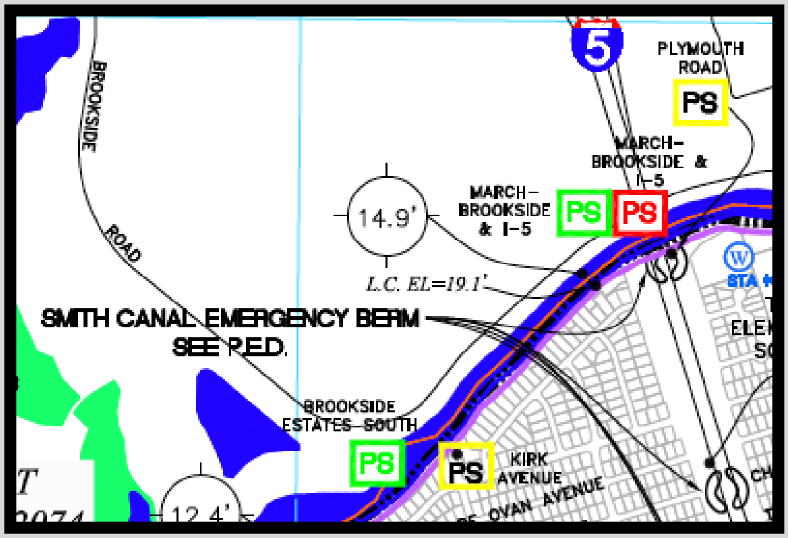
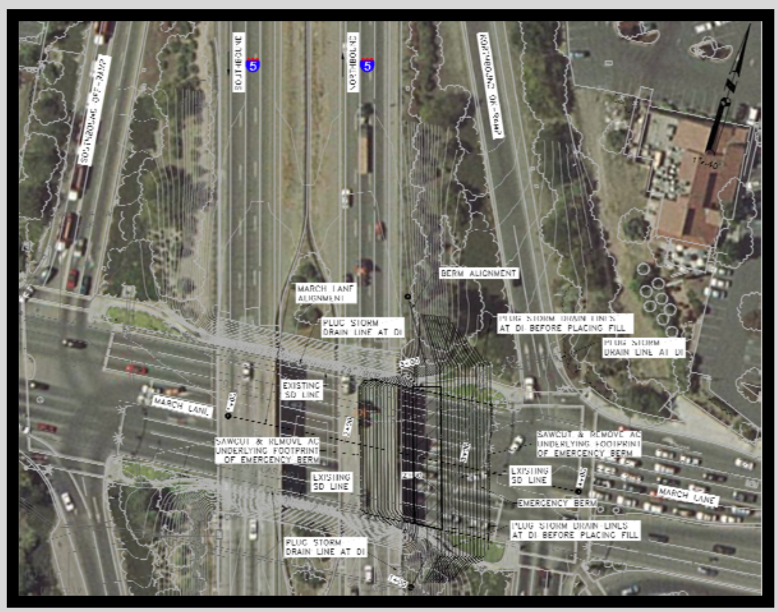
Guide to Flood Contingency Mapping, 2nd Edition





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Guide to Flood Contingency Mapping, 2nd Edition

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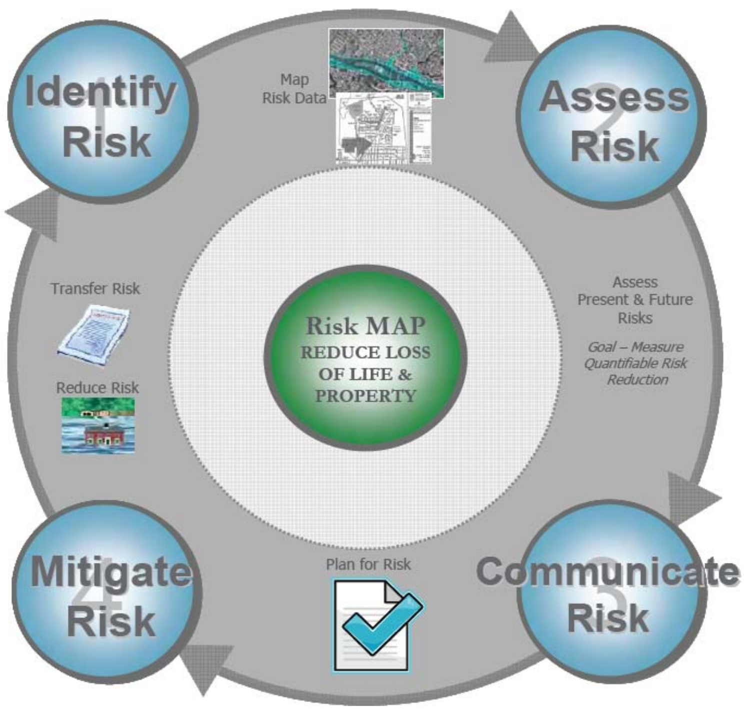

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INTRODUCTION TO FLOOD CONTINGENCY MAPPING

PROGRAM GOAL AND OBJECTIVES

The goal of this Guide is to encourage the development of flood contingency mapping programs in all areas of the Country with a flood threat. The primary objective of the mapping program is to improve emergency operations aimed at 1) preventing levee failure and 2) limiting flood extent, depth, and duration if a levee or other flood protection structure fails. A second objective is to stimulate more pro-active risk assessment and mitigation activities before a flood event.

A NEW APPROACH TO THINKING ABOUT FLOODS - DEFENSE IN DEPTH

The National Flood Insurance Program (NFIP) has for many years provided a detailed process for certifying that levees or other flood control structures meet its 100-year protection standard. This regulatory certification removes most insurance and land use restrictions from subsequent development in the protected floodplain. An unfortunate side effect of the certification process has been an overly restricted focus on the primary levee or dam as the means for flood protection. This narrow focus can lead to a "Maginot Line" mentality where officials assume that a levee or other structure, having been procedurally "certified", is of itself adequate and sufficient flood protection. The result in flood control, as with the French in World War II, is that opportunities for limiting damage if the primary means of protection fails are addressed in a rudimentary and incomplete manner.

However, in almost every community protected by levees or dams opportunities exist to limit flood extent, depth, and/or duration in the event those structures fail. A new attitude about flood protection would help ensure that these opportunities can be effectively exploited if needed. This new way of thinking about flood protection can be summarized as "defense in depth". Applied to flood planning, the new approach encourages officials to look more closely and professionally behind their levees or floodways for opportunities to limit damages in case the unthinkable occurs. The application of modest resources to the development of such multiple "lines" of flood defense would more effectively address the residual risks remaining after compliance with the certification process.

Such a new attitude would have the secondary benefit of stimulating more attention to the organization and professionalization of flood fight operations attempting to prevent levee failure in the first place.

The flood fight would no longer be a more or less ad hoc affair organized at the time of the emergency but instead a professional and thoroughly pre-planned effort.

A NEW APPROACH TO DISPLAY OF EMERGENCY PLANS - MAPS

In this new approach maps replace written documents as the means of displaying command level flood fight information. Procedures and information displayed on a map are more easily and accurately accessed, comprehended, and shared by responders in fast moving field operations. Digital map files are more easily shared over great distances and with large numbers of involved agencies. Modern mapping software allows rapid modification of maps, once produced, to meet evolving emergency response requirements. Finally, substitution of maps for binders integrates response procedures and decision making with the key component of a flood event, geography.

The flood suddenly arrives. The flood control structure relied upon for so many quiet years is in doubt. The response coalesces in the difficult field environment where the situation is best evaluated and response activity initiated. Will the long interval between major floods and past over confidence in the primary flood control structure slow the organization of the response and critical decision-making? A flood contingency mapping program is a cost-effective means of professionalizing flood response using a display format that is more easily maintained during the long periods between floods and is more user-friendly when the crisis arrives.

The challenging environment in which decisions will be made…

requires response information in a format suited to it….

to facilitate rapid and appropriate action.

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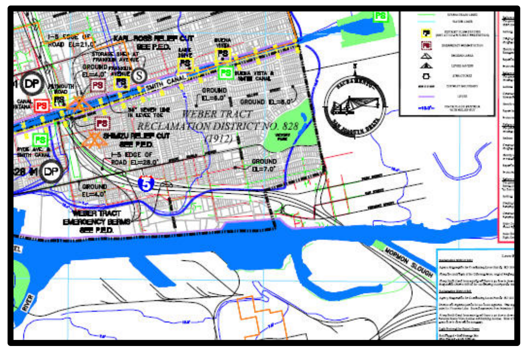
MAPPING AND THE EMERGENCY PLANNING PROCESS

The basic product of a flood contingency mapping program is a set of hard copy maps covering the targeted flood control system. These maps are created before an emergency and become a “standard reference map” for use by officials responsible for flood fight operations in the area covered by each map. The maps do not replace all plans and procedures but are a command-and-control tool which improves 1) the quality and effectiveness of command level situation assessment and decision-making, and 2) the efficiency of subsequent engineering actions.

Each flood contingency map in the map set is a “tactical” map that displays the following types of information critical to effective situation assessment, decision making, and response:

1) Historical flood data
2) Key topographical and elevation data
3) Flood fight command and logistical procedures
4) Pre-planned options for limiting the extent, depth, and duration of floodwaters in the event the primary flood control structure fails.
5) Chokepoints of local and regional critical infrastructure



The number of individual maps in a set will depend on factors discussed below. But once these maps are completed, they are easily maintained and accessed in an emergency. The maps are then supplemented with additional planning to address specific issues identified in the map development process. But as with many emergency planning efforts, initiating such a mapping program successfully involves some key first steps.

STEP 1: IDENTIFY PROGRAM RESOURCES, BUDGET, AND KEY PARTICIPANTS

A flood contingency mapping program involves many agencies and organizations from all levels of government. These agencies will work collaboratively over an extended period of time to develop final map products. Some agencies will be involved only for a short period for a single map and other agencies will be involved throughout the entire program. A sound management structure is needed to ensure that such a complex process and timeline can be properly sustained.

Program Staff

A program manager responsible for overseeing the mapping program and the production of final products should be identified along with a program budget. Staff available to help with coordination of agencies, research, and collection of data should be identified. It is a clear advantage if these individuals are part of the flood response organization for their community. The number of project staff assigned will determine how complex the program can be and how rapidly products can be completed.

Technical Resources

There are numerous techniques available for creating hard copy maps. The technical means to be used to create the maps should be identified early in program implementation. Once the map creation technology is selected then resources for applying it can be assembled. These resources - equipment and staff - may be provided by a single agency or by multiple agencies. These decisions will depend on local circumstances but should be worked out early and costs incorporated into the program budget.

Key Agency Players

Different areas of the country organize responsibility for maintenance of flood control structures differently. Emergency response to threats to the integrity of these structures is also organized in different ways. When initiating a flood contingency mapping program several key questions should be asked. Which agencies have jurisdiction for maintenance of the levees or dams for which maps will be prepared? Will those agencies have sole final approval for completed map products? What agencies provide support and expertise to these responsible agencies in an emergency? What role will these supporting agencies play in developing the map products and in the map approval process? Participating agencies will generally fall into two categories.

Levee districts, boards, or agencies and affiliated engineers. These entities generally have day-to-day responsibility for operation and maintenance of levee systems and will be a critical source for historical, technical, and community information. But since there is often multiple similar entities within an overall flood protection system, an agency with wider geographical jurisdiction will more likely initiate the mapping program. However, the manner in which these organizations and their consulting engineers are brought into the program and compensated for their costs will be a key program issue.

