DRAFT

CONSTRAINED ADJUSTMENT GUIDELINES

Last Update: 1/22/2009

INTRODUCTION

The following instructions provide a guide to submitting GPS projects to the National Geodetic Survey (NGS). Read the guidelines thoroughly before beginning your project. With experience, you may revise the order of procedures from what is presented here. If you see any procedures consistently incorrect, notify Julie Prusky at *julie.prusky@noaa.gov*.

References to “GPS” will be revised to “GNSS” as other satellite constellations become viable and NGS develops procedures to handle the additional data types.

Description of Terminology

The following terminology will be used throughout this document:

A-file - Adjustment constraints and processing options
B-file - Data from field observation logs; equipment codes; station designations, positions, heights and related codes
D-file - Station descriptions and recovery notes
dfile - Doppler information (unused; retained only because of a prompt in Adjust)

G-file - Processed GPS vectors and statistics
IDB – National Geodetic Survey Integrated Data Base
NAD 83 – North American Datum of 1983
NAVD 88 – North American Vertical Datum of 1988
NGVD 29 – National Geodetic Vertical Datum of 1929
NSRS2007 – National Spatial Reference System of 2007
Serfil – Station-specific 4-character identifier and 4-digit serial number list
Bluebook – Federal Geodetic Control Subcommittee document "Input Formats and Specifications of the National Geodetic Survey Data Base", http://www.ngs.noaa.gov/FGCS/BlueBook/ -- its various chapters and annexes.

SECTION 1

GATHER MATERIAL FOR THE PROJECT

I. Necessary items for submission to NGS will include:
(See Annex_L http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_L.pdf for details)

Project report (see Appendix C)
NGS Approved Project Proposal
Project Sketch
Project Instructions or Contract Specifications
Final Station List
Final Observing Schedule
Station Visibility Diagrams
Observation Logs
Equipment Failure Logs (NGS Projects)
Loop Misclosures (optional, seldom used)
Initial Free Adjustment with Analysis
Constrained Horizontal Adjustment
Constrained Vertical Adjustment
Final Free Adjustment with Accuracies
Meteorological Instrument Comparison Logs (if specified)
Photographs of Views from Stations (if specified)
Photographs (digital) or Rubbings of Station Marks
CHKOBS Output (Checking Program - B-file)
COMPGB Output (Checking Program - B/G-files)
OBSCHK Output (Checking Program - B/G-files)
OBSDES Output (Checking Program - B/D-files)
CHKDESC Output (Checking Program - D-file)
NEIGHBOR Output (Checking Program – D-file)
DISCREP Output (Checking Program – D-file)
ELLACC Output (Ellipsoid height accuracies)
BBACCUR2 Output (Internal and external horizontal accuracies)
Raw Phase Data (R-files, digital)
Base Line Vectors (G-file, digital)
Project and Station Occupation Data (final B-file, digital)
Descriptions and Recovery Notes (D-file, digital)

All items above which are not listed as digital may be submitted as digital and are preferred this way, such as Adjust and checking program output and scanned field logs.

II. Keeping a project log is recommended for analyzing the project and preparing the final report. For example, list station names, whether a station was new or

recovered, and whether it was fixed, readjusted, or new. Note bench marks on the station list. Also note any unusual situations or procedures.

III. The project report should include any problems mentioned in the field report, especially those which affected the adjustment or analysis. Review the output of the format checking programs, adhering to the discussion in Section 2 of allowed error messages. Verify that the final positions and heights submitted have the correct adjusted values, and that the files are free of format errors.

IV. Verify that the Solution Coordinate Reference System Code in columns (cc) 52-53 of the G-file B Records matches the ephemeris header record. This code represents the reference system of the orbits used to reduce the vectors. Solution coordinate system codes are listed in Bluebook Annex N , http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_N.pdf.

V. If the project is in an area known for significant crustal motion such as California, Arizona, Oregon, Washington, Wyoming or southern Alaska, determine the epoch required for the final positions. Use program HTDP to update the observations and positions to the correct epoch.

VI. Attachment 1 is a condensed step-by-step outline for running the programs and analysis described below. It provides suggested file names for the various steps until one gains experience and may prefer other names.

