

FEMA's MAP MODERNIZATION

PAPER TO DIGITAL A CONTRACTOR'S POINT OF VIEW

FEDERAL EMERGENCY MANAGEMENT AGENCY



FEMA

and

NOLTE ASSOCIATES, INC.
June 2004

NOLTE
BEYOND ENGINEERING

FEMA's MAP MODERNIZATION PAPER TO DIGITAL, A CONTRACTOR'S POINT OF VIEW

ABSTRACT

Beginning in fiscal year 2004, the Federal Emergency Management Agency (FEMA) is undertaking an ambitious plan to spend approximately one billion dollars over five years to streamline its way of doing business. One key facet of this plan is to convert its inventory of over 100,000 Flood Insurance Rate Maps (FIRMs) from paper to digital format incorporating Geographic Information Systems (GIS) capability. Assistance for the conversion is being provided by multiple sources including Cooperating Technical Partners (CTP), State and local communities, other Federal Agencies and FEMA Study Contractors. This paper will serve as an insightful reference or primer for those already involved or about to be involved in FEMA's Map Modernization Program.

PROJECT OVERVIEW

In 1977 FEMA began an ambitious project, called Map Modernization. Its basic goal was to modernize FEMA's hazard mapping program. Map Modernization was to be implemented in three basic areas: Products & Standards, Processes, and Other Program Improvements.

Products and Standards are the basic building tools of the FEMA's National Flood Insurance Program (NFIP). This program touches almost everyone in every state. The ubiquitous Flood Insurance Rate Maps (FIRMs) are one of its more popular products. Presently, these are only available as paper or scanned images available from the FEMA's Map Service Center (MSC). The MSC maintains and delivers the FIRMs for approximately 20,000 communities that are in the NFIP. This translates to an inventory of about 100,000 map panels. One of the challenges faced by Map Modernization was to translate this huge inventory from paper into a digital format. Along the way, FEMA wanted to ensure participation by its stakeholders, the communities. FEMA also wanted to use the knowledge of the local communities and to leverage their most up-to-date data. In order to effectively convert its inventory of existing paper products to digital, new standards needed to be created to be able to deliver a uniform product. As a task under Map Modernization, the Standards were also updated. FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners (G&S) are available via the web. They give guidance and set standards for delivery of the new digital products. They were developed to be flexible enough to enable any qualified CTP, community, organization, or study contractor to successfully perform this paper to digital conversion of a FIRM panel. This paper will describe one implementation of the G&S to create a digital version of the FIRM. There may be other variants using the same G&S but many of the processes or steps described here may be common to all of them.

The process discussed in this paper only speaks to the initial aspect of data collection and processing required to convert the basic flood hazard information that is depicted on a

FIRM map into digital form. Once this initial set of data is collected, converted and organized, it is subjected to more formal and detailed review. Upon completion of this process, the fully converted digital flood hazard data is released back to the community in the form of “effective” FIRM maps. These maps can now be called Digital FIRM maps (DFIRMs). They may look and feel like the paper product they are replacing but they also contain a combination of vector and raster data that can be imported into any GIS system.

THE DFIRM CONVERSION TIMELINE

The entire DFIRM Conversion process consumes approximately two years of time from start to finish for each County. Each step is an integral part of the process. The first portion of the conversion process is completed by a Study Contractor and is outlined in detail in the following pages. These steps include:

- Community Coordination
- Base Map Acquisition
- FIRM Map and LOMC Inventory
- Georeferencing
- Digitizing
- Technical Support Data Notebook (TSDN) and
- Quality Assurance/Quality Control (QA/QC)

These steps take approximately six months (of the two year process) to complete. A Gantt chart can be found in Appendix A that outlines the durations of each of the steps during the six month timeframe.

