UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HANDBOOK
For
FEDERAL INSURANCE ADMINISTRATION
FLOOD-INSURANCE STUDIES

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CONTENTS

HANDBOOK FOR FIA FLOOD-INSURANCE STUDIES

A flood insurance study, made for the Federal Insurance Administration (FIA) of the Department of Housing and Urban Development (HUD) is an analysis of flood inundation frequency for all flood plains within the corporate limits of the community being studied. The study is an application of surveying, hydrology, and hydraulics to determine flood insurance premium rates. Much of the surveying needed can be done by private firms, either by ground methods or photogrammetry. Contracts are needed to let large surveys but purchase orders can be used for small ones. Photogrammetric stero models, digital regression models, and step-backwater models are needed for most studies. Damage survey data are not involved.

The principal steps in a flood insurance study are: (1) estimate the flood peak discharges at several recurrence intervals in the reach, (2) translate these to flood profiles, (3) outline inundated areas corresponding to 100 and 500 year profiles, (4) adjust the boundaries of these inundated areas according to special FIA procedures, (5) compute flood hazard factors (descriptors of elevation-frequency characteristics), and (6) compute floodway (the channel of a stream and adjacent land areas required to carry and discharge the 100 year flood without increasing flood heights more than a specified amount) boundaries if required. A basic study without floodway is Type 10. The same study with floodway is Type 15. A floodway analysis made for a previous Type 10 study is Type 16.

A short report is prepared that usually takes from four to six months to complete, costs about $1,500 per river mile studied, and requires a project chief with flood-study background and strong support for surveying, computer, drafting, and administrative services. The report contains about four pages of writeup followed by about a dozen graphs, profiles, and maps. The flood hazard map (example in appendix) is the major product and is reproduced and distributed to individual private insurance agents. Principal map features are the 100 and 500 year flood inundation boundaries (ZONE A, ZONE B) and the base-flood elevation lines (water-surface contours of the 100 year flood, usually abbreviated BFE). The base flood elevation is the prime insurance premium factor defined by a flood insurance study. Its specified accuracy is $\pm$0.5 feet. ZONE D is common in reports of large areal extent and covers areas of possible flood hazard which were not studied for one reason or another.

FIA specifies the scope and format of reports. This is done by FIA guidelines which will be distributed from time to time and by conferences with representatives of the federal agencies involved. Each agency maintains its own guidelines and revises them as often as necessary to keep up with changes in FIA's requirements. These Survey Guidelines have been reviewed by FIA and our Surface Water Branch. They can be considered authoritative in general but are not likely to apply to unusual local situations where individual judgement is vital. Serious departures from recommended practices should be cleared in advance by FIA through your Regional Hydraulic Specialist.

BACKGROUND

The National Flood Insurance Act of 1968 made specified amounts of flood insurance, previously unavailable from private insurers, available under federal auspices. One currently important feature is subsidized insurance for existing property sold at "chargeable rates" (one uniform scale throughout the country). Actuarial rates (self supporting) may range from less than to more than ten times chargeable rates. In return for subsidized insurance to existing properties, the Act requires that local governments, usually with state cooperation, adopt and enforce land use regulation measures. The required regulations are designed to avoid or reduce future flood damage. Amendments to the Act include mudslides as flood damage and require mudslide area building restrictions.

Communities apply to FIA for inclusion in the flood insurance program. They must show that certain minimal land use regulations are in effect. They must express intent to adopt additional specified measures. Upon acceptance of a community's application, FIA provides a temporary "emergency program" under which local insurance agents sell insurance at subsidized rates for up to full value of some structures and contents. FIA then arranges for a flood insurance study of the community, generally by the Survey, Corps, SCS, TVA, NOAA, or consulting engineering firms. The completed study is the basis for determination of actuarial rates and a factor in establishing land use control measures. The remaining insurance can then be sold at actuarial rates and the community has six months to enact the land use ordinances. After December 31, 1973, under existing law, no properties can be newly insured or have policies renewed except those in communities for which actuarial rates have been established.

Flood insurance studies indicate approximate zones inundated by the 100 and 500 year floods, mostly for zoning purposes. They also furnish information from which two insurance parameters can be determined. These factors are (1) elevation of 100 year flood at any point in the study area, and (2) flood hazard factor, a descriptor of flood range and frequency. Insurance applicants provide information on building types and first floor elevations. From these data the actuarial insurance premium rate is determined.

ASSIGNMENT OF PROJECTS

Most information about FIA flood insurance studies will be by phone with mail followup from SW Branch personnel to WRD districts as follows:

1. About every two weeks a list of newly accepted applicant communities for flood insurance is sent to districts involved. Each community listed will eventually require an insurance study, possibly by the Survey. This list is only for advance information.

2. About every two months a list of communities scheduled for flood insurance studies is sent to all organizations that make FIA studies. <u>All</u> agencies are invited to indicate their interest or lack of interest in making flood insurance studies for the municipalities shown. They are also asked to list available data pertinent to the study. Do not indicate interest in a study unless you are, or can become, prepared to perform the study. No costs or other estimates are wanted at this time. Replies are usually needed within a week.

3. About a month after the indications of interest are received FIA has selected <u>one</u> agency for each study. The selection, for studies where more than one agency has indicated interest, is based on information shown by previous correspondence and in consideration of cost, quality, and promptness of past reports. The names of communities allocated to the Survey are given to the district involved. A time and cost estimate is requested for each study. These estimates should be based on thorough reconnaissance and carefully prepared work plans. The expense of such preparatory work is substantial but will be recovered when included in the project cost. Two weeks are usually allotted to estimate preparation. FIA intends that an agency consider both the time and cost figures as binding contractual obligations, not ordinarily subject to revision.

4. FIA initiates work orders as their funds permit. The affected districts are notified as soon as the work order has been prepared. It is safe to start work at this time. The complete execution of all documents involved by FIA and the Survey may take months. If contracting-out is necessary before the documents are processed, checking with FIA through your regional hydraulic specialist is advised prior to signing any contracts. Program summaries should be prepared and transmitted at this time.

5. An official notification requesting Project Description or revised Part F should follow in a month or two.

The detailed guidelines that follow are in separate chapters. As HUD's needs and our methods evolve, the guidelines will be revised to correspond. Future revisions will be by chapters rather than the entire guidelines package.

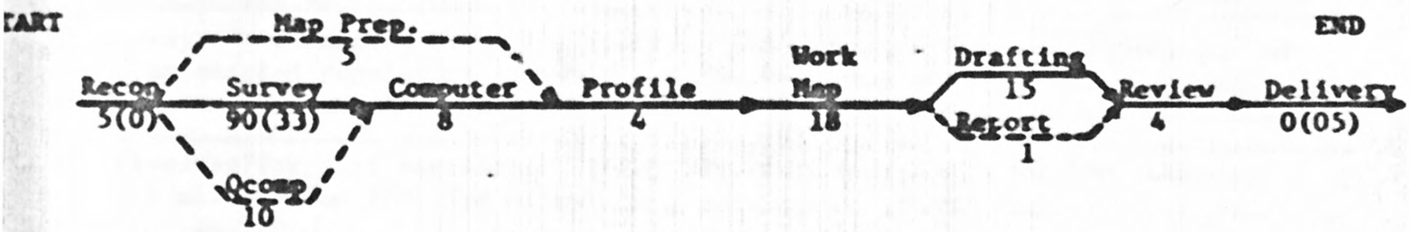
RECONNAISSANCE AND COST ESTIMATES

The reconnaissance is the foundation of a flood insurance study. Whether the study will be excellent or poor, late or early, under or overfinanced, and a rewarding or onerous task is largely determined during the planning stage. "On the site" reconnaissance allows project personnel to collect first-hand flood information and to get a personal perspective of the job at hand. Serious underestimation of time and cost or the omission of high priority problem areas from the study is almost always traceable to "quick and dirty" reconnaissance.

FIA stresses the importance of personal contact with local officials, leading citizens, and the involvement of the state official designated by FIA as state coordinator.

The reconnaissance should also include visits to other agencies and private firms who have active or completed studies in the area. Profiles and base flood elevation lines must agree where two studies adjoin. If both studies are being done at the same time, negotiation of differences is possible. If another agency has a published HUD or similar study for an adjoining area, your study must agree with it unless the reasons for a discrepancy are overwhelming. In this case, the differences should be cleared through FIA before proceeding.

Accurate time and cost estimates are vital to the continued success of FIA studies. Cost less than $1,000 per river mile of narrow channel to be cross sectioned and modelled are probably underestimated. Those costs in excess of $2,000 per mile where the channel is too deep to wade and the overbank is wide are probably overestimated or are planned for closer precision than the ±0.5 ft that FIA wants. Time and cost estimates based on a thorough reconnaissance and some simple critical path method of planning are strongly encouraged. A flow-chart of a typical CPM analysis of a Flood Insurance Study is illustrated below:



Time estimate 87 working days = 20 weeks = 5 months

Cost estimate 160 direct days at $113 = $18,100

Cost per mile of studied channel = $\frac{18,100}{17}$ = $1,070

Cost estimates for small communities should generally be for the complete study area. Any cost estimate over $30,000 requires special handling by FIA. Large areas, such as counties, townships, and major cities should be estimated in phases. Phase I should cover all of the areas of greatest present and potential flood hazard that can be studied for less than $30,000. Phases II and III etc. should cover other areas, in order of priority, that can similarly be studied for increments smaller than $30,000.

The reconnaissance sheet that you are asked to complete is primarily for USGS use in answering any questions that FIA might ask. It is not a binding document furnished to FIA.

RECONNAISANCE REPORT FOR FLOOD INSURANCE STUDY

Community ____________________ State ________________ Type ____

Estimated cost of study from ☐ Work Plan, ☐ CPM Analysis, ☐ Other ________

		Starting Date	Completion Date
Phase 1	Cost ________	____________	____________
Phase 2	Additional Cost ________		____________
Phase 3	Additional Cost ________		____________

Completion date assumes that work will be authorized before ____________

Municipal officials contacted (Name, Title, Date) ____________

State Coordinating Official contacted (Name, Title, Date) ____________

Principal flood problems and locations (may be shown on page-size sketch map)

Other sources of data explored ☐ Corps, ☐ SCS, ☐ NOAA, ☐ Other ________

Planned work:	Miles	No. Cross Sec.
Total channel to be studied		
Total channel to be modeled		
Channel with cross sections furnished by ____________		
Profiles to be computed from USGS historic profile		—
Channel with acceptable historic profile furnished by ________		—
Bridge geometry to be obtained	—	
Control levels to be run		—

Floodway: Community has ☐ no floodway preference, ☐ proposed floodway, or ☐ an enacted regulatory floodway for the following streams ____________

Floodway for ___ ft surcharge (+70, 30, 0% of surcharge) will be computed for all streams profiled except ____________

Base map (sample attached) will have publication scale 1" = _____ ft.

Work maps, contour interval ___ ft., ☐ GS 7 1/2', ☐ GS 15', ☐ Other ____________

Photogrammetry planned with ± ___ ft allowable error

D Zones, if any, anticipated as shown on enclosure ☐ , or ☐ None

Adjacent areas previously studied or being studied by others ____________

Coordination of profiles and T-year peaks planned with, ☐ Corps, ☐ SCS, ☐ ______

Submitted by ____________ Date ________

WORK SCHEDULE FOR HYPOTHETICAL FLOOD INSURANCE STUDY

	Min	Likely	Max	Wt. Av.	Cal. Days
	Time in days				
RECONNAISSANCE					
Map study of area	.5	.5	.5	.5	
Drive to and from	.5	.5	1	.5	
Interview officials	.2	.3	.5	.3	
Get historic flood data	.5	.7	1	.7	
Obtain other agency data	.1	.2	.5	.2	
Select X section sites	.5	.7	1	.7	
Prepare work plan	1	1.4	2	1.4	
Make time and cost estimates	.5	.5	.5	.5	
				5.0	5
URVEYING (3 man party)					
Drive to and from (2 hours)	9	10	12	10	
Run control levels	10	12	15	12	
Run X sections (57 at 1 or 3 per day)	57	63	70	63	
Locate sections on map	.5	.7	1	1	
Prepare punched cards	3	4	5	4	
				90	33
ISCHARGE COMPUTATIONS					
Select best model	.1	.1	.1	.1	
Run drainage areas	4	5	7	500	
Run river distances	.7	.8	1	.8	
Compute basin slope	.7	1	2	1.1	
Compute area lakes and ponds	.1	.1	.2	.1	
Compute other parameters	.2	.3	.4	.3	
Compute 10, 25, 100, 500 Q	1	1.5	2	1.5	
Tabulate results	.5	.6	.7	.6	
				9.5	9.
AP PREPARATION					
Obtain best work map	.2	.3	.4	.3	
Obtain best presentation map	.2	.3	.4	.3	
Select final scale and placement	.2	.3	.4	.3	
Obtain final base map segments	.1	.1	.2	.1	
Prepare profile sheets, plot streambed	3	4	5	4.0	
				5.0	5.
OMPUTER RUN					
Prepare all input data	2	3	4	3	
Travel to and from terminal	1	1.5	2	1.5	
Plot profiles, justify anamolies	1.5	2	3	2	
Scrutinize floodway output	.2	.3	.4	.3	
Reconcile all apparent problems	.2	1	2	1.0	
				7.8	8

WORK SCHEDULE FOR HYPOTHETICAL FLOOD INSURANCE STUDY

	Min	Likely	Max	Wt. Av.	Cal. Days
	Time in days				
PROFILE ANALYSIS					
Select reaches	1.5	2.0	3	2.1	
Compute FHF	.2	.5	1	.5	
Group FHF	.2	.5	1	.5	
Tabulate FHF	.2	.5	1	.5	
				3.6	4
WORK MAP ANALYSIS					
Plot 100-500 zones	3	4.0	6	4.2	
Plot floodway cross sections	.3	.5	1	.5	
Add floodway pips	.2	.5	.7	.5	
Block zone boundaries	8	10	15	10.5	
Plot base-flood elevation lines	1.5	2	4	2.2	
Accent lines for transfer	.5	.5	.5	.5	
				18.4	18
DRAFTING					
Transfer zone boundaries	1.5	2	4	2.2	
Zip-a-tone Zone A	.4	.5	1	5.7	
Transfer base-flood elevation lines	2	3	4	3.0	
Transfer floodway limits (1.0 and 2.0)	.5	.5	.5	.5	
Apply lettering and dimensions	2	3	5	3 2	
				14.6	15
REPORT					
Write	1	1	2	1.2	1
DISTRICT REVIEW					
Report	.2	.5	1	.5	
Map	1	2	3	2.0	
Revise	0	1	3	1.2	
Assemble	.2	.5	.5	.5	
				4.2	4
MAIL TO WASHINGTON	0	0	0	0	4

PREPARATION OF MAP AND PROFILE SHEETS

Flood insurance studies require work maps on which flood boundaries and river distances are originally determined, presentation maps for the final drafting of flood hazard information, cover sheets which also serve as index maps where presentation maps are on more than one panel, and floodway maps. These maps are best assembled at the start of the project because they may involve long delivery and processing periods and are needed for the surveying and profiling phases. Profile graph sheets with river distances indicated and river crossings plotted will also be needed early in the study.

Work maps.--The USGS topographic 7-1/2 minute quadrangle is usually the most satisfactory map for original delineation of flood information. Some municipalities have large scale, small contour interval maps available and these make ideal work sheets. A few areas have no topographic maps and a planimetric work map must be used. The flood boundaries in the latter case must often be laid out in the field possibly at substantial expense, or they might be based on high water aerial photography if available. Photogrammetry may eliminate the need for special work maps as inundated areas can be delineated directly on the stereo plotter. A more complete discussion of this method and its many advantages is given in the "surveying" chapter.

Presentation maps.-- FIA specifications for the base map, ready for addition of flood hazard information, are:

1. The map must be neat and legible with sharp black lines on a white background.
2. The district shall obtain a letter of release for any copyrighted maps used.
3. The map must reflect up-to-date planimetric features.
4. The scale may be no larger than one inch equals 400 feet in urban areas and no smaller than one inch equals 2,000 feet in undeveloped rural areas.
5. Detail not pertinent to the insurance map should be removed (property lines, block numbers, etc.) for clarity.
6. The community boundary must reflect the current limits of jurisdiction.
7. Water control structures such as levees, flood walls and sea walls must be added to the map, using U.S. Geological Survey symbols.
8. Streets and roads should be depicted by double lines.

