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7.0 LEVEED AREAS

Flood plains cover a significant area within Fort Bend County, Texas. This area may be developed to the limits of the floodway if a levee system is constructed to protect the area from high water levels on the adjacent watercourse (usually the Brazos River). The components of the levee system shall include an internal drainage system, a levee, a pump station or adequate storage capacity, and a gravity outlet with an outfall channel to the river. The Fort Bend County design criteria for each component are defined in the following sections.

The county's minimum design standards shall be governed by the rules and regulations as established by the Federal Emergency Management Agency (FEMA) including any updates as they occur. In general, FEMA is not responsible for building, maintaining, operating, or certifying levee systems. FEMA does, however, develop and enforce the regulatory and procedural requirements that are used to determine whether a completed levee system should be credited with providing 100-year (1-percent-annual-chance) flood protection. These requirements are documented in Section 65.10 of the National Flood Insurance Program (NFIP) regulations. The engineer is advised to check the current FEMA rules and regulations. Maintenance of these facilities generally will not be the responsibility of Fort Bend County.

7.1 INTERNAL DRAINAGE SYSTEM

The internal drainage system for the leveed area shall include the network of channels, lakes, and storm sewers which drain the leveed area to the outfall structure. Refer to Section 3.0 Open Channel Flow, Section 5.0 Storm Sewers and Overland Flow and Section 6.0 Storm Runoff Storage for Fort Bend County construction requirements and design criteria.

7.2 LEVEE SYSTEM

7.2.1 Frequency Criteria

The levee system shall include a levee embankment that will protect the development from the 100-year frequency flood event on the adjacent watercourse. Protection from the 100-year frequency event shall include protection from the 100-year water surface elevation on the watercourse, as well as protection from any associated wind and wave action.

7.2.2 Design Criteria

General design criteria for levees in Fort Bend County are shown below. However, all levees should be designed in accordance with the U.S. Army Corps of Engineers (COE) Engineer Manual EM 1110-2-1913 (30 April 2000, or most current edition). If conflicts exist between the COE manual and the criteria shown below, the Fort Bend County Drainage District Engineer should be consulted for direction.

1. A geotechnical investigation shall be required on the levee foundation (the existing natural ground). Soil borings shall be required with a maximum spacing of 1,000 feet and a minimum depth equal to twice the height of the levee embankment.

2. The foundation area shall be stripped for the full width of the levee. Stripping shall include removal of all grass, trees, and surface root systems.

3. Embankment material shall be CH or CL as classified under the Unified Soil Classification System and shall have the following properties:

    a. Liquid Limit greater than or equal to 30.
    b. Plasticity Index greater than or equal to 15.
    c. Percent Passing No. 200 Sieve greater than or equal to 50.

    A geotechnical investigation shall be required on the embankment material to determine the levee side slopes and methods employed to control subsurface seepage.

4. The embankment material shall be compacted to a minimum density of 95 percent using the standard proctor compaction test at approximately plus or minus three percent optimum moisture content. The embankment material shall be placed in lifts of not more than 12 inches thick.

5. The levee top and side slopes shall be adequately protected by grass cover or other suitable material.

6. The minimum levee top width shall be ten feet.

7. The levee side slope shall be one vertical to a minimum of three horizontal.

8. Both levees and floodwalls should provide at least 1 foot freeboard above FEMA minimum requirement. The FEMA minimum for riverine levees is as shown below:

    a. In accordance with Section 65.10 of the NFIP, a minimum freeboard of 3 feet above the water-surface level of the base flood must be provided for riverine levees.
    b. An additional 1 foot above the minimum is required within 100 feet on either side of structure (e.g., bridges) riverward of the levee or wherever the flow is constricted.
    c. An additional 0.5 foot above the minimum at the upstream end of the levee tapering to not less than the minimum at the downstream end of the levee, is also required.
    d. Occasionally, exceptions to minimum riverine freeboard requirements above may be approved if the following criteria are met:
        1) Appropriate engineering analyses demonstrating adequate protection with a lesser freeboard must be submitted.
        2) The material presented must evaluate the uncertainty in the estimated base flood elevation profile and include, but not necessarily be limited to a) an assessment of statistical confidence limits of the 1 % AEP discharge b) Changes in stage-discharge relationships and c) Sources, potential, and magnitude of debris, sediment, and ice accumulation.
        3) It must be shown that the levee will remain structurally stable during the base flood when such additional loading considerations are imposed.
    e. Under no circumstances will freeboard of less than 2 feet above BFE be accepted.

9. The levee shall be continuous and shall either completely encompass the development or tie into natural ground located outside of the limits of the adjacent watercourse's 100-year floodplain.

10. All pipes and conduits passing through the levee shall have anti-seepage devices, flap gates, and slope protection.

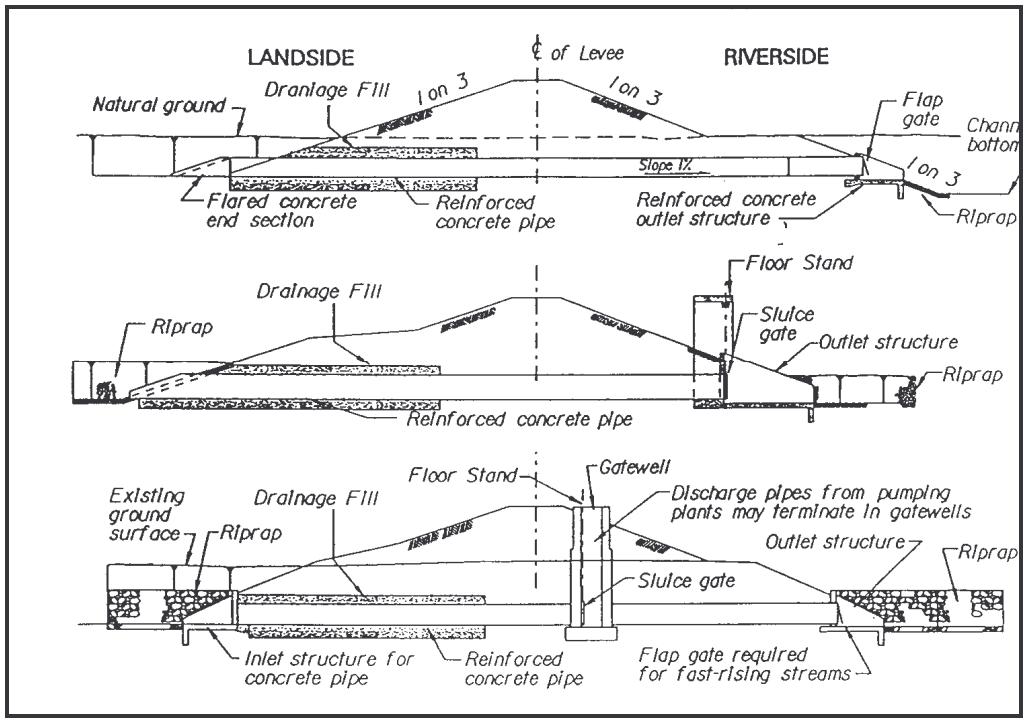
    a. Antiseepage devices have been employed in the past to prevent piping or erosion along the outside wall of the pipe. The term "antiseepage devices" usually referred to metal diaphragms (seepage fins) or concrete collars that extended from the pipe into the backfill material. The diaphragms and collars were often referred to as "seepage rings." However, many piping failures have occurred in the past where seepage rings were used. Assessment of these failures indicated that the presence of seepage rings often results in poorly compacted backfill at its contact with the structure.

    b. Where pipes or conduits are to be constructed through new or existing levees:

        1) Seepage rings or collars should not be provided for the purpose of increasing seepage resistance. Except as provided herein, such features should only be included as necessary for coupling of pipe sections or to accommodate differential movement on yielding foundations. When needed for these purposes, collars with a minimum projection from the pipe surface should be used.

        2) A 0.45-m (18-in) annular thickness of drainage fill should be provided around the landside third of the pipe, regardless of the size and type of pipe to be used, where landside levee zoning does not provide for such drainage fill. For pipe installations within the levee foundation, the 0.45-m (18-in) annular thickness of drainage fill shall also be provided, to include a landside outlet through a blind drain to ground surface at the levee toe, connection with previous underseepage features, or through an annular drainage fill outlet to ground surface around a manhole

structure. The figure below shows typical sections of drainage structures through levees.



Typical Sections, Drainage Structures through Levees
(From EM 1110-2-1913)

11. The minimum right-of-way for the levee shall be from toe to toe. In addition, the establishment of an easement for maintenance and access, which may be located within the right-of-way, shall be required. Access shall be provided with either a minimum 10-foot easement adjacent to the levee, a minimum 10-foot levee top width or a minimum 10-foot horizontal berm on either side of the levee. A minimum 20-foot wide easement should be established in at least two locations to provide access to the levee right-of-way from a nearby public road.

7.3 PUMP STATIONS

7.3.1 Frequency Criteria

To prevent flooding within leveed areas, pumps are recommended (instead of only storage) to remove interior drainage when the exterior river stage reaches a level that prevents gravity outflow. In order to determine the required pump capacity so that the maximum ponding level within the leveed area will not be exceeded on the average more than about once in 100 years, the following design criteria have been developed.

The two sets of criteria provided below differ depending on whether the storm that occurs over the leveed area during high exterior river stages is an independent or dependent event as compared to the storm that produced the high river stages. For a detailed discussion of the development of this criteria, see Appendix C. In Fort Bend County, the levees along the Brazos River should be analyzed independently (using coincidental events, criteria 7.3.1.1) and all other levees should be analyzed dependently (using same events, criteria 7.3.1.2).

7.3.1.1 Design Criteria Assuming Coincidental Events

This criterion presumes that the storm event causing a high flood stage outside of the leveed area is independent of the storm event occurring over the leveed area (e.g. a leveed area draining into the Brazos River in Fort Bend County). The following steps should be taken for determining the required pumping capacity.

1. Select the maximum ponding level within the leveed area that should not be exceeded more than once in 100 years on the average. Normally, this level will be equal to the maximum water surface elevations associated with the 100-year flood event computed in designing the internal drainage system (channels) of the leveed area, including the required minimum freeboard of one foot. This will be the level which, when equaled or exceeded by exterior flood stages, will prevent gravity outflow and require total pumping to remove any runoff that might occur within the leveed area.

2. From a rating or backwater curve applicable to the location on the watercourse where the gravity outflow point of the leveed area exists, determine the discharge corresponding to the maximum ponding level. See Figures 7-1-1 through 7-1-18 for multiple flood profiles from which a discharge can be derived. These profiles are based on the hydraulic model from the (Preliminary) Flood Insurance Study of Fort Bend County, Texas, 2009.)

3. Determine the percentage of time that the discharge (obtained from Step 2 above) is equaled or exceeded. Given this percentage of time, determine the frequency of the rainfall event corresponding to the coincidental probability of these two events. (For the Brazos River, Figure 7-2 shall be used to determine directly the frequency of rainfall from the discharge corresponding to the maximum ponding elevation.)

4. Use TP-40 (see Figure 7-3) or other appropriate rainfall frequency curve to obtain the rainfall amounts associated with the return period (obtained from Step 3 above) to be used for determining the required pumping capacity.

7.3.1.2 Design Criteria Assuming Same Event

This criteria presumes the storm event causing high flood stages outside of the leveed area is the same (dependent) storm event occurring over the leveed area. The design rainfall amounts to be used for sizing the required pump capacity will be associated with the 100-year rainfall event. (See Table 2-1 for rainfall amounts derived from TP-40 and Hydro-35).

7.3.2 Design Criteria

All leveed areas within Fort Bend County that are equipped with a pump station shall be capable of maintaining the design pumping capacity with its largest single pump inoperative. The capacity of a pump station designed under Section 7.3.1.1 shall be adequate to remove a minimum volume of water from the leveed area within 24 hours without exceeding the maximum ponding elevation within the leveed area. If a pump station is not provided, adequate storage volume below the maximum ponding level must be provided to contain the entire design storm. The volume of runoff to be pumped shall be the greater of either:

1. The runoff resulting from the appropriate rainfall amount as determined in Step 4 of Section 7.3.1.1.

2. A minimum of 1½ inches of runoff from fully developed areas and 1 inch of runoff from undeveloped areas over the contributing watershed.

A pump station designed under Section 7.3.1.2 shall have a combination of storage volume/pumping capacity adequate to maintain the runoff resulting from the 100-year frequency event below the maximum ponding level. The minimum pumping capacity shall be the same as number two above. All pump stations in Fort Bend County shall be equipped with auxiliary power for emergency usage.

7.4 GRAVITY OUTLET AND OUTFALL CHANNEL

An outlet shall be required to release by gravity from the leveed area through the outfall channel to the adjacent watercourse during low flow conditions on the receiving channel. The outlet shall be equipped with an automatically functioning gate to prevent any external flow from entering the leveed area.

The outlet and outfall channel shall be designed in accordance with Section 3 - Open Channel Flow. The velocities within the outfall channel at the adjacent river shall not exceed 5.0 feet per second.

7.5 REVIEW PROCESS

When a levee system is required for development, the following information shall be submitted to the Fort Bend County Drainage District for review:

1. Preliminary Submittal

    a. A vicinity map showing the proposed levee location in relation to the 100-year flood plain and floodway of the adjacent river.
    b. The preliminary design of the levee cross-section based upon the geotechnical investigation.
    c. The preliminary design of the pump station capacity

2. Final Submittal

    a. The final design of the levee cross-section and location.
    b. The final design of the pump station capacity.
    c. The hydraulic calculations showing that the maximum ponding elevation is not exceeded within the leveed area more than once in 100 years on the average.
    d. The construction drawings and technical specifications for the levee and pump station along with final design computations for the levee, pump station and channels.

In accordance with the current Texas Water Code, Texas Commission on Environmental Quality (TCEQ) approval shall be required on the following.

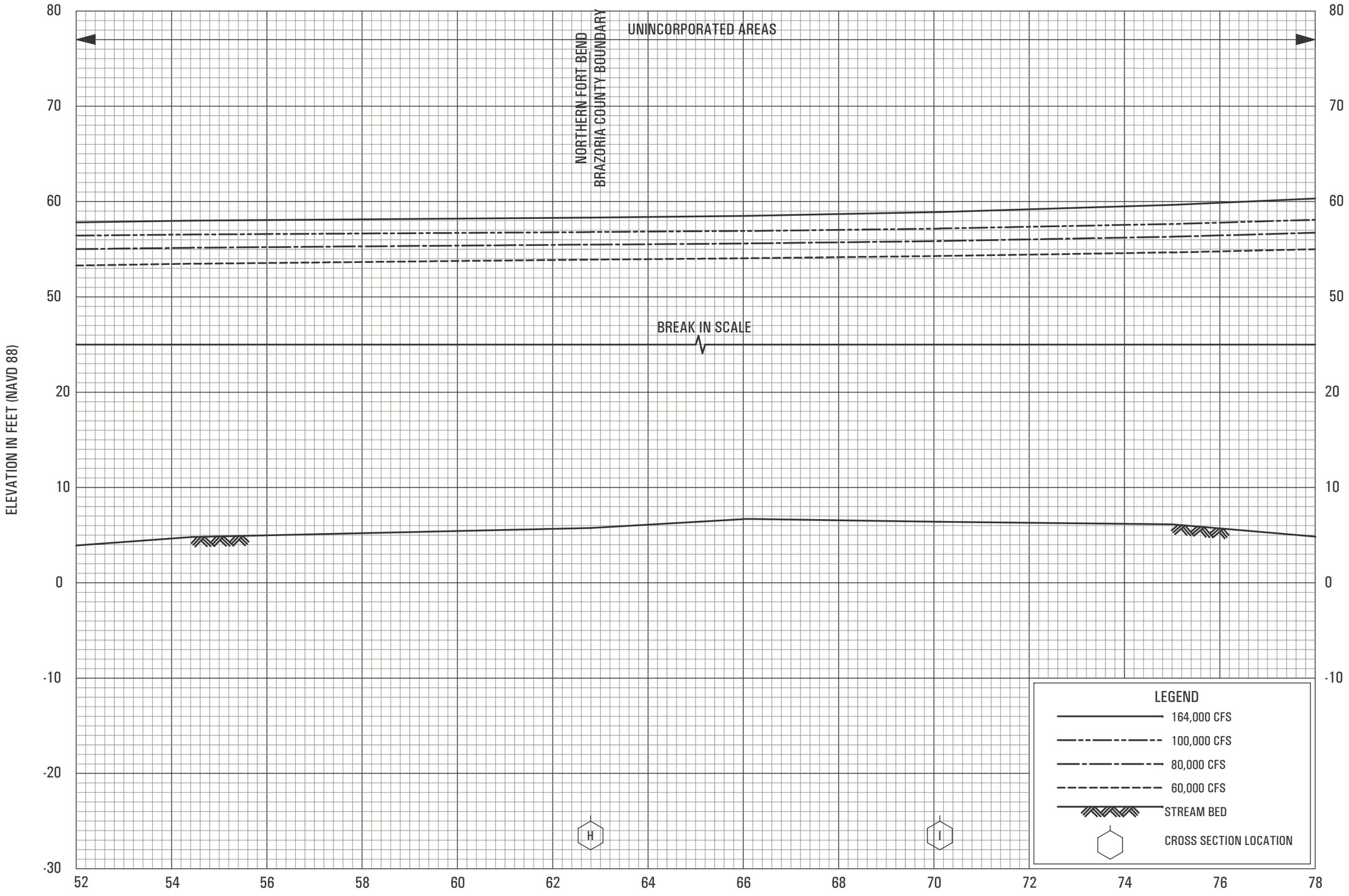
1. Levee improvement district proposed plans of reclamation.

2. Preliminary plans for construction of levees or other improvements.

3. Final plans for levees and other improvements.

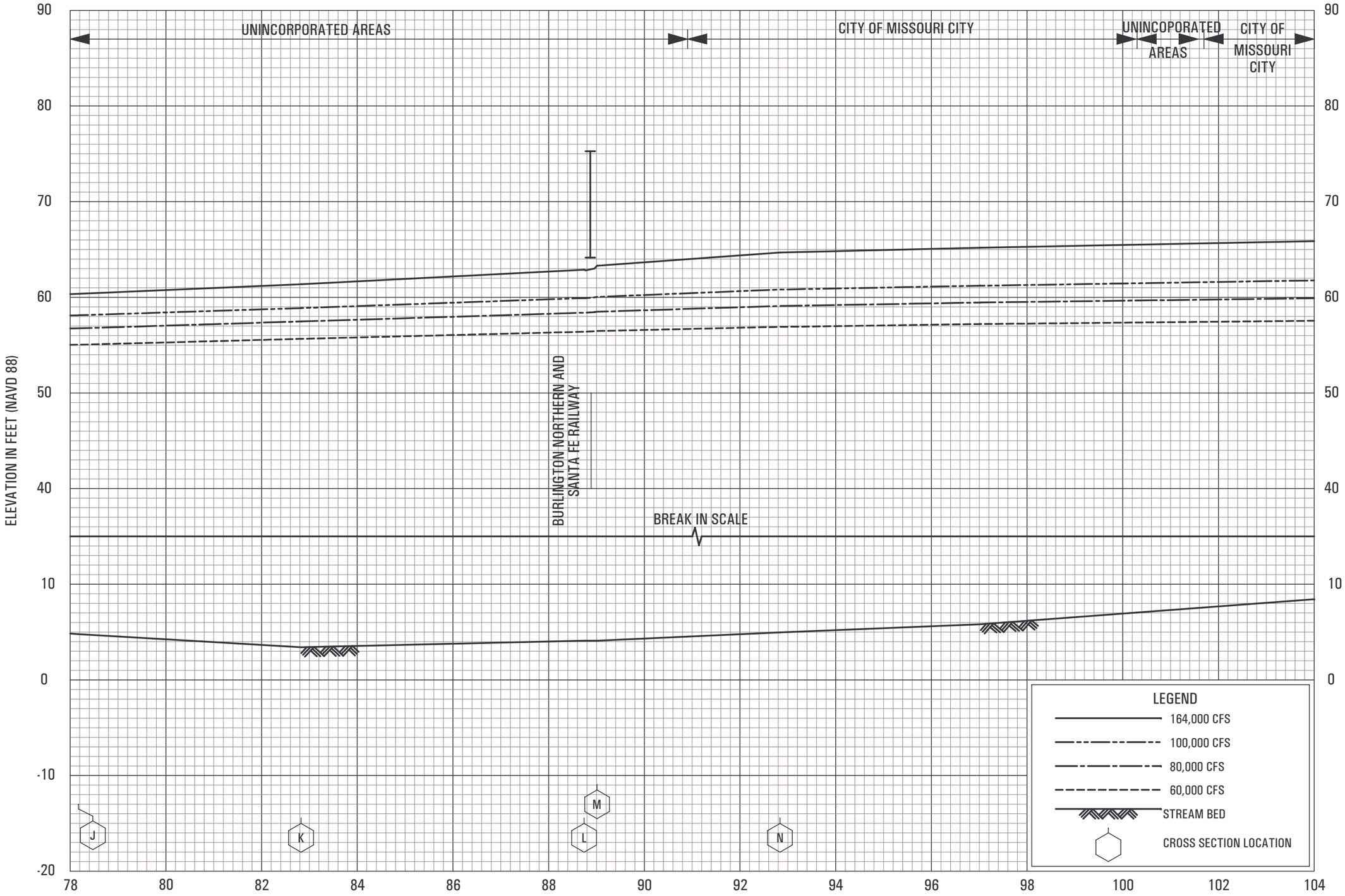
WATER SURFACE PROFILES

BRAZOS RIVER



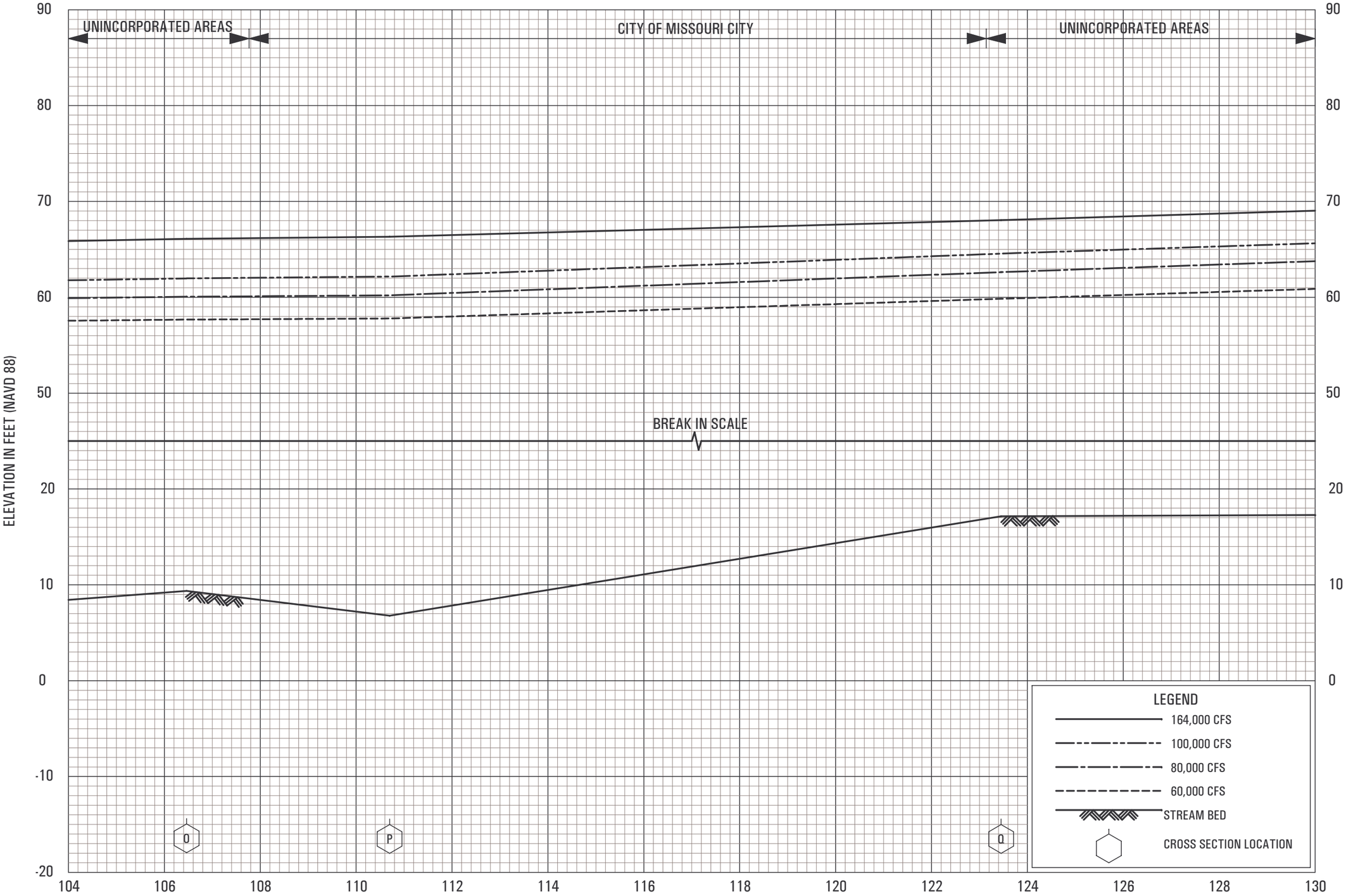
FORT BEND COUNTY DRAINAGE DISTRICT
DRAINAGE CRITERIA MANUAL
SECTION 7 - PUMP STATION DESIGN

7-1-1



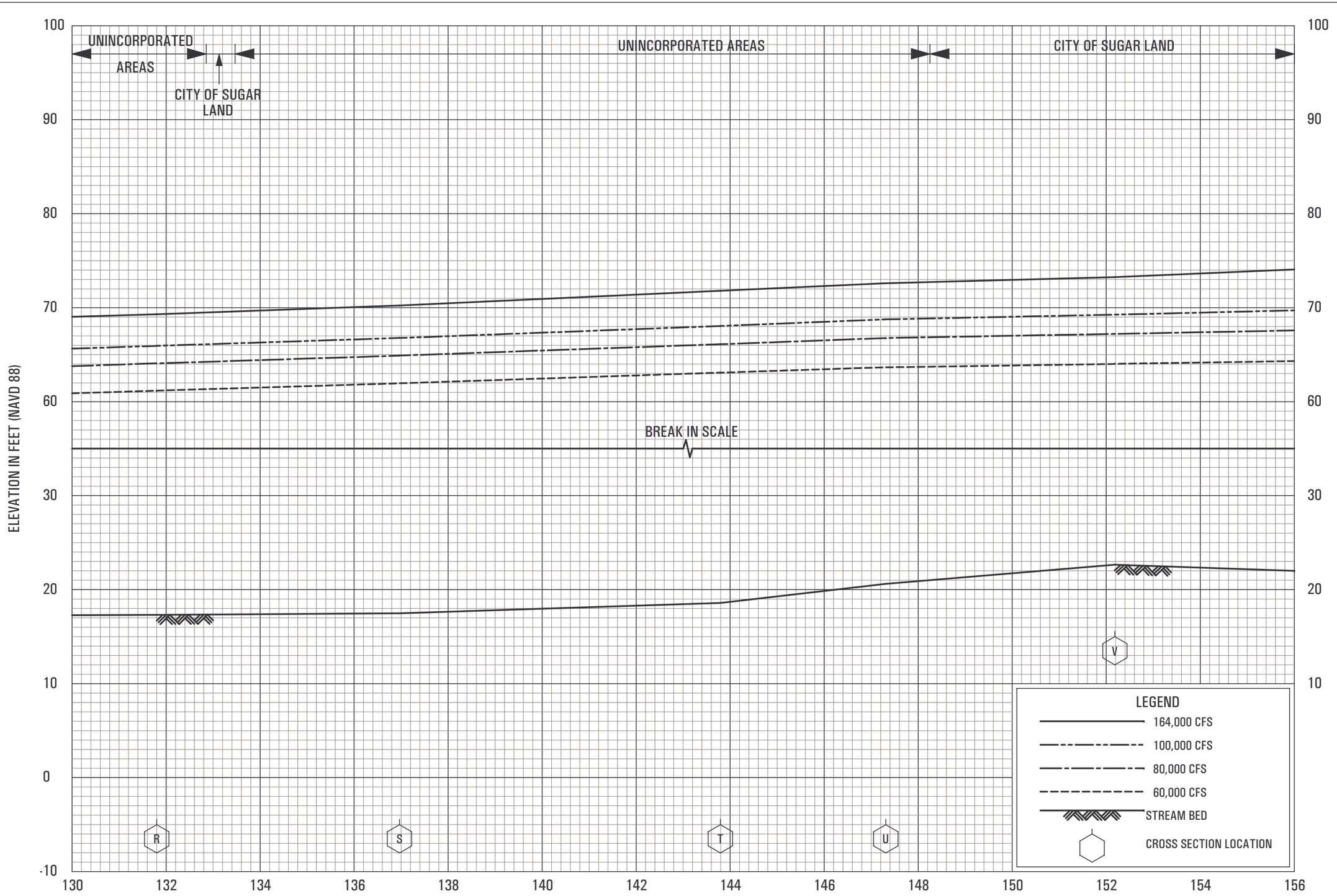
WATER SURFACE PROFILES

BRAZOS RIVER



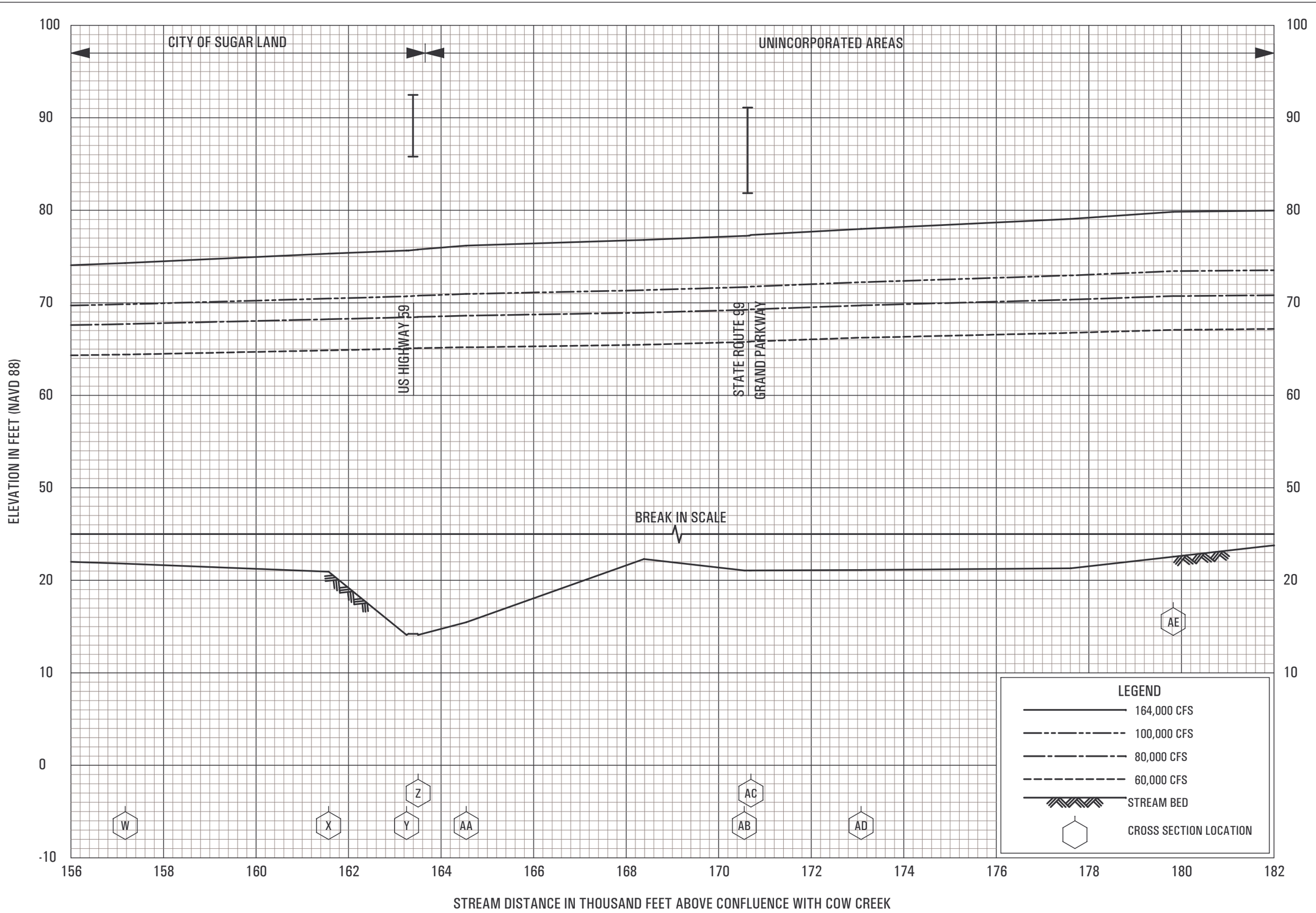
WATER SURFACE PROFILES

BRAZOS RIVER



WATER SURFACE PROFILES

BRAZOS RIVER



WATER SURFACE PROFILES

BRAZOS RIVER

FORT BEND COUNTY DRAINAGE DISTRICT
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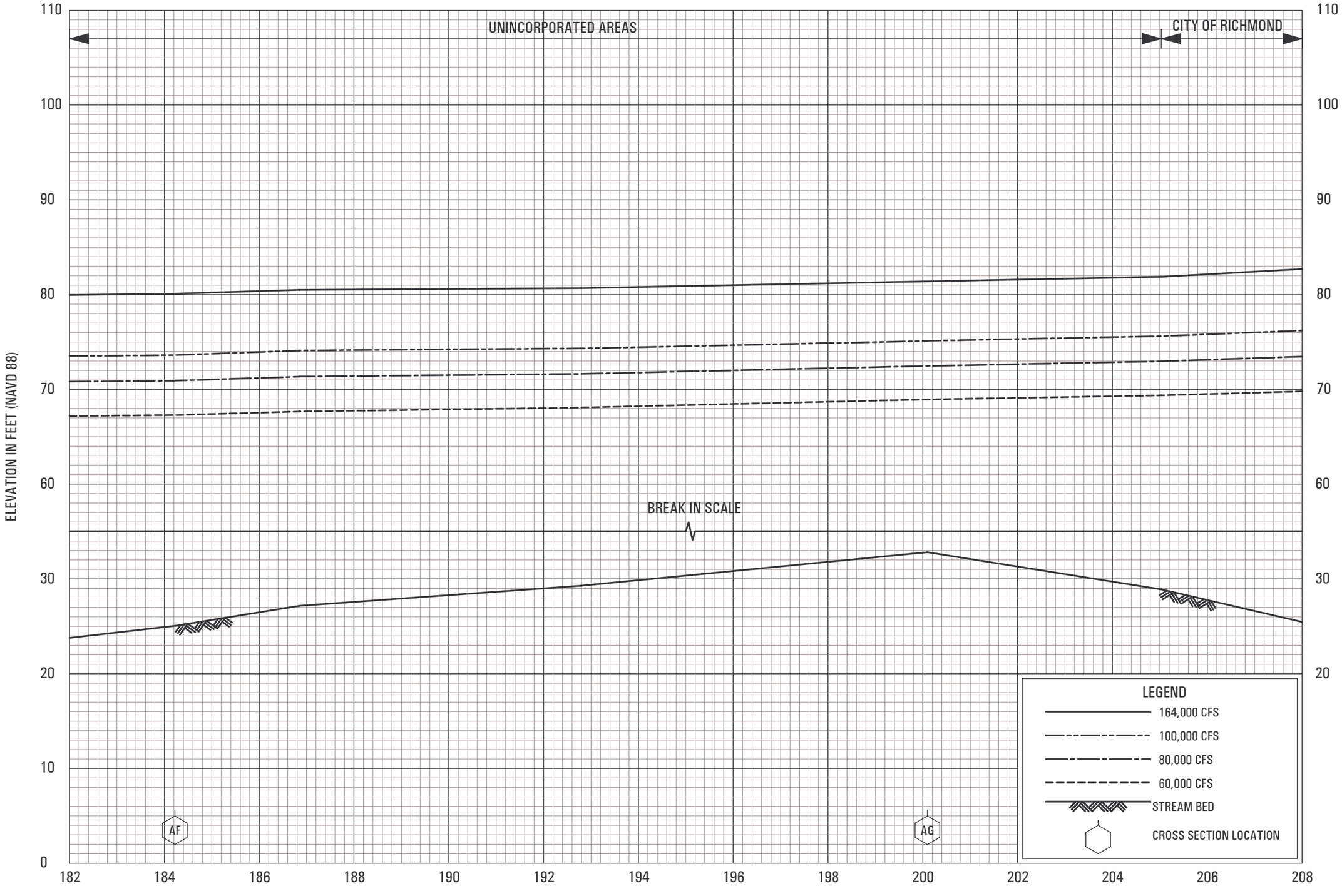
SECTION 7 - PUMP STATION DESIGN



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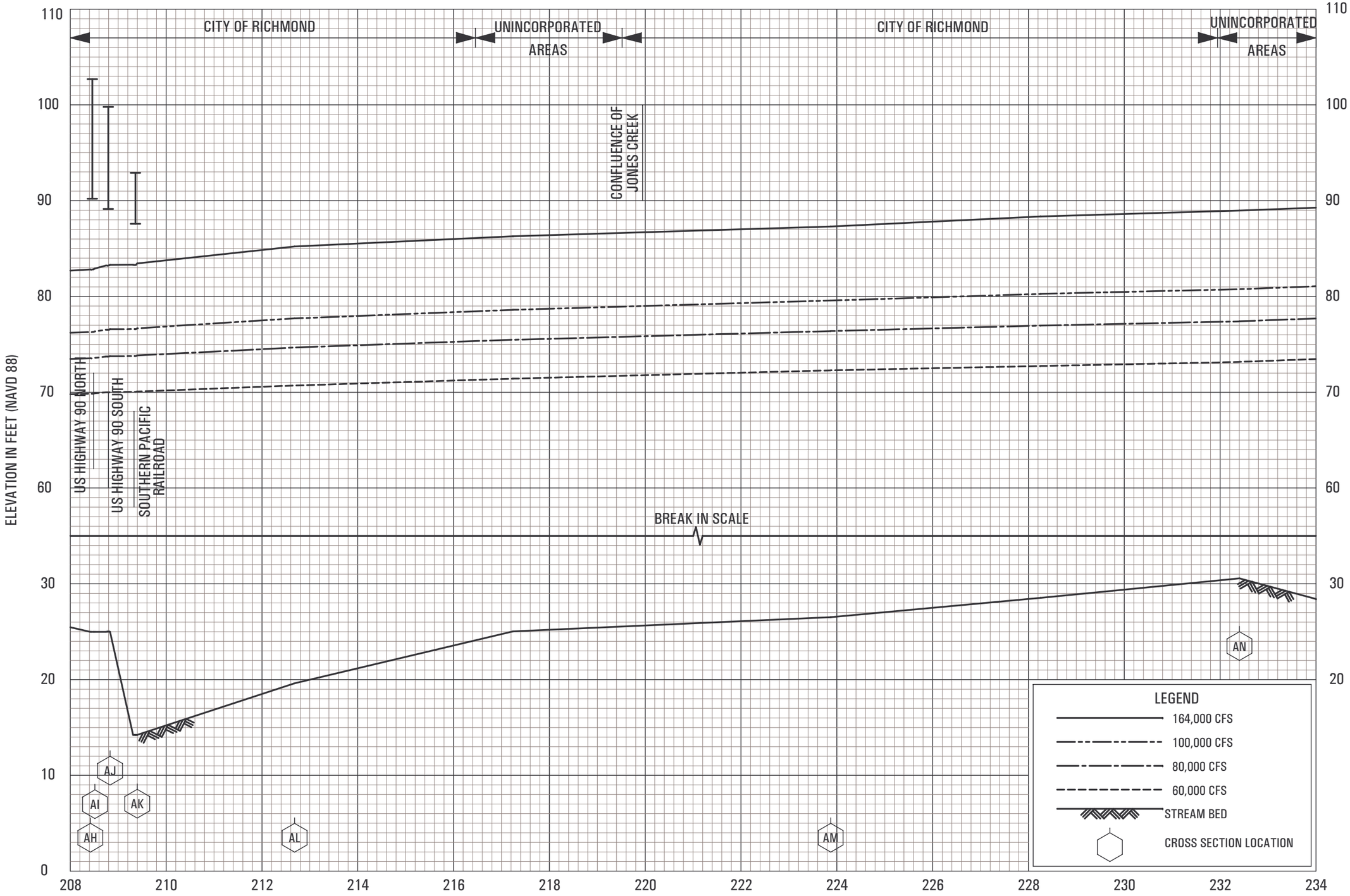

WATER SURFACE PROFILES

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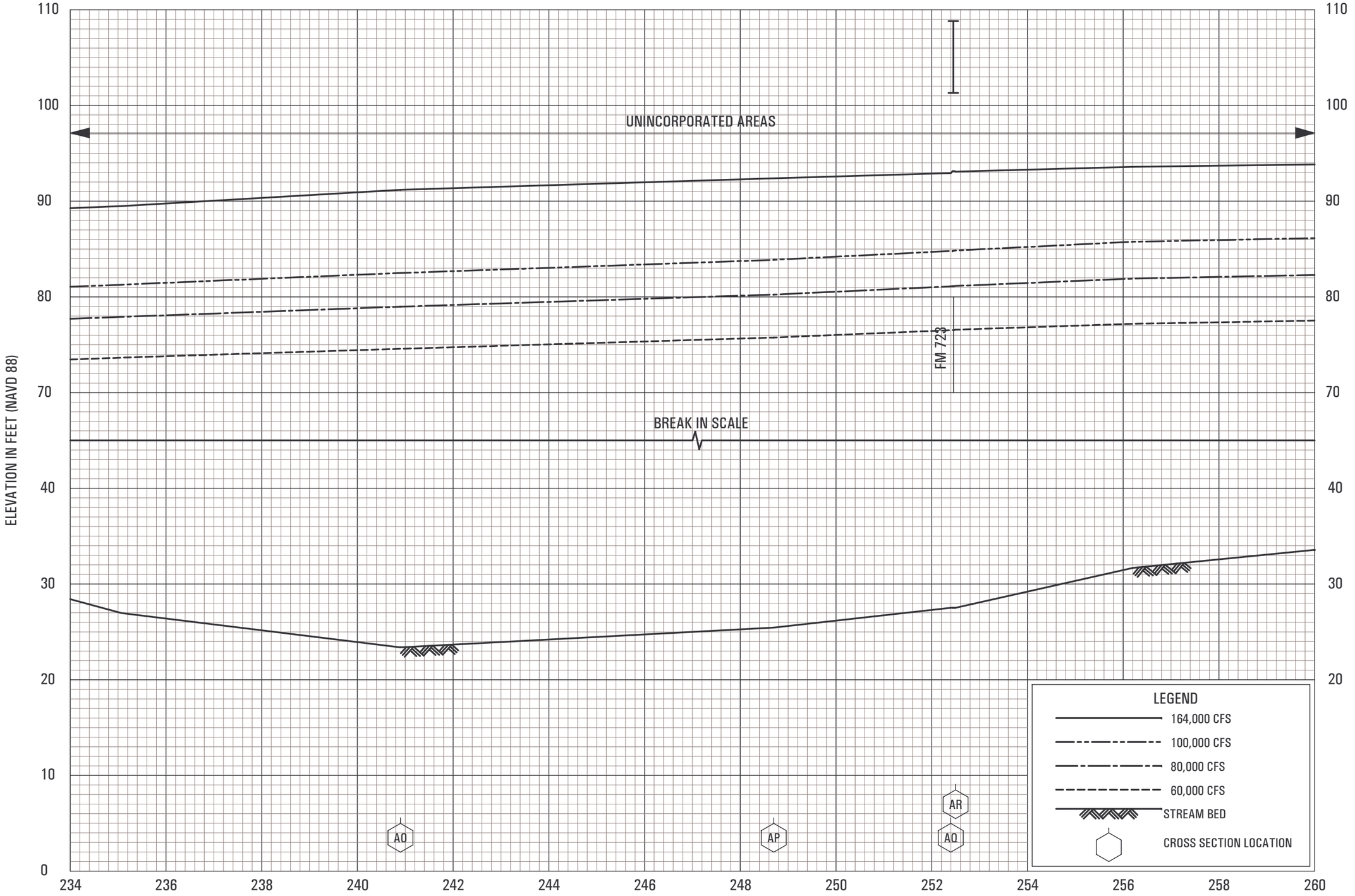

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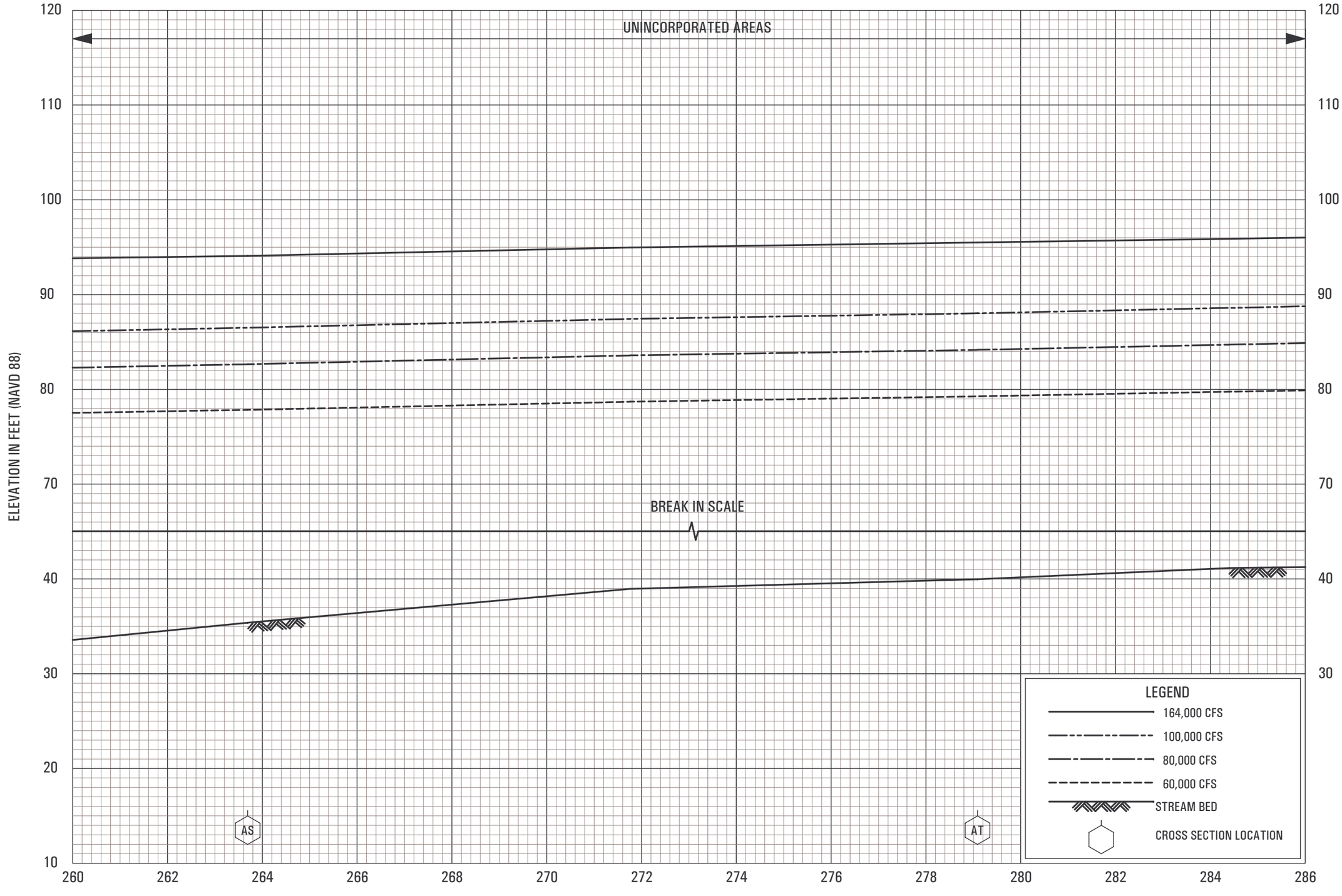

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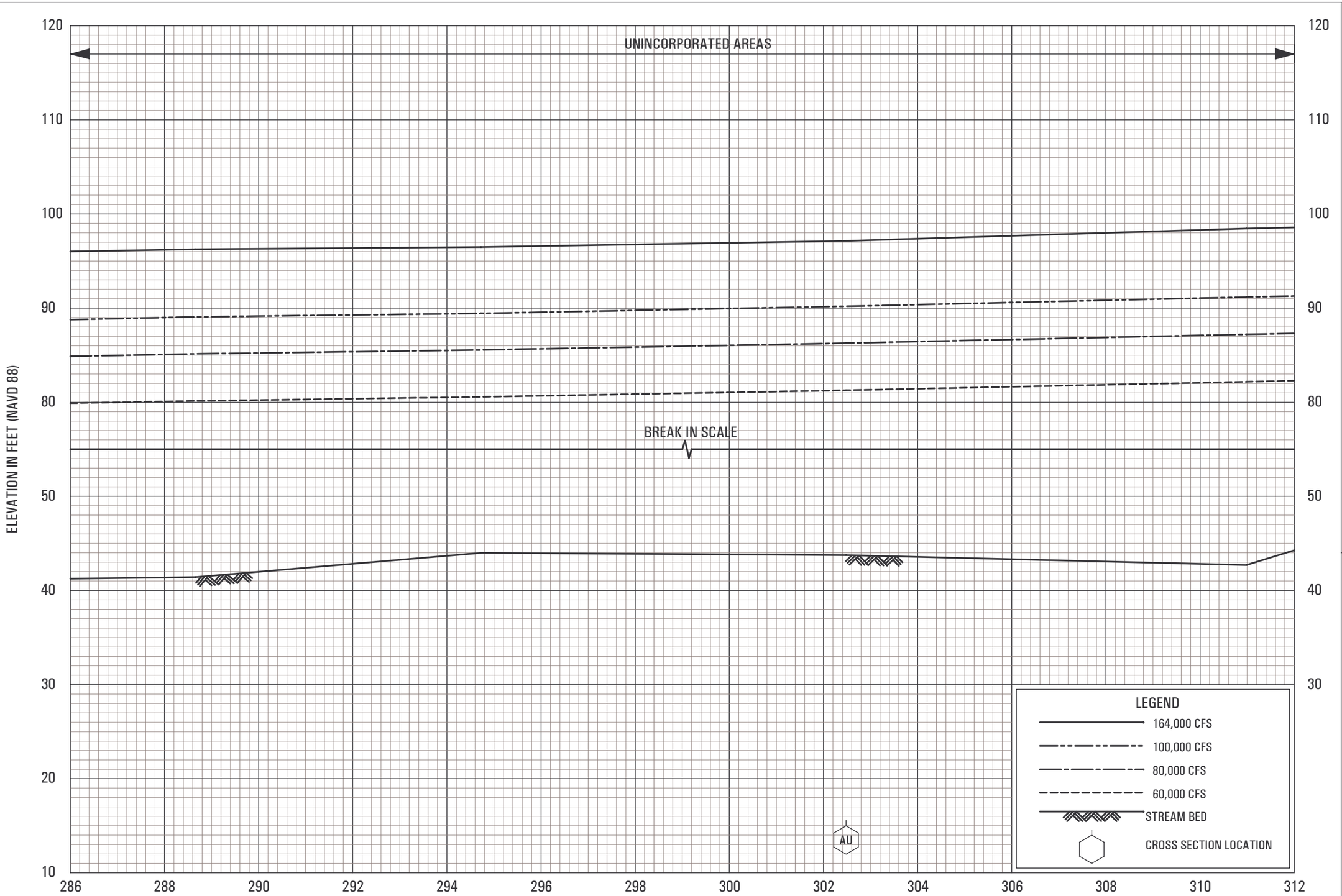
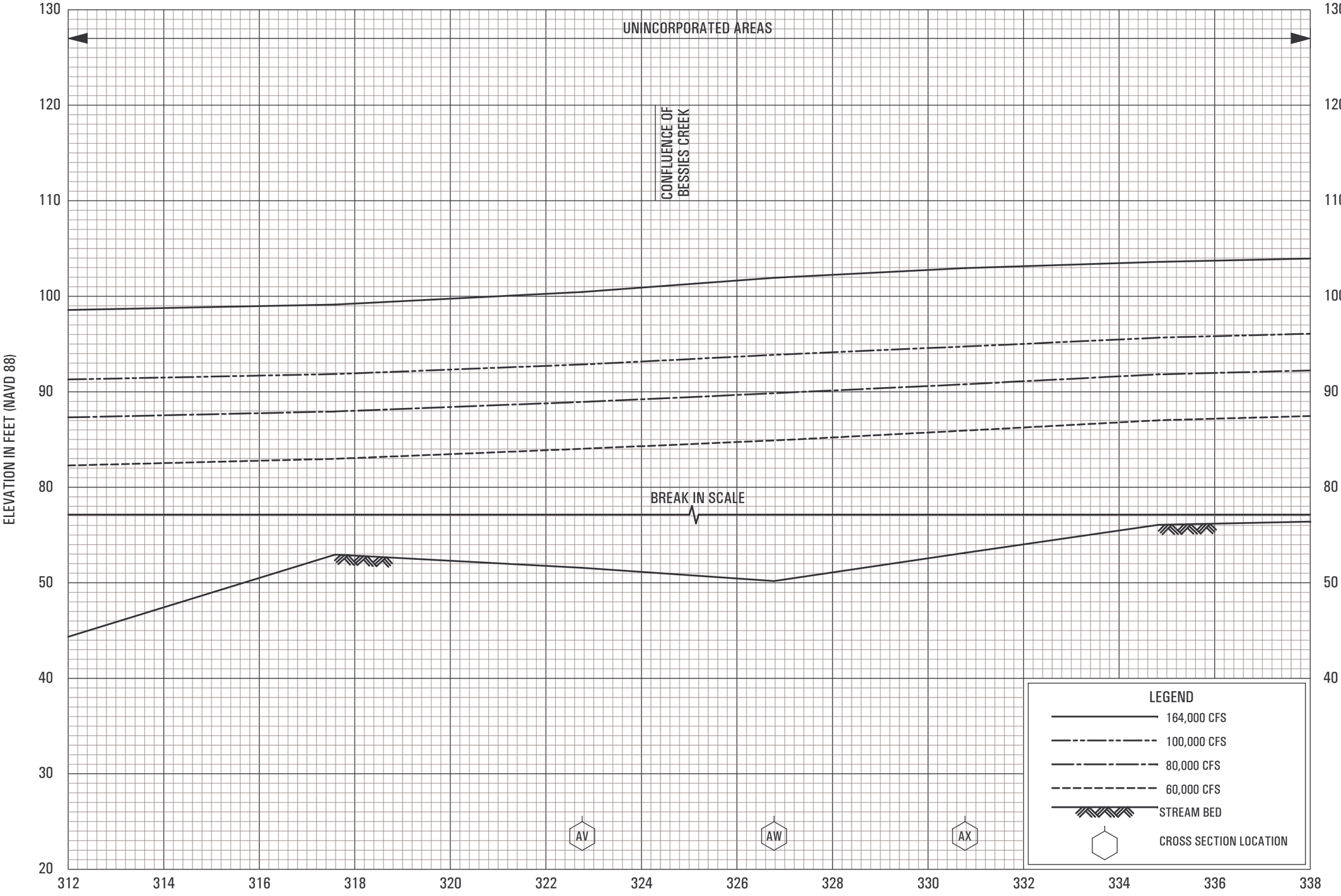


WATER SURFACE PROFILES

BRAZOS RIVER



WATER SURFACE PROFILES

BRAZOS RIVER

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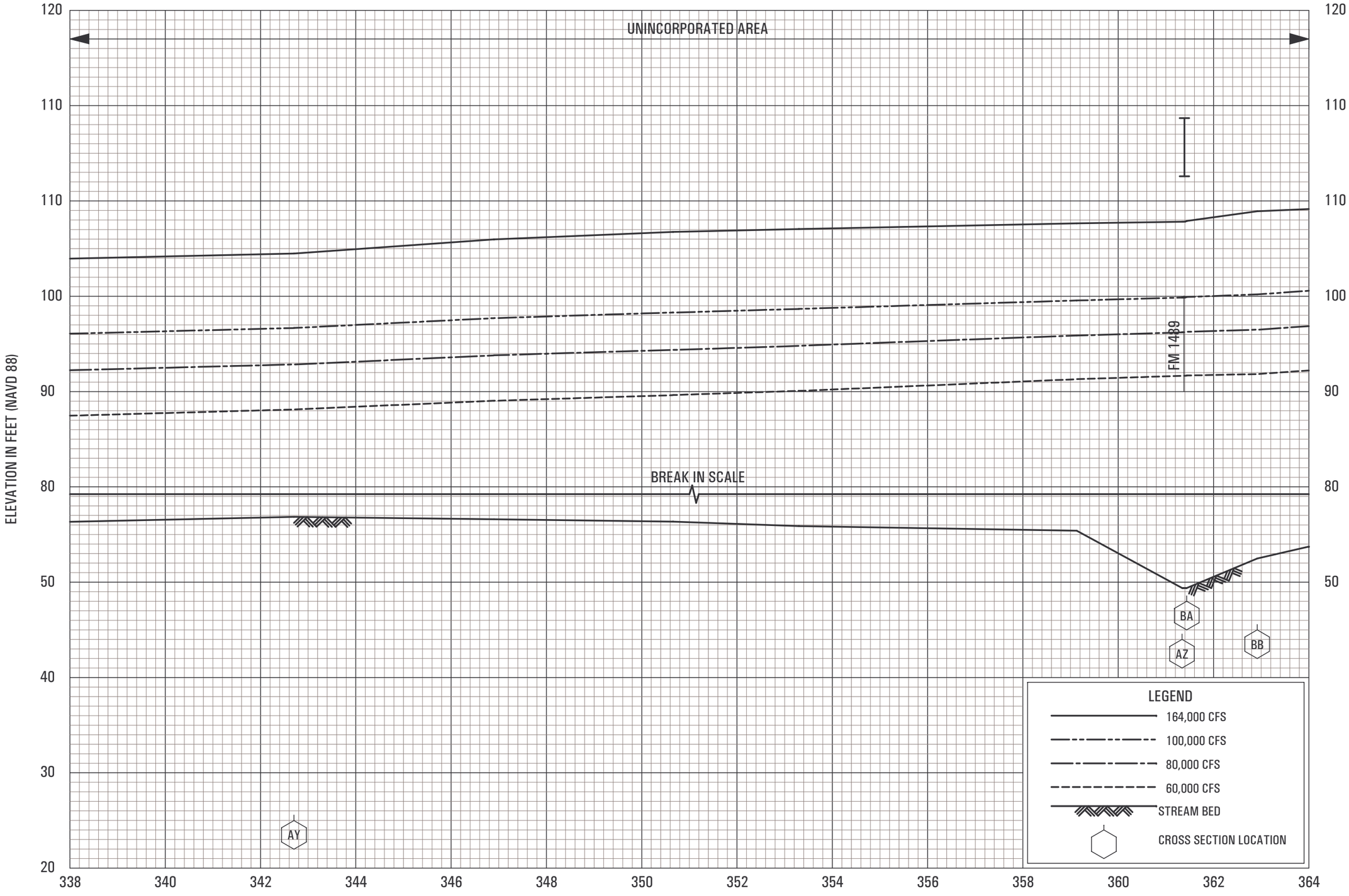

WATER SURFACE PROFILES

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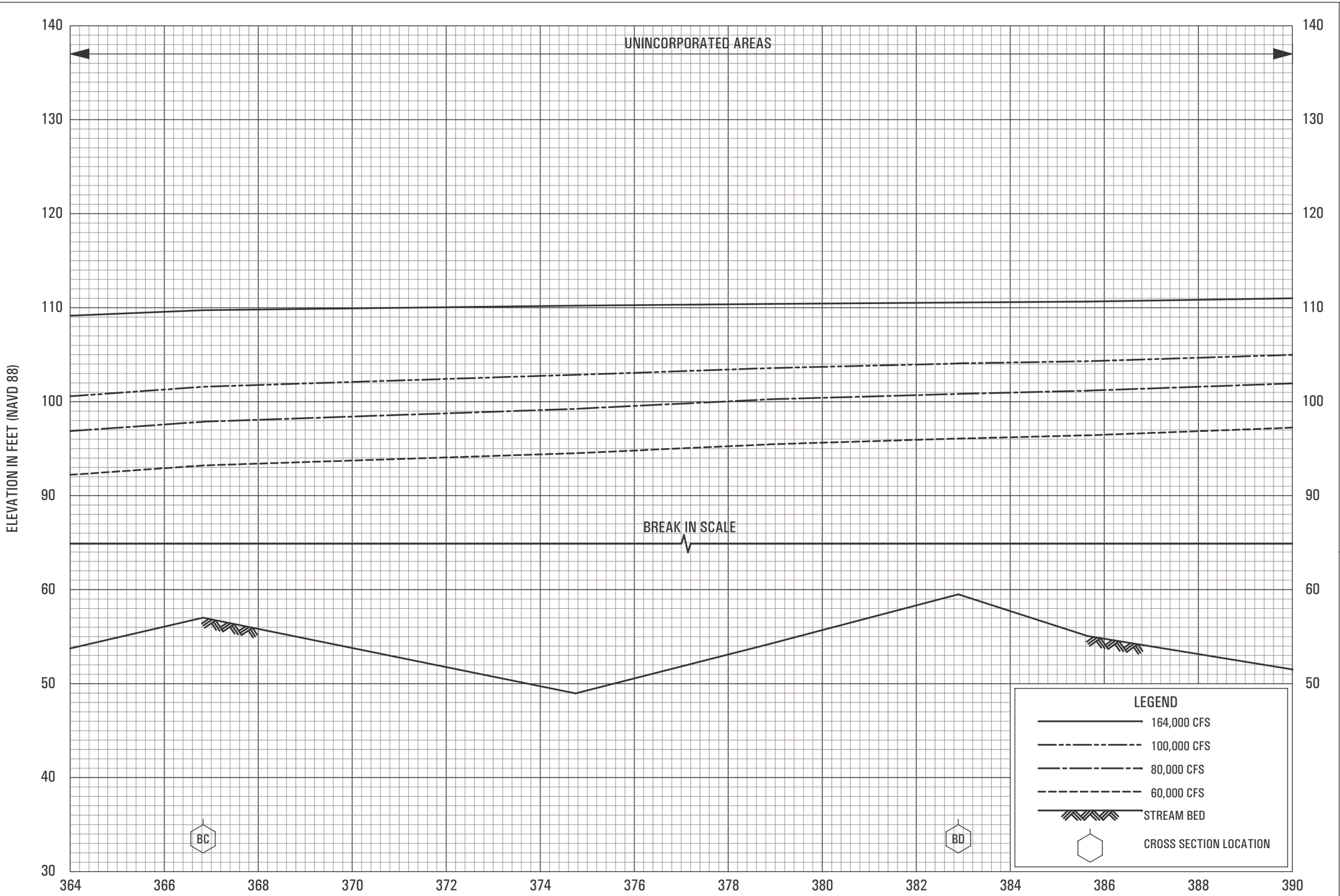

WATER SURFACE PROFILES

BRAZOS RIVER

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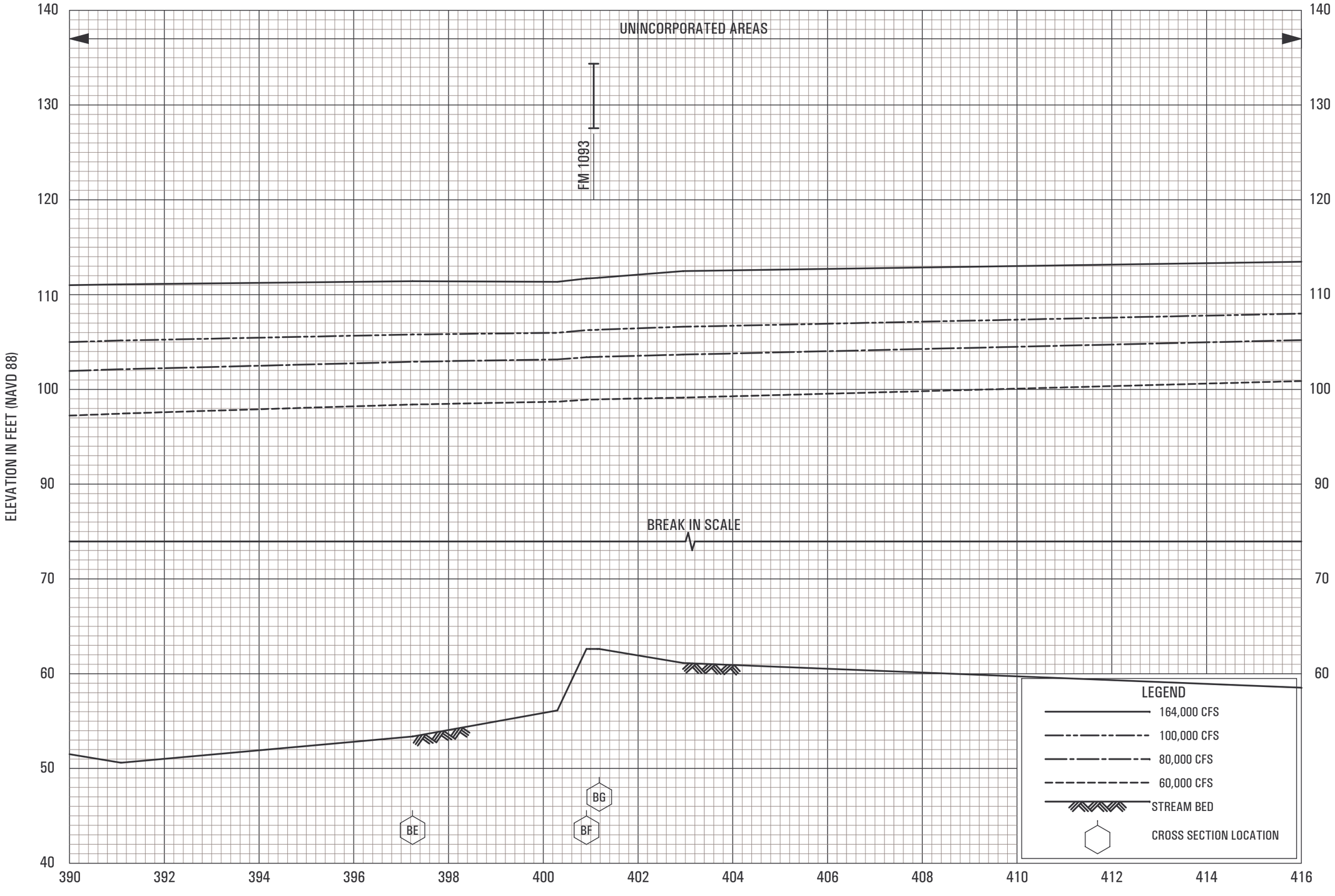

WATER SURFACE PROFILES

BRAZOS RIVER

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SECTION 7 - PUMP STATION DESIGN

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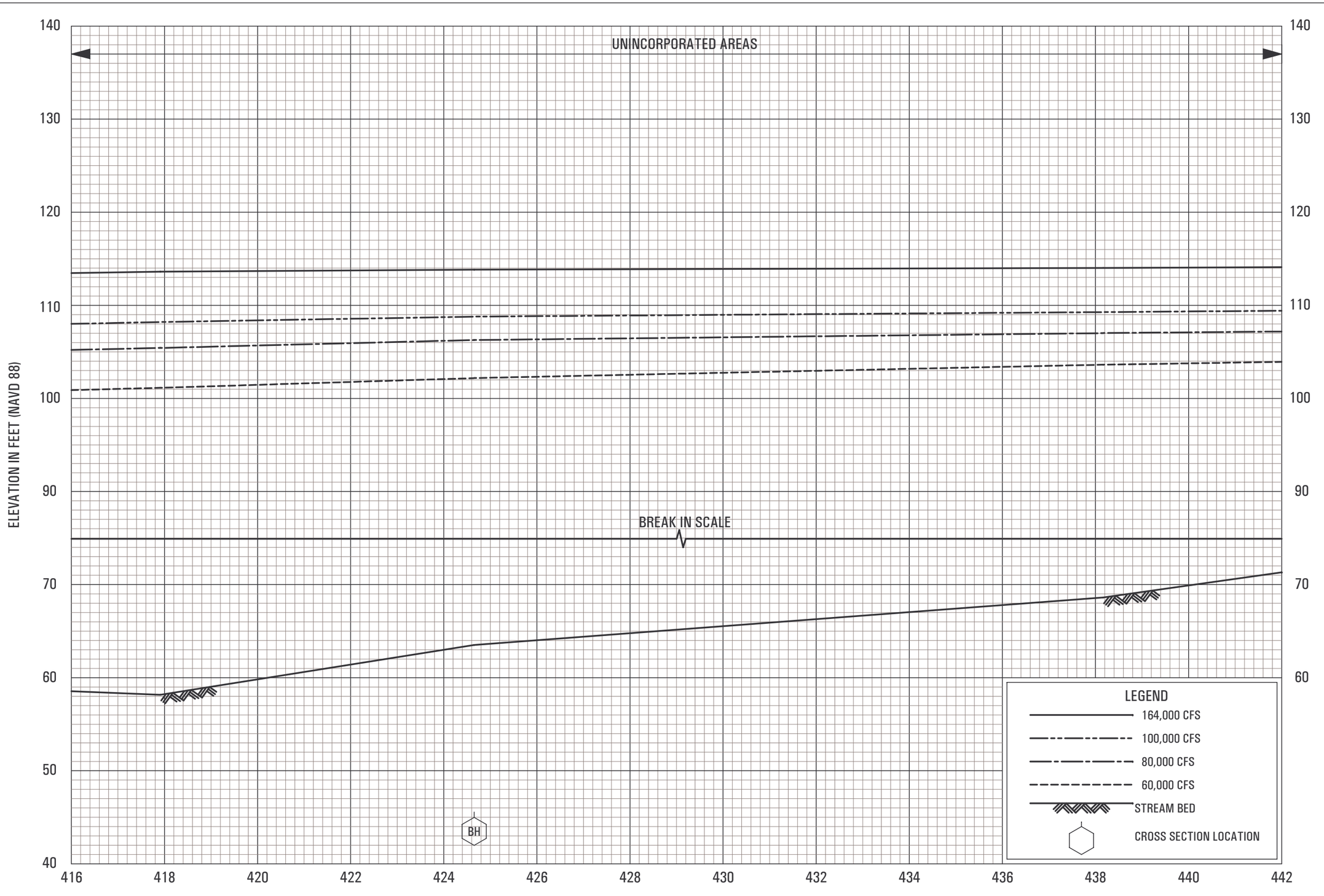

WATER SURFACE PROFILES

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SECTION 7 - PUMP STATION DESIGN

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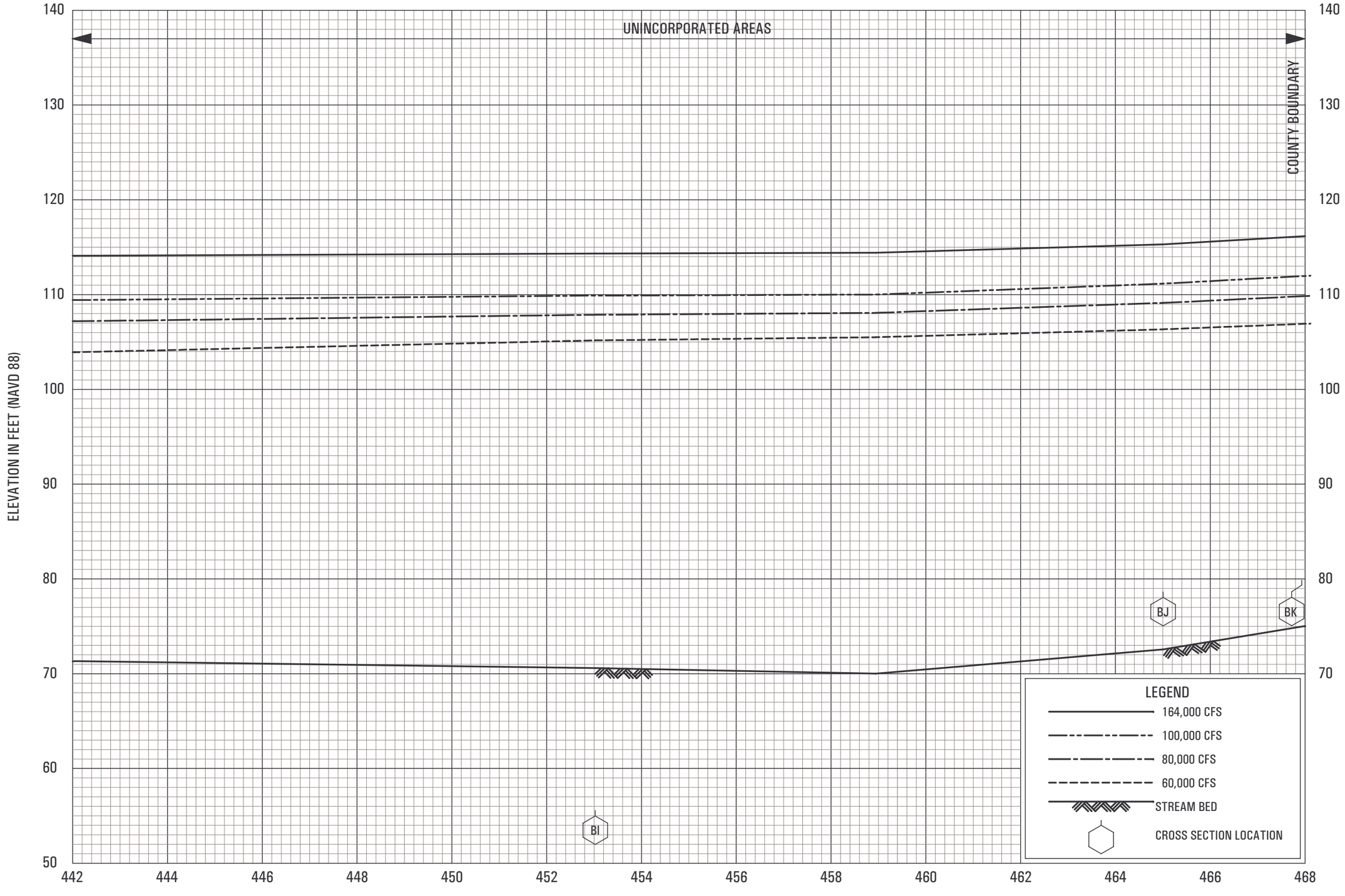

WATER SURFACE PROFILES

BRAZOS RIVER

FORT BEND COUNTY DRAINAGE DISTRICT
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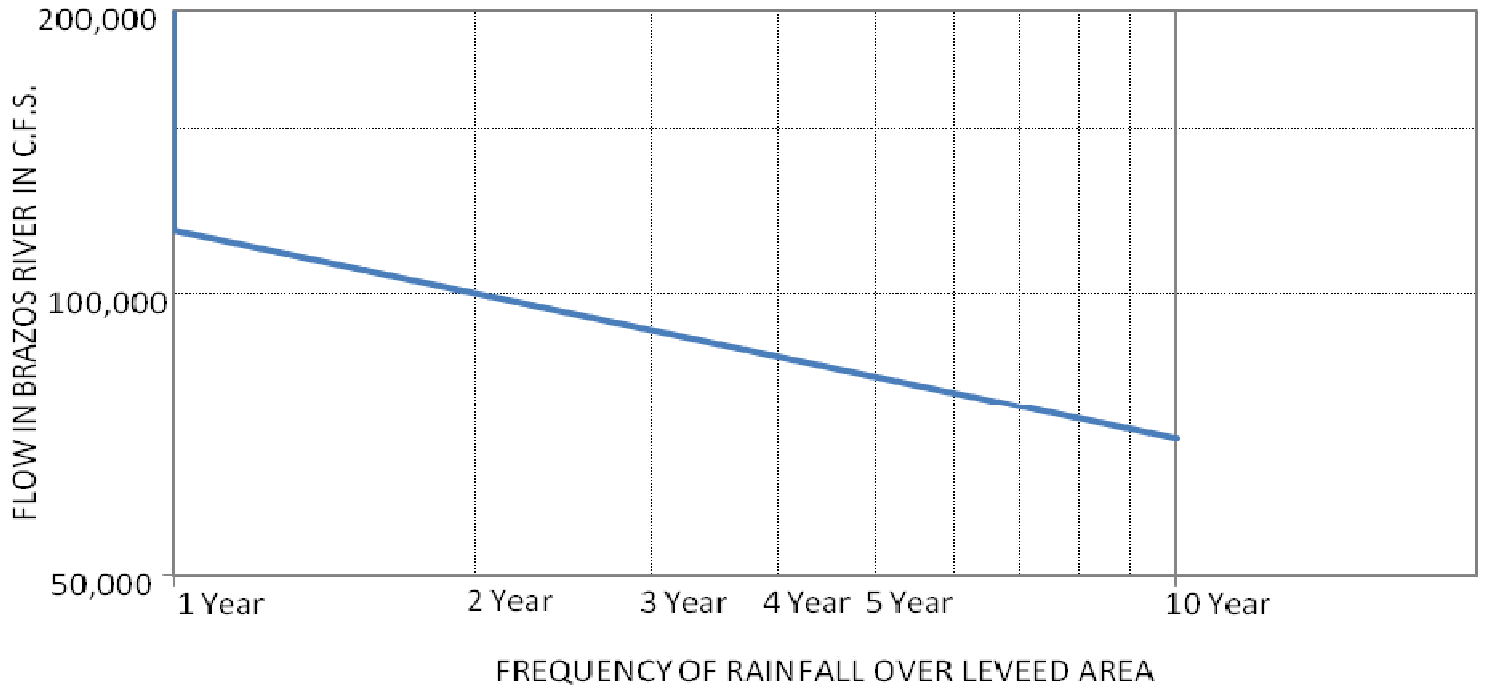
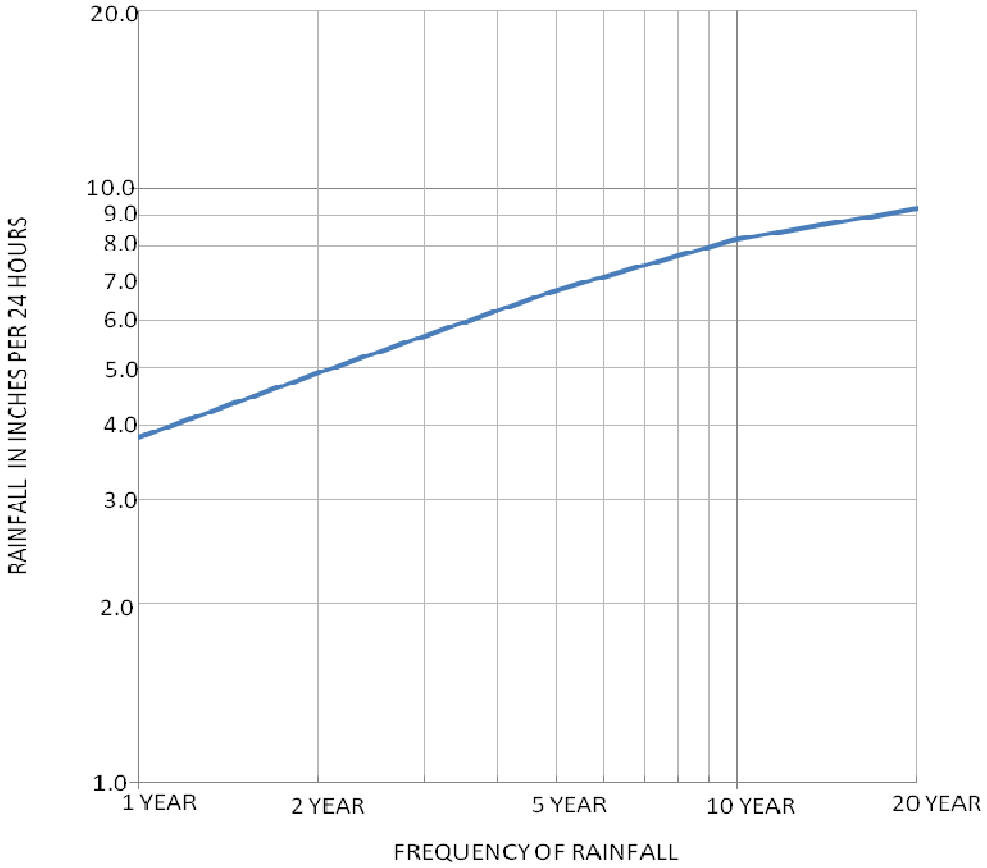


Flow/Frequency For Fort Bend County, Texas	
August 1986	Figure 7-2



Rainfall / Frequency For Fort Bend County, Texas	
August 1986	Figure 7-3