10
C
C.. FIND DERIVATIVE OF GRAVITY WRT ZD IF KVAR=20
C
      IF(KVAR.EQ.20)THEN
C
      C1=SQRT(XL(J)*XL(J)+ZD(J,KEPTRK)*ZD(J,KEPTRK)+Y(I,J)*Y(I,J))
      C2=SQRT(XR(J)*XR(J)+ZD(J,KEPTRK)*ZD(J,KEPTRK)+Y(I,J)*Y(I,J))
C
      ANOM(I,J)=((1./((XL(J)*C1)+(C1*C1)))-(1./((XR(J)*C2)+(C2*C2))))
     &*ZD(J,KEPTRK)*100000.*G0
C
      RETURN
      END IF
C
```

```
C
        A0=ZD(J,KEPTRK)*ZD(J,KEPTRK)+Y(I,J)*Y(I,J)
        B=ZU(J)*ZU(J)+Y(I,J)*Y(I,J)
        A1=XL(J)+SQRT(XL(J)*XL(J)+B)
        A2=XR(J)+SQRT(XR(J)*XR(J)+B)
        B1=XR(J)+SQRT(XR(J)*XR(J)+A0)
        B2=XL(J)+SQRT(XL(J)*XL(J)+A0)
        IF((A1.EQ.0.0).OR.(A2.EQ.0.0).OR.(B1.EQ.0.0)
     &.OR.(B2.EQ.0.0))M1=M1+1
C
C... PREVENT TAKING LOG OF 0.0
C
        IF(A1.EQ.0.0)A1=.001
        IF(A2.EQ.0.0)A2=.001
        IF(B1.EQ.0.0)B1=.001
        IF(B2.EQ.0.0)B2=.001
C
        IF(A1.EQ.0.001.OR.A2.EQ.0.001.OR.B1.EQ.0.001.OR
     &.B2.EQ.0.001)THEN
        PRINT *,' HAVE HIT A ZERO OR NEGATIVE NUMBER; THIS NUMBER HAS BEEN'
        PRINT *,' CHANGED TO .001 SO THAT TAKING ITS LOG IS POSSIBLE.'
        PRINT *,' YOU MAY WANT TO CHANGE THE GEOMETRY OF BLOCK :',J
        END IF
C
C... THE 100000 IS TO GET THE ANOMALY IN UNITS OF MGALS
C
        ANOM(I,J)=-100000.*G0*(ALOG(A1)
     &+ALOG(B1)-ALOG(A2)-ALOG(B2))
C
        RETURN
        END
C
C
C...  SUBROUTINE GRID GIVES X,Y GRID POSITIONS
C
C
        SUBROUTINE GRID(KNT,CHECK,XDELTA,YDELTA)
C
        COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
        COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
        NI=KNT/NCOLS
        XPOS=KNT*XDELTA-(NI*XSIZE+XDELTA*NI)
        IF(ABS(XPOS).LE.1.0E-01)XPOS=0.00E+00
        YPOS=NI*YDELTA
        IF(XSIZE.GT.CHECK)THEN
                CHECK=CHECK+XDELTA
                DO J=1,NBLKS
                XL(J)=XL(J)-XDELTA
                XR(J)=XR(J)-XDELTA
                END DO
        ELSE
                CHECK=0.0
                DO J=1,NBLKS
```

```
C
                XL(J)=XL(J)+XDELTA*(NCOLS-1)
                XR(J)=XR(J)+XDELTA*(NCOLS-1)
C
                DO I=1,LAMNUM(J)
                Y(I,J)=Y(I,J)-YDELTA
                END DO
                END DO
        END IF
        RETURN
        END
C
C
C...  SUBROUTINE QUAD CALCULATES THE ANOMALY ASSOCIATED WITH EACH BLOCK
C...  BY DOING THE INTEGRATION IN THE Y-DIRECTION USING TALWNI'S
C...  QUADRITURE FORMULA
C
C
        SUBROUTINE QUAD(K)
C
        COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
        COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
        DIMENSION TEMP(500)
C
C...  FIND THE ANOMALY
C
        IF(LAMNUM(K)-1.GT.1)THEN
                I=1
                V(1)=0.0
        DO J=2,((LAMNUM(K)-1)/2)+1
C
        A1=ANOM(I,K)*((Y(I,K)-Y(I+2,K))/(Y(I,K)-Y(I+1,K)))
     &*(3.0*Y(I+1,K)-Y(I+2,K)-2.0*Y(I,K))
C
        B=ANOM(I+1,K)*((Y(I,K)-Y(I+2,K))**3)/((Y(I+1,K)-
     &Y(I+2,K))*(Y(I+1,K)-Y(I,K)))
C
        C=ANOM(I+2,K)*((Y(I,K)-Y(I+2,K))/(Y(I+2,K)-Y(I+1,K)))
     &*(3.0*Y(I+1,K)-Y(I,K)-2.*Y(I+2,K))
C
        TEMP(J-1)=(A1+B+C)/6.0
C
        V(J)=V(J-1)+TEMP(J-1)
        I=I+2
        END DO
C
        ELSE
C
C...  TRAPEZOIDAL RULE FOR ONE AREA
C
        V(((LAMNUM(K)-1)/2)+1)=(Y(2,K)-Y(1,K))*.5*(ANOM(1,K)+ANOM(2,K))
        END IF
C
```

```
      RETURN
      END
C
C
C..  SUBROUTINE DERIV IS USED TO SET KVAR TO 20 SO THAT DERIVITIVES
C..  OF GRAVITY WRT ZD WILL BE CONTAINED IN THE A MATRIX.  THE A
C..  MATRIX IS USED TO LINEARIZE THIS NONLINEAR PROBLEM SO THAT
C..  INCREMENTAL PARAMETER JUMPS TOWARD THE SOLUTION CAN BE FOUND.
C
      SUBROUTINE DERIV(A)
C
      COMMON /GRAV/XL(100),XR(100),ZD(100,100),ZU(100),
     &DEN(100),Y(500,500),NBLKS,XSIZE,YSIZE,NCOLS,
     &NROWS,YMAX(500),YMIN(500),MAXPER,LAMNUM(500),
     &XPOS,YPOS,ANOM(500,500),V(500),ELEV(500)
C
      COMMON /CBGINV/NDAT,NPARMS,KEPTRK,IA,IB,IC,LL,KVAR
C
      DIMENSION A(500,500),DPRED(500,500)
      KVAR=20
      CALL FWRD(A,DPRED)
      KVAR=0
      RETURN
      END
$
```

PROGRAM 3D:

A FORWARD GRAVITY MODELING PROGRAM BASED ON TALWANI AND EWING'S (1960) ALGORITHM

```
      COMMON NUMPTS(150),DENLAM(150),DEPTH(150),LAMNUM,
      &X(150,150),Y(150,150)
      DIMENSION STAELV(500),ELEV(500)
         INTEGER COLS,ROWS
      CHARACTER*20 FILENAME
C
      OPEN(1,FILE='3DGRV.DAT',STATUS='OLD')
C
C**********************************************************************
C                    MODEL INPUT
C
C...  FILENAME OF SAVED SURFII FILE CONTAINING STATION ELEVATIONS
C...  UNITS=METERS
C
C... IF NUMB=1 THEN INPUT STATION ELEVATIONS FROM SAVED SURFII FILE
      READ(1,*)NUMB
      IF(NUMB.EQ.1)READ(1,'(A20)')FILENAME
C
      OPEN(10,FILE=FILENAME,STATUS='OLD',FORM='UNFORMATTED',
      &ACCESS='SEQUENTIAL')
C
      READ(1,*),LAMNUM
      L1=LAMNUM/2
      T1=(LAMNUM/2.)-L1
C
      IF(T1.EQ.0.0.AND.LAMNUM.NE.2)THEN
      PRINT *,'MUST HAVE ODD NUMBER OF LAMINAE FOR PROGRAM
      &TO WORK - START OVER SLAMEEL!'
      CALL EXIT
      END IF
C
      READ(1,*),(NUMPTS(J),J=1,LAMNUM)
      READ(1,*),(DENLAM(J),J=1,LAMNUM)
      READ(1,*),(ELEV(J),J=1,LAMNUM)
      READ(1,*),XSIZE,YSIZE,COLS,ROWS
      DO I=1,LAMNUM
            READ(1,*),(X(J,I),Y(J,I),J=1,NUMPTS(I)+1)
      END DO
C
C... IF NUMB=1 READ IN ELEVATIONS
C
      IF(NUMB.EQ.1)THEN
C**********************************************************************
C
C...              STATION ELEVATION INPUT
C
C... READ IN FIRST RECORD
C
      READ(10)NCOLS,NROWS,IZERO
C
C... READ IN SECOND RECORD
C
      READ(10)IROWS,JCOLS,DIFY,DIFX,XMN,XMX,YMN,YMX,DUMMY
C
C... READ IN ELEVATIONS (METERS)
C
      DO I=NROWS,1,-1
      IBEG=(I-1)*NCOLS+1
```

```
      IEND=IBEG+NCOLS-1
      READ(10)(STAELV(J),J=IBEG,IEND)
      END DO
C
C*********************************************************************
C
      END IF
C
      XDELTA=XSIZE/(COLS-1)
      YDELTA=YSIZE/(ROWS-1)
      CHECK=0.0
      XPOS=0.0000E+00
      YPOS=0.0000E+00
C
      IF(NUMB.EQ.1)THEN
              DO J=1,LAMNUM
              DEPTH(J)=STAELV(1)-ELEV(J)
              IF(ABS(DEPTH(J)).LT.2.)DEPTH(J)=2.
              END DO
      END IF
C
      CALL TDCALC(XPOS,YPOS)
      DO I=1,COLS*ROWS-1
C
      IF(NUMB.EQ.1)THEN
              DO J=1,LAMNUM
              DEPTH(J)=STAELV(I+1)-ELEV(J)
              IF(ABS(DEPTH(J)).LT.2.)DEPTH(J)=2.
              END DO
      END IF
C
              NI=I/COLS
              XPOS=I*XDELTA-(NI*XSIZE+XDELTA*NI)
              IF ( ABS(XPOS).LE.1.0000E-01)XPOS=0.0000E+00
              YPOS=NI*YDELTA
              IF (XSIZE.GT.CHECK)THEN
                      CHECK=CHECK+XDELTA
                      DO J=1,LAMNUM
                              DO K=1,NUMPTS(J)+1
                                      X(K,J)=X(K,J)-XDELTA
                              END DO
                      END DO
              ELSE
                      CHECK=0.0
                      DO J=1,LAMNUM
                              DO K=1,NUMPTS(J)+1
                                      Y(K,J)=Y(K,J)-YDELTA
                                      X(K,J)=X(K,J)+XDELTA*(COLS-1)
                              END DO
                      END DO
              END IF
      CALL TDCALC(XPOS,YPOS)
      END DO
      CALL EXIT
      PRINT *,'OUTPUT IN FILE 3DGRVT.DAT!'
      END
C
      SUBROUTINE TDCALC(GRIDX,GRIDY)
```

```
C... SUBROUTINE 3DCALC CALCULATES THE GRAVITY ANOMALY
C... PER UNIT THICKNESS OF HORIZONTAL LAMINAE OF UNIT
C... THICKNESS(=V). TO GET THE TOTAL ANOMALY OF THE 3D BODY,
C... THE AREA UNDERNEATH THE RESULTING V-Z CURVE IS CALCULATED.
C... THIS PROGRAM IS BASED ON THE 1960 TALWANI AND EWING
C... PAPER FOUND IN GEOPHYSICS, VOLUME 25, 1960.
C
C... SET UP MEMORY
C
      COMMON NUMPTS(150),DENLAM(150),DEPTH(150),LAMNUM,
     &X(150,150),Y(150,150)
            REAL*8  R(100,100),R1(100,100),R2(100,100),XM(100,100),
     &                P(100,100),Q(100,100),F(100,100),GANOM(100),
     &             TEMP(100),TEMP1(100,100),TEMP2(100,100),V(100)
          REAL*8  A,B,C,C1,C2,C3,C4,C5,C6,C7,C8,C9,C10
C
C... OPEN FILE TO WRITE GRAVITY ANOMALY AND SURFACE OBSERVATION
C... POINTS INTO - IN FORMAT USABLE FOR SURFACEII AND DISSPLA
C... GRAPHICS. FILE CALLED 3DGRVT.DAT.
C
      OPEN(10,FILE='3DGRVT.DAT',STATUS='NEW')
C
C... UNIVERSAL GRAVITY CONSTANT IN CGS UNITS
C
      G0=0.0000000667
C
C... CALCULATE THE GRAVITY ANOMALY/UNIT THICKNESS FOR EACH LAMINAE
C
      DO J=1,LAMNUM
              TEMP2(1,J)=0.0
              IF(NUMPTS(J).EQ.1)GO TO 10
              M=2
              DO I=1,NUMPTS(J)
C
C... R,R1,R2 CANNOT EQUAL 0.0 (COMPUTER WILL NOT LIKE IT)
C
              R(I,J)=(X(I,J)**2. + Y(I,J)**2.)**0.5
              IF(R(I,J).EQ.0.0)R(I,J)=0.00000000005
              R1(I,J)=(X(I+1,J)**2. + Y(I+1,J)**2.)**0.5
              IF(R1(I,J).EQ.0.0)R1(I,J)=0.00000000005
              R2(I,J)=((X(I,J)-X(I+1,J))**2+(Y(I,J)
     &-Y(I+1,J))**2)**0.5
              IF(R2(I,J).EQ.0.0)R2(I,J)=0.00000000005
C
              C1=X(I,J)/R(I,J)
              C2=Y(I,J)/R(I,J)
              C3=X(I+1,J)/R1(I,J)
              C4=Y(I+1,J)/R1(I,J)
              C5=(X(I,J)-X(I+1,J))/R2(I,J)
              C6=(Y(I,J)-Y(I+1,J))/R2(I,J)
C
                 XM(I,J)=C2*C3-C4*C1
              P(I,J)=(C6*X(I,J))-(C5*Y(I,J))
C
              IF(P(I,J).GE.0.0)THEN
                      S=1.0
              ELSE
                      S=-1.0
```

```
            END IF
            IF(XM(I,J).GE.0.0)THEN
                    W=1.0
            ELSE
                    W=-1.0
            END IF
            C7=(P(I,J)*P(I,J)+DEPTH(J)*DEPTH(J))**0.5
C
            Q(I,J)=C5*C1+C6*C2
            F(I,J)=C5*C3+C6*C4
C
            C8=C1*C3+C2*C4
            C9=(DEPTH(J)*Q(I,J)*S)/C7
            C10=(DEPTH(J)*F(I,J)*S)/C7
C
C... PREVENT ROUNDOFF ERROR IN COMPUTER FROM GIVING NUMBER
C... G.T. 1.0 OR L.T.-1 -  COMPUTER WILL NOT LIKE THIS NUMBER (DEALING
C... WITH SINES AND COSINES)
C
            IF(C8-1.0.GT.0.0)C8=1.0
            IF(C9-1.0.GT.0.0)C9=1.0
            IF(C10-1.0.GT.0.0)C10=1.0
            IF(C8.LT.-1.0)C8=-1.0
            IF(C9.LT.-1.0)C9=-1.0
            IF(C10.LT.-1.0)C10=-1.0
C
            TEMP1(I,J)=W*ACOS(C8)-ASIN(C9)+ASIN(C10)
C
            TEMP2(M,J)=TEMP2(M-1,J)+TEMP1(I,J)
            M=M+1
            END DO
C
C... THE 100000 IS TO PUT V IN UNITS OF MGALS/METER
C
            V(J)=G0*DENLAM(J)*TEMP2(NUMPTS(J)+1,J)*100000.0
C
            GO TO 20
10             V(J)=0.0
20   END DO
C
C... FIND THE ANOMALY (AREA UNDER V-Z CURVE)
C
     IF(LAMNUM-1.GT.1)THEN
            I=1
            GANOM(1)=0.0
     DO J=2,((LAMNUM-1)/2)+1
C
```

```
      A=V(I)*((DEPTH(I)-DEPTH(I+2))/(DEPTH(I)-DEPTH(I+1)))
     &*(3.0*DEPTH(I+1)-DEPTH(I+2)-2.0*DEPTH(I))
C
      B=V(I+1)*((DEPTH(I)-DEPTH(I+2))**3)/((DEPTH(I+1)-
     &DEPTH(I+2))*(DEPTH(I+1)-DEPTH(I)))
C
      C=V(I+2)*((DEPTH(I)-DEPTH(I+2))/(DEPTH(I+2)-DEPTH(I+1)))
     &*(3.0*DEPTH(I+1)-DEPTH(I)-2.0*DEPTH(I+2))
C
      TEMP(J-1)=(A+B+C)/6.0
C
C...    HAVE TO DIVIDE BY 1000 BECAUSE MULTIPLIED V BY
C...    1000 EARLIER TO PREVENT ROUNDOFF ERROR
C
      TEMP(J-1)=TEMP(J-1)
C
            GANOM(J)=GANOM(J-1)+TEMP(J-1)
            I=I+2
      END DO
C
      ELSE
C
C... TRAPEZOIDAL RULE FOR ONE AREA
C
      GANOM(((LAMNUM-1)/2)+1)=(DEPTH(2)-DEPTH(1))*0.5*(V(1)+V(2))
      END IF
C
C... PRINT THE 3D ANOMALY TO FILE 3DGRVT.DAT
C
      WRITE(10,'(E12.4,2X,E12.4,2X,E12.4)')GRIDX,GRIDY,
     &GANOM(((LAMNUM-1)/2)+1)
      RETURN
      END


$
```

APPENDIX C

PREPARING OBSERVED GRAVITY DATA FOR USE WITH PROGRAMS GRAVBL AND GINDEP

Preparing Observed Gravity Data

1)Saving gridded data on a file:

Once an observed data set has been gridded using SURFACE II, grid information may be stored in a file of the form FORO__.dat (where __ represents a number from 11 to 99) using the SAVE command of the SURFACE II contouring package. The following is an example of a SURFACE II program used to grid and save the observed gravity data for my modeling area in file FOR015.DAT:

```
TITLE  SAVING GRID INFORMATION IN FILE FOR015.DAT
DEVICE 5,'CJWIDEMAN'
ROUTLINE 39,1,'(2F12.7)'
EXTREMES -111.74222,-111.68778,45.36077,45.37962
IDXY 158,11,3,2,1,3,0,0,0,9999,'(3F12.4)'
BOX .01,2,.005,1,3,-111.74222,45.36077,1,.2
GRID 0,15,8,0,0,1,0
SAVE 15
PERFORM
STOP
```

File FOR015.DAT will have a specific format (see SAVE command in the SURFII manual) and GRAVBL and GINDEP were written to read in a data grid based on the format of a saved SURFII file.

2) Changing units from latitude, longitude to meters north, east:

If the saved SURFII file has grid points locations based on units of latitude and longitude, the units must be converted to meters east and meters north before GINDEP and GRAVBL can be used. Also, the first point in the grid [(0,0) in units of meters] must be located in the upper left hand corner of the grid because of the way GRAVBL and

GINDEP expect to receive the data. I have written a program to read the saved SURFII file, output pertinent grid information, and to convert latitude and longitude to meters east and meters north based on the scale of the Ennis 15 minute quadrangle map. This program will write the data to a file called GRID.DAT in the following order:

xpos on grid, ypos on grid, data value

in 3F12.4 format. GRID.DAT will contain the number of columns (NCOLS) times the number of rows (NROWS) lines of data. Code for the program is as follows:

```
      DIMENSION A(10000), DUMMY(12), VAR(4)
      CHARACTER TOPOFILE*20,BLOCKFILE*20,OUTPUTFILE*20,CHAR*1
C
      WRITE(*,'(''$TYPE IN SAVED SURFII FILE>'')')
      READ(*,'(A20)')TOPOFILE
      OPEN(21,FILE=TOPOFILE,ACCESS='SEQUENTIAL',STATUS='OLD',
     &FORM='UNFORMATTED')
C
C     READ IN FIRST RECORD OF THE SAVED SURFII FILE
C
      READ(21)NCOLS,NROWS,IZERO
      PRINT *,'       '
C
C     READ IN SECOND RECORD
C
      READ(21)IROWS,JCOLS,DIFX,DIFY,XMIN,XMAX,YMIN,YMAX,DUMMY
C
C     CONVERT TO METERS
C
      WRITE(*,'(''$CONVERT TO METERS(Y/N)>'')')
      READ(*,'(A1)')CHAR
C
      IF(CHAR.EQ.'Y'.OR.CHAR.EQ.'y')THEN
      DIFY=DIFY*111840.
      DIFX=DIFX*79040.
      XSIZE=ABS((XMAX-XMIN)*79040)
      YSIZE=ABS(((YMAX-YMIN)*111840)
      XDELTA=DIFX
      YDELTA=DIFY
      ELSE
      XSIZE=ABS(XMAX-XMIN)
      YSIZE=ABS(YMAX-YMIN)
      IF(DIFY.LT.0.0)THEN
      YDELTA=-DIFY
```

```
      ELSE
      YDELTA=DIFY
      END IF
      END IF
C
      PRINT *,'-----------------------------------------'
      PRINT *,'          '
      PRINT *,'              MATRIX INFO'
      PRINT *,'          '
      PRINT *,'NCOLS,NROWS',NCOLS,NROWS
C
      PRINT *,'        '
      PRINT *,'DIFY(METERS)='',DIFY,
     &DIFX(METERS),DIFX
      PRINT *,'XMIN=',XMIN,'    XMAX=',XMAX
      PRINT *,'YMIN=',YMIN,'    YMAX=',YMAX
C
      PRINT *,'XSIZE(M)=',XSIZE,
     &'       YSIZE(M)=',YSIZE
      PRINT *,'-----------------------------------------'
C
C
C     NOW READ IN THE GRID MATRIX VALUES
C
      DO I=NROWS,1,-1
      IBEG=(I-1)*NCOLS+1
      IEND=IBEG+NCOLS-1
      READ(21)(A(J),J=IBEG,IEND)
      END DO
      DO I=1,NROWS*NCOLS
      IF(A(I).LE.-9.9999E+33)A(I)=0.0
      END DO
C
C     PRINT GRID VAULES TO FILE GRID.DAT
C
      WRITE(*,'(''$PRINT GRID VALUES IN FILE
&GRID.DAT(Y/N)>'')')
      READ(*,'(A1)')CHAR
      IF(CHAR.EQ.'N')CALL EXIT
      OPEN(10,FILE='GRID.DAT,STATUS='NEW')
      XPOS=0.0
      YPOS=0.0
      WRITE(10,'(3F12.4)')XPOS,YPOS,A(1)
      DO I=1,NCOLS*NROWS-1
           NI=I/NCOLS
           XPOS=I*XDELTA-(NI*XSIZE+XDELTA*NI)
           IF(ABS(XPOS).LE..1)XPOS=0.0
           YPOS=NI*YDELTA
           WRITE(10,'(3F12.4)')XPOS,YPOS,A(I+1)
      END DO
      CLOSE(10)
      CLOSE(21)
      CALL EXIT
      END
```

Example of using RSURFILE:

Say you have used SURFII to create a grid of four columns and three rows where the distance between columns is 25 meters and the distance between rows is 30 meters (the data was collected in units of meters east and north), and this grid information is saved in file FOR019.dat. If RSURFILE is used to read FOR019.dat and output the grid values in file GRID.DAT, these are the input steps and output displayed when RSURFILE is run:

```
RUN RSURFILE
TYPE IN SAVED SURFII FILE>FOR019.DAT
CONVERT TO METERS(Y/N)>N

-------------------------------------------------
                  MATRIX INFO

     NCOLS, NROWS  4,3

     DIFY(METERS)=30          DIFX(METERS)=25
     XMIN=0.0                 XMAX=75.0
     YMIN=0.0                 YMAX=60.0

     XSIZE=75.0               YSIZE=60.0
-------------------------------------------------

     PRINT GRID VALUES IN FILE GRID.DAT(Y/N)>Y
```

Now file GRID.DAT has been created where the grid points are numbered as follows:

```
     •1     •2     •3     •4

     •5     •6     •7     •8

     •9     •10    •11    •12
```

And the output contained in GRID.DAT will be:

0.0000	0.0000	GRID VALUE 1 (mgals) top left of grid
25.0000	0.0000	GRID VALUE 2
50.0000	0.0000	.
75.0000	0.0000	.
0.0000	30.0000	.
25.0000	30.0000	.
50.0000	30.0000	.
75.0000	30.0000	.
0.0000	60.0000	.
25.0000	60.0000	.
50.0000	60.0000	.
75.0000	60.0000	GRID VALUE 12 bottom right of grid

4) Removal of Topography

Program 3D (coding is in Appendix B) is based on Talwani and Ewing's (1960) method of describing 3-D bodies with horizontal, n-sided polygons. Because n-sided polygons accurately describe elevation contours, program 3D was used to model the topography in the survey area. In general, topography from the highest elevation in the modeled area to the lowest station elevation should be included in the topography model. A model may be created by digitizing points of contours taken from a topographic map in the survey area. Enough points on each contour and enough contours should be chosen so that the topography is described reasonably. Input to program 3D is read from a command file called 3DGRV.DAT, and the input must be ordered as follows:

Line	Input
1	1 if the station elevations are to be read from a saved SURFII grid file any other integer if the stations are assummed to be collected on a plane.
2	Saved SURFII file of elevations (i.e. FOR032.DAT).

3 Number of laminae (horizontal polygons) used in the model. For example, if five elevation contours are digitized, then 5 would be input on this line.

4 Number of verticies in each laminae of the model separated by a comma. For example, if three laminae were used in the model where:

top laminae: 5 verticies,
middle laminae: 16 verticies, and
bottom laminae: 8 verticies,

then input here would be: 5,16,8

5 Density of each laminae (gm/cm^3) separated by a comma.

6 Elevation (meters above sea level) of each laminae separated by a comma.

7 X-size of grid(m), Y-size of grid(m), number of columns in grid, number of rows in grid. These numbers should match the grid parameters used for programs GINDEP and GRAVBL.

8 - EOF X,Y location in meters of each piont on each laminae entered in clockwise order. The starting point must be repeated as the final point so that the laminae is closed. For example, consider a model with three laminae:

top laminae- 5 verticies: (0,0),(100,200), (200,300),(100,20), and (-50,20)

middle laminae- 3 verticies: (-100,20), (100,20), and (50,-20)

bottom laminae- 3 verticies: (-40,60), (50,10), and (-10,-10).

Then input would be ordered as follows:

Line	Input
8	0.0,0.0
9	100.0,200.0
10	200.0,300.0
11	100.0,20.0
12	-50.0,20.0
13	0.0,0.0
14	-100.0,20.
15	100.0,20.0
16	50.,-20.

17	-100.0,20.0
18	-40.0,60.0
19	50.0,10.0
20	-10.0,-10.0
21	-40.,60.

Note: Those repeat points used to close the laminae are not counted as extra points for the input of line #4. For the model above the input for line #4 would be 5,3,3.

Output of program 3D is written to a file named 3DGRVT.DAT which will contain (NCOLS x NROWS) lines of data (NCOLS = number of columns in the grid, NROWS = number of rows in the grid), and each line will contain the X-position on the grid, the Y-position on the grid, and the gravity value of the grid point (in mgals). This information is written in 3F12.4 format, and the first data point output is the one located in the upper left hand corner of the grid. The data in contained in file 3DGRVT.DAT can best be explained using an example. Say you create a grid of data with 4 columns and three rows with the distance between columns = 30 meters and the distance between rows = 25 meters. Assume the values of the 12 grid points in this grid are as follows:

Grid point	Grid value(mgals)
1	12
2	15
3	16
4	20
5	7
6	9
7	12
8	17
9	5
10	7
11	10
12	15

The output in file 3DGRVT.DAT for this example would be:

0.0000	0.0000	12.0000	(upper left corner of grid)
30.0000	0.0000	15.0000	
60.0000	0.0000	16.0000	
90.0000	0.0000	20.0000	
0.0000	25.0000	7.0000	
30.0000	25.0000	9.0000	
60.0000	25.0000	12.0000	
90.0000	25.0000	17.0000	
0.0000	50.0000	5.0000	
30.0000	50.0000	7.0000	
60.0000	50.0000	10.0000	
90.0000	50.0000	15.0000	(bottom right corner of grid)

The gravity contributions of the topography to each grid point should be removed from the gridded observed gravity set contained in file GRID.DAT output from program RSURFILE.

4) Removing a DC (constant) gravity value from the data

If the observed gravity data is tied into a gravity "net" consisting of base stations where actual gravity values are known, a constant must be removed from the each gridded gravity value so that the gravity values generated by the modeling program will match the observed gravity values. For example, the gravity data that I collected is tied to base stations at Helena and Three Forks at which actual values of gravity are known. Therefore, the gravity values in my data set represent actual gravity values which range from -(980)178 mgals to -(980)198 mgals (the 980 mgals is constant for all the stations and is not recorded in my data set). However, the gravity modeling program duplicates the relative changes in the gravity data (a maximum of 20 milligals in my data area) not the actual gravity

values. Consequently, I removed a constant value of -178 mgals from each of the gridded observed data values before using the modeling programs because these programs should generate numbers in a range from 0-20 milligals to match my data set.

Summary

In summary, the following four steps should be used to prepare the data used in the gravity modeling programs:

1) Grid the gravity and elevation data with SURFII and save the gridded data using the SAVE command of SURFII;
2) Run RSURFILE for both the gridded gravity and elevation data. RSURFILE will convert station locations in units of latitude and longitude to meters east and meters north, display grid information, and write grid locations and values to file GRID.DAT in 3F12.4 format;
3) Run 3D to remove the topograghy from the highest elevation in the modeled area to the lowest station elevation; and
4) Remove a constant value from each of the gravity stations so that the gravity values represent the range of gravity values across the survey area.

APPENDIX D

OBSERVED GRAVITY DATA AND CHANGES IN THE OBSERVED GRAVITY DATA RESULTING FROM THE STEPS USED TO PREPARE THE OBSERVED GRAVITY DATA FOR PROGRAMS GINDEP AND GRAVBL

A

LATITUDES, LONGITUDES, OBSERVED GRAVITY DATA, TERRAIN CORRECTIONS, AND ELEVATIONS OF THE GRAVITY STATIONS USED IN MY GRAVITY MODELING AREA:

LATITUDES AND LONGITUDES	- DEGREES
GRAVITY DATA	- MILLIGALS
TERRAIN CORRECTIONS	- MILLIGALS
ELEVATIONS	- METERS

45.36415863 , -111.71366119 , -190.32000000 , 1.42 , 1493.
45.36415863 , -111.71582794 , -189.55000000 , 1.39 , 1494.
45.36066055 , -111.71665955 , -190.14000000 , 1.38 , 1496.
45.36415863 , -111.71798706 , -188.60000000 , 1.39 , 1494.
45.36066055 , -111.71883392 , -189.71000000 , 1.38 , 1496.
45.36415863 , -111.72016907 , -187.22000000 , 1.40 , 1495.
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45.36415863 , -111.72698975 , -185.02000000 , 1.45 , 1493.
45.36066055 , -111.72783661 , -186.48000000 , 1.43 , 1497.
45.36666107 , -111.72783661 , -184.32000000 , 1.40 , 1501.
45.36066055 , -111.72998047 , -185.24000000 , 1.45 , 1497.
45.36832809 , -111.73065948 , -183.64000000 , 1.38 , 1501.
45.36415863 , -111.73116302 , -183.82000000 , 1.39 , 1502.
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45.36233139 , -111.73149109 , -182.94000000 , 1.38 , 1504.
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45.36415863 , -111.73999023 , -178.58000000 , 1.55 , 1502.
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45.36415863 , -111.74233246 , -178.20000000 , 1.65 , 1502.
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45.36970000 , -111.72800000 , -184.37000000 , 1.38 , 1500.30
45.36970000 , -111.72650000 , -184.75000000 , 1.36 , 1500.30
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45.37040000 , -111.71930000 , -188.02000000 , 1.44 , 1483.53
45.37090000 , -111.71950000 , -188.29000000 , 1.44 , 1489.32
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45.37140000 , -111.72100000 , -187.67000000 , 1.46 , 1488.72
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45.37140000 , -111.72720000 , -185.73000000 , 1.39 , 1497.56
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45.37140000 , -111.73050000 , -184.56000000 , 1.42 , 1498.17
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45.37060000 , -111.72630000 , -185.09000000 , 1.37 , 1498.47
45.37120000 , -111.72650000 , -185.59000000 , 1.37 , 1498.47

45.37020000 , -111.72800000 , -184.76000000 , 1.39 , 1499.08
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45.37000000 , -111.73170000 , -183.55000000 , 1.39 , 1500.00
45.37000000 , -111.73320000 , -183.15000000 , 1.45 , 1500.00
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45.36980000 , -111.73880000 , -181.00000000 , 1.56 , 1499.69
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45.36980000 , -111.74170000 , -179.75000000 , 1.71 , 1498.78
45.36980000 , -111.74300000 , -179.55000000 , 1.69 , 1499.39
45.36980000 , -111.74450000 , -179.31000000 , 1.77 , 1500.91
45.37020000 , -111.73320000 , -183.31000000 , 1.45 , 1499.39
45.37070000 , -111.73300000 , -183.31000000 , 1.44 , 1498.78
45.37120000 , -111.73300000 , -183.47000000 , 1.45 , 1497.25
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45.37430000 , -111.73450000 , -186.07000000 , 1.52 , 1494.20
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45.37270000 , -111.73950000 , -183.50000000 , 1.62 , 1496.34
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45.37270000 , -111.73550000 , -184.06000000 , 1.53 , 1496.03
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45.37820107 , -111.72900000 , -187.46000000 , 1.46 , 1492.38
45.37820107 , -111.72750000 , -187.87000000 , 1.45 , 1491.77
45.37820000 , -111.73010000 , -187.21 , 1.48 , 1491.92
45.37820000 , -111.72880000 , -187.16 , 1.48 , 1492.02
45.37820000 , -111.72740000 , -187.39 , 1.47 , 1491.97
45.37820000 , -111.72610000 , -188.69 , 1.47 , 1484.85
45.37820000 , -111.72470000 , -188.42 , 1.46 , 1484.85
45.37820000 , -111.72340000 , -188.79 , 1.46 , 1484.80
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45.37820000 , -111.72060000 , -189.69 , 1.45 , 1484.34
45.37820000 , -111.71930000 , -190.09 , 1.44 , 1484.55
45.37820000 , -111.71790000 , -190.45 , 1.44 , 1484.50
45.37820000 , -111.71660000 , -190.84 , 1.43 , 1484.50
45.37820000 , -111.71530000 , -191.36 , 1.43 , 1484.50
45.37820000 , -111.71390000 , -191.79 , 1.42 , 1484.14
45.37820000 , -111.71260000 , -192.21 , 1.42 , 1484.04
45.37820000 , -111.71120000 , -192.69 , 1.41 , 1483.63
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45.37630000 , -111.70990000 , -192.83 , 1.40 , 1484.50
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45.37630000 , -111.71260000 , -191.94 , 1.40 , 1485.16
45.37630000 , -111.71390000 , -191.59 , 1.40 , 1485.31
45.37630000 , -111.71530000 , -191.13 , 1.40 , 1485.36
45.37630000 , -111.71660000 , -190.72 , 1.41 , 1485.77

45.37630000 , -111.71790000 , -190.69 , 1.42 , 1485.31
45.37630000 , -111.71930000 , -189.91 , 1.42 , 1485.41
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45.37630000 , -111.72200000 , -189.08 , 1.43 , 1486.07
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45.37630000 , -111.72470000 , -188.40 , 1.44 , 1486.07
45.37630000 , -111.72610000 , -188.18 , 1.45 , 1492.07
45.37630000 , -111.72740000 , -187.13 , 1.45 , 1491.62
45.37630000 , -111.72880000 , -187.71 , 1.46 , 1491.62
45.37630000 , -111.73010000 , -187.13 , 1.47 , 1492.22
45.3782 , -111.7311 , -186.65 , 1.48 , 1492.59
45.3792 , -111.6832 , -196.22 , 1.57 , 1493.32
45.3808 , -111.6832 , -195.80 , 1.58 , 1494.01
45.3825 , -111.6831 , -195.44 , 1.59 , 1496.33
45.3826 , -111.6857 , -194.52 , 1.57 , 1497.99
45.3826 , -111.6882 , -193.82 , 1.55 , 1499.76
45.3827 , -111.6908 , -192.95 , 1.51 , 1500.52
45.3824 , -111.6935 , -192.54 , 1.47 , 1499.97
45.3807 , -111.6943 , -193.01 , 1.46 , 1499.15
45.3790 , -111.6944 , -193.19 , 1.46 , 1498.57
45.3772 , -111.6943 , -193.51 , 1.45 , 1497.67
45.3754 , -111.6943 , -193.95 , 1.44 , 1497.06
45.3750 , -111.6922 , -194.14 , 1.46 , 1495.63
45.3749 , -111.6897 , -194.65 , 1.50 , 1494.86
45.3766 , -111.6863 , -195.06 , 1.55 , 1494.69
45.3784 , -111.6863 , -195.16 , 1.55 , 1494.37
45.3676 , -111.6942 , -196.55 , 1.38 , 1491.88
45.3676 , -111.6979 , -195.90 , 1.35 , 1492.41
45.3676 , -111.7013 , -195.22 , 1.30 , 1491.57
45.3641 , -111.7027 , -194.95 , 1.27 , 1494.54
45.3606 , -111.7033 , -195.12 , 1.24 , 1497.16
45.3569 , -111.7038 , -195.51 , 1.26 , 1499.41
45.3533 , -111.7046 , -196.06 , 1.30 , 1501.54
45.3494 , -111.7046 , -196.36 , 1.33 , 1503.35
45.3493 , -111.6992 , -198.66 , 1.37 , 1504.95
45.3494 , -111.6944 , -200.06 , 1.44 , 1505.55
45.3491 , -111.6887 , -201.80 , 1.50 , 1505.00
45.3532 , -111.6887 , -200.98 , 1.50 , 1501.62
45.3568 , -111.6884 , -199.00 , 1.50 , 1498.06
45.3604 , -111.6888 , -198.34 , 1.46 , 1495.67
45.3639 , -111.6890 , -197.65 , 1.46 , 1493.89
45.3644 , -111.6936 , -196.93 , 1.40 , 1493.66

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B

THE GRIDDED OBSERVED GRAVITY DATA (GRIDDING DONE USING THE SURFII GRAPHICS PACKAGE), THE DATA LOCATIONS ARE IN METERS NORTH AND EAST (PROGRAM RSURFILE HAS BEEN USED) AND A CONSTANT OF -178.0 MGALS HAS BEEN REMOVED FROM THE GRIDDED DATA.

0.0000	0.0000	-6.2456
307.3571	0.0000	-7.0016
614.7143	0.0000	-8.6886
922.0715	0.0000	-8.9612
1229.4286	0.0000	-10.0066
1536.7858	0.0000	-11.0436
1844.1429	0.0000	-12.1878
2151.5000	0.0000	-13.4277
2458.8572	0.0000	-14.6772
2766.2144	0.0000	-14.8803
3073.5715	0.0000	-14.9301
3380.9287	0.0000	-15.2296
3688.2859	0.0000	-15.1491
3995.6428	0.0000	-15.0607
4303.0000	0.0000	-16.9155
0.0000	301.1429	-5.8193
307.3574	301.1429	-6.9799
614.7144	301.1429	-7.9930
922.0718	301.1429	-9.0803
1229.4287	301.1429	-9.8372
1536.7861	301.1429	-10.9372
1844.1431	301.1429	-12.0887
2151.5005	301.1429	-13.2235
2458.8574	301.1429	-14.4745
2766.2148	301.1429	-14.8325
3073.5718	301.1429	-14.8991
3380.9287	301.1429	-15.5044
3688.2856	301.1429	-15.5643
3995.6431	301.1429	-16.0091
4303.0005	301.1429	-17.0441
0.0000	602.2857	-5.3093
307.3574	602.2857	-6.8343
614.7148	602.2857	-8.0680
922.0723	602.2857	-8.5218
1229.4287	602.2857	-9.4780
1536.7861	602.2857	-10.5596
1844.1436	602.2857	-11.9487
2151.5010	602.2857	-13.2372
2458.8574	602.2857	-14.3983
2766.2148	602.2857	-14.7083
3073.5723	602.2857	-15.7718
3380.9287	602.2857	-16.0971
3688.2861	602.2857	-15.9077
3995.6436	602.2857	-16.1846
4303.0010	602.2857	-16.7656
0.0000	903.4286	-3.2598
307.3574	903.4286	-5.2534
614.7148	903.4286	-6.1512
922.0723	903.4286	-6.5455
1229.4287	903.4286	-7.6686
1536.7861	903.4286	-8.9017
1844.1436	903.4286	-10.2781
2151.5000	903.4286	-10.8911
2458.8574	903.4286	-14.2811
2766.2139	903.4286	-14.8713
3073.5713	903.4286	-17.1438
3380.9287	903.4286	-17.4496
3688.2861	903.4286	-17.0677

3995.6436	903.4286	-16.5722
4303.0010	903.4286	-16.7407
0.0000	1204.5714	-1.7076
307.3574	1204.5714	-3.2491
614.7148	1204.5714	-4.6244
922.0723	1204.5714	-5.7017
1229.4297	1204.5714	-6.5639
1536.7871	1204.5714	-8.9084
1844.1445	1204.5714	-9.8071
2151.5020	1204.5714	-10.5374
2458.8574	1204.5714	-12.5361
2766.2148	1204.5714	-16.4002
3073.5723	1204.5714	-17.2346
3380.9297	1204.5714	-17.6338
3688.2871	1204.5714	-18.3562
3995.6445	1204.5714	-18.4422
4303.0020	1204.5714	-18.5923
0.0000	1505.7142	-0.3980
307.3574	1505.7142	-1.3524
614.7148	1505.7142	-3.4130
922.0723	1505.7142	-5.7634
1229.4297	1505.7142	-6.4776
1536.7871	1505.7142	-8.2832
1844.1445	1505.7142	-10.0138
2151.5000	1505.7142	-11.7385
2458.8574	1505.7142	-12.1449
2766.2148	1505.7142	-16.2952
3073.5723	1505.7142	-17.0943
3380.9297	1505.7142	-17.5983
3688.2871	1505.7142	-18.4901
3995.6445	1505.7142	-18.9499
4303.0000	1505.7142	-19.5983
0.0000	1806.8572	-0.2381
307.3574	1806.8572	-1.2580
614.7148	1806.8572	-3.3230
922.0723	1806.8572	-5.6154
1229.4297	1806.8572	-7.0894
1536.7871	1806.8572	-8.3272
1844.1445	1806.8572	-10.2566
2151.5000	1806.8572	-11.7504
2458.8574	1806.8572	-12.2137
2766.2148	1806.8572	-16.4700
3073.5723	1806.8572	-16.9687
3380.9297	1806.8572	-17.3787
3688.2871	1806.8572	-18.8211
3995.6445	1806.8572	-19.2724
4303.0000	1806.8572	-19.7176
0.0000	2108.0000	-1.0497
307.3574	2108.0000	-1.3476
614.7148	2108.0000	-3.4017
922.0703	2108.0000	-6.6133
1229.4297	2108.0000	-9.1166
1536.7852	2108.0000	-10.2946
1844.1445	2108.0000	-11.7094
2151.5000	2108.0000	-11.9822
2458.8594	2108.0000	-12.2989
2766.2148	2108.0000	-16.9908
3073.5703	2108.0000	-17.1202

```
  3380.9297   2108.0000    -17.2363
  3688.2852   2108.0000    -18.9562
  3995.6445   2108.0000    -19.9944
  4303.0000   2108.0000    -20.3214
$
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C

