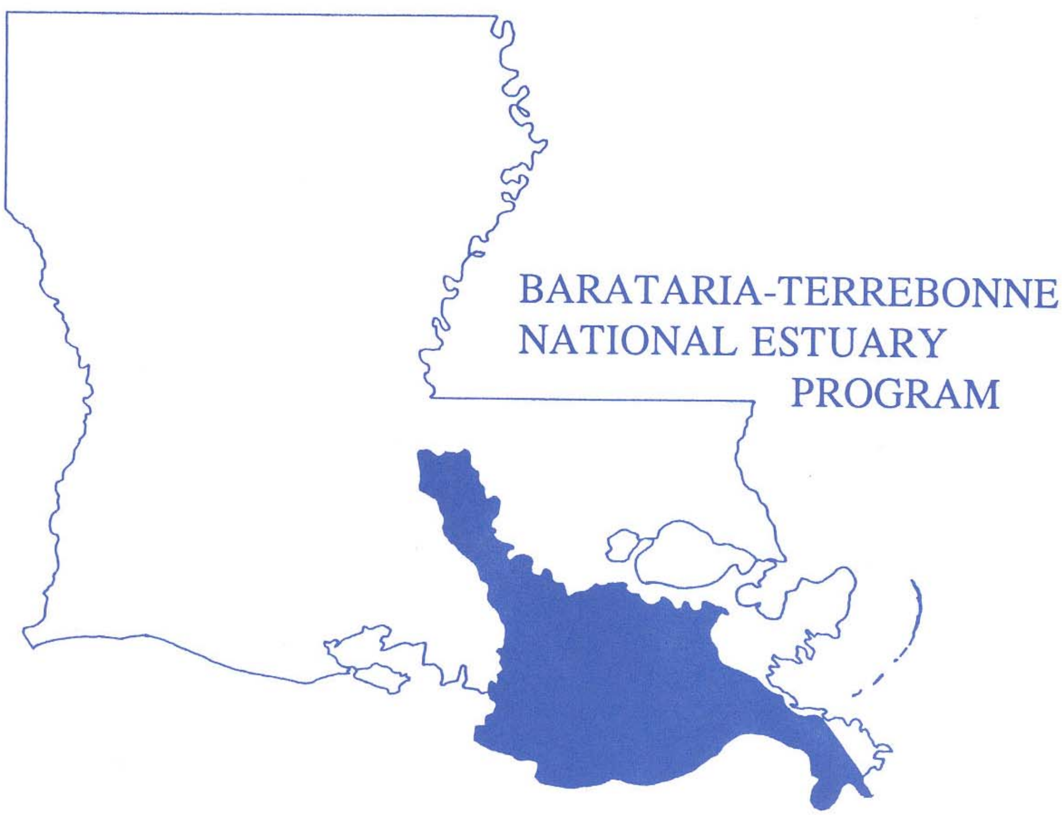
Barataria-Terrebonne
NATIONAL ESTUARY PROGRAM

Elevational Data Gathering

BTNEP - 25
December 1995

ELEVATIONAL DATA GATHERING



BTNEP Publication - 25
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Elevational Data Gathering

A publication of the
Barataria-Terrebonne National Estuary Program

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Barataria - Terrebonne National Estuary Program .... BTNEP
Coastal Ecology Institute .... CEI
Coastal Ecological Landscape Spatial Simulation .... CELSS
Comprehensive Conservation and Management Plan .... CCMP
Corps of Engineers .... COE
Global Positioning System .... GPS
Ground Water Protection Division .... GWPD
High Accuracy Reference Network .... HARN
Louisiana Department of Environmental Quality .... LDEQ
Louisiana Department of Transportation and Development .... LDOTD
Louisiana Department of Wildlife and Fisheries .... LDWF
Louisiana State University .... LSU
Louisiana Universities Marine Consortium .... LUMCON
National Biological Service .... NBS
National Geodetic Survey .... NGS
National Geodetic Vertical Datum .... NGVD
North American Datum .... NAD
Parts Per Million .... PPM
United States Department of Agriculture/Natural Resource Conservation Service ... USDA/NRCS
Water Pollution Control Division .... WPCD
Water Quality Management Division .... WQMD

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ABSTRACT

The overall objective of this project was to assess orthometric heights (elevation) at 81 sites within the lower Barataria and Terrebonne basins based on National Geodetic Vertical Datum (NGVD) North American Datum (NAD) 1929. This required coordination of effort and technical management for the field crews provided by various state and federal agencies to collect global positioning system (GPS) elevation data, as well as an accuracy assessment of the collected data. The participating state and federal agencies provided survey crews with GPS receivers and provided transportation for the participants in the project in return for their employee training in the GPS area. A total of 12 GPS crews were formed. This relatively large number of survey crews required a considerable amount of planning and organization to insure an efficient observation process.

The project involved four major tasks: field reconnaissance and network planning, GPS training and mission planning, GPS data collection and leveling, and post processing and analysis. While only 81 sites were requested, 60 potential control and check points were included to insure accuracy and integrity of the results. Reconnaissance and site verification required proper planning due to the relatively long distance between sites and potential problems associated with transportation. During reconnaissance, sites were verified and flagged. Two training seminars were conducted prior to actual data collection.

The overall accuracy of the data gathered was excellent. The average confidence region in elevation of all points was three cm, with a maximum value of 16 cm. The total number of points included in the final network was 134, 71 of which were requested points and 63 of which were potential control points. From the 63 potential control points in the network, 34 were selected to be final control points. Seventeen elevation check points were selected from the final control set to evaluate the accuracy of the final network. A special adjustment of the network showed an average of 3.7 cm (with a maximum of 6.2 cm) difference between the check points' published elevations and the adjusted elevations in the project network, indicating a good fit. A comparison of a network adjustment performed with the check points included, and a network adjustment performed with the check points excluded, showed a difference of two centimeters. Most loop closures ranged between one and three ppm mis-closure, which is better than first class specifications for geodetic observations. Vectors causing loop mis-closures above ten ppm were excluded from the network adjustment.

ELEVATIONAL DATA GATHERING PROJECT

BACKGROUND

The Barataria-Terrebonne National Estuary Program's (BTNEP) goals are to develop a comprehensive management plan to protect and where possible, rebuild wetlands, protect and improve water quality, and enhance living resources within the Barataria and Terrebonne basins. First, the program seeks to identify the problems of the estuary. Second, it identifies the cause of the problems. Third, BTNEP seeks to develop a series of action plans to address these environmental problems.

The BTNEP supports several scientific studies which will comprise the basis for an integrated, system-wide assessment of the Barataria and Terrebonne basins. The results of these studies will be compiled into a final Characterization Report that documents trends, evaluates causes, and recommends short-term and long-term management goals. The final phase of the Program involves the development of a Comprehensive Conservation and Management Plan (CCMP) for the Barataria-Terrebonne basins. The CCMP will include several stages which will recommend specific management actions and monitoring plans that address the priority problems. The CCMP is being developed through consensus between academia; estuary user groups; the public; industry; and local, state, and federal government agencies. Implementation of the CCMP is expected to require up to 20 years after its adoption.

Several BTNEP research projects in the Barataria and Terrebonne basins require elevational data. Two of these projects include the Coastal Ecological Landscape Simulation Modeling led by Mary White at LSU/Coastal Ecology Institute and Hydrologic Modeling led by Joe Suhayda at LSU/Civil Engineering. The following section gives a brief description of these projects.

SPATIAL LANDSCAPE MODELING[1]

The Coastal Ecological Landscape Spatial Simulation (CELSS) model is a process-based spatial simulation model. The CELSS dynamic simulation model was constructed with the assumption that each cell could be connected to its four nearest neighbors by the exchange of water and suspended materials (salts, nitrogen, phosphorus and suspended organic and inorganic sediments). The buildup of land or the development of open water in a cell depends on the balance between net inputs of sediments and local organic peat deposition on one hand and outputs due to erosion and subsidence on the other. The balance of sediment inputs and outputs is critical for predicting how marsh succession and productivity are affected by natural and human activities.

Forcing functions (inputs) are specified in the form of time series over the simulation period. Included are the weekly values of Gulf of Mexico salinity and sea level and sediment and nutrient inputs from runoff of the Atchafalaya River in the Terrebonne model and from the 22 pumping stations located around the basin in the Barataria model. Other forcing functions include rainfall,

[1]This section was provided by Mary White at LSU/Coastal Ecology Institute.

temperature, and wind speed and direction. The location, time of construction, and characteristics of the major waterways, canals, and levees are an important geomorphic input and must be updated annually in order to keep simulations timely and accurate.

HYDROLOGIC MODELING

Due to the hydrological complexity of the area's bayous, lakes, open bays, and drainage areas as a whole, it is imperative that the nature of water movement within the area be well understood. An assessment of the environmental conditions which influence circulation patterns and associated movement of sediments, freshwater, nutrients, contaminants, and other materials, is critical to the formulation of management measures to modify that transport.

The Hydrologic Model is a computer-based methodology for managing marsh hydrology, and for assessing the effectiveness of management alternatives. The methodology consists of a data base and a hydrodynamic computer model for simulating estuarine hydrology. The objective of the model is to evaluate the possible changes in the water salinity, water current patterns, and water level variations that could result from different management plans.

Several aspects of wetland hydrology are included in the simulation model: a) the primary energy sources causing wetland water movement, such as barometric pressure, winds, tides, and freshwater runoff; b) the morphology and physical properties of the wetlands, including topography, vegetation, canals and streams, in addition to man-made features such as levees, roadways, and control structures; c) and the fact that the watershed acts as an integrated system where processes and responses are linked by feedback mechanisms.

A number of important management questions can be addressed with the Hydrologic and CELSS type spatial models which have been kept up to date with current environmental conditions. The effects of global warming and sea level rise on the shallow wetlands of southern Louisiana could be significant. Various scenarios of sea level rise have been investigated and there appears to be a critical rate of sea level rise which the wetland system cannot accommodate. The marshes subsequently revert almost totally to open water. Apart from global warming, the global increase of CO_2 and its accompanying effect on the productivity of wetlands could be simulated to determine if there are similar threshold increases due to anthropomorphic input for which the system could not recover.

Hydrologic alterations both in quantity and quality can be simulated. The proposed enhancement of wetlands with freshwater provided by diversion structures should be carefully modeled for cumulative effects. Simulated freshwater diversion into the Terrebonne wetlands yields gains as well as losses in wetland habitat depending on the location and timing of the released water. Water quality questions can be investigated. The effects of effluent pumped into adjacent wetlands can be simulated for the case of planned municipal tertiary treatment, for agricultural runoff, as well as for the effects of increased urbanization and the accompanied disposal of storm water runoff.

SCOPE AND OBJECTIVES -- ELEVATION DATA GATHERING

The overall objective was to collect elevational data (orthometric heights) at numerous sites throughout the Barataria-Terrebonne complex. The data will be incorporated into two projects entitled: "Landscape Simulation Model Upgrading: Spatial Ecological Modeling of the Wetlands of the Barataria-Terrebonne (CELSS)" and "Hydrologic Model of the Barataria-Terrebonne Estuary". The northern and eastern boundaries of the study area are delimited by the west bank of the Mississippi River, south to the end of the levee. The western boundary is the eastern bank of the lower Atchafalaya River, and the eastern shore of Atchafalaya Bay. The southern boundary is the Gulf of Mexico as shown in Figure 1.

Insufficient elevational data currently exists for the Barataria-Terrebonne estuary. Because soil surface elevation can greatly influence the vulnerability of the estuary to degradation through geological, climatological, and/or environmental stresses, such information is pertinent for developing an effective management plan. The BTNEP organized an effort to survey elevations using the high precision technology of global positioning systems (GPS). The information generated is to be provided to the Landscape Simulation and Hydrological modeling teams. The project called for elevational data to be collected for 81 points in the Barataria-Terrebonne estuary for areas below the five-foot contour. Since this technology was new to most participating agencies, there was a need to train field crews and test the equipment in order to formulate an efficient strategy for surveying.

The objective of this project was to collect elevational data at numerous sites throughout the Barataria-Terrebonne complex for use in various modeling efforts. The objective required coordination of effort and technical management for field crews provided by various state and federal agencies to collect GPS elevation data, as well as an accuracy assessment of the collected data.

Various state and federal agencies provided survey crews, GPS equipment and transportation facilities. Louisiana Department of Transportation and Development (LDOTD) provided five GPS teams equipped with Ashtech dual frequency receivers. Louisiana Department of Wildlife and Fisheries (LDWF) provided two GPS teams with Trimble dual frequency receivers. The United States Department of Agriculture/Natural Resource Conservation Service (USDA/NRCS) provided two GPS teams with dual frequency Ashtech receivers. Louisiana Department of Environmental Quality (LDEQ) also provided two teams to operate Trimble dual frequency receivers from LSU and Navigation Electronics Inc. In addition, the LSU base station collected dual frequency GPS data during the time scheduled for GPS field work. A total of 12 GPS receivers were available to use in this project.

PROJECT PLAN

The project involved four major tasks: field reconnaissance and network planning, GPS training and mission planning, GPS data collection and leveling, and post processing and analysis.

Figure 1. Project Area for BTNEP GPS Survey.

Requested Sites for Elevation Data

Elevation data was requested for 81 sites scattered within Barataria and Terrebonne basins. Sites fell into three categories: tide gauges, representative marsh elevations and pressure sensors. These sites were marked on 15' quad sheets and color coded red for tide gauges, yellow for marsh elevations and blue for pressure sensors. Along with the maps, description sheets were provided for each site showing their accessibility, approximate location, and requested elevation. While most of the sites had a structure, some did not. Non-structured sites were either a representative elevation of marsh or swamp floors, or abandoned research sites where the original structure had been removed. Sites with structures consisted of tide gauges, with or without automatic recorders, and pressure sensors. Water levels have been collected on these sites for an extended period of time and this data could be very useful to modeling efforts if all the gauges were calibrated to a single datum. Researchers requested the elevations to be provided based on NGVD (NAD-1929).

Reconnaissance

The first task was to identify, validate and flag the requested sites in the field. While only 81 sites were requested, control points needed to be added to the network to insure accuracy and integrity of the results. Reconnaissance was accomplished in three phases: mapping and navigation-charts preparation, field reconnaissance and flagging, and sketching and documenting of each site.

Planning and Navigation Charts

For planning and navigation-charts preparation, a list of coordinates for all requested sites and control points was assembled. Descriptions of horizontal and vertical control points in the project area were acquired from National Geodetic Survey (NGS). Descriptions were also obtained of two sets of bench marks recently established in the area during research projects by the U.S. Corps of Engineers (COE) and the Natural Resource Conservation Service (NRCS) Research Center. A complete set of 7.5' quad sheets, 1:24,000 satellite photographs for navigation and 1:250,000 maps were obtained for the project area. The requested sites and potential control points were plotted on the maps and photographs. Stickers with different colors were used to mark each set of points to distinguish their nature: yellow for the marsh sites, red for the tide gauges and blue for the pressure sensor's sites.

To distinguish among various kinds of points in the network, the following labeling strategy was used: numbers 1-81 were given to requested sites, numbers 101-141 were given to COE points (e.g., point COE 21 became 121), numbers 201-227 were given to HARN (High Accuracy Reference Network) and other horizontal control points, and numbers 301-323 were given to leveling-line benchmarks. A few additional points of interest in the area were also labeled (e.g., numbers 91-95 were given to Natural Resource Conservation Service benchmarks NRCS1-NRCS5 respectively).

Site Visiting and Flagging

Reconnaissance and site verification required proper planning due to the relatively long distance between the sites and transportation difficulties. While some sites were easily accessible by road, others required special boats such as a mud boat, or an airboat. In addition, boat landings and marine fuel stations needed to be identified to insure safe transportation and efficient routing during the survey. A hand-held GPS unit was used to navigate to sites where coordinates existed for site positions.

Once verified, sites were flagged and a location for the GPS station was determined. Because many requested sites consisted of either tide gauges or representative marsh elevations, a monument for the GPS station was needed on each site from which leveling could be done to gauges and other requested points. Each site was documented with a descriptive sketch and photographs. The documentation was intended to facilitate finding these stations and keep travel time between GPS sessions to a minimum. Temporary monuments used as GPS stations were either paint on concrete, nails in wood structures, or 3.5" diameter wood posts driven into the ground. Posts on sites without structures were removed after the survey was completed to eliminate liability.

