OAKLAND COUNTY
WATER RESOURCES COMMISSIONER

ENGINEERING DESIGN STANDARDS
FOR STORM WATER FACILITIES

**Requirements, Rules and Design Criteria for
Storm Water Management**

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Appendices

- Act 288 of the Public Acts of 1967, as amended, is known as the Subdivision Control Act of 1967 (the "Plat Act"). All subdivision plats to be recorded with the County Register of Deeds must conform to this Act. Under the Plat Act, the Water Resources Commissioner is required to review and approve the storm water drainage for the plat.

- The provisions of Section 192 of the Plat Act include:
  a. That the Proprietor provides for adequate storm water facilities within the lands proposed for platting and outlets thereto.
  b. That the Proprietor provide adequate storm water retention basins where deemed necessary.

- The rules presented herein, with the authority provided for in Section 105, sub-section (c) of the Plat Act, are issued to guide land developers, engineers and surveyors interested in developing land in Oakland County and to provide for a uniform method of preparing plats and construction plans submitted to the office of the Oakland County Water Resources Commissioner for review and approval.

- The Plat Act gives the Water Resources Commissioner the authority to require that County Drains and natural water courses, both inside and outside the plat boundaries, be improved to the standards established by the Water Resources Commissioner when deemed necessary.

- The Water Resources Commissioner will also require that an appropriate entity be responsible for the perpetual maintenance of all storm water drainage facilities within the plat or the storm drainage system may be established as a County Drain, at the Proprietor's expense, to insure adequate maintenance.

- The rules presented herein will also apply to:
  -Mobile home development plans submitted to the Water Resources Commissioner under Act 96 of the Public Acts of 1987
  -Site development plans that require review and approval by the Water Resources Commissioner's office
  -Site condominium development plans prepared under Act 59 of the Public Acts of 1978 that require review and approval by the Water Resources Commissioner's office
  -Private storm drain systems that are to be established as a County Drain under Chapter 18 of the Drain Code.
  -Any other storm drainage system review requested to be performed by the Water Resources Commissioner's office.

- These rules are the minimum design standard accepted by this office. In addition to the rules herein, the Proprietor must also abide by the rules, standards, specifications and master plan of the municipality where the site is located. In the case where conflicting standards arise, the more stringent requirements will govern.

- These rules will be revised as necessary with the most recently dated sheets being applicable.

- These storm water standards are intended to generally comply with the requirements of the Phase II National Pollutant Discharge Elimination System Storm Water Regulations, however, more stringent storm water standards may be required to meet the goals and objectives of State of Michigan approved Watershed Management Plans. Storm water Best Management Practices should be incorporated to the maximum extent practicable as required.

BMP-Best Management Practice – Structural device, measure, facility or activity that helps to achieve storm water management control objectives at a designated site. Ex: A detention basin is a BMP.

Commissioner - The Water Resources Commissioner of the County of Oakland, State of Michigan.

County Drain- The Water Resources Commissioner of Oakland County, through legislative enactment, has acquired jurisdiction over a storm water conveyance system. Ex: An enclosed drain or an open watercourse.

Design Storm- The rain storm used as the basis of design for storm water drainage facilities.

Detention Basin- A reservoir or structure that stores storm water and releases it at a controlled rate.

Drainage Area- The area of land that has runoff tributary to a specific point.

Drainage System- All storm drainage facilities within a site, including storm drains, detention basins, swales and channels.

Easement- A right afforded to a person or entity to make limited use of another's real property.

Engineer - The Engineer of the Office of the Oakland County Water Resources Commissioner.

Forebay- A pond-like structure that pre-treats storm water runoff to remove pollutants, predominantly sand, dirt and silt, before discharging into an adjacent storm water pond.

Freeboard- The space between the high water elevation and the top of bank of a storm water pond or storage structure.

Hydrograph- A graph of discharge or flow rate as a function of time.

Infiltration- A process whereby precipitation seeps into the ground.

In-line Basin- A storm water reservoir constructed within a watercourse.

Low-Flow Channel- A small swale within a basin designed to convey the runoff from a small rain event through the basin in a manner that will facilitate infiltration.

Precipitation- Any water or ice with sufficient mass that it falls to the earth.

Proprietor - Any person, firm, association, partnership, corporation, or combination of any one of them.

Retention Basin- A reservoir that stores storm water without releasing it. The storm water ultimately evaporates or infiltrates into the ground.

Runoff- Precipitation that flows over land.

Storm Drain- A pipe, conduit or open watercourse that conveys storm water.

Surcharge- A condition in which the water level in a storm drain rises above the crown of the conduit.

Swale- A natural or constructed wide, shallow ditch that conveys storm water.

Watercourse- A natural or artificial channel for flowing water.

Watershed- Area of land that drains to a single outlet and is separated from other watersheds by a divide.

100-yr Storm- A rainstorm that has a 1% chance of occurring in a year.

10-yr Storm- A rainstorm that has a 10% chance of occurring in a year.

I.   APPLICATION FOR REVIEW

An application for review must accompany all plans submitted to WRC for review. The application shall be submitted by the Owner/Developer or the Design Engineer on behalf of the Owner/Developer. Application for review shall be made prior to the start of any work requiring a permit from WRC.

For project sites that will be developed in phases an application is required for the initial work and new applications will be required for additional work not indicated on the original application.

A minimum, non-refundable, up-front application fee is required for certain developments. The total review and permit fees will be determined upon completion of the review.

The review period begins upon the receipt of a completed application, plans and fees.

II.   SUBDIVISIONS- Sites to be platted under Act 288

A.   Preliminary Plat

1.   General Requirements

A preliminary or tentative plan showing the layout of the area intended to be platted shall be submitted by the Proprietor. This plan shall be prepared under the direction of and sealed by a registered professional engineer or a registered land surveyor. The plan shall be drawn to a standard engineering scale no smaller than 1" = 100' and the sheet(s) of paper must not be larger than 24" x 36". This preliminary plan is what the Subdivision Control Act of 1967 refers to in Section 111 as a "preliminary plat".

Section 114, Sub-section (3) of the Subdivision Control Act of 1967 requires that the Water Resources Commissioner approve or reject preliminary plats within 30 days of their receipt.

Three copies of the preliminary plat, prepared in accordance with the following requirements, shall be submitted with a letter of transmittal requesting that the preliminary plan be reviewed and, if found satisfactory, approved. The names of the Proprietor and engineering or surveying firm with mailing addresses, telephone and fax numbers for each shall be included with the transmittal.

The preliminary plat shall include:

a.   The location of the proposed subdivision with reference to the section and part of section in which the parcel is situated, the name of the township, city or village, a proposed legal description of the site, the number of acres proposed to be platted and a location map with north arrow.

b.   The proposed street and alley layout and approximate lot and plat dimensions.

c.   All on-site and off-site pertinent factors, the existence and description of which might be of value in determining the overall requirements for the subdivision, such as:

- Adjoining roads, subdivisions and parcels
- Railroads
- High-tension tower lines, under ground transmission lines and gas pipelines
- Cemeteries and parks
- Rivers, natural water courses, county drains, lagoons, slips, waterways, streams, lakes, bays, canals, wetlands, wetland boundaries and floodplains
- Existing utilities; storm drains, sanitary sewers, water main, telephone, cable or fiber optic lines
- Existing and proposed easements

d. Contour information in two-foot intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, shall be shown on the same plan, otherwise it shall be submitted on a separate sheet.

e. A drainage map, using a United States Geological Survey (USGS) topographic map, or equivalent, that shows the existing drainage area and flow patterns and indicates the proposed drainage pattern.

Inasmuch as improper utility easement location can result in a change in plat layout, the Proprietor is advised to consult with the respective utility companies before presentation of the preliminary plan for approval.

In the case where the Proprietor wishes to subdivide a given area but wishes to begin with only a portion of the total area, the original plan shall include the proposed general layout for the entire area. The part that is proposed to be subdivided first shall be clearly superimposed upon the overall plan in order to illustrate clearly the method of development which the Proprietor intends to follow. Each subsequent plat shall follow the same procedure until the entire area controlled by the Proprietor is subdivided. The final acceptance of a subdivision that is a partial development of a larger general layout does not automatically insure the final acceptance of the overall layout. The intent is to permit some flexibility in the overall layout if future conditions make it desirable or necessary to make any changes.

If the proposed preliminary plan as submitted meets with all the requirements, one approved copy of the preliminary plan will be returned. Approval of the preliminary plan is recommended before proceeding with the preparation of final construction plans. If the proposed plan is not approved as originally submitted, the Commissioner notifies the Proprietor in writing setting forth the reasons for withholding approval and requests that the necessary changes be made and the revised layout resubmitted.
In accordance with Section 560.120 of Act 288, the preliminary plat approval is valid for two years. If construction plans have not been submitted within that time, a new preliminary plat must be submitted and approved. The two-year period may be extended if applied for by the proprietor and approved by the Water Resources Commissioner in writing.

2. Drainage Requirements

The preliminary plan must include the general drainage scheme for the proposed subdivision, or the plan will be rejected. The general drainage scheme shall indicate how storm drainage will be provided and where it will outlet. Preliminary calculations for detention and contributing off-site flow must be included on the plan.

Drainage proposed for subdivisions shall conform to established County Drain districts, existing natural drainage patterns and community master plans. The design shall consider the effect that the drainage proposed in the subdivision has upon the entire drainage basin.

The preliminary plan shall indicate in general, on a USGS topographic map, any drainage originating outside of the subdivision limits which has previously flowed onto or across the subdivision, as well as any natural watercourses and County Drains that traverse or abut the subdivision.

The preliminary plan shall indicate in general any proposed onsite and/or offsite facilities, proposed or existing, required to conduct the drainage to an adequate outlet.

The Water Resources Commissioner's office is not responsible for roadside ditches. Road drainage ditches are under the jurisdiction of the Road Commission for Oakland County (RCOC) or other authority. Any drainage plan that proposes to outlet storm water to a road ditch must be approved by the RCOC or authority that has jurisdiction.

The Water Resources Commissioner shall require that the developer provide assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.

3.   Easement Requirements

The following minimum easement widths are required for all storm drainage facilities within the boundaries of the subdivision:

a.   Open drains and watercourses-

The extreme width of the drain or watercourse plus 15 feet from top of bank on both sides of the channel.

b.   Enclosed drains-

A minimum of twenty (20) feet centered on the centerline of the pipe . However, larger pipe size, certain soil conditions, or depth of pipe may require larger easements.

c.   Rear yard drains-

For pipe sizes less than 12 inches in diameter, a minimum of twelve (12) feet centered on the centerline of the pipe.

d.   Pump stations, detention/retention basins and other storm drainage facilities-

Sufficient easement area to allow for operation and maintenance of the entire facility, including freeboard area, the banks and any berms at the top of the banks.

Easement widths for legally established County Drains shall be sized by the Oakland County Water Resources Commissioner's office. In general these will conform to the above referenced requirements. Additional easements may be required by the Water Resources Commissioner's office should soil, construction conditions or other circumstances so warrant.

Easement information shall be shown on the preliminary plan, final construction plans and final "Mylar" plat.

The wording relative to easement information shown on the final plat shall be as specifically required by the Water Resources Commissioner's office. All County Drain easements shall be labeled as follows: "Permanent private easement for the NAME County Drain".

The Oakland County Water Resources Commissioner's office reserves the right to modify easement requirements at its discretion.

B.   Construction Plans

The Proprietor will submit final construction plans that have been prepared under the direction of, and sealed by, a Registered Professional Engineer with a completed application form. The Water Resources Commissioner's Office will review the plans for adequacy of storm water management design to ensure that the proposed storm water drainage system has the capacity to handle all contributing flow without diminution of the existing off-site natural drainage patterns.

Two complete sets of final construction plans shall be submitted. The plans must be drawn to a scale not smaller than 1"= 50' on sheets no larger than 24" x 36" and designed in accordance with the design criteria presented herein.

1.   Required Information

The plans should include, at minimum, the following:

a.   A cover sheet which includes a site legal description and location map with north arrow and the number of acres proposed to be platted. For phased developments, indicate clearly the phase limits and the number of acres in each phase.

b.   Subdivision layout of lots, roads and all existing and proposed easements.

c.   Plans, profiles and details of all roads.

d.   Plans, profiles and details of all enclosed storm drains, open ditch drains, drainage swales and drainage structures.

e.   Plans and details of the soil erosion and sedimentation control measures. Indicate which measures are temporary or permanent and the party responsible for maintaining the control measures.

f.   Plans, cross-section views and details of the detention or retention basins and the outlet. If an existing basin on or off-site will be used then as-built information must be provided.

g.   A drainage breakup sheet indicating the number of acres, calculated to the nearest tenth, contributing to each specific drainage structure.

h.   Topographic map or maps at two foot contour intervals with North American Vertical Datum of 1988 (NAVD 88), or most current national datum, showing existing topography and proposed grades of the entire area to be subdivided, as well as the topography of all adjacent property to the extent that off-site contributing flow can be determined.   All off-site contributing flow must be accommodated. This map or maps shall also show all existing watercourses, lakes and swamps.

i.   Design data and criteria used for sizing all drainage structures, channels and detention/ retention basins.

j.   Storm drain hydraulic, detention/ retention and runoff coefficient calculations as well as design calculations for all drainage swales and overflow structures. Overflow structures must be sized to pass all contributing off-site flow.

k.   Specifications governing construction, i.e. material specifications, pipe bedding, construction notes, compaction requirements, etc.

l.   A plan and a proposed schedule for the perpetual maintenance of the complete storm drainage system. Indicate who will be responsible (i.e. municipality or homeowners' association) for the maintenance. If the homeowners' association will be responsible for the system, the subdivision deed restrictions must have a section indicating such responsibility and a copy must be submitted to the Water Resources Commissioner. If there is a maintenance agreement with the City, Village or Township, a copy of the agreement must be submitted to the Water Resources Commissioner. The maintenance plan must be submitted prior to plan approval.

2.   Review Time

The Water Resources Commissioner's office will attempt to review these plans in the shortest possible time. A preliminary plan must be submitted and approved prior to submitting the final construction plans, so that no time is wasted on a drainage design that would be unacceptable. The construction plan approval is valid for one (1) year. The one-year period may be extended if applied for by the proprietor and approved by the Water Resources Commissioner in writing.

3.   Changes To The Plans

Approval of the final construction plans is intended to be final approval, and the actual signing of the "Mylar" plat is only a formality, as long as there are no changes in the final construction plans from what was approved. If either the Proprietor or the Commissioner find it advantageous to make changes before the "Mylar" plat is presented to the Commissioner for signature, such changes can be made, provided that the same procedures outlined above are repeated with each change in the layout. The Proprietor is reminded that approval of the proposed subdivision by the local governing body is also required under the Plat Act. Such changes shall be incorporated in the layout and revised construction plans shall be resubmitted even though the original layout may have already been approved by the Commissioner. If the Proprietor does not present his "Mylar" plat to the Commissioner for approval within a period of one year

after receiving approval of the final construction plans, it may be necessary that he resubmit the layout for review in the light of new information which may have become available during the interim.

C.   Final Plat

The Proprietor shall submit the final "Mylar" plat to the Water Resources Commissioner for certification. The plat will be reviewed for accurate drainage easements and equivalence with the approved construction plans. If the Commissioner approves the plat, he will affix his signature to it and the plat will be executed. If the Commissioner rejects the plat, written notice of such rejection and the reasons therefore are given to the Proprietor within ten days.

Prior to the Proprietor submitting the final "Mylar" plat for certification, the following is required:

- ✓ Approval of the preliminary plat.

- ✓ Approval of the final construction plans.

- ✓ Assurance of adequate maintenance and inspection of the installation of both the external and internal storm drainage facilities.

- ✓ A soil erosion and sedimentation control permit under Part 91 of Act 451 of the Public Acts of 1994 as amended.

- ✓ Payment by the Proprietor of the plat review fee, according to the latest schedule posted on the Oakland County Water Resources Commissioner's website www.co.oakland.mi.us/drain .

- ✓ A minimum, non-refundable application fee is required upon submittal of the preliminary plat and the construction plans.

III.   MOBILE HOME DEVELOPMENTS

Public Act 96 of 1987, The Mobile Home Commission Act, requires a developer of a Mobile Home Park to submit a preliminary plan to the Water Resources Commissioner.

A.   Preliminary Plan

The preliminary plan shall include the location, layout, general design and a general description of the project. The preliminary plan does not include detailed construction plans.

B.   Outlet Drainage

The Water Resources Commissioner must review and may approve the outlet drainage for the park. The design standards covered in Section II of Design Criteria and Engineering Methods will be used for this review. All pertinent design calculations must be submitted. The interior drainage within the park will not be reviewed unless the park storm drain system is to be established as a County Drain under Chapter 18 of the Drain Code.

The Water Resources Commissioner may approve or reject preliminary plans within 60 days of their receipt, otherwise the plan is considered approved.

Mobile home park construction plans are reviewed by the Mobile Home Commission.

IV.   DRAINS UNDER THE JURISDICTION OF THE WATER RESOURCES COMMISSIONER

A.   Permits

A permit shall be required from the Water Resources Commissioner prior to performing any work to a County Drain or it's appurtenances. The following are examples of work:

a.   Connecting to any part of an open ditch, enclosed drain or manhole or drainage structure. A tap can be a direct connection or a pipe outlet.

b.   Crossing any part of an open ditch or enclosed pipe. Examples of crossings are utility lines, driveways, culverts and bridges. A minimum clearance of five (5) feet for an open ditch drain and eighteen (18) inches for an enclosed drain must be maintained between the drain and any proposed utility or other underground crossings of the drain.

c.   Relocating any part of a County Drain.

d.   Enclosing any portion of an existing open ditch drain.

e.   Performing work within a County Drain easement.

f.   When the installation of a fence, driveway, patio, pool or other structure that does not have a foundation, encroaches into the County Drain easement.

The following requirements of the permit must be met:

- Construction plans must be submitted to this office for review. The plans shall include design calculations for storm water storage volume and allowable outflow. A drainage area map must be included with the plans.

- The review application and application fee, appropriate permit fee and inspection deposit must be submitted before a permit is issued. Permit fees are determined on a site-specific basis.

- A notice of 48 hours must be given to the Oakland County Water Resources Commissioner's Inspection Department prior to any construction affecting the drain. In the event that our Inspection Department is not notified as stipulated herein the entire inspection deposit will be forfeited.

- Flow shall be maintained in the drain at all times during construction.

- All work must be completed in accordance with the plans and specifications submitted by the Owner/Developer and approved by this office.

- Work performed on the County Drain or it's appurtenances must be performed in accordance with the Oakland County Water Resources Commissioner's Storm Drain Notes and Details Sheet.

- A drain permit issued by the Water Resources Commissioner's Office will not relieve the applicant and/or his contractor of the responsibility of obtaining permits, approvals or clearances as may be required from federal, state or local authorities, the public utilities and private property owners.

- An as-built plan of the drain involvement must be submitted.

- The Water Resources Commissioner shall be notified in writing within ten days of the completion of a project. A final inspection will be performed and a letter of permit closure may be issued.

- A letter of permit closure must be issued by the Water Resources Commissioner before any remaining deposit money is refunded.

- A permit shall expire when work has not commenced within one year of the date of issuance. The Water Resources Commissioner may extend the permit for a period of time upon the request of the Owner/Developer in writing.

- The Water Resources Commissioner may revoke a permit if there is a violation of the conditions of the permit or if there is a misrepresentation or failure to disclose relevant facts in the application.

- A drain permit is separate from a Soil Erosion Control permit.

B.   Construction Plans

Any development that will outlet storm water directly to a County Drain will be reviewed by the Water Resources Commissioner for adequate storm water storage volume and outlet drainage. The standards covered in the Design Criteria and Engineering Methods section will be used for this review. All other involvements will have a drainage review performed relevant to the work proposed.

The Proprietor shall submit three (3) sets of construction plans with a transmittal requesting plan review. The plans must be prepared in accordance with the design standards presented herein and sealed by a Registered Professional Engineer or Land Surveyor. All pertinent design calculations must be submitted with the final construction plans. Preliminary plans may be submitted, but are not required.

Certain County Drains have limited capacity. The allowable discharge to these drains will be dictated by the Water Resources Commissioner and may be more stringent than these design requirements.

C.   Drainage Districts and Easements

County Drain Drainage District limits must be adhered to when designing the site. Drainage Districts do not necessarily conform to existing topography. If drainage originating outside of a certain district is discharged within the district, a drainage district enlargement will be required.   Contact the Water Resources Commissioner's office regarding this process.

Drains constructed prior to 1956 may not have a recorded easement, however the easement exists in the permanent records at the Water Resources Commissioner's office. At that time easements for drainage purposes were not required to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain office.   Therefore, it may be necessary to record a new County Drain easement, depending upon the work that is proposed and the County Drain involved. If a new easement is required, contact the Water Resources Commissioner's Office regarding this process.

V.   CHAPTER 18 DRAINS

Chapter 18 drains are new developments within Oakland County where the local municipality has passed an ordinance that requires all residential and certain commercial drainage systems to be established as County Drains in accordance with the provisions of Section 433, Chapter 18 of the Public Acts of 1956, as amended, the Michigan Drain Code. At present, Oakland and West Bloomfield Townships each have such an ordinance.

A.   Construction Plans

Plan submittal must be in accordance with the regulations of the municipality where the development is located. It is the responsibility of the Developer to contact the municipality and ascertain whether plans should be submitted directly to WRC or to the Municipality first.

When submitting plans directly to WRC, the Developer must submit three (3) complete sets of construction plans prepared according to the same specifications as a platted subdivision along with a letter from the Developer requesting that the storm drainage facilities be established as a County Drain. In the case where the Chapter 18 Drain development will be platted, the procedures for a preliminary and final plat must also be adhered to.

Final construction plan approval will not be granted until all required documents and fees have been received. Construction of the storm drain system may not begin until the construction plans have been approved. This office will provide full time construction inspection of the storm drain system. Drainage facilities constructed without appropriate inspection by this office or its designated representative may not be accepted by this office as a County Drain.

After the construction plans have been approved, this office will process the final subdivision plat as set forth in the Subdivision Control Act of 1967, as amended.

B.   Required Documents and Information

- A letter from the Developer requesting that the storm drainage facilities be established as a County Drain.
- A certificate from the design engineer certifying the adequacy of the storm drainage outlet. The Developer's Engineer must certify that the outlet for the proposed drain is adequate and will not cause detriment or diminution of the drainage service presently provided. An Engineer's Certificate must be sealed.
- A copy of the Title Policy or other proof of land ownership.
- A metes and bounds property description with proof of survey closure.
- Sidwell number(s) of all property proposed to be included in the drainage district.
- An estimate of the construction cost of the drainage facilities.
- The Developer and/or Landowner of Record must enter into an Agreement to establish the new County Drain or Branch Drain of an existing Chapter 18 County Drain. The Agreement will be prepared by the Water Resources Commissioner.
- Company name and address and name and professional title of individuals who will execute the Agreement.
- Payment of fees and contingency deposit. The Developer must pay administrative, inspection and maintenance fund fees and deposit a construction contingency amount.
- A copy of the recorded deed restrictions which includes the appropriate County Drain easement language.

C.   Final Acceptance

Following construction, submittal of all required documents and final as-built mylars of the storm drain system, the drain may be conditionally accepted for operation and maintenance if the site is substantially vegetated and stabilized.

One year after conditional acceptance of the Drain the Developer may request, in writing, a refund of the contingency deposit. Our Maintenance Unit will perform a final walk through inspection of the Drain and the project file will be reviewed by this office. If all requirements have been met, then a final accounting will be made and a letter of final acceptance will be issued along with any remaining refundable amounts of the contingency deposit.

Chapter 18 Drain requirements are explained in further detail in Section IV of "Design Criteria and Engineering Standards".

DESIGN CRITERIA AND ENGINEERING STANDARDS

I.   SITE DRAINAGE

The standards and design criteria set forth herein are intended to guide designers to develop a storm water management system that controls the quantity and quality of storm water discharge from a site. The internal drainage for a site as well as the downstream conditions will be reviewed. Every site is part of an overall watershed and the system should be designed with this in mind. The system should conform to natural drainage patterns both on and off-site. These standards are the minimum requirements of the Oakland County Water Resources Commissioner and should not be construed as all-inclusive. The design engineer should consider many factors when planning the storm water management system. In particular, Federal, State and Local standards may be more strict than these standards. In the case where conflicting standards arise, the more stringent requirements will govern. Exceptions will be considered when conforming to a local community master plan or storm water management plan is required.

A.   General Information

The County Water Resources Commissioner has been given the responsibility of determining the adequacy of the proposed storm drainage, and therefore the engineering unit will review the final construction plans for conformance with the following general drainage standards.

- An adequate outlet for the storm water must be demonstrated. The designer must show that the outlet has the capacity to handle the discharge from the site. *In no case will the discharge be allowed to exceed the site's pro-rata share of the capacity of the outlet.* There shall be no diminution of the drainage service presently provided by the outlet for the area that it serves. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

- There may be cases where the existing outlet has limitations due to downstream conditions. In this situation the discharge from the site will be restricted to conform to the governing downstream conditions.

- There may also be cases where the outlet has already reached capacity. The burden is on the proprietor to design and construct, at his expense, any necessary improvements to the downstream outlet. Such designs will be reviewed by the Water Resources Commissioner's office for adequacy. Additional controls may be required in these cases in order to protect downstream properties.

- The discharge from a site should outlet within the watershed, drainage sub-basin or county drain drainage district where it originated. The drainage should not be diverted to another sub-basin.

- Storm water detention or retention shall be provided. The detention basin shall be designed for a 100-year storm event and include a sediment fore bay or manufactured storm water treatment system.

B.   Lot Grading

The Water Resources Commissioner will review the grading plan for sites that will be platted under Act 288 and a subdivision or site included in the Chapter 18 Drain program. Positive drainage is required. Final lot grading inspection is under the jurisdiction of the local municipality. The minimum requirements are as follows:

- The grading of the lot shall be such that surface runoff is directed away from homes and towards swales, ditches or drainage structures. Provision for drainage either by filling and grading or by providing some type of outlet shall be made for all areas within the proposed subdivision.

- A proposed finished floor grade and proposed lot grading must be shown for each home or structure. A minimum of ½ foot of fall is required away from the home and between lots. Proposed grades may

be indicated with spot grades or contours. A distinction between existing and proposed should be evident.

- Where a walkout or daylight basement is proposed, sufficient grades should be shown at the location of the walkout to indicate positive drainage away from the walkout. Additional spot grades at the house corners and rear yard should be shown.

- Where finished grades indicate a substantial amount of drainage across adjoining lots, a drainage swale of sufficient width, depth and slope shall be provided on the lot line to intercept this drainage.

- Sufficient off-site topography must be shown to determine the extent of contributing runoff. Provisions must be made to accommodate the off-site contributing flow.

- Lots that lie within a flood plain shall satisfy the Michigan Department of Environmental Quality and FEMA requirements for subdivisions within a flood plain. In no case will the filling of a lot be permitted if the flood plain is so restricted as to cause possible flooding or back up of the stream.

Examples of correct lot grading are included in Appendix 1.

C.   Determination of Surface Runoff

1.   Rational Method

For small areas, such as sizing swales, channels and culverts, the "Rational Method" will be used to determine surface runoff. Because the "Rational Method" assumes a uniform rainfall intensity, it is best suited for small areas. The "Rational Method" is defined as follows:

$$Q = C \times I \times A$$

Where, $Q =$ peak runoff (cfs)

$C =$ runoff coefficient, a composite for the drainage area shall be used

$I =$ average rainfall intensity (inches/ hour)

100-yr storm will be used and I = 275/ (T_c + 25)

$T_c =$ Time of Concentration, in minutes

$A =$ drainage area in acres

Larger sites should use a more appropriate method of determining flow. For watersheds up to 20 square miles, the suggested method for determining surface runoff is the Soil Conservation Service (SCS) Methodology. The computations should be based on the Type II rainfall distribution, 100-year, 24-hr storm. It is the responsibility of the design engineer to determine the best method to use for the site.

2.   Coefficient of Runoff

A realistic coefficient of runoff will be used based upon the imperviousness of the contributing acreage. The range of this coefficient may vary from 0.15 for completely grassed areas to 0.90 for impervious areas and 1.0 for open water. The runoff coefficient calculation must be included with plan submittal.

Certain calculations require a composite runoff coefficient value. A composite runoff coefficient is calculated as follows:

$$\overline{C} = \frac{\sum\limits_{i=1}^{n}(A_i x C_i)}{\sum\limits_{i=1}^{n} A_i}$$

Where, $C_i =$ runoff coefficient for each sub-area

  $n =$ total number of sub-areas

  $A_i =$ drainage area in acres for each sub-area

3.   Time of Concentration

An initial time of concentration of 20 minutes will be used on residential subdivisions. The time of concentration must be calculated for commercial and industrial subdivisions.

The design engineer may also use a calculated time of concentration if desired. The methodology and computations must be submitted for review. The time of concentration for unimproved, pre-development lands will be checked using the following formulas:

Small tributary- $T_c \, (\text{min}) = \dfrac{L'}{2.1 * \sqrt{So} * 60}$

Waterway- $T_c \, (\text{min}) = \dfrac{L'}{1.2 * \sqrt{So} * 60}$

Sheet Flow- $T_c \, (\text{min}) = \dfrac{L'}{.48 * \sqrt{So} * 60}$

Where, $L' =$ flow length, in feet

  $So =$ slope, in %

When more than one type of flow exists, the individual flows should be summed up to find the total time of concentration.

These equations were taken from: Richard C. Sorrell, <u>SCS Methodology</u>, Michigan Department of Natural Resources, May, 1977

4.   Allowable Discharge Rate

The allowable discharge rate from a site shall be restricted to agricultural runoff, which is defined by this office as a maximum of 0.20 cfs per acre.

There may be cases where the existing outlet has limitations due to downstream conditions. In this situation the discharge from the site will be restricted to conform to the governing downstream conditions. For example, if there is an existing culvert downstream, then the allowable outflow from the proposed site will be limited to the pro-rata share of the capacity of the culvert. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

Certain established Oakland County Drains have limited capacity and the allowable discharge will be less than agricultural rate.

II.   Storm Water Storage Facilities

On-site storage of storm water runoff is required for all sites. Cases where the outlet or community master plan allows for undetained storm water discharge will be evaluated on an individual basis.

A.   Determining Storm Water Storage Volume Required

1.   Detention Basin

a.   General Requirements

Following are the minimum requirements for a detention facility:

- A sediment fore bay, or equivalent structure, designed to capture the runoff from a 1 year storm is required for all sites. The fore bay should be a separate cell from the main detention basin and designed such that it will dewater within 48 hours. The volume of detention within the fore bay, above any proposed permanent pool of water, can be considered when calculating total detention volume required for a site.

- A manufactured storm water treatment system may be used in lieu of a sediment fore bay.

- The volume of detention provided must be equal to or in excess of that required by the Oakland County Water Resources Commissioner's "A Simple Method Of Retention Basin Design" for a 100-year frequency storm, included in Appendix 4.

- Detention volume must be provided for all on-site acreage contributing to the detention basin. All offsite tributary acreage must be accommodated by sizing the basin overflow structure to pass the off-site flow.

- Detention volume on a gravity outflow detention basin is defined by this office as the volume of detention provided above the invert of the outflow pipe. Any volume provided below the invert of the outflow pipe is considered a permanent pool of water and will not be considered as detention volume.

- All detention basins must have a positive method by which to be de-watered. Use of a pumped outlet is discouraged. If a permanent pool of water is proposed, the basin must completely de-water to the elevation of the permanent pool.

- The velocity of storm water entering the storage facility should be a non-erosive velocity. This velocity is generally between 2.5 fps and 5 fps.

- Detention basin side slopes may not exceed 1foot vertical to 6 feet horizontal for a wet basin and 1 foot vertical to 4 feet horizontal for a dry basin unless fencing is provided. Requirements regarding fencing will be evaluated on a case by case basis.

- The basin shape should be such that flow entering the basin is evenly distributed and no stagnant zones can develop. An irregularly shaped basin is best. The inlet and the outlet should be at opposite ends with the maximum distance possible between them. For dry basins, use of swales or berms on the bottom of the basin to maximize travel distance during periods of low flow are encouraged.

- When there is no permanent pool of water, the bottom of all detention basins shall be graded in such a manner as to provide positive flow to the pump or pipe outlet.

- All detention basins must have an internal overflow.

- One foot of freeboard shall be provided above the 100-year storm water elevation.

- Fencing will be required as needed, depending upon basin depth, steepness of side slopes, depth of permanent pool, etc. Requirements regarding fencing will be evaluated on a case by case basis.

- All detention basins must be permanently stabilized to prevent erosion.
- Detention basins constructed by building up on existing grade must have berms with a clay core keyed into native ground.

Provisions for maintenance of the detention basin shall be made by the developer with the subdivision association or the local municipality. Evidence of such provisions must be submitted. This office will not accept the responsibility for the maintenance of any detention basin unless it is being constructed as a Chapter 18 County Drain.

b.   Design Procedure

When calculating the volume of an irregularly shaped basin or lake, the Oakland County Water Resources Commissioner will use the formula for calculating the volume of a frustum of a circular cone. This formula is:

$$V = \tfrac{H}{3}\left(A_1 + A_2 + \sqrt{A_1 \times A_2}\right)$$

Where: $V =$ volume
                $H =$ difference in depth between two successive depth contours
                $A_1 =$ area of the basin within the outer depth contour being considered
                $A_2 =$ area of the basin within the inner depth contour line under consideration

The procedure consists of determining the volumes of successive layers of water (frustums), and then summing these volumes to obtain the total volume of the basin.

Taken from: Clarence M. Taube., Chapter 12: Three Methods for Computing the Volume of a Lake, Manual of Fisheries Survey Methods II, Michigan Department of Natural Resources, 2000

An example calculation is included in Appendix 2. The following procedure will be used to review detention basin volume calculations:

1)   Using the Oakland County Water Resources Commissioner's "A Simple Method Of Retention Basin Design" for a 100-year frequency storm, calculate the total volume of storage required for the entire site. This is the volume required (V_t).

2)   Using the formula for computing the volume of an irregularly shaped basin, calculate the total volume of the proposed detention basin by summing the volumes of successive contour elevations. This is the actual volume provided (V_{prov}). The volume provided must be equal to or greater than the total volume required.

3)   Calculate the actual discharge rate from the basin at each of the successive elevations used to compute the volume provided. This is the actual flow rate out of the basin (Q_{act}) at each elevation.

4)   Using the calculated discharge rates (Q_{act}) calculate the volume required (V_{req}) at each of the elevations used to compute a volume provided. The elevation at which the required volume and provided volume are approximately equal will be the 100-year storage level in the detention basin. The actual flow rate out of the basin at the 100-year storage level must be equal to or less than the allowable outflow ($Q_{allowable}$) for the basin.

2.   Retention Basin

A "no-outlet" retention basin is only permissible subject to certain conditions that include, but are not limited to, the following:

- There is no other available positive outlet for the storm water runoff from the property. Every effort should be made to provide a means to de-water the basin, including a pump outlet and possible downstream improvements.

- The permeability of the existing soils must be demonstrated such that percolation of the retained storm water is possible. Soil boring logs must be submitted for review. The borings must be taken within the proposed basin bottom area to a distance of 20 feet below the proposed basin bottom elevation. Calculations performed by a professional geotechnical engineer must be submitted. The calculations must indicate the percolation rates for the soils encountered during soil boring.

➢ An infiltration trench is not considered an acceptable substitution for permeable soils.

The proposed storage volume of the retention basin is calculated on the basis of total contributing acreage, including all offsite areas that flow onto the property. Sufficient storage capacity must be provided for two consecutive 100-year storm events, which WRC defines by the following formula:

$$V = 2 \times 16{,}500 \times A \times C$$

Where, V = volume Required (ft.^{3})
A = contributing acreage
C = composite runoff coefficient

- The retention storage is calculated as volume provided in the basin above the existing ground water elevation.

- The side slopes of the proposed retention basin can be no steeper than one foot vertical to six foot horizontal.

- An overflow facility from the retention basin must be provided. Elevations of surrounding buildings, development or other features that would be impacted by a basin overflow must be indicated. If an overflow structure cannot be constructed a defined overflow route must be indicated. The overflow route may not endanger any existing structures or features. Downstream drainage easements may be required for the overflow route.

- One foot of freeboard must be provided above the proposed storage elevation.

3.   Sediment Forebay

All detention and retention basins shall have a sediment forebay. A forebay must be installed at all incoming discharge points to the basin. The purpose of the forebay is to capture sediment in one area and prevent sediment buildup in the main basin. The forebay shall be a separate basin, which can be formed within the main basin by creating a separation with an earthen berm, riprap berm or rock or concrete retaining wall. A manufactured storm water treatment system can be used in lieu of a sediment forebay.

- The sediment forebay shall be sized to accommodate a one-year storm event. This office will use the "Detention Time" method of design from the WRC Erosion Control Manual to check the forebay design calculations. An example calculation is included in Appendix 2.

- The forebay may be included as part of the total required basin volume, above any permanent pool of water. The forebay cannot be included as available storage if it remains full of water.

- The side slopes cannot exceed 1 foot vertical to 4 feet horizontal.

- The forebay should have a sump a minimum of 2 feet deep to capture sediment and prevent resuspension of sediment. The bottom of the basin should slope toward the sump area to capture the sediment.

- The outlet shall be designed to capture the <u>one-year storm event and dewater the basin within 48 hours.</u> An outlet structure with restricted discharge may also be used within the separation.

- An outlet (overflow) spillway should be constructed on the separation which allows water to exit the forebay at non-erosive velocities.

- An access road should be provided for forebay maintenance. An access road is required for all facilities that will be established as a Chapter 18 County Drain.

- The forebay should also have a fixed sediment depth marker to measure the amount of sediment that has accumulated. The sediment should be removed when half of the sediment storage capacity has filled in.

4.   *Manufactured Storm Water Treatment Systems*

Manufactured treatment systems may be used in lieu of a sediment forebay. These devices are used to remove sediment and other particulate matter from storm water runoff. The following are requirements for manufactured treatment systems:

- Manufactured treatment systems must be installed upstream of the storm water detention system. If the site is not required to provide storm water detention, a manufactured treatment system must be installed upstream of the connection to a county drain.

- The storm drain system shall be designed with an external bypass at the manufactured treatment system location to allow continuance of flow in the event the manufactured treatment system becomes obstructed.

- The system shall conform to the standards set forth by the New Jersey Department of Environmental Protection (NJDEP) for manufactured treatment systems, as defined at http://www.njstormwater.org/treatment.html, including inline and/or offline use, manhole diameter size, and custom or multiple units.

- Calculations for designing mechanical treatment devices shall be based on the Rational Method.

- The following criteria shall be used for determining the peak discharge at the mechanical treatment device:

  Frequency shall be a 1-year, 24-hour storm event

  Rainfall shall be 2.13 inches (NOAA Atlas 14)

  Rainfall intensity I, shall be calculated using the upstream drainage area's time of concentration T, with

  $$I = 97/ (T + 30) \qquad \text{(NOAA Atlas 14)}$$

  Peak discharge, $Q = C \times A \times I$

- The NJDEP Certified Treatment Flow rate (cfs) for a manufacturer and model shall be greater than or equal to the calculated peak discharge (Q) for a particular site.

- The minimum total suspended solids (TSS) to be removed shall be 50% as certified by NJDEP.

- Manufactured treatment systems are designed for post-construction runoff conditions and are not an acceptable alternative for controlling soil erosion during construction.

5.   *Underground Detention Facilities*

Generally, underground detention facilities are discouraged because of difficulty in maintaining them. However, underground detention facilities may be allowed on sites where traditional storm water

management measures are infeasible, such as sites less than 1 acre in size or renovation of an existing site that originally did not have a basin. Each site will be evaluated on an individual basis.

Complete details, calculations and specifications must be submitted for the facility. The underground facility must comply with all standards imposed on traditional facilities; Including, but not limited to, a restricted outlet, overflow structure and a perpetual maintenance plan.

Underground detention facilities are prohibited in developments where the storm water detention facilities are under the jurisdiction of this office.

6.   Infiltration Trench

An infiltration trench is not considered a preferred means of discharging storm water. Routing storm water runoff directly to an infiltration trench could contaminate ground water. Storm water must be routed through a facility or structure that filters the storm water prior to discharging to the trench. No outflow credit will be given for detention basins with an infiltration trench that is intended to function as a basin outlet.

7.   Leaching Basin

A leaching basin is not an effective means of controlling and treating storm water runoff. A leaching basin must be used in conjunction with other drainage facilities.

8.   Innovative BMP's

Non-traditional storm drainage facilities that improve the quality and reduce the quantity of storm water runoff are encouraged as long as the required detention volume and allowable outflow are achieved.

Complete details and specifications for the proposed storm drainage facilities must be submitted. There should be sufficient information provided such that a comprehensive review can be performed. Each case will be evaluated on a site-specific basis.

B.   Utilizing Wetlands, Waterbodies and Natural Low Areas for Storage

Prior to approval of any proposed plan to use existing wetlands or waterbodies for detention purposes, permits from the appropriate state and local agencies must be applied for. Proof of such application must be submitted.

Direct discharge of storm water runoff to a wetland or waterbody is not allowed. The runoff must be routed through a facility that is specially designed to remove silt, sediment, trash, oil, grease and other debris and pollutants before discharging.

The minimum design requirements are as follows:

- Calculations must be submitted that indicate the stage rise of the wetland or waterbody due to the runoff. Each site is entitled to their pro-rata share of the capacity of the wetlands.

- A freeboard elevation must be established at one foot above the calculated stage rise.

- The stage rise should be calculated from the ordinary high water elevation.

- There shall not be point discharge of storm water to wetlands. The discharge must be routed through a level spreader or through stones, on the wetland fringe, prior to discharging to the wetlands to avoid erosion.

- A natural buffer strip is recommended around the perimeter. A drainage easement that encompasses the entire area on site, including freeboard and buffer strip, will be required. In addition, off site easements may be necessary.

- The character of the wetlands must not be altered by the addition of the storm water. A control structure must be constructed at the outflow of the wetland area to release storm water at a restricted rate as determined in Section 1. The wetland must return to it's normal water level within 24 to 48 hours.

- In no case will retention of storm water within a wetland area be allowed.

- Storm water runoff directed to natural low areas will be considered the same as retention. The area must have the capacity to hold two consecutive 100-yr storm events and have a designated overflow route. Each site is entitled to their pro-rata share of the capacity of the depression for the land area tributary to it. A drainage easement that includes the entire area up to the freeboard elevation will be required.

C.   Detention Basin Outlet Design and Overflow Structure Design

If an adequate outlet for the site's storm water has been demonstrated, the allowable outflow from a detention basin is a maximum 0.20 cfs per acre. The allowable discharge calculations must be submitted.

- There may be cases where the existing outlet has limitations due to downstream conditions. In this situation the discharge from the site will be restricted to conform to the governing downstream conditions. For example, if there is an existing culvert downstream, then the allowable outflow from the proposed site will be limited to the pro-rata share of the capacity of the culvert. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

- There may also be cases where the outlet has already reached capacity. The burden is on the proprietor to design and construct, at his expense, any necessary improvements to the downstream outlet. Such designs will be reviewed by the Water Resources Commissioner's office for adequacy.

Additional controls may be required in these cases in order to protect downstream properties.

- The basin outlet must control the runoff from the 100-year storm event. The actual outflow from the basin at the design storm water level may not exceed the allowable outflow.

- The outlet pipe or drainage path must be designed to carry the flow from all on-site and off-site contributing acreage.

- A cut-off collar or anti-seep diaphragm may be required to be installed around the outlet pipe within the bank of the basin, depending on the depth of storage in the basin.

The standard orifice equation will be used to check restrictor sizing calculations:

$$Q = C \times A\sqrt{2gh}$$

Where, $Q =$ allowable outflow (cfs)
            $C =$ orifice coefficient
            $A =$ orifice area (ft^2)
            $g =$ gravity constant, 32.2 ft/s^2
            $h =$ total head on orifice measured from the design water level (feet)

- The minimum restrictor size is 3" diameter. If a 3" diameter restrictor permits discharge in excess of the allowable outflow then a restricted outlet design may be required, such as a weir. For storm drain systems being established as Chapter 18 Drains, the restrictive orifice outlet must be grouted inside a minimum 12" diameter pipe with an end section, at the upstream end of the pipe. The restrictor must be sized for the on-site flow that is tributary to the basin. The basin overflow structure shall be sized to pass the on-site flow and the off-site tributary flow.

The following equations will be used to check weir design:

Sharp-Crested Weir-

$$Q = C \times L \times h^{3/2}$$

Where, $Q =$ Discharge over the weir (cfs)
                $C =$ Discharge coefficient, 3.33
                $L =$ Length of weir crest (ft)
                $h =$ Head above the weir crest (ft)

Triangular Sharp-Crested Weir-

$$Q = C \times h^{5/2}$$

Where, $Q =$ Discharge over the weir (cfs)
                $C =$ Discharge coefficient for a 90° triangular weir, 2.5
                $h =$ Head above the weir notch bottom (ft)

Broad-Crested Weir-

$$Q = C \times L \times h^{3/2}$$

Where, $Q =$ Discharge over the weir (cfs)
                $C =$ Discharge coefficient, 3.0
                $L =$ Length of weir crest (ft)
                $h =$ Head above the weir crest (ft)

Trapezoidal Weir-

$$Q = C \times L \times h^{3/2}$$

Where, $Q =$ Discharge over the weir (cfs)
                $C =$ Discharge coefficient, 3.367
                $L =$ Length of weir crest (ft)
                $h =$ Head above the weir crest (ft)

Equations taken from: Michael R. Lindeburg, P.E., <u>Civil Engineering Reference Manual</u>, Professional Publications, Inc., CA, 1999

- All detention basins must have an internal overflow structure located at the design water level. This is a structure that will discharge the storm water by by-passing the restrictor in emergency situations. The overflow must have the capacity to pass the on-site flow as well as the off-site tributary flow and have a bar screen or trash hood.

Examples of basin outlet and overflow calculations are included in Appendix 2.

III. STORM WATER CONVEYANCE

Storm water drainage systems may consist of open ditch drains, swales, closed conduits or a combination of methods to convey storm water. Drainage facilities shall be constructed in accordance with these WRC minimum specifications. Other standards such as: Michigan Department of Transportation, Road Commission for Oakland County, City or Township, which may be more stringent shall also be adhered to. WRC construction standards for enclosed storm drains are available from the WRC office.

A. Enclosed Storm Drains

An enclosed storm drain system must be designed to accommodate the storm water runoff from a 10-year storm from the entire contributing watershed. The "Manning" formula will be used to check the pipe size:

$$Q = \frac{1.486}{n} \times A \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}$$

where,
$Q =$ flow capacity (cfs)
$n =$ Manning coefficient of roughness
$A =$ cross-sectional area of pipe (ft^2)
$R =$ hydraulic radius of pipe, A/P (ft)
$P =$ wetted perimeter of pipe (ft)
$S =$ pipe slope (ft/ft)

The following values will be used for "n":

pipe material	n
smooth concrete pipe, approved flexible pipe	0.013
unlined cmp	0.025

- The hydraulic grade line must be calculated for the entire system. The hydraulic grade will be assumed to start at the elevation of 0.80 x pipe diameter of the outlet pipe or the permanent pool elevation, whichever is higher. The hydraulic gradient should be kept below the top of the pipe; in no case shall it be higher than the rim elevation of any structure.

- The minimum pipe size for storm drains accepting surface runoff is 12" diameter. Rear yard pipes may be smaller, but must be used in conjunction with a drainage swale that directs runoff to a minimum 12" diameter pipe structure.

- Pipe joints must prevent excessive infiltration.

- Storm drains shall be designed to have a minimum velocity flowing full of 2.5 ft/sec and a maximum velocity of 10 ft/sec. The velocity at a pipe outfall should be between 2.5 to 5 ft/sec to prevent scouring at the outlet.

- Riprap shall be installed at all outlets according to the Oakland County Water Resources Commissioner's Storm Drain Notes and Details Sheet. Riprap may consist of minimum 8" diameter to 15" diameter fragmented limestone or other suitable rock underlain with geotextile fabric. Cobblestone, broken concrete or grouted riprap is not preferred. Larger diameter outlets may require larger riprap as velocity and flow conditions dictate.

- A bar screen is required for all pipe outlets and inlets 18" diameter and larger.

A sample calculation for enclosed drains is included in Appendix 2.

B.   Drainage Structures

The flows to specific catch basin or inlet covers shall conform to the following:

1.   Combination curb and gutter inlet (MDOT Cover K, or equivalent):
       A maximum of 3.1 cfs at 0% grade (sump condition), and then decreasing as grade increases.

2.   Gutter inlet (MDOT Cover D, or equivalent):
       A maximum of 3.2 cfs as 0% grade (sump condition), and then decreasing as grade increases.

3.   Rear yard or ditch inlet (MDOT Beehive Cover E, or equivalent):
       In general, a maximum of 2.5 cfs at 0% grade (sump condition), and then decreasing as grade increases. However, a smaller or larger maximum inflow may be allowed as is warranted by surrounding finished grading.

See Appendix 3 for MDOT cover specifications. Calculations for grate inlet capacities must be submitted if different inlets are used.

Drainage inlets shall be located as follows:

1.   To assure complete positive drainage of all areas of the site.

2.   At all low points of streets and rear yards.

3.   Such that there is a maximum of 600 feet of drainage from any particular point on the site to a structure.

C.   Open Watercourses

Appropriate permits from agencies such as the Michigan Department of Environmental Quality must be applied for and a copy of such application must be submitted.

The "Rational Method", SCS method or other prior approved method will be used to determine the amount of flow contributing to the watercourse. All watercourses must be sized to accommodate the runoff from a 10-yr storm event. The "Manning" formula will be used to check the capacity of the watercourse. Appropriate values will be used for "n".

Examples of Manning "*n" values* for open channels

surface	*n*
maintained grass channel, rear yard swales, earth channel with stones and weeds	0.025
natural channels, somewhat irregular side slopes; fairly even, clean and regular bottom, very little variation in cross-section	0.035
dredge channel, irregular sideslopes and bottom, sides covered with some saplings and brush, slight and gradual variations in cross-section	0.045

- Open channel flow velocities shall be neither siltative nor erosive. In general the minimum acceptable non-siltative velocity will be 2.5 ft/sec. Every effort should be made to reduce the velocity of flow as much as possible at all storm drain outlets. The outlet velocity should be at maximum 2.5 to 5 feet/second.

- Outlets to channels shall be placed at the bottom of the channel with headwalls or flared end sections with erosion protection as required. Natural stabilization shall be provided where necessary to prevent erosion.

- Erosion protection shall be placed at bends, drain inlets and outlets, and other locations as required in all open ditches.

- Back slopes of channels shall be no steeper than 1 foot vertical to 3 feet horizontal, unless fencing is provided. Ditches with steep grades shall be protected by sod, vegetation or other means to prevent scour.

- A minimum of 5-foot clearance shall generally be between open ditch inverts and underground utilities.

- All bridges shall be designed to provide a 2 foot minimum flood stage freeboard to the underside of the bridge. The bridge footings shall be deep enough to be below the frost line and to allow a 3 foot channel deepening and may not be located within the open channel.

- Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched or vegetated in some manner.

- A manhole sump or catch basin should be provided at the last structure prior to a storm drain outletting to an open drain as a minimum method of erosion protection.

D.   Determination of Culvert Size

All culvert design calculations must be submitted to this office for review. Calculations must be sealed by a Professional Engineer and must include:

1.   Delineation on a topographic map of the area contributing to the culvert.
2.   Hydrologic calculations to determine the amount of flow.
3.   Hydraulic calculations used to determine the size of the culvert.
4.   Calculations for height of cover, gage size and expected loads.
5.   When an existing culvert is proposed to be modified, backwater calculations and/ or downstream calculations may also be submitted.

- This office will use the "Rational Method", the SCS Method or other prior approved method to determine the flow contributing to the culvert. Culverts shall be sized to pass a minimum 10-year storm event or the governing design storm of the watercourse, which may be higher.

- The velocity within the culvert shall be neither siltative nor erosive.

- The "Manning" formula or inlet headwater control or outlet tailwater control nomographs will be used to check the culvert design.

Construction requirements and end section treatments are as stated on the Oakland County Water Resources Commissioner's Storm Drain Notes and Details Sheet.

E.   Easements

Easement provisions shall conform to the widths indicated in the "Preliminary Plat" section (Part 3, "Easement Requirements").

All drainage easements, including freeboard and buffer strip, shall be so designated on the plans as well as on the "Mylar" plat.

All existing easements are to be shown and identified on the mylar including the Liber and Page.

Existing County Drain easements shall be indicated on the plans as well as the "mylar" plat and shall be designated as 'XX feet wide easement for the "Name" (County) Drain as recorded in Liber___ Page___'.

In cases where storm water is discharged to a drain or watercourse on adjoining private property, an improvement to the drain and an agreement with the property owner may be necessary. An off-site drainage easement will be required if:

    a. The watercourse is not depicted as a blue line on a USGS map.
    b. It is not indicated on the MIRIS map.
    c. The watercourse is not considered wetlands by the governing municipality.

F.   Drains Under The Jurisdiction Of The Water Resources Commissioner

When a County Drain is the proposed outlet for a site's storm drainage system, the standards outlined herein regarding storm water storage volume and allowable outflow must be complied with. There may be cases where the existing outlet has limitations due to downstream conditions. In this situation the discharge from the site will be restricted to conform to the governing downstream conditions. The allowable outflow from the proposed site will be limited to the pro-rata share of the capacity of the drain. The site's pro-rata equitable share of the outlet capacity should be calculated and shown on the construction plans.

There may also be cases where the outlet has already reached capacity. The burden is on the proprietor to design and construct, at his expense, any necessary improvements to the downstream outlet. Such designs will be reviewed by the Water Resources Commissioner's office for adequacy.

Locations, easements and drainage service area boundaries for County Drains are available from the Water Resources Commissioner's Office. Permanent structures may not be constructed within the easement of a County Drain. This includes storm water storage facilities. All basins must be located entirely outside of the permanent easement.

1.   *Easements*

Prior to 1956, County Drain easements were not required by statute to be recorded with the County Clerk; it was legally sufficient to have them on file at the drain office. Therefore, it is necessary to check the permanent records of the Water Resources Commissioner's Office to see if a drain easement is in existence on the subject property.

It may be necessary to record a new easement for that part of the County Drain that traverses the site. The existing easement may be abandoned in consideration for the granting of the new easement.

For open ditch drains, the easement must be at minimum, wide enough to include the extreme width of the open ditch drain plus 15' on each side measured from the top of bank. In addition, a vegetated buffer strip may be required. For enclosed drains, the easement must be a minimum of twenty (20) feet centered on the centerline of the pipe. However, larger pipe size, certain soil conditions, or depth of pipe may require larger easements.

The proposed easement must be submitted to this office for review. Upon completion of the project the owner's engineer will be required to provide the Oakland County Water Resources Commissioner's Right-of-Way Department with an existing or "as-built" metes and bounds centerline description of the entire length of the drain through the referenced property. Upon submittal of the description, along with proof of property ownership, WRC Right-of-Way Department will prepare the necessary documents for execution by the owner(s).

This office must also be provided with one set of "As-Built" mylars reproduced from the original engineering drawings, cleaned of all background debris, showing plan, profile and the new easement of the drain. A digital version of the "As-Built" plans must also be submitted.

Proposed County Drain easements shall be indicated on the plans as well as the "mylar" plat and shall be designated as 'permanent private easement for the "<u>Name</u>" (County) Drain'. In addition the following note must be added to the mylar:
"Use of the word "private" does not limit in any way the scope of the easement granted to the "<u>Name</u>" (County) Drain Drainage District"

2.   Drainage Service Areas (Districts)

A Drainage Service Area and Special Assessment District are each a legally established boundary for the area served by a County Drain. Drainage Service Areas do not always match the topographical area tributary to a County Drain. Drainage Service Areas shall not be violated when designing a drainage system.

Alterations to a Drainage Service Area and/or a Special Assessment District may be made by following the procedure established in the Drain Code. Approval must be granted by the Water Resources Commissioner or the Drainage Board.

G.   Soil Erosion and Sediment Control

Soil erosion and sediment control devices shall be installed as required by the Oakland County Water Resources Commissioner's "Erosion Control Manual" within municipalities where the Soil Erosion and Sedimentation Control Program is administered by the Oakland County Water Resources Commissioner. The following points should be kept in mind when designing an erosion control plan for a site:

- Areas within open drain rights-of-way, which have been cleaned, re-shaped or in any manner disturbed shall be seeded and mulched or otherwise vegetated.

- The smallest practical area of raw land should be exposed at one time during development.

- When raw land is exposed during development, the exposure should be kept to the shortest practical period of time.

- Temporary vegetation and/or mulching should be used to protect critical areas exposed during development.

- The permanent final vegetation and structures should be installed as soon as practicable in the development.

- The development plan should be fitted to the topography and soil so as to create the least erosion potential.

- Wherever feasible, natural vegetation should be retained and protected.

IV.   CHAPTER 18 DRAINS

Chapter 18 drains are new developments within Oakland County where the local municipality has passed an ordinance that requires all residential and certain commercial drainage systems to be established as County drains in accordance with the provisions of Section 433, Chapter 18 of the Public Acts of 1956, as amended, the Michigan Drain Code. At present, Oakland and West Bloomfield Townships each have such an ordinance.

Following are the specific requirements of the Oakland County Water Resources Commissioner in accordance with the provisions of the Drain Code.

A.   Request To Establish a County Drain

The Developer must submit three (3) complete sets of construction plans prepared and sealed by a Registered Professional Engineer or Professional Surveyor. A letter from the Developer requesting that the storm drainage facilities be established as a County Drain and a certificate from the design engineer certifying the adequacy of the storm drainage outlet must accompany the construction plans. An Engineer's Certificate must be sealed.

B.   Agreement to Establish a County Drain

The Developer and/or Land Owner of Record must enter into an Agreement to establish the proposed drainage system as a County Drain or Branch Drain of an existing legally established County Drain. A district enlargement may be necessary for Branch Drain establishment. The Developer and/or Land Owner must provide this office with the following items for Agreement preparation:

- A copy of the Title Policy or other proof of land ownership
- A metes and bounds property description with proof of closure
- Sidwell number(s) of all property proposed to be included in the drainage district
- An estimate of the construction cost of the drainage facilities
- Company name and address and name and title of individuals who will execute the Agreement.

Once this office has received all of the above information, the Agreement will be prepared.   The Agreement must be executed prior to construction plan final approval.

After the Agreement has been signed by all parties and notarized the Water Resources Commissioner will have the Agreement recorded with the County Clerk's Office.

C.   Construction Plans

The construction plans must be prepared according to the design standards and specifications presented herein. If the local municipality has more stringent standards then the municipality standards will govern.

In the case where the Chapter 18 Drain development will be platted, the procedures for a preliminary and final plat must also be adhered to.

Final construction plan approval will not be granted until all required documents and fees have been received. Construction of the storm drain system may not begin until the construction plans have been approved. After the construction plans have been approved, this office will process the final subdivision plat as set forth in the Subdivision Control Act of 1967, as amended.

This office will provide full time construction inspection of the storm drain system. Drainage facilities constructed without appropriate inspection by this office or its designated representative may not be accepted by this office as a County Drain.

D.   Easement Requirements

The Developer and/or Land Owner shall provide easements for the proposed drainage facilities. Easement requirements vary with the type of site being developed. If the site is a platted subdivision, the easements must be shown on the plat mylar and the standard WRC easement language must be included in the deed restrictions. If the site is a condominium development, the easements must be shown on the "Exhibit B" drawings and the standard WRC easement language must be included in the deed restrictions. A copy of the proposed deed restrictions must be submitted to this office for review. A recorded copy must be on file at this office prior to the final inspection.

Easement widths are to be in accordance with Part F of Section III of these standards.

E.   Inspections

This office or its designated representative will perform daily inspection of the construction of the storm drainage facilities. Full time inspection is required for all aspects of storm drain construction. This is to ensure that the storm drainage system is constructed according to the plans and specifications approved by this office.

The Developer and/or Land Owner is responsible for the liability and maintenance of the storm drainage system until it is accepted for service by the Water Resources Commissioner.

The WRC Inspection Department must be notified **2 WORKING DAYS** prior to commencing construction and for all acceptance inspections.

All field changes must be **PRE-APPROVED** by the Oakland County Water Resources Commissioner prior to installation.

1.   First Inspection

The purpose of the first (Construction) inspection approval is to release the underground contractor from responsibility of damage to the underground drainage system by others during future construction on the project site. The requirements of the first inspection are as follows:

   a.   All pipes and structures must be free of dirt and debris.

   b.   Structures must be complete, plastered or pointed with channels, benches and castings in place.

   c.   All inlets and outlets must be completed with riprap in place.

   d.   The storm water storage facility is constructed and stabilized.

   e.   The storm drainage system must be completed and fully functional.

   f.   All erosion control measures in place and all outstanding soil erosion violation addressed.

2.   Second Inspection

The second inspection will be performed after the completion of the road paving to insure that the drainage system has not been damaged by the paving process. The purpose of the second inspection is to relieve the Pavement Contractor from responsibility for future damage to the storm drainage system.

3.   Third Inspection

The purpose of the third inspection is to conditionally accept the drainage system for maintenance and operation by the Oakland County Water Resources Commissioner and to relieve the Developer and/or Land Owner from the responsibility of maintenance of the storm drainage system. The Developer and/or Land Owner is still responsible for the integrity of the system until the completion of the final accounting and final acceptance by the Oakland County Water Resources Commissioner.

The third inspection will consist of a thorough and complete inspection of the entire storm drain system. A punch list of outstanding construction items will be generated and forwarded to the Developer and/or Developer's representative for resolution. Once these punch list items have been addressed and corrected, then a third inspection approval may be issued.

The third inspection can be scheduled after the following requirements have been met:

   a.   All disturbed areas must be vegetated. Right-of-ways, easement areas, detention ponds and swales must be sodden or vegetated with an approved plant material.

   b.   As-built drawings have been submitted to the Oakland County Water Resources Commissioner.

c. The local governing body has no objections

d. There are no outstanding soil erosion issues and no history of poor soil erosion practices by the Developer and/or Land Owner.

e. All required documents and fees have been submitted and approved, including "Exhibit B" drawings, offsite drainage easements and recorded Deed Restrictions or a Master Deed with the appropriate drain easement language.

F.   As-built Plans and Mylar Requirements

Immediately following the completion of construction, the Developer and/or Land Owner shall furnish this office with a set of drawings corrected to indicate as-built conditions. Upon approval of these "As-Built" drawings, the Developer and/or Land Owner shall submit one (1) set of reproducible "Mylar" as-built construction drawings. A digital version of the "As-Built" plans must also be submitted.

G.   Final Acceptance and Final Accounting

One year from the date of the third inspection approval (conditional acceptance) the Developer may request, in writing, a final accounting of the project. The project file will be reviewed and a final walk through inspection of the Drain will be performed to ensure that the integrity of the system is intact. The final inspection can be scheduled after the following requirements have been met:

1) All conditions of the Agreement are satisfied,

2) The drain is functional and serviceable,

3) There are no outstanding liens or judgments against the storm drainage system,

4) A Developer's Declaration and Developer's affidavit are on file at this office.

If all requirements are met and the final inspection approval has been issued, a final accounting will be made of the project fund. A letter of final acceptance will be issued along with the remaining refundable amount of the deposit.
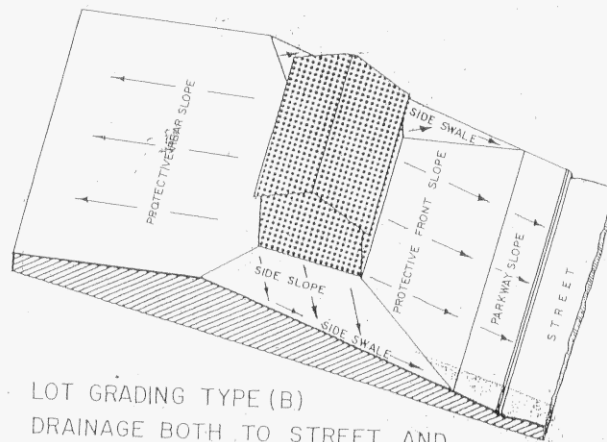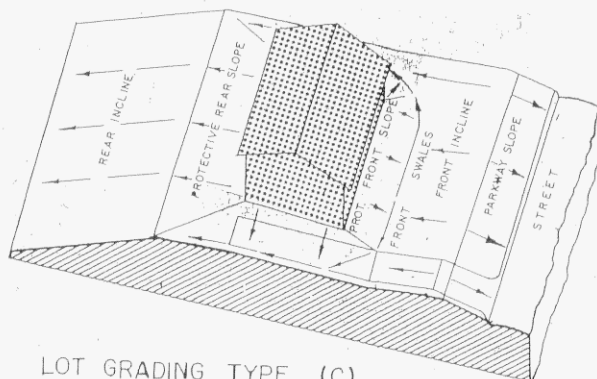
Appendix 1

Lot Grading Sketches
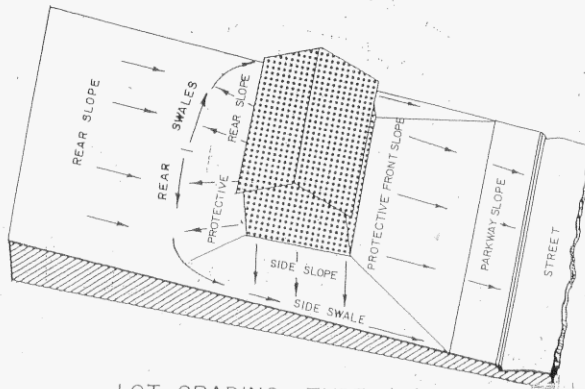
LOT GRADING TYPE (A)
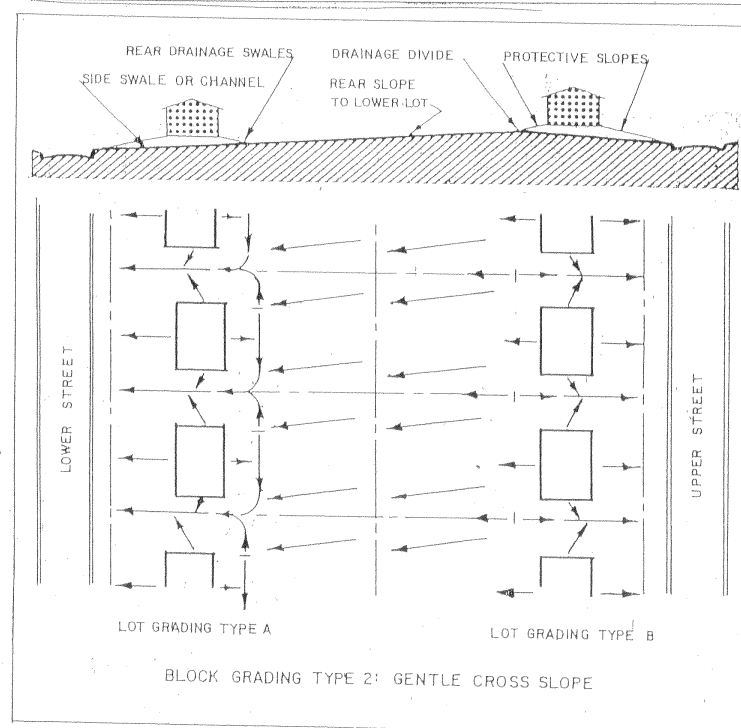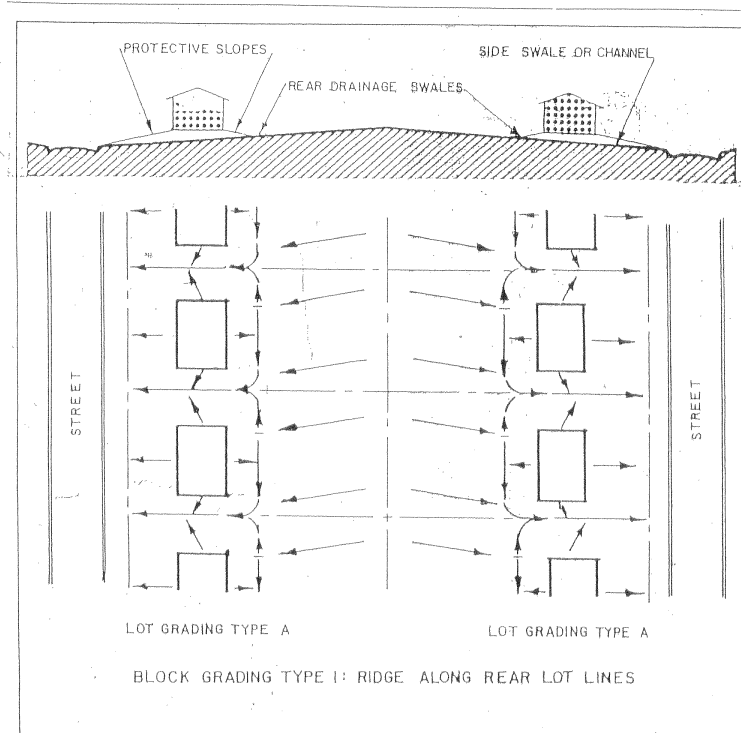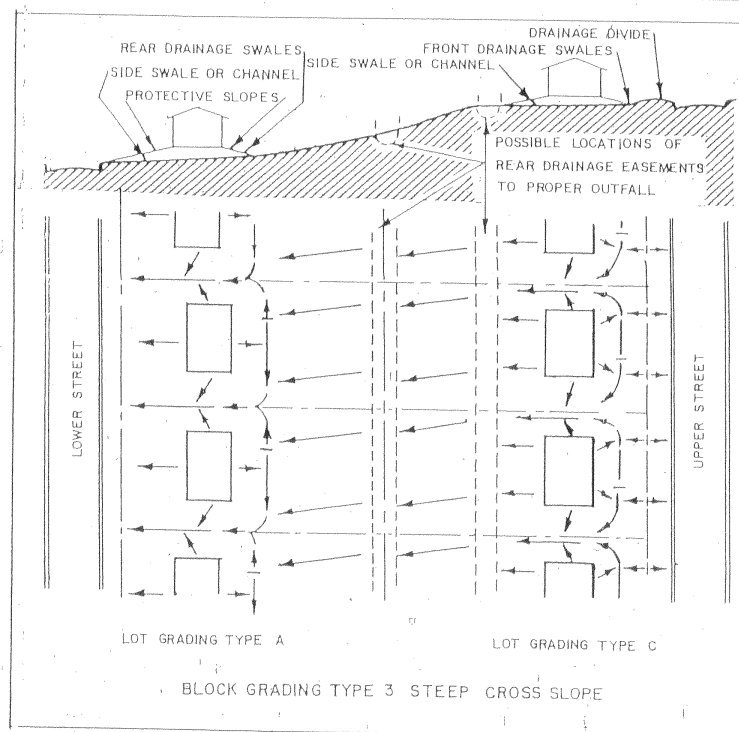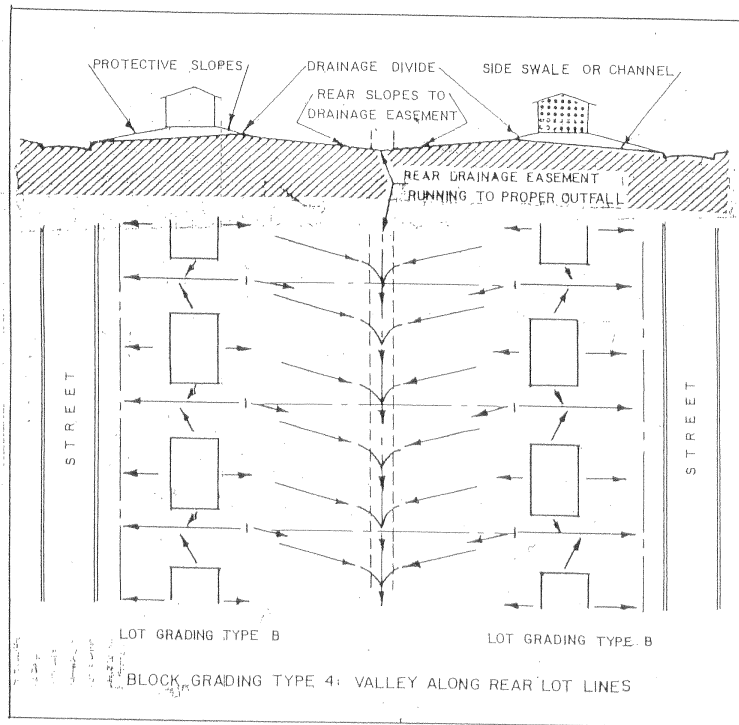ALL DRAINAGE TO STREET

LOT GRADING TYPE (B)
DRAINAGE BOTH TO STREET AND
TO REAR LOT LINE

LOT GRADING TYPE (C)
ALL DRAINAGE TO REAR LOT LINE
(LEAST DESIRABLE: CHECK WITH COMMUNITY BUILDING CODE)

PROTECTIVE SLOPES

SIDE SWALE OR CHANNEL

REAR DRAINAGE SWALES

STREET

STREET

LOT GRADING TYPE A

LOT GRADING TYPE A

BLOCK GRADING TYPE 1: RIDGE ALONG REAR LOT LINES

REAR DRAINAGE SWALES

DRAINAGE DIVIDE

PROTECTIVE SLOPES

SIDE SWALE OR CHANNEL

REAR SLOPE
TO LOWER LOT

LOWER STREET

UPPER STREET

LOT GRADING TYPE A

LOT GRADING TYPE B

BLOCK GRADING TYPE 2: GENTLE CROSS SLOPE

34

PROTECTIVE SLOPES   DRAINAGE DIVIDE   SIDE SWALE OR CHANNEL

REAR SLOPES TO
DRAINAGE EASEMENT

REAR DRAINAGE EASEMENT
RUNNING TO PROPER OUTFALL

STREET

STREET

LOT GRADING TYPE B   LOT GRADING TYPE B

BLOCK GRADING TYPE 4: VALLEY ALONG REAR LOT LINES

REAR DRAINAGE SWALES   DRAINAGE DIVIDE
SIDE SWALE OR CHANNEL   FRONT DRAINAGE SWALES
PROTECTIVE SLOPES   SIDE SWALE OR CHANNEL

POSSIBLE LOCATIONS OF
REAR DRAINAGE EASEMENTS
TO PROPER OUTFALL

LOWER STREET

UPPER STREET

LOT GRADING TYPE A   LOT GRADING TYPE C

BLOCK GRADING TYPE 3 STEEP CROSS SLOPE

35

Appendix 2

Sample Calculations

SAMPLE CALCULATIONS

Example Problem:

The proposed project is a 20 acre subdivision with a composite runoff coefficient of 0.35. There are 5 acres of off-site contributing acreage. The basin will have a permanent pool of water up to elevation 100.00' and the depth of storage will be approximately four feet. The proposed invert of the discharge pipe into the basin is 101.00'. The proposed invert of the restrictor is 99.50'. The outlet pipe for the basin is 24" diameter. Determine the following:

1) The volume required for the forebay, the median surface area and the size of the outlet, in order to dewater the forebay within 48 hrs.

2) The volume required for the detention basin and the size of the restricted outlet pipe.

3) The elevation and size of the basin overflow structure and the size of the overflow outlet pipe.

4) The size of a portion of storm drain on the site and the hydraulic grade line of the pipe run.

Solution:
1)
Volume of storage   Vr= 4,320 (0.35) (20ac)
                          Vr= 30,240 cuft

Median surface area Am= Vr / 5 ft
                          Am= 6,048 sqft

Size of outlet   a= (0.3988 (6,048) v5) / 172,800
                          a= 0.0312 sqft

2) The volume provided for the forebay can be counted as part of the volume required for the detention basin.

Calculate volume required
$$
\begin{array}{rll}
Qallow= & 4.00 & cfs \\
Qo= & 0.57 & \\
T= & 109.51 & \\
Vs= & 10936.49 & \\
Vt= & 76555 & cf \\
Vadj= & 76555 & cf \\
\end{array}
$$

Estimate restrictor size using the orifice equation. The restrictor should be sized using on-site area only.
$$
\begin{array}{rll}
outlet\ inv. = & 99.50 & \\
springline = & 99.83 & \\
h= & 4.17 & ft. \\
a= & 0.39 & sf \\
d= & 6.67 & in. \\
try\ outlet\ size= & 8.00 & in. \\
\end{array}
$$

Make a chart to calculate the volume provided in the basin. The volume should be calculated in one foot increments starting at the permanent pool elevation. Calculate the actual outflow from the basin at each elevation.

elevation	Area	h	sum Vprov	*ha*	Qact
100.00	10000	0.00	0	0.17	0.709
101.00	20000	1.00	14714	1.17	1.876
102.00	30000	1.00	39546	2.17	2.556
103.00	40000	1.00	74426	3.17	3.091
103.15	41500	0.15	**80538**	3.32	3.163
104.00	50000	0.85	112597	4.17	3.545
105.00	freeboard	1.00			

Using the value for **Qact** at each elevation, calculate the volume required at each elevation. The elevation at
which **Vreq** and **sum Vprov** are approximately equal is the storage elevation. Interpolate between elevations
to find the values that are approximately equal.

elevation	Qo	T	Vs	Vreq
100.00	0.10	294.08	14016	98110
101.00	0.27	171.17	12562	87937
102.00	0.37	143.04	11956	83690
103.00	0.44	127.83	11543	80804
103.15	0.45	126.07	11491	**80436**
104.00	0.51	117.70	11225	78575
105.00	freeboard			

The overflow rim should be set at the 100-year storage elevation **103.15'**. At this elevation the actual flow out
is less than the flow allowed, 4.00 cfs. Therefore, an 8" diameter restrictor is adequate.

3) Try a four foot diameter structure to start. The overflow structure will act as a weir. If the structure is near the
bank of the basin, only approximately 50% of it's perimeter will be utilized. If the structure were located in the
center of the basin, 100% of the perimeter would be used. The off-site contributing acreage is assumed to
be undeveloped.

Sizing Overflow Structure-

size of overflow manhole:	4.00	ft
% of MH that can be used as a weir:	50.00	%
calculated length of weir =	6.28	ft
acreage tributary to overflow (on + off site):	25.00	ac
composite runoff coefficient =	0.31	
longest time of flow to basin:	25.00	min
(from pipe flow calculations)		
sum of all flow into basin (on + off-site):	30.15	cfs
volume of basin (Vprov from detention calc's):	80538	cf
storage elevation:	103.15	ft
freeboard elevation:	105.00	ft
time to fill basin= Vprov / flow into basin =	44.52	min
I =	1.85	
Qexp = CIA =	14.35	cfs

Qweir= $3.33 (L) h^{1.5}$
calculate how high the water will rise above the overflow
structure to pass the expected flow:

h=	0.78	ft
elevation of water during overflow conditions=	103.93	ft

Is this elevation less than the freeboard elevation?
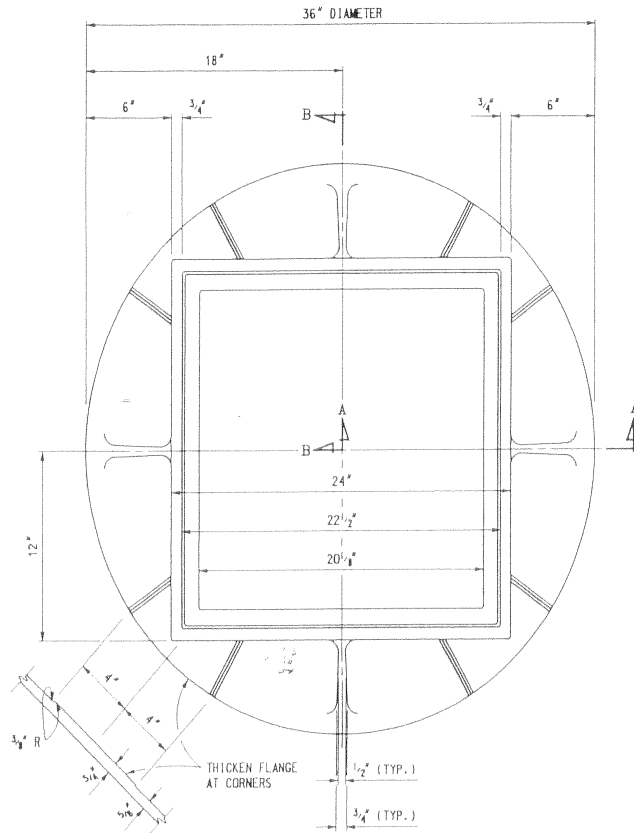If yes, then the four foot diameter structure is large enough.

Sizing Overflow Outlet Pipe-

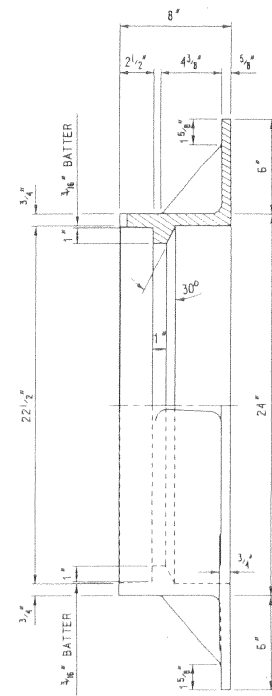|		
size of pipe:	24.00	in
area =	3.14	sf
invert of pipe:	99.50	ft
springline=	100.50	ft
h=	2.65	ft
capacity, Q = 0.62* a* sqrt(64.4* h) =	25.45	cfs

Is capacity of pipe greater than Qexp?
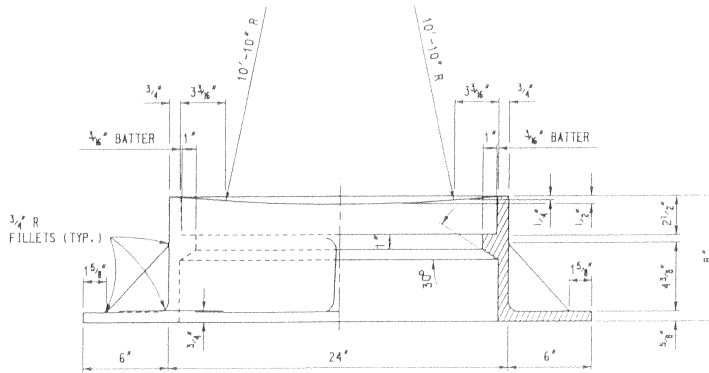If no, then outflow pipe is not large enough.
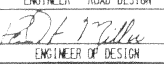
Appendix 3

MDOT Inlet Covers

PLAN VIEW OF FRAME

36" DIAMETER
18"
6"   3/4"
B
24"
22 1/2"
20 1/2"
12"
3/8" R
THICKEN FLANGE AT CORNERS
1/2" (TYP.)
3/4" (TYP.)
A   B   A

SECTION B - B

8"
2 1/2"   4 3/8"   5/8"
3/16" BATTER
3/4"
30°
1"
1"
22 1/2"
24"
6"
3/4"
5/8"
3/4"
3/16" BATTER

HALF FRONT ELEVATION
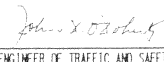
HALF SIDE ELEVATION   SECTION A - A

10'-10" R
10'-10" R
3/4"   3 3/16"
3/16" BATTER
1"
3/4" R FILLETS (TYP.)
1 5/8"
6"   3/4"   24"
3 3/16"   3/4"
1"   3/16" BATTER
1/4"   1/2"
2 1/2"
8"
30°
1 5/8"
4 3/8"
5/8"
6"

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY TECHNICAL SERVICES STANDARD PLAN FOR

COVER D

FOR USE WITH
STRAIGHT CURB AND CURB & GUTTER

R-9-B

SHEET
1 OF 2

40

PLAN VIEW OF GRATE

SECTION C - C

SECTION X - X   SECTION Y - Y
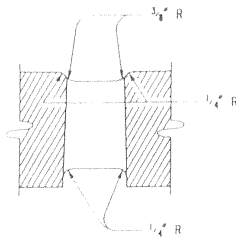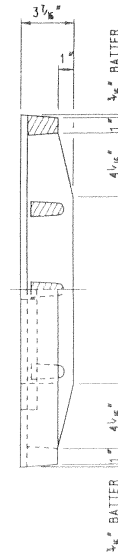
HALF FRONT
ELEVATION
OF GRATE

SECTION D - D
OF GRATE

NOTES:

THE CASTINGS SHALL MEET THE REQUIREMENTS OF THE CURRENT STANDARD
SPECIFICATION FOR GRAY-IRON CASTINGS AASHTO M 105, AND SHALL
HAVE A MINIMUM STRENGTH AS PROVIDED FOR CLASS NO. 30 GRAY - IRON
CASTINGS.

ALL CASTINGS SHALL BE CLEANED BY CURRENT APPROVED BLASTING
METHODS.

THE SEATING FACE OF THE GRATE AND THE SEAT FOR THE SAME ON THE
FRAME AND THE CURB BOX SHALL BE GROUND SO THAT THE GRATE WILL
HAVE AN EVEN BEARING ON ITS SEAT TO PREVENT ROCKING OR TILTING.

THE CASTINGS SHALL BE FREE OF POURING FAULTS, BLOW HOLES, CRACKS
AND OTHER IMPERFECTIONS. THEY SHALL BE SOUND, TRUE TO FORM AND
THICKNESS, CLEAN AND NEATLY FINISHED, AND SHALL BE COATED WITH
COAL TAR PITCH VARNISH.

THIS COVER IS DESIGNED TO FIT ON ANY INLET, CATCH BASIN OR ON
ANY EXISTING SIMILAR STRUCTURE WHEN SO DESIGNATED ON THE PLANS.

36" DIAMETER

3"
1½" DIA.
BOSS

1" R
(TYP.)

¹¹⁄₈" DIA.
CORED HOLES

10¼" 10¼"

¹¹⁄₈" DIA.
CORED HOLES

¾" DIA.
CORED HOLES

A

2½"

12"

22½"

5¾"

¹¹⁄₈" DIA.
CORED HOLES

THICKEN FLANGE
AT CORNERS

½" (TYP.)

¾" (TYP.)

⅜" R

NOTE:
BOLT CURB BOX TO FRAME WITH THREE
⅝" x 2½" GALVANIZED MACHINE BOLTS.
ADJUST FOR HEIGHT AFTER FORMS FOR
CURB ARE IN PLACE.

PLAN VIEW OF FRAME

¾" R
FILLETS (TYP.)

SECTION A - A
OF FRAME

24"

2½"

4"

8"

2"

4"
(TYP.)

2⅝"

4"   ⅝"
(TYP.)

HALF FRONT ELEVATION
OF FRAME

23½"   PAVEMENT EDGE FOR CURB & GUTTER DETAILS C3, C4, F3, & F4

¾"   5¾"   17"   6"   PAVEMENT EDGE FOR CURB & GUTTER DETAILS C5, C6, F5, & F6

2¼"

7¾"

1½" DIA. BOSS

2⅝"

¾" R
FILLET (TYP.)

¾" R
FILLET (TYP.)

4⅛"   ¾"

6⅝"   11½"   12¼"   5½"

SIDE ELEVATION OF FRAME

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY TECHNICAL SERVICES STANDARD PLAN FOR

COVER K

FOR USE WITH CONCRETE CURB & GUTTER
DETAILS C3, C4, C5, C6, F3, F4, F5, & F6

9-14-2001
F.H.W.A. APPROVAL

2-26-2001
PLAN DATE

R-15-C

SHEET
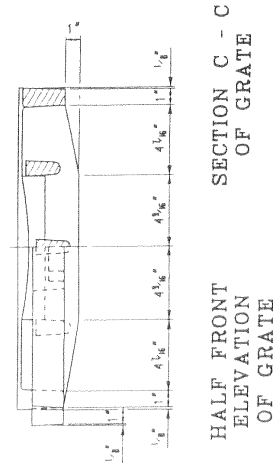1 OF 3

42

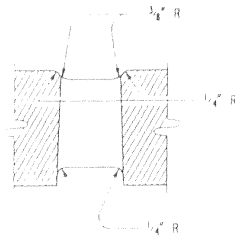PLAN VIEW OF GRATE

SECTION C - C
OF GRATE
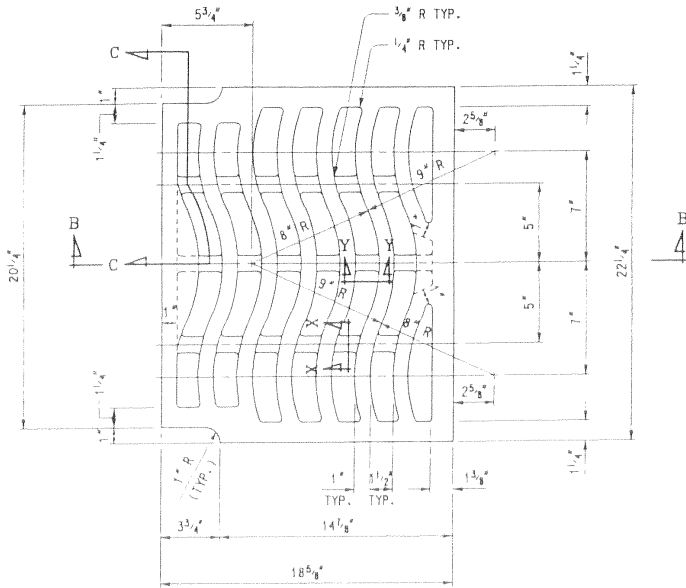
HALF FRONT
ELEVATION
OF GRATE
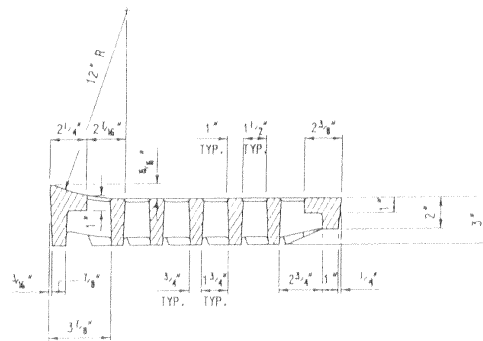
SECTION B - B

SECTION X - X

SECTION Y - Y

9-14-2001	2-26-2001	R-15-C	SHEET
F.H.W.A. APPROVAL	PLAN DATE		2 OF 3

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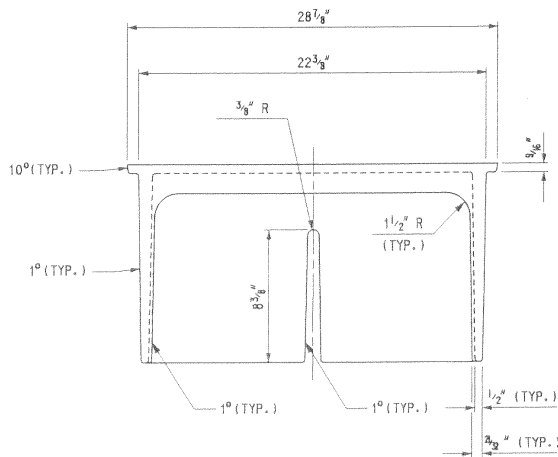
FRONT VIEW OF CURB BOX

SIDE VIEW

NOTES:

THE CASTINGS SHALL MEET THE REQUIREMENTS OF THE CURRENT STANDARD SPECIFICATION FOR GRAY - IRON CASTINGS AASHTO M 105, AND SHALL HAVE A MINIMUM STRENGTH AS PROVIDED FOR CLASS NO. 30 GRAY - IRON CASTINGS.

ALL CASTINGS SHALL BE CLEANED BY CURRENT APPROVED BLASTING METHODS.

THE SEATING FACE OF THE GRATE AND THE SEAT FOR THE SAME ON THE FRAME SHALL BE GROUND OR MACHINED SO THAT THE GRATE WILL HAVE AN EVEN BEARING ON ITS SEAT TO PREVENT ROCKING OR TILTING.

THE CASTINGS SHALL BE FREE OF POURING FAULTS, BLOW HOLES, CRACKS AND OTHER IMPERFECTIONS. THEY SHALL BE SOUND, TRUE TO FORM AND THICKNESS, CLEAN AND NEATLY FINISHED, AND SHALL BE COATED WITH COAL TAR PITCH VARNISH.

THE CURB BOX AND FRAME SHALL BE SHIPPED ASSEMBLED.

THIS COVER IS DESIGNED TO FIT ON ANY INLET, CATCH BASIN OR ON ANY EXISTING SIMILAR STRUCTURE WHEN SO DESIGNATED ON THE PLANS.

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY TECHNICAL SERVICES STANDARD PLAN FOR

COVER K

FOR USE WITH CONCRETE CURB & GUTTER
DETAILS C3, C4, C5, C6, F3, F4, F5, & F6

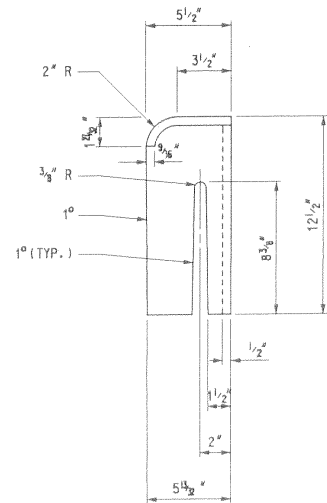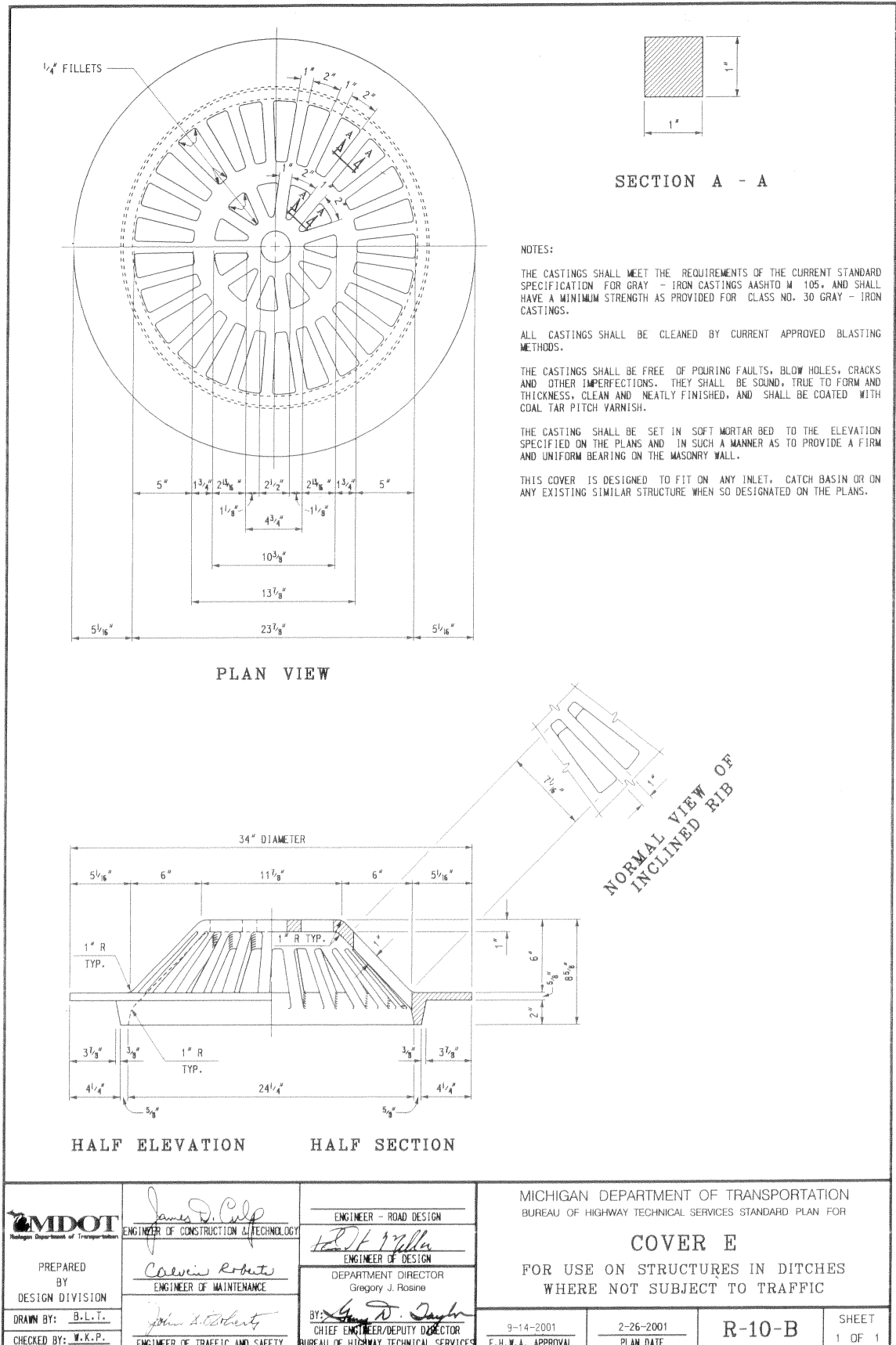| 9-14-2001	2-26-2001	R-15-C	SHEET
F.H.W.A. APPROVAL	PLAN DATE		3 OF 3

SECTION A - A

NOTES:

THE CASTINGS SHALL MEET THE REQUIREMENTS OF THE CURRENT STANDARD
SPECIFICATION FOR GRAY - IRON CASTINGS AASHTO M 105, AND SHALL
HAVE A MINIMUM STRENGTH AS PROVIDED FOR CLASS NO. 30 GRAY - IRON
CASTINGS.

ALL CASTINGS SHALL BE CLEANED BY CURRENT APPROVED BLASTING
METHODS.

THE CASTINGS SHALL BE FREE OF POURING FAULTS, BLOW HOLES, CRACKS
AND OTHER IMPERFECTIONS. THEY SHALL BE SOUND, TRUE TO FORM AND
THICKNESS, CLEAN AND NEATLY FINISHED, AND SHALL BE COATED WITH
COAL TAR PITCH VARNISH.

THE CASTING SHALL BE SET IN SOFT MORTAR BED TO THE ELEVATION
SPECIFIED ON THE PLANS AND IN SUCH A MANNER AS TO PROVIDE A FIRM
AND UNIFORM BEARING ON THE MASONRY WALL.

THIS COVER IS DESIGNED TO FIT ON ANY INLET, CATCH BASIN OR ON
ANY EXISTING SIMILAR STRUCTURE WHEN SO DESIGNATED ON THE PLANS.

PLAN VIEW

NORMAL VIEW OF INCLINED RIB

HALF ELEVATION   HALF SECTION

MDOT

ENGINEER OF CONSTRUCTION & TECHNOLOGY

PREPARED
BY
DESIGN DIVISION

ENGINEER OF MAINTENANCE

DRAWN BY: B.L.T.

CHECKED BY: W.K.P.

ENGINEER OF TRAFFIC AND SAFETY

ENGINEER – ROAD DESIGN

ENGINEER OF DESIGN

DEPARTMENT DIRECTOR
Gregory J. Rosine

BY:
CHIEF ENGINEER/DEPUTY DIRECTOR
BUREAU OF HIGHWAY TECHNICAL SERVICES

MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAY TECHNICAL SERVICES STANDARD PLAN FOR

COVER E
FOR USE ON STRUCTURES IN DITCHES
WHERE NOT SUBJECT TO TRAFFIC

| 9-14-2001 | 2-26-2001 | R-10-B | SHEET |
| F.H.W.A. APPROVAL | PLAN DATE | | 1 OF 1 |

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Appendix 4

"A Simple Method of Detention Basin Design"

VII. A SIMPLE METHOD OF DETENTION BASIN DESIGN
(By Glen Yrjanainen, P.E., Civil Engineer and Alan W. Warren, Engineering Technician)

A. INTRODUCTION

Because development of land from agrarian to residential, commercial or industrial use continues to increase, the temporary storage of storm runoff in an onsite detention basin has become essential, due to inadequate outlets for the increased storm runoff created by development. In most cases, and primarily for economic reasons, adequately designed collector storm water systems (capable of handling the storm runoff from ultimate development) lag behind the development increases. Because of ever increasing construction costs and the infeasibility of installing large diameter storm drains, the concept of ultimate design or improvement of collector storm water systems is impractical. The detention basin that meters or restricts flow is here to stay.

B. THE USE OF CALCULUS

If a detention basin were to have no outlet, all of the storm runoff would have to be stored. However, most detention basins do have an outlet, with the outflow depending upon the amount of water that is ponded and the depth of detention. The outflow is instantaneously changing as the head varies. This type of outlet can be analyzed by applying basic calculus to the controlling outflow equation. If the outflow is at a constant rate, i.e., a pump, the analysis is easier. The volume of storm water into the detention basin can be determined by the rational formula. The required storage volume is the volume of runoff that flows into the basin minus that which flows out.

An equation can be obtained that relates volume of storage to allowable outflow using the storage time as a parameter. This equation can then be maximized by basic calculus to find the peak storage time, which in turn can be used to calculate the maximum volume of storage required. The one assumption in this method is that storm water rises in the detention basin at a constant rate to fill the basin to the peak volume, and that the maximum allowable outflow is reached only at this peak volume, and then begins to recede.

The derivations of detention equations for detention basins with a gravity flow, changing rate orifice outlet, and a constant rate pump outlet follow. These derivations are for a ten-year frequency storm in the Oakland County, Michigan area. Detention equations for different year frequency storms and other areas can be obtained in the same manner.

C. DERIVATION FOR AN ORIFICE OUTLET

1. OUTFLOW

$$Q_i = ca\sqrt{2gh} \quad \text{(Orifice Formula)}$$

Assume that the storm that fills the basin to the peak volume causes the water level to rise at a constant rate. $(h = K_1 t)$

$$Q_i = ca\sqrt{2gK_1 t}$$

Let
$$K_2 = ca\sqrt{2gK_1}$$

$$Q_i = K_2 t^{1/2}$$

$$V_o = 60 \int_o^T Q_i\, dt$$

A conversion factor of 60 sec./min. is required because Q_i is in cfs and t is in minutes.

$$V_o = 60K_2 \int_o^T t^{1/2}\, dt$$

$$V_o = 60K_2 T^{3/2}\, (2/3)$$

$$V_o = 40K_2 T^{1/2}\, (T)$$

Assume the maximum outflow occurs only at the time of peak storage, such that $Q_o = K_2 T^{1/2}$

$$V_o = 40Q_o T$$

2. INFLOW

$$Q_n = CIA \quad \text{(Rational Formula)}$$

Let
$$C = 100\%$$

$$A = 1 \text{ Acre}$$

$$I = \frac{175}{T + 25}$$

$$Q_n = (100\%)\ \frac{175}{T + 25} \quad (1)$$

$$Q_n = \frac{175}{T + 25}$$

$$V_n = Q_n\, (T)\, (60 \text{ sec./min.})$$

$$V_n = \frac{10{,}500\ T}{T + 25}$$

3. STORAGE

$$Vs = Vn - Vo$$

$$Vs = \frac{10,500\ T}{T + 25} - 40QoT$$

Since Qo is a fixed maximum outflow that will only occur at peak storage, it is necessary to find the time from the instant the storage begins until the instant the peak storage is attained. This can be done by taking the first derivative of the storage volume equation and setting it equal to zero.

$$\frac{dVs}{dT} = \frac{d\left(\frac{10,500\ T}{T + 25}\right)}{dT} - \frac{d(40QoT)}{dT}$$

$$\frac{dVs}{dT} = \frac{(T + 25)(10,500) - (10,500\ T)(1)}{(T + 25)^2} - 40Qo$$

$$\frac{dVs}{dT} = \frac{262,500}{T^2 + 50T + 625} - 40Qo = 0$$

$$T^2 = 50T + 625 - \frac{262,500}{40Qo} = 0$$

This is a quadratic equation that may be reduced to the form:

$$ax^2 + bx + c = 0$$

Where x is T, a = 1, b = 50 and $c = 625 - \dfrac{262,500}{40Qo}$

The general solution is:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$T = \frac{-50 \pm \sqrt{(50)^2 - 4(1)\left(625 - \dfrac{262,500}{40Qo}\right)}}{2(1)}$$

$$T = \frac{-50 \pm \sqrt{2,500 - 2,500 + \dfrac{26,250}{40Qo}}}{2}$$

$$T = -25 + \sqrt{\frac{6,562.5}{Qo}}$$

D. DERIVATION FOR A CONSTANT RATE OUTLET

A basin with a constant outflow device, such as a pump, is simpler to derive. The constant outlet rate implies that the total outflow is merely the rate multiplied by the storage time.

$$Vo \quad = \quad 60QoT$$

$$Vs \quad = \quad Vn - Vo$$

$$Vs \quad = \quad \frac{10,500\ T - 60QoT}{T + 25}$$

$$\frac{dVs}{dT} \quad = \quad \frac{(T + 25)\ (10,500) - 10,500\ T(1) \ - 60\ Qo}{(T + 25)^2}$$

$$\frac{dVs}{dT} \quad = \quad \frac{262,500}{T^2 + 50T + 625} \quad - 60Qo$$

$$T^2 + 50T + 625 - \frac{262,500}{60Qo} = 0$$

$$T \quad = \quad -25 + \sqrt{\frac{4,375}{Qo}}$$

E. GRAPHING THE DERIVATIONS

In both outlet situations the storage time to fill the basin to its maximum can be found as a function of the maximum outflow. The peak storage volume can then be found by substituting the storage time into the storage volume equation, reducing the storage volume equation to an equation with only one independent variable. This makes it possible to draw a graph of storage volume as a function of the maximum outflow rate. The included graph shows that as the outlet gets larger, the required storage volume decreases. The ideal basin will fall at a point on its respective curve. A basin that is oversized will fall at a point above its respective curve, and as a result, it will not reach its maximum outflow rate during the storm. An inadequate basin will fall at a point below its curve, and will rise above the design depth, producing more than the design outflow and possibly causing flooding. It should be pointed out that the constant rate system allows the least storage for a given size outlet. This is due to the fact that it functions at the maximum rate throughout the storm, while a gravity system has to head up before it will reach the maximum rate.

FOR:
$$I = \frac{175}{T+25}$$
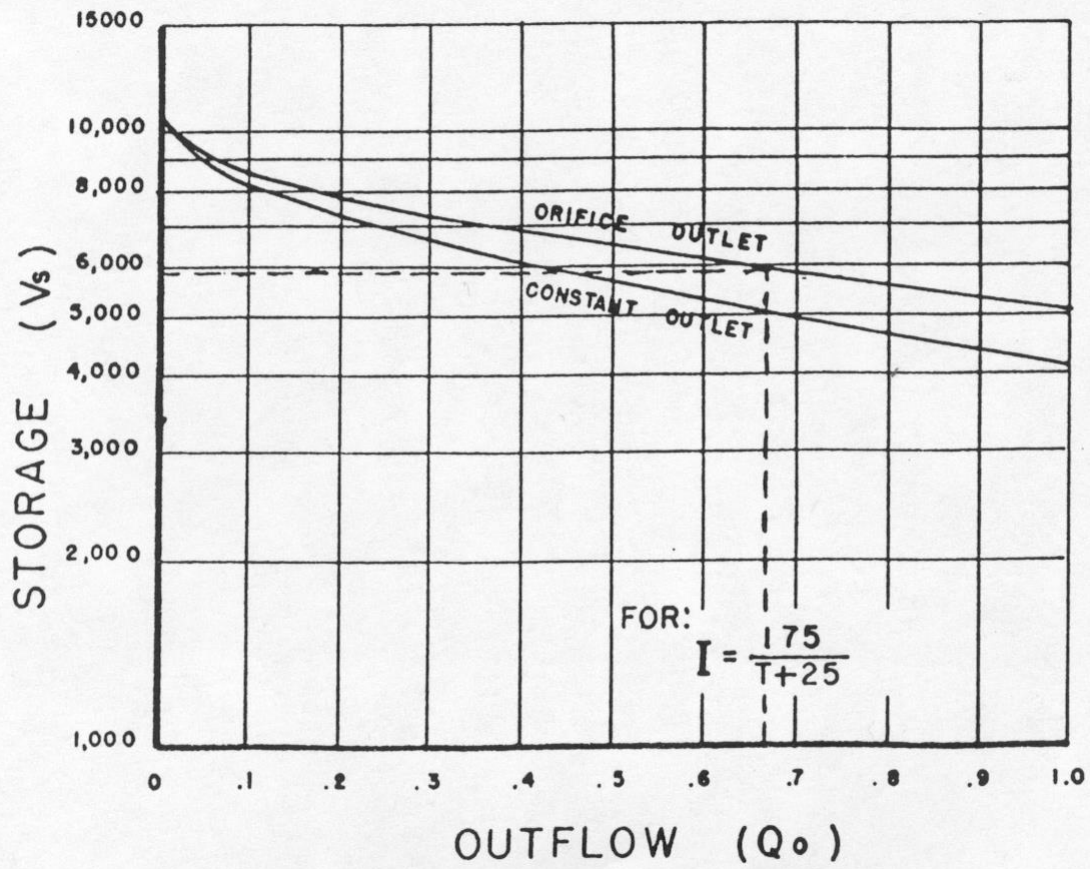
F. TIME OF CONCENTRATION

It should be noted that no mention has been made of the time of concentration, which is defined as the flow time, in minutes, from the most remote point in the drainage area to the point in question. The reason for this is because it is assumed that runoff from the entire drainage area contributes to the detention basin immediately, and that the time of concentration is zero. This is a reasonable assumption that can be made for developments with relatively short times of concentration, such as subdivisions, multiples and parking lots. This assumption also makes this method of design conservative, since in actuality a certain volume of runoff will have already flowed out of the detention basin before the runoff from the most remote point of the drainage area arrives. As the time of concentration increases, this method of design becomes more conservative.

G. DETENTION BASIN DESIGN PROCEDURE

1. Determine the amount of acreage (A) contributing runoff to the detention basin and its runoff coefficient (C).

2. Determine the maximum allowable outflow, Qa, in CFS from the local municipal government regulations and/or the existing outlet conditions.

3. Calculate Qo = $\dfrac{\text{allowable outflow, Qa}}{\text{(acreage) (runoff coefficient)}}$

4. Determine the type of outlet that will be used. (orifice or pump)

5. Calculate the maximum storage time (T) from the storage time equation corresponding to the type of outlet selected in step 4.

6. Calculate the maximum storage (Vs) from the storage equation corresponding to the type of outlet selected in step 4. (Vs will be in ft^3 /(acres) (runoff coefficient))

7. Calculate the total volume of storage required for the entire site. (Vt = (Vs) (C) (A))

8a. If the outlet is to be a pump, select a depth of detention and a pump that will yield an outflow in CFS equal to the maximum allowable as determined in step 2.

8b. If the outlet is to be an orifice operating under a head, select a depth of detention and then use the orifice equation to calculate the cross-sectional area of outflow pipe required to outlet the allowable outflow, as determined in step 2, operating under a head equal to the depth of detention. After obtaining this cross-sectional area, the pipe diameter can be obtained.

Please be advised that the size of this outflow pipe may have to be increased if the outflow operates according to a Bernoulli analysis instead of as an orifice. If this is the case, then the outflow should be either (1) sized by the Bernoulli equation to yield the allowable outflow for the design depth or (2) the orifice condition should be created by selecting a larger size pipe then is calculated by the orifice equation, and then installing within this pipe a restriction plate containing an opening equal to the original cross-sectional calculated.

H. EXAMPLE PROBLEM

In order to illustrate the use of the equations and graphs derived in this article, an example problem will be worked.

1. DESIGN CRITERIA

A 50-acre parcel of land is to be developed into a residential subdivision with a developed runoff coefficient of 0.30. An open ditch drain is available adjacent to this 50 acre parcel of land and can accept storm runoff at a rate of no greater than 10 CFS from the proposed subdivision. Sufficient grade is available to allow 6.5 feet depth of detention and a gravity flow orifice outlet. Determine (1) the volume of detention required, and (2) the size of outflow pipe required.

2. SOLUTION

a. From the design criteria, calculate Qo

$$Q_o = \frac{\text{allowable outflow, Qa}}{(\text{acreage}) \, (\text{runoff coefficient})}$$

$$Q_o = \frac{10 \text{ CFS}}{(50 \text{ ac}) \, (0.30)} = 0.667 \, \frac{\text{CFS}}{\text{acre imperviousness}}$$

b. Calculate the storage time, T, in minutes, from the orifice outlet storage time equation.

$$T = -25 + \sqrt{\frac{6,562.5}{Q_o}}$$

$$T = -25 + \sqrt{\frac{6,562.5}{0.667}}$$

$$T = 74.22 \text{ min.}$$

c. Calculate the maximum volume of storage per acre imperviousness, Vs, from the orifice outlet storage equation.

$$V_s = \frac{10,500 \, T - 40 Q_o T}{T + 25}$$

$$V_s = \frac{10,500 \, (74.22) - 40 \, (0.667) \, (74.22)}{74.22 + 25}$$

$$V_s = 5,875.18 \text{ ft}^3 \text{/acre imperviousness}$$

d. Calculate the total volume of storage, Vt, required for the entire site.

$$V_t = (V_s) \, (\text{\# acres}) \, (\text{runoff coefficient})$$

$$V_t = 5,875.18 \, (50) \, (0.30)$$

$$V_t = 88,127.76 \text{ ft}^3$$

e.   Because of sufficient grade available, the design depth of detention is 6.5 feet. Now select an outflow pipe from the orifice formula that will yield the allowable outflow of 10 CFS operating under a head of 6.5 feet.

$$Q = 0.62 \ a \sqrt{2gh}$$

$$\text{Area} = \frac{Q}{0.62 \sqrt{2gh}} = \frac{10 \text{ CFS}}{0.62 \sqrt{64.4 \frac{\text{feet}}{\text{sec}^2} (6.5 \text{ feet})}}$$

$$\text{Area} = 0.785 \text{ ft}^2$$

Select a 12" diameter outflow pipe

f.   Plot the storage required per acre imperviousness (Vs) versus the outflow per acre imperviousness (Qo) on the orifice outlet graph. One will see that it falls exactly on the curve.

DETENTION BASIN DESIGN FORMULAS

(Pump Outlet)

Frequency Of Storm	Rainfall Intensity	Storage Time Equation	Storage Volume Equation
1 Year	$\dfrac{72}{T+25}$	$T=-25+\sqrt{\dfrac{1800}{Q_o}}$	$V_s=\dfrac{4320T}{T+25}-60Q_oT$
5 Year	$\dfrac{145}{T+25}$	$T=-25+\sqrt{\dfrac{3625}{Q_o}}$	$V_s=\dfrac{8700T}{T+25}-60Q_oT$
10 Year	$\dfrac{175}{T+25}$	$T=-25+\sqrt{\dfrac{4375}{Q_o}}$	$V_s=\dfrac{10500T}{T+25}-60Q_oT$
25 Year	$\dfrac{215}{T+25}$	$T=-25+\sqrt{\dfrac{5375}{Q_o}}$	$V_s=\dfrac{12900T}{T+25}-60Q_oT$
50 Year	$\dfrac{245}{T+25}$	$T=-25+\sqrt{\dfrac{6125}{Q_o}}$	$V_s=\dfrac{14700T}{T+25}-60Q_oT$
100 Year	$\dfrac{275}{T+25}$	$T=-25+\sqrt{\dfrac{6875}{Q_o}}$	$V_s=\dfrac{16500T}{T+25}-60Q_oT$

(Orifice Outlet)

Frequency Of Storm	Rainfall Intensity	Storage Time Equation	Storage Volume Equation
1 Year	$\dfrac{72}{T+25}$ *	$T=-25+\sqrt{\dfrac{2700.0}{Q_o}}$	$V_s=\dfrac{4320T}{T+25}-40Q_oT$
5 Year	$\dfrac{145}{T+25}$	$T=-25+\sqrt{\dfrac{5437.5}{Q_o}}$	$V_s=\dfrac{8700T}{T+25}-40Q_oT$
10 Year	$\dfrac{175}{T+25}$	$T=-25+\sqrt{\dfrac{6562.5}{Q_o}}$	$V_s=\dfrac{10500T}{T+25}-40Q_oT$
25 Year	$\dfrac{215}{T+25}$	$T=-25+\sqrt{\dfrac{8062.5}{Q_o}}$	$V_s=\dfrac{12900T}{T+25}-40Q_oT$
50 Year	$\dfrac{245}{T+25}$	$T=-25+\sqrt{\dfrac{9187.5}{Q_o}}$	$V_s=\dfrac{14700T}{T+25}-40Q_oT$
100 Year	$\dfrac{275}{T+25}$	$T=-25+\sqrt{\dfrac{10312.5}{Q_o}}$	$V_s=\dfrac{16500T}{T+25}-40Q_oT$

*For manufactured treatment system design, use NOAA Atlas 14 rainfall intensity found on page 21.