Tropical Storm Allison Recovery
DR-1379 Harris County, Texas

Benchmark Control Network

Technical Report

Addicks Dam, Cypress Creek, Spring Creek, White Oak Bayou, and Willow Creek

Landtech Consultants, Inc.

June 2003

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Appendices

1. Introduction

In response to the flooding in June of 2001 that occurred during Tropical Storm Allison, the Harris County Flood Control District (HCFCD) and the Federal Emergency Management Agency (FEMA) initiated the Tropical Storm Allison Recovery Project. When the project is complete, Harris County will have new Flood Insurance Rate Maps (FIRMs). These maps will be used not only to determine flood insurance zones but also to aid the efforts to limit future flood related damages. This report covers the Control Surveying portion of the project. Control surveys were performed between September 2002 and April 2003 by four surveying consultants to create a large network of benchmarks known as Reference Marks (RMs) that will be shown on the new FIRMs and used by local surveyors and engineers. This report covers the portion of the project performed by Landtech Consultants, Inc.

This project was performed under a contract between HCFCD and Landtech. Landtech was assigned the watersheds of Addicks Dam, Cypress Creek, Spring Creek, White Oak Bayou, and Willow Creek. All RMs which will be shown on the new FIRMs that fall within these watersheds were a part of this survey.

2. General Requirements for the Control

All of the bayous, creeks, streams, and major drainage channels within Harris County's 22 watersheds were surveyed for HCFCD by other firms in 2001 and 2002. Those surveys were tied in to existing permanent benchmarks, or, where no mark existed, temporary benchmarks which were set on site. Our survey had to include all of the existing permanent and temporary benchmarks which were used for the channel surveys. Where no permanent benchmark existed, a new one had to be set. The spacing requirements were generally one monument (either existing or new) for every mile along the main stem of studied streams, and two monuments per FIRM panel.

2.1 Project Standards

This survey was performed as much as possible with the Global Positioning System (GPS), using only dual frequency, full-wavelength GPS receivers. The National Geodetic Survey (NGS) 2-CM standard, as published in the National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NOS NGS-58 dated November 1997, was chosen as the project's vertical surveying standard. The horizontal standard that was chosen was the NGS Second Order Class I standard as published in the Federal Geodetic Control Committee (FGCC) document entitled "Geometric Geodetic Accuracy Standards and Specifications for Using GPS Relative Positioning Techniques" dated August 1, 1989. In areas where it was impossible to use GPS due to conditions such as obstructed sky visibility, precise differential leveling was performed to connect such obstructed benchmarks to the rest of the network. Differential leveling was performed so as to meet the maximum loop misclosure specifications for the NGS Second Order Class II vertical standard for leveling, as published in the FGCC document entitled "Standards and Specifications for Geodetic Control Networks" dated September 1984.

In the interest of keeping up with the latest standards developed by NGS, the control surveyed in this network substantially meets the new NGS Classification system for Range VI positions. Range VI indicates that these positions meet the 0.02m-0.05m Accuracy Standard for Horizontal Position, Ellipsoidal Height, and Orthometric Height (elevation) at the 95% confidence level (m = meters).

2.2 Categories of Benchmarks

The network of RMs established for this project is comprised of several categories of new and existing marks. Existing benchmarks were typically HCFCD disks used for the drainage channel surveys of 2001 and 2002. New benchmarks were set where needed to comply with the FEMA guidelines of one RM per stream mile or two per FIRM. Existing control monuments were tied in and held to constrain the network. All of these marks together make up the survey network. Temporary benchmarks (TBMs) were also set by IDIQ firms and

used for drainage channel surveys. These had to be tied in to new benchmarks so as to establish their relationship to the final survey network. A description of each RM type follows.

2.3 Existing Permanent BM Used by TSARP IDIQ

The TSARP IDIQ surveyors who performed the drainage channel surveys used existing HCFCD benchmarks wherever possible. These benchmarks typically consist of a brass disk set in the bridge, over the center of channel, on the downstream side in the top of the concrete sidewalk. They are typically stamped with the channel unit number and a benchmark number. These benchmarks were part of older benchmark networks established and maintained by HCFCD.

2.4 New Benchmarks

Where new benchmarks were required they were set by Landtech and surveyed into the network. There are two types of benchmarks set. The preferred type was a brass disk anchored in a substantial concrete structure such as a bridge. The second type was an aluminum rod driven into the earth (see also Section 4.1 of this report regarding benchmark construction). The initial locations were provided by the TSARP Program Management Team (PMT) and every effort was made to establish the preferred benchmark type whenever possible due to the reduced cost and effort.

2.5 Releveled Existing Benchmarks

Some existing HCFCD benchmarks which were not used by the TSARP IDIQ surveyors were releveled and included in this network. Their composition consists of the typical HCFCD brass disk in concrete bridge with unit and benchmark numbers stamped.

2.6 HGCSD (Existing NGS Control)

The control monuments held to constrain this survey network are a part of the National Spatial Reference System established and maintained by NGS, a division of NOAA. Many of the benchmarks used were installed by the Harris Galveston Coastal Subsidence District (HGCSD). In October of 2000 these marks were resurveyed under the direction of NGS. NGS completed the adjustment of the data and published new positions of the points in 2001.

Another type of existing control monument tied to this survey network was the Continuously Operating Reference Station (CORS). In Harris County there are three such CORS sites maintained by NGS, plus about 24 “Port-A-Measure” or PAM stations operated by HGCSD. See also Sections 4.2 and 4.3 of this report for additional information about these marks.

2.7 New Benchmarks in the Vicinity of Temporary IDIQ RM's

In many instances during the drainage channel surveys the IDIQ firms could not locate an existing benchmark nearby. In those cases they set a TBM at their site to be tied in later. Our project scope included the tying of these monuments to the survey network which we established. These points are not considered RMs in the final listing of TSARP benchmarks, however they are tied to the closest RM in the network.

These TBMs were typically either a chiseled square set in the upstream left corner of the bridge or a nail set in asphalt or wood timber. A new benchmark was established by Landtech nearby which met the project criteria, and differential leveling was run to tie the TBM to the new benchmark. See also Section 6.5 of this report.

3. Surveyor's Statement

I, William J. Massey, a Registered Professional Land Surveyor in the State of Texas, do hereby certify that the surveying work reported herein was performed under my direct supervision.

_____ date_____

William J. Massey
Registered Professional Land Surveyor
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4. Chronology of Field and Office Operations

The field surveying operations occurred between September 2, 2002, and April 23, 2003. White Oak Bayou was surveyed first, followed by Addicks Dam, Willow Creek, Cypress Creek, and Spring Creek. Some overlapping of surveying between watersheds occurred when tying in existing control monuments and during the differential leveling phase. For a chronological summary of all field operations see also Section 13 of this report.

In general terms the tasks to be performed were as follows:

Reconnaissance of existing or proposed sites – tasks include detail sketch, route sketch, to reach description, obstruction diagram, photos, and rubbings;
Construction of new monuments (Brass Disk or Aluminum Rod);
GPS observations;
Precise leveling for monuments not suitable for GPS observation.

4.1 Benchmark Construction

Benchmark stability was a prime consideration in the selection of new benchmark sites and construction materials. The initial approximate locations for all new benchmarks were provided by the TSARP PMT (see Appendix C). If a substantial reinforced concrete structure such as a bridge was available in the vicinity of the selected location, a brass disk was set in a drilled hole in the concrete and fastened with epoxy cement. If no such structure of a substantial nature was available, an aluminum rod was driven into the ground to a depth of about 24 feet and surrounded at the top three feet with a greased sleeve and 6 inches of sand, with 12 inch diameter concrete around the outside and a metal protective cover over the top. For reasons of economy the disk in concrete option was used wherever possible, and in some cases benchmark locations were moved as much as one-half mile in order to utilize an appropriate structure. In such cases the moves were approved by the TSARP PMT.

4.2 Existing Benchmarks

Existing benchmarks were also used throughout the project that had been set by others over the years for HCFCD. Primarily, they consist of brass disks set in the center spans of bridges over drainage ways on the downstream side. Many of these benchmarks have a HCFCD Unit designation on the disk. These benchmarks were observed and included in this network to compare with previously published elevations and to supplement the new network of control stations.

In addition, there were several existing benchmarks that were established by the National Geodetic Survey (NGS), the U. S. Coast & Geodetic Survey (USCGS, now a part of NGS), and the Texas Department of Transportation. These benchmarks also serve to supplement the new network of stations.

4.3 Survey Control Basis – NGS 2001 Adjustment

The primary control points utilized in the performance of this survey are the CORS monitored by NGS. The CORS sites that are located at extensometer sites were given the highest weight in the evaluation of this control survey. In addition to these CORS sites, the network of stations surveyed in October 2000 by NGS and adjusted in 2001 made up the second tier of points to which this 2003 survey is referenced. These stations consist of the HGCSD network of control monuments, HGCSD's PAMs, and other NGS stations in the Harris County region. These stations are First Order or better horizontal control stations, with published orthometric heights determined using GPS observations and the GEOID99 geoid model.

4.3.1 CORS Stations

The CORS stations located at the extensometer sites are constructed so as to be virtually unaffected by the subsidence of the ground around them. They are considered by HGCSD and others to be the most stable control monuments in Harris County. The three CORS sites included in this survey and held for horizontal position in the final fully constrained adjustment are as follows:

PID AJ6426 ADDICKS 1795 CORS ARP (ADKS)
PID AJ6430 NORTHEAST 2250 CORS ARP (NETP)
PID AF9521 LAKE HOUSTON CORS ARP (LKHU)
PID = Permanent Identifier
ARP = Antenna Reference Point (physical bottom of the antenna)

NETP was the only point held for vertical position in the final adjustment. See also Sections 9 and 10 of this report for a detailed discussion of the Horizontal and Vertical Constraints for this project.

Because all of the HGCSD control stations were surveyed in 2000, the published positions were referenced to the NGS 1997.00 Epoch Date. It should be noted that, although 2002.00 Epoch Date positions are currently available for the CORS sites, they were not used so as to be consistent with the rest of the existing control stations surveyed in 2000.

4.3.2 PAM Stations

The following PAM stations were located within the assigned watersheds:

TSARP RM#	PID	STATION NAME
050190	AJ6427	PAM 1 ARP
111040	AJ6418	PAM 11 ARP
100110	AJ6419	PAM 13 ARP

120215	AJ6411	PAM 17 ARP
110700	AJ6423	PAM 18 ARP
200130	AJ6424	PAM 19 ARP
110320	AJ6428	PAM 2 ARP
200005	AJ6412	PAM 3 ARP
200135	AJ6414	PAM 6 ARP
050435	AJ6415	PAM 7 ARP

All of the above PAM stations were included in the survey and their published horizontal positions, based on the October 2000 survey which was adjusted and published by NGS in 2001, were held in the fully constrained adjustment.

4.3.3 HGCSD Stations

The following HGCSD stations were located within the assigned watersheds:

TSARP RM#	PID	STATION NAME
111095	BL1989	HGCSD 1
110695	AB7496	HGCSD 10 RESET
200120	AW5416	HGCSD 16
200290	AW5441	HGCSD 17
200225	AW5439	HGCSD 18
050330	AJ6408	HGCSD 19 RESET
120220	BL1991	HGCSD 2
050015	AW5609	HGCSD 28
110595	BL1994	HGCSD 3
120135	BL2001	HGCSD 4
110370	BL1998	HGCSD 5
110195	AW5443	HGCSD 9

All of the above HGCSD stations were included in the survey and their published horizontal positions, based on the October 2000 survey which was adjusted and published by NGS in 2001, were held in the fully constrained adjustment, with the exception of HGCSD 17 which was not held. A new position for HGCSD 17, referenced to the TSARP survey network, is included in this report.

4.3.4 Other Stations

The following NGS stations, including those set by the USCGS, were located within the assigned watersheds:

TSARP RM#	PID	STATION NAME
110230	AW2192	A 1026
100195	BL1869	A 1281
200050	AW4539	BL 239 RESET

110310	BL1202	E 1021
110385	BL1236	G 666
200045	AW1864	Q 1281
050400	AW1771	Q 667
110935	AW1830	S 1010
200280	AW1817	Z 1215
050325	AW1807	Z 1218

All of the above NGS stations were included in the survey and their published horizontal positions, based on the October 2000 survey which was adjusted and published by NGS in 2001, were held in the fully constrained adjustment.

There were two disks bearing a Texas Department of Transportation stamping which were utilized as new benchmark disks for this project. They are TSARP RM Nos. 050025 and 100270.

No other outside agencies' monuments, to our knowledge, were utilized as benchmarks for this project within our assigned watersheds. There were some existing monuments with no agency stampings on the face of the disks, and in those cases the agency that set the mark is unknown.

5. Project Planning

The execution of a GPS leveling network of this size and scope requires a large amount of mission planning in order to assure the ultimate compliance with the project specifications. Each task in the sequence is dependent upon the previous task. During this survey, work was performed on multiple watersheds at the same time, with each watershed at a different stage in its sequence of tasks. This allowed the reconnaissance crews to start a watershed and then move on to the next watershed while monument installation crews would begin their task. The GPS and leveling crews followed. At one point 22 field and office personnel were working on the project at one time in different watersheds on various tasks.

Each GPS baseline had to be observed at least twice in accordance with the NOAA Technical Memorandum NOS NGS-58. Many of the baselines connecting CORS stations to the network were observed three times. Connecting baselines to CORS and PAM stations also had to be occupied when the CORS or PAM station were active. CORS sites normally operate continuously, but over the longer time span of a large project such as this, some of the sites did occasionally become inoperative. PAM stations only operate one week out of four, so connections to those stations had to be performed when each particular station was in operation.

A more detailed description of field survey tasks is contained in Section 6 of this report. Copies of daily GPS mission schedules are contained in Appendix D.

Project coordination also was critical after the field work was completed and the analysis of the data began. Each of the consulting surveying firms tied in enough HGCSD monuments outside of their respective watersheds to allow for a comparison between consultants and a verification of results. See also Section 8 of this report.

6. Field Survey Narrative

6.1 Reconnaissance

At the beginning of the project the TSARP PMT provided existing benchmark data and proposed benchmark sites in map and spreadsheet formats. These are included in Appendix C. Based on those locations reconnaissance of the benchmark sites began. As the reconnaissance proceeded some sites had to be relocated for various reasons, the most frequent being a lack of public access to the selected site.

Reconnaissance tasks included the creation of detailed field sketches, route sketches, to-reach descriptions, obstruction diagrams, digital photos, and mark rubbings. For new marks some of this had to be done after the mark was constructed. This data was later utilized in the creation of the two-page Control Data Sheets which are contained in Appendix H and provide recovery and positional information for each benchmark.

6.2 One Calls for New Monuments

New monument sites had to be accessible to the public. For that reason in virtually all instances they had to be located on public rights of way or within HCFCD property. In the case of rods set in the earth, in order to minimize the risk of damaging underground utilities during benchmark installation, the Texas One-Call System was contacted and provided with the proposed site. Utility companies marked their lines in the vicinity and crews were successful in avoiding any damage to underground facilities.

6.3 Monument Setting

There were two types of new monuments set for this project, either a disk in concrete or a rod in earth. See Section 4.1 of this report regarding Benchmark Construction.

After a site had been reconned and, in the case of earthen locations, any utilities had been located, it was ready for the setting of the monument. After the monument was set, photos and rubbings were taken.

In some cases the initial location provided by the PMT was unusable due to lack of public access. In those cases the survey consultant coordinated with the PMT to find a suitable replacement site whenever possible. In some cases a monument could not be set due to its remote location and lack of public access.

6.4 GPS Observations

After a watershed was fully reconned and all new monuments were set, GPS observations for that watershed were begun. GPS mission planning was performed to design the network of GPS baselines and plan the daily missions. Each mission consisted of multiple static or rapid-static GPS sessions. During each session, points which were to be connected together in the network were observed simultaneously so as to capture common epochs of data at each site. In order to determine the relative position of two points it is required that GPS observations are performed at both points at the same time. While the crew made the observations, they also kept log sheets and took rubbings of the monument to document their activities. At the end of the day all data was downloaded and log sheets were collected for processing.

