Marquette
www.mqtcty.org

City of Marquette Engineering Department

General Guidelines and Standards for

Street and Utility Design

Acknowledgments

City Staff

Engineering Department

Keith Whittington, City Engineer
Greg Borzick, Assistant City Engineer
Jim Compton, Hydrology Engineer
Mikael Kilpela, Staff Engineer
Dan Salmon, Engineering Technician II
Matthew Koss, GIS Technician
Sven Holmquist, City Surveyor
Jared Kangas, Engineering Aid
Jim Minard, Retired City Surveyor

Public Works Department

Scott Cambensy, Public Works Director

Community Development

Dennis Stachewicz, Community Development Director
David Stensaas, City Planner

Community

Robert Cambensy, P.E., P.S.
Steve Lawry, P.E.
Kurt Simandl, P.E., North Country Engineering
George Meister, P.E., GEI Consultants of Michigan, Inc.
Lynn R. Swadley, President of Sunrise Builders Inc.
Jim Perry, Oberstar Construction

REVISIONS LOG: DESIGNERS SHOULD ENSURE THEY HAVE REVIEWED THE LIST AND INCORPORATE THE REVISED PAGES.

Revisions Log

1. March, 2015 Storm Sewer, Design Criteria for Storm Sewers, pg. 88, changed manning's "n" value for concrete to 0.013 and for plastic 0.011.

2. March, 2015 Storm Sewer, Layout of Storm Sewers, pg, 112, changed "All new main line storm sewer on street projects should be located outside the pavement area" to "All new main line storm sewer on street projects should be located outside the pavement area if feasible."

3. March, 2015 Storm Sewer, Layout of Storm Sewers, pg. 112, changed in the "Drainage Structure- Manhole Size" table 21" - 42", 48" - 54", and 60" and larger as follows: 21" - 36", 42" - 48", and 54" and larger.

4. March, 2015 Storm Sewer, Vertical and Horizontal Alignment, pg. 114, Added paragraph "Piping placed under roadways designated as a truck route will comply with AASHTO HS-25 loading."

5. March, 2015 Storm Sewer, Types of Sewer Pipe, pg. 115, changed the following paragraph: "If cover is less than three (3) feet, use C-76, Class IV for twenty-four (24) inch and smaller pipe, and C-76, Class II for larger pipe. C-76, Class IV pipe shall be used for all cross-drains between catch basins, including the leads to the manhole." to "If cover is less than three (3) feet, use C-76, Class IV for all pipe, Class IV pipe shall be used for all cross-drains between catch basins, including the leads to the manhole."

6. March, 2015 Storm Sewer, Storm Sewer Joints, pg. 115, changed the paragraph: "Twenty-one(21) inch diameter pipe and smaller shall be flexible rubber compression gaskets conforming to ASTM C 443 for concrete pipe." to "All concrete pipe shall have flexible rubber compression gaskets conforming to ASTM C 443."

7. March, 2015 Storm Sewer, Storm Sewer Joints, pg. 116, added the following paragraph: "All pipe manufacturers regardless of the accepted pipe material, shall have successfully performed and passed MDOT's MTM 723 "*Michigan Test Method for Watertightness Testing of Culvert and Sewer Joints up to 24"*

inches in Diameter."

8.	*March, 2015*	*Storm Sewer, Storm Sewer Drainage Structures, pg. 116, added the following sentence: " All precast reinforced manhole sections will conform to ASTM C 478 requirements.*
9.	March, 2015	Storm Sewer, Added following section, pg.116: "F. Deflection Testing for Flexible Pipe. A mandrel test is required for all flexible pipe per ASTM 2321. Requirements will meet or exceed what is required for sanitary sewer piping as called out in the City of Marquette Standard Specifications.
10.	May, 2016	Water Main, changed the following sentence, pg. 62: Fire hydrants shall be placed at each street intersection, at water main termination in cul-de-sacs, and at other locations so that the distance between them does not exceed 500 feet. This distance shall be measured in the street as fire hose laid down from a fire vehicle. Fire hydrants shall be located such that all proposed or existing building sites are within 300 feet of fire hose laid down from a fire hydrant.
11.	May, 2016	Added the following chapters: Storm Sewer Open Channel Design Standards Storm Sewer Retention and Detention Design Standards Storm Water Management and Quality Design Standards

Table of Contents

STATEMENT OF PURPOSE
CITY OF MARQUETTE
ENGINEERING DESIGN STANDARDS

The purpose of the this document is to provide a set of standards for designing streets, drainage facilities, water lines, sanitary sewer lines and preparing construction plans for such facilities that are to be owned, operated and/or maintained by the City of Marquette. These standards will be used by the City Staff and consulting engineers employed by the City for the above described improvement projects, and engineers for private developments in the City of Marquette. Unusual circumstances or special designs requiring variance from the standards in this manual may be approved by the City Engineer.

(Code of Ordinances City of Marquette, Michigan – Section 2-285. City Engineer, Duties and Functions).

AMENDMENTS, REVISION, VARIANCE AND APPEALS PROCESS
CITY OF MARQUETTE
ENGINEERING DESIGN STANDARDS

A. Amendments and Revisions to Standards

These Standards may be periodically amended as necessary to provide additional clarity or to reflect changes in policy or in construction or engineering practice. Such revisions to these Standards may consist of either “policy” revisions or “technical” revisions.

B. Policy Revisions

Policy revisions shall be considered changes in law.

(Code of Ordinances City of Marquette, Michigan – Section 2-522. Policies and Procedures).

C. Technical Revisions

Technical revisions shall consist solely of such minor additions, revisions, and corrections to these Standards as may, in the judgment of the City Engineer, be necessary to better conform to standard engineering and/or construction standards and practice. The City Engineer and shall approve only those proposed technical revisions that: (1) are consistent with all existing policies relevant to the revision, (2) do not result in any significant additional cost to persons affected by the revision, and (3) are consistent with existing law. Technical revisions shall become effective when approved, in writing, by the City Engineer. If technical revisions are deemed necessary, the revisions may occur through one of two processes.

1. Normal Technical Revision Process. The normal technical revision process will occur during planned periodic revisions. Technical revisions determined necessary by Engineering and Public Works staff shall be accomplished (without a public hearing process) through discussion and agreement among the parties.

2. Accelerated Process. The accelerated process may occur outside of the planned periodic revision schedule. If a technical revision is determined to be immediately necessary, the Engineering and Public Works Staff may discuss and agree upon the revision. Affected parties will be notified of the revision through the proper communication channels.

D. Interpretation of Standards

In the interpretation and application of the provisions of these Standards, the following principles apply:

1. Governing Standards. Any items which are not included in these Standards shall be constructed in accordance with State of Michigan Design Standards or the American Association of State Highway and Transportation Officials (AASHTO), A Policy of Geometric Design of Highways and Streets, or other nationally accepted engineering design standards. In case of a conflict, the more restrictive shall apply.

E. Variances Processes

1. Variances

   Any design that does not conform to these Standards must be approved by the City Engineer. Variances from these Standards will be considered administratively on a case-by-case basis following a written request for a variance prepared by a Professional Engineer and submitted to the City Engineer. If the developer, contractor, or utility responsible for public improvements desires to design and construct such improvements in variance to criteria in these standards, such variance(s) shall be identified in a written attachment to the initial submittal of construction plans to the City Engineer.

   The design submitted for review shall show the variance. To assist with their plan preparation, designers may submit variance requests, along with sufficient documentation to support the variance, prior to formal submittal of construction plans to the Planning Commission for informal advisory consideration. Such advisory consideration shall not be binding on the City Engineer, but may help to guide the requestor in the preparation of plans. Variances may be considered by either of the following two administrative processes:

   a. Variances requested as part of a preliminary development plan and shall also be specifically substantiated and justified in a letter (complete with technical justification) addressed to the City Engineer.

   b. Variances requested as part of the submittal for approval of final public improvements construction plans shall be shown in the plans and shall also be specifically substantiated and justified in a letter addressed to the City Engineer. A summary of all approved variances shall be listed in the general notes on the approved plans.

2. Information Required for Variance Request(s)

   a. Identifying Issue. Identification of the standard to be waived or varied and why the standard is unfeasible or is not in the public interest.

   b. Proposing Alternate Design. Identification of the proposed alternative design or construction criteria.

   c. Comparing to Standards. A thorough description of the variance request including impact on capital and maintenance requirements, costs, and how the new design compares to the standard.

   d. Justification. The Professional Engineer must determine and state that the variance will not be detrimental to the public health, safety and welfare, will not reduce design life of the improvement nor cause the City of Marquette additional maintenance costs. The proposed plan (as varied) must advance the public purpose of the standard sought to be varied equally well or better than would compliance with such standard.

e. Approval or Denial of Variance. Based upon review of the plans and additional information submitted, and an analysis of the criteria set forth in this subsection (2), the City Engineer approve or deny the variance request. If the City Engineer approves the variance request, the plans will continue to be reviewed and approved within the typical review process.

If the City Engineer denies the variance request, the developer shall subsequently submit revised plans in compliance with these Standards. The City Engineer shall provide a written Response outlining the basis for all approvals or denials of variance requests.

F. Appeals Process

1. Appeal to the Community Development Director. If a variance request is denied by the City Engineer, the Developer may appeal the decision to the Director. All appeals shall be processed through the City Engineer. The Developer shall give written notice of appeal to the Director within 10 days after denial by the City Engineer. The Director shall respond within 15 working days after receipt of the Developer's notice to appeal. If the Director overturns the City Engineer's decision, the developer may then proceed with the requested variance(s) in the plans. Subsequently the plans will continue to be reviewed and approved within the typical review process.

   If the Director concurs with the City Engineer's, the Developer shall bring the Plans into compliance with these Standards, or appeal the Director's decision to the Planning Commission.

2. Appeal to City Commission. The Developer may appeal to the City Commission through the City Manager within 10 days from receipt of denial from the Director. The appeal shall be placed on the agenda for consideration by the City Commission in accordance with City Commission procedures.

(Code of Ordinances City of Marquette, Michigan – Section 5-4. City Manager).

(Code of Ordinances City of Marquette, Michigan – Chapter 2. City Commission).

(Code of Ordinances City of Marquette, Michigan – Section 50-37. Appeals).

DEFINITIONS
CITY OF MARQUETTE
ENGINEERING DESIGN STANDARDS

A. Words used in the present tense include the future tense; and in the singular include the plural, unless the context clearly indicates the contrary.

B. The term “shall” is mandatory; the term “may” is permissive.

C. The word or term not interpreted or defined by this Article shall be used with a meaning of common or standard utilization.

<u>TERMS DEFINED</u>

The following is a list of words and phrases defined for the purpose of their use in interpretation of the Design Standards Manual. These definitions shall apply in the interpretation, administration and enforcement of the Design Standards Manual. Words and phrases not specifically defined shall rely on their definition in the City of Marquette’s Zoning Ordinance, Master Plan or finally the Merriam-Webster’s Dictionary.

“AASHTO” shall mean the “American Association of State Highway and Transportation Officials”.

“ADA” shall mean the “Americans with Disabilities Act”.

“Alley” shall mean any dedicated public way affording a secondary means of access to abutting property and not intended for general traffic circulation, and not more than twenty (20) feet wide.

“Average Daily Traffic” shall mean the average number of vehicles crossing a specific point on a roadway on any given day.

“Average Control Delay” shall mean the average of delay that results from the type of control at the intersection; it is measured by comparison with the uncontrolled condition. It is the difference between the travel time that would have occurred in the absence of the intersection control, and the travel time that results because of the presence of the intersection control.

“Arterials” shall mean that part of a roadway system serving as the principal network for through traffic flow. Arterials connect areas of principal traffic generation,

“As-Built Drawings” shall mean the revised set of drawings submitted by the city engineering department, a contractor or developer upon completion of a project or a particular job. They reflect all changes made in the specifications and working drawings during the construction process, and show the exact dimensions, geometry, and location of all elements of the work completed under the contract or project.

“APWA” shall mean the “American Public Works Association”.

“ASSE” shall mean the “American Society of Sanitary Engineering”.

“ASTM” shall mean the “American Society for Testing and Materials”.

“AWWA” shall mean the “American Water Works Association”.

“Background Traffic” shall mean an estimate of future traffic within the vicinity of the proposed development, without the site development traffic, but with existing traffic adjusted for expected growth, and addition of traffic from major vested projects.

“Best Management Practices” or “BMP” shall mean combining of practices that form an effective, predictable means of preventing or reducing storm water pollution generated by dischargers into the storm water system. Best management practices shall follow the current “Michigan Department of Transportation’s Soil Erosion and Sedimentation Control Manual and designated key numbering system.

“Bicycle Facilities” shall mean a general term denoting improvements and provisions made by public agencies to accommodate or encourage bicycling, including parking facilities, mapping of all bikeways, and shared roadways not specifically designated for bicycle use.

“Bicycle Lane (Bike Lane)” shall mean the portion of the shoulder or roadway that has been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists.

“Bicycle Route (Bike Route)” shall mean a segment of a bicycle system, designated by the Local Entity. Bicycle routes have appropriate directional or informational markers, with or without specific bicycle route number.

“Bridge” shall mean any structure conveying a roadway or path over a body of water or other feature. Bridges shall be designed to carry a varying combination of loading, including vehicular, bicycle, and/or pedestrian traffic.

“Building Storm Sewer Lateral” shall mean any storm water lateral pipe that extends from a point of connection with the building storm sewer pipe to a point of connection to a public storm water drain or structure.

“Building Sanitary Sewer Lateral” shall mean the connection between a building’s plumbing and drain system and the property line and it is considered an extension of the structure facilities, thus, is installed under the County’s plumbing and building codes and inspected and approved by County building inspectors. The connection at the property line (right-of-way) line is inspected and approved by the City Engineering Department.

“Building Water Service” shall mean the connection between any water supply mains, pipes, services and/or appurtenances, except meters, at the property line. It is considered an extension of the structure facilities, thus, is installed under the County’s plumbing and building codes and inspected and approved by County building inspectors. The connection at the property line (right-of-way) line is inspected and approved by the City Engineering Department.

“Capacity” shall mean the maximum rate of flow at which persons or vehicles can be reasonably expected to traverse a point or uniform segment of a lane or roadway during a specific time period under prevailing roadway, traffic, and control conditions; usually expressed as vehicles per hour (VPH) or persons per hours.

“Capture Rate” shall mean the percentage of the total number of trips from a site that are contained within on-site circulation systems only.

“City” shall mean the City of Marquette, Michigan and/or the duly authorized deputy, agent or representative.

“Clean Out” shall mean a small diameter pipe connected to the sanitary sewer lateral at the property line and as per plumbing code regulations and brought to the surface of the ground for maintenance access.

“Clean Water Act” shall mean the Federal Water Pollution Control Act, 33 USC Sec. 1251 et. seq., as amended, and applicable regulations promulgated there under.

“Clear-Vision Triangle” shall mean a triangular shaped zone formed by the existing or proposed curb lines of two or more intersecting streets, roads, or alleys and a third line connecting said curb lines at a specified distance in each direction from the point of curb line intersection, in order to provide vehicular traffic an unobstructed view of cross traffic at intersections.

“Collector Sanitary Sewer Main” shall mean the sewers constructed in a public street, alley or dedicated public easement that receives the waste discharged from the individual building service laterals. These sewers may serve one or more blocks before they discharge into larger interceptor sewers.

“Complete Street” shall mean a transportation policy and design approach that requires streets to be planned, designed, operated, and maintained to enable safe, convenient and comfortable travel and access for users of all ages and abilities regardless of their mode of transportation.

“Condominium Unit” shall mean that portion of a condominium project which is designed and intended for separate ownership and use, as described in the master deed, regardless of whether it is intended for residential, office, industrial, business, recreational, use as a time-share unit, or any other type of use. A condominium unit may consist of either vacant land or space which either encloses or is enclosed by a building structure. Any "condominium unit", or portion thereof, consisting of vacant land shall be equivalent to the term "lot" for the purposes of determining compliance of the condominium project with the provisions of these documents pertaining to minimum lot area, minimum lot width, minimum lot frontage, and maximum building coverage.

“Condominium Subdivision Plan” shall mean the drawings attached to the master deed for a condominium project which describes the size, location, area, horizontal and vertical boundaries and volume of each condominium unit contained in the condominium project, as well as the nature, location and size of common elements, and as subject to the provisions of Condominium Act 59 of 1978 and as amended.

“Control Points” shall mean a labeled on-site survey point with magnetic characteristics, the horizontal coordinates (Northing and Easting) of which are relative to the design site and Michigan State Plan Coordinates – North (2011), international foot ground distance, and the vertical coordinate of which is relative to the design site and the North American Vertical Datum of 1988 (NAVD 88) adjusted. The horizontal and vertical tolerance of $\pm$ 0.02 ft.

“Crash Rate” shall mean the number of crashes per a defined period of time or length of travel in a given segment of roadway.

“Curb Stop” shall mean the valve placed on a building service water supply pipe that is located at a “Customer Water Supply Outlet”.

“Customer Wastewater Disposal Outlet” shall mean either the outlet on the customer side of a “clean out” near the public easement or public right of way (in the case of a supply for a single building) or on the customer side of a manhole structure where the City of Marquette has allowed the use of a common outlet to serve special types of customers.

“Customer Water Supply Outlet” shall mean either the outlet on the customer side of a “curb stop” near the public easement or public right of way (in the case of a supply for a single building, irrigation system, fire protection system or similar use) or on the customer side of a master water meter where the City of Marquette has allowed the use of a master water meter to serve special types of customers.

“Culvert” shall mean a closed conduit such as a pipe designed for the conveyance of surface drainage water under a roadway, railroad, embankment or other impediment.

“Design Speed” shall mean the speed determined for design which takes into account the physical features of a street influencing vehicle operation; the maximum safe speed maintainable on a specified section of street when conditions permit design features to govern. Design speed is 5 to 10 mph higher than the posted speed limit to provide a factor of safety and allow for other conditions or uses of the street that may affect vehicle operation.