In addition to the 81 requested sites, 60 potential control and check points were also visited. Since any network adjustment results are greatly affected by separation and quality of control points, an effort was made to include as many first class horizontal and vertical control points as possible. All HARN points in the region were identified and included. There was a sufficient number of horizontal control points to secure the project perimeter and insure accurate adjustment. However, the main problem was to secure enough vertical control points. Unlike the horizontal control points, vertical control points are needed in the middle of the project to correctly capture vertical datum variations beyond the ability of available Geoid models. Benchmarks recently constructed by the COE and NRCS were very useful in helping to close the gaps between NGS points. However, these COE and NRCS points were only in Terrebonne parish. Due to time constraints, not all control points were flagged prior to field survey. However, LDOTD survey crews were familiar with HARN points and other first class benchmarks. They were able to locate these sites without prior flagging.

Training

Several state and federal agencies made their GPS survey teams available in support of this project. The level of surveying skills varied from highly experienced professional surveyors to beginners in the GPS field. Other participants were from scientific disciplines not related to surveying, yet they needed to know how to use GPS in their projects. An initial plan for detailed conceptual and hands on seminars was suggested to the project manager who consulted participating groups for their input. Two training seminars were carried out prior to the field GPS surveying and a third seminar was presented after the field work was completed. Each seminar lasted three days. The following subsections describe the contents and activities of these seminars.

GPS Concept

The first three-day seminar was intended to introduce the GPS concept. An introduction on satellite geodesy, satellite orbital parameters (Kepler elements) and coordinate systems was presented. The lectures focused on GPS satellite constellation and principals. The following topics were presented:

- Satellite messages, frequencies, and GPS receiver operation; clock errors; observations and processing
- Methods of GPS surveys: Static, Kinematic, Real-time (dynamic)
- Coordinate systems (universal inertial system, geographic coordinates, ellipsoidal coordinates, state plane coordinates), orthometric and ellipsoidal heights
- Geoid undulation models, orthometric and ellipsoidal heights

This seminar included a field session on using GPS receivers, setting and leveling antennas, measuring antenna heights, and saving data files.

Day one topics:

A. Project Overview
B. Plan for the Training Workshop
C. Introduction to Satellite Geodesy
D. GPS Surveying
E. GPS Applications

Day two topics:

A. Coordinate Systems
B. Geodetic Heights
C. GPS Surveying
D. GPS Receiver Operations

Day three topics:

A. GPS Receiver Training (Field)
B. Other GPS Modes (Field)

GPS Project Planning

The second seminar was for training on GPS project planning. The following topics were addressed in this session:

- GPS mission planning software
- Receiver pre-programming (stations and sessions)
- Data logging
- Memory management and Downloading GPS data

- Differential GPS vector processing
- Gross error detection and loop closures

Fifty percent of the time was spent in lectures and the rest of the time was used for field GPS observations, downloading data and vector processing. The class was split into four groups which occupied several stations on control points in the Baton Rouge area. Two Trimble and two Ashtech receivers were used in the exercise. Participants used Trimble and Ashtech software to process differential GPS vectors.

Part two of the training seminar focused on the following GPS Project topics:

Day one topics:
A. GPS Mission Planning
B. Receiver Programming
C. Data Logging
D. Memory Management and Downloading

Day two topics:
A. GPS Post-Processing
B. Hands on Mission Planning
C. GPS Field Training

Day three topics:
A. Second Option GPS Field Plan
B. Downloading/Post-Processing
C. Loop Closures

Post Processing

The last "three-day" seminar took place after the field work was completed. By that time, the participants had gained experience in the field for several weeks and were familiar with the project aspects. This seminar focused on the following topics:

- Post-Processing, GPS vectors (TRIMVEC software)
- Gross error detection and loop closure (LOOP software)
- Cycle slips
- Tropospheric and Ionospheric effects
- Network pre-adjustment
- Network adjustment elements
- Statistical analysis and gross error detection
- Reliability studies (internal and external reliability factors)

Data from project session observations were used as an exercise. Trimble and Ashtech software were used to process the data and demonstrate statistical analysis and network adjustment. The following topics were discussed in part three of the training seminar:

Day one topics:

A. GPS Vectors
B. Gross Error Detection
C. Post Processing Vectors
D. Exercise on Post Processing Vectors

Day two topics:

A. Network Adjustment Methods
B. Statistical Analysis/Reliability
C. Network Pre-Adjustment
D. Pre-Adjustment lab

Day three topics:

A. GPS Error Sources
B. Hands on Adjustment
C. Statistical Analysis

Participants

The list of names, affiliations and contact numbers for the individuals who volunteered in this project and actively participated in the training seminars are listed in the acknowledgments.

Field Observations

For most new sites, the required elevation was for a point that could not be occupied with a GPS antenna. Some of these points were tide gauges attached to a structure unsuitable for setting an antenna. Others were pressure sensors attached to two inch PVC pipe set either in deep water or on unstable floating marsh. It was therefore more efficient to occupy a nearby location (called the "station") and level to the requested site. In addition, some of the sites were in the vicinity of control points that were occupied with GPS. Leveling between stations close to each other was possible during GPS sessions without delay in the GPS observation plan. Most network adjustment programs allow terrestrial observations such as leveling to be combined with GPS and other observations in the adjustment. Level observations between nearby stations increase the accuracy of the results significantly and are also used to check the GPS performance. The GPS survey crews were instructed to take leveling observations whenever necessary during each session.

GPS Observations

Due to the high accuracy needed, a minimum of two-hour sessions on each station were planned. Stations were occupied at least twice to improve accuracy and reliability of the network. The relatively large number of observed vectors allowed for the removal of bad observations and accommodation for any data lost or corrupted due to hardware failure.

<u>Session Planning</u>

GPS field work was scheduled for Monday through Thursday each week for four weeks. Session planning had to be completed on a weekly basis for each following week. Three sessions were planned for each day starting at 7:30 am and ending at 4:30 pm. One hour was scheduled for travel time between sessions. Table 1 shows a sample weekly schedule.

Due to schedule changes caused by weather, hardware failure, etc., the actual observation scheme and the initial, scheduled plan were different. However, because of the excellent communication facilities, it was possible to maneuver crews around to fill the gaps and make sure that the field time was used efficiently. The weather conditions were excellent for the first three weeks of observations. More than 90% of planned sessions were executed during the first two weeks. Rain and bad weather during the last week inhibited small boat operations and caused delays. Because of the weather conditions during the last week, 60% of its pre-planned sessions were executed. Figures 2 and 3 are examples of an initial plan and actual observation scheme for a single day. The significant number of changes in this day is due to the gradual build up of changes from previous days since this was the last field day in that week.

<u>Table 1. Weekly Field Survey Schedule Example</u>

GPS site number by team and date.

	31-Oct Day 304		1-Nov Day 305			2- Nov Day 306			3-Nov Day 307		
	10:30-12:30	1:30-3:30	1:30-9:30	10:30-12:30	1:30-3:30	7:30-9:30	10:30-12:30	1:30-3:30	7:30-9:30	10:30-12:30	1:30-3:30
GPS 1	205	205	310	311	312	209	209	209	43	116	44
GPS 2	49	138	91	75	75	1	1	225	32	210	210
GPS 3	35	34	208	205	203	204	44	206	33	24	206
GPS 4	32	221	224	224	224	412	313	314	224	225	208
GPS 5	225	302	312	310	311	313	314	315	209	204	203
GPS 6	11	139		46	46		54	54	61	64	6

Table 1. Continued

GPS 7	137	4	17	76	92		55	55	21	56	59
GPS 8	2	2	5	5	67	68	68	73	25	22	23
GPS 9	4	67	41	122	303	10	9	9	26	26	22
GPS 10	12	16	5	5	67	134	67	91	20	20	25
GPS 12	93	73	41	122	303	135	91	92	56	59	21

Task Sheets and Navigation Charts

Maps, sketches, photographs, and satellite photos were prepared in advance. Files were generated for each crew complete with instruction sheets and access descriptions for each site. It was necessary that a separate task sheet with special instructions be made for each point because the leveling requirements were different for each site. Field-survey crews were able to find their sites between sessions without much difficulty. However, there were a few incidents where sketches to sites were missing or, due to transportation constraints, crews were rescheduled at the last minute and could not be provided with the proper charts on time. In most of these incidents, radio communication helped to enable crews to find their sites and receive proper instructions for data collection.

Communication

Radio communication was essential in coordinating sessions and accommodating delays as they occurred. Navigation in the marsh areas was at times difficult, and the chances of missing a small channel or a lake that would lead to a specific site was high. Radio communication was essential in these cases to ensure the crews reached the proper site on time. Boat breakdowns, receiver failures and other unexpected events often forced schedule changes that were only made possible by radio communication between the crews and the project manager.

DEQ provided ten boat radios and two hand held units. The groups were allowed to use the state communication towers to cover the large areas involved in the project. Houma-Main was the most suitable channel for the project. Training on proper use of these radios was also provided by DEQ to insure safe and efficient communication. (In addition, there were backup radios and mobile phones with various ranges available to the sub-groups.) Some problems with the radio system occurred due to bad power connections or in remote areas such as Venice, LA near the mouth of the Mississippi River. The availability of radio communication proved to be essential in the success of this project.

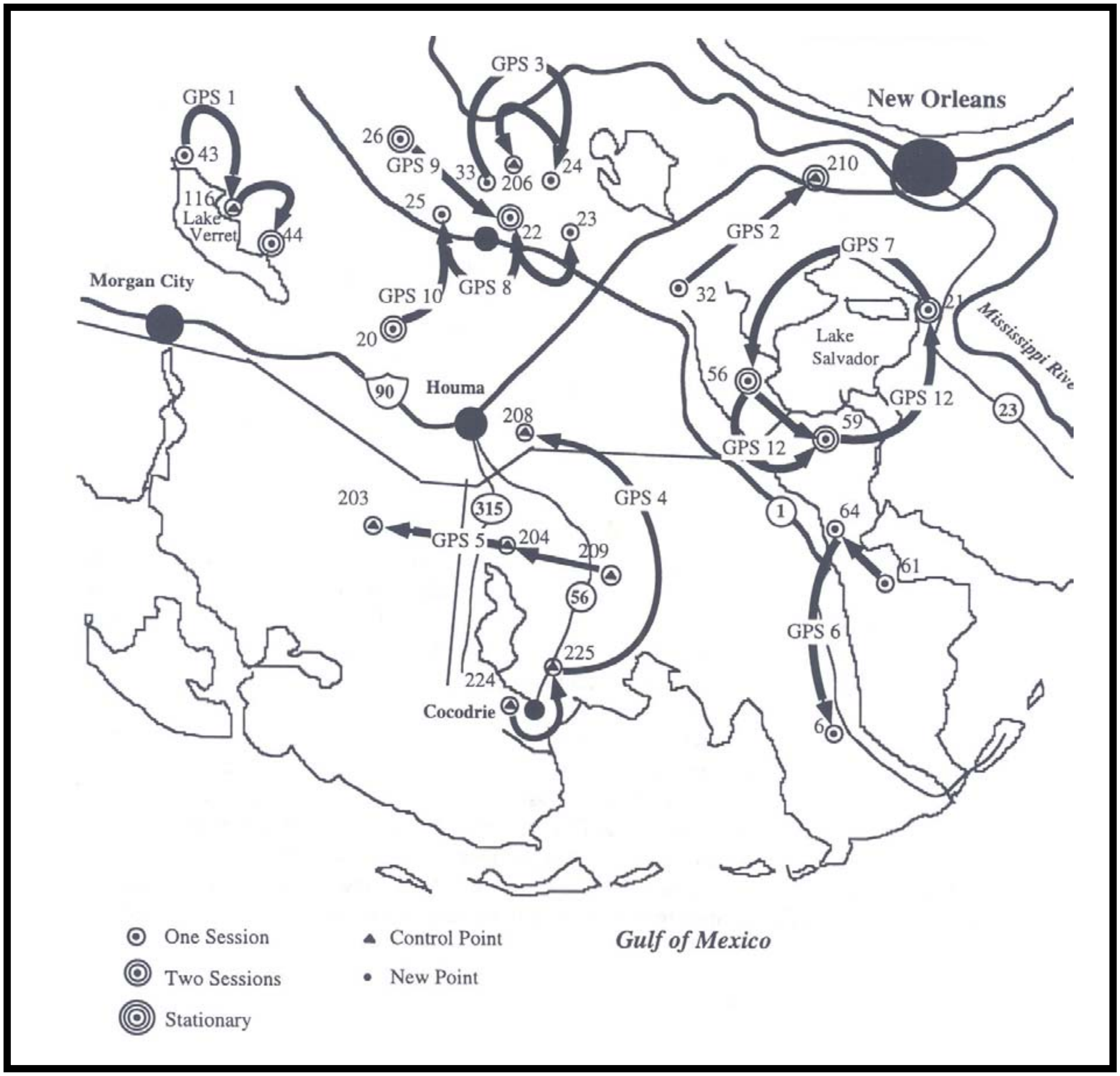


Figure 2. Initial Plan for Day 307 Observation Sessions.

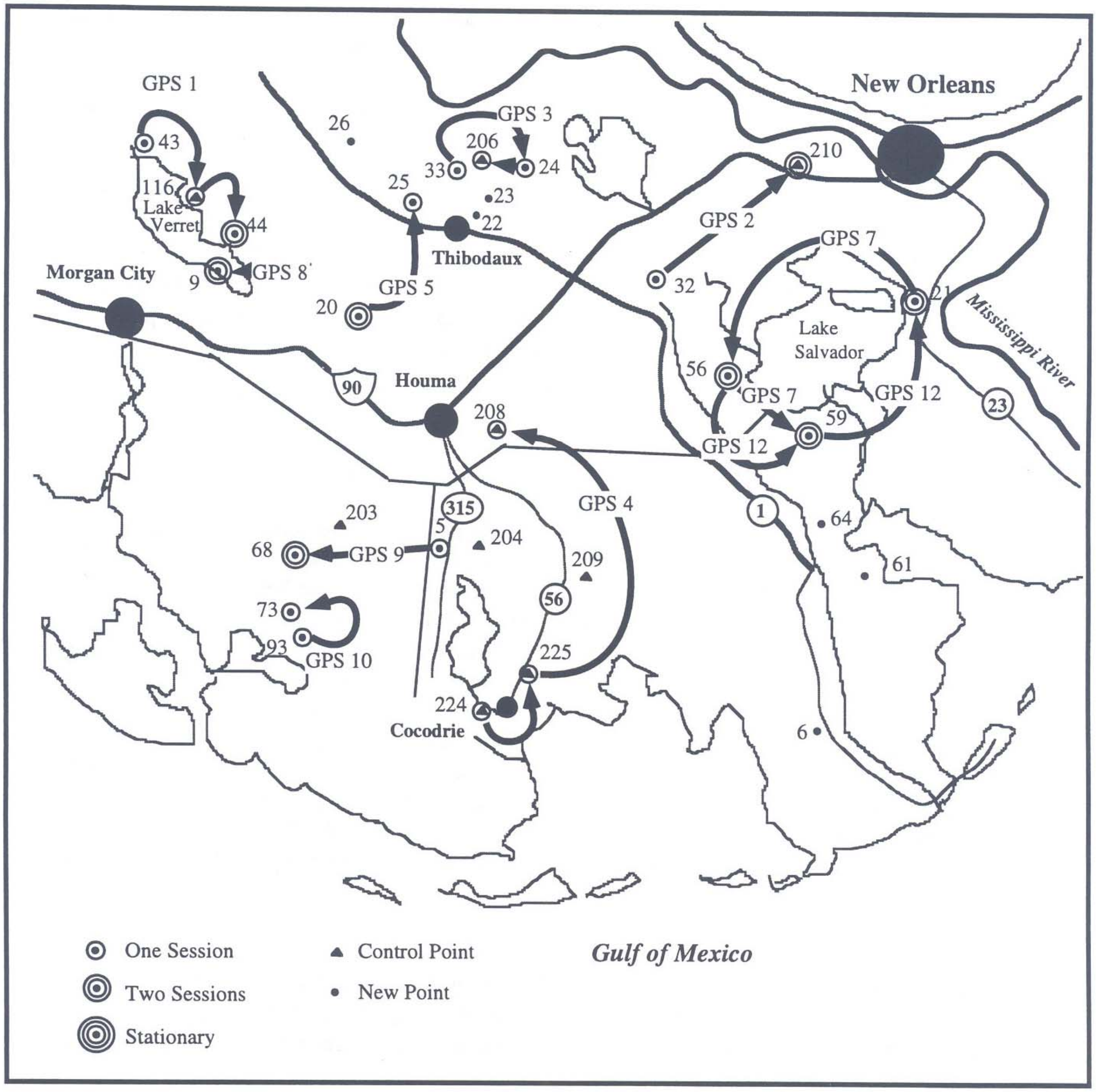


Figure 3. Actual Observation Sessions on Day 307.