The 2 CM Standard as described in the NOS NGS-58 memorandum requires careful planning and execution. Prescribed field procedures include the following:

- Each baseline must be observed at least two times on separate days with different satellite geometry for a minimum of 30 minutes.
- Dual frequency GPS receivers are required for all baselines over ten kilometers and preferred for all observations. Geodetic quality antennas with ground planes are required. Corrections for differing antenna phase patterns between different antenna models must be applied.
- Fixed height poles must be used.
- Networks must be designed using the specified spacing between points so as to create Control, Primary, Secondary, and Local tiers of monuments. Secondary tiers may be omitted in smaller networks.
- Connections from control to primary points must be made using five hour observation sessions on three separate days with different satellite geometry.
- Primary monuments must be traceable back to two control stations along independent paths. Secondary monuments must be traceable back to two primary monuments along independent paths.
- Each local monument must be tied to, at a minimum, its two closest neighbors.

It was agreed by the survey consultants and the PMT that the requirement for meteorological data at each observation would be waived for this project.

6.5 Differential Leveling

Differential levels were run using conventional automatic levels and a 3-wire field procedure, or with digital/barcode leveling systems. All of the levels that were used are models that are approved by the FGCC for Second Order differential leveling work. Copies of all leveling field notes are contained in Appendix B. There were two situations were it was necessary to use differential leveling procedures:

- Some of the TSARP RMs were located in areas too obstructed to use GPS effectively. In those cases a temporary offset point was set as close to the RM as conditions would permit. Then GPS observations were obtained at the offset point, a position was determined in the final adjustment, and differential levels were run from the offset point to the RM. In some instances the differential leveling had to be run from the next closest RM. In either case, there is no precise horizontal positional data for the TSARP RM. The only precise data available in these cases is the RM elevation. The horizontal positions shown for these points are approximate and intended for map scaling purposes only.

- Some of the channel surveys were run by IDIQ firms from TBMs which were typically either a chiseled square set in a concrete bridge structure or a nail set in asphalt or wood timber. In those cases differential levels were run from the TSARP RM to the IDIQ TBM.

6.5.1 TSARP IDIQ TBMs

The following table lists the results of the level ties from TSARP RM to IDIQ TBM using differential leveling:

TSARP RM	Elev.	Delta H	TBM Elev.	Description
050005	57.12	-5.06	52.06	Chiseled Square
050045	53.05	0.83	53.87	Chiseled Square
050070	72.10	-0.05	72.05	Chiseled Square
050080	78.70	3.19	81.89	Chiseled Square
050085	86.79	0.84	87.63	Chiseled Square
050090	87.13	3.60	90.73	PK Nail w/Shiner
050095	95.31	2.02	97.33	Chiseled Square
050100	103.28	2.16	105.43	Chiseled Square
050120	121.72	3.64	125.36	Chiseled Square
050125	127.77	1.76	129.53	Chiseled Square
050135	33.73	2.35	36.08	Chiseled Square
050140	48.22	2.81	51.03	Chiseled Square
050145	47.24	-4.88	42.35	Chiseled Square
050150	47.72	-0.02	47.70	Chiseled Square
050155	54.91	-0.03	54.87	Chiseled Square
050160	56.40	3.12	59.52	Chiseled Square
050165	63.41	-0.98	62.43	Chiseled Square
050170	70.48	0.27	70.74	Chiseled Square
050175	76.46	-1.59	74.86	Chiseled Square
050180	80.98	-0.02	80.96	Chiseled Square
050195	62.14	3.00	65.14	Chiseled Square
050200	65.72	3.11	68.82	Chiseled Square

050205	70.25	-0.05	70.20	Chiseled Square
050210	74.24	-0.03	74.21	Chiseled Square
050215	74.20	-0.41	73.79	Chiseled Square
050220	80.84	-0.22	80.62	Chiseled Square
050225	85.32	-0.16	85.16	Chiseled Square
050235	95.48	-0.03	95.45	Chiseled Square
050250	81.37	3.45	84.82	Chiseled Square
050265	76.21	-0.22	75.99	Chiseled Square
050270	76.70	-0.04	76.67	Chiseled Square
050285	75.44	1.12	76.57	Chiseled Square
050290	80.94	-0.04	80.90	Chiseled Square
050295	83.28	-0.07	83.21	Chiseled Square
050300	86.54	-0.04	86.50	Chiseled Square
050305	88.63	-0.03	88.60	Chiseled Square
050310	95.15	0.70	95.85	Chiseled Square
050315	94.76	-0.03	94.73	Chiseled Square
050335	75.50	-0.06	75.43	Chiseled Square
050340	78.53	-0.05	78.49	Chiseled Square
050380	94.19	-0.05	94.14	Chiseled Square
050415	101.91	-0.04	101.87	Chiseled Square
050420	108.60	-0.71	107.89	Chiseled Square
050425	104.74	-0.01	104.73	Chiseled Square
050440	108.90	-0.44	108.47	Chiseled "X"
050445	111.43	-0.12	111.30	Chiseled Square
050450	115.67	2.71	118.38	Chiseled Square
050460	103.69	1.02	104.71	Chiseled Square
050465	108.56	1.03	109.59	Chiseled Square
100055	129.82	-35.76	94.07	Chiseled Square
100075	115.07	1.91	116.98	Chiseled Square
100125	143.57	-0.03	143.54	Chiseled Square
100145	152.78	3.33	156.10	Chiseled Square
100160	180.88	-20.11	160.77	PK Nail w/Shiner
100200	171.27	0.11	171.38	Chiseled Square
100260	269.53	-25.49	244.04	60d Nail
100290	282.56	-11.92	270.64	PK Nail w/Shiner*
100295	288.01	-0.04	287.98	Chiseled Square
100325	158.08	0.01	158.09	Chiseled Square
100330	163.02	1.58	164.61	PK Nail w/Shiner
100340	169.28	0.05	169.32	Chiseled Square
100345	175.90	-0.04	175.86	Chiseled Square
100355	179.93	-0.04	179.90	Chiseled Square
100360	180.24	-0.02	180.22	Chiseled Square
100365	180.65	-0.03	180.62	Chiseled Square

100370	181.93	1.41	183.34	Chiseled Square
100380	172.89	0.01	172.90	Chiseled Square
100385	166.40	-0.04	166.36	Chiseled Square
100390	165.15	-0.30	164.85	Chiseled Square
100395	171.59	-0.04	171.55	Chiseled Square
100405	244.31	2.72	247.04	Chiseled Square
100410	255.23	2.54	257.77	Chiseled Square
100415	262.66	0.07	262.73	Chiseled Square
110005	88.43	4.77	93.20	Mag. Nail w/ Shiner
110465	96.78	-0.05	96.73	Mag. Nail w/ Shiner
110725	157.27	-1.45	155.83	Mag. Nail w/ Shiner
110995	193.29	0.65	193.94	Mag. Nail w/ Shiner
120010	113.48	2.85	116.33	Chiseled Square
120015	120.24	-6.54	113.70	Chiseled Square
120020	114.58	0.70	115.28	PK Nail w/Shiner
120030	137.86	2.59	140.45	Chiseled Square
120090	165.46	3.60	169.05	PK Nail w/Shiner
120130	130.21	2.00	132.21	Chiseled Square
120155	135.53	-0.01	135.52	Chiseled Square
120190	150.88	0.36	151.24	PK Nail w/Shiner
120205	173.57	-0.04	173.52	Chiseled Square
100065	92.63	-0.04	92.59	Chiseled Square**

* PK nail w/Shiner is IDIQ TBM for RM 100285 which was deleted due to no public access to private property. Therefore RM 100290 was used for differential level tie.
** Chiseled Square is IDIQ TBM for RM 100070 which was deleted due to no public access to private property. Therefore RM 100065 was used for differential level tie.

7. Data Processing Narrative

Field GPS data was downloaded daily at the offices of Landtech. The data and log sheets were checked to verify that the correct point was set upon for the correct time period. Then the data was inserted into the GPS project file. Common epochs of GPS data were processed to generate the network's baselines. Since each baseline was occupied at least twice, it was possible to compare the redundant baselines and verify that the relative positions matched within the NOS NGS-58 2CM Standards, which include the following specifications:

- Precise ephemerides must be used to process all GPS data. There are several such ephemerides available from the NGS website. The most precise file available was used. Broadcast ephemerides were not used for this project.
- In final processing all integers must be fixed, except for some longer lines to control sites. For this project all solutions were ionospheric free solutions with fixed integer ambiguities.
- A tropospheric model must be used. For this project the Hopfield model was selected.
- RMS values for each computed baseline must not exceed 1.5 cm.
- Reobservations are required for any baseline where the difference in ellipsoid height between repeat observations exceeds 2.0 cm. For station pairs involving control stations, reobservations are required if the difference exceeds 5.0 cm.

Baselines connecting CORS or PAM sites were scheduled so that our personnel were observing at the same time that those sites were active. The data for those sites typically was not available until as much as three weeks later. Once the data became available it was downloaded from NGS or HGCSD websites and inserted into the GPS project file for processing.

After all baselines in all watersheds had been observed and all repeat observations agreed within the cited specification, a minimally constrained adjustment was performed. All of the survey consultants held the same CORS station so that each consultant's adjusted data could be compared with the others. After it was verified that all consultants were finding consistent results, the final constraints were agreed to and fully constrained adjustments were generated for the final positional values for all RMs.

8. Analysis of Results of Control Survey

All of the survey consultants performed minimally constrained adjustments based on the most centrally located CORS extensometer site (NETP). They compared their minimally constrained results and found that wherever existing control stations were tied by two or more firms, the different firms' positions matched very closely. Horizontally 24 of 31 common stations matched within 0.02 feet, and none exceeded 0.035 feet. Vertically 24 of 31 common stations (ellipsoid heights) matched within 0.04 feet, and none exceeded 0.083 feet. The average of the sum of the differences between two firm's positions on 31 stations was 0.004 feet horizontally and 0.005 feet vertically. This indicated a high level of consistency in survey quality throughout the network.

Comparisons were made between the existing control stations' published values from 2000 and the measured values from this survey's minimally constrained adjustment. Horizontally, the average difference was 0.03 feet. 84 of 111 stations matched horizontally within 0.05 feet, and all but one of the control station positions, relative to its closest neighboring control station, matched within the tolerance for NGS 1st-Order Specifications.

Vertically, the differences between published ellipsoid heights from 2000 and this survey's measured values were much higher. They averaged -0.13 feet and ranged from an apparent rise of 0.20 feet to an apparent subsidence of 0.48 feet. The majority of the marks were found to be lower in 2003 than they were in 2000 relative to the one extensometer benchmark, NETP, held in the minimally constrained adjustment. It became apparent that most of the HGCSD 2000 benchmarks and PAMs had been affected in a vertical direction and in varying amounts by subsidence, and we were therefore unable to hold their elevations in the final network adjustments.

Based on the above analysis, the survey firms were in agreement as to how the network should be finally constrained. The recommendations were presented to the TSARP PMT and accepted.

8.1 Minimally Constrained Control Station Comparison

Tropical Storm Allison Recovery Project
Benchmark Control Network

Results of Control Survey - Comparison of Control Utilized - Published vs. Measured
All units of measurement are U.S. Survey Feet. Geoid99 was used to convert Ellipsoid Heights to Orthometric Elevations.
The NGS Continuously Operating Reference Station "NORTHEAST 2250 CORS ARP" (PID AJ6430) was held for purposes of this comparison.

			NGS	NGS	NGS	NGS	NGS	NGS Published		Measured	Measured	Measured					
			Published	Published	Published	Published	Published	NAVD88(2000)		Ellipsoid	TxSC	TxSC	Measured		Delta	Delta	Delta	Delta
RM No.	NGS PID	NGS Station Name	Latitude (N)	Longitude (W)	Ellipsoid Ht.	TxSC Northing	TxSC Easting	Elevation		Ht.	Northing	Easting	Elevation		Ellips. Ht.	Northing	Easting	Elevation
110230	AW2192	A 1026	29 55 01.61740	95 57 28.95189	113.550	13893547.216	2932056.531	203.740		113.486	13893547.207	2932056.620	203.676		0.064	0.010	-0.089	0.064
100195	BL1869	A 1281	30 11 49.36422	95 45 10.68941	141.470	13997056.812	2994172.237	231.758		141.457	13997056.809	2994172.205	231.719		0.013	0.003	0.031	0.039
210350	AJ6426	ADDICKS 1795 CORS ARP	29 47 27.47147	95 35 11.04301	13.484	13850941.209	3051083.130	103.346		13.445	13850941.176	3051083.131	103.290		0.039	0.032	-0.001	0.056
110905	BM0146	B 1029	PT NOT FOUND															
200050	AW4539	BL 239 RESET	29 52 46.94901	95 41 35.18102	41.634	13882227.088	3016339.676	131.725		41.401	13882227.097	3016339.686	131.483		0.233	-0.009	-0.010	0.243
050405	AW1772	C 1221	PT NOT FOUND															
050020	AW0332	C 760	PT NOT FOUND															
110310	BL1202	E 1021	30 00 24.34362	95 23 55.22042	9.547	13931164.585	3108184.564	99.540		9.318	13931164.594	3108184.552	99.301		0.230	-0.009	0.013	0.240
110385	BL1236	G 666	30 01 14.67460	95 23 32.38600	12.926	13936308.367	3110034.400	102.920		12.733	13936308.397	3110034.392	102.730		0.193	-0.029	0.008	0.190
111095	BL1989	HGCSD 1	30 03 50.47310	95 50 29.56021	163.189	13947929.460	2967506.381	253.477		163.094	13947929.482	2967506.393	253.370		0.094	-0.023	-0.012	0.107
110695	AB7496	HGCSD 10 RESET	29 58 27.71730	95 42 17.29745	58.989	13916531.504	3011663.888	149.245		58.752	13916531.506	3011663.911	148.998		0.237	-0.002	-0.023	0.247
150770	AW5511	HGCSD 11	29 57 58.14333	95 32 22.42912	31.168	13915056.195	3064047.976	121.260		30.776	13915056.234	3064047.980	120.858		0.392	-0.039	-0.003	0.401
150620	AB7497	HGCSD 12 RESET	29 56 24.01990	95 25 40.41886	-0.066	13906615.615	3099681.238	89.862		-0.245	13906615.649	3099681.242	89.676		0.179	-0.034	-0.004	0.186
200120	AW5416	HGCSD 16	29 52 28.61660	95 49 27.50458	68.504	13879223.751	2974827.357	158.661		68.456	13879223.735	2974827.357	158.597		0.048	0.016	0.000	0.064
200290	AW5441	HGCSD 17	29 52 46.79604	95 42 14.04448	44.947	13882115.077	3012920.329	135.039		44.708	13882115.097	3012920.255	134.799		0.240	-0.020	0.074	0.240
200225	AW5439	HGCSD 18	29 52 45.31234	95 36 41.68786	28.051	13882801.276	3042170.038	118.077		27.647	13882801.269	3042170.038	117.653		0.404	0.007	0.000	0.424
050330	AJ6408	HGCSD 19 RESET	29 51 57.74284	95 29 16.44438	-7.907	13879154.446	3081492.147	81.955		-8.101	13879154.453	3081492.138	81.778		0.194	-0.007	0.009	0.177
120220	BL1991	HGCSD 2	30 03 33.59345	95 41 49.87295	88.320	13947486.249	3013202.356	178.641		88.087	13947486.258	3013202.350	178.415		0.233	-0.010	0.006	0.227
150245	AW5414	HGCSD 24	29 47 08.08818	95 49 06.69046	50.558	13846908.340	2977539.698	140.518		50.459	13846908.325	2977539.686	140.440		0.098	0.015	0.012	0.079
210410	AW5603	HGCSD 25	29 47 07.78457	95 42 53.94398	24.934	13847785.556	3010371.125	114.862		24.635	13847785.573	3010371.118	114.563		0.299	-0.018	0.007	0.299
050015	AW5609	HGCSD 28	29 46 32.22564	95 23 21.58996	-43.602	13847240.324	3113734.612	45.964		-43.661	13847240.294	3113734.599	45.909		0.059	0.030	0.014	0.055
110595	BL1994	HGCSD 3	30 01 04.67861	95 35 09.02479	50.000	13933460.844	3048851.337	140.223		49.699	13933460.839	3048851.341	139.929		0.301	0.005	-0.005	0.294
120135	BL2001	HGCSD 4	30 05 45.08701	95 31 17.56867	56.660	13962374.575	3068347.515	146.916		56.462	13962374.571	3068347.542	146.731		0.198	0.004	-0.027	0.185
110370	BL1998	HGCSD 5	30 03 40.07036	95 24 52.92817	19.455	13950771.501	3102507.243	109.514		19.181	13950771.505	3102507.205	109.266		0.275	-0.003	0.038	0.249
110195	AW5443	HGCSD 9	29 56 28.39502	95 48 28.83263	75.197	13903576.392	2979329.589	165.420		75.145	13903576.358	2979329.594	165.378		0.051	0.034	-0.005	0.041
	AF9521	LAKE HOUSTON CORS ARP	29 54 48.43963	95 08 44.68952	-23.524	13899802.558	3189315.907	66.240		-23.523	13899802.553	3189315.909	66.110		-0.001	0.006	-0.001	0.130
080180	AJ6430	NORTHEAST 2250 CORS ARP	29 47 28.14234	95 20 03.16582	-30.249	13853429.580	3131034.227	59.285		-30.249	13853429.580	3131034.227	59.285		0.000	0.000	0.000	0.000
050190	AJ6427	PAM 1 ARP	29 54 42.73203	95 36 59.80458	43.471	13894611.174	3040232.794	133.530		43.137	13894611.169	3040232.823	133.199		0.334	0.005	-0.029	0.331
111040	AJ6418	PAM 11 ARP	30 01 55.76898	95 51 54.77617	147.867	13936144.851	2960331.661	238.123		147.816	13936144.851	2960331.671	238.082		0.051	0.000	-0.010	0.041
	AJ6403	PAM 12 ARP	30 03 34.89523	95 15 47.03775	-3.970	13951750.390	3150469.539	85.991		-4.076	13951750.397	3150469.519	85.898		0.106	-0.007	0.020	0.093
100110	AJ6419	PAM 13 ARP	30 11 41.29059	95 29 23.94178	61.811	13998641.324	3077244.564	152.099		61.640	13998641.335	3077244.562	151.935		0.171	-0.011	0.002	0.164
120215	AJ6411	PAM 17 ARP	30 05 28.16704	95 36 55.03390	97.408	13959796.326	3038765.730	187.762		97.262	13959796.323	3038765.726	187.613		0.146	0.002	0.004	0.149
110700	AJ6423	PAM 18 ARP	29 57 53.74662	95 40 41.58894	63.123	13913339.381	3020175.357	153.346		62.929	13913339.386	3020175.369	153.146		0.194	-0.005	-0.012	0.200
200130	AJ6424	PAM 19 ARP	29 50 28.00719	95 48 19.21116	68.602	13867208.929	2981170.042	158.694		68.542	13867208.914	2981170.041	158.620		0.061	0.015	0.001	0.074
110320	AJ6428	PAM 2 ARP	30 00 02.33620	95 24 57.08640	23.556	13928775.423	3102815.989	113.550		23.272	13928775.425	3102815.982	113.268		0.285	-0.002	0.007	0.281
200005	AJ6412	PAM 3 ARP	29 49 14.90336	95 36 48.14574	12.894	13861539.783	3042217.164	102.821		12.563	13861539.802	3042217.143	102.487		0.331	-0.019	0.020	0.334
200135	AJ6414	PAM 6 ARP	29 48 58.91787	95 40 39.99963	27.034	13859340.050	3021849.570	116.995		26.787	13859340.076	3021849.548	116.748		0.247	-0.025	0.022	0.247
050435	AJ6415	PAM 7 ARP	29 56 10.64628	95 34 35.91486	42.060	13903856.461	3052630.112	132.119		41.707	13903856.487	3052630.108	131.773		0.353	-0.027	0.004	0.346
150720	AJ6416	PAM 8 ARP	29 58 46.81814	95 28 34.54377	31.004	13920569.327	3083934.610	121.030		30.706	13920569.331	3083934.589	120.742		0.298	-0.004	0.021	0.288
200045	AW1864	Q 1281	29 52 46.32785	95 40 59.56928	38.090	13882253.131	3019475.093	128.149		37.790	13882253.131	3019475.046	127.865		0.301	0.000	0.047	0.284
050400	AW1771	Q 667	29 56 15.58468	95 31 19.74531	24.508	13904864.247	3069866.954	114.534		24.307	13904864.232	3069866.990	114.323		0.201	0.015	-0.036	0.211
110935	AW1830	S 1010	29 59 07.61804	95 41 57.69082	61.942	13920609.163	3013273.829	152.198		61.687	13920609.163	3013273.830	151.946		0.255	0.000	-0.001	0.252
200280	AW1817	Z 1215	29 56 55.64157	95 40 06.62563	51.443	13907559.685	3023416.532	141.634		51.152	13907559.730	3023416.534	141.333		0.291	-0.045	-0.002	0.301
050325	AW1807	Z 1218	29 52 50.65696	95 34 17.72923	16.765	13883710.205	3054821.541	106.758		16.437	13883710.217	3054821.531	106.411		0.328	-0.012	0.010	0.348