“Designer” shall mean the person or persons responsible for the creation and submission of contract documents or construction plans for the purpose of one-time construction of a facility. This person shall be a Michigan licensed professional engineer.

“Design Standards” are the applicable standards relevant to the planning, design and construction of infrastructure improvements or additions within the City, as adopted and contained in the City’s Design Standards Manual.

“Detached Sidewalk” shall mean a sidewalk that is offset from the curb.

“Developer” shall mean the private party or parties desiring to construct a public or private improvement within the City rights-of-way or easements, securing all required approvals and permits from the City, and assuming full and complete responsibility for the project.

“Development” or “Developer’s Project” or “Project” shall mean a specifically designated site being developed (or proposed for development) by a Developer.

“Developed Parcel” shall mean a parcel upon which man-made improvements have been made, such as buildings, roads, parking areas and lawns. Undeveloped areas include forested areas and property in its natural state, free of man-made improvements.

“Discharger” shall mean any individual, firm, partnership, association, public or private corporation or public agency or instrumentality or any other entity owning or in possession of a parcel of property which directly or indirectly impacts, influences or has an effect upon the storm water system.

“Ditch” or “Drainage Swale” shall mean an open channel used to transport water, groundwater, surface water run-off, or drainage water from any source.

“Driveway” shall mean a private access from a public or private roadway.

“Driveway Approach” shall mean the portion of the driveway lying in the public right-of-way or public access easement between the street gutter lip or roadway of a public street and the right-of-way or public access easement line, for the full width of the access, including both apron and side slopes.

“Dwelling Unit” shall mean a single unit providing complete, independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

“Distribution Mains” shall mean water mains connecting the transmission mains to the Service line connections. The distribution mains provide area-wide fire protection. Generally, the distribution mains will be in a grid or branched configuration.

“Earthwork” shall mean the removal of earth materials, clearing of vegetation, mass grading, filling, or re-grading of a site.

“Easement” shall mean a described area or parcel of land set aside or over which a liberty, privilege or advantage is granted by the owner to the public, a corporation, or some particular person or part of the public for specific uses and purposes, and shall be designated a "public" or "private" easement depending on the nature of the user.

“Engineer” is the City’s Engineer or other representative acting on behalf of the City in the administration of the City’s Design Standards Manual.

“Food Waste” shall mean solid wastes from the preparation, cooking and dispensing of food, and from the handling, storage, and sale of produce.

“Frontage” shall mean the distance along the street right-of-way line of a single property or development within the property lines. Corner property at an intersection would have a separate frontage along each street.

“Foundation Drain Service Pipe” shall mean a conveyance pipe that receives only foundation drain groundwater seepage, exclusive of directly and intentionally introduced surface water runoff.

“Final Plat” shall mean a map of all or part of a subdivision prepared and certified as to its accuracy by a registered engineer or land surveyor. Such maps must meet the requirements of the Plat Act, Public Act 288, as amended, and be suitable for recording by the County Register of Deeds.

“HMA” shall mean Hot Mix Asphalt

“ITE” shall mean Institute of Transportation Engineers.

“Improvements” shall mean all public or private improvements within City rights-of-way or easements.

“Interceptor Sanitary Sewer” are the mains that carry the waste discharged from one or more collector sanitary sewers to the ultimate point of disposal or treatment plant.

“ISO” shall mean the “Insurance Services Office”.

“Impervious Land Area” shall mean the surface area within a parcel that is covered by any material which retards or prevents the entry of water into the soil. Impervious Land Area includes, but is not limited to, surface areas covered by buildings, porches, patios, parking lots, driveways, walkways and other structures. In some cases, non-vegetative land areas shall be considered impervious.

“Intersection Level of Service (LOS)” shall mean the efficiency of traffic operations at a location is measured in terms of level of service (LOS), which is a description of traffic performance at intersections. The level of service concept is a measure of average operating conditions at intersections during an hour. It is based on volume-to-capacity (V/ C) ratio with the ability to carry (the capacity) compared to the level of traffic during the peak hours (volume). Levels range from A to F with A representing excellent (free-flow) conditions and F representing extreme congestion. Intersections with vehicular volumes, which are at or near capacity, experience greater congestion and longer vehicle delays.

“ITE Trip Generation” is the most widely used reference source, published by the Institute of Transportation Engineers (ITE) since 1976, for trip generation data, by traffic engineers and transportation planners for site level planning and analysis.

“Landscaping” shall mean the materials including, without limitation, grass, ground cover, shrubs, vines, trees, and non-living materials, commonly used in landscape development, as well as attendant irrigation systems.

“Land Developer” or “Developer” shall mean a person, firm, association, partnership, corporation or any other legal entity who intends to develop land by making various improvements to the land as described under “Site Improvements”.

“Land Development” or “The Development of Land” shall mean the reshaping of the land environment to provide for the elements or amenities associated with community living. Items considered as these elements or amenities include any of the items listed under the definition for “Site Improvements”.

“Lane Width” shall mean the width of a travel lane measured from the centerline of the lane striping to the centerline of the parallel lane stripe, or to the face of the curb, whichever is applicable.

“Lift” shall mean the maximum specified thickness of material that may be placed at one time.

“Lip” shall mean the outermost edge of the gutter pan.

“Lot” shall mean a parcel of land occupied or intended to be occupied by a main building or a group of such buildings and accessory buildings, or utilized for the principal use and uses accessory thereto, together with such yards and open spaces as are required under the provisions of the Zoning Ordinance. A lot may or may not be specifically designated as such on public records. Each such parcel shall also have its front line abutting a public street or a recorded public easement.

“ Level of Service (LOS)” shall mean a qualitative measure describing the operational conditions within a section of roadway or at an intersection that includes factors such as speed, travel time, ability to maneuver, traffic interruptions, delay and driver comfort. Level of service is described as a letter grade system (similar to a school grading system) where delay (in seconds) is equivalent to a certain letter grade from A through F.

“Marquette County Drain Commissioner” shall mean that person or agency responsible for drainage improvements under the jurisdiction of the State Drain Act, PA 40 of 1956, as amended.

“Master Plan” shall mean the comprehensive land use plan adopted by the City of Marquette Planning Commission pursuant to Act 285, Laws of 1931.

“Michigan Department of Environmental Quality” or “MDEQ” shall mean the State Agency which regulates water supply and wastewater disposal facilities in the State.

“Michigan Department of Transportation” or “MDOT” shall mean the State Agency which maintains the Michigan State Trunk line Highway System which includes all Interstate, US and state highways in Michigan with the exception of the Mackinac Bridge. Other responsibilities that fall under MDOT's mandate include airports, shipping and rail in Michigan.

“Multi-Use Path” shall mean any road or path that is designed for bicycle or pedestrian traffic, but not necessarily for their exclusive use. The pathway is physically separated from motorized vehicular traffic by open space or barriers and either within the City right-of-way or within an easement.

“MUTCD” shall mean the Manual on Uniform Traffic Control Devices.

“NFPA” shall mean the “National Fire Protection Association”.

“National Pollution Discharge Elimination System” or “NPDES” shall mean that system required by the State of Michigan to regulate treatment and discharge of storm water and/or wastewater to the waters of the State.

“NPDES Permit” or ”National Pollution Discharge Elimination System Permit” shall mean according to the Federal Water Pollution Control Act, as amended by Public Law 92-500, it prohibits any person from discharging pollutants into a waterway from a point source unless his discharge is authorized by a permit issued either by the U.S. Environmental Protection Agency or by an approved state agency.

“On-Site Retention” shall mean the withholding of all storm water from the system in an on-site area for a sufficient time to provide for it to dissipate by evaporation, infiltration into the soil, or other natural means in which no connection is made to the storm water system directly or indirectly.

“On-Site Detention” shall mean any facility employed to reduce the rate of storm water discharge from a property to the storm water system.

“Ordinance” shall mean a law established by the City’s Governing Body.

“Open Drain” shall mean a large open channel used to transport water, groundwater, surface water runoff or drainage water from any source.

“Parcel” shall mean a designated lot, tract or other area of land established by plat, subdivision, tax record description or as otherwise permitted or existing by law.

“Parking Lot Bay” shall mean a portion of the width of a parking lot which includes a set of parking stalls on either side of a driveway provided for access to such parking stalls.

“Parking Lot” shall mean a designated area used primarily for the off-street parking of motor vehicles.

“Parking Stall” shall mean a defined area for the storage or parking of a single permitted vehicle.

“Pass-By Trips” shall mean trips that are attracted to a site from existing traffic passing the site on the adjacent street or roadway that provides direct access to the site.

“Peak Hour” shall mean the single hour of a representative day when the traffic volume on the highway or roadway represents the most critical period for operation and the highest typical capacity requirements.

“Peak Hour Factor (PHF)” shall be the ratio of the hourly volume to four times the peak 15-minute volume.

“Peak Hour of Generator” shall be the single hour of highest volume of traffic entering and exiting a site.

“Person” shall mean an individual, firm, partnership, association, public or private corporation, or public agency or instrumentality or any other entity.

“Pervious Land Area” shall mean all surface area within a parcel which is not Impervious Land Area.

“Planning Commission” shall mean the City Planning Commission of the City of Marquette.

“Plot Plan” shall mean a scaled topographic drawing of existing and proposed modifications to land utilized for or zoned for single and duplex residential dwelling.

“Preliminary Subdivision Plan” shall mean a preliminary plat showing the salient features of a proposed subdivision of land submitted to an approving authority for purposes of preliminary consideration, as defined in Act No. 288 of Michigan Public Acts of 1967 as amended.

“Pollutant” shall mean any substance defined as a pollutant under the Clean Water Act.

“Precipitation Event” shall mean any occurrence of atmospheric precipitation of water which can be characterized as a separate storm event. The terms rain, rainstorm, rainfall, snow, snowstorm, sleet, hailstorm, etc., shall be considered synonymous with the term precipitation event.

“Public Sanitary Sewer” shall mean a sanitary sewer owned and operated by a governmental agency intended to be located in public easements or public right of way that collects, or is intended to collect wastewater from more than one user or premises and that is required to receive the approval and issuance of a construction permit from the Municipal Wastewater Control Section of the MDEQ.

“Public Water Main” shall mean a main, existing or proposed, in public easements or public rights of way that is intended to serve more than one user or premises and that is required to receive the approval and issuance of a construction permit from the Municipal Water Supply Section of the Michigan Department of Environmental Quality.

“Public Walkway” shall mean a right of way dedicated for the purpose of a pedestrian access through residential areas, and located so as to connect to two or more streets, or a street and a public land parcel.

“Public Utility” shall mean a firm, corporation, or municipal authority providing gas, electricity, telecommunication services, cable, sewer, water or other services of a similar nature.

“Recyclables” shall mean those materials that are separated or diverted from the mixed solid waste stream for the purposes of processing it or causing it to be processed into a material product, including the production of compost, in order to provide for disposition of the item or items in a manner, other than incineration or land filling, which will best protect the environment.

“Right of Way” or “ROW” shall mean land dedicated, reserved, used or to be used for a street, utilities, alley, walkway or other public purposes.

“Roadway” shall mean the portion of the highway, arterial, collector, or local street, including shoulders, intended for vehicle and/or bicycle use.

“Sanitary Sewer Lateral” shall mean the sewer connection between the property line and the sewer main in the street or dedicated public easement, including the sewer main connection and it is considered a private line, thus is installed under City standards, inspected, and approved by the Engineering Department and Department of Public Works.

“Sanitary Sewer Lift Station” shall mean any arrangement of pumps, valves and controls that lift, and/or convey wastewater to a higher elevation. Same as Pump Station.

“Sanitary Sewer Main” or “Wastewater Sewer Main” shall mean a sewer pipe with a diameter of six (6) inches or larger, that carries liquid and water carried wastes from multiple residences, commercial buildings, industrial plants and institutions, together with minor quantities of ground, storm and surface waters that are not admitted intentionally.

“Scoping Meeting” shall mean a required meeting for the Applicant and Applicant’s traffic engineer to review all the requirements for a Transportation Impact Study.

“Service Line” shall mean a pipe or conduit connected to a water main, which is intended to deliver water from the public water supply system to the customer’s property for their own consumption or use.

“Sewage Force Main” or “Force Main” shall mean a wastewater conveyance pipe which carries wastewater under pressure.

“Sewer” shall mean a pipe or conduit that carries wastewater or drainage water.

“Sanitary Sewer System” shall mean a term to describe the entire system of sanitary sewer mains, valves, pumps, and other appurtenances owned by the City of Marquette which are intended to dispose and treat sewage for all the customers of the system.

“Sharrow” shall mean a bicycle symbol that is placed in the roadway lane to indicate that motorists should expect to see and share the lane with bicycles. Unlike bicycle lanes, they do not designate a particular part of the roadways for the exclusive use of bicycles.

“Sidewalks” shall mean paved or otherwise improved area for pedestrian use, located within the public street rights-of-way that also contain roadway for vehicular traffic.

“Sight Distance” shall mean the unobstructed straight line length of view from a driver’s eye height to an object height.

“Site Improvements” or “Improvements” shall mean such operations, acts of construction or changes affecting land that increases the value, utility or habitability of the site and including, but not limited to, site grading; drainage water sewers, culverts or drains; sanitary sewers; wastewater disposal facilities; water supply piping; water supply facilities; gas piping; oil piping; television cable; electric power supply wiring; telephone wiring; roadway surfacing or paving; parking lot paving; driveways; bridges; lakes, ponds, or lagoons; sidewalks; landscape walls and fences, and/or other appropriate appurtenant items.

“Site Plan” shall mean the plan required under the City of Marquette’s Zoning Ordinance for “Site Plan Review” for all projects other than a land subdivision plat. Such plan shall meet zoning compliance requirements.

“Stopping Sight Distance” shall mean the distance required by the driver of a vehicle traveling at the design speed to bring the vehicle to a stop after an object on the road becomes visible. This distance is measured from the driver’s eye, 3.5 feet above the pavement to the top of an object 6 inches high on the pavement anywhere on the roadway.

“Storm Water” shall mean the runoff and drainage of precipitation resulting from rainfall or snowmelt or similar precipitation event.

“Storm Water Drain” or “Storm Drain” or “Storm Sewer” shall mean a watercourse or a sewer intended for the conveyance of water, groundwater, surface water runoff, drainage water or other water from any source, exclusive of intentionally admitted wastewater.

“Storm Water Facilities” shall mean any storm sewers, lakes, ponds, streams, rivers or storm drains, ditches, swales, storm water treatment units, retention/detention facilities, wetlands, including facilities designated as County Drains that receive water from lands owned by more than one Owner.

“Storm Water Inlet Structure” shall mean a structure designed and constructed to intentionally admit surface water runoff, drainage water or other water from any source, exclusive of intentionally admitted wastewater.

“Storm Outlet” shall mean any drainage water outlet, including storm drains and sewers into a watercourse, pond, ditch, lake, other body of surface water, or groundwater.

“Storm Water System or Systems” shall mean all rivers, streams, tributaries and lakes, including Lake Superior, within the City limits of the City of Marquette and all City owned storm sewers, ditches, swales, culverts, retention and detention facilities, lift stations, curbs, gutters, and all other appurtenances now and thereafter existing, used or useful, in connection with the collection, control, transportation, treatment, or discharge of storm water. The storm water system does not include sewers or facilities connected with the sanitary sewage disposal system, or streets.

“Street” shall mean a right of way dedicated to public use, which provides vehicular and pedestrian access to adjacent abutting properties by the general public whether designated as a street, highway, thoroughfare, parkway, road, avenue, lane, or however otherwise designated, and including the land between the right-of-way lines whether improved or unimproved and may comprise pavement, curbs and gutters, shoulders, sidewalks, parking areas, lawn areas and other areas within the right-of-way lines.

1. “Street, public” shall mean a right of way that provides for vehicular and pedestrian access to abutting properties that is deeded or dedicated to the City or other governmental agency authorized to own road right of way and/or operate vehicular transportation facilities.

2. “Street, private” shall mean a right of way or easement that provides for vehicular and pedestrian access to abutting properties for the general public, but is not deeded or dedicated to a governmental agency for ownership, operation or maintenance. The landowners of the property served by the private street are responsible for its maintenance.

3. “Street, major” shall mean streets meeting one or more of the following:

    a. Any street designated as a major street pursuant to Act 51 of the public Acts of 1951.

    b. Streets that provide extensions to State Trunk Lines or County Primary Roads in facilitating through traffic.

    c. Streets that provide an integral network to service the traffic demands created by industrial, commercial, educational or other traffic generating centers.

    d. Streets that provide for the circulation of traffic in and around the central business district.

    e. Streets that are designated truck routes.

    f. Streets that collect traffic from an area served by an extensive network of local streets.

4. “Street, local” shall mean streets not meeting any of the criteria from major streets.

“Subdivision” shall mean any land which is divided or proposed to be divided into two (2) or more lots, parcels, sites, units, or plots, for the purpose of offer, sale, lease, or development, upon any terms and conditions including re-subdivision. This definition includes the division of land, whether recorded or unrecorded, by deed, condominium master deed, metes and bounds description, devise, lease, map, or other instrument. For the purpose of this manual a subdivision may include but is not limited to a platted subdivision as subject to the provisions of the Land Division Act, as amended.

“Surface Water Runoff” shall mean that part of rainfall or melting snowfall that reaches the stormwater drain as runoff from natural land surfaces, building roofs or pavements.

"Superintendent" shall mean the Superintendent of Public Works of the City, or his authorized deputy, agent, or representative.

“Traffic Impact” shall mean the effect of site traffic on highway and/or roadway operations and safety.

“Traffic Impact Analysis” shall be a traffic engineering study which determines the potential traffic impacts of a proposed traffic generator. A complete analysis includes an estimation of future traffic with and without the proposed generator, analysis of the traffic impacts, and recommended roadway improvements which may be necessary to accommodate the expected traffic.