SECTION 2

PRELIMINARY PROCESSING

Examine the B-file for obvious errors requiring correction. Verify the organization abbreviation in cc 19-24 of the first record against the corresponding entry in the contrib.dat file for the submitting organization. New organization abbreviations (contributor codes) can be requested from *Burt.Smith@noaa.gov*.

Perform the following series of checks:

I. Run CHKOBS on the B-file and COMPGB and OBSCHK on the B- and G-files. It is recommended to delete *86* records, if they exist, to avoid excessive error messages, adding them back in by running MAKE86 after the checking programs have been run. Resolve messages not related to *86* record codes and note the resolutions in the project report.

In CHKOBS and OBSCHK, error messages are generated for "0" antenna heights. **Only if** these messages refer to CORS can they be construed as warnings and ignored; other stations in the project should not have 0 antenna heights. NOTE: This message is the only allowed error message in OBSCHK which need not be resolved before submittal to NGS; any other OBSCHK error message prevents loading of the data in the IDB. Note also, the ARP height and the L-1 phase center height for a station occupation, should not be the same value if both exist in the B-file.

II. Verify and change, if necessary, the 4-digit station serial numbers (SSN's) in the D-file to match the B- and G-files. Make sure the full station names in the D-file and *80* records of the B-file are correct and match (e.g. do not use 4-character IDs for station names in the B-file). Run OBSDES and CHKDESC (see below) and resolve error messages and inconsistencies.

A description or recovery note should NOT be submitted for CORS currently published by NGS. Therefore, messages about missing descriptions for these CORS

are allowed in the OBSDES output. CORS which are expected to be published by NGS should have a minimal description for the purpose of assigning a permanent identifier (PID) in the IDB.

III. Currently, WINDESC (http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml#WinDesc) is the recommended program for creating D-files. It uses a proprietary file type *.des which must be converted to D-file *.dsc. After creation of the D-file, NEIGHBOR and DISCREP must be run from WINDESC Tools, then WINDESC Check must be run. NEIGHBOR and DISCREP access the IDB to check for stations not assigned a PID but which might be already in the IDB (NEIGHBOR) and any code mismatches between the IDB and the recovery notes (DISCREP). CHKDESC does a format and information check on the D-file. WINDESC Check 'ERROR' messages are not allowed and **MUST** be corrected--the loading programs will not accept a D-file which resulted in even one error message. 'WARNING' messages should be checked, and corrected if appropriate.

Special note: At this time, NGS is changing to a new description loading program; as part of this process, issues with errors resulting from codes already in the IDB which are not currently acceptable are also under review. (Such codes result from preparing the recovery notes from currently published data sheets). NGS asks for your assistance in correcting these errors. Until these issues are resolved, files containing 'ERRORS' as flagged by the description checking program in WINDESC are prevented from loading by the program. The D-file should be corrected to conform to current acceptable codes as noted in the checking program output. After completion of the analysis and changes resulting from the output of these programs, export the *.des file to *.dsc inside WINDESC (File->Export->D-file) for submission to NGS.

NOTE: If excessive errors are found during the review of a project, the files will be returned for corrections to the submitting agency.

After a checking program has identified errors and these have been corrected, run the checking program again to confirm that the needed corrections occurred with no new errors. Run the checking programs on the final files to assure that all applicable codes have been added.

SECTION 3

DETERMINE CONTROL

I. Determine which horizontal and vertical datums will control the adjustment and note them in the project report. Currently only NAD 83 (NSRS2007) and NAVD 88 are the only datums allowed in the contiguous US; the use of any other datums must be cleared with the Director of NGS. Outside the contiguous US, check the data sheets in the area to determine valid datums. See also http://www.ngs.noaa.gov/INFO/incorp_data.shtml

II. If the B-file does not contain *86* records, run MAKE86, which creates a new output B-file to use as input to the GEOID program and adjustments.

III. Retrieve a file of datasheets for the existing marks in the project. Ensure that all published positions, ellipsoid heights and orthometric heights used [constrained] in the project match the values currently published on the data sheets.

IV. Research orthometric heights. If adequate NAVD 88 vertical control exists, use only that control in the vertical adjustment. Acceptable heights include

bench marks and stations with heights determined by a height modernization project as noted on the data sheet. Usually, 3-4 are considered sufficient for a non height modernization or non airport project. If insufficient NAVD 88 control exists, determine whether there are NGVD 29 control points that can be transformed to NAVD 88 using VERTCON. (The *86* record for the transformed stations should have a "D" in the orthometric height code field.) Document such stations in the project report. Verify height codes for all stations per *86* record formats in Bluebook Chapter 2, http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Chapter2.pdf).