8.2 Fully Constrained Control Station Comparisons with Previously Surveyed Stations

Addicks Dam

Existing Permanent BM used by TSARP IDIQ (21)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
200020	13874316.27	3037031.83	100.82	13874809.95	3035683.26	107.81	-493.68	1348.56	-6.99
200025	13878235.71	3030932.23	113.95	13877771.50	3031614.84	112.23	464.22	-682.62	1.72
200030	13879464.82	3019552.77	124.31	13879464.80	3019552.71	123.97	0.02	0.06	0.34
200035	13880581.52	3018480.02	125.64	13880581.61	3018479.77	125.29	-0.08	0.25	0.35
200040	13882373.47	3018345.94	131.33	13882400	3018300	131.26	-26.53	45.94	0.08
200070	13854381.92	3018804.06	107.84	13854381.87	3018804.08	107.69	0.05	-0.02	0.15
200080	13856469.18	3004239.01	125.07	13856469.36	3004239.08	124.84	-0.17	-0.08	0.23
200090	13864229.62	2998067.37	133.57	13864229.57	2998067.38	133.37	0.06	-0.01	0.20
200095	13869341.01	2992694.21	139.56	13869341.03	2992693.96	139.57	-0.02	0.25	-0.01
200115	13879370.13	2977562.30	157.53	13879370.24	2977562.37	157.41	-0.11	-0.08	0.12
200160	13863837.77	3019173.60	114.93	13863837.55	3019173.37	114.63	0.22	0.22	0.30
200165	13864589.03	3018880.27	116.8	13864589.25	3018880.05	116.55	-0.23	0.22	0.25
200185	13877878.18	2996130.53	149.11	13877900	2996200	148.90	-21.82	-69.47	0.21
200200	13884985.83	2986344.95	159.18	13884985.77	2986344.50	158.98	0.06	0.45	0.20
200230	13883503.46	3042472.12	113.37	(Deleted)					
200235	13883625.21	3042700.38	108.36	(Deleted)					
200245	13884214.74	3034770.16	115.5	13884214.87	3034770.24	115.16	-0.13	-0.08	0.34
200250	13887255.27	3032900.28	122.17	13887255.26	3032900.41	122.07	0.01	-0.12	0.10
200255	13888724.25	3031156.36	123.55	13888724.33	3031156.20	123.45	-0.07	0.17	0.10
200260	13889567.81	3029578.28	128.64	13889660.50	3029653.11	127.31	-92.69	-74.83	1.33
200265	13891855.99	3025117.12	135.66	13891855.93	3025116.90	135.51	0.06	0.22	0.15
Relevel Existing BM (11)									
200010	13866941.90	3038138.43	104.37	(Deleted)					
200060	13852277.38	3032447.28	98.39	13850296.80	3032485.05	118.52	1980.57	-37.77	-20.13
200075	13854696.58	3008471.47	115.7	13854711.48	3008514.49	114.19	-14.90	-43.02	1.51
200100	13871150.61	2991085.20	144.29	13871118.49	2991118.05	142.42	32.11	-32.86	1.87
200125	13853233.09	3012316.70	114.43	13853273.95	3012309.19	113.16	-40.86	7.50	1.27
200145	13862584.71	3031980.22	104.91	13860280.98	3032103.86	101.40	2303.72	-123.63	3.51
200190	13879914.83	2992162.25	149.45	13879887.63	2992145.78	148.37	27.20	16.48	1.08
200210	13864787.13	3025928.50	107.42	13864756.55	3025989.82	104.63	30.58	-61.32	2.79
200215	13876736.40	3038302.86	112.9	13876710.50	3038285.86	108.87	25.90	17.00	4.03
200240	13883344.99	3036732.95	118.47	13883404.05	3036775.10	114.23	-59.06	-42.15	4.24
200305	13865939.94	3052859.47	102.2	13865962.42	3054419.96	98.46	-22.48	-1560.49	3.74

Cypress Creek

Existing Permanent BM used by TSARP IDIQ (82)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
110015	13940452.51	3129648.45	79.6	13940500	3129600	79.65	-47.49	48.45	-0.05
110030	13941260.97	3117758.98	85.5	13941260.89	3117758.88	85.39	0.08	0.10	0.11
110035	13943476.10	3112987.07	89.1	13943476.06	3112986.96	89.06	0.04	0.11	0.04
110040	13940000.98	3105835.61	95	13940000.93	3105835.47	94.85	0.05	0.14	0.15
110050	13941415.16	3098363.46	102.1	13941415.14	3098363.36	101.82	0.02	0.11	0.28
110065	13936825.79	3083434.60	109.4	13936825.74	3083434.48	109.01	0.05	0.13	0.39
110080	13930078.87	3072322.73	116.6	13930078.84	3072322.62	115.95	0.03	0.11	0.65

Cypress Creek (continued)

Existing Permanent BM used by TSARP IDIQ (82)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
110090	13926708.33	3066566.15	111	13926708.35	3066566.01	110.31	-0.02	0.14	0.69
110100	13924287.47	3060441.75	120.4	13924287.37	3060441.73	120.21	0.10	0.02	0.19
110105	13924216.07	3058143.72	121.8	13924215.99	3058143.72	121.47	0.08	0.00	0.33
110110	13921913.46	3054198.20	128.9	13921913.35	3054198.20	128.69	0.11	-0.01	0.21
110120	13918684.24	3048438.35	128.6	13918770.77	3048457.73	128.42	-86.53	-19.38	0.18
110125	13917233.46	3045244.43	127.5	13917233.34	3045244.40	127.25	0.12	0.03	0.25
110135	13912445.12	3035098.75	134	13912444.97	3035098.70	133.66	0.15	0.04	0.34
110140	13909242.87	3029582.66	139.9	13909247.15	3029580.71	139.71	-4.28	1.95	0.19
110145	13910385.72	3020284.48	147.7	13910385.68	3020284.41	147.52	0.04	0.07	0.18
110160	13910888.60	3007722.92	149.2	13910888.49	3007722.74	149.00	0.11	0.18	0.20
110190	13906818.05	2979142.36	162.3	13906818.04	2979142.27	162.20	0.01	0.09	0.10
110210	13895920.34	2969251.39	164.4	13895920.33	2969251.23	164.42	0.01	0.16	-0.02
110240	13898707.05	2927930.07	208	13898707.07	2927929.97	207.98	-0.02	0.11	0.02
110245	13899395.11	2945641.13	181.3	13899395.12	2945641.01	181.35	-0.01	0.11	-0.05
110250	13900298.09	2954446.25	177.3	13900298.08	2954446.12	177.32	0.01	0.13	-0.02
110255	13905087.53	2942502.91	186.6	13905087.54	2942502.79	186.61	-0.01	0.12	-0.01
110280	13916592.88	2947282.93	198.4	13916592.88	2947282.83	198.35	0.00	0.10	0.05
110285	13918873.57	2944484.20	206.3	(Deleted)					
110290	13917693.40	2933555.61	238.3	13917693.42	2933555.49	238.20	-0.02	0.12	0.10
110300	13934227.23	3119133.55	82.1	13934227.16	3119133.50	81.99	0.07	0.04	0.11
110305	13932899.22	3115690.93	88.5	13932919.11	3115737.93	86.22	-19.89	-46.99	2.28
110315	13928687.07	3105396.27	99.6	13928687.03	3105396.15	99.23	0.04	0.12	0.37
110325	13930575.34	3111510.18	95.8	13930575.31	3111510.10	95.62	0.03	0.08	0.18
110330	13944232.27	3122184.60	80.5	13944232.22	3122184.47	80.44	0.05	0.13	0.06
110335	13945713.02	3120427.37	83.8	13945712.95	3120427.27	83.78	0.07	0.10	0.02
110395	13945024.22	3101003.67	92.3	13945024.22	3101003.60	92.14	0.00	0.07	0.16
110400	13949706.22	3100855.89	101.5	13949706.23	3100855.81	101.35	-0.01	0.08	0.15
110405	13954910.61	3100582.08	114.5	13954910.63	3100582.03	114.48	-0.02	0.06	0.02
110415	13945635.82	3097766.78	94.5	13945635.85	3097766.68	94.35	-0.03	0.10	0.15
110420	13946572.25	3093646.19	101.8	13946572.24	3093646.12	101.64	0.01	0.07	0.16
110425	13950915.30	3091838.48	113.3	13950915.29	3091838.37	113.11	0.01	0.11	0.19
110440	13944391.33	3092674.20	96.9	13944400	3092600	96.76	-8.67	74.20	0.14
110450	13946268.53	3084997.42	113.7	13946268.51	3084997.28	113.45	0.02	0.14	0.25
110455	13948171.02	3080923.83	124.7	13948171.02	3080923.69	124.40	0.00	0.14	0.30
110470	13934466.15	3076196.45	106.7	13934466.15	3076196.21	106.36	0.00	0.24	0.34
110475	13938565.70	3073582.51	114.3	13938565.71	3073582.38	113.68	-0.01	0.13	0.62
110480	13944340.92	3064711.03	140.7	13944340.92	3064710.88	140.15	0.00	0.15	0.55
110490	13935384.76	3068864.93	116.2	13935400	3068900	115.67	-15.24	-35.07	0.53
110495	13937740.63	3066029.53	122.4	13937740.66	3066029.41	121.87	-0.03	0.12	0.53
110505	13942726.87	3061564.01	140	13942726.87	3061563.87	139.44	0.00	0.14	0.56
110550	13928935.11	3065545.85	113.6	13928935.15	3065545.71	112.98	-0.04	0.14	0.62
110560	13931531.36	3063158.80	128.7	13931531.37	3063158.68	128.08	-0.01	0.13	0.62
110580	13926098.95	3054842.40	122.6	13926098.83	3054842.40	122.31	0.12	0.00	0.29
110590	13931040.83	3051550.33	134.4	13931000	3051500	134.04	40.83	50.33	0.36
110600	13934748.51	3048856.02	143.1	13934748.47	3048855.97	142.83	0.04	0.05	0.27
110615	13923166.08	3046860.43	128.3	13923165.99	3046860.40	128.06	0.09	0.03	0.24
110620	13925509.92	3043807.58	129.9	13925509.90	3043807.51	129.74	0.02	0.07	0.16
110625	13926853.19	3040886.70	133.9	13926853.13	3040886.62	133.70	0.06	0.08	0.20

Cypress Creek (continued)