GRAVITY CONTRIBUTION FROM TOPOGRAPHY

(OUTPUT OF PROGRAM 3D) - TOPOGRAPHY

WAS REMOVED DOWN TO AN ELEVATION OF

1475 METERS ABOVE SEA LEVEL

0.0000	0.0000	-0.3499
307.4000	0.0000	-0.3549
614.7000	0.0000	-0.3558
922.1000	0.0000	-0.4243
1229.0000	0.0000	-0.0796
1537.0000	0.0000	-0.0776
1844.0000	0.0000	-0.0779
2152.0000	0.0000	-0.0780
2459.0000	0.0000	-0.0779
2766.0000	0.0000	-0.0778
3074.0000	0.0000	0.0103
3381.0000	0.0000	-0.0903
3688.0000	0.0000	-0.0904
3996.0000	0.0000	-0.0951
4303.0000	0.0000	-0.4204
0.0000	301.1000	-0.3544
307.4000	301.1000	-0.3567
614.7000	301.1000	-0.4269
922.1000	301.1000	-0.4243
1229.0000	301.1000	-0.0823
1537.0000	301.1000	-0.0137
1844.0000	301.1000	0.0033
2152.0000	301.1000	0.0047
2459.0000	301.1000	-0.0779
2766.0000	301.1000	-0.0776
3074.0000	301.1000	-0.0775
3381.0000	301.1000	-0.0805
3688.0000	301.1000	-0.0808
3996.0000	301.1000	-0.0838
4303.0000	301.1000	-0.4200
0.0000	602.3000	-0.3566
307.4000	602.3000	-0.3528
614.7000	602.3000	-0.4265
922.1000	602.3000	-0.4258
1229.0000	602.3000	-0.4230
1537.0000	602.3000	-0.0313
1844.0000	602.3000	-0.0161
2152.0000	602.3000	-0.0011
2459.0000	602.3000	-0.0777
2766.0000	602.3000	-0.0773
3074.0000	602.3000	-0.0509
3381.0000	602.3000	-0.0829
3688.0000	602.3000	-0.0835
3996.0000	602.3000	-0.0845
4303.0000	602.3000	-0.4190
0.0000	903.4000	-0.3787
307.4000	903.4000	-0.4265
614.7000	903.4000	-0.4266
922.1000	903.4000	-0.3888
1229.0000	903.4000	-0.4252
1537.0000	903.4000	-0.4170
1844.0000	903.4000	-0.4232
2152.0000	903.4000	-0.0562
2459.0000	903.4000	-0.0769
2766.0000	903.4000	0.0059
3074.0000	903.4000	-0.4219
3381.0000	903.4000	-0.4211
3688.0000	903.4000	-0.4189

3996.0000	903.4000	-0.4183
4303.0000	903.4000	-0.4215
0.0000	1205.0000	-0.3798
307.4000	1205.0000	-0.3788
614.7000	1205.0000	-0.3794
922.1000	1205.0000	-0.3749
1229.0000	1205.0000	-0.4024
1537.0000	1205.0000	-0.4276
1844.0000	1205.0000	-0.4275
2152.0000	1205.0000	-0.4269
2459.0000	1205.0000	-0.2005
2766.0000	1205.0000	-0.1036
3074.0000	1205.0000	-0.4253
3381.0000	1205.0000	-0.4254
3688.0000	1205.0000	-0.4249
3996.0000	1205.0000	-0.4239
4303.0000	1205.0000	-0.4223
0.0000	1506.0000	-0.3617
307.4000	1506.0000	-0.3615
614.7000	1506.0000	-0.3609
922.1000	1506.0000	-0.3675
1229.0000	1506.0000	-0.3983
1537.0000	1506.0000	-0.4274
1844.0000	1506.0000	-0.4270
2152.0000	1506.0000	-0.4251
2459.0000	1506.0000	-0.0875
2766.0000	1506.0000	-0.4163
3074.0000	1506.0000	-0.4256
3381.0000	1506.0000	-0.4258
3688.0000	1506.0000	-0.4250
3996.0000	1506.0000	-0.4238
4303.0000	1506.0000	-0.4218
0.0000	1807.0000	-0.3610
307.4000	1807.0000	-0.3603
614.7000	1807.0000	-0.3602
922.1000	1807.0000	-0.4262
1229.0000	1807.0000	-0.4281
1537.0000	1807.0000	-0.4277
1844.0000	1807.0000	-0.4272
2152.0000	1807.0000	-0.4263
2459.0000	1807.0000	-0.4235
2766.0000	1807.0000	-0.4248
3074.0000	1807.0000	-0.4259
3381.0000	1807.0000	-0.4257
3688.0000	1807.0000	-0.4249
3996.0000	1807.0000	-0.4235
4303.0000	1807.0000	-0.4212
0.0000	2108.0000	-0.3615
307.4000	2108.0000	-0.3603
614.7000	2108.0000	-0.4124
922.1000	2108.0000	-0.3974
1229.0000	2108.0000	-0.4276
1537.0000	2108.0000	-0.4276
1844.0000	2108.0000	-0.4272
2152.0000	2108.0000	-0.4269
2459.0000	2108.0000	-0.4268
2766.0000	2108.0000	-0.4261
3074.0000	2108.0000	-0.4259

3381.0000	2108.0000	-0.4254
3688.0000	2108.0000	-0.4247
3996.0000	2108.0000	-0.4231
4303.0000	2108.0000	-0.4204

$

D

THE GRIDDED OBSERVED GRAVITY DATA OF PART B WITH THE TOPOGRAPHY CORRECTION VALUES OF PART C REMOVED - THIS DATA IS THE DATA USED AS THE GRIDDED OBSERVED GRAVITY DATA FOR PROGRAMS GRAVBL AND GINDEP

0.0000	0.0000	-5.8957
307.4000	0.0000	-6.6467
614.7000	0.0000	-8.3328
922.1000	0.0000	-8.5369
1229.0000	0.0000	-9.9270
1537.0000	0.0000	-10.9660
1844.0000	0.0000	-12.1099
2152.0000	0.0000	-13.3497
2459.0000	0.0000	-14.5993
2766.0000	0.0000	-14.8025
3074.0000	0.0000	-14.9404
3381.0000	0.0000	-15.1393
3688.0000	0.0000	-15.0587
3996.0000	0.0000	-14.9656
4303.0000	0.0000	-16.4951
0.0000	301.1000	-5.4649
307.4000	301.1000	-6.6232
614.7000	301.1000	-7.5661
922.1000	301.1000	-8.6560
1229.0000	301.1000	-9.7549
1537.0000	301.1000	-10.9235
1844.0000	301.1000	-12.0920
2152.0000	301.1000	-13.2282
2459.0000	301.1000	-14.3966
2766.0000	301.1000	-14.7549
3074.0000	301.1000	-14.8216
3381.0000	301.1000	-15.4239
3688.0000	301.1000	-15.4835
3996.0000	301.1000	-15.9253
4303.0000	301.1000	-16.6241
0.0000	602.3000	-4.9527
307.4000	602.3000	-6.4815
614.7000	602.3000	-7.6415
922.1000	602.3000	-8.0960
1229.0000	602.3000	-9.0550
1537.0000	602.3000	-10.5283
1844.0000	602.3000	-11.9326
2152.0000	602.3000	-13.2361
2459.0000	602.3000	-14.3206
2766.0000	602.3000	-14.6310
3074.0000	602.3000	-15.7209
3381.0000	602.3000	-16.0142
3688.0000	602.3000	-15.8242
3996.0000	602.3000	-16.1001
4303.0000	602.3000	-16.3466
0.0000	903.4000	-2.8811
307.4000	903.4000	-4.8269
614.7000	903.4000	-5.7246
922.1000	903.4000	-6.1567
1229.0000	903.4000	-7.2434
1537.0000	903.4000	-8.4847
1844.0000	903.4000	-9.8549
2152.0000	903.4000	-10.8349
2459.0000	903.4000	-14.2042
2766.0000	903.4000	-14.8772
3074.0000	903.4000	-16.7219
3381.0000	903.4000	-17.0285
3688.0000	903.4000	-16.6488

3996.0000	903.4000	-16.1539
4303.0000	903.4000	-16.3192
0.0000	1205.0000	-1.3278
307.4000	1205.0000	-2.8703
614.7000	1205.0000	-4.2450
922.1000	1205.0000	-5.3268
1229.0000	1205.0000	-6.1615
1537.0000	1205.0000	-8.4808
1844.0000	1205.0000	-9.3796
2152.0000	1205.0000	-10.1106
2459.0000	1205.0000	-12.3356
2766.0000	1205.0000	-16.2966
3074.0000	1205.0000	-16.8093
3381.0000	1205.0000	-17.2084
3688.0000	1205.0000	-17.9313
3996.0000	1205.0000	-18.0183
4303.0000	1205.0000	-18.1700
0.0000	1506.0000	-0.0363
307.4000	1506.0000	-0.9909
614.7000	1506.0000	-3.0521
922.1000	1506.0000	-5.3959
1229.0000	1506.0000	-6.0793
1537.0000	1506.0000	-7.8558
1844.0000	1506.0000	-9.5868
2152.0000	1506.0000	-11.3134
2459.0000	1506.0000	-12.0574
2766.0000	1506.0000	-15.8789
3074.0000	1506.0000	-16.6687
3381.0000	1506.0000	-17.1725
3688.0000	1506.0000	-18.0651
3996.0000	1506.0000	-18.5261
4303.0000	1506.0000	-19.1765
0.0000	1807.0000	0.1229
307.4000	1807.0000	-0.8977
614.7000	1807.0000	-2.9628
922.1000	1807.0000	-5.1892
1229.0000	1807.0000	-6.6613
1537.0000	1807.0000	-7.8995
1844.0000	1807.0000	-9.8294
2152.0000	1807.0000	-11.3241
2459.0000	1807.0000	-11.7902
2766.0000	1807.0000	-16.0452
3074.0000	1807.0000	-16.5428
3381.0000	1807.0000	-16.9530
3688.0000	1807.0000	-18.3962
3996.0000	1807.0000	-18.8489
4303.0000	1807.0000	-19.2964
0.0000	2108.0000	-0.6882
307.4000	2108.0000	-0.9873
614.7000	2108.0000	-2.9893
922.1000	2108.0000	-6.2159
1229.0000	2108.0000	-8.6890
1537.0000	2108.0000	-9.8670
1844.0000	2108.0000	-11.2822
2152.0000	2108.0000	-11.5553
2459.0000	2108.0000	-11.8721
2766.0000	2108.0000	-16.5647
3074.0000	2108.0000	-16.6943

```
   3381.0000    2108.0000    -16.8109
   3688.0000    2108.0000    -18.5315
   3996.0000    2108.0000    -19.5713
   4303.0000    2108.0000    -19.9010
$
```

APPENDIX E

INPUT TO AND OUTPUT OF PROGRAMS GRAVBL AND GINDEP

Input to and output of program GRAVBL:

1)Input:

Program GRAVBL is a 3-D forward gravity modeling program in which up to 100 rectangular blocks of earth may be used. GRAVBL reads input out of a command file called GRAVBL.DAT, and the input data in file GRAVBL.DAT must be ordered as follows:

Line	Input
1	Number of blocks in the model (max=100)
2	XL(1),XR(1),ZU(1),ZD(1),YMIN(1),YMAX(1),DEN(1)

where:

XL(1) = minimum X-edge of block 1
XR(1) = maximum X-edge of block 1
ZU(1) = Upper edge of block 1 (Z pos. down)
ZD(1) = Lower edge of block 1
YMIN(1) = minimum Y-edge of block 1
YMAX(1) = maximum Y-edge of block 1
DEN(1) = density of block 1

distance units = meters
density = gm/cc

3	XL(2),XR(2),ZU(2),ZD(2),YMIN(2),YMAX(2),DEN(2)
4	XL(3),XR(3),ZU(3),ZD(3),YMIN(3),YMAX(3),DEN(3)
.	.
.	.
.	.
NBLKS + 1	XL(NBLKS),XR(NBLKS),ZU(NBLKS),ZD(NBLKS)
NBLKS + 2	XSIZE,YSIZE,NCOLS,NROWS

Where:

XSIZE = x-size of grid (meters)
YSIZE = y-size of grid (meters)
NCOLS = number of columns in the grid
NROWS = number of rows in the grid

NBLKS + 3	Input integer multiplier that effects the number of laminae used in the quadrature formula used to approximate the 3-D gravity integral (see text).
NBLKS + 4	NUMB: If NUMB = 1 then include topography in model. If NUMB is not equal to 1 then asuume the data is collected on a plane.

Last two lines used only if NUMB = 1

NBLKS + 5	Datum elevation (meters above sea level) for the tops of the blocks after the removal of topography.
NBLKS + 6	Saved SURFII file of elevations (see Appendix C.)

2) Output

The output of program GRAVBL is written to a data file called GBL.DAT. GBL.DAT will contain a (NCOLS x NROWS) lines of data which indicate the the location of the grid point (in units of meters east and north) and its value. The data is written in 3F12.4 format and the first and last grid points represent the upper left and lower right grid values respectively. See the output of program RSURFILE (Appendix C) for an example of what the output to file GBL.DAT will look like.

Input to and output of program GINDEP:

1) Input

Program GINDEP is an inverse 3-D gravity modeling program that uses the forward modeling results of program GRAVBL to determine depths of the bedrock which reduce the the error between the gridded observed gravity data and the predicted gravity data. Therefore, the model output using the forward program GRAVBL is used as the input model for program GINDEP. In order for program GINDEP to work, the blocks used

in the forward modeling process must extend from the elevation that was used as the base elevation for the removal of topography to the assumed bedrock depth (see text for an explanation). The input to program GINDEP is read from a command file called G.DAT, and the input in file G.DAT must be ordered as follows:

Line	Input
1	Filename of saved SURFII data file containing the prepared (see Appendix C) gridded observed gravity data.
2	TDEPL,TDEPH

where:

TDEPL = minimum expected depth (meters below the surface, z positive down) of valley fill. The program will constrain the parameter jumps so that each block's minimum depth will not go below this value during the inversion process.

TDEPH = maximum expected depth (meters below the surface, z positive down) of valley fill. The program will constrain the parameter jumps so that each block's maximum depth will not exceed this value in the inversion process.

3	Number of blocks in the model (NBLKS).
4	XL(1),XR(1),ZU(1),ZD(1),YMIN(1),YMAX(1),DEN(1)

where:

XL(1) = Minimum X edge of block 1
XR(1) = Maximum X edge of block 1
ZU(1) = Upper edge of block 1 (Z positive down)
ZD(1) = Lower edge of block 1
YMIN(1) = Minimum Y edge of block 1
YMAX(1) = Maximum edge of block 1
DEN(1) = Density of block 1

Distances in meters, Density in gm/cm^3

5 XL(2),XR(2),ZU(2),ZD(2),YMIN(2),YMAX(2),DEN(2)

.
.
.

NBLKS + 3 XL(NBLKS),XR(NBLKS),ZU(NBLKS),ZD(NBLKS),YMIN(NBLKS)
YMAX(NBLKS),DEN(NBLKS)

NBLKS + 4 MAXPER

where:

MAXPER = Multiplier which directly effects the number of laminae used in the quadrature formula. For example if MAXPER = 5, then five times as many laminae will be used for the quadrature formula then if MAXPER was equal to one.

NBLKS + 5 RATIO

where:

RATIO = Number which weights the overdetermined part of the solution relative to the underdetermined part. If RATIO = 0, then the standard overdetermined solution is used (see text for an explanation).

NBLKS + 6 STDDEV

where:

STDDEV = An input error value (mgals). When the error between the gridded observed and calculated data is less then this value the program will output the depth to bedrock values.

NBLKS + 7 Maximum number of iterations allowed (i.e. 10)

Last three lines:

- NUMB

where:

If NUMB = 1, then topography is included in the model. If NUMB is not equal to 1, the data is assumed to be collected on a plane.

- DATELV

where:

DATELV = Datum elevation (meters above sea level) at which the tops of the blocks are located (elevation to which topography has been removed).

- Filename of saved SURFII file of elevations.

2) Output

Output from program GINDEP will be written to a file called GINDEP.OUT. GINDEP.OUT will contain the input model, a table of convergence (showing the parameter jumps, the new parameters, the Marquardt damping factor, and the error between the gridded observed and calculated data for each iteration), and finally a listing of the blocks along with the maximum depth of each block (meters) if the error between the observed and calculted data is less than the value of STDDEV as input.

APPENDIX E

INPUT TO AND OUTPUT OF PROGRAMS GRAVBL AND GINDEP BASED ON MODELS OF THE ENNIS GEOTHERMAL SYSTEM

PROGRAM GRAVBL RESULTS

A

MODEL USED IN PROGRAM GRAVBL FOR THE ENNIS GEOTHERMAL AREA

BLOCK	XL	XR	ZU	ZD	YMIN	YMAX	DEN
1	0.0	500.0	0.0	320.0	0.0	400.0	-0.5
2	500.0	1000.0	0.0	450.0	0.0	400.0	-0.5
3	1000.0	1500.0	0.0	500.0	0.0	400.0	-0.5
4	1500.0	2000.0	0.0	700.0	0.0	400.0	-0.5
5	2000.0	2500.0	0.0	850.0	0.0	400.0	-0.5
6	2500.0	3000.0	0.0	800.0	0.0	400.0	-0.5
7	3000.0	3500.0	0.0	900.0	0.0	400.0	-0.5
8	3500.0	4000.0	0.0	900.0	0.0	400.0	-0.5
9	4000.0	4500.0	0.0	1000.0	0.0	400.0	-0.5
10	0.0	500.0	0.0	125.0	400.0	800.0	-0.5
11	500.0	1000.0	0.0	400.0	400.0	800.0	-0.5
12	1000.0	1500.0	0.0	450.0	400.0	800.0	-0.5
13	1500.0	2000.0	0.0	600.0	400.0	800.0	-0.5
14	2000.0	2500.0	0.0	800.0	400.0	800.0	-0.5
15	2500.0	3000.0	0.0	750.0	400.0	800.0	-0.5
16	3000.0	3500.0	0.0	950.0	400.0	800.0	-0.5
17	3500.0	4000.0	0.0	1000.0	400.0	800.0	-0.5
18	4000.0	4500.0	0.0	900.0	400.0	800.0	-0.5
19	0.0	500.0	0.0	125.0	800.0	1200.0	-0.5
20	500.0	1000.0	0.0	100.0	800.0	1200.0	-0.5
21	1000.0	1500.0	0.0	210.0	800.0	1200.0	-0.5
22	1500.0	2000.0	0.0	230.0	800.0	1200.0	-0.5
23	2000.0	2500.0	0.0	700.0	800.0	1200.0	-0.5
24	2500.0	3000.0	0.0	950.0	800.0	1200.0	-0.5
25	3000.0	3500.0	0.0	900.0	800.0	1200.0	-0.5
26	3500.0	4000.0	0.0	1100.0	800.0	1200.0	-0.5
27	4000.0	4500.0	0.0	1100.0	800.0	1200.0	-0.5
28	0.0	500.0	0.0	30.0	1200.0	1600.0	-0.5
29	500.0	1000.0	0.0	100.0	1200.0	1600.0	-0.5
30	1000.0	1500.0	0.0	200.0	1200.0	1600.0	-0.5
31	1500.0	2000.0	0.0	230.0	1200.0	1600.0	-0.5
32	2000.0	2500.0	0.0	400.0	1200.0	1600.0	-0.5
33	2500.0	3000.0	0.0	1050.0	1200.0	1600.0	-0.5
34	3000.0	3500.0	0.0	900.0	1200.0	1600.0	-0.5
35	3500.0	4000.0	0.0	1200.0	1200.0	1600.0	-0.5
36	4000.0	4500.0	0.0	1200.0	1200.0	1600.0	-0.5
37	0.0	500.0	0.0	10.0	1600.0	2000.0	-0.5
38	500.0	1000.0	0.0	200.0	1600.0	2000.0	-0.5
39	1000.0	1500.0	0.0	230.0	1600.0	2000.0	-0.5
40	1500.0	2000.0	0.0	500.0	1600.0	2000.0	-0.5
41	2000.0	2500.0	0.0	525.0	1600.0	2000.0	-0.5
42	2500.0	3000.0	0.0	1000.0	1600.0	2000.0	-0.5
43	3000.0	3500.0	0.0	900.0	1600.0	2000.0	-0.5
44	3500.0	4000.0	0.0	1250.0	1600.0	2000.0	-0.5
45	4000.0	4500.0	0.0	1300.0	1600.0	2000.0	-0.5
46	0.0	500.0	0.0	40.0	2000.0	2400.0	-0.5
47	500.0	1000.0	0.0	230.0	2000.0	2400.0	-0.5
48	1000.0	1500.0	0.0	525.0	2000.0	2400.0	-0.5
49	1500.0	2000.0	0.0	600.0	2000.0	2400.0	-0.5
50	2000.0	2500.0	0.0	600.0	2000.0	2400.0	-0.5
51	2500.0	3000.0	0.0	1000.0	2000.0	2400.0	-0.5
52	3000.0	3500.0	0.0	900.0	2000.0	2400.0	-0.5
53	3500.0	4000.0	0.0	1250.0	2000.0	2400.0	-0.5
54	4000.0	4500.0	0.0	1400.0	2000.0	2400.0	-0.5
55	0.0	1000.0	0.0	425.0	-800.0	0.0	-0.5
56	1000.0	2000.0	0.0	550.0	-800.0	0.0	-0.5

57	2000.0	3000.0	0.0	800.0	-800.0	0.0	-0.5
58	3000.0	4000.0	0.0	850.0	-800.0	0.0	-0.5
59	4000.0	5500.0	0.0	950.0	-800.0	0.0	-0.5
60	4500.0	5500.0	0.0	955.0	0.0	800.0	-0.5
61	4500.0	5500.0	0.0	1000.0	800.0	1600.0	-0.5
62	4500.0	5500.0	0.0	1000.0	1600.0	2400.0	-0.5
63	4000.0	5500.0	0.0	1000.0	2400.0	3200.0	-0.5
64	3000.0	4000.0	0.0	900.0	2400.0	3200.0	-0.5
65	2000.0	3000.0	0.0	600.0	2400.0	3200.0	-0.5
66	1000.0	2000.0	0.0	400.0	2400.0	3200.0	-0.5
67	0.0	1000.0	0.0	200.0	2400.0	3200.0	-0.5
68	-1000.0	0.0	0.0	200.0	0.0	800.0	-0.5
69	-1000.0	0.0	0.0	350.0	-800.0	0.0	-0.5
70	-1000.0	1000.0	0.0	200.0	-2400.0	-800.0	-0.5
71	1000.0	3000.0	0.0	600.0	-2400.0	-800.0	-0.5
72	3000.0	5500.0	0.0	600.0	-2400.0	-800.0	-0.5
73	5500.0	7500.0	0.0	1500.0	-2400.0	-800.0	-0.5
74	5500.0	7500.0	0.0	1100.0	-800.0	0.0	-0.5
75	5500.0	7500.0	0.0	1250.0	0.0	1600.0	-0.5
76	5500.0	7500.0	0.0	1400.0	1600.0	3200.0	-0.5
77	5500.0	7500.0	0.0	1350.0	3200.0	4600.0	-0.5
78	3000.0	5500.0	0.0	1100.0	3200.0	4600.0	-0.5
79	1000.0	3000.0	0.0	700.0	3200.0	4600.0	-0.5
80	-1000.0	1000.0	0.0	300.0	3200.0	4600.0	-0.5