Local, state, and federal agencies. These types of agencies may have direct levee maintenance responsibilities but are more generally involved in operating other flood control structures like dams. However, these agencies can have an important role in responding to emergencies with any flood control structure. These agencies will also be more widely involved in the overall mapping process since they generally cover a larger jurisdiction than individual levee districts.

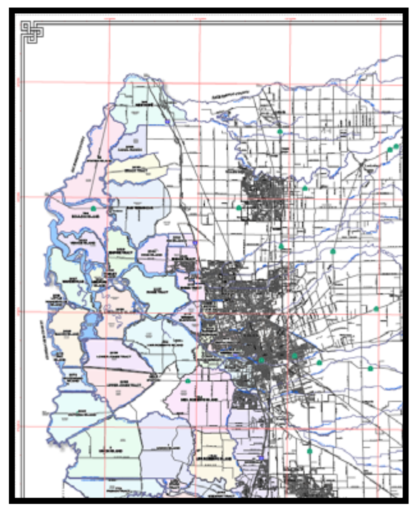
STEP 2: DETERMINE THE TYPES OF MAPS TO BE PRODUCED AND THEIR SPECIFICATIONS

This Guide describes a single type of map product - the flood contingency map – for support of local, “tactical”, flood fight operations. Other map products could be identified for a flood mapping program such as a set of smaller scale maps for regional, "strategic", coordination. Types of map products to be produced should be identified as soon as program resources are known. Map specifications are developed for each type of planned map and a similar process for producing individual maps followed.

STEP 3: IDENTIFY INDIVIDUAL MAPS NEEDED

The area targeted for mapping will need to be divided into the individual map products. Flood control systems generally encompass large areas with many different levee maintaining and support agencies responsible for maintaining portions of the overall system. While the area to be mapped will generally depend on the organization initiating and funding the mapping program, how the area is divided into individual maps will benefit from some analysis and thought.

The first rule for identifying the coverage of individual maps is to focus on the geographical, hydrological, and infrastructure characteristics of the area to be mapped. Coverage of individual maps should not be determined solely on political, administrative, or jurisdictional boundaries. Levee maintaining agencies may enjoy separate political status but share an interdependent protection situation with neighboring agencies. This is apparent when a cursory look at a map shows that a levee failure in one jurisdiction automatically leads to flooding of others, or to a greatly increased threat of additional damage. Existing transportation systems, access constraints, and the existence of mutual aid agreements will play a role in determining the coverage of each individual map. Practical issues, such as effective map scale and minimizing the number of individual maps to be produced, will be a consideration as well.



In sum, areas that are interdependent for a critical reason should, to the extent possible, be on a common map. While there may be modifications once planning begins, this initial identification of individual maps and their geographical scope should be completed early in the program.

STEP 4: IDENTIFY AGENCIES THAT WILL DEVELOP EACH MAP

Once the tentative set of maps and their coverage is determined, the agencies that will need to participate in the development of each map should be identified. Their participation should be confirmed along with their level of commitment to the program. Contact information and agency lists should be finalized. Time or seasonal participation constraints should be identified so that an effective and practical schedule for completing individual maps can be developed.

STEP 5: ESTABLISH THE COLLABORATIVE MAP DEVELOPMENT PROCESS

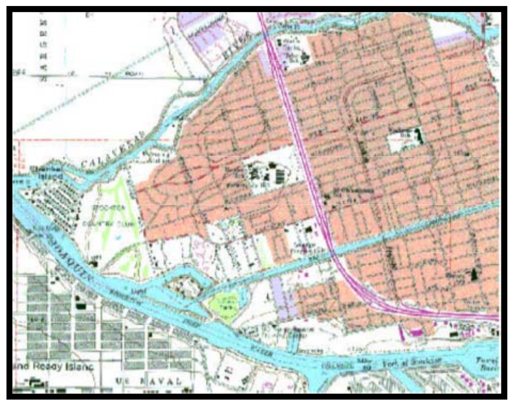
Program funding and available resources determine whether maps are scheduled for completion sequentially or in groups. It is important not to underestimate the time needed to complete an individual map. Most maps will require several meetings and map drafts to arrive at a final product. The time of year this work can be efficiently performed affects the collaborative process and schedule. Once an initial schedule is finalized it should be shared with participating agencies prior to starting the map development process. While the schedule will inevitably change as the program evolves, its existence will help maintain progress.

DEVELOPING INDIVIDUAL MAPS

The development of individual maps will follow a similar process although the overall complexity for any one map will vary. The following process description refers to flood contingency maps (see model maps for examples) but the details can be modified as needed for other map products.

IDENTIFY THE BACKGROUND

An early decision will be the selection of the background for the maps. The United States Geological Survey (USGS) topographical map series may be used if that older data still adequately portray the area being mapped, or if cost is a major issue. Aerial photos may be used in lieu of the USGS data as an alternate background. Use of existing map products such as the USGS topographical map series means that details not of interest or use in flood fight operations may end up cluttering the final map. If possible, digitized versions of such existing general map products can be manipulated to “erase” unneeded or out-of-date content and add needed information.



Creation of a vector background from scratch is possible with more sophisticated mapping software. While more costly and time consuming, the advantage is that the final maps will not be muddied with unneeded information and will only include background elements needed by responders. For example, only key elevation contours, rather than all contours, could be displayed in a custom-made background.

CREATE AN INITIAL DRAFT MAP

Program and technical staff should create an initial draft map prior to the involvement of the agencies or organizations providing the input for that individual map. The availability of a draft map at initial meetings will facilitate discussion and improve results. This preliminary work also allows program staff to resolve technical issues such as best map scale, exact map coverage, and best placement of text boxes and legends. While completing the initial draft map, project staff can collect historical and other data obtained from the same documents and sources and add this to the map. All of this work will save time once group discussions begin.

CONDUCT AGENCY MEETINGS

Program staff now schedule and conduct meetings with the different levee maintaining and support agencies responsible for flood fight operations in the area covered by each map. An agenda, the initial draft map, and the list of data elements and other map specifications worked out at the beginning of the program are used to facilitate discussions. Table 1 shows an example list of data elements for the model flood contingency maps that come with this Guide. The resulting collaborative discussions will generally address the following key issues.

Identification of Information Needs

Information needed for analyzing potential failure scenarios and response options will be identified in the course of discussions. Program staff records these needs and develops a collection plan. Some technical field work may be required so resources to pay for this should be built into the program budget.

This work generally only involves straightforward data collection. For example, a tentative location for installing emergency pumps for dewatering may have been identified in the map development meetings but a follow up survey is needed to confirm that this is the best site for placement of intakes and pumps. Information collected is added to the draft map or otherwise shared at the next meeting for approval by the group.

Coordination of Future Flood Fight Operations

Agencies will collaboratively pre-plan supply delivery points, patrol and mutual aid procedures, and multi-agency coordination processes. These locations and procedures are placed on the map as symbols or in text boxes to serve as cues and references. If a procedure is too extensive for placement on the map, a summary of the procedure can be placed on the map with a pointer to the complete document. Detailed technical surveys can also be summarized on the map with an appropriate pointer.

Analysis of Failure Scenarios and Response Options

Identification of failure scenarios for the primary levee or other control structure, and related opportunities for containing the resulting floodwaters, will be a key product of the discussions. Historical information, input from local residents, and local institutional knowledge help in this process. The potential use of relief cuts, emergency berms, and existing embankments and elevated freeways to contain floodwaters will be analyzed for each distinct failure scenario. Options determined to be impractical are also added to the map to prevent unproductive discussion in a future crisis.

A common problem at this stage is the tendency of officials to exclude potential containment options based on pre-conceived notions of what the future flood will be like. Ingrained use of 100-year flood elevations from the NFIP process should be discarded and the demonstrated fact that actual floods come in all sizes and depths kept in mind. Similarly, what is politically acceptable at the time of a flood can well differ from what is thought to be acceptable in discussions before the emergency. The intent of the mapping program is to identify practical engineering options for containing floodwaters that officials can consider once the characteristics of the actual flood are known.

Detailed risk assessment, mitigation, and implementation planning will often follow the identification of potential options for containing a flood. This additional work will increase the possibility of success in limiting damage. This follow-on planning is discussed later in this Guide.

Identification of Mitigation Opportunities

During the map development process, critical infrastructure vulnerable to flooding if the primary flood protection structure fails will become apparent. In some cases, an option for protecting the structure during the flood if that contingency materializes may be identified. In many cases, however, there may be no practical option for protecting this infrastructure from damage in the event of failure once the flood arrives. These vulnerabilities should be noted on the maps for future risk assessment and mitigation purposes. In this way, the map becomes a stimulus for pre-event efforts to add second "lines" of local protection (e.g. ring dikes or flood proofing of structures) to facilities critical to the functioning of the community and region. Noting such issues on the map prevents them from being forgotten by community officials.

Note on Evacuation, Rescue, and Security Planning

Participants in this planning process may want to consider the issues of evacuation, rescue, and security for the areas under discussion. Two practical issues must be considered in this case. First, the agencies responsible for evacuation and public safety measures will generally differ from those responsible for the flood fight. Second, trying to address those types of public safety issues on the same map with flood fight issues can clutter the map and render it difficult to use (see discussion below on visual hierarchy).

Experience has shown that in the case of lightly populated rural areas evacuation information can be effectively integrated into the flood contingency map along with storage sites of hazardous materials or petroleum products. Public safety agencies would need to be involved in this portion of the map development process. In the case of more populated areas it is better to address evacuation and related public safety operations on a separate map (see separate Guide to Urban Evacuation Mapping).

REVIEW AND APPROVAL OF FINAL MAP AND FUTURE MAINTENANCE

The process for final approval of completed maps should be clearly worked out with the participants at the beginning of the program. A formal sign off by all involved agencies may be needed or one key agency may be authorized to approve the final map after receiving input from the others. It is also important to identify the agency or agencies that will maintain the maps and initiate their periodic update. This maintenance function may be centralized or de-centralized depending on local circumstances but must be established if the program is to remain effective into the future.

THE STANDARD REFERENCE MAP

INTRODUCTION

To reiterate, the primary product of a flood contingency mapping program is a set of maps created before a flood and printed for use by responders when flood operations begin. This product is called the "standard reference map" throughout this Guide. These hard copy maps may be the sole product of a mapping program or they may be the basic product around which a more dynamic mapping program is designed (see Making Dynamic Maps section). Regardless of the complexity of the mapping program envisioned, this set of "standard reference maps" is the first and primary product of a flood contingency mapping program.

DESIGNING THE STANDARD REFERENCE MAP

There is no pre-existing national standard outside of this Guide prescribing the contents and design of flood contingency maps. In the absence of a national standard, jurisdictions initiating a flood contingency mapping program are free to work out the map design and specifications that best meets their local needs. The following discussion covers considerations for determining map content, display specifications, geographic framework, and administrative protocols based on the experiences of a model program conducted over the period of a decade. Each of those map specifications must be addressed although details will vary depending on the specific objectives of jurisdictions initiating a program.

MAP CONTENT AND DISPLAY

Map Content

The first map design component is the specific data elements that will make up the content of the maps. The primary criterion for including information on the map is, of course, usefulness to responders in flood emergency operations. But other considerations will play a part such as the cost of obtaining information not readily available. Limits to map content may also need to be set to avoid a map product that is difficult to use.

Map content may be divided into two key types of data, objective and subjective. Objective data elements are technical or historical facts that merely need to be collected and verified. Examples are ground elevations, dates and characteristics of past floods, and elevation profiles of existing dry land levees. Subjective data elements result from decisions made in the collaborative planning process. Examples would be joint decisions on where to locate a command post or supply delivery point, whether a relief cut is an option for limiting floodwater extent, or the trigger condition that will be used to start levee patrols.

Once map content is identified, each data element making up that content is defined as to the degree of detail required, metadata standards, and the process for collection. It may be decided to collect some data in detail but to display it summarily on the map with a reference to the location of the full version. These data element definitions become part of the program map specifications.

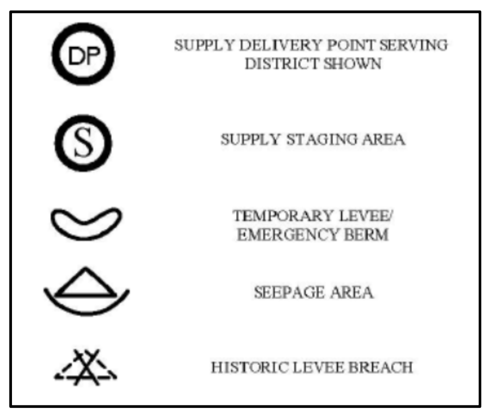
Table 1 provides a list of the data elements making up the content of the model maps. This list was updated as practical experience was gained and initial products were used and evaluated in the field. The final list is the result of a decade of feedback and can be used as a starting point for new programs.

<u>Content Display Specifications</u>

The next specification to be considered is how map data elements will be graphically displayed on the map. The basic cartographic display options are symbols, labels, text boxes, and within the map background. General display specifications include type size and fonts, visual hierarchy requirements, placement decisions, and standardized color schemes.

Map Symbols

The use of symbols is a key advantage of using the map format to display information. Symbols with a short accompanying label convey information very economically. With a little familiarity, responders can assimilate information conveyed by symbols more rapidly than from reading text descriptions. This makes the maps easier to use under difficult light or other conditions or time stresses.



There is no national, comprehensive, standard symbol set for the specific needs of flood response. Table 2 shows the symbol set developed for the model flood contingency mapping program. Some symbols were part of the National Incident Management System (NIMS) and others, with no counterpart in NIMS, were developed by the California Department of Water Resources. Still others were developed for a specific map content not addressed elsewhere.

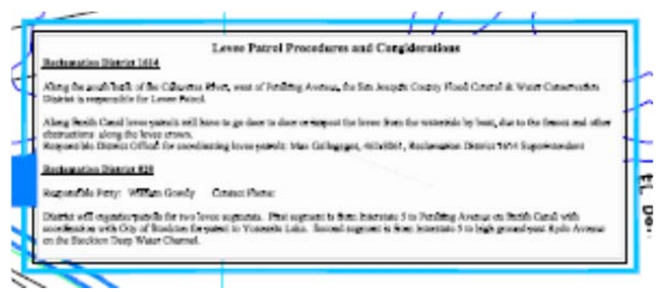
Two general observations should be made about the design of symbols for emergency operations maps. First, all symbols should have the simplest possible design while still being easily recognizable. This will facilitate hand drawing of symbols on maps during emergency operations and help ensure consistency of look if the symbols are created with different mapping software.

Second, symbols and any accompanying label should be prominently displayed on the map. Information conveyed by symbols will rank high in the intellectual and visual hierarchy of the map so they will need to standout boldly from the background. Making symbols too small, or printing maps at a too small a scale, weakens the maps effectiveness (see discussion on visual hierarchy).

Labels and Text Boxes

Some information will not lend itself to display through a symbol. The feature of concern may already be in the map background necessitating only the addition of a simple label. Text heavy information such as summaries of historical floods, descriptions of flood containment options, or levee patrol plans, will require a different means of display.

Any text beyond a short label should be placed inside "text boxes". Text boxes are placed in peripheral portions of the map where they do not obstruct the area of focus of the map. When the boundaries of individual maps are set at the beginning of the mapping program, the need for this peripheral area should be considered. Text placed outside of text boxes should be limited and rigorously edited to prevent map clutter.



Use of text boxes on maps has several advantages. Since they are closed figures they help ensure that the information within them stands out clearly from the background. Their borders can be color-coded to facilitate the rapid identification of needed information. Color-coding may be by category of information, e.g. historical, operations, or it may be by specific type of information, e.g. patrol plan, flood history. Table 3 shows text boxes used on the model maps and their color scheme.

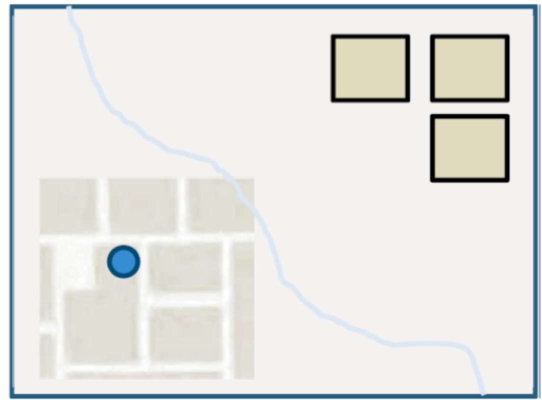
Map Background

The map background shows the topographical context within which map data elements reside. Some desired data elements may be best displayed as part of this map background. Examples would include linear information such as elevated highways, key elevation contours, elongated topographic and hydrological features, and sub-division street schemes.

INTELLECTUAL AND VISUAL HIERARCHY

An important concept in cartography is figure-ground. This element of map design involves giving a map visual depth so that its intended message is clearly communicated to users. Techniques for developing good figure-ground include differentiation, use of enclosed forms or figures, centrality, and smoothing of outlines or contours. These techniques are used to convert a pre-planned map "intellectual hierarchy" to a corresponding map "visual hierarchy".

The "intellectual hierarchy" of a map is the relative importance of map contents for communicating the map's purpose as determined by the potential map users. An intellectual hierarchy, or scale of concepts, should be consciously defined when map content is first identified. Intellectual hierarchy, by ordering the importance of map data elements, drives how each will be visually presented on the map.



Good Visual Hierarchy makes the most important map elements *stand out* to better communicate the information that responders need to see and focus on

Proper intellectual hierarchy also includes a clear and logical separation of information needed by distinctly different emergency functions into separate map products. This last is an important consideration because combining different information used by different responders with distinctly different missions on one map risks making the map difficult to read by all of them.

The "visual hierarchy" of the map contents will be developed to reflect the intellectual hierarchy established by users. Again, visual hierarchy is the planned differentiation in appearance of map information to draw initial attention to relatively more important information, to assist with locating needed information, and to allow more rapid distinction between different kinds of information. Visual hierarchy techniques include sizing, placement, closed forms, and other visual qualities that give map content a planned visual "order" and clarity. For example, use of easily distinguishable symbols and their relative sizing can help bring more important information to the forefront. Use of enclosed forms or figures such as boxes can help draw initial attention to key information by taking advantage of the tendency of users' eyes to be drawn to real or perceived forms. Placement of information closer to central parts of the map can make that information more prominent. These, and other techniques such as color-coding and orientation, are the means for creating visual hierarchy.

Intellectual and visual hierarchy may well be the most important element of conscious map design since good information poorly displayed undermines the key advantage of the map format. This visual "depth" will be the key to rapid comprehension of the map in difficult operational circumstances.

GEOGRAPHIC FRAMEWORK

The geographic framework of a map includes the datum, projection and coordinate system, and the range of map scales that will be used.

Datum

The choice of the vertical and horizontal datum would have been an easier decision a decade ago. In the past, the horizontal datum NAD83 or WGS84 was to be used. But the transition to the new North American Vertical Datum 1988 (NAVD88) has complicated the issue. The use of the newer vertical datum is preferable and will eventually be a necessity. But the fact is that much relevant survey information has been collected using an older datum and has not yet been re-surveyed or converted. Map designers will have to consider their individual situation and calculate the costs and time needed to bring all map content to NAVD88 standards.

It may be necessary due to cost considerations to create initial map products using an old datum as the standard pending an eventual transition to the newer datum at some future date. *But under no circumstances should the maps contain information collected under different datum.*

Projection and Coordinate Systems

The map projection standard and coordinate system will need to be defined. Most states and engineering firms use the State Plane Coordinate System (SPCS). This standard should be clearly set and the same projection and coordinate system used on all maps. In the case where dynamic mapping is envisioned with new information from remote sources added to the map, a method for ensuring that this information is geo-rectified and standardized to the rest of the map content projection will be critical.

Scale

There will almost certainly be an initial desire to create and print all flood contingency maps in a set at the same scale. In practice this is hard to accomplish. As discussed previously, the geographic boundaries of an individual map may include multiple levee-maintaining agencies that are interdependent due to their proximity and the hydrological characteristics of the area. This operational need will lead to individual maps that cover relatively small areas and maps that cover relatively large areas. The printing of hard copy maps at a common physical size to facilitate their use in the field will therefore require that different scales be used for individual products. Map designers can, however, establish a standard set of scales to keep scale differences within control.

ADMINISTRATIVE PROTOCOLS

File Naming Protocols

Final maps, regardless of the mapping software used, will be maintained in electronic files. It is important to establish a set of rules for naming electronic files and the maps they contain to prevent the accidental use of out-of-date versions. Naming protocols help users find the appropriate map in a computer folder, ensure that files are properly maintained, and assist with tracking modifications that result from emergency operations. Figure 3 provides an example of a map and file naming protocol.

Reporting Geographic Location

In the actual world one finds a wide range of methods used for reporting locations from the field. In the case of a location on a levee, stationing points, levee miles, and/or river miles may be used to meet day-to-day reporting needs. Residents in areas protected by levees may tend to report locations in relation to well-known landmarks or features. To complicate the issue, local officials and residents often develop colloquial terms, or nicknames, for prominent topographic features of their area.

A standard should be established for reporting locations that can be referenced on the flood contingency maps. This could be National Map Grid coordinates (printed on the map margins) or something as simple as longitude and latitude. But even where such a standard is set, map design should accommodate the human habit to fall back into use of short-hand expressions or other methods of reporting a location. Known colloquialisms can be added as a label next to the feature it refers to or next to more standard reporting points shown on the map, e.g. stationing points. This will help prevent confusion particularly among responders unfamiliar with the area.

Data Collection and Metadata

Metadata should be maintained for each map produced. Metadata should be created and maintained in accordance with the Federal Geographic Data Committee Standard (FGDCS). Metadata for GIS files will be maintained within the files while metadata for CADD and other non-GIS electronic files will be maintained in a WORD text document.

CONCLUSION

The above discussion covers the elements needed to create the standard reference map ready for field use in an emergency. But as noted before, the mapping concept can be expanded to a more dynamic, real-time mapping system. The next section discusses the process of creating a more sophisticated and dynamic program from the foundation created by the completion of the standard reference maps.

MAKING DYNAMIC MAPS

THE NEXT STEP UP – MAKING DYNAMIC MAPS

Advances in modern geographical information systems (GIS) and computer aided drawing programs (CADD) offer improved ability to create digital map files that can be quickly manipulated to create modified products from existing maps for real-time response needs. Remotely hosted geographic information provided by web-based map services (both proprietary and open-source), and digital maps distributed in industry standard formats such as GeoTIFF and KML/KMZ, can also now be readily accessed and incorporated into existing maps.

These enhanced mapping capabilities have obvious advantages for timely, effective, flood response. Real-time information such as flood extent, road-closures, and status of critical infrastructure can be quickly added to maps created prior to the emergency. Layers of completely new information can be added. Information on the original maps that is no longer required can be easily dropped off. The desire to incorporate such real-time information will be an inevitable result of having the maps in the first place. But to add this dynamic capability, a mapping program must be more carefully thought out, designed, and managed.

EVOLUTION OF A DYNAMIC FLOOD CONTINGENCY MAPPING CAPABILITY FROM FLOOD CONTINGENCY STANDARD REFERENCE MAPS

Clearly no GIS or CADD software is necessary to produce the static standard reference map since hard copy maps can be produced by traditional hand-drawn cartographic techniques and software. But in a more dynamic mapping environment real-time data will be provided from a variety of sources using a variety of technical means to transmit and share the information. There will also be concerns by private utilities and other entities about potential compromise of proprietary or sensitive data that need to be addressed. The sheer quantity of new data arriving into the mapping system during emergency operations will be a potential source of confusion or error. Therefore, the number of players and technical steps involved in the design and implementation of the mapping program will need to expand.

New Key Players and Roles

New players now have an expanded role in a dynamic flood contingency mapping system.

GIS/CADD consultants or staff

GIS/CADD staff takes on a new importance to the program. Their task is to develop a layer model of the standard reference map to facilitate the rapid modification and sharing of those maps. These resources will also now need to be available at all times into the future to update data and manage the dynamic mapping system in an emergency.

Other GIS/CADD data providers

As the universe of geographic data available from many public and private sources expands, a dynamic mapping program will want to incorporate relevant data from these many sources. As a result, providers of these data become important players in designing and operating the mapping system. There will need to be coordination between the outside data providers and the mapping program staff to work out transmission issues. Security and proprietary issues will need to be addressed. Outside providers may use different data formats or projection/coordinate systems than those used in the mapping program and GIS/CADD staff will need to work out these and the other issues as much as possible.

Other geographic information providers

In a real event much time-dependent information may be available, such as current river stage, anticipated local flooding, and flood-fighting resource dispositions, which are not in ready GIS or CADD digital files. Information may be provided by geographic information services (e.g., Google Earth) or in the form of text, picture, and other digital file formats, and even as hard copy. Potential providers of non-traditional GIS or CADD data (fire or law agencies, levee patrols, etc.) will need to be involved in developing protocols for its transmission and incorporation into existing maps.

Overview of the development of a dynamic mapping program

The process of evolving to a dynamic flood contingency mapping system can occur at two levels of complexity. A program may select either level for implementation depending on local objectives or may start at the least complex level with the intent of adding the more complex capability later. Either way, it is important to note that a dynamic mapping capability is developed around the initial product of the mapping program, the standard reference map. These paper maps and their digital files produced as the first objective of a flood contingency mapping program are the basis of subsequent dynamic mapping.

First Level Dynamic Mapping Capability: This level involves structuring the content of the initial standard reference maps in a way that the display of the existing information on the maps can be rapidly modified to meet specific response needs. The key technical step for creating this dynamic capability is the creation of a more sophisticated data layer model for the maps. The model breaks the map contents down into "layers" representing the map's separate data elements (such as levee center line graphics, seepage and erosion site symbols, text boxes, or relief cut symbols). These distinct layers of pre-collected data can then be more easily and selectively turned on and off by mapping technicians to create modified products. This structuring also allows mapping technicians to more quickly render the layers with new or different graphics such as adding a new symbol to a layer.

Second Level Dynamic Mapping Capability: This level involves further development of the dynamic mapping system to allow for direct import of real-time data provided by outside providers. The data layer model designed for first level dynamic mapping capability is expanded to include additional pre-planned layer structure to accommodate completely new datasets obtained at the time of the emergency. Data management and transmission protocols must now be developed so this ever-expanding data from outside sources can be received in an orderly manner and efficiently incorporated into the existing maps.

FIRST LEVEL DYNAMIC MAPPING – MODIFYING THE STANDARD REFERENCE MAP

The prevalence of GIS and CADD software in government and engineering communities means that no agency needs proprietary software to start a mapping program with dynamic capabilities. An effective dynamic mapping capability can be created with a wide variety of mapping systems and some advanced planning. Mapping software for what is a multi-agency effort should be chosen based on three principals: start simple; use what everyone else is using; and make all data available in open-format, non-proprietary formats.

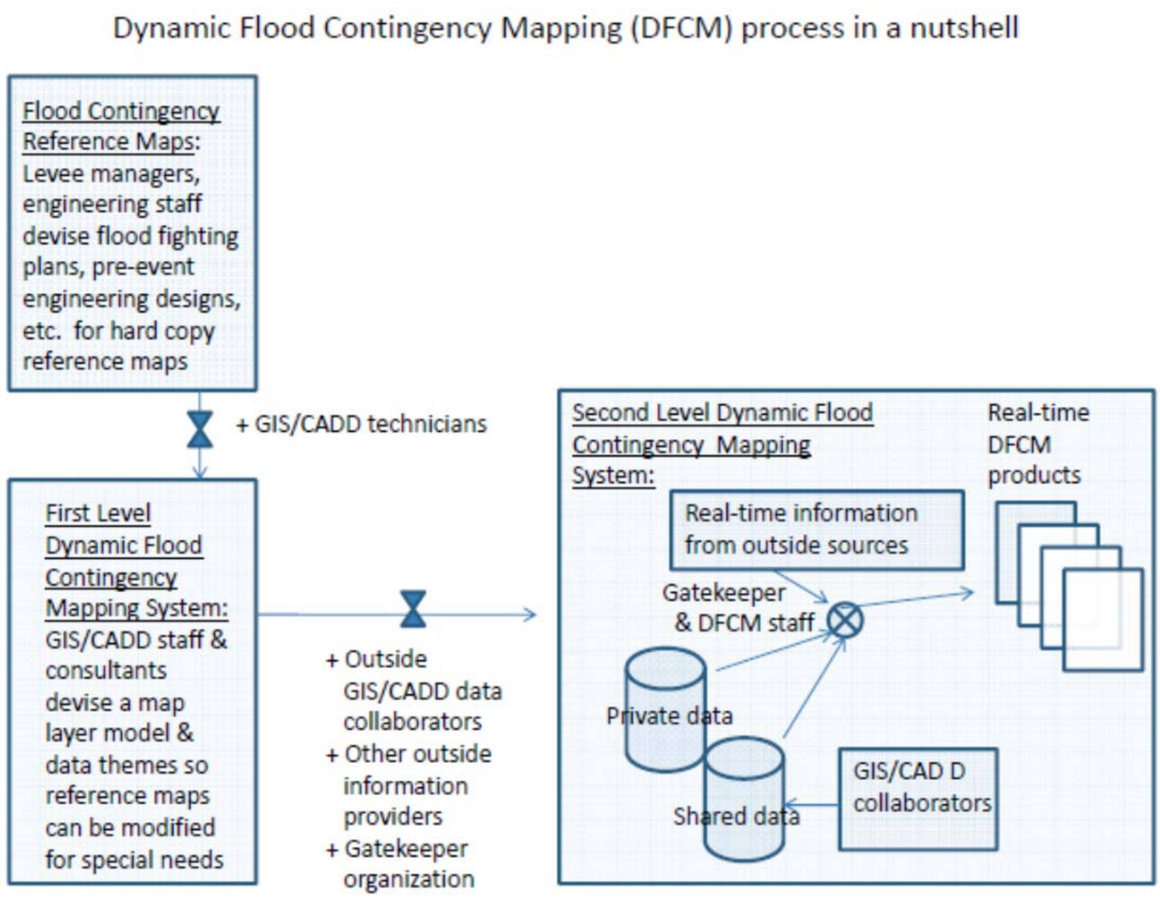


Figure 1: Dynamic Flood Contingency Mapping Diagram

Start Simple: GIS and CADD systems can use the simplest file systems to access and store geographical data, proprietary or open-source, backed by relational database managers. This complex software allow for the wide distribution of geodata in real-time and the continuous updating of datasets by multiple users. Start with the simplest systems and file formats.

Use what everyone else is using: Among the various technical participants of the flood contingency mapping process, jurisdictional data providers, engineering staff/consultants, and GIS/CADD staff/consultants, the common system for creating and maintaining the maps should be the one that most are already using. This will minimize data conversion problems as long as this common software meets the key technical requirement of a dynamic flood contingency mapping program, the ability to use a variety of data types as layers and to efficiently modify the graphics and symbology of those layers.

Make data available in non-proprietary formats: Use data files in an open format such as GIS shapefiles or CADD dxf files to store spatial data since virtually all mapping systems can utilize these file formats. In the case of server-based systems where data may be held internally in a proprietary format, interfaces should be written to quickly provide copies of filtered data files in open formats.

WORKFLOW: DESIGNING DYNAMIC FLOOD CONTINGENCY MAPS

In the case of static map products, how the GIS or CADD technician creates the maps is not highly important. The only criterion of success is that the printed map is visually correct. However, if users want to be able to rapidly and efficiently modify the display of information on existing map products, then exactly how the map files are structured and the maps created becomes highly important. Figure 2 shows the design process for a map file structure that lends itself to rapid modification of map display.

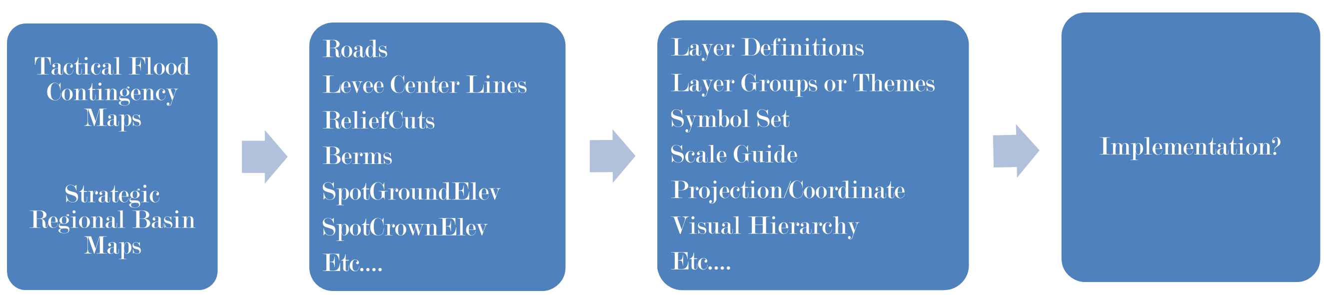


Figure 2: Map Design Process

Program staff and participating agencies start at the left in Figure 2 by first defining the final products and their content. The second step is to further define the data elements that will make up each product. These steps are similar to the development of the standard reference map described above. But, in the case of a dynamic mapping program the process of defining map products and data elements is supplemented with knowledge and experience of how the map products may need to be modified in an emergency. For example, logistics personnel may indicate what information they would need and not need from the list of map content for a specialized map to support their logistical operations. Such potential modifications for specific anticipated response needs are identified to the extent possible as the first two design steps are completed.

Each map data element now becomes a corresponding "layer" for the standard reference map linked to the unique dataset for each individual map. Detailed "map specifications" are developed which will be necessarily more complex and technical than those for a static map product. Mapping technicians will use these specifications to set up the mapping software and work out implementation issues.

The process of establishing map specifications is not very different from that for the design of the static standard reference map but must now take into consideration the specific GIS or CADD software that will be used to create and modify the maps. Dataset layers are now assigned into "layer groups" or "themes". Such grouping of data elements is based on the anticipated need to modify maps for special purposes (e.g. situation maps, logistics maps, etc.) identified in the first stages of the map design process.

The final step in the map creation process shown in Figure 2 is figuring out implementation protocols. This box contains a large question mark because the question of exactly how data are manipulated to meet the map specifications will depend on numerous factors such as the mapping system or software version being used, hardware capability, time and resources available, and the level of expertise of mapping technicians. These implementation protocols will be a user-specific construct and will invariably be unique to each mapping program.

SECOND LEVEL DYNAMIC MAPPING – IMPORTING NEW DATA INTO THE STANDARD REFERENCE MAP

Second level dynamic mapping expands program capabilities to allow for the direct import of completely new data submitted by outside providers at the time of the emergency. New issues will now need to be addressed to ensure that such data can be efficiently received and turned into new map products for responders. File formats will need to be defined and transfer protocols created and provided to outside agencies as noted earlier.

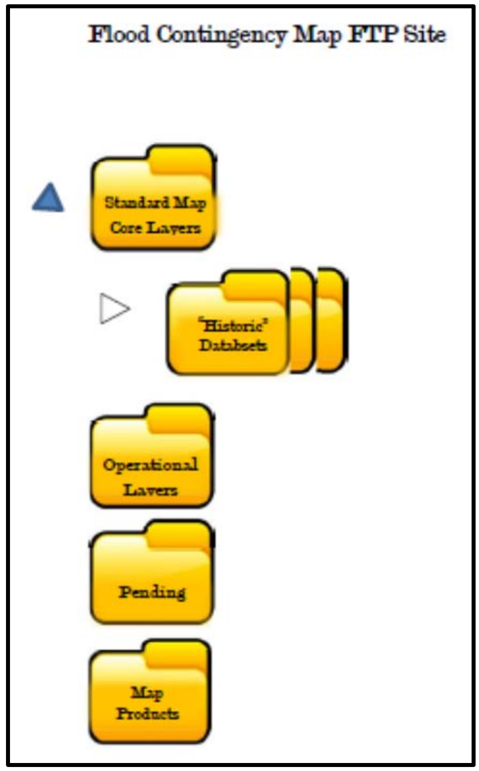
Finally, an easily accessible and used dataset repository will need to be established for this dynamic back and forth flow of data and new map products in the stress of an emergency. The following is a detailed description of a basic FTP site that would meet this need of a second level dynamic mapping system.

Data Contributors, Map Creators and Users, and the Gatekeeper

A second level dynamic mapping system has three distinct types of entities involved in its operation. There is the world of potential data contributors, the staff which maintains the standard reference maps and will be creating new map products, and the map users. The staff maintaining the standard reference maps becomes the system "gatekeeper" who provides central control of the data sharing process. If more than one agency will be creating new map products in an emergency then one must be assigned to perform this "gatekeeper" role.

The gatekeeper performs several distinct control functions. First, it ensures that mapping technicians follow map specifications and implementation protocols. Second, it reviews real-time data contributions to determine their type and quality before transfer to the data repository. Third, it maintains the data repository which data providers, map creators, and map users will use to share information and map products.

While central control of the process is essential, it cannot be allowed to become a bottleneck to efficient system operation. The gatekeeper function should be a team effort with a system manager, data librarian, and one or more technicians trained in the protocols for receiving new data and creating and distributing new map products.

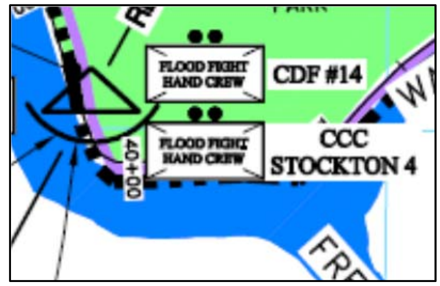


Interacting with the gatekeeper will be the world of data contributors and users of final map products. Potential data contributors should be pre-identified to the extent possible and classified by the gatekeeper as “trusted” or “non-trusted” according to the level of quality assurance needed for the information arriving from each. Some data contributors may be classified as “reluctant” where the sensitive or proprietary nature of their potential data contribution may require special procedures (see Additional Technical Issues section). Instructions or procedures for handling data submitted by each type of contributor are then developed.

Dataset Repository – Basic Folder Structure

The repository for new or existing map datasets could be a simple FTP folder structure accessible to both product users and data contributors. Each folder for holding datasets would adhere to a basic two-level structure. The top repository level consists of a single file and four folders. The single file is a simple ASCII text file used to track changes to the repository in chronological order. The specific functions of the four folders would be as follows.

The *Standard Reference Map Core Layers Folder* contains the existing geospatial and other datasets that make up the set of flood contingency maps created before an emergency. This data will have been collected in accordance with the program map specifications and will have been fully quality controlled. An ASCII file within this folder will be used to record version changes and description of changes.



The *Operations Layers Folder* will contain the new datasets collected during the flood emergency. No datasets are actually in this folder at the beginning of an emergency, but the folder is set up to hold them in an orderly manner once they begin to come in. Actual datasets placed in this folder by gatekeeper staff will have less rigorous quality assurance review which can be noted on map products.

The *Pending Folder* will be used by agencies contributing data to upload their data to the mapping system for review and handling by the gatekeeper. The gatekeeper confirms the data type and characteristics and performs any quality assurance required prior to moving it to one of the maintenance folders (Standard Reference Map or Operations). There could also be a special sub-folder in the Pending Folder for requests for new map products.

The *Map Products Folder* will contain final map products for distribution to users. These would be the initial set of standard reference maps as well as custom products created during the emergency. Final map products placed in this folder would be in a pdf or other common non-alterable format.

Dataset Repository – Secondary Sub-Folder Structure

Structuring the Contents of the Standard Reference Map Core Layers Folder

There will be a similar but unique set of datasets (layers) for each map in the set of flood contingency maps. Sub-folders are placed in the Standard Reference Map Core Layers Folder to hold the unique datasets of each separate map. This organization of sub-folders within the Standard Reference Map Core Layers Folder will allow mapping technicians to rapidly identify the specific datasets needed for modification and prevent accidental combining of datasets from different map products.

Structuring the Contents of the Operations Dataset Layers Folder

This folder should have a sub-folder organization to facilitate maintenance of datasets once data begins to come in. This sub-folder organization could be organized around types of data that are anticipated to be received or some other scheme established by system participants. Specific sub-folders should be created for any pre-identified layer groups or data themes and for holding completely new data. Table 5 shows some examples of dataset layer groups or themes for sub-folders for this folder.

Structuring the Contents of the Pending Folder

The Pending Folder will contain a wide variety of data contributed from a wide variety of agencies, organizations, or individuals during an emergency. Data might be in Excel Spreadsheets, pictures as TIFF or JPEG files, geodatabase files, or even simple text files. Sub-folders based on subject or data format are created to help organize this incoming data for subsequent review by the gatekeeper. A sub-folder can also be added where map user agencies can submit requests for custom map products.

Structuring the Contents of the Map Products Folder

This folder will have sub-folders for holding the set of standard reference maps and any custom map products created by mapping technicians during the emergency. This will assist map users to quickly find needed products. Products will be in a non-modifiable format.

CONCLUSION

To this point, the discussion has been on the creation of the basic product of a flood contingency mapping program, a hard copy standard reference map, and the creation of a dynamic mapping system allowing modification of this basic product in an emergency. But the initial preparation of the set of standard reference maps with response options and information on critical infrastructure can be the stimulus for additional follow-on planning. This subject is discussed next.

AFTER THE MAPS ARE DONE: FOLLOW-ON PLANNING

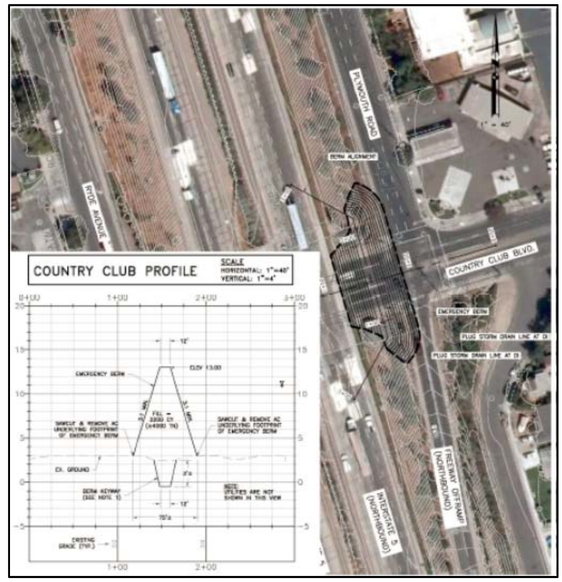
The identification of relief cuts, emergency berms, and other practical options for containing a flood during map development will lead to a desire to ensure that such actions can be expeditiously implemented if needed. In addition, identification of vulnerabilities to critical infrastructure may stimulate a desire to initiate longer-term mitigation actions and planning.

TACTICAL RESPONSE PLANS – PRELIMINARY ENGINEERING DESIGNS

One type of follow-on planning is the development of tactical plans, or preliminary engineering designs (PED), for implementing flood containment options identified in the mapping process. A PED is a low cost preliminary design that helps decision makers determine if a contingency action is practical at the time of the emergency and saves time if it is decided to implement it. The availability of PEDs also helps focus the flood response command on solutions deemed practical in quieter times. Some examples of emergency engineering actions amenable to development of a PED are:

1) Emergency flood control berms
2) Relief cuts to return impounded waters to the river
3) Emergency pump sites for dewatering flooded areas
4) Modification of elevated freeways and other linear structures to hold flood waters
5) Emergency ring dikes around critical infrastructure

These types of actions are, in many cases, complex engineering challenges. Completion of a PED before a flood event allows engineers to gather needed information and perform some basic design work in a less stressful environment than that of a real-time disaster.



Preliminary engineering designs (PED) generally consist of a single sheet technical drawing showing overhead views, profiles, cross sections and notes. They will include the assumptions and other criteria used to complete the design along with estimates of material needed to complete the emergency action. Future engineers will use this preliminary work to more rapidly create a final design based on the actual flood conditions being experienced.

An illustrative example would be the development of a PED for an emergency berm to block an underpass in an elevated freeway. Ground elevations around the site would be collected from field surveys, existing data, or other sources. Engineers would determine berm tie-ins and exact placement and identify complicating culverts, drainage systems, and underground utility infrastructure. Collection of this information is time-consuming but not necessarily expensive. The pre-event completion of PEDs reduces response time when time is critical as well as the potential for inadvertent collateral damages.

Once finished, PEDs can be placed with the relevant flood contingency map for rapid access or imbedded in the digital map file if a GIS system is being used. They are then available to help the expeditious implementation of response decisions made in an emergency.

HIGHLIGHTING VULNERABILITIES FOR LONG-TERM ACTION

In regard to critical infrastructure, such as water treatment plants and waste water treatment plants, it may be determined that there is no practical action that can be taken at the time of the flood to protect the asset if the primary flood control structure fails. These critical infrastructure vulnerabilities should still be noted on the map in order to stimulate more effective long-term mitigation action.

RISK ASSESSMENT, MITIGATION, AND DISASTER RESILIENCE

A flood contingency mapping program (in the form of both static and dynamic maps) can also improve community risk assessment and long-term risk management priority setting. It is an unfortunate fact that much critical infrastructure (e.g. waste treatment plants, water systems, and many others) in communities protected by levees or dams has been built without particular regard to the potential failure of those primary flood control structures. In many cases, infrastructure has been built after certification of the primary flood control structure removed any requirement to consider potential flooding in design and construction. Accordingly, new vulnerabilities to infrastructures have arisen affecting the ability of the community, and even region, to rapidly recover if the structure protecting such a facility fails.

To reiterate, one outcome of the collaborative community review of potential flooding scenarios in the map development process will be the identification of critical infrastructure facilities protected by only one line of flood defense. It may be possible to provide adequate additional protection for these key sites by preparing a PED that can be implemented at the time of the emergency if needed. But in many cases planners may determine that creating an improvised line of flood defense after the emergency arrives is not a practical option.

In that latter case, the mapping process may stimulate a regional (strategic) and longer-term approach to reducing infrastructure risk and damage. A flood contingency map program covers large areas that contain regional infrastructure systems. By analyzing the pattern of identified infrastructure vulnerabilities revealed in the mapping process, zones of weaknesses can be identified that would put multiple regional systems at risk if flooded. These chokepoints are created where a local levee or other flood protection structure protects critical infrastructure—such as key sections of transportation lines (road, shipping and rail), electricity transmission, and telecommunications systems among others—whose loss would have regional or even national impacts, or ripple effects on the ability of other critical infrastructures, possibly situated outside of the floodplain, to function.

The identification of such “chokepoints” can form the basis for more sophisticated regional mitigation planning. In these cases of co-located or key regional infrastructure locations, the levee and flood management structures protecting that area may be constructed to higher protective standards than normal. The pre-event placement of additional flood protection (e.g. ring dikes, flood walls, elevation of key equipment) may be justified to provide the highest possible assurance that this key infrastructure will continue to function under the worst scenario. The completion of flood contingency maps would be the foundation for the strategic analysis that would prioritize and justify such expenditures.

The acknowledgement of such critical residual risk vulnerabilities would help prioritize new feasibility studies and mitigation planning. Such improved priority setting would then become a critical part of the ongoing planning and budgeting of infrastructure construction, maintenance and expansion activities and will help ensure that priority regional mitigation projects receive funding.

USING THE MAPS IN AN EMERGENCY

A major advantage of maps is the ease with which digital map files can be shared over great distances and among many different agencies. Just download the file and print the map and suddenly all involved agencies are viewing the same information in the same format. The key to exploiting this advantage is a properly maintained and easily accessible central map repository.

SYSTEMS FOR ACCESSING MAPS

If a dynamic mapping capability has been implemented then a simple FTP site may be created to provide access to map products. In simpler mapping systems a dedicated webpage may be created to provide access to PDF versions of the standard reference maps. Figure 3 displays the main page of a sample flood contingency map website. In the example shown, users can identify desired maps by viewing the map of the jurisdiction or from a tabular list. The website only provides copies of completed maps in a non-modifiable format thereby reducing the potential for unauthorized revisions and changes.

Any dedicated FTP site or website should be maintained by a central agency which maintains the original GIS or CADD digital files. Protocols should be established for accessing the central repository and distributing downloaded maps. Any additional documents created through the flood contingency planning process can also be maintained on the dedicated FTP site or website for rapid and easy access.

HARD COPY MAPS

Once the emergency starts, there will be an immediate demand for hard copy maps for use in discussions and initial situation assessment. Officials operating in the field, in particular, will rely on hard copies of the maps for the typical “hood of the pickup” crisis discussions. There are several issues to keep in mind to ensure that hard copy maps are effectively used and shared in an emergency.

Confirming Use of Current Versions

Numerous copies of the maps will have been printed by many agencies before the emergency for training, exercise, and reference purposes. Accordingly, the maps will be periodically updated and revised. Once actual emergency operations begin, it is important to ensure that only the most up-to-date versions of the standard reference maps are being used. A general rule is to have agencies destroy all hard copies printed prior to the beginning of the incident and download and print new copies from the central repository. Technicians maintaining the website can confirm that all posted files are the most current versions and can change the file names to include the name of the event or the current date. If the standard reference map will be modified and reissued during the emergency, technicians should add version information to the map itself as well as to the name of the map digital file. Establishing such protocols prior to an emergency make it easier for agencies downloading or printing map files to confirm they are using the most current version.

Maximizing Map Durability

Hard copy maps also pose the problem of durability, particularly in harsh field conditions. More durable plotting paper is now available which is very difficult to tear and resists excessive creasing. The use of waterproof ink to print the maps will provide additional durability in wet weather. It should be noted that the more durable paper can generally be used with any map plotter while waterproof ink may require a specialized machine. If availability of such specialized plotters is limited, these can be used to print field maps while less sophisticated machines are used to print maps for use in more benign conditions.

USE OF DIGITAL MAP FILES

If the maps are available as a digital file, they can easily be used for computer, audio-visual, and other electronic displays. Their digital nature makes it easy to isolate, enlarge, and print or display key portions of a map. In some cases, the digital map files can be imported into existing incident management software systems for use with the other features of those systems.

CREATING CUSTOM MAPS

A dynamic mapping capability may have been created as part of the flood contingency mapping program. In this case, map users will need some forms and process for submitting orders for custom maps during an emergency. For a level one dynamic capability simple forms can be created that officials in the field or in the emergency operations centers can use to order modified maps from mapping technicians. Figure 4 shows a sample form.

ADDITIONAL TECHNICAL ISSUES

FILE NAMING PROTOCOLS

Since final maps will be maintained and accessed from digital files, it is important to establish a set of rules for naming these electronic files and the maps they contain. Naming protocols will help ensure that files are properly maintained and that the most correct or most recent map is accessed in an emergency. Figure 5 provides an example of a map and file naming protocol.

STANDARD FOR REPORTING MAP LOCATIONS

In the actual world one finds a wide range of methods used for reporting locations from the field. In the case of levees, engineers may use a system of stationing points, levee miles, and/or river miles to meet day-to-day location reporting needs. Many officials and residents of levee maintaining agencies may tend to report specific locations in relation to well-known landmarks or features in the area. To further complicate the issue, local officials and residents may use local nicknames for prominent features or historic names and sub-divisions for reporting locations. A standard should be established for reporting locations for reference on the flood contingency maps. Such a standard will help ensure that the maps are developed to facilitate the use of the reporting standard. In acknowledgement of human habit, nicknames of features and other colloquialisms may be added to the map for reference.

One standard for reporting position is the US National Grid—essentially an alphanumeric encoding of UTM location values—that is increasingly being used by emergency service providers. GIS and CADD systems can print National Grid coordinate tics on the map margins, or print a grid overlay on top of the map. The advantage of the Grid is that it is efficient since only a few letters and numbers are needed to define a location and the number values represent meters making the calculation of relative distances between locations relatively easy.

Another method for reporting location is the use of longitude/latitude coordinates. While there are disadvantages for using longitude/latitude, the universal use of GPS technology in the field makes the longitude/latitude system imminently practicable. Provision for the failure by field personnel to use the adopted reporting standard can be incorporated into the maps by adding common local landmarks and their nicknames to the map for reference by officials unfamiliar with the area.

COLLECTION OF SENSITIVE DATA AND THE USE OF GEO-IMAGES

One issue with operating a dynamic mapping system is the collection of sensitive data. In many cases, utilities and organizations with proprietary or sensitive data may be reluctant to provide any data at all prior to an emergency. They may refuse to transfer complete geographical datasets under any circumstances. In this case, the use of geo-rectified map images instead of raw data to import information critical to flood fight operations into the mapping system should be developed. The use of the technique described below can help ensure that data needed from these “reluctant” data providers can be obtained in a rapid and effective manner.

The problem with raw GIS/CADD data. (For the following discussion, these datasets are referred to as “geodatabases” – not to be confused with the proprietary Esri product - and their use in GIS systems described.) Geodatabases are composed of spatial primitives (points, lines, or polygons) linked to attributes stored in tables. In the enterprise setting of private infrastructure utility providers, such data are typically very detailed and may be linked to many attributes. The problem for data providers is that such data are typically too revealing—they give exact locations of sensitive and vulnerable features and may reveal too much proprietary information to competitors. Reducing spatial resolution is technically challenging and editing attribute data can be a time consuming task. From the perspective of the data consumer a problem with geodatabases is that raw data needs to be interpreted to be useful for the flood fight. Most likely, it is only the data provider who has the technical knowledge and staff to render risk and vulnerability judgments—not the GIS/CADD staff creating the flood contingency maps. Another difficulty is that while there are open standards for storing raw geodata in files, there are few widely supported standards—many of which are proprietary such as “Esri layer packages”—for storing rendered (interpreted) data: that is data which have been selected, manipulated, combined and graphically rendered with colors and symbols to indicate, for example, system vulnerability to flooding. One solution, the real-time sharing of interpreted data (maps) over the Internet, has problems too since typically such services are difficult to set up, may require proprietary servers and clients, and often have performance problems.

Solving the problem with geo-images. However, virtually all GIS and CADD systems can produce rendered geographic data as image files such as jpegs and tiffs that can be shared via ftp. The security advantage of such images is that they cannot be scaled beyond their pixel resolution and they contain no attribute information other than the colors and labels used in their production. Also, most GIS and CADD systems can bring in such images into the layer stack; thus, the flood contingency map staff can use these to improve their maps of flood fighting problems and opportunities. The only technical issue to resolve is that they be must be produced with agreed-upon projection, coordinate system and geo-location attributes. There are several open standards for these files—geo-tiffs, geo-jpegs, and supplementary Esri “world files”. Communication between the GIS/CADD staff and potential data providers can easily resolve the technical requirements.

ADVANCED GEOGRAPHICAL INFORMATION SYSTEM FUNCTIONALITY

Developers of a dynamic mapping program may also want to take advantage of the powerful functionalities of Geographical Information Systems if they are using one of those systems to create the flood contingency maps. GIS databases can be exploited for storage and rapid access to other flood response information such as separate preliminary engineering designs for flood containment options shown on the maps. Map data can also be manipulated to produce additional useful data, e.g. best traffic routing or distances between map objects. An example is described below.

Advanced traffic infrastructure vulnerability assessment

In 2012, University of California, Berkeley, professor John Radke and his associates used a GIS network model to predict changes in emergency service availability during flooding events in the Sacramento-San Joaquin Delta. His method used data typically found on emergency-management GIS servers: elevation data, roads and fire station locations (fire stations are typical emergency service providers). An accessibility index was calculated by dividing the fire station 30-minute service areas (based on travel times over the road network) by the number of households in each such area. In a simulated event, his method removed roads from the network as flooding progressed (modeled from elevation data) and generated new 30 minute service areas and new service indexes. During real events, as flood information comes in, his methodology can produce maps of altered service availability, isolated areas and stranded emergency service facilities. Radke’s method is an example advanced infrastructure network analysis and can be implemented on most GIS systems, with map output distributed via online GIS services and ftp map distribution.

AUTOCAD (CADD) to GIS CONVERSION

Autocad (CADD) software is commonly used in engineering firms for development of technical drawings and maps. It may be necessary in some cases to allow an agency developing one of the flood contingency maps to use CADD software for initial production of the map file. However, all maps developed with CADD software should be produced in a manner to facilitate ultimate conversion to a GIS format if needed. CADD technical specifications must be developed to address "storage" as well as "presentation" requirements. The recommended requirements below are not intended to restrict the visual presentation of the data, but rather to dictate the internal storage requirements necessary to facilitate the conversion of CADD data into GIS systems. Visual presentation may differ from storage through the use of hidden layers, masking, or other such techniques. CADD users should use the following additional specifications to ensure maximum compatibility with GIS systems.

File Format

At a minimum, the CADD drawing will be made available in DXF and DWG formats. (Autodesk AutoCAD R14 or later, including 2000 and 2004, or equivalent).

Coordinate Systems

Real-world features present in the drawing will be stored in a projected coordinate system that matches the County's internal standards. Real-world features will never be stored in "paper space" coordinates, or any other arbitrary coordinate systems.

Projection Standards

Coordinate System: State Plane Coordinate System (SPCS) of 1983
Horizontal Datum: North American Datum 1983 (NAD83)
Horizontal Units: US Survey Foot
Vertical Datum: North American Vertical Datum 1988 (NAVD88)
Vertical Units: US Survey Foot

Point Features

Examples: levee break locations, gauging stations, mileage markers, spot elevations, logistics bases, staging/supply bases, etc.

- Each "class" of point feature will be placed on a separate layer dedicated and descriptively named for that class of feature. For example, gauging stations will occupy a separate layer from mileage markers.

- Additionally, whenever required to logically identify the characteristics of a single feature, that feature will be placed on a separate and dedicated layer descriptively named for that specific feature. For example, staging locations associated with a particular flood event separate from those of other flood events.
- Each point feature will be represented by a literal point object in the CADD drawing. For example, it is not sufficient to merely indicate the presence of a point feature with label text and a leader - the feature labeled and pointed to must exist as a true point.

Linear Features

Examples: levee locations, relief cuts, contour lines, rivers, canals, ditches, etc.

- Each "class" of linear feature will be placed on a separate layer dedicated and descriptively named for that class of feature. For example, contour lines will occupy a separate layer from rivers.
- Additionally, whenever required to logically identify the characteristics of a single feature, that feature will be placed on a separate and dedicated layer descriptively named for that specific feature. For example, an abandoned levee that no longer exists separate from existing levees.
- Each linear feature will be completely drawn and be unbroken throughout its length, e.g., contour lines will not be broken into multiple pieces where text labels occur.

Areal Features

Examples: historical flooded area boundaries, flooded area projections, reclamation district boundaries, etc.

- Each "class" of areal feature will be placed on a separate layer dedicated and descriptively named for that class of feature.
- Additionally, whenever required to logically identify the characteristics of a single feature, that feature will be placed on a separate and dedicated layer descriptively named for that specific feature. For example, overlapping historical flood boundaries separate from each other.
- Each areal feature will be completely drawn and be contiguous throughout its area. For example, overlapping flood boundaries will not be clipped at the area of intersection.

Annotation/Marginalia

Examples: drawing borders, title blocks, text blocks and labels within the drawing area, any other non-real-world points/lines/polygons.

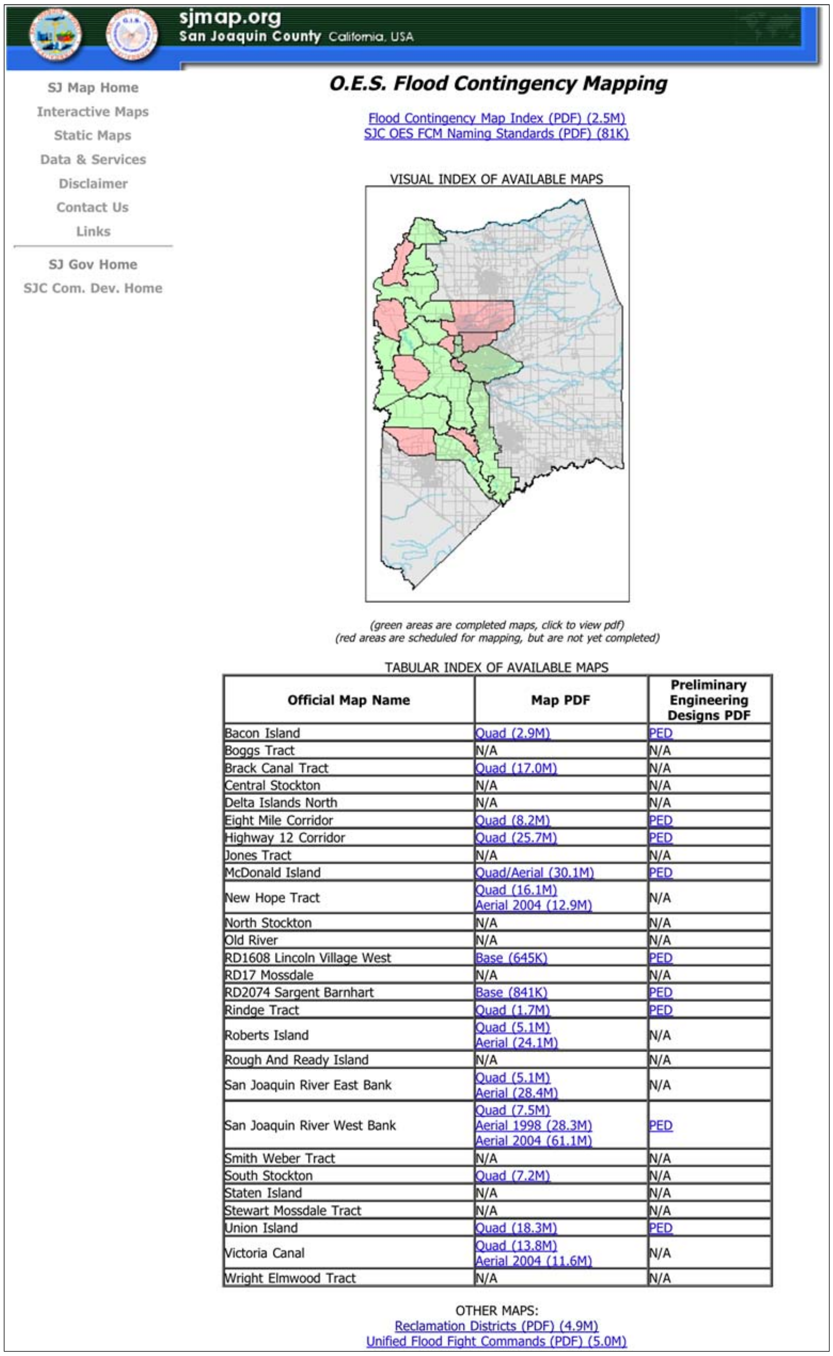
- All such non-real-world features will occupy layers separate from the layers that contain real-world features.

- It is suggested, though not required, that such features be further categorized into meaningful layers. For example, drawing borders will occupy a separate layer from text blocks containing historical flood documentation.

Documentation

A description of the contents and purpose of each drawing layer present in the CADD drawing file will be provided. A member of the drafting team will be available to answer questions regarding the identity, purpose and/or characteristics of any CADD drawing entity whose identity/purpose/characteristics are unclear after conversion into GIS.

Figure 3: Flood Contingency Map Website



sjmap.org
San Joaquin County California, USA

SJ Map Home
Interactive Maps
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Data & Services
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SJC Com. Dev. Home

O.E.S. Flood Contingency Mapping

Flood Contingency Map Index (PDF) (2.5M)
SJC OES FCM Naming Standards (PDF) (81K)

VISUAL INDEX OF AVAILABLE MAPS

(green areas are completed maps, click to view pdf)
(red areas are scheduled for mapping, but are not yet completed)

TABULAR INDEX OF AVAILABLE MAPS

Official Map Name	Map PDF	Preliminary Engineering Designs PDF
Bacon Island	Quad (2.9M)	PED
Boggs Tract	N/A	N/A
Brack Canal Tract	Quad (17.0M)	N/A
Central Stockton	N/A	N/A
Delta Islands North	N/A	N/A
Eight Mile Corridor	Quad (8.2M)	PED
Highway 12 Corridor	Quad (25.7M)	PED
Jones Tract	N/A	N/A
McDonald Island	Quad/Aerial (30.1M)	PED
New Hope Tract	Quad (16.1M) Aerial 2004 (12.9M)	N/A
North Stockton	N/A	N/A
Old River	N/A	N/A
RD1608 Lincoln Village West	Base (645K)	PED
RD17 Mossdale	N/A	N/A
RD2074 Sargent Barnhart	Base (841K)	PED
Rindge Tract	Quad (1.7M)	PED
Roberts Island	Quad (5.1M) Aerial (24.1M)	N/A
Rough And Ready Island	N/A	N/A
San Joaquin River East Bank	Quad (5.1M) Aerial (28.4M)	N/A
San Joaquin River West Bank	Quad (7.5M) Aerial 1998 (28.3M) Aerial 2004 (61.1M)	PED
Smith Weber Tract	N/A	N/A
South Stockton	Quad (7.2M)	N/A
Staten Island	N/A	N/A
Stewart Mossdale Tract	N/A	N/A
Union Island	Quad (18.3M)	PED
Victoria Canal	Quad (13.8M) Aerial 2004 (11.6M)	N/A
Wright Elmwood Tract	N/A	N/A

OTHER MAPS:
Reclamation Districts (PDF) (4.9M)
Unified Flood Fight Commands (PDF) (5.0M)

Figure 4: Custom Map Order Form

Custom Map Order Form

Instructions: Indicate Layer(s) desired. Forward to EOC Planning/Intelligence Section.

Background: __ Topographical _____ Aerial _____ Other: ______________________

Changes to Current Data Attached: __ YES __ NO New Data Attached: __ YES __ NO

Documents/Maps Attached with new data:____

Copies Needed: ___ Size: __ 8.5x11" __ 11"x17" __ 17x22" __ 22x34" __ 34x44"

Include	Layer#	Map Element	Type
_____	1	Topographic Information and Elevation Contours	Graphic
_____	2	100-Year Flood Elevations	Numeric
_____	3	Levees with Levee Miles/Stationing/River Miles	Numeric
_____	4	Spot Elevations of Levee Crowns	Numeric
_____	5	Profiles of Dry Land Levees/Elevated Freeways	Numeric Ranges
_____	6	Levee Anomalies - Old pipes/known sand lens, etc.	Labeled Symbol
_____	7	Critical Infrastructure - power lines/aqueducts etc.	Symbol
_____	8	Occupied/Unoccupied Structures or Streets	Graphic
_____	9	Flood History Synopsis	Text Box
_____	10	Location of Historic Breaks/Seepage/Erosion	Labeled Symbol
_____	11	Extent of Historic or Calculated Flooding	Graphic
_____	12	Historic water flow patterns and channels	Graphic
_____	13	Levee Maintaining Agency Patrol Plan	Text Box
_____	14	Levee Maintaining Agency Supply Delivery Point	Text Box/Symbol
_____	15	Flood Fight Supply Logistics Base	Labeled Symbol
_____	16	Flood Fight Supply Staging Areas	Labeled Symbol
_____	17	Special Considerations (Past Problems or issues)	Text Box
_____	18	Flood Contingency Options	Text Box
_____	19	Locations of Levee Relief Cuts	Labeled Symbol
_____	20	Locations for Emergency Pumping Stations	Labeled Symbol
_____	21	Locations of potential emergency berms/barriers	Labeled Symbol
_____	22	________________________________	__________
_____	23	________________________________	__________

Figure 5: Map/File Naming Protocol

FLOOD CONTINGENCY MAPPING PROJECT
PUBLISHED MAP FILE FORMAT AND NAMING CONVENTIONS
Rev: 2006-12-13 DB/GIS/SJC

PURPOSE
In order to assure that subsequent revisions of a given map are consistently identified as such for posting to website and use in an emergency.

USAGE
Each engineering firm developing base maps will use the official map name within the map product and in the digital file name.

FORMAT
Published maps shall be delivered in Adobe Portable Document Format (PDF).

DATES
All maps are required to contain an accurate revision date, printed in some obvious location within the marginalia of the map.

DIGITAL FILENAMES
Published maps shall be delivered with filenames according to this convention:

`OfficialMapName_Variation.pdf`

Explanation of Convention:

"OfficialMapName"	- The recognized official map name as shown on Map Index without spaces in proper case
"_Variation"	- Some areas include multiple maps with different background imagery. The variation portion of the filename is used to distinguish those maps from each other. The values are:

_None	*(when there is no imagery background)*
_Quad	*(when the background is USGS DRG Quads)*
_Aerial	*(when the background is aerial photography)*
_AerialYY	*(where YY is a two-digit year, to distinguish when multiple aerial maps exist)*

Figure 5: Map/File Naming Protocol, Continued

“.pdf” - Extension expected of documents in PDF format

MAP NAME CONVENTION

1. Where a map covers a single tract or island (regardless of number of RD's) then the tract/island name is used (e.g. Jones Tract, Roberts Island)
2. Where a map covers a single RD, and that RD is not itself a single named tract/island, then the RD name is used (e.g. RD1608 Lincoln Village West)
3. Where a map covers a large area and multiple tracts, islands, and/or RD's, the name of the area is used (i.e. South Stockton, Highway 12 Corridor, San Joaquin River East Bank)
4. Where a map covers exactly two tracts, and is not an otherwise named area, a combination of tract names is used (e.g. Brack Canal Tracts)

CURRENT OFFICIAL MAP NAMES
See Flood Contingency Map Index.

```
BaconIsland
BrackCanalTract
CentralStockton
EightMileCorridor
Highway12Corridor
JonesTract
McDonaldIsland
NewHopeTract
NorthStockton
OldRiver
RD1608LincolnVillageWest
RD2074SargeantBarnhard
RindgeTract
RobertsIsland
RoughAndReadyIsland
SanJoaquinRiverEastBank
SanJoaquinRiverWestBank
UnionIsland
VictoriaCanal
WrightElmwoodTract
```

Table 1: Map Data Elements

Data Element	Display Type
Topographic	
Topographic Information and Elevation Contours	Graphic
100-year Flood Elevations	Numeric Symbol
Levees with Levee Miles/Stationing/River Miles	Numeric Symbol
Spot Elevations of Levee Crowns	Numeric Symbol
Spot Ground Elevations	Numeric Symbol
Dry Land/Secondary Levees with elevation profiles	Symbol with Numeric Ranges
Elevated Freeways, RR Embankments, etc. with elevation profile	Symbol w/ Numeric Ranges
Levee Anomalies - Old pipes/known sand lens etc.	Labeled Symbol
Critical Infrastructure – e.g. regional power lines, treatment plants	Symbol/Graphic
Occupied/Unoccupied Structures (Rural areas only)	Symbol
Large Hazardous Materials Storage Containers (Rural areas only)	Symbol with Label
Commonly used nicknames for key topographic or other features	Label to background feature
Source/Datum/Methodology for Topographic Information	Text Box
Historical	
Flood History Synopsis (Historic Flows/Dates/Description)	Text Box
Location of Prior Breaks/Seepage/Erosion/Settlement	Labeled Symbol
Extent of Flooding (Historic or 100 year Projections)	Graphic
Historic water flow patterns and historic channels	Graphic

Table 1: Map Data Elements, continued

Emergency Response

Levee Maintaining Agencies Patrol Plan	Text Box
Levee Maintaining Agencies Supply Delivery Points	Text Box and Symbol
Flood Fight Supply Logistics Bases	Labeled Symbol
Flood Fight Supply Staging Areas	Labeled Symbol
Flood Fight Command Post	Symbol
Special Considerations (Past problems or critical issues)	Text Box
Flood Contingency Options (Scenario with Response Options)	Text Box
Locations for Possible Levee Relief Cuts	Labeled Symbol
Locations for placement of emergency pumping stations	Labeled Symbol
Locations of potential emergency berms and barriers	Labeled Symbol
Available Preliminary Engineering Designs	Text Box
Description of Vulnerability to Critical Infrastructure/Assets	Text Box

Table 2: Map Symbols

Symbol	Description	Symbol	Description
XX.X'	100 - YEAR FLOOD ELEVATION FLOOD INSURANCE STUDY	L.M.=1.0 R.M.=1.0 100+00	LEVEE MILE RIVER MILE STATION
B	LOGISTICS BASE	L.C. EL=20.1'	SPOT ELEVATION (SOURCE OF DATA)
	COMMAND POST	PS	MUNICIPAL SANITARY PUMP STATION
DP	SUPPLY DELIVERY POINT SERVING DISTRICT SHOWN	PS	MUNICIPAL STORM PUMP STATION
S	SUPPLY STAGING AREA	PS	RURAL DRAINAGE PUMP STATION
	TEMPORARY LEVEE/ EMERGENCY BERM	PS	SITE FOR EMERGENCY PUMP STATION
	SEEPAGE AREA		WATER WELL
	HISTORIC LEVEE BREACH		MUNICIPAL FACILITIES SANITARY SEWER LINES
	LEVEE BREACH		STORM DRAIN LINES
	RELIEF CUT		WATER LINES
	EROSION AREA	—OH—OH—OH—	OVERHEAD TRANSMISSION LINE
A	LEVEE ACCESS	—UG—UG—UG—	UNDERGROUND PIPELINE
	DRYLAND LEVEE/EMBANKMENT	—GL—GL—GL—	GROUND LEVEL PIPELINE
	DRYLAND LEVEE/EMBANKMENT (LOW OR CRITICAL SECTION)		STRUCTURES
	LEVEE		DISTRICT BOUNDARY
		10.0'	CRITICAL CONTOUR

Table 3: Text Box Borders

Text Box Content	Border Color
PREPAREDNESS	
Communications Plans	Black, Single Line
Flood Fight History	Black, Single Line
Special Considerations	Black, Single Line
Reference to Existing Evacuation Plans	Black, Single Line
LEVEE PATROL	
Levee Patrol Procedures	Blue, Single Line
FLOOD FIGHT PLAN	
Flood Contingency Options	Red, Single Line
Supply Delivery Points	Red, Single Line
Preliminary Engineering Designs Reference	Red, Single Line
Flood Water Removal Plan	Red, Single Line
REFERENCE	
Legend	Black, Double Line
Survey Information	Black, Double Line
Elevation Information or Data	Black, Double Line

Table 4: Standard Reference Map Core Layers Folder

Datasets and Themes	Display Type
"Topography" Dataset Theme	
Elevation Contours	Vector Line Shapes
100-year Flood Elevations	Numeric Symbol
Spot Ground Elevations	Numeric Symbol
Nicknames or Colloquial Names for key topographic features	Label
Source/Datum for topographic information	Text Box
Labels of Names of Topographic Feature	Labels
Levee Access Points	Symbol w/label
"Social Infrastructure" Dataset Theme	
Freeways, RR Embankments, etc.	Vector Shape
Levees with Levee Miles/Stationing/River Miles	Vector Shape
Spot Elevations of Levee Crowns	Numeric Symbol
Dry Land/Secondary Levees	Vector Shape
Levee Anomalies – Old pipes, known sand lens, etc.	Symbol w/label
Subdivision street layouts for urban areas	Vector Shape
Occupied/Unoccupied Structure for rural areas	Symbol
Large Hazardous Materials Storage Containers/Sites	Symbol w/label

Table 4: Standard Reference Map Core Layers Folder
(Continued)

"Critical Infrastructure" Dataset Theme	
Regional power lines, Above/Below Ground	Symbol/Graphic
Major Pipelines – Above/Below Ground or at Grade	Symbol/Graphic
Regional Waste Water Treatment Plants	Symbol w/label
Regional Water Treatment Plants	Symbol w/label
Critical or Control Element of a Critical Infrastructure	Symbol w/label
"Historical" Dataset Theme	
Flood History Synopsis (Historic Flows/Dates/Description)	Text Box
Location of Prior Breaks/Seepage/Erosion/Settlement	Labeled Symbol
Extent of Flooding (Historic or 100 year Projections)	Vector Area Shape
Historic water flow patterns and historic channels	Vector Line Shape
Special Considerations (Past problems or critical issues)	Text Box
"Command and Control" Dataset Theme	
Evacuation Plan - Responsible Agency and Location	Text Box
Communications Plan – Flood Fight communications protocols	Text Box
Pre-Planned Flood Fight Command Post	Symbol
Command or Sub-commands boundaries	Vector Line Shape
Staging Areas (Public Safety)	Symbol w/lable

Table 4: Standard Reference Map Core Layers Folder
(Continued)

"Flood Fight" Dataset Theme	
Levee Maintaining Agencies Levee Patrol Plans	Text Box
Patrol Sectors	Label
Flood Contingency Options	Text Box
Flood Dewatering Plan	Text Box
Location for Relief Cut	Symbol w/label
Location for placement of emergency pumping stations	Symbol w/label
Location of possible emergency berms or barriers	Symbol w/label
Available Flood Fight Tactical Plans (Preliminary Engineering Designs)	Text Box
"Logistics" Dataset Theme	
Levee Maintaining Agencies Resource Delivery Points	Text Box and Symbol
Flood Fight Supply Logistics Bases	Symbol w/label
Flood Fight Supply Staging Areas	Symbol w/label

Table 5: Operational Layers Folder

Datasets and Themes	Display Type
"Response" Dataset Theme	
Locations of Flood Fight Crews	Symbol w/label
Locations of Specialized or Heavy Equipment	Symbol w/label
Locations of camps, bases, or staging areas	Symbol w/label
Command boundaries and operational sub-divisions	Vector Line Shape
Status of public safety actions	Text Box
Summary assessment of threat to Levee Stability	Text Box
"Flood Emergency" Dataset Theme	
Locations of actual breaks	Symbol w/label
Extent of spread of impounded flood waters	Vector Area Shape
Estimated spot depths of impounded flood waters	Symbol w/label
Locations of Active Seepage	Symbol w/label
Locations of Active Erosion	Symbol w/label
Locations of Levee Slippage or Settlement	Symbol w/label
"Critical Infrastructure" Dataset Theme	
Critical Infrastructure Data (Sensitive)	Geo-Image
Critical/Control Elements of Threatened Critical Infrastructure	Geo-Image
Regional Impact summaries from loss of Critical Infrastructure	Text Box