Existing Permanent BM used by TSARP IDIQ (82)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
110635	13929692.75	3037282.11	143	13929800	3037400	142.81	-107.25	-117.89	0.19
110645	13934183.24	3030943.71	153.6	13934183.20	3030943.62	153.37	0.04	0.09	0.23
110660	13936563.46	3041686.88	153.1	13936563.39	3041686.81	152.92	0.07	0.07	0.18
110665	13913463.75	3020672.63	143.3	13913500	3020700	143.09	-36.25	-27.37	0.21
110670	13917433.70	3020578.50	148.2	13917400	3020500	148.01	33.70	78.50	0.19
110675	13919197.35	3017152.83	153.8	13919100	3017200	153.59	97.35	-47.17	0.21
110680	13919214.67	3013360.84	151.4	13919214.60	3013360.68	151.20	0.07	0.16	0.20
110760	13913294.58	2968340.14	176.9	13913300	2968400	176.91	-5.42	-59.86	-0.01
110770	13921947.99	2964762.53	204.2	13921948.00	2964762.46	204.14	-0.01	0.07	0.06
110850	13925979.26	2947055.65	206.9	13925979.27	2947055.59	206.86	-0.01	0.06	0.04
110855	13924925.15	2940184.25	218.6	13924925.16	2940184.16	218.52	-0.01	0.08	0.08
110860	13925143.01	2936125.41	231.8	13924800	2936100	231.73	343.01	25.41	0.07
110875	13936559.45	2940684.08	219.8	13936559.47	2940684.03	219.67	-0.02	0.05	0.13
110890	13943448.12	2927797.75	239.8	13943448.15	2927797.75	239.75	-0.03	-0.01	0.05
110895	13948102.59	2925497.60	252.4	13948102.65	2925497.65	252.34	-0.06	-0.05	0.06
110910	13955701.63	2936860.60	266.2	13955701.64	2936860.62	266.06	-0.01	-0.01	0.14
110915	13964773.83	2933146.29	303.5	13964773.88	2933146.31	303.40	-0.05	-0.03	0.10
110925	13937505.21	2952860.26	237.3	13937505.22	2952860.21	237.17	-0.01	0.05	0.13
110950	13918323.05	3035170.15	137.3	13918400	3035200	137.03	-76.95	-29.85	0.27
110955	13922112.44	3027673.87	145.5	13922112.35	3027673.78	145.20	0.09	0.09	0.30
110970	13931762.54	3013580.79	162.6	13931762.57	3013580.61	162.34	-0.03	0.19	0.26
110980	13933681.11	3004812.30	167.4	13933681.04	3004812.14	167.20	0.07	0.15	0.20
111010	13937159.47	2986807.73	190.3	13937159.40	2986807.56	190.03	0.07	0.17	0.27
111015	13935065.53	2981296.69	200.3	13935100	2981300	200.12	-34.47	-3.31	0.19
111020	13936165.67	2976141.48	204.3	13936165.58	2976141.31	204.10	0.09	0.17	0.20
111025	13938097.55	2973954.37	213	13938097.44	2973954.22	212.93	0.11	0.15	0.07
111090	13937954.75	2967858.03	220	13937954.61	2967857.91	220.01	0.14	0.12	-0.01
Relevel Existing BM (16)									
110340	13948846.76	3118303.99	96.77	13948804.46	3118323.19	95.14	42.30	-19.20	1.63
110345	13944872.81	3123068.20	82.86	13944849.79	3123089.08	81.41	23.02	-20.88	1.45
110375	13940248.00	3109219.33	82.82	13940010.40	3108851.05	81.12	237.61	368.29	1.70
110380	13938731.89	3110434.34	94.29	13938523.71	3109970.07	92.51	208.19	464.27	1.78
110410	13957118.75	3100199.52	118.97	13957092.48	3100178.42	117.18	26.27	21.10	1.79
110445	13945377.77	3088372.34	103.13	13945378.85	3087735.13	101.34	-1.08	637.21	1.79
110460	13950593.52	3076722.91	136.16	13950657.38	3076694.18	134.40	-63.86	28.72	1.76
110485	13935061.74	3071128.43	113.02	13935102.10	3071134.78	111.22	-40.35	-6.35	1.80
110510	13943711.57	3062852.82	140.4	13943665.41	3062768.84	140.16	46.17	83.98	0.24
110530	13940878.65	3073908.57	120.24	13940862.97	3073879.55	118.58	15.69	29.02	1.66
110545	13928688.43	3066755.27	109.89	13928668.57	3066808.43	108.36	19.85	-53.16	1.53
110555	13930199.48	3064218.39	121.41	13930216.24	3064243.11	119.67	-16.76	-24.72	1.74
110585	13928366.11	3052866.56	130.19	13928354.00	3052860.48	128.35	12.12	6.08	1.84
110610	13932167.43	3048616.88	143.74	13932100	3048600	141.87	67.43	16.88	1.88
110630	13928022.65	3033272.45	146.53	13928004.80	3033181.66	144.94	17.85	90.79	1.59
110655	13925620.60	3046686.26	138.9	13925682.55	3046727.31	137.12	-61.95	-41.05	1.78

Spring Creek

Existing Permanent BM used by IDIQ (39)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
100055	13962341.72	3104977.46	94.348	13960566.16	3102718.61	129.83	1775.55	2258.85	-35.48
100070	13969938.88	3098433.01	104.439	(Deleted)					
100075	13968191.98	3094993.09	115.195	13968191.83	3094993.15	115.07	0.15	-0.06	0.13
100105	13981440.84	3072748.41	132.842	13979657.49	3073204.97	133.66	1783.35	-456.56	-0.82
100125	13988560.62	3060931.39	143.534	13988573.17	3060935.56	143.57	-12.55	-4.17	-0.03
100145	13976284.01	3044077.37	154.02	13975698.03	3044193.33	152.78	585.97	-115.97	1.24
100155	13976010.48	3036684.71	156.014	(Deleted)					
100160	13972836.35	3034196.39	160.775	13971455.84	3034043.85	180.87	1380.51	152.53	-20.10
100165	13969826.16	3028711.53	166.918	13969900	3028800	167.51	-73.84	-88.47	-0.59
100185	13961861.59	3011234.62	172.191	13961861.48	3011234.67	171.76	0.11	-0.04	0.43
100200	13959757.70	3000827.52	171.564	13959757.63	3000827.49	171.26	0.06	0.03	0.30
100205	13959444.52	2995190.03	177.528	13959400	2995200	177.31	44.52	-9.97	0.22
100210	13956918.46	2992065.51	181.113	13956900	2992000	180.69	18.46	65.51	0.42
100225	13955588.89	2976269.98	203.179	13955588.92	2976269.92	202.96	-0.03	0.05	0.22
100235	13955887.38	2967178.48	217.342	13956100	2967100	217.14	-212.62	78.48	0.20
100245	13962830.43	2960715.05	231.415	13962830.52	2960715.09	231.06	-0.09	-0.04	0.35
100255	13968092.36	2955261.81	243.169	13968100	2955300	242.69	-7.64	-38.19	0.48
100260	13967813.05	2951059.28	244.502	13965842.52	2950872.36	269.54	1970.53	186.92	-25.04
100270	13970660.71	2944951.94	255.415	13970660.75	2944951.86	254.96	-0.04	0.08	0.46
100280	13976458.74	2938383.08	264.919	13978484.81	2939667.34	295.06	-2026.07	-1284.26	-30.14
100285	13976333.58	2935958.85	271.116	(Deleted)					
100290	13977684.22	2934108.57	283.119	13977700	2934100	282.56	-15.78	8.57	0.56
100295	13982620.26	2929847.11	288.432	13982620.12	2929847.01	288.01	0.14	0.10	0.42
100325	13972843.11	3043859.09	158.373	13972849.72	3043992.58	158.08	-6.61	-133.50	0.29
100330	13972287.75	3042787.13	164.053	13972077.33	3043221.61	163.03	210.42	-434.48	1.03
100340	13968923.92	3040676.21	169.422	13968927.19	3040670.38	169.27	-3.27	5.83	0.15
100345	13965902.07	3038158.89	176.014	13965909.08	3038204.31	175.89	-7.01	-45.42	0.12
100350	13965612.26	3037504.81	183.044	(Deleted)					
100355	13965192.99	3037290.00	179.969	13965192.98	3037290.07	179.94	0.01	-0.07	0.03
100360	13963853.67	3036663.78	180.525	13963856.39	3036724.30	180.24	-2.73	-60.53	0.28
100365	13963404.19	3036262.85	180.943	13963404.10	3036262.56	180.65	0.09	0.29	0.29
100370	13962743.29	3035678.07	183.624	13962788.41	3035689.78	181.93	-45.12	-11.71	1.70
100380	13968857.16	3043621.35	173.003	13968843.39	3043616.24	172.89	13.76	5.11	0.11
100385	13967425.20	3039867.37	166.423	13967424.97	3039867.66	166.39	0.23	-0.29	0.03
100390	13967470.45	3040562.98	164.963	13967433.61	3040570.53	165.15	36.84	-7.55	-0.19
100395	13967132.27	3038141.36	171.773	13967131.35	3038141.19	171.59	0.93	0.17	0.19
100405	13959135.04	2955571.42	247.313	13959126.21	2955574.64	244.32	8.83	-3.22	2.99
100410	13959181.34	2951167.10	258.061	13959124.86	2951204.04	255.23	56.47	-36.94	2.83
100415	13958674.13	2945684.03	263.132	13958676.72	2945725.69	262.67	-2.59	-41.66	0.47

White Oak Bayou

Existing Permanent BM used by TSARP IDIQ (20)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
050010	13848583.52	3119075.59	43.3735	13848583.54	3119075.58	43.26	-0.03	0.01	0.12
050025	13846911.03	3111124.20	39.9778	13846911.08	3111124.17	39.93	-0.05	0.03	0.05
050030	13847124.44	3110791.67	43.4008	13847124.48	3110791.70	43.35	-0.04	-0.03	0.05

White Oak Bayou (continued)

Existing Permanent BM used by TSARP IDIQ (20)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
050035	13848519.98	3107246.90	50.664	13848520.03	3107246.90	50.55	-0.05	0.00	0.12
050040	13850993.09	3104915.77	53.173	13850993.14	3104915.80	53.10	-0.05	-0.02	0.08
050050	13856317.73	3101659.47	55.4975	13856317.82	3101659.37	55.55	-0.09	0.10	-0.05
050055	13858734.41	3097137.62	61.223	13858734.38	3097137.61	61.27	0.03	0.01	-0.05
050060	13862214.78	3095054.68	59.7128	13862214.78	3095054.71	59.69	-0.01	-0.03	0.02
050065	13867282.65	3092865.16	69.7925	13867282.63	3092865.08	69.85	0.03	0.08	-0.05
050105	13887446.80	3058236.41	101.803	13887446.79	3058236.31	101.43	0.01	0.11	0.37
050110	13894017.23	3054849.44	111.706	13894017.20	3054849.41	111.58	0.03	0.03	0.13
050130	13900856.64	3036276.28	132.386	13900856.59	3036276.26	131.99	0.05	0.02	0.40
050245	13867384.57	3081594.32	77.278	13867384.51	3081594.35	77.07	0.06	-0.03	0.21
050345	13885566.87	3087738.74	79.205	13885566.84	3087738.70	78.97	0.02	0.04	0.23
050350	13889608.10	3087483.17	89.222	13889608.15	3087483.14	89.00	-0.04	0.04	0.22
050355	13893577.44	3084878.58	99.215	13893600	3084900	99.03	-22.56	-21.42	0.19
050360	13894615.84	3080450.83	98.61	13894615.86	3080450.76	98.39	-0.02	0.06	0.22
050365	13897971.39	3076751.83	103.444	13897971.35	3076751.78	103.20	0.04	0.05	0.25
050370	13900027.35	3074096.97	105.702	13900027.36	3074096.90	105.47	-0.01	0.07	0.23
050410	13884142.93	3066408.80	93.801	13884143.02	3066408.79	93.51	-0.09	0.01	0.29
Relevel Existing BM (1)									
050230	13866296.03	3068768.93	93.4	13866105.16	3070504.03	87.83	190.87	-1735.10	5.57

Willow Creek

Existing Permanent BM used by TSARP IDIQ (9)

	Previous TSARP Positions			Final TSARP Positions			Previous - Final		
TSARP No.	Northing	Easting	Elev.	Northing	Easting	Elev.	delta N	delta E	delta Elev.
120040	13958376.95	3056825.03	138.043	13958376.90	3056824.96	137.93	0.05	0.06	0.12
120045	13957159.74	3054748.92	143.106	13957159.68	3054748.83	142.96	0.06	0.10	0.14
120055	13949371.49	3047279.66	149.65	13949300	3047300	149.43	71.49	-20.34	0.22
120065	13949539.43	3037450.68	164.089	13949500	3037400	164.02	39.43	50.68	0.06
120080	13944594.15	3025080.98	162.052	13944594.14	3025081.01	161.83	0.01	-0.03	0.22
120095	13941912.54	3013235.87	169.143	13941900	3013200	168.79	12.54	35.87	0.35
120100	13942093.81	3010818.50	175.666	13942100	3010700	178.12	-6.19	118.50	-2.45
120145	13969227.06	3057731.94	143	13969200	3057700	142.69	27.06	31.94	0.31
120185	13956817.92	3051662.84	143.612	13956800	3051700	143.68	17.92	-37.16	-0.07
Relevel Existing BM (1)									
120175	13968836.13	3048817.94	145.25	13966600	3050400	144.30	2236.13	-1582.06	0.95

9. Horizontal Constraints

It was agreed that virtually all of the 2000 control that was surveyed for the TSARP project matches within the 1st-Order tolerance (1:100,000) and would therefore be held in the final adjustment. The recommended method for determining whether or not this is true for any given point was as follows:

> For a given point A, determine the distance to the closest control point B. Calculate the combined 2-d positional difference for the two points. Calculate the maximum allowable difference for line AB (distance AB x .00001). If the combined difference is less than the maximum allowed, the baseline passes the test and the published value of point A may be held. For example, given a line AB which is 15,000 feet long; Point A's delta N = -0.05 feet and delta E = 0.04 feet; Point B's delta N = 0.03 feet and delta E = (0.02 feet. The combined differences are - delta N = 0.08 feet and delta E = 0.06 feet and the 2-d difference = 0.10 feet. The maximum allowable difference = 0.15 feet and point A can therefore be held in the final adjustment.

The following metadata statement regarding horizontal control will apply:

> "Unit of measure is the U. S. Survey Foot. Horizontal positions are referenced to NAD83 (1993), resurveyed in 2000 and adjusted in 2001, 1997.00 Epoch Date. Coordinates are referenced to the Texas Coordinate System of 1983, South Central Zone. Positions determined using GPS substantially conform to NGS Second Order Class I Specifications."

10. Vertical Constraints

It was agreed that, because of subsidence in varying amounts across the county over the approximate 2.5 years that have elapsed between the two surveys, all of the 2000 benchmarks cannot be held. After further discussion it was concluded that even holding a few benchmarks might introduce distortions in the network that would be undesirable, especially at the outer fringes of the network. It was therefore agreed that a minimally constrained adjustment in the vertical component would be performed, holding the ellipsoid height of the CORS station at Northeast Treatment Plant (NETP – PID AJ6430), based on the 1997.00 Epoch Date. The published ellipsoid height is -9.22 m or -30.249 ft. The differences due to subsidence between the TSARP channel surveys in 2001 and the TSARP control survey in 2002-2003 will be about half of the subsidence rates seen since October 2000 and in general should not exceed about 0.20 feet.

For this project orthometric heights of all benchmarks were determined using a two-step process. First the ellipsoid heights were converted to orthometric heights using the GEOID99 model. Then all elevations throughout the network were vertically translated by an additional amount, a single constant value for the entire network, in order to bring the orthometric height at NETP up to the published value of 18.07m or 59.285 ft. The constant needed to bring the orthometric heights up to this published value at NETP is 0.253 feet. This constant is necessary to account for the fact that the NGS published ellipsoid and geoid heights do not directly correlate mathematically to NGS published orthometric heights.

The following metadata statement regarding vertical control will apply:

> "Elevations are referenced to the NAVD88 2000 survey, adjusted in 2001 and are based on the published elevation at NORTHEAST 2250 CORS ARP (PID AJ6430), 1997.00 Epoch Date. Elevations determined by GPS substantially conform to the NOAA Technical Memorandum NOS NGS-58 2-CM Standard. Elevations determined by precise leveling substantially conform to the NGS Second Order Class II vertical standard for leveling, as published in the FGCC document entitled "Standards and Specifications for Geodetic Control Networks" dated September 1984."

11. Subsidence

The Subsidence District's observed height changes at their PAM sites are in close agreement with the delta-elevations seen in the results of this TSARP control survey. It may be inferred that the delta-elevations seen by TSARP surveyors at other 2000 benchmarks are also representative of subsidence in the vicinity of those other benchmarks. A model has been developed from this data using the delta-elevations observed at all control stations of Stability Order A or B that shows the approximate Annual Rate of Subsidence (AROS) for any given area within the network. The AROS value is calculated for each RM based on this model and provided in the database. As benchmarks continue to move, this data could be used in later years to reconcile differences in benchmark height observations.

11.1 Data Provided by HGCSD

HGCSD provided data which demonstrated that the three CORS stations which they operate are relatively stable compared to other surface marks. Of particular interest was movement since the October 2000 survey. The data indicated that the Lake Houston (LKHU) and Northeast Treatment Plant (NETP) CORS sites had moved less than 0.01 foot since 2000.