$

B

INPUT FILE (GRAVBL.DAT) FOR PROGRAM GRAVBL BASED ON THE MODEL INDICATED IN PART A

```
80
0.,500.,0.,320.,0.,400.,-.5
500.,1000.,0.,450.,0.,400.,-.5
1000.,1500.,0.,500.,0.,400.,-.5
1500.,2000.,0.,700.,0.,400.,-.5
2000.,2500.,0.,850.,0.,400.,-.5
2500.,3000.,0.,800.,0.,400.,-.5
3000.,3500.,0.,900.,0.,400.,-.5
3500.,4000.,0.,900.,0.,400.,-.5
4000.,4500.,0.,1000.,0.,400.,-.5
0.,500.,0.,125.,400.,800.,-.5
500.,1000.,0.,400.,400.,800.,-.5
1000.,1500.,0.,450.,400.,800.,-.5
1500.,2000.,0.,600.,400.,800.,-.5
2000.,2500.,0.,800.,400.,800.,-.5
2500.,3000.,0.,750.,400.,800.,-.5
3000.,3500.,0.,950.,400.,800.,-.5
3500.,4000.,0.,1000.,400.,800.,-.5
4000.,4500.,0.,900.,400.,800.,-.5
0.,500.,0.,125.,800.,1200.,-.5
500.,1000.,0.,100.,800.,1200.,-.5
1000.,1500.,0.,210.,800.,1200.,-.5
1500.,2000.,0.,230.,800.,1200.,-.5
2000.,2500.,0.,700.,800.,1200.,-.5
2500.,3000.,0.,950.,800.,1200.,-.5
3000.,3500.,0.,900.,800.,1200.,-.5
3500.,4000.,0.,1100.,800.,1200.,-.5
4000.,4500.,0.,1100.,800.,1200.,-.5
0.,500.,0.,30.,1200.,1600.,-.5
500.,1000.,0.,100.,1200.,1600.,-.5
1000.,1500.,0.,200.,1200.,1600.,-.5
1500.,2000.,0.,230.,1200.,1600.,-.5
2000.,2500.,0.,400.,1200.,1600.,-.5
2500.,3000.,0.,1050.,1200.,1600.,-.5
3000.,3500.,0.,900.,1200.,1600.,-.5
3500.,4000.,0.,1200.,1200.,1600.,-.5
4000.,4500.,0.,1200.,1200.,1600.,-.5
0.,500.,0.,10.,1600.,2000.,-.5
500.,1000.,0.,200.,1600.,2000.,-.5
1000.,1500.,0.,230.,1600.,2000.,-.5
1500.,2000.,0.,500.,1600.,2000.,-.5
2000.,2500.,0.,525.,1600.,2000.,-.5
2500.,3000.,0.,1000.,1600.,2000.,-.5
3000.,3500.,0.,900.,1600.,2000.,-.5
3500.,4000.,0.,1250.,1600.,2000.,-.5
4000.,4500.,0.,1300.,1600.,2000.,-.5
0.,500.,0.,40.,2000.,2400.,-.5
500.,1000.,0.,230.,2000.,2400.,-.5
1000.,1500.,0.,525.,2000.,2400.,-.5
1500.,2000.,0.,600.,2000.,2400.,-.5
2000.,2500.,0.,600.,2000.,2400.,-.5
2500.,3000.,0.,1000.,2000.,2400.,-.5
3000.,3500.,0.,900.,2000.,2400.,-.5
3500.,4000.,0.,1250.,2000.,2400.,-.5
4000.,4500.,0.,1400.,2000.,2400.,-.5
0.,1000.,0.,425.,-800.,0.,-.5
1000.,2000.,0.,550.,-800.,0.,-.5
2000.,3000.,0.,800.,-800.,0.,-.5
```

```
3000.,4000.,0.,850.,-800.,0.,-.5
4000.,5500.,0.,950.,-800.,0.,-.5
4500.,5500.,0.,955.,0.,800.,-.5
4500.,5500.,0.,1000.,800.,1600.,-.5
4500.,5500.,0.,1000.,1600.,2400.,-.5
4000.,5500.,0.,1000.,2400.,3200.,-.5
3000.,4000.,0.,900.,2400.,3200.,-.5
2000.,3000.,0.,600.,2400.,3200.,-.5
1000.,2000.,0.,400.,2400.,3200.,-.5
0.,1000.,0.,200.,2400.,3200.,-.5
-1000.,0.,0.,200.,0.,800.,-.5
-1000.,0.,0.,350.,-800.,0.,-.5
-1000.,1000.,0.,200.,-2400.,-800.,-.5
1000.,3000.,0.,600.,-2400.,-800.,-.5
3000.,5500.,0.,600.,-2400.,-800.,-.5
5500.,7500.,0.,1500.,-2400.,-800.,-.5
5500.,7500.,0.,1100.,-800.,0.,-.5
5500.,7500.,0.,1250.,0.,1600.,-.5
5500.,7500.,0.,1400.,1600.,3200.,-.5
5500.,7500.,0.,1350.,3200.,4600.,-.5
3000.,5500.,0.,1100.,3200.,4600.,-.5
1000.,3000.,0.,700.,3200.,4600.,-.5
-1000.,1000.,0.,300.,3200.,4600.,-.5
4303.,2108.,15,8
5
1
1475.
FOR012.DAT
```

C

OUTPUT OF PROGRAM GRAVBL (CONTAINED IN FILE GBL.DAT)

COMPARE RESULTS GIVEN IN THIS SECTION WITH PART D OF APPENDIX D WHICH CONTAINS THE REDUCED GRIDDED OBSERVED GRAVITY DATA

0.0000	0.0000	-6.6192
307.3571	0.0000	-7.4935
614.7143	0.0000	-8.3830
922.0715	0.0000	-9.2980
1229.4286	0.0000	-10.2627
1536.7858	0.0000	-11.2571
1844.1429	0.0000	-12.2625
2151.5000	0.0000	-13.2278
2458.8572	0.0000	-14.0482
2766.2144	0.0000	-14.7135
3073.5715	0.0000	-15.2845
3380.9287	0.0000	-15.7356
3688.2859	0.0000	-16.1916
3995.6428	0.0000	-16.6071
4303.0000	0.0000	-17.0156
0.0000	301.1429	-5.7212
307.3574	301.1429	-6.6192
614.7144	301.1429	-7.8590
922.0718	301.1429	-8.9517
1229.4287	301.1429	-9.9492
1536.7861	301.1429	-11.0608
1844.1431	301.1429	-12.2014
2151.5005	301.1429	-13.2857
2458.8574	301.1429	-14.2237
2766.2148	301.1429	-15.0034
3073.5718	301.1429	-15.6688
3380.9287	301.1429	-16.1615
3688.2856	301.1429	-16.6620
3995.6431	301.1429	-17.0966
4303.0005	301.1429	-17.4792
0.0000	602.2857	-4.6266
307.3574	602.2857	-5.1739
614.7148	602.2857	-6.8308
922.0723	602.2857	-8.0727
1229.4287	602.2857	-9.1446
1536.7861	602.2857	-10.3027
1844.1436	602.2857	-11.6051
2151.5010	602.2857	-12.9799
2458.8574	602.2857	-14.1582
2766.2148	602.2857	-15.1042
3073.5723	602.2857	-15.8820
3380.9287	602.2857	-16.5026
3688.2861	602.2857	-17.0437
3995.6436	602.2857	-17.4891
4303.0010	602.2857	-17.8500
0.0000	903.4286	-3.0331
307.3574	903.4286	-4.3154
614.7148	903.4286	-5.1062
922.0723	903.4286	-6.2344
1229.4287	903.4286	-7.7572
1536.7861	903.4286	-8.9815
1844.1436	903.4286	-10.5032
2151.5000	903.4286	-12.4333
2458.8574	903.4286	-14.0141
2766.2139	903.4286	-15.1945
3073.5713	903.4286	-16.0709
3380.9287	903.4286	-16.8018
3688.2861	903.4286	-17.3824

3995.6436	903.4286	-17.8380
4303.0010	903.4286	-18.1890
0.0000	1204.5714	-2.1519
307.3574	1204.5714	-3.2093
614.7148	1204.5714	-4.2028
922.0723	1204.5714	-5.3093
1229.4297	1204.5714	-6.9208
1536.7871	1204.5714	-8.1771
1844.1445	1204.5714	-9.7781
2151.5020	1204.5714	-11.8881
2458.8574	1204.5714	-13.6944
2766.2148	1204.5714	-15.1236
3073.5723	1204.5714	-16.1831
3380.9297	1204.5714	-16.9894
3688.2871	1204.5714	-17.6306
3995.6445	1204.5714	-18.1160
4303.0020	1204.5714	-18.4585
0.0000	1505.7142	-1.6647
307.3574	1505.7142	-2.4687
614.7148	1505.7142	-4.1488
922.0723	1505.7142	-5.3684
1229.4297	1505.7142	-6.9174
1536.7871	1505.7142	-8.3269
1844.1445	1505.7142	-9.9377
2151.5000	1505.7142	-11.8114
2458.8574	1505.7142	-13.5758
2766.2148	1505.7142	-15.0943
3073.5723	1505.7142	-16.2350
3380.9297	1505.7142	-17.0998
3688.2871	1505.7142	-17.7809
3995.6445	1505.7142	-18.2916
4303.0000	1505.7142	-18.6448
0.0000	1806.8572	-1.4786
307.3574	1806.8572	-2.2407
614.7148	1806.8572	-4.8097
922.0723	1806.8572	-6.1934
1229.4297	1806.8572	-7.5442
1536.7871	1806.8572	-9.1130
1844.1445	1806.8572	-10.6751
2151.5000	1806.8572	-12.1429
2458.8574	1806.8572	-13.6557
2766.2148	1806.8572	-15.0618
3073.5723	1806.8572	-16.1936
3380.9297	1806.8572	-17.0820
3688.2871	1806.8572	-17.7968
3995.6445	1806.8572	-18.3346
4303.0000	1806.8572	-18.7081
0.0000	2108.0000	-1.8152
307.3574	2108.0000	-2.8952
614.7148	2108.0000	-5.2239
922.0703	2108.0000	-6.8298
1229.4297	2108.0000	-8.4128
1536.7852	2108.0000	-9.8129
1844.1445	2108.0000	-11.1049
2151.5000	2108.0000	-12.3639
2458.8594	2108.0000	-13.6873
2766.2148	2108.0000	-14.9502
3073.5703	2108.0000	-16.0459

3380.9297	2108.0000	-16.9557
3688.2852	2108.0000	-17.7057
3995.6445	2108.0000	-18.2583
4303.0000	2108.0000	-18.6547