One procedure for obtaining such base maps is:

1. Select best available map and determine the degree of enlargement or reduction that will give the fewest panels smaller than 9 7/8 X 14 3/8 inches and the best scale.

2. Cut the map into rectangles that when enlarged or reduced (if necessary) will measure 9-7/8 X 14 3/8

3. Edit map with white opaque fluid

4. Have panels photographed, ask for return of full size negatives (9 7/8 X 14 3/8)

5. Clean up and edit negatives with dark opaque fluid.

6. Have panels printed on mylar with appropriate screen to lighten print.

7. Write or phone SWB representative (E. J. Kennedy) giving number of panels, scale, and a description of layout of panels. Titled mounting sheets and pages of lettering will be prepared from this information and sent to you for later use in final drafting as covered under "Drafting of Presentation Map"

Satisfactory base maps, in order of preference, are:

1. A well drawn planimetric map showing street names that can be clearly read at what will be chosen as publication scale. Such maps are usually available for most small communities. Where an official city map is copyrighted, the municipality can usually furnish a release. If the map was made by a private firm for private sales, the owner may furnish a letter of release for a reasonable fee or may ask so much that the map cannot be used.

   If the best available map is well drawn but poorly lettered (too large, too small, illegible, etc.) the lettering can be whited out or covered with Leroy-lettered labels. Lot lines and similar irrelevances may best be opaqued on the negatives.

   If the best map of a small community is hopeless (single line street symbols, etc.) consideration might be given to tracing it. The inadequate map can be photostated to scale and a tracing made. Plastic road and intersection templates are available to ease the drafting. Redrafting of larger community maps is generally too time consuming to be practical.

2. USGS 7 1/2' quadrangles, paper copy, without contours are satisfactory for larger communities. These maps are available for some quads marked X on some state index maps. They are often out of print and not being replaced. The streams are in blue and must be inked prior to photography or they will not show up on the Mylar print. The excellent drafting of these maps will permit as much as 2x enlargement.

3. USGS 7 1/2' quadrangle chronoflex green line prints can be prepared from the separation prints of most recent maps. Cost of these excellent prints is very high when prepared by the USGS Publications Unit expecially if splicing of several quadrangles is required. Time required may exceed a month. Some prints can be obtained through the Menlo P ark and Denver Map Sales Offices within a week for about $15 per quadrangle and you can do your own splicing.

4. Standard USGS 7 1/2' or 15' quads without woodland overprint. Streams must be inked before printing. The contours are likely to overwhelm the flood hazard information shown on the final maps unless extensive opaqueing and screening of the negatives is used. Continuous red tint for some metropolitan areas will photograph as a large black blob. Maps with this tint require special handling by the printer who should be consulted before such a map is chosen for use.

The chosen map should be cropped at the corporate limits then cut into the least number of rectangular panels required to show the area of the community. If the map is to final scale, the rectangles should not exceed 9-7/8 X 14-3/8 inches. If the map is to be reduced or enlarged, the rectangles should be correspondingly larger or smaller. The panels may be arranged horizontally or vertically or in some combination of both. Size and shape of the community and convenient breakdown into panels are considerations in choosing a scale.

Flood-insurance studies are too costly to warrant inclusion of irrelevant or low priority areas. In order to keep cost within reason, most of a county or large township may be classified as area of unknown flood hazard (ZONE D) and not studied. This imposes a complication. The outer edges of the area actually studied are usually in areas of minimal flood hazard (ZONE C). A ZONE C must be completely enclosed by a Zone boundary and Zone boundaries should coincide with landmarks, usually roads or streets. The outer edges of all maps for partially studied communities must be in ZONE D. The limits of the area covered by such maps, or sets of maps, should be chosen with landmark roads in mind so that a ZONE D - ZONE C boundary can be drawn inside the map limits.

Printing on Mylar is a photographic process. It provides two opportunities for editing, one on the original and one on the negative. Editing of lettering is best done with white opaqueing fluid or white stick-on labels on the original map prior to photography. Removal of lines and large areas of detail is often easier with dark opaqueing fluid, on the negative, or for fine detail with ink. Spotting and removal of shadows around labels is best done on the negative. Ineligible areas (incorporated towns within a county or township being studied) should print out faintly on the final map. To accomplish this the ineligible area should be covered exactly <u>on the negative</u> with Zip-A-Tone Screen No. 600-70B(60 line 70% background black), or on the original with Zip-A-Tone Screen No. 600-30W (white printing, transparent dots).

Almost all maps will benefit from overall screening of the negative. Printers usually have an assortment of screens that can be inserted between the negative and the sensitized Mylar used for the print. The screen will cause all black lines and areas to print as a series of dots and appear gray instead of black. The shade of gray and dot texture depends on the screen used. Screens are measured in lines per inch and percent of opaque area. A 90% screen applied to the negative makes a solid black area on the original map print out as 10% black and 90% white on the positive print. The best screen for the better quality original map will have about 60% density. A badly cluttered map with numerous contour lines might require about 90% density screening of the negative. Our final map will be reproduced by FIA using a photo-mechanical process that is not capable of resolving very fine dots. The coarsest screen through which the finest lettering can be read, but no coarser than 80 lines per inch, is usually about right. However, the judgement of the printer after he has seen the actual copy to be reproduced is usually the best guide to screening.

Floodway maps and cover sheets.-- These are not necessarily prepared in advance of the drafting phase of the study and are covered under "Drafting."

Profiles.-- The basic graph sheets, for subsequent plotting of profiles, should be prepared at this time. They will be used during the surveying operations to plot low water and stream bed profiles and for quality control of contract work. River stationing is measured on the work maps and landmark locations can be plotted on the profile sheets. Use river miles or river feet for horizontal position rather than a combination of the two. Conventional vertical scales such as one major division equals 1, 2, 5, 10, 20 ft. etc. are much superior to such odd values as 3, 4, etc. If the profile sheets are neatly hand lettered on standard graph paper, further drafting though desirable is not mandatory. The sheets will be completed after the T-year profiles have been defined and coordinated, and will become a part of the report.

SURVEYING

Surveying is a major component of a flood insurance study. It ranges from simple ground procedures to complex photogrammetry. Levels are needed to tie various datums together, to determine mean sea level elevations of high water marks, and for vertical control of photogrammetry. Transit-stadia methods may be used to run cross-section surveys with vertical error tolerance of ±0.5 ft and to locate the cross sections and their zero stations on the maps used. Photogrammetry is often used to measure cross sections and, under some conditions, to delineate flood inundation boundaries on a map directly from the stereo models.

The stream system to be studied in an FIA project includes, as a minimum, all channels with 100 year flood width greater than the following:

1.	Rural areas with low land value	400 feet
2.	Within corporate limits of communities	200 feet
3.	Areas of known, or potential, flood problems	100 feet

The nature of the surveying depends on the method of analysis used and this in turn depends upon the type of community under study. Most communities can be placed in one of four categories.

1. A community that fulfills the following criteria: (a) no floodway analysis required, (b) has only one or two simple streams to be studied, (c) these streams are without constricting bridges or dams, (d) streams have high water marks at horizontal intervals close enough to define profiles of a major flood, and (e) the recurrence interval of the documented flood can be determined. The basic approach in such a study is to define the historic profile from the flood marks, transform it to T-year flood profiles, and delineate flood zones accordingly. The surveying consists of tying in the flood marks by levels.

2. A community similar to the above but with highwater marks too scattered to define a profile within ±0.5 ft. In this case, or wherever a floodway is called for, a step-backwater model will almost always be needed to define the T-year flood profiles. Any floodmarks available are used mainly to verify the stepbackwater model. This type of study may often be done by ground surveying, either by district personnel or under contract. Photogrammetry might be considered for sizeable communities.

3. A community with a complex drainage pattern of streams, all to have floodways delineated. A step-backwater model of the drainage network is needed and photogrammetry is usually called for.

4. A community with some combination of the above situations may require a combination of approaches. For instance, the community may have a major stream against a high bluff or floodwall where no floodway analysis is needed. That stream may have adequate data for historic profile definition. The community may also have a complex tributary network needing floodway delineation. In this case the major stream might be analyzed by use of the historic profile and the tributaries studied by step-backwater model and photogrammetry.

The desired accuracy of final water-surface profiles is, like the cross section levels, ±0.5 ft. A major factor of profile accuracy from step-backwater models is distance between cross sections. Conveyance change, difficult to discern on maps or pictures, should not generally exceed 30 percent between sections. In ground surveying, cost varies directly with number of sections. In photogrammetry, cost is mainly a function of the number of stereo models and distance between cross sections has very little bearing on cost. Experience, available if needed from the Regional Hydraulic Specialist, is the best guide to judgement of optimal section location.

Where ground surveying is used, cross sections are usually run by transit or level and tag line or stadia. Boat equipment and 25 ft rod may be needed. Use of water surface as starting elevation for cross-section levels should be considered where this elevation can be determined within 0.5 ft (relatively flat streams with bench marks near some bridges). This eliminates long lines of cross-country tie-in levels. Where large scale (1"=200 ft±) close contour (2 ft. interval) maps are available, most cross sections can be taken directly from the maps. Very large streams (Mississippi, Ohio, Colorado, Potomac, etc.) cross sections can be obtained, except for the underwater portions, from 5 or 10 ft. interval 7 1/2 min. quad sheets. Extra cross sections and bridge geometry are necessary for most crossings. Sections should also be taken near each gaging station. The step-backwater elevations at the gage can then be compared to the station rating for verification of the field selected "n" values.

Photogrammetry, as used for flood insurance studies, is usually done in two phases, photography and interpretation. Often one firm takes the pictures and another analyzes them but one firm might do both jobs. The flood-prone areas are photographed from an airplane, with a special door or a camera hole through its fuselage, using a precise aerial camera and flown by a crew with special training and skills. Most parts of the country can be photographed only after the snow is gone and before the trees leaf out, or after the leaves have fallen and before snow. Both these times may be short so pre-planning is vital. Aerial photography is impractical in areas where the ground surface is continuously obscured by heavy foliage.

The photographs are studied and locations of cross-section are selected and plotted on the prints. The negatives and prints showing section locations are turned over to the contractor who usually performs the control surveying. The pictures are set in pairs in a stereo plotter and adjusted to form optical models of the covered area. The cross section stations and elevations (above water only) are measured in the stereo model using an accessory that punches out the information on computer cards. A planimetric map with cross sections plotted is an important by-product of the photogrammetric process which usually ends at this point. District personnel run the levels for quality control, usually as part of bridge geometry measurement, and complete the underwater portions of the cross sections.

Datum.--The earth's surface is in a state of movement, even in hard rock areas. The Upper Mississippi Valley is known to have raised as much as six feet in places and the Chicago vicinity has lowered about two feet since precise leveling was started. Rapid subsidence of land surface is common where coal, oil, gas, or ground water is being removed. These phenomena create datum problems in flood insurance studies.

Ordinarily flood hazard map elevations are referred to the same mean sea level datum as was used to prepare the USGS topographic maps of the area. Subsequent re-leveling that indicates differences in bench mark elevations of only a few tenths of a foot should be ignored.

Many states, cities, and counties have their own networks of levels and refer all road and sewer elevations to that datum. The datums of some are arbitrary. Others are mean sea level based on levels run when the network was started many years ago. Municipal bench mark datums are not usually revised when more recent mean sea level data become available. These local networks will often be used to determine flood elevations of insured property. Consequential discrepancies between level networks in the study area should be evaluated during the flood insurance study reconnaissance. They should be discussed in the report and an appropriate note placed on the map. Example: (Base flood elevations are above mean sea level datum of 1929, adjustment of 1954. Elevations referred to municipal datum should be increased by 1.7 feet to correspond).

Where rapid subsidence from water, oil, or gas removal exists in a riverine flood area, it should be ignored as the bench marks probably move at about the same rate as the stream channels. However, if the published national or local bench mark elevations have been updated, this substantial datum difference must be provided for by preparing an appropriate not for inclusion on the map. Subsidence due to collapse of abandoned mines should be considered case by case as it may or may not be a factor in flood insurance.

Subsidence in an area subject to tidal flooding is a serious problem. As tidal land settles the flood-prone area increases, sometimes dramatically. If subsidence has occurred since the topographic map was prepared, special consideration is vital. Current elevations of the map contours must be determined before flood zone delineation can be started. Levels may have been run from outside the subsidence area to local bench marks several times over a span of years. An estimate of subsidence rate can be obtained by plotting elevation changes of bench marks against dates of leveling. The average curve through the plotted points can be extended to the present date. The resulting value can be used to adjust contour elevations and for a map notation. Example: (Base Flood Elevations shown were obtained by deducting 2.3 ft, estimated subsidence, from 1959 elevations of NGS and USGS bench marks. See City Engineering Department for corresponding adjustments to other bench-mark elevations). The flood hazard map should represent current conditions. Problems related to future subsidence will be handled as they arise.

All unusual datum problem solutions are best cleared with FIA through your regional hydraulic specialist before proceeding further with the study.

CONTRACTING FOR SURVEYING WORK

The land surveying required for the larger flood insurance studies is substantial and beyond the capacities of most district staffs. Many private firms have highly skilled crews and sophisticated equipment available. They can furnish the surveys at reasonable cost in minimum time. However, if private firms are to be used, development of district skills in procedures for placing open-market purchase orders and negotiating contracts may be necessary. The following guidelines are intended primarily for those districts with little or no past experience in contracting-out survey work. With the guidelines and help with the first few contracts by the Administrative Division arranged by the Regional Hydraulic Specialist through the WRD Administrative Officer, the necessary experience in efficient contract negotiation with private firms can be gained.

The Survey can buy products but not services (without special approvals) from private firms. We can purchase a product that we can describe but not the hours of time to make that product. A district can procure items costing up to $1,000, and a region up to $2,500, on the open market. These limits may be raised in the future but are completely binding now. A purchase must not be "split" so as to keep it under the $1,000 or $2,500 limitations. Larger purchases require contracts. Any substantial purchase by contract or on the open market, requires that potential vendors be given an opportunity for consideration. Purchases between $250 and $5,000 should have supporting information in the files that at least three, and preferably more, vendors were considered or that proposals were invited by posting notices in prominent and logical places for reasonable lengths of time. Purchases over $5,000 should be preceded by publication of a synopsis in the "Commerce Business Daily" published by the Department of Commerce.

Procurements in excess of $2,500 must be handled by the Administrative Division. For these procurements you provide the specifications and they obtain the proposals and proceed with your technical assistance to award a contract. Due to short program time it is advisable to telephone the applicable Administrative Division procurement office in Washington, Denver, or Menlo Park as soon as the requirement is known; i.e. when FIA has requested time and cost proposals. Such an early start should save 15-30 days in processing time. The contact in Washington, D.C. is Mr. Jim Duncan, 202-343-6511. The districts and regions who go to Denver and Menlo Park for procurement assistance should contact the Service and Supply officers for those areas.

The general procedure for procurement of most surveys is (a) prepare statement of work to be done, (b) prepare list of local firms capable and likely to do the work, (c) synopsize the work to be done if applicable, and release through the procurement office a request for proposals with technical portion to be submitted in one envelope and cost proposal in a second envelope, (d) wait the specified interval for proposal preparation, (e) open the proposals and evaluate which, if any, are acceptable, (f) negotiate further for the best offer to the Government if modification of their proposals would result in a more satisfactory job or price, (g) prepare the purchase order or contract.

The item to be purchased should be described so that it cannot be misunderstood. Aerial photography descriptions should include camera type, focal length of lens, negative scale, area to be covered, overlap, photo quality, allowable clouds, snow and foliage, and any other factors whose neglect could lead to rejection of the product. Cross sections, high water marks, or level lines can be illustrated on maps or photographs. The descriptions for ground surveying work need not be as meticulous as for photogrammetry, but accuracy requirements should be stated. The work to be described in contract specifications must be planned in greater detail than is usual for "in shop" work. Planning and describing level lines and cross section surveys by ground methods presents no unusual problems. Planning and describing aerial work requires greater understanding of photogrammetry than most WRD hydrologists have. Help in planning the first job or so can usually be obtained from an aerial photography firm interested in doing the job, or consultation can be arranged through the Regional Hydraulics Specialist. In either case a general knowledge of the factors involved is very helpful.

Photogrammetry, as used for flood insurance studies, requires (1) aerial photographs of adequate scale, clarity, and stereo coverage, (2) ground control to determine scale, (3) optical stereo models of the terrain made by using the photography and control in a stereo plotter, and (4) measurement of the desired cross section data in the model. Precise maps of coins can be made photogrammetrically from close up pictures or 100 ft. contour interval maps can be made from relatively few high altitude photographs. Maximum precision of measurement in an optical model varies directly with flight height of the original photography. Doubling flight height reduces number of stereo models, or photographs, by a factor that may approach 4. Cost of the work depends largely on the number of models. Photography is relatively inexpensive, compilation and control surveying are the main cost items.

Specified accuracy of photogrammetry is its major cost factor, a complex consideration, and is usually thought of by photogrammetrists in terms of contour intervals and National Map Accuracy Standards. These standards include the requirement that 90 percent of the elevations indicated by the contours be correct within half a contour interval. Flood insurance photogrammetry does not ordinarily involve contours but the accuracy requirement can be related to contour intervals. A 4 ft. contour interval limits vertical error tolerance to 2 ft. Contouring is an averaging process. Point elevations are given individual attention and can be determined with about twice the precision of contours. Accordingly, photogrammetry adequate for 4 ft. contours should furnish individual point elevations of cross sections within 1 ft., 90 percent of the time.

Design of photogrammetric operations, assuming the usual 6 inch lens on a modern precision aerial camera, is based on an emperical formula in general use: Contour interval x C Factor = Max Flight Height. This can be written for cross section measurement as: Max height = Allowable error x C Factor x 4.

Maximum height above average terrain, directly related to accuracy, should usually be left up to the contractor where one firm is proposing to do both photography and compilation. If photography alone is being purchased and compilation is likely to be by another firm maximum flight height or minimum scale of photo negative should be specified as well as ownership of the negatives.

C factor is a universally used measure of technical excellence that usually varies between 800 and 1500. Its magnitude depends on the quality and condition of the aerial camera and stereo plotter used as well as the skills and moods of pilot, photographer, stereo compiler, and ground survey crew. Most firms will risk a higher C factor with correspondingly higher flight heights if they control the job from start to finish than they will if they are using some one else's photography or ground control.

Allowable error will be specified as "Ninety percent or more of the elevations read will be within ___ foot of their correct elevations". The value of the error tolerance for flood-insurance work will be between 0.5 and 1.0 ft. The smaller value is the lower practical limit and might be used for small areas of high value land. The larger value is adequate for most large streams and is generally close to the upper practical limit.

FIA uses of flood insurance studies require rounding of elevations to the nearest foot. Accuracy tolerance smaller than ±0.5 ft. is not useful and FIA is unwilling to pay for greater precision. The 100 year flood profile is the major flood insurance parameter. Definition of that profile within ±0.5 ft. is desirable but not always attainable. Profile accuracy depends on errors not only in surveying, but also in 100 year discharge determined from hydrologic studies, errors in Manning's "n" used in the step backwater model, indeterminate energy losses in the stream network, and numerous other factors. For large projects where the cost of 0.5 ft. error work is much greater than for 1.0 ft. tolerance and where the hydrologic basis for T-year flood peak flows is dubious, the higher limit should be considered.

Selection of firm or firms to do the work is important and often difficult. Time limitations imposed by seasonal limits for photography and FIA deadlines for study completions allow little delay. Ordinarily the spring and fall periods when foliage, snow, and shadow conditions are satisfactory are the most pressing deadlines. If the pictures are obtained then, using open-market procedures, minor delays in negotiating a well planned contract for compilation can be tolerated. It is usually best to have the flying done by a firm likely to obtain the compilation contract but ownership of the film by WRD should be specified. This enables other firms to submit proposals for compilation. Lists of firms with records of satisfactory performance, mostly for Topographic Division contracts, are maintained by the procurement offices. Most firms have standard forms 251 (GSA) or other documentation of qualifications on file. Firms without these credentials can establish eligibility to have proposals considered by writing to the SWB representative (E. J. Kennedy) for instructions.

Some communities have been photographed at satisfactory altitudes during recent years. The films are usually owned by the firm who had them made. There may be some advantage, usually time, in having that firm do our work from the existing film. Such a contract is "sole source" and prevents all competition. Contracts of this type have a universally bad reputation and should generally be avoided. If the need is unusually strong a sole source contract may be attempted. However, the documentation needed and delays in approval that accumulate are such as to make the WRD districts use sole source contracts as a last resort only. The district might explore the possibility of purchasing existing photography (prints and diapositives) from the firm that owns it. That firm, if qualified to do the compilation required, should be one of those invited to submit proposals for a contract.

Specifications describe what we want done. A proposal offers to comply with those specifications with equipment described and within a time deadline. Some alternatives may be proposed. Price figures are kept sealed in a separate envelope which will not be opened until the proposals have been ranked in order of technical desirability. Upon completion of the technical ranking and consideration of price, a decision is made as to the successful offeror by the project leader and the contracts representative. The decision and reasons for it are kept for the record. Once the contract is approved, it is signed and the work may be started.

After the specified results are received from the contractor, quality control work is done by district personnel. This operation is usually combined with cross section completion (underwater portions) and measurement of bridge geometry. Profiles of highway and rail crossing fills should be included with other cross sections in the contract. These should be resurveyed by district personnel when the bridges are measured. Cross sections near bench marks should also be rerun. Comparison of ground survey results with the contractor's will be adequate quality checks in most cases. Profiles of the contractor's waters edge elevations at all cross sections compared to those determined by USGS personnel for completion of the underwater portions of the sections make another valid quality check. Agreement within specified accuracy is expected. An evaluation of the contractor's work should be sent to the procurement officer involved and to SWB representative (E. J. Kennedy). It will be considered in future awards.

Typical procedure for WRD district personnel using photogrammetry.--

The following procedure is applicable where one firm does the entire job, photography, control, and compilation, all under one contract. This is the quickest, best, and least expensive method where it can be used. Its only drawback is that the work cannot be started until the contract is awarded. Seasonal limitations on photography may require that the area be flown sooner than the four to six week contract letting time will permit. If photography must be obtained immediately, it can usually be purchased by open market procedures and eliminated from the contract specifications.

1. Contact the appropriate contracts office in Washington, Denver, or Menlo Park as soon as it is apparent that a photogrammetry contract will be needed. The WRD Administrative Officer (Mr. Barrick) and Regional Hydraulics Specialist should also be alerted. This is usually done immediately after the reconnaisance. Do not wait for FIA's final authorization of the work for this first step. The contracts office will help you locare firms capable to do photogrammetry and can help, if necessary, to determine qualifications of any local firms interested in the job. Contact the firms most likely to do the work and obtain expressions of interest.

2. Determine, on a reproducible map, the minimum areas to be covered by the photography. This area should include the estimated 500-year flood plains and enough additional area to ensure a substantial margin of safety, should your estimates later prove to be conservative.

3. Determine the degree of accuracy required and the output needed for the flood insurance study. Prepare specifications.

4. Send to the appropriate contracts office a DI-1 (requisition) accompanied by the reproducible map, specifications, and list of firms who have expressed interest. The transmittal memorandum should request that the contracts office prepare all additional material necessary to send to the qualified firms but to hold them until you have FIA's verbal notice that a HUD work order is in process. When you notify the contracts office to proceed they will send out invitations to submit proposals for the work. Proposals from the firms will be requested in two envelopes, one for the technical proposal and a separate one for the price. An opening date, about 20 days later, will be set.

5. The proposals are opened, preferably in the procurement office of an Administrative Division Center in Washington, Denver, or Menlo Park on the date and at the time previously set. Where this is impractical the Regional Hydraulics Specialist's or District Chief's office might be used by experienced personnel for small contracts. One proposal might be accepted at the opening but more often the best proposal requires further negotiation and subsequent meetings with representatives of some of the firms. In some instances, usually where the district is surprised at the high cost of either the specified accuracy or of some innocent sounding extra items (model resetting, contours, map drafting), the best proposal is more than double the figure finally negotiated for a simpler but adequate job. Expert technical and procurement advice and assistance is extremely valuable at the opening and with subsequent negotiation. It can also help us to avoid an uncomfortable confrontation with an indignant representative of a firm possibly accompanied by his congressman.

6. After a proposal is chosen (possibly weeks after the opening if negotiation is required when all firms within the zone of contention have been given a chance to negotiate for revised specifications) a contract is signed with the winning firm and work can be started. The work order from FIA must have been received by the Survey, but not necessarily processed, before the contract is signed.

7. Upon receipt of the specified photographic prints from the contractor a portion of the prints, chosen for minimum overlap, should be assembled to form a mosaic of the area and checked for complete coverage of specified area. Cross section locations should be plotted in one color on the mosaic. Indicate in another color all streets, roads, landmarks, section corners, etc. to be plotted on the planimetric map. Some provision, either on the prints or in the specifications should be made to define the limits of the cross sections. It is usually best to err on the high side, as additional length of section costs almost nothing while subsequent manual surveying is costly. The prints with the above items plotted are returned to the contractor and a similar set retained by the district for subsequent checking of the planimetric map.

8. Upon receipt of the cross section data and planimetric map from the contractor, quality checks must be made promptly and before the receiving report is signed and final payment made. The cross section locations should agree with those indicated on the aerial photography, and the accuracy should be as specified. The quality check is usually combined with measurement of bridge geometry and underwater segments of the cross sections. Profile sheets (scales, river distance of landmarks only at this stage) prepared earlier in the study are first needed at this point. Water-surface elevations shown by the contractor's cross sections plus any determined by the district in the process of measuring the underwater portions should be plotted on prints of the pre-prepared profile sheets.

Any major anomolies should be evident on these plots. Contractor's cross section data (above water portion), plotted before district field work starts, are helpful in the field when the underwater work is being done. The plots can be completed as the work is done and confusion in stationing eliminated. The quality check points can be plotted and evaluated in the field at substantial saving of time and return trips. The cross section plots will also be needed later during the floodway analysis.

9. The contractor's involvement usually ends with satisfactory quality checks and the district chief's signature on the receiving report. However, some additional work is specified in some contracts. After the 100 and 500 year flood profiles have been computed, existing maps may be inadequate to delineate flood boundaries. The profiles may be given to the contractor who will reset his optical stereo models. The boundaries corresponding to the profiles can be plotted on the planimetric map directly from the stereo model. This may be very expensive where many models are involved and should be done only after considering available alternatives. Most firms have excellent drafting facilities and can prepare final maps. This also is expensive and may yield a better product than FIA wants to pay for.

Typical procedure for Photogrammetry Contractor.--(Total job by one firm).

1. Prepare a proposal, priced in separate envelope, to (a) obtain stereo photographic coverage of the areas indicated on a map furnished by USGS adequate to define point elevations to the specified accuracy, (b) make the necessary ground surveys for vertical and horizontal control of the model, (c) furnish cross section station and elevation data for stream valley and channel (above water portion) cross sections at locations to be indicated on the photographs, and (d) planimetric map of the covered area (pencil or print on scale stable material). The proposal will be required within about 20 days of arrival of specifications.

2. Assuming the best proposal and award of a contract, furnish a 2x film positive and two 2x paper prints of each photograph. A set of paper prints will be returned with cross section locations plotted and landmarks to be included on the planimetric map indicated.

3. Furnish cross section information and map specified to complete job.

4. Receive final payment after quality check of work by USGS.

Typical specifications for photogrammetry.--(Total job by one firm, ±1 foot accuracy)

PART I. STATEMENT OF WORK

The contractor shall furnish all facilities, equipment, personnel, and services (except as otherwise set forth herein) to perform the work described herein below:

A. General

The purpose of the work is to provide information required for administration of the Federal Flood Insurance Program for the community of , . The engineering study to be conducted by the U.S. Geological Survey will include computation of flood profiles for the 10, 25, 50, 100, and 500 year floods, determination of areas flooded by the 100 and 500 year floods, and determination of boundaries of a preliminary floodway. The specifications as set forth in Part B below provide for obtaining some of the data, by photogrammetric techniques, needed to calculate the flood characteristics of the streams in the community. The data required are stream channel and valley cross sections, and a planimetric map of the stream channels and flood plains.

B. Specifications

1. The contractor shall obtain aerial photography of the area outlined on the attached map by a 6-inch precision mapping camera at photo scale of approximately 1 inch = 800 ft. The photography must be adequate to determine ground elevations within limits of plus or minus one foot in a stereo plotter.

2. The contractor shall perform necessary field surveys to obtain vertical photogrammetric control, with at least four control points in each model with elevations above mean sea level datum of 1929, adjustment of , determined within plus or minus 0.4 ft. Absolute horizontal position is not essential and existing government control may be used where available. If horizontal control must be established by the contractor, it should be adequate to obtain the vertical accuracy specified in paragraph B5 and to ensure uniform scale throughout the project.

3. The following applies to the performance of the contract. Wherever the term "Technical Officer" is used it is meant that the Government's authorized designee will perform the task or service there described.

4. The Technical Officer will use 2x enlargements of the photographs furnished by the contractor to designate the position and approximate termini of each cross section to be measured and each feature to be plotted on a map. Final termini of each cross section will be determined by the contractor based on elevations or heights above streambed furnished by the Technical Officer. A total of not more than   cross sections will be required.

5. Using a precise stereo plotter the contractor will measure a profile for each cross section. Elevations will be taken at all significant breaks along the profile, with no adjacent points separated horizontally by more than   ft. The information will be listed in a format provided by the Technical Officer to indicate position and elevation. Ninety (90) or more percent of the elevations read shall be within one (1) foot of their correct elevations.

6. A planimetric map of the entire area outlined on the attached map will be compiled in pencil on scale-stable matte finish material. The scale shall be 1" =   ft and the map furnished on a set of sheets of a size specified by the Technical Officer. Features shown on the map will be cross section locations, stream channels, streets, highways, railroads, and other significant landmarks. Those features to be shown will be marked by the Technical Officer on the photographs.

7. A map showing the areas to be included in the contract is attached. It is for informational purposes only.

PART II. PERIOD OF PERFORMANCE AND DELIVERY

The contract is to be completed on or before   . The preceding delivery date is predicated upon contract award on or before   and return of photographs with cross section locations marked thereon within ten (10) working days from receipt of these photographs. The specified delivery date will be extended by the number of days past   in which the contract is in fact awarded plus the number of working days more than 10 that elapses between Technical Officer's receipt and return of the photographs. The finished material will be delivered FOB Destination to:

U.S. Geological Survey
Water Resources Division
____
____
____

Model letter of invitation to indicate interest.-- This model represents a letter to a firm whose name is on the list of those qualified.

Gentlemen:

The ______________ District of the Water Resources Division, U.S. Geological Survey, makes flood insurance studies from time to time. These studies require photogrammetry to define elevations of stream and valley cross sections to mean sea level datum. We expect to have this work done by contract. Photography may or may not be included in the contracts but control surveying will be.

The cross sections will be measured by use of equipment that will furnish point elevations with 90% within ±1 ft, from a negative scale no smaller than 1 inch = 800 feet. Cross sections of the valleys will describe the channel below the 500 year flood elevation. End products will be a planimetric strip map, scale 1 inch = 400 ft, on reproducible film positive made from the map compilation manuscript, and a set of computer cards or tabulation of cross-section stations and elevations. The map will show the low water channels of the streams, some landmarks, and the cross-section locations.

If you are interested in performing these services and want to be considered for negotiating a contract, please let me know.

____

District Chief, WRD

PEAK FLOW DETERMINATION

Peak discharges for the 10, 25, 50, 100, and 500 year floods, for all reaches of the studied streams, are the basis for the computed corresponding T-year profiles. The peak discharges should be computed by using the "best available methods." Scores of methods and variations of methods qualify as "best available" in some areas. The choices are up to the district, subject to some general policy constraints. Policy at present is contained in WRC Bulletin 15 with the options given in that bulletin amplified in Surface Water Branch Technical Memoranda Nos. 70.08, 72.04, and others that may be circulated.

Most flood-insurance studies involve a stream or two with gaging station records at points in the general vicinity, and several small ungaged streams. The four principal steps used to compute peak flow are (a) review of flood-frequency reports for the area, (b) computation of T-year peaks at gaged points, (c) use of point data to compute flood frequency of gaged streams at other points in the study, (d) use of flood-frequency reports or other studies to compute T-year peaks for ungaged streams, and (e) coordination of results with relevant federal, state, and private organizations prior to use.

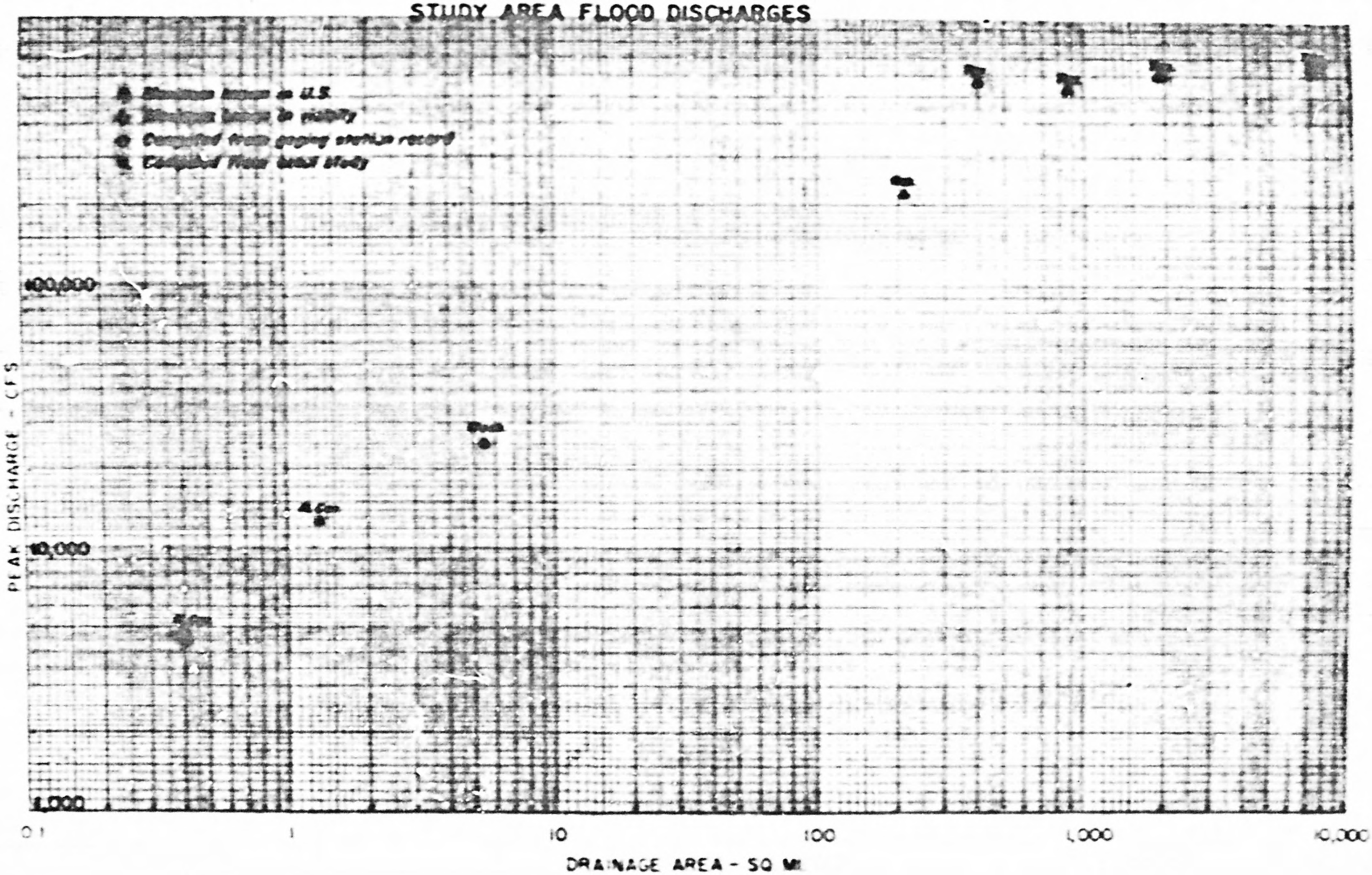
Flood-insurance studies and local flood reports by the Corps, SCS, and the Survey have been published for many areas. Flood-hazard information submitted to FIA sometimes conflicts with this published material. Flood insurance studies submitted by different organizations for adjacent communities often show major discrepancies at the common boundaries. These situations can lead to serious problems for FIA. They ask us to coordinate our data with all published material and if possible with related flood insurance studies being worked on. Minimal coordination, for use in making current studies compatible with future ones by others, would consist of sending copies of your peak-flow graph or tabulation to all appropriate organizations with a request for comments by a reasonable deadline. Later, after profiles are computed from the peaks, much closer coordination of the 100-yr profiles is necessary. The profile coordination, covered in the "Profiles" chapter is much easier to accomplish if the peak discharges have been coordinated first.

After final figures have been obtained, and primarily for review purposes, they should be plotted on a log sheet of drainage area vs. peak discharge, similar to the example shown. "Maximum known" points can be plotted from information in Chow's "Handbook of Applied Hydrology" (McGraw-Hill), Table 25-I-1 and from local or more recent data. All T-year peaks used for profile computation should be plotted and the sheet included in the final report. Unusual plotting should be discussed in the report such as low and high outliers caused by urbanization, lakes and ponds, anamolous geology, etc. If only one or two streams is involved and the same discharge is used for the entire reach of each stream, the T-year peaks may be tabulated instead of plotted. Drainage areas should be listed also if tabulations are used.

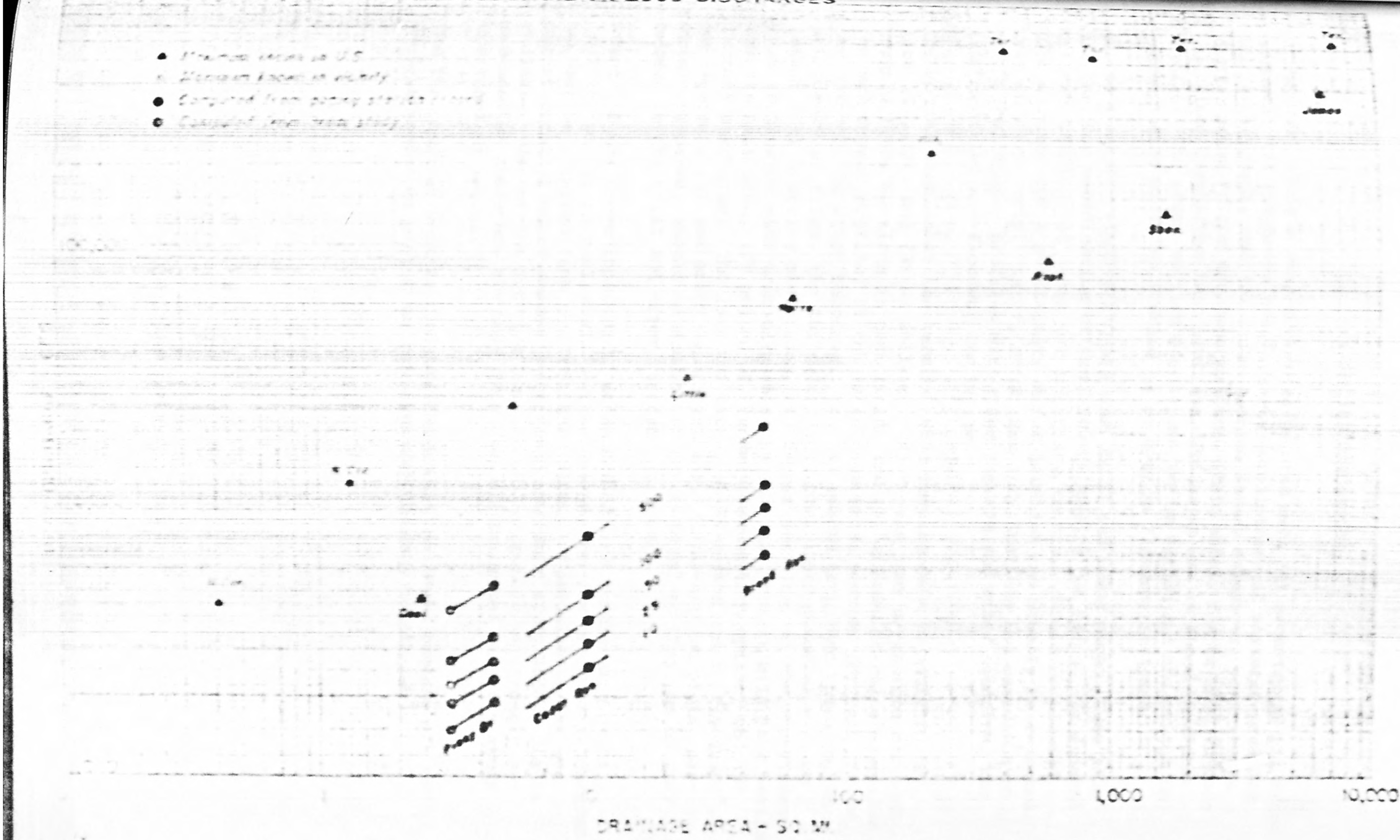
Flood magnitude and frequency of regulated streams should generally be obtained from the organization responsible for operation of the stream system or for the design of its controlling structures. If the furnished data are reasonable they should be used and acknowledged in the report.

The peak flows should provide for any changes (dams, by-passes, relocations, etc.), that will be in effect within six months after study completion. Planned structures that will change the mapped flood hazards within two years but not within six months, and which are partially funded, will require two separate analyses and map sets, one for present and one for future conditions. If the change affects T-year peaks as it would where a new dam is under construction, the design agency's T-year peaks may be used for the study. If the channels will be changed, cross section data may be taken from the construction plans.

STUDY AREA FLOOD DISCHARGES



STUDY AREA FLOOD DISCHARGES



COMPUTER OPERATIONS

A computer, using a step-backwater program with (1) geometry of all cross sections, (2) roughness coefficients (preliminary if historic profiles must be matched), and (3) cross section stream distances, constitutes a digital model of the drainage network. This model, can be used to convert flood discharges into profiles, its major use in flood insurance studies. The cross section dimensions may be varied and the effect on corresponding profiles studied as is done in floodway analysis.

The more complex studies require some trial and error work. This plus the need for coordination of results may require two steps. In general for such studies, at least two trips to a terminal should be planned. Data adequate for a preliminary set of profiles can usually be expected from the first trip. Later, after some modifications and coordination of the preliminary profiles with other reports and other agencies, the final profiles and floodway can be run.

The initial session at the terminal will require data in addition to items (1), (2), and (3) as follows: (4) T-year peak discharges for each group of cross sections in each reach, and (5) assumed starting elevation for each T-year profile, at the downstream cross section for each stream that crosses the study boundary. For the second trip, and based on the preliminary profiles, the following additional input material will be needed: (6) Starting elevations, for T-year profiles, at the downstream cross section on each tributary which is so small that it will peak earlier than the main stem, (7) choice of floodway computation option, and (8) floodway surcharge. The last two items, as discussed under "Floodways", may require trial and error determinations. Cross-section plots, previously prepared, should be brought to the terminal as they can be very helpful in the trial and error floodway analyses.

Format for the above inputs will be described in a forthcoming manual. Until the manual is published, instructions needed for computer procedures can best be obtained from the Regional Hydraulic Specialist or at the nearest terminal where someone with flood insurance study experience is available. Use of the Survey's programs and computers is strongly recommended as these are the only ones that all concerned with the study understand in detail.

When the computer work is finished the printouts should contain all of the data needed to plot final profiles and floodway boundaries.

FLOODWAYS

A floodway is a land-use control measure usually defined as "the channel of a watercourse and adjacent land areas which are required to carry and discharge the floodwater of the watercourse of a regulatory flood without substantially increasing flood heights". A regulatory floodway is one that has been enacted into a community's land-use control ordinances. A regulatory floodway is kept open to carry floodwater and no building or fill is permitted. Flood plain outside the floodway is called "floodway fringe" where building is permitted if protected by fill or floodproofing. Floodways are designed by some state, local, and basin authorities, usually with consideration for legal, economic, and political factors as well as hydraulic analysis. Various river authorities use different regulatory floods and flood-height increases (surcharges) in their floodway design.

The floodway requirement for most FIA flood insurance studies is to furnish a map showing the boundaries of a preliminary floodway defined by hydraulic analysis only. The 100 year is the regulatory flood. Carrying capacity (conveyance) is removed equally from each bank wherever possible. Surcharge is 1.0 foot unless the state or local authority specifies a lesser figure which should be cleared by FIA before use.

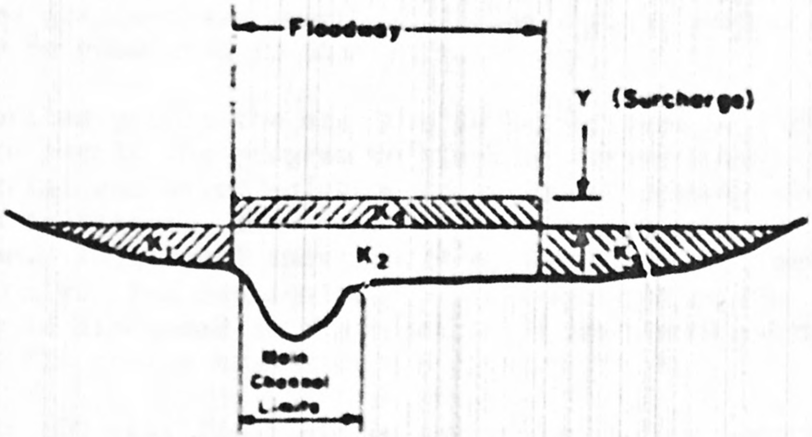
If the community studied already has a regulatory floodway, or even a preliminary or preferred one, that floodway is checked instead of preparing a new one. Such a floodway may have been designed using values of surcharge or regulatory flood discharge unacceptable to FIA. A surcharge profile (surcharge vs. river distance) is prepared using the 100 year flood. The computation involved is much simpler than floodway delineation and a map is generally not needed.

The preliminary floodway map is presented to the community by FIA to illustrate the feasibility of a community floodway. The community may decide not to use a floodway, to use the preliminary floodway as a regulatory one, or may modify the preliminary design using economic and other considerations. If the modified floodway boundaries are outside the preliminary boundaries, the proposed floodway is acceptable to FIA for use in community land-use control ordinances. If the surcharge profile of an existing regulatory floodway does not exceed 1.0 foot at any point, the floodway complies with FIA regulations.

Some parts of some communities may not be suitable for floodway use because of existing development close to the channel. If a floodway is called for in the study, it is usually best to make the floodway analysis for the entire stream system and let FIA decide which areas are not applicable.

Few floodway analyses are routine. Some unique conditions are apparent during the first reconnaissance. A city, where no state or basin flood zoning plan is used, has no jurisdiction beyond it's corporate limits. It may be necessary to bring floodway surcharge to zero at the upstream corporate limits and on boundary streams. Constricted openings of existing bridges can have a dominant influence on floodway design and make the floodway meaningless. A floodway might be computed by ignoring the constrictions but only with prior approval of FIA. Many streams, especially sluggish ones in flat country or where flood plains are narrow, could have their entire flood plains blocked without raising their 100 year flood profiles more than a tenth of a foot or less. For these streams, and those with areas where damage from an additional foot of flooding would be extreme, the relationship of surcharge to floodway width is important. Curves of width vs. surcharge are prepared for all cross sections in urban reaches and for representative cross sections in other reaches. These curves may be omitted where the 1.0 ft surcharge is obviously satisfactory. However, all one-foot surcharge floodways should be run with surcharges of 1.0, 0.7, 0.3, and 0. If a surcharge less than a foot is used the floodway should also be computed using 100, 70, 30, and 0 percent of that value. A zero surcharge floodway is the 100 year flood limit less estuaries and other ponded areas. The extra floodway computations are used to define the width vs. surcharge curves. The same floodway width result for different surcharges indicates invalid solutions (item 3 below) and calls for additional computations with lower surcharge values.

The Survey's floodway analysis is computer based, and is used in conjunction with the step backwater program. The basic concepts are illustrated below:



Computer simulation to determine floodway boundaries starts with a given surcharge, Y. Conveyance is removed from the sides until the following conditions are satisfied

Total conveyance $K = K_1 + K_2 + K_3 = K_2 + K_4$

$$K_1 + K_3 = K_4$$

In addition there are several constraints

1. No conveyance (K_1 or K_3) can be removed from the main channel. (There are exceptions such as very shallow or poorly defined channels)
2. $K_1 = K_3$ until main channel encroachment starts. Then the remaining conveyance is removed from the other overbank area until $K_1 + K_3 = K_4$.
3. If, for a given value of Y, all conveyance is removed except from the main channel, and $K_1 + K_3 \neq K_4$, the solution is invalid for the given Y as a lesser surcharge will give the same boundaries.

After the above conditions have been satisfied the velocity heads for the section under study and the next one downstream are distributed and the corrected elevation of floodway water surface is determined. Some change, usually minor, to the specified surcharge is made in the process.

The program has several options that increase its versatility. They are described in a manual of computer input instructions now being prepared. All Regional Hydraulic Specialists are familiar with floodways and are available for consultation.

After the floodway program has been run it should be carefully scrutinized before proceeding. A profile of indicated surcharge at each section should be plotted. The floodway limits should also be plotted provisionally on the map. If the surcharge profile is reasonably close to and never above the surcharge limit it can be considered satisfactory. If it rises above the surcharge limit further work must be done as the corresponding floodway cannot be used. If the surcharge is substantially less than the limit for very long portions of the reach, the corresponding floodway may not be close to the best that could be run. Very erratic surcharge may indicate too much conveyance change between sections and the need for intermediate sections, actual or synthetic. An erratic floodway width where natural channel and gradient are smooth indicates serious problems and should not ordinarily be submitted in that form.

Program options permit the sections to be narrowed or widened at some sections to permit the program to widen or narrow other sections. This allows a trial and error solution to optimize floodway width and surcharge at various locations. Such trial and error solutions may cost more than their value. In general they should be limited to correction of excess surcharge only. The advisability of further work on the floodway submitted may be discussed in the report. If such work becomes economically justified, FIA or the community can arrange for it.

Curvilinear 100 year flood limits and cross-section locations for the step-backwater model are plotted on a suitable floodway base map. The floodway limits are plotted on each cross section except the approach section for each bridge or similar constriction. Approach sections are treated differently from others and the indicated floodway boundaries are incorrect. The corresponding points in each section are then connected to indicate the floodway boundary for the surcharge programmed. The areas between Zone A and the floodway boundaries are shaded with Zip-a-tone No. 113. As the shading represents potential encroachment areas, do not shade across unstudied tributaries.

Flood analyses are practical only where a step-backwater model is used for T-year flood profiling. A community may have adequate historic information to define the T-year floods without cross-section surveys. If so the surveys would be needed only to make floodway analysis practical. In this event, usually apparent during the reconnaisance, a study without floodway might cost so much less that FIA would elect to forego the floodway. This decision should be made before the cost and time estimate is submitted. Once the FIA work order is prepared the floodway analysis should not be completely or partially omitted without written FIA approval and an understanding on cost adjustment.

PROFILES

Profiles of the stream bed and the 10, 25, 50, 100, and 500 year floods are prepared for the entire drainage network as a basis for inundation boundaries and flood insurance premium rates. The 100 year flood profile is the only one that actually appears (as base flow elevation lines) on the flood hazard map and is one of the principal determinents of flood insurance premium rates.

Most profiles are defined by step-backwater computer models. Others are based on historic profiles transformed by hydraulic analysis into T-year profiles. For both types the point elevations are usually plotted and connected, using the stream bed profile as a guide, to make profiles. The water-surface profiles for each T-year flood should generally be about parallel to each other and to the stream bed. Serious departures from parallel or sudden breaks should be accounted for. For computer derived profiles the reaches between major constrictions and the next cross sections downstream should be closely scrutinized. If such a reach is anomalous, especially if the floodway computation for that reach is irregular also, consideration should be given to surveying or estimating extra sections in that reach before rerunning the program.

When the profiling is complete, the 100 year ones, at least, should be coordinated to eliminate conflict with any report previously published or being prepared by the Survey or any other organization. Where two adjacent flood insurance studies abut, the common points of profiles for the same stream should be identical. If they cannot be made exactly alike FIA should be consulted before proceeding with the study.

Differences can be caused by use of different methods or by different interpretations of the same data. A hydrologic analysis made several years ago may differ substantially from one made recently using additional years of record. Many Survey offices have regional flood frequency reports, state reports, and the flood-frequency relations developed for the 1970 network analysis all available for use. These three studies would furnish three different sets of T-year floods, and they would often produce three 100-year profiles with a spread of more than a foot.

In general, if profiles previously published can be verified by any valid analysis they should be used without modification and the source cited in the write up. If the published profiles cannot be verified, the discrepancy should be taken up with the agency (or Survey author) and an agreement reached for a mutually satisfactory profile. If this fails the appropriate state authority should be consulted and asked for a written opinion. Your recommendation plus the opinions, favorable or contrary to your recommendation, of all consulted should be sent through channels to FIA. They will make a decision which will probably favor the published material unless your position is technically strong and clearly stated.

After coordination the profiles can be considered final. They can then be drafted for inclusion in the report and be used to delineate flood boundaries and compute Flood Hazard Factors.

TIDAL STUDIES

The FIA insures against losses from coastal or tidal flooding as well as river flooding. FIA therefore needs a technical basis for establishing insurance rates and land-use regulations in coastal areas. As in river flood plains, this technical basis is data on water-surface elevations and areal extent of inundation for several selected probabilities of exceedance. There is no need for "floodway" determinations, although FIA will furnish criteria for "high energy" zones where wave action is likely to increase inundation damage.

Coastal flooding is a complex phenomenon and maximum water-surface elevations reflect three additive components--astronomical tide, storm surge, and wave effects. The magnitude of the astronomical tide varies in time and location, reflecting the positions of the sun and moon and the topography of the coast and offshore bottom. Even though the tide magnitudes may range up to 30 or more feet and may change rapidly in short distances, for most of the U.S. coast they can be predicted with considerable reliability. Storm surge is a depth of water added upon the astronomical tide, and is caused primarily by winds piling water against the coast and by reduced atmospheric pressures associated with storms. Wave action results in a surging water surface and the energy of a wind-driven wave may carry the water surface up a beach to a level several feet above the static water-surface elevation. This added onshore wave elevation is called "runup".

The National Weather Service has created a complex computer model that analyzes the tidal flood components separately. Operation of the model requires numerous assumptions, but it has been used to estimate elevations along the open Atlantic Coast of Florida, Georgia, and South Carolina. The model is still under development for estimating water-surface elevations in back bays, behind barrier reef islands, in river mouths, or in estuaries.

The figure on page 37 shows the profiles of several tidal floods for the open coast as determined by operation of the NWS model. These profiles are preliminary and are not by themselves considered a satisfactory basis for flood insurance studies, but they do give an idea of the possible variability of tidal flood profiles.

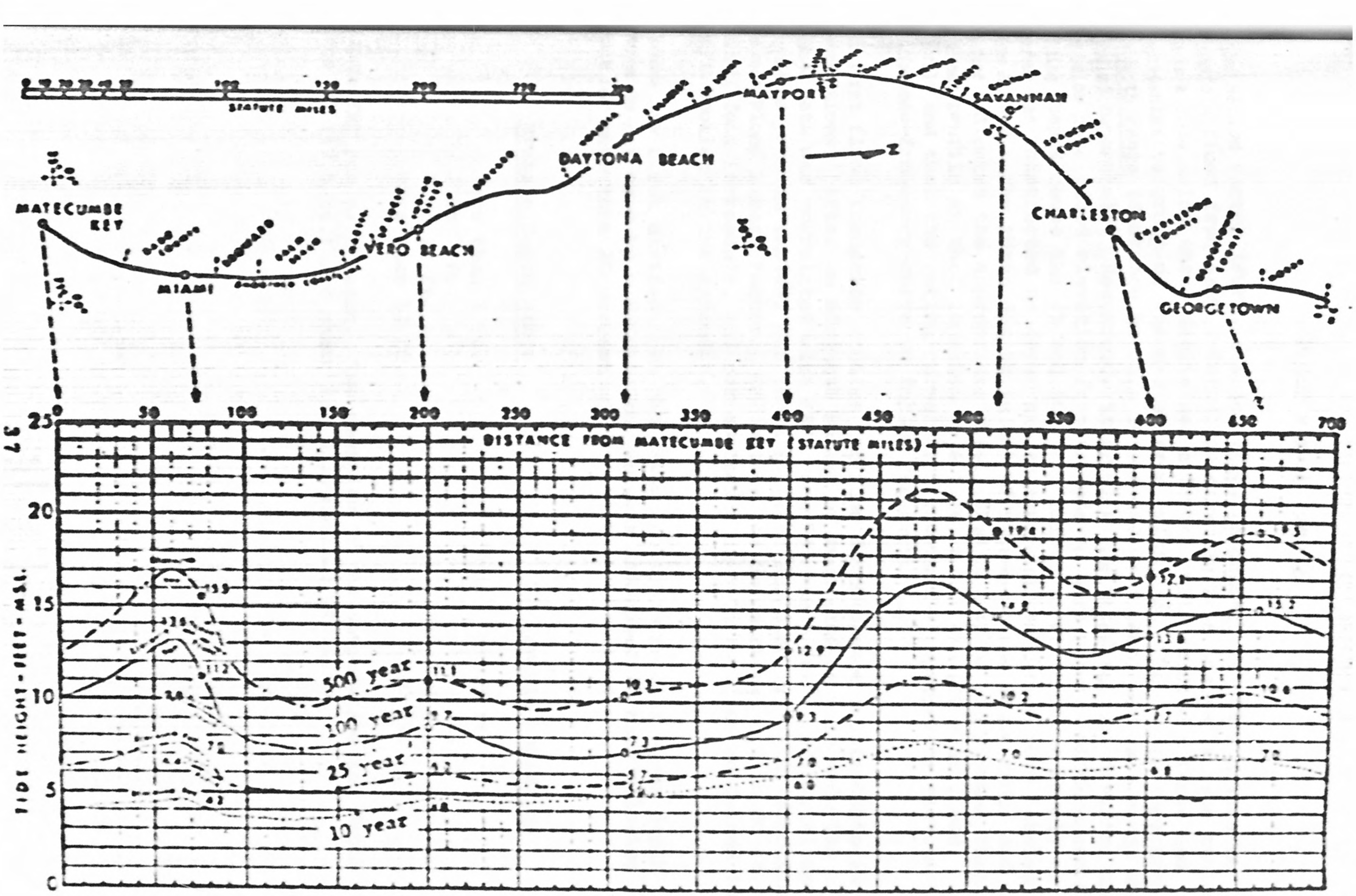
A more direct and more readily usable basis for flood insurance studies in tidal areas is to establish from high-water marks the onshore elevations of past floods and to relate these profiles to frequency of exceedance on the basis of a tidal gaging record. Several factors complicate the determinations of both the profile and the gage frequency relation. The water surface over a large area may not be level. Effects of subsidence-related datum instability on flood marks, historic data, levels, and contour line location, may require consideration. Mean sea level and consequently the T-year flood heights may be changing with time. Tide-frequency analysis is unusual. The two main components: storm surge plus wave runup, and astronomical tide, are statistically unrelated. A major storm surge occurring at low astronomical tide time may cause a much lower water-surface elevation than the same surge added to a high astronomical tide. The high tides, corresponding to a historic flood, at two or more gages nearest the study site may have markedly different recurrence intervals. The difference may cause excessive noise in the correlation of gage and profile data. None of these problems is insurmountable. However, a new area without flood experience may be impossible to study within reasonable expenditures of time and money. Such sites are rare, but those whose historic data require considerable effort and ingenuity to find are common. Many tidal flood insurance studies follow procedures similar to those outlined below:

Records for all relevant NWS long-term gages are assembled. Other records, usually shorter term, collected by the Corps of Engineers and some others may also be useful. A valuable reference is "Harris and Lindsay, 1957, An Index of Tide Gages and Tide Gage Records for the Atlantic and Gulf Coast of the United States": U.S. Department of Commerce, Weather Bureau, National Hurricane Research Project Report 7. This report, and an index of NWS primary tide gage locations can be obtained through State offices of NWS. Records for NWS gages are published on one sheet for thirty years of record at one station. The maximum monthly and annual tides and annual average mean sea level are listed. The annual mean plotted against time indicates variation, if any, in mean sea level. NWS personnel warn that tide gages are often inoperative during the storms of major importance to flood insurance, and the recovered or estimated maxima may not be reliable.

A high-tide frequency curve for each tide gage used is needed. The curve is used to determine recurrence intervals of specific recorded storm tides. One way to define a tide frequency curve is first to adjust all annual high tides to current mean sea level. Surge frequency can then be determined graphically on arithmetic probability paper using (n+1)/M to compute recurrence intervals. Other graphic methods or the log-Pearson III computer program may also be used for most studies. If any log ordinates are involved the computations could be affected by the gage-height scale used, ordinarily mean sea level. The effect of varying gage datum on the magnitudes of the 100 and 500 year tides can then be studied by repeating the computations using gage datums several feet higher. FIA is sponsoring some NWS studies of long-term tidal records that will eventually furnish adequate tide frequency curves for the entire coast.

The recurrence interval for a specific study-site flood is assumed to be the same as that for the corresponding high tide at nearby tide gages. The mean interval from several gages, possibly weighted with distance from site, may be used. Serious discrepancies between correlations may require more intensive study. Graphs of predicted astronomical tidal cycles (generally sine waves) at the gages involved, can be prepared from "Tide Tables". These can be used as indications of the effect of astronomical tide heights on the recorded peaks. From this and similar data a decision can be made whether to use one of the values in disagreement or a mean. The specific storm profiles determined for the site are raised or lowered to obtain the T-year profiles needed. The same slope of frequency curves at site and nearest tide gage is usually assumed. The computed T-year elevations, particularly the 100 year value, must be approved by FIA before being used.

Tsunami (seismic tide) information, if required, will be furnished by FIA. If an area is subject to both tidal and riverene floods, separate analyses are required for each. The highest of the two profiles for each T-year event is used.



Interpolated tide frequencies for the 10-, 25, 100-, and 500-year return period.

FLOOD HAZARD FACTOR

Flood Hazard Factor (FHF), a major study component, is FIA's device to transform flood frequency information directly into insurance rate tables. It is a code using three digits and a letter. FIA studied a large and representative group of stage-discharge relations. These were separated by depth range (distance between 10 and 100 yr floods) and each range was studied separately. Recurrence interval was plotted against distance above or below base flood elevation (see example on next page). Differences in rating shapes cause the 25 and 500 year points to scatter. A family of curves was constructed to cover the scatter and the curves were labeled from A to H. The three digits in an FHF represent the depth range and the letter indicates the appropriate skew. Thus an FHF of 065 D means that the 10 year profile at that location is 6.5 ft. below the 100 year flood profile and that the rating-curve shape causes the appropriate elevation difference-frequency curve to follow FHF curve D.

The first flood insurance studies included depth-damage relationship investigations. After an adequate number of such studies were made the damage data was correlated with FHF. Now FIA has a set of actuarial rate insurance premium tables, one table for each building type, corresponding to each Flood Hazard Factor. FHF curves for depth ranges 0.5 to 20 ft., in half foot increments, and corresponding rate tables, are contained in an FIA booklet in the appendix.

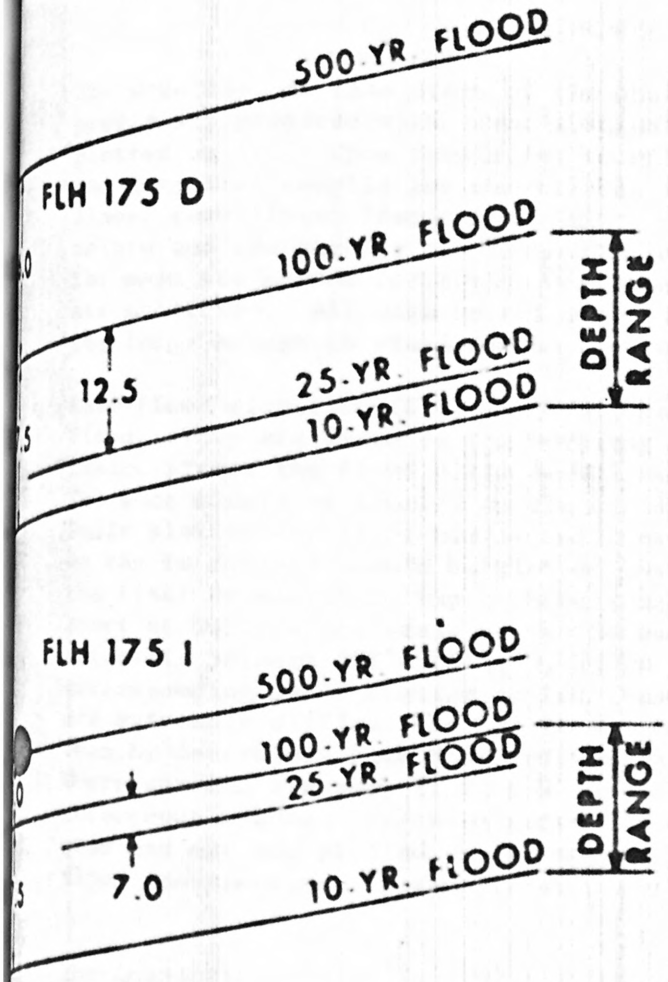
Streams are first divided into the fewest possible reaches whose depth ranges do not vary by more than the amounts indicated in the following table for more than 20 percent of the reach:

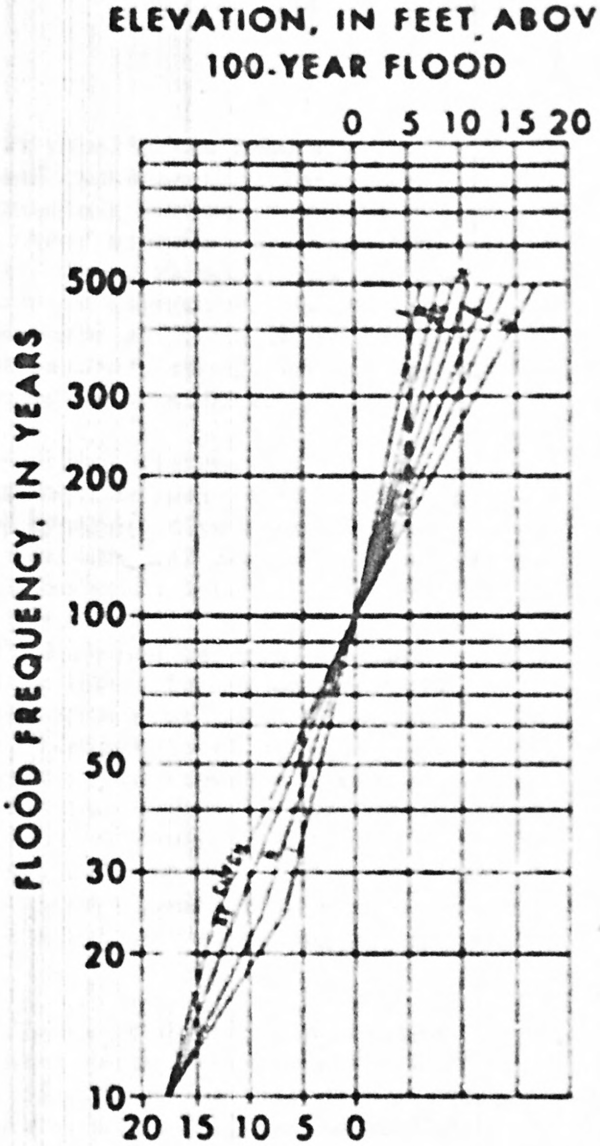
Average Depth Range	Allowable Variation
less than 2 ft.	0.5 ft.
2 to 7 ft.	1.0 ft.
7 to 12 ft.	2.0 ft.
more than 12 ft.	3.0 ft.

Compute FHF for each reach. Two examples of the computation for depth range 175 (17.5 ft.) are shown for hypothetical profiles.

ELEVATION—FREQUENCY CURVES
FLOOD HAZARD FACTOR 175

WATER SURFACE PROFILE





The top profile indicates depth range of 17.5 ft so the FHF digits are 175. The 25-year profile is 12.5 ft below the 100-year. A plot of 12.5 ft on the 25-year frequency indicates that letters CDFG and H will fit. The 500-year profile is 16 ft above the 100 year flood. Plotting of 16 ft at the 500-year frequency indicates that letter D gives best fit. Letter D is one of the choices from the 25-year plot so FHF is 175 D.

The bottom profile also has 17.5 ft as its depth range so FHF digits are 175. The 25-year profile is 7 ft below the 100-year flood. Plotting 7 ft against 25 year frequency indicates that the letter I gives best fit and that B would be satisfactory. The 500-year flood is 5.0 ft above the 100 year. Plotting 5.0 against 500-year frequency gives I as best fit. FHF is 175 I.

Where lower and upper letter designation are in conflict, a common occurrence, the lower should be given the most weight.

WORK MAP

The work map, at this stage of the study, is usually the base map previously prepared with river stationing and cross-section locations plotted on it. Upon completion it will contain a wealth of information and graphical compilation unavailable from other sources (detailed BFE lines, curvilinear inundation limits, etc.). The work maps will involve colors and are usually too large and numerous to reproduce. Copies of the maps are needed for review and other purposes so 35 mm color slides are specified. All work on the maps should be heavy enough and the lettering large enough to stand out on the projected color slides.

Base-flood elevation (BFE) lines are water-surface contours of the 100 year flood. They are drawn on the work map from the 100 year profiles and extended across the flood plain normal to the apparent direction of flow. The ends should be located on the basis of contours, if adequate, and carefully plotted for later use in delineating inundation lines. As many BFE's as can be defined should be plotted though not all will be transferred to the final presentation map. Those transferred should be about an inch apart at publication scale of the presentation map. To accomplish this, intervals between BFE's of 1, 2, 5, or 10 ft. should be chosen and the corresponding BFE's heavied in for transfer. Intervals of 3, 4, 6, etc are extremely difficult for an insurance agent to interpolate between when he determines base flood elevation at a site to the nearest foot. Where streams are very flat, and in tidal areas, BFE may be constant throughout a zone. In these cases BFE's are tabulated on a map index diagram and are not plotted on the maps. Base flood elevation is the prime flood insurance rate parameter and should be given corresponding attention.

The inundation limits for 100 and 500 year floods at each cross section are plotted. The 100 year limit is drawn using these points and the BFE line ends. The 500 year limit is interpolated between cross sections using the contour lines as a guide. If photogrammetry was used, consideration should be given to resetting the optical models and using them to draw the inundation lines. Floodway boundaries may be interpolated between computed locations in each cross section in the same manner as inundation lines.

The 100 and 500 year flood inundation limits, after "blocking" or being moved away from the stream to the nearest landmarks, are used to divide the community into Flood Hazard Zones as follows:

ZONE A Special hazard area subject to inundation by floods of recurrence intervals less than 100 years. This zone is divided into as many subzones (A1, A2, A3, etc.) as there are flood hazard factors.

ZONE V Special hazard area subject to both inundation and velocity damage from wave action in coastal waters only.

ZONE B Moderate hazard area subject to inundation by floods of recurrence intervals between 100 and 500 years. This zone is not further divided.

Zone B1 Moderate hazard area subject to sheet flow or swift shallow flooding, often with extreme velocities. As base-flood profiles cannot be prepared for B1 zones an average curve of depth vs. frequency for all B1 areas must be prepared and included in the study report. The supporting data are usually obtained from documented interviews with long-term residents and depth is measured at center of street. B1 Zones are rare and hard to distinguish from mudslide areas.

ZONE C Minimal hazard area not inundated by floods of less than 500 year recurrence interval and not in mudslide area.

ZONE D Possible hazard area not studied for reasons that are usually economic. Sparsely settled areas of large communities or counties and the portions of streams with 100 year flood widths less than the criteria are the most usual D areas.

ZONE M Special hazard area subject to mudslides. Mudslide data are usually furnished, or the M zones added, by FIA.

ZONE N Moderate hazard from mudslides (data furnished or added by FIA).

ZONE P Possible hazard from mudslides. (data furnished or added by FIA).

An area with both flood and mudslide hazard is designated AM or MA, etc. with predominent hazard indicated first. If study has not called for mudslide hazard identification it should be considered minimal.

Zones should not be narrower than a quarter-inch on the presentation map. Narrower zones should be included in adjacent ones, preferably of higher risk.

All zone boundaries, including those between two "A" subzones, must be locatable on the ground by non-technical people without measuring equipment and dressed in business attire. The zone boundary would ideally be the flood limit but the curving flood limit line is not readily identifiable under the conditions stated above. A zone boundary can usually be moved away from the stream a considerable distance with negligible effect on the insurance process. It cannot be set inside the flood limit at all. The zone boundaries are all "blocked" or moved away from the stream until they coincide with landmarks where possible. Otherwise the boundaries are made parallel to and are dimensioned from landmarks.

Landmarks in order of desirability include streets, highways, railroads, well defined trails, pipelines, transmission lines, well defined toes of slopes and tops of bluffs, and in certain parts of the country well marked section lines. Less desirable but useful landmarks include section lines, the edges of quarter-quarter sections, the well defined low water banks of streams, centerlines of permanent stream channels less than 20 feet wide, and projections of straight landmarks. Landmarks not to be used include unmarked political or all property boundaries, non-permanent fences, the ends of roads otherwise unmarked, and landmark extensions that cannot be seen from the landmarks.

Dimensions should be used with pacing in mind. Multiples of 50 and 250 feet (20 and 100 average paces) are favored. Very long dimensions are permissible if they are along a road where an automobile odometer can be used. Dimensions that would require long pacing over rough terrain or that require crossing a swamp or stream or scaling a bluff are obviously of no value.

In many rural areas there will be no landmark except the stream itself. The usual boundary for this condition is at a fixed distance from the bank or centerline of the stream. Such boundaries can be rapidly and accurately drawn by using a template. The template can be a small sheet of mylar with a pencil point hole surrounded by a circle. The radius of the circle is the scale distance from stream to boundary. The circumference of the circle is kept tangent to the stream bank at one or two points while the pencil traces the boundary. Change from one boundary distance to another must be made at or dimensioned from a landmark.

At some point on a small tributary the A zone may become narrower than the 100 to 400 ft. specified in the "Surveying" chapter. If the A zone width at this point, when plotted to presentation map publication scale, is less than minimum specified width for any zone (1/4"), it should be terminated. The zone end should be referred to a landmark. If wider than a quarter inch the zone should be continued upstream as a D zone until it narrows to a quarter inch and be terminated then. The D zone boundary will be largely estimated and should be plotted on a line obviously well above the 500 year flood limit.

If the B zone is so narrow that the "blocking" process covers it with the A zone, the B zone may be eliminated. If only a few small B zones appear they may be combined with A zones for the entire study area. Where the 100 year flood is contained by both banks of a stream or between two levees, zone boundaries are not necessary. Only the BFE lines need be plotted.

Delineation of zone boundaries is one of the more difficult processes in the flood insurance study. Advantages of available landmarks are balanced against their distances from the flood limits. Boundary location is then chosen by judgement starting with the easier ones along obvious landmarks. The most difficult boundaries might best be delineated in the field.

When all work is complete on the map, material to be transferred to the final flood hazard map should be intensified and all other work and lettering checked for clarity before the color slide is made.

The slides can best be made with a 35 mm single lens reflex camera. A normal lens will usually allow the camera to be brought close enough so that a map taped to the wall will fill the entire frame. A tripod and neutral gray exposure card are very helpful. If four slides of each map are needed, it is usually faster and cheaper to take four pictures of each map instead of getting copies made.

DRAFTING OF PRESENTATION MAP

Flood hazard map.--The presentation map is the end product of the Flood Insurance Study. Quality of the entire study will be judged more by the appearance and workmanship of the presentation map than by the much more difficult hydrologic and hydraulic processes used. Unusual drafting skill is not vital. Most of the work is paste-up and can be well done by anyone with a good sense of composition, a steady hand, and a willingness to adhere closely to FIA s simple specifications. An ideal flood hazard map would be absolutely free of individual style with the flood hazard information standing out boldly from the base and easy for a layman to understand and use.

The following items are sent to the district early in the study:

1. FIA paper map panel with title block and bar scale completed, one per panel.
2. Sheet of standard lettering on wax backed paper, one per panel.
3. FIA cover sheet with title block completed and north arrow attached.

The following items should be obtained locally:

1. Zip-A-Tone shading 112 Do not substitute.
2. Zip-A-Tone dot screen 428 ●●●●●● 429●●●●●●●●● Do not substitute.
3. Zip-A-Tape 226 ——————— Do not substitute.
4. Para-Tipe 4009 (or similar) ◄———
5. Artype No. HR 200C (or similar) ◄———
6. Leroy Template 61 0600 120 C with 000, 00, 0 pens
7. Sheets of adhesive backed (peel off) paper

All drafting can be done with the above materials. Additional equipment is helpful but not vital. Most drafting will consist of applying wax or adhesive backed material to the previously prepared base-map panels. Drafting of ink lines directly on the Mylar should be held to a minimum and that should be done on the side without emulsion so that it can be removed if necessary.

FIA lettering specifications are: All lettering applied by the contractor to flood insurance maps must be (essentially) equivalent to the size and style noted below:

Items	Size and Style	Example
Base flood elevations	12 point italic univers	*732*
Panel Number	18 point univers	10
Index Diagram Numbers	18 point univers	02
Panel "Joins XX"	12 point typewriter (all caps)	JOINS 02
All other (except base map)	12 point univers (all caps)	ZONE A1

Some essentially equivalent letters can be obtained from

1. VARITYPE HEADLINER WITH FONT 12-270
2. PARA-TIPE RUB ON NO 11342
3. LEROY TEMPLATE 61 0600-120C WITH 0 PEN
4. *LEROY 61 0600 WITH 000 PEN FOR BFE ELEV*

(BFE lettering not furnished)

The transfer of material from work map to base map is usually done by tracing if both maps have the same scale. If, as is more common, they have different scales an optical projection device or proportional dividers may be needed.

The zone boundaries are usually placed first, using diagonal strips, cut from the dot pattern sheet most suitable. The dots should be centered on the boundary lines. A dot should be located at every turning point of the boundary and at every intersection point with another boundary. If the boundary symbol obliterates the name of a street or road, that name should be moved. The flood boundary symbol should be omitted when it coincides with a political division boundary (ordinarily the edge of the study area) or where the 100 year flood is contained within both banks of a stream or between two levees. Zip-A-Tone shading is then applied on the back of the mylar to all ZONE A areas (except oceans and Gulf) and cropped 1/16th inch short of the centerline of the boundary symbol. Critical information within the shaded areas may be exposed by cutting neat, rectangular windows in the shading. BFE symbols are placed on the top of the mylar and extended completely across the A ZONES. Each panel requiring base flood elevation symbols should have at least two even if they indicate the same elevation. If BFE is constant within a Zone it should be shown in tabular form on the map index diagram sheet and omitted from the map proper. A Zone label should be placed near the center of each Zone, and should not cover any critical detail. All lettering should be readable from the bottom and right sides of the map panel. Which sides are bottom and right is usually determined by the lettering already present on the base map. Arrows and leaders for Zone labels should be omitted. Many draftsmen (not necessarily USGS) become carried away with extra leaders and giant arrowheads which detract from the map's utility. FIA has decided to add the few arrows that they think are necessary to the maps and to encourage use of conservative stick-on arrows on the flood boundary dimensions that you will apply.

BFE labels, printed with 12 pt italic numerals, are placed on the top side of the map. They should not obscure other information and may be placed to one side and offset with an arrow if necessary. Boundary notes and dimensions should be lettered in standard 12 pt but can be smaller if necessary. Dimension arrows, especially those for short distances from stream centerline to boundary, should be sharp and clear (Artipe-HR 2000) and finer than the landmark pointed to. Heavier arrowheads tend to obscure minor landmarks. Ineligible areas should be labeled and surrounded by a 1/16 inch solid boundary.

When completed, the mylar map is mounted on the furnished paper panel and the north arrow placed, usually near the upper right corner. A reproducible high quality print of the finished map is made and kept as insurance against loss of the original sheet which goes to FIA. The prints for inclusion in the report copies are made from the reproducible copy.

Cover sheet.-- A cover sheet is required for all studies. If more than one flood hazard map panel was used, the cover sheet will also serve as an index map. For one sheet flood hazard maps FIA will print the cover sheet on the reverse side of the flood map and use it to list certain information and the map legend. Much of the cover sheet will be complete when you receive the panel. The principal job in the district is to prepare an index diagram, if required, or for situations where only a portion of an eligible community was studied, an outline map of the entire community with the map panel limits shown

The transfer of material from work map to base map is usually done by tracing if both maps have the same scale. If, as is more common, they have different scales an optical projection device or proportional dividers may be needed.

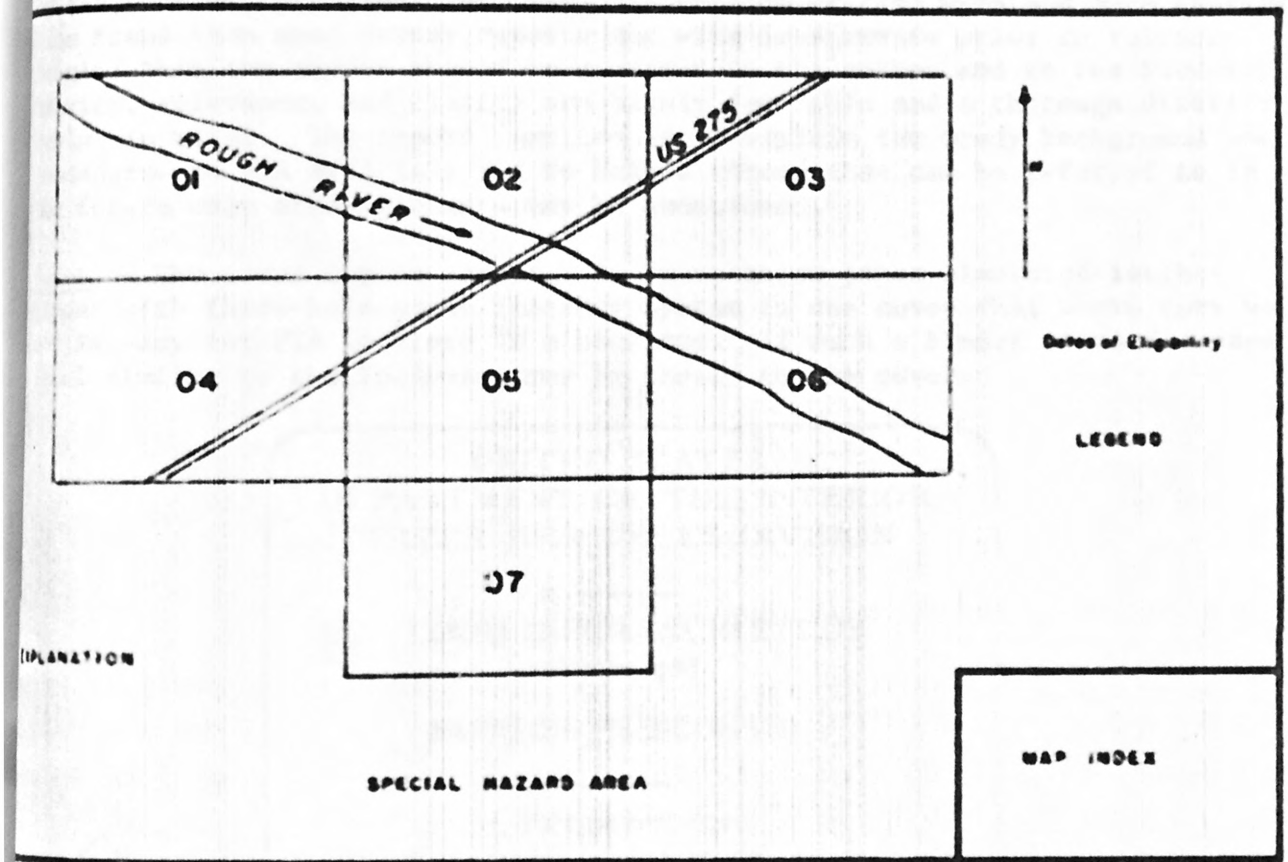
The zone boundaries are usually placed first, using diagonal strips, cut from the dot pattern sheet most suitable. The dots should be centered on the boundary lines. A dot should be located at every turning point of the boundary and at every intersection point with another boundary. If the boundary symbol obliterates the name of a street or road, that name should be moved. The flood boundary symbol should be omitted when it coincides with a political division boundary (ordinarily the edge of the study area) or where the 100 year flood is contained within both banks of a stream or between two levees. Zip-A-Tone shading is then applied on the back of the mylar to all ZONE A areas (except oceans and Gulf) and cropped 1/16th inch short of the centerline of the boundary symbol. Critical information within the shaded areas may be exposed by cutting neat, rectangular windows in the shading. BFE symbols are placed on the top of the mylar and extended completely across the A ZONES. Each panel requiring base flood elevation symbols should have at least two even if they indicate the same elevation. If BFE is constant within a Zone it should be shown in tabular form on the map index diagram sheet and omitted from the map proper. A Zone label should be placed near the center of each Zone, and should not cover any critical detail. All lettering should be readable from the bottom and right sides of the map panel. Which sides are bottom and right is usually determined by the lettering already present on the base map. Arrows and leaders for Zone labels should be omitted. Many draftsmen (not necessarily USGS) become carried away with extra leaders and giant arrowheads which detract from the map's utility. FIA has decided to add the few arrows that they think are necessary to the maps and to encourage use of conservative stick-on arrows on the flood boundary dimensions that you will apply.

BFE labels, printed with 12 pt *italic* numerals, are placed on the top side of the map. They should not obscure other information and may be placed to one side and offset with an arrow if necessary. Boundary notes and dimensions should be lettered in standard 12 pt but can be smaller if necessary. Dimension arrows, especially those for short distances from stream centerline to boundary, should be sharp and clear (Artipe-HR 2000) and finer than the landmark pointed to. Heavier arrowheads tend to obscure minor landmarks. Ineligible areas should be labeled and surrounded by a 1/16 inch solid boundary.

When completed, the mylar map is mounted on the furnished paper panel and the north arrow placed, usually near the upper right corner. A reproducible high quality print of the finished map is made and kept as insurance against loss of the original sheet which goes to FIA. The prints for inclusion in the report copies are made from the reproducible copy.

Cover sheet.-- A cover sheet is required for all studies. If more than one flood hazard map panel was used, the cover sheet will also serve as an index map. For one sheet flood hazard maps FIA will print the cover sheet on the reverse side of the flood map and use it to list certain information and the map legend. Much of the cover sheet will be complete when you receive the panel. The principal job in the district is to prepare an index diagram, if required, or for situations where only a portion of an eligible community was studied, an outline map of the entire community with the map panel limits shown.

The locations and numbers of the panels should be indicated. The panel symbols should be grouped in a diagram or map small enough to fit in the odd shaped space at the center of the cover sheet. If a map is needed one or more ZONE D labels should be mounted. In any event two to four landmarks should be shown on the diagram.



Each panel represents a flood hazard map, numbered in 18 pt characters from left to right and top to bottom. An FIA north arrow should be used. If USGS and district insignia are used they should be on the cover sheet only and waxed for easy removal for final FIA use. Paper, rather than Mylar, is adequate for cover sheet work.

Floodway map.— The floodway map can usually be made from all or part of the presentation base map. The scale should be no larger than 1" = 400' and no smaller than 1" = 1500'. The larger scales are usually preferable. This map will not be published so the drafting need not be on mylar nor so meticulous as on the flood hazard map. The appendix contains a sample floodway map that indicates desired format. The 100 year flood boundaries and locations of cross sections made for the step-backwater model are plotted on the floodway base map. The floodway limits are plotted on each cross section. The corresponding points in each section are then connected with smooth curves to indicate the floodway boundary for the surcharge programmed. The areas between 100-year flood and the floodway boundaries are shaded with Zip-A-Tone No. 112. As the shading represents potential encroachment areas, do not shade across unstudied major tributaries. FIA might best be sent the original of the floodway map also. The floodway boundary symbol is Zip-A-line No. 279-M. The maps should be mounted on standard FIA map panels.

REPORT

The report consists of a cover, frontispiece, text with headings specified by FIA, tables, profiles, and maps. It must be written within a much shorter time frame than most Survey reports and with less review prior to release. Despite this the report should be a credit to the author and to the Survey. Brevity, relevance, and clarity are highly desirable and a thorough district review is vital. The report function is to explain the study background and procedures to FIA officials and to make a record that can be referred to in the future when study elements may be questioned.

Cover.-- The cover may be simple. An inexpensive paper simulated-leather binder with three-hole paper fastener system is one cover that works very well and is easy for FIA to store in a bookcase. If such a binder is used a paper label similar to the following may be pasted to the cover.

UNITED STATES
DEPARTMENT OF THE INTERIOR
WATER RESOURCES DIVISION

FLOOD INSURANCE STUDY
(Type 15)

HUDSON, WISCONSIN

Prepared for

DEPARTMENT OF HOUSING
AND URBAN DEVELOPMENT
FEDERAL INSURANCE AGENCY

Binders with backs thicker than the rest of the report should be avoided. Some districts have prepared standard FIA report binders with art work on the covers. These, though not necessary, compare favorably with reports submitted by other agencies.

Frontispiece.-- This may be similar to the cover label but must contain the inter-agency agreement number. It may give the author's name.

Write up.-- This should be brief and relevant yet complete. Most write ups contain from three to five single spaced sheets. The following headings should be used:

Authorization: "This flood-insurance study of
was made by the Geological Survey at the request of the Federal Insurance Administration of the Department of Housing and Urban Development. It was authorized by Inter Agency Agreement IAA-H-17- , Project Order No. , 197 .

Description of area.-- State the study limits such as "unincorporated areas of   County", unusual features such as covered channels, unusually high or low degrees of urbanization (paved areas), drainage channels paved or covered, flood control structures and their effect on the various streams, problem flood areas, location of low areas likely to be developed, and any other material needed to give the reader a clear understanding of flood conditions.

Available information.-- List all sources of basic data used or considered in the report. Include relevant flood-frequency reports, gaging station records, sources of historic data and their probable reliability, and information from other agencies and consulting firms. Discrepancies in available data and conclusions reached should also be covered.

Description of work.-- Indicate the methods used in hydrologic and hydraulic studies. Unusual methods should be covered in detail. If log-Pearson III analyses were used indicate the skew (data defined, regional, etc.) used and the treatment of outliers and historic floods. Standard methods may be covered with such brief statements as "Water-surface profiles were computed using a step-backwater computer model defined by surveys. The profiles were divided into uniform reaches from which flood-hazard factors were computed". Methods used to compute depth-frequency curves for B1 Zones (sheet flow) should be explained in detail.

Floodway studies.-- Indicate the method used (equal conveyance removed from each bank until main channel reached and from remaining overbank conveyance thereafter"), the surcharge intended, and the maximum practical surcharge indicated by the surcharge-width curves. If computer limitations are apparent in the computed floodway, describe them and make recommendations for further study.

Data Summary.--

Flood Discharges.-- (Page 29)

Profiles.--

Flood Hazard Maps.--

Floodway Data.--

Floodway Width vs. Surcharge Curves

Floodway Maps.--

These should follow the text in formats similar to those illustrated on the following sheets.

Slides.-- The work map slides may be placed in an envelope glued to the inside back cover of the copies requiring slides.

Some flood insurance study results, especially the base flow elevations, are questioned by local people, especially indignant land developers. The report should be complete enough to indicate the reliability of the study. On the other hand it should be brief enough to be readable and avoid long detailed explanation of standard procedures. Even with an excellent report district personnel may be called on, a year or more after the report is distributed, to explain the derivation of the results to local groups. Complete files should be maintained indefinitely.

SUMMARY OF ELEVATION-FREQUENCY DATA, FLOOD HAZARD FACTORS AND BASE FLOOD ELEVATIONS

SAMPLE, MA

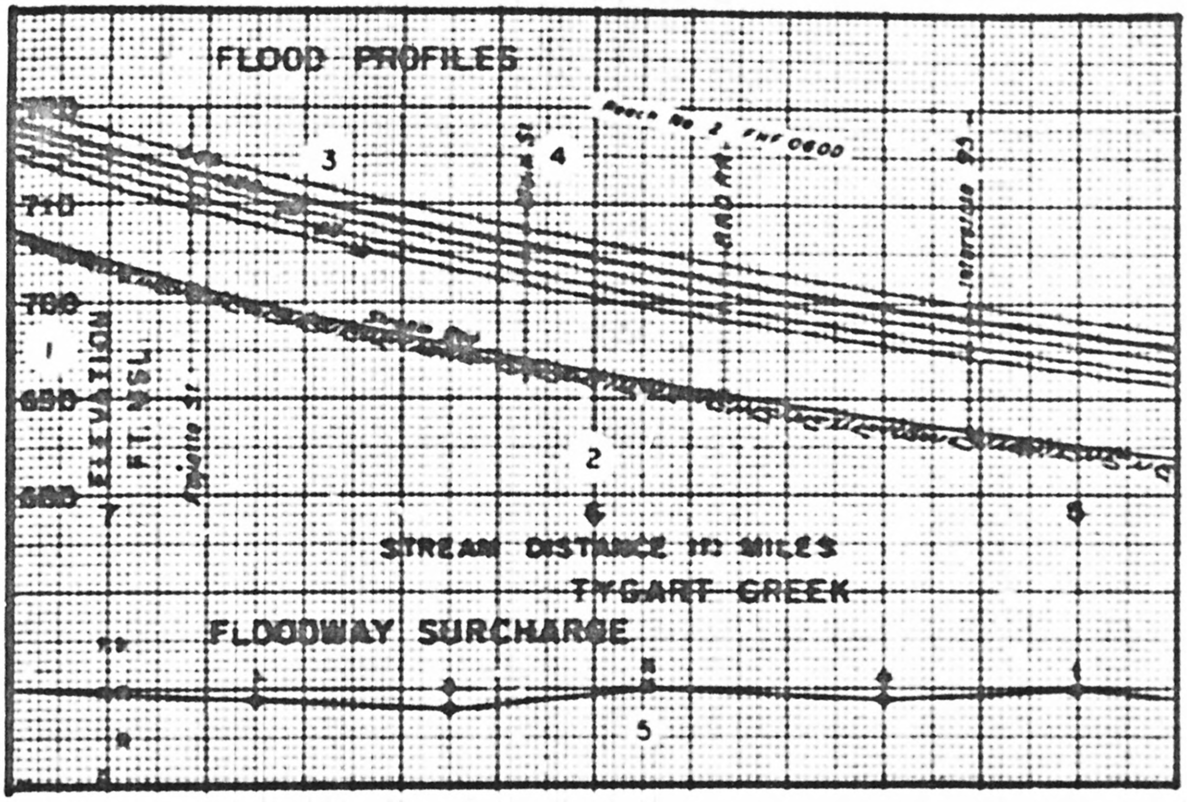
Flooding Source	Reach No.	Zones	Sheet or Panel	Elevation-frequency curve plotting points*				Flood hazard** factor (FHF)	Base Flood Elevation***
				10%	4%	1%	0.2%		
Las Trampas Creek	1	A1	01	-5.6	-3.7	0	5.0	055D	varies
	2	A2	02	-4.8	-3.3	0	5.2	050D	969 MSL
	3	A3		-5.5	-3.7	0	4.3	055C	varies
Las Trampas Creek trib. No. 1	1	A7		-2.4	-1.7	0	1.3	025F	varies
	2	A8		-1.3	- .8	0	.6	015A	980 MSL
Grizzly Creek	1	A9		-3.6	-3.0	0	2.0	035G	varies
	2	A10		-4.0	-3.0	0	2.8	040C	varies

* Weighted average for zone.

** Rounded to nearest 1/2 foot.

*** Rounded to nearest foot.

FLOOD PROFILES



① Select a scale so that the smallest graph division is a multiple of 1, 2, or 5. Other multiples such as 25 or 40 are difficult to plot by using the grid lines.

② Use uniform stationing, either river miles or river feet, but not a mixture of both. Stationing should agree with that plotted on the work map. Scale should be selected as in 1 above.

③ Choose scales so that profiles are no steeper than 30°.

④ Indicate principal landmarks shown on presentation map.

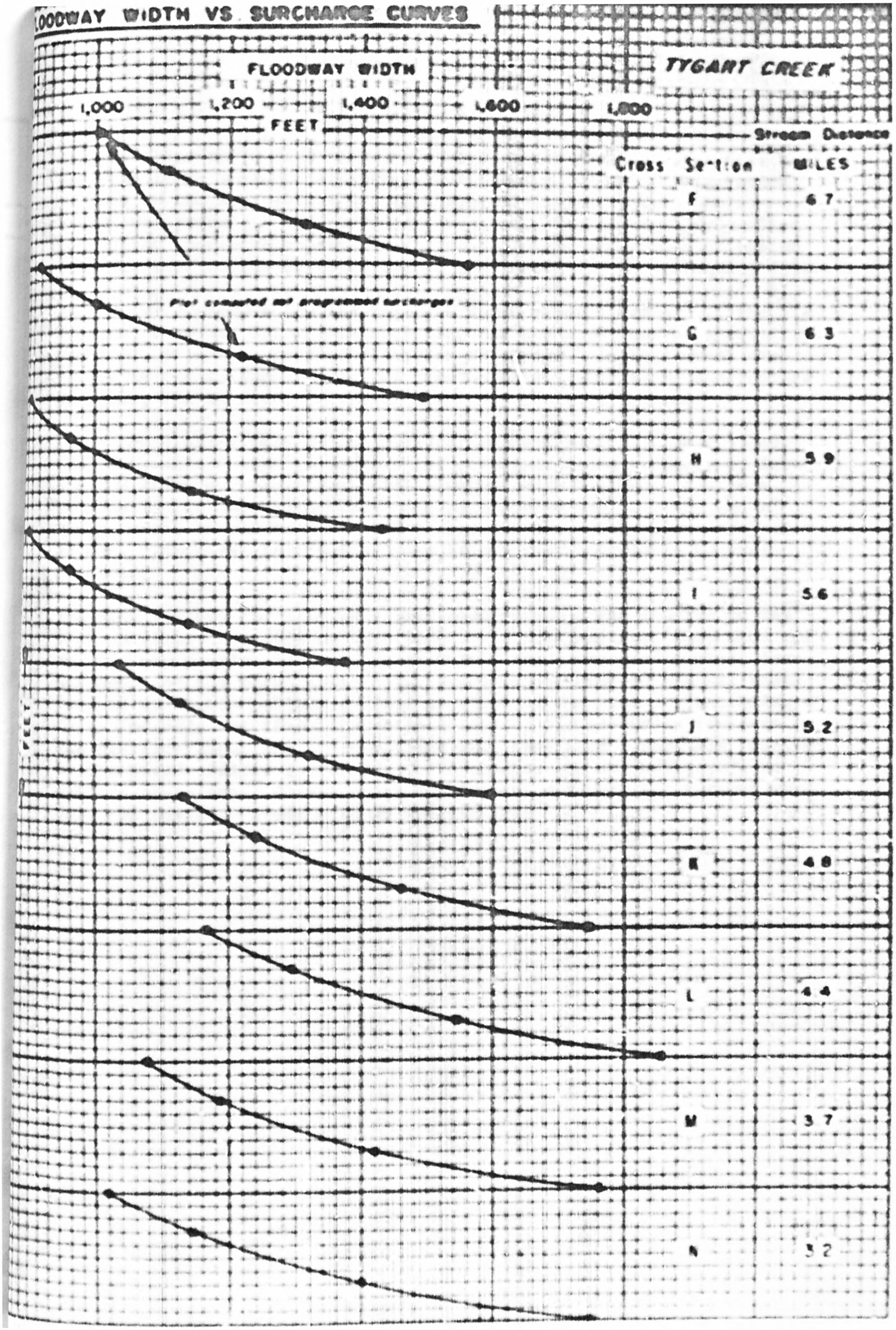
⑤ Plot computed surcharge at each cross section.

6 Do not plot profiles for two streams on one sheet.

FLOODWAY DATA

Cross Section	Stream Dist.	Floodway				W.S. Elev. W.O. Floodway	Surcharge
		Width	Area	Mean Vel.	Wat. Surf. Elev.		
	mi.	ft.	sq. ft.	f.p.s.	ft.	ft.	ft.
Tygart Creek							
*F	6.7	1,050	9,870	4.7	712.8	711.9	0.9
G	6.3	895	10,100	4.6	708.2	707.4	.8
H	5.9	870	9,210	5.0	704.6	703.6	1.0

*FIA prefers letters to numbers. In order they would be, starting downstream, Section A, B, ... Y, Z, AA, AB, . . . AZ, BA, BB, BC etc. The first section would be called Section A, not AA or A-A.


FLOODWAY WIDTH VS SURCHARGE CURVES
FLOODWAY WIDTH
TYGART CREEK
1,000
1,200
1,400
1,600
1,800
FEET
Stream Distance
Cross Section
MILES
F
6 7
Plot computed not programmed surcharges
G
6 3
H
5 9
I
5 6
J
5 2
K
4 8
L
4 4
M
3 7
N
3 2
FEET

Review

All flood insurance studies are reviewed by the Surface Water Branch for compliance with HUD specifications. A memorandum of this review is sent to the appropriate Regional Hydraulics Specialist, who reviews the hydraulics and hydrology involved. The Regional Hydraulics Specialist incorporates the Branch review into a memorandum of review which is sent to the District and to the Branch for the permanent files.

The review procedure usually takes at least several weeks. If the FIA deadline does not allow this much time and the study has no special problems, it can be sent to FIA prior to review. In this event the review is for guidance in future studies only. If a major discrepancy is found, FIA is asked to return the study for modification.

Those few studies that had to be returned were generally ones whose reconnaissance failed to uncover the principal flood problems or for problem areas worked without close contact with Regional or Branch personnel. If unusual problems are encountered the work map and a report draft should be submitted at least a month before the project is due. The first few studies done by any district should be prereviewed.

FIA also reviews the studies. They compare the areas studied to the problem areas indicated on the community's application. They also cut out the map panels and assemble them into one large map to check for agreement on the match lines. The profiles are checked against those for all available published flood profiles in the vicinity including those for adjacent flood insurance studies. FIA generally contacts the district about any discrepancies that they find. Most are resolved by the field offices involved and FIA changes the map and report to reflect revisions. Occasionally FIA returns a report for further work when the revision appears to be substantial.

To: Mr. Earl L. Moss
Federal Insurance Administration
Room 9243 HUD Building
Washington, D.C. 20410

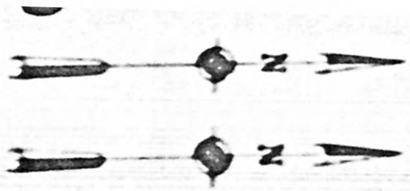
Registered mail: Original drafted flood hazard and floodway map panels.
Regular mail: 15 copies of study (plus 2 unfolded copies of each map).
1 set of slides

Code: 4351 4016
E. J. Kennedy, Staff Hydrologist
Branch of Surface Water, WRD
U.S. Geological Survey
General Services Building
Washington, D.C. 20244

Regular mail: 1 copy of study
1 set of slides

Regional Hydrologist

Regular mail: 1 copy of study
1 set of slides (omit for NE Region)



ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A ZONE A

ZONE B ZONE B ZONE B ZONE B ZONE B ZONE B ZONE B ZONE B ZONE B ZONE B

ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C ZONE C

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ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M ZONE M

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ZONE V ZONE V ZONE V ZONE V ZONE V ZONE V ZONE V ZONE V ZONE V ZONE V

0 1 2 3 4 5 6 7 8 9 10 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

AREA NOT INCLUDED AREA NOT INCLUDED AREA NOT INCLUDED AREA NOT INCLUDED

CORPORATE LIMITS CORPORATE LIMITS CORPORATE LIMITS CORPORATE LIMITS

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

JANUARY JANUARY FEBRUARY FEBRUARY MARCH MARCH APRIL APRIL APRIL MAY MAY MAY JUNE JUNE

JULY JULY AUGUST AUGUST SEPTEMBER SEPTEMBER OCTOBER OCTOBER NOVEMBER NOVEMBER DECEMBER DECEMBER

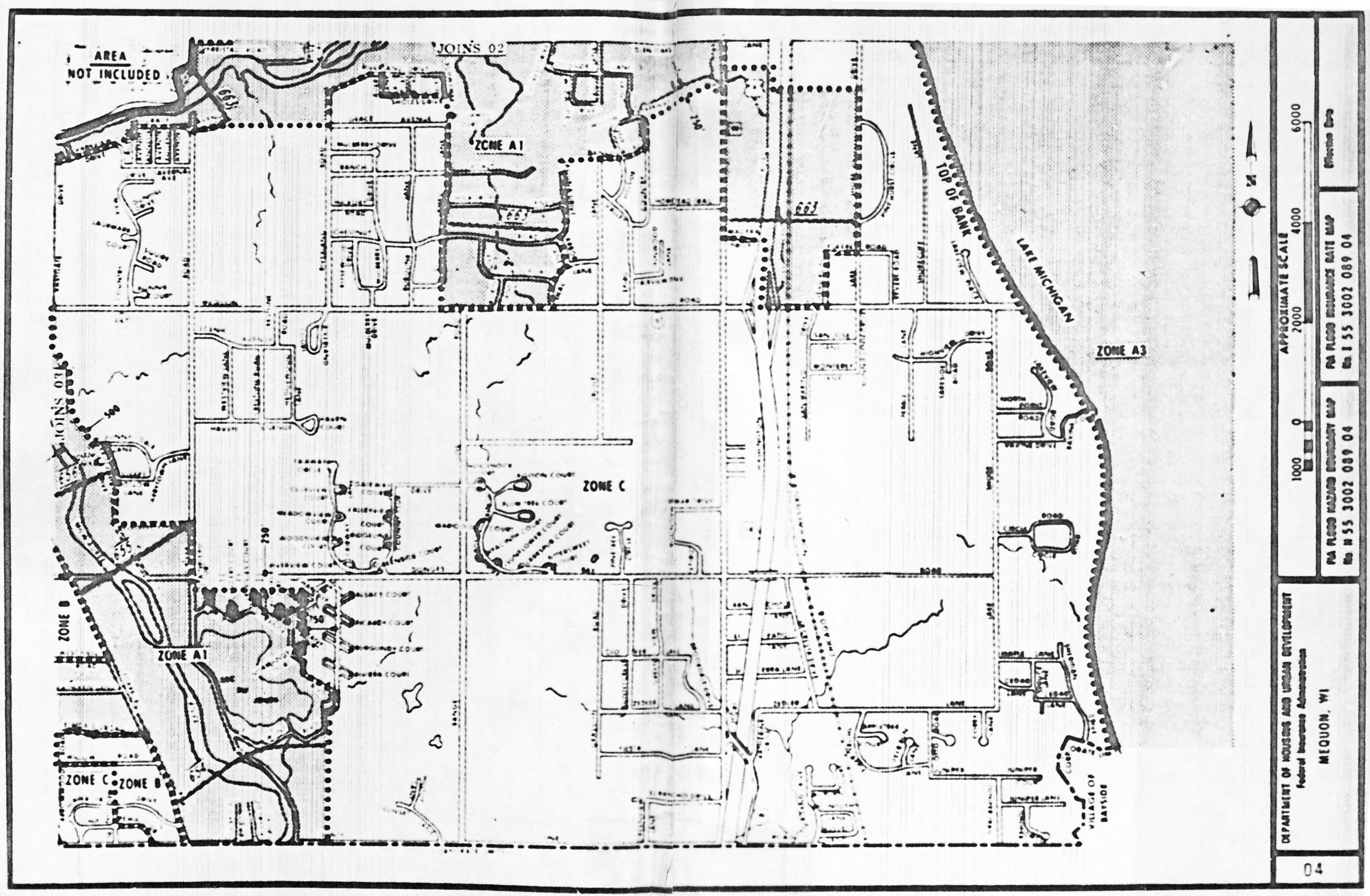
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31.

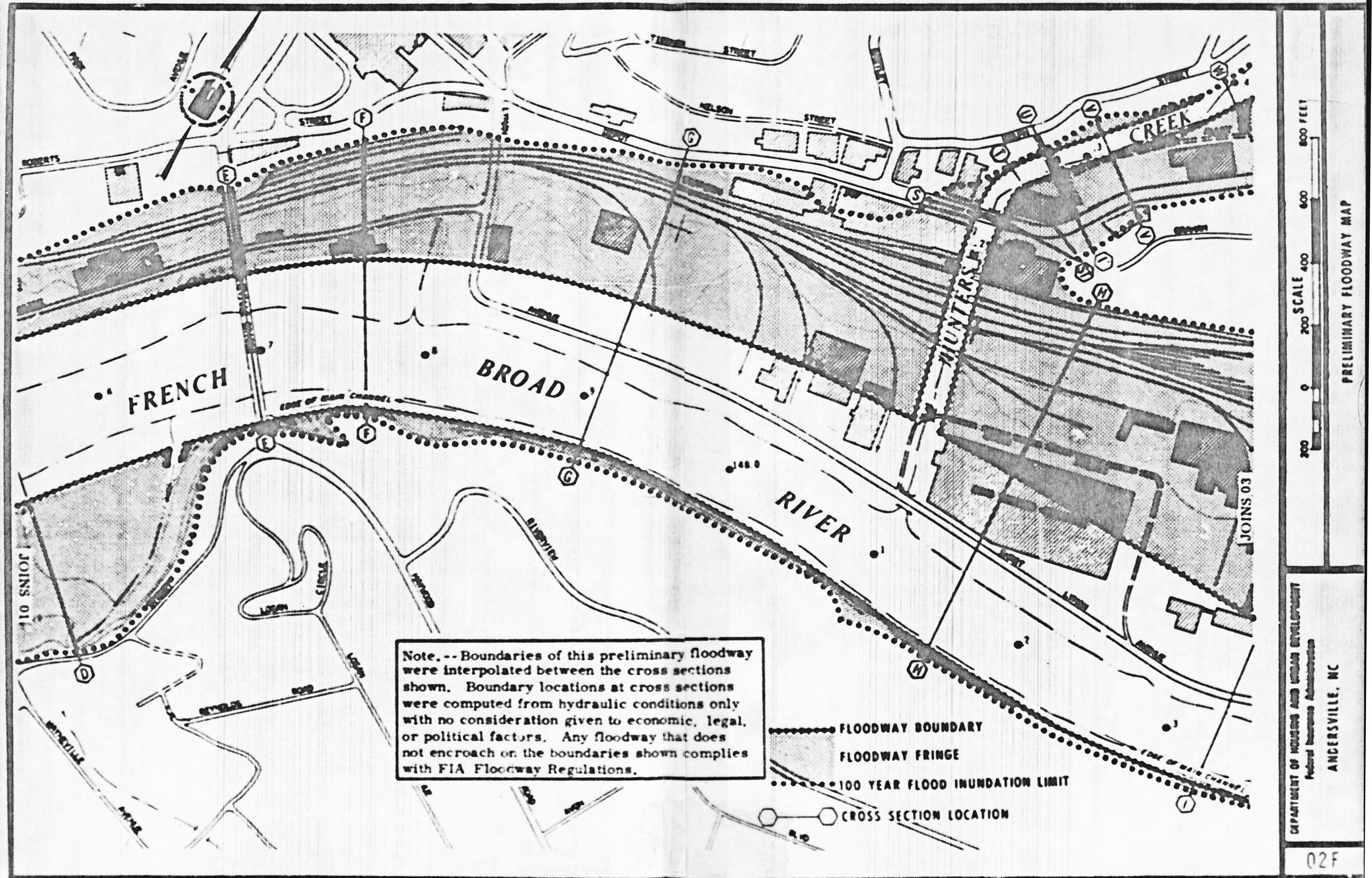
1969 1969 1969 1970 1971 1971 1972 1972 1973 1973 1974 1974 1975 1975

AREA NOT INCLUDED AREA NOT INCLUDED

JOINS JOINS JOINS JOINS 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



AREA NOT INCLUDED
JOINS 02
ZONE A1
TOP OF BANK
LAKE MICHIGAN
ZONE A3
ZONE C
JOINS 03
ZONE B
ZONE A1
ZONE C
ZONE B
VILLAGE OF BAYSIDE
APPROXIMATE SCALE
1000 0 2000 4000 6000
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
Federal Insurance Administration
MEQUON, WI
FIA FLOOD HAZARD BOUNDARY MAP
No. H 55 3002 089 04
FIA FLOOD INSURANCE RATE MAP
No. I 55 3002 089 04
Effective Date
04


FRENCH
BROAD
RIVER
CREEK
HUNTERS
EDGE OF MAIN CHANNEL
STREET
NELSON
STREET
ROBERTS
JOINS 01
JOINS 03
Note.--Boundaries of this preliminary floodway were interpolated between the cross sections shown. Boundary locations at cross sections were computed from hydraulic conditions only with no consideration given to economic, legal, or political factors. Any floodway that does not encroach on the boundaries shown complies with FIA Floodway Regulations.
FLOODWAY BOUNDARY
FLOODWAY FRINGE
100 YEAR FLOOD INUNDATION LIMIT
CROSS SECTION LOCATION
SCALE
800 FEET
PRELIMINARY FLOODWAY MAP
ANCERSVILLE, NC
02F