“Traffic Generation” shall mean the estimation of the number of origins from and destinations to a site resulting from the land use activity on that site.

“Traffic Generator” shall mean a designated land use (residential, commercial, office, industrial, etc.) or change in land use that generates vehicular and/or pedestrian traffic to and from the site.

“Traffic Mitigation” shall mean the reduction of traffic impacts on roadways and/or intersections to an acceptable level of service by way of roadway construction improvements, the upgrade of existing traffic control devices, or the modification of the site.

“Traffic Volume” shall mean the number of vehicles passing a point on a highway during aspecific time period.

“Transportation Impact Study” shall mean the analyses of the impact of development conducted under the supervision of a registered Professional Engineer to determine the full impact of proposed development on the transportation system.

“Trip” shall mean a single or one way directional movement. Transportation engineers & planners refer to trips as “internal,” “external,” or “through.” Internal trips have both origin and destination within a particular projects area. External trips have only one end within the project area. Through trips neither originate or end within the analysis area, but pass through it.

“Trip Distribution” shall mean the allocation of the site-generated traffic among all possible approach and departure routes.

"Transmission Mains" shall mean large diameter mains connecting the water treatment plant with the water distribution mains.

"Underdrain Pipe" shall mean a geotextile wrapped perforated pipe installed underground for the specific purpose of lowering a high groundwater condition or draining a granular subbase by receiving groundwater seepage and conveying it to a stormwater drain.

"Unpolluted Water" or "Drainage Water" is water of a quality equal to or better than the effluent criteria currently in effect, as specified by the MDEQ, or water that would not cause violation of receiving water quality standards and would not be benefited by discharge to the City sanitary sewers and wastewater disposal system.

"Urban Principal Arterial" shall mean a street that serves the major centers of activity of urbanized areas, the highest traffic volume corridors, and the longest trip desires and carries a high proportion of the total urban area travel on minimum mileage.

The principal arterial system carries most of the trips entering and leaving the urban area, as well as most of the through movements bypassing the central city. In addition, this class of facility serves significant intra-area travel, such as between central business districts and outlying residential areas, between major inner-city communities, and between major suburban centers.

"Urban Minor Arterial" shall mean a street that interconnects with and augments the urban principal arterial system. It accommodates trips of moderate length at a somewhat lower level of travel mobility than principal arterials do. This system distributes travel to geographic areas smaller than those identified with the higher system.

The minor arterial street system includes all arterials not classified as principal. This system places more emphasis on land access than the higher system does and offers lower traffic mobility. Such a facility may carry local bus routes and provide intra-community continuity, but ideally does not penetrate identifiable neighborhoods.

"Urban Collector" shall mean a street that provides both land access service and traffic circulation within residential neighborhoods and commercial and industrial areas. It differs from the arterial system in that facilities on the collector system may penetrate residential neighborhoods, distributing trips from the arterials through the area to their ultimate destinations. Conversely, the collector street also collects traffic from local streets in neighborhoods and channels it into the arterial system.

"Urban Local" shall mean a street that comprises all facilities not on one of the higher street classifications. It primarily permits direct access to abutting lands and connections to the higher order systems. It offers the lowest level of mobility. Service to through-traffic movement usually is deliberately discouraged.

"User" shall mean the owner or occupant of any premises connected with and/or using any of the facilities operated by the City of Marquette.

“U.S. EPA” or “The United States Environmental Protection Agency” shall mean the Federal Agency which assures the protection of the environment by abating or controlling pollution on a systematic basis.

“Water Distribution System” shall mean a term to describe the entire system of water mains, sub mains, valves, pumps, fire hydrants, tanks, and other appurtenances owned by the City of Marquette which are intended to supply and deliver water to all the customers of the system.

“Water Mains” as applied to the water supply facilities and connections thereto, shall mean any water supply conveyance pipe larger than four (4) inches in diameter.

“Water Tap” shall mean a device, such as a corporation stop or tapping valve, which is installed on a water main by the City Water Department pursuant to a tapping permit and providing a point of connection for a customer water supply outlet.

DESIGN CRITERIA MANUALS

SPECIFIC DESIGN CRITERIA:

The design engineer shall prepare construction drawings not only in conformance to City requirements and accepted engineering practice, but also with consideration of future maintenance and operational concerns.

The following are specific criteria the design engineer shall use in his/her design. Where conflict exists between State or Federal codes and City criteria, the more restrictive shall govern. The criteria below and following checklists are intended as a guide for the design engineer and are not intended to be an exhaustive list. All items may not apply in all cases.

DESIGN CRITERIA REFERENCE MANUALS AND PUBLICATIONS:

The following Reference Manuals and Publications are included as if copied at length herein and shall govern design and construction of all public improvements. Where there is any conflict between any of the criteria in the Reference Manuals and Publications listed below and other criteria contained herein, whichever imposes the more stringent restrictions shall prevail. Reference Manuals and Publications shall be the current publication.

1. City of Marquette Codes and Ordinances
2. City of Marquette General Requirements and Covenants
3. City of Marquette Special Provisions
4. City of Marquette Supplemental Specifications
5. City of Marquette Standard Plans and Specifications
6. City of Marquette Master Plan
7. Michigan Department of Transportation Standard Specifications for Construction
8. AASHTO "A Policy on Geometric Design of Highways and Streets"
9. Great Lakes – Upper Mississippi River board of State and Provincial Public Health and Environmental Managers "Recommended Standards for Wastewater Facilities"
10. Great Lakes – Upper Mississippi River board of State and Provincial Public Health and Environmental Managers "Recommended Standards for Water Works"
11. AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
12. Americans with Disabilities Act Accessibility Guidelines
13. Michigan Manual on Uniform Traffic Control Devices
14. The Natural Resources Conservation Service Technical Release 55 (TR55) and Technical Release 20 (TR20) Urban Hydrology for Small Watersheds
15. American Water Works Association Standards
16. Michigan Department of Environmental Quality (Safe Water Drinking Water Act)
17. AASHTO Guide for the Development of Bicycle Facilities (Current Publication)
18. AASHTO Guide Specifications for Design of Pedestrian Bridges
19. Environmental Protection Agency Federal Water Pollution Control Act (known as the Clean Water Act
20. Michigan Department of Environmental Quality Guidebook of Best Management Practices for Michigan Watersheds

21. Michigan Building Code
22. Michigan Residential Code
23. Federal Highway Administration “Roundabouts An Informational Guide”
24. Institute of Transportation Engineers “Trip Generation Manual”

CONSTRUCTION PLAN CRITERIA AND CHECKLIST

GENERAL:

1. Plans shall be sealed and signed by the professional engineer or architect that prepared the plans or directly supervised the preparation of the plans. The professional engineer or architect shall be licensed in the State of Michigan.

2. An acceptance block shall be provided (usually on the cover sheet) on each set of plans in the following form:

   REVIEWED FOR COMPLIANCE:

   ____

   CITY OF MARQUETTE, MICHIGAN DATE
   CITY ENGINEER

   Review is for general compliance with the City of Marquette Engineering Department "General Guidelines and Standards for Street and Utility Design" and "Standard Specifications" for the design and construction of public infrastructure improvements. Sole responsibility for completeness and/or accuracy of these Documents shall remain with the Registered Professional Engineer sealing these Plans. The City does not accept liability for facilities designed by others.

3. The following statement shall be included (usually on the cover sheet) on each set of plans:

   STATE OF MICHIGAN
   COUNTY OF MARQUETTE

   I, (Licensed Professional Engineer/Architect), do hereby certify that the underground infrastructure, drainage improvements, and site Improvements described herein have been designed in compliance with the Local and State subdivision and building regulation ordinances, County building regulations, City of Marquette zoning ordinance, State and Federal Requirements, and storm water drainage and management policy adopted by the City of Marquette, Michigan.

   (Seal & Signature of Professional Engineer/Architect)

   ____

   DATE

4. Each cover sheet shall clearly indicate the project name, parcel(s) legal description and/or parcel identification number, location, consultant's name, owner's name and the type of plans included.

5. Each cover sheet shall have a legible index listing the included drawings.

6. Each cover sheet shall have a legible location map and legend.

7. All City of Marquette construction plan notes shall be included on the plans. All notes may not be appropriate in all cases and the Design Engineer should consult with City Engineering Department regarding specific deletions.

8. A copy of the preliminary plat or lot layout shall be included in each set of construction drawings. A copy of the recorded dedicated rights of ways or public easements shall be substituted upon submission of "As-built" plans prior to acceptance by the City for infrastructure ownership or maintenance.

9. All site plans will be "As –Built" when construction is complete and a copy will be submitted to the City of Marquette Engineering Department in a CAD.dwg format.

Street, Drainage and Grading Construction Plans shall address the following general aspects of the project. Specific guidelines are listed on the checklist included at the end of this section.

1. Erosion and sedimentation control.
2. Storm water management.
2. Overall drainage and grading.
3. Street plan, profiles and cross sections.
4. Storm sewer main and appurtenances plan and profiles.
5. Channel plan, cross sections, and profiles.
6. City of Marquette Standard and site specific details.
7. Sidewalk ramp and driveway apron minimum and maximum slopes as recognized by the City of Marquette Engineering Department.
8. Any State, Local, and Federal permitting requirements.

Water and Wastewater Construction Plans shall address the following general aspects of the project. Specific guidelines are listed on the checklist included at the end of this section.

1. Water main and appurtenances layout (plan view).
2. Water main profiles.
3. Water service layout (plan view).
4. Wastewater (sanitary sewer) main and appurtenances layout (plan view).
5. Wastewater (sanitary sewer) main profiles.
6. Sanitary sewer lateral layout (plan view).
7. City of Marquette Standard and site specific details.
8. Any State, Local, and Federal permitting requirements.

CHECKLIST

Existing Site Plan:

- ☐ Min scale 1"=20' for sites 2 acres or less, 1”=50’ for sites 2 to 5 acres, and 1” = 100’ for sites over 5 acres. Appropriate size to show sufficient and legible detail.
- ☐ Parcel boundary lines of the property with dimensions and area (recorded/measured/or calculated dimensions)
- ☐ Minimum of 2 control points. (Refer to “Control Point” definition)
- ☐ Location, width and identification of existing easements (both public and private).
- ☐ Existing contours 2 ft. min.
- ☐ Existing buildings, trees, landscaping, structures, driveways (on-site, adjacent to proposed development, and across adjacent public rights-of-way), parking and loading areas, outdoor storage areas, fire lanes, and any other manmade features.
- ☐ All adjacent and on-site streets, including dedicated right-of-way width, pavement widths, curb and gutter locations, sidewalks and curb ramps.
- ☐ Street names, proposed or existing.
- ☐ North Arrow and Legend
- ☐ Within and/or adjacent to property: existing municipal utilities including light poles, water and sewer mains, service lines, connections, curb stops and valves, manholes, hydrants, inlets, and any other storm water facilities (location and size).
- ☐ Within and/or adjacent to property: existing public utilities including electric, gas, cable, and telephone.
- ☐ The boundaries of any floodway, floodway fringe, 100-year floodplain, streams and/or wetlands.
- ☐ Standard sheet size will be 24” x 36” max.

Erosion and Sedimentation Control Plan:

- ☐ Min scale 1"=20' for sites 2 acres or less, 1”=50’ for sites 2 to 5 acres, and 1” = 100’ for sites over 5 acres. Appropriate size to show sufficient and legible detail.
- ☐ Existing contours 2 ft. min.
- ☐ Proposed contours 2 ft. min.
- ☐ Project boundaries
- ☐ Existing drainage facilities
- ☐ Proposed streets and drainage facilities
- ☐ Location / limits of proposed control
- ☐ Street names
- ☐ North arrow
- ☐ Legend
- ☐ The boundaries of any floodway, floodway fringe, 100-year floodplain, streams and/or wetlands.
- ☐ Pertinent permit has been processed for application.
- ☐ Applicable Soil Erosion and Sedimentation Control Measure Key System shown on the plans.

Overall Drainage Plan and Pertinent Calculations:

☐ Min. scale 1"=20' for sites 2 acres or less, 1”=50’ for sites 2 to 5 acres, and 1” = 100’ for sites over 5 acres. Appropriate size to show sufficient and legible detail.
☐ Existing contours 2 ft. min.
☐ Proposed contours 2 ft. min.
☐ Existing and proposed drainage structures and facilities
☐ The boundaries of any floodway, floodway fringe, 100-year floodplain, streams and/or wetlands.
☐ Project boundaries
☐ Street names
☐ Line designations
☐ Legend
☐ Pre and Post developed flows
☐ North arrow
☐ Drainage area boundaries
☐ Areas in square feet or acres
☐ $Q_{10\text{ yr.} - 24\text{ hr.}}$ per the design standards in the Storm Sewer Design Standards Section
☐ $Q_{100\text{ yr.} - 24\text{ hr.}}$ per the design standards in Storm Sewer Design Standards Section
☐ Flow Arrows
☐ Pertinent permit has been processed for application.

Note: Submit drainage data (calculations, hydrographs, etc.) separately (ie. on 8½ x 11 sheets) that are sealed and signed by the design engineer. Synopsis of pertinent data shall be included on the plans.

Street Plan and Profiles:

☐ Min. scale 1"=20'H, 1"=5'V
☐ Street name
☐ Existing ground, building, misc. structures, utilities, etc. locations. Retaining wall locations if in right of way or easement.
☐ Proposed Street curb lines, sidewalks, center lines and widths
☐ ROW lines and widths
☐ Lot lines
☐ Lot numbers
☐ Line designations
☐ Stationing of all points of curvature/tangency
☐ Flow arrows
☐ Horizontal curve data
☐ Existing ground profiles
☐ Proposed top of right and left curb profiles with grades (Elevations every 25' max.) where public utilities are present.
☐ Proposed centerline profile with grades (Elevations every 25' max.) where public utilities are present.
☐ Vertical curve data
☐ Sight distance and stopping distance when applicable
☐ Legend and North Arrow

- ☐ Match lines with stationing
- ☐ Miss Dig Statement (Plan View)
- ☐ Pertinent permit has been processed for application
- ☐ Soil boring locations and data.
- ☐ Bedrock profile if applicable

Storm Sewer Plan and Profiles:

Note: Storm sewer plan and profiles may be included on street plan and profiles.

- ☐ Min. scale 1"=20'H, 1"=5'V
- ☐ Stationing, Alignment/Assignment (Proposed and Existing)
- ☐ Horizontal and vertical curve data
- ☐ Inlets, Catch Basins (w/top and invert elevations in profile) (Proposed and Existing)
- ☐ Manholes (w/top and invert elevations in profile) (Proposed and Existing)
- ☐ Headwalls/endwalls (Proposed and Existing)
- ☐ Pipe sizes (Proposed and Existing)
- ☐ Pipe lengths (Proposed)
- ☐ Pipe materials (Proposed and Existing)
- ☐ Pipe Slopes (Proposed)
- ☐ Line designations
- ☐ Proposed and existing ground at piping location
- ☐ Water/wastewater crossings (Proposed and Existing)
- ☐ Existing public utilities including electric, gas, cable, and telephone. Call out any potential conflict points
- ☐ Design flows
- ☐ North Arrow and Legend
- ☐ Street names
- ☐ Street curb lines
- ☐ ROW lines
- ☐ Lot Numbers
- ☐ Pertinent permit has been processed for application.
- ☐ Channel cross-sections
- ☐ Existing ground profiles
- ☐ Proposed Flow line profile
- ☐ Proposed Top of bank profiles
- ☐ Culvert crossing details
- ☐ Easements
- ☐ Proposed channel material (sod, riprap, concrete, etc.)
- ☐ Proposed bank stabilization
- ☐ Outlet discharge volume
- ☐ Flood plain, stream channel, and wetland locations when applicable
- ☐ Soil boring locations and data
- ☐ Bedrock profile if applicable

Detention/Retention Basin Plans:

- ☐ Required Volume/Release Rate
- ☐ Basin Volume Provided
- ☐ Side Slopes including surface treatments.
- ☐ Overflow Spillway & Emergency Overflow Floodway Details
- ☐ Basin outlet and inlet details
- ☐ Minimum Basement Floor Elevations & Minimum Building Opening Elevations Established
- ☐ Subsurface Storage details (if applicable)
- ☐ Basin minimum freeboard elevation
- ☐ Dam/berm typical cross section details
- ☐ Drawdown pipe details if applicable
- ☐ Proposed contour lines and drainage patterns (Flow arrows)
- ☐ Most Current FEMA flood zone delineation if applicable
- ☐ Proposed vegetation and landscaping for detention area

Grading Plans:

- ☐ Min. scale 1"=20' for sites 2 acres or less, 1”=50’ for sites 2 to 5 acres, and 1” = 100’ for sites over 5 acres. Appropriate size to show sufficient detail
- ☐ Existing 2 ft. (min.) contours and lot corner elevations for 1 acre or greater
- ☐ Proposed 2 ft. (min.) contours and lot corner elevations for 1 acre or greater
- ☐ Proposed top of curb or edge of metal elevations
- ☐ Proposed swales and typical cross sections
- ☐ Drainage area boundaries from overall drainage plan
- ☐ North arrow
- ☐ Street names
- ☐ Flow arrows
- ☐ Line designations
- ☐ Legend
- ☐ Fill/compaction specifications
- ☐ Pertinent permit has been processed for application.

Standard Details (Streets, Sidewalks & Drainage):
Use City of Marquette Standard Details unless specific details are warranted or standard details are not provided. If standard details are not provided refer to the State of Michigan.