HGCSD also provided data for their PAM sites which indicated the amount of subsidence at each of those sites. One of the other survey consultants, CDS Muery, took on the task of compiling and comparing the HGCSD subsidence data to the actual surveyed elevations as determined by the TSARP survey consultants. When the rates of subsidence since October 2000 were applied to the October 2000 elevations, the predicted elevations matched the TSARP surveys within 0.02 feet. This demonstrates that a model of subsidence can be developed from the available data which can estimate reasonably well how much subsidence may be experienced in a particular area over the next few years and possibly beyond, assuming rates of subsidence remain constant during that time. *It should be emphasized that this data is approximate and is only provided herein for the purposes of evaluating benchmark movement.*

11.2 Observed Subsidence

Based on the successful predictions made using the PAM data, it was agreed that the observed subsidence values at all of the control points which were surveyed in October 2000 and which had a Stability of A or B could be used to create a model for Harris County. This model could then be used to calculate an approximate AROS value for all of the RMs in the TSARP network. Observed subsidence in this case refers to the difference between the published elevation, based on the October 2000 survey, and the current elevation as determined by the TSARP surveys. CDS Muery developed a DTM using observed subsidence values and approximate AROS values for every TSARP RM were extracted from

it. Those values are included in the Database Listing of All Benchmarks (Fully Constrained Adjustment) contained in Appendix N.

12. Final Station Position Summary Listing

The following is a summary of stations surveyed with their final adjusted positions. This data was extracted from the complete Database Listing of all Benchmarks (Fully Constrained Adjustment) contained in Appendix N.

RM No.	Latitude	Longitude	Ellips. Ht.	Northing	Easting	Elev.
050005	29° 46' 27.59560" N	95° 21' 58.50308" W	-32.42	13846999.60	3121067.23	57.12
050010	29° 46' 43.88106" N	95° 22' 20.53610" W	-46.30	13848583.54	3119075.58	43.26
050015	29° 46' 32.22564" N	95° 23' 21.58996" W	-43.66	13847240.32	3113734.61	45.91
050025	29° 46' 29.76452" N	95° 23' 51.31482" W	-49.65	13846911.08	3111124.17	39.93
050030	29° 46' 31.97746" N	95° 23' 55.01137" W	-46.23	13847124.48	3110791.70	43.35
050035	29° 46' 46.86575" N	95° 24' 34.73340" W	-39.06	13848520.03	3107246.90	50.55
050040	29° 47' 12.04561" N	95° 25' 00.31600" W	-36.54	13850993.14	3104915.80	53.10
050045	29° 47' 31.35018" N	95° 25' 10.29015" W	-36.59	13852915.28	3103977.70	53.06
050050	29° 48' 05.72111" N	95° 25' 35.41104" W	-34.14	13856317.82	3101659.37	55.55
050055	29° 48' 30.99861" N	95° 26' 25.87944" W	-28.45	13858734.38	3097137.61	61.27
050060	29° 49' 06.06518" N	95° 26' 48.31316" W	-30.05	13862214.78	3095054.71	59.69
050065	29° 49' 56.87081" N	95° 27' 11.41583" W	-19.93	13867282.63	3092865.08	69.85
050070	29° 50' 32.25109" N	95° 27' 31.27903" W	-17.69	13870801.82	3091008.32	72.11
050075	29° 51' 15.63829" N	95° 27' 47.31888" W	-18.46	13875139.73	3089463.94	71.37
050080	29° 52' 14.41339" N	95° 28' 49.34482" W	-11.17	13880909.34	3083826.29	78.71
050085	29° 52' 35.99199" N	95° 29' 39.55419" W	-3.10	13882955.34	3079342.64	86.80
050090	29° 52' 30.73556" N	95° 31' 01.42568" W	-2.79	13882209.30	3072154.32	87.14
050095	29° 52' 38.48740" N	95° 31' 29.28559" W	5.39	13882919.04	3069679.52	95.32
050100	29° 53' 03.56343" N	95° 32' 54.26247" W	13.31	13885229.45	3062127.38	103.28
050105	29° 53' 26.63950" N	95° 33' 37.70641" W	11.45	13887446.79	3058236.31	101.43
050110	29° 54' 32.64037" N	95° 34' 13.97988" W	21.56	13894017.20	3054849.41	111.58
050115	29° 55' 04.83294" N	95° 35' 05.41953" W	24.76	13897135.28	3050229.48	114.80
050120	29° 55' 30.94493" N	95° 35' 52.28925" W	31.67	13899651.67	3046030.13	121.73
050125	29° 55' 41.20182" N	95° 36' 55.72123" W	37.68	13900525.41	3040421.09	127.77
050130	29° 55' 45.66394" N	95° 37' 42.69986" W	41.88	13900856.59	3036276.26	131.99
050135	29° 47' 07.01387" N	95° 21' 57.35118" W	-55.83	13850982.48	3121044.98	33.73
050140	29° 47' 33.17079" N	95° 22' 06.36063" W	-41.37	13853598.68	3120169.50	48.22
050145	29° 48' 14.59096" N	95° 22' 25.72130" W	-42.38	13857727.64	3118334.84	47.24
050150	29° 48' 56.24332" N	95° 22' 38.79514" W	-41.92	13861897.30	3117053.35	47.72
050155	29° 49' 26.58529" N	95° 22' 52.87151" W	-34.75	13864922.34	3115719.20	54.92
050160	29° 49' 50.59315" N	95° 23' 10.45267" W	-33.28	13867298.39	3114096.51	56.41
050165	29° 50' 17.44484" N	95° 23' 46.26429" W	-26.30	13869912.13	3110860.44	63.42
050170	29° 51' 00.03155" N	95° 24' 10.66523" W	-19.27	13874145.74	3108580.28	70.48
050175	29° 51' 17.42677" N	95° 24' 45.62434" W	-13.30	13875807.51	3105449.50	76.46
050180	29° 51' 55.87346" N	95° 24' 52.52475" W	-8.80	13879670.66	3104723.16	80.98
050185	29° 52' 37.61406" N	95° 24' 52.96279" W	-6.28	13883883.85	3104555.37	83.53
050190	29° 54' 42.73203" N	95° 36' 59.80458" W	43.14	13894611.18	3040232.79	133.20
050195	29° 49' 36.11850" N	95° 27' 29.72462" W	-27.63	13865138.50	3091316.83	62.15
050200	29° 49' 41.26674" N	95° 28' 21.55076" W	-24.07	13865520.36	3086738.61	65.72

050205	29° 49' 34.19147" N	95° 28' 53.11071" W	-19.54	13864722.28	3083981.75	70.26
050210	29° 49' 25.80038" N	95° 29' 19.30437" W	-15.56	13863805.74	3081701.20	74.25
050215	29° 49' 22.01912" N	95° 29' 46.78884" W	-15.59	13863351.37	3079292.95	74.22
050220	29° 49' 26.07296" N	95° 30' 32.89962" W	-8.98	13863639.24	3075221.15	80.85
050225	29° 49' 46.36817" N	95° 31' 12.71020" W	-4.52	13865583.90	3071655.28	85.33
050230	29° 49' 51.86513" N	95° 31' 25.60003" W	-2.02	13866105.16	3070504.03	87.83
050235	29° 50' 04.11685" N	95° 32' 37.92222" W	5.61	13867153.44	3064100.71	95.48
050240	29° 50' 39.68903" N	95° 32' 43.15062" W	6.95	13870731.49	3063534.33	96.85
050245	29° 50' 01.24542" N	95° 29' 19.29722" W	-12.75	13867384.51	3081594.35	77.07
050250	29° 50' 29.40669" N	95° 29' 46.75637" W	-8.47	13870155.35	3079091.91	81.38
050255	29° 50' 45.47859" N	95° 30' 23.39200" W	-5.82	13871681.58	3075818.63	84.04
050260	29° 51' 03.59718" N	95° 31' 07.09986" W	-5.05	13873396.22	3071917.00	84.83
050265	29° 50' 18.34745" N	95° 26' 49.40144" W	-13.56	13869509.87	3094737.12	76.22
050270	29° 50' 17.99220" N	95° 25' 46.54220" W	-13.04	13869642.56	3100271.37	76.71
050275	29° 50' 49.96042" N	95° 25' 44.55362" W	-11.11	13872875.58	3100347.83	78.67
050280	29° 51' 48.59291" N	95° 25' 44.21845" W	-6.75	13878796.35	3100196.52	83.05
050285	29° 50' 47.54285" N	95° 28' 23.29680" W	-14.38	13872207.37	3086383.04	75.45
050290	29° 51' 03.77413" N	95° 29' 15.69970" W	-8.91	13873707.34	3081721.38	80.94
050295	29° 51' 13.03815" N	95° 30' 00.08364" W	-6.58	13874525.56	3077786.92	83.29
050300	29° 51' 25.61110" N	95° 30' 55.87027" W	-3.35	13875648.36	3072839.13	86.55
050305	29° 51' 40.07059" N	95° 31' 28.43027" W	-1.28	13877023.02	3069930.12	88.63
050310	29° 52' 02.70331" N	95° 32' 14.58818" W	5.21	13879187.68	3065800.21	95.15
050315	29° 51' 58.66145" N	95° 33' 03.35377" W	4.83	13878652.73	3061520.78	94.77
050320	29° 51' 41.25288" N	95° 33' 48.21978" W	10.09	13876778.74	3057624.09	100.03
050325	29° 52' 50.65696" N	95° 34' 17.72923" W	16.44	13883710.20	3054821.54	106.41
050330	29° 51' 57.74284" N	95° 29' 16.44438" W	-8.10	13879154.44	3081492.15	81.78
050335	29° 51' 47.72237" N	95° 28' 00.62842" W	-14.35	13878343.73	3088194.65	75.50
050340	29° 52' 27.00000" N	95° 28' 03.00000" W	N/A	13882300	3087800	78.54
050345	29° 52' 59.33267" N	95° 28' 03.32721" W	-10.91	13885566.84	3087738.70	78.97
050350	29° 53' 39.39828" N	95° 28' 04.84281" W	-0.89	13889608.15	3087483.14	89.00
050355	29° 54' 20.00000" N	95° 28' 33.00000" W	N/A	13893600	3084900	99.03
050360	29° 54' 31.04590" N	95° 29' 22.99709" W	8.45	13894615.86	3080450.76	98.39
050365	29° 55' 05.34602" N	95° 30' 03.86929" W	13.23	13897971.35	3076751.78	103.20
050370	29° 55' 26.47575" N	95° 30' 33.32879" W	15.49	13900027.36	3074096.90	105.47
050375	29° 55' 50.47993" N	95° 30' 34.84472" W	18.47	13902447.08	3073891.22	108.46
050380	29° 52' 56.62987" N	95° 31' 02.76673" W	4.26	13884820.29	3071958.43	94.19
050385	29° 53' 38.28477" N	95° 31' 29.93772" W	11.77	13888955.02	3069442.69	101.72
050390	29° 54' 29.61920" N	95° 31' 29.49719" W	16.09	13894139.38	3069327.38	106.06
050395	29° 55' 22.33535" N	95° 31' 29.94494" W	20.88	13899460.96	3069129.79	110.87
050400	29° 56' 15.58468" N	95° 31' 19.74531" W	24.31	13904864.25	3069866.95	114.32
050410	29° 52' 51.55968" N	95° 32' 06.01135" W	3.56	13884143.02	3066408.79	93.51
050415	29° 53' 34.26862" N	95° 32' 02.45625" W	11.95	13888464.59	3066593.77	101.91
050420	29° 54' 22.68235" N	95° 32' 18.98569" W	18.62	13893309.83	3064994.79	108.61
050425	29° 53' 17.77210" N	95° 34' 26.84726" W	14.76	13886424.51	3053939.01	104.75
050430	29° 53' 18.82475" N	95° 35' 21.78796" W	19.84	13886389.47	3049101.96	109.84
050435	29° 56' 10.64628" N	95° 34' 35.91486" W	41.71	13903856.46	3052630.11	131.77
050440	29° 53' 44.09550" N	95° 34' 21.12695" W	18.91	13889097.15	3054364.40	108.91
050445	29° 53' 52.24539" N	95° 35' 04.66576" W	21.42	13889807.95	3050509.88	111.43
050450	29° 53' 54.93915" N	95° 35' 43.18011" W	25.66	13889981.12	3047113.59	115.68

050455	29° 53' 46.76034" N	95° 36' 22.81232" W	29.19	13889053.93	3043650.87	119.21
050460	29° 53' 26.90307" N	95° 32' 39.26545" W	13.72	13887625.03	3063377.28	103.69
050465	29° 54' 10.68596" N	95° 32' 57.23737" W	18.57	13891999.08	3061665.60	108.56
050470	29° 55' 01.37287" N	95° 33' 01.96207" W	13.01	13897104.70	3061098.97	103.02
050475	29° 55' 29.74979" N	95° 32' 54.73271" W	25.38	13899988.71	3061650.27	115.40
050480	29° 55' 33.87771" N	95° 32' 02.65632" W	26.12	13900541.00	3066218.15	116.13
100005	30° 02' 06.57356" N	95° 15' 27.40224" W	-11.26	13942887.93	3152479.58	78.70
100010	30° 01' 25.13338" N	95° 17' 39.89948" W	-31.89	13938333.04	3140972.18	58.07
100025	30° 03' 01.62833" N	95° 19' 37.07090" W	3.48	13947751.17	3130371.19	93.48
100040	30° 04' 22.02537" N	95° 22' 29.21571" W	-2.44	13955397.00	3114998.35	87.62
100045	30° 04' 47.42009" N	95° 22' 58.41791" W	5.22	13957881.72	3112354.45	95.30
100050	30° 04' 45.07466" N	95° 23' 37.41170" W	17.37	13957539.12	3108937.52	107.46
100055	30° 05' 16.91798" N	95° 24' 47.10585" W	39.71	13960566.16	3102718.61	129.83
100060	30° 05' 44.69049" N	95° 24' 57.49472" W	5.72	13963342.47	3101720.41	95.86
100065	30° 06' 17.00000" N	95° 25' 23.00000" W	N/A	13966500	3099400	92.63
100075	30° 06' 34.70589" N	95° 26' 12.36001" W	24.89	13968191.83	3094993.15	115.07
100080	30° 07' 13.09897" N	95° 27' 19.59608" W	21.06	13971889.16	3088972.92	111.27
100085	30° 07' 02.15684" N	95° 27' 56.49342" W	22.84	13970686.22	3085767.41	113.06
100090	30° 06' 47.98147" N	95° 28' 49.55606" W	26.50	13969114.33	3081152.41	116.73
100095	30° 07' 19.88439" N	95° 29' 33.03636" W	21.10	13972221.06	3077238.70	111.36
100100	30° 07' 57.00000" N	95° 29' 43.00000" W	N/A	13976000	3076200	105.54
100105	30° 08' 34.65821" N	95° 30' 16.41696" W	43.38	13979657.49	3073204.97	133.66
100110	30° 11' 41.29059" N	95° 29' 23.94178" W	61.64	13998641.32	3077244.56	151.94
100120	30° 10' 10.00000" N	95° 31' 10.00000" W	N/A	13989100	3068200	148.69
100125	30° 10' 06.48245" N	95° 32' 33.09315" W	53.25	13988573.17	3060935.56	143.57
100135	30° 09' 34.01592" N	95° 34' 08.72154" W	46.62	13985047.51	3052641.11	136.95
100145	30° 08' 03.95050" N	95° 35' 48.00859" W	62.42	13975698.03	3044193.33	152.78
100160	30° 07' 24.88482" N	95° 37' 44.93763" W	90.51	13971455.84	3034043.85	180.87
100165	30° 07' 11.00000" N	95° 38' 45.00000" W	N/A	13969900	3028800	167.51
100170	30° 06' 30.05673" N	95° 39' 15.09953" W	59.42	13965691.93	3026287.61	149.78
100175	30° 05' 38.55307" N	95° 40' 24.27279" W	137.75	13960317.78	3020362.41	228.10
100180	30° 05' 54.00000" N	95° 40' 56.00000" W	N/A	13961800	3017500	197.97
100185	30° 05' 56.38661" N	95° 42' 07.64370" W	81.41	13961861.48	3011234.67	171.76
100190	30° 05' 50.00000" N	95° 42' 48.00000" W	N/A	13961100	3007700	180.88
100195	30° 11' 49.36422" N	95° 45' 10.68941" W	141.46	13997056.81	2994172.24	231.72
100200	30° 05' 38.45906" N	95° 44' 06.74420" W	80.93	13959757.63	3000827.49	171.26
100205	30° 05' 37.00000" N	95° 45' 11.00000" W	N/A	13959400	2995200	177.31
100210	30° 05' 13.00000" N	95° 45' 48.00000" W	N/A	13956900	2992000	180.69
100215	30° 04' 30.99606" N	95° 47' 15.85345" W	143.52	13952485.09	2984408.78	233.83
100225	30° 05' 03.91319" N	95° 48' 47.49001" W	112.67	13955588.92	2976269.92	202.96
100230	30° 04' 09.50908" N	95° 49' 28.91666" W	147.92	13949996.04	2972781.01	238.21
100235	30° 05' 11.00000" N	95° 50' 31.00000" W	N/A	13956100	2967100	217.14
100240	30° 05' 56.78692" N	95° 50' 31.89849" W	138.70	13960679.55	2966956.49	228.97
100245	30° 06' 19.73420" N	95° 51' 42.26981" W	140.81	13962830.52	2960715.09	231.06
100255	30° 07' 13.00000" N	95° 52'43.00000" W	N/A	13968100	2955300	242.69
100260	30° 06' 52.14031" N	95° 53' 33.37873" W	179.32	13965842.52	2950872.36	269.54
100270	30° 07' 41.37077" N	95° 54' 39.31726" W	164.77	13970660.75	2944951.86	254.96
100280	30° 09' 00.17030" N	95° 55' 37.13337" W	204.91	13978484.81	2939667.34	295.06
100290	30° 08' 53.00000" N	95° 56' 41.00000" W	N/A	13977700	2934100	282.56