Leveling

Leveling was necessary to provide elevational data at various requested locations. These locations were specified to each survey crew in the form of a task sheet. Each of the three types of sites required different leveling standards. For example, in the marsh sites, leveling was required from the temporary bench mark set as a GPS station to a representative marsh elevation and to the water surface. Since water surface is time dependent, the date and time were also recorded. In the Red, or tide gauge, sites, leveling was done to the tide gauge and to the water surface. Often tide gauges were not visible because they were enclosed inside the automatic recorder cylinder. In these cases, the date and time of the observation were recorded. This enabled the gauge zero to be determined later by matching the time of the survey measurement with the tide gauge recorder reading.

POST-PROCESSING

Post-processing of GPS vectors started immediately after the field work was completed. Determining the best method for combining Trimble and Ashtech data together in a single network was a challenging task. To ensure the best possible results, several post-processing options were processed. Figure 4 shows these three options. The final elevation data at all new sites are derived from elevations of stations and leveling data (i.e. staff gauges, marsh soil surface, etc.). A complete list of these elevations are given in Appendix A.

ACCURACY ASSESSMENT

To optimize the project's results and assess their reliability, gross error detection, statistical analysis, and comparisons of control point published values were performed. The overall accuracy of the project was excellent. Check points averaged three centimeters difference between their published elevation and the adjustment results. While some bad data sets were excluded, closure loops using the remaining vectors included in the adjustment produced less than 100 ppm mis-closure. That meets the NGS standard for first class geodetic observations. Bad data was caused mostly by battery failure resulting in short observation time. The total number of points included in the network was 134 new and control points. A summary of the final network results are presented in Appendix B. A check adjustment was performed using the entire network in RINEX format processed in Trimble software. The check adjustment agreed with the original solution within four cm. A summary of the check adjustment results and a combined solution is shown in Appendix B. The solution entitled "Original Solution" is to be considered the final solution. Other solutions are provided for reference.

Loop Closures

While loop closures are not essential for an adjustment, they are a good tool to test for gross errors and bad vectors. Most gross errors were found to be due to wrong station numbering or incomplete observation sessions. Most loop closures ranged between one and three ppm, which is better than

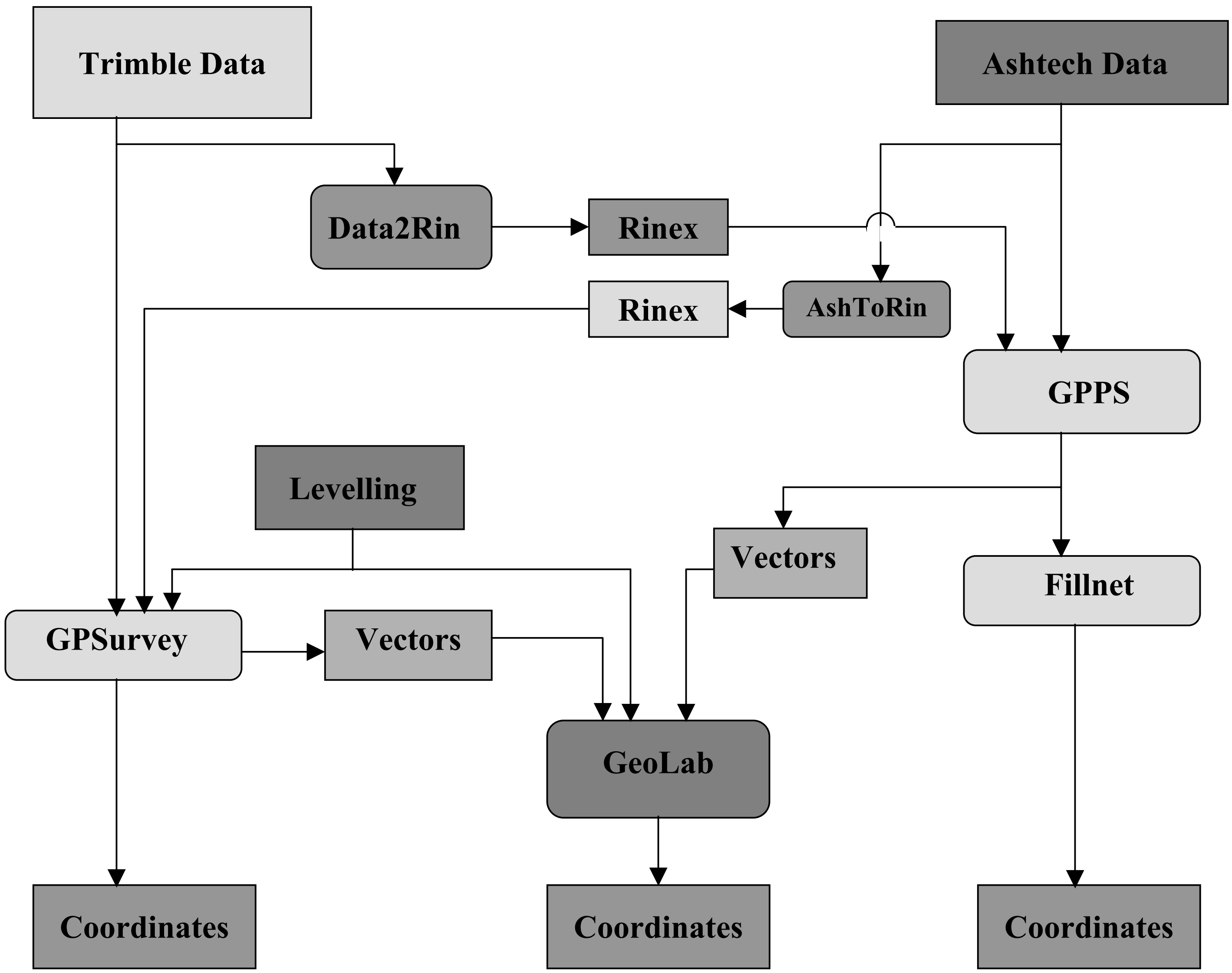


Figure 4. Post Processing Scheme Showing Several Adjustment Options

first class specifications for geodetic observations. Vectors generating loop mis-closures above 10 ppm were excluded from the network adjustment.

Free Adjustment and GPS Internal Accuracy

A free adjustment is an adjustment made by fixing horizontal and vertical coordinates of any single point in the network. The purpose of this adjustment is to test the internal accuracy of the GPS vectors and check for errors not seen by the loop closure mechanism. A control point at the center of the project (Point 208) was selected to be fixed. The results of the free adjustment are listed in Appendix B. An iterative process of cleaning the data set was carried out by disabling vectors showing normalized residuals greater than three and residuals greater than ten cm. A normalized residual is produced by subdividing a vector's residual by the standard deviation of its vector. Looking at normalized residuals alone may be misleading. Normalized residuals could be large if either the residual is large or the standard deviation is very small. For example, a residual of one centimeter yields a normalized residual of ten if the estimated standard deviation of the vector is only one millimeter. Because GPS solution often overestimates the accuracy of GPS vectors due to instrumental setting and other factors, the GPS vector accuracy estimates were scaled by a factor of three for Ashtech and a factor of five for the Trimble solution. The Estimated Variance Factor of the free adjustment was less than one (.27) which indicates good adjustment result. A contour line representation of variations in elevations between the free and the final adjustment for all the network points is plotted in Figure 5.

Constrained Adjustment and Effects of Control-Point Selection

A full constrained adjustment is different from a free adjustment in that the ground control points are fixed. While the free adjustment shows inter-relation strength of the GPS vectors, the constrained adjustment will attempt to fit these vectors to ground control values. In addition, the final adjustment also included leveling information and the 1993 Geoid Model for the central zone of North America. All HARN points and other selected ground control points were fixed in the final adjustment. The Estimated Variance Factor of the final adjustment was 0.54. Two factors were used to evaluate the accuracy of the elevations in the final adjustment: variations at check points and confidence regions.

Check Points

Seventeen elevation check points scattered throughout the project area were selected to evaluate the final accuracy of the network. These points represent about half of the overall number of control points used in the adjustment. A separate adjustment was carried out freeing these check points. The difference between their actual elevation and their elevations in the project adjustment output averaged 3.7 cm with a maximum value of 6.2 cm. A contour line plot of these variations is shown in Figure 6. A complete list of these differences is shown in Table 2.

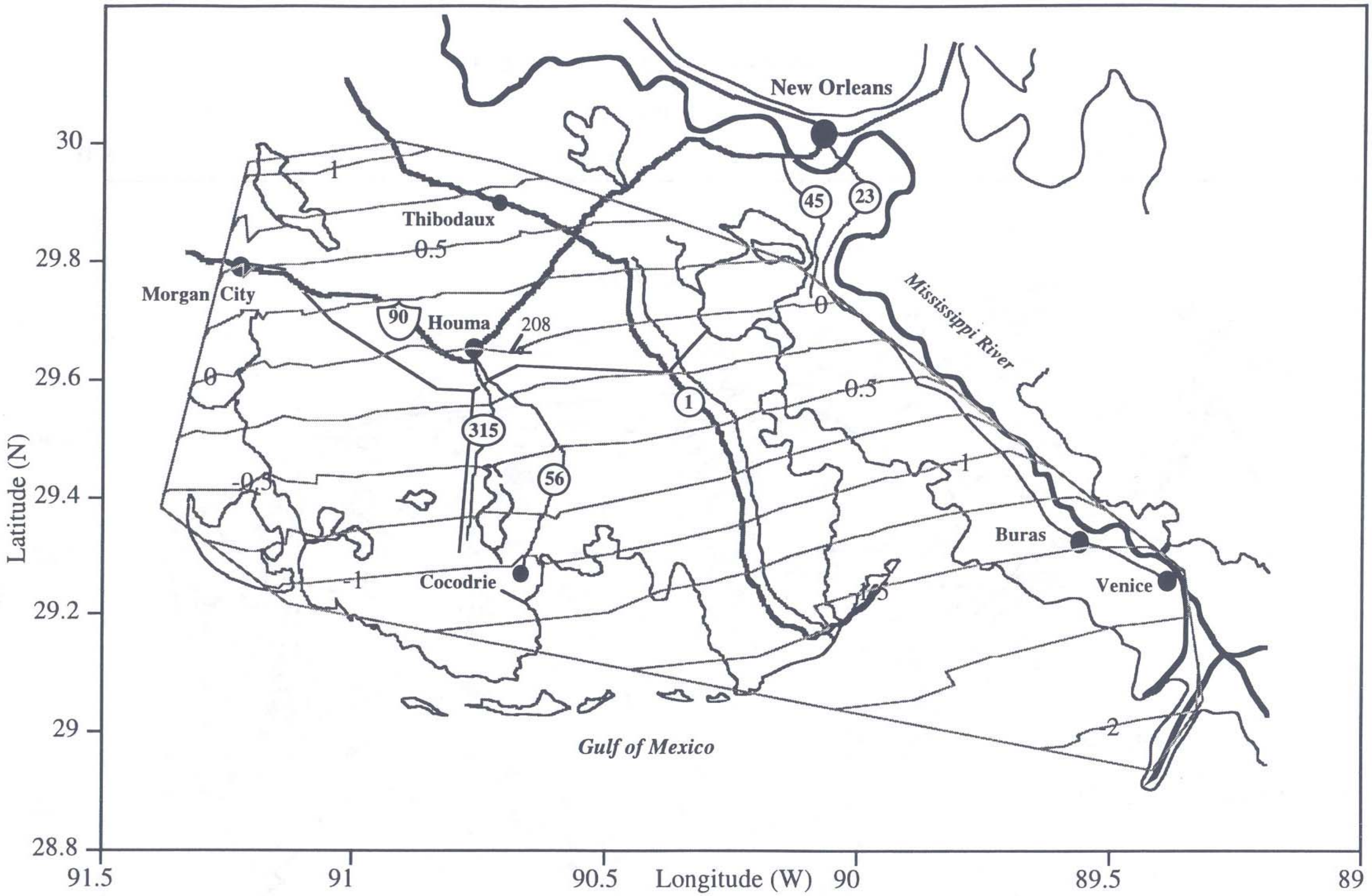
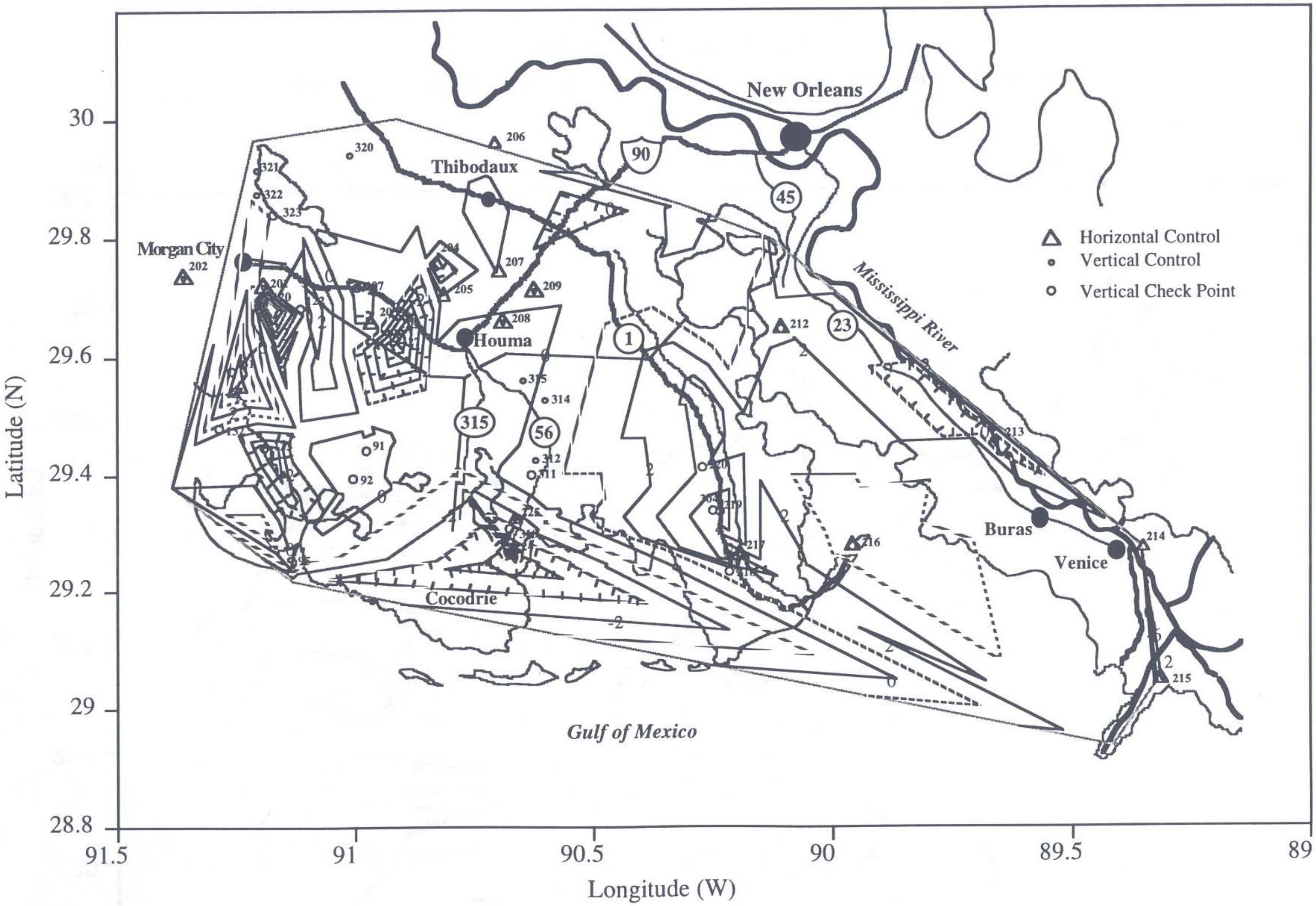


Figure 5. Variations Between Free and Constrained Adjustment (in Meters)
Geoid Model Not Included



Figue 6. Variations at Check Points (in cm.)