Constrained leveled heights may be of several types, per the *86* record Table of orthometric height codes. The most common such codes are A, B and L.

If the field crew leveled from a known bench mark, the leveled height (generally code L) can be used for control subject to consistency with other bench mark heights in the project. Discuss any such leveling in the project report.

In rare situations, it may be desirable to add leveled differences of elevation to the IDB for documentation purposes. This is achieved by including *45* and *47* records in the B-file. In order to load any such leveling observations in the IDB, *80* series records must exist in the B-file for both ends of the line. If neither the standpoint nor forepoint is positioned, do not include the *45* and *47* records. If one end of the line is unpositioned, add a *82* record for the point, coding it as if it were a peripheral point for the positioned end of the line. However, ADJUST does not recognize these records in the B-file. In order for these leveling differences to participate in the adjustment, code a CH record for them in the A-file (See adjust_suppl52 in the adjustment toolkit.)

Orthometric heights determined by GPS observations and a geoid model should have one of three codes: ‘K’ (restricted to height-modernization projects, published to cm), “G” (for regular GPS projects, generally published to dm, and FAA projects published to cm) or “J” (when the GPS height is only published to a meter--as in Alaska for some projects). Airport stations designated as PACS and SACS are published to cm in order to maintain the required differential relationship between the stations. Therefore, “G” would be the correct code unless other circumstances exist (e.g. the station is a bench mark).

Leveling to be included in the IDB should be discussed with NGS. Contact Vasanthi Kammula: *Vasanthi.Kammula@noaa.gov*.

V. Make certain that station names in the *80* records match the naming conventions per Bluebook Annex D, (e.g. remove dates and agency abbreviations) (and those used in the description file). If a change from a published name is needed, include the changed designation in the B-file and note it in the project report. Optional but helpful for analysis: Sort the *80* records alphabetically and assign SSNs accordingly, possibly grouping CORS together at the end. Follow each *80* record with its associated *86* record, one pair for each SSN (MAKE86 does this automatically).

VI. Assign identical order and type codes (*80* record cc 79-80) for all marks in the project. Use the intended order of the project as the order in cc 79 (either A, B or 1) and A as the type in cc 80 (meaning satellite relative positioning). For recovered stations, the order will be what the project requires, not what is published. Higher-order stations will retain their present order in the IDB; lower-order stations will be upgraded in the IDB. Thus, an A-order station in a B-order project would be coded B for the project, but would remain A in the IDB; a 1st-order station would be coded B and be upgraded to B in the IDB.

Document in the project report any stations published as a lower order than the project but which were used for control and will therefore be upgraded.

No processing changes have been implemented due to the publication of the local and network accuracies. Future changes are possible.

See Bluebook Annex E, (http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_E.pdf) and Bluebook Chapter 2, (http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Chapter2.pdf), pp 35-38 for further discussion of station order and type.

SECTION 4

MINIMALLY CONSTRAINED (FREE) ADJUSTMENT

I. Run ADJUST in 3D with minimum constraints. Constrain only one station position and ellipsoid height per component. (Multiple components occur in rare cases when disjointed networks are combined in one adjustment.)

II. Attempt to resolve large residuals by identifying and correcting blunders and/or reprocessing with options such as raising the elevation mask and deleting a noisy satellite. With blunders corrected and reprocessing options exhausted, reject observations which continue to have a high residual (usually anything over 4 cm). Do not, however, allow rejections to result in a no-check station (only one observation to it). Remaining large residuals may indicate the need for additional observations. Large residuals in the UP component may indicate an antenna height error in the fieldwork or vector reduction process. (Also see Section 8.1.A.)

Do not run MODGEE--it is no longer used to scale projects. Scale factors will be applied to all projects by NGS as part of general readjustments designed to compute local and network accuracies.

Run all adjustments in mode 3 (normalized residuals). Do this by coding the MM record in the A-file as “MM3”. This mode computes residuals scaled relative to the standard deviation of the residual (normalized residuals).

Compare the output positions of published marks with the data sheet. Large shifts may indicate readjustment will be necessary.

