



RHODE ISLAND
DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
OFFICE OF WATER RESOURCES
Groundwater and Wetlands Protection Program



Floodplain Impacts: Regulatory Provisions Pertaining to Floodplains and Floodways

The following packet has been designed to help engineers produce the best possible applications for the RIDEM Wetlands Program.

In particular, these guidance sheets are intended to provide Design Engineers with information on floodplain definitions, as well as provide helpful tips and techniques regarding the determination of floodplain elevation, displacement and compensation.

In addition, these guidance sheets contain visual examples of several different methods commonly used to determine the 100-year flood plain elevation.

Please Note: This guidance packet is for general information purposes only and is not meant to be used as a substitute for the Freshwater Wetlands Act or the *Rules and Regulation Governing the Administration and Enforcement of the Freshwater Wetlands Act*.

Office of Water Resources
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Freshwater Wetland Rule Excerpts Pertaining to Floodplains

Protected Wetland Definitions (as defined by Rule 4.00)

- **Area Subject to Flooding** shall include, but not be limited to, flood plains, depressions or low-lying areas flooded by rivers, streams, intermittent streams, or areas subject to storm flowage which collect, hold or meter out storm and flood waters.
- **Area Subject to Storm Flowage** means those drainage swales and channels that lead into, out of, pass through or connect other freshwater wetlands or coastal wetlands, and that carry flows resulting from storm events, but may remain relatively dry at other times.
- **Flood Plain**, as defined in Section 2-1-20(3) of the Act, means that land area adjacent to a river or stream or other flowing body of water that is, on average, likely to be covered with flood waters resulting from a one hundred (100) year frequency storm. A storm of this nature is one that is to be expected to be equaled or exceeded once in one hundred (100) years, and hence may be said to have a one percent (1%) probability of being equaled or exceeded in any given year. Rainfall intensity data for such a storm are those established for New England locations by the National Weather Service (formerly the U.S. Weather Bureau).
- **Floodway** means the channel of a river or stream and any immediately adjacent areas that must be kept free of encroachment to allow one hundred (100) year flood waters to be carried without increase in flood heights or flows and without endangering life or property.
- **Flowing Body of Water** means any river, stream, or intermittent stream that flows long enough during the year to develop and maintain defined channels, and generally has flowing waters at times other than those periods immediately following storm events. Such watercourses have defined banks, a bed, and maintain visible evidence of flow or continued reoccurrence of flowing water.
- **River**, as defined in Section 2-1-20(8) of the Act, means a body of water that is designated as a perennial stream by the United States Department of Interior Geologic Survey on 7.5-minute series topographic maps, and that is not a “pond.”
- **Stream/Intermittent Stream** means any flowing body of water or watercourse other than a river that flows long enough each year to develop and maintain a defined channel. Such watercourses may carry groundwater discharge or surface runoff. Such watercourses may not have flowing water during extended dry periods but may contain isolated pools or standing water.

Wetland Function and Value Protection

- **Rule 2.02C(3) Flood Protection**

Freshwater wetlands protect life and property from flooding and flood flows by storing, retaining, metering out and otherwise controlling flood waters from storm events. Wetlands also control the damaging impacts of flood flows by providing frictional resistance to flood flows, dissipating erosive forces, and helping to anchor the shoreline.

- **Rule 10.02E(4)(c)(iv) Compensation for Loss of Flood Storage**

Projects which propose filling or placement of structures in a flood plain or area subject to flooding may provide compensatory flood storage in order to comply with the review criteria as set forth in Rule 10.05 by excavation or by permanently eliminating structures which currently displace flood waters; however, compensatory storage may not be proposed beneath or within the confines of any building or structures. Where applicable, compensatory flood storage must be proposed in accordance with the following requirements:

- (aa) The volume of compensatory flood storage must be equal to or greater than the volume of floodwaters displaced by the project;
- (bb) The compensation area must have an unrestricted hydraulic connection to the affected wetland and provide the same rate of flood storage capture and discharge over the course of the flood event as in pre-project conditions;
- (cc) Compensatory storage must be located within the same reach of the river or flowing body of water (i.e., between the nearest features controlling the flood water elevations upstream and downstream from the proposed displacement area) as the project involving flood water displacement, and must be located as close to the proposed displacement area as possible;
- (dd) Compensatory storage must precede the construction of any portion of the project which displaces flood waters;
- (ee) Where the applicant proposes a compensatory storage area on property owned by others, the applicant must submit a written agreement between such landowner and the applicant wherein the landowner agrees to convey an easement or other property interest or right to the applicant allowing compensatory storage, and to permanently maintain such area for flood storage purposes in the event that the Department approves the applicant's project; and
- (ff) The design must include all features and best management practices to ensure that impacts to other freshwater wetland functions and values have been mitigated.

Wetland Edge Criteria

- APPENDIX 2

- E. **Flood Plain Wetlands**

The edge of any flood plain shall be identified as the maximum horizontal extent of flood water which will result from the statistical 100-year frequency storm event.

- 1) The 100-year flood plain elevation shall be determined by the most recently available flood profile data prepared under the National Flood Insurance Program of the Federal Emergency Agency (FEMA); or
- 2) In the event that FEMA profile data is unavailable, or if the applicant disagrees with the data, the flood plain edge shall be determined by engineering calculations completed by a registered professional engineer. These calculations shall be:

- (a) Based on a widely accepted hydrologic and hydraulic model (e.g., HEC-RAS). The applicant must demonstrate that the selected model is appropriate for the determination; and
 - (b) Based upon a design storm of at least seven inches (7") of precipitation in twenty-four (24) hours (a Type III rainfall as defined by the National Weather Service).
- 3) The flood plain edge must coincide with the flood plain elevation and topographic contour elevations as depicted on submitted plans. Transposing flood boundaries from FEMA maps by using horizontal scaling is not acceptable for plans submitted to the Department. Identification of the 100-year flood elevation must be expressed in National Geodetic Vertical Datum as related to Mean Sea Level.

Site Plan Requirements

- Rule 7.03
 - K. All site plans submitted with a Request to Verify Wetland Edges, a Request for Preliminary Determination or an Application to Alter a Freshwater Wetland must accurately depict the edge of all freshwater wetlands in accordance with Rule 7.04.
- Rule 7.04
 - A. Depiction on Site Plans – All site plans must accurately depict the following freshwater wetland edges as follows:
 - 5) The edge and elevation of any flood plain and the limit of any floodway (Note: The Department may grant an exception to this requirement when a) pre-determined 100-year flood elevations are not available from published sources including previous engineering studies; and b) when a Registered Professional Engineer provides clear and convincing documented evidence that the project site is above any probable 100-year flood elevation).

Review Criteria

- Rule 10.05
 - C. Before issuing a permit, the Department must be satisfied that a proposed project or alteration will not result in:
 - (16) Any decrease in the flood storage capacity of any freshwater wetland which could impair the wetland's ability to protect life or property from flooding or flood flows;
 - (17) Significant reduction of the rate at which flood water is stored by any freshwater wetland during any flood event;
 - (18) Restriction or significant modification of the path or velocities of flood flows for the 2-year, 10-year, 25-year, or 100-year frequency, 24-hour, Type III storm events so as to cause harm to life, property, or other functions and values provided by freshwater wetlands;
 - (19) Placement of any structure or obstruction within a floodway so as to cause harm to life, property, or other functions and values provided by freshwater wetlands.

Preliminary Considerations

Once it is determined that the project involves work near a river, stream, or intermittent stream, then determine which of the following three scenarios applies:

- (1) The 100-year flood hazard area that is depicted on the FEMA Flood Insurance Rate Map (FIRM) provides elevations of the 100-year flood plain. Unless this elevation is shown to be erroneous (such as where the FEMA study is superceded or it is known who is determined to be in or on subsequent analysis), this elevation needs to be used as the basis for the delineation of the 100-year floodplain limits on the site plan.
- (2) The FEMA FIRM depicts a flood hazard area, but does not provide the elevation(s) or the profile(s) of the 100-year flood plain level. In this case, the designer would need to provide a study or an approximate study (as per Rule 7.04A(5) of the *Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act*, June 2007) to determine a floodplain elevation, or to show that a precise flood plain elevation determination is not warranted.
- (3) The FEMA FIRM does not depict a flood hazard area, but the project is adjacent to a river, stream, or intermittent stream. In this case, the designer would need to provide a study or an approximate study (as per Rule 7.04A(5)) to determine a floodplain elevation, or to show that a precise flood plain elevation determination is not warranted.

For all of the three above situations:

- (a) The presence of the floodplain needs to be indicated on the site plan, and,
- (b) The designer needs to determine and indicate whether or not the proposed project is located within the floodplain.

As per Rule 7.04A(5), the designer may elect to provide “clear and convincing documented evidence that the project site is above any probable 100 year flood elevation.” In that case, no further floodplain study would be necessary. However, the designer would need to indicate the following items on the site plan:

- (a) Include a notation that states that 100-year floodplain is present in association with the pertinent river, stream, or intermittent stream, and
- (b) Include a notation that the proposed project site is above any probable 100 -year flood elevation

If the project site is within the floodplain, the designer needs to establish the edge and elevation of the floodplain and the limit of any floodway. The designer also needs to address impacts to floodplain and floodway as per review criteria 10.05 (16), (17), (18), and (19), and may need to provide volumetric floodplain compensation as per 10.02 E(4)(c)(iv).

Determining the Floodplain Elevation through Analysis

The process of floodplain analysis for the determination of a floodplain elevation profile can be summarized in two steps. First is the determination of a peak discharge rate for the 100-year flood event. Next is the hydraulic modeling of this discharge rate through the pertinent sections of the watercourse to produce a floodplain elevation profile. This profile is then used with the site's topography to map the limits of the 100-year floodplain.

(A) Determination of the 100-year flood discharge rate.

The peak flood discharge rate for the 100-year flood event may be determined by any of several methods. The method chosen is typically a function of the size and /or complexity of the contributing watershed. In relatively small watersheds that lack any significant hydraulic controls (for example, culverts with upgradient storage), a comparatively simple hydrologic model can be used, such as TR-55. In somewhat larger and more complex watersheds, a TR-20 analysis or similar method is appropriate, so as to account for the storage effects of ponds, swamp areas, and areas upstream of culverts, bridges and dams.

The following are some key considerations in the submittal of the hydrologic analysis portion of a floodplain analysis:

- Include a watershed map showing topography, soils types, ground cover information, and time of concentration flow path.
- Show important areas of natural and manmade detention storage.
- Provide pertinent analysis of weighted curve numbers and time of concentration.
- Provide pertinent input and output information regarding the analysis of storage routing through areas of natural and manmade detention (such as ponds, swamps, culverts, roads, and dams).
- Provide all pertinent information that is used to perform the analysis. This information needs to be presented in a manner that can be easily followed, and that is conducive to verification (spot checks). The submittal needs to provide sufficient plan/map detail as well as sufficient computational detail.
- Provide adequate narrative to explain the methodology used, as well as any parts of the analysis that may need clarification.

(B) Performance of a hydraulic analysis to determine a flood profile for the pertinent reaches and length of watercourse:

Once the 100-year peak discharge rate is obtained for the watershed that contributes to the location in question, the designer needs to provide a hydraulic analysis to determine the corresponding flood elevation/ flood profile that this discharge causes at this location. Typically, all of the methods of analysis used rely on Manning's equation. Thus, the key inputs to any of these analyses will involve the cross-sectional area of the watercourse channel and overbank areas, the wetted perimeter of the flow, Manning's n-values for channel and overbank areas, and the slope. (Many programs will automatically compute the wetted perimeter and the slope from the details of the watercourse cross-sections that are input.) The primary output is the resulting depth of flow, which can easily be translated to a flood elevation /flood profile.

There are many models available to perform this type of analysis. These models have varying levels of precision. These may range from a simple hand-held calculator analysis using the Manning's equation at two or three relatively consistent stream cross-sections, to a complex HEC-RAS modeling analysis of a large river having numerous changes in section and/or slope. An intermediate method might be a spread-sheet analysis based on Manning's equation, developed in-house. An appropriate model needs to be chosen based on the consideration of many factors, among which are the complexity of the floodplain, the size and scope of the project, the potential for floodplain impact, and cost. Use of the more elaborate models is appropriate where complex river hydraulics are involved and/or where large amounts of floodplain displacement and/or floodplain compensation are involved.

The following are some key considerations regarding the submittal of a hydraulic analysis:

- Provide cross-section drawings, to scale, that depict the cross-sectional information that is input into the analysis.
- The locations of the cross-sections used in the analysis need to be shown on a site plan view.
- Manning's n-values need to be provided for the main channel area of each cross-section, as well as for each overbank area of that cross-section. Appropriate documentation and/or explanation should be used to support the selected n-value. It is advised that the n-values be developed using Chow, Open Channel Hydraulics as a reference. Also, in order to be conservative, the summer-condition assumption (vegetation in leaf) should be used for vegetated areas of floodplain/ overbank areas.
- The submitted analysis needs to clearly show which values are inputs and which values are outputs.
- Existing and proposed condition analyses need to be clearly labeled as such.
- The analysis needs to account for the effects of any and all tailwater conditions that may exist downstream of the segment of watercourse being modeled.
- Provide the name and version of any software package used in the analysis.
- As with any analysis submission, number the pages of the analysis. This facilitates reference to any part of the analysis by the reviewer, should questions arise.

Floodplain Compensation: Requirements and Considerations

If volumetric floodplain compensation is employed to address floodplain impact issues, the design of the floodplain compensation needs to meet the standards of Rule 10.02 E4(c)(iv), (aa) through (ee), of the Rules and Regulations Governing the Administration and Enforcement of the Freshwater Wetlands Act, April 1998. The following items provide guidance that may be helpful toward the preparation of a plan that meets these standards.

- (1) As per 10.02 E4(c)(iv) **(aa)**, provide calculations that will show that the proposed floodplain compensation area will provide an equal or greater volume of flood storage than the amount being displaced.
- (2) As per 10.02 E4(c)(iv) **(bb)**, the above-mentioned compensation condition needs to be met over the entire elevation range of the site's floodplain. Therefore, analysis of floodplain compensation volume vs. floodplain displacement volume needs to be performed on an incremental elevation range of the site's floodplain. Employ an analysis based on a foot by foot elevation range basis, or at most on a two-foot by two-foot incremental basis.
- (3) As per 10.02 E4(c)(iv) **(cc)**, the floodplain compensation volume needs to be located within the same reach of the river, stream, or intermittent stream. The physical boundaries of reaches are typically located at dams, bridges, culverts, major changes in river bottom slope, and other changes which tend to affect river hydraulics.
- (4) As per 10.02 E4(c)(iv) **(bb)**, the design needs to provide an unrestricted hydraulic connection to the river, such that floodwaters can readily enter the compensation storage area at the appropriate elevation range of the flood. The grading necessary to accomplish this needs to be shown on the plans. If the proposed hydraulic connection is a relatively small opening, provide an analysis to show that the length of time it will take to fill the floodplain compensation volume will be sufficiently short, so as to allow the compensation to be effective during the peak portion of the flood event. Small openings should be avoided to minimize the potential for clogging.
- (5) The plans need to depict the grading and/or hydraulic structure details of the hydraulic connection between the floodplain compensation and the river.
- (6) As per 10.02 E4(c)(iv) **(ee)**, the plans need to indicate any and all permanent easements which are needed to ensure that the floodplain compensation areas will be permanently maintained.
- (7) Submitted plans need to indicate the perimeter of all areas that are within the areas of grading for floodplain compensation.
- (8) Submitted plans need to provide existing and proposed condition topography, with a maximum contour interval of two feet, although a one-foot contour interval is preferable.
- (9) If the project involves a floodplain analysis that utilizes floodplain cross-sections, the locations of these cross-sections needs to be indicated on the site plan, or on a similar plan view to accompany the analysis.
- (10) For floodplain analyses that include floodplain cross-sections, provide cross-section drawings, to scale, of all cross-sections used in the submitted floodplain analysis. These cross-sections need to include elevations, including the 100-year floodplain elevation.
- (11) Pertinent calculations prepared by a registered professional engineer (registered in the State of Rhode Island) need to be included in the submission, in support of the design of the floodplain compensation.

Floodplain Displacement and Compensation Analysis Methods

Average End Area Method Using Stationed Cross-Sections

This method is typically used for linear projects, such as roadways, bike paths, and utility lines. It can also be used on most other types of projects, provided that the locations of cross-sections are selected to properly represent the volume being evaluated. This method is conducive to the analysis of displacement and compensation on an incremental basis over the entire elevation range of the floodplain.

This method involves the use of a number of cross-sections taken in the vertical plane, typically at a set interval along the length of the area of floodplain fill and /or cut to be evaluated. At each cross-section, an area is obtained for each elevation increment (for example, two feet) of floodplain. The same calculations are performed for each successive cross-section. To obtain the volume of floodplain cut or fill for each elevation increment between successive cross-sections, the areas within the incremental elevation range of each successive pair of cross sections is averaged. The resulting value is then multiplied by the distance between the pair of cross-sections used. This process is then repeated along the entire length of the area being evaluated. The total volume of fill (displacement) and cut (compensation) is then summed for each elevation range of the floodplain. The total floodplain displacement obtained for each elevation increment can then be compared with the total floodplain compensation for the same increment. A successful result would show that the volume of floodplain compensation would equal or exceed the volume of floodplain displacement for each increment of floodplain elevation range.

Note that it is permissible to use variable lengths between cross-sections provided that they are accounted for in the analysis. In some cases it may be appropriate to vary the distance interval, so as to provide an adequate number of cross-sections in areas where the section may vary substantially. (Examples of the need to do this may be at the ends of the volume being evaluated, and at bends in the baseline.)

Please note that the analysis needs to be done separately for each reach of the floodplain.

Also note that no calculation of volume may occur above the elevation level of the 100-year floodplain, nor below the normal level of the river or stream.

Typical calculation:

Volume of cut or fill = $((\text{XS-area 1} + \text{XS-area 2})/2) \times (\text{distance between XS's})$

Average End Area Method Using Sections Taken in a Horizontal Plane

This method is suitable for use on most types of project sites, but especially those where the floodplain displacement and compensation sites can be readily enclosed by a perimeter area, so as to facilitate evaluation of areas using a planimeter. This method is conducive to the analysis of displacement and compensation on an incremental basis over the entire elevation range of the floodplain. This is the preferred method of analysis for most projects, except for projects of a linear nature.

This method involves the use of cross-sections taken in a horizontal plane in both the areas of floodplain displacement and the areas of floodplain compensation. The first step consists of setting up polygons around the perimeter of the floodplain displacement and the areas of floodplain compensation. The next step is to select a base elevation that is located at or below the lowest elevation of the proposed floodplain displacement. The object of the analysis is to compare the volume of pre-project floodplain storage within one or more selected perimeter areas with the post-project floodplain storage within those same perimeters. This comparison needs to be made on an incremental basis over the entire elevation range of the floodplain. The steps are as follows:

- (a) Set up polygons around the areas of floodplain displacement and/or floodplain compensation. These polygons will serve as the areas of comparison between the pre-project and the post-project conditions. Therefore, they must remain unchanged between the pre- and post- project conditions so as to allow a valid comparison.
- (b) Note that these polygons need to be located in the same reach of the river or stream. Floodplain compensation needs to be located as close as possible to the area of floodplain displacement that it is intended to mitigate.
- (c) Select a base elevation that is located at or below the lowest elevation of the proposed floodplain displacement. This base elevation must not be located below the normal river or stream level. Increased storage that is located below the normal river or stream level is not considered as floodplain compensation.
- (d) Indicate the 100-year floodplain elevation on the topography within the polygons. This elevation is intended to serve as the upper limit elevation for the analysis. Available storage that is situated higher than the 100-year flood elevation is not pertinent to the analysis of 100-year floodplain storage.
- (e) By using a planimeter or other method, determine the area that would be flooded at each incremental elevation being evaluated. Continue to determine these areas, proceeding from the bottom to top. Do this for each perimeter/polygon that is being used in the analysis. (In some cases the floodplain compensation may be located in the same perimeter as the floodplain displacement; in other cases, the compensation and displacement may be situated within different perimeter areas.)
- (f) Calculate the volume within each elevation range by using the areas available to be flooded (determined above) and the height of the elevation range interval using the following equation:

$$\text{Floodplain volume for interval} = \frac{(\text{Available area 1} + \text{Available area 2})}{2} \times \text{Elevation range interval.}$$

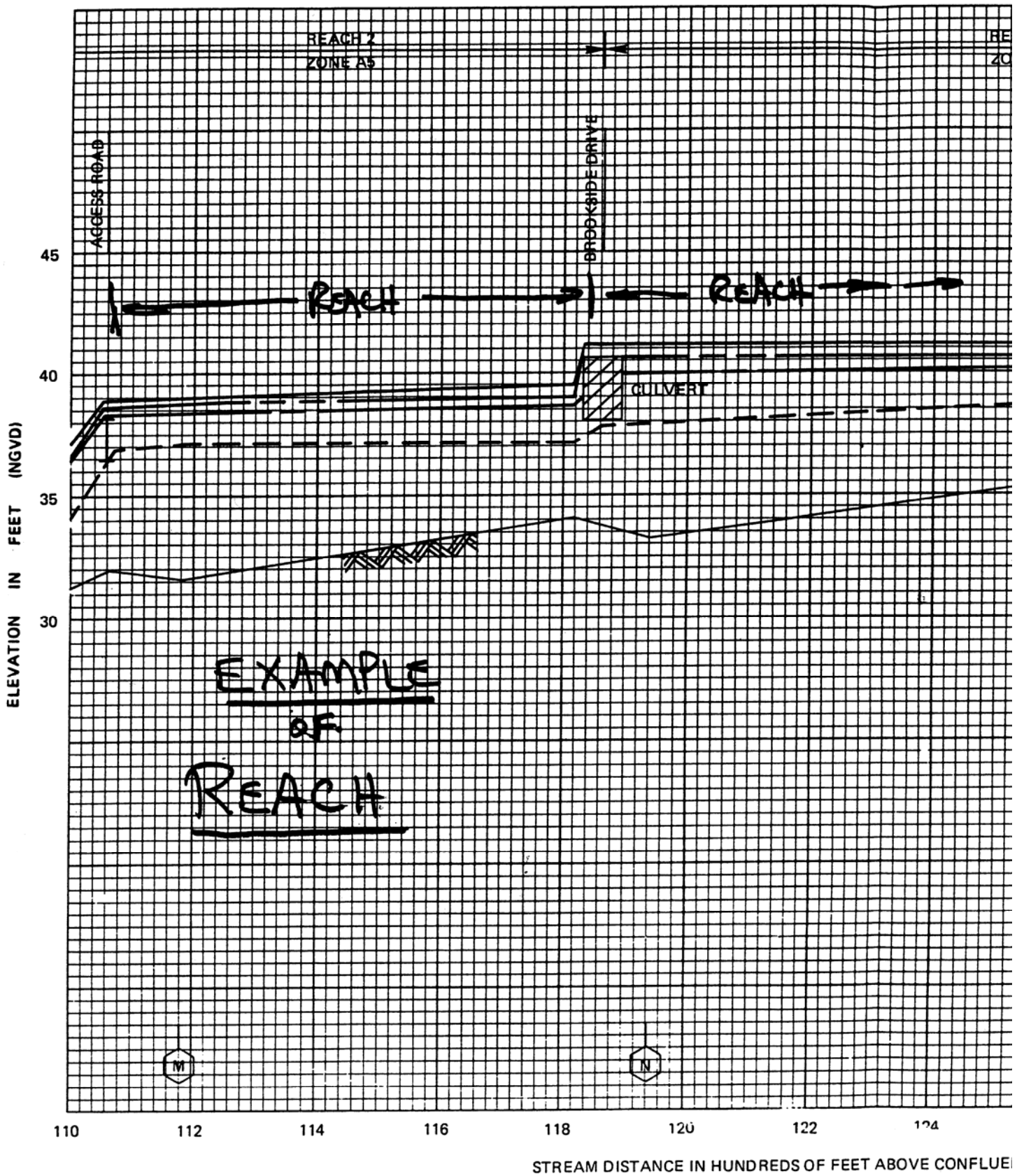
- (g) The floodplain volume for each elevation range interval is computed for each perimeter area. A grand total of floodplain volume for each elevation range interval is then calculated.
- (h) The above analysis is performed for both the pre-project and post-project conditions.
- (i) A successful result would show that, for each elevation range interval, the grand total of volume of floodplain storage for post-project conditions is equal to or greater than that for pre-project conditions.

Grid Method

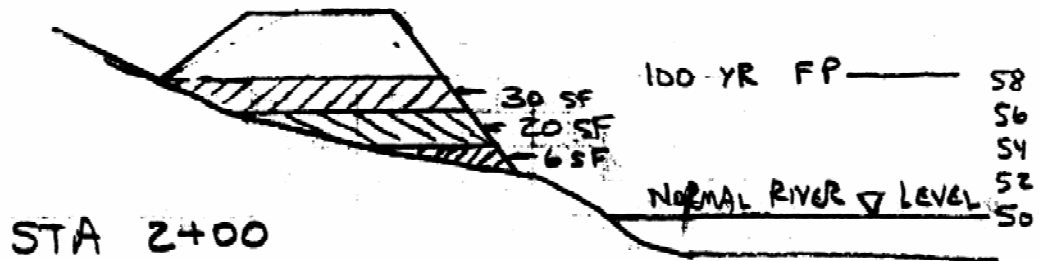
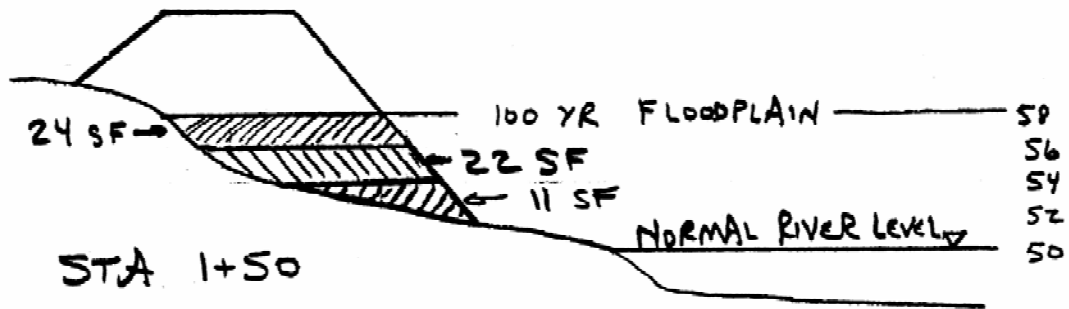
This method is especially useful in situations that have an area of relatively intricate and/or irregular topographic detail, and also have many areas of relatively shallow grade fills and cuts. An example of this type of situation is the proposed regrading of an athletic field, park, or golf course. This method does not lend itself well to the analysis of displacement and compensation on an incremental basis over the entire elevation range of the floodplain. Therefore, it is best used in situations that involve floodplain displacement that is generally considered to be within the same narrow approximate elevation range as the proposed floodplain compensation.

This method involves creation of a grid of corner points (typically in a square pattern) over the area of study, and subsequently determining the pre-project and post-project storage volumes between a base elevation and the floodplain elevation. The steps are as follows:

- (a) Enclose each area to be analyzed within a polygon.
- (b) Set up a grid system (square pattern) over each area to be analyzed. The size of the squares in the grid needs to be small enough to adequately capture the level of variation in site topography.
- (c) Indicate the elevation of the 100-year floodplain.
- (d) Calculate the depth of flooding (FD) at each grid corner point using the following relationship:
Flooding depth = 100-year floodplain elevation – Site elevation
(Enter zero (0) for negative values)
(For site elevations that are below the normal river or stream level, enter the normal river/stream level.)
- (e) Calculate the volume of floodplain storage within each grid area using the following equation:
 $((FD\ 1 + FD\ 2 + FD\ 3 + FD\ 4)/4) \times SIDE^2$ where FD 1 = flood depth at corner #1 of each grid, etc., and where SIDE = the length of the side of the grid.
- (f) To compute the volumes found within grids that extend beyond the project area (those at the edges of the project), make an adjustment to account for this partial coverage. Do this by using a partial grid area.
- (g) Compute the grand total of floodplain storage volume for the pre-project condition and the post-project condition.
- (h) A successful result would show that the amount of floodplain storage present in the post-project condition would equal or exceed that in the pre-project condition.



AVERAGE END AREA METHOD - STATIONED X-S'S



SCALE 1" = 10'

CALCULATE DISPLACEMENT IN EACH RANGE OF FLOODPLAIN:

$$52' \text{ TO } 54' : \frac{11 + 6}{2} \times 50 \rightarrow 425 \text{ CF} \rightarrow 15.7 \text{ CY}$$

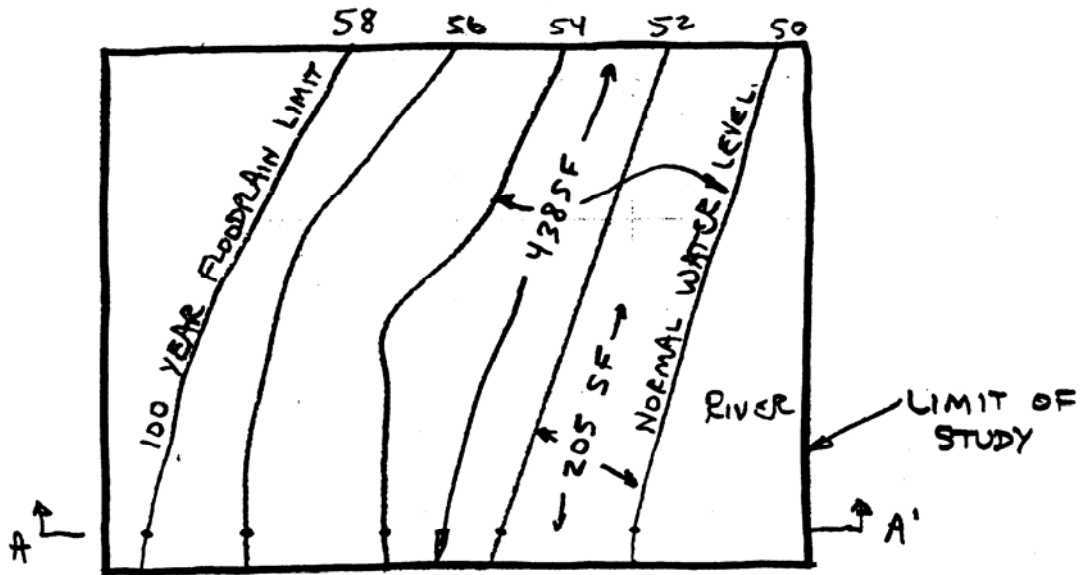
$$54' \text{ TO } 56' : \frac{22 + 20}{2} \times 50 \rightarrow 1050 \text{ CF} \rightarrow 38.9 \text{ CY}$$

$$56' \text{ TO } 58' : \frac{24 + 30}{2} \times 50 \rightarrow 1350 \text{ CF} \rightarrow 50.0 \text{ CY}$$

FLOODPLAIN COMPENSATION VOLUMES WOULD BE CALCULATED IN THE SAME MANNER

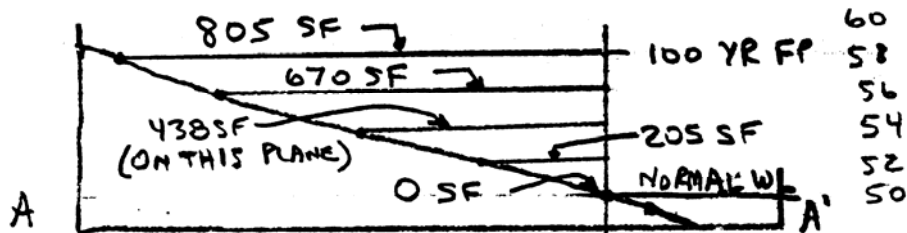
11/8/01 YAP

AVERAGE END AREA METHOD - SECTIONS IN HORIZ. PLANE



PLAN VIEW

SCALE 1" = 10'



SECTION VIEW

CALCULATE FLOODPLAIN VOLUME IN LIMIT OF STUDY FOR EACH INTERVAL.

$$50' \text{ TO } 52' \quad \left(\frac{0 + 205}{2} \right) \times 2' \rightarrow 205 \text{ CF}$$

$$52' \text{ TO } 54' \quad \left(\frac{205 + 438}{2} \right) \times 2' \rightarrow 643 \text{ CF}$$

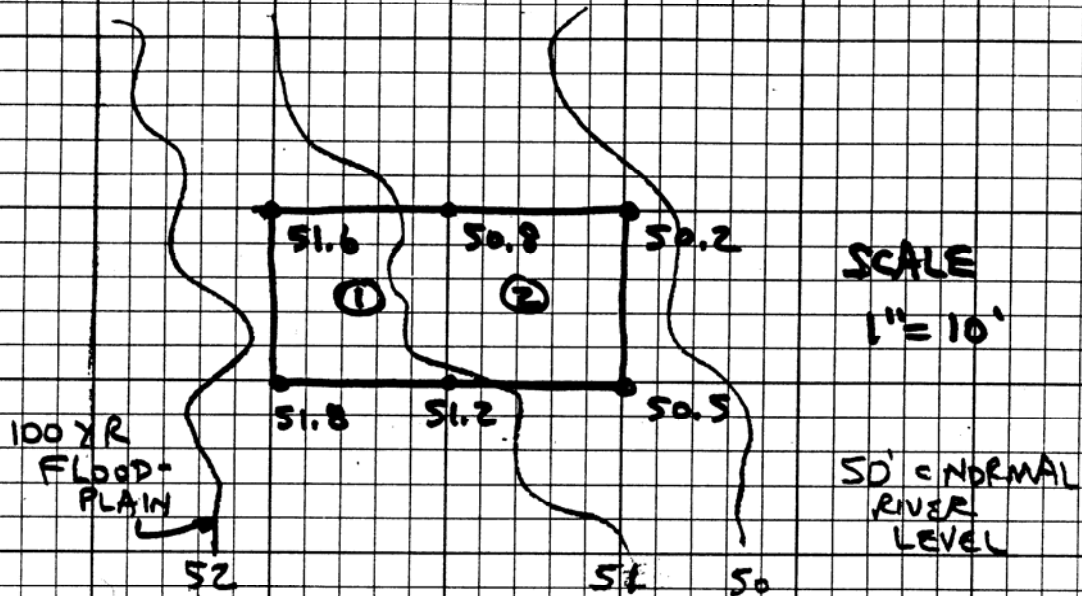
$$54' \text{ TO } 56' \quad \left(\frac{438 + 670}{2} \right) \times 2' \rightarrow 1108 \text{ CF}$$

$$56' \text{ TO } 58' \quad \left(\frac{670 + 805}{2} \right) \times 2' \rightarrow 1475 \text{ CF}$$

FLOODPLAIN DISPLACEMENT & COMPENSATION DONE SIMILARLY

11/8/01 MAP

GRID METHOD



CALCULATE AVAILABLE FLOODPLAIN
STORAGE VOLUME WITHIN THE
INDICATED AREA

$$\text{GRID 1: } \frac{(51.6 - 50) + (50.8 - 50) + (51.8 - 50) + (51.2 - 50)}{4} \times 10^2$$

$$= 1.35 \times 10^2 = 135 \text{ CF}$$

$$\text{GRID 2: } \frac{.8 + 1.2 + .2 + .5}{4} \times 10^2 = 67.5 \text{ CF}$$

$$\text{E VOLUME} = 202.5 \text{ CF}$$

FLOODPLAIN DISPLACEMENT & COMPENSATION
CALCULATIONS ARE DONE SIMILARLY

11/9/01 YAP