Table 2. Variations in Elevations at Check Points.

Check Point #	Longitude	Latitude	Height	Variations in cm.
107	90.9934306	29.7048231	0.742	1.3
120	91.1742599	29.683638	2.042	-6.2
122	91.0977526	29.6683916	3.914	-3.4
127	90.9029748	29.6199925	1.278	5.7
131	91.2450857	29.5523074	0.959	-4.9
133	91.1705246	29.4342886	0.907	3.9
151	91.5335657	29.5727456	1.487	-1.2
216	89.9553527	29.2642976	0.98	-3.5
218	90.2097754	29.2350629	0.582	-1.7
219	90.2391984	29.3216873	0.259	-4.8
224	90.6615382	29.2464487	0.665	4.7
304	90.2397621	29.3218785	0.472	-4.8
310	90.6566148	29.2609484	0.35	4.9
311	90.6240506	29.3712708	0.394	-0.5
323	91.1771671	29.8353675	2.948	-1
91	90.9667067	29.4176501	0.658	-0.2
92	91.0000375	29.3741481	0.614	-0.9
		σ Max. Min.	(rms)	3.7 cm 5.7 cm -6.2 cm

In addition to looking at check points, we evaluated the difference in elevation between the final adjustment and the one excluding the check points. The difference in elevation at all new sites averaged two cm and the maximum difference was six cm. A complete list of the elevation and differences between the two adjustments at all new sites are shown in Table 3.

Table 3. Variations in Elevation When Including or Excluding Check Points.

Point Number	Elevation in Final Adjustment (m)	Elevation Excluding Check Points (m)	Difference in cm.
1	0.811	0.813	-0.2
10	0.97	0.984	-1.4
11	0.566	0.57	-0.4
12	3.201	3.228	-2.7
13	3.171	3.17	0.1
14	3.377	3.382	-0.5
15	0.969	0.972	-0.3
16	0.589	0.613	-2.4
17	0.944	0.947	-0.3
171	0.94	0.946	-0.6
18	0.684	0.684	0
19	0.991	0.974	1.7
2	0.867	0.872	-0.5
20	2.428	2.429	-0.1
21	0.868	0.865	0.3
22	1.306	1.288	1.8
23	1.203	1.199	0.4
24	1.089	1.08	0.9
25	1.107	1.102	0.5
26	1.481	1.478	0.3
27	0.687	0.66	2.7
28	0.713	0.687	2.6
29	1.723	1.733	-1

Table 3. Continued

3	1.164	1.17	-0.6
30	1.137	1.122	1.5
31	1.621	1.603	1.8
32	3.364	3.362	0.2
33	0.996	0.993	0.3
34	5.706	5.702	0.4
35	4.522	4.519	0.3
36	1.174	0.138	3.6
37	1.337	1.333	0.4
38	5.196	5.184	1.2
39	1.715	1.653	6.2
4	1.28	1.285	-0.5
40	2.556	2.494	6.2
41	1.232	1.198	3.4
42	1.86	1.834	2.6
43	1.077	1.073	0.4
44	3.22	3.216	0.4
45	1.391	1.393	-0.2
46	3.293	3.293	0
47	1.499	1.423	2.6
48	1.2	1.246	-4.6
49	1.923	1.929	-0.6
5	0.632	0.632	0
51	1.346	1.297	4.9
52	1.851	1.908	-5.7

Table 3. Continued

53	3.237	3.209	2.8
54	1.545	1.545	0
55	0.944	0.95	-0.6
56	0.91	0.903	0.7
57	1.038	1.024	1.4
58	1.023	1.011	1.2
59	0.794	0.792	0.2
6	0.452	0.411	4.1
60	0.886	0.852	3.4
61	0.755	0.73	2.5
62	0.739	0.729	1
64	0.803	0.771	3.2
67	0.924	0.93	-0.6
68	0.582	0.581	0.1
7	4.055	4.02	3.5
73	1.736	1.73	0.6
74	1.032	1.039	-0.7
75	1.019	1.02	-0.1
76	0.918	0.921	-0.3
8	0.887	0.858	2.9
80	0.983	0.966	1.7
9	0.709	0.705	0.4
		Average	2
		Maximum	6.2
		Minimum	-5.7

Confidence Regions

Another factor of accuracy assessment based on the adjustment results is the confidence regions (or error ellipses). These regions describe the positional maximum error for a point under the 95% significant level. The average range of confidence regions for elevations at all points was three cm with a maximum value of 16 cm. The list of confidence regions results are shown in Table 4 and a contour line presentation of the vertical component (elevation) is given in Figure 7.

Table 4. Confidence Regions Results From the Constrained Adjustment.

Station	Major Semi-Axis	AZ	Minor Semi-Axis	Vertical (m)	Vertical (cm)
1	0.058	88	0.032	0.032	3.2
10	0.167	86	0.055	0.088	8.8
107	0.021	108	0.017	0	0
11	0.04	79	0.036	0.015	1.5
116	0.051	80	0.043	0.034	3.4
119	0.071	68	0.037	0.054	5.4
12	0.067	96	0.063	0.045	4.5
120	0.066	118	0.005	0	0
122	0.066	83	0.056	0	0
125	0.092	86	0.044	0.031	3.1
127	0.033	71	0.024	0	0
13	0.038	76	0.034	0.01	1
131	0.084	71	0.051	0	0
132	0.153	81	0.149	0	0
133	0.044	99	0.035	0	0
135	0.03	86	0.027	0.018	1.8
137	0.03	80	0.027	0.027	2.7
138	0.027	89	0.02	0.004	0.4

Table 4. Continued

139	0.062	80	0.61	0.052	5.2
14	0.042	81	0.038	0.031	3.1
141	0.054	95	0.05	0.042	4.2
15	0.032	83	0.028	0.023	2.3
151	0.048	81	0.037	0.043	4.3
152	0.037	78	0.03	0.029	2.9
153	0.042	72	0.031	0.043	4.3
155	0.022	89	0.021	0.018	1.8
16	0.045	94	0.041	0.024	2.4
17	0.095	84	0.048	0.057	5.7
171	0.064	70	0.054	0.06	6
18	0.038	76	0.034	0.006	0.6
19	0.08	83	0.065	0.063	6.3
2	0.02	85	0.016	0.014	1.4
20	0.031	87	0.022	0.022	2.2
201	0	0	0	0.009	0.9
203	0	0	0	0.017	1.7
204	0	0	0	0.024	2.4
205	0	0	0	0.024	2.4
206	0	0	0	0.04	4
207	0	0	0	0.048	4.8
21	0.054	91	0.039	0.039	3.9
210	0.048	87	0.039	0.041	4.1
211	0.116	93	0.064	0	0
212	0	0	0	0.026	2.6
213	0.06	87	0.042	0	0

Table 4. Continued

214	0	0	0	0.043	4.3
215	0	0	0	0.159	15.9
218	0.048	99	0.027	0.03	3
219	0.033	87	0.023	0.001	0.1
22	0.03	57	0.026	0.036	3.6
224	0.027	89	0.02	0	0
226	0.041	81	0.025	0.001	0.1
227	0.142	86	0.108	0.115	11.5
23	0.023	81	0.021	0.038	3.8
24	0.032	64	0.027	0.035	3.5
25	0.027	76	0.02	0.023	2.3
26	0.029	78	0.024	0.023	2.3
27	0.07	89	0.067	0.054	5.4
28	0.041	87	0.034	0.047	4.7
29	0.035	84	0.027	0.031	3.1
3	0.025	82	0.016	0.016	1.6
30	0.019	78	0.017	0.027	2.7
301	0.053	85	0.037	0.036	3.6
302	0.042	82	0.03	0.036	3.6
303	0.035	92	0.03	0.038	3.8
304	0.039	82	0.032	0	1
31	0.043	90	0.018	0.026	2.6
310	0.028	89	0.021	0	0
311	0.033	89	0.023	0	0
312	0.035	92	0.02	0	0
313	0.05	88	0.025	0.024	2.4

Table 4. Continued

314	0.04	87	0.024	0	0
315	0.041	87	0.025	0.016	1.6
32	0.06	86	0.031	0.036	3.6
320	0.03	77	0.025	0	0
321	0.053	81	0.044	0	0
322	0.109	71	0.098	0	0
323	0.029	87	0.022	0	0
33	0.027	84	0.023	0.031	3.1
34	0.034	75	0.023	0.027	2.7
35	0.034	75	0.023	0.028	2.8
36	0.056	76	0.042	0.001	0.1
37	0.029	84	0.013	0.019	1.9
38	0.049	67	0.034	0.043	4.3
39	0.039	84	0.024	0.001	0.1
4	0.019	83	0.015	0.014	1.4
40	0.029	70	0.021	0.001	0.1
406	0.036	87	0.026	0.012	1.2
41	0.053	89	0.034	0.001	0.1
42	0.135	81	0.133	0.108	10.8
43	0.042	90	0.033	0.034	3.4
44	0.029	85	0.021	0.026	2.6
46	0.117	41	0.166	0.094	9.4
47	0.029	75	0.023	0.001	0.1
48	0.044	67	0.023	0.041	4.1
49	0.079	89	0.062	0.004	0.4
5	0.02	87	0.016	0.015	1.5

Table 4. Continued

50	0.045	77	0.035	0.001	0.1
51	0.039	84	0.031	0.001	0.1
52	0.054	87	0.025	0.001	0.1
53	0.106	86	0.089	0.083	8.3
54	0.136	90	0.134	0.108	10.8
55	0.197	105	0.197	0.161	16.1
56	0.03	90	0.026	0.027	2.7
57	0.054	64	0.048	0.058	5.8
58	0.053	88	0.045	0.053	5.3
59	0.093	91	0.086	0.072	7.2
6	0.046	88	0.039	0.017	1.7
60	0.034	80	0.03	0.03	3
61	0.042	87	0.031	0.047	4.7
62	0.039	73	0.029	0.033	3.3
64	0.019	87	0.016	0.021	2.1
67	0.032	104	0.028	0.04	4
68	0.045	85	0.039	0.041	4.1
7	0.037	86	0.025	0.043	4.3
73	0.035	86	0.032	0.011	1.1
74	0.016	84	0.015	0.03	3
75	0.03	86	0.026	0.018	1.8
76	0.062	71	0.057	0.045	4.5
8	0.059	89	0.041	0.034	3.4
8	0.028	75	0.02	0.016	1.6
9	0.029	85	0.022	0.025	2.5
91	0.029	86	0.026	0	0

Table 4. Continued

92	0.036	86	0.033	0	0
93	0.025	80	0.021	0.024	2.4
95	0.039	76	0.035	0	0
				Average (cm)	2.96
				Maximum (cm)	16.10

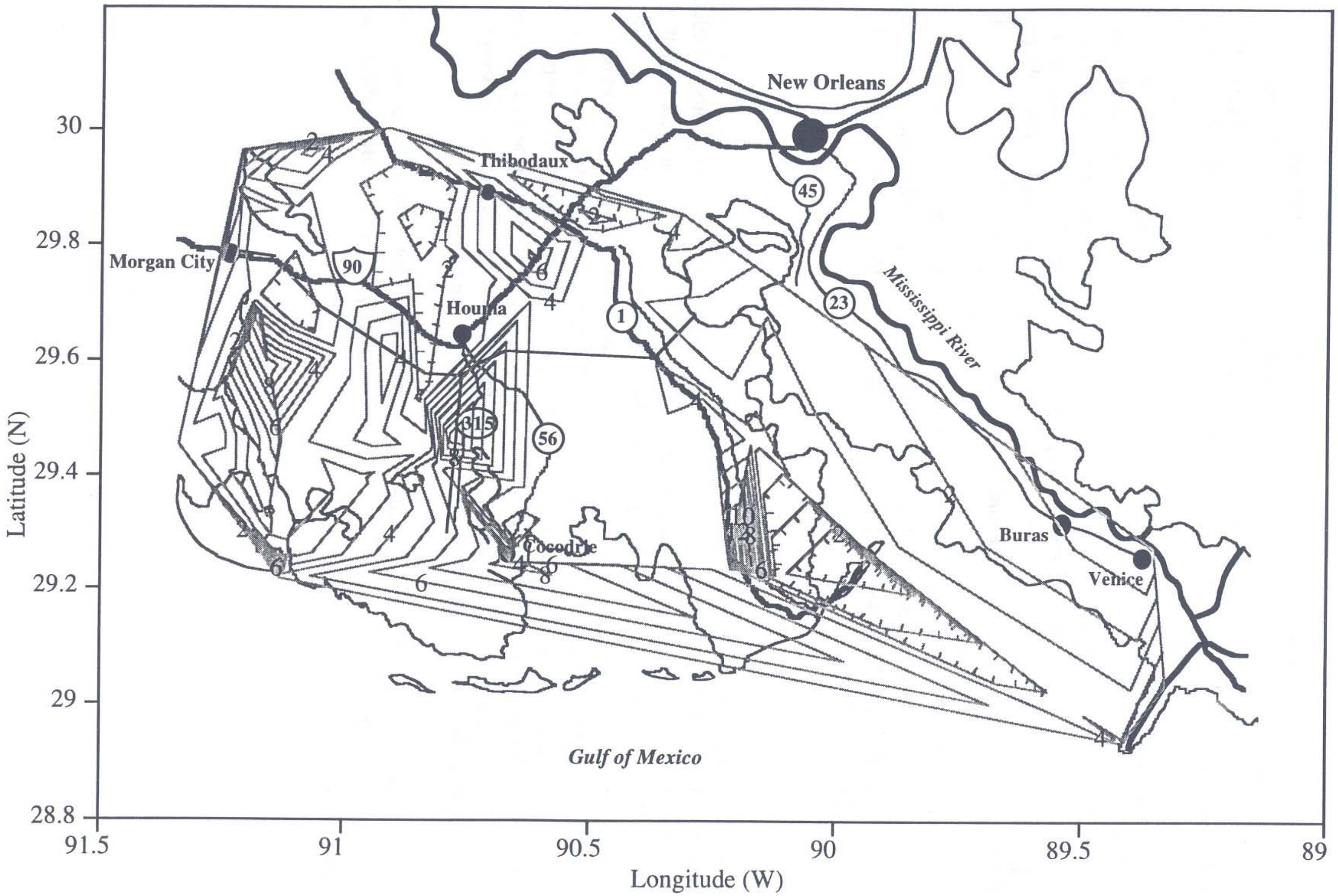


Figure 7. Vertical Component for Confidence Regions (in cm.) at New Sites

Effects of the Geoid Model

The 1993 Ohio State University Model for Geoid in Central America was used for the final adjustment. A Geoid undulation of any point is the difference between its ellipsoidal and orthometric height. Any GPS solution will automatically generate ellipsoidal heights (heights above the ellipsoid) rather than the orthometric heights (heights above the Geoid). A Geoid is an equipotential surface that best represents the mean sea level. Orthometric heights, such as NGVD 1929 are those measured above the Geoid. By including the Geoid undulations model to the GPS vectors, orthometric heights will be generated at each point. The accuracy of these heights is bound by the accuracy of the undulations themselves. Ground control points are then used to further refine the accuracy of the adjustment. A graph of the Geoid model in the project area is given in Figure 8. The example of free adjustment results previously shown in Figure 5 illustrate how similar the differences are between free and final adjustment and the undulation surface. In other words, the free adjustment variations were mostly due to the Geoid undulations being excluded. When the Geoid undulations are included in a free adjustment, the results improve drastically. A graph of variations between free and constrained adjustment when the Geoid model is included is shown in Figure 9. These variations are in the range of ten cm and are taken care of by fixing the heights at control points.