SECTION 5

CONSTRAINED HORIZONTAL ADJUSTMENT

I. Run ADJUST holding all previously published positions and ellipsoid heights fixed. Compare the results with the free adjustment. A good rule-of-thumb is the constrained variance of unit weight (reference variance) should be no more than 3 times that of the free variance of unit weight.

II. Residuals which increased markedly from free to constrained adjustments indicate a need for specific investigation. Large residuals in the constrained run which were not in the free adjustment are the result of problems with the constraints. Do not reject any observations due to constraints. Verify that the control used is correct and on a consistent datum realization (e.g. do all positions have the (NSRS2007) datum tag?). For observations with large residuals, check for misidentifications, such as a wrong SSN. If no problems can be identified and solved, determine whether you should readjust some of the existing positions. Consider the requirements of the project. Save the adjusted

positions (output B-file) from the final constrained run. Discuss all readjusted stations in the project report in addition to any investigations and conclusions reached as a result of the analysis.

III. Run the current GEOID program to add geoid heights to the B-file *86* records if this step has not already been done.

SECTION 6

VERTICAL ADJUSTMENTS (FREE AND CONSTRAINED)

I. Run ADJUST with minimum constraints. Constrain one previously adjusted orthometric height and one NAD 83 adjusted position. At this point it can be helpful to compute the shifts between freely adjusted and published heights. It can be helpful to plot these shifts on a project sketch to determine if several heights near each other are shifting consistently or a height appears to be an outlier--in which case should not be used as control. For inconsistent shifts, look at the recovery notes and possibly the photograph or rubbing of the mark to see if any movement has occurred, or an unintended mark was observed, such as the underground mark instead of the surface mark or a reference mark instead of the parent station. Look for inconsistent shifts as opposed to areas where the shifts, even high shifts, are consistent. Likewise, look at the geoid heights to ensure they are consistent. If no cause for the shift can be found, the orthometric height may need to be readjusted.

II. Run ADJUST with vertical constraints. Constrain previously adjusted orthometric heights, as indicated above, and one NAD 83 adjusted position.

Investigate observations with large residuals. Apply the same rule as in the horizontal constrained adjustment: no rejections due to constraints. Free any heights in question and rerun as a test. Note the differences between the published and readjusted heights obtained from the vertically constrained adjustment. Consider the requirements of the project before deciding whether to readjust additional points.

Save the output B-file from the final constrained vertical adjustment.

III. When the constrained horizontal and vertical adjustments are complete, run ELEVUP to combine the positions and ellipsoid heights from the horizontal adjustment with the orthometric and geoid heights from the vertical adjustment into a final B-file.

SECTION 7

FINAL FREE ADJUSTMENT WITH ACCURACIES

Run a final adjustment with minimal constraints as in SECTION 4. Accuracies will be produced by ADJUST if you include QQ records in the A-file. Program QQRECORD can be used to generate the QQ records for the A-file. For multiple-order projects, you will have to edit the order on the QQ records in the A-file.

In order to compute accuracies correctly, the G-file standard errors must be treated as scaled. To do this, change cc 4 in the MM record of the A-file to "Y", i.e. scale the error propagation statistics by the a posteriori variance of unit weight.

While local and network accuracies are used to define the accuracy of stations which are part of and computed from a general NSRS readjustment, the accuracies from this final free adjustment can be used to determine that the specifications for the local project are met. Run program BBACCUR2, using the output of the final free adjustment, to create a formatted listing of all accuracies for easy analysis. Check both sets of accuracy estimates, the internal and external, to ensure the standards of the project were met. If internal accuracies do not meet the standards, then perhaps the specifications were not adhered to; verify the field procedures. If internal accuracies look good, but external accuracies are low, then perhaps a station or stations need to be readjusted. Perform test constrained adjustment(s) where the stations associated with low accuracies are freed up. Then do a test free adjustment with accuracies to see if the standards are now met. If the second adjustment is significantly better, consider the project requirements to determine which adjustment should be accepted. The report should document accuracies which still do not meet the project's specifications and the possible reasons (e.g., a short line where the setup errors are a significant and unavoidable part of the distance-dependent error).

