Volume IX
General Appendices

Contents

Appendix A
Data Repository – Organization and Content

The IPET Data Repository is a data management system for storing, delivering, and maintaining the authoritative datasets associated with this study. The Data Repository contains a comprehensive set of data and information about the conditions before and after Hurricane Katrina, a complete history of the hurricane protection projects' construction and maintenance, as well as the information and analytic results of this performance evaluation. The architecture of the Data Repository, described in the Data Collection and Management section of IPET Report 1, is comprised of three main components: an unstructured data component, a GIS data component, and a large datasets component. An overall data manager integrates the data stored in the three components such that users may access all datasets from one central application without having to know which data is stored in which component. Following is a description of each component of the Repository:

Unstructured Data Component

Unstructured data, such as .pdf files, .doc files, .jpg files, .txt files, .ppt files, etc., as well as engineering design files (.dgn) are stored in a Microsoft SQLServer database managed by Bentley ProjectWise Software. Documents are stored with spatial extents corresponding to the geographic area to which they relate. This allows users to search for documents/data by location. Metadata describing each document is stored in the database to facilitate searches by name, type, date, etc. Currently, the following data are stored in this component:

- IPET News Releases
- IPET Presentations
- IPET Reports
- IPET Soil borings and cone penetrometer test data
- IPET Pump Station preliminary performance data for St. Bernard Parish
- USACE Operations Center briefing slides
- Post-Katrina reports
- Photographs of various New Orleans and Southeast La. Sites post-Katrina
- Project Information Reports for the rehabilitation efforts currently underway in New Orleans

- Post-Katrina surveys of the levees and floodwalls
- Aerial videos of the New Orleans and Southeast La. Area
- Annual inspection reports for the maintenance of completed flood control works in the New Orleans District
- NEXRAD hourly gridded multisensor precipitation data for 28,29,30 August 2005
- Pre-Katrina geodetic, geotechnical, hurricane, and miscellaneous reports
- Design Memoranda for the Hurricane Protection Projects within the IPET study area
- Periodic Inspection Reports for the Hurricane Protection Projects within the IPET study area
- Miscellaneous reports related to the Hurricane Protection Projects within the IPET study area
- Plans and Specifications for the some of the Hurricane Protection Projects within the IPET study area
- Contract documents for some of the Hurricane Protection Projects within the IPET study area
- Microstation design files (.dgn) of the Hurricane Protection Projects within the Lake Pontchartrain LA and Vicinity area.

GIS Data Component

GIS is a computer technology that uses a geographic information system as an analytic framework for managing and integrating data, solving a problem, or understanding a past, present, or future situation. GIS provides an automated capability to link information to location data, such as people to addresses or buildings to parcels. The information can be graphically layered to provide a better understanding of how it all works together. A GIS is based on a structured database that describes features (buildings, streets, streams, monitoring wells, etc.) in geographic terms. The visualization component of GIS allows the geographic feature information to be displayed in a map view and supports queries, analysis, and editing of the data. The geoprocessing capabilities of GIS allow users to combine existing datasets, apply analytic rules, and create new derived datasets to support decision making. GIS is generally used as a decision support tool to map the location and description of features, to determine patterns of certain features, to determine what is near a specified feature, to map change in an area, or to perform ‘what-if’ analyses.

USACE enterprise standards have been defined to ensure that GIS is implemented and managed in a manner that facilitates data sharing and interoperability. An important feature of the enterprise GIS architecture is its scalability and repeatability across corporate, regional, district, and field office levels. Scalable refers to its ability to accommodate a range in volumes of data and users, while repeatable means that this configuration can be replicated at corporate, regional, district, and field levels.

GIS is a fundamental component of this performance evaluation. GIS is being used to perform structural, hydrologic, economic, and risk analyses and visualizations. The Hurricane Protection System (levees, pumping stations, floodwalls), breach locations, roads, water bodies, parish boundaries, levee districts, digital elevations, and high water marks are just a few of the real-world objects represented as GIS features (Figure A-1).

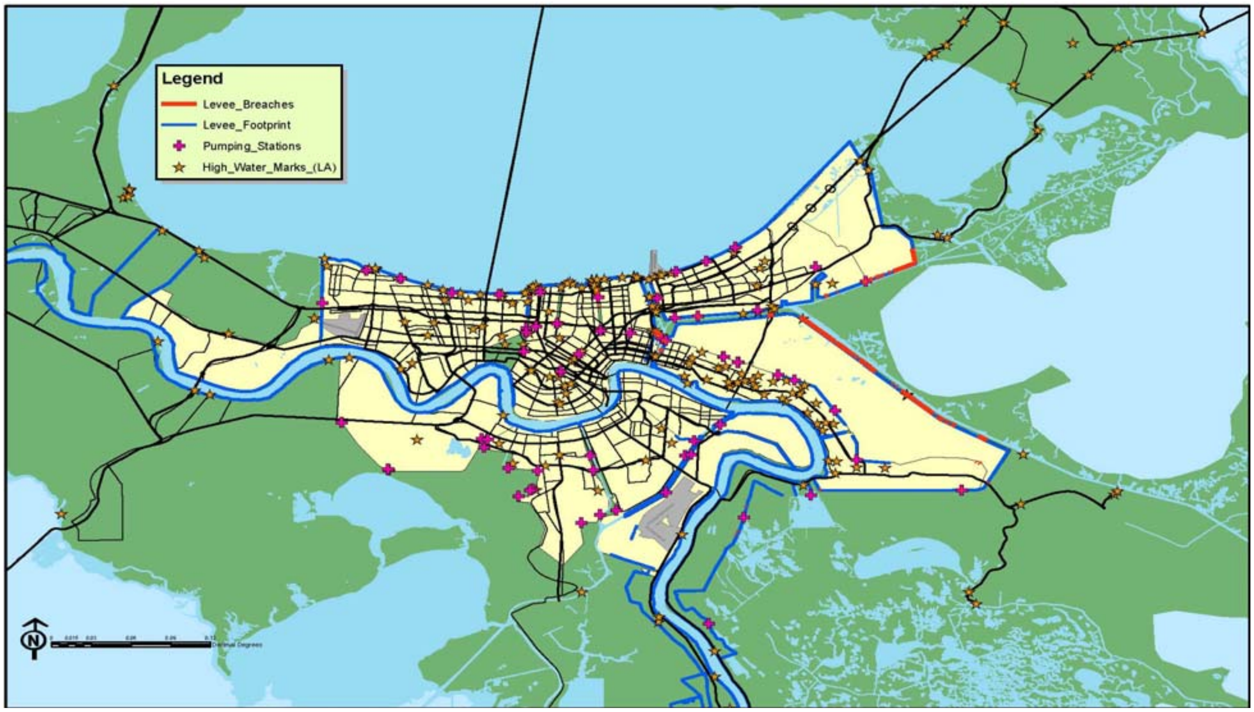


Figure A-1. Example of GIS Features Displayed in ArcGIS

To assure that we are maximizing the effectiveness and efficiency of our geospatial resources within IPET, TFG, TFH, TFX, MVD Forward and MVN, a Geographic Information System (GIS) working group was established. The working group consists of representatives from TFG, TFH, MVD Forward, MVN, and each IPET Task. This group conducts weekly conference calls to coordinate GIS efforts and to facilitate a smooth transition of IPET GIS data to MVN when the performance evaluation is concluded. The IPET GIS component was designed and implemented according to the Corps GIS Enterprise Architecture. Data are stored in an Oracle database on a USACE Central Processing Center server. Metadata is being collected and stored according to the FGDC metadata standard. Web Mapping Services are being developed to deliver some of the data layers and documents produced by the IPET. All USACE GIS users can request and receive access information to connect to this data. GIS data that is being developed by MVN, MVD Forward, TFG, and TFH will be sent to the IPET Data Manager for inclusion in this enterprise GIS database.

Once the IPET has completed their work, all raster products, vector data products and data sets will be replicated on MVN servers in Oracle databases. This will allow quick retrieval of large raster and vector products at MVN and provide a mirrored back up system at MVD to protect against data loss from catastrophic events.

A list of IPET GIS data layers is provided below.

Layer Name	Layer Description	Data Source
CENSUS_C2K_BLKGRP_X	Blockgroup point data for total population and housing	Census Bureau
ESRI_ADI	ESRI U.S. Areas of Dominant Influence (ADIs)	ESRI
ESRI_AIRPORTS	ESRI U.S. GDT Airports	ESRI
ESRI_AREACODE	ESRI U.S. Telephone Area Code Boundaries	ESRI
ESRI_CITIES	ESRI U.S. Cities	ESRI
ESRI_DTL_CNTY	ESRI U.S. Counties	ESRI
ESRI_DTL_ST	ESRI U.S. States	ESRI
ESRI_GBLDINGS	ESRI U.S. Geographic Names Information System Building	ESRI
ESRI_GCEMETRY	ESRI U.S. Geographic Names Information System Cemetery	ESRI
ESRI_GCHURCH	ESRI U.S. Geographic Names Information System Church	ESRI
ESRI_GGOLF	ESRI U.S. Geographic Names Information System Golf Locale	ESRI
ESRI_GHOSPITL	ESRI U.S. Geographic Names Information System Hospital Locale	ESRI
ESRI_GLOCALE	ESRI U.S. Geographic Names Information System Proper Names	ESRI
ESRI_GPPL	ESRI U.S. Geographic Names Information System Populated Place	ESRI
ESRI_GSCGOOLS	ESRI U.S. Geographic Names Information System Schools	ESRI
ESRI_GSUMMIT	ESRI U.S. Geographic Names Information System Mt Summits	ESRI
ESRI_HIGHWAYS	ESRI U.S. Geographic Names Information System Highways	ESRI
ESRI_INSTITUT	ESRI U.S. Geographic Names Information System U.S. GDT	ESRI
ESRI_INTERSTAT_SHIELD	Interstate shields	ESRI
ESRI_INTRSTAT	ESRI U.S. Geographic Names Information System Interstate Highways	ESRI
ESRI_LALNDMRK	ESRI U.S. Geographic Names Information System Landmarks	ESRI
ESRI_MAJRDNET	ESRI U.S. Geographic Names Information System Major roads network	ESRI
ESRI_MJRRDS	ESRI U.S. Geographic Names Information System major roads	ESRI
ESRI_MJWATER	ESRI U.S. Geographic Names Information System Major water bodies	ESRI
ESRI_MSA	ESRI U.S. Metropolitan Statistical Areas	ESRI
ESRI_PARKS	ESRI U.S. Geographic Names Information System Parks	ESRI
ESRI_PLACES	ESRI U.S. Geographic Names Information System Places	ESRI
ESRI_RAIL100K	ESRI U.S. Geographic Names Information System Railroad	ESRI
ESRI_RECAREAS	ESRI U.S. Geographic Names Information System Recreation Areas	ESRI
ESRI_RETLCNTR	ESRI U.S. Geographic Names Information System Retail Centers	ESRI
ESRI_RIVERS	ESRI U.S. Geographic Names Information System Rivers	ESRI
ESRI_ROADS	ESRI U.S. Geographic Names Information System Roads	ESRI
ESRI_ROADS_RT	ESRI U.S. Geographic Names Information System U.S. Road Routes	ESRI
ESRI_STATES	ESRI U.S. Geographic Names Information System States	ESRI
ESRI_TRACTS	ESRI U.S. Geographic Names Information System Census Tracts	ESRI
ESRI_TRANTERM	ESRI U.S. GDT Transportation Terminals	ESRI
ESRI_URBAN	ESRI U.S. Urbanized Areas	ESRI
ESRI_URBAN_DTL	ESRI U.S. National Atlas Urbanized Areas	ESRI
ESRI_USROUTE	ESRI U.S. National Transportation Atlas U.S. Highway Routes	ESRI
ESRI_ZIP3	ESRI U.S. Three-Digit ZIP Code Areas	ESRI
ESRI_ZIP_POLY	ESRI U.S. ZIP Code Areas represents five-digit ZIP Code areas	ESRI
ESRI_ZIP_USA	ESRI U.S. ZIP Code Points represents five-digit ZIP Code areas	ESRI
G2908901NE	5 Meter DEM from Lidar LSU Atlas	LSU
HIGHWATERMARKS_USGS_FEMA_LA	High water marks collected by USGS and FEMA for LA	USGS/FEMA
HIGHWATERMARKS_USACE_LA	High water marks collected by USACE LA	CHL
HIGHWATERMARKS_MS	High water marks collected by CHL for MS	CHL
Levees_and_Floodwalls	Levee centerlines in the CEMVN digitized from the best available	MVN

Layer Name	Layer Description	Data Source
	imagery	
K_28089_H2_04	3001 Inc. 1ft true color imagery - post-Katrina (42 files)	3001 inc.
LANDUSE_MRLC	Multi Resolution Land Cover	USGS
LEVEES	MVN levee layer with section names	MVN
LEVEE_CENTERLINE	Center of levees	MVN
LEVEE_DISTRICTS	Levee District boundaries	MVD
MVK_LEVEE_FOOTPRINT	footprints of the Ms. River levees within MVN	MVK
MVN_LANDSAT	LANDSAT of the IPET study area	TEC
NEWEST_LIDAR_MOSAIC_15_SEPT	LIDAR_MOSAIC_15_SEPT_New Orleans area	TEC
NEW_ORLEANS_001_001_RGB	True color 1-meter air photos	Jeff Lillycrop
NEW_ORLEANS_001_001_CIR	Color IR 1-meter air photos	Jeff Lillycrop
NORTH_MS_RIVER_001_011_RGB	True color 1-meter air photos	Jeff Lillycrop
NORTH_MS_RIVER_001~011_CIR	Color IR 1-meter air photos	Jeff Lillycrop
PEARLINGTON_009_001_RGB	True color 1-meter air photos	Jeff Lillycrop
PEARLINGTON_009~001_CIR	Color IR 1-meter air photos	Jeff Lillycrop
SE_NEW_ORLEANS_001~001_CIR	Color IR 1-meter air photos	Jeff Lillycrop
SE_NEW_ORLEANS_001~001_RGB	True color 1-meter air photos	Jeff Lillycrop
SOUTH_MS_RIVER_001~001_CIR	Color IR 1-meter air photos	Jeff Lillycrop
SOUTH_MS_RIVER_001~001_RGB	True color 1-meter air photos	Jeff Lillycrop
SW_NEW_ORLEANS_001~029_CIR	Color IR 1-meter air photos	Jeff Lillycrop
SW_NEW_ORLEANS_001~029_RGB	True color 1-meter air photos	Jeff Lillycrop
NHD_STREAMS	National Hydrologic Dataset Streams USGS	USGS
NOE_PEAK	Estimated peak water depth for New Orleans East	MVK
NOE_DEM	Digital Elevation Model for the New Orleans East Levee District, derived from 1999 LIDAR measurements, 5-m resolution	MVK
NOE_SEP12…NOE_SEP28	Estimated water depth for the specified day's inundation for New Orleans East	MVK
NO_LEVEE_BREACHES	New Orleans Levee Breaches not attributed	TFG
NO_LEVEE_FOOTPRINT	Footprints of all levees within the IPET study area	MVN
NO_DEM	Digital Elevation Model for the New Orleans Metro area, derived from 1999 LIDAR measurements, 5-m resolution	MVK
NO_PEAK	Estimated peak water depth for New Orleans	MVK
NO_SEP12…SEP27	Estimated water depth for the specified day's inundation for New Orleans	MVK
PLAQUEMINESLODTM	PLAQUEMINES lower parish Digital Terrain Model	MVN
PLAQUEMINESUPDTM	PLAQUEMINES upper parish Digital Terrain Model	MVN
PUMPING_STATIONS	Pumping station locations within the IPET study area	CHL
SSURGO_JEFFERSON	SSURGO Soils for the stated Parish	USDA - NRCS
SSURGO_ORLEANS	SSURGO Soils for the stated Parish	USDA – NRCS
SSURGO_PLAQUEMINES	SSURGO Soils for the stated Parish	USDA - NRCS
SSURGO_ST_BERNARD	SSURGO Soils for the stated Parish	USDA - NRCS
SSURGO_ST_CHARLES	SSURGO Soils for the stated Parish	USDA - NRCS
SSURGO_ST_JOHN_THE_BAPTIST	SSURGO Soils for the stated Parish	USDA - NRCS
STATSGO	STATSGO Soils for the IPET study area	USDA - NRCS

Layer Name	Layer Description	Data Source
STBERN_PEAK	Estimated peak water depth for St. Bernard	MVK
STB_A_DEM	Digital Elevation Model for the St. Bernard Levee District, part 1	MVK
STB_B_DEM	Digital Elevation Model for the St. Bernard Levee District, part 2	MVK
STB_SEPT16…Sept28	Estimated water depth for the specified day's inundation for St. Bernard	MVK
STUDYAREAPARISHES	Parish boundaries in the IPET study area	USGS
USGS_GNIS03	USGS Geographic Names Information System 03	USGS
USGS_HUCS8DIGIT	USGS 8 digit hydrologic units	USGS
USGS_QUADS24K	USGS 24K quads	USGS
preKatrinaleveefloodwalmaxel	maximum levee/ floodwall elevations extracted from the adjusted pre-Katrina DEMs	IPET
Stcharles_storageareas	Basin delineation of St. Charles Parish used in the Risk and Losses analyses	IPET/HEC
Stbernard_storageareas	Basin delineation of St. Bernard Parish used in the Risk and Losses analyses	IPET/HEC
Plac_storageareas	Basin delineation of Plaquemines Parish used in the Risk and Losses analyses	IPET/HEC
Orleanswest_storageareas	Basin delineation of Orleans Parish West Bank used in the Risk and Losses analyses	IPET/HEC
Orleans_storageareas	Basin delineation of Orleans Parish East Bank used in the Risk and Losses analyses	IPET/HEC
Noe_storageareas	Basin delineation of New Orleans East basin used in the Risk and Losses analyses	IPET/HEC
Jeffwest_storageareas	Basin delineation of Jefferson Parish West Bank used in the Risk and Losses analyses	IPET/HEC
Jeffeast_storageareas	Basin delineation of Jefferson Parish East Bank used in the Risk and Losses analyses	IPET/HEC
Reach_line	endpoints of a levee reach	MVN
Reach_text	labels for levee reaches	MVN
Organizational_control_levees	defines which organization is in control of which levee, i.e., Local, Federal, etc.	MVN
Existing_Elevation	labels for levee reach elevations; should be used for labeling the Levees_and_Floodwalls layer with existing elevations	MVN
non_existing_reach	label markers for planned levee reaches	MVN
Proposed_Design_Elevation	labels for levee reach proposed elevations; should be used for labeling the Levees_and_Floodwalls layer with proposed elevations	MVN
Other_structures	Point features, such as pumps, locks, floodgates, diversion structures, and other relevant structures	MVN
Levee_Damage_reports	levee damage points	TFG

Large Datasets Component

Large Datasets, such as LIDAR, imagery, and Digital Elevation Model (DEM) data, are stored on a terabyte server, with metadata and geospatial extents of each dataset stored in an Oracle SDO database. Currently, the following datasets are available:

- LIDAR data for both pre-Katrina and post-Katrina timeframes at varying resolutions and spatial extents
- DEM datasets derived from LIDAR data
- Existing pre-Katrina DEM datasets provided by other organizations
- Post-Katrina 1-ft. Imagery collected by 3001, Inc. and GE-Hardin
- Bathymetric survey data for the lower Mississippi River, 17th Street Outfall Canal, London Avenue Outfall Canal, and the Inner Harbor Navigation Canal (IHNC).

Digital Bathymetric Survey Data

High resolution bathymetric surveys collected following the storm by various agencies for selected areas are stored in the large datasets component of the Repository. The spatial extents of these datasets are shown in Figure A-2. The bathymetry data for the IHNC and the lower Mississippi River were originally converted to raster format using MicroStation Inroads. The processing steps for making the data available for IPET involved converting from rotated raster data sets to ERDAS Imagine Elevation files. All elevations are relative to the NAVD88 (2004.65) vertical datum. No vertical datum adjustments were made to the original bathymetric data. The Post-Katrina outfall canal bathymetric data were delivered as XYZ point data. The points followed a dual-beam sonar track and represented a sparse data set, as show in Figure A-3. The data were converted into a raster DTM surface using the QT modeler software. QT modeler uses a modified TIN to Raster technique with smoothing options. The data were converted to DTM with 1 ft. vertical resolution.

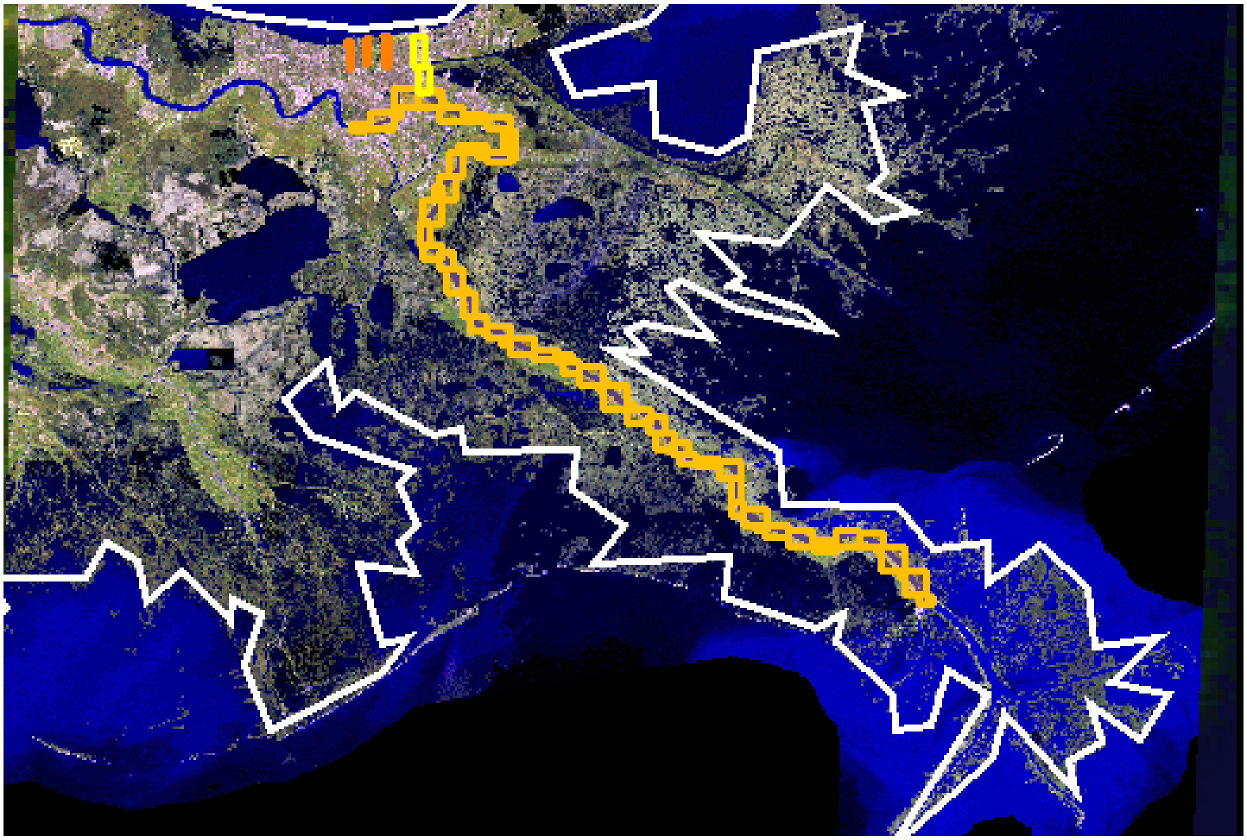


Figure A-2. Spatial Extent of the Bathymetric Survey Data for the Lower Mississippi River, IHNC, and Outfall Canals

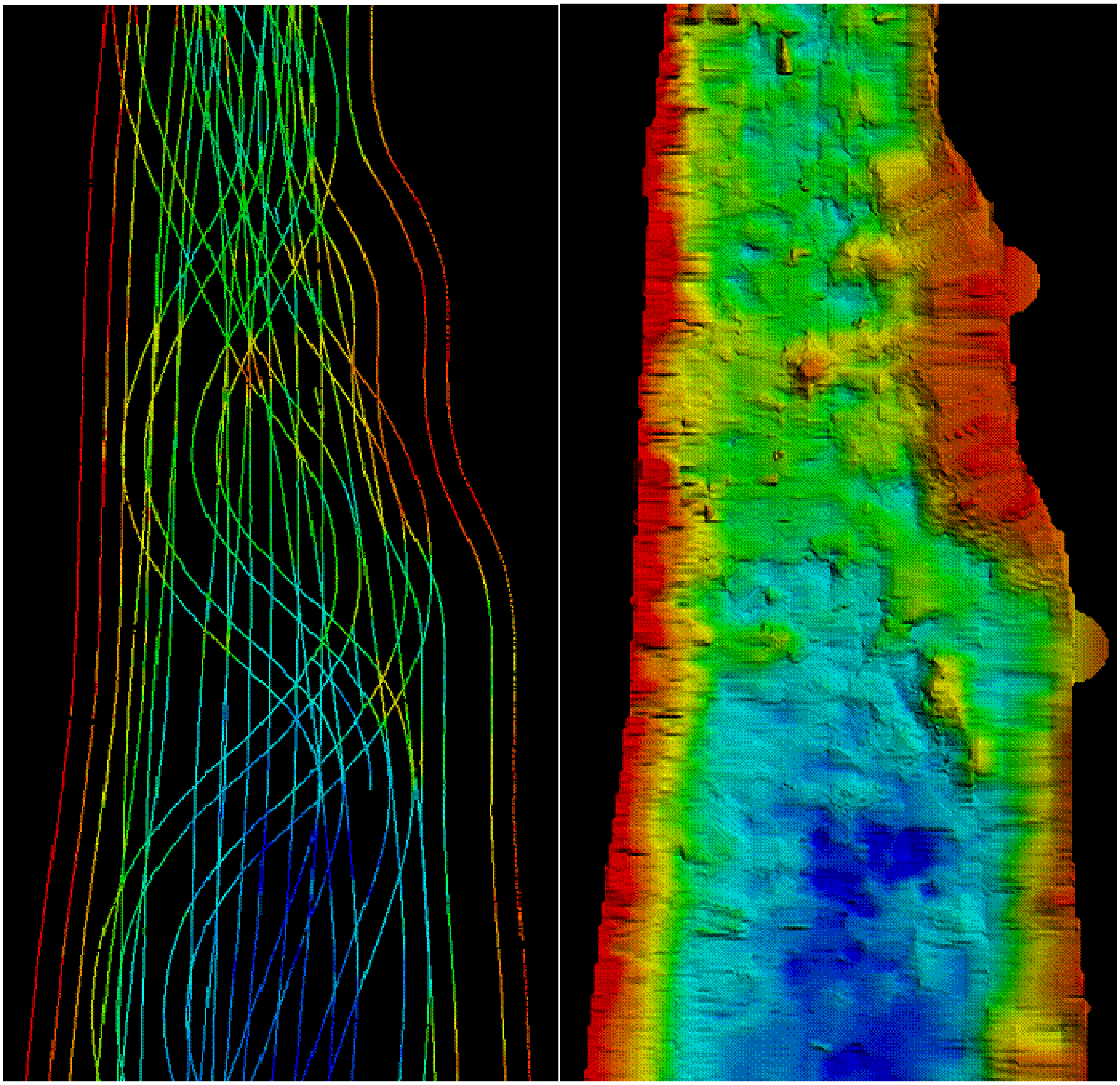


Figure A-3. Images of the XYZ bathymetric data (on left) and the converted raster DTM surface. (on right)

Digital Elevation Models (DEMs)

The development of accurate terrain surfaces was a critical element of this component. Numerous LiDAR surveys were conducted within the affected areas both prior to and after the storm. However, most of the computational modeling required that LiDAR point cloud data be converted into surface representations. Furthermore, the vertical accuracy of the NGS control network used by these LiDAR surveys was compromised due to continued soil consolidation and the resultant settling within the affected areas. A new vertical datum epoch was established and all LiDAR and resultant surface representations were required to be adjusted to conform to this new elevation standard. This section will document the processing procedure for the various LiDAR and elevation data sets that have been developed for the IPET study. In addition to the LiDAR surveys, ground surveys conducted over a significant number of years were also available for use by the modeling teams. These surveys, while not having the spatial completeness of the LiDAR data sets, provide a more accurate representation of the levee elevations. However, because of the vertical datum issues in the study area, many of these surveys required adjustments to the NAVD88 (2004.65) elevation datum.

LiDAR Surveys

Several LiDAR surveys were identified that covered portions of the IPET study area, as listed in Table A-1. The spatial extents and horizontal resolution of each data set is unique depending on the purposes for which the survey was originally conducted. Some data sets were developed into surfaces before they were obtained by IPET while other data sets required the development of a non-discrete elevation surface.

Table A-1
Digital Elevation Models and Associated Sources Used for the IPET Study

DEM	Source	Collected by	Year Collected	Postings	Coverage
Pre-Katrina 1ft. Levee	LIDAR	John E. Chance Inc.	2000	Horizontal ~1ft.	Levees alignments surrounding East Orleans, Pontchartrain South Shore, St. Bernard Parish (MRGO, ICWW)
Post-Katrina 2ft. Levee	LIDAR	John E. Chance Inc.	2005	Horizontal ~2ft.	Levee alignments surrounding East Orleans, St. Bernard and Plaquemines
Post-Katrina 3ft. Levee	LIDAR	Joint Airborne Lidar Bathymetry Technical Center of Expertise	Jan-06	Horizontal ~3ft.	Levee alignment and back of levees for Pontchartrain South Shore, London Ave. Canal, 17th St. Canal, IHNC
Pre-Katrina 15ft. Interior	LIDAR (existing DEM from http://atlas.lsu.edu)	3001, Inc.	2003	Horizontal ~15ft.	All surface areas in Southern Louisiana
Pre-Katrina 3ft Interior	Rapid Terrain Visualization (RTV)	Topographic Engineering Center	2005	Horizontal ~3ft	Surface areas within Central Orleans Parish

The IPET modeling teams required the data to be in a surface format so that cross sections and profile information could be generated. Furthermore, the teams also requested the surface model to be as detailed as possible. Previous to IPET, DEM surfaces had already been generated for two of the LiDAR surveys. This work did not replicate these previous efforts but simply utilized the existing DEM's generated from the LiDAR data. The other three surveys required additional processing to create surface models. The following paragraphs describe the data and processing steps that were accomplished for each data set.

Pre-Levee-1ft. The John E. Chance survey was conducted using the Fli-Map, helicopter based LiDAR system. The point cloud data was collected at extremely high spatial resolution with significant overlap between survey paths. This produced a point cloud data set of several hundred million points, located only along the major levee corridors. The original horizontal datum for this data set was State Plane – Zone 1702 (Louisiana South) – US Survey Feet. Figure A-4 shows the spatial extents of this data set. Because of the extreme density of data and the need for very high spatial resolution data sets, it was determined that a 1ft horizontal DEM elevation surface could be created for the areas covered by this survey. To do this, the following processing steps were conducted:

1. The LiDAR data points from each survey line were separated into 1.875 arc minute tiles according to the tiling system described previously in this document. This tile interval was chosen in response to the need for 1ft spatial resolution in the final surface DEM's. Because of this resolution requirement, standard quadrangle (7.5 arc minute) or quarter quadrangle (3.25 arc minute) tiles created resulting raster files with greater than 20,000 x 20,000 grid cells.

2. The XYZ points contained in each file were processed by the ESRI ArcInfo software using an Inverse Distance Weighted (IDW) algorithm. The following ArcInfo command was used to develop these DEM surfaces.

    gridData = idw(pointData.gen, #, #, 2, SAMPLE, 5, 03, 01)

   This command generates a raster surface with 1 ft horizontal resolution by searching the five closest LiDAR points within a 3 ft radius of the cell center.

   Three primary, yet competing, factors influenced the selection of the processing algorithm used to convert the LiDAR XYZ points into a continuous surface representation:

    1. Small errors in the vertical resolution of LiDAR XYZ points from subsequent passes over the same geospatial area. This can cause a developed surface to exhibit hedgerows that are problematic for hydrologic modeling software.
    2. Sharp elevation changes over a short distance. Such situations occur at the edges of buildings or along the top of levee walls.
    3. Small errors in the horizontal resolution of the LiDAR XYZ points that produce near but not exact representations of a vertical surface.

   In order to eliminate the effects of the first error, an algorithm that smooths these irregularities is preferred. The Inverse Distance Weighted (IDW) algorithm is one example. IDW samples a number of points from the area surrounding the raster cell being interpolated to compute the elevation at that cell. This reduces the impact of small vertical errors and eliminates the “hedgerow” effect caused by such errors. However, because IDW utilizes surrounding points, it cannot identify areas where sharp elevation changes occur and is not well suited to solve the problems exhibited by the second problem.

   One algorithm that can incorporate these sharp changes is a Triangulated Irregular Network (TIN). TIN’s can represent sharp changes in elevation over a short distance. However, they do not resolve the hedgerow effect directly. Furthermore, because of factor three above, the points representing the vertical feature may produce spikes in the resulting TIN or DTM surface. Therefore, a TIN representation may not be able to resolve any of the three factors described above.

   Based on these factors, it was determined that the IDW interpolation methodology produced the best surface for a majority of areas. However, due to the problems described previously, caution is advised when using the elevations from derived surfaces in areas where levee flood walls are present.

3. The deviation surface discussed previously was then used to adjust the elevations of the IDW derived surfaces so they would conform to the NAVD88 (2004.65) elevation datum. This was done by first splitting the deviation surface into the same 1.875 arc minute tiles as the LiDAR data; then using the ArcInfo GRID algebraic command set, the deviations were subtracted from the elevation surface.

Figure A-4. Spatial Extent of the Pre-Levee 1ft DEM

Pre-Interior-15ft. This data set was derived from the 5 meter elevation data developed by 3001, inc. for FEMA and distributed by Louisiana State University on the atlas.lsu.edu website. Figure A-5 shows the spatial extents of this data. The elevation data was tied to the older NAVD88 control elevations. Elevation surfaces were previously created and so no further processing of the LiDAR data points was required. The processing steps for this data set include the following:

1. The data set was re-projected from UTM Zone 15N to State Plane Louisiana South and re-sampled to a horizontal resolution of 15.0 ft using bi-linear interpolation.
2. The deviation surface discussed previously was then used to adjust the elevations of the elevation surfaces so they would conform to the NAVD88 (2004.65) elevation datum. This was done by first splitting the deviation surface into the 3.75 arc minute USGS quarter quad tiles; then using the ArcInfo GRID algebraic command set, the deviations were subtracted from the elevation surfaces.

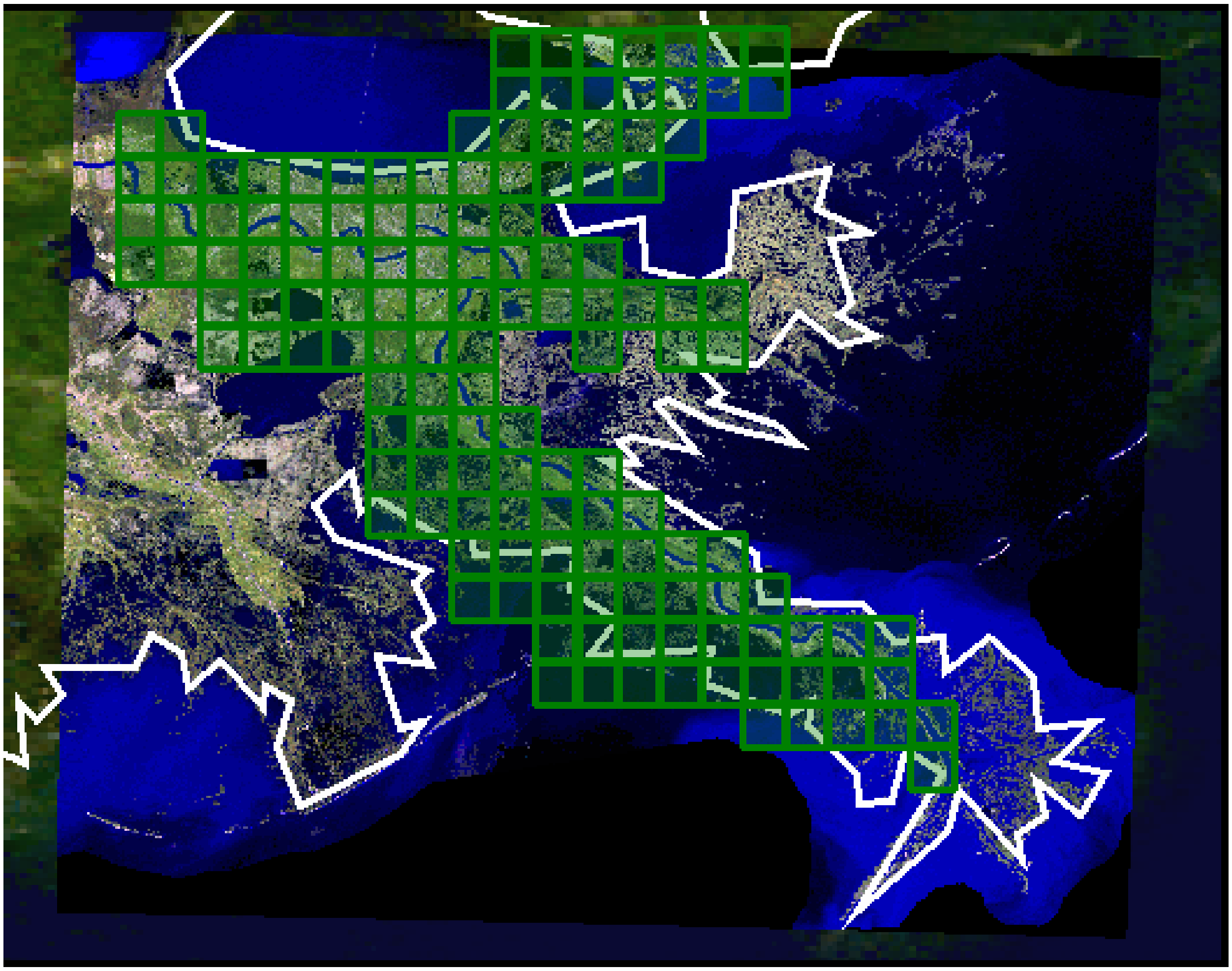


Figure A-5. Spatial Extent of the Pre-Interior 15ft DEM

Pre-Interior-3ft. This data set was derived from the LiDAR collected by the Rapid Terrain Visualization group at USACE-ERDC-TEC. Figure A-6 shows the spatial extents of this data. Elevation surfaces were created prior to delivery of this data to IPET. First return and last return LiDAR surfaces were delivered in this data set. Only the last return data was utilized. Processing steps for this data set include the following:

1. Raster cells were converted to point data representing the center of the raster cell.
2. Elevation values were converted from spherical coordinates based on the WGS84 datum to NAVD88 (2004.65) using the GEOID03 methodology.
3. The data set was re-projected from UTM Zone 15N to State Plane Louisiana South and re-sampled to a horizontal resolution of 3.0 ft using bi-linear interpolation.
4. The cell center points were then split into 1.875 arc minute tiles
5. Raster surfaces were then re-created by first creating a TIN from the data points and then sampling a new raster surface from the TIN.

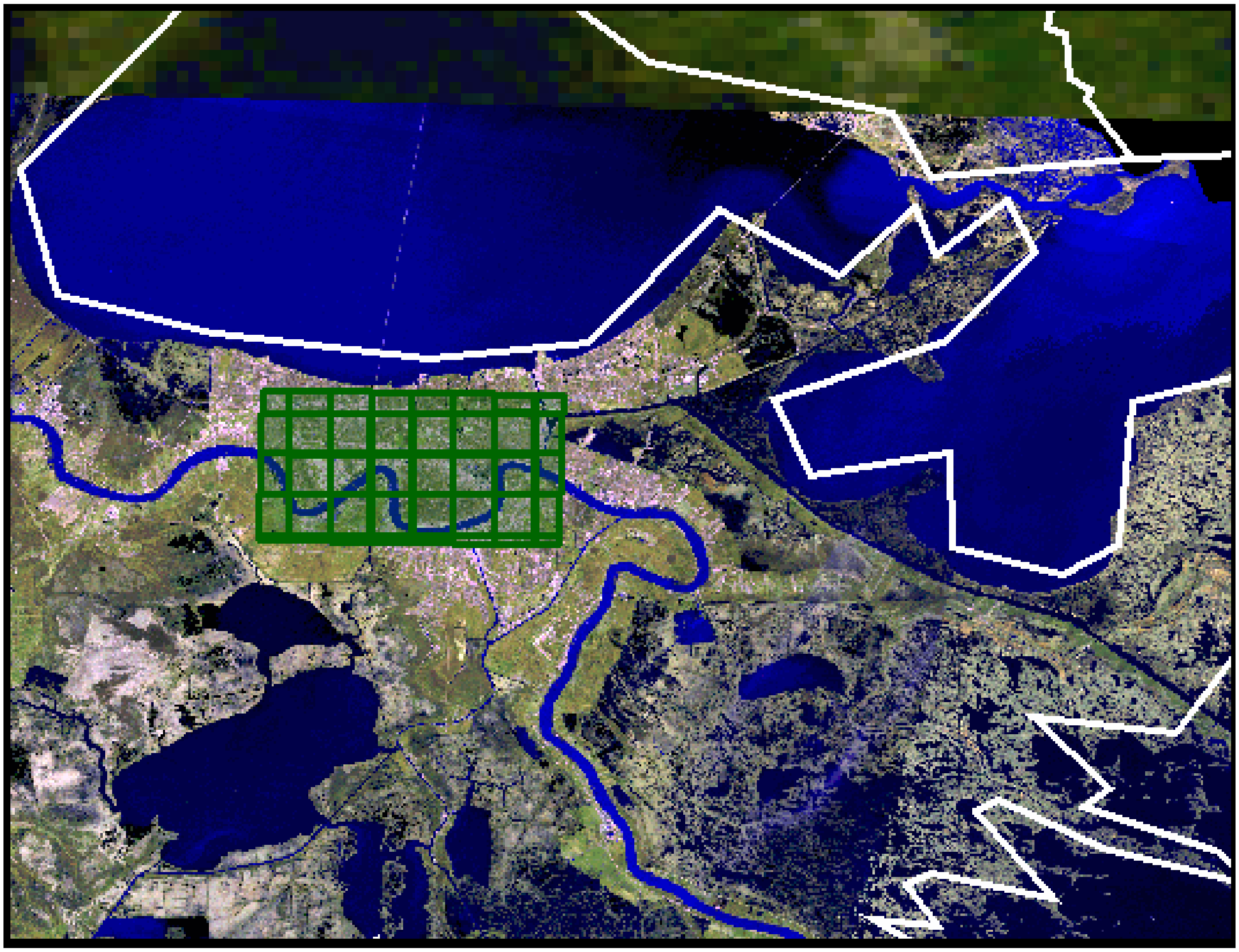


Figure A-6. Spatial Extent of the Pre-Interior 3ft DEM

Post-Levee-2ft. This data set was derived from a LiDAR survey conducted by John E. Chance using the Fli-Map system shortly after Hurricane Katrina. The survey was confined to areas very near the major levee systems in East Orleans Parish, Chalmette Parish and Plaquemines Parish. The elevation values for this survey were delivered with reference to the NAVD88 (2004.65) vertical datum. Figure A-7 shows the spatial extents of this data. The survey processing steps for this data set include the following:

1. The LiDAR data points from each survey line were separated into 1.875 arc minute tiles according to the tiling system described previously in this document.
2. The XYZ points contained in each file were processed within the ESRI ArcInfo GIS program using an Inverse Distance Weighted (IDW) algorithm. The following ArcInfo command was used to develop these DEM surfaces.

   gridData = idw(pointData.gen, #, #, 2, SAMPLE, 5, 06, 02)

3. This command generates a raster surface with 2 ft horizontal resolution by searching the five closest LiDAR points within a 6 ft radius of the cell center. The decision to use this approach was explained previously.

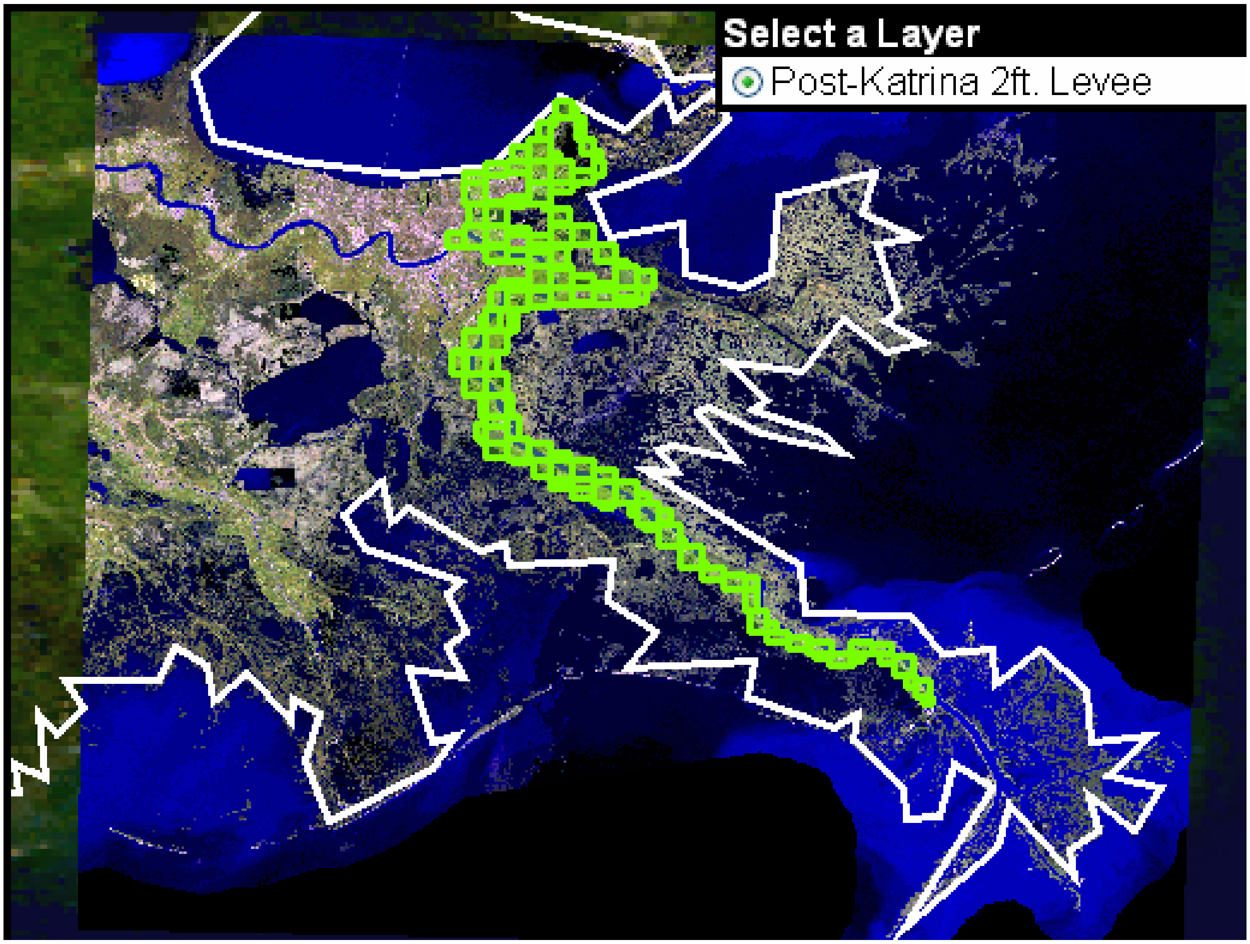


Figure A-7. Spatial Extent of the Post-Levee 2ft DEM

Post-Levee-3ft. This data set was derived from a LiDAR survey conducted by the Joint Airborne Lidar Bathymetry Technical Center of Expertise using the SHOALS-3000 system shortly after Hurricane Katrina. The survey covered areas near the south shore of Lake Pontchartrain and the primary outfall canals. The elevation values for this survey were delivered with reference to the NAVD88 (2004.65) vertical datum. Figure A-8 shows the spatial extents of this data. The survey processing steps for this data set include the following:

1. The LiDAR data points from each survey line were separated into 1.875 arc minute tiles according to the tiling system described previously in this document.
2. The XYZ points contained in each file were processed within the ESRI ArcInfo GIS program using an Inverse Distance Weighted (IDW) algorithm. The following ArcInfo command was used to develop these DEM surfaces.

   gridData = idw(pointData.gen, #, #, 2, SAMPLE, 5, 12, 03)

3. This command generates a raster surface with 3 ft horizontal resolution by searching the five closest LiDAR points within a 12 ft radius of the cell center. The decision to use this approach was explained previously.

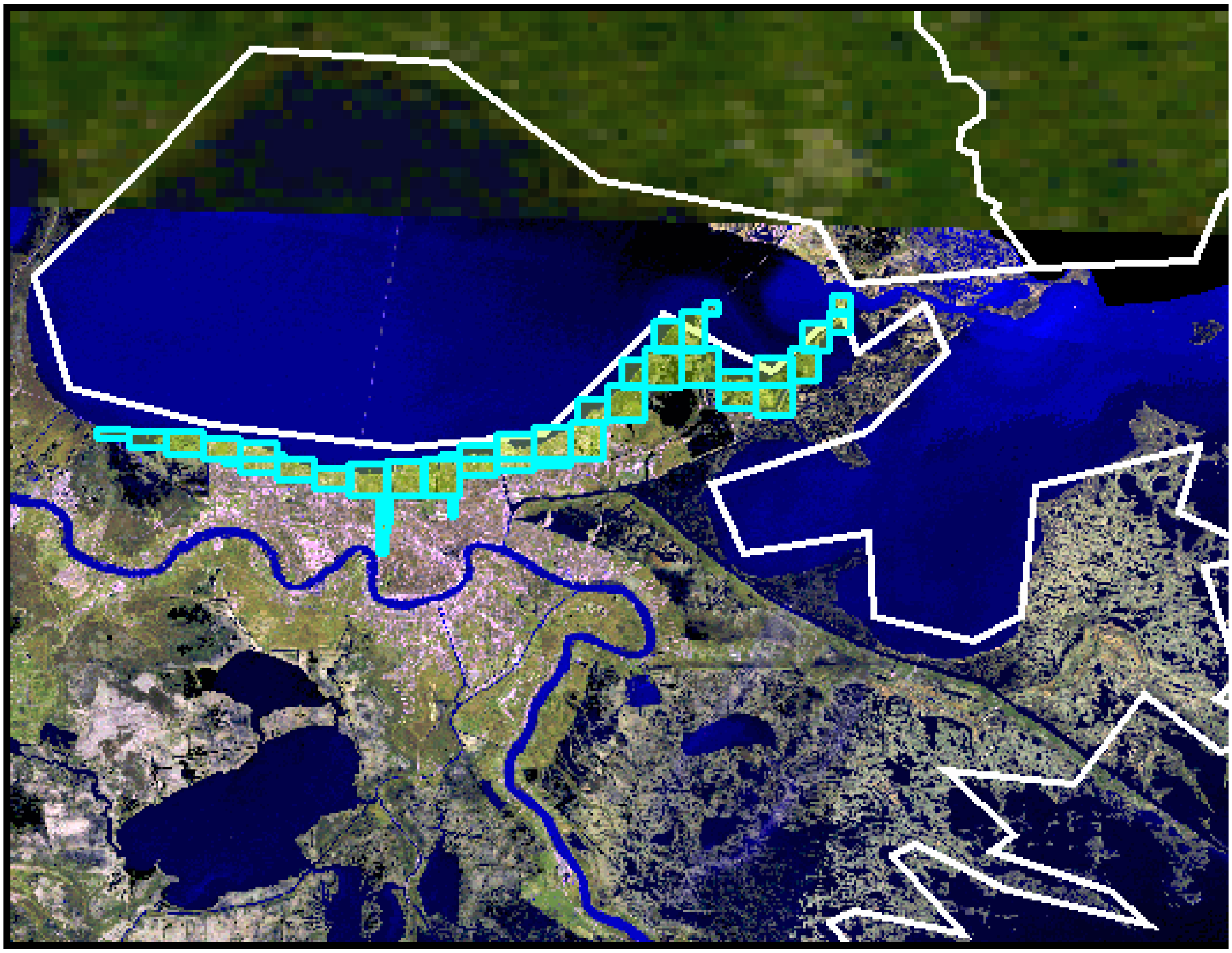


Figure A-8. Spatial Extent of the Post-Levee 3ft DEM

Vertical Datum Adjustments

Because all LiDAR and ground surveys conducted prior to Hurricane Katrina used outdated elevation control, they required adjustments to be in conformance with the NAVD88 (2004.65) elevation datum. This section will discuss the methodology utilized to make these adjustments.

Only a small number of control stations were available in the affected areas which had updated NAVD88 (2004.65) elevations. Most of the control stations that were used in the original LiDAR and ground survey observations were not updated prior to this study. Therefore, it was not possible to directly shift the vertical elevations to the proper values. An indirect method was selected in which a deviation surface was developed utilizing the stations for which elevation control was known. The table below indicates the available control stations, old NAVD88 elevations and the NAVD88 (2004.65) elevations.

STATION	PID	Lat	Lon	Old NAVD88 Elev (US Survey Feet)	New 2004.65 Elev (US Survey Feet)	Diff
L 278	AT0332	29.87615875555560	-89.89594031944440	7.39	6.92	0.47
N 278	AT0351	29.87516515555560	-89.95616993888890	5.31	4.79	0.52
Q 368	AU2123	29.87585119166670	-90.11533822500000	2.80	2.33	0.47
G 365	AU2110	29.91097798333330	-90.21286312222220	1.12	0.79	0.33
E 299	AU0332	29.91392784166670	-90.34488892222220	2.72	2.30	0.42
G 165	AU0316	29.83271346388890	-90.46164717500000	1.58	1.21	0.37
876 1899 B TIDAL	AU2310	29.66723475277780	-90.10932137222220	0.46	0.03	0.43
B 369	AU2163	29.76818572500000	-90.10046901944440	6.48	6.04	0.44
V 375	AT0760	29.91709741666670	-89.97167838333330	2.92	2.33	0.59
J 370	AT0733	29.31729959444440	-89.38827714166670	-3.99	-4.04	0.05
S 188	AU0520	29.96675348055560	-90.22925131388890	8.10	7.71	0.39
A 148	AU0429	29.98916315000000	-90.08728192222220	6.28	5.81	0.48
WASTE WELL 2 RESET	BH1089	30.02297626666670	-89.91299944722220	5.09	4.69	0.40
C 189	BH1119	30.07347194166670	-89.84052781111110	2.61	2.07	0.54
PIKE RESET	BH1164	30.16657738333330	-89.73740822500000	8.63	8.14	0.49
A 193	BH1212	30.23872298055560	-89.61955755555550	2.88	2.46	0.42
S 379	BJ3744	30.05094205833330	-90.54047153055550	14.70	14.14	0.56
REGGIO 2	AT0804	29.84464421111110	-89.75900855277780	5.62	5.02	0.60
876 1724 TIDAL 11	AT0685	29.26479975833330	-89.95752265833330	3.99	3.12	0.87
N 221	AU1291	29.20458551111110	-90.04007175833330	6.17	5.45	0.73
H 359	AU2042	29.15725589444440	-90.17542961944440	5.38	4.76	0.62
G 358	AU2028	29.46079473055560	-90.30865718333330	3.30	2.69	0.61
F 220	AU1091	29.60520827500000	-90.48985493055560	6.21	5.58	0.63
B 358	AU2014	29.72775913055560	-90.59796179444440	11.08	10.63	0.45
N 367	AT0731	29.35230480000000	-89.45713212222220	1.54	1.12	0.43
X 276	AU0272	29.73704631111110	-90.83763516944440	6.13	5.35	0.79
CLUB	AU0286	29.78561673888890	-90.78471878611110	16.30	15.39	0.91
194/2 CAP	AU1510	29.99564758333330	-90.81309936666670	19.55	18.67	0.88
C 195	AT0458	29.53677862222220	-89.76309890000000	2.31	1.57	0.74
G 95	BJ0710	30.00065352500000	-90.42914642777780	27.83	27.13	0.70
MILAN 2	AT0200	29.46826213333330	-89.68159164444450	0.02	-0.49	0.51
A 152	AT0407	29.62460792777780	-89.90296365000000	2.85	2.20	0.66
D 194	AT0357	29.86033619722220	-89.97097324444450	6.02	5.51	0.51
EMPIRE AZ MK 2 1934 1966	AT0231	29.39392922777780	-89.60315771944440	0.42	-0.03	0.46
R 194	AT0376	29.72955933888890	-89.98809776111110	5.10	4.56	0.54
C 279	AT0247	29.36397300277780	-89.55622931111110	-0.33	-0.75	0.43
R 210	BK1406	30.22743360277780	-93.18711595277780	13.09	12.37	0.72
E 356	BK2249	30.23716077777780	-93.26610417500000	12.94	12.24	0.70
4164 LAGS RESET 1959	BK1468	30.21722974166670	-93.37606345833330	11.56	11.06	0.51
D 211	BK1484	30.05078393055560	-93.34153183333330	4.52	3.97	0.55
TT 147 USGS	AV0338	29.93692009722220	-93.37537985000000	7.10	6.73	0.37
V 211	AV0346	29.87880749444440	-93.42583932500000	3.98	3.61	0.37
F 212	AV0360	29.77185718333330	-93.45135065000000	3.78	3.41	0.37

STATION	PID	Lat	Lon	Old NAVD88 Elev (US Survey Feet)	New 2004.65 Elev (US Survey Feet)	Diff
M 212	AV0375	29.80413348611110	-93.34906991666670	3.94	3.41	0.53
10 V 28	BK1612	30.17266846388890	-93.17958646944440	16.53	15.52	1.02
D 215	AV0426	29.86043003888890	-93.08769595277780	3.18	2.23	0.95
C 213	AV0399	29.81574498611110	-93.12290411388890	3.14	2.36	0.78
V 212	AV0390	29.78777296944440	-93.25111426388890	4.36	3.81	0.55
R 295	BJ0634	30.10661751944440	-90.98559804166670	31.06	30.31	0.75
P 228	AU1624	29.94167900277780	-91.02303238611110	19.92	19.09	0.83
Z 221	AU1436	29.58898177777780	-90.72041203611110	5.41	4.79	0.62
R 227	AU1415	29.60564701388890	-90.83880958333330	5.71	4.82	0.88
R 155	AU1126	29.54606370000000	-90.33909516666670	4.80	4.13	0.67
JESSE	AU1255	29.23506302222220	-90.20977578055560	1.88	1.21	0.66
G 233	AU1299	29.49936572777780	-90.57718260000000	4.01	3.41	0.60
S 233	AU1309	29.38575998611110	-90.62007700555550	10.16	9.55	0.61
E 191	BJ1655	30.01868861111110	-90.73071530555560	15.16	14.40	0.76
B 201	AU0179	29.70762715555560	-91.38332858888890	9.57	8.89	0.68
V 275	AU0193	29.71457853611110	-91.30079006666670	7.37	6.56	0.81
F 198	AU0218	29.69410220000000	-91.20446501388890	8.55	7.81	0.74
R 277	BJ2179	30.00569186666670	-91.82160140555560	17.50	17.32	0.17
D 171	BJ2147	30.11994220000000	-91.93498643055560	34.19	33.92	0.27
28 A 015	BK0241	30.21272475277780	-92.00656476388890	35.81	35.33	0.48
U 266	BK0223	30.23505585833330	-92.05556958611110	37.72	37.37	0.35
Q 164	BK0208	30.23485655000000	-92.16349483055560	34.83	33.96	0.87
416	BK0182	30.21409605833330	-92.31459121111110	20.84	19.88	0.96
X 267	BK0159	30.18045488611110	-92.47690235555560	14.94	14.17	0.77
P 163	BK0696	30.19307612222220	-92.61104272500000	12.38	11.32	1.06
K 267	BK0662	30.23182740000000	-92.72382836944440	18.82	18.11	0.71
LACAS AZ MK	BK0629	30.23143250277780	-92.91667467777780	20.37	19.59	0.78
A 4172	BK1435	30.23127168333330	-93.02133605277780	19.81	19.06	0.75
Q 359	AU2033	29.33524856944440	-90.24317305277780	3.68	3.02	0.66
DREUX 2	AU3293	29.28998594722220	-90.64839448055560	2.30	1.94	0.36
RIVER MISSISSIPPI MP 65	BJ1112	30.08235757777780	-90.90296724444450	20.83	20.14	0.69
D 380	AV0573	29.88869226111110	-92.16745968888890	3.30	3.12	0.18
57 V 35	AV0250	29.84219327222220	-92.21070087500000	4.05	3.71	0.34
57 V 120 LADTD	BK0907	30.02094995277780	-92.59878431944440	7.08	6.23	0.84
X 215	AV0079	29.65077187777780	-92.46970240833330	4.64	3.81	0.83
DOLAND AZ MK	AV0295	29.71865680277780	-92.73188140833330	2.81	2.23	0.58
E 380	AV0571	29.83260546111110	-92.30699571944440	16.93	16.73	0.19
L 223	AV0171	29.75809473888890	-92.32981732222220	4.86	4.49	0.36
F 382	AV0566	29.67840651388890	-92.36325317500000	4.24	3.71	0.53
ALCO	BJ1342	30.02681192500000	-90.11283625833330	6.59	6.14	0.45
SAVOIE RESET	AU3539	29.64629676666670	-90.68853480000000	7.31	6.59	0.71
U 362	BJ3209	30.30209426111110	-91.84800177222220	20.93	20.73	0.20
A 374	BH1811	30.07537505833330	-89.94397706666670	-0.64	-1.20	0.56

The following steps were utilized to create the elevation deviation surface:

1. The location and elevation of the available NGS (National Geodetic Survey) control points for the New Orleans area were obtained from (USACE-ERDC-TEC). These control point locations have both the old (epoch varies) and new (2004.65 epoch) elevation values obtained from NGS.
2. The deviations from the old elevation to the new elevations were computed for each point using the following equation: dev = old_elv – new_elv. Since all new elevation data is lower than the old data, all deviation values were positive. The data was converted to feet using the following conversion factor: 1 m = 3.28083333 ft.
3. The location and deviation values were converted into ESRI generate format. Only those control points where both old and new elevations were known were converted.
4. The deviation values at these control points were used to create a raster deviation surface with 1000' horizontal spacing using the following ArcInfo command: idw0_100 = idw(adjust.gen, #, #, 2, SAMPLE, 12, #, 100, 3227549.1114483, 181878.84143203, 3936932.6150204, 733296.72876957)
5. The deviation surface was then rounded to three decimal places to reduce interpolation artifacts using the following ArcInfo command: idw1_100 = (float(int((idw0_1000 * 1000) + .5)) / 1000)
6. Each raster tile from the pre-Katrina data sets was then converted to the new datum by subtracting the deviation surface from the elevation data.

LiDAR Data Accuracy

The typical stated vertical accuracy for most LiDAR surveys is ± 15 cm (.5 ft). However, it should be noted that the actual vertical accuracy of the resultant DEM's may be greater (worse) than this. This is due to a number of factors:

- The laser pulses used to measure the elevation do not always make contact with the ground. This is especially true when vegetation can obstruct the LiDAR pulse. Bare Earth Algorithms can be employed to identify many of the LiDAR data points which are obstructed by vegetation. However, these algorithms do not eliminate all such points, especially in areas with grasses or other short vegetation types that do not have significant variance in elevation between the first response and last response of the LiDAR pulse.
- DEM processing using the IDW algorithm tends to provide a local "smoothing" to the data. While this produces a DEM surface that is more consistent with the perception of how the ground surface should actually be, it may not represent the actual ground surface. Other interpolation algorithms have different, but equally limiting characteristics.
- There are only a small number of locations where the new NAVD88 (2004.65) elevations are known, and still fewer where they are directly coincident with the collected LiDAR data. For this reason, the vertical transformation approach employed within IPET is not capable of providing absolute accuracy.

- The stated vertical accuracy for LiDAR surveys (± 15 cm) is on the same magnitude as the vertical displacement from the old NAVD88 epoch to the current 2004.65 NAVD88 epoch. Because of this, the variation in the data set may overwhelm or at least shadow the elevation difference between elevation epochs

LiDAR and Elevation Data Organization

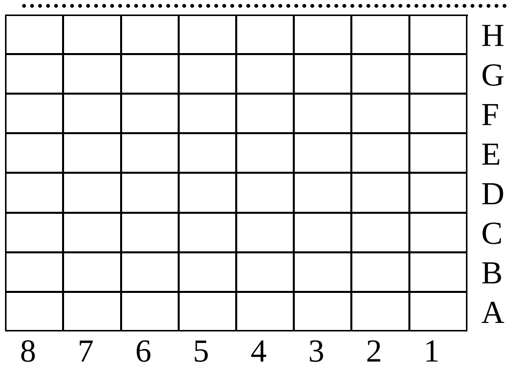
Data was organized in tiles at 1.875 minutes of arc latitude and longitude to facilitate the storage of extremely high resolution raster data sets without creating extremely large data files. The naming convention used for the tiles follows a similar pattern as the USGS quadrangle naming convention with slight modifications. File names are based on three primary grid systems. The first order grid is comprised of one degree block. These are spaced every one degree of latitude and longitude. The second order grid splits the primary grid into 64, 7.5 x 7.5 minute blocks. These are equivalent to the USGS quadrangles. The third order grid splits the quadrangles into 16, 1.875 x 1.875 arc minute blocks. Each file name is derived from the following convention:

YYXXX2233

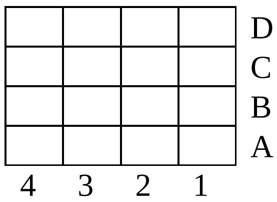
where:

YY – degree of latitude of the southeast corner of the first order grid
XXX – degree of longitude of the southeast corner of the first order grid
22 – two-digit alphanumeric identifier for the second order grid
33 – two-digit alphanumeric identifier for the third order grid

The following schematic illustrates how the second order grid is organized.



The third order grid is organized similarly, but on a smaller scale.



As an example, the following Lat/Lon coordinate pair would be located in the corresponding data file:

Latitude	**Longitude**	**File**
N 30º 02’ 25.23423”	W 90º 14’ 34.234425”	30090A2B4

Overall Data Manager

An overall data manager integrates the data stored in the three components such that users may access all datasets from one central application without having to know which data is stored in which component. The Bentley ProjectWise software provided the integrating mechanism to manage the overall data environment. The large data sets component is integrated into ProjectWise as an html document such that the large data sets web portal is displayed when a user opens the document. The GIS component is integrated using the ProjectWise Geospatial Connector. The ProjectWise software provides both a desktop client interface and a web interface to support user access of the data.

The taxonomy for the IPET Data Repository is organized according to Pre-Katrina and Post-Katrina data. While the Pre-Katrina data is organized primarily according to New Orleans Hurricane Protection Projects names and the type of data stored (as shown in Report 1, Appendix G), the Post-Katrina data is organized as follows:

- (IPET) Interagency Performance Evaluation TaskForce
  - High Water Marks
  - History
  - News Releases
  - Presentations
  - Reports
  - Soils
  - Structures
  - Task 6 Survey support
- Region Wide Data
  - Basemap
  - Presentations
  - Reports

  - Damage Survey Reports
  - Lake Pontchartrain LA and Vicinity
- Photographs
  - Chef Menteur Hwy US 09 – 2005 Oct
  - Entergy Plant – Paris Rd and GIWW – 2005 Sep
  - Helicopter Tour – 2005 Nov 15
  - Intercoastal Pumphouse – 2005 Oct 05
  - Lake Pontchartrain LA and Vicinity
  - MRGO – Mississippi River – Gulf Outlet
  - MS River Levee East Bank Vic Pointe A La Hache LA – 2005 Oct
  - New Orleans Docks – 2005 Oct
  - Plaquemines Parish – 2005 Nov
- Project Information Reports
  - Jefferson Plaquemines St Bernard Pumping Stations
  - Lake Pontchartrain LA and Vicinity
  - New Orleans to Venice
  - West Bank of the MS River in the Vicinity of New Orleans
- Survey
  - Floodwall Survey Profiles
  - HYPACK
  - Miscellaneous Surveys
  - Multi-Beam Channel Data
  - Single-Beam Channel Data
  - Topographic Surveys
- Videos - Aerial
  - New Orleans East
  - Plaquemines Parish Lower
  - Plaquemines Parish Upper
  - St. Bernard Parish

As of 10 May 2006, there were over 6,500 documents/datasets stored in the IPET Data Repository.

Participants

This appendix is the result of work accomplished by the following list of individuals that actively participated on this project during the period October 2005 through May 2006, and directly or indirectly contributed to this report.

Name	Agency
Denise Martin	USACE/ERDC-ITL
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Dan MacDonald	USACE/ERDC-CRREL
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