CONCLUSION

Final analysis of the data provided excellent results. The average confidence region in elevation of all points was three cm, with a maximum value of 16 cm. The total number of points included in the final network was 134, 71 of which were requested points and 63 of which were potential control points. From the 63 potential control points in the network, 34 were selected to be final control points. Seventeen elevation check points were selected from the final control set to evaluate the accuracy of the final network. A comparison of a network adjustment performed with the check points included, and a network adjustment performed with the check points excluded, showed a difference of two cm. Most loop closures ranged between one and three ppm mis-closure, which is better than first class specifications for geodetic observations. An overall network configuration including fixed control points is shown in Figure 10.

A contour map was developed for the Barataria-Terrebonne basin based on the data provided by this study. It will be used within both modeling efforts mentioned previously. The contour map is shown in Figure 11.

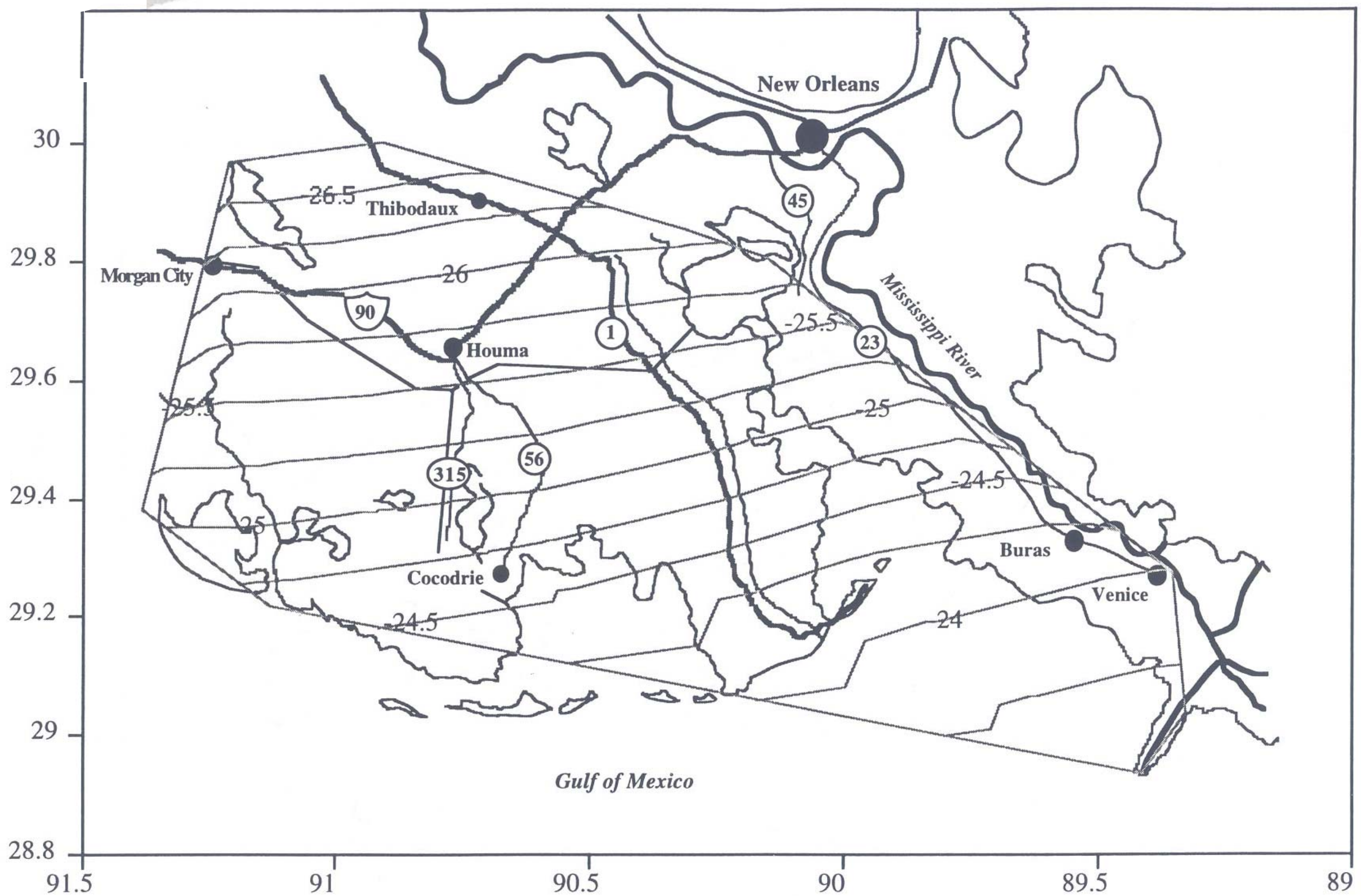


Figure 8. Geoid Undulations Based on 1993 Central Model (in Meters)

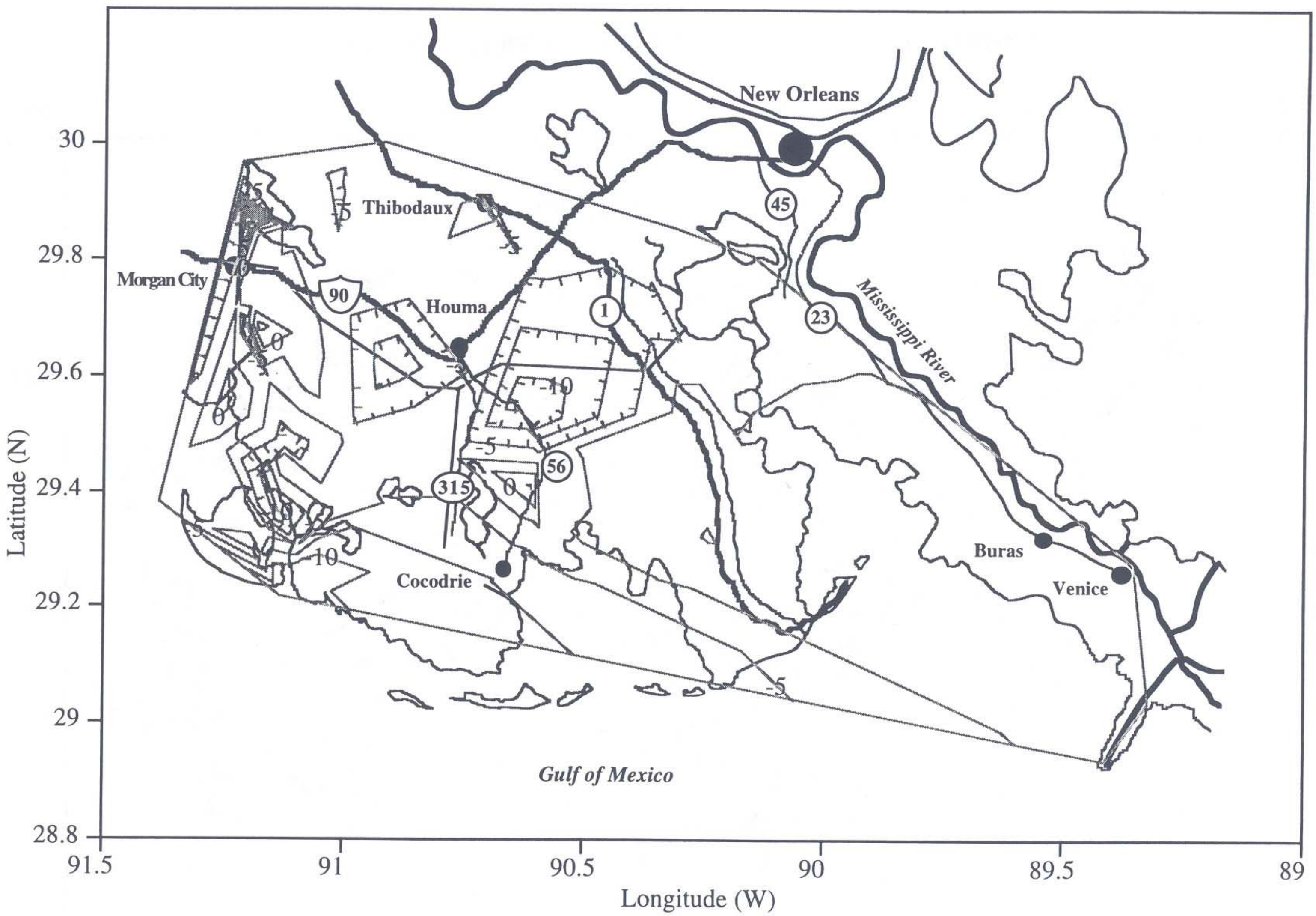


Figure 9. Variations Between Free and Constrained Adjustment (in cm)
Geoid Model Included

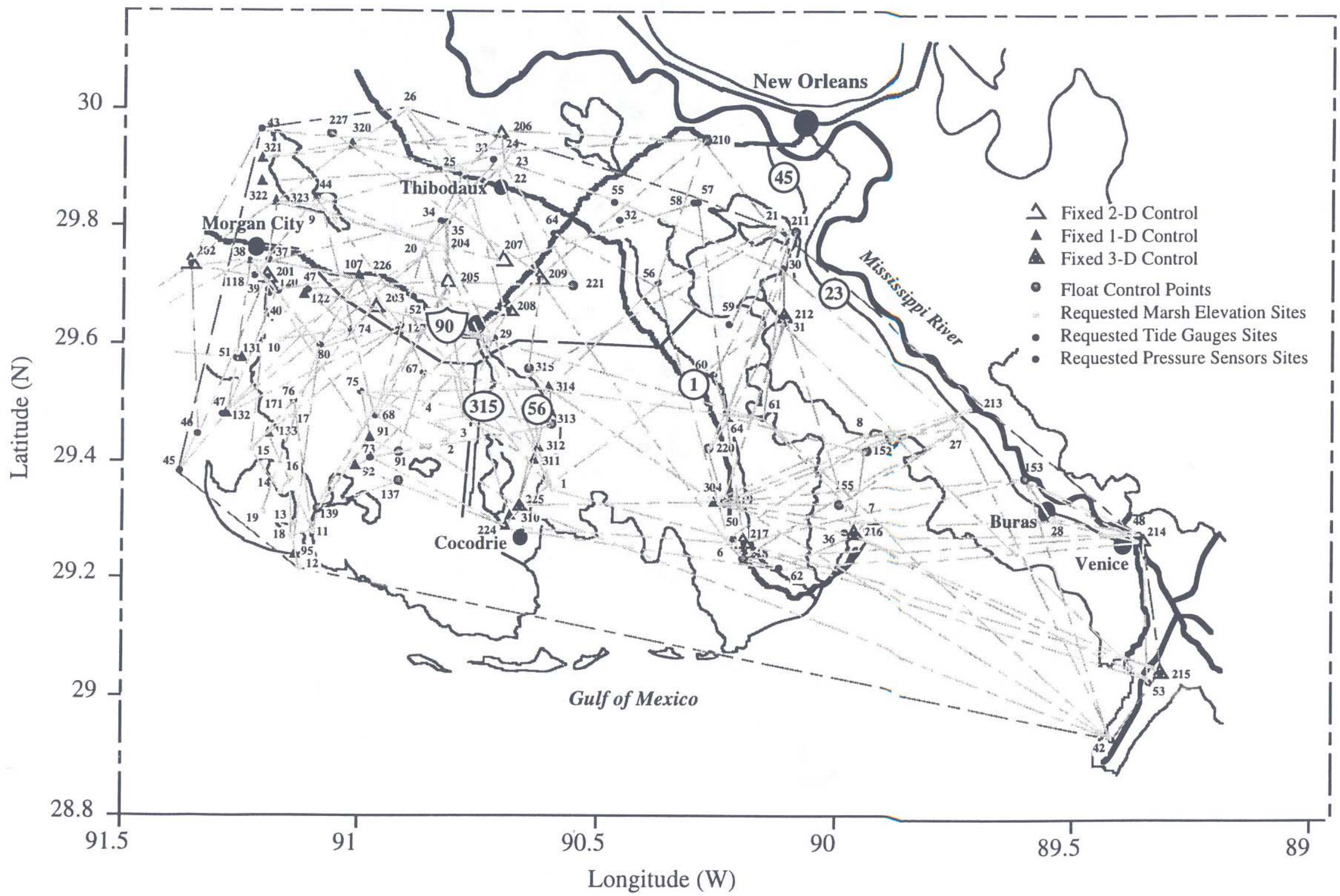


Figure 10. Project Network Configuration

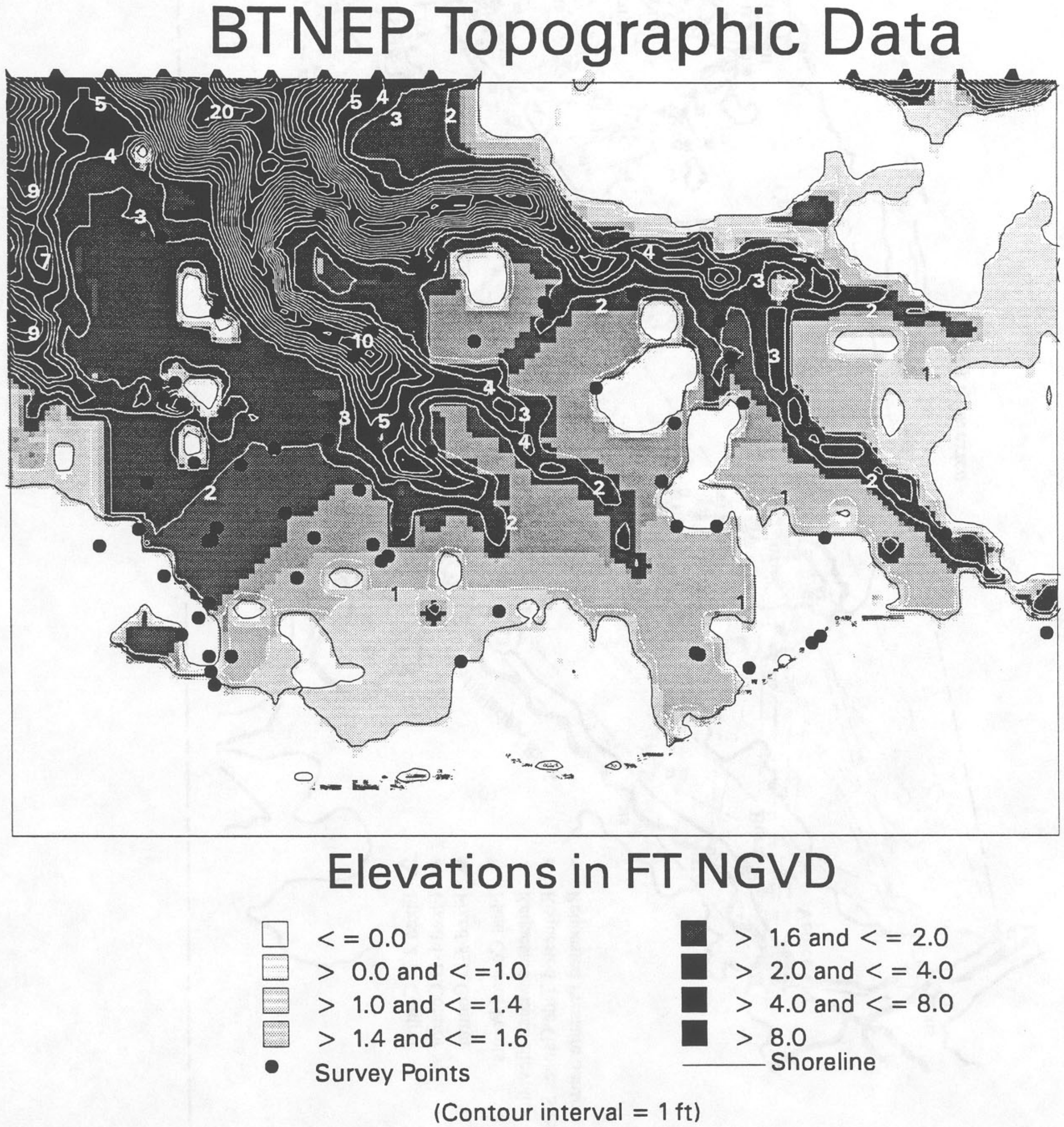


Figure 11. Contour map of the Barataria and Terrebonne basins.