Run ELLACC using the output of the final free adjustment with accuracies to classify the ellipsoid heights' order and class. From the listing, select the predominant classification and add it to all *86* records in columns 54-55. For example, if the majority of lines have '41' as their ellipsoid height order/class, that classification should be used for all stations in the project. Submit the ELLACC output file with the project. Confirm that the correct ellipsoid height code is used in column 53 (almost always 'A') and the correct datum in column 56 (almost always A); add these items as needed. These are discussed in Bluebook Chapter 2 under the *86* record section. If 'A' is not used, document the reason in the report. Refer to information about the ellipsoid height code in the bluebook documentation of the *86* record.

SECTION 8

POST-ADJUSTMENT PREPARATION FOR SUBMISSION

I. Prepare the B-file for submission. Most of these items will have been completed before the final adjustment, but should be double-checked at this time. Use the checklist in Appendix B.

A. Identify horizontal and vertical no-check stations in the project. In the *80* record, change cc 5 to 'N' for vertical no-checks, and cc 6 to 'N' for horizontal no-checks. A new station is no-check when all of its observations get a zero residual in the constrained adjustment. The 'N' in the observational summary is a means of identifying stations which have only one vector but this may not correctly identify a no-check station. For example, in a GPS project, a station determined by only one vector might be correlated with other vectors resulting in a non-zero residual. The observational summary will show an 'N' but unless the residuals on all components of the vector are zero, the station is checked. Document any no-check cases in the report. (See also information in Section 4 II).

B. Verify that station names conform to the bluebook naming conventions, e.g., no dates or agency abbreviations, and that a currently published stations' designation matches that on the datasheet. Bluebook Annex D http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_D.pdf discusses correct designations.

C. Check order/type codes. Determinations of upgrades or downgrades to orders should be based on the accuracy achieved as discussed in Section 3.V. It is important to document all changes in the report.

D. Check all height codes as discussed in Section 3.IV. It is important to ensure all orthometric height codes are correct as they affect future publication on the datasheet. For example, if a bench mark was not held fixed, it should not carry a leveled code (B or L) in the final B-file. Similarly a leveled height held fixed should not have a GPS code (G or K) but rather a leveled code.

E. Rerun the checking programs.

F. Verify state abbreviations in cc 77-78 of the *80* records.

G. The first record in the B-file must contain the initials of the observing organization (left-justified). This organization must be listed in 'Annex C' of the Bluebook:
http://www.ngs.noaa.gov/FGCS/BlueBook/annexc/annexc.index.html. If the organization is not listed, request an addition to the contributor table as noted in Section 2)

II. Write the project report. See Annex K and/or Annex L of the Bluebook for instructions, http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_K.pdf and http://www.ngs.noaa.gov/FGCS/BlueBook/pdf/Annex_L.pdf.

ATTACHMENT 1

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ADJUST, step by step

Dataset Files

The sample files included in this package may be used to practice or test the Adjustment processing software. You may download the software from the NGS website: http://www.ngs.noaa.gov/PC_PROD/pc_prod.shtml. The package consists of the following:

ADJUST and UTILITIES (in Adjust_all.zip)
(http://www.ngs.noaa.gov/PC_PROD/ADJUST/)

CR8BB (http://www.ngs.noaa.gov/PC_PROD/CR8BB/)

GEOID (current model)

There are several other useful programs available, but the following are the programs which you will need for this tutorial:

1. Create an 'ADJUST' directory/folder; download and unzip ADJUST_ALL.zip
   All documentation can be left in the directory, or printed and deleted, or moved to a sub-directory

3. Download CR8BB (http://www.ngs.noaa.gov/PC_PROD/CR8BB/) if desired for use in creating the B-file. It may not be needed if vendor software has created the B-file. See CR8BB documentation for instructions.

4. Download current GEOID model software (or use this function on the NGS Geodetic Toolkit, http://www.ngs.noaa.gov/TOOLS/. (It is important to have good positions in the B-file before running this program.)

5. Vendor Software
Follow vendor instructions for creating the B-file (bluebook) and G-file (or use NGS CR8BB to create the B-file as noted above).

Adjustment Processing Tutorial

Note: Output file names used herein are suggestions designed for ease in identifying the program used to create the output file. There is no requirement to use these or any particular file designations.

Preliminary Processing: (*Guidelines, Section 2*):

1. Save original B-file and G-file in a project directory separate from ADJUST; copy the files into the ADJUST directory, because some checking programs must be run there.