PROGRAM GINDEP RESULTS

D

INPUT FILE FOR PROGRAM GINDEP (FILE G.DAT)

```
FOR018.DAT
5.
2100.
80
0.,500.,0.,320.,0.,400.,-.5
500.,1000.,0.,450.,0.,400.,-.5
1000.,1500.,0.,500.,0.,400.,-.5
1500.,2000.,0.,700.,0.,400.,-.5
2000.,2500.,0.,850.,0.,400.,-.5
2500.,3000.,0.,800.,0.,400.,-.5
3000.,3500.,0.,900.,0.,400.,-.5
3500.,4000.,0.,900.,0.,400.,-.5
4000.,4500.,0.,1000.,0.,400.,-.5
0.,500.,0.,125.,400.,800.,-.5
500.,1000.,0.,400.,400.,800.,-.5
1000.,1500.,0.,450.,400.,800.,-.5
1500.,2000.,0.,600.,400.,800.,-.5
2000.,2500.,0.,800.,400.,800.,-.5
2500.,3000.,0.,750.,400.,800.,-.5
3000.,3500.,0.,950.,400.,800.,-.5
3500.,4000.,0.,1000.,400.,800.,-.5
4000.,4500.,0.,900.,400.,800.,-.5
0.,500.,0.,125.,800.,1200.,-.5
500.,1000.,0.,100.,800.,1200.,-.5
1000.,1500.,0.,210.,800.,1200.,-.5
1500.,2000.,0.,230.,800.,1200.,-.5
2000.,2500.,0.,700.,800.,1200.,-.5
2500.,3000.,0.,950.,800.,1200.,-.5
3000.,3500.,0.,900.,800.,1200.,-.5
3500.,4000.,0.,1100.,800.,1200.,-.5
4000.,4500.,0.,1100.,800.,1200.,-.5
0.,500.,0.,30.,1200.,1600.,-.5
500.,1000.,0.,100.,1200.,1600.,-.5
1000.,1500.,0.,200.,1200.,1600.,-.5
1500.,2000.,0.,230.,1200.,1600.,-.5
2000.,2500.,0.,400.,1200.,1600.,-.5
2500.,3000.,0.,1050.,1200.,1600.,-.5
3000.,3500.,0.,900.,1200.,1600.,-.5
3500.,4000.,0.,1200.,1200.,1600.,-.5
4000.,4500.,0.,1200.,1200.,1600.,-.5
0.,500.,0.,10.,1600.,2000.,-.5
500.,1000.,0.,200.,1600.,2000.,-.5
1000.,1500.,0.,230.,1600.,2000.,-.5
1500.,2000.,0.,500.,1600.,2000.,-.5
2000.,2500.,0.,525.,1600.,2000.,-.5
2500.,3000.,0.,1000.,1600.,2000.,-.5
3000.,3500.,0.,900.,1600.,2000.,-.5
3500.,4000.,0.,1250.,1600.,2000.,-.5
4000.,4500.,0.,1300.,1600.,2000.,-.5
0.,500.,0.,40.,2000.,2400.,-.5
500.,1000.,0.,230.,2000.,2400.,-.5
1000.,1500.,0.,525.,2000.,2400.,-.5
1500.,2000.,0.,600.,2000.,2400.,-.5
2000.,2500.,0.,600.,2000.,2400.,-.5
2500.,3000.,0.,1000.,2000.,2400.,-.5
3000.,3500.,0.,900.,2000.,2400.,-.5
3500.,4000.,0.,1250.,2000.,2400.,-.5
4000.,4500.,0.,1400.,2000.,2400.,-.5
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0.,1000.,0.,425.,-800.,0.,-.5
1000.,2000.,0.,550.,-800.,0.,-.5
2000.,3000.,0.,800.,-800.,0.,-.5
3000.,4000.,0.,850.,-800.,0.,-.5
4000.,5500.,0.,950.,-800.,0.,-.5
4500.,5500.,0.,955.,0.,800.,-.5
4500.,5500.,0.,1000.,800.,1600.,-.5
4500.,5500.,0.,1000.,1600.,2400.,-.5
4000.,5500.,0.,1000.,2400.,3200.,-.5
3000.,4000.,0.,900.,2400.,3200.,-.5
2000.,3000.,0.,600.,2400.,3200.,-.5
1000.,2000.,0.,400.,2400.,3200.,-.5
0.,1000.,0.,200.,2400.,3200.,-.5
-1000.,0.,0.,200.,0.,800.,-.5
-1000.,0.,0.,350.,-800.,0.,-.5
-1000.,1000.,0.,200.,-2400.,-800.,-.5
1000.,3000.,0.,600.,-2400.,-800.,-.5
3000.,5500.,0.,600.,-2400.,-800.,-.5
5500.,7500.,0.,1500.,-2400.,-800.,-.5
5500.,7500.,0.,1100.,-800.,0.,-.5
5500.,7500.,0.,1250.,0.,1600.,-.5
5500.,7500.,0.,1400.,1600.,3200.,-.5
5500.,7500.,0.,1350.,3200.,4600.,-.5
3000.,5500.,0.,1100.,3200.,4600.,-.5
1000.,3000.,0.,700.,3200.,4600.,-.5
-1000.,1000.,0.,300.,3200.,4600.,-.5
5
0
.835
15
1
1475.
FOR012.DAT
$
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E

OUTPUT OF PROGRAM GINDEP (FILE GINDEP.OUT)

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GRID INFO

GRID SIZE IN X DIRECTION (METERS)= 0.4303E+04
GRID SIZE IN Y DIRECTION (METERS)= 0.2108E+04
NUMBER OF COLUMNS= 15
NUMBER OF ROWS= 8

INPUT MODEL

BLOCK #	XMIN	XMAX	YMIN	YMAX	ZMIN	ZMAX	DENSITY
1	0.0	500.0	0.0	400.0	0.0	320.0	-0.5
2	500.0	1000.0	0.0	400.0	0.0	450.0	-0.5
3	1000.0	1500.0	0.0	400.0	0.0	500.0	-0.5
4	1500.0	2000.0	0.0	400.0	0.0	700.0	-0.5
5	2000.0	2500.0	0.0	400.0	0.0	850.0	-0.5
6	2500.0	3000.0	0.0	400.0	0.0	800.0	-0.5
7	3000.0	3500.0	0.0	400.0	0.0	900.0	-0.5
8	3500.0	4000.0	0.0	400.0	0.0	900.0	-0.5
9	4000.0	4500.0	0.0	400.0	0.0	1000.0	-0.5
10	0.0	500.0	400.0	800.0	0.0	125.0	-0.5
11	500.0	1000.0	400.0	800.0	0.0	400.0	-0.5
12	1000.0	1500.0	400.0	800.0	0.0	450.0	-0.5
13	1500.0	2000.0	400.0	800.0	0.0	600.0	-0.5
14	2000.0	2500.0	400.0	800.0	0.0	800.0	-0.5
15	2500.0	3000.0	400.0	800.0	0.0	750.0	-0.5
16	3000.0	3500.0	400.0	800.0	0.0	950.0	-0.5
17	3500.0	4000.0	400.0	800.0	0.0	1000.0	-0.5
18	4000.0	4500.0	400.0	800.0	0.0	900.0	-0.5
19	0.0	500.0	800.0	1200.0	0.0	125.0	-0.5
20	500.0	1000.0	800.0	1200.0	0.0	100.0	-0.5
21	1000.0	1500.0	800.0	1200.0	0.0	210.0	-0.5
22	1500.0	2000.0	800.0	1200.0	0.0	230.0	-0.5
23	2000.0	2500.0	800.0	1200.0	0.0	700.0	-0.5
24	2500.0	3000.0	800.0	1200.0	0.0	950.0	-0.5
25	3000.0	3500.0	800.0	1200.0	0.0	900.0	-0.5
26	3500.0	4000.0	800.0	1200.0	0.0	1100.0	-0.5
27	4000.0	4500.0	800.0	1200.0	0.0	1100.0	-0.5
28	0.0	500.0	1200.0	1600.0	0.0	30.0	-0.5
29	500.0	1000.0	1200.0	1600.0	0.0	100.0	-0.5
30	1000.0	1500.0	1200.0	1600.0	0.0	200.0	-0.5
31	1500.0	2000.0	1200.0	1600.0	0.0	230.0	-0.5
32	2000.0	2500.0	1200.0	1600.0	0.0	400.0	-0.5
33	2500.0	3000.0	1200.0	1600.0	0.0	1050.0	-0.5
34	3000.0	3500.0	1200.0	1600.0	0.0	900.0	-0.5
35	3500.0	4000.0	1200.0	1600.0	0.0	1200.0	-0.5
36	4000.0	4500.0	1200.0	1600.0	0.0	1200.0	-0.5
37	0.0	500.0	1600.0	2000.0	0.0	10.0	-0.5
38	500.0	1000.0	1600.0	2000.0	0.0	200.0	-0.5
39	1000.0	1500.0	1600.0	2000.0	0.0	230.0	-0.5
40	1500.0	2000.0	1600.0	2000.0	0.0	500.0	-0.5

41	2000.0	2500.0	1600.0	2000.0	0.0	525.0	-0.5
42	2500.0	3000.0	1600.0	2000.0	0.0	1000.0	-0.5
43	3000.0	3500.0	1600.0	2000.0	0.0	900.0	-0.5
44	3500.0	4000.0	1600.0	2000.0	0.0	1250.0	-0.5
45	4000.0	4500.0	1600.0	2000.0	0.0	1300.0	-0.5
46	0.0	500.0	2000.0	2400.0	0.0	40.0	-0.5
47	500.0	1000.0	2000.0	2400.0	0.0	230.0	-0.5
48	1000.0	1500.0	2000.0	2400.0	0.0	525.0	-0.5
49	1500.0	2000.0	2000.0	2400.0	0.0	600.0	-0.5
50	2000.0	2500.0	2000.0	2400.0	0.0	600.0	-0.5
51	2500.0	3000.0	2000.0	2400.0	0.0	1000.0	-0.5
52	3000.0	3500.0	2000.0	2400.0	0.0	900.0	-0.5
53	3500.0	4000.0	2000.0	2400.0	0.0	1250.0	-0.5
54	4000.0	4500.0	2000.0	2400.0	0.0	1400.0	-0.5
55	0.0	1000.0	-800.0	0.0	0.0	425.0	-0.5
56	1000.0	2000.0	-800.0	0.0	0.0	550.0	-0.5
57	2000.0	3000.0	-800.0	0.0	0.0	800.0	-0.5
58	3000.0	4000.0	-800.0	0.0	0.0	850.0	-0.5
59	4000.0	5500.0	-800.0	0.0	0.0	950.0	-0.5
60	4500.0	5500.0	0.0	800.0	0.0	955.0	-0.5
61	4500.0	5500.0	800.0	1600.0	0.0	1000.0	-0.5
62	4500.0	5500.0	1600.0	2400.0	0.0	1000.0	-0.5
63	4000.0	5500.0	2400.0	3200.0	0.0	1000.0	-0.5
64	3000.0	4000.0	2400.0	3200.0	0.0	900.0	-0.5
65	2000.0	3000.0	2400.0	3200.0	0.0	600.0	-0.5
66	1000.0	2000.0	2400.0	3200.0	0.0	400.0	-0.5
67	0.0	1000.0	2400.0	3200.0	0.0	200.0	-0.5
68	-1000.0	0.0	0.0	800.0	0.0	200.0	-0.5
69	-1000.0	0.0	-800.0	0.0	0.0	350.0	-0.5
70	-1000.0	1000.0	-2400.0	-800.0	0.0	200.0	-0.5
71	1000.0	3000.0	-2400.0	-800.0	0.0	600.0	-0.5
72	3000.0	5500.0	-2400.0	-800.0	0.0	600.0	-0.5
73	5500.0	7500.0	-2400.0	-800.0	0.0	1500.0	-0.5
74	5500.0	7500.0	-800.0	0.0	0.0	1100.0	-0.5
75	5500.0	7500.0	0.0	1600.0	0.0	1250.0	-0.5
76	5500.0	7500.0	1600.0	3200.0	0.0	1400.0	-0.5
77	5500.0	7500.0	3200.0	4600.0	0.0	1350.0	-0.5
78	3000.0	5500.0	3200.0	4600.0	0.0	1100.0	-0.5
79	1000.0	3000.0	3200.0	4600.0	0.0	700.0	-0.5
80	-1000.0	1000.0	3200.0	4600.0	0.0	300.0	-0.5

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TABLE OF CONVERGENCE

ITERATION # 1
STARTING DATA ERROR= 0.1513E+01

BLOCK	PARM. JUMP.	NEW PARMS.
1	0.4782E+02	0.3678E+03
2	-0.1586E+03	0.2914E+03
3	0.1749E+03	0.6749E+03
4	-0.1117E+03	0.5883E+03
5	-0.6717E+03	0.1783E+03
6	-0.8489E+02	0.7151E+03

7	0.3583E+03	0.1258E+04
8	-0.1659E+03	0.7341E+03
9	0.1109E+04	0.2109E+04
10	0.1703E+03	0.2953E+03
11	0.3894E+03	0.7894E+03
12	-0.4013E+02	0.4099E+03
13	0.1151E+04	0.1751E+04
14	0.2191E+04	0.2981E+04
15	-0.4727E+03	0.2773E+03
16	-0.1865E+03	0.7635E+03
17	0.1868E+03	0.1187E+04
18	-0.4166E+03	0.4834E+03
19	0.9471E+02	0.2197E+03
20	0.5785E+02	0.1579E+03
21	-0.6077E+02	0.1492E+03
22	-0.9440E+01	0.2206E+03
23	-0.3035E+03	0.3965E+03
24	0.3348E+04	0.4298E+04
25	0.1881E+04	0.2781E+04
26	0.4380E+02	0.1144E+04
27	-0.2132E+03	0.8868E+03
28	-0.2886E+02	0.1144E+01
29	0.6557E+02	0.1656E+03
30	0.7110E+02	0.2711E+03
31	0.3397E+03	0.5697E+03
32	-0.2112E+03	0.1888E+03
33	0.9427E+03	0.1993E+04
34	0.9805E+03	0.1881E+04
35	-0.3846E+02	0.1162E+04
36	0.4334E+04	0.5534E+04
37	0.4269E+01	0.1427E+02
38	-0.7978E+02	0.1202E+03
39	-0.1141E+03	0.1159E+03
40	-0.1127E+03	0.3873E+03
41	0.7825E+03	0.1308E+04
42	-0.1507E+03	0.8493E+03
43	-0.1431E+03	0.7569E+03
44	-0.2224E+03	0.1028E+04
45	0.3384E+04	0.4684E+04
46	0.4534E+01	0.4453E+02
47	-0.7161E+02	0.1584E+03
48	0.1324E+04	0.1849E+04
49	0.2210E+04	0.2810E+04
50	-0.3115E+03	0.2885E+03
51	0.1717E+04	0.2717E+04
52	-0.2363E+02	0.8764E+03
53	-0.2223E+03	0.1028E+04
54	0.2569E+04	0.3969E+04
55	0.6111E+03	0.1036E+04
56	0.2542E+03	0.8042E+03
57	0.1014E+04	0.1814E+04
58	0.3501E+03	0.1200E+04
59	0.8142E+03	0.1764E+04
60	0.1808E+04	0.2763E+04
61	-0.6611E+02	0.9339E+03
62	0.1377E+04	0.2377E+04
63	0.2947E+04	0.3947E+04
64	0.1225E+04	0.2125E+04

65	0.2223E+04	0.2823E+04
66	0.2956E+03	0.6956E+03
67	-0.7961E+02	0.1204E+03
68	0.3909E+02	0.2391E+03
69	0.4300E+03	0.7800E+03
70	-0.5457E+02	0.1454E+03
71	-0.2098E+03	0.3902E+03
72	-0.9041E+02	0.5096E+03
73	-0.4255E+03	0.1074E+04
74	0.3050E+04	0.4150E+04
75	-0.5868E+03	0.6632E+03
76	-0.2196E+03	0.1180E+04
77	-0.8739E+03	0.4761E+03
78	-0.1164E+03	0.9836E+03
79	-0.3386E+03	0.3614E+03
80	-0.3630E+02	0.2637E+03

DAMPING (MARQUARDT) VALUE= 0.1000E-02
NEW DATA ERROR= 0.8787E+01

BLOCK	PARM. JUMP.	NEW PARMS.
1	-0.2594E+01	0.3174E+03
2	-0.3160E+02	0.4184E+03
3	-0.1987E+02	0.4801E+03
4	-0.8771E+02	0.6123E+03
5	0.3250E+03	0.1175E+04
6	0.4784E+02	0.8478E+03
7	-0.3678E+03	0.5322E+03
8	-0.6134E+03	0.2866E+03
9	0.1613E+03	0.1161E+04
10	0.1457E+03	0.2707E+03
11	0.1978E+03	0.5978E+03
12	-0.8268E+01	0.4417E+03
13	0.4524E+03	0.1052E+04
14	0.2422E+02	0.8242E+03
15	-0.1023E+02	0.7398E+03
16	-0.7755E+02	0.8725E+03
17	-0.7214E+03	0.2786E+03
18	-0.1468E+03	0.7532E+03
19	0.5429E+02	0.1793E+03
20	0.4220E+02	0.1422E+03
21	-0.8291E+02	0.1271E+03
22	-0.1020E+02	0.2198E+03
23	-0.1235E+03	0.5765E+03
24	0.6543E+03	0.1604E+04
25	0.1257E+04	0.2157E+04
26	-0.3840E+03	0.7160E+03
27	-0.1310E+03	0.9690E+03
28	-0.5393E+01	0.2461E+02
29	0.3535E+02	0.1353E+03
30	0.2318E+02	0.2232E+03
31	0.2207E+03	0.4507E+03
32	-0.3034E+03	0.9656E+02
33	0.4778E+03	0.1528E+04
34	0.7297E+03	0.1630E+04
35	-0.1431E+03	0.1057E+04
36	0.3566E+03	0.1557E+04
37	-0.1306E+01	0.8694E+01
38	-0.1174E+03	0.8255E+02

39	-0.1099E+03	0.1201E+03
40	-0.5282E+02	0.4472E+03
41	-0.4541E+01	0.5205E+03
42	0.5659E+03	0.1566E+04
43	-0.4690E+03	0.4310E+03
44	-0.3784E+03	0.8716E+03
45	0.9778E+03	0.2278E+04
46	0.5930E+01	0.4593E+02
47	-0.8582E+02	0.1442E+03
48	0.7234E+03	0.1248E+04
49	0.3346E+03	0.9346E+03
50	-0.1145E+03	0.4855E+03
51	0.8801E+03	0.1880E+04
52	-0.4111E+02	0.8589E+03
53	-0.3340E+03	0.9160E+03
54	0.1038E+04	0.2438E+04
55	0.8483E+02	0.5098E+03
56	-0.4475E+02	0.5052E+03
57	0.3176E+03	0.1118E+04
58	-0.6687E+02	0.7831E+03
59	0.3492E+03	0.1299E+04
60	0.2875E+03	0.1242E+04
61	-0.1252E+03	0.8748E+03
62	0.8529E+03	0.1853E+04
63	0.7611E+03	0.1761E+04
64	0.2592E+03	0.1159E+04
65	0.3951E+03	0.9951E+03
66	0.5814E+03	0.9814E+03
67	-0.2753E+02	0.1725E+03
68	-0.2185E+02	0.1781E+03
69	0.1648E+02	0.3665E+03
70	-0.1176E+03	0.8243E+02
71	-0.1024E+03	0.4976E+03
72	-0.7830E+02	0.5217E+03
73	-0.9108E+03	0.5892E+03
74	0.4240E+03	0.1524E+04
75	-0.1259E+03	0.1124E+04
76	-0.2784E+03	0.1122E+04
77	-0.1708E+03	0.1179E+04
78	-0.2797E+03	0.8203E+03
79	-0.7808E+02	0.6219E+03
80	-0.2046E+03	0.9537E+02

DAMPING (MARQUARDT) VALUE= 0.1000E-01
NEW DATA ERROR= 0.2396E+01

BLOCK	PARM. JUMP.	NEW PARMS.
1	0.1571E+02	0.3357E+03
2	0.8317E+01	0.4583E+03
3	-0.4953E+02	0.4505E+03
4	0.8058E+02	0.7806E+03
5	0.2224E+03	0.1072E+04
6	0.1874E+03	0.9874E+03
7	-0.1929E+03	0.7071E+03
8	-0.4469E+03	0.4531E+03
9	-0.2328E+03	0.7672E+03
10	0.1198E+03	0.2448E+03
11	0.1465E+03	0.5465E+03
12	-0.4366E+01	0.4456E+03

13	0.5648E+02	0.6565E+03
14	-0.6112E+02	0.7389E+03
15	0.1032E+03	0.8532E+03
16	-0.2582E+02	0.9242E+03
17	-0.4842E+03	0.5158E+03
18	-0.6975E+03	0.2025E+03
19	0.3869E+02	0.1637E+03
20	0.3468E+02	0.1347E+03
21	-0.5598E+02	0.1540E+03
22	-0.5278E+01	0.2247E+03
23	-0.3774E+03	0.3226E+03
24	0.8463E+02	0.1035E+04
25	0.3794E+03	0.1279E+04
26	-0.2647E+03	0.8353E+03
27	-0.6367E+03	0.4633E+03
28	-0.6054E+01	0.2395E+02
29	0.1784E+02	0.1178E+03
30	-0.3835E+01	0.1962E+03
31	0.9852E+02	0.3285E+03
32	-0.2607E+03	0.1393E+03
33	0.4234E+02	0.1092E+04
34	0.4598E+03	0.1360E+04
35	0.1055E+02	0.1211E+04
36	-0.6831E+02	0.1132E+04
37	-0.2760E+01	0.7240E+01
38	-0.1198E+03	0.8020E+02
39	-0.5502E+02	0.1750E+03
40	-0.1451E+03	0.3549E+03
41	-0.2376E+03	0.2874E+03
42	0.8211E+02	0.1082E+04
43	0.2808E+03	0.1181E+04
44	0.1661E+03	0.1416E+04
45	0.3947E+03	0.1695E+04
46	-0.2623E+02	0.1377E+02
47	-0.7893E+02	0.1511E+03
48	0.2933E+03	0.8183E+03
49	0.1274E+03	0.7274E+03
50	-0.3206E+03	0.2794E+03
51	0.7945E+02	0.1079E+04
52	0.2384E+03	0.1138E+04
53	0.2751E+03	0.1525E+04
54	0.6248E+03	0.2025E+04
55	-0.3309E+02	0.3919E+03
56	-0.3438E+02	0.5156E+03
57	0.1248E+03	0.9248E+03
58	-0.6859E+02	0.7814E+03
59	0.9384E+02	0.1044E+04
60	-0.5040E+02	0.9046E+03
61	-0.9840E+02	0.9016E+03
62	0.3708E+03	0.1371E+04
63	0.3612E+03	0.1361E+04
64	0.1092E+03	0.1009E+04
65	0.2019E+02	0.6202E+03
66	0.2518E+03	0.6518E+03
67	-0.2925E+02	0.1708E+03
68	-0.2385E+02	0.1762E+03
69	-0.7573E+02	0.2743E+03
70	-0.4195E+02	0.1581E+03

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 71    -0.4904E+02   0.5510E+03
 72    -0.9763E+00   0.5990E+03
 73    -0.3044E+03   0.1196E+04
 74    -0.6372E+02   0.1036E+04
 75    -0.8157E+02   0.1168E+04
 76    -0.2669E+02   0.1373E+04
 77    -0.3885E+03   0.9615E+03
 78    -0.7508E+02   0.1025E+04
 79    -0.3144E+03   0.3856E+03
 80    -0.1161E+03   0.1839E+03
DAMPING (MARQUARDT) VALUE=  0.1000E+00
NEW DATA ERROR=  0.1070E+01

ITERATION #  2
STARTING DATA ERROR=  0.1070E+01

BLOCK    PARM. JUMP.  NEW PARMS.
  1    -0.4484E+02   0.2909E+03
  2     0.3745E+01   0.4621E+03
  3     0.9875E+01   0.4603E+03
  4    -0.3442E+03   0.4364E+03
  5    -0.4601E+03   0.6122E+03
  6    -0.4904E+03   0.4970E+03
  7    -0.3060E+03   0.4011E+03
  8    -0.1588E+02   0.4373E+03
  9     0.5025E+03   0.1270E+04
 10     0.1141E+03   0.3589E+03
 11    -0.7767E+02   0.4689E+03
 12     0.4895E+02   0.4946E+03
 13     0.2495E+03   0.9059E+03
 14     0.7307E+03   0.1470E+04
 15     0.3833E+03   0.1237E+04
 16     0.2249E+02   0.9467E+03
 17     0.5087E+02   0.5667E+03
 18     0.8801E+02   0.2905E+03
 19     0.3225E+01   0.1669E+03
 20     0.1269E+02   0.1474E+03
 21    -0.2734E+02   0.1267E+03
 22    -0.5033E+02   0.1744E+03
 23    -0.3459E+02   0.2880E+03
 24     0.7111E+03   0.1746E+04
 25     0.5240E+03   0.1803E+04
 26     0.4886E+03   0.1324E+04
 27    -0.5393E+02   0.4094E+03
 28    -0.5613E+01   0.1833E+02
 29     0.8410E+00   0.1187E+03
 30    -0.4028E+02   0.1559E+03
 31     0.2121E+03   0.5406E+03
 32     0.1032E+03   0.2425E+03
 33    -0.4602E+03   0.6321E+03
 34     0.2863E+02   0.1388E+04
 35     0.3872E+03   0.1598E+04
 36     0.8515E+03   0.1983E+04
 37    -0.2124E+01   0.5115E+01
 38     0.4604E+01   0.8480E+02
 39    -0.5035E+02   0.1246E+03
 40    -0.3773E+02   0.3171E+03
 41     0.1160E+03   0.4034E+03
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42	-0.1103E+03	0.9718E+03
43	-0.2336E+03	0.9472E+03
44	-0.3449E+03	0.1071E+04
45	-0.1917E+03	0.1503E+04
46	0.2383E+02	0.3760E+02
47	0.6000E+01	0.1571E+03
48	0.4687E+03	0.1287E+04
49	0.7620E+03	0.1489E+04
50	-0.2515E+03	0.2790E+02
51	-0.6263E+03	0.4532E+03
52	-0.9806E+02	0.1040E+04
53	-0.7706E+03	0.7545E+03
54	-0.1947E+04	0.7750E+02
55	0.1383E+03	0.5303E+03
56	0.3124E+02	0.5469E+03
57	0.1724E+03	0.1097E+04
58	0.9415E+02	0.8756E+03
59	0.5983E+01	0.1050E+04
60	0.3484E+03	0.1253E+04
61	0.3218E+03	0.1223E+04
62	0.5213E+03	0.1892E+04
63	0.3606E+03	0.1722E+04
64	0.2880E+03	0.1297E+04
65	0.5407E+03	0.1161E+04
66	0.4214E+03	0.1073E+04
67	-0.3937E+02	0.1314E+03
68	-0.9606E+01	0.1665E+03
69	0.1423E+03	0.4166E+03
70	-0.1874E+02	0.1393E+03
71	-0.3598E+02	0.5150E+03
72	-0.1948E+03	0.4042E+03
73	-0.8633E+03	0.3324E+03
74	0.1834E+03	0.1220E+04
75	0.9714E+02	0.1266E+04
76	-0.7256E+02	0.1301E+04
77	-0.1413E+03	0.8202E+03
78	-0.1517E+03	0.8732E+03
79	-0.4655E+02	0.3391E+03
80	-0.2896E+02	0.1549E+03

DAMPING (MARQUARDT) VALUE= 0.1000E-01
NEW DATA ERROR= 0.1731E+01

BLOCK	PARM. JUMP.	NEW PARMS.
1	-0.2358E+02	0.3121E+03
2	-0.9726E+01	0.4486E+03
3	-0.3784E+01	0.4467E+03
4	0.8342E+01	0.7889E+03
5	0.1194E+02	0.1084E+04
6	0.5128E+02	0.1039E+04
7	-0.8310E+02	0.6240E+03
8	-0.6587E+00	0.4525E+03
9	0.2790E+03	0.1046E+04
10	0.6704E+02	0.3118E+03
11	-0.5474E+02	0.4918E+03
12	0.3759E+01	0.4494E+03
13	0.4566E+02	0.7021E+03
14	0.1189E+03	0.8577E+03
15	0.1382E+03	0.9914E+03

16	0.9939E+02	0.1024E+04
17	0.8785E+02	0.6037E+03
18	0.8131E+02	0.2838E+03
19	-0.1046E+02	0.1532E+03
20	0.6752E+01	0.1414E+03
21	-0.1712E+02	0.1369E+03
22	-0.9771E+01	0.2150E+03
23	-0.1702E+03	0.1524E+03
24	0.4838E+02	0.1083E+04
25	0.7026E+02	0.1350E+04
26	0.1357E+03	0.9710E+03
27	-0.1577E+03	0.3056E+03
28	-0.5883E+01	0.1806E+02
29	-0.6210E+01	0.1116E+03
30	-0.2992E+02	0.1662E+03
31	0.8268E+02	0.4112E+03
32	0.7623E+02	0.2155E+03
33	-0.8701E+02	0.1005E+04
34	-0.4083E+02	0.1319E+04
35	0.1403E+03	0.1351E+04
36	0.2545E+03	0.1386E+04
37	-0.3176E+01	0.4064E+01
38	0.2165E+01	0.8236E+02
39	-0.1201E+02	0.1630E+03
40	-0.7017E+02	0.2847E+03
41	0.5903E+02	0.3464E+03
42	-0.1561E+03	0.9260E+03
43	-0.7155E+02	0.1109E+04
44	0.3777E+02	0.1454E+04
45	0.1038E+03	0.1799E+04
46	-0.9560E+01	0.4214E+01
47	-0.8863E+01	0.1422E+03
48	0.1388E+02	0.8322E+03
49	0.2516E+03	0.9789E+03
50	-0.5933E+02	0.2200E+03
51	-0.1413E+03	0.9381E+03
52	-0.7761E+02	0.1061E+04
53	-0.7881E+02	0.1446E+04
54	-0.3813E+03	0.1644E+04
55	0.8164E+01	0.4001E+03
56	-0.1381E+02	0.5018E+03
57	0.2301E+02	0.9478E+03
58	-0.3908E+02	0.7423E+03
59	0.5653E+02	0.1100E+04
60	0.1487E+03	0.1053E+04
61	0.9618E+02	0.9978E+03
62	0.1851E+03	0.1556E+04
63	0.1032E+03	0.1464E+04
64	0.2722E+02	0.1036E+04
65	0.6083E+02	0.6810E+03
66	0.9665E+02	0.7484E+03
67	-0.2471E+02	0.1460E+03
68	-0.1522E+02	0.1609E+03
69	0.9263E+01	0.2835E+03
70	-0.4850E+02	0.1096E+03
71	-0.8252E+02	0.4684E+03
72	-0.6349E+02	0.5355E+03
73	-0.1452E+03	0.1050E+04

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 74     0.1455E+03   0.1182E+04
 75     0.6604E+02   0.1234E+04
 76     0.8557E+01   0.1382E+04
 77    -0.3898E+03   0.5716E+03
 78    -0.9078E+02   0.9341E+03
 79    -0.2531E+03   0.1325E+03
 80    -0.1501E+03   0.3377E+02
DAMPING (MARQUARDT) VALUE=  0.1000E+00
NEW DATA ERROR=  0.9227E+00

ITERATION #  3
STARTING DATA ERROR=  0.9227E+00

BLOCK    PARM. JUMP.  NEW PARMS.
  1     0.8095E+01   0.3202E+03
  2     0.4185E+02   0.4904E+03
  3     0.3043E+02   0.4771E+03
  4    -0.2674E+03   0.5215E+03
  5    -0.5976E+03   0.4867E+03
  6    -0.4510E+03   0.5877E+03
  7    -0.3695E+03   0.2545E+03
  8    -0.3456E+01   0.4490E+03
  9     0.4052E+03   0.1451E+04
 10     0.7993E+02   0.3918E+03
 11    -0.6942E+02   0.4224E+03
 12     0.1085E+03   0.5579E+03
 13    -0.7567E+02   0.6265E+03
 14     0.6462E+03   0.1504E+04
 15     0.8468E+03   0.1838E+04
 16    -0.2752E+03   0.7484E+03
 17    -0.7625E+02   0.5274E+03
 18    -0.3318E+01   0.2805E+03
 19     0.2415E+02   0.1774E+03
 20     0.1670E+02   0.1581E+03
 21     0.2464E+00   0.1371E+03
 22    -0.5735E+02   0.1576E+03
 23    -0.3626E+02   0.1162E+03
 24     0.1221E+04   0.2304E+04
 25    -0.1368E+03   0.1213E+04
 26     0.3037E+03   0.1275E+04
 27    -0.2254E+03   0.8014E+02
 28    -0.4161E+01   0.1390E+02
 29     0.1634E+02   0.1280E+03
 30    -0.6140E+01   0.1601E+03
 31     0.1279E+03   0.5391E+03
 32    -0.3369E+02   0.1818E+03
 33     0.3190E+03   0.1324E+04
 34    -0.2577E+03   0.1061E+04
 35    -0.8444E+02   0.1266E+04
 36     0.8757E+03   0.2262E+04
 37    -0.8101E-01   0.4919E+01
 38     0.1359E+02   0.9596E+02
 39    -0.1213E+02   0.1508E+03
 40    -0.1770E+03   0.1077E+03
 41     0.5995E+02   0.4064E+03
 42    -0.8611E+03   0.6485E+02
 43    -0.2611E+03   0.8481E+03
 44    -0.5976E+03   0.8563E+03
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45	-0.1075E+04	0.7233E+03
46	0.2839E-01	0.5028E+01
47	-0.4621E+02	0.9600E+02
48	-0.2276E+03	0.6046E+03
49	0.6465E+03	0.1625E+04
50	-0.1130E+03	0.1070E+03
51	-0.6026E+03	0.3355E+03
52	0.1244E+03	0.1185E+04
53	-0.5284E+03	0.9179E+03
54	0.1250E+03	0.1769E+04
55	0.2305E+03	0.6305E+03
56	0.1244E+03	0.6262E+03
57	0.1682E+03	0.1116E+04
58	0.2387E+03	0.9810E+03
59	0.8880E+02	0.1189E+04
60	0.4844E+03	0.1538E+04
61	0.6293E+03	0.1627E+04
62	0.6184E+03	0.2174E+04
63	0.4935E+03	0.1958E+04
64	0.4263E+03	0.1463E+04
65	0.5712E+03	0.1252E+04
66	0.4896E+03	0.1238E+04
67	0.3975E+03	0.5436E+03
68	0.1850E+02	0.1794E+03
69	0.2197E+03	0.5033E+03
70	-0.4070E+02	0.6886E+02
71	-0.1714E+03	0.2970E+03
72	-0.1557E+03	0.3799E+03
73	-0.1864E+03	0.8640E+03
74	-0.4430E+03	0.7388E+03
75	0.1107E+02	0.1246E+04
76	-0.2250E+03	0.1157E+04
77	-0.3425E+03	0.2292E+03
78	-0.3105E+03	0.6236E+03
79	-0.1521E+02	0.1173E+03
80	-0.1423E+02	0.1954E+02

DAMPING (MARQUARDT) VALUE= 0.1000E-01
NEW DATA ERROR= 0.1799E+01

BLOCK	PARM. JUMP.	NEW PARMS.
1	0.3063E+01	0.3152E+03
2	0.2053E+02	0.4691E+03
3	0.2996E+02	0.4767E+03
4	-0.4761E+02	0.7413E+03
5	-0.4109E+02	0.1043E+04
6	0.7346E+02	0.1112E+04
7	-0.1020E+03	0.5220E+03
8	0.4823E+01	0.4573E+03
9	0.1484E+03	0.1195E+04
10	0.2571E+02	0.3376E+03
11	-0.5100E+02	0.4408E+03
12	0.1239E+02	0.4618E+03
13	-0.3273E+02	0.6694E+03
14	0.1672E+03	0.1025E+04
15	0.2859E+03	0.1277E+04
16	0.6247E+02	0.1086E+04
17	-0.5391E+02	0.5498E+03
18	0.3139E+02	0.3152E+03

19	0.3452E+01	0.1567E+03
20	0.1035E+02	0.1518E+03
21	0.3542E+01	0.1404E+03
22	-0.1988E+02	0.1951E+03
23	0.4529E-01	0.1525E+03
24	0.2433E+03	0.1326E+04
25	0.9859E+01	0.1360E+04
26	0.5144E+02	0.1022E+04
27	-0.8550E+02	0.2201E+03
28	-0.4817E+01	0.1325E+02
29	0.4766E+01	0.1164E+03
30	-0.4618E+00	0.1658E+03
31	0.3152E+02	0.4427E+03
32	-0.5439E+01	0.2101E+03
33	0.9258E+02	0.1098E+04
34	-0.2304E+02	0.1296E+04
35	0.6688E+02	0.1418E+04
36	0.2913E+03	0.1678E+04
37	-0.7720E-01	0.4923E+01
38	0.4594E+01	0.8696E+02
39	0.1870E+02	0.1817E+03
40	-0.1772E+02	0.2670E+03
41	0.2408E+02	0.3705E+03
42	-0.7475E+02	0.8512E+03
43	-0.1209E+02	0.1097E+04
44	0.3522E+01	0.1457E+04
45	-0.1195E+03	0.1679E+04
46	0.3557E-01	0.5036E+01
47	0.1926E+02	0.1615E+03
48	-0.1708E+03	0.6613E+03
49	0.3444E+02	0.1013E+04
50	0.1593E+02	0.2360E+03
51	-0.5418E+02	0.8840E+03
52	0.1946E+02	0.1080E+04
53	-0.1770E+02	0.1429E+04
54	0.1124E+03	0.1756E+04
55	0.2589E+02	0.4260E+03
56	0.1388E+02	0.5157E+03
57	0.1354E+01	0.9492E+03
58	0.1056E+02	0.7529E+03
59	0.3198E+02	0.1132E+04
60	0.1080E+03	0.1161E+04
61	0.1652E+03	0.1163E+04
62	0.1670E+03	0.1723E+04
63	0.6627E+02	0.1531E+04
64	0.4560E+02	0.1082E+04
65	0.9855E+02	0.7796E+03
66	0.1710E+02	0.7655E+03
67	-0.1412E+03	0.4810E+01
68	0.1702E+01	0.1626E+03
69	0.2021E+02	0.3037E+03
70	-0.9175E+02	0.1780E+02
71	-0.1181E+03	0.3503E+03
72	-0.5699E+02	0.4785E+03
73	-0.4274E+03	0.6230E+03
74	-0.1287E+03	0.1053E+04
75	0.9401E+01	0.1244E+04
76	-0.5459E+02	0.1327E+04

77	-0.1039E+03	0.4677E+03
78	-0.1566E+03	0.7775E+03
79	-0.8960E+02	0.4291E+02
80	-0.6425E+01	0.2735E+02

DAMPING (MARQUARDT) VALUE= 0.1000E+00
NEW DATA ERROR= 0.9463E+00

BLOCK	PARM. JUMP.	NEW PARMS.
1	-0.1890E+01	0.3102E+03
2	-0.7784E+01	0.4408E+03
3	0.2151E+01	0.4488E+03
4	-0.1782E+02	0.7711E+03
5	-0.1815E+02	0.1066E+04
6	0.2974E+02	0.1068E+04
7	-0.1095E+01	0.6229E+03
8	0.2868E+01	0.4553E+03
9	0.5432E+02	0.1101E+04
10	-0.2965E+01	0.3089E+03
11	-0.3114E+02	0.4607E+03
12	-0.3427E+01	0.4460E+03
13	-0.6773E+01	0.6954E+03
14	0.4157E+02	0.8993E+03
15	0.7459E+02	0.1066E+04
16	0.5251E+02	0.1076E+04
17	0.1498E+02	0.6187E+03
18	0.1697E+02	0.3008E+03
19	-0.1426E+02	0.1390E+03
20	0.2638E+01	0.1441E+03
21	0.1909E+01	0.1388E+03
22	-0.6340E+00	0.2143E+03
23	0.8439E+01	0.1609E+03
24	0.6299E+02	0.1146E+04
25	0.2822E+02	0.1378E+04
26	0.6036E+02	0.1031E+04
27	-0.5227E+01	0.3003E+03
28	-0.2805E+01	0.1526E+02
29	-0.6244E+01	0.1054E+03
30	0.2497E+01	0.1687E+03
31	0.8746E+01	0.4199E+03
32	0.7749E+01	0.2233E+03
33	0.5037E+02	0.1056E+04
34	0.2918E+02	0.1348E+04
35	0.5920E+02	0.1410E+04
36	0.9157E+02	0.1478E+04
37	-0.8040E-01	0.4920E+01
38	-0.3005E+01	0.7936E+02
39	0.9769E+01	0.1727E+03
40	0.8706E+01	0.2934E+03
41	0.2336E+02	0.3698E+03
42	0.3289E+02	0.9589E+03
43	0.5564E+02	0.1165E+04
44	0.2681E+02	0.1481E+04
45	-0.6076E+02	0.1738E+04
46	-0.8680E-01	0.4913E+01
47	-0.1638E+02	0.1258E+03
48	-0.1790E+03	0.6532E+03
49	-0.1201E+03	0.8588E+03
50	0.1982E+02	0.2399E+03

51	0.1791E+02	0.9561E+03
52	0.4524E+02	0.1106E+04
53	-0.9487E+01	0.1437E+04
54	-0.3104E+02	0.1612E+04
55	-0.4298E+01	0.3958E+03
56	-0.2557E+01	0.4993E+03
57	-0.7106E+01	0.9407E+03
58	-0.1229E+01	0.7411E+03
59	0.8001E+01	0.1108E+04
60	0.3015E+02	0.1083E+04
61	0.4073E+02	0.1039E+04
62	0.1774E+02	0.1574E+04
63	-0.2083E+02	0.1444E+04
64	-0.3668E+01	0.1033E+04
65	-0.1074E+01	0.6799E+03
66	-0.8648E+02	0.6619E+03
67	-0.1676E+02	0.1293E+03
68	-0.2544E+01	0.1584E+03
69	-0.1819E+02	0.2653E+03
70	-0.3226E+02	0.7730E+02
71	-0.5318E+02	0.4153E+03
72	-0.2291E+02	0.5126E+03
73	-0.1399E+03	0.9105E+03
74	-0.5799E+02	0.1124E+04
75	-0.8339E+01	0.1226E+04
76	-0.4703E+02	0.1335E+04
77	-0.4901E+03	0.8157E+02
78	-0.8786E+02	0.8463E+03
79	-0.6203E+02	0.7048E+02
80	-0.2615E+02	0.7619E+01

DAMPING (MARQUARDT) VALUE= 0.1000E+01
NEW DATA ERROR= 0.8540E+00

ITERATION # 4
STARTING DATA ERROR= 0.8540E+00

BLOCK	PARM. JUMP.	NEW PARMS.
1	0.6761E+01	0.3170E+03
2	0.3015E+02	0.4710E+03
3	0.3265E+02	0.4815E+03
4	-0.2959E+02	0.7415E+03
5	-0.2424E+02	0.1042E+04
6	0.6656E+02	0.1135E+04
7	-0.1012E+03	0.5218E+03
8	0.3142E+01	0.4585E+03
9	0.1326E+03	0.1233E+04
10	0.3082E+02	0.3397E+03
11	-0.2024E+02	0.4404E+03
12	0.1402E+02	0.4600E+03
13	-0.3379E+02	0.6616E+03
14	0.1421E+03	0.1041E+04
15	0.2224E+03	0.1288E+04
16	0.3383E+02	0.1110E+04
17	-0.8329E+02	0.5354E+03
18	0.1653E+02	0.3173E+03
19	0.1616E+02	0.1551E+03
20	0.9187E+01	0.1533E+03
21	0.2176E+01	0.1410E+03

22	-0.1999E+02	0.1943E+03
23	-0.6657E+01	0.1542E+03
24	0.1570E+03	0.1303E+04
25	-0.6415E+02	0.1314E+04
26	0.2474E+02	0.1056E+04
27	-0.9194E+02	0.2084E+03
28	-0.4460E+01	0.1080E+02
29	0.9544E+01	0.1149E+03
30	-0.2417E+01	0.1663E+03
31	0.1644E+02	0.4364E+03
32	-0.1385E+02	0.2094E+03
33	0.3876E+02	0.1094E+04
34	-0.9458E+02	0.1254E+04
35	0.1607E+01	0.1412E+04
36	0.2336E+03	0.1711E+04
37	-0.1581E+00	0.4842E+01
38	0.6281E+01	0.8564E+02
39	0.3373E+01	0.1761E+03
40	-0.4556E+02	0.2478E+03
41	0.7956E+01	0.3777E+03
42	-0.1005E+03	0.8584E+03
43	-0.5087E+02	0.1114E+04
44	-0.3431E+02	0.1446E+04
45	-0.1077E+02	0.1727E+04
46	0.4020E-01	0.5040E+01
47	0.2807E+02	0.1539E+03
48	0.1805E+03	0.8337E+03
49	0.1759E+03	0.1035E+04
50	-0.2249E-01	0.2398E+03
51	-0.6594E+02	0.8901E+03
52	0.1428E+02	0.1120E+04
53	0.2408E+02	0.1461E+04
54	0.2488E+03	0.1861E+04
55	0.3411E+02	0.4299E+03
56	0.2178E+02	0.5210E+03
57	0.1724E+02	0.9579E+03
58	0.2193E+02	0.7630E+03
59	0.3724E+02	0.1146E+04
60	0.1090E+03	0.1192E+04
61	0.1788E+03	0.1217E+04
62	0.1917E+03	0.1765E+04
63	0.1187E+03	0.1562E+04
64	0.7796E+02	0.1111E+04
65	0.9867E+02	0.7786E+03
66	0.8199E+02	0.7439E+03
67	-0.1167E+03	0.1263E+02
68	0.4339E+01	0.1627E+03
69	0.4319E+02	0.3085E+03
70	-0.1260E+02	0.6469E+02
71	-0.1089E+03	0.3063E+03
72	-0.4624E+02	0.4664E+03
73	-0.4753E+03	0.4352E+03
74	-0.1211E+03	0.1003E+04
75	0.1247E+02	0.1239E+04
76	-0.2860E+02	0.1306E+04
77	-0.6198E+02	0.1959E+02
78	-0.1373E+03	0.7089E+03
79	-0.1656E+02	0.5393E+02

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 80    -0.1154E+01   0.6465E+01
DAMPING (MARQUARDT) VALUE=  0.1000E+00
NEW DATA ERROR=  0.9629E+00

BLOCK    PARM. JUMP.   NEW PARMS.
  1      0.2638E+01   0.3129E+03
  2      0.2936E+01   0.4437E+03
  3      0.9562E+01   0.4584E+03
  4     -0.4997E+01   0.7661E+03
  5     -0.1373E+02   0.1052E+04
  6      0.1386E+02   0.1082E+04
  7     -0.4135E+01   0.6188E+03
  8      0.1461E+01   0.4568E+03
  9      0.3838E+02   0.1139E+04
 10      0.5931E+01   0.3148E+03
 11     -0.1069E+02   0.4500E+03
 12      0.2000E+01   0.4480E+03
 13     -0.6118E+01   0.6892E+03
 14      0.2051E+02   0.9198E+03
 15      0.3493E+02   0.1101E+04
 16      0.2237E+02   0.1098E+04
 17      0.9676E+00   0.6196E+03
 18      0.1013E+02   0.3109E+03
 19     -0.4815E+01   0.1342E+03
 20      0.4266E+01   0.1483E+03
 21      0.1632E+01   0.1404E+03
 22     -0.2488E+01   0.2118E+03
 23      0.3298E+01   0.1642E+03
 24      0.1826E+02   0.1164E+04
 25     -0.9182E+01   0.1369E+04
 26      0.3669E+02   0.1068E+04
 27     -0.9803E+01   0.2905E+03
 28     -0.2548E+01   0.1271E+02
 29     -0.1519E+01   0.1039E+03
 30      0.3169E+01   0.1719E+03
 31      0.3266E+01   0.4232E+03
 32     -0.8954E-01   0.2232E+03
 33      0.1295E+02   0.1069E+04
 34     -0.5941E+01   0.1342E+04
 35      0.2747E+02   0.1438E+04
 36      0.6301E+02   0.1541E+04
 37     -0.1209E+00   0.4879E+01
 38      0.7680E+00   0.8013E+02
 39      0.1411E+02   0.1868E+03
 40      0.8896E+01   0.3023E+03
 41      0.1347E+02   0.3833E+03
 42      0.7245E+01   0.9661E+03
 43      0.2591E+02   0.1191E+04
 44      0.1368E+02   0.1494E+04
 45     -0.1777E+02   0.1720E+04
 46     -0.8423E-01   0.4916E+01
 47      0.4485E+00   0.1263E+03
 48     -0.3152E+02   0.6217E+03
 49     -0.2772E+02   0.8311E+03
 50      0.1646E+02   0.2563E+03
 51      0.4180E+01   0.9602E+03
 52      0.3061E+02   0.1137E+04
 53      0.1116E+02   0.1448E+04
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54	0.2106E+02	0.1634E+04
55	0.1265E+00	0.3959E+03
56	0.2952E+01	0.5022E+03
57	-0.1673E+01	0.9390E+03
58	0.1371E+01	0.7425E+03
59	0.7030E+01	0.1115E+04
60	0.2358E+02	0.1107E+04
61	0.3722E+02	0.1076E+04
62	0.2460E+02	0.1598E+04
63	-0.3964E+00	0.1443E+04
64	0.7238E+01	0.1040E+04
65	0.3813E+01	0.6838E+03
66	-0.4408E+02	0.6179E+03
67	-0.1575E+02	0.1135E+03
68	-0.1712E+00	0.1582E+03
69	-0.7060E+01	0.2583E+03
70	-0.3519E+02	0.4210E+02
71	-0.4028E+02	0.3750E+03
72	-0.1695E+02	0.4957E+03
73	-0.1350E+03	0.7755E+03
74	-0.5193E+02	0.1072E+04
75	-0.7297E+01	0.1219E+04
76	-0.3253E+02	0.1302E+04
77	-0.2507E+02	0.5650E+02
78	-0.6891E+02	0.7774E+03
79	-0.8716E+01	0.6177E+02
80	-0.4227E+01	0.3391E+01

DAMPING (MARQUARDT) VALUE= 0.1000E+01
NEW DATA ERROR= 0.8459E+00

BLOCK	PARM. JUMP.	NEW PARMS.
1	-0.2547E+01	0.3103E+03
2	-0.5688E+01	0.4381E+03
3	-0.2901E+01	0.4555E+03
4	-0.1029E+02	0.7558E+03
5	-0.1684E+02	0.1036E+04
6	-0.7335E+01	0.1075E+04
7	0.2551E+01	0.6213E+03
8	0.2733E+01	0.4595E+03
9	0.7783E+01	0.1147E+04
10	-0.4157E+01	0.3106E+03
11	-0.1007E+02	0.4399E+03
12	-0.4263E+01	0.4437E+03
13	-0.6945E+01	0.6823E+03
14	-0.4119E+01	0.9157E+03
15	-0.3162E+01	0.1098E+04
16	0.1021E+01	0.1099E+04
17	0.5248E+01	0.6249E+03
18	0.3161E+01	0.3141E+03
19	-0.3691E+01	0.1305E+03
20	-0.9977E+00	0.1473E+03
21	-0.7833E-01	0.1404E+03
22	0.3122E-01	0.2119E+03
23	0.1294E+01	0.1655E+03
24	-0.8237E+01	0.1156E+04
25	-0.1534E+02	0.1353E+04
26	0.7931E+01	0.1076E+04
27	0.1225E+01	0.2918E+03

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 28    -0.5135E+01   0.7575E+01
 29    -0.2495E+01   0.1014E+03
 30    -0.7600E+00   0.1712E+03
 31    -0.1956E+01   0.4213E+03
 32     0.1139E+01   0.2243E+03
 33    -0.7939E+01   0.1061E+04
 34    -0.1821E+02   0.1324E+04
 35    -0.9721E+01   0.1428E+04
 36    -0.4174E+01   0.1537E+04
 37    -0.1148E+00   0.4885E+01
 38    -0.2057E+01   0.7807E+02
 39    -0.3717E+00   0.1865E+03
 40    -0.9634E+00   0.3013E+03
 41     0.1745E+01   0.3850E+03
 42    -0.9540E+01   0.9566E+03
 43    -0.1267E+02   0.1178E+04
 44    -0.2499E+02   0.1469E+04
 45    -0.4270E+02   0.1677E+04
 46    -0.2400E+00   0.4760E+01
 47    -0.6346E+01   0.1199E+03
 48    -0.3481E+02   0.5869E+03
 49    -0.3750E+02   0.7936E+03
 50     0.1703E+01   0.2580E+03
 51    -0.1853E+02   0.9417E+03
 52    -0.2017E+02   0.1116E+04
 53    -0.3836E+02   0.1410E+04
 54    -0.4810E+02   0.1585E+04
 55    -0.2625E+01   0.3933E+03
 56    -0.2032E+01   0.5002E+03
 57    -0.4728E+01   0.9343E+03
 58     0.3500E+00   0.7428E+03
 59     0.6794E-01   0.1115E+04
 60     0.3570E+01   0.1111E+04
 61     0.5047E+01   0.1081E+04
 62    -0.9584E+01   0.1589E+04
 63    -0.1779E+02   0.1425E+04
 64    -0.1369E+02   0.1026E+04
 65    -0.1119E+02   0.6726E+03
 66    -0.2659E+02   0.5913E+03
 67    -0.4359E+02   0.6995E+02
 68    -0.1596E+01   0.1566E+03
 69    -0.6225E+01   0.2521E+03
 70    -0.1065E+02   0.3145E+02
 71    -0.1630E+02   0.3587E+03
 72    -0.6131E+01   0.4895E+03
 73    -0.4247E+02   0.7330E+03
 74    -0.2311E+02   0.1049E+04
 75    -0.7129E+01   0.1212E+04
 76    -0.1998E+02   0.1282E+04
 77    -0.9354E+01   0.4715E+02
 78    -0.3122E+02   0.7461E+03
 79    -0.2906E+02   0.3271E+02
 80    -0.9779E+00   0.4022E+01
DAMPING (MARQUARDT) VALUE=  0.1000E+02
NEW DATA ERROR=  0.8425E+00

ITERATION #  5
STARTING DATA ERROR=  0.8425E+00
```