APPENDIX A: Elevational Data at New Sites

Barataria_Terrebonne National Estuary GPS Elevation Study

Point I.D.		GPS Station								Marsh Elevation		SET Pipe A	SET Pipe B	Tide Gauge 0	Water Level		
Point No.	Point Name	GPS Station	Lat. North			Lon. West			Height NGVD (m)	Description	Height NGVD (m)	Height NGVD (m)	Height NGVD (m)	Height NGVD (m)	Date	Time	Height NGVD (m)
1	Y1	3.5” wood post	29	19	40.0	90	35	12.1	0.811	Bayou Chitique	0.199	0.525	0.445				
2	Y2	Removed	29	24	58.5	90	48	28.6	0.867	Fina Contral South	0.352			-0.428	10/31/94	11:55	0.373
3	Y3	3 Nail Mark Fina	29	25	25.7	90	47	45.2	1.164	None							
4	Y4	3 Nail Mark	29	26	42.7	90	49	28.4	1.28	West Bank	0.902						
										East Bank	0.765				10/31/97	12:16	0.381
5	Y5	SET Pipe	29	27	41.8	90	46	37.3	1.923	Fina North End	0.472	0.564		-0.247	11/1/94	7:45	0.433
6	Y6	SET Pipe	29	15	3.3	90	12	48.5	0.452	Brush Fence marsh bottom	-0.272				11/16/94	8:15	0.03
7	Y7	3 Nail Mark	29	16	30.4	89	56	32.6	4.055	None				0.05	11/17/94	12:30	0.1411
8	Y8	Removed	29	26	30.4	89	56	7.84	0.887	St. Mary’s Point	0.494				11/16/94	7:10	-0.009
9	Y9	Removed	29	50	7.0	91	6	31.6	0.709	Swamp Floor	0.45				10/28/94	10:30	0.474
10	Y10	Removed	29	35	12.4	91	9	17.1	0.97	Bayou Penchant Cutoff							
			29	15	40.8	91	5	42.1		Near Mark	0.619						
										41’ East of Mark	0.68						
										25’ West of Mark	0.86						
11	Y11	SET Pipe	29						0.566	Old Oyster Baqyou	0.296	0.566		0.304	10/27/94	13:34	0.03
12	Y12	Platform, Oyster Bayou Outer End, Daymark “O”	29	12	52.6	91	7	42.5	3.201						10/31/94	12:41	0.363
13	Y13	Platform, Head of Oyster Bayou, Daymark “A”	29	15	39.4	91	8	8.04	3.171						10/26/94	15:32	-0.096

14	Y14	Platform Mosquito Point, Daymark B”	29	19	35.0	91	9	11.6	3.377								
15	Y15	Removed	29	23	49.0	91	12	53.4	0.969	Four Leauge Bay North	0.489						
16	Y16	SET Pipe	29	20	58.7	91	8	2.12	0.589	USGS Station @ Carencro	0.444						
17	Y17	Removed	29	27	20.9	91	7	31.9	0.944	Willow Bayou	.0441				11/1/94	10:00	0.109
17-1	Y17-b	Removed	29	27	12.5	91	7	54.3	0.94	Willow Bayou	0.58				11/2/94	13:06	0.321
18	Y18	Removed	29	14	13.9	91	8	1.99	0.684	West Bank, Oyster Bayou	0.346						
19	Y19	Removed	29	17	54.5	91	11	5.07	0.991	Point au Fer	0.565				10/26/94	12:30	0.086
20	Y20	Paint Mark on Fan	29	45	30.1	90	51	13.3	2.428		0.602				11/3/94	11:50	0.998
21	Y21	Removed	29	48	20.2	90	9	5.1	0.868	Jean Lafitte Nat’l Park	0.551				11/3/94	8:30	0.414
22	Y22	Removed	29	53	48.9	90	43	4.25	1.306	Swamp Floor	0.529				10/20/94	16:15	0.696
23	Y23	Removed	29	54	8.4	90	42	27.2	1.203	Swamp Floor	0.517				10/20/94	17:00	0.639
24	Y24	Removed	29	55	33.2	90	40	58.5	1.089	Swamp Floor	0.4				11/3/94	12:35	0.476
25	Y25	3 Nail Mark on Dock	29	53	26.1	90	47	4.1	1.107	Swamp Floor	0.491				11/14/94	10:35	0.375
															2/8/95	14:25	0.049
26	Y26	3.5” wood post	29	59	53.6	90	54	41.9	1.481	Head of Bayou Verrete							
										Swamp North of Mark	0.975						
										Swamp South of Mark	1.021						
27	Y27	Removed	29	27	3.1	89	42	33	0.687	SE Sulphur	0.346				12/1/94	7:00	0.114
28	Y28	Removed	29	17	26.4	89	30	52	0.713	Dry Cypress Bayou	0.323				11/15/94	15:30	0.308

Barataria-Terrebonne National Estuary GPS Elevation Study

Point I.D.		GPS Station							Bolt on Sensor	Tide Gauge 0	Water Level			Water Level			Marsh Elevation
Point No.	Point Name	Lon. North			Lon. West			Height NGVD (m)	Height NGVD (m)	Height NGVD (m)	Date	Time	Height NGVD (m)	Date	Time	Height NGVD (m)	Height NGVD (m)
54	B1	29	46	44.8	90	37	18.1	1.545	1.667	0.139	11/3/94	12:41	0.417				
55	B2	29	50	26.6	90	29	7.46	0.944	1.505	-0.022	11/2/94	12:44	0.34				10': -.415
																	35': .365
56	B3	29	41	57.8	90	23	22.9	0.91	1.507	-0.026	11/3/94	10:30	0.45	11/15/94	7:30	0.41	0.422
57	B4	29	51	10.7	90	18	44.6	1.038			11/15/95	16:30	0.462				
58	B5	29	51	10.4	90	18	58.4	1.023			11/15/94	13:30	0.337				
59	B6	29	38	14.7	90	14	28.9	0.794			11/3/94	13:30	0.319				
60	B7	29	32	23.7	90	16	16	0.886	1.572		11/4/94	12:47	0.392	11/14/94	15:35	0.404	0.433
61	B8	29	27	46.0	90	10	3.21	0.755			11/1/94	12:35	0.344	11/14/94	15:43	0.27	
62	B9	29	13	22.1	90	6	45.9	0.739			11/16/94	12:55	0.096	11/17/94	9:05	0.011	0.317
64	B11	29	27	51.0	90	14	33.8	0.803			1/14/94	12:40	0.357	11/14/94	15:37	0.379	High: .779
																	Low: .379
67	ET1	29	32	14.9	90	50	50	0.924	1.558	-0.006	11/1/94	13:30	0.378	10/31/94	13:50	0.476	0.435
68	ET2	29	27	27.7	90	56	3.61	0.582	1.527	1.097	11/2/94	8:05	0.387				0.405
73*	ET7	29	23	25.9	90	58	5.81	1.736			11/3/94	14:05	0.371				
74	WT1	29	36	33.2	91	0	21.2	1.032	1.657	0.09							
75	WT2	29	29	54.8	90	59	12.7	1.019	1.513		11/2/94	9:39	0.403				0.523
76	WT3	29	28	35.7	91	7	1.09	0.918	1.273	-0.251	11/1/94	10:30	0.208				0.525
80	WT7	29	34	48.5	91	4	12.1	0.983			10/26/94	15:45	0.392	10/26/94	12:56	0.425	

*Point 73 is a 4 nail mark on Unocal Platform

Barataria-Terrebonne National Estuary GPS Elevation Study

Point I.D.		GPS Station							Tide Gauge 0	Water Level			Water Level			C.O.E. Subsidence Mark	
Point No.	Point Name	Lon. North			Lon. West			Height NGVD (m)	Height NGVD (m)	Date	Time	Height NGVD (m)	Date	Time	Height NGVD (m)	Long Rod NGVD (m)	Short Rod NGVD (m)
29	R 76320	29	35	5.5	90	42	38.2	1.723	-0.167								1.616
30	R 82750	29	44	30	90	7	54.8	1.137	-0.021	11/14/94	15:00	0.351					
31	R 82875	29	40	2.2	90	6	36.8	1.621	-0.065	11/15/94	15:35	0.307					
32	R 82700	29	49	25.8	90	28	32.9	3.364		9/7/94	16:45	0.418					
33	R 82520	29	54	44.5	90	43	44.6	0.996		11/3/94	7:15	0.453					
34	R 82157	29	47	53.1	90	49	20.8	5.706		10/31/94	13:20	1.424					
35	USGS	29	47	57.7	90	49	4.14	4.522		10/31/94	10:35	0.712	10/31/94	12:36	0.712		
36	R 88400	29	15	53.3	89	57	27.1	1.174	0.05	11/15/94	12:32	0.28					
37	R 52750	29	43	12.1	91	11	15.9	1.337	0.009	11/16/94	12:35	0.473					
38	R o3780	29	43	7.0	91	13	27.6	5.196	-0.004	10/25/94	14:00	0.53					
39	R 76360	29	40	59.3	91	10	34.1	1.715	0.061	10/26/94	13:00	0.488					
40	R 76400	29	40	59.7	91	10	19	2.556	0.068	10/26/94	14:00	0.495					
41	R 52800	29	40	6.9	91	5	52.2	1.232	0.04	2/8/95	16:47	0.577				2.042	
42	Pilot Station	28	55	54.0	89	24	48.8	1.86	-0.356	11/16/94	15:12	0.6				2.042	
43	R 52680	29	57	47.4	91	12	34.4	1.077	0.083	2/8/95	15:11	0.577				1.786	1.226
44	R 52720	29	51	3.9	91	6	12.3	3.22	-0.209	11/3/94	7:30	0.556	11/2/94	10:50	0.544		
46	R 88550	29	26	57.2	91	20	15.6	1.391		11/1/94	10:31	0.175	11/1/94	12:32	0.388		
47	R o3850	29	28	28.7	91	15	45.9	3.293		10/25/94	16:20	0.282				1.028	
48	R 03820	29	16	19.4	89	21	7.73	1.449	-0.008	11/17/94	10:40	0.455					
49	R 76305	29	14	43.9	90	39	51.4	1.2	0.027	11/1/94	13:45	0.148				0.696	0.676
50	R 82305	29	14	51.3	90	12	28.6	0.632	-0.252	11/16/94	10:15	0.022					
51	R o1480	29	33	8.8	91	14	39.9	1.346	-0.355							0.959	
52	R 52800	29	37	12.1	90	54	10.8	1.851		10/25/94	10:42	0.482				1.278	1.269
53	R 01670	29	2	5.8	89	19	27.2	3.237		11/16/94	9:40	0.137					

APPENDIX B: Final and Free Adjustment Results

Original Solution/Free Adjustment
(Point 208 Fixed)

Point #	North Latitude					West Longitude				Ht: NGVD m
1	N	29	19	39.99914		W	90	35	12.14414	1.681
2	N	29	24	58.50577		W	90	48	28.55566	1.456
3	N	29	25	25.6576		W	90	47	45.18499	1.735
4	N	29	26	42.68469		W	90	49	28.43419	1.787
5	N	29	27	41.83135		W	90	46	37.34877	2.391
6	N	29	15	3.27771		W	90	12	48.47112	1.754
7	N	29	16	30.44863		W	89	56	32.5975	5.512
8	N	29	26	30.38756		W	89	56	7.84939	1.857
9	N	29	50	6.97784		W	91	6	31.54975	0.083
10	N	29	35	12.38218		W	91	9	17.06285	1.079
11	N	29	15	40.8		W	91	5	42.08099	1.541
12	N	29	12	52.62335		W	91	7	42.54268	4.281
13	N	29	15	39.37031		W	91	8	8.03364	4.138
14	N	29	19	35.00328		W	91	9	11.60683	4.098
15	N	29	23	48.97064		W	91	12	53.42906	1.502
16	N	29	20	58.69346		W	91	8	2.11644	1.328
17	N	29	27	20.88746		W	91	7	31.9029	1.34
18	N	29	14	13.91727		W	91	8	1.98527	1.717
19	N	29	17	54.49066		W	91	11	5.06011	1.762
20	N	29	45	30.08579		W	90	51	13.29189	2.118
21	N	29	48	20.20883		W	90	9	5.11144	0.607
22	N	29	53	48.87412		W	90	43	4.24943	0.608
23	N	29	54	8.35749		W	90	42	27.16579	0.539
24	N	29	55	33.16022		W	90	40	58.53044	0.33
25	N	29	53	26.14225		W	90	47	4.10045	0.414
26	N	29	59	53.55846		W	90	54	41.92725	0.407
27	N	29	27	3.13548		W	89	42	33.05415	1.748
28	N	29	17	26.37796		W	89	30	51.98628	2.283
29	N	29	35	53.5844		W	90	42	38.16321	1.878
30	N	29	44	29.58379		W	90	7	54.78695	1.086
31	N	29	40	2.20942		W	90	6	36.81131	1.808
32	N	29	49	25.77651		W	90	28	32.90251	2.997
33	N	29	54	44.45353		W	90	43	44.6014	0.276
34	N	29	47	53.10564		W	90	49	20.79461	5.281
35	N	29	47	57.68508		W	90	49	4.13586	4.094
36	N	29	15	53.28465		W	89	57	27.09292	2.647
37	N	29	43	12.07083		W	91	11	15.94129	1.056
38	N	29	43	6.9722		W	91	13	27.58183	4.926
39	N	29	40	59.33287		W	91	10	34.12534	1.494
40	N	29	40	59.67733		W	91	10	19.01166	2.335
41	N	29	40	6.94913		W	91	5	52.2191	1.091
42	N	28	55	53.98885		W	89	24	48.81213	4.001
43	N	29	57	47.42811		W	91	12	34.3822	-0.011
44	N	29	51	3.8541		W	91	6	12.29995	2.542

46	N	29	26	57.24697		W	91	20	15.56704	1.796
47	N	29	28	28.72896		W	91	15	45.9124	3.636
48	N	29	16	19.38895		W	89	21	7.74911	3.074
49	N	29	14	43.95213		W	90	39	51.44152	2.308
50	N	29	14	51.28202		W	90	12	28.58772	1.949
51	N	29	33	8.75337		W	91	14	39.86633	1.469
52	N	29	37	12.13642		W	90	54	10.78011	1.954
53	N	29	2	5.77428		W	89	19	27.23663	5.235
54	N	29	46	44.77411		W	90	37	18.1172	1.269
55	N	29	50	26.64421		W	90	29	7.46178	0.527
56	N	29	41	57.8024		W	90	23	22.87043	0.918
57	N	29	51	10.65591		W	90	18	44.58738	0.608
58	N	29	51	10.43001		W	90	18	58.37008	0.584
59	N	29	38	14.74974		W	90	14	28.89024	1.018
60	N	29	32	23.72191		W	90	16	16.00455	1.331
61	N	29	27	46.0148		W	90	10	3.21868	1.502
62	N	29	13	22.06007		W	90	6	45.87207	2.212
64	N	29	27	51.0173		W	90	14	33.84154	1.477
67	N	29	32	14.91431		W	90	50	49.96456	1.2
68	N	29	27	27.70246		W	90	56	3.61156	1.017
73	N	29	23	25.91136		W	90	58	5.8095	2.338
74	N	29	36	33.16589		W	91	0	21.17162	1.086
75	N	29	29	54.82386		W	90	59	12.73762	1.357
76	N	29	28	35.72133		W	91	7	1.08967	1.329
80	N	29	34	48.45944		W	91	4	12.06265	1.085
91	N	29	25	3.5444		W	90	58	0.14125	1.206
92	N	29	22	26.93784		W	91	0	0.13226	1.246
93	N	29	24	58.06014		W	90	53	45.0261	1.286
95	N	29	13	14.22592		W	91	7	53.57479	1.832
107	N	29	42	17.36178		W	90	59	36.34355	0.557
116	N	29	57	48.38671		W	91	12	36.068639	0.698
119	N	29	41	45.89423		W	91	12	39.26413	1.876
120	N	29	41	1.09808		W	91	10	27.33074	1.821
122	N	29	40	6.20998		W	91	5	51.90721	3.773
125	N	29	35	53.59923		W	90	42	38.4079	1.771
127	N	29	37	11.97338		W	90	54	10.70633	1.381
131	N	29	33	8.30825		W	91	14	42.29838	1.082
132	N	29	28	27.70158		W	91	15	46.47777	1.371
133	N	29	26	3.44221		W	91	10	13.88192	1.421
135	N	29	28	55.23371		W	90	59	0.96901	1.519
137	N	29	22	32.68791		W	90	54	33.13676	1.462
138	N	29	14	44.20202		W	90	39	50.94445	1.805
139	N	29	18	6.45686		W	91	5	33.95891	2.544
141	N	29	22	45.23863		W	91	22	54.38288	6.677
151	N	29	34	21.8853		W	91	32	0.82351	1.552
152	N	29	25	56.66406		W	89	59	21.12552	1.756
153	N	29	22	31.20386		W	89	36	3.59265	5.43
155	N	29	19	3.31842		W	89	58	51.86803	2
171	N	29	27	12.46357		W	91	7	54.30795	1.356