2. Inspect the B-records in the G-file, columns 52-53, to ensure the correct "Solution Coordinate Reference System Code" exists and matches the epoch of the observations as mentioned in Section 1-IV of this document. (refer to Annex N

GPS Data Transfer Format p. N-6 for more details). Ideally the software that created the G-file will have inserted the correct code.

3. Run CHKOBS *(Checking Programs, Guidelines, Section 2-I)*
Input: bfile
Output: chkobs.out

Resolve errors

Note: The B-file generated by vendor software or CR8BB will likely contain *86* records. Ignore errors for these records in these first runs of the checking programs. These errors will be resolved in the course of adjustment processing. Alternatively and perhaps preferably, avoid the *86* records at this stage. Copy the original B-file and work with the copy. Delete the *86* records from it; run the checking programs on that B-file, then add them back in with MAKE86 after the checking programs have been successfully run.

4. Run OBSCHK *(Checking Programs, Guidelines, Section 2-I)*

Input: bfile, gfile
Output: obschks.out, obschkl.out

Resolve errors

Note: With the sole exception of messages relating to zero antenna heights, all errors identified by OBSCHK must be resolved. This program mimics the program used for loading the project data into the IDB and any error will prevent data loading.

5. If *86* records are not in the b-file (preferable situation for running CHKOBS and OBSCHK), run MAKE86:

Input: bfile
Output: bfile.86 (new b-file)

If the *86* records are added to the B-file after the initial OBSCHK and CHKOBS runs, numerous messages relating to those records will be avoided.

6. Run GEOID

Input: bfile.86
Output: bfile.ght

Horizontal Free Adjustment (*Guidelines, Section 4*):

1. Create afilef (suggestion: carefully edit an existing afile to insert data for project carefully matching the column alignments) – constrain one (1) position (latitude, longitude) and one (1) ellipsoid height (EH) obtained from a data sheet. Generally, these will be for a CORS, but in principle, any well positioned mark can be constrained in the free adjustment. The latitude, longitude and EH can all refer to the same mark (usual procedure), or the EH can be from a different mark. All three data elements can be in one CC record, or the lat/long in one and EH in another, as long as the columns are correct. An ellipsoid height is indicated by ‘E’ in column 77. To include comments in the afile or to comment out a record permanently or temporarily, place “**” in cc 1-2.

2. Run ADJUST

Input: bfile.ght, afilef, g-file, NODFILE*
Output: adjf1.out, bfilef1

View adjf1.out, ADJUST output file. Check first for successful run indicated by "HAVE A NICE DAY" at the bottom. Check for large residuals indicating blunders or outliers, also for large shifts between published positions and free-adjusted positions.

***NOTE: 'NODFILE' refers to a Doppler file and indicates to ADJUST that no Doppler observations exist.**

Once you are satisfied that there are no blunders or outliers:

Horizontal Constrained Adjustment *(Guidelines, Section 5)*

1. Create afilec, fixing all previously published positions and all previously published ellipsoid heights from a data sheet retrieval. As with the free adjustment, lat/long and EH can be combined on one CC record for each station or separated--lat/long on CC records in one group, EH in another.
2. Run ADJUST

Input: bfilef1, afilec, gfile, NODFILE
Output: adjc1.out, bfilec1

Check position shifts and residuals in adjc1.out; decide whether to readjust any stations or wait and check borderline cases in adjqq.out

Vertical Free Adjustment *(Guidelines, Section 6-I)*

1. Create afilevf, fix one (1) position and one (1) published orthometric height. They can be from the same station or different stations (e.g., good horizontal position in one CC record for a CORS, good OH in separate CC record for a bench mark). A blank in column 77 of the CC record means the value in columns 70-76 is an orthometric height, similar to 'E' meaning ellipsoid ht in the horizontal adjustments.

2. Run ADJUST

Input: bfilef1, afilevf, gfile, NODFILE
Output: adjvf1.out, bfilevf1

Check adjvf1.out for blunders and large shifts between published and free-adjusted heights.

Vertical Constrained Adjustment *(Guidelines, Section 6-II)*

1. Create afilevc, fix 1 position, all published orthometric heights. Same comments about CC records apply.

2. Run ADJUST

Input: bfilevf1, afilevc, gfile, NODFILE
Output: adjvc1.out, bfilevc1

Check shifts and residuals to see if any heights should be readjusted.