BLOCK	PARM. JUMP.	NEW PARMS.
1	0.7676E+01	0.3180E+03
2	0.1067E+02	0.4487E+03
3	0.1720E+02	0.4727E+03
4	0.9361E+01	0.7652E+03
5	0.2431E+01	0.1038E+04
6	0.2206E+02	0.1097E+04
7	0.5851E+00	0.6219E+03
8	0.2630E+01	0.4622E+03
9	0.4067E+02	0.1187E+04
10	0.9323E+01	0.3200E+03
11	-0.3207E+01	0.4367E+03
12	0.5524E+01	0.4492E+03
13	-0.6647E+00	0.6816E+03
14	0.2031E+02	0.9360E+03
15	0.2898E+02	0.1127E+04
16	0.1966E+02	0.1119E+04
17	-0.5438E+01	0.6194E+03
18	0.6159E+01	0.3202E+03
19	0.8610E+00	0.1313E+03
20	0.5017E+01	0.1524E+03
21	0.1713E+01	0.1421E+03
22	-0.9317E+00	0.2109E+03
23	0.2032E+01	0.1675E+03
24	0.1012E+02	0.1166E+04
25	-0.9888E+01	0.1344E+04
26	0.3898E+02	0.1115E+04
27	-0.1185E+02	0.2799E+03
28	-0.2241E+01	0.5333E+01
29	-0.3086E+00	0.1011E+03
30	0.2255E+01	0.1734E+03
31	0.2385E+01	0.4236E+03
32	-0.1697E+01	0.2226E+03
33	0.8506E+01	0.1069E+04
34	-0.5030E+00	0.1323E+04
35	0.3375E+02	0.1462E+04
36	0.6732E+02	0.1604E+04
37	-0.2635E+00	0.4737E+01
38	0.4316E+00	0.7850E+02
39	0.1768E+02	0.2042E+03
40	0.1252E+02	0.3139E+03
41	0.1466E+02	0.3997E+03
42	0.1176E+02	0.9683E+03
43	0.3963E+02	0.1218E+04
44	0.3985E+02	0.1509E+04
45	0.3647E+02	0.1714E+04
46	-0.1080E+00	0.4892E+01
47	0.5141E+01	0.1251E+03
48	0.4196E+01	0.5910E+03
49	0.5764E+00	0.7942E+03
50	0.2170E+02	0.2797E+03
51	0.1955E+02	0.9612E+03
52	0.5949E+02	0.1176E+04
53	0.6278E+02	0.1472E+04
54	0.8434E+02	0.1670E+04
55	0.4821E+01	0.3981E+03
56	0.8788E+01	0.5090E+03

57	0.6254E+01	0.9406E+03
58	0.6562E+01	0.7494E+03
59	0.1018E+02	0.1126E+04
60	0.2553E+02	0.1136E+04
61	0.4447E+02	0.1125E+04
62	0.3653E+02	0.1625E+04
63	0.1641E+02	0.1442E+04
64	0.2419E+02	0.1051E+04
65	0.8900E+01	0.6815E+03
66	-0.3584E+02	0.5554E+03
67	-0.2870E+02	0.4125E+02
68	0.1029E+01	0.1576E+03
69	0.2017E+01	0.2541E+03
70	-0.7656E+01	0.2380E+02
71	-0.3685E+02	0.3218E+03
72	-0.1260E+02	0.4769E+03
73	-0.1712E+03	0.5618E+03
74	-0.5409E+02	0.9946E+03
75	-0.7079E+01	0.1205E+04
76	-0.2836E+02	0.1254E+04
77	-0.4770E+01	0.4238E+02
78	-0.7218E+02	0.6740E+03
79	-0.1856E+02	0.1415E+02
80	-0.3864E+01	0.1136E+01

DAMPING (MARQUARDT) VALUE= 0.1000E+01
NEW DATA ERROR= 0.8343E+00

BLOCK	PARM. JUMP.	NEW PARMS.
1	-0.4762E+00	0.3175E+03
2	-0.1287E+01	0.4474E+03
3	0.1021E+01	0.4737E+03
4	-0.1452E+01	0.7637E+03
5	-0.3919E+01	0.1034E+04
6	0.1300E+01	0.1098E+04
7	0.3629E+01	0.6255E+03
8	0.2402E+01	0.4646E+03
9	0.8087E+01	0.1195E+04
10	-0.1485E+01	0.3185E+03
11	-0.4296E+01	0.4324E+03
12	-0.6467E+00	0.4486E+03
13	-0.1287E+01	0.6803E+03
14	0.1012E+01	0.9370E+03
15	0.2236E+01	0.1129E+04
16	0.4913E+01	0.1124E+04
17	0.3849E+01	0.6233E+03
18	0.2087E+01	0.3223E+03
19	-0.1819E+01	0.1295E+03
20	-0.1496E+00	0.1522E+03
21	0.3513E+00	0.1424E+03
22	0.5598E+00	0.2115E+03
23	0.1027E+01	0.1685E+03
24	-0.1325E+01	0.1165E+04
25	-0.3812E+01	0.1340E+04
26	0.9075E+01	0.1124E+04
27	0.3441E+00	0.2802E+03
28	-0.4023E+01	0.1311E+01
29	-0.1370E+01	0.9970E+02
30	0.5633E-01	0.1735E+03

31	0.1810E+00	0.4238E+03
32	0.9683E+00	0.2236E+03
33	-0.1174E+01	0.1068E+04
34	-0.4815E+01	0.1319E+04
35	0.1093E+00	0.1462E+04
36	0.2733E+01	0.1607E+04
37	-0.1629E+00	0.4837E+01
38	-0.1178E+01	0.7732E+02
39	0.9877E+00	0.2051E+03
40	0.1097E+01	0.3150E+03
41	0.2740E+01	0.4024E+03
42	-0.1589E+01	0.9667E+03
43	-0.1125E+01	0.1217E+04
44	-0.6345E+01	0.1503E+04
45	-0.1252E+02	0.1701E+04
46	-0.1142E+00	0.4886E+01
47	-0.3579E+01	0.1215E+03
48	-0.1679E+02	0.5743E+03
49	-0.1756E+02	0.7766E+03
50	0.2622E+01	0.2823E+03
51	-0.5895E+01	0.9554E+03
52	-0.4331E+01	0.1172E+04
53	-0.1134E+02	0.1461E+04
54	-0.1528E+02	0.1654E+04
55	-0.7849E+00	0.3973E+03
56	0.3233E+00	0.5093E+03
57	-0.6056E+00	0.9399E+03
58	0.1433E+01	0.7508E+03
59	0.1157E+01	0.1127E+04
60	0.3724E+01	0.1140E+04
61	0.5600E+01	0.1131E+04
62	-0.2512E+01	0.1623E+04
63	-0.7896E+01	0.1434E+04
64	-0.5124E+01	0.1045E+04
65	-0.5568E+01	0.6759E+03
66	-0.1706E+02	0.5384E+03
67	-0.5407E+01	0.3585E+02
68	-0.6848E+00	0.1570E+03
69	-0.2930E+01	0.2511E+03
70	-0.1532E+02	0.8476E+01
71	-0.9701E+01	0.3121E+03
72	-0.2998E+01	0.4739E+03
73	-0.3378E+02	0.5280E+03
74	-0.1389E+02	0.9807E+03
75	-0.3759E+01	0.1201E+04
76	-0.1180E+02	0.1242E+04
77	-0.1102E+02	0.3136E+02
78	-0.2201E+02	0.6519E+03
79	-0.3960E+01	0.1019E+02
80	-0.3472E+01	0.1528E+01

DAMPING (MARQUARDT) VALUE= 0.1000E+02
NEW DATA ERROR= 0.8330E+00

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OUTPUT-PROGRAM GINDEP

	ZD(I)	+/- STD.DEV.
1	0.318E+03	0.813E+01
2	0.447E+03	0.100E+02
3	0.474E+03	0.102E+02
4	0.764E+03	0.153E+02
5	0.103E+04	0.205E+02
6	0.110E+04	0.198E+02
7	0.626E+03	0.135E+02
8	0.465E+03	0.101E+02
9	0.120E+04	0.244E+02
10	0.318E+03	0.882E+01
11	0.432E+03	0.112E+02
12	0.449E+03	0.113E+02
13	0.680E+03	0.137E+02
14	0.937E+03	0.181E+02
15	0.113E+04	0.200E+02
16	0.112E+04	0.157E+02
17	0.623E+03	0.115E+02
18	0.322E+03	0.811E+01
19	0.130E+03	0.546E+01
20	0.152E+03	0.499E+01
21	0.142E+03	0.516E+01
22	0.211E+03	0.589E+01
23	0.169E+03	0.517E+01
24	0.116E+04	0.203E+02
25	0.134E+04	0.185E+02
26	0.112E+04	0.157E+02
27	0.280E+03	0.813E+01
28	0.131E+01	0.327E+01
29	0.997E+02	0.431E+01
30	0.173E+03	0.567E+01
31	0.424E+03	0.845E+01
32	0.224E+03	0.627E+01
33	0.107E+04	0.184E+02
34	0.132E+04	0.186E+02
35	0.146E+04	0.180E+02
36	0.161E+04	0.260E+02
37	0.484E+01	0.138E+00
38	0.773E+02	0.390E+01
39	0.205E+03	0.609E+01
40	0.315E+03	0.745E+01
41	0.402E+03	0.863E+01
42	0.967E+03	0.171E+02
43	0.122E+04	0.180E+02
44	0.150E+04	0.213E+02
45	0.170E+04	0.312E+02
46	0.489E+01	0.136E+00
47	0.121E+03	0.547E+01
48	0.574E+03	0.200E+02
49	0.777E+03	0.215E+02
50	0.282E+03	0.899E+01
51	0.955E+03	0.212E+02
52	0.117E+04	0.221E+02

53	0.146E+04	0.268E+02
54	0.165E+04	0.360E+02
55	0.397E+03	0.559E+01
56	0.509E+03	0.594E+01
57	0.940E+03	0.690E+01
58	0.751E+03	0.655E+01
59	0.113E+04	0.819E+01
60	0.114E+04	0.109E+02
61	0.113E+04	0.109E+02
62	0.162E+04	0.131E+02
63	0.143E+04	0.121E+02
64	0.105E+04	0.103E+02
65	0.676E+03	0.101E+02
66	0.538E+03	0.145E+02
67	0.358E+02	0.402E+02
68	0.157E+03	0.536E+01
69	0.251E+03	0.133E+02
70	0.848E+01	0.128E+03
71	0.312E+03	0.127E+02
72	0.474E+03	0.880E+01
73	0.528E+03	0.319E+02
74	0.981E+03	0.266E+02
75	0.120E+04	0.987E+01
76	0.124E+04	0.132E+02
77	0.314E+02	0.718E+03
78	0.652E+03	0.162E+02
79	0.102E+02	0.242E+03
80	0.153E+01	0.187E+02

INPUT STD. DEV. = 0.8350E+00
CALC. DATA STD. DEV. = 0.8330E+00
NUMBER OF ITERATIONS FOR SOLUTION = 5

MODEL RESOLUTION MATRIX

I	...(I,I-2)		(I,I)		(I,I+2)...
1			0.06	0.02	0.00
2		0.06	0.06	0.03	0.01
3	0.02	0.04	0.06	0.02	0.01
4	0.04	0.07	0.05	0.02	0.01
5	0.06	0.06	0.04	0.03	0.02
6	0.04	0.04	0.04	0.05	0.03
7	0.01	0.02	0.05	0.05	0.01
8	0.01	0.02	0.05	0.01	0.00
9	0.05	0.11	0.04	-0.01	-0.01
10	0.00	0.00	0.07	0.03	0.01
11	0.00	0.06	0.06	0.03	0.01
12	0.02	0.04	0.06	0.02	0.01
13	0.03	0.06	0.05	0.02	0.01
14	0.05	0.05	0.04	0.02	0.01
15	0.05	0.05	0.03	0.02	0.02
16	0.03	0.03	0.03	0.05	0.04
17	0.01	0.01	0.04	0.07	-0.02
18	0.00	0.01	0.06	-0.01	-0.01
19	0.00	0.00	0.08	0.02	0.00
20	0.00	0.03	0.07	0.02	0.00

21		0.00	0.02	0.07	0.01	0.00	
22		0.00	0.03	0.07	0.03	0.00	
23		0.00	0.02	0.07	0.00	0.00	
24		0.13	0.27	0.03	0.02	0.01	
25		0.22	0.04	0.03	0.03	0.04	
26		0.02	0.02	0.03	0.12	-0.05	
27		0.00	0.01	0.06	-0.02	-0.01	
28		0.00	0.00	0.08	0.00	0.00	
29		0.00	0.03	0.08	0.01	0.00	
30		0.00	0.04	0.07	0.01	0.00	
31		0.02	0.08	0.05	0.04	0.01	
32		0.00	0.02	0.06	0.00	0.00	
33		0.08	0.18	0.03	0.02	0.01	
34		0.16	0.04	0.03	0.02	0.01	
35		0.03	0.03	0.03	0.02	0.06	
36		0.03	0.03	0.03	0.06	0.03	
37		0.00	0.00	0.00	0.00	0.00	
38		0.00	0.02	0.08	0.01	0.00	
39		0.00	0.05	0.07	0.01	0.00	
40		0.01	0.06	0.06	0.02	0.00	
41		0.00	0.04	0.05	0.01	0.00	
42		0.08	0.11	0.04	0.02	0.01	
43		0.10	0.04	0.03	0.02	0.01	
44		0.04	0.04	0.03	0.02	0.10	
45		0.04	0.04	0.03	0.18	0.06	
46		0.00	0.00	0.00	0.00	0.00	
47		0.00	0.05	0.07	0.01	0.00	
48		0.19	0.16	0.05	0.02	0.01	
49		0.12	0.07	0.04	0.06	0.01	
50		0.00	0.01	0.07	0.01	0.00	
51		0.04	0.15	0.04	0.02	0.01	
52		0.13	0.05	0.03	0.02	0.01	
53		0.05	0.04	0.03	0.02	0.01	
54		0.04	0.04	0.03	0.02	0.03	
55		0.00	0.00	0.06	0.02	0.00	
56		0.00	0.04	0.06	0.02	0.00	
57		0.02	0.05	0.04	0.03	0.01	
58		0.01	0.02	0.05	0.02	0.01	
59		0.01	0.05	0.04	0.03	0.02	
60		0.04	0.04	0.04	0.03	0.01	
61		0.03	0.03	0.04	0.02	0.02	
62		0.04	0.05	0.03	0.04	0.03	
63		0.03	0.02	0.03	0.04	0.03	
64		0.01	0.02	0.04	0.05	0.04	
65		0.01	0.02	0.04	0.04	0.01	
66		0.01	0.02	0.05	0.03	0.00	
67		0.01	0.05	0.07	0.00	0.00	
68		0.00	0.00	0.07	0.02	0.00	
69		0.00	0.12	0.07	0.00	0.01	
70		1.10	0.54	0.05	0.17	0.04	
71		0.03	0.00	0.04	0.02	0.00	
72		0.00	0.02	0.04	0.01	0.01	
73		0.05	0.11	0.03	0.04	0.08	
74		0.09	0.03	0.03	0.08	0.04	
75		0.01	0.01	0.03	0.02	0.00	
76		0.01	0.04	0.03	0.00	0.03	
77		0.98	0.93	0.03	1.18	0.14	
78		0.02	0.00	0.03	0.00	0.00	

79	0.00	0.14	0.04	0.03	
80	0.00	0.00	0.00		

DATA RESOLUTION MATRIX

I	...(I,I-2)		(I,I)		(I,I+2)...
1			0.09	0.05	0.03
2		0.06	0.05	0.04	0.02
3	0.04	0.04	0.05	0.03	0.02
4	0.03	0.04	0.04	0.03	0.03
5	0.03	0.03	0.04	0.04	0.02
6	0.03	0.04	0.04	0.03	0.01
7	0.03	0.04	0.03	0.02	0.01
8	0.03	0.03	0.02	0.01	0.01
9	0.02	0.02	0.02	0.02	0.02
10	0.02	0.02	0.02	0.02	0.03
11	0.01	0.02	0.03	0.03	0.03
12	0.02	0.03	0.04	0.04	0.03
13	0.02	0.04	0.05	0.04	0.03
14	0.03	0.04	0.04	0.03	0.00
15	0.04	0.04	0.04	0.00	0.00
16	0.00	0.00	0.07	0.02	0.01
17	0.00	0.05	0.03	0.02	0.01
18	0.03	0.02	0.02	0.02	0.01
19	0.02	0.02	0.02	0.02	0.01
20	0.01	0.02	0.02	0.02	0.01
21	0.01	0.02	0.02	0.01	0.01
22	0.01	0.02	0.01	0.01	0.01
23	0.01	0.01	0.01	0.01	0.01
24	0.01	0.01	0.01	0.01	0.01
25	0.01	0.01	0.01	0.01	0.02
26	0.01	0.01	0.02	0.02	0.02
27	0.01	0.02	0.03	0.03	0.03
28	0.01	0.02	0.04	0.03	0.03
29	0.02	0.03	0.04	0.03	0.00
30	0.03	0.03	0.04	0.00	0.00
31	0.00	0.00	0.05	0.02	0.01
32	0.00	0.04	0.02	0.01	0.01
33	0.02	0.02	0.01	0.01	0.01
34	0.01	0.01	0.01	0.01	0.01
35	0.01	0.01	0.02	0.01	0.01
36	0.01	0.01	0.01	0.01	0.01
37	0.01	0.01	0.01	0.01	0.00
38	0.01	0.01	0.01	0.01	0.00
39	0.01	0.01	0.01	0.01	0.01
40	0.01	0.01	0.01	0.01	0.01
41	0.01	0.01	0.01	0.01	0.01
42	0.01	0.01	0.01	0.02	0.03
43	0.01	0.01	0.02	0.04	0.04
44	0.01	0.02	0.04	0.07	0.00
45	0.02	0.05	0.09	0.00	0.00
46	0.00	0.00	0.01	0.04	0.01
47	0.00	0.02	0.06	0.03	0.01
48	0.01	0.03	0.05	0.04	0.02
49	0.02	0.04	0.04	0.04	0.02
50	0.02	0.03	0.08	0.03	0.02
51	0.02	0.06	0.04	0.04	0.03

52	0.03	0.04	0.05	0.05	0.02
53	0.02	0.04	0.08	0.04	0.00
54	0.03	0.08	0.05	0.00	0.00
55	0.05	0.04	0.01	0.00	0.01
56	0.04	0.01	0.01	0.01	0.01
57	0.00	0.01	0.01	0.01	0.02
58	0.00	0.01	0.01	0.03	0.05
59	0.01	0.01	0.04	0.08	0.00
60	0.01	0.04	0.10	0.00	0.01
61	0.00	0.00	0.01	0.03	0.01
62	0.00	0.01	0.05	0.01	0.01
63	0.00	0.03	0.03	0.03	0.01
64	0.02	0.03	0.03	0.02	0.01
65	0.01	0.02	0.05	0.02	0.01
66	0.02	0.03	0.02	0.02	0.02
67	0.02	0.03	0.03	0.04	0.02
68	0.02	0.02	0.06	0.03	0.00
69	0.02	0.06	0.04	0.00	0.00
70	0.04	0.03	0.01	0.00	0.00
71	0.03	0.01	0.00	0.01	0.01
72	0.01	0.00	0.01	0.01	0.02
73	0.00	0.01	0.01	0.02	0.03
74	0.01	0.01	0.02	0.04	0.01
75	0.01	0.03	0.05	0.01	0.03
76	0.00	0.00	0.01	0.04	0.00
77	0.00	0.01	0.08	0.01	0.01
78	0.00	0.03	0.04	0.03	0.01
79	0.03	0.04	0.04	0.02	0.01
80	0.01	0.03	0.05	0.02	0.01
81	0.02	0.04	0.02	0.01	0.02
82	0.02	0.02	0.02	0.04	0.02
83	0.01	0.02	0.06	0.03	0.00
84	0.01	0.05	0.04	0.01	0.00
85	0.03	0.03	0.01	0.01	0.01
86	0.03	0.01	0.01	0.01	0.01
87	0.01	0.01	0.01	0.01	0.01
88	0.01	0.01	0.01	0.01	0.01
89	0.01	0.01	0.01	0.02	0.01
90	0.01	0.01	0.02	0.01	0.05
91	0.00	0.00	0.00	0.02	0.01
92	0.00	0.01	0.03	0.01	0.01
93	0.01	0.04	0.06	0.05	0.01
94	0.05	0.06	0.07	0.03	0.01
95	0.03	0.06	0.06	0.03	0.01
96	0.05	0.05	0.04	0.03	0.02
97	0.03	0.04	0.04	0.03	0.01
98	0.02	0.03	0.03	0.02	0.01
99	0.02	0.03	0.02	0.01	0.01
100	0.02	0.02	0.01	0.01	0.01
101	0.02	0.01	0.01	0.01	0.01
102	0.01	0.01	0.01	0.01	0.01
103	0.01	0.01	0.01	0.01	0.02
104	0.01	0.01	0.01	0.02	0.01
105	0.01	0.01	0.02	0.01	0.05
106	0.00	0.00	0.01	0.05	0.01
107	0.00	0.01	0.08	0.02	0.02
108	0.02	0.10	0.06	0.05	0.01
109	0.10	0.06	0.06	0.01	0.01

110	0.03	0.04	0.01	0.01	0.01
111	0.04	0.01	0.02	0.02	0.03
112	0.01	0.02	0.02	0.05	0.03
113	0.01	0.02	0.08	0.06	0.01
114	0.02	0.08	0.06	0.02	0.01
115	0.05	0.05	0.02	0.02	0.01
116	0.04	0.02	0.02	0.02	0.02
117	0.02	0.02	0.02	0.02	0.02
118	0.02	0.02	0.02	0.02	0.02
119	0.02	0.02	0.02	0.03	
120	0.02	0.02	0.03		

COVARIANCE MATRIX

I	...(I,I-2)		(I,I)		(I,I+2)...
1			0.66E+02	0.39E+02	0.17E+01
2		0.39E+02	0.10E+03	0.57E+02	0.41E+02
3	0.17E+01	0.57E+02	0.10E+03	0.11E+03	0.72E+02
4	0.41E+02	0.11E+03	0.23E+03	0.26E+03	0.17E+03
5	0.72E+02	0.26E+03	0.42E+03	0.35E+03	0.15E+02
6	0.17E+03	0.35E+03	0.39E+03	0.12E+03	0.74E+01
7	0.15E+02	0.12E+03	0.18E+03	0.86E+02	0.10E+03
8	0.74E+01	0.86E+02	0.10E+03	0.16E+03	-0.60E+01
9	0.10E+03	0.16E+03	0.60E+03	-0.11E+02	-0.23E+02
10	-0.60E+01	-0.11E+02	0.78E+02	0.59E+02	0.10E+02
11	-0.23E+02	0.59E+02	0.13E+03	0.76E+02	0.46E+02
12	0.10E+02	0.76E+02	0.13E+03	0.11E+03	0.60E+02
13	0.46E+02	0.11E+03	0.19E+03	0.20E+03	0.17E+03
14	0.60E+02	0.20E+03	0.33E+03	0.34E+03	0.16E+03
15	0.17E+03	0.34E+03	0.40E+03	0.25E+03	-0.22E+02
16	0.16E+03	0.25E+03	0.25E+03	0.81E+02	0.69E+01
17	-0.22E+02	0.81E+02	0.13E+03	0.54E+02	-0.54E+01
18	0.69E+01	0.54E+02	0.66E+02	-0.21E+01	-0.15E+01
19	-0.54E+01	-0.21E+01	0.30E+02	0.74E+01	-0.14E+01
20	-0.15E+01	0.74E+01	0.25E+02	0.48E+01	-0.17E+01
21	-0.14E+01	0.48E+01	0.27E+02	0.68E+01	-0.28E+01
22	-0.17E+01	0.68E+01	0.35E+02	0.75E+01	0.43E+02
23	-0.28E+01	0.75E+01	0.27E+02	0.77E+02	0.55E+02
24	0.43E+02	0.77E+02	0.41E+03	0.34E+03	0.32E+02
25	0.55E+02	0.34E+03	0.34E+03	0.12E+03	-0.15E+01
26	0.32E+02	0.12E+03	0.25E+03	0.83E+02	-0.59E+01
27	-0.15E+01	0.83E+02	0.66E+02	-0.21E+01	-0.23E+01
28	-0.59E+01	-0.21E+01	0.11E+02	0.34E+01	-0.43E+00
29	-0.23E+01	0.34E+01	0.19E+02	0.68E+01	0.23E+01
30	-0.43E+00	0.68E+01	0.32E+02	0.24E+02	-0.32E+01
31	0.23E+01	0.24E+02	0.71E+02	0.20E+02	0.74E+02
32	-0.32E+01	0.20E+02	0.39E+02	0.76E+02	0.55E+02
33	0.74E+02	0.76E+02	0.34E+03	0.31E+03	0.16E+03
34	0.55E+02	0.31E+03	0.35E+03	0.25E+03	0.19E+03
35	0.16E+03	0.25E+03	0.32E+03	0.42E+03	0.30E+00
36	0.19E+03	0.42E+03	0.68E+03	0.31E+00	0.41E+01
37	0.30E+00	0.31E+00	0.19E-01	0.74E-01	-0.43E-01
38	0.41E+01	0.74E-01	0.15E+02	0.80E+01	-0.74E+00
39	-0.43E-01	0.80E+01	0.37E+02	0.17E+02	-0.34E+01
40	-0.74E+00	0.17E+02	0.56E+02	0.27E+02	0.35E+02
41	-0.34E+01	0.27E+02	0.75E+02	0.11E+03	0.77E+02
42	0.35E+02	0.11E+03	0.29E+03	0.28E+03	0.19E+03

43	0.77E+02	0.28E+03	0.32E+03	0.30E+03	0.28E+03
44	0.19E+03	0.30E+03	0.45E+03	0.61E+03	0.49E+00
45	0.28E+03	0.61E+03	0.97E+03	0.88E+00	0.28E+02
46	0.49E+00	0.88E+00	0.19E-01	0.25E+00	0.96E+00
47	0.28E+02	0.25E+00	0.30E+02	0.68E+02	0.48E+02
48	0.96E+00	0.68E+02	0.40E+03	0.38E+03	-0.32E+02
49	0.48E+02	0.38E+03	0.46E+03	0.22E+02	0.24E+03
50	-0.32E+02	0.22E+02	0.81E+02	0.12E+03	0.76E+02
51	0.24E+03	0.12E+03	0.45E+03	0.42E+03	0.35E+03
52	0.76E+02	0.42E+03	0.49E+03	0.50E+03	0.47E+03
53	0.35E+03	0.50E+03	0.72E+03	0.89E+03	-0.14E+00
54	0.47E+03	0.89E+03	0.13E+04	0.31E+01	-0.25E+01
55	-0.14E+00	0.31E+01	0.31E+02	0.11E+02	0.40E+01
56	-0.25E+01	0.11E+02	0.35E+02	0.22E+02	-0.10E+01
57	0.40E+01	0.22E+02	0.48E+02	0.16E+02	0.32E+01
58	-0.10E+01	0.16E+02	0.43E+02	0.33E+02	0.17E+02
59	0.32E+01	0.33E+02	0.67E+02	0.73E+02	0.41E+02
60	0.17E+02	0.73E+02	0.12E+03	0.10E+03	0.78E+02
61	0.41E+02	0.10E+03	0.12E+03	0.11E+03	0.37E+02
62	0.78E+02	0.11E+03	0.17E+03	0.13E+03	0.58E+02
63	0.37E+02	0.13E+03	0.15E+03	0.96E+02	0.56E+02
64	0.58E+02	0.96E+02	0.11E+03	0.83E+02	0.86E+02
65	0.56E+02	0.83E+02	0.10E+03	0.90E+02	0.14E+03
66	0.86E+02	0.90E+02	0.21E+03	0.45E+03	0.13E+01
67	0.14E+03	0.45E+03	0.16E+04	0.15E+01	0.17E+02
68	0.13E+01	0.15E+01	0.29E+02	0.40E+02	0.34E+03
69	0.17E+02	0.40E+02	0.18E+03	0.12E+04	0.44E+02
70	0.34E+03	0.12E+04	0.16E+05	0.11E+04	0.21E+03
71	0.44E+02	0.11E+04	0.16E+03	0.42E+02	0.17E+03
72	0.21E+03	0.42E+02	0.77E+02	0.21E+03	0.15E+03
73	0.17E+03	0.21E+03	0.10E+04	0.79E+03	0.25E+03
74	0.15E+03	0.79E+03	0.71E+03	0.24E+03	0.25E+03
75	0.25E+03	0.24E+03	0.97E+02	0.11E+03	0.37E+04
76	0.25E+03	0.11E+03	0.17E+03	0.83E+04	0.16E+03
77	0.37E+04	0.83E+04	0.52E+06	0.11E+05	0.16E+06
78	0.16E+03	0.11E+05	0.26E+03	0.36E+04	0.25E+03
79	0.16E+06	0.36E+04	0.59E+05	0.43E+04	
80	0.25E+03	0.43E+04	0.35E+03		

CORRELATION MATRIX

I	...(I,I-2)		(I,I)		(I,I+2)...
1			1.00	0.48	0.02
2		0.48	1.00	0.56	0.26
3	0.02	0.56	1.00	0.69	0.34
4	0.26	0.69	1.00	0.84	0.55
5	0.34	0.84	1.00	0.87	0.05
6	0.55	0.87	1.00	0.46	0.04
7	0.05	0.46	1.00	0.63	0.31
8	0.04	0.63	1.00	0.67	-0.07
9	0.31	0.67	1.00	-0.05	-0.09
10	-0.07	-0.05	1.00	0.60	0.10
11	-0.09	0.60	1.00	0.60	0.30
12	0.10	0.60	1.00	0.69	0.30
13	0.30	0.69	1.00	0.81	0.61
14	0.30	0.81	1.00	0.93	0.58
15	0.61	0.93	1.00	0.79	-0.09

16	0.58	0.79	1.00	0.45	0.05	
17	-0.09	0.45	1.00	0.58	-0.09	
18	0.05	0.58	1.00	-0.05	-0.04	
19	-0.09	-0.05	1.00	0.27	-0.05	
20	-0.04	0.27	1.00	0.19	-0.06	
21	-0.05	0.19	1.00	0.22	-0.10	
22	-0.06	0.22	1.00	0.25	0.36	
23	-0.10	0.25	1.00	0.74	0.58	
24	0.36	0.74	1.00	0.91	0.10	
25	0.58	0.91	1.00	0.42	-0.01	
26	0.10	0.42	1.00	0.65	-0.11	
27	-0.01	0.65	1.00	-0.08	-0.06	
28	-0.11	-0.08	1.00	0.24	-0.02	
29	-0.06	0.24	1.00	0.28	0.06	
30	-0.02	0.28	1.00	0.50	-0.09	
31	0.06	0.50	1.00	0.37	0.47	
32	-0.09	0.37	1.00	0.66	0.47	
33	0.47	0.66	1.00	0.91	0.47	
34	0.47	0.91	1.00	0.75	0.40	
35	0.47	0.75	1.00	0.89	0.12	
36	0.40	0.89	1.00	0.09	0.04	
37	0.12	0.09	1.00	0.14	-0.05	
38	0.04	0.14	1.00	0.34	-0.03	
39	-0.05	0.34	1.00	0.38	-0.06	
40	-0.03	0.38	1.00	0.43	0.28	
41	-0.06	0.43	1.00	0.73	0.49	
42	0.28	0.73	1.00	0.90	0.52	
43	0.49	0.90	1.00	0.80	0.51	
44	0.52	0.80	1.00	0.92	0.17	
45	0.51	0.92	1.00	0.21	0.16	
46	0.17	0.21	1.00	0.34	0.35	
47	0.16	0.34	1.00	0.62	0.41	
48	0.35	0.62	1.00	0.88	-0.18	
49	0.41	0.88	1.00	0.11	0.52	
50	-0.18	0.11	1.00	0.62	0.38	
51	0.52	0.62	1.00	0.90	0.61	
52	0.38	0.90	1.00	0.84	0.59	
53	0.61	0.84	1.00	0.93	0.00	
54	0.59	0.93	1.00	0.02	-0.01	
55	0.00	0.02	1.00	0.33	0.10	
56	-0.01	0.33	1.00	0.54	-0.03	
57	0.10	0.54	1.00	0.35	0.06	
58	-0.03	0.35	1.00	0.62	0.23	
59	0.06	0.62	1.00	0.81	0.46	
60	0.23	0.81	1.00	0.85	0.54	
61	0.46	0.85	1.00	0.74	0.28	
62	0.54	0.74	1.00	0.84	0.43	
63	0.28	0.84	1.00	0.77	0.46	
64	0.43	0.77	1.00	0.79	0.58	
65	0.46	0.79	1.00	0.61	0.34	
66	0.58	0.61	1.00	0.78	0.02	
67	0.34	0.78	1.00	0.01	0.03	
68	0.02	0.01	1.00	0.57	0.50	
69	0.03	0.57	1.00	0.73	0.26	
70	0.50	0.73	1.00	0.68	0.19	
71	0.26	0.68	1.00	0.38	0.43	
72	0.19	0.38	1.00	0.75	0.66	
73	0.43	0.75	1.00	0.93	0.81	

74		0.66	0.93	1.00	0.93	0.71
75		0.81	0.93	1.00	0.83	0.53
76		0.71	0.83	1.00	0.87	0.74
77		0.53	0.87	1.00	0.95	0.89
78		0.74	0.95	1.00	0.92	0.84
79		0.89	0.92	1.00	0.96	
80		0.84	0.96	1.00		

F

GRAVITY MODEL RESULTING FROM PROGRAM GINDEP

BLOCK	XL	XR	ZU	ZD	YMIN	YMAX	DEN
1	0.0	500.0	0.0	317.0	0.0	400.0	-0.5
2	500.0	1000.0	0.0	447.0	0.0	400.0	-0.5
3	1000.0	1500.0	0.0	474.0	0.0	400.0	-0.5
4	1500.0	2000.0	0.0	764.0	0.0	400.0	-0.5
5	2000.0	2500.0	0.0	1034.0	0.0	400.0	-0.5
6	2500.0	3000.0	0.0	1098.0	0.0	400.0	-0.5
7	3000.0	3500.0	0.0	626.0	0.0	400.0	-0.5
8	3500.0	4000.0	0.0	465.0	0.0	400.0	-0.5
9	4000.0	4500.0	0.0	1195.0	0.0	400.0	-0.5
10	0.0	500.0	0.0	318.0	400.0	800.0	-0.5
11	500.0	1000.0	0.0	433.0	400.0	800.0	-0.5
12	1000.0	1500.0	0.0	449.0	400.0	800.0	-0.5
13	1500.0	2000.0	0.0	681.0	400.0	800.0	-0.5
14	2000.0	2500.0	0.0	937.0	400.0	800.0	-0.5
15	2500.0	3000.0	0.0	1130.0	400.0	800.0	-0.5
16	3000.0	3500.0	0.0	1124.0	400.0	800.0	-0.5
17	3500.0	4000.0	0.0	633.0	400.0	800.0	-0.5
18	4000.0	4500.0	0.0	322.0	400.0	800.0	-0.5
19	0.0	500.0	0.0	130.0	800.0	1200.0	-0.5
20	500.0	1000.0	0.0	152.0	800.0	1200.0	-0.5
21	1000.0	1500.0	0.0	142.0	800.0	1200.0	-0.5
22	1500.0	2000.0	0.0	212.0	800.0	1200.0	-0.5
23	2000.0	2500.0	0.0	169.0	800.0	1200.0	-0.5
24	2500.0	3000.0	0.0	1165.0	800.0	1200.0	-0.5
25	3000.0	3500.0	0.0	1340.0	800.0	1200.0	-0.5
26	3500.0	4000.0	0.0	1124.0	800.0	1200.0	-0.5
27	4000.0	4500.0	0.0	280.0	800.0	1200.0	-0.5
28	0.0	500.0	0.0	1.0	1200.0	1600.0	-0.5
29	500.0	1000.0	0.0	100.0	1200.0	1600.0	-0.5
30	1000.0	1500.0	0.0	174.0	1200.0	1600.0	-0.5
31	1500.0	2000.0	0.0	423.0	1200.0	1600.0	-0.5
32	2000.0	2500.0	0.0	224.0	1200.0	1600.0	-0.5
33	2500.0	3000.0	0.0	1068.0	1200.0	1600.0	-0.5
34	3000.0	3500.0	0.0	1319.0	1200.0	1600.0	-0.5
35	3500.0	4000.0	0.0	1462.0	1200.0	1600.0	-0.5
36	4000.0	4500.0	0.0	1607.0	1200.0	1600.0	-0.5
37	0.0	500.0	0.0	5.0	1600.0	2000.0	-0.5
38	500.0	1000.0	0.0	79.0	1600.0	2000.0	-0.5
39	1000.0	1500.0	0.0	205.0	1600.0	2000.0	-0.5
40	1500.0	2000.0	0.0	315.0	1600.0	2000.0	-0.5
41	2000.0	2500.0	0.0	402.0	1600.0	2000.0	-0.5
42	2500.0	3000.0	0.0	967.0	1600.0	2000.0	-0.5
43	3000.0	3500.0	0.0	1217.0	1600.0	2000.0	-0.5
44	3500.0	4000.0	0.0	1503.0	1600.0	2000.0	-0.5
45	4000.0	4500.0	0.0	1701.0	1600.0	2000.0	-0.5
46	0.0	500.0	0.0	5.0	2000.0	2400.0	-0.5
47	500.0	1000.0	0.0	122.0	2000.0	2400.0	-0.5
48	1000.0	1500.0	0.0	574.0	2000.0	2400.0	-0.5
49	1500.0	2000.0	0.0	777.0	2000.0	2400.0	-0.5
50	2000.0	2500.0	0.0	282.0	2000.0	2400.0	-0.5
51	2500.0	3000.0	0.0	955.0	2000.0	2400.0	-0.5
52	3000.0	3500.0	0.0	1172.0	2000.0	2400.0	-0.5
53	3500.0	4000.0	0.0	1461.0	2000.0	2400.0	-0.5
54	4000.0	4500.0	0.0	1654.0	2000.0	2400.0	-0.5
55	0.0	1000.0	0.0	397.0	-800.0	0.0	-0.5
56	1000.0	2000.0	0.0	509.0	-800.0	0.0	-0.5

57	2000.0	3000.0	0.0	940.0	-800.0	0.0	-0.5
58	3000.0	4000.0	0.0	751.0	-800.0	0.0	-0.5
59	4000.0	5500.0	0.0	1127.0	-800.0	0.0	-0.5
60	4500.0	5500.0	0.0	1140.0	0.0	800.0	-0.5
61	4500.0	5500.0	0.0	1131.0	800.0	1600.0	-0.5
62	4500.0	5500.0	0.0	1623.0	1600.0	2400.0	-0.5
63	4000.0	5500.0	0.0	1434.0	2400.0	3200.0	-0.5
64	3000.0	4000.0	0.0	1045.0	2400.0	3200.0	-0.5
65	2000.0	3000.0	0.0	676.0	2400.0	3200.0	-0.5
66	1000.0	2000.0	0.0	538.0	2400.0	3200.0	-0.5
67	0.0	1000.0	0.0	359.0	2400.0	3200.0	-0.5
68	-1000.0	0.0	0.0	157.0	0.0	800.0	-0.5
69	-1000.0	0.0	0.0	251.0	-800.0	0.0	-0.5
70	-1000.0	1000.0	0.0	8.0	-2400.0	-800.0	-0.5
71	1000.0	3000.0	0.0	312.0	-2400.0	-800.0	-0.5
72	3000.0	5500.0	0.0	474.0	-2400.0	-800.0	-0.5
73	5500.0	7500.0	0.0	528.0	-2400.0	-800.0	-0.5
74	5500.0	7500.0	0.0	980.0	-800.0	0.0	-0.5
75	5500.0	7500.0	0.0	1201.0	0.0	1600.0	-0.5
76	5500.0	7500.0	0.0	1242.0	1600.0	3200.0	-0.5
77	5500.0	7500.0	0.0	31.0	3200.0	4600.0	-0.5
78	3000.0	5500.0	0.0	651.0	3200.0	4600.0	-0.5
79	1000.0	3000.0	0.0	10.0	3200.0	4600.0	-0.5
80	-1000.0	1000.0	0.0	2.0	3200.0	4600.0	-0.5

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GRAVITY MODEL RESULTS USING THE MODEL RESULTING FROM PROGRAM GINDEP - COMPARE THESE RESULTS WITH THE REDUCED GRIDDED OBSERVED DATA CONTAINED IN PART D OF APPENDIX D

0.0000	0.0000	-5.8740
307.3571	0.0000	-7.0459
614.7143	0.0000	-7.9690
922.0715	0.0000	-8.8553
1229.4286	0.0000	-9.8378
1536.7858	0.0000	-10.9447
1844.1429	0.0000	-12.1266
2151.5000	0.0000	-13.2644
2458.8572	0.0000	-14.1541
2766.2144	0.0000	-14.6827
3073.5715	0.0000	-14.8982
3380.9287	0.0000	-14.9224
3688.2859	0.0000	-15.1024
3995.6428	0.0000	-15.5397
4303.0000	0.0000	-16.1702
0.0000	301.1429	-5.4494
307.3574	301.1429	-6.7881
614.7144	301.1429	-7.8344
922.0718	301.1429	-8.7737
1229.4287	301.1429	-9.7521
1536.7861	301.1429	-10.9729
1844.1431	301.1429	-12.2527
2151.5005	301.1429	-13.4486
2458.8574	301.1429	-14.4725
2766.2148	301.1429	-15.1894
3073.5718	301.1429	-15.5249
3380.9287	301.1429	-15.5128
3688.2856	301.1429	-15.5607
3995.6431	301.1429	-15.7898
4303.0005	301.1429	-16.3271
0.0000	602.2857	-4.9503
307.3574	602.2857	-6.2159
614.7148	602.2857	-7.1967
922.0723	602.2857	-8.0655
1229.4287	602.2857	-8.9996
1536.7861	602.2857	-10.2186
1844.1436	602.2857	-11.5176
2151.5010	602.2857	-12.7877
2458.8574	602.2857	-14.1458
2766.2148	602.2857	-15.3385
3073.5723	602.2857	-15.9946
3380.9287	602.2857	-16.1884
3688.2861	602.2857	-16.1734
3995.6436	602.2857	-16.0446
4303.0010	602.2857	-16.3169
0.0000	903.4286	-3.1602
307.3574	903.4286	-4.7537
614.7148	903.4286	-5.6335
922.0723	903.4286	-6.4016
1229.4287	903.4286	-7.2627
1536.7861	903.4286	-8.6379
1844.1436	903.4286	-10.0039
2151.5000	903.4286	-11.1832
2458.8574	903.4286	-13.1592
2766.2139	903.4286	-15.3021
3073.5713	903.4286	-16.3761
3380.9287	903.4286	-16.8767
3688.2861	903.4286	-16.9391

3995.6436	903.4286	-16.6535
4303.0010	903.4286	-16.7412
0.0000	1204.5714	-1.9483
307.3574	1204.5714	-2.9391
614.7148	1204.5714	-4.3366
922.0723	1204.5714	-5.2510
1229.4297	1204.5714	-6.4444
1536.7871	1204.5714	-8.0158
1844.1445	1204.5714	-9.4425
2151.5020	1204.5714	-10.5078
2458.8574	1204.5714	-12.6557
2766.2148	1204.5714	-15.1534
3073.5723	1204.5714	-16.6148
3380.9297	1204.5714	-17.3890
3688.2871	1204.5714	-17.7050
3995.6445	1204.5714	-17.6635
4303.0020	1204.5714	-17.7936
0.0000	1505.7142	-1.2910
307.3574	1505.7142	-1.8008
614.7148	1505.7142	-3.6760
922.0723	1505.7142	-4.8477
1229.4297	1505.7142	-6.4975
1536.7871	1505.7142	-8.2038
1844.1445	1505.7142	-9.6740
2151.5000	1505.7142	-10.7895
2458.8574	1505.7142	-12.7986
2766.2148	1505.7142	-15.1373
3073.5723	1505.7142	-16.7176
3380.9297	1505.7142	-17.6990
3688.2871	1505.7142	-18.2715
3995.6445	1505.7142	-18.5825
4303.0000	1505.7142	-18.8564
0.0000	1806.8572	-1.2738
307.3574	1806.8572	-1.8190
614.7148	1806.8572	-3.5592
922.0723	1806.8572	-4.9820
1229.4297	1806.8572	-7.0657
1536.7871	1806.8572	-8.6319
1844.1445	1806.8572	-9.9561
2151.5000	1806.8572	-11.2059
2458.8574	1806.8572	-13.0187
2766.2148	1806.8572	-15.0599
3073.5723	1806.8572	-16.6313
3380.9297	1806.8572	-17.7198
3688.2871	1806.8572	-18.4659
3995.6445	1806.8572	-18.9664
4303.0000	1806.8572	-19.3214
0.0000	2108.0000	-1.4570
307.3574	2108.0000	-2.1694
614.7148	2108.0000	-4.2976
922.0703	2108.0000	-5.9754
1229.4297	2108.0000	-8.1765
1536.7852	2108.0000	-9.5257
1844.1445	2108.0000	-10.4687
2151.5000	2108.0000	-11.3290
2458.8594	2108.0000	-12.8944
2766.2148	2108.0000	-14.8028
3073.5703	2108.0000	-16.3243

3380.9297	2108.0000	-17.4607
3688.2852	2108.0000	-18.3123
3995.6445	2108.0000	-18.8927
4303.0000	2108.0000	-19.2907