201	N	29	41	31.25706		W	91	11	13.03887	3.224
202	N	29	42	40.24266		W	91	20	16.15666	1.668
203	N	29	38	17.83033		W	90	57	14.10329	1.469
204	N	29	44	52.82204		W	90	49	36.11483	2.227
205	N	29	41	33.99361		W	90	48	41.23873	3.427
206	N	29	57	55.5674		W	90	42	49.47871	1.668
207	N	29	44	30.61262		W	90	42	0.20979	3.649
208	N	29	38	46.66876		W	90	41	18.72349	2.3
209	N	29	42	20.67694		W	90	37	20.45363	0.528
210	N	29	58	16.73385		W	90	18	25.62265	0.693
211	N	29	47	36.23258		W	90	7	18.08153	2.119
212	N	29	40	7.05055		W	90	6	35.60564	0.869
213	N	29	28	5.74732		W	89	40	53.74592	1.131
214	N	29	16	0.53455		W	89	21	10.37607	2.701
215	N	29	3	6.05338		W	89	18	36.16526	4.525
216	N	29	15	51.47814		W	89	57	19.2824	2.453
217	N	29	14	51.34407		W	90	12	22.76806	2.455
218	N	29	14	6.23379		W	90	12	35.19972	1.923
219	N	29	19	18.08019		W	90	14	21.12251	1.331
220	N	29	24	7.72587		W	90	16	21.59929	1.302
221	N	29	41	39.7009		W	90	33	6.32946	3.74
224	N	29	14	47.22177		W	90	39	41.53937	1.773
225	N	29	17	23.95586		W	90	38	54.2202	1.668
226	N	29	42	20.07004		W	90	59	30.63686	0.724
227	N	29	57	37.28037		W	91	4	9.36756	2.809
301	N	29	43	7.93017		W	91	13	30.66755	1.991
302	N	29	15	15.51342		W	90	39	38.51769	1.884
303	N	29	40	6.54225		W	91	6	0.10099	3.764
304	N	29	19	18.76844		W	90	14	23.15202	1.544
310	N	29	15	39.42035		W	90	39	23.81555	1.426
311	N	29	22	16.57971		W	90	37	26.58488	1.131
312	N	29	24	28.10668		W	90	36	28.40632	1.413
313	N	29	27	0.15926		W	90	35	35.35672	2.123
314	N	29	31	17.19845		W	90	35	56.45293	2.388
315	N	29	33	12.78855		W	90	38	19.78215	2.584
320	N	29	56	28.11707		W	91	1	25.91615	4.86
321	N	29	54	34.17542		W	91	12	56.05921	1.254
322	N	29	52	4.03949		W	91	12	23.87042	1.208
323	N	29	50	7.32115		W	91	10	37.79597	2.3
406	N	29	15	3.27973		W	90	12	48.4592	1.901
LSU1	N	30	24	26.69761		W	91	10	48.90801	20.38

Original Solution/Constrained Adjustment

Point #	North Latitude				West Longitude					Ht: NGVD m
1	N	29	19	39.99382		W	90	35	12.14255	0.811
2	N	29	24	58.50161		W	90	48	28.55583	0.867
3	N	29	25	25.6535		W	90	47	45.1853	1.164
4	N	29	26	42.68097		W	90	49	28.4346	1.28
5	N	29	27	41.82791		W	90	46	37.34854	1.923
6	N	29	15	3.27095		W	90	12	48.46209	0.452
7	N	29	16	30.44202		W	89	56	32.5847	4.055
8	N	29	26	30.38349		W	89	56	7.83662	0.887
9	N	29	50	6.97972		W	91	6	31.55438	0.709
10	N	29	35	12.38194		W	91	9	17.07122	0.97
11	N	29	15	40.79399		W	91	5	42.08636	0.566
12	N	29	12	52.61666		W	91	7	42.54886	3.201
13	N	29	15	39.36431		W	91	8	8.03958	3.171
14	N	29	19	34.99829		W	91	9	11.61333	3.377
15	N	29	23	48.96657		W	91	12	53.43641	0.969
16	N	29	20	58.68875		W	91	8	2.12264	0.589
17	N	29	27	20.88306		W	91	7	31.90731	0.944
18	N	29	14	13.91092		W	91	8	1.99119	0.684
19	N	29	17	54.48546		W	91	11	5.06824	0.991
20	N	29	45	30.08694		W	90	51	13.29285	2.428
21	N	29	48	20.21099		W	90	9	5.10196	0.868
22	N	29	53	48.87752		W	90	43	4.24834	1.306
23	N	29	54	8.36234		W	90	42	27.16313	1.203
24	N	29	55	33.16395		W	90	40	58.52888	1.089
25	N	29	53	26.14589		W	90	47	4.10014	1.107
26	N	29	59	53.56353		W	90	54	41.92847	1.481
27	N	29	27	3.13148		W	89	42	33.03821	0.687
28	N	29	17	26.37096		W	89	30	51.96682	0.713
29	N	29	35	53.58337		W	90	42	38.16403	1.723
30	N	29	44	29.58455		W	90	7	54.77726	1.137
31	N	29	40	2.20884		W	90	6	36.80091	1.621
32	N	29	49	25.77896		W	90	28	32.89791	3.364
33	N	29	54	44.45801		W	90	43	44.59925	0.996
34	N	29	47	53.10778		W	90	49	20.79493	5.706
35	N	29	47	57.68724		W	90	49	4.13611	4.522
36	N	29	15	53.27795		W	89	57	27.08052	1.174
37	N	29	43	12.0705		W	91	11	15.94719	1.337
38	N	29	43	6.97339		W	91	13	27.59083	5.196
39	N	29	40	59.33303		W	91	10	34.13469	1.715
40	N	29	40	59.67719		W	91	10	19.01987	2.556
41	N	29	40	6.94819		W	91	5	52.22365	1.232
42	N	28	55	53.97702		W	89	24	48.79193	1.86
43	N	29	57	47.432		W	91	12	34.3884	1.077
44	N	29	51	3.85622		W	91	6	12.30451	3.22
46	N	29	26	57.24367		W	91	20	15.57615	1.391

47	N	29	28	28.72625		W	91	15	45.92082	3.293
48	N	29	16	19.38165		W	89	21	7.72738	1.449
49	N	29	14	43.94566		W	90	39	51.43879	1.2
50	N	29	14	51.27475		W	90	12	28.57933	0.632
51	N	29	33	8.75216		W	91	14	39.87521	1.346
52	N	29	37	12.13671		W	90	54	10.7823	1.851
53	N	29	2	5.76364		W	89	19	27.21456	3.237
54	N	29	46	44.77558		W	90	37	18.11459	1.545
55	N	29	50	26.64631		W	90	29	7.4564	0.944
56	N	29	41	57.8027		W	90	23	22.86404	0.91
57	N	29	51	10.65837		W	90	18	44.58045	1.038
58	N	29	51	10.43171		W	90	18	58.36238	1.023
59	N	29	38	14.74939		W	90	14	28.88208	0.794
60	N	29	32	23.71935		W	90	16	15.99665	0.886
61	N	29	27	46.01124		W	90	10	3.20936	0.755
62	N	29	13	22.05252		W	90	6	45.86215	0.739
64	N	29	27	51.01365		W	90	14	33.83324	0.803
67	N	29	32	14.91201		W	90	50	49.9645	0.9247
68	N	29	27	27.69929		W	90	56	3.61429	0.582
73	N	29	23	25.90688		W	90	58	5.81185	1.736
74	N	29	36	33.16609		W	91	0	21.17867	1.032
75	N	29	29	54.82094		W	90	59	12.74093	1.019
76	N	29	28	35.71827		W	91	7	1.0949	0.918
80	N	29	34	48.45834		W	91	4	12.06915	0.983
91	N	29	25	3.54035		W	90	58	0.14445	0.658
92	N	29	22	26.93313		W	91	0	0.13504	0.614
93	N	29	24	58.05596		W	90	53	45.02753	0.712
95	N	29	13	14.21933		W	91	7	53.58068	0.753
107	N	29	42	17.36326		W	90	59	36.35033	0.742
116	N	29	57	48.39048		W	91	12	36.07479	1.786
119	N	29	41	45.8941		W	91	12	39.26983	2.04
120	N	29	41	1.09688		W	91	10	27.3356	2.042
122	N	29	40	6.20962		W	91	5	51.90945	3.914
125	N	29	35	53.59841		W	90	42	38.4082	1.616
127	N	29	37	11.97311		W	90	54	10.70947	1.278
131	N	29	33	8.30648		W	91	14	42.30848	0.959
132	N	29	28	27.6993		W	91	15	46.4869	1.028
133	N	29	26	3.43873		W	91	10	13.8887	0.907
135	N	29	28	55.23056		W	90	59	0.97227	1.14
137	N	29	22	32.68313		W	90	54	33.13837	0.787
138	N	29	14	44.19558		W	90	39	50.94259	0.696
139	N	29	18	6.45201		W	91	5	33.96299	1.734
141	N	29	22	45.23394		W	91	22	54.39219	6.11
151	N	29	34	21.8842		W	91	32	0.83655	1.487
152	N	29	25	56.65981		W	89	59	21.11275	0.76
153	N	29	22	31.19814		W	89	36	3.57467	4.121
155	N	29	19	3.31246		W	89	58	51.85579	0.699
171	N	29	27	12.45992		W	91	7	54.31303	0.94
201	N	29	41	31.256		W	91	11	13.04381	3.409

202	N	29	42	40.24324		W	91	20	16.16575	1.929
203	N	29	38	17.83106		W	90	57	14.10967	1.477
204	N	29	44	52.8232		W	90	49	36.1173	2.489
205	N	29	41	33.99367		W	90	48	41.23667	3.545
206	N	29	57	55.57401		W	90	42	49.4757	2.517
207	N	29	44	30.61177		W	90	42	0.20655	3.892
208	N	29	38	46.66876		W	90	41	18.72349	2.3
209	N	29	42	20.67719		W	90	37	20.45166	0.643
210	N	29	58	16.73873		W	90	18	25.61541	1.426
211	N	29	47	36.23401		W	90	7	18.07149	2.365
212	N	29	40	7.05018		W	90	6	35.5958	0.682
213	N	29	28	5.74365		W	89	40	53.7294	0.091
214	N	29	16	0.52708		W	89	21	10.35407	1.063
215	N	29	3	6.04516		W	89	18	36.13924	2.379
216	N	29	15	51.47138		W	89	57	19.26968	0.98
217	N	29	14	51.33677		W	90	12	22.76042	1.139
218	N	29	14	6.22627		W	90	12	35.19144	0.582
219	N	29	19	18.07438		W	90	14	21.11416	0.259
220	N	29	24	7.72131		W	90	16	21.59143	0.48
221	N	29	41	39.7011		W	90	33	6.32516	3.779
224	N	29	14	47.21534		W	90	39	41.53747	0.665
225	N	29	17	23.94912		W	90	38	54.21916	0.634
226	N	29	42	20.07114		W	90	59	30.64209	0.909
227	N	29	57	37.28432		W	91	4	9.37206	3.859
301	N	29	43	7.93177		W	91	13	30.67712	2.273
302	N	29	15	15.50697		W	90	39	38.51569	0.813
303	N	29	40	6.54341		W	91	6	0.10949	3.873
304	N	29	19	18.76235		W	90	14	23.14375	0.472
310	N	29	15	39.41413		W	90	39	23.81357	0.35
311	N	29	22	16.57497		W	90	37	26.58235	0.394
312	N	29	24	28.10235		W	90	36	28.40353	0.815
313	N	29	27	0.15577		W	90	35	35.355	1.575
314	N	29	31	17.19634		W	90	35	56.44944	1.939
315	N	29	33	12.78691		W	90	38	19.77923	2.23
320	N	29	56	28.12146		W	91	1	25.91912	2.794
321	N	29	54	34.17964		W	91	12	56.06499	2.105
322	N	29	52	4.04194		W	91	12	23.87666	2.12
323	N	29	50	7.32283		W	91	10	37.80153	2.948
406	N	29	15	3.2729		W	90	12	48.45049	0.601
LSU1	N	30	24	26.70834		W	91	10	48.91438	22.253

Check Solution/Constrained Adjustment

Point #	North Latitude				West Longitude					Ht: NGVD m
1	N	29	19	39.99327		W	90	35	12.13939	0.722
2	N	29	24	58.50175		W	90	48	28.55661	0.853
3	N	29	25	25.65374		W	90	47	45.18517	1.144
4	N	29	26	42.68141		W	90	49	28.4358	1.263
5	N	29	27	41.82837		W	90	46	37.34937	1.914
6	N	29	15	3.27085		W	90	12	48.463	0.473
7	N	29	16	30.44183		W	89	56	32.58348	4.038
8	N	29	26	30.38335		W	89	56	7.83499	0.867
9	N	29	50	6.98074		W	91	6	31.55494	0.689
10	N	29	35	12.38119		W	91	9	17.07023	0.951
11	N	29	15	40.79339		W	91	5	42.08608	0.606
12	N	29	12	52.61649		W	91	7	42.54783	3.203
13	N	29	15	39.36356		W	91	8	8.03918	3.211
14	N	29	19	34.9978		W	91	9	11.61342	3.344
15	N	29	23	48.96653		W	91	12	53.43659	0.916
16	N	29	20	58.68851		W	91	8	2.12193	0.606
17	N	29	27	20.88501		W	91	7	31.90792	0.921
18	N	29	14	13.9101		W	91	8	1.9907	0.724
19	N	29	17	54.48515		W	91	11	5.06687	0.97
20	N	29	45	30.0873		W	90	51	13.29314	2.399
21	N	29	48	20.21122		W	90	9	5.09898	0.849
22	N	29	53	48.87789		W	90	43	4.24763	1.289
23	N	29	54	8.36179		W	90	42	27.16255	1.232
24	N	29	55	33.16441		W	90	40	58.52806	1.093
25	N	29	53	26.14575		W	90	47	4.09947	1.104
26	N	29	59	53.56311		W	90	54	41.92865	1.462
27	N	29	27	3.13091		W	89	42	33.03762	0.73
28	N	29	17	26.37225		W	89	30	51.96573	0.605
29	N	29	35	53.583		W	90	42	38.16318	1.723
30	N	29	44	29.58597		W	90	7	54.7757	1.092
31	N	29	40	2.209		W	90	6	36.80125	1.678
32	N	29	49	25.7785		W	90	28	32.98638	3.34
33	N	29	54	44.45707		W	90	43	44.6008	0.966
34	N	29	47	53.10745		W	90	49	20.79376	5.711
35	N	29	47	57.68696		W	90	49	4.13493	4.52
36	N	29	15	53.27815		W	89	57	27.07951	1.174
37	N	29	43	12.07043		W	91	11	15.94709	1.33
38	N	29	43	6.97444		W	91	13	27.59059	5.198
39	N	29	40	59.33289		W	91	10	34.13232	1.715
40	N	29	40	59.67729		W	91	10	19.01886	2.556
41	N	29	40	6.9473		W	91	5	52.22375	1.232
42	N	28	55	53.97705		W	89	24	48.79302	1.868
43	N	29	57	47.43271		W	91	12	12.30506	1.08
44	N	29	51	3.85723		W	91	6	34.30506	3.217
46	N	29	26	57.24342		W	91	20	15.57675	1.342

47	N	29	28	28.72628		W	91	15	45.9029	3.274
48	N	29	16	19.38286		W	89	21	7.72614	1.319
49	N	29	14	43.94467		W	90	39	51.43902	1.197
50	N	29	14	51.27507		W	90	12	28.58012	0.632
51	N	29	33	8.752		W	91	14	39.87398	1.346
52	N	29	37	12.13585		W	90	54	10.78396	1.851
53	N	29	2	5.76213		W	89	19	27.22437	3.197
54	N	29	46	44.77538		W	90	37	18.11211	1.534
55	N	29	50	26.64817		W	90	29	7.45785	0.958
56	N	29	41	57.80225		W	90	23	22.86192	0.872
57	N	29	51	10.65856		W	90	18	44.5802	1.076
58	N	29	51	10.43154		W	90	18	58.36164	1.014
59	N	29	38	14.74964		W	90	14	28.87963	0.79
60	N	29	32	23.71975		W	90	16	15.99576	0.818
61	N	29	27	46.01042		W	90	10	3.20719	0.714
62	N	29	13	22.05271		W	90	6	45.86267	0.739
64	N	29	27	51.01364		W	90	14	33.83161	0.749
67	N	29	32	14.91303		W	90	50	49.96796	0.883
68	N	29	27	27.69797		W	90	56	3.61541	0.585
73	N	29	23	25.90718		W	90	58	5.81329	1.724
74	N	29	36	33.16629		W	91	0	21.1786	1.046
75	N	29	29	54.82128		W	90	59	12.74103	1.002
76	N	29	28	35.71782		W	91	7	1.09415	0.957
80	N	29	34	48.45791		W	91	4	12.06799	0.983
91	N	29	25	3.5408		W	90	58	0.14457	0.644
92	N	29	22	26.93342		W	91	0	0.13649	0.596
93	N	29	24	58.05659		W	90	53	45.02858	0.681
95	N	29	13	14.21849		W	91	7	53.58019	0.797
107	N	29	42	17.36062		W	90	59	36.34693	0.742
116	N	29	57	48.39161		W	91	12	36.07574	1.789
119	N	29	41	45.89403		W	91	12	39.26893	2.049
120	N	29	41	1.09681		W	91	10	27.33545	2.042
122	N	29	40	6.20943		W	91	5	51.91217	3.914
125	N	29	35	53.5987		W	90	42	38.40956	1.616
127	N	29	37	11.9725		W	90	54	10.7098	1.278
131	N	29	33	8.30751		W	91	14	42.30407	0.959
132	N	29	28	27.69954		W	91	15	46.48489	1.009
133	N	29	26	3.43856		W	91	10	13.88763	0.907
135	N	29	28	55.23085		W	90	59	0.97238	1.123
137	N	29	22	32.68382		W	90	54	33.13942	0.761
138	N	29	14	44.19548		W	90	39	50.94335	0.694
139	N	29	18	6.45218		W	91	5	33.96408	1.712
141	N	29	22	45.23423		W	91	22	54.39255	6.079
151	N	29	34	21.88522		W	91	32	0.836074	1.49
152	N	29	25	56.66009		W	89	59	21.11206	0.756
153	N	29	22	31.19838		W	89	36	3.57396	4.013
155	N	29	19	3.31252		W	89	58	51.85557	0.693
171	N	29	27	12.46008		W	91	7	54.31365	0.891
201	N	29	41	31.256		W	91	11	13.04381	3.409

202	N	29	42	40.24324		W	91	20	16.16575	1.929
203	N	29	38	17.83106		W	90	57	14.10967	1.516
204	N	29	44	52.8232		W	90	49	36.1173	2.497
205	N	29	41	33.99367		W	90	48	41.23667	3.579
206	N	29	57	55.57401		W	90	42	49.4757	2.557
207	N	29	44	30.61177		W	90	42	0.20655	3.734
208	N	29	38	46.66876		W	90	41	18.72349	2.3
209	N	29	42	20.67719		W	90	37	20.45166	0.643
210	N	29	58	16.73898		W	90	18	25.61406	1.393
211	N	29	47	36.23069		W	90	7	18.08526	2.534
212	N	29	40	7.05018		W	90	6	35.5958	0.739
213	N	29	28	5.74369		W	89	40	53.72936	0.091
214	N	29	16	0.52708		W	89	21	10.35407	0.982
215	N	29	3	6.04516		W	89	18	36.13924	2.379
216	N	29	15	51.47138		W	89	57	19.26968	0.98
217	N	29	14	51.33677		W	90	12	22.76042	1.139
218	N	29	14	6.22627		W	90	12	35.19168	0.562
219	N	29	19	18.07587		W	90	14	21.11285	0.259
220	N	29	24	7.72161		W	90	16	21.59015	0.466
221	N	29	41	39.70085		W	90	33	6.32455	3.761
224	N	29	14	47.21521		W	90	39	41.53842	0.665
225	N	29	17	23.94912		W	90	38	54.21916	0.634
226	N	29	42	20.07188		W	90	59	30.64351	0.909
227	N	29	57	37.28454		W	91	4	9.37431	3.758
301	N	29	43	7.93124		W	91	13	30.6758	2.275
302	N	29	15	15.50696		W	90	39	38.51652	0.809
303	N	29	40	6.5431		W	91	6	0.10958	3.901
304	N	29	19	18.76273		W	90	14	23.14461	0.472
310	N	29	15	39.41391		W	90	39	23.81475	0.35
311	N	29	22	16.57485		W	90	37	26.58347	0.394s
312	N	29	24	28.10235		W	90	36	28.40405	0.815
313	N	29	27	0.1556		W	90	35	35.35237	1.587
314	N	29	31	17.19606		W	90	35	56.4481	1.939
315	N	29	33	12.78739		W	90	38	19.77916	2.282
320	N	29	56	28.1209		W	91	1	25.91909	5.794
321	N	29	54	34.1782		W	91	12	56.0675	2.093
322	N	29	52	4.04232		W	91	12	23.8778	2.12
323	N	29	50	7.32369		W	91	10	37.80177	2.948
406	N	29	15	3.27606		W	90	12	48.44939	0.619
LSU1	N	30	24	26.70919		W	91	10	48.9155	22.079

Combined Solution/Constrained Adjustment

Point #	North Latitude				West Longitude					Ht: NGVD m
1	N	29	19	39.99299		W	90	35	12.13938	0.824
2	N	29	24	58.50173		W	90	48	28.55649	0.85
3	N	29	25	25.6537		W	90	47	45.18508	1.142
4	N	29	26	42.68116		W	90	49	28.43551	1.269
5	N	29	27	41.82815		W	90	46	37.34924	1.915
6	N	29	15	3.27135		W	90	12	48.46176	0.456
7	N	29	16	30.44184		W	89	56	32.58349	4.038
8	N	29	26	30.38296		W	89	56	7.83535	0.872
9	N	29	50	6.98009		W	91	6	31.55439	0.679
10	N	29	35	12.3822		W	91	9	17.07131	0.944
11	N	29	15	40.79359		W	91	5	42.08604	0.609
12	N	29	12	52.61635		W	91	7	42.54776	3.209
13	N	29	15	39.36383		W	91	8	8.03926	3.216
14	N	29	19	34.99817		W	91	9	11.61357	3.348
15	N	29	23	48.96653		W	91	12	53.43674	0.925
16	N	29	20	58.68855		W	91	8	2.12187	0.607
17	N	29	27	20.88465		W	91	7	31.90773	0.925
18	N	29	14	13.91042		W	91	8	1.99083	0.731
19	N	29	17	54.4855		W	91	11	5.06704	0.974
20	N	29	45	30.08705		W	90	51	13.29287	2.413
21	N	29	48	20.21114		W	90	9	5.10032	0.851
22	N	29	53	48.87777		W	90	43	4.24793	1.283
23	N	29	54	8.36197		W	90	42	27.16327	1.221
24	N	29	55	33.16427		W	90	40	58.52838	1.086
25	N	29	53	26.14577		W	90	47	4.09972	1.096
26	N	29	59	53.56325		W	90	54	41.92856	1.468
27	N	29	27	3.13069		W	89	42	33.0377	0.726
28	N	29	17	26.37152		W	89	30	51.96585	0.636
29	N	29	35	53.58333		W	90	42	38.16351	1.716
30	N	29	44	29.58472		W	90	7	54.77654	1.106
31	N	29	40	2.2081		W	90	6	36.80029	1.661
32	N	29	49	25.7788		W	90	28	32.89674	3.348
33	N	29	54	44.45762		W	90	43	44.59971	0.985
34	N	29	47	53.10753		W	90	49	20.79408	5.694
35	N	29	47	57.68703		W	90	49	4.13525	4.504
36	N	29	15	53.2776		W	89	57	27.08004	1.174
37	N	29	43	12.07043		W	91	11	15.94705	1.331
38	N	29	43	6.97396		W	91	13	27.59041	5.202
39	N	29	40	59.33317		W	91	10	34.13317	1.715
40	N	29	40	59.67743		W	91	10	19.01913	2.556
41	N	29	40	6.94761		W	91	5	52.22375	1.232
42	N	28	55	53.97688		W	89	24	48.79257	1.864
43	N	29	57	47.43211		W	91	12	34.38854	1.0741
44	N	29	51	3.85645		W	91	6	12.30454	3.221

46	N	29	26	57.24356		W	91	20	15.57667	1.348
47	N	29	28	28.72644		W	91	15	45.9207	3.274
48	N	29	16	19.38218		W	89	21	7.7264	1.357
49	N	29	14	43.94463		W	90	39	51.43736	1.198
50	N	29	14	51.27489		W	90	12	28.57986	0.632
51	N	29	33	8.75215		W	91	14	39.87464	1.345
52	N	29	37	12.1368		W	90	54	10.78295	1.851
53	N	29	2	5.76213		W	89	19	27.22437	3.199
54	N	29	46	44.7758		W	90	37	18.11251	1.539
55	N	29	50	26.64807		W	90	29	7.45787	0.954
56	N	29	41	57.80237		W	90	23	22.86271	0.88
57	N	29	51	10.65806		W	90	18	44.58045	1.064
58	N	29	51	10.43119		W	90	18	58.36143	1.026
59	N	29	38	14.74964		W	90	14	28.88054	0.791
60	N	29	32	23.72007		W	90	16	15.99624	0.833
61	N	29	27	46.01107		W	90	10	3.20802	0.722
62	N	29	13	22.05264		W	90	6	45.86249	0.738
64	N	29	27	51.01426		W	90	14	33.83245	0.758
67	N	29	32	14.9126		W	90	50	49.96615	0.879
68	N	29	27	27.69799		W	90	56	3.61496	0.592
73	N	29	23	25.907		W	90	58	5.81228	1.723
74	N	29	36	33.16626		W	91	0	21.17863	1.021
75	N	29	29	54.82117		W	90	59	12.741	1.003
76	N	29	28	35.71785		W	91	7	1.0943	0.952
80	N	29	34	48.45841		W	91	4	12.06865	0.983
91	N	29	25	3.54063		W	90	58	0.14445	0.644
92	N	29	22	26.93324		W	91	0	0.13607	0.596
93	N	29	24	58.0564		W	90	53	45.02819	0.688
95	N	29	13	14.21882		W	91	7	53.58032	0.804
107	N	29	42	17.363		W	90	59	36.34981	0.742
116	N	29	57	48.3909		W	91	12	36.07503	1.783
119	N	29	41	45.89402		W	91	12	39.26895	2.049
120	N	29	41	1.09684		W	91	10	27.33551	2.042
122	N	29	40	6.20967		W	91	5	51.90956	3.914
125	N	29	35	53.59852		W	90	42	38.40889	1.609
127	N	29	37	11.97292		W	90	54	10.70971	1.278
131	N	29	33	8.30746		W	91	14	42.30487	0.959
132	N	29	28	27.69951		W	91	15	46.48554	1.009
133	N	29	26	3.43873		W	91	10	13.88777	0.907
135	N	29	28	55.23075		W	90	59	0.97235	1.123
137	N	29	22	32.68359		W	90	54	33.13903	0.766
138	N	29	14	44.19548		W	90	39	50.94326	0.694
139	N	29	18	6.45185		W	91	5	33.96384	1.717
141	N	29	22	45.23428		W	91	22	54.39292	6.083
151	N	29	34	21.88479		W	91	32	0.83601	1.495
152	N	29	25	56.6597		W	89	59	21.11243	0.762
153	N	29	22	31.19808		W	89	36	3.57474	4.054
155	N	29	19	3.31239		W	89	58	51.85563	0.697
171	N	29	27	12.4601		W	91	7	54.31378	0.886
201	N	29	41	31.256		W	91	11	13.04381	3.409

202	N	29	42	40.24324		W	91	20	16.16575	1.929
203	N	29	38	17.83106		W	90	57	14.10967	1.487
204	N	29	44	52.8232		W	90	49	36.1173	2.48
205	N	29	41	33.99367		W	90	48	41.23667	3.559
206	N	29	57	55.57401		W	90	42	49.4757	2.54
207	N	29	44	30.61177		W	90	42	0.20655	3.81
208	N	29	38	46.66876		W	90	41	18.72349	2.3
209	N	29	42	20.67719		W	90	37	20.45166	0.643
210	N	29	58	16.73898		W	90	18	25.61481	1.398
211	N	29	47	36.23315		W	90	7	18.07511	2.45
212	N	29	40	7.04935		W	90	6	35.59598	0.722
213	N	29	28	5.74344		W	89	40	53.72943	0.091
214	N	29	16	0.52708		W	89	21	10.35407	0.987
215	N	29	3	6.04516		W	89	18	36.13924	2.379
216	N	29	15	51.47138		W	89	57	19.26968	0.98
217	N	29	14	51.33677		W	90	12	22.76042	1.139
218	N	29	14	6.22652		W	90	12	35.19142	0.562
219	N	29	19	18.07495		W	90	14	21.11362	0.259
220	N	29	24	7.7198		W	90	16	21.59056	0.479
221	N	29	41	39.70095		W	90	33	6.32488	3.757
224	N	29	14	47.21523		W	90	39	41.53828	0.665
225	N	29	17	23.94912		W	90	38	54.21916	0.634
226	N	29	42	20.07171		W	90	59	30.64305	0.909
227	N	29	57	37.28462		W	91	4	9.37353	3.758
301	N	29	43	7.93167		W	91	13	30.67656	2.27
302	N	29	15	15.50697		W	90	39	38.51638	0.808
303	N	29	40	6.54324		W	91	6	0.10955	3.878
304	N	29	19	18.76253		W	90	14	23.14429	0.472
310	N	29	15	39.41396		W	90	39	23.81453	0.35
311	N	29	22	16.57482		W	90	37	26.58334	0.394
312	N	29	24	28.10228		W	90	36	28.40399	0.815
313	N	29	27	0.15553		W	90	35	35.35246	1.59
314	N	29	31	17.19617		W	90	35	56.44834	1.939
315	N	29	33	12.78673		W	90	38	19.7781	2.243
320	N	29	56	28.1211		W	91	1	25.91921	5.794
321	N	29	54	34.1784		W	91	12	56.06586	2.148
322	N	29	52	4.04197		W	91	12	23.87689	2.12
323	N	29	50	7.32306		W	91	10	37.80145	2.948
406	N	29	15	3.27387		W	90	12	48.44998	0.605
LSU1	N	30	24	26.70919		W	91	10	48.9155	22.079