3.Run ELEVUP to combine final horizontal constrained output with the final vertical constrained output into a final B-file. This will be the file that is loaded into the IDB. The file name should indicate that it is indeed the final.

Input: bfilevc1, bfilec1
Output: final.bfl

Final Free Adjustment with Accuracies *(Guidelines, Section 7)*

1. Copy afilef to afileqq
Edit MM record in afileqq to scale standard deviations with a-posteriori standard deviation of unit weight (cc4 = "Y")

2.Run QQRECORD

Input: gfile, afileqq

Output: afileqq-including the QQ records

3. Run ADJUST

Input: final.bfl, afileqq, gfile, NODFILE
Output: adjqq.out, bfileqq

View adjqq.out(or bbaccur.out-the formatted listing below), check lines of observation which fall below required accuracy, determine if readjustment is warranted.

4. Run BBACCUR2

Input: adjqq.out
Output: bbaccur.out

5. Run ELLACC

Input: adjqq.out
Output: ellacc.out

6. Edit final.bfl to add ellipsoid height accuracies (value resulting from step 5 which shows the greatest # of stations) to cc 54/55 of *86* record.

NOTE: Whenever the B-file or G-file is changed because of errors or blunders, or an afile is changed to reflect a change in the constraints or options, rerun ADJUST.

Post-Processing (Guidelines, Section 8)

1. Write report

2. Double check all outputs

3. Rerun checking programs on final files-there should be no errors except as noted above.

4. Process Descriptions

APPENDIX A

Processing Programs

ADJUST - required
Performs a least-squares adjustment in 3 dimensions using the B-file and G-file.

Input – B-file (observations, positions and heights), A-file (ADJUST instruction parameters), G-file (GPS vectors), dfile (doppler observations)
Output - adjustment output (messages, results and statistics) and B-file output (positions updated with adjusted values), if requested

BBACCUR2 - optional
Generates a file of single line accuracies from an ADJUST output file. (Produces an efficient listing for use in analysis.)

Input – final free adjustment with accuracies
Output – listing of sorted accuracies

CHKDESC - required
Description file validity check. This routine is part of the WINDESC suite of programs.

Input – .des file, WINDESC format description file before conversion to .dsc D-file
Output - listing of format error messages

CHKOBS - required
B-file validity check.

Input – B-file
Output - listing of format error messages

CLUSTER – optional
Compares *80* records between files, e.g. B-file and an IDB retrieval file or another B-file.

Input - 2 B-files or files of *80* format records
Output - listing showing the positional and height differences between the same stations in the 2 files and a file of common stations

COMPGB - required
Validity check on B-file and G-file for consistency and compatibility

Input – G-file B-file, serfil
Output - listing of inconsistencies

CR8BB - optional
B-file creation program

DIFLATLON2 - optional

Computes differences between stations with the same SSN in two different B-files, e.g. free versus constrained adjustment results. Lists the differences in latitude, longitude, and height as well as the shift in meters.

Input – two (2) B-files or files of *80* records
Output - listing of differences between the same stations

DISCREP –required
Identifies differences between codes in the D-file and those already in the IDB for all stations with PIDs.

Input – WINDESC D-file
Output – listing of comparisons between codes in IDB and those in file

ELEVUP – required for GPS projects.
Combines *80* and *86* records from constrained horizontal and constrained vertical B-files to produce a final B-file containing the final adjusted positions and heights to be loaded into the IDB.

Input – two (2) B-files, one with adjusted orthometric and geoid heights and one with adjusted positions and ellipsoid heights
Output - 1 updated B-file containing all adjusted values

ELLACC - required
Uses the final free adjustment with accuracies output, computes the order and type of the ellipsoid heights for the project.

Input - final free adjustment output
Output - listing of totals of ellipsoid height accuracies computed

GEOID - required
Updates *86* records with geoid heights from NGS latest geoid model.

Input – B-file
Output - updated B-file

HTDP – optional, (see comments in Sections 1.V)
Predicts and updates coordinates and/or observations to a user-specified date to facilitate adjusting survey data to particular epochs in crustal motion areas.

Input –Interactive or B-file, G-file
Output – updated coordinates or B-file, G-file

MAKE86 - optional
Creates *86* records in B-file. Will not remove existing *86* records; uses orthometric heights from the *80* records if present.