- ☐ Street cross-sections
- ☐ Curb and gutter
- ☐ Manholes
- ☐ Inlets, Catch Basins
- ☐ Erosion & Sedimentation controls
- ☐ Barricades
- ☐ Sidewalk and curb ramps
- ☐ Storm sewer bedding
- ☐ Headwalls/endwalls/retaining walls

- ☐ Driveway
- ☐ ADA Details per current City of State specifications
- ☐ Typical swale cross sections

Water Layout Plan: (Maybe Included with Sanitary Sewer and Road Plans as Appropriate)

- ☐ Min. scale 1"=20
- ☐ ROW lines and dimensions
- ☐ Lot lines
- ☐ Lot numbers
- ☐ Street names
- ☐ North Arrow
- ☐ Existing mains
- ☐ Existing public utilities including electric, gas, cable, and telephone. Call out any potential conflict points
- ☐ Proposed mains w/stationing at structures
- ☐ Main length, sizes and materials
- ☐ Typical ground cover requirements over top of main/services
- ☐ Valves
- ☐ Fittings
- ☐ Misc. structures, meter pits, PRV structures, check valve structures, etc.
- ☐ Fire hydrants
- ☐ Services
- ☐ Taps/connections
- ☐ Easements and widths
- ☐ Main designations with stationing
- ☐ Curve data
- ☐ Design maximum and minimum pressure
- ☐ Culverts, bridges, retaining walls and other structures
- ☐ Lateral Table showing Sizes matched to address
- ☐ Stubs for future areas
- ☐ Special utility crossing details

Water Main Profiles:

- ☐ All existing mains 4" or larger than and proposed mains
- ☐ Min. scale 1"=20' H, 1"=5'V
- ☐ Existing ground at the centerline of the main
- ☐ Proposed finished ground elevation at the centerline of the main or in the profile (right, center, left) that is closest to the main location.
- ☐ Wastewater/storm sewer crossings with stations and elevations
- ☐ Existing public utility crossings including electric, gas, cable, and telephone. Call out any potential conflict points
- ☐ Main stationing, lengths, sizes and grades (w/stationing and elevations of all starting/ending points, crosses, tees, intersections, valves, hydrants, etc.)
- ☐ Culverts, bridges, retaining walls with stations and elevations
- ☐ Place note or dimension that specifies that the minimum cover over the water main shall be 6.5 feet in a roadway.

- ☐ Soil boring locations and data
- ☐ Bedrock profile if applicable

Wastewater (Sanitary Sewer) Layout:

- ☐ Min. scale 1"=20'
- ☐ ROW lines
- ☐ Lot lines
- ☐ Lot numbers
- ☐ Street names
- ☐ Existing mains, sizes, materials, and line designations
- ☐ Existing public utilities including electric, gas, cable, and telephone. Call out any potential conflict points
- ☐ Proposed mains w/stationing, lengths, sizes, and line designations
- ☐ Existing and Proposed Manholes w/stationing
- ☐ Cleanouts
- ☐ Existing contours (lighter color and line type designations)
- ☐ Laterals
- ☐ Lateral Table showing Sizes matched to address
- ☐ Easements
- ☐ Stubs for future areas

Wastewater (Sanitary Sewer) Main Profiles:

- ☐ All mains
- ☐ Min. scale 1"=20' H, 1"=5'V
- ☐ Existing ground (as appropriate)
- ☐ Existing public utility crossings including electric, gas, cable, and telephone. Call out any potential conflict points
- ☐ Proposed finished ground elevation at the centerline of the main or in the profile (right, center, left) that is closest to the main location.
- ☐ Main sizes
- ☐ Main grades, materials & lengths
- ☐ Manhole rim and invert elevations.
- ☐ Cleanouts
- ☐ Water/storm sewer crossings
- ☐ Stationing and Manhole numbers
- ☐ Soil boring locations and data
- ☐ Bedrock profile if applicable

Standard Details (Water & Wastewater):
Use City of Marquette Standard Details unless specific details are warranted or standard details are not provided. If standard details are not provided refer to the State of Michigan.

- ☐ Water/wastewater bedding
- ☐ Water service
- ☐ Wastewater lateral
- ☐ Manhole

☐ Drop manhole
☐ Cleanout
☐ Fire hydrant installation
☐ Valve installation
☐ Water Main Casing if required
☐ Valve box assembly
☐ Water main and fitting restraint schedule
☐ Trench Details

Traffic Control Plans and Details:

☐ ROW lines
☐ Street names
☐ Full road closures require detour and resident/business notification. Full road closures may only be used when there are no other types of traffic control feasible for the work involved.
☐ Show the exact location of the work zone and how it is to be protected (e.g. barricades, drums, signing, etc.) during construction.
☐ If work is done in phases, submit a separate traffic control plan for each phase.
☐ If using a Flashing Arrow Board include its size, panel display and location on the traffic control plan.
☐ Flaggers should be identified where required with their position shown on the the traffic control plan.
☐ Show dimensions, types, and locations of all channelizing devices, warning lights, signing, portable barriers. All devices must meet the criteria in the Michigan Manual on Uniform Traffic Control Devices and City of Marquette Standards.
☐ Include location of all existing and proposed traffic signals and traffic signal detection devices within the traffic control area.
☐ Pedestrians/Bicyclists must have a safe route to walk/ride through or around work area whenever appropriate. Show all pedestrian/bicycle entry, paths and exits. Clearly show description and location of all traffic control devices, including fences and barricades, within the pedestrian's/bicyclist's safe route to walk/ride on the traffic control plan.
☐ Detour Route (Location and size of temporary signing and control devices)
☐ Proposed traffic markings and signing

CONSTRUCTION PLAN NOTES

(These shall appear on the plans as written provided the plans dictate their use)

GENERAL NOTES:

1. Except where otherwise indicated on these plans or in the proposal and supplemental specifications contained therein, all materials and workmanship shall be in accordance with the Michigan Department of Transportation Standard Specifications for Construction, the Michigan Manual of Uniform Traffic Control Devices, and the City of Marquette Standard Specifications.

2. The proposed improvements covered by these plans are in accordance with the AASHTO; A Policy on Geometric Design of Roads and Streets, or per the City of Marquette Engineering Department General Guidelines for Street and Utility Design Standards.

3. Any existing utilities, pavement, curbs, sidewalks, structures, trees, etc., not planned for demolition or removal that are damaged or removed shall be repaired or replaced at the Contractor's expense.

4. The Contractor shall verify all depths and locations of existing utilities prior to any construction. Any discrepancies with the construction plans found in the field shall be brought immediately to the attention of the Developer's Engineer who shall be responsible for revising the plans as appropriate. All revisions shall be brought to the attention of the City Engineer. Plan revisions may need Zoning Administrator and City Engineer approval.

5. Manhole frames, covers, valves, cleanouts, etc. shall be raised to finished grade prior to final paving construction per City of Marquette Standard Details.

6. All areas disturbed or exposed during construction shall be revegetated in accordance with the plans and specifications. However, the type of revegetation must equal or exceed the type of vegetation present before construction.

7. Prior to any construction, a preconstruction conference between the City of Marquette, the Developer, the Contractor, utility companies, any affected parties, and any other entity the City or Developer may require shall convene.

8. The Developer or his/her designated agent shall keep accurate records of all Construction that deviates from the plans. The Developer or his/her designated agent shall furnish the City of Marquette accurate "As-Built" drawings following completion of all construction. These "As-Built" drawings shall meet with the satisfaction of the City Engineering Department prior to final acceptance. Final "As-Builts" drawings shall be delivered to the City Engineering Department in paper form and on a CD/DVD in CAD.dwg format.

9. The City of Marquette City Commission shall not be petitioned for acceptance until all necessary easement and/or right of way deed documents have been signed and recorded, and all materials, piping, structures have been inspected and tested to the City Engineers approval.

10. All utility construction work to be accepted by the City of Marquette into their utility system and all work done in public rights of way or easements must be done in accordance with Michigan Department of Transportation and City of Marquette standards and specifications.

11. When construction is being carried out within easements, the Contractor shall confine his work to within the permanent and any temporary easements. Prior to final acceptance, the Contractor shall be responsible for removing all trash and debris within the permanent and temporary easements. Clean-up shall be to the satisfaction of the City Engineer.

12. Prior to any construction, the Developer or his/her designated agent shall apply for and secure all proper permits from the appropriate authorities, such as, but not limited to, the City of Marquette, Michigan Department of Environmental Quality, County of Marquette, etc.

13. Construction inspection shall be performed by the City of Marquette for infrastructure that will be dedicated to the City for public use. Contractor shall provide 72 hour notice of construction activities.

PROJECT SAFETY NOTES:

1. Project safety shall be in accordance with the Laws of the State of Michigan and the Michigan Occupational Safety and Health Administration's current regulations.

STREET AND DRAINAGE NOTES:

1. All field testing shall be done by an independent laboratory at the Owner's expense. Any retesting shall be paid for by the Contractor. A City inspector shall be present during all tests. Testing shall be coordinated with the City's inspector and he/she shall be given a minimum of 2 business days notice prior to any testing.

2. Backfill behind the curb shall be compacted to obtain a minimum of 95% maximum density to within 5" of the top of curb. Backfill material used shall be MDOT Class II. The remaining backfill behind the curb shall be 4" of clean topsoil free from all clods and suitable for sustaining plant life.

3. Depth of cover for all crossings under pavement for gas, electric, telephone, and cable TV, shall be a minimum of 30".

4. Street rights-of-way shall be graded at a slope to provide positive drainage toward the curb unless otherwise indicated due to special circumstances.

WATER AND WASTEWATER NOTES:

1. The Contractor shall contact the City Engineer to coordinate utility main, structure, and utility tie-ins and notify him/her at least 2 business days prior for inspection services.

2. All water and wastewater taps into the City of Marquette public system shall be done by the City of Marquette Public Works Department. A minimum of 72 hours notice will be given to the department for work required for tapping activities. Permits are required from the City of Marquette Engineering Department for water, wastewater, and storm water taps into the public system. Allow 3 business days to process permit applications.

3. The Contractor must obtain a water meter from the City of Marquette Public Works Department for all public water used during construction.

4. The Contractor, at his expense, shall perform quality testing for all wastewater pipe installed and pressure pipe hydrostatic testing of all water lines constructed and shall provide all equipment (including pumps and gauges), supplies and labor necessary to perform the tests per City of Marquette specification requirements. Quality and pressure testing shall be monitored by the inspector from the City of Marquette Engineering Department.

5. The Contractor shall coordinate testing with the City Inspector and provide no less than 2 business days notice prior to performing disinfection, quality testing or pressure testing.

6. The Contractor shall not open or close any valves on the public system. Valve operation must be coordinated with the City of Marquette Public Works Department.

7. For protection of underground utilities and in conformance with Public Act 53, the Contractor shall notify Miss Dig a minimum of three full working days, excluding Saturdays, Sundays, and holidays prior to beginning each excavation. The contractor is responsible for notifying the adjoining property owner to locate private utilities that may be placed not only on private property but on public property.

TRAFFIC CONTROL NOTES:

1. Any methods, street markings and signage necessary for warning motorists, warning pedestrians or diverting traffic during construction shall conform to the Michigan Manual of Uniform Traffic Control Devices for Streets and Highways, latest edition.

2. All pavement markings, markers, paint, traffic buttons, traffic controls and signs shall be installed in accordance with the Michigan Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges and the Michigan Manual of Uniform Traffic Control Devices for Streets and Highways, latest editions.

3. All public streets that are to be closed or interrupted due to the construction activities will require coordination with the City of Marquette Engineering Department for a

Public Service Announcement. A minimum of 72 hours notice will be given to the City Engineering Department for said closures or interruptions.

4. Parking restrictions must be posted 24 hours before work starts and will be at the expense of the contractor/developer. Contact the Police Department and Public Works Department when restrictions are placed.

5. The hours of construction operations will follow the noise restrictions as per the City of Marquette Nuisance Ordinance and as specified in the City of Marquette Standard Construction Specifications.

EROSION AND SEDIMENTATION CONTROL NOTES:

1. Erosion control measures, site work and restoration work shall be in accordance with the Michigan Department of Environmental Quality Guidebook of Best Management Practices for Michigan Watersheds.

2. All slopes shall be sodded or seeded with approved grass, grass mixtures or ground cover suitable to the area and season in which they are applied.

3. Silt fences, rock berms, sedimentation basins and similarly recognized techniques and materials shall be employed during construction to prevent point source sedimentation loading of downstream facilities. Such installation shall be regularly inspected by the contractors certified storm water operator for effectiveness. Additional measures may be required if, in the opinion of the City of Marquette's Hydrology Engineer or field representative, they are warranted.

4. All mud, dirt, rocks, debris, etc., spilled, tracked or otherwise deposited on existing paved streets, drives and areas used by the public shall be cleaned up immediately.

RECORD (AS-BUILT) DRAWING CHECKLIST
CITY OF MARQUETTE
ENGINEERING DESIGN STANDARDS

The attached checklist should be utilized prior to submittal of any As-Built Drawing for City approval. This check list is not to be considered a complete specification, but rather as a guideline. This checklist cannot reflect all conditions for all types of As-Built drawings, but should provide guidance in their preparation.

As-Built drawings should not be submitted for City review until all construction items are in place and complete. Basically, an As-Built drawing is a product of a final post construction topographic survey. The survey must be performed by a Professional Surveyor that is licensed in the State of Michigan. Since the surveyor cannot see the location or depth of newly constructed underground pipes, the information for same must be obtained from the Contractor's marked up record drawings. These must be furnished to the Surveyor prior to the survey. Many times, changes have been made on the location or depth of these items due to found existing conditions and the surveyor has no information on such changes.

The As-Built drawings are to be a true representation of elements that exist as a result of a completed construction project. Therefore, all references to PROPOSED or any other that refers to a construction process must not be on the survey drawing.

All questions on As-Built drawings, reviews, comments, etc should be directed to the office of the City Engineer. That office can be reached at 906-228-0440.

RECORD (AS-BUILT) DRAWING CHECKLIST

ROADWAYS

PAVEMENT:
- ☐ Centerline of roadway control line with stations
- ☐ Curbs or Curb and Gutters with top of curb elevations
- ☐ Finish pavement elevations along edge of pavement
- ☐ Horizontal alignment with radii, P.C.'s, and P.T.'s of all curves
- ☐ Vertical alignment with vertical curve lengths and station, and elevation of all PVC's and PVT's
- ☐ Typical pavement section
- ☐ Typical cross section
- ☐ Clear vision areas

TRAFFIC CONTROL:
- ☐ Lane paint lines or centerline paint lines
- ☐ Painted Pavement Markings (Arrows, Symbols, Etc.)
- ☐ Traffic control signage (Stop, Yield, Street Name, Speed, Etc.)
- ☐ Signal light Poles, control boxes, etc.

MISCELLANEOUS:
- ☐ Street Light Poles
- ☐ Right of way width shown
- ☐ Right of way monuments found during survey shown
- ☐ Concrete sidewalks that were replaced or extended (limits)
- ☐ Curbing that was replaced or extended (limits)
- ☐ Driveways or aprons that were replaced or extended (limits)
- ☐ ADA Accessible ramps that were replaced or newly constructed
- ☐ Trees that were removed, replaced, or placed.

STORM DRAINAGE SYSTEM

STRUCTURES:
- ☐ Type of structure is clearly defined in PLAN and PROFILE views
- ☐ Rim of structure
- ☐ Invert elevation of each pipe in structure
- ☐ End wall or flared end sections clearly noted and shown
- ☐ Riprap limits outlined
- ☐ Swale or ditch centerline elevations

PIPES:
- ☐ Length, size and type of pipe
- ☐ Invert of both ends of each pipe
- ☐ Slope of pipe based on actual invert elevations
- ☐ Stormwater velocity at all outlets

MISCELLANEOUS:
- ☐ Size of riprap dissipation pad
- ☐ Show permanent stormwater BMP's
- ☐ Show all retention and detention ponds
- ☐ A separate, recorded easement dedication for stormwater and utility extension outside of the right-of-way
- ☐ Typical swale or ditch cross section

PUBLIC UTILITIES

WATER:
- ☐ Valves, hydrants, air release structures, etc.
- ☐ Water main with location (PLAN and PROFILE), size and type of pipe
- ☐ Water service with location, size and type of pipe
- ☐ Water service curb stop location
- ☐ Water main and water service tap locations
- ☐ Bends, tees, reducers, etc. locations (PLAN and PROFILE)
- ☐ Length of pipe between pipe fittings
- ☐ A separate, recorded easement dedication for water main and utility extension outside of the right-of-way

SANITARY SEWER:
- ☐ Sewer manhole locations with rim and invert elevations (PLAN and PROFILE)
- ☐ Sewer main with location, length, size, and type of pipe (PLAN and PROFILE)
- ☐ Sewer lateral with location, size, and type of pipe
- ☐ Sewer lateral cleanout locations
- ☐ Slope of pipe based on actual invert elevations
- ☐ A separate, recorded easement dedication for sanitary sewer main and utility extension outside of the right-of-way

DRAWINGS

GENERAL:
- ☐ Survey and Drawing prepared by Professional Surveyor licensed in the State of Michigan
- ☐ Surveyor's seal on all sheets, signed and dated
- ☐ Name and address of surveyor
- ☐ Horizontal control datum note with control point references
- ☐ Vertical control datum note with bench mark reference
- ☐ Graphic scales
- ☐ North arrow on all plan sheets/cover sheet
- ☐ Cover sheet with sheet index if more than two drawing sheets, vicinity map
- ☐ Drawing sheets numbered in sequence
- ☐ All easements shown and labeled
- ☐ Final approved plans will be submitted on CAD format on a DVD, CD, or flash drive

PLAN AND PROFILE SHEETS:
- ☐ 24" X 36" Sheets
- ☐ State **"AS-BUILT DRAWING"** on all sheets
- ☐ Match Lines with sheet match data

APRPOVAL BLOCK ON THE COVER SHEET WILL BE AS FOLLOWS:

City of Marquette Use Only for Record (As-Built) Drawings

Reviewed by: ____________________ **Date:**___________________

Reviewed by: ____________________ **Date:**___________________

Reviewed by: ____________________ **Date:**___________________

Approved by:_____________________ **Return Date:**____________

WASTEWATER (SANITARY) SEWERS
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL AND REQUIRED INFORMATION

A. General Information
Wastewater (Sanitary) sewers shall be designed to the fullest extent practicable for conveyance in a separate gravity system at such depths that all structures within the tributary area may be served at full basement depths so that the estimated ultimate tributary population and area is served.

