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Morgan Byars, PE
COA WPDRD

Guidance on Establishing the Preliminary "Erosion Hazard Zone" for Structure and Utility Locations Near Streams

City of Austin Watershed Protection and Development Review Department

A procedure has been developed to provide guidance in the determination of a preliminary erosion hazard zone for prudent location of resources near streams for the City of Austin. An erosion hazard zone can be defined as an area where erosion may potentially result in damage to a resource. Erosion is ubiquitous in urban streams and the intent of defining an erosion hazard zone is to provide a boundary outside of which resources would not be threatened as a result of stream erosion. In the context of this document a "resource" may be inclusive of private or public houses, buildings, apartments, fences, utilities, infrastructure or any other feature of appreciable value. The procedure provides a step-wise process to delineate an erosion hazard zone boundary inside of which placement of these resources should be avoided to minimize the potential threat from stream erosion.

The methodology described in this document has been developed by staff as a tool for planners, designers, engineers and developers; who have the duty to locate and/or protect resources such that they are not threatened by erosion. The code requirement for property protection due to erosion is included under Chapter 25-12 Technical Codes, Appendix Chapter 58 Flood Damage Prevention, Article 8 Administration, C. Permit Procedures:

(2) Approval or denial of a site plan by the Floodplain Administrator shall be based on all of the provisions of this chapter and the following relevant factors:

a. The danger to life and property due to flooding or **erosion** damage;

i. The availability of alternative locations, not subject to flooding or **erosion** damage, for the proposed use;

The methodology was based on knowledge of the erosion response of streams following urbanization in the Austin area. This safe and relatively conservative approach was developed based on historical observations, geotechnical soil properties, and the expected channel movement and enlargement resulting from the channel incision process. The procedure incorporates the results of studies on erosion depths and enlargement ratios of Austin streams. In cases where the results of this preliminary analysis are challenged as being too conservative, then an independent detailed erosion hazard analysis may be performed as approved by the City of Austin on a case by case basis. Alternatively stream stabilization measures could be implemented upon approval from the City of Austin. Stream stabilization approaches should comply City of Austin Environmental Criteria in attempt to preserve the natural and traditional character of the stream and riparian corridor.

There are a five steps to be conducted in the determination of an preliminary erosion hazard zone as outlined in **Figure 1**.

Preliminary Erosion Hazard Zone Procedure

STEP 1

Identify and Delineate Location and Stream Reach

STEP 2

Identify and Delineate Meander Belt

STEP 3

Determine Existing

Channel Width (W_{ex}) and Depth (D_{ex})

STEP 4

Estimate Potential Future Incision Depth (D_i)

STEP 5

Delineate Estimated Future Incised Bed Level and Bottom Width (B_{ult})

STEP 6

Delineate Sideslope Projections

STEP 7

Delineate Erosion Hazard Zone

Figure 1 Preliminary Erosion Hazard Zone Procedure Steps

Work Maps and Data Requirements

Prior to conducting the Erosion Hazard Zone analyses, the user must obtain detailed topographic mapping (1-ft contour interval preferred) for use in measuring and mapping the stream features included in the analyses. Similar to a site plan the erosion hazard work maps should include topographic contours, stream centerlines, property lines, roads, bridges, existing utilities, other infrastructure and the resource of interest. Current aerial photography is also useful in identifying riparian vegetation and geomorphic features affecting stream stability. The work maps will be used to delineate the planimetric limits of the erosion hazard zone. The following steps describe the procedure.

STEP 1: Identify and Delineate Location and Stream Reach

A stream reach is to be defined that will include the location of the resource adjacent to the creek and an additional length of stream both up and down valley. The purpose of defining an extended stream reach is to identify stream characteristics (i.e. meanders, grade controls) upstream and downstream that may have an impact on erosion processes at the project location. The stream reach should extend upstream and downstream a minimum distance of 10 channel widths from the outer limits of the resource project location. An approximate channel width based on visual indicators from scaled aerial photography or topographic contours may be used in this step. More detailed measurements of channel width using cross sections will be performed in step 3. For example, a development with a series of houses spanning 300 feet of creek frontage on a stream with an average channel width of 25 feet would require definition of a stream reach that is 800 feet in length (300 feet + 250 feet + 250 feet). For a discrete utility crossing in this case the minimum reach length would need to be 500 feet long. The reach length may be extended further if the user determines that the minimum length requirement is not sufficient to depict the meander belt width or other factors affecting stream stability at the project location.

In some cases, a structural feature such as a bridge, culvert, dam, weir or grade control structure may extend across the channel and serve as a base level control. In these cases, subject to approval by the City, they can be used as the upstream or downstream reach boundary as long as they are located at least 5 channel widths up or down valley from the project site. The stream reach should be delineated as continuous lines along the tops of bank for the length defined.

STEP 2: Identify and Delineate Meander Belt

Meandering streams generally have a belt or area within which they actively meander. In actively meandering streams, meander bends form, enlarge, and migrate and ultimately may cutoff within this meander belt. Resources within this meander belt are highly susceptible to erosion threat. This step will be performed for sinuous streams and is not required for relatively straight streams. For the purposes of this procedure straight streams are those with a sinuosity less than 1.2. Sinuosity is defined as the ratio of the length of the centerline of the channel (C_L) to the length of a line defining the general trend of the valley or stream reach (V_L) as shown in **Figure 2**.

Sinuosity = Channel Length (C_L) / Valley Length (V_L)

Straight Streams - Sinuosity < 1.2 (skip STEP 2)
Sinuous Streams – Sinuosity >= 1.2

For sinuous streams the erosion hazard zone shall be measured relative to the meander belt boundary as will be described in a later step. For straight streams it will be measured relative to the top of bank location. The meander belt is defined by connecting a line between the apex of successive bends as shown in Figure 2. The meander belt should be delineated on the work maps as two continuous lines; one on each side of the channel for the length of stream reach defined in STEP 1. The meander belt, channel length and valley length are illustrated in Figure 2**.**

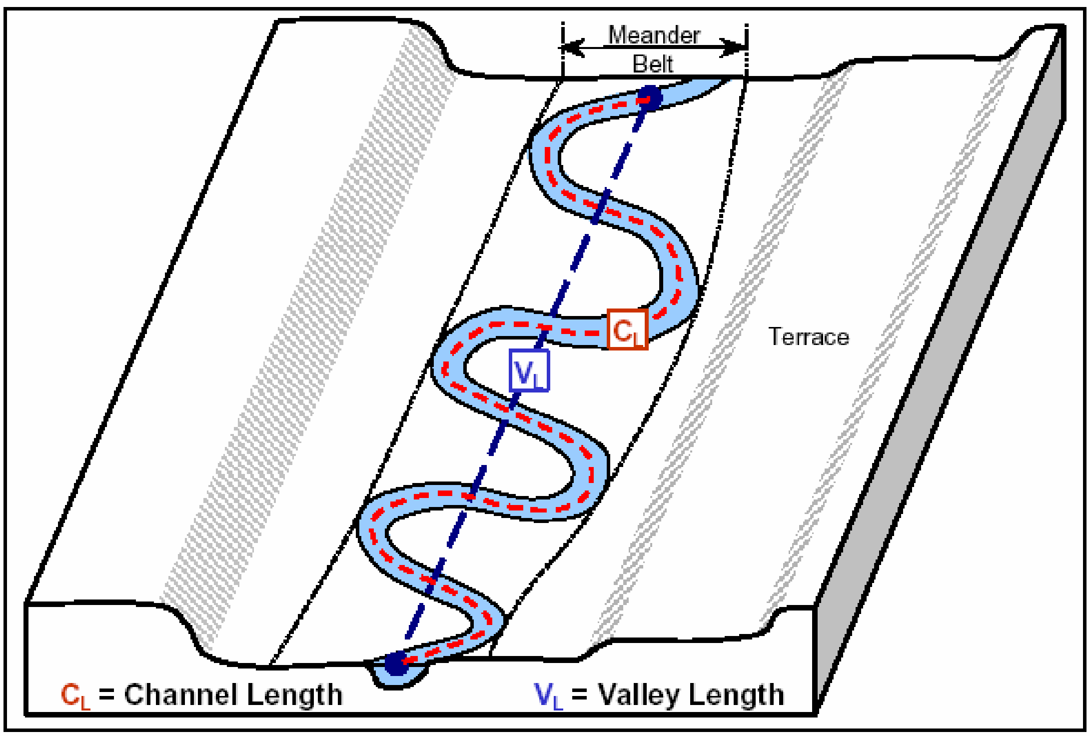

Figure 2. Typical sinuous stream and approximate meander belt.