Input – B-file
Output - updated B-file

NEIGHBOR – required
Compares description/recovery notes within a specified radius to aid in identifying marks already in the IDB.

Input – D-file
Output – listing of IDB matches with each description/recovery note

OBSCHK - required

Validity checks a B-file and G-file as well as the relationship between the two.

Input – B-file, G-file
Output - listing of validity check errors

OBSDES - required
Validity checks a B-file against a D-file format (or older unified format) description file

Input - .dsc D-file or older .ha unified format description file, B-file
Output - listing of inconsistencies

QQRECORD - optional
Generates and adds QQ records to an AFILE using a B-file or G-file. (Only one QQ record will be generated over each line of observation.)

Input – A-file, B-file or G-file
Output - updated A-file

SPCS83 (not required for submission to NGS)
Computes state plane coordinates from geodetic positions (or vice versa) on the NAD 83 datum. (Also SPCS83EH, showing ellipsoid heights).

Input -Interactive, or file of coordinates
Output - file of computed state plane coordinates or NAD 83 positions.

UTMS (not required for submission to NGS)
Computes UTM coordinates from geodetic positions and vice verse for NAD 27 and NAD 83.

Input - Interactive or file of UTM coordinates or geodetic positions
Output - file of updated positions or coordinates

VERTCON - optional
Transforms NGVD 29 heights to NAVD 88

APPENDIX B

B-File Checklist:

1. The first record contains the observing organization's initials (contributor code).

2. Antenna heights and types match field logs.

3. Names of new stations follow current conventions and names of existing stations match data sheets.

4. State codes and order/type codes in *80* records and height codes in *86* records are correct.

5. *80* or *81* records exist for the marks at both ends of leveled height differences.

6. In the rare case of horizontal and/or vertical no-checks, they have been identified with 'N' in cc 6 and cc 5 respectively in the *80* records.

7. *80* records are sorted alphabetically (recommended, optional).

8. *86* records are interleaved with *80* records, one pair for each SSN.

9. Checking programs have been run on the final B-, D- and G-files and show no errors.

10. Positions and heights match final submitted adjustments.

APPENDIX C

Project Report Checklist

Title Pages – Project Title, Location

Project statistics – start & stop dates, number of new and existing stations, number of CORS, number and type of antennas and receivers

Purpose, order and type of project, datums

Problems encountered in the field and resolution

Procedural changes (not expected); if so, process of approval by NGS

Checking program results

Geoid model used

Results of free, horizontally constrained, and vertically constrained adjustments

Horizontal and vertical fixed control and source of each

Accuracies which fall below expectations, and discussion

Any readjusted stations and discussion

Overall results

Notes on description file - CORS not included, changes to the IDB revealed by DISCREP, unusual designations, etc.

Final files are correctly identified. (e.g. if more than one constrained adjustment is submitted, it should be documented which adjustment was used for final coordinates in the final B-file.)

APPENDIX D

UPDATES

September 2000

Section 7, step added to process ADJUST using a-posteriori standard deviation of unit weight for A- and B-order projects to assure the accuracies are computed correctly.
Input B-file name changed from final.bfl to cons1.bfl.
Add Solution Coordinate Reference System Codes 18-20 to Section One.

July 2002

Recommended filenames removed since they are inconsistent with other documentation and therefore confusing.

Appendix describing description processing removed. These procedures are no longer used since new description formats have been in place. Refer to instructions which come with WDDPROC software.

Add Solution Coordinate Reference System Codes 21 and 22 to Section One.

February 2003

Remove references to OBSDESED; program is obsolete.
Added information to Appendix A identifying which programs are appropriate for in-house use, and which programs were required for project submission.

Update Appendix A, Adjustment Processing Programs.

November 2004
Changes in procedures resulting from update to ADJUST to identify ellipsoid height constraints.
Changes to text to clarify procedures and other instructions.
New contact for guidelines.
Refer to Bluebook for orbit codes.
Refer to Bluebook for detailed project report instructions.

January 2009

Rewrite to address only GPS projects.

Delete references to scaling project.
Delete programs only available for in-house users.
Delete reference to programmers for each software program.
Delete APPENDIX B-Processing Outline (duplicate of step-by-step)
Delete most references to in-house processing for loading.
Include ATTACHMENT 1-step-by-step (revised)