B. Information Required
The information required for the design report shall indicate the approximate site size, zoning, probable upstream tributary area of future system expansion and any special factors to be considered in the system design.

Information on all existing conditions shall be listed. The designer shall list the total capacity of the existing outlet sewer and the current peak flow into the existing outlet sewer. Existing sanitary sewers being received into a pump station will require the design capacity flow rate (capacity with the largest pump out of service) and the current peak hour flow rate into the pumping station.

Consideration shall be given to potential overall development of tributary area and how such future development will affect the design of the project under consideration. Special analysis shall be required for known areas with high inflow and infiltration.

C. Variations
Variation from a separate gravity sanitary sewerage system or from the normal depth required to serve the entire tributary area shall be considered a special circumstance. Special circumstances shall require that the City of Marquette Engineering and Public Works Departments approve the variation in concept prior to final design. Variations shall include shallow depth, materials of construction, methods of construction, pressure sewer systems, and type of sewage generated.

SEWER CAPACITY DETERMINATION

A. General Information
Sanitary sewers shall be designed for peak flow plus infiltration and inflow allowance basis.

B. Design Basis
1. Tributary Area
    a. Sanitary sewers shall be designed to serve all tributary areas, with due consideration given to topography, the master sanitary sewer plan, established zoning, and the adopted Master Land Use Plan.

2. Population
    a. For design purposes, population shall be based on a minimum of 3 persons per detached

single-family home site. The average 3 people per residence along with 100 gallons per day per person equates to 300 gallons per day per residence. This GPD/residence is henceforth defined as a "Residential Equivalent Unit". The Residential Equivalent Unit (REU) factors required for other occupancy usage types can be obtained from the Residential Equivalent Unit Factor Schedule within this section.

b. Submissions for review shall include a tabulation of occupancy (usage) types and the conversion of these into terms of residential equivalent units, design population, peaking factor calculations, and design flow calculations. The areas of the site, in acres, may be used to calculate dwelling units based on density allowed in the Zoning Ordinance.

C. Sewage Contribution
The design per capita sewage contribution will be based on 100 gpd or design contribution per REU of 300 gpd.

D. Infiltration and Inflow
For new systems, allowance shall be 375 gallons per acre day for the upstream tributary acreage.

E. Additional Design Factors
These include additional requirements such as maximum sewage or waste flow from industrial plants, pumping requirements, and other situations that may exist but are not included in these Standards.

RESIDENTIAL EQUIVALENT UNIT FACTOR SCHEDULE

PLACE	UNIT FACTORS	UNITS OF MEASUREMENT
Apartments and Condominiums	0.70	One bedroom
	0.85	Two bedroom
	1.00	Three bedroom
Assembly Halls	0.006	Per seat
Auto Dealers	0.30	Per 1000 sq. ft.
Barber Shops	0.10	Per Seat
Beauty Shop, Styling Salon	0.57	Per Basin
Bowling Alleys (no food service)	0.21	Per lane
Car Wash		
- Manual, Do-It-Yourself Car Wash	2.5	Per Stall
- Semi-Automatic (Mechanical Without Conveyor)	12.5	Per Stall
- Automatic With Conveyor	33.0	Per Lane
- Automatic With Conveyor Conserving and Recycling Water	8.4	Per Lane
Churches (small)	0.014	Per sanctuary seat
Churches (large with kitchen)	0.02	Per sanctuary seat
Country Clubs	0.08	Per member

Doctors/Dentists (Use each factor to add to the total units for this category)	0.20 0.06 0.02	Per doctor Per employee Per patient
Factories (no showers)	0.07	Per employee
Factories (with showers)	0.10	Per employee
Food Service Operations - Ordinary Restaurant (not 24 hour) - 24-Hour Restaurant - Banquet Rooms - Tavern (very little food service)	 0.10 0.14 0.014 0.10	 Per seat Per seat Per seat Per seat
Homes in Subdivision	1.00	Per dwelling
Funeral Homes, Including One Resident	1.00	Per Funeral Home
Hospitals (no resident personnel)	0.85	Per bed
Institutions (residents)	0.28	Per person
Laundries (coin-operated)	1.14	Per standard size washing machine
Marinas (restrooms and showers only)	0.04	Per boat mooring/slip/dock
Mobile Home Parks	0.86	Per mobile home space
Motels	0.28	Per unit
Nursing and Rest Homes (Use each factor to add to the total units for this category)	0.57 0.28 0.14	Per patient Per resident employee Per non-resident employee
Office Buildings	0.40	Per 1000 sq. ft.
Retail store	0.06	Per employee
Schools - Elementary - High and Junior High	0.04 0.06	Per pupil Per pupil
Service Stations	0.24	per pump
Shopping Centers (no food service or laundries)	0.0002	Per 1000 sq. ft. of floor space
Swimming Pool (average) With hot water shower	0.014 0.02	Per swimmer (design load) Per swimmer (design load)
Vacation Cottages	0.14	Per person
Veterinarians and Animal Hospitals (Use each factor to add to the total units for this category)	0.028 0.028 0.06	Per run Per cage Per employee
Warehouses	0.10	Per 1000 sq. ft.

F. Residential Equivalent Unit (REU) and Design Population (DP) Determination

The number of REUs will be calculated by using the unit factors and the units from the Residential Equivalent Unit Factor Schedule. The design population will be based on 3 persons/unit.

Example: Office building with 100,800 sq. ft. of floor space.

Residential Equivalent Unit (REU) = (100,800)(0.4/1000) = 40 units
Design Population (DP) = (3 persons/unit)(40 units) = 120 persons

D. **Sewer Capacity Determination**
The sewer capacity shall be based on the ultimate tributary population, the peak flow generated, and infiltration.

The peaking factor required for the peak flow will be calculated using the equation below:

Peak Factor (PF) = $1 + 14/(4 + p^{0.5})$

Where p is the contributing design population in thousands.

The design sanitary sewer flow shall be computed using the following formula:

QD = QP + IA

Where: QD = Design flow
I = Infiltration and inflow
A = Tributary area in acres
QP = Peak flow

QP = (PF)(100 gal/person/day)(DP) = gpd

Where: PF = Peaking Factor
DP = Design Population

<u>Conversion Factors:</u>
gpd = 0.00069 gpm
cfs = 449 gpm
MGD = 1.55 cfs = 695 gpm
cu ft = 7.48 gal

DESIGN CRITERIA FOR SANITARY SEWERS

A. General Information
In general, all sewers shall be designed using the following criteria, with variations from such for special circumstances.

A. Energy Concept
The energy concept of hydraulic design shall be used on all projects, with the energy line occurring above the free water surface by an amount equal to the velocity head of $h_f = V^2/2g$.

B. Flow Formulas
Manning's Formula [$Q = A\,(1.49/n)\,R^{2/3}\,S^{1/2}$] shall be used to determine pipe capacity. The "n" value shall be 0.013 or the pipe manufacturer's recommendation. Manning's "n" values, which are less than 0.013 shall require City Engineer approval and shall only be allowed if minor losses

are accounted for.

Where: Q = Discharge (cu. ft./sec.)
A = Cross-sectional Area of Flow (sq. ft.)
n = Coefficient of Roughness
R = Hydraulic Radius (ft.)
S = Slope of Pipe (ft./ft.)

The hydraulic radius is calculated from the following equation:

Where: R = A / p
R = Hydraulic Radius (ft.)
A = Cross-sectional Area of Flow (sq. ft.)
p = Wetted perimeter (ft.)

Manning's Formula symbol values for a pipe flowing full are provided in the following table. To find Q (discharge) multiply the last column value by $S^{1/2}$. To find the velocity use the following equation:

Where: V = Q/A
V = Velocity (ft./sec.)
Q = Discharge (cu. ft./sec.)
A = Cross-sectional Area of Flow (sq. ft.)

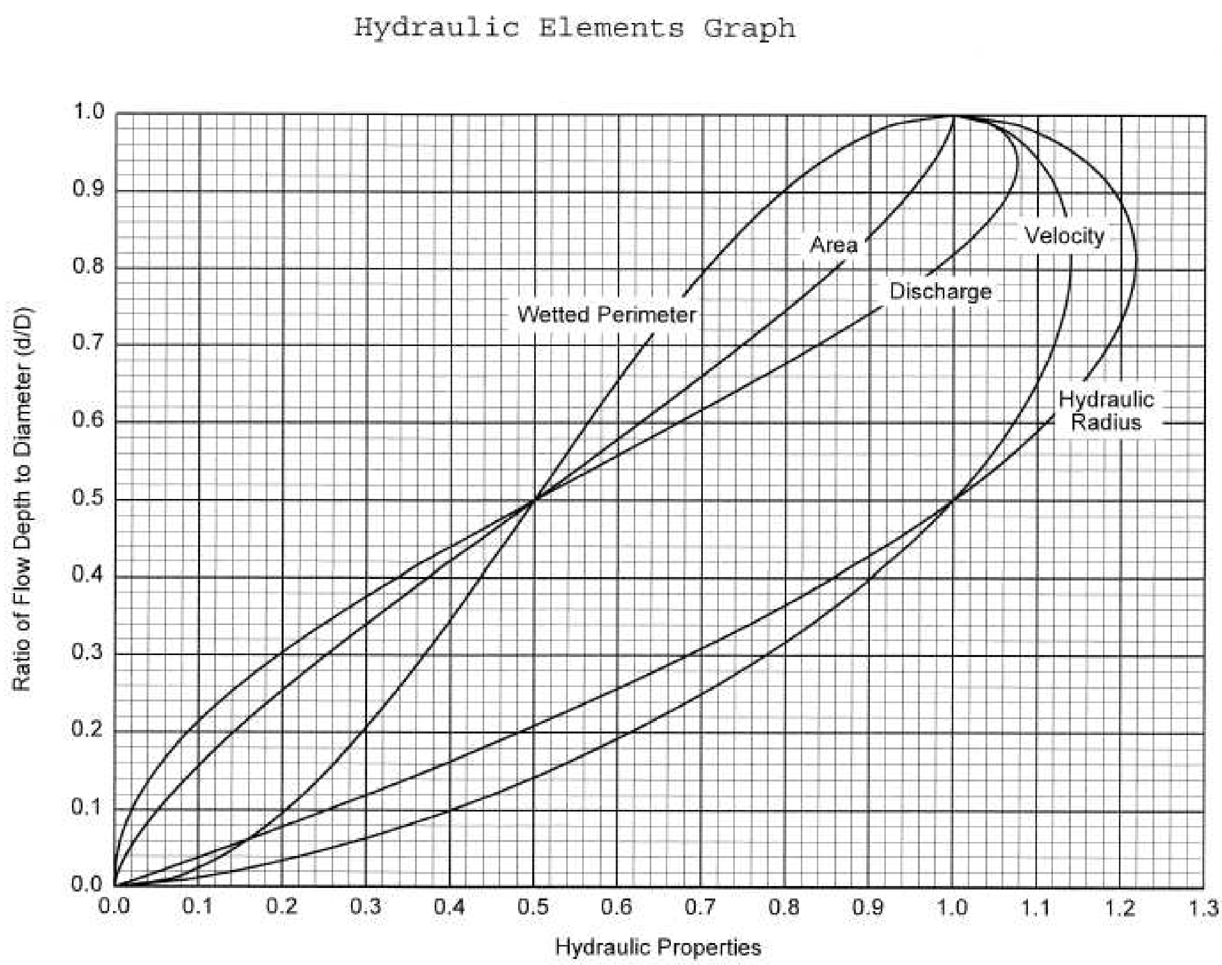
MANNING'S FORMULA SYMBOL VALUES (n = 0.013)

PIPE DIA. (INCHES) D	RADIUS (FEET) R	WETTED PERIMETER (FEET) P	AREA (SQ.FEET) A	HYDRAULIC RADIUS (FEET) R	$R^{2/3}$ (FEET)	A (1.49/N) $R^{2/3}$
8"	0.333	2.0944	0.34907	0.16667	0.30286	12.0845
10"	0.4167	2.6182	0.5455	0.20835	0.35145	21.9146
12"	0.500	3.14159	0.785398	0.250	0.39685	35.628
15"	0.625	3.927	1.227	0.3125	0.46046	64.5821
18"	0.750	4.7124	1.767	0.37497	0.51999	105.02846
21"	0.875	5.49779	2.4053	0.4375	0.5763	158.450396
24"	1.000	6.2832	3.14159	0.500	0.62996	226.2236
27"	1.125	7.0686	3.9761	0.5625	0.6814	309.69593
30"	1.25	7.8540	4.9087	0.62499	0.730999	410.60075
36"	1.50	9.425	7.0686	0.74998	0.82547	666.9759
42"	1.75	10.99557	9.62113	0.875	0.91483	1006.1018
48"	2.00	12.5664	12.5664	1.000	1.000	1436.4362
54"	2.25	14.13717	15.9043	1.125	1.19324	2169.2910
60"	2.50	15.708	19.635	1.25	1.1604	2604.438

66”	2.75	17.27876	23.7583	1.3750	1.2365	3358.033
72”	3.00	18.8496	28.2743	1.50	1.3104	4235.1735
78”	3.25	20.4204	33.1831	1.625	1.38219	5242.7622
84”	3.50	21.9915	38.4845	1.745	1.4494	6376.0184
90”	3.75	23.5619	44.1786	1.875	1.5206	7678.9598

D. Hydraulic Properties of Circular Sewers

The hydraulic properties for partially full circular sections of pipe may be derived from the following graph:



E. Hydraulic Calculations
Gravity sanitary sewers: Manning’s Formula shall be used.
Low-pressure sewer systems and force mains: Hazen-Williams Formula shall be used.

F. Minimum Size
The minimum nominal size of all wastewater (sanitary) sewer mains, excluding lateral connections, shall be eight inches (8") in diameter.

G. Minimum and Maximum Velocities
Minimum design velocities for gravity and low pressure sanitary sewers shall be two (2.5) feet per second, and a maximum design velocity shall be ten (10) feet per second with pipe flowing full.

H. Allowable Minimum Pipe Slopes

Pipe Diameter (inches)	Minimum Slope (feet per 100 feet)
4 (services only)	2.00
6 (services only)	1.00
8	0.40
10	0.28
12	0.22
18	0.12
24	0.10
30	0.10
36	0.10

SANITARY SEWER MATERIALS

A. General Information
All piping materials, manholes, and appurtenances furnished for public sanitary sewers shall comply with the latest applicable national standards, such as the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), American Water Works Association (AWWA), or other representative standards organizations. Some products are specified with more than one applicable reference standard for such items as testing, installation, or supplementary material specifications.

The following materials listed are not all-inclusive. Developers and Consulting Engineers must familiarize themselves with the City of Marquette Standard Specifications and Standard Details to find all requirements and specifics.

B. Types of Sewer Pipe
Product description, materials testing, field testing and installation techniques shall be governed by the City of Marquette Standard Specifications and Standard Details.

- Polyvinyl Chloride (PVC) Sewer Pipe and Fittings conforming to ASTM D-3034, SDR-26, and ASTM F-949 up to 36 inches in diameter.
- Reinforced Concrete Pipe ASTM C-76 or C-507 may be used for 24 inches in diameter or larger.

For plastic pipes, the 5 percent diametric, in place deflection limits on the average inside diameter shall be adhered to. All sewer pipes within a manhole to manhole increment shall be one type and class. Deflection test is required on all plastic pipes. Air testing required for all sanitary sewers in areas where the new main is not servicing existing residents or businesses. Televising is required on all sanitary sewer mains per City of Marquette specifications.

C. Sanitary Sewer Joints
All sanitary sewers shall be installed with premium water tight joints of the bell and spigot type to insure maximum durability, flexibility, strength and water-tightness. All sewer materials listed above provide for joint water-tightness tests in their specifications.

Joints for PVC pipe shall be of shall be elastomeric O-ring. Solvent cement joints for lateral pipes six (6) inches or under is acceptable.

D. Force Mains
All materials for the force main shall comply with the latest applicable national organizations standards. Minimum cover of six (6) feet shall be used on force mains.

The force main material shall be push on joints or Mechanical Joints Ductile Iron Pipe ANSI A21.51 Class 52 (AWWA C-151) for force mains 4” or larger. The force main material for mains smaller than 4” shall be Schedule 80 PVC (ASTM D1785), jointed with solvent welds unless otherwise noted or specified.

For force mains 4" or larger, only ductile iron fittings are allowed. For force mains smaller than 4”, the fittings shall be of the same material as the pipe, and in no case shall have thinner walls than that of the pipe furnished.

E. Thrust Blocks
All thrust blocks can be either 4,000 PSI concrete or of the pipe restraint type such as the ones manufactured by Uni-flange, such as megalugs, or retaining glands. Locking gaskets are an option.

LAYOUT OF SANITARY SEWERS

A. General Location Information
In general, the layout of the sewerage systems shall be such that the wastewater (sanitary) sewer main shall be placed down the middle of the street with the eccentric cone or the flat top is positioned such that the manhole casting is off to one side of the centerline on a uniform pavement slope. The parallel separation between the storm and sanitary sewers shall be a minimum of six (6) feet edge to edge. The parallel separation between the water main and sanitary sewer main shall be ten (10) feet edge to edge. The vertical separation between the wastewater sewer piping and other utilities shall be a minimum clearance of eighteen (18) inches.

Manholes shall be placed at the end of all sewer runs; at all changes in grade, size, or alignment; at all sewer main intersections; and at a distance not greater than 400 feet.

All wastewater (sanitary) sewer mains shall be constructed to straight lines and grades.

Where changes in size occur for all wastewater (sanitary) sewer mains, the pipe shall be constructed with the crown of the pipes matching. Certain circumstances may warrant alternate designs and shall require the City of Marquette Engineering and Public Works Departments review and approval prior to final design.

Wastewater (sanitary) sewers placed on streets with curves will require additional manholes to maintain the position of the wastewater (sanitary) sewer piping in the generally pavement area and in all cases in the right of way or dedicated easement.   The designer shall place all manholes outside of the wheel path area. When sanitary sewer mains are installed outside street rights-of-way, they shall be located in the center of an easement.

B. Lateral Piping and Connections

Sanitary sewer laterals from the public wastewater sewer main to the clean out for all building sites shall be a minimum of four inches (4") in diameter and constructed of Polyvinyl Chloride (PVC) Schedule 40 piping.

In the case of building lateral sewer (wastewater) connections, proper watertight transition connections of differing materials may be permitted (e.g. fernco fittings). Only wye branch fittings will be accepted for service connections for sewers up to and including 6 inch diameter. For sewers 8 inches and larger, a manhole structure is required.

All sanitary sewer laterals from the public wastewater sewer main to the right of way or dedicated easement line shall be placed at a maximum slope of 2 percent as per the City of Marquette Standard Details. Laterals connecting to a wastewater sewer main with a depth greater than 12 feet shall refer to the City of Marquette Standard Details for typical installation.

C. Clean-out Locations

Each sanitary lateral connection to building sites shall have a clean-out installed one foot inside the right-of-way line or public easement line.

Clean-outs shall be PVC Schedule 40 piping and constructed per City of Marquette Standard Drawings and Specifications.   Clean-outs placed in paved surfaces will require a Monument Box per City Specifications. Clean-outs placed in lawn areas shall have a magnet placed on the side near the cap per City Specifications.

D. Manholes Frames and Castings

Standard manhole frames and castings shall have a solid cover as manufactured by East Jordan Iron Works Catalog Number 1040 or equal.

E. Depth of Sanitary Sewers

In general, the top of the pipe of sanitary sewers shall be at least 8 feet below the finished grade. Conduits shallower than this requirement shall be considered a special circumstance and require City of Marquette Engineering and Public Work Department approvals.

F. Manhole Drop Type

A drop pipe shall be provided for a wastewater sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert shall be filleted to prevent solids deposition. All drop manholes shall have an outside connection. No inside drop connections will be allowed.

G. Manhole Diameter and Requirements
The minimum diameter for manholes shall be 48 inches; larger diameters shall be required for large diameter sewers or manholes with multiple piping. A minimum access diameter of 24 inches shall be provided. Each pipe entering or exiting a manhole structure shall have a side clearance of 12 inches from edge to edge of piping to insure structural stability of the manhole section. The diameter of the manhole must be large enough so that the distances between adjacent openings have enough strength to resist lateral and vertical loads, as well as stresses caused by handling. The angle between incoming and outgoing wastewater sewer piping in a manhole shall never be less than 90^{o}. The piping entering and exiting the manhole will tap into the manhole structure with gasketed flexible water tight connections.

The following manhole diameters shall be utilized dependent upon the pipe diameter and a scenario of four pipes intersecting the manhole at roughly the same elevation. For those cases with fewer pipes intersecting the manhole, the aforementioned 12 inch rule will come into effect.

Manhole Diameter	*Pipe Diameter*
4'-0"	8" - 12"
5'-0"	15" - 24"
6'-0"	30" - 36"
8'-0"	≥ 42"

Variance from this design specification must be approved by the City of Marquette Engineering and Public Works Departments prior to construction.

H.Bedding, Haunching, and Initial Backfill
Embedment materials for bedding, haunching, and initial backfill shall meet City of Marquette, Michigan Department of Environmental Quality, and State of Michigan Transportation requirements based on the type of soil encountered and potential groundwater conditions. Haunching of the embedment materials will be done by industry and construction standards.

WATER MAIN
ENGINEERING DESIGN GUIDELINES AND STANDARDS

A. General Information
This chapter of the City of Marquette Engineering Department General Guidelines for Street and Utility Design Standards outlines the minimum design criteria and design procedures to aid in the preparation of construction plans and specifications for City-maintained and on-site water system improvements. Developers and/or Design Engineers shall check with the City Engineering Department and the Office of Community Development to determine the availability of water at the site of a proposed subdivision or site development.

B. Information Required
The description shall indicate the approximate site size, land use requirements, total number of ultimate service connections served by the entire project and any special factors to be considered in the system design.

The designer and the developer should investigate the requirement of fire sprinklers for the type of use and building materials planned and compare to the systems capability.

Information on all existing conditions shall be listed. The designer shall list the actual flows and pressures of the existing system at the connection points. Consideration shall be given to potential overall development of area and how such future development will affect the design of the project under consideration. Special analysis shall be required for the sizing of major components of the City water supply system such as major transmission mains, storage facilities, and booster
pumping facilities which are beyond the scope of these guidelines. The City may require developers design these facilities as well as finance and construct them.

C. Variations
Variations in design from these documents shall be considered a special circumstance. Special circumstances shall require that the City of Marquette Engineering and Public Works Departments approve the variation in concept prior to final design. Variations shall include shallow depth,
materials of construction, and methods of construction.

DESIGN CRITERIA

A. General Information
The design engineer who is responsible for designing the extensions of distribution mains shall follow the guidelines in this manual for the derivation of design flows. The calculation of water demands will usually require the determination of the average daily rate for the facility, application of a peaking factor to derive the maximum daily rate, and the addition of the fire flow requirement.

B. Design Basis
1. Service Area
   a. Water mains shall be designed to serve all ultimate service areas, with due

consideration given to topography, the master water distribution plan, established land use requirements and the adopted Master Land Use Plan.

2. Population

a. For design purposes, population shall be based on a minimum of 3 persons per detached single-family home site. The Residential Equivalent Unit factors required for other occupancy usage types can be obtained from the Residential Equivalent Unit Factor Schedule as called out in the sanitary sewer design requirements.

b. Submissions for review shall include a tabulation of occupancy (usage) types and the conversion of these into terms of residential equivalent units, design population, average day flow, maximum day flow, peaking factor calculations, and total design flow calculations. The areas of the site, in acres, may be used to calculate dwelling units based on density allowed in the Land Development Code.

C. Demand Contribution

The design per capita water demand contribution will be based on 100 gpd per person or design contribution per REU of 300 gpd.

1. Residential demands may be higher as related to lot size and greater lawn sprinkling. This factor should be considered for a project site or subdivision area during the basis of design.

2. Commercial and Industrial demands are greatly dependent on the type of facility. With the exception of industries using process water, the fire demand generally is the major component of the design used to size distribution main extensions and service connections to buildings having sprinkler systems. The design engineer shall refer to the current edition of the "Michigan Department of Consumer & Industry Services Bureau of Construction Codes" plumbing code or the current edition of the "Building Officials & Code Administrators" basic plumbing code publication for derivation of building design flows when the numbers of fixture units are known.

D. Fire Flow Rates

<u>Residential</u>: [1]

Single Family	1,000 gpm at 20 psi residual
Multi Family	2,000 gpm at 20 psi residual
High Rise Apartments	2,500 gpm at 20 psi residual

<u>Commercial:</u> [1]

Malls and Regional Shopping Centers	3,000 gpm at 20 psi residual
Office Building Complex	3,000 gpm at 20 psi residual

<u>Industrial:</u> [1]	4,000 gpm at 20 psi residual

<u>Institutions:</u> [1]

Hospitals	3,000 gpm at 20 psi residual

Schools	3,000 gpm at 20 psi residual
Universities	3,000 gpm at 20 psi residual
Churches	3,000 gpm at 20 psi residual

1 Above fire flows to be used in the absence of site specific data from fire underwriters or construction plans which would permit a determination of fire flow requirements using insurance industry standards (Insurance Services Office -ISO). Consideration will be given to reducing the requirement where proposed construction includes sprinkler system; refer to current ISO recommendations.

E. Hydraulic Calculations

1. General

The hydraulic design of water mains shall be in accordance with the requirements of the American Water Works Association, the current edition of the Pipeline Design for Water and Wastewater, ASCE, and the additional guidelines and criteria in this Chapter.

2. Design Flows and Residual Pressures

a. Service connections, distribution mains and transmission mains shall be sized based on the following design flow rates and residual pressures:

   Maintain a minimum of 20 psi at ground level anywhere in the system under all conditions.

   or

   Normal working pressure of 60 psi and not less than 35 psi residual pressure at the service connection during peak hourly rate.

   The City Engineer and/or Public Works Director will determine which criterion is more critical.

b. In some locations, the main size will be determined by the flow rate required to refill a storage facility which may be more critical than the above requirements. The City will identify this requirement, if applicable.

3. Flow Velocities

Although the flow velocities and direction may vary considerably in distribution mains, there are upper and lower velocity bounds that indicate to the design engineer that design weaknesses may exist. The following are useful guidelines:

a. Velocities greater than 7 fps at design flow

   This condition may produce large friction losses and high potential for valve and joint damage due to water hammer.

b. Velocities less than 0.5 fps at design flow

   This condition indicates that the main may be oversized. Future maintenance problems may result from siltation at valves and there may be water quality degradation.

4. Pipe Carrying Capacity and Network Analysis

Pipe carrying capacity depends on pipe size, pressure, pipe roughness and length of pipe. The required pipe size shall be calculated when the other requirements and characteristics are known. The Hazen-Williams equation shall be used in hydraulic analysis of water pipelines. This will be used to calculate the pressure drop in a water pipeline given the pipe diameter and flow rate, taking into account the internal condition of the pipe using the dimensionless parameter C. Nomographs have been developed for various sizes and types of pipe by piping manufactures to help in selecting proper pipe size.

When the distribution system or system expansion is extensive, it will be necessary to analyze the system and balance the flow among all areas in relation to demand. This analysis requires a plot of pressures and flows at points throughout the system and may be accomplished using the Sparse Matrix Solution, Hardy-Cross Method, Newton-Raphson Method or other recognized methods.

5. Hazen-Williams Equation

The classical form of the Hazen-Williams equation for pressure drop in water pipelines is as follows:

$$h = 4.73\ L\ (Q/C)^{1.852} / D^{4.87} (2.23)$$

Where: h = Head loss due to friction in ft of water.
L = Length of the pipe (ft.)
D = Diameter of the pipe (ft.)
Q = Flow rate (cu. ft./sec.)
C = Function of the internal roughness of the pipe (see Table below)

A more commonly used version of the Hazen-Williams equation is as follows:

$$Q = 6.7547 \times 10^{-3} (C)\ (D)^{2.63} (h\ )^{0.54}$$

Where Q is in gal/min, D is in inches and h is the head loss due to friction in ft of liquid per 1000 ft of pipe.

6. Hazen-Williams "C" and Minor Losses

a. The total head loss at the point of discharge for design flows shall be the sum of both friction and minor losses. The elevation difference between the source and discharge point shall be algebraically added to the total head losses.

b. Head losses for new pipes shall be computed using the nomograph below and the following coefficients:

Type	Pipe Diameter	Hazen-Williams "C"
Service Connections		
Copper	1 inch - 2 inch	130
DIP	4 inch – 6 inch	100
Distribution Mains		
DIP	4 inch - 8 inch	100
DIP	10 inch - 12 inch	110
DIP	16 inch - 24 inch	120
Transmission Mains		
DIP	16 inch - 24 inch	120
DIP	24 inch and larger	130

c. Minor losses due to fittings and valves shall be included as equivalent lengths of pipe as shown below or as fractional losses in velocity head as described in Pipeline Design for Water and Wastewater, ASCE, 1992, or other hydraulics texts.

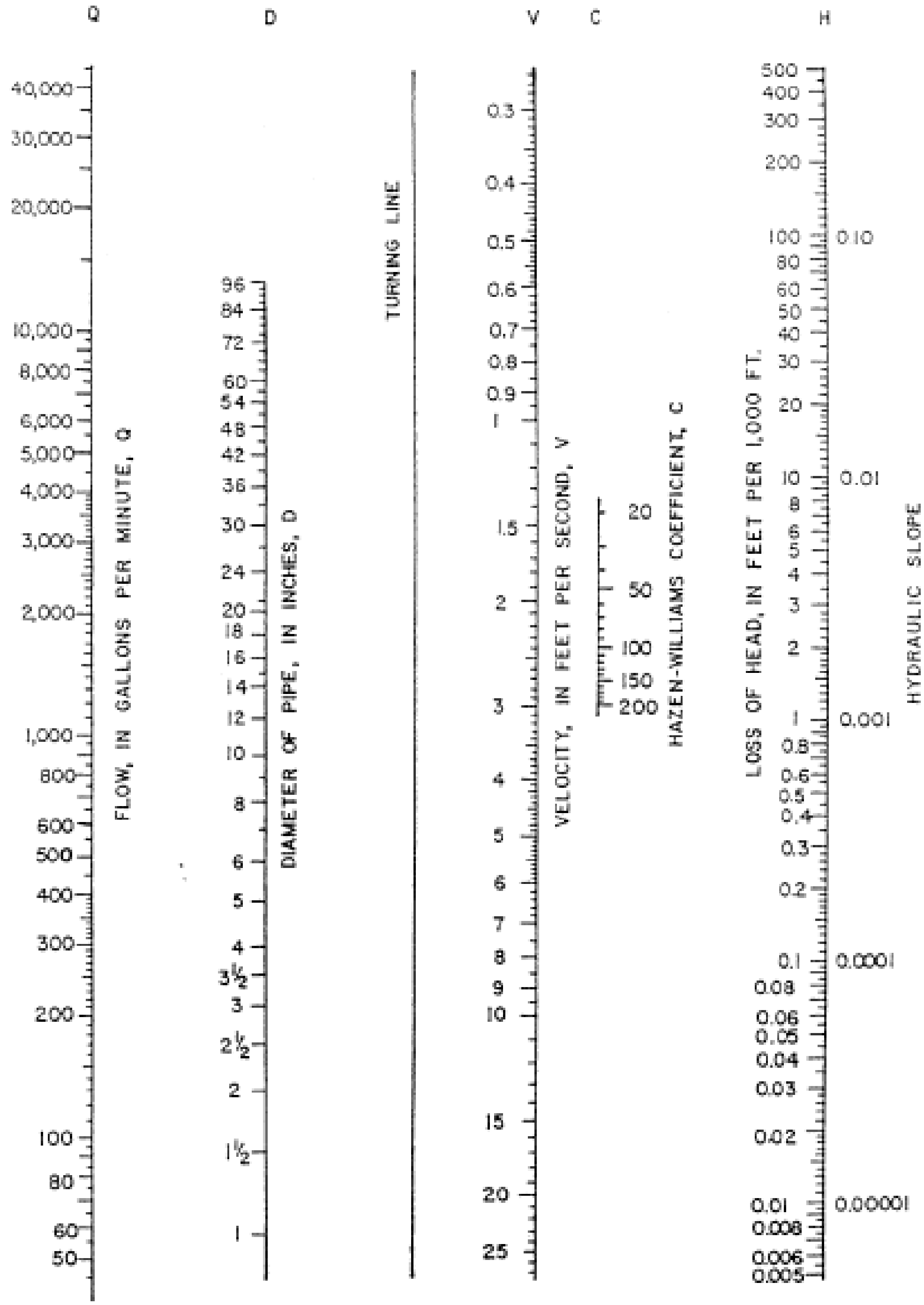
Using the equivalent length concept, the valve or fitting is said to have the same frictional pressure drop as that of a certain length of straight pipe. Once the equivalent length of the device is known, the pressure drop in that straight length of pipe can be calculated. For example, a gate valve is said to have an equivalent length to the diameter ratio of 8. This means that a 16 inch gate valve has the same amount of pressure drop as a straight piece of 16 inch pipe with a length of 8 x 16 or 128 inches.

MINOR LOSSES OF HEAD IN EQUIVALENT LENGTHS

NATURE OF RESISTANCE	**LENGTH TO PIPE DIAMETER RATIO (L/D)**
Angle Valve	
Open	170
Check Valve	
Swing Type, Open	80
Gate Valve	
Wide Open	8
1/4 Closed	40
1/2 Closed	200
3/4 Closed	850
Globe Valve	
Open	340
Standard Elbow	32
Long Swing Elbow	20
45-Degree Elbow	15
Tee	
Flow Through Run	20
Flow Side to Run or Run to Side	

No Throat	65
With Throat	45
Lateral	45
Sudden Contraction	
d/D = 1/4	15
d/D = 1/2	12
d/D = 3/4	7
Sudden Enlargement	
d/D = 1/4	32
d/D = 1/2	20
d/D = 3/4	7

HAZEN-WILLIAMS NOMOGRAPH



6. Velocity and Flow Calculations
Expressing the Hazen-Williams Equation for the average velocity and flow:

$$V = 1.318CR^{0.63}S^{0.54}$$

$$Q = 0.432CD^{2.63}S^{0.54}$$

Where: V = Mean flow velocity (ft./sec.)
Q = Flow rate (cu. ft./sec.)
C = Function of the internal roughness of the pipe (see Table above)
D = Diameter of the pipe (ft.)
S = Hydraulic grade line slope (ft./ft.)
R = Hydraulic Radius (ft.)

F. Design Loads and Pipe Design
In special circumstances where deemed necessary by the City, the design engineer shall submit all calculations necessary to support the selection of the type and class of pipe indicated on the Contract Drawings.

The calculations may account for the following:

Vehicle (H-20, etc.);
Pipe loading factors (dead, live, impact);
Internal pressure (static, dynamic, surge);
Installation trench configuration.

G. Corrosion Protection
If soil tests or inspection of existing utilities in the project area reveals evidence of, or potential for, corrosion, the City shall be notified of the condition. Should the City deem it necessary, the design engineer shall design suitable galvanic and/or cathodic corrosion protection measures using AWWA Controlling Corrosion within Water Systems, 1978. The City reserves the right to require a soils analysis for corrositivity.

WATER DISTRIBUTION SYSTEM MATERIALS

A. General Information
All piping materials, manholes, and appurtenances furnished for public water main and services shall comply with the latest applicable national standards, such as the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), American Water Works Association (AWWA), or other representative standards organizations. Some products are specified with more than one applicable reference standard for such items as testing, installation, or supplementary material specifications.

The following materials listed are not all-inclusive. Developers and Consulting Engineers must familiarize themselves with the City of Marquette Standard Specifications and Standard Details to find all requirements and specifics.

Product description, materials testing, field testing and installation techniques shall be governed by the City of Marquette Standard Specifications and Standard Details.

B. Types of Water Main Pipe

All distribution and transmission mains and fittings shall be Ductile Iron, double cement lined (latest AWWA C-151) with standard mechanical joints or push on joints. Pipe designation will be thickness Class 52 unless special circumstances dictate.

Conditions that may warrant the use of HDPE (SDR 11 with tracer wire) piping are those areas that require a trenchless application such as:

- Highway crossings
- Railroad crossings
- Stream, river, or lake crossings
- Backyard easements that are developed
- Areas that may compromise an existing building or retaining wall structure

C. Size of Water Main Pipe

1. Distribution Mains

Shall be 8-inch minimum size and shall be interconnected at all intersecting streets, with valves on all mains at the intersection. Where the required flow exceeds the capacity of an 8-inch main or of the existing system, larger mains will be required. Water main piping placed under a street will have a minimum of 6.5 foot bury cover.

a. Distribution mains shall be sized to provide the required design flow rate and residual pressures as detailed herein.

2. Transmission Mains

Sizing shall be based on a computerized network analysis performed by the design engineer or as provided by the City, if available.

D. Water Main Joints

All water mains shall be installed with premium water tight joints meeting the requirements of ANSI/AWWA C111/A21.11 and as called out in the City of Marquette standard specifications for water main.

All joints shall provide electrical continuity. Continuity can be provided by copper straps welded to the pipe or continuity clips integral with the gaskets. Whichever method is used, it shall provide 200 AMPS of electrical continuity without overheating.

E. Thrust Blocks

All thrust blocks can be either 4,000 PSI concrete or of the pipe restrain type such as manufactured by Uni-flange, megalugs, or equal. Locking gaskets are an option.

F. Water Main Appurtenances

1. Gate Valves

a. Size and Type

Mains 4-inches to 16-inches shall have valves of the same size as the main. Valves shall be resilient seat gate valves for mains 4 inch to 12 inch. All valves 16-inches and larger shall be butterfly valves.

b. Tapping Sleeves and Valves

The City reserves the right to require that a tee or cross be inserted into an existing main for connection to a new main system. If a tapping sleeve and valve are proposed, its use must be requested and reviewed by the City Engineer prior to consideration. If a tapping sleeve and valve are allowed the following criteria must be followed:

Tapping sleeves and valves on ductile iron mains to serve as line valves shall be used for all connections 6-inches and larger to any existing main 12-inches or larger. The main being tapped may be the same size as the proposed main or tapping valve, but the tapping cutter shall be 1/4-inches or more undersized.

2. Fire Hydrants
Hydrant leads shall be a minimum of 6-inches and composed of ductile iron piping class 52. Hydrant manufacturers shall be as called out in the City of Marquette standard water main specifications. Hydrants shall be designed for 7 foot bury and 6 inch mechanical joint inlet.

2. Valve Boxes
Valve boxes for use with buried gate valves or butterfly valves shall be three piece, screw type adjustable, cast iron boxes with a 5 ¼ inch diameter shaft.

3. Manholes, Meter Pits, and Vaults
Special circumstances such as the installation of a meter pit, check valve, pressure reducing valve, and other specialized fittings will require the use of special details and specifications. Unless there are extenuating circumstances, meters, check valves, pressure reducing valves or other specialty items shall be placed in a concrete vault. These special circumstances will require the approval of the City Engineering and Public Works Departments.

4. Miscellaneous Fittings
Bends, tees, crosses, anchoring couplings, sleeves, and etc. will meet the material requirements of the City of Marquette standard specifications for water main.

G. Service Line and Appurtenances

1. Sizing
   a. Service lines shall be no smaller than 1 inch, the normal size for a residential dwelling.

   b. For other than a single family residential dwelling, determine the water supply demand pursuant to the design criteria as previously described. The velocity in the service connection must not exceed 8 fps.

   c. Refer to “Manifold Water Service System for Condo’s/Town-Homes” of these guidelines for common service lines.

2. Materials
   a. Piping material must be Type 'K' copper for residential service lines and ductile iron for larger sizes.

   b. Curb stops and fittings can be flared or compression type as called out in the City of Marquette standard specifications.

   c. Curb stop boxes shall be buffalo style and meet the requirements of City of Marquette standard specifications.

3. Cross Connections

   No cross connections where any potential contamination whatsoever can enter the potable water supply are permitted. No cooling water or condensate may be returned to the potable water supply line. All connections shall be reviewed for approval by the City of Marquette Public Works Utility Inspector and other appropriate reviewing authorities.

4. Meter Sizing

   Meter types for Residential, Commercial, Industrial and Institutional applications shall be determined by the City of Marquette Public Works Department or authorized agent. Meters shall be installed to record all water usage, including fire flow.

   a. A valve or corporation cock shall be provided on the water main side of each meter installation.

   b. Backflow Prevention Device

      All private use connections to the water system not being used for everyday uses, such as, irrigation, fire suppression systems, or others determined by the City of Marquette shall require the inclusion of a pre-approved back flow prevention device.

      Reduced pressure backflow prevention devices shall be located immediately adjacent to the outlet side of the water meter, fully accessible. Refer to AWWA, *Cross Connection and Backflow Prevention* for additional design criteria.

5. Installation

   Installation of all service connections to the building service water supply pipe and appurtenances shall be in accordance with these documents, the latest City of Marquette Standard Specifications, AWWA standards, and/or manufacturer's recommendations. Such requirement shall be noted in specifications and on contract drawings.

6. Booster Pumps

   Booster Pumps may be permitted for individual domestic or fire flow service with the approval of the City. Their use, however, shall be discouraged and will only be considered on a case-by-case basis.

LAYOUT OF WATER MAINS, SERVICES AND APPURTENANCES

A. General Location Information

1. Horizontal and Vertical Alignment

In general, the layout of the water distribution and transmission systems shall be such that the water main shall be placed within the pavement area, wherever possible, no less than six (6) feet from curb or proposed curb. The parallel separation between the water main and sanitary sewer shall be a minimum of ten (10) feet edge to edge and between the water main and storm sewer main shall be a minimum of six (6) feet edge to edge. The vertical separation at crossings between the water main piping and other sewer utilities shall be a minimum clearance of eighteen (18) inches.

When specified clearance is not physically possible between sewer and water in a new subdivision, in locations where sewer is built along roads having existing water mains, or already exist in a road, and the water main cannot be built to specified clearances, ductile iron pipe with mechanical joints or other approved safety joints shall be used for the water mains. In these cases the reviewing authority, the Michigan Department of Natural Resources and Environment (MDNRE), shall be consulted.

2. Easement Location

All water mains placed in utility easements shall be centered in the easement and the easement shall be 20 feet minimum width. No permanent structures shall be allowed to be built over the easement. Also, no other utilities will be allowed in the water utility easement without the City of Marquette's permission. Other utilities that have been approved for placement near the water main easement will require a separate easement.

3. Dead End Mains/Future Extension

All water mains shall be looped, except where capped for future extension to adjoining property. A fire hydrant shall be placed at the end of the main and may be relocated at the time the main is extended, if approved by the City Engineer and City Public Works.

4. Deflections

Distribution mains may be designed on a curved alignment to reduce the number of bends. Along curves, the water main may be deflected at each joint within the limits given in the City of Marquette standard details and specifications.

5. Bury Depth

Bury depth shall be six an one half (6.5) feet minimum measured from finished grade of the road or as specified by the City Engineer. If such grades are not available, the design engineer shall submit proposed grades for approval by the City Engineer.

B. Service Piping and Connections

1. General

Water service connections to the building service water supply piping shall be placed one (1) foot off the right of way or easement. All connections will be by means of a curb stop and fittings necessary to make the private connection after the curb stop. Curb stops are considered the delineating point where the City system meets the privately owned building service supply piping.

2. Location

Water service lines will be located at a minimum ten (10) feet from the side property line of the lot or at a location desired by the homeowner if the lot is already developed. Service lines will be run perpendicular to the water main. Service lines will not be located underneath driveways.

3. Bury Depth

Bury depth over service lines must be a minimum of six and one half (6.5) feet.

4. Clearances

Water services that are placed near a sanitary sewer lateral shall have a parallel distance of ten (10) feet if a vertical distance of eighteen (18) inches (water service being higher) can not be obtained. Instances where a vertical distance of eighteen (18) inches can be obtained with the minimum cover depth requirements the water service and sanitary sewer lateral can be placed in the same trench. The water and sewer utilities in the same trench will require the vertical separation and a parallel separation of eighteen (18) inches with the water service being higher.

5. Water Meters

Water meters for building service water supply piping shall be placed on the basement wall fronting the street. Other areas such as mechanical rooms may apply pending approval by the City of Marquette Public Works. Meters, touch pads, or other devices used to record the water usage will be placed by the City of Marquette Public Works Department.

6. Fire Protection Service Lines

The domestic supply lead shall be a separate lead from the fire protection line inside the building.

7. Sprinkler Systems

All in-house irrigation sprinkler systems shall have a double check detector assembly equipped with a by-pass meter assembly to monitor low flow. All in ground irrigation sprinkler systems shall have a double backflow preventer and a separate meter to monitor flow. All meters and backflow preventers shall be inspected by the City of Marquette Public Works Utility Inspector. Refer to AWWA, *Cross Connection and Backflow Prevention* for additional design criteria.

8. Manifold Water Service System for Condo's/Town-Homes

Separate water service connections to a City controlled water main for individual condominium or townhouse units may be waived in lieu of the installation of a manifold water service system (see attached drawing). This will only apply to condominium or townhouse units that have private lot lines less than 40 feet in width. The owner or association will be responsible for each leg of the water service system and the manifold outside the right of way or dedicated utility easement. The City of Marquette will be responsible for future replacement of the common service connection within the right of way or dedicated utility easement. Future replacement outside the right of way or dedicated utility easement will be the responsibility of the owner or the association.

C. Curb Stop/Gate Valve and Box Locations

Each water service connection to building sites shall have a curb stop or a gate valve installed one foot inside of the right-of-way or public easement.

Valves shall be installed on the loop or network of the transmission main system at such places as to isolate the branch sections as may be necessary with a maximum spacing of 600 feet. They shall be installed on all fire hydrant leads as close to the water main as is feasible. A valve shall be placed on all branch lines, regardless of size, near the main. Valves at intersections shall be placed on projection of road right-of-way lines per the City's standard details. In no case shall the valve be placed in the sidewalk or pathway.

D. Bedding, Haunching, and Initial Backfill

Embedment materials for bedding, haunching, and initial backfill shall meet City of Marquette, MDNRE, and State of Michigan Transportation requirements based on the type of soil encountered and potential groundwater conditions.

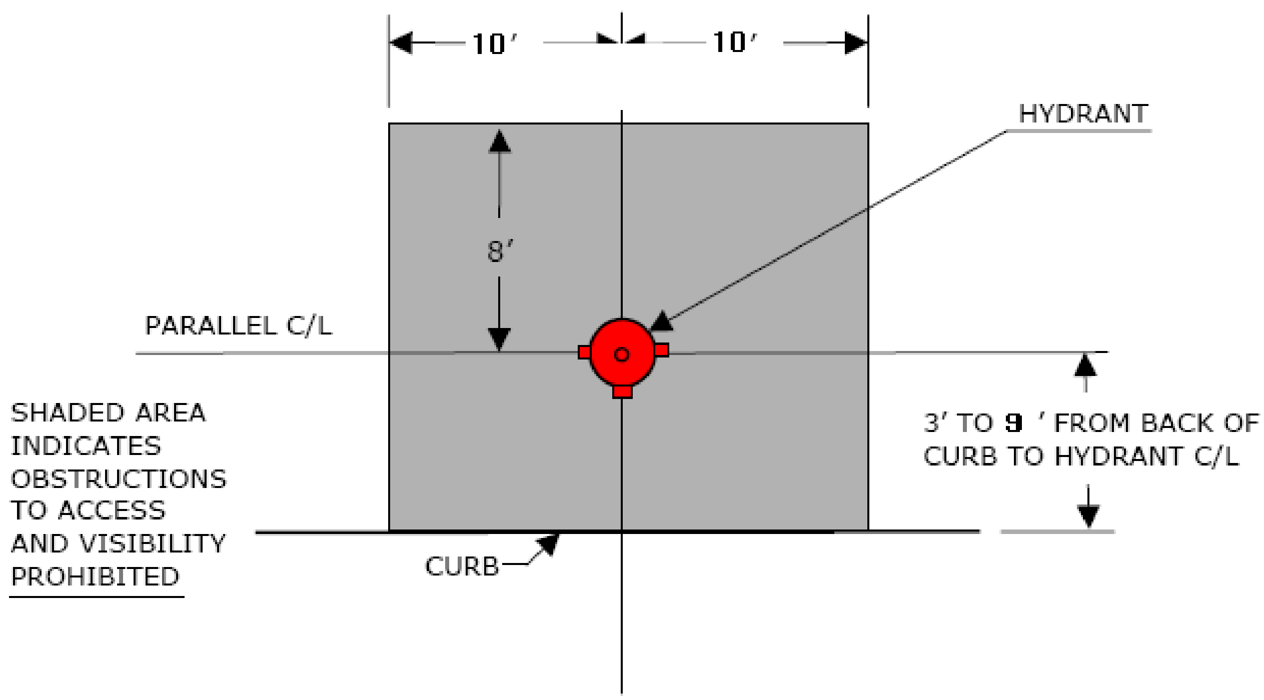
Haunching of the embedment materials will be done by industry and construction standards.

E. Fire Hydrant Layout

All fire hydrants shall be located in street right-of-way or easement. In a platted subdivision all fire hydrants shall be located at the lot line, or lot line extension which is shared with the adjacent lot, have a ten (10) foot clearance on each side, and at the finish grade elevation at the point shown on the plans.

1. The following restrictive covenant shall be placed on the final plat to advise future property owners adjacent to the fire hydrant: "The property owner is specifically prohibited from causing any access or visibility obstruction to any fire hydrant on or adjacent to their property. This includes but is not limited to planting of any tree, bush or plant; erection of any fence, wall, mail box, or sign; or changing the contours of the land. The prohibited area shall extend to ten (10) feet on all sides parallel and perpendicular to the centerline of the hydrant.

2. Except as herein provided, a fire hydrant shall be located between 3 ft. and 9 ft. from the back of curb (or edge of pavement) to the centerline of the barrel.



3. Fire hydrants shall be placed at each street intersection, at water main termination in cul-de-sacs, and at other locations so that the distance between them does not exceed 500 feet. This distance shall be measured in the street as fire hose laid down from a fire vehicle. Fire hydrants shall be located such that all proposed or existing building sites are within 300 feet of fire hose laid down from a fire hydrant.

4. All fire hydrants shall be located apart from buildings and shall be fully accessible from paved driveways, streets and fire lanes.

5. The fire hydrants connection to the water main shall be in accordance with the City's "Standard Specifications and Construction Drawings". All fire hydrants shall be installed with valves to isolate the fire hydrant.

6. Normally, fire hydrants will have a seven (7) foot bury, with extension as needed. A base elevation for each fire hydrant shall be shown on the profile.

7. In general, fire hydrants shall be placed at all high points along the main and at the terminus of dead end mains.

F. Air and Vacuum Release Valves

The proper ventilation of distribution and transmission mains is often overlooked by design engineers. Trapped air pockets can significantly reduce the capacity of the mains as well as cause increased pumping heads and corresponding higher pumping costs. The following guidelines shall be used to locate air and vacuum release valves:

Peaks in profiles
Abrupt increase in downward slope
Abrupt decrease in upward slope
Long ascents - 1500 ft to 3000 ft intervals
Long descents - 1500 ft to 3000 ft intervals
Long horizontals - 1500 ft to 3000 ft intervals
Pumps - on the discharge side of pump having suction as close to
the check valve as possible

G. Abandonment Procedures

1. Service connections shall be abandoned by turning off the corporation stop at the water main and the removing the curb box near the property line.

2. Distribution mains that are to be abandoned shall be plugged at the point of abandonment and on each side of any existing valves, and the valves and hydrants removed and salvaged if their reuse appears practicable.

H. Flushing, Disinfection, Pressure, and Continuity Tests

New mains shall not go into service until they have been adequately flushed, pressure tested, disinfected, and continuity tested according to the City of Marquette Standard Specifications and the Michigan Department of Natural Resources and Environment. The procedures shall be conducted under the inspection of a representative from the City Engineer's Office.

STORM SEWER
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL AND REQUIRED INFORMATION

A. Intent
The Storm Water Design Standards are intended to provide for a comprehensive and integrated storm water utility system to convey and manage storm waters, mitigate safety hazards, minimize property losses, and disruption due to heavy storm runoff and flooding, maintain travel on public streets during storm events, enhance water quality of storm runoff by mitigating erosion, sediment and pollutant transport, control and manage increased runoff due to local development, provide for ongoing emergency maintenance of public storm water systems, establish effective long-term management of natural drainage ways, and protection of the water quality of our lakes, streams, and rivers.

The components that contribute to the storm water system consist of curbs, gutter, catch basins, intakes, manholes, swales, ditches, retention/detention areas, treatment units, and storm sewers. These components as a whole contribute to the conveyance and management of the storm waters in the City of Marquette.

B. Information Required
The information required shall be submitted in a design report, stamped by a Professional Engineer licensed in the State of Michigan, and shall contain calculations, maps, and other descriptive material showing but not limited to the following:

1. The extent and area of each watershed tributary to the drainage facilities in the development.

2. The capacity of the existing receiving sewer and the current peak flow into the existing receiving sewer.

3. The street storm sewers and other storm drains to be built, the basis of their design, outfall/outlet locations and elevations, the receiving water body and its high water elevation, and the functioning of the drains during high water conditions.

4. The parts of the proposed street system where pavements are planned to be depressed sufficiently to convey or temporarily store overflow from storm sewers and over the curb runoff resulting from the heavier rainstorms and the outlets for such overflow.

5. Existing streams and floodplains, and new channels to be constructed, their locations, cross sections and profiles.

6. Proposed culverts and bridges to be built, their materials, elevations, waterway openings and basis of their design.

7. Existing detention basins and ponds to be maintained, enlarged, or otherwise altered and new basins or ponds to be built and the basis of their design.

8. The location and percentage of impervious surfaces existing and expected to be constructed when the development is completed.

9. The slope, type and size of all storm sewers and other waterways.

10. For all detention basins, a plot or tabulation of storage volumes with corresponding water surface elevations and a plot or tabulation of the basin outflow rates for those water surface elevations.

11. Temporary and permanent control measures for erosion and sediment containment.

12. Water quality treatment measures.

C. Variations
Any unique storm water improvements shall be considered a special circumstance. Special circumstances shall require that the City of Marquette Engineering and Public Works Departments approve the variation in concept prior to final design. Variations shall include pressure systems, materials of construction, methods of construction, retention/detention structures, and water quality treatment measures.

DETERMINATION OF RUNOFF QUANTITIES

A. General Information
Storm drainage systems shall be designed for a peak runoff from a ten (10) year intensity rainfall. Sufficient capacity shall be provided in the storm sewer system to take fully developed upstream tributary drainage into the system. When a storm sewer is designed to provide capacity for upstream tributary areas, the hydraulic gradient shall remain in the pipe.

B. Design Basis
Runoff quantities shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel under development. The quantity of runoff which is generated as the result of a given rainfall intensity may be calculated as follows:

For areas up to and including twenty (20) acres, the Rational Method may be used. In the Rational Method, the peak rate of runoff, Q_p, in cubic feet per second is computed as:

$$Q_p = CIA$$

Where:

Q_p is defined as the peak runoff in cubic feet per second. Actually, Q_p is in units of inches per hour per acre. Since this rate of in/hr/ac differs from cubic feet per second by less than one (1) percent (1 in/hr/ac = 1.008 cfs), the more common units of cfs are used.

C is the coefficient of runoff representing the ratio of peak runoff rate "Q_p" to average rainfall intensity rate "I" for a specified area "A".

I is the average intensity of rainfall in inches per hour for a period of time equal to the time of concentration (tc) for the drainage area to the point under consideration.

A is the area in acres contributing runoff to the point of design.

The following basic assumptions are associated with the Rational Method:

- The storm duration is equal to the time of concentration.
- The computed peak rate of runoff to the design point is a function of the average rainfall rate during the time of concentration to that point.
- The return period or frequency of the computed peak flow is the same as that for the design storm.
- The necessary basin characteristics can be identified and the runoff coefficient does not vary during a storm.
- Rainfall intensity is constant during the storm duration and spatially uniform for the area under analysis.

1. Runoff Coefficient

The proportion of the total rainfall that will reach the drainage system depends on the imperviousness of the surface and the slope and ponding characteristics of the area. Impervious surfaces, such as asphalt pavements and roofs of buildings, will be subject to approximately one hundred (100) percent runoff (regardless of the slope). On-site inspections and aerial photographs may prove valuable in estimating the nature of the surfaces within the drainage area.

The runoff coefficient "C" in the Rational Formula is also dependent on the character of the soil. The type and condition of the soil determines its ability to absorb precipitation. The rate at which a soil absorbs precipitation generally decreases as the rainfall continues for an extended period of time. The soil infiltration rate is influenced by the presence of soil moisture (antecedent moisture), the rainfall intensity, the proximity of the ground water table, the degree of soil compaction, the porosity of the subsoil, and ground slopes.

It should be noted that the runoff coefficient "C" is the variable of the Rational Method which is least susceptible to precise determination. A reasonable coefficient must be chosen to represent the integrated effects of infiltration, detention storage, evaporation, retention, flow routing and interception, all of which affect the time distribution and peak rate of runoff.

Values for the runoff coefficient “C” are shown in Table 1 and Table 2 which show values for different types of surface characteristics. The composite “C” value used for a given drainage area with various surface types shall be the weighted average value for the total area calculated from a breakdown of individual areas having different surface types.

The calculation of a weighted runoff coefficient *CA* value should be based on a ratio of the drainage areas associated with each *C* value as follows:

$$\text{Total } CA = A_1C_1 + A_2C_2 + A_3C_3 \ldots$$

TABLE 1
RUNOFF COEFFICIENTS (C), RATIONAL FORMULA

		Hydrologic Soil Group											
	PERCENT	A			B			C			D		
	IMPERVIOUS	SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)		
LAND USE	AREA	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over
Industrial...	90	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial...	95	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
High-Density													
Residential...	60	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.64	0.69
Medium-Density													
Residential...	30	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low-Density													
Residential...	15	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture...	5	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open space...	2	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and													
Expressways...	70	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78

TABLE 2
RUNOFF COEFFICIENTS FOR SPECIFIC LAND USE

	Hydrologic Soil Group											
	A			B			C			D		
	SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)			SLOPE RANGE (PERCENT)		
LAND USE	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over	0 - 2	2 - 6	6 & over
Row Crops	0.08	0.16	0.22	0.12	0.20	0.27	0.15	0.24	0.33	0.19	0.28	0.38
	0.22	0.30	0.38	0.26	0.34	0.44	0.30	0.37	0.50	0.34	0.41	0.56
Median strip-turf	0.19	0.20	0.24	0.19	0.22	0.26	0.20	0.23	0.30	0.20	0.25	0.30
	0.24	0.26	0.30	0.25	0.28	0.33	0.26	0.30	0.37	0.27	0.32	0.40
Side slope-turf			0.25			0.27			0.28			0.30
			0.32			0.34			0.36			0.38
Forest/Woodland	0.08	0.11	0.14	0.10	0.14	0.18	0.12	0.16	0.20	0.15	0.20	0.25
PAVEMENT:												
Asphalt						.70 - .95						
Concrete						.80 - .95						
Brick						.70 - .80						
Drives, Walks						.75 - .85						
Roofs						.75 - .95						
Gravel Roads Shoulders						.40 - .60						

NOTE: The lower C values in each range should be used with the relatively low intensities associated with 2 to 10 year design recurrance intervals whereas the higher C values should be used for intensities associated with the longer 25 to 100 year design recurrence intervals.

Due to assumptions made in the formula, *C* can vary depending on the design storm. The value for *C* can be expressed as follows:

Where: *C = kC*

k = factor to adjust formula. It should be taken as follows:

Design Storm	*k*
2- to 10-year	1.0
25-year	1.1
50-year	1.2
100-year	1.25

2. Average Rainfall Intensity (I) and Time of Concentration (t_c)

Rainfall intensity (I) is the average rainfall rate in inches per hour, and is selected on the basis of design rainfall duration and design frequency of occurrence. The design duration is equal to the time of concentration for the drainage area under consideration. The design frequency of occurrence is a statistical variable which is established by design standards or chosen by the Engineer as a design parameter.

The selection of the frequency criteria is necessary before applying any hydrologic method. **Storm drainage improvements in the City of Marquette must be designed to intercept and carry the runoff from a ten (10) year frequency storm.** Situations where a DEQ permit is required the design must incorporate a one hundred (100) year frequency storm.

3.The rainfall intensity used in the rational method can be read from the intensity-duration frequency curves (Fig. 1) based on the selected design frequency and design duration (t_c), as discussed below.

RAINFALL INTENSITY DURATION-FREQUENCY CURVES FOR MARQUETTE, MICHIGAN

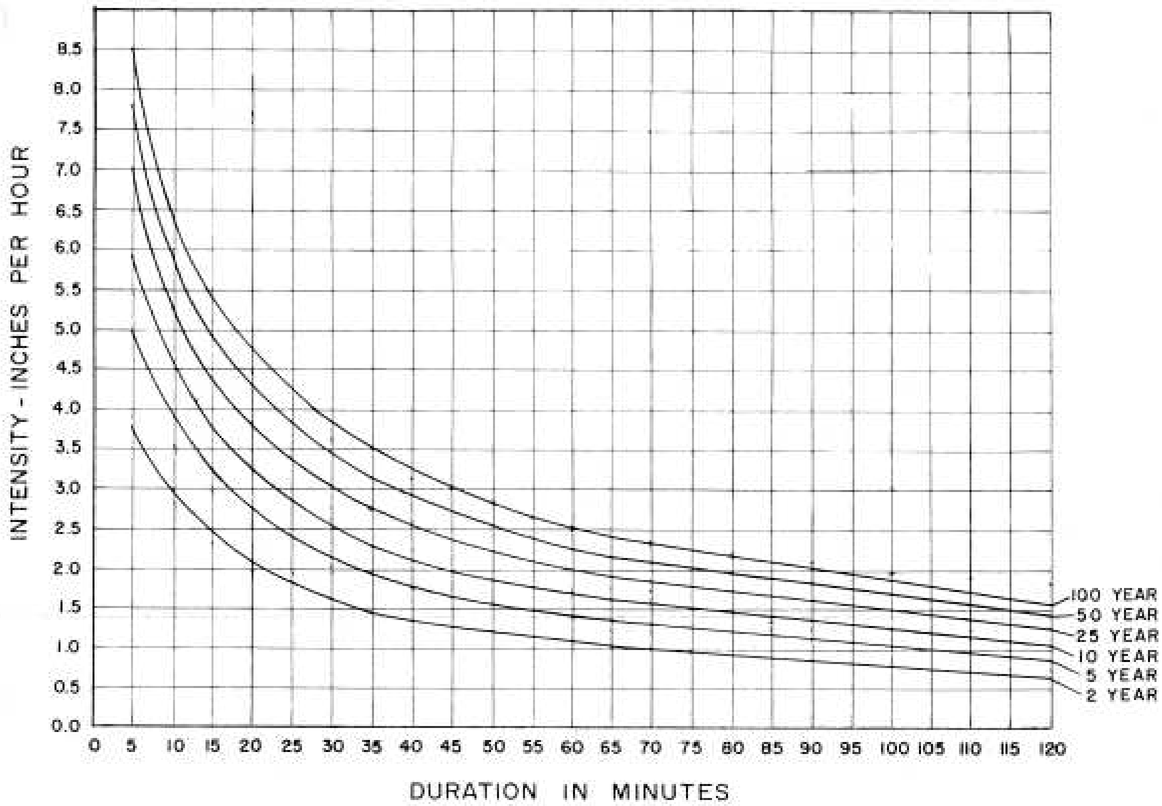


Figure 1

4. Time of Concentration (t_c)

The time of concentration is the time associated with the travel of runoff from an outer point which best represents the shape of the contributing areas. Runoff from a drainage area usually reaches a peak at the time when the entire area is contributing, in which case the time of concentration is the time for a drop of water to flow from the most remote point in the watershed to the point of interest. Runoff may reach a peak prior to the time the entire drainage area is contributing. Sound engineering judgment should be used to distinguish which the time of concentration is representative.

For urban areas, the time of concentration consists of an inlet time or overland sheet flow time of travel segment plus a shallow concentrated flow time of travel segment. The shallow concentrated flow time of travel segment can be further divided into additional segments, such as, storm sewer pipe flow, gutter flow, or open channel flow. For non-urban areas, the time of concentration consists of an overland sheet flow time of travel plus a shallow concentrated flow time of travel in a open channel form, such as a swale, channel, or drainage way.

The travel time is computed for each flow segment and the time of concentration is equal to the sum of the individual travel times as follows:

Where $tc = t_{osf} + t_{scf} + t_{ocf} + t_{pf}$ (Minutes)

tc = time of concentration in minutes
t_{osf} = travel time for the overland sheet flow segment in minutes
t_{scf} = travel time for the shallow concentrated flow segment in minutes
t_{ocf} = travel time for the open channel flow segment(s) in minutes
t_{pf} = travel time for the pipe flow segment(s) in minutes

(a) **Overland Sheet Flow.** Overland **s**heet flow is shallow flow over land surfaces which usually occurs in the furthest upstream segment of the drainage path, which is located immediately downstream from the drainage divide. The Engineer should realize that sheet flow occurs for only very short distances in urbanized conditions. Urbanized areas are assumed to have sheet flow of three hundred (300) feet or less.

The following equation has been developed for sheet flow of less than three hundred (300) feet.

Where: $\mathbf{t_{osf} = Ln/(42s^{0.5})}$

t_{osf} = Time of concentration for overland sheet flow in minutes
L = Length of the reach in ft.
n = Manning's n (see Table 3)
s = Slope of the ground in ft/ft

(b). **Shallow Concentrated Flow.** After a maximum of three hundred (300) feet sheet flow becomes shallow concentrated flow or open channel flow as it progresses down the drainage system. To calculate choose one of the following methods and consider the conditions for which the equation was developed and how they compare to the drainage area being designed.

The time of concentration for shallow concentrated flows can be computed from the equation as follows:

Where: $\mathbf{t_{scf} = Ln/(60s^{0.5})}$

t_{scf} = Time of concentration for shallow concentrated flow in minutes
L = Length of the reach in ft.
n = Manning's n (see Table 3)
s = Slope of the ground in ft/ft

TABLE 3 - ROUGHNESS COEFFICIENTS (MANNING'S N) FOR SHEET FLOW

SURFACE DESCRIPTION	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover <20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.40
Dense underbrush	0.80

When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

1. The n values are a composite of information compiled by Engman (1986).

(c). **Open Channel Flow.** Overland sheet flow, or shallow concentrated flow, becomes open-channel flow when it enters a defined channel with known cross-sectional geometry. To obtain the total time of concentration, the open channel-flow time must be calculated and added the other the travel time flow segments. The velocity must first be determined for open channel or pipe flow flow. Once the velocity has been determined, the time of concentration for open channel flows can be computed from the following equation:

Where: $t_{ocf} = L/(60V)$

t_{ocf} = travel time, min
L = length which runoff must travel, ft
V = estimated or calculated velocity, ft/s

The velocity in an open channel or a storm sewer not flowing full can be determined by using Manning's Equation. Usually, average flow velocity is determined assuming a bank-full condition.

Where: $V = 1.49R^{2/3} S^{1/2}/n$

n = Coefficient of Roughness (see Table 4 below)

R = Hydraulic Radius (ft.)
S = Slope of Pipe (ft./ft.)

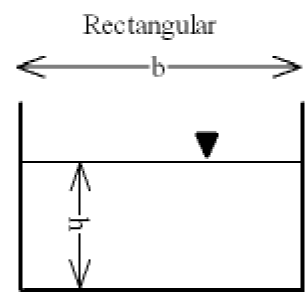
The hydraulic radius is calculated from the following equation:

Where: R = A / p
R = Hydraulic Radius (ft.) (hydraulic radius is approximated by depth in wide channels)
A = Cross-sectional Area of Flow (sq. ft.)
p = Wetted perimeter (ft.)

Area, wetted perimeter and hydraulic diameter for some common geometric sections like rectangular channels, trapezoidal channels, triangular channels, and circular channels have been included for application.

Rectangular Channel

Flow Area
Flow area of a rectangular channel can be expressed as
A = b h



Where:
A = flow area (in^2)
b = width of channel (in)
h = height of flow (in)

Wetted Perimeter
Wetted perimeter of a rectangular channel can be expressed as
P = b + 2 h

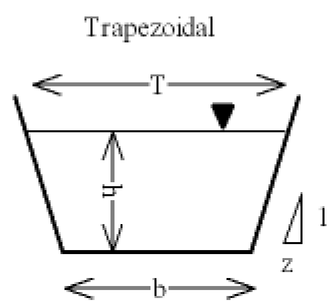
Where:
P = wetted perimeter (in)

Hydraulic Radius
Hydraulic radius of a rectangular channel can be expressed as
R_h = b h / (b + 2 y)

Where:
R_h = hydraulic radius (in)

Trapezoidal Channel

Flow Area
Flow area of a trapezoidal channel can be expressed as
A = (b + z h) h



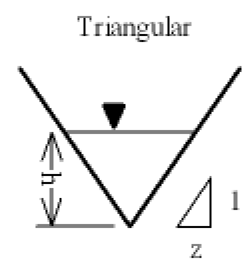
Where:
z = see figure to the right

Wetted Perimeter
Wetted perimeter of a trapezoidal channel can be expressed as
$P = b + 2\ h\ (1 + z^2)^{1/2}$

Hydraulic Radius
Hydraulic radius of a trapezoidal channel can be expressed as
$R_h = (b + z\ h)\ h\ /\ b + 2\ h\ (1 + z^2)^{1/2}$

Triangular Channel

Flow Area
Flow area of a triangular channel can be expressed as
$A = z\ h^2$
Where:
z = see figure to the right

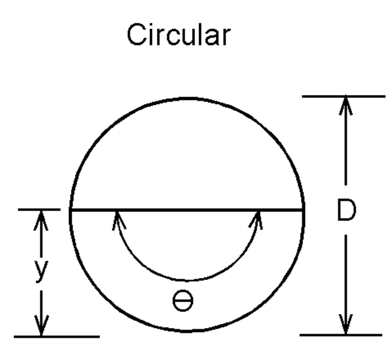


Wetted Perimeