GLOSSARY

ABUTMENT - A wall supporting the end of a bridge or span, and sustaining the pressure of the abutting earth.

ADVERSE FLOODING IMPACT – An increase in flood risk or hazards. This includes, but is not limited to, the following conditions: Any increase in the depth of flooding; any increase in the water surface elevation that causes stormwater to travel outside of defined public rights-of-way, defined drainage easements or FEMA floodplains or to exacerbate any of these situations if the water surface elevation already exceeds these boundaries; any increase in the duration of flooding, even if the water surface elevation is decreased; and increased velocity of stormwater flows that overtop roadways or other crossings.

APRON - A floor or lining of concrete~~, timber,~~ or other suitable material located at the inlet or discharge side of hydraulic structures (box culverts, spillways, etc.) designed to protect the waterway from erosion from falling water or turbulent flow.

BACKWATER - The rise of the water level upstream due to an obstruction or constriction in the channel.

BACKWATER CURVE - The term applied to the longitudinal profile of the water surface in an open channel when flow is steady but non-uniform.

BAFFLE CHUTE - A drop structure in a channel or outlet of a pond with baffles for energy dissipation to permit the lowering of the hydraulic energy gradient in a short distance to accommodate topography.

BAFFLES - Deflector vanes, guides, grids, gratings, or similar devices constructed or placed in flowing water, to: (1) cause a more uniform distribution of velocities; (2) dissipate energy; (3) divert, guide, or agitate the flow; and (4)mitigate eddy currents.

BERM, EARTHEN - An earthen mound used to direct the flow of stormwater runoff or to contain stormwater runoff within a storm water management facility.

BRIDGE - A structure, including supports, erected over a waterway which allows for the conveyance of the waterway beneath the structure.

CALIBRATION - Process of checking, adjusting, or standardizing operating characteristics of instruments and model appurtenances on a physical model or coefficients in a mathematical model. The process of evaluating the scale readings of an instrument in terms of the physical quantity to be measured.

CHANNEL ROUGHNESS - The estimated measure of texture at the perimeters of channels and conduits. Usually represented by the Manning coefficient "n" used in the Manning Equation.

CHUTE - An inclined conduit or structure used for conveying water to a lower level.

CONCENTRATED FLOW - Stormwater runoff that moves through an open waterway or channel that is bounded by banks or walls, such as a swale, ditch, creek, river, or open pipe or culvert.

CONDUIT - Any open or closed device for conveying flowing water.

CRITERIA - A standard or rule on which a judgment or decision is based.

CRITICAL FLOW - The state of flow for a given discharge at which the specific energy is a minimum with respect to the bottom of the conduit.

CRITICAL SLOPE - The minimum slope of a conduit which will produce critical flow.

CROWN - (1) The highest point on a transverse section of a conduit,
- (2) the highest point of a roadway cross section.

CULVERT - Pipe or other conduit through which flow passes under a road or street.

CURB - A vertical or sloping structure located along the edge of a roadway, normally constructed integrally with the gutter, which strengthens and protects the pavement edge and clearly defines the pavement edge to vehicle operators.

DAM - A barrier constructed across a watercourse for the purpose of either temporarily or permanently impounding water.

DESIGN STORM or RAINFALL ~~FLOOD~~ - The storm (rainfall and areal distribution) ~~or flood~~ which is used as the basis for design, i.e., against which the structure is designed to provide a stated degree of protection or other specified result. The City code requires consideration of several different design storms depending on the type of structure, system or development under consideration. For floodplain management purposes, the 25-year and 100-year storms are the key design events.

1. 25-YEAR STORM or 4-PERCENT-ANNUAL-CHANCE EVENT- Size of storm equaled or exceeded on the average once in 25 years (with given duration), or that storm having a 4% chance of occurring in any given year.

2. 100-YEAR STORM or 1-PERCENT-ANNUAL-CHANCE EVENT- Size of storm equaled or exceeded on the average once in 100 years (with given duration), or that storm having a 1% chance of occurring in any given year.

DESIGN FLOOD - The flood which is used as the basis for design, i.e., against which a structure or conveyance system is designed to provide a stated degree of protection or other specified result. The design flood is the flow from a drainage area that results from the design storm or rainfall. For floodplain management purposes, the 25-year and 100-year storms are the key design floods.

1. 25-YEAR FLOOD or 4-PERCENT-ANNUAL-CHANCE FLOOD - Size of flood equaled or exceeded on the average once in 25 years (with given duration), or that flood having a 4% chance of occurring in any given year.

2. 100-YEAR FLOOD or 1-PERCENT-ANNUAL-CHANCE FLOOD - Size of flood equaled or exceeded on the average once in 100 years (with given duration), or that flood having a 1% chance of occurring in any given year.

DETENTION - The storage of storm runoff for a controlled release during or immediately following the design storm.

1. Off-site detention - A detention pond located outside the boundary of the area it serves.

2. On-site detention - A detention pond which is located within the specific site or subdivision it serves.

3. On-stream detention - The temporary storage of storm runoff behind embankments or dams located in a channel.

4. Regional detention - Detention facilities with a drainage area of at least 64 acres provided to control excess runoff based on a watershed-wide hydrologic analysis.

DITCH - A manmade drainage way designed and used for collecting and conveying stormwater.

DRAINAGE AREA - The area contributing storm runoff to a stream or drainage system at a particular point.

DROP STRUCTURES - The function of a drop structure is to reduce channel velocities by allowing for flatter

upstream and downstream channel slopes.

ENGINEER - The engineer responsible for the design under consideration.

ENERGY GRADIENT LINE - A line representing the energy in flowing water. The elevation of the energy line is equal to the summation of elevation of the flow line plus the depth plus the velocity head plus the pressure head.

ENTRANCE HEAD - The head required to force flow into a conduit or other structure; it includes both entrance loss and velocity head.

ENTRANCE LOSS - Head lost in eddies or friction at the inlet to a conduit, headwall or structure.

EROSION HAZARD ZONE – An area where future stream channel erosion is predicted to occur using an analysis of land cover, hydrology, geology, and soils as prescribed in Appendix F of the this manual. An erosion hazard zone provides a boundary outside of which resources are not expected to be threatened as a result of future stream erosion.

EXISTING CONDITION - The level of development within a watershed or drainage area at the time that hydrologic and hydraulic analyses are performed for a portion of that drainage area.

FLOOD CONTROL - The elimination or reduction of flood losses by the construction of flood storage reservoirs, channel improvements, dikes and levees, by-pass channels, or other engineering works.

FLOODPLAIN - Any land area that is susceptible to being inundated by water from any source. ~~Geographically the entire area subject to flooding.~~

FREEBOARD - The distance between the calculated water surface elevation and the maximum physical elevation of the channel or pond, which is provided as an additional factor of safety.

FREQUENCY (of storms, floods) - Average recurrence interval of events, over long periods of time. Mathematically, frequency is the reciprocal of the exceedance probability.

FRICTION SLOPE - The friction head or loss per unit length of channel or conduit. For uniform flow the friction slope coincides with the energy gradient, but where a distinction is made between energy losses due to bends, expansions, impacts, etc., a distinction must also be made between the friction slope and the energy gradient. The friction slope is equal to the bed or surface slope only for uniform flow in uniform open channels.

FROUDE NUMBER - A flow parameter, which is a measure of the extent to which gravitational action affects the flow. A Froude number greater than 1 indicates supercritical flow and a value less than 1 subcritical flow.

FULLY DEVELOPED CONDITION - The assumption that all land within a watershed or drainage area has been developed to its maximum allowable extent as defined by zoning or other regulatory limitations. It is alternatively referred to as ultimate development condition.

GABION - A wire basket containing rocks which is placed uniformly with others to provide protection against erosion.

GEOGRAPHIC INFORMATION SYSTEM (GIS) - Is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

GRADE - The inclination or slope of a channel, conduit, or natural ground surface, usually expressed in terms of the ratio of vertical rise to horizontal distance.

GUTTER - A shallow concrete waterway adjacent to a curb for conveying street flow.

HEADWALL - The normal functions of properly designed headwalls and endwalls are to anchor the culvert in order to prevent movement due to hydraulic and soil pressures, to control erosion and scour resulting

from excessive velocities and turbulence and to prevent adjacent soil from sloughing into the waterway opening.

HEADWATER - (1) The upper reaches of a stream near its sources; (2) the region where ground waters emerge to form a surface stream; (3) the headwater depth on the upstream side of a structure. (See Entrance Head)

~~100-YEAR STORM - Size of storm equaled or exceeded on the average once in 100 years (with given duration), or that storm having a 1% chance of occurring in any given year.~~

~~100-YEAR FLOOD - Size of flood which might be expected to be equaled or exceeded once in 100 years on the average, or has a 1% chance of occurring in any given year. Usually associated with the 100-year storm.~~

HYDROLOGIC ENGINEERING CENTER (HEC) - The designated center of expertise for the US Army Corps of Engineers in the technical areas of surface and groundwater hydrology, river hydraulics and sediment transport, hydrologic statistics and risk analysis, reservoir system analysis, planning analysis, real-time water control management and a number of other closely associated technical subjects.

HYDRAULIC GRADIENT - A hydraulic profile of the piezometric level of the water, representing the sum of the depth of flow and the pressure head. In open channel flow it is the water surface.

HYDRAULIC JUMP - The hydraulic jump is an abrupt rise in the water surface which occurs in an open channel when water flowing at supercritical velocity transitions to subcritical velocity. The transition through the jump results in a marked loss of energy, evidenced by turbulence of the flow within the area of the jump. The hydraulic jump is sometimes used as a means of energy dissipation.

HYDRAULICS - A branch of science that deals with practical applications of the mechanics of water movement.

HYDROGRAPH - A graph or table showing discharge versus time at a given point on a stream or conduit.

1. Synthetic Hydrograph - Runoff or unit hydrographs which are devised by empirical means (as opposed to derivation based upon natural, measured data).

2. Unit Hydrograph - The direct runoff hydrograph resulting from one inch of precipitation excess distributed uniformly over a watershed for a specified duration.

HYDROLOGY - The science that deals with the processes governing the depletion and replenishment of the water resources of the earth.

HYETOGRAPH - A histogram or graph of rainfall intensity versus time for a storm.

IMPERVIOUS - A term applied to a material through which water cannot pass, or through which water passes with great difficulty.

INFILTRATION - The process of water entry into the soil profile, together with the associated downward flow away from the ground surface. ~~The absorption of water by the soil, either as it falls as precipitation, or from a stream flowing over the surface.~~

INLET - The inflow point for a storm sewer system which is usually associated with streets (e.g., curb opening inlets, grate inlets, etc.).

INTENSITY - See Rainfall Intensity.

INVERT - The floor, bottom, or lowest portion of the internal cross section of a conduit. Used particularly with reference to sewers, tunnels, and drains.

LAG TIME - In hydrograph analysis lag time is the time from the centroid of the mass of excess rainfall to the peak of the runoff hydrograph.

LATERAL - For design purposes, wherever two or more incoming conduits intersect at a single location, all of the incoming conduits other than the trunk line are laterals.

LEVEL-SPREADER - A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow (i.e., not though channels). The purpose of level spreaders are to prevent concentrated, erosive lows from occurring, and to enhance infiltration.

MANNING ROUGHNESS COEFFICIENT OR MANNINGS N - The coefficient of ~~roughness~~ friction used in the Manning Equation to describe the surface roughness characteristics of a channel, floodplain or sheet flow surface. For sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. Sheet flow roughness coefficients are typically higher than those for channel flow.

MANNING EQUATION - A uniform flow equation used to relate velocity, hydraulic radius and the energy gradient slope.

MAY - A permissive condition. No requirement for design or application is intended.

MUST - This is a mandatory condition. Where certain requirements in the design or application of the guidelines are described with the "must" stipulation, it is mandatory that the requirements be met.

OPTIONAL - Not a requirement. Purely the applicants choice.

ORIFICE - ~~(1)~~ An opening with closed perimeter, and of regular form in a plate, wall, or partition, through which water may flow.

OVERLAND FLOW - Runoff which is not considered concentrated. Other term is sheet flow.

PEAK FLOW (Peak Rate of Runoff) - T~~t~~he maximum rate of flow past a particular point for a given storm.

POLICY - A definite course or method of action selected to guide and determine present and future decisions.

PRECIPITATION - Any moisture that falls from the atmosphere, including snow, sleet, rain and hail.

PRISMATIC CHANNEL - A channel built with unvarying cross section and constant bottom slope.

PROBABLE MAXIMUM FLOOD (PMF) - The flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region.

PROBABLE MAXIMUM PRECIPITATION - The critical depth-duration-area rainfall relationship which would result from a storm containing the most critical meteorological conditions considered probable of occurring.

RAINFALL DURATION - The length of time over which a discrete rainfall event lasts.

RAINFALL FREQUENCY - The average recurrence interval of rainfall events, averaged over long periods of time.

RAINFALL INTENSITY - The rate of precipitation ~~accumulation of rainfall~~, usually in inches per hour.

RATIONAL FORMULA - A traditional means of relating the peak rate of runoff from an area and the intensity of the storm rainfall (Q = CiA).

REACH - Any length of river or channel. Usually used to refer to sections which are uniform with respect to discharge, depth, area or slope, or sections between gaging stations.

RECOMMENDED - A condition which should be met if it is physically and economically reasonable to do so.

REQUIRED - This is a mandatory condition. Where certain requirements in the design or application of the

guidelines are described with the "required" stipulation, it is mandatory that they be met.

RECURRENCE INTERVAL - The average interval of time within which a given event will be equaled or exceeded once. For an annual series (as opposed to a partial duration series) the probability of occurrence in any one year is the inverse of the recurrence interval. Thus a flood having a recurrence interval of 100 years has a 1 percent probability of being equaled or exceeded in any one year.

RETENTION - The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

RETURN PERIOD - See Recurrence Interval

RIPRAP (REVETMENT) - Forms of bank protection, usually using rock. Riprap is a term applied to stone which is dumped rather than placed more carefully. In Austin concrete is often called riprap.

ROUTING - ~~Routing is a~~ A technique used to predict the temporal and spatial variations of a flood wave as it traverses a river reach or reservoir. Generally, routing techniques may be classified into two categories - hydrologic routing and hydraulic routing.

ROW (Right-of-way) - A strip of land dedicated for public streets and/or related facilities, including utilities and other transportation uses.

ROW WIDTH - The shortest horizontal distance between the lines which delineate the right-of-way of a street.

RUNOFF - That part of the precipitation which reaches a stream, drain or sewer.

RUNOFF COEFFICIENT (C) - A decimal number used in the Rational Formula which defines the runoff characteristics of the drainage area under consideration. It may be applied to an entire drainage basin as a composite representation or it may be applied to a small individual area such as one residential lot.

SCS RUNOFF CURVE NUMBER (CN) - Index number used by the Soil Conservation Service as a measure of the tendency of rainfall to run off into streams rather than evaporate or infiltrate.

SEDIMENT - Material of soil and rock origin transported, carried, or deposited by water.

SHALL - This is a mandatory condition. Where certain requirements in the design or application of the guidelines are described with the "shall" stipulation, it is mandatory that the requirements be met.

SHEET FLOW – Stormwater runoff that flows downslope over the ground surface as ~~relatively smooth surfaces in the form of~~ a thin, continuous layer that does not vary in depth in a direction perpendicular to the direction of flow.

SHOULD - An advisory condition. Where the word "should" is used, it is considered to be advisable usage, recommended but not mandatory.

SOFFIT - The bottom of the top of a pipe. In a sewer pipe, the uppermost point on the inside of the structure. In contrast, the crown is the uppermost point on the outside of the pipe wall.

STEADY FLOW - Open channel flow is said to be steady if the depth of flow does not change or if it can be assumed to be constant during the time interval of consideration.

STILLING BASIN - Pool of water conventionally used, as part of a drop structure or other structure, to dissipate energy.

~~STORM HYDROLOGY - The branch of hydrology that concentrates on the calculation of runoff from storm rainfall.~~

STREET CLASSIFICATIONS - Alley - An alley is a passageway designed primarily to provide access to or from the rear or side of property otherwise abutting on a public street.

Local Street - The primary function of a local street is to serve abutting land use, and traffic within a neighborhood or limited residential district. A local street is not generally continuous through several districts.

Collector Street - The primary function of a collector street is to intercept traffic from intersecting local streets and expedite the movement of this traffic in the most direct route to an arterial street or other collector street.

Arterial Street - Arterial streets are designed to carry high volumes of through traffic. Access is usually limited to intersections and major driveways. Arterial streets serve as a link between major activity centers within the urban area.

Freeway - Freeways are divided arterial highways designed with full control of access and grade separations at all intersections. Freeways provide movement of high volumes of traffic at relatively high speeds. This system carries most of the trips entering and leaving the urban area, as well as most of the through movements bypassing the central city.

Parkway - A parkway is a freeway which does not have continuous frontage roads. Parkways have a greenspace buffer between the roadway and adjacent development and preserves and enhances the natural landscape as much as possible.

SWALE - A natural or manmade drainage way that is below the adjacent ground level to collect and move surface runoff.

~~SYNTHETIC HYDROGRAPH - see Hydrograph~~.

TAILWATER - The depth of flow in the stream immediately downstream of a hydraulic structure.

TIME OF CONCENTRATION - The time associated with the travel of runoff from an outer point which best represents the shape of the contributing area.

TOTAL HEAD - In the flow process, the total energy for a given point is represented by the summation of $V^2/2g$, p/γ and z. The units for these three items are foot-pounds force per pound force. It is common practice to lump all these three items together as total head in feet. The item of $V^2/2g$ is called velocity head (in feet) and p/γ is the pressure head (in feet).

TRUNK LINE - For design purposes, wherever two or more incoming conduits intersect at a single location, the incoming conduit having the greatest cross-sectional area shall be considered to be the trunk line. If more than one incoming conduit has the same cross-sectional area, then the conduit having both the greatest cross-sectional area and the highest peak flow rate for the design storm shall be the “trunk line.” ~~The primary collector line of a storm sewer system.~~

UNIFORM CHANNEL - A channel with a constant cross section and roughness.

UNIFORM FLOW - Open channel flow is said to be uniform if the depth of flow is the same at every section of the channel, for a constant flow.

~~UNIT HYDROGRAPH - See Hydrograph.~~

WATERSHED - The total area contributing storm runoff to a stream or drainage system ~~creek~~.

WEIR - A weir is a notch of regular form through which water flows.

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~~APPENDIX D. REGIONAL STORMWATER MANAGEMENT PARTICIPATION FEES~~

Comment [PK1]: Delete Appendix D; refer users to COA website

~~The RSMP fee consists of two components; the construction cost component (CCC) and the land cost component (LCC). The two components are calculated independently for single-family developments and multi-family/commercial developments. Below are the details of how to calculate the fees.~~

~~The Watershed Engineering Division (WED) of the Watershed Protection and Development Review Department of the City of Austin will determine the actual fees paid by the participant. The fee schedule is posted on the RSMP section of the Watershed Protection website.~~

~~1. Construction Cost Component (CCC)~~

~~The number of impervious acres is used to determine this part of the fee. The number of impervious acres is based on the maximum allowable impervious acreage as allowed by the more restrictive of zoning or watershed ordinance for subdivisions. Site plans may use the actual impervious cover for the site. The construction cost component will be adjusted annually by using the "Engineering News Record" construction cost index with the base construction cost index being referenced to October 2002.~~

~~Single-family Residential Development:~~

~~Impervious Acre Range~~

~~From~~	~~To~~	~~Cost per Impervious Acre~~	~~Number of Impervious Acres~~	~~Sub-Total Cost~~
~~0.00~~	~~1.00~~	~~$35000~~	-	~~$~~
~~1.01~~	~~2.00~~	~~$15000~~	-	~~$~~
~~2.01~~	~~5.00~~	~~$10000~~	-	~~$~~
~~5.01~~	~~10.00~~	~~$7000~~	-	~~$~~
~~10.01~~	~~20.00~~	~~$5000~~	-	~~$~~
~~20.01~~	~~50.00~~	~~$3000~~	-	~~$~~
~~50.01~~	~~100.00~~	~~$2000~~	-	~~$~~
~~100.01~~	~~Infinity~~	~~$1500~~	-	~~$~~
-	-	-	-	-
~~Total~~	-	-	-	~~$~~

~~Commercial and Multi-family Residential Development:~~

~~Impervious Acre Range~~

~~From~~	~~To~~	~~Cost per Impervious Acre~~	~~Number of Impervious Acres~~	~~Sub-Total Cost~~

~~0.00~~	~~1.00~~	~~$60000~~	~~-~~	~~$~~
~~1.01~~	~~2.00~~	~~$18000~~	~~-~~	~~$~~
~~2.01~~	~~5.00~~	~~$8000~~	~~-~~	~~$~~
~~5.01~~	~~10.00~~	~~$6000~~	~~-~~	~~$~~
~~10.01~~	~~20.00~~	~~$5000~~	~~-~~	~~$~~
~~20.01~~	~~50.00~~	~~$4000~~	~~-~~	~~$~~
~~50.01~~	~~Infinity~~	~~$2500~~	~~-~~	~~$~~
~~-~~	~~-~~	~~-~~	~~-~~	~~-~~
~~Total~~	~~-~~	~~-~~	~~-~~	~~$~~

~~2. Land Cost Component (LCC):~~

~~The land cost component (LCC) is calculated separately for each type of development, in conjunction with the construction cost component.~~

~~**Land Cost Component = Land Cost per Acre * Land Cost Area**~~

~~where:~~

~~**Land Cost per Acre =** (Appraised value /Appraised area) * 0.05~~

~~OR~~

~~= Capped value * 0.05~~

~~Capped Land Cost per Acre:~~

~~Development Type~~	~~Capped Value~~
~~Single-Family~~	~~$40,000 per acre~~
~~Multi-Family / Commercial~~	~~$120,000 per acre~~

~~**Land Cost Area =**~~

~~New Development = Gross Site Area – Deductible Areas~~

~~Redevelopment = Limits of construction – Deductible Areas~~

~~Deductible Areas = (Drainage Easements, Water Quality Easements, and Conservation Easements)~~

~~Note: Impervious cover areas within easements cannot be deducted from the land cost area.~~

~~Land costs will be based on the land valuation. This may be established by a certified appraisal or by the values established by Appraisal Districts. The RSMP applicant must provide the parcel identification number for each parcel within the proposed development prior to RSMP approval. Upon RSMP participation approval, the applicant must provide dated copies of either a certified appraisal or the appraisal district's valuation for each parcel within the proposed development. Properties that are not appraised by Appraisal Districts, such as property owned by a governmental entity, may choose to use the capped land cost per acre values for RSMP participation or provide a certified appraisal. The land cost will be determined by the appraised value at the time of payment of the RSMP fee, not when the site is approved for participation in~~

~~the RSMP. The effective date for Appraisal District valuations is the first of October for the current City of Austin fiscal year.~~

~~If a development encompasses more than one tax parcel, the land cost per acre will be based on the arithmetic mean of the land valuation from all parcels.~~

~~3. Total Cost = (CCC) _____ + (LCC) _____ = $_____~~

~~Exceptions:~~

~~All Developments:~~

~~For sites that are in more than one watershed, the calculated RSMP fee will be apportioned by the percentage of the site in each watershed.~~

~~Single Family:~~

~~Single-family developments may restrict the allowable impervious cover by plat note or by a legally recorded separate instrument if the plat was previously approved.~~

~~Fee Incentives for Certain Single Family Developments:~~

~~Lot Size (from plat)~~		~~Percent Impervious Cover~~	~~Pay a Reduced Fee of~~
~~Greater than or equal to:~~	~~But less than:~~	~~Less Than:~~	-
~~2 acres~~	~~5 acres~~	~~20-percent~~	~~50-percent of total cost~~
~~5 acres~~	~~Not Applicable~~	~~20-percent~~	~~25-percent of total cost~~

~~**RSMP Agreements Mutually Exclusive:**~~

~~Each Regional Stormwater Management Program (RSMP) agreement is mutually exclusive. No credit will be given for impervious cover paid for in previous RSMP agreements for subsequent phases of development. However, applicants may combine all related phases of a development into one RSMP agreement and remit the associated total fee at the time the permit for the first phase is approved.~~

~~**Example Fee Calculation:**~~

~~This example is based on a 10-acre single-family development in a watershed with an allowable maximum impervious cover of 40-percent.~~

~~Maximum impervious acres = 10 * 40% = 4-acres~~

~~Construction Cost Component (CCC):~~

~~Impervious Acre Range~~

~~From~~	~~To~~	~~Cost per Impervious Acre~~	~~Number of Impervious Acres~~	~~Sub-Total Cost~~
~~0.00~~	~~1.00~~	~~$35,000~~	~~1~~	~~$ $35,000~~
~~1.01~~	~~2.00~~	~~$15,000~~	~~1~~	~~$ $15,000~~
~~2.01~~	~~5.00~~	~~$10,000~~	~~2~~	~~$ $20,000~~

~~5.01~~	~~10.00~~	~~$7,000~~	~~0~~	~~$ 0~~
~~10.01~~	~~20.00~~	~~$5,000~~	~~0~~	~~$ 0~~
~~20.01~~	~~50.00~~	~~$3,000~~	~~0~~	~~$ 0~~
~~50.01~~	~~100.00~~	~~$2,000~~	~~0~~	~~$ 0~~
~~100.01~~	~~Infinity~~	~~$1,500~~	~~0~~	~~$ 0~~
~~-~~	~~-~~	~~-~~	~~-~~	~~-~~
~~Total~~	~~-~~	~~-~~	~~4~~	~~$ 70,000~~

~~Construction Cost Component (CCC) = $70,000~~

~~Land Cost Component (LCC):~~

~~Land Cost per Acre = $500,000 /10 acres * 0.05 = $2,500~~

~~OR~~

~~= $40,000 * 0.05 = $2,000~~

~~USE Land Cost per Acre = $2,000~~

~~Land Cost Component = $2,000 * 10 acres = $20,000~~

~~Total Cost = (CCC) $70,000 + (LCC) $20,000 = $90,000~~

~~RSMP Participation Fee = $90,000 for the example shown~~

~~Program Description~~
~~Regional Stormwater Management Program~~
~~City of Austin, Texas~~

~~The Regional Stormwater Management Program is administered by the Watershed Engineering Division of the City of Austin's Watershed Protection and Development Review Department. This program provides for the planning, design and construction of regional drainage improvements to prevent flooding caused by increased runoff from developments, using fees paid by the owners of those developments.~~

~~Beginning in 1974, City ordinances have required proposed developments to mitigate the effects of increased stormwater runoff leaving their sites. On site stormwater detention ponds were and still are the primary method used to meet these requirements. However, studies have established that a system of numerous small ponds, designed for individual sites, may provide only minimal flood protection when evaluated on a watershed wide basis. In addition, regular and effective maintenance of on site ponds is a major economic issue. Although they reduce peak flood flows immediately downstream, on site ponds can change the overall timing of flood flow movement through the watershed to the extent of possibly increasing peak flood flows at points further downstream. Recognizing the limited effectiveness of on site detention ponds in many situations, but also recognizing that all new developments contribute to the increased amounts of stormwater runoff in the watershed, the Watershed Engineering Division (WED) established the Regional Stormwater Management Program (RSMP) in 1984.~~

~~The Watershed Engineering Division (WED) uses a watershed wide approach to analyze potential flooding problems, identify appropriate mitigation measures, and select site locations and design criteria for regional drainage improvements. These improvements include detention and retention ponds, waterway conveyance improvements, other improved conveyance structures and property buyout. The RSMP is established in watersheds in and around the City (Full Purpose, Limited Purpose and Extraterritorial Jurisdiction) that are currently developing and have potential for flooding problems as undeveloped land is converted to~~

~~impervious cover. In these watersheds, the RSMP allows developers to participate in the program instead of constructing on site controls if the proposed development will produce no identifiable adverse impact to other nearby properties due to increased runoff. Existing limitations for RSMP participation include existing buildings in and near flood prone areas and substandard roadway crossings. An ongoing long term goal of the Watershed Engineering Division is to develop master plans for all watersheds in and around the City. These plans typically include hydrologic analyses, hydraulic analyses, floodplain mapping, and planning information for potential regional drainage improvements.~~

~~The fees charged for participation in the RSMP are non-refundable and are based upon the size of the development, the proposed land use, and the development intensity. The fee structure was established in 1984 and is subject to change to reflect current construction costs. The current fee structure allows undevelopable areas by regulations or restrictive covenants to be excluded in the RSMP fee calculation. The fees are deposited in a dedicated fund and they are allocated for regional stormwater management improvements. Please contact the Watershed Engineering Division of the Watershed Protection and Development Review Department at 974-3377 for additional information.~~

~~Regional Stormwater Management Participation Request Form~~

~~Mail or deliver to:~~

~~City of Austin – Watershed Protection and Development Review Department~~

~~Regional Stormwater Management Program~~

~~Watershed Engineering Division~~

~~206 E. 9th Street, Suite 17.160~~

~~Austin, Texas 78701~~

~~(512) 974-3377~~

~~(512) 974-3390 (Fax)~~

~~Date: _____ Name of Site: _____~~

~~Address of Site: _____~~

~~Watershed: _____ Mapsco Grid: _____~~

~~Type of Development: _____ Acreage of Participation: _____~~

~~Owner-Developer: _____ Engineer/Contact: _____~~

~~Firm: _____ Phone: _____~~

~~COA File Number: _____~~

~~COA Case Manager: _____~~

~~COA Drainage Reviewer: _____~~

~~Cost per Acre: _____~~

~~Total Cost: _____~~

~~Method of Payment: Check _____ LOC _____ Land _____~~

~~Off-site Improvement _____ Future Participant _____~~

Attachments: Engineer's Report _____ Location Map _____

Letter of Request to Participate _____

RSMP Reviewer Comments: _____

_____

_____

_____

RSMP Review: _____ Date: _____

AGREEMENT FOR PARTICIPATION IN
REGIONAL STORMWATER MANAGEMENT PROGRAM

STATE OF TEXAS)
_____)
COUNTY OF TRAVIS)

THIS AGREEMENT is made by and between _____, (hereinafter "Participant") and the City of Austin, ("hereinafter called "C.O.A");

WITNESSETH:

WHEREAS, Participant, is the owner and developer of the _____ acre property located in the _____ watershed, known as the _____ Project, C.O.A. Case Number _____; hereinafter "the Project"; and

WHEREAS, Participant desires to comply with C.O.A. requirements applicable to the regulation of peak flows from new developments;

NOW, THEREFORE, for and in consideration of the covenants contained herein and the fee to be paid by Participant pursuant to this Agreement, the parties contract as follows:

1. C.O.A. shall be responsible for the management and operation of a Regional Stormwater Management Program (R.S.M.P.), in accordance with the C.O.A. Drainage Criteria Manual.

2. The Participant, having requested participation in the R.S.M.P. for the Project, and having provided engineering documentation to demonstrate compliance with R.S.M.P. guidelines, agrees to pay to the C.O.A. the amount of $_____ in accordance with the participation fee schedule in effect as of the date of this Agreement. Such payment shall be made concurrent with execution by Participant of this Agreement. The Participant acknowledges that this is a one-time, non-refundable fee and that no rights of reimbursement exist.

3. The fee paid shall be applied to the R.S.M.P. for use within the referenced watershed. A percentage, not to exceed fourteen percent (14%) of the total fee, may be appropriated by the C.O.A. as required to offset the cost anticipated for engineering analysis and program management.

4. The C.O.A. acknowledges that the participation fee paid by Participant for the Project is sufficient to meet the City requirements for the regulation of peak flows from this site and no on-site detention shall be required for the Project.

5. The understanding of the parties as reflected by this Agreement shall be binding upon the parties and their respective heirs, executors, administrators, successors, and assigns.

6. This Agreement reflects the entire understanding of the parties concerning the subject matter hereof; all other representations or agreements made previously or contemporaneously, whether orally or in writing, are merged herein.

7. This Agreement may be amended only by a written document executed by the parties hereto.

8. Failure of the Participant to tender the fee as required by paragraph 2 shall render this Agreement null and void. The C.O.A. and Participant execute this Agreement to be effective as of the date of the last party to sign.

CITY OF AUSTIN:

By: _____

_____
(Typed Name)

Director, Watershed Protection and Development Review Department

Date: _____

PARTICIPANT

BY: _____

_____
(Typed Name)

Its:

_____
(Title)

Date: _____

CHECKLIST
STORMWATER MANAGEMENT CONCEPT PLAN

The concept plan will typically consist of two sheets: a preliminary plan, final plat, construction plans or site plan(called Site Development) and a drainage area plan. The "Site Development" site plan should be at a scale suitable to fit the entire site on one sheet, but shall not be less than 1" = 1000'. An electronic copy of the site boundary shall be included. All electronic CAD drawings shall be in NAD 83 **Grid Coordinates**, State Plane Central Texas (feet).

The "Site Development" should show the following:

_____1) Project name and address.

_____2) City of Austin Case Number.

_____3) Vicinity Map, including City of Austin grid number.

_____4) Site boundary.

_____5) General site layout.

_____6) Existing and proposed 2 foot contours.

_____7) Existing and proposed drainage area boundaries within the site for all discharge points from the site.

_____8) Discharges and velocities at each discharge point for the 2, 10, 25, and 100 year storm events for existing and ultimate developed conditions, in accordance with the accepted methodologies listed in Section 2.3.0 and 2.2.1 of the Drainage Criteria Manual. The urban extension must be used if HEC 1 is

the selected methodology.

_____9) Existing and developed land use including existing and proposed impervious cover.

_____10) Existing and developed time of concentration flow paths used to calculate sheet, shallow, concentrated and channel flow. Include roughness coefficient values.

_____11) SCS soil types and hydrologic soil groups.

_____12) Proposed drainage and stormwater management improvements.

The drainage area plan should be at a scale suitable to show the entire drainage area for flows through the site and downstream drainage conveyance systems to the main branch of the watershed, but shall not be less than 1" = 2000'. The purpose of the drainage area plan is to show drainage areas which discharge through or into the site and the downstream conveyance systems.

_____1) Site boundary.

_____2) Existing and proposed drainage areas for all discharge points from or through the site.

_____3) Calculations certified by a Professional Engineer in the State of Texas demonstrating the adequacy of the intervening system (storm sewer tributary channel, etc.), to convey the fully developed 100 year storm from the entire drainage area to the main branch of the watershed, or to a point where the 100 year floodplain elevation has been established by current FEMA Flood Insurance Study or accepted City of Austin watershed study. Fully developed conditions for storm flow analysis are listed in Section 2.2.1 of the Drainage Criteria Manual. An electronic copy of the hydrologic and hydraulic models shall be included. Acceptable hydrologic and hydraulic methods are HEC 1, HEC HMS, TR 20, HEC 2 and HEC RAS.

_____4) Calculations demonstrating the adequacy of the existing or proposed drainage easements to a studied section of the drainage system. Include a topographic map showing locations of HEC 2 or HEC RAS cross-sections.

_____5) Verification certified by a Professional Engineer in the State of Texas that no adverse flooding of other property will occur as a result of the proposed improvements.

_____6) Proposed drainage and Stormwater Management improvements.

In addition, all backup calculations and computer models shall be certified by a Professional Engineer in the State of Texas and submitted to the Watershed Engineering Division.

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1.800.445.5588.

APPENDIX ~~E~~D. FIGURE AND DIAGRAMS

FIGURES FROM SECTION 1

Figure 1-1 Conceptual Layout

Click to view figure

Figure 1-2 Pond Maintenance Access

Click to view figure

Figure 1-3 Gate at Ramp

Click to view figure

FIGURES FROM SECTION 2

Figure 2-1 Effects of Urbanization on Flood Hydrograph

Click to view figure

Figure 2-2 Austin Intensity-Duration-Frequency Curves

Click to view figure

Figure 2-3 Dimensionless Curvilinear Unit Hydograph and Equivalent Triangular Hydrograph

Click to view figure

Figure 2-4 Temporal Distribution For all PMP Durations

The Temporal Distributions are from the Hydrologic and Hydraulic Guidelines for Dams in Texas Chapter 4 “Determining the Design Flood-Precipitation”, Equation 4.1 and Figure 4.1

* All distributions use a 15-minuted cumulative time increment.

FIGURES FROM SECTION 3

Figure 3-1 Nomograph for Flow in Gutters

Click to view figure

FIGURES FROM SECTION 4

Figure 4-1 Curb Opening Inlet in a Sump (Type S-1)

Click to view figure

Figure 4-2 Grate Inlet in a Sump (Type S-2)

Click to view figure

Figure 4-3 Combination Inlet in a Sump (Type S-3)

Click to view figure

Figure 4-4 Area Inlet Without Grate (Type S-4)

Click to view figure

Figure 4-5 Curb Opening, Inlet on Grade (Type G-1)

Click to view figure

Figure 4-6 Grate, Inlet on Grade (Type G-2)

Click to view figure

Figure 4-7 Combination Inlet on Grade (Type G-3)

Click to view figure

Figure 4-8 Curb-Opening Inlets

Figure 4-9 Depressed Curb-Opening Inlet Capacity in Sump Locations

Figure 4-10 Undepressed Curb-Opening Inlet Capacity in Sump Locations

Figure 4-11 Curb-Opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats

Figure 4-12 Definition of Depth

Figure 4-13 Grate Inlet Capacity in Sump Conditions

Figure 4-14 Curb-Opening & Slotted Drain Inlet Length for Total Interception

Figure 4-15 Curb-Opening & Slotted Drain Inlet Interception Efficiency

Figure 4-16 Depressed Curb Opening Inlet

Figure 4-17 Ratio of Frontal Flow to Total Gutter Flow

~~Figure 4-8 Inlet Capacity for Type S-1 and S-3~~

~~Click to view figure~~

~~Figure 4-9 Inlet Capacity for Type S-2~~

~~Click to view figure~~

~~Figure 4-10 Capacity for Inlets on Grade~~

~~Click to view figure~~

~~Figure 4-11 Ratio of Intercepted to Total Flow for Inlets on Grade~~

~~Click to view figure~~

FIGURES FROM SECTION 5

~~Figure 5-1 Uniform Flow For Pipe Culverts~~

~~Click to view figure~~

~~Figure 5-2 Critical Depth of Flow For Circular Conduits~~

~~Click to view figure~~

~~Figure 5-3 Velocity in Pipe Conduits~~

~~Click to view figure~~

~~Figure 5-4 Uniform Flow For Concrete Elliptical Pipe~~

~~Click to view figure~~

~~Figure 5-5 Critical Depth For Elliptical Pipe~~

~~Click to view figure~~

~~Figure 5-6 Velocity in Elliptical Pipe~~

~~Click to view figure~~

~~Figure 5-7 Uniform Flow For Pipe Arch~~

~~Click to view figure~~

~~Figure 5-8 Critical Depth of Flow For Pipe-Arch~~

~~Click to view figure~~

~~Figure 5-9 Velocity in Pipe-Arch~~

~~Click to view figure~~

~~Figure 5-10 Minor Head Losses Due to Tubulence at Structures~~

~~Click to view figure~~

~~Figure 5-11 Minor Head Losses Due to Turbulence at Structures~~

~~Click to view figure~~

Figure 5-3~~12~~

Click to view figure

~~Figure 5-13 Flow For Circular Pipe Flowing Full (n=0.010)~~

~~Click to view figure~~

~~Figure 5-14 Flow For Circular Pipe Flowing Full (n=0.011)~~

~~Click to view figure~~

~~Figure 5-15 Flow For Circular Pipe Flowing Full (n=0.012)~~

~~Click to view figure~~

~~Figure 5-16 Flow For Circular Pipe Flowing Full (n=0.013)~~

~~Click to view figure~~

FIGURES FROM SECTION 6

Figure 6-1 Uniform Flow For Trapezoidal Channels

Click to view figure

Figure 6-2 Sloping and Vertical Channel Drops

Click to view figure

Figure 6-3 Baffled Apron and Its Design Curve

Click to view figure

Figure 6-4 Conceptual Design of Alternative Channel

Click to view figure

FIGURES FROM SECTION 7

Figure 7-1 Headwall Entrance Type

Click to view figure

Figure 7-2 Conceptual Design of Debris Fins

Click to view figure

Figure 7-3 Inlet and Outlet Conditions For Culverts

Click to view figure

Figure 7-4 Hydraulics of a Culvert Under Outlet Control Condition

Click to view figure

~~Figure 7-5 Inlet Control Nomograph, Circular Pipe~~

~~Click to view figure~~

~~Figure 7-6 Inlet Control Nomograph, Box Culverts~~

~~Click to view figure~~

~~Figure 7-7 Inlet Control Nomograph, CSP Arch~~

~~Click to view figure~~

~~Figure 7-8 Inlet Control Nomograph, RCP Arch~~

~~Click to view figure~~

~~Figure 7-9 Inlet Control Nomograph, SSP Arch~~

~~Click to view figure~~

~~Figure 7-10 Inlet Control Nomograph, RCP Ellipse~~

~~Click to view figure~~

~~Figure 7-11 Outlet Control Nomograph, Circular CSP~~

~~Click to view figure~~

~~Figure 7-12 Outlet Control Nomograph, Circular RCP~~

~~Click to view figure~~

~~Figure 7-13 Outlet Control Nomograph, Box Culverts~~

~~Click to view figure~~

~~Figure 7-14 Outlet Control Nomograph, CSP Arch~~

~~Click to view figure~~

~~Figure 7-15 Outlet Control Nomograph, RCP Arch~~

~~Click to view figure~~

~~Figure 7-16 Outlet Control Nomograph, SPP Arch~~

~~Click to view figure~~

~~Figure 7-17 Outlet Control Nomograph, RCP Ellipse~~

~~Click to view figure~~

~~Figure 7-18 Critical Depth Curves, Circular Pipe~~

~~Click to view figure~~

~~Figure 7-19 Critical Depth Curves, CSP Arch~~

~~Click to view figure~~

~~Figure 7-20 Critical Depth Curves, RCP Arch~~

~~Click to view figure~~

~~Figure 7-21 Critical Depth Curves, SSP Arch~~

~~Click to view figure~~

~~Figure 7-22 Critical Depth Curves, RCP Ellipse~~

~~Click to view figure~~

Figure 7-5~~23~~ Types of Flow For Bridge Design

Click to view figure

FIGURES FROM SECTION 8

Figure 8-1 Concept of Detention Pond

Click to view figure

Figure 8-2 Weir and Orifice Flows

Click to view figure

~~Figure 8-6 Flow Chart of Design Procedures For Example 2~~

~~Click to view figure~~

~~Figure 8-7 Conceptual Layout~~

~~Click to view figure~~

~~Figure 8-8 Gate at Ramp~~

~~Click to view figure~~

~~Figure 8-9 Pond Maintenance Access~~

~~Click to view figure~~

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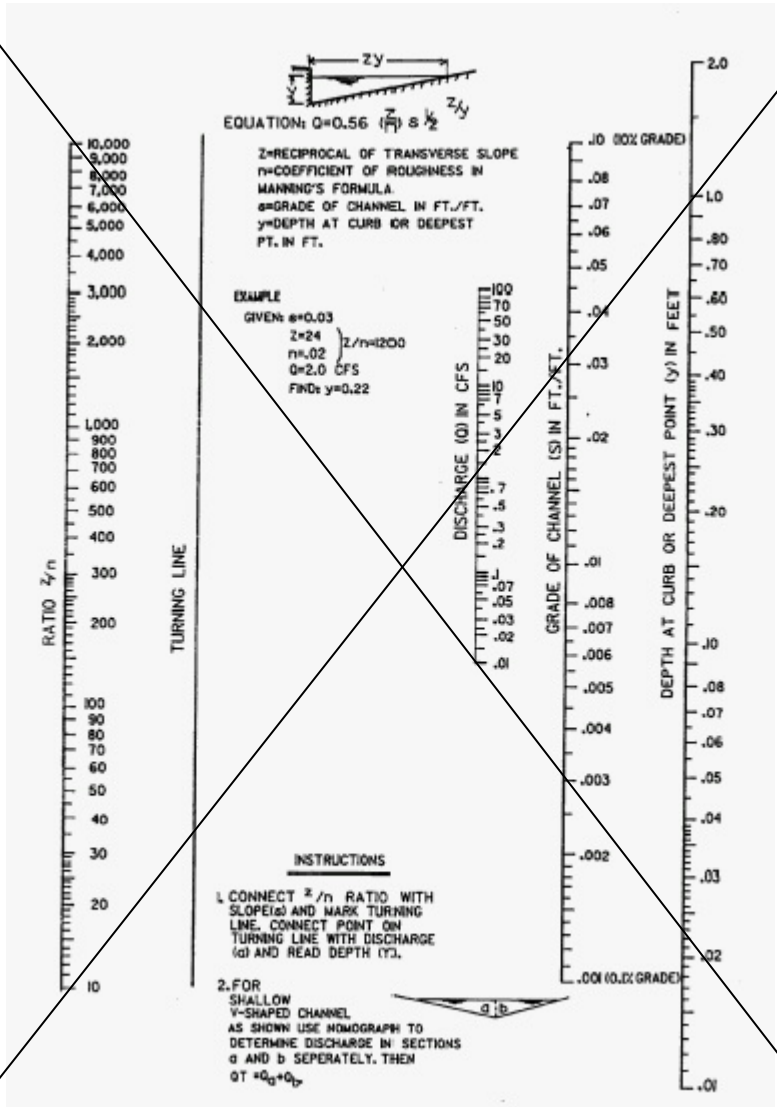
1.800.445.5588.

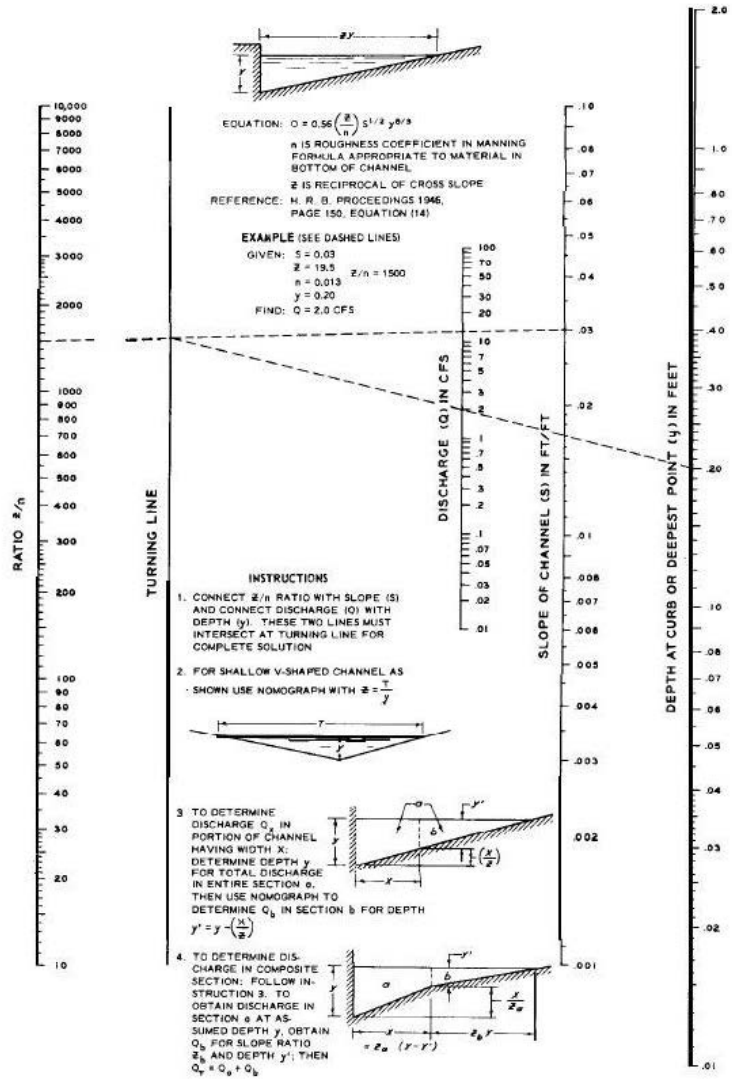
Old DCM Appendix E, New DCM Appendix D, *Figures and Diagrams*

Delete old Figure 3-1



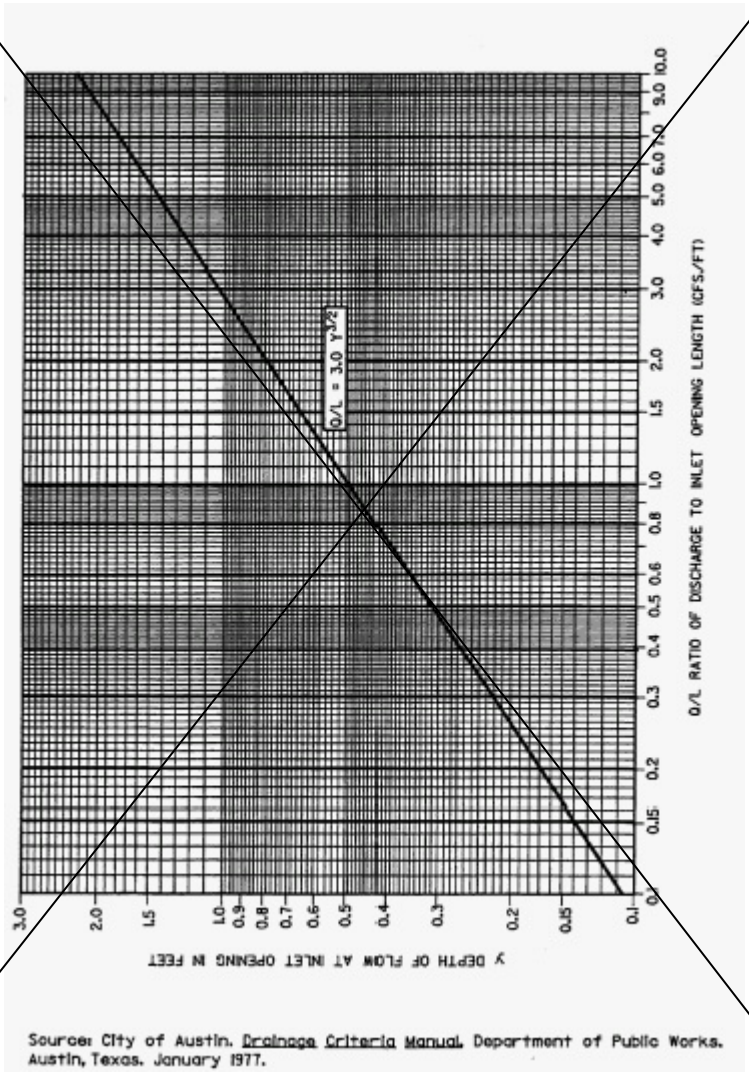
Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Insert new Figure 3-1



Source: US Army Corps of Engineers

Delete old Figure 4-8



Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Insert new Figure 4-8

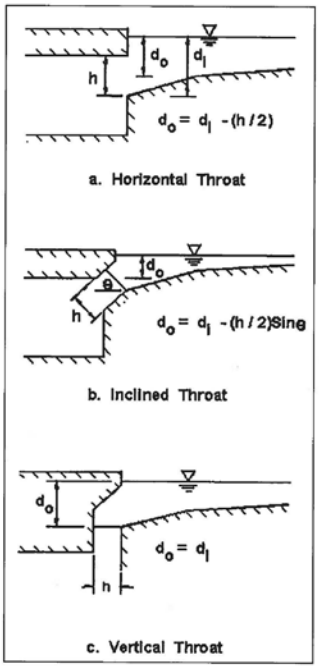
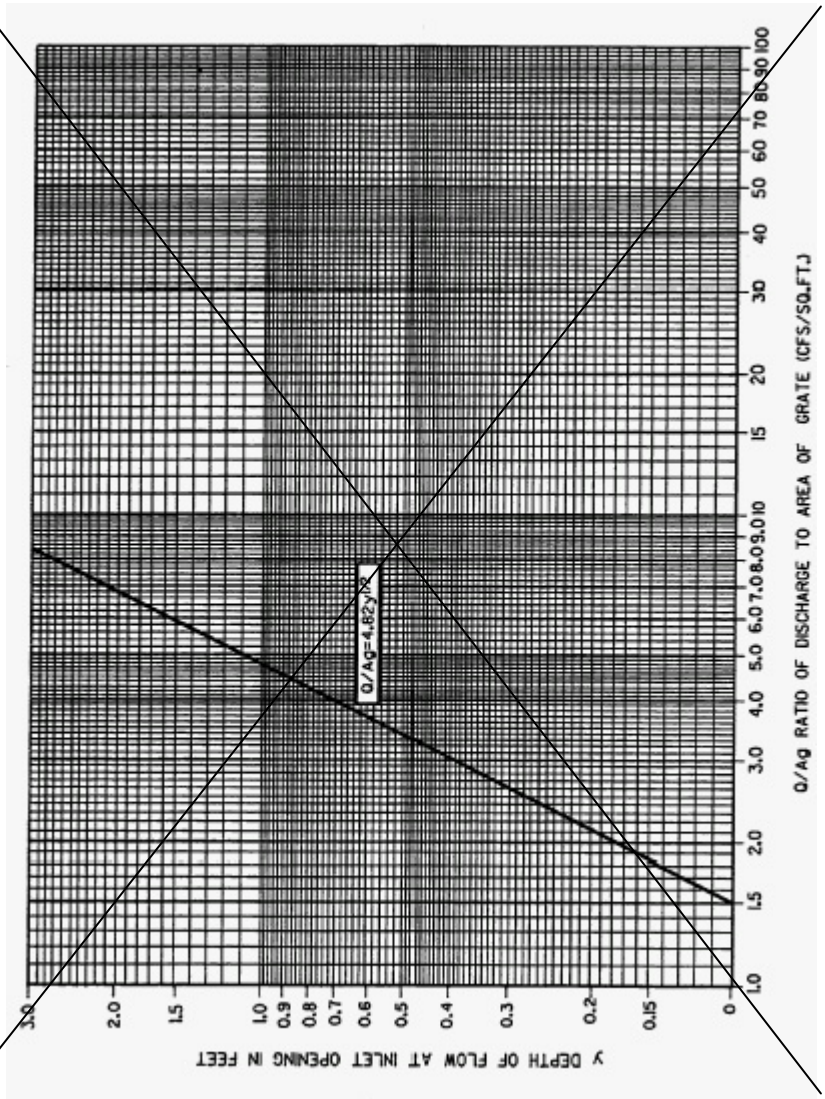


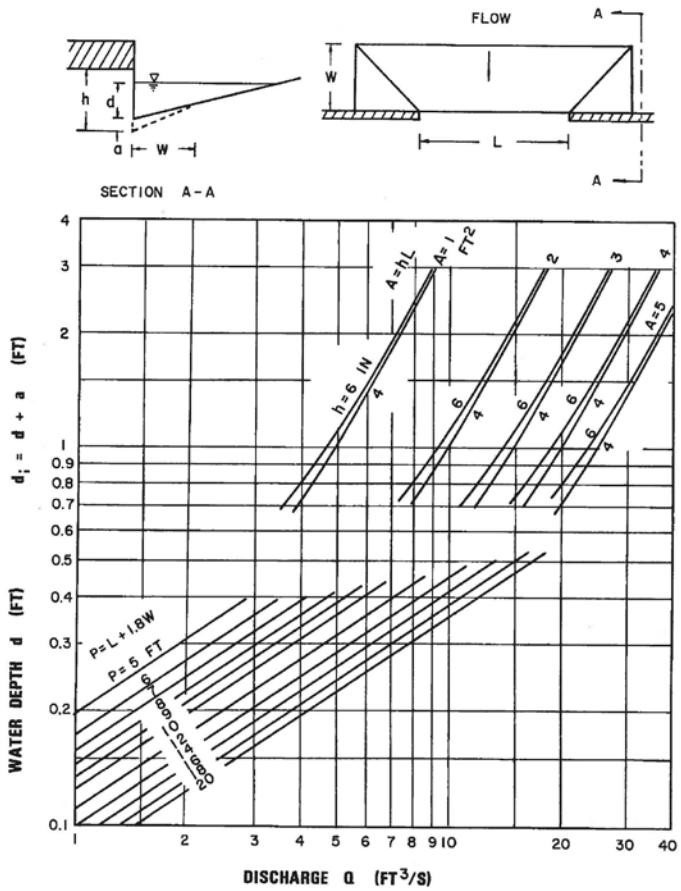
FIG. 4-8 Curb-opening inlets.

Delete old Figure 4-9



Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

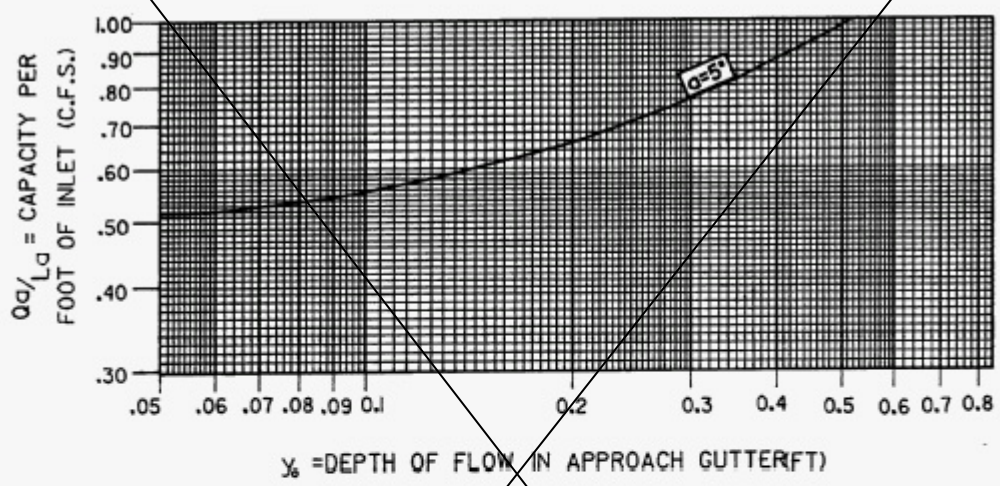
Insert New Figure 4-9



Depressed Curb-opening Inlet Capacity in Sump Locations - English Units

FIG. 4-9

Delete Old Figure 4-10



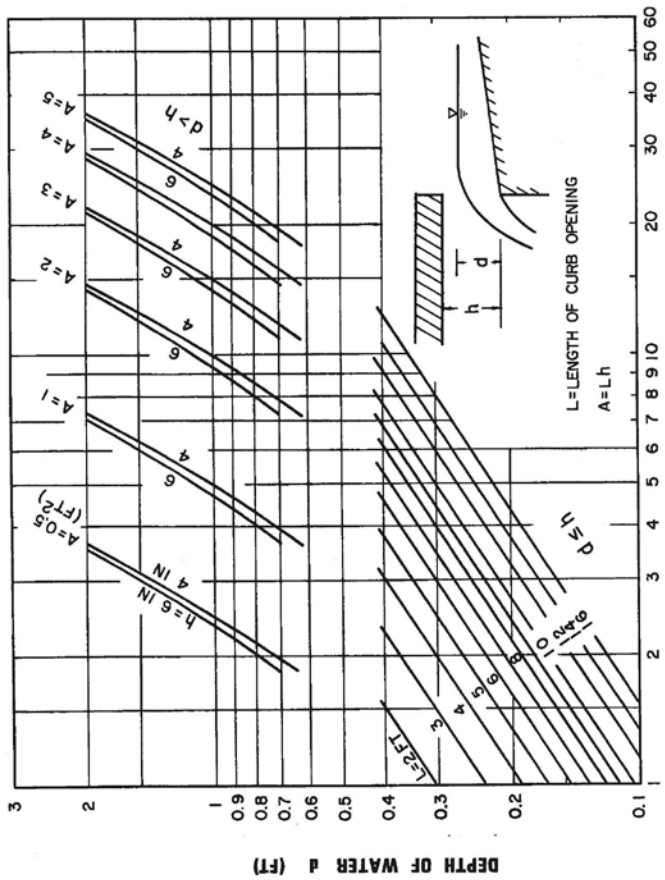
$$Q_a/L_a = 0.7\left[\frac{1}{H_1 - H_2}\right]\left[(H_1)^{5/2} - (H_2)^{5/2}\right]$$

$H_1 = a + y_o$

$H_2 = a$ = GUTTER DEPRESSION

Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

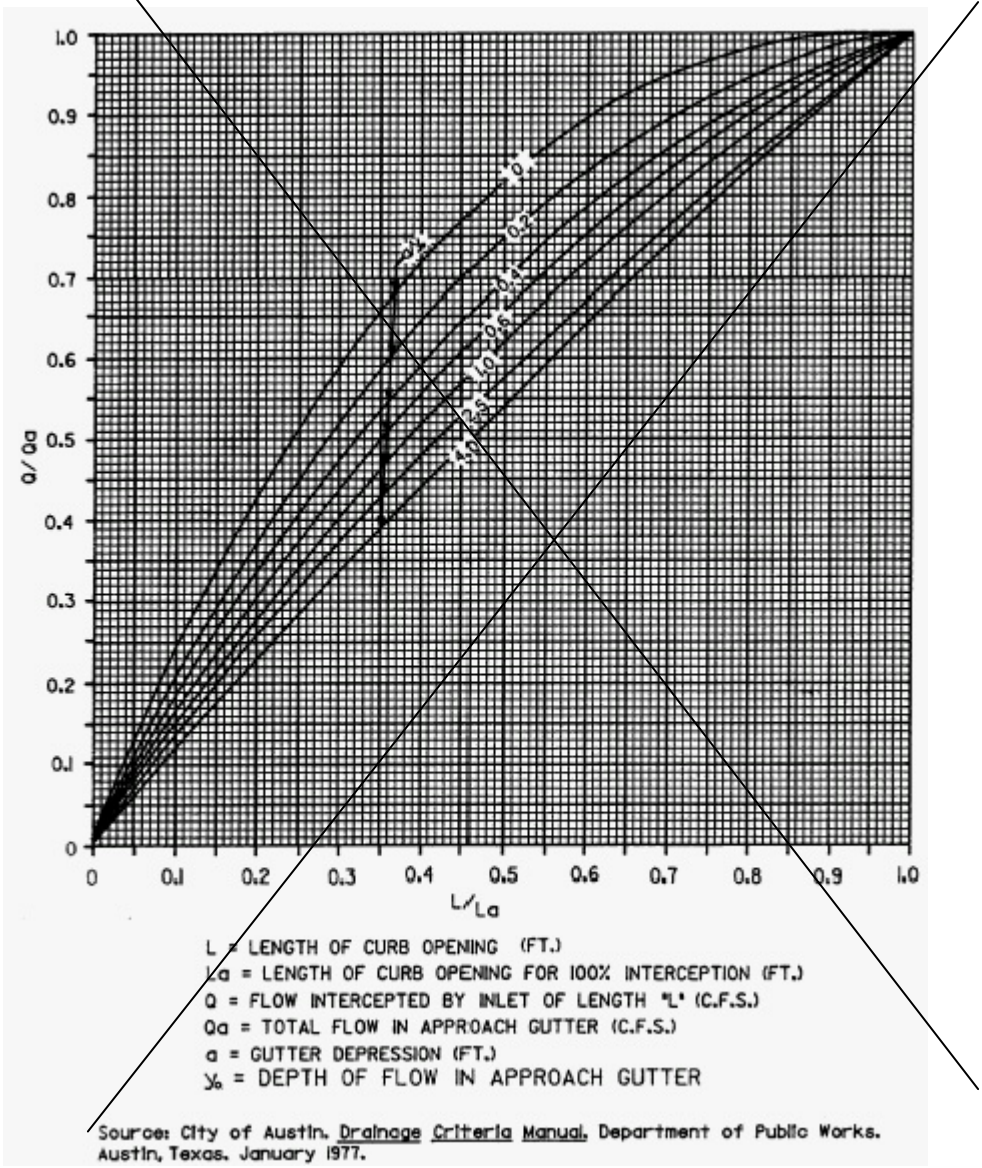
Insert New Figure 4-10



Undepressed Curb-opening Inlet Capacity in Sump Locations - English Units

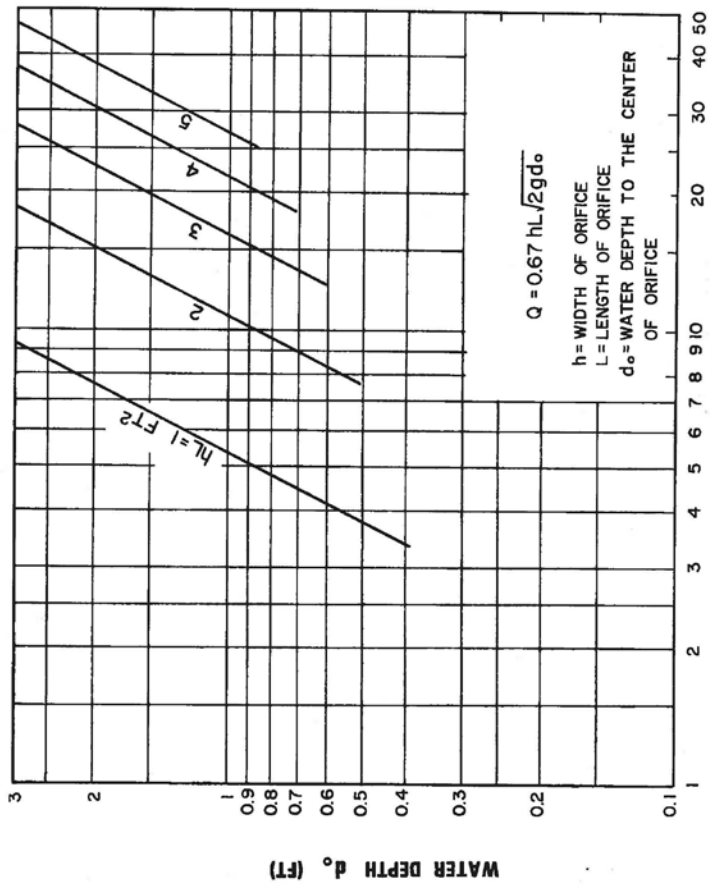
FIG. 4-10

Delete Old Figure 4-11



Source: City of Austin. Drainage Criteria Manual. Department of Public Works. Austin, Texas. January 1977.

Insert New Figure 4-11



Curb-opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats - English Units

FIG. 4-11

Insert New Figure 4-12

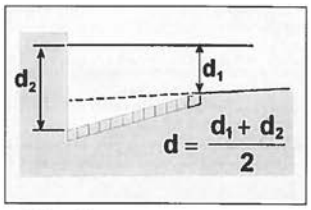
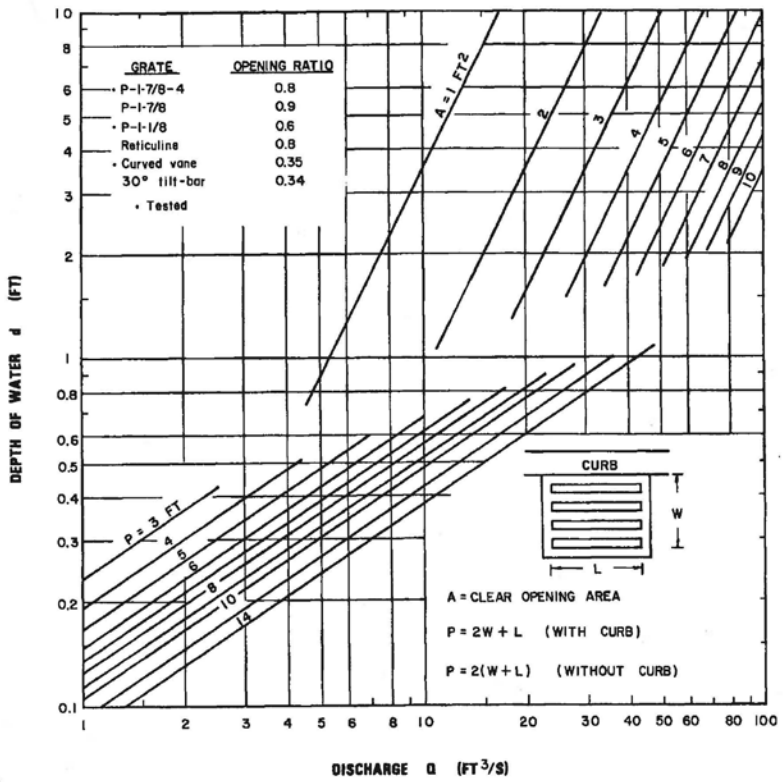


FIG. 4-12 Definition of depth.

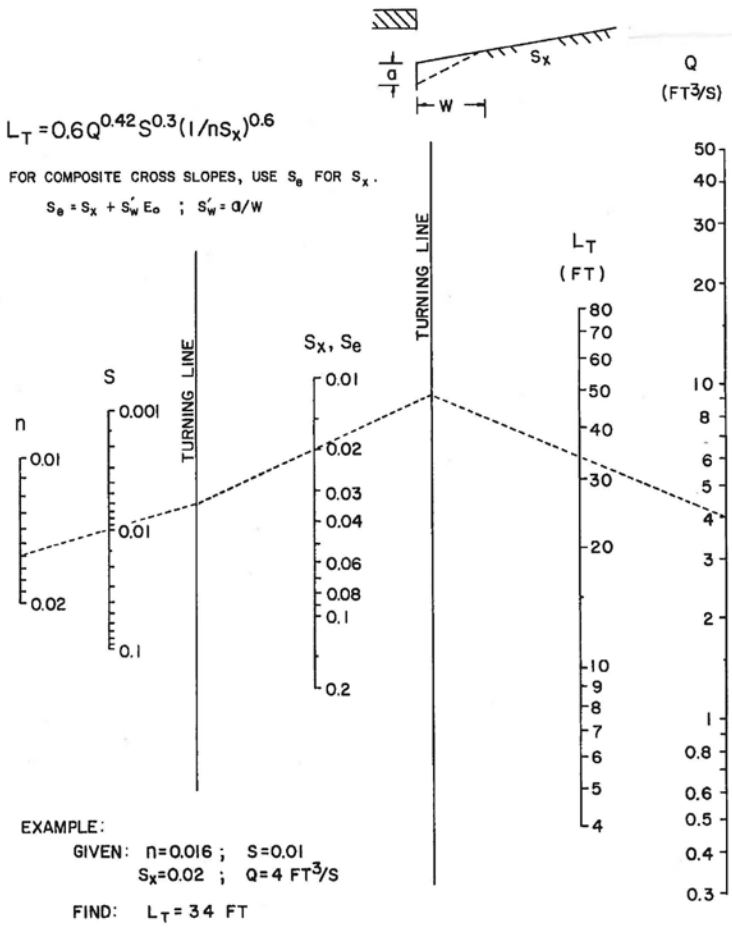
Insert New Figure 4-13



Grate Inlet Capacity in Sump Conditions - English Units

FIG. 4-13

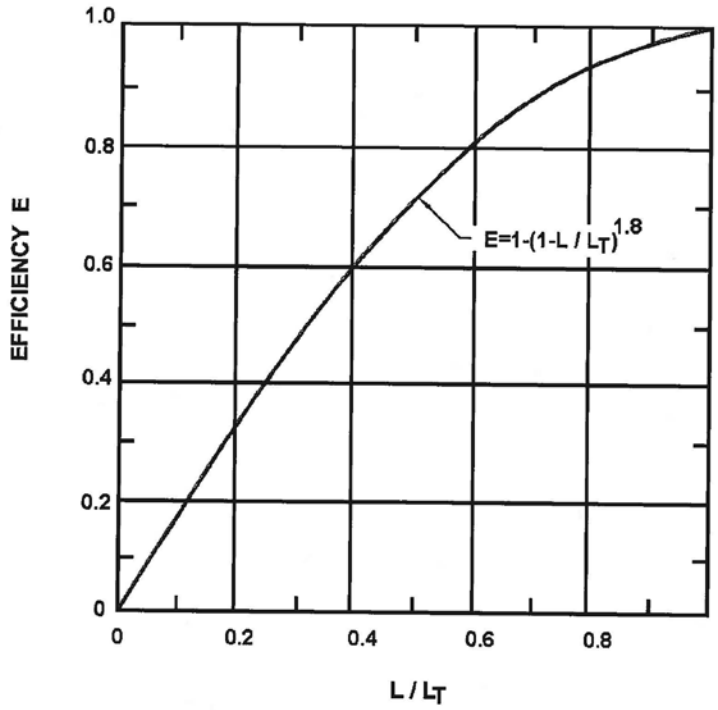
Insert New Figure 4-14



Curb-opening & Slotted Drain Inlet Length for Total Interception - English Units

FIG. 4-14

Insert New Figure 4-15



Curb-opening and Slotted Drain Inlet Interception Efficiency.

FIG. 4-15

Insert New Figure 4-16

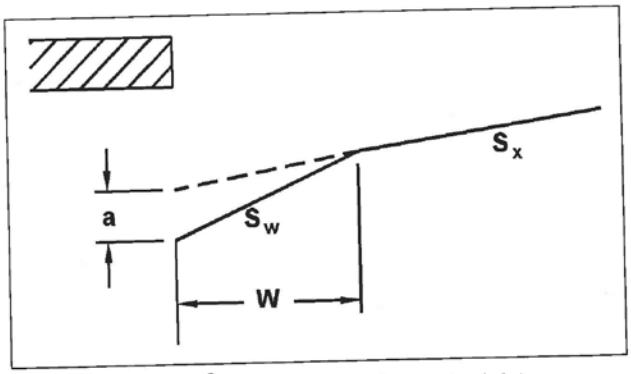
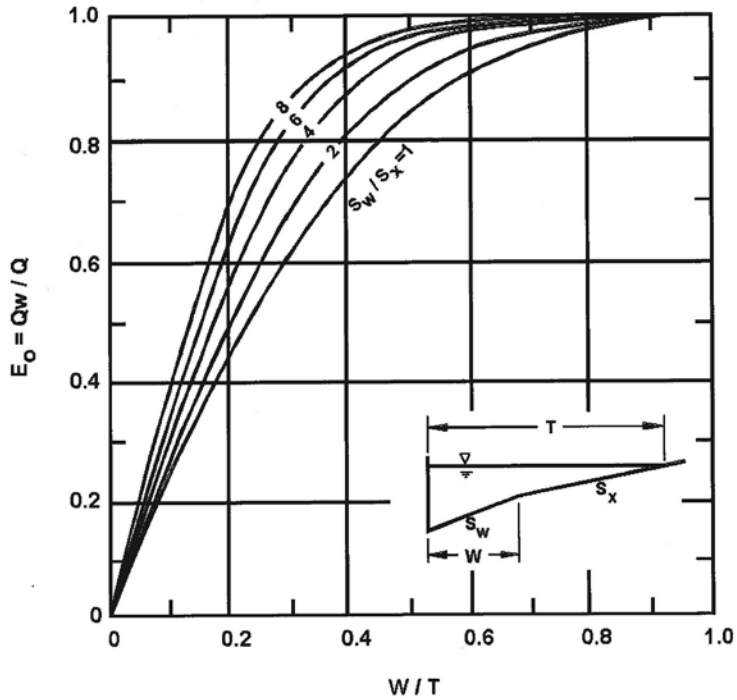


FIG. 4-16 Depressed curb opening inlet.