STEP 3: Determine Existing Channel Top Width and Depth

The existing channel top width and depth shall be determined using channel cross sections obtained from survey data or detailed topographic maps (1-ft contour interval resolution or better preferred). The existing channel top width and depth should be calculated in reference to the top of channel bank elevation within which most flows are contained (bankfull). The channel top of bank can be defined as the location where the topography abruptly changes from a relatively steeply sloping to a flatter or gently sloping gradient on the floodplain. Generally this will correspond to the elevation of the 1 to 2-year return period discharge.

In many places in Austin, streams are entrenched into a well-defined valley or floodway and may have a lower bank that is defined by an inset floodplain and a higher bank that is the margin of the floodplain valley. Varying bank heights may also be observed on the outside of bendways or in cases where the adjacent floodplains differ in elevation. **Figure 3** is an example of an entrenched valley and inset channel. This lower bank will be used to define the existing channel top width and depth in this step.

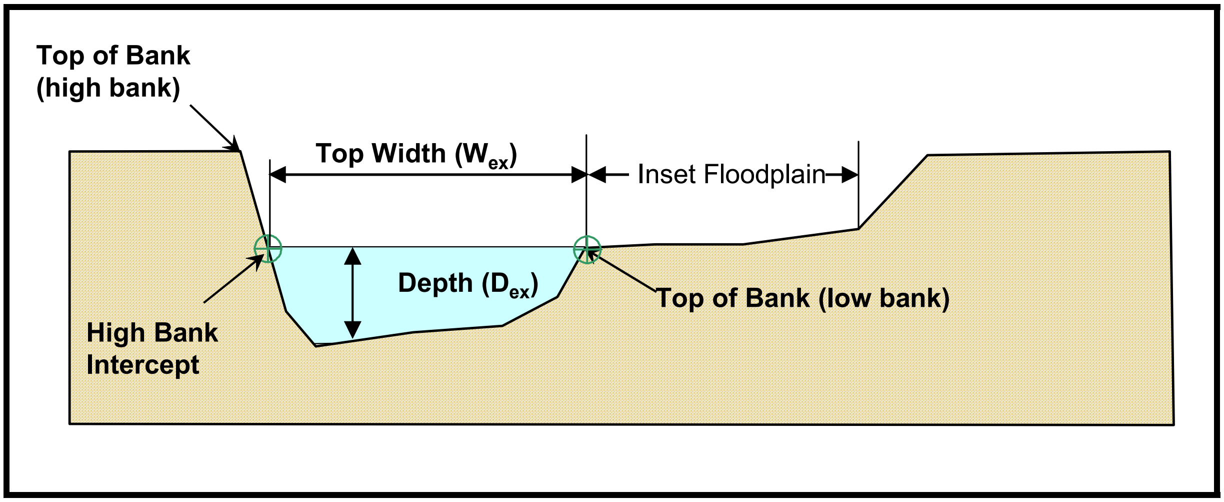

Figure 3. Typical Entrenched Valley and Channel and Inset Floodplain.

For proposed resources that span a distance along a channel, the existing top width and depth should be measured at a number of regularly spaced cross sections for the distance of stream reach defined in STEP 1. At a minimum the top width and depth measurements should be made at approximately 5 to 7 channel width intervals. For sinuous streams cross section may be obtained at the crossing or riffle locations between bends. However additional cross sections may be used to better define the erosion hazard zone throughout the reach. For discrete channel crossings a single cross section for the top width and depth measurement may be made at the proposed crossing location. Cross sections should extend sufficiently landward away from the channel to delineate the ground surface at the end of erosion hazard zone boundary. The cross section locations should be shown on the work maps and will be used to delineate the horizontal extents of the erosion hazard zone.

STEP 3A: Determine Existing Channel Top Width (W_{ex})

The channel top width should be measured relative to the top of the lower bank within which most flows are contained (bankfull). For channels with similar top of bank elevations (non-incised or straight reaches) the top width is simply the horizontal distance between the left and right top of bank locations. For channels with variable bank heights the channel top width is defined as the horizontal distance between the top of lower bank and where a horizontal line from this location intersects the opposite channel bank as shown with the green circles in Figure 3.

Step 3B: Determine Existing Channel Depth (D_{ex})

The existing channel depth shall be measured relative to the top of the lower bank within which most flows are contained (bankfull)as performed for calculation of top width in STEP 3A. The depth used in the analysis may be either the hydraulic depth or depth of flow. The hydraulic depth is defined as the channel cross sectional area (A_{ex}) divided by the channel top width at bankfull conditions ($D_{ex} = A_{ex}/W_{ex}$). Hydraulic depth is most often computed from a hydraulic model or cross section analysis program. The depth of flow is simply the vertical distance between the channel top of bank elevation and the minimum channel flow line elevation and does not require calculation of channel area. Generally the depth of flow is larger than the hydraulic depth and will provide a more conservative estimate of the potential future incision depth and a larger erosion hazard zone.

STEP 4: Estimate Potential Future Incision Depth (D_i)

The potential future incision depth represents the anticipated depth to which a channel may erode over time. Urbanization of natural streams can result in significant channel down-cutting and observations in the Austin area show that the incision depth may be as much as or greater than 3 times the pre-development depth. Therefore, for the purposes of the preliminary erosion hazard zone, the future incision depth (D_i) will be calculated as 3 times the existing average depth (D_{ex}).

$$D_i = D_{ex} * 3$$

For example a channel with an initial depth of 2 feet may ultimately achieve a total depth of 6 feet following erosion.

STEP 5: Delineate Potential Future Incised Bed Level and Bottom Width (B_{ult})

To delineate the elevation and location of the future incised bed level, measure down from the line defining the top of lower bank a distance equal to the estimated future incision depth (D_i) and delineate a horizontal line equal to the computed existing top width (W_{ex}). The ultimate channel bottom width (B_{ult}) is estimated as equivalent to the existing channel top width (W_{ex}) determined in STEP 3. The future toe of bank locations are at the endpoints of this line and are shown by the red circles in Figure 4.

STEP 6: Delineate Side Slope Projections

Beginning at the ultimate channel toe locations defined in the previous step, project a line upward and away from the channel at a slope of 4-horizontal to 1-vertical (4:1) until it intersects the ground surface as shown in Figure 4. The side slope projection is based on general geotechnical stability of alluvial stream banks in the Austin area with an additional factor of safety for the erosion hazard zone. Slope stability analyses generally yield a stable slope of 2 – 3H:1V depending on the soil strength and bank height and an erosion hazard zone factor of safety has been utilized for the slope projections in this methodology.

For sinuous streams the side slope projections will be made from the edges of the meander belt boundary delineated in STEP 2 as shown in Figure 5.

STEP 7: Delineate Erosion Hazard Zone

Delineation of the erosion hazard zone boundary includes both a subsurface and surface representation. Subsurface representation may be shown on channel cross-sections and profiles where the surface representation is plotted on the planimetric work maps.

STEP 7A: Subsurface Erosion Hazard Zone Delineation

For developments with subsurface resources the vertical limits of the erosion hazard zone are finally determined by vertically offsetting the trapezoidal geometry established in the previous steps by 3 feet as represented by the red line in Figures 4 and 5. This offset is described as a utility offset. The intent of this offset is to retain an appropriate depth of cover over subsurface resources after erosion has occurred. This does not affect the horizontal limits of the erosion hazard zone.

STEP 7B: Surface Erosion Hazard Zone Boundary Delineation

The horizontal (planimetric) limits of the erosion hazard zone shall be transposed to the work maps by defining boundary points on the cross sections where measurements and calculations were made along the stream reach. The left and right channel setback (S_{left} and S_{right}) distance should be used to locate the boundary points relative to the top of bank on each cross section line within the stream reach. The erosion hazard zone boundary then should then be delineated as a smooth line connecting the boundary points that generally parallel the bank line or meander belt boundary.

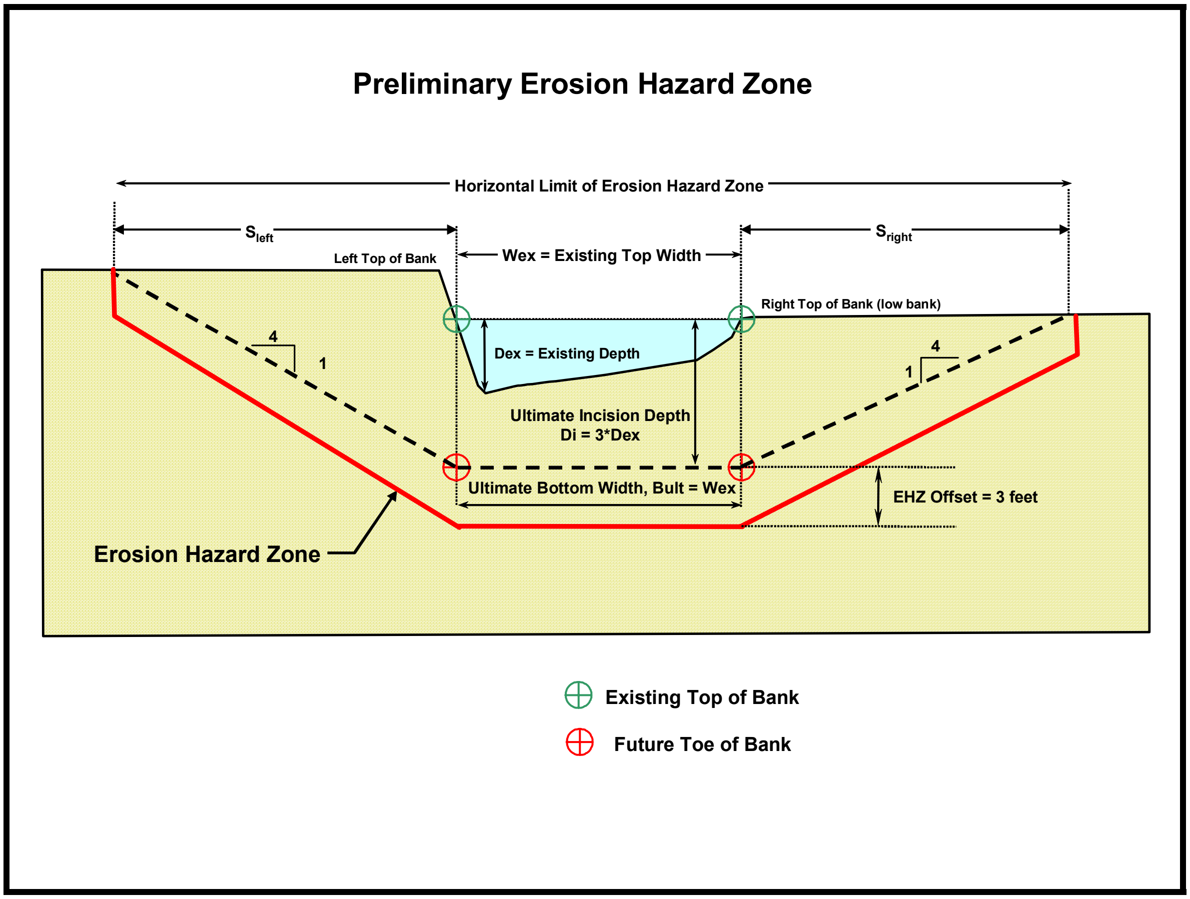

Figure 4. Erosion Hazard Zone Determination

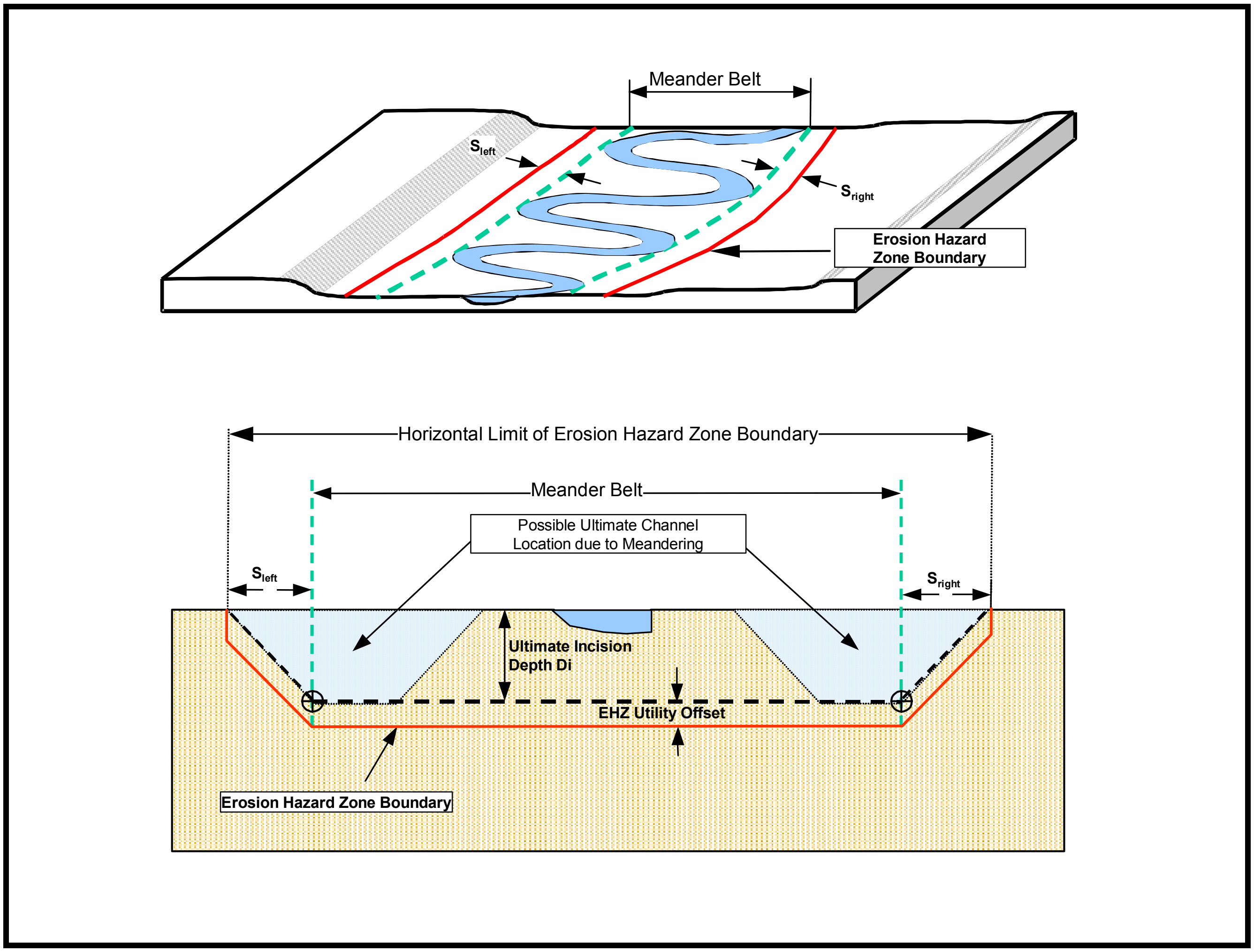

Figure 5. Erosion Hazard Zone Determination for Meandering Streams

SUMMARY

This preliminary erosion hazard zone procedure identifies an area inside of which erosion may potentially result in damage to a resource. Buildings and infrastructure should be placed outside of this area to ensure that they are not placed in harms way. The City of Austin has applied this procedure to a number of locations and found the criteria to reasonably define an effective erosion hazard zone that is not excessive. In cases where the preliminary procedure results are challenged as being too conservative, then a detailed study must be provided as approved by the City on a case-by-case basis. Alternatively stream stabilization measures could be implemented upon approval from the City of Austin. The stream stabilization approach should comply City of Austin Environmental Criteria in attempt to preserve the natural and traditional character of the stream and riparian corridor.

Attached is a standard worksheet for computation and guidance in using the erosion hazard zone procedure.

City of Austin

Prelminary Erosion Hazard Zone Procedure

(Multiple sheets should be filled out for each surveyed cross section within the project reach)

Developer/Owner____

Stream Channel____________________ **Cross Section #**_________ **Date**__________

(Provide plotted cross sections and work maps with submittal of worksheets)

Note: Prior to completing this form, the user must have detailed work maps as described in the erosion hazard zone procedure.

STEP 1: IDENTIFY AND DELINEATE LOCATION AND STREAM REACH		
1.1	Identify and delineate the top of bank for both banks for the length of the resource on the work maps.	
1.2		Enter approximate bank-to-bank channel width from work maps. Use an average of several measurements taken in straight segments throughout the project reach.
(Note: This approximate channel width is to be used for determining the reach length only and may not be used in STEP 3)		
1.3		Measure and enter channel centerline length encompassed by project.
1.4		Determine channel centerline length to be added to upstream and downstream ends of project reach (Recommended: multiply approximate channel width by 10).
1.5		Total reach length (**L**) for which the analysis will be applied [Recommended: sum of steps 1.3 + 2*1.4 above].
1.6	Identify and delineate the tops of bank for the additional length of the reach on the work maps.	
STEP 2: IDENTIFY AND DELINEATE MEANDER BELT BOUNDARY		
2.1		Measure valley length ($\mathbf{V_L}$) for entire project stream reach.
2.2		Measure channel centerline length ($\mathbf{C_L}$) for entire project stream reach
2.3		Determine channel sinuosity $\mathbf{P} = C_L / V_L$
2.4	Delineate the meander belt on the workmaps if sinuousity is 1.2 or greater otherwise skip to step 3.	
STEP 3: DETERMINE EXISTING CHANNEL TOP WIDTH (W_{ex}) AND DEPTH (D_{ex})		
Note: Channel top width and channel depth are determined from cross sections compiled from from surveyed cross sections or detailed topographic maps (1-ft contour interval or better) and are based on the channel geometry within which most flows are contained. Cross section locations shall be marked on the work maps.		
3A		Measure and enter existing channel top width ($\mathbf{W_{ex}}$).
3B		Determine either hydraulic depth (A_{ex}/W_{ex}) or depth of flow which is elevation difference between top of bank elevation and minimum channel flow line elevation and enter as $\mathbf{D_{ex}}$.
STEP 4: ESTIMATE POTENTIAL FUTURE INCISION DEPTH (D_i)		
4.1		Estimate the future incision depth ($\mathbf{D_I}$) by multiplying the existing depth (D_{ex}) by 3. Enter the estimated future incision depth ($\mathbf{D_I}$).
STEP 5: DELINEATE POTENTIAL FUTURE INCISED BED LEVEL AND BOTTOM WIDTH (B_{ult})		
5.1	On the cross section measure down from the reference top of bank level a distance equal to the estimated future incision depth (D_I) and delineate a horizontal line equal to the width of the existing top width. For sinuous streams extend the horizontal line to the meander belt width as as (**Bult**).	
STEP 6: DELINEATE SIDESLOPE PROJECTIONS		
6.1	Beginning at the end of the line defining B_{ult} (hypothetical bank toes at the predicted future incised channel bottom or ends of meander beltwidth), project lines upward and away from the channel at a slope of **4H:1V**	
STEP 7: DELINEATE EROSION HAZARD ZONE		
7A Subsurface		Vertically offset the trapezoidal geometry established by Bult and the sideslope projections in the previous steps by 3 feet. This depth is the **Utilities Offset**. The boundary defined by these lines represents the subsurface erosion hazard zone boundary outside of which all underground resources should be placed.
7B Surface		Measure out from either the predefined banklines or meander belt boundary a distance S_{left} and S_{right} as they correspond to each cross section for which the analysis was performed. Mark these locations as EHZ boundary points. Complete the analysis and location of EHZ boundary points for all cross sections within the stream reach. Connect the EHZ boundary points with a smooth line that generally parallels the bankline or meander belt boundary.

References/Acknowledgements

The erosion hazard zone described in this document was adapted from recommendations included in "Erosion Hazard Zone and Channel Stabilization Criteria for City of Austin Streams" prepared by Ayres Associates, Fort Collins, Colorado.