

HANDBOOK FOR ARIZONA COMMUNITIES
On Floodplain Management and the National Flood
Insurance Program

APPENDIX I



Federal Emergency Management Agency

Region IX Building 105
Presidio of San Francisco, California 94129

DEC 10 1990

FOREWORD

The National Flood Insurance Program makes flood insurance available to property owners in communities that adopt and enforce floodplain management measures to reduce future flood losses. The Program provides flood hazard maps and risk information on which local floodplain management measures are based.

One aspect of a sound floodplain management program is the maintenance of a floodway area to assure that the elevations of future floods will not be increased significantly. The adoption of a floodway by a community preserves the necessary conveyance area for passage of the flood waters by restricting actions within the floodway which will result in any increase in flood elevation.

After a floodway is adopted, a community may encounter a compelling need to change the configuration of their floodway and therefore request that the floodway map prepared by the Federal Emergency Management Agency (FEMA) be revised. The purpose of these conditions and criteria is to set forth the nature and extent of the material needed to support such a request. Compliance with the criteria described herein will allow FEMA to review the material and revise the floodway maps as appropriate in a timely manner.

CONDITIONS AND CRITERIA FOR FLOODWAY REVISIONS

This document sets forth FEMA policy concerning requests for revising the Flood Boundary and Floodway Map (FBFM) prepared by FEMA for adoption by the community to regulate floodways in accordance with Title 44, Part 60.3(d) of the Code of Federal Regulations.

A. FEMA Role in Establishing Floodways

The National Flood Insurance Act of 1968, Section 1361 authorized FEMA to carry out flood studies relating to encroachments and obstructions on stream channels and floodways. The purpose of the studies is to support state and local efforts to:

- (1) regulate the development of land which is exposed to flood damage, where appropriate,
- (2) guide proposed construction away from locations which are threatened by flood hazard,
- (3) assist in reducing damages caused by floods, and
- (4) otherwise improve the long-range land management and use of floodprone areas.

The section is explicit in that FEMA shall work closely with, and provide necessary technical assistance to, state, interstate, and local government agencies in their efforts toward sound floodplain management.

The FEMA role consists of establishing minimum standards and providing information to state and local regulating agencies. Established criteria are contained in Part 60.3(d) of Chapter 1, Title 44 of the Code of Federal Regulations. The regulation states that when FEMA has provided data from which a regulatory floodway shall be designated, the community shall select and adopt a regulatory floodway based on the principle that the area chosen for the regulatory floodway must carry the waters of the base flood (100-year) without increasing the water surface elevation of that flood more than 1.0 foot at any point. However, the community may adopt a more restrictive floodway in which the surcharge limit is less than 1.0 foot.

The FEMA role, therefore, is to provide data from which the community can formulate and adopt a floodway for regulatory purposes. From a practical standpoint, FEMA coordinates with communities during the data generation stage and prepares data on a single floodway delineation which reflects community input. Once a floodway is adopted by the community, FEMA continues to support the community in its efforts to enforce the floodway and provides copies of the maps to users.

B. Definition and Purpose of Floodway

The floodway is defined as the channel of a stream and any adjacent floodplain areas that must be reserved in order to discharge the 100-year flood without increasing flood heights by a specified amount. The purpose for establishing a floodway is to provide for the balancing of the competing uses of development against the resulting increase in flood hazards. FEMA has set a minimum standard, limiting the floodway width to that which will not result in an increase of the 100-year flood by more than 1.0 foot. Several states have adopted requirements which limit the increases to less than the FEMA minimum standard. In cases where the state has adopted more stringent standards by legally enforceable statute or regulation, FEMA computes floodways based upon these standards. Once the floodway has been adopted, encroachments, including fill, new construction, substantial improvements, and other development within the adopted floodway that would result in any increase in flood levels within the community during the occurrence of the base flood discharge is prohibited.

C. Floodway Revision - General Policies

Within the criteria established by FEMA, many floodway configurations may be generated. However, once adopted by a community, a particular floodway configuration becomes administratively established, much the same as other community regulations. An adopted floodway represents a reasonable allocation of an area for the passage of flood waters and does not necessarily represent the minimum area required to meet the FEMA minimum standard. Once the floodway is adopted, the floodway boundaries are intended to remain static.

During a restudy, the existing floodway configuration should be checked to assure that it meets acceptable surcharge limits under present conditions. Where surcharge limits are exceeded, the floodway should be expanded.

A floodway may be reduced in size if the discharges have been reduced as a result of a physical change, such as a diversion of the flow, or the construction of a dam or other major retention measures. A floodway may also be reduced as a result of stream modifications. Floodway changes should not be based on physical changes, unless it has been established that adequate maintenance has been provided to assure continuation of the structural effects.

A further basis for a floodway revision is the desire by a community to respond to a social or economic need for development within a floodway. This need may be met by shifting the floodway boundaries, using appropriate hydraulic analysis, while maintaining the flood carrying capacity of the floodway.

After a floodway is established, development may occur in the fringe area (the area within the floodplain but outside the floodway), but should not occur in the floodway unless it is shown that the development will not reduce the conveyance of the floodway. If it becomes necessary to revise the floodway, the original hydraulic model must be used to establish the base profile for the new encroachment analysis. The model would then be modified to include the in-place encroachment for the revised floodway runs.

D. Community Floodway Map Revision Request

The floodway designation is not "appealable" to FEMA by individuals, since it is the community that selects and adopts the regulatory floodway. Thus, an individual should appeal the floodway designation to, or seek amendments from, the community. The community, in turn, may support the amendment and request FEMA to revise the original, FEMA-produced Flood Boundary and Floodway Map (FBFM). FEMA will review the request to ascertain that the following conditions are met before expending effort on the revision:

Condition Number 1

The community must demonstrate that it is prepared to adopt the modified floodway and that all legal requirements will have been met before the floodway is revised. Before changes are made to community regulated areas, communities are required by the state to follow certain administrative procedures. The request to FEMA needs to include evidence that appropriate procedures have been followed. Typical information to be submitted are as follows:

- 1.1 Copy of a public notice of the intent to modify the floodway.
- 1.2 A statement that the community has notified, and obtained approval from, any adversely impacted property owners or adjacent jurisdictions.
- 1.3 In lieu of the above, a statement that the change will result in no adverse impact.
- 1.4 A copy of the notification of the floodway change to the state.

Condition Number 2

An engineering analysis has been performed to substantiate that the revised floodway meets FEMA minimum standards as well as any state or community requirements.

Floodway revisions must be based on the hydraulic model used to develop the floodway currently in effect. The community should request, through the FEMA Regional Office, a copy of the input data used in the computer model for its effective Flood Insurance Study. Where the input data representing the original hydraulic model is unavailable, an approximation should be developed. A new model should be established using the original cross section topographic information, where possible, and the discharges contained in the Flood Insurance Study which

established the original floodway. The model must use the same effective flow areas as established in the original analysis and be calibrated to reproduce the original base flood elevations within 0.1 foot. Where reproduction of the original base flood elevations within 0.1 foot is not possible, or results in unsound engineering practices, the community should contact the appropriate FEMA Regional Office for direction.

After the model has been checked and matches the original base flood elevations, the model can be modified for new floodway runs. The analysis will be accomplished as specified for the following basis for revision:

Discharge Decreases

Floodways may be revised when a base flood discharge decreases as a result of structural improvements, such as the construction of a flood control dam or other significant retention facilities. Floodways should not be revised based on a computed discharge reduction which results from changed methodology or longer stream gage records, unless the change is statistically significant. The statistical significance criteria are discussed in Section 2-6 "Hydrologic Analyses" of FEMA's Guidelines and Specifications for Study Contractors (dated September 1982). In cases where the statistical significance test does not apply, a determination by a state or Federal agency that the change is significant may be accepted as a basis for a floodway revision. If evident that the change is statistically significant, the original hydraulic model should be rerun, changing only the discharges. This will serve as the base run for the subsequent floodway encroachment runs. The floodway model should then be modified to include current conditions, as well as any encroachment that may have occurred since the original model was produced. The resulting floodway elevations must not exceed the base run elevations by more than 1.0 foot, or as specified by the state or community.

Discharge Increases

If watershed conditions have resulted in a significant increase in discharge, the original hydraulic model needs to be run with the increased discharges. The resulting base flood profile will serve as the base for the floodway runs. The floodway runs must include any encroachment that may have occurred since the delineation of the original floodway.

Channel Modification

The original model will be modified to include the channel modification, and any other encroachment occurring subsequent to the original floodway delineation. The resulting base flood profile will serve as the base for the floodway runs. The floodway runs must include any encroachment that may have occurred since the delineation of the original floodway. The resulting floodway elevations must not exceed the new base flood elevations or the original base flood elevations by more than 1.0 foot, or as specified by the state or community.

Social or Economic

Where it is desired to shift the floodway for social or economic reasons, the base flood elevations from the original model would serve as the base profile for the new floodway run. The model would then be modified to account for any encroachment in the floodplain since the original study. The new floodway limits are to be set in a manner which will not result in an increase to the original base flood elevation in excess of that permitted by FEMA or the state.

Condition Number 3

Submittal includes technical data that enables FEMA to determine whether the floodway revision meets the FEMA minimum standard. Submittal must include the following:

- 3.1 A copy of the printout for the original hydraulic computer model representing the 100-year flood profile run for conditions existing at the time the currently effective floodway was developed. The printout must include full input and output listings.
- 3.2 A copy of the printout for the original hydraulic computer model representing the floodway run for conditions under which the currently effective floodway was developed. The printout must include full input and output listings.
- 3.3 A copy of the printout from the hydraulic computer model representing the new 100-year profile. The model should be the same as that used in item 3.1, but modified to include any channel modification, fill or other encroachment that may have occurred in the floodplain since the original floodway was delineated.
- 3.4 A copy of the printout from the hydraulic computer model representing the floodway run for the proposed floodway, including channel modifications and encroachments since the original floodway was established. The equal conveyance reduction method should be used to compute the revised floodway limits unless agreements have been made with affected property owners to utilize a different method. The printout must include full input and output listings with all input changes from the original model highlighted. The net effects of the channel modifications, the encroachments made subsequent to the establishment of the original floodway, and the new proposed floodway limits must not increase the water surface elevation by more than 1.0 foot above that computed in item 3.1, and also must not exceed 1.0 foot above the new 100-year elevations computed in item 3.3.
- 3.5 A copy of the revised Floodway Data Table representing data for the proposed floodway configuration.
- 3.6 One copy of the currently effective FBFM showing the existing floodway and one copy showing the proposed floodway configurations.

- 3.7 Certification from a registered professional engineer that the physical parameters used in the proposed floodway delineation represent actual conditions and that the standards contained in these "Conditions and Criteria" are met.
- 3.8 If the basis for the proposed floodway revision is a channel modification, the completion of a dam, or any other structural measure, evidence is required to demonstrate the design is adequate, and that maintenance and operation provisions, where applicable, have been made. The submittal must indicate what entity has maintenance responsibility and how maintenance will be accomplished. If maintenance is to be accomplished by agencies other than the community, a legal provision for community monitoring and back-up assistance is required.
- 3.9 Documentation of approval of the proposed floodway revision from the appropriate state agency for communities where the state regulates the floodway.
- 3.10 Documentation of any variation from Condition 2 and/or Condition 3. This includes approval from the appropriate agencies and an explanation of the reason for variation.

E. FEMA Response to Floodway Revision Request

FEMA will review a community's request for a floodway map revision. It is recognized that while the floodway is adopted by a community, Flood Insurance Study users other than the community may request copies of the floodway delineations. Therefore, in support of the community and other users, FEMA maintains a system for distributing floodway information and revising delineations as the need arises. When the revision is considered to be significant, FEMA will revise floodway maps and distribute them to recognized users. Significant floodway revisions are identified based on the size of area, as well as the number of interests affected by the revision.

FEMA will respond to a request from the community for a floodway revision by one of the following means:

- (1) Reprinting the affected FBFM panels with corresponding map revised dates. The panels will be accompanied by a revised index panel showing the most up-to-date floodway panels maintained at FEMA. Copies of the revised floodway panels will be sent to previous recipients of the floodway maps. A revised Flood Insurance Study report will accompany the floodway maps. Included in the report will be a description of the revision and revised Floodway Data Tables.
- (2) Send one copy of the FBFM designating the approved floodway revision to the community, and a letter of floodway revision stating that the review of the submitted material has resulted in the determination that FEMA minimum requirements have been met but a reprinting of the FBFM is not warranted at this time. The material, including the copy of the FBFM showing the revised floodway, will be filed for incorporation at a later time into a

floodway map revision. The approved FBFM revision copies will be dated. Since it is possible that FEMA has responded to a floodway revision request in this manner, all Flood Insurance Study users are encouraged to contact the community before proceeding with plans for development within the flood fringe areas or near floodways.

- (3) Send a letter to the community stating that the submittal material is incomplete and/or that the revised floodway does not meet FEMA minimum criteria.

F. Submittal of Material

Submit material to the FEMA Regional Office. The Regional Office will review material for completeness, concur with the proposed changes, approve any maintenance ordinances, and forward the necessary material to the FEMA Central office.

FEMA Central will review the hydrologic/hydraulic back-up material, engineering design, and any plans of operation and maintenance (where appropriate), request additional revisions or corrections as necessary, then respond to the community by means of the appropriate action defined under Section E above.

- G. To obtain further information on the conditions and criteria for floodway revisions, communities are encouraged to contact the appropriate FEMA Regional Office or FEMA Central in Washington, D. C. at (202) 287-0230, prior to the request for a floodway revision.



Federal Emergency Management Agency

Washington, D.C. 20472

CERTIFICATION REQUIREMENTS FOR SIMPLE FLOODWAY ENCROACHMENTS

10 1990

Introduction

This document is intended to provide guidance to local floodplain administrators in evaluating requests for the placement of fill at a single location, a building, or another simple encroachment within an adopted regulatory floodway. The procedure contained in this document is not intended to evaluate complex encroachments, such as extensive fills, multiple structures, bridges, or levees, where flow expansion and contraction losses may be significant. In such cases, full hydraulic analyses by computer backwater models should be employed. The minimum floodplain management requirements for communities participating in the National Flood Insurance Program (NFIP) in which a regulatory floodway has been designated prohibit any floodway development that would result in an increase in flood levels within the community during the occurrence of the base (100-year) flood discharge. This requirement is outlined in Paragraph 60.3(d)(3) of the NFIP regulations.

Because floodway development is contradictory to the tenets of sound floodplain management, such development is discouraged by the Federal Emergency Management Agency (FEMA). Therefore, these certification requirements assume that all practical alternatives to floodway development have been investigated thoroughly and have been deemed not feasible.

In accordance with the NFIP regulations, it is ultimately the responsibility of each community participating in the NFIP to prohibit floodway development that would result in increases in 100-year flood levels. Communities must make determinations of this type and maintain backup calculations and certifications in their files for review by FEMA personnel upon request.

This document also does not address the many cases and situations requiring the actual revision of the floodway via redelineation of the floodway boundary, the criteria for which are presented in Section 65.7 of the NFIP regulations. A FEMA document, entitled "Conditions and Criteria for Floodway Revisions," and dated August 27, 1984, addresses these issues.

Definition of "No-Rise"

It is important that the concept of "no rise" be clarified and understood. The actual wording of Paragraph 60.3(d)(3) of the NFIP regulations is that the community shall "prohibit ... any increase in flood levels during the occurrence of the base flood discharge." If an adopted regulatory floodway has been computed and is displayed on the effective NFIP map, all areas within the floodway are considered to be effective in conveying the 100-year flood discharge. Therefore, no obstruction, regardless of size, can be

placed within the floodway without obstructing flow and causing some increase in the base flood elevation (BFE). Such increases may be localized and may seem insignificant; if modeled, they may yield changes on the order of hundredths or thousandths of a foot.

There has been a tendency to misinterpret the "no-rise" criterion to include rounding allowances and also to conclude that an increase in computed water-surface elevation of 0.01 foot or less, as determined by a backwater computer model, is sufficient evidence to support the acceptability of development in a floodway.

Although the backwater computer model output may show little change in water-surface elevation, closer examination will, in all likelihood, reveal changes in other variables (e.g., topwidth, flow area, velocity). These changes can be translated into increases in water-surface elevation that may not be considered significant by themselves. However, the long-term cumulative effects of such increases will eventually result in significant changes. Therefore, no development in the floodway should occur without proper compensation for the lost conveyance. This is the intent of Paragraph 60.3(d)(3) of the NFIP regulations.

It is FEMA's position that this regulation is to be interpreted exactly, and strictly, as written; that is, "no" rise above the BFE will be permitted. Therefore, nothing that offers any resistance to the flow of floodwaters may be placed within a regulatory floodway unless compensatory action is taken to restore the lost conveyance.

Loss of Conveyance

In the case of a simple floodway encroachment, as discussed previously, a "no-rise" determination can usually be made based on consideration of conveyance only. In such a situation, it is the difference in the conveyance before and after encroachment, or the aforementioned loss of conveyance, that must be addressed if the effects of development are to be compared against the "no-rise" criterion. The computation of loss of conveyance is most appropriately accomplished on a micro scale by isolating a portion of a cross section, separate from the backwater computer model, and performing hand computations. Examples of typical hand computations for proposed fill and bridge pier construction are attached for reference. However, it is appropriate to incorporate one or more new cross sections at the site of the proposed construction that reflect existing conditions into the unencroached and encroached backwater computer models. This is done to establish the base flood conditions at that location, which are to be used in the hand computations. The formula used to determine conveyance (K) is

$$K = 1.49/n AR^{2/3}$$

where n = Manning's roughness coefficient
 A = Flow area
 R = Hydraulic radius

The loss of conveyance is computed using the "n" value and hydraulic radius at the site of the encroachment as applied in the computer model.

Compensation

Once a determination has been made as to the amount of conveyance lost as a result of the proposed development, the designer or engineer is required to adequately compensate for this loss. This compensation is accomplished by including some means or measures within the proposed floodway development for providing an increase in effective conveyance, at some point on the cross section, equal to or greater than that lost. Equal area exchanges are only valid if the "n" value and hydraulic radius remain unchanged between the encroachment site and the compensation site. It is also important that the flow area provided be truly effective; that is, open to inflow and outflow and not just an isolated low spot or depression. This increased effective conveyance could be computed by hand in a manner similar to that used to compute the loss of conveyance.

The means or measures used to provide this effective conveyance (e.g., excavation, roughness coefficient reduction) would be at the discretion of the designer or engineer but must be approved by the community. Where these means and measures require some form of maintenance, the community must assume ultimate responsibility for their maintenance.

Data Requirements

The items identified below are necessary to document and demonstrate compliance with the "no-rise" criterion for simple floodway encroachments.

1. Hydraulic backwater models of the 100-year flood and floodway water-surface profiles for the following:
 - a. Duplicate of the effective Flood Insurance Study (FIS) model.
 - b. Existing-conditions (effective FIS) model modified to include cross sections through the project site. Cross sections must reflect conditions prior to construction of the project.
 - c. Post-project conditions model. This model must include cross sections through the project site reflecting floodplain conditions after construction of the project. The 100-year flood (without floodway) and floodway elevations for this model must not be greater than those in the existing-conditions model described at letter "b" above. This hydraulic backwater model is necessary to ensure that any changes in transition losses, which are based on velocity heads rather than conveyance, do not cause increases in water-surface elevations. Also, a hydraulic backwater model provides a means of evaluating effective flow areas upstream and downstream of the encroachment and compensation sites.
2. A copy of the appropriate NFIP map showing the existing floodway and indicating the project area
3. Topographic mapping of the entire project area indicating the locations of all cross sections used in the modified hydraulic model and a plan view of all project elements

4. Construction plans, certified by a registered professional engineer, for all project elements, including those measures employed to provide additional effective conveyance
5. The following information, to be obtained by hand computation using the cross section and 100-year encroached hydraulic data in the modified existing-conditions computer model output provided under Item 1b:
 - a. Calculation of the reduction in conveyance (K) caused by the proposed obstruction, assuming no change in floodway water-surface elevation, and using the "n" value appropriate for the site of the proposed obstruction
 - b. Calculation of the increase in conveyance (K) obtained by the proposed offsetting measure, using the "n" value appropriate for the site of this measure
 - c. Comparison showing that the conveyance increase computed in 5b equals or exceeds the loss computed in 5a
6. Evidence that the increase in effective conveyance provided for in Item 5b will be maintained perpetually. This should be in the form of a self-maintaining measure or certified maintenance plans for the measure provided.
7. An executed copy of the attached certification statement signed and sealed by a registered professional engineer

A copy of the hydraulic computer model for the effective FIS for the specified stream and community may be obtained by written request to the following address:

Federal Emergency Management Agency
Federal Insurance Administration
Risk Studies Division
500 C Street, SW
Washington, D.C. 20472



Federal Emergency Management Agency

Washington, D.C. 20472

CERTIFICATION OF A "NO-RISE" DETERMINATION

FOR A PROPOSED FLOODWAY DEVELOPMENT

Community Name

Development Name

Lot/Property Designation

Property Owner

I hereby certify that the proposed remedial measures, in combination with the property development designated above, will result in no loss of flow conveyance during the occurrence of the 1 percent annual chance of exceedence (100-year flood) discharge.

I further certify that the data submitted herewith in support of this request are accurate to the best of my knowledge, that the analyses have been performed correctly and in accordance with sound engineering practice, and that the proposed structural works are designed in accordance with sound engineering practice.

Date

Registered Professional Engineer

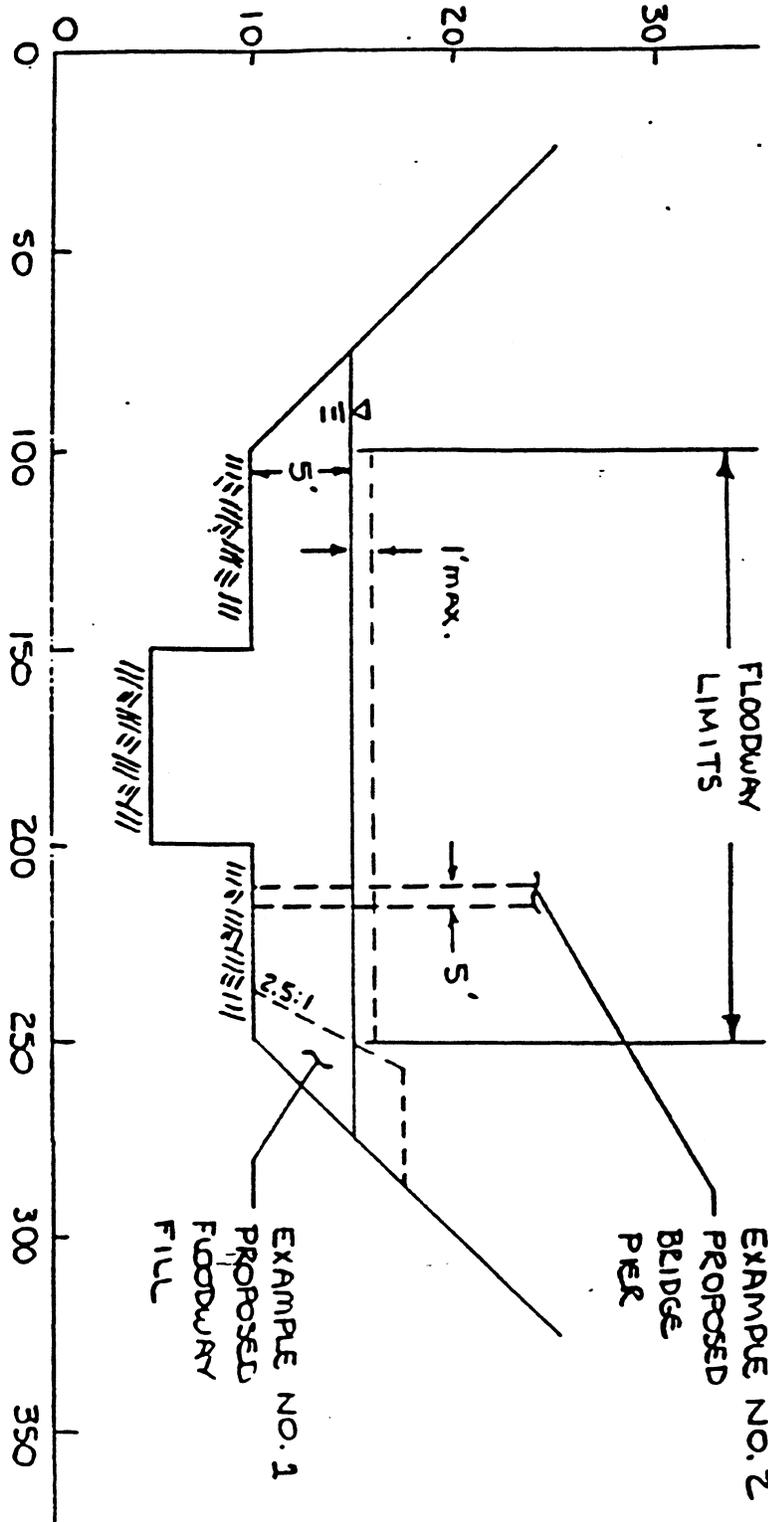
Seal

Subject: CONVEYANCE CALCULATION

NO RISE FLOODWAY Sheet No. 1 of 6

TYPICAL SECTION Drawing No. _____

Computed by RCH Checked By JTP Date 5.14.90



RIGHT OVBANK CONVEYANCE (PRE-DEVELOPMENT)

- ASSUMPTIONS:
1. PORTION OF FILL IN FLOODWAY FRING IS ALLOWABLE AND IS ACCOUNTED FOR IN FLOODWAY SURCHARGE
 2. PREDEVELOPMENT CONVEYANCE SHOULD ASSUME EXISTENCE OF WETTED PERIMETER ALONG FLOODWAY BOUNDARY
 3. MAXIMUM CONVEYANCE LOSS WILL OCCUR IN CONJUNCTION WITH FLOODWAY DEPTH THEREFORE USE FLOODWAY WATER SURFACE ELEVATION IN COMPUTATION
 4. CONVEYANCE LOSSES COMPUTED WITH FLOODWAY WATER SURFACE ELEVATION AND PROPERLY COMPENSATED FOR WILL NOT INCREASE 100-YEAR (BASE FLOOD) ELEVATION

THEREFORE:

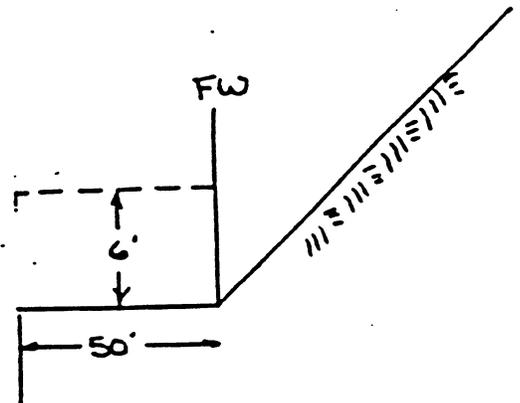
$$K_{PRE} = 1.49/N A R^{2/3}$$

$$A = 50 \times 6 = 300 \text{ FT}^2$$

$$WP = 50 + 6 = 56 \text{ FT}$$

$$R = 300/56 = 5.36 \quad R^{2/3} = 3.06$$

$$K_{PRE} = 1.49/.050 (300)(3.06) = \underline{\underline{27356.40 \text{ CFS}}}$$



Subject: CONVEYANCE CALCULATIONEXAMPLE NO. 1Sheet No. 3 of 6PROPOSED FLOODWAY FILL

Drawing No. _____

Computed by RCH Checked By JTPDate 5.14.90RIGHT OVBANK CONVEYANCE (POST-DEVELOPMENT)

ASSUMPTIONS: 1. ALL PREVIOUS

2. PROPOSED FILL SLOPES ABOVE FLOODWAY WATER SURFACE ELEVATION AND OUTSIDE FLOODWAY LIMIT DO NOT CONTRIBUTE TO WETTED PERIMETER

THEREFORE:

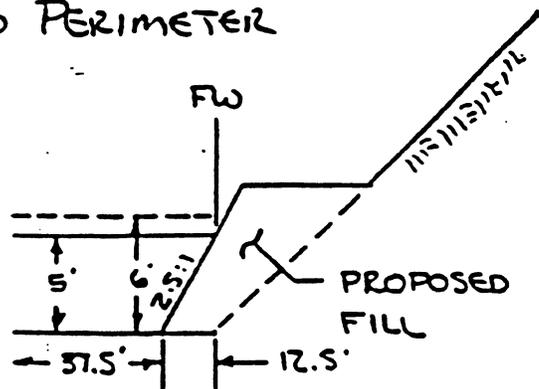
$$K_{POST} = 1.49/N A R^{2/3}$$

$$A = (1)(50) + \frac{1}{2}(5)(50+37.5) \\ = 268.75 \text{ FT}^2$$

$$WP = 37.5 + (12.5^2 + 5^2)^{1/2} + 0 = 50.96$$

$$R = 268.75 / 50.96 = 5.27 \quad R^{2/3} = 3.03$$

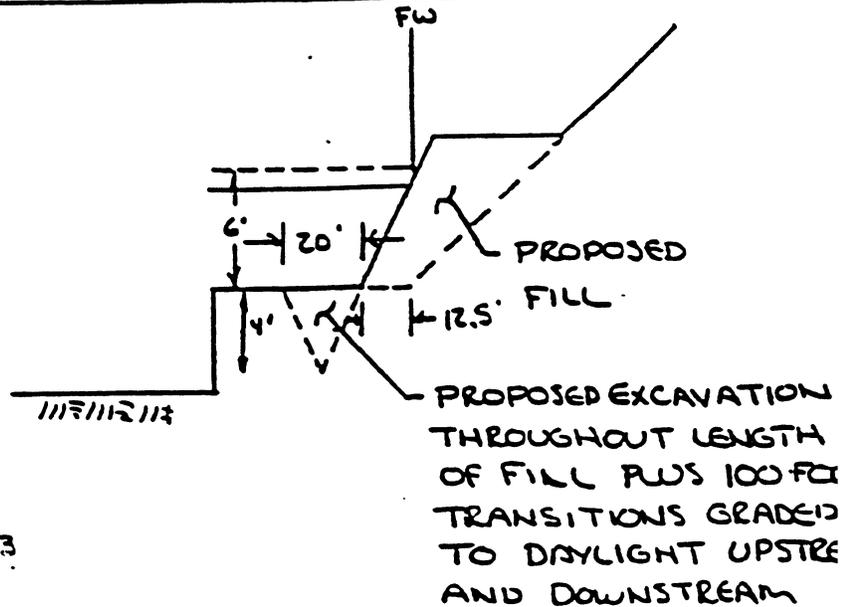
$$K_{POST} = 1.49 / .05 (268.75) (3.03) = \underline{24,266.51}$$

TOTAL CONVEYANCE LOSS IN FLOODWAY

$$K_{PRE} - K_{POST} = 27,356.40 - 24,266.51 = \underline{\underline{3089.89 \text{ CF}}}$$

Subject: CONVEYANCE CALCULATIONEXAMPLE NO. 1Sheet No. 4 of 6PROPOSED FLOODWAY FILL

Drawing No. _____

Computed by RCH Checked By JTPDate 5-14-90DESIGN OF CONVEYANCE COMPENSATION MEASURE

$$K_{PROP} = 1.49/N A R^{2/3}$$

$$A = 268.75 + \frac{1}{2}(20)(4)$$

$$= 308.75 \text{ FT}^2 > 300 \text{ FT}^2 \text{ (PRE)}$$

$$WP = 50.96 - 20 + (2)(10^2 + 4^2)^{1/2} = 30.96 + 21.54 = 52$$

$$R = 308.75 / 52.50 = 5.88 \quad R^{2/3} = 3.26$$

$$K_{PROP} = 1.49 / .05 (308.75)(3.26) = 29994.45 \text{ CFS}_{PROP}$$

$$> 27356.40 \text{ CFS}_{PRE}$$

∴ OKAY

COMPENSATION

MEASURE

ADEQUATE

NOTE: FILL SLOPE WOULD REQUIRE ADEQUATE PROTECTION AGAINST VELOCITIES AND CHECKS FOR STABILITY

Subject CONVEYANCE CALCULATION

EXAMPLE NO. 2 Sheet No. 5 of 6

PROPOSED BRIDGE PIER Drawing No. _____

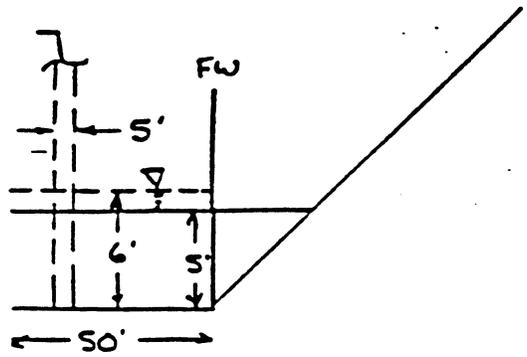
Computed by RCH Checked By JTP Date 5.14.9

RIGHT OVERBANK CONVEYANCE (PRE-DEVELOPMENT)

SAME AS EXAMPLE NO. 1 = 27356.40 CFS

RIGHT OVERBANK CONVEYANCE (POST-DEVELOPMENT)

PROPOSED
PIER
CONCRETE



$$A = (6)(50) - (6)(5)$$

$$= 300 - 30 = 270 \text{ FT}^2$$

$$WP = (50 - 5) + 2(6) + 6$$

$$= 63 \text{ FT}$$

$$R = 270 / 63 = 4.29 \quad R^{2/3} = 2.64$$

WEIGHTED "N"

"N" ROB : .050 (50 - 5) + 6 = 51

"N" CONC. : .013 2(6) = 12

$$51 + 12 = 63 = WP$$

$$N_w = \frac{51}{63} (.050) + \frac{12}{63} (.013) = .043$$

$$K_{POST} = 1.49 / .043 (270) (2.64) = \underline{24,699.35 \text{ CFS}}$$

TOTAL CONVEYANCE LOSS IN FLOODWAY

$$K_{PRE} - K_{POST} = 27356.40 - 24699.35 = 2657.05$$

DESIGN OF CONVEYANCE COMPENSATION MEASURE

TRIAL NO. 1

PLACEMENT OF DUMPED
RIP-RAP ACROSS ENTIRE
RIGHT OVERBANK* BENEATH
BRIDGE $N = .035$

* EXCAVATED AND PREPARED

WEIGHTED "N"

$$N_w = \frac{51}{63} (.035) + \frac{12}{63} (.013) = .031$$

$$K_{PROP} = 1.49 / .031 (270) (2.64) = 34,260.39 \text{ CFS}_{PROP}$$

$$> 27356.40 \text{ CFS}_{PRE}$$

∴ OKAY

COMPENSATION

MEASURE

ADEQUATE