Insert New Figure 4-17

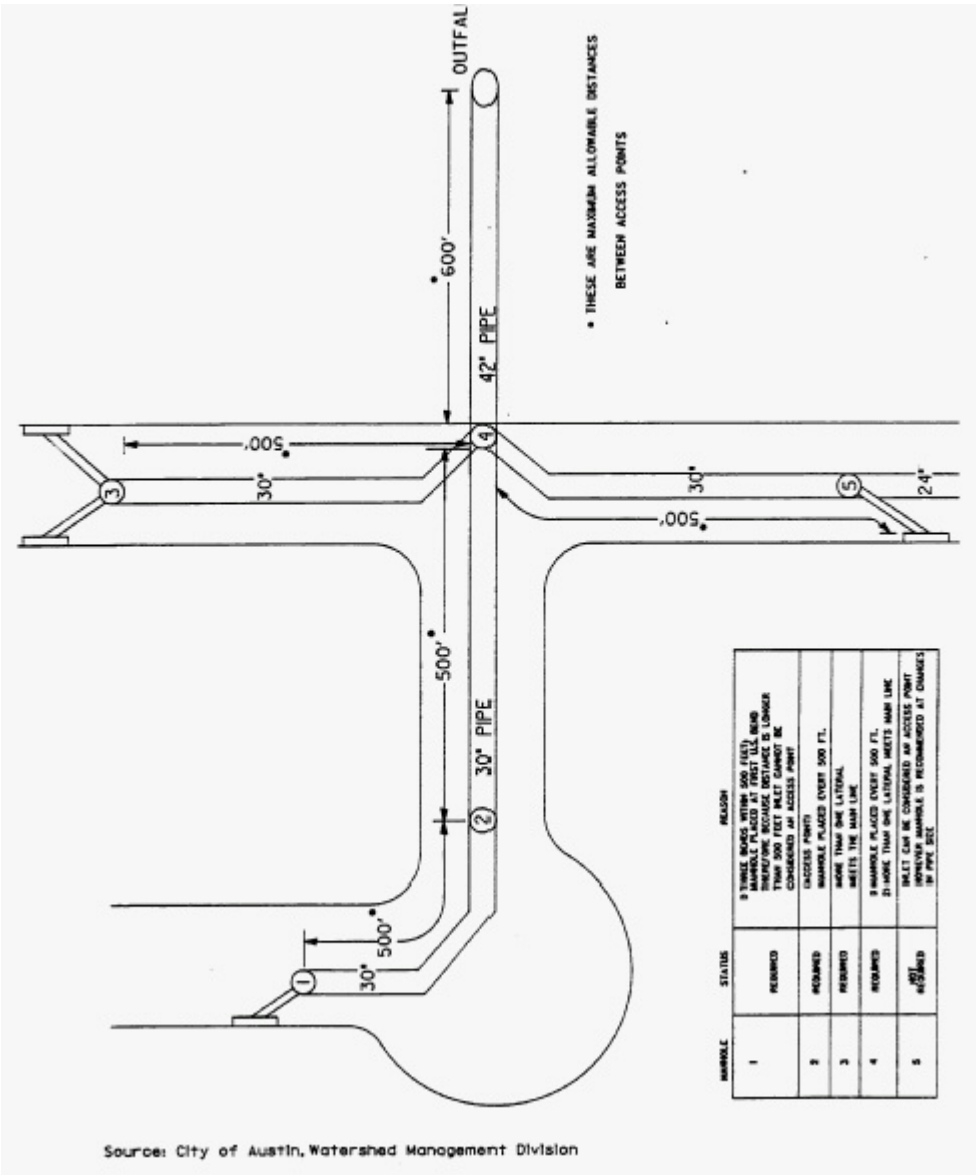


Ratio of Frontal Flow to Total Gutter Flow

FIG. 4-17

Delete Figures 5-1 through 5-11

Renumber current Figure 5-12 to become Figure 5-3

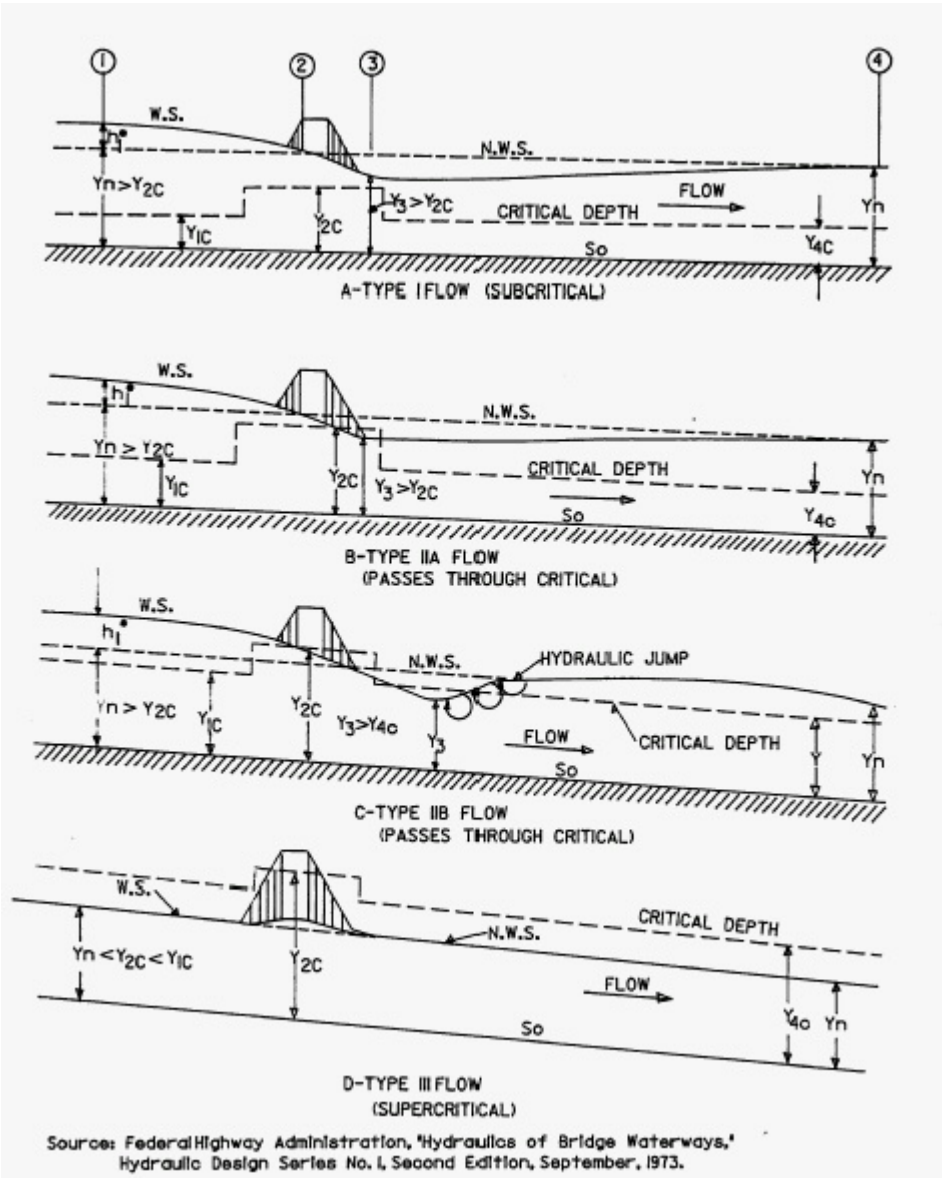


Source: City of Austin, Watershed Management Division

Delete Figures 5-3 through 5-16

Delete Figures 7-5 through 7-22

Renumber current Figure 7-23 to become Figure 7-5



Source: Federal Highway Administration, 'Hydraulics of Bridge Waterways,' Hydraulic Design Series No. 1, Second Edition, September, 1973.

Delete Figures 8-6 though 8-9

Updated: September 10, 2007
Morgan Byars, PE
COA WPDRD

New ECM Appendix E
Guidance on Establishing an "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 roads, buildings, fences, utilities, other infrastructure or 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.

Authority

City of Austin Code (25-12) and the Code of Federal Regulations (CFR 44 Ch. 1) direct the City to avoid construction of improvements in flood hazard areas subject to erosion.

City of Austin Code Chapter 25-12 Technical Codes, 25-12-3 Local Amendments to the Building Code, Section 1612 Flood Loads, 1612.4 Design and Construction states that "The design and construction of buildings and structures, and additions and alterations to buildings and structures located in flood hazard areas, shall be in accordance with ASCE 24." Section 3.5 in ASCE Standard 24 Flood Resistant Design and Construction (ASCE/SEI 24-05, copyright 2006 by the American Society of Engineers) includes:

ASCE 24

<u>3.5 Erosion-Prone Areas</u>

Structures shall not be constructed within flood hazard areas subject to erosion from such phenomena as caving banks, meandering streams, or eroding shorelines, where such erosion is predicted to affect the structure unless the structure is protected as specified in Section 3.5.1. Erosion-prone areas shall be determined by analyzing available studies, historical data, watershed trends, average annual erosion rates, wave effects, flood velocities and duration of flow, geotechnical data, and existing protective works. Results of these analyses shall be documented in an engineering report, which defines the data and methodology used to identify erosion prone areas.

3.5.1 Protective Works in Erosion-Prone Areas

The limits of an erosion-prone area shall be subject to revision where protective works have been designed and constructed to control erosion processes during all flow and wave conditions up to and including the design flood, and where a maintenance and operations plan for the protective works has been provided.

The Code of Federal Regulations Title 44 (CFR 44) Emergency Management and Assistance, Chapter 1 Federal Emergency Management Agency, Department of Homeland Security, Part 60 Criteria for Land Management and Use, Subpart A - Requirements for Flood Plain Management Regulations, Section 60.5 Flood plain Management Criteria for Flood-related Erosion-prone Areas requires communities to manage erosion hazards through the land development process with the following minimum requirements:

.

CFR 44 60.5

(a) When the Administrator has not yet identified any area within the community as having special flood related erosion hazards, but the community has indicated the presence of such hazards by submitting an application to participate in the Program, the community shall:

(1) Require the issuance of a permit for all proposed construction, or other development in the area of flood-related erosion hazard, as it is known to the community;

(2) Require review of each permit application to determine whether the proposed site alterations and improvements will be reasonably safe from flood-related erosion and will not cause flood-related erosion hazards or otherwise aggravate the existing flood-related erosion hazard

(3) If a proposed improvement is found to be in the path of flood-related erosion or to increase the erosion hazard, require the improvement to be relocated or adequate protective measures to be taken which will not aggravate the existing erosion hazard.

Erosion Hazard Zone Methodology

The methodology described herein 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. The procedure described in this document is considered a level 1 analysis and may provide an acceptable means of satisfying the requirements of ASCE 24. In cases where the results of this analysis are challenged as being too conservative, then a more detailed (level 2) erosion hazard analysis may be performed as approved by the City of Austin. Alternatively stream stabilization measures

could be implemented to limit the erosion hazard zone upon approval from the City of Austin. Stream stabilization approaches intended for this purpose should be designed to remain stable during rare floods (100-year event) and also comply City of Austin Environmental Criteria in attempt to preserve the natural and traditional character of the stream and riparian corridor.

There are five steps to be conducted in the determination of the level 1 erosion hazard zone as outlined in Figure 1.

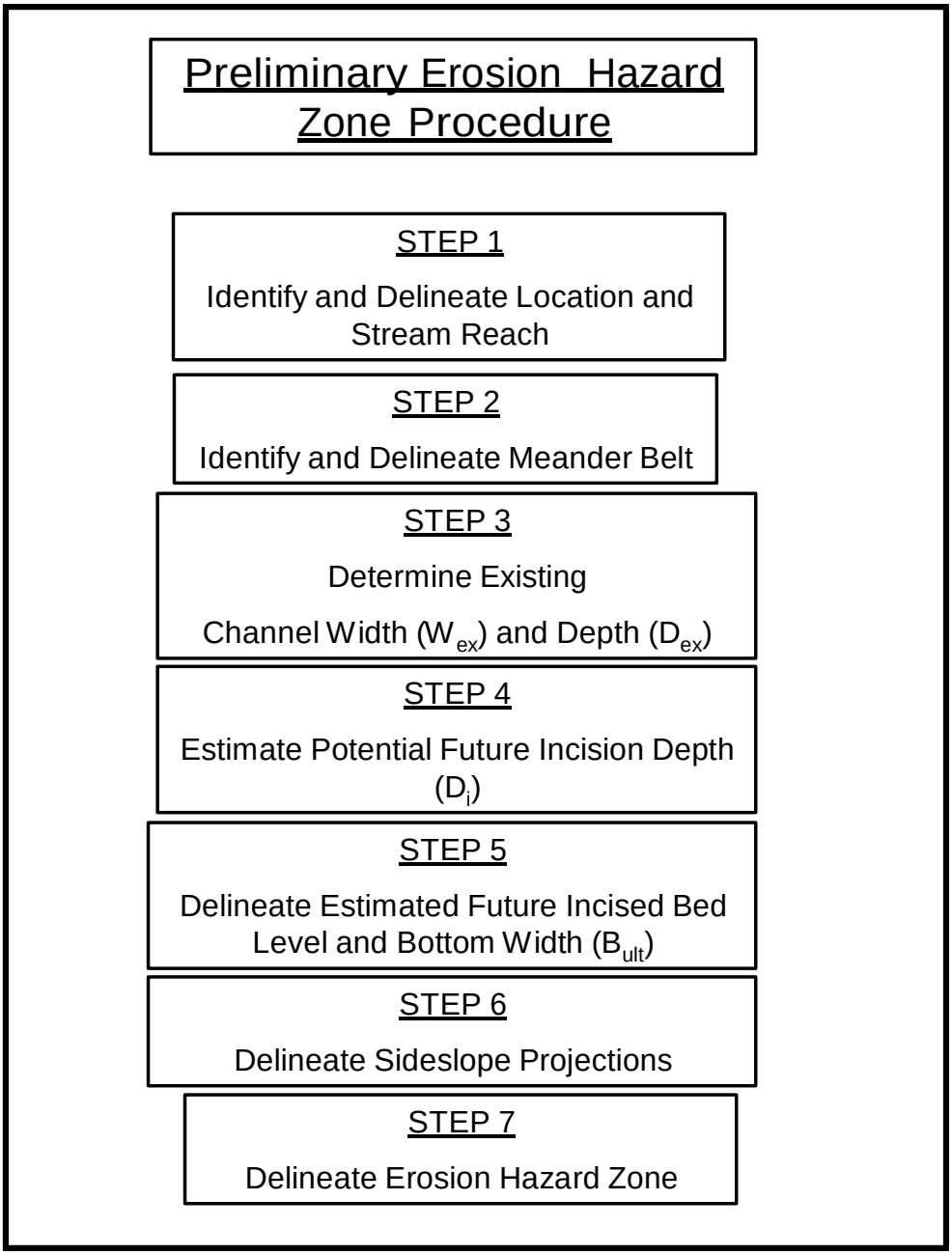


Figure 1 Preliminary Erosion Hazard Zone Procedure Steps

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 apexes 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.

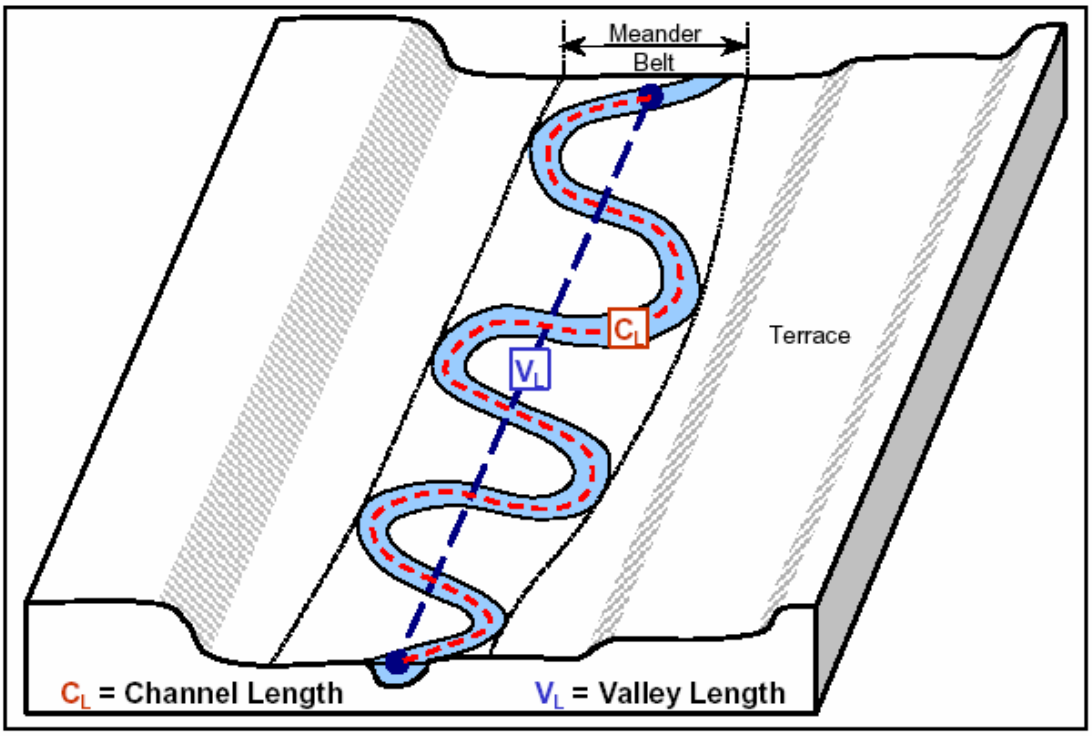


Figure 2. Typical sinuous stream and approximate meander belt.

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.

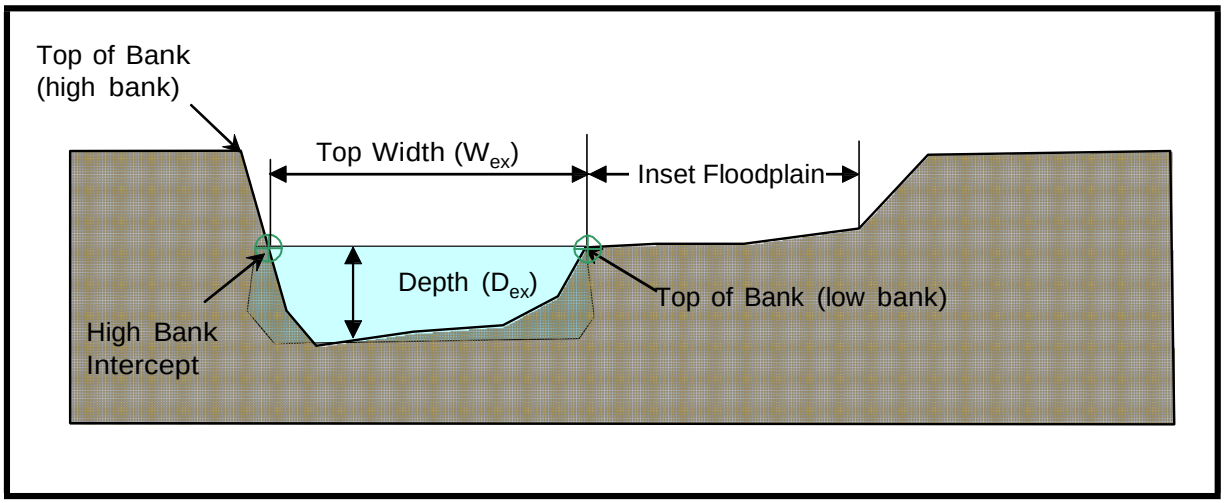


Figure 3. Typical Entrenched Valley and Channel and Inset Floodplain.

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 toes 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 1 foot 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 the meander belt boundary.

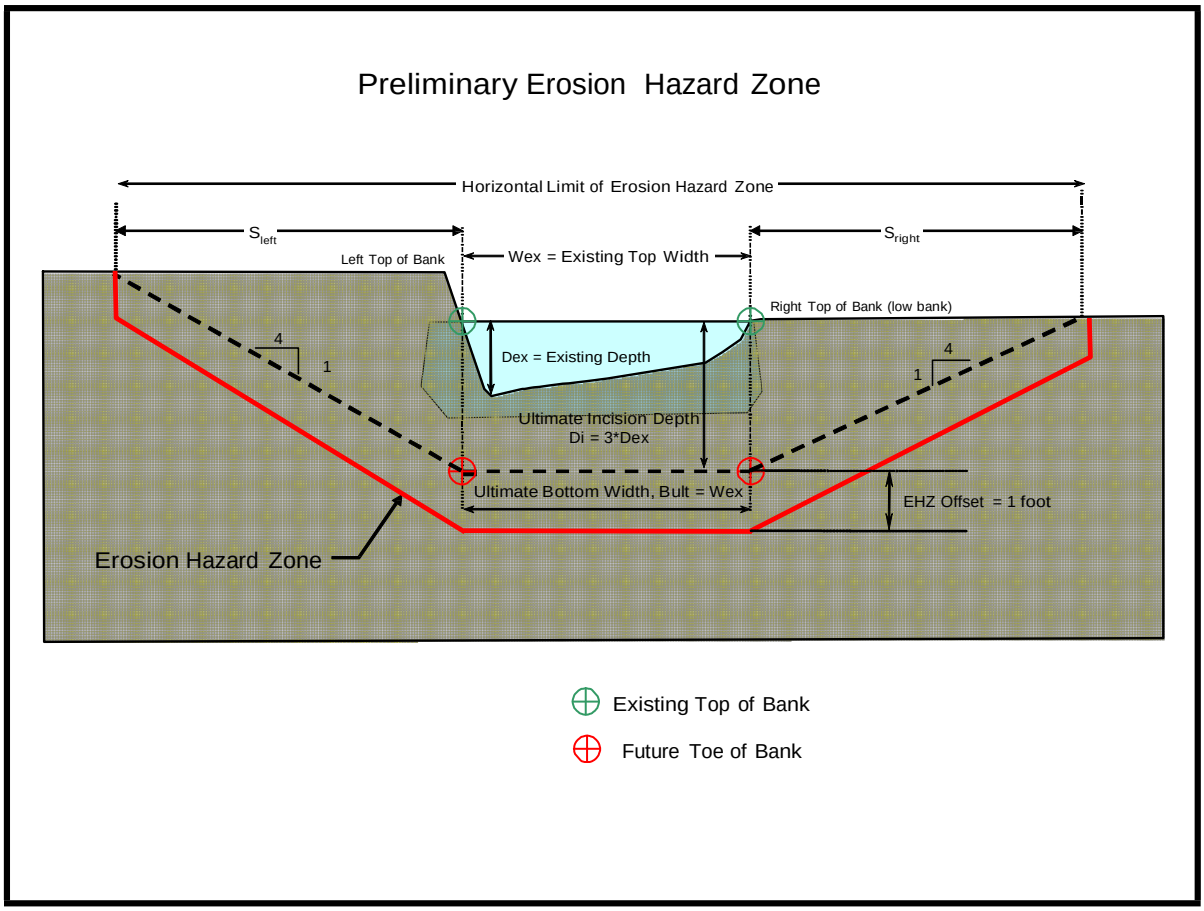


Figure 4. Erosion Hazard Zone Determination

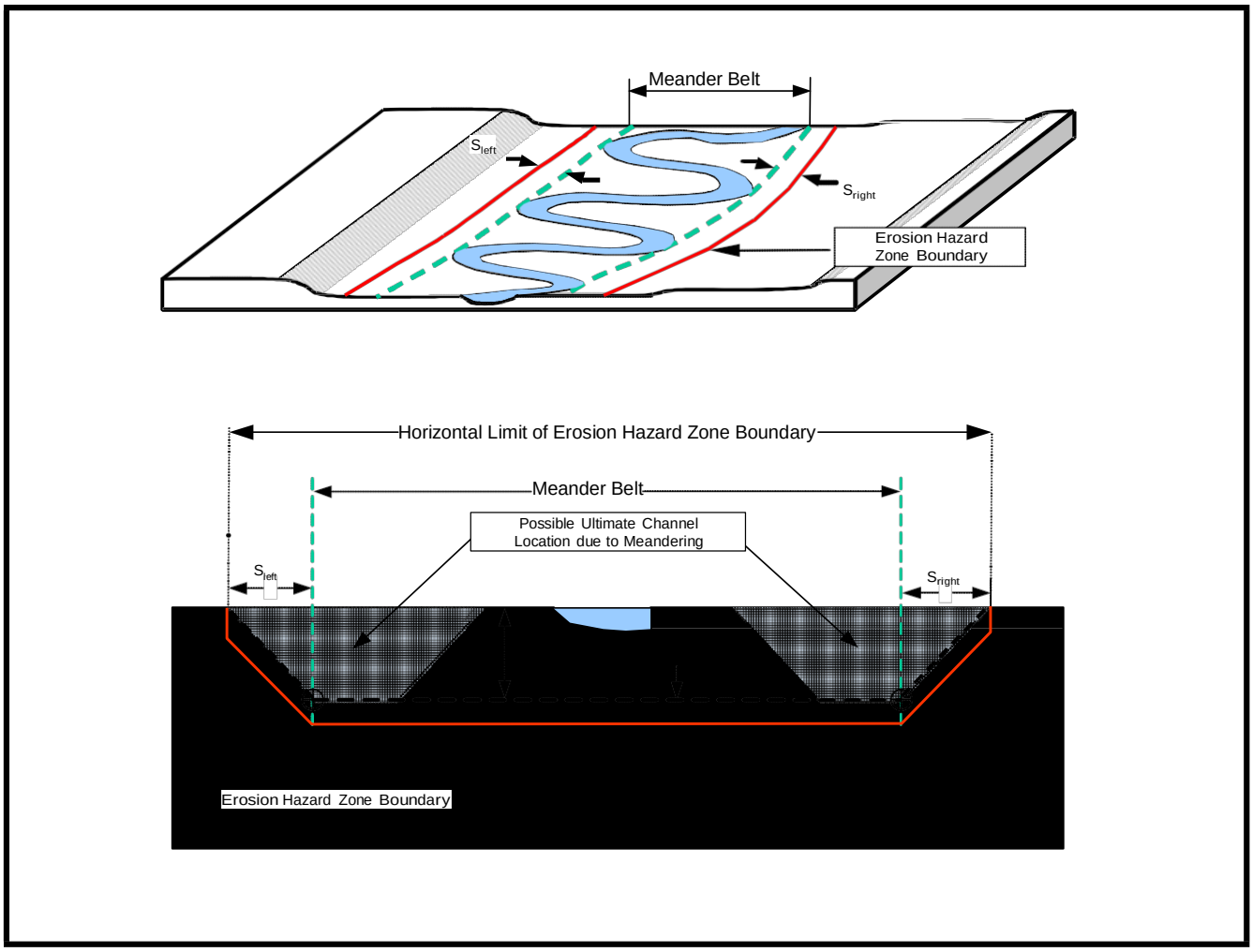


Figure 5. Erosion Hazard Zone Determination for Meandering Streams

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.

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 (V_L) for entire project stream reach.
2.2		Measure channel centerline length (C_L) for entire project stream reach
2.3		Determine channel sinuosity $P = C_L / V_L$
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 (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 D_{ex}.
STEP 4: ESTIMATE POTENTIAL FUTURE INCISION DEPTH (D_i)		
4.1		Estimate the future incision depth (D_i) by multiplying the existing depth (D_{ex}) by 3. Enter the estimated future incision depth (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 1 foot. 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” (2004) prepared by Ayres Associates, Fort Collins, Colorado.