

ARTICLE VIII

Basic Design Criteria for Storm Water Open Channels, Culverts, and Bridges

Section ST 801

General

(a) The Developer's Engineer should become familiar with these Rules and Regulations, in particular, Articles I, III, IV, VII, XI, XII. The hydraulic principles of open channels such as drainage channels, existing watercourses, existing watercourse alterations or relocations, swales, ditches, gutters, etc., (paved and/or unpaved), and the various design aids that pertain to open channel flow in the EXHIBITS and PLATES before proceeding with open channel, culvert, and bridge design and detail. The Hamilton County Department of Public Works reviews only the hydraulic design of bridges. The Hamilton County Engineers or the Hamilton County Department of Building Inspections regulate all structural elements of bridge construction.

(b) Open channels, culverts, and bridges proposed to be located partially or wholly within any special flood hazard area will be approved if they do not constitute encroachment as defined in Section ST 112, and all requirements of the Flood Damage Prevention Regulations (EXHIBIT NO. 36) are met. Design criteria must be established on a case-by-case basis.

Section ST 802

Degree of Protection

Storm water open channels shall be adequate to handle runoff from storms of the frequencies of occurrence shown for the degrees of site development as follows:

(a) For all areas/sites with drainage sheds of less than 1 acre, 10 year frequency.

(b) For all areas/sites with drainage sheds 1 acre or greater, 100 year frequency.

(c) For all areas/sites flood routing relative to buildings and roadways, 100 year frequency.

(d) The runoff capacity of existing swales and watercourses that are to be altered or relocated shall be maintained, if flooding problems do not exist. Flood controls, when necessary, shall be the same as for Section ST 802(c) above, 100 year frequency.

Section ST 803

Determination of Quantity of Runoff

Each portion of the storm water open channel shall be capable of handling the peak flows as determined by the methods indicated in Section ST 702(a) or (b) except that flow quantities provided in the Flood Insurance Study for Unincorporated Hamilton County, Ohio and the Storm Drainage and Open Space Master Plan for Hamilton County, Ohio shall be used within any Special Flood Hazard Area as defined herein, whichever provides the more stringent restrictions.

Section ST 804

Open Channel Capacity and other Controls

(a) The required capacity of an open channel involves a determination of the velocity and depth of flow for a given discharge. Those characteristics can best be obtained from the Manning Formula See EXHIBIT NO.7 (Sheet 1 and/or 2 of 2) and EXHIBIT NO. 32.

(b) Open channel cross section areas shall be determined by the Manning Formula, using a value of "n" as indicated in EXHIBIT NO. 6. The cross section areas shall be designed and sized for the degree of protection as indicated in Section ST 802 and the velocities as indicated in Section ST 805.

(c) Various construction details recommended for the cross sectional areas are shown in Sta. Drawing. Plates 4, 6, 7 and 8.

(d) Cut and fill side slopes of open channels shall not be steeper than 4:1 as indicated in Section ST 414. Where side slopes must be steeper than 4:1, the Developer's Engineers shall follow the procedures as indicated in Section ST 414 to obtain approval.

(e) The longitudinal slope of an open channel shall be established so as to provide a velocity somewhere between the recommended minimum and maximum velocities as indicated in Section ST 805. A longitudinal slope flatter than 0.5% is not acceptable.

(f) For any building proposed to be constructed adjacent to, but outside of any Special Flood Hazard Area and/or the one hundred (100) year flood plain limits of any open channel not designated as a special flood hazard area, the lowest flood elevation is to be at least one (1) foot higher than the applicable flood elevation indicated above.

(g) Where existing swales or watercourses are permitted to remain undisturbed in any new development, the Developer's Engineer may be required to provide flood study information as indicated in Section ST 1104(d), (not needed for preliminary plan).

(h) At the discretion of the Director of Public Works, existing swales and watercourses with runoff through a new development, that are not to be disturbed by the development, shall be studied to determine the need for remedial work. This work may consist of tree, debris and obstruction removal, bottom channel and side slope erosion control, re-grading of side slopes to eliminate slope instability, or elimination of other potential hazards. The Developer may be required to provide the necessary labor and/or materials to perform required construction items. The Improvement Plans to be submitted for approval shall indicate the work to be performed.

Section ST 805

Ditch Design Criteria

(a) Velocity

(1) Determination of velocity shall be based on the storm frequencies indicated in Section ST 802, (refer to EXHIBIT NO. 32 for open channel symbols, equations and geometric formulas).

(2) The velocity for the design frequency storm shall not exceed the values shown in the following table.

(3) Allowable Ditch Velocities Table:

Grass Lining Maximum Flow Velocity				
Soil			Maximum Velocity ft./sec.	
Texture	Type	Seed Lining	Seed & Mulching	Sod
Sand, Silt, Sandy Loam, Silt Loam	Sand	1.5	3.0	3.5
Silty Clay Loam, Sandy Clay Loam	Firm Loam	2.0	4.0	4.0
Clay	Clay	2.5	4.0	5.0-6.0
N/A	Gravel	3.5	5.0	
N/A	Weathering Shale	4.5	5.0	N/A

Note: Soil texture/type can be determined from the soil surveys. If the channel is on fill, the soil should be tested.

Maximum Permissible Velocities for Bare Soil Channels	
Soil Texture	Maximum Velocity ft./sec.
Sand, Silt, Sandy Loam, Silt Loam, Loamy Sand	1.5
Silty Clay Loam, Sandy Clay Loam (ML-CL, SC)	2.0
Clay (CL)	2.0
Shale, Hard Pans	6.0

NOTE: REFER TO ODOT CONSTRUCTION & MATERIAL SPECIFICATIONS FOR ABOVE ITEMS.

If the calculated velocity exceeds that shown in the table, a concrete lining or rock channel protection lining shall be provided, (refer to ODOT Standard Paved

Gutter MC-5 (or DM-2.1M) and Hamilton County Storm water Standard Details Plates 4,5,6,7 & 8). The designer may substitute alternative concrete paving specifications for approval by the Public Works Director.

Seeding and erosion control with matting may be used instead of RCP or concrete pavement, where average flow velocity is less than ten (10) feet per second and the ditch slope is less than 10%, with approval by the Public Works Director.

Check dams' drop structures, energy dissipaters, etc., for open channel erosion control when velocities exceed ten (10) feet per second may be used with approval by the Public Works Director.

(b) Roughness

Suggested values for Manning's Roughness Coefficient "n" for the various types of open water carriers.

(1) Existing Watercourses - (Dense weeds, irregular sections, meandering, some trees, assumed average for Hamilton County)= 0.100

(2) Drainage Channels - (For analysis of a drainage channel to be constructed to replace a segment of an existing watercourse that will be sodded or seeded, privately maintained, connected on both ends to an existing watercourse and assumed over the subsequent years to have the same natural growth characteristics of Item (1) above = 0.100

(3) Consoer/Townsend Streams - Large drainage channels subject to flooding with published pre-determined depth of flow for one hundred (100) year frequency storm = 0.07

(4) TABLE ROUGHNESS COEFFICIENT

Type of Lining	Roughness Coefficient
Bare Earth	.02
Seeded	.03
Sod	.04
Jute Mat	.04
Excelsior Mat	.04
Item 838 Matting	.04
Concrete	.015
Bituminous	.018
Grouted Rip Rap	.02
Rock Channel Protection	.06 for ditches
	.04 for large channels
Drainage Channels Not Maintained	.07

(c) Depth of Flow

(1) Depth of flow shall be limited to twelve inches (12") below edge of pavement for paved ditch and twelve inches (12") below top of bank for non-paved ditch for the design discharge.

(2) Depth for less significant flows may be limited to a few inches below top of bank or pavement for paved gutter, where flooding is not a potential problem.

Section ST 806

Open Channel Alterations or Relocation

All earthwork should conform to the "Earthwork Rules and Regulations" of the Hamilton County Soil and Water Conservation District. The Hamilton County Public Works Director may also require the developer to have a report prepared

by a qualified Geotechnical Engineer as indicated in Section ST 414 to make recommendations. Also, refer to Section ST 416, relative to compaction of fill.

Section ST 807

Swales, Ditches, Gutters (Paved and Unpaved)

(a) Swales, ditches, gutters (paved and unpaved) may be used for the collection of surface flows from relatively small drainage areas of less than one acre, and designed for a ten (10) year storm frequency, as per Section ST 802(a). Any potential flooding problem should be resolved using the one hundred (100) year storm frequency.

(b) Where the drainage areas exceed one acre, swales, ditches, gutters, etc., shall be designed for a one hundred (100) year storm frequency, as per Section ST 802(b). The Minimum Opening Elevation (MOE) for all buildings shall be 1'- 0" above the flow elevation.

(c) Swales, ditches, gutters, etc., should, if practical, be located at the rear of lots or along common property lines. The flow shall discharge into an open channel, catch basin or inlet.

(d) Refer to Section ST 710(d) for maximum surface flow between buildings in a new development.

(e) Refer to Section ST 710(e) for maximum surface flow onto a public roadway.

(f) If an owner desires to eliminate a swale, ditch, or gutter through his property, he shall first secure approval by the Public Works Director and obtain a work permit for the installation therein, of a yard drain of adequate capacity, with a sewer connection to a storm sewer or open channel.

Section ST 808

Emergency Overflow Ditches Required a Low Point Cul-de-sacs, Low Sag Areas.

(a) Surface ditches required at low point cul-de-sacs, low sag areas, etc. shall be designed in the same manner as indicated in Section ST 801 through 805 and 807 for open channel flow, to give all buildings flood protection for a one hundred year frequency storm. The maximum water level at the centerline of pavement shall be 12". All Section A-A emergency overflow swales within subdivisions are to be directed to the property line. No diagonal swales across the front of single-family lots will be permitted. Also a note shall be on the improvement plans indicating that no utility boxes are to be placed within Section A-A swales.

(b) The surface ditches normally shall begin at the roadway right-of-way line and end at least forty (40) feet where practical beyond the rear of any

building, or end at an existing watercourse if the additional surface ditch length is not excessive.

(c) Other means of disposing of floodwater at these locations must be provided if a surface ditch is not feasible.

Section ST 809

Culvert Design Criteria and Controls

(a) Culvert analysis and design methods for the unincorporated areas of Hamilton County shall be basically the same as described in the State of Ohio Department of Transportation "Location and Design Manual" except as follows:

(1) The drainage area to the culvert entrance shall be indicated on the 200 scale City of Cincinnati and Hamilton County Metropolitan Topographic Survey or CAGIS Topographic maps.

(2) Design discharge (Q) shall be adequate to handle runoff as indicated in Section ST 802 and 803.

(3) Inlet or outlet control must be determined in the analysis.

(4) The hydraulic analysis shall include a determination of the headwater and tail water or backwater depths of any downstream open channel for the one hundred (100) year flood, to determine whether any flooding problems are being created. The downstream open channel shall be assumed to flood at the same time as the open channel with the proposed culvert.

(5) EXHIBIT NOS. 4, 6, 20 through 32 and 36 shall be used as design aids, when applicable.

(6) Minimum Cover: The minimum cover for culverts generally shall be two (2) feet from the bottom of the roadway base material to the top of the culvert.

Maximum Cover: The maximum cover for any culvert shall be as specified in ODOT "Height of Cover" tables.

(7) Refer to Section ST 404 (a) and (b), 409, 801(a), 810, 811 and 812 for additional controls.

(b) For storm sewer culverts, Type "A" or "B" conduit shall be used under publicly maintained roadways. Type "A" or "B" conduits are also recommended for privately maintained roadways that serve two (2) or more lot owners. Refer to Section ST 713.

(c) For storm sewer culverts, Type "C" conduit shall be used in embankments without roadways. Refer to Section ST 713.

(d) For storm sewer culverts, Type "D" conduit may be used under the driveway to a single owner lot. Refer to Section ST 713.

Section ST 810

Inlet Controls Placed in Open Channels

(a) For inlet controls that are to be publicly maintained within open channels refer to the following table:

INLET CONTROLS FOR PUBLICLY MAINTAINED SYSTEMS		
Description	Type of Inlet Structure to be Used	Type of Erosion Control to be Used
Pipe culvert or storm sewer system for pipe size up to and including 72" in diameter	"Plate 5 Wingwall Headwall	Rock Channel Protection as per EXHIBIT NO. 30; sodding, seeding, and mulching as indicated in Section ST 805
Pipe Culvert or storm sewer pipe system for pipe size over 72" in diameter	State of Ohio Std. Construction. Drawing. HW-3 (or HW-1.1M) Headwall, but modified by providing reinforced concrete cutoff wall, apron and wingwalls to conform to 3:1 side slopes	SAME AS ABOVE
Precast reinforced concrete box or arch sections used for culverts as per State of Ohio specifications	Reinforced concrete headwalls and wingwalls required	SAME AS ABOVE
For any culvert or storm sewer system a special inlet structure is required to fit existing or proposed conditions	Structure shall include reinforced concrete wingwalls, headwall, cutoff wall and apron. Details must be shown on Improvement Plan	SAME AS ABOVE

For any culvert or storm sewer system where the inlet is located within any roadway right-of-way maintained by the Hamilton County Engineer	To be controlled by the Hamilton County Engineer	To be controlled by the Hamilton County Engineer
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(b) For inlet controls that are to be privately maintained within open channels, refer to the following table:

RECOMMENDED INLET CONTROLS FOR PRIVATELY MAINTAINED SYSTEM		
Description	Type of Inlet Structure to be Used	Type of Erosion Control to be Used
Pipe culvert or storm sewer pipe system for pipe sizes up to and including 72" in diameter, under privately maintained roadway serving two (2) or more lot owners	"Plate 5 Wingwall Headwall"	Rock Channel Protection as per EXHIBIT NO. 30; sodding, seeding and mulching as indicated in Section ST 805
Pipe culvert or storm sewer pipe system for pipe sizes over 72" in diameter, under privately maintained roadway serving two (2) or more lot owners	State of Ohio Std. Construction Drawing "HW-3 (or HW-1.1M) Headwall", but modified by providing reinforced. conc. cut off wall, apron and wingwalls to conform to 3:1 slopes	SAME AS ABOVE
For any culvert or storm sewer system under a privately maintained roadway serving two (2) or more lot owners where a special inlet structure is required to fit existing or proposed conditions	Structure shall include reinforced concrete wingwalls, headwall, cutoff wall and apron. Details must be shown on Improvement Plans.	SAME AS ABOVE
Precast reinforced concrete box or arch sections used for culverts as per State of Ohio Specifications	Reinforced concrete headwalls and wingwalls required	SAME AS ABOVE

Pipe culvert or storm sewer pipe system under a privately maintained roadway or driveway and serving only one (1) lot owner.	Plate 5 wingwall headwall or State of Ohio Std. Construction Drawing half headwalls are recommended but not required under favorable field conditions	SAME AS ABOVE
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(c) Other inlet controls in open channels are as follows:

(1) A culvert inlet end or storm sewer inlet structure should not be constructed within forty (40) feet of any proposed or existing building where practical. Also, one hundred (100) year flood plain limits should not be closer than thirty (30) feet to any proposed building. See Section ST 804(g), also.

(2) Multiple span culverts or multiple storm sewer pipes used as culverts with single or multiple inlet headwalls and wingwalls generally will not be accepted. See Section ST 812 also, regarding multiple span structures.

(3) Flood study information and other inlet controls must be provided by the Developers Engineer as per Section ST 710(d), (e), (f), 1104(d)(5) and any other applicable Rules and Regulations.

(4) Drop Channel detail on EXHIBIT NO. 29 is generally not recommended in the unincorporated areas of Hamilton County. If they are proposed for any Improvement Plan, safety features such as trash racks, chain link fencing, etc., will be required.

Section ST 811

Outlet Controls in Open Channels

(a) For outlet controls in open channels that are to be publicly maintained refer to the following table:

OUTLET CONTROLS FOR PUBLICLY MAINTAINED SYSTEMS		
Description	Type of inlet Structure to be Used	Type of Erosion Control to be Used
Pipe culvert or storm sewer pipe system for pipe size up to and including 72" in diameter	Plate 5 Wingwall Headwall	Rock Channel Protection as per EXHIBIT NO. 30; sodding, seeding, and mulching as indicated in Section ST 805

Pipe culvert or storm sewer pipe system for pipe size over 72" in diameter	State of Ohio Std. Construction Drawing "HW-3 Headwall" (or HW-1.1M), but modified by providing reinforced concrete cutoff wall apron and wingwalls to conform to 3:1 side slopes	SAME AS ABOVE
Precast reinforced concrete box or arch sections used for culverts as per State of Ohio Specifications	Reinforced Concrete headwalls and wingwalls required	SAME AS ABOVE
For any culvert or storm sewer system where a special outlet structure is required to fit existing or proposed conditions	Structure shall include reinforced concrete wingwalls, headwall, cutoff wall and apron. Details must be shown on Improvement Plans	SAME AS ABOVE
For any culvert or storm sewer system where the outlet is located within any roadway right-of-way maintained by the Hamilton County Engineer	To be controlled by the Hamilton County Engineer	To be controlled by the Hamilton County Engineer

(b) For outlet controls in open channels that are to be privately maintained, refer to the following table:

RECOMMENDED OUTLET CONTROLS FOR PRIVATELY MAINTAINED SYSTEMS		
Description	Type of Inlet Structure to be Used	Type of Erosion Control to be Used
Pipe culvert or storm sewer pipe system for pipe sizes up to and including 72" in diameter under privately maintained roadway serving two (2) or more lot owners	"Plate 5 Wingwall Headwall"	Rock Channel Protection as per EXHIBIT NO. 30; sodding, seeding and mulching as indicated in Section ST 805
Pipe culvert or storm sewer pipe system for pipe sizes over 72" in diameter, under privately maintained roadway serving two (2) or more lot owners	State of Ohio Std. Construction Drawing. "HW-3 Headwall" (or HW-1.1M), but modified by providing reinforced concrete cutoff wall, apron and wingwalls to conform to 3:1 side slope	SAME AS ABOVE
For any culvert or storm sewer system under privately maintained roadway serving two (2) or more lot owners where a special outlet structure is required to fit existing or proposed conditions	Structure shall include reinforced concrete wingwalls headwalls, cutoff wall and apron. Details must be shown on Improvement Plan	SAME AS ABOVE
Precast reinforced concrete box or arch sections used for culverts as per State of Ohio Specifications	Reinforced concrete headwalls and wingwalls required	SAME AS ABOVE
Pipe culvert or storm sewer pipe system under a privately maintained roadway or driveway and serving only one (1) lot owner.	Plate 5 wingwall, headwall or State of Ohio Std. Construction. Drawing half headwalls are recommended but not required under favorable field conditions.	SAME AS ABOVE

(c) Other outlet control requirements in open channels are as follows:

(1) A culvert outlet end or storm sewer outlet structure should not be constructed within forty (40) feet where practical of any proposed or existing building. One hundred (100) year flood plain limits should not be closer than thirty (30) feet to any proposed building. See Section ST 804(g), also.

(2) Outlet structures are required if multiple span culverts or multiple storm sewer pipes used as culverts are accepted. Refer to Section ST 810(c)(2) and 812 regarding multiple span structures.

(3) When a culvert or storm sewer outlet structure outlets into the flood plain of another existing watercourse or drainage channel, the outlet structure may be subject to frequent floods or backwaters. The flow line elevation may be set at some convenient location between the ten (10) and one hundred (100) year flood level, or higher, if practical.

(4) If the outlet structure aligns favorably with an existing watercourse or drainage channel not subject to floodwater from another downstream open channel, the flow line of the outlet structure should meet the flow line of the existing watercourse or drainage channel.

(5) If the velocity, based on the design discharge, at the outlet of a storm sewer pipe requires an energy dissipater as per EXHIBIT NO. 30, a reinforced concrete stilling basin similar to EXHIBIT NO. 31 or an alternate by the Designer.

Section ST 812

Large Culverts and Bridges

(a) Large culverts and bridges with spans of ten (10) feet or greater, or multiple span culverts with total spans of ten (10) feet or greater, or multiple storm sewer pipes used as culverts whose diameters total ten (10) feet or greater, shall be reviewed for approval by the Hamilton County Public Works Director, the Hamilton County Engineer and/or the Hamilton County Building Commissioner, depending on the type of development being proposed.

(b) The Hamilton County Engineer will review for approval these type of structures on township and/or county roads and those that will become a township or county road.

(c) The Hamilton County Engineer will review and make recommendations and comments to the Hamilton County Public Works Director relative to these type of structures on private developments and private roads that are not

destined for public dedication and acceptance, the details of which are included on Improvement Plans to be approved by the Hamilton County Public Works Director.

(d) The Hamilton County Engineer will review and make recommendations and comments to the Hamilton County Building Commissioner relative to these type of structures for any development that requires only a building permit and the Hamilton County Public Works Director is otherwise not involved in the review and approval process.

(e) Multiple span culverts and multiple storm sewer pipes used as culverts generally are not acceptable because of maintenance problems and debris blockage potential. The only time a multiple opening culvert shall be approved by the Hamilton County Department of Public Works is when no other single span structure is feasible.

(f) Culverts, except as otherwise indicated in Article VIII, and bridges shall be designed in accordance with the "Standard Specifications for Highway Bridges" adopted by the American Association of State Highway and Transportation Official, 1992 and the Ohio Supplement to these specifications. The culverts and bridges shall also be capable of handling runoff quantities that are determined as follows:

(1) For new culverts and bridges proposed to be located, or constructed, on private property and located within any Special Flood Hazard Area as herein defined. Section 802(e) shall be used. Compliance with this Section and EXHIBIT NO. 36 shall be certified by a Registered Professional Engineer prior to issuance of a building permit by the office of the Building Commissioner for all bridges and prior to approval of Improvement Plans by the Hamilton County Public Works Director for all culverts.

(2) For culverts and bridges proposed to be relocated or replaced on private property within the same reach of a watercourse or drainage channel that is within any Special Flood Hazard Area as herein defined, the proposed structure(s) shall not allow any increase to the flood levels during the base flood beyond that condition which existed with the prior structure(s) in place.

(3) For culverts and bridges proposed to be located, relocated, constructed, or reconstructed within the existing or proposed public right-of-way any county or township maintained roadway, the Hamilton County Engineer will have jurisdiction over the development of design details.

(4) For culverts and bridges proposed to be located, relocated, constructed, or reconstructed within the existing or proposed public right-of-way of any state maintained roadway, the State of Ohio Department of Transportation will have jurisdiction over the development of design details.

(5) For culverts and bridges proposed to be located, constructed, relocated, or reconstructed on private property outside any Special Flood Hazard Area as herein defined, Section 802(b) shall apply as appropriate. Consideration must be given to potential flooding and its effect on adjacent properties using the one hundred (100) year flood frequency as indicated in Section 802(c) and (d).

Section ST 813

Bridge Openings in Consoer/Townsend Streams

1.00 To determine Consoer/Townsend Q_{100} for new bridge located between published structures

1.01 SAMPLE

Q_{100} at nearest upstream structure = 745 c.f.s.

Tributary acreage at nearest upstream structure = 694 AC

Q_{100} per 1 AC = $\frac{745}{694} = 1.07$ cfs = 1.07 c.f.

Tributary acreage at new structure = 720 AC

Q_{100} at new structure = 720 (1.07) = 770 c.f.

2.00 Design opening with outlet control

2.01 Determine depth of flow at outlet by measuring Consoer/Townsend profiles at new bridge location.

2.02 Maximum headwater one hundred (HW_{100}) is to be 0 to 1'-0" or as directed by Hamilton County Department of Public Works.

2.03 HW_{100} is to be at least 1'-0" below any existing floor including basement floor elevation.

2.04 Provide new structure with emergency spillway by setting top of embankment at least 1'-0" below existing floor including basement floor elevation.

2.05 Use ODOT charts for submerged outlet control to determine standard drainage structure sizes available that will limit the HW_{100} as required.

3.00 In the event ODOT charts indicate that no standard drainage structure limits HW_{100} to 0 to 1'-0" use Manning's formula to determine bridge opening.

3.01 Manning's Formula

$$Q = A \frac{(1.486)}{(n)} R^{-} (S^{\frac{1}{2}})$$

A = Area

n = Manning's roughness coefficient

$$R = \frac{A}{WP}$$

WP = Wetted perimeter

S = Slope in feet per feet

3.02 For bridge openings in Consoer/Townsend stream use $n = 0.07$ (unless requested in writing and approved by Hamilton County Department of Public Works) and based on actual site investigations, the use of $n = 0.04$ will not be allowed.

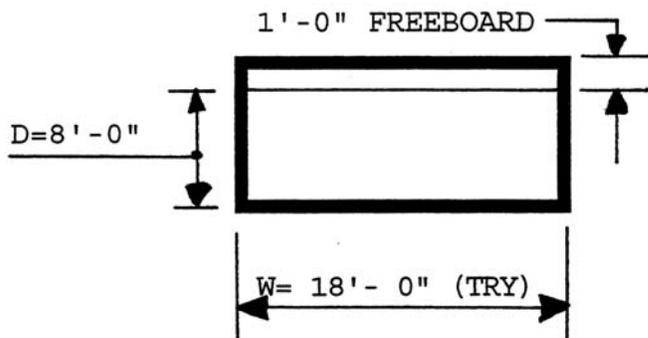
3.03 EXAMPLE GIVEN

$$Q_{100} = 770$$

Depth of Flow = 8'-0" C/T

Slope = 1%

$$n = 0.07$$



FIND: WIDTH

SOLVE:

$$A = 8 (18) = 144$$

$$WP = 34$$

$$R^{2/3} = \left(\frac{144}{34} \right)^{2/3} = 2.59$$

$$S^{1/2} = (0.01)^{1/2} = 0.1$$

$$Q = 144 \left(\frac{1.486}{0.07} \right) 2.59 (0.1) = 791.7 \text{ cfs}$$

792 > 770 (bridge opening okay)

Section ST 814

Specifications for Construction and Materials

Unless otherwise indicated in Section ST 713 or other articles in these Rules and Regulations, the design, materials, and construction shall be as specified in the current edition of the State of Ohio Department of Transportation "Construction and Material Specifications", the State of Ohio Department of Transportation "Standard Construction Drawings" and the Hamilton County

Public Works Department "Standard Drawings".