The second portion of the conversion process takes up the remainder of the two year time line and consists of:

- DFIRM Graphics
- QA/QC by the Reviewing Agency
- Community Appeal Process
- Flood Insurance Study (FIS) production
- Issuing Preliminary FIS and DFIRM
- Post Preliminary Processing
- Condensed GPO Processing
- Appeals/Protest Processing
- Post Preliminary Comment Review
- Condensed GPO Processing
- Final Map Production
- Project Management and
- Reporting

As the purpose of this paper is to only outline the DFIRM process from our point of view, the latter portion of the timeline will not be discussed in further detail.

FIRM Map and LOMR Inventory, Community Coordination, Base Map Acquisition

In order to begin a DFIRM conversion, the Study Contractor (SC) must first begin to acquire and assimilate background flood hazard data for those communities that fall in the DFIRM study area as a pre-scoping task. A general survey of FIRMs in the DFIRM study area can be performed by logging on to the FEMA Map Service Center (MSC) website and downloading the Index map for each community. These maps can be used to make a count of FIRM maps and provide progress status when digitizing features.

The SC should then contact the FEMA Library and Map Service Center to order all pertinent data relative to the DFIRM study area, including:

- Letter of Map Change (LOMC) Case Files (hard-copy)
- Letter of Map Change (LOMC) Case File Database
- FIRM panels (hard copy *and* digital), including indexes
- Floodway Panels (hard copy *and* digital), including indexes
- Flood Insurance Studies (FIS) for each Community (hard copy *and* digital)

Once these items have been received from FEMA, the SC can begin inventory and data management steps necessary to begin the DFIRM production.

Working with FIRM and Floodway Maps

Depending upon their publication date, FIRM panels and corresponding floodway panels may be published as separate entities or combined into one map. To quickly establish the general fit of the data, it is recommended that the SC acquire the 'Q3' Flood data from FEMA in GIS format. The Q3 data is usually available as an Arc Export file (.e00) and can easily be transformed into Arc Shapefile (.shp) format by using the Import71 utility available in both ArcGIS 8.x or ArcView 3.x environments. Once the Q3 is converted into shapefile, the SC would then run a dissolve operation based on FIRM Panel number. This new shapefile can then be used to inventory existing FIRM panels in the DFIRM study area. The Q3 data shapefile can be used as a guide to georeferencing FIRM panels to the underlying base maps, but due to the data scale accuracy, Q3 data should not be used in absolute panel fitting. A drawback to using the Q3 data shapefile is that no Floodway information exists in the attributes, therefore, a hard-copy reference sheet must be created or acquired in order to detail the locations of each Floodway panel.

Generally, a Floodway panel is named according to its corresponding FIRM panel. FEMA typically names FIRM and Floodway panels following this convention: Community ID (6 digits), Panel Number. FIRM panels will have a Letter following the panel number which exhibits its level of revision in Alphabetical format. As an example, the FIRM Panel Name for Unincorporated Santa Cruz County, panel number 395, 4th revision would be 0603530395D. The corresponding Floodway panel would have the same name, minus the revision letter, which would serve as a determining agent between the two. In the same example, the Floodway Panel would be named 0603530395.

In extreme cases, Floodway panels will not follow the naming convention nor the spatial coverage of its corresponding FIRM panel. For this example, the Study Contractor

would need to manually inventory and detail the spatial coverages of FIRM's and Floodway panels before beginning digitization of features.

LOMC Inventory

Developing an inventory of LOMC case files can be a daunting challenge, especially for urbanized DFIRM communities. Santa Clara County, California, has no less than 1,160 Letters of Map Change (LOMC) issued within its communities at present date. Creating, analyzing and managing a LOMC inventory for a DFIRM community can be handled through utilization of Geospatial and Database technologies.

Using the LOMC database delivered from FEMA, the SC can begin to inventory hard-copy case files and noting unaccounted records. An inventory of the most-recent published FIRM dates should be created by viewing individual FIRM panels for each community. This inventory (called 'effective dates') can be cross-referenced with the LOMC database to determine which case files are to be included into the DFIRM conversion. If the case file determination date precedes the effective date for the Panel in which it is located, the case file has been incorporated into the Effective FIRM panel, and therefore can be discarded. However, if the determination date of the LOMC case file is preceded by its corresponding FIRM panel effective date, the case file must then be incorporated into the DFIRM database before submitting the final product to FEMA.

The FEMA Services Group (FSG, Joint-Venture of Nolte Associates, DHI, and William Lettis) has developed a way to inventory LOMC case files that saves time and covers most LOMC requirements for submittal. Individual addresses for each case file are plugged into a separate database file, then geocoded into a point spatial file. This spatial file is then linked to the original LOMC database to populate required fields such as determination date, affected FIRM panel, Case file number and Community.

In cases where the map revision covers a large area, actual maps are issued by FEMA under the LOMC type "102" or "102a" which signifies detailed, updated effective areas on the corresponding FIRM panel. These areas are digitized into the spatial data file S_LOMR, which is required by FEMA as part of the DFIRM submittal. Use of this methodology, along with the creation of internally-relevant fields within the spatial data files, allows the Study Contractor to fully analyze and manage the numerous LOMC case files in existence for the DFIRM communities.

Community Coordination and Participation

Before production begins on the DFIRM conversion, the FEMA Contracting Officer's Technical Representative (COTR) may elect to set up community coordination meetings as a means to brief the individual communities on the upcoming DFIRM conversion. The communities may be requested to provide their assistance in acquiring digital Base Maps and taking part in the overall Quality Assurance/Quality Control (QA/QC) process. Each community has the option of taking part in the QA/QC process. The communities are also encouraged to join as Cooperating Technical Partners (CTPs) by signing the corresponding Memorandum of Agreement, which indicates their willingness to continue to work with FEMA in regards to floodplain management and maintaining accurate up to date hazard maps.

Depending on the findings of coordination meetings, the Study Contractor conducts a follow up with the community's floodplain manager or GIS manager and requests the following data and corresponding metadata:

- Orthophotos
- Stream centerlines
- Street Centerlines (with annotation)
- Community Boundaries
- Public Land Survey System (PLSS) lines
- Topo Contours (refer to sections 4 and 5 below)
- Parks, Forest Lands

Because of the need for county-wide base map information, our experience has found that the first contact should probably be the County's floodplain manager, who will most likely provide an introduction to their GIS manager. If their data does not meet minimum accuracy standards as stated in the G & S would then contact other sources. If these contacts fail to produce community or agency-generated spatial data, then the SC uses the default base map, which is the USGS Digital Ortho Quarter Quadrangle (DOQQ).

Once spatial data has been received from the Cooperating Technical Partner (CTP), or Community that cooperates in sharing of spatial data) the SC would then request a hardcopy letter from the community/County/Special District, on the agency's letterhead, which contains the following:

1. Certification of the data as reflected in the metadata file.
2. Base Map data is being made available to FEMA with the understanding that the data can be released into the Public Domain

This certification letter complies with FEMA requirements pertaining to Spatial Data availability and the Public Domain, and certifies that the data is complete and has an accuracy factor that meets or exceeds FEMA specifications.

Once these spatial dataset accuracies are verified and certified, the Study Contractor may begin Georeferencing digital FIRM and Floodway Panels, along with 102 and 102a LOMCs to the base map spatial files.

The timeframe for the steps above is approximately 2-3 weeks from the start of the contract.