100295	30° 09' 43.63168" N	95° 57' 27.72387" W	197.91	13982620.12	2929847.01	288.01
100300	30° 10' 23.57381" N	95° 58' 09.39970" W	230.64	13986558.90	2926085.14	320.73
100305	30° 04' 13.76640" N	95° 22' 44.47510" W	4.47	13954521.55	3113684.08	94.53
100310	30° 03' 54.03821" N	95° 23' 34.10025" W	20.85	13952394.83	3109387.31	110.91
100315	30° 05' 30.97310" N	95° 28' 41.61262" W	44.15	13961359.36	3082083.98	134.36
100320	30° 05' 01.33448" N	95° 29' 30.94164" W	49.46	13958236.37	3077842.35	139.67
100325	30° 07' 35.82538" N	95° 35' 51.23735" W	67.73	13972849.72	3043992.58	158.08
100330	30° 07' 28.40483" N	95° 36' 00.26867" W	72.67	13972077.33	3043221.61	163.03
100340	30° 06' 57.96841" N	95° 36' 30.34782" W	78.91	13968927.19	3040670.38	169.27
100345	30° 06' 28.81213" N	95° 36' 59.40927" W	85.53	13965909.08	3038204.31	175.89
100355	30° 06' 21.98816" N	95° 37' 10.04942" W	89.57	13965192.98	3037290.07	179.94
100360	30° 06' 08.92476" N	95° 37' 16.92758" W	89.88	13963856.39	3036724.30	180.24
100365	30° 06' 04.58145" N	95° 37' 22.33092" W	90.29	13963404.10	3036262.56	180.65
100370	30° 05' 58.65298" N	95° 37' 29.05124" W	91.57	13962788.41	3035689.78	181.93
100380	30° 06' 56.29260" N	95° 35' 56.84760" W	82.53	13968843.39	3043616.24	172.89
100385	30° 06' 43.33473" N	95° 36' 39.97942" W	76.03	13967424.97	3039867.66	166.39
100390	30° 06' 43.21859" N	95° 36' 31.97732" W	74.79	13967433.61	3040570.53	165.15
100395	30° 06' 40.92416" N	95° 36' 59.72502" W	81.23	13967131.35	3038141.19	171.59
100400	30° 04' 55.63818" N	95° 51' 38.03182" W	170.61	13954348.10	2961315.22	260.86
100405	30° 05' 44.44044" N	95° 52' 41.89860" W	154.08	13959126.21	2955574.64	244.32
100410	30° 05' 45.57926" N	95° 53' 31.63591" W	165.01	13959124.86	2951204.04	255.23
100415	30° 05' 42.58161" N	95° 54' 34.11414" W	172.46	13958676.72	2945725.69	262.67
110005	30° 01' 37.07415" N	95° 18' 29.88660" W	-1.53	13939399.73	3136542.16	88.42
110010	30° 02' 02.12210" N	95° 19' 34.71906" W	-15.90	13941749.37	3130766.57	74.07
110015	30° 01' 50.00000" N	95° 19' 48.00000" W	N/A	13940500	3129600	79.65
110020	30° 01' 31.32478" N	95° 20' 29.77031" W	-26.87	13938488.13	3126027.43	63.10
110025	30° 02' 04.83118" N	95° 21' 03.49731" W	-12.75	13941778.64	3122958.55	77.24
110030	30° 02' 01.31048" N	95° 22' 02.80877" W	-4.61	13941260.89	3117758.88	85.39
110035	30° 02' 24.69221" N	95° 22' 56.29330" W	-0.96	13943476.06	3112986.96	89.06
110040	30° 01' 52.49030" N	95° 24' 18.83759" W	4.82	13940000.93	3105835.47	94.85
110045	30° 02' 11.39877" N	95° 24' 55.62861" W	-6.85	13941810.89	3102544.56	83.20
110050	30° 02' 08.74901" N	95° 25' 43.31471" W	11.75	13941415.14	3098363.36	101.82
110055	30° 01' 52.92064" N	95° 26' 22.86322" W	6.70	13939710.94	3094937.52	96.78
110060	30° 02' 28.64003" N	95° 27' 33.52154" W	24.77	13943129.10	3088620.37	114.89
110065	30° 01' 27.82080" N	95° 28' 34.65952" W	18.90	13936825.74	3083434.48	109.01
110070	30° 01' 00.27873" N	95° 29' 19.13715" W	13.46	13933927.17	3079609.97	103.58
110075	30° 00' 41.27494" N	95° 30' 09.96307" W	15.90	13931874.44	3075201.19	106.02
110080	30° 00' 24.35869" N	95° 30' 43.29976" W	25.82	13930078.84	3072322.62	115.95
110085	30° 00' 21.09409" N	95° 31' 07.02191" W	12.62	13929687.07	3070247.71	102.76
110090	29° 59' 52.70286" N	95° 31' 49.88357" W	20.18	13926708.35	3066566.01	110.31
110095	29° 59' 08.70042" N	95° 32' 03.80376" W	32.61	13922229.01	3065474.28	122.72
110100	29° 59' 30.54062" N	95° 33' 00.31666" W	30.06	13924287.37	3060441.73	120.21
110105	29° 59' 30.50450" N	95° 33' 26.46289" W	31.32	13924215.99	3058143.72	121.47
110110	29° 59' 08.86732" N	95° 34' 12.08109" W	38.53	13921913.35	3054198.20	128.69
110115	29° 59' 18.03177" N	95° 34' 29.72912" W	26.30	13922793.25	3052619.82	116.46
110120	29° 58' 39.43304" N	95° 35' 18.37410" W	38.26	13918770.77	3048457.73	128.42
110125	29° 58' 25.14634" N	95° 35' 55.40481" W	37.09	13917233.34	3045244.40	127.25
110130	29° 57' 45.14241" N	95° 37' 13.34126" W	37.12	13912995.29	3038509.63	127.28
110135	29° 57' 40.67096" N	95° 37' 52.28431" W	43.49	13912444.97	3035098.70	133.66

110140	29° 57' 10.59651" N	95° 38' 56.03363" W	49.54	13909247.15	3029580.71	139.71
110145	29° 57' 24.48787" N	95° 40' 41.30327" W	57.31	13910385.68	3020284.41	147.52
110150	29° 57' 11.69548" N	95° 41' 07.87737" W	48.31	13909027.65	3017984.43	138.51
110155	29° 57' 13.77122" N	95° 42' 12.46262" W	59.99	13909076.70	3012299.46	150.20
110160	29° 57' 32.97397" N	95° 43' 03.89249" W	58.77	13910888.49	3007722.74	149.00
110165	29° 57' 23.27714" N	95° 43' 44.54311" W	58.83	13909809.17	3004175.86	149.06
110170	29° 57' 22.05955" N	95° 44' 34.92582" W	62.15	13909562.55	2999749.17	152.38
110190	29° 57' 00.52419" N	95° 48' 29.95562" W	71.96	13906818.04	2979142.27	162.20
110195	29° 56' 28.39502" N	95° 48' 28.83263" W	75.15	13903576.39	2979329.59	165.38
110210	29° 55' 15.34066" N	95° 50' 25.69868" W	74.21	13895920.33	2969251.23	164.42
110215	29° 55' 11.15212" N	95° 51' 27.95102" W	76.24	13895349.82	2963786.74	166.45
110230	29° 55' 01.61740" N	95° 57' 28.95189" W	113.49	13893547.21	2932056.53	203.68
110235	29° 55' 27.00913" N	95° 52' 46.03628" W	80.21	13896767.09	2956875.33	170.43
110240	29° 55' 53.74054" N	95° 58' 14.31159" W	117.78	13898707.07	2927929.97	207.98
110245	29° 55' 55.96666" N	95° 54' 52.87920" W	91.13	13899395.12	2945641.01	181.35
110250	29° 56' 02.59270" N	95° 53' 12.56583" W	87.10	13900298.08	2954446.12	177.32
110255	29° 56' 53.11730" N	95° 55' 26.83336" W	96.39	13905087.54	2942502.79	186.61
110260	29° 57' 00.30304" N	95° 53' 00.14276" W	89.99	13906154.76	2955383.41	180.23
110270	29° 57' 50.18741" N	95° 54' 28.08594" W	122.94	13910986.79	2947516.64	213.17
110280	29° 58' 45.72603" N	95° 54' 29.05840" W	108.11	13916592.88	2947282.83	198.35
110290	29° 59' 00.18403" N	95° 57' 04.77145" W	147.99	13917693.42	2933555.49	238.20
110295	30° 01' 22.36170" N	95° 21' 07.03165" W	-17.66	13937480.83	3122781.85	72.31
110300	30° 00' 51.29309" N	95° 21' 49.66491" W	-7.97	13934227.16	3119133.50	81.99
110305	30° 00' 39.39404" N	95° 22' 28.73152" W	-3.74	13932919.11	3115737.93	86.22
110310	30° 00' 24.34362" N	95° 23' 55.22042" W	9.32	13931164.58	3108184.56	99.30
110315	30° 00' 00.67802" N	95° 24' 27.78618" W	9.24	13928687.03	3105396.15	99.23
110320	30° 00' 02.33620" N	95° 24' 57.08640" W	23.27	13928775.42	3102815.99	113.27
110325	30° 00' 17.49801" N	95° 23' 17.62091" W	5.65	13930575.31	3111510.10	95.62
110330	30° 02' 29.34661" N	95° 21' 11.42951" W	-9.56	13944232.22	3122184.47	80.44
110335	30° 02' 44.53937" N	95° 21' 30.88846" W	-6.23	13945712.95	3120427.27	83.78
110340	30° 03' 15.77559" N	95° 21' 53.72460" W	5.11	13948804.46	3118323.19	95.14
110345	30° 02' 35.17776" N	95° 21' 00.92277" W	-8.59	13944849.79	3123089.08	81.41
110350	30° 02' 27.13443" N	95° 22' 56.94332" W	-1.01	13943720.89	3112922.23	89.01
110355	30° 02' 57.45122" N	95° 23' 15.25301" W	-3.57	13946732.27	3111219.17	86.47
110360	30° 03' 27.81066" N	95° 23' 53.48763" W	19.30	13949694.09	3107766.14	109.36
110365	30° 03' 39.92418" N	95° 24' 21.34881" W	23.43	13950841.90	3105281.37	113.50
110370	30° 03' 40.07036" N	95° 24' 52.92817" W	19.18	13950771.50	3102507.24	109.27
110375	30° 01' 51.66536" N	95° 23' 44.54321" W	-8.90	13940010.40	3108851.05	81.12
110380	30° 01' 36.61387" N	95° 23' 32.34023" W	2.50	13938523.71	3109970.07	92.51
110385	30° 01' 14.67460" N	95° 23' 32.38600" W	12.73	13936308.37	3110034.40	102.73
110390	30° 02' 01.23296" N	95° 24' 21.11969" W	1.72	13940877.52	3105607.83	91.75
110395	30° 02' 43.66011" N	95° 25' 12.03346" W	2.07	13945024.22	3101003.60	92.14
110400	30° 03' 30.03084" N	95° 25' 12.08374" W	11.27	13949706.23	3100855.81	101.35
110405	30° 04' 21.60817" N	95° 25' 13.38545" W	24.37	13954910.63	3100582.03	114.48
110410	30° 04' 43.31849" N	95° 25' 17.21718" W	27.06	13957092.48	3100178.42	117.18
110415	30° 02' 50.69117" N	95° 25' 48.63448" W	4.26	13945635.85	3097766.68	94.35
110420	30° 03' 01.19898" N	95° 26' 35.17466" W	11.54	13946572.24	3093646.12	101.64
110425	30° 03' 44.71504" N	95° 26' 54.23474" W	22.98	13950915.29	3091838.37	113.11
110430	30° 04' 45.37079" N	95° 26' 10.50741" W	31.57	13957156.77	3095492.31	121.71

110435	30° 04' 58.71677" N	95° 26' 48.88454" W	41.58	13958401.79	3092081.20	131.73
110440	30° 02' 40.00000" N	95° 26' 48.00000" W	N/A	13944400	3092600	96.76
110445	30° 02' 51.16549" N	95° 27' 42.81484" W	11.22	13945378.85	3087735.13	101.34
110450	30° 03' 00.78711" N	95° 28' 13.64788" W	23.31	13946268.51	3084997.28	113.45
110455	30° 03' 20.82636" N	95° 28' 59.32865" W	34.23	13948171.02	3080923.69	124.40
110460	30° 03' 46.68439" N	95° 29' 46.58896" W	44.20	13950657.38	3076694.18	134.40
110465	30° 01' 48.47481" N	95° 27' 42.51948" W	6.68	13939049.58	3087952.64	96.78
110470	30° 01' 06.62473" N	95° 29' 57.76803" W	16.23	13934466.15	3076196.21	106.36
110475	30° 01' 47.96242" N	95° 30' 26.09529" W	23.51	13938565.71	3073582.38	113.68
110480	30° 02' 47.71874" N	95° 32' 05.03164" W	49.93	13944340.92	3064710.88	140.15
110485	30° 01' 14.41341" N	95° 30' 55.10213" W	21.06	13935102.10	3071134.78	111.22
110490	30° 01' 18.00000" N	95° 31' 21.00000" W	N/A	13935400	3068900	115.67
110495	30° 01' 42.02376" N	95° 31' 52.26262" W	31.68	13937740.66	3066029.41	121.87
110500	30° 02' 07.73942" N	95° 32' 32.78902" W	42.18	13940231.82	3062391.86	132.39
110505	30° 02' 32.66974" N	95° 32' 41.36657" W	49.21	13942726.87	3061563.87	139.44
110510	30° 02' 41.60377" N	95° 32' 27.34669" W	49.93	13943665.41	3062768.84	140.16
110515	30° 03' 02.00915" N	95° 32' 23.13920" W	53.08	13945736.78	3063077.48	143.31
110520	30° 03' 08.94791" N	95° 32' 57.94729" W	52.03	13946347.05	3059999.12	142.28
110525	30° 03' 41.48056" N	95° 32' 44.15207" W	54.64	13949667.84	3061113.87	144.90
110530	30° 02' 10.60532" N	95° 30' 21.93533" W	28.41	13940862.97	3073879.55	118.58
110535	30° 03' 05.76721" N	95° 30' 19.20505" W	40.54	13946440.05	3073952.94	130.73
110540	30° 03' 44.94912" N	95° 30' 11.09249" W	43.20	13950417.73	3074547.23	133.40
110545	30° 00' 12.02794" N	95° 31' 46.46635" W	18.22	13928668.57	3066808.43	108.36
110550	30° 00' 15.03635" N	95° 32' 00.73182" W	22.83	13928935.15	3065545.71	112.98
110555	30° 00' 28.09456" N	95° 32' 15.10934" W	29.51	13930216.24	3064243.11	119.67
110560	30° 00' 41.42525" N	95° 32' 26.99597" W	37.91	13931531.37	3063158.68	128.08
110565	30° 01' 43.93297" N	95° 33' 54.45146" W	51.28	13937616.48	3055287.85	141.51
110570	30° 02' 10.32619" N	95° 34' 04.00034" W	54.36	13940256.90	3054370.62	144.61
110575	30° 02' 55.04953" N	95° 33' 53.29305" W	52.84	13944800.49	3055178.64	143.10
110580	29° 59' 50.09573" N	95° 34' 03.36192" W	32.14	13926098.83	3054842.40	122.31
110585	30° 00' 12.98584" N	95° 34' 25.14116" W	38.16	13928354.00	3052860.48	128.35
110590	30° 00' 39.00000" N	95° 34' 39.00000" W	N/A	13931000	3051500	134.04
110595	30° 01' 04.67861" N	95° 35' 09.02479" W	49.70	13933460.84	3048851.34	139.93
110600	30° 01' 17.41834" N	95° 35' 08.54458" W	52.60	13934748.47	3048855.97	142.83
110605	30° 01' 33.35067" N	95° 35' 52.27842" W	56.81	13936245.23	3044966.26	147.07
110610	30° 00' 51.00000" N	95° 35' 13.00000" W	N/A	13932100	3048600	141.87
110615	29° 59' 23.38523" N	95° 35' 35.07345" W	37.87	13923165.99	3046860.40	128.06
110620	29° 59' 47.45747" N	95° 36' 09.00227" W	39.54	13925509.90	3043807.51	129.74
110625	30° 00' 01.58762" N	95° 36' 41.76460" W	43.48	13926853.13	3040886.62	133.70
110630	30° 00' 15.18522" N	95° 38' 08.98202" W	54.69	13928004.80	3033181.66	144.94
110635	30° 00' 31.00000" N	95° 37' 21.00000" W	N/A	13929800	3037400	142.81
110640	30° 01' 00.75683" N	95° 37' 29.35680" W	55.10	13932706.80	3036531.32	145.37
110645	30° 01' 16.95795" N	95° 38' 32.40908" W	63.09	13934183.20	3030943.62	153.37
110650	30° 01' 30.16960" N	95° 39' 28.03755" W	65.12	13935377.22	3026017.33	155.41
110655	29° 59' 48.32514" N	95° 35' 35.75277" W	46.92	13925682.55	3046727.31	137.12
110660	30° 01' 37.44173" N	95° 36' 29.46513" W	62.65	13936563.39	3041686.81	152.92
110665	29° 57' 55.00000" N	95° 40' 36.00000" W	N/A	13913500	3020700	143.09
110670	29° 58' 34.00000" N	95° 40' 36.00000" W	N/A	13917400	3020500	148.01
110675	29° 58' 52.00000" N	95° 41' 14.00000" W	N/A	13919100	3017200	153.59

110680	29° 58' 53.79402" N	95° 41' 57.15112" W	60.95	13919214.60	3013360.68	151.20
110685	29° 59' 05.20267" N	95° 42' 48.42200" W	63.98	13920239.64	3008821.23	154.24
110690	29° 59' 19.98943" N	95° 43' 15.73239" W	62.46	13921665.37	3006378.65	152.73
110695	29° 58' 27.71730" N	95° 42' 17.29745" W	58.75	13916531.50	3011663.89	149.00
110700	29° 57' 53.74662" N	95° 40' 41.58894" W	62.93	13913339.38	3020175.36	153.15
110705	29° 56' 48.63517" N	95° 43' 46.35673" W	57.38	13906306.69	3004114.24	147.60
110710	29° 56' 32.84338" N	95° 44' 58.09897" W	61.72	13904536.16	2997849.72	151.94
110715	29° 57' 59.37637" N	95° 42' 32.97915" W	58.32	13913630.91	3010365.81	148.56
110720	29° 58' 50.46720" N	95° 43' 11.79371" W	62.22	13918694.01	3006808.50	152.48
110725	29° 56' 57.42497" N	95° 45' 46.79356" W	67.04	13906899.53	2993498.71	157.28
110730	30° 00' 20.74787" N	95° 47' 12.39974" W	109.28	13927223.14	2985406.59	199.57
110735	29° 57' 26.44040" N	95° 48' 30.39291" W	68.06	13909433.96	2979032.38	158.32
110740	29° 58' 01.50545" N	95° 49' 20.34050" W	77.57	13912855.17	2974544.25	167.84
110745	29° 58' 20.56571" N	95° 49' 23.30829" W	82.16	13914772.77	2974231.02	172.43
110760	29° 58' 08.00000" N	95° 50' 31.00000" W	N/A	13913300	2968400	176.91
110765	29° 58' 51.47728" N	95° 50' 53.96376" W	114.91	13917678.52	2966176.67	205.18
110770	29° 59' 34.10389" N	95° 51' 08.73256" W	113.87	13921948.00	2964762.46	204.14
110775	30° 00' 35.37419" N	95° 50' 55.39516" W	125.21	13928166.71	2965768.06	215.49
110820	29° 58' 36.98246" N	95° 52' 12.80705" W	107.64	13916028.64	2959284.68	197.89
110825	29° 59' 33.91499" N	95° 51' 57.69919" W	122.25	13921813.31	2960458.78	212.52
110830	29° 57' 42.12564" N	95° 53' 00.58658" W	105.34	13910376.97	2955231.82	195.57
110840	29° 58' 59.79413" N	95° 53' 25.13775" W	121.49	13918162.52	2952864.49	211.73
110845	29° 59' 39.86786" N	95° 53' 59.54903" W	110.58	13922128.90	2949732.12	200.82
110850	30° 00' 18.67167" N	95° 54' 28.81994" W	116.61	13925979.27	2947055.59	206.86
110855	30° 00' 10.03222" N	95° 55' 47.26184" W	128.29	13924925.16	2940184.16	218.52
110860	30° 00' 10.00000" N	95° 56' 34.00000" W	N/A	13924800	2936100	231.73
110865	30° 00' 42.60524" N	95° 54' 25.06265" W	116.03	13928404.88	2947321.88	206.28
110870	30° 01' 18.87119" N	95° 55' 16.86765" W	125.24	13931946.97	2942672.57	215.48
110875	30° 02' 05.03300" N	95° 55' 38.10231" W	129.44	13936559.47	2940684.03	219.67
110880	30° 02' 32.81479" N	95° 54' 30.22844" W	149.69	13939522.18	2946573.62	239.93
110885	30° 02' 51.61272" N	95° 55' 30.50972" W	144.18	13941280.82	2941227.46	234.41
110890	30° 03' 16.53085" N	95° 58' 02.62936" W	149.55	13943448.15	2927797.75	239.75
110895	30° 04' 03.18023" N	95° 58' 27.42400" W	162.16	13948102.65	2925497.65	252.34
110900	30° 04' 00.40987" N	95° 55' 02.41569" W	176.49	13948293.26	2943512.47	266.71
110910	30° 05' 15.44981" N	95° 56' 15.88494" W	175.87	13955701.64	2936860.62	266.06
110915	30° 06' 46.18519" N	95° 56' 55.45652" W	213.23	13964773.88	2933146.31	303.40
110920	30° 01' 18.08813" N	95° 53' 29.99280" W	129.69	13932116.37	2952066.43	219.94
110925	30° 02' 11.20547" N	95° 53' 19.33563" W	146.92	13937505.22	2952860.21	237.17
110930	30° 02' 47.13604" N	95° 52' 26.25639" W	151.46	13941257.99	2957426.92	241.72
110935	29° 59' 07.61804" N	95° 41' 57.69082" W	61.69	13920609.16	3013273.83	151.95
110940	30° 04' 12.91963" N	95° 55' 42.18454" W	165.48	13949464.63	2939986.08	255.69
110945	30° 04' 43.18724" N	95° 55' 17.91945" W	184.06	13952577.26	2942036.92	274.27
110950	29° 58' 39.00000" N	95° 37' 49.00000" W	N/A	13918400	3035200	137.03
110955	29° 59' 18.44221" N	95° 39' 13.51859" W	54.96	13922112.35	3027673.78	145.20
110960	29° 59' 41.29173" N	95° 39' 54.33747" W	56.22	13924317.09	3024019.99	146.48
110965	30° 00' 13.72560" N	95° 40' 50.69061" W	69.77	13927451.21	3018973.86	160.04
110970	30° 00' 57.89889" N	95° 41' 50.62251" W	72.04	13931762.57	3013580.61	162.34
110975	30° 00' 47.10472" N	95° 42' 49.08500" W	74.81	13930527.83	3008473.72	165.10
110980	30° 01' 19.32338" N	95° 43' 29.71370" W	76.89	13933681.04	3004812.14	167.20

110985	30° 01' 35.21088" N	95° 44' 28.66991" W	91.80	13935140.59	2999586.79	182.10
110995	30° 01' 14.05014" N	95° 44' 56.40946" W	102.98	13932935.94	2997208.76	193.28
111000	30° 01' 13.40439" N	95° 45' 54.25009" W	96.61	13932729.76	2992127.85	186.91
111005	30° 01' 40.05120" N	95° 46' 22.22828" W	98.35	13935352.61	2989595.01	188.66
111010	30° 01' 58.69038" N	95° 46' 53.36158" W	99.72	13937159.40	2986807.56	190.03
111015	30° 01' 40.00000" N	95° 47' 57.00000" W	N/A	13935100	2981300	200.12
111020	30° 01' 51.74623" N	95° 48' 54.97316" W	113.81	13936165.58	2976141.31	204.10
111025	30° 02' 11.45185" N	95° 49' 19.24861" W	122.64	13938097.44	2973954.22	212.93
111030	30° 01' 54.66632" N	95° 49' 55.78065" W	123.84	13936315.31	2970790.37	214.12
111035	30° 02' 11.00000" N	95° 51' 26.00000" W	N/A	13937700	2962800	231.55
111040	30° 01' 55.76898" N	95° 51' 54.77617" W	147.82	13936144.85	2960331.66	238.08
111045	30° 01' 58.86277" N	95° 43' 31.61471" W	80.90	13937669.01	3004533.27	171.22
111050	30° 02' 13.00789" N	95° 44' 19.79666" W	85.99	13938979.05	3000260.02	176.30
111055	30° 02' 38.02640" N	95° 46' 13.11451" W	106.39	13941229.08	2990234.11	196.71
111060	30° 04' 24.09817" N	95° 46' 02.64099" W	137.41	13951965.75	2990858.11	227.73
111065	30° 03' 46.20759" N	95° 46' 23.39870" W	123.36	13948089.14	2989140.58	213.67
111070	30° 03' 13.09171" N	95° 45' 07.93883" W	121.98	13944928.60	2995861.71	212.30
111075	30° 02' 13.65106" N	95° 46' 37.17044" W	95.95	13938709.32	2988188.53	186.25
111080	30° 02' 23.20623" N	95° 47' 13.69695" W	102.01	13939585.88	2984952.78	192.31
111085	30° 03' 05.35055" N	95° 47' 44.47250" W	117.28	13943767.47	2982132.25	207.58
111090	30° 02' 11.67320" N	95° 50' 28.62679" W	129.73	13937954.61	2967857.91	220.01
111095	30° 03' 50.47310" N	95° 50' 29.56021" W	163.09	13947929.46	2967506.38	253.37
120010	30° 06' 52.05973" N	95° 30' 24.13700" W	23.21	13969277.12	3072836.98	113.48
120015	30° 07' 13.71690" N	95° 31' 06.89273" W	29.95	13971352.04	3069018.42	120.24
120020	30° 07' 01.19636" N	95° 31' 20.00879" W	24.29	13970053.48	3067904.66	114.58
120025	30° 06' 41.00000" N	95° 32' 21.00000" W	N/A	13967800	3062600	122.59
120030	30° 06' 13.17544" N	95° 32' 51.49418" W	47.55	13964966.42	3060016.67	137.86
120035	30° 05' 31.78132" N	95° 33' 08.53371" W	43.42	13960742.41	3058643.89	133.72
120040	30° 05' 08.90563" N	95° 33' 30.02284" W	47.62	13958376.90	3056824.96	137.93
120045	30° 04' 57.46574" N	95° 33' 54.05177" W	52.65	13957159.68	3054748.83	142.96
120050	30° 04' 06.04057" N	95° 34' 27.60005" W	59.25	13951880.48	3051954.87	149.56
120055	30° 03' 42.00000" N	95° 35' 21.00000" W	N/A	13949300	3047300	149.43
120060	30° 03' 34.83072" N	95° 36' 18.27142" W	58.21	13948445.47	3042326.17	148.53
120065	30° 03' 47.00000" N	95° 37' 13.00000" W	N/A	13949500	3037400	164.02
120070	30° 03' 34.64029" N	95° 37' 55.82371" W	62.97	13948178.43	3033757.95	153.30
120075	30° 03' 10.44275" N	95° 38' 43.68117" W	68.35	13945614.16	3029624.35	158.67
120080	30° 03' 01.63669" N	95° 39' 35.69069" W	71.51	13944594.14	3025081.01	161.83
120085	30° 02' 58.88284" N	95° 40' 28.42594" W	69.61	13944184.01	3020456.31	159.93
120090	30° 02' 42.25981" N	95° 41' 36.42850" W	75.14	13942336.01	3014529.91	165.46
120095	30° 02' 38.00000" N	95° 41' 51.00000" W	N/A	13941900	3013200	168.79
120100	30° 02' 41.00000" N	95° 42' 20.00000" W	N/A	13942100	3010700	178.12
120110	30° 05' 55.57187" N	95° 29' 55.36020" W	41.38	13963648.75	3075534.04	131.62
120115	30° 04' 34.75587" N	95° 30' 11.73460" W	49.95	13955445.28	3074340.41	140.17
120120	30° 07' 18.04019" N	95° 31' 35.25979" W	33.07	13971714.53	3066515.30	123.37
120125	30° 08' 01.15811" N	95° 32' 02.80108" W	44.82	13975996.74	3063968.60	135.13
120130	30° 06' 22.79006" N	95° 31' 53.59176" W	39.92	13966087.74	3065071.59	130.21
120135	30° 05' 45.08701" N	95° 31' 17.56867" W	56.46	13962374.57	3068347.51	146.73
120140	30° 05' 27.77564" N	95° 31' 52.22505" W	53.17	13960536.12	3065356.40	143.44
120145	30° 06' 56.00000" N	95° 33' 16.00000" W	N/A	13969200	3057700	142.69

120150	30° 06' 40.23936" N	95° 33' 26.77411" W	50.82	13967607.94	3056838.69	141.14
120155	30° 07' 05.67990" N	95° 32' 52.68193" W	45.22	13970265.12	3059755.85	135.53
120160	30° 08' 01.05294" N	95° 33' 12.17432" W	71.94	13975806.12	3057879.87	162.26
120165	30° 05' 40.18315" N	95° 33' 53.10562" W	50.37	13961475.60	3054705.18	140.69
120170	30° 05' 46.89891" N	95° 34' 49.63774" W	64.41	13962008.23	3049721.45	154.74
120175	30° 06' 32.00000" N	95° 34' 41.00000" W	N/A	13966600	3050400	144.30
120185	30° 04' 55.00000" N	95° 34' 29.00000" W	N/A	13956800	3051700	143.68
120190	30° 04' 57.97917" N	95° 34' 54.30181" W	60.56	13957056.46	3049456.34	150.88
120195	30° 05' 56.06043" N	95° 35' 38.31227" W	87.93	13962808.60	3045420.62	178.27
120205	30° 04' 53.33010" N	95° 39' 06.17414" W	83.22	13955946.94	3027350.94	173.56
120210	30° 04' 56.29006" N	95° 37' 39.13091" W	89.75	13956465.53	3034986.40	180.10
120215	30° 05' 28.16704" N	95° 36' 55.03390" W	97.26	13959796.33	3038765.73	187.61
120220	30° 03' 33.59345" N	95° 41' 49.87295" W	88.09	13947486.25	3013202.36	178.42
200005	29° 49' 14.90336" N	95° 36' 48.14574" W	12.56	13861539.78	3042217.16	102.49
200015	29° 51' 18.96378" N	95° 36' 53.61287" W	16.75	13874052.20	3041373.14	106.72
200020	29° 51' 28.08801" N	95° 37' 57.95869" W	17.81	13874809.95	3035683.26	107.81
200025	29° 51' 58.55173" N	95° 38' 43.18143" W	22.21	13877771.50	3031614.84	112.23
200030	29° 52' 18.71361" N	95° 40' 59.58612" W	33.91	13879464.80	3019552.71	123.97
200035	29° 52' 30.06621" N	95° 41' 11.40927" W	35.22	13880581.61	3018479.77	125.29
200040	29° 52' 48.00000" N	95° 41' 13.00000" W	N/A	13882400	3018300	131.26
200045	29° 52' 46.32787" N	95° 40' 59.56987" W	37.80	13882253.13	3019475.04	127.88
200050	29° 52' 46.94909" N	95° 41' 35.18094" W	41.40	13882227.10	3016339.68	131.49
200055	29° 54' 15.65336" N	95° 42' 59.49751" W	49.22	13890974.82	3008668.72	139.36
200060	29° 47' 26.42180" N	95° 38' 42.25228" W	28.62	13850296.80	3032485.05	118.52
200070	29° 48' 10.70727" N	95° 41' 16.15438" W	17.75	13854381.87	3018804.08	107.69
200075	29° 48' 16.83953" N	95° 43' 12.80306" W	24.22	13854711.48	3008514.49	114.19
200080	29° 48' 35.41994" N	95° 44' 00.75890" W	34.86	13856469.36	3004239.08	124.84
200085	29° 49' 18.11835" N	95° 44' 45.70546" W	39.00	13860670.36	3000161.28	129.01
200090	29° 49' 53.91645" N	95° 45' 08.34700" W	43.34	13864229.57	2998067.38	133.37
200095	29° 50' 45.97278" N	95° 46' 07.73263" W	49.50	13869341.03	2992693.96	139.57
200100	29° 51' 03.99322" N	95° 46' 25.06504" W	52.33	13871118.49	2991118.05	142.42
200105	29° 51' 22.11328" N	95° 47' 25.37529" W	55.97	13872802.05	2985759.25	146.07
200110	29° 51' 39.90557" N	95° 48' 25.34410" W	66.51	13874454.11	2980431.90	156.62
200115	29° 52' 29.33015" N	95° 48' 56.40316" W	67.28	13879370.24	2977562.37	157.41
200120	29° 52' 28.61660" N	95° 49' 27.50458" W	68.46	13879223.75	2974827.36	158.60
200125	29° 48' 01.55847" N	95° 42' 30.20410" W	23.21	13853273.95	3012309.19	113.16
200130	29° 50' 28.00719" N	95° 48' 19.21116" W	68.54	13867208.93	2981170.04	158.62
200135	29° 48' 58.91787" N	95° 40' 39.99963" W	26.79	13859340.05	3021849.57	116.75
200140	29° 49' 09.99592" N	95° 38' 21.29389" W	8.53	13860807.64	3034030.27	98.47
200145	29° 49' 05.33174" N	95° 38' 43.32704" W	11.46	13860280.98	3032103.86	101.40
200155	29° 48' 57.88424" N	95° 40' 31.31164" W	18.18	13859257.43	3022617.51	108.14
200160	29° 49' 44.17612" N	95° 41' 08.92285" W	24.64	13863837.55	3019173.37	114.63
200165	29° 49' 51.69709" N	95° 41' 12.01022" W	26.56	13864589.25	3018880.05	116.55
200170	29° 50' 14.88111" N	95° 41' 26.11035" W	27.84	13866895.02	3017572.46	117.84
200175	29° 51' 09.72506" N	95° 43' 06.83525" W	43.04	13872182.84	3008550.09	133.09
200180	29° 51' 57.85468" N	95° 43' 57.89448" W	45.56	13876916.79	3003920.12	135.64
200185	29° 52' 09.00000" N	95° 45' 26.00000" W	N/A	13877900	2996200	148.90
200190	29° 52' 30.49131" N	95° 46' 10.64762" W	58.25	13879887.63	2992145.78	148.37
200195	29° 53' 06.95150" N	95° 46' 56.82725" W	62.83	13883457.15	2987980.64	152.97

200200	29° 53' 22.52379" N	95° 47' 14.93047" W	68.83	13884985.77	2986344.50	158.98
200205	29° 53' 41.43349" N	95° 48' 27.01133" W	67.94	13886721.48	2979950.10	158.11
200210	29° 49' 51.35211" N	95° 39' 51.26197" W	14.65	13864756.55	3025989.82	104.63
200215	29° 51' 46.15255" N	95° 37' 27.78945" W	18.88	13876710.50	3038285.86	108.87
200220	29° 52' 19.35892" N	95° 37' 34.24649" W	19.26	13880046.98	3037620.84	109.27
200225	29° 52' 45.31234" N	95° 36' 41.68786" W	27.65	13882801.28	3042170.04	117.65
200240	29° 52' 52.82044" N	95° 37' 42.75007" W	24.21	13883404.05	3036775.10	114.23
200245	29° 53' 01.41548" N	95° 38' 05.25084" W	25.12	13884214.87	3034770.24	115.16
200250	29° 53' 32.03398" N	95° 38' 25.49169" W	32.02	13887255.26	3032900.41	122.07
200255	29° 53' 47.06672" N	95° 38' 44.82122" W	33.38	13888724.33	3031156.20	123.45
200260	29° 53' 56.75710" N	95° 39' 01.58718" W	37.23	13889660.50	3029653.11	127.31
200265	29° 54' 19.76533" N	95° 39' 52.39499" W	45.41	13891855.93	3025116.90	135.51
200270	29° 54' 39.08702" N	95° 40' 18.64731" W	44.98	13893741.09	3022751.90	135.09
200275	29° 54' 49.31369" N	95° 41' 09.49208" W	49.39	13894646.67	3018249.95	139.53
200280	29° 56' 55.64157" N	95° 40' 06.62563" W	51.15	13907559.69	3023416.53	141.33
200285	29° 52' 12.10027" N	95° 39' 34.76311" W	25.97	13879009.55	3027036.29	116.01
200290	29° 52' 46.79627" N	95° 42' 14.04537" W	44.71	13882115.10	3012920.25	134.80
200295	29° 52' 47.26438" N	95° 42' 55.37411" W	45.74	13882060.02	3009282.20	135.84
200300	29° 53' 35.09961" N	95° 43' 29.58444" W	45.16	13886805.69	3006136.56	135.28
200305	29° 49' 55.15038" N	95° 34' 28.19364" W	8.56	13865962.42	3054419.96	98.46
200315	29° 50' 49.86088" N	95° 35' 47.19915" W	21.06	13871283.39	3047304.02	111.01

13. Personnel

A total of 34 field and office employees of Landtech worked on this project over the length of the project. A total of five Registered Professional Land Surveyors worked on this project, as well as numerous technicians, cadd operators, and other support staff. Additional contract staff was utilized as needed. The following is a detailed chronological summary of all field operations and the personnel used for all field surveying tasks:

Sept. 2, 2002 thru Sept. 22, 2002 – One to Two Survey Crews (Three to four personnel)
Reconnaissance of existing and proposed sites in the White Oak Bayou Watershed.

Oct. 14, 2002 thru Oct. 27, 2002 – Two Survey Crews (Five personnel)
Reconnaissance of existing and proposed sites in the White Oak Bayou Watershed.
Reconnaissance of existing and proposed sites in the Addicks Dam Watershed.
Reconnaissance of existing and proposed sites in the Willow Creek Watershed.

Oct. 28, 2002 thru Nov. 3, 2002 – Two Survey Crews (Five personnel)
Reconnaissance of existing and proposed sites in the Addicks Dam Watershed.
Reconnaissance of existing and proposed sites in the Willow Creek Watershed.
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.

Nov. 4, 2002 thru Nov. 10, 2002 – Two Survey Crews (Five personnel)
Reconnaissance of existing and proposed sites in the Willow Creek Watershed.
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.

Nov. 11, 2002 thru Nov. 17, 2002 – Three Survey Crews (Six personnel)
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.

Nov. 18, 2002 thru Nov. 24, 2002 – Three Survey Crews (Six personnel)
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Attend Workshop for building deep aluminum rod monuments.
Pick up supplies for new monuments.

Nov. 25, 2002 thru Dec. 1, 2002 – Five Survey Crews, Four GPS units (Eight personnel)
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Build monuments in the White Oak Bayou Watershed (Brass Disk and Aluminum Rods).
Begin White Oak Bayou GPS observations.

Dec. 2, 2002 thru Dec. 8, 2002 – Five Survey Crews, Four GPS units (Eight personnel)
Received New Benchmark Placement Hierarchy.

Begin reconnaissance of designated earth sites and alternate sites suitable for Brass Disk Second and Third Tier monuments in all watersheds.
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Build monuments in the White Oak Bayou Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Addicks Dam Watershed (Brass Disk and Aluminum Rods).
Continue White Oak GPS observations.

Dec. 9, 2002 thru Dec. 15, 2002 – Seven Survey Crews, Six GPS units (Twelve personnel)
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Addicks Dam Watershed (Brass Disk and Aluminum Rods).
Continue White Oak GPS observations.

Dec. 16, 2002 thru Dec. 22, 2002 – Seven Survey Crews, Six GPS units (Twelve personnel)
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Addicks Dam Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Willow Creek Watershed (Brass Disk and Aluminum Rods).
Continue White Oak GPS observations.

Dec. 23, 2002 thru Dec. 29, 2002 – Seven Survey Crews, Six GPS units (Twelve personnel)
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Willow Creek Watershed (Brass Disk and Aluminum Rods).
Continue White Oak GPS observations.
Begin Addicks Dam GPS observations.

Dec. 30, 2002 thru Jan. 5, 2003 – Nine Survey Crews, Eight GPS units (Fourteen personnel)
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Willow Creek Watershed (Brass Disk and Aluminum Rods).
Continue Addicks Dam GPS observations.
Continue White Oak GPS observations.

Jan. 6, 2003 thru Jan. 12, 2003 – Nine Survey Crews, Eight GPS units (Fourteen personnel)
Reconnaissance of existing and proposed sites in the Cypress Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).

Build monuments in the Willow Creek Watershed (Brass Disk and Aluminum Rods).
Substantially complete White Oak GPS observations.
Substantially complete Addicks Dam GPS observations.
Begin Willow Creek GPS observations.

Jan. 13, 2003 thru Jan. 19, 2003 – Ten Survey Crews, Eight GPS units (Eighteen personnel)
Reconnaissance of proposed sites in the Cypress Creek Watershed.
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Continue Willow Creek GPS observations.
Begin Cypress Creek GPS observations.
Begin Spring Creek GPS observations.
Begin Precise Leveling on White Oak Bayou.

Jan. 20, 2003 thru Jan. 26, 2003 – Ten Survey Crews, Eight GPS units (Eighteen personnel)
Reconnaissance of proposed sites in the Cypress Creek Watershed.
Reconnaissance of existing and proposed sites in the Spring Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Spring Creek Watershed (Brass Disk and Aluminum Rods).
Substantially complete Willow Creek GPS observations.
Continue Cypress Creek GPS observations.
Continue Spring Creek GPS observations.
Begin Precise Leveling on Addicks Dam.
Begin Precise Leveling on Willow Creek.

Jan. 27, 2003 thru Feb. 2, 2003 – Eight Survey Crews, Seven GPS units (Fourteen personnel)
Reconnaissance of proposed sites in the Cypress Creek Watershed.
Reconnaissance of proposed sites in the Spring Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Spring Creek Watershed (Brass Disk and Aluminum Rods).
Continue Cypress Creek GPS observations.
Continue Spring Creek GPS observations.
Continue Precise Leveling on Willow Creek.
Begin Precise Leveling on Spring Creek.

Feb. 3, 2003 thru Feb. 9, 2003 – Eight Survey Crews, Six GPS units (Twelve personnel)
Reconnaissance of proposed sites in the Cypress Creek Watershed.
Reconnaissance of proposed sites in the Spring Creek Watershed.

Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Spring Creek Watershed (Brass Disk and Aluminum Rods).
Continue Cypress Creek GPS observations.
Continue Spring Creek GPS observations.
Continue Precise Leveling on Spring Creek.

Feb. 10, 2003 thru Feb. 16, 2003 – Eight Survey Crews, Six GPS units (Twelve personnel)
Reconnaissance of proposed sites in the Cypress Creek Watershed.
Reconnaissance of proposed sites in the Spring Creek Watershed.
Continue reconnaissance of designated earth sites and alternate sites suitable for Second Tier and Third Tier (Brass Disk) monuments in all watersheds.
Build monuments in the Cypress Creek Watershed (Brass Disk and Aluminum Rods).
Build monuments in the Spring Creek Watershed (Brass Disk and Aluminum Rods).
Continue Cypress Creek GPS observations.
Continue Spring Creek GPS observations.
Continue Precise Leveling on Spring Creek.

Feb. 17, 2003 thru Feb. 23, 2003 – Seven Survey Crews, Six GPS units (Nine personnel)
Build monuments in the Cypress Creek Watershed (Aluminum Rods).
Continue Cypress Creek GPS observations.
Continue Spring Creek GPS observations.

Feb. 24, 2003 thru Mar. 2, 2003 – Six Survey Crews, Six GPS units (Six personnel)
Substantially complete Cypress Creek GPS observations.
Continue Spring Creek GPS observations.

Mar. 3, 2003 thru Mar. 9, 2003 – Six Survey Crews, Six GPS units (Six personnel)
Substantially complete Spring Creek GPS observations.
Begin miscellaneous GPS reobservations.
Continue Precise Leveling on Willow, Cypress and Spring Watersheds.

Mar. 10, 2003 thru Apr. 23, 2003 – (Two to Five personnel)
Perform misc. GPS reobservations and precise leveling as needed.

14. Equipment

Make	Model	Description	Serial No.
Leica	SR530	GPS Sensor/Receiver w/Firmware V4.01	0033479
"	AT502	GPS Antenna	00627
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	0036449
"	AT502	GPS Antenna	11857
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	0030440
"	AT502	GPS Antenna	00509
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	0030484
"	AT502	GPS Antenna	7576
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	130978
"	AT502	GPS Antenna	12445
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	130971
"	AT502	GPS Antenna	4265
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	0035139
"	AT502	GPS Antenna	5922
"	SR530	GPS Sensor/Receiver w/Firmware V4.01	0035134
"	AT502	GPS Antenna	5938
SECO	2-meter Fixed Height Tripods (8) (No serial numbers)		
Leica	SKI-PRO	Version 2.5 Post-Processing Software	10685
Zeiss	Ni2	Automatic Level	68574
Leica	NA2002	Digital Level	282711

Appendix A. – Definitions

(Common abbreviations are shown in parentheses.)

Annual Rate of Subsidence (AROS) - When evaluating benchmark movement, used as an estimate of the amount of subsidence in a given area over one year based on past observations in recent years.

Antenna Reference Point (ARP) - The point on a GPS antenna from which all measurements are referenced.

Continuously Operating Reference Station (CORS) - A GPS receiver fixed in position and constantly logging GPS data which can be accessed by the public.

Digital Terrain Model (DTM) - A three dimensional model of an area based on a sampling of 3-d point data within that area.

East or Easting (E)

Elevation (Elev.) - Height above mean sea level.

Ellipsoid Height (Ellips. Ht.) - Height above the ellipsoid. GPS measures heights above the GRS80 ellipsoid. NAD83 is based on the GRS80 ellipsoid.

Federal Emergency Management Agency (FEMA)

Federal Geodetic Control Committee (FGCC)

feet (ft.) - U. S. Survey Feet

Flood Insurance Rate Map (FIRM)

GEOID99 (GEOID99) - NGS's model representing the height of the ellipsoid above or below the geoid. The geoid is the equipotential surface of earth's gravity field which best fits mean sea level.

Global Positioning System (GPS) - A system whereby distance measurements can be obtained based on the reception of phase and code radio signals from multiple satellites orbiting the Earth.

Harris County Flood Control District (HCFCD)

Harris Galveston Coastal Subsidence District (HGCSD)

Indefinite Delivery/Indefinite Quantity (IDIQ)

Magnetic Nail (Mag. Nail) - A nail with a magnetic signature which aids in its relocation.

meters (m)

National Geodetic Survey (NGS)

National Oceanic and Atmospheric Administration (NOAA)

North American Datum of 1983 (NAD83)

North American Vertical Datum of 1988 (NAVD88)

North or Northing (N)

Not Applicable or Not Available (N/A)

Permanent Identifier (PID) - A unique alpha-numeric designator used by NGS to identify their benchmarks.

Port-A-Measure (PAM) - A CORS station operated by HGCSD mounted on a trailer which allows it to be moved from point to point.

Program Management Team (PMT)

Reference Mark (RM) - A benchmark shown on a FIRM which can be used to establish a vertical relationship to the Base Flood Elevation.

Root mean square (RMS) - Statistic used to evaluate error in a series of measurements; a lower rms generally indicates smaller errors.

South (S)

Temporary Benchmark (TBM) - A benchmark of a less permanent nature than a normal RM.

Tropical Storm Alison Recovery Project (TSARP)

United States Coastal and Geodetic Survey (USCGS)

West (W)