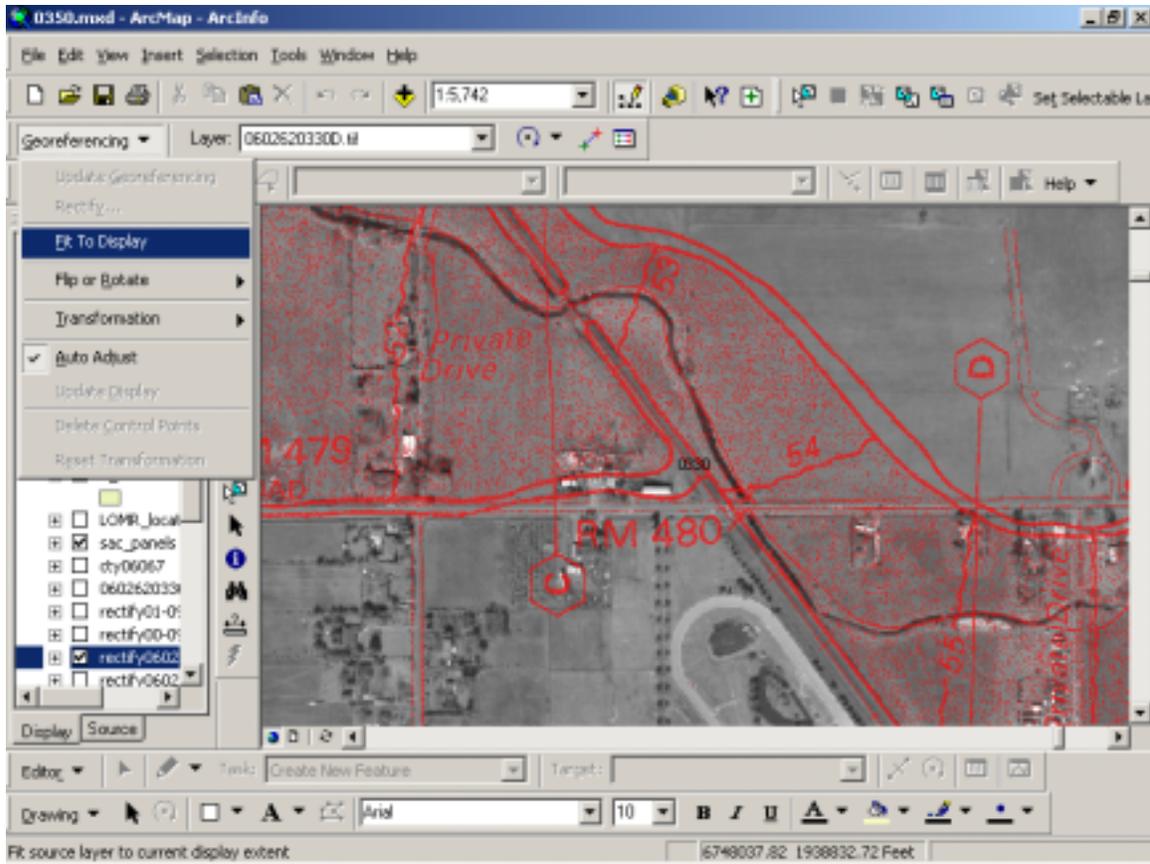
Georeferencing

Georeferencing is the first major step in the DFIRM conversion from paper maps to digital. It begins after the base data is determined. This step involves referencing the scanned FIRM panel to the base data so that the FIRM panel is in a projected coordinate system. The choice of coordinate system will depend on the base data.

It is a good idea to create an ESRI map document (mxd) for each DOQ area. This will include the area for four FIRM panels that were printed at a scale of 1:1000. Having one mxd per DOQ will ease the confusion of which photos to bring into the map document. The actual number of photos will vary depending upon the resolution of the photos and their tile size.

To georeference the FIRM panels to the photos, the georeferencing tool in ArcMap is used. To get the FIRM panel in an approximate position, the FIRM panel is fitted using the 'FIT TO DISPLAY' command. The 'ADD CONTROL POINTS' button is used to fine tune the fit. This procedure works for many of the panels, but sometimes one fit cannot accommodate the entire panel. Occasionally, a good fit can be performed in one area of the map, but on other areas of the map the fit will be poor. When this occurs and the entire map cannot be referenced to the photo in all areas, secondary 'Slip and Slide' references are performed. The transition area between the areas of good fit are adjusted accordingly to best match the flood boundaries from the FIRM panel. It is from slipping the FIRM panel over the photo that the term 'Slip and Slide' is derived. This method is preferred over rubbersheeting the FIRM over the photo.

After the FIRM panel is referenced on the photo, it needs to be rectified to preserve the fit. Although the 'Slip and Slide' procedure produces many different fits, only one image is required for the submittal.



Example of FIRM panel Georeferenced to Aerial

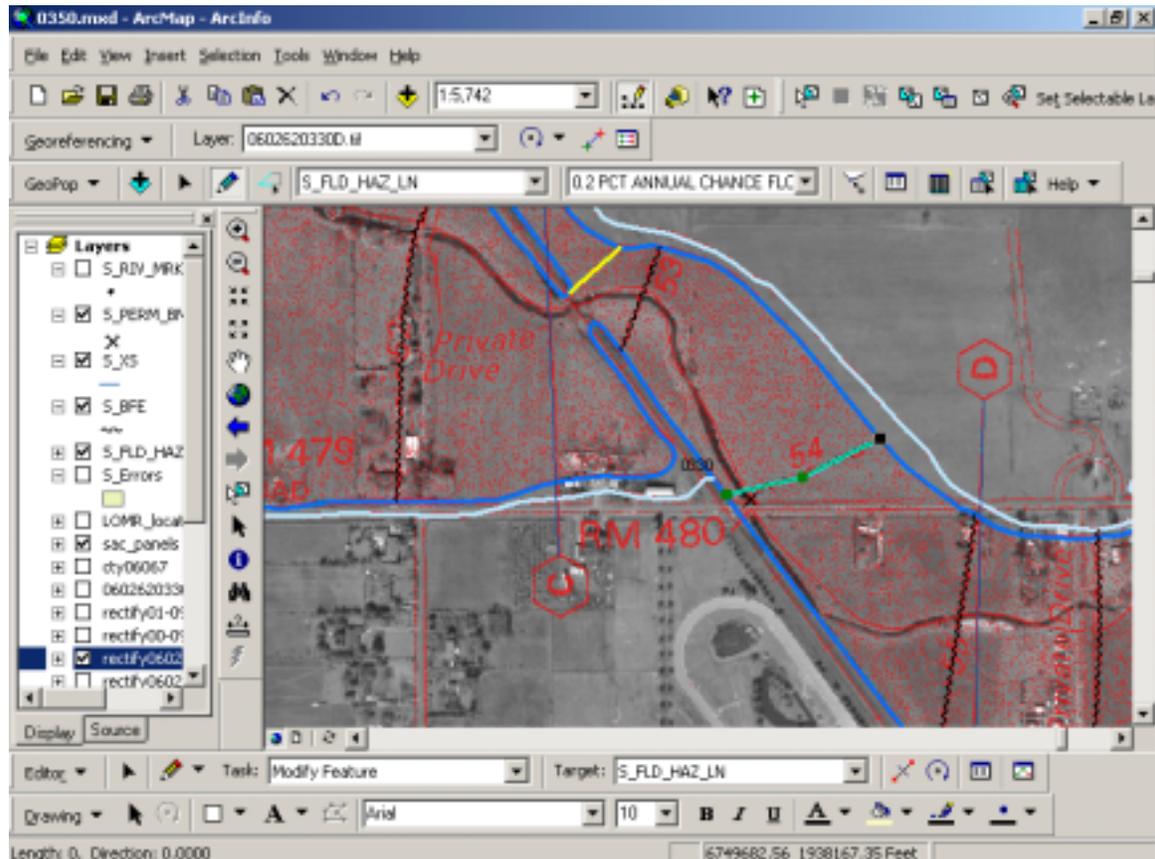
New FIRM panel numbering system

The conversion process will result in new panel numbers. Cities and counties that previously had their own community ID on their FIRMs will be merged into one county-wide map with a unique identifier. The impact this will have on the communities is that the panels numbers that they are accustomed to will no longer exist. Also, there will be only one FIS which encompasses all of the communities. The advantage of this new DOQQ based county-wide system is that it will eliminate areas in the present FIRM panels that have “AREA NOT INCLUDED. The new system also brings standardization on map scales. The resulting map scales are 1”=500, 1”= 1000 and 1”=2000. Having these defined scales will mean that the paper maps will be of uniform size, thus bringing economies of scale

Digitizing

Digitizing is the heart and soul of the DFIRM conversion process. This is the step where all Flood Hazard data are converted from paper to digital format. To assist with the data capture for the DFIRM conversion, a tool was created to minimize user input error. The tool is called GEOPOP and was created by Michael Baker Jr., Inc. This tool is used to create the geodatabase that is required for the submittal. For more information about the tool and how to use it, please see contact Michael Baker Jr., Inc..

To give a brief description of the tool, GEOPOP creates the geodatabase that is required for the Preliminary Draft Submittal. In addition to numerous facilities, the tool provides pop up menus that allow the user to choose from lists of values that the data represent. This minimizes user input error since only allowed values can be chosen from the list, facilitating the attributing process.



Example of Digitized Features in an Edit Session

NON-MAPPABLE LOMCs

Some information on the non-mappable LOMCs are required for submittal. The new panel numbers must be given to the reviewing agency. This can be done in an excel spreadsheet format. The non-map able LOMC can either be geocoded or their new panels numbers can be verified manually.

QUALITY ASSURANCE / QUALITY CONTROL

In order to establish and formalize procedures to provide Quality Control and Quality Assurance (QA/QC) for the DFIRM conversion, a set of check procedures were implemented to allow review of data accuracy and completeness. Since the QA/QC responsibilities may lie not only with the Study Contractor but also the community for which the DFIRM is being processed, the QA/QC procedures needed to be thorough and

provide a means to cover a wide range of issues prior to the Draft DFIRM submittal being passed on to the contractor responsible for the final map production. A list of QA/QC issues and a brief description follows that outlines many of the QA/QC considerations.

Visual Light Table Check

Initially, a visual check can be accommodated by the use of a light table. By overlaying a scaled plot of the digitized DFIRM data with an original copy of the corresponding FIRM panel a simple but effective test can be made by comparing the alignments of the digitized data with that of the original floodway and floodplain alignments. It also allows one to observe the completeness of digitized data and the placement of Base Flood Elevation (BFE) lines and cross section lines. Items of observation include lines that do not appear coincident and missing lines among other visually apparent elements.

Heads-Up Display Check

A second but effective check is performed using the actual digitized data and the scanned version of the FIRM panel using a computer monitor. This check allows one to zoom into specific areas in question for more detailed scrutiny of digitized alignments and placement of BFE lines and Cross Sections.

One aspect of this check includes colorizing the digitized arcs and closed polygons with vivid and contrasting colors classified by layer in order to view that all similar lines and polygons are represented on the correct layer. This check can be further refined by using topology rules within the Geodatabase that ensure that lines meet, lines do not have breaks and that polygons close. Other rule based topology checks can also be employed.

Attribute Label Check

While performing a Heads-Up Display Check, attribute labels are activated to observe the labels attached to lines and polygons. This is a secondary check of proper attribution for all lines and polygons.

Attribute Table Check

An Attribute Table check is performed by checking for “Null” values and for stray or orphan records that do not appear to be consistent with the expected data attributes.

Consistency Between DFIRM and Adjacent Counties

A check for consistency between adjacent County and political boundaries is performed to ensure that Flood Hazard data is uniform when moving from County to County or County to City or City to City.

Mappable LOMC Check

All mappable LOMCs are reviewed to ensure that they are consistent with their case file map representation.

ERROR Data Table and Spatial Locations

Mapping errors that are identified during the digitizing process are placed in a spatial error file within the Geodatabase. This error file is checked to determine if any errors can be rectified prior to being submitted.

Review Sources of Data

An important check near the end of the QA/QC process was to review the sources of all external data such as political boundaries, Public Land Survey data, Federal Lands or other types of data that were incorporated into the DFIRM dataset.

Review Log

One very helpful aid in the review process incorporated a spreadsheet that listed the type of check being performed and the initials of the reviewer. This spreadsheet traveled with the QA/QA maps and Geodatabase in order that other reviewers could see the types of checks that had already been performed or who to contact in the event of questions.

TECHNICAL SUPPORT DATA NOTEBOOK

An important aspect of the DFIRM conversion process is a method to document the conversion process. The Technical Support Data Notebook (TSDN) provides for that mechanism. As the DFIRM data progresses through further refinement after it is submitted by the Study Contractor, the TSDN allows those working with the data to find historical data and documentation to assist in resolving questions or contacting individuals who assembled the initial DFIRM data.

The FEMA Guidelines and Specifications for Flood Hazard Mapping Partners specify five sections of the TSDN but depending on the County or Community that is being processed, usually only two and possibly three are needed for DFIRM conversions. The remaining sections pertain to more detailed studies and analysis that fall within the Map Modernization process.



Generally, the two sections that pertain to DFIRM conversion are *Section 1. General Documentation* and *Section 4. Mapping Information*. A third is *Section 5. Miscellaneous Reference Materials* that pertain to specific issues not covered in Section 1 and 4.

Section 1. General Documentation holds information such as Contact Reports, Meeting Minutes, Correspondence and other information that track the progress of the DFIRM conversion.

Section 4. Mapping Information holds the actual map data that was assembled in the conversion process. This includes the revised County or Community panel index, Base Map information, DFIRM work maps, project Narrative, mapping metadata and other mapping documents.

Since the volume of paper generated during a DFIRM conversion process can become somewhat overwhelming, many of the documents within Section 4 remain in digital format and are submitted on Compact Discs or Digital Video Disc format.

Over all, the TSDN in its entirety is also submitted in digital format by scanning and converting all documents found within Section 1 to Portable Document Format (PDF) files.

Of utmost importance in the DFIRM conversion process is that the TSDN be understood and be updated continuously throughout the process. If this constant update process is not followed, it is impossible to recover the multitude of contacts, meeting notes and correspondence that accumulate during the DFIRM process.

DRAFT SUBMITTAL

Essentially, the Draft DFIRM submittal that is forwarded contains the entire contents of the TSDN with all documents pertaining to the DFIRM conversion. It also has the Geodatabase with the digital data collected and generated during the process that represents the flood hazard data taken from the paper FIRM panels.

SUMMARY

This paper attempts to provide a general outline of the FEMA DFIRM conversion process from one contractor's experience. It endeavors to identify common issues that are important to keep in the forefront as one proceeds through the conversion process. By working through an initial DFIRM conversion project, by trial and error, a methodology was established that worked well in our particular work environment. This methodology may not work for all but it does provide a condensed overview that may help others who are contemplating this type of work.

ACKNOWLEDGEMENTS

The project timeline and methodology outlined above was generated during an initial Map Modernization project undertaken by Nolte Associates, Inc., under the guidance of Les Sakumoto, Project Officer, Federal Emergency Management Agency, Region IX, and Scott Lyle, Project Manager, Nolte-San Diego.

Data for the projects mentioned were furnished by United States Geological Survey, Federal Emergency Management Agency, Environmental Systems Research Institute, County of Lake, County of Sacramento and County of Santa Cruz, California.

The GEOPOP was created by Michael Baker Jr., Inc. Alexandria, Virginia.

Methodology and timelines were developed by Charmaine Yeung, Dean Halstead and Maria Uhlenhop, Nolte Associates, Inc., Sacramento and by Brett Marraccini, Nolte Associates, Inc., San Diego.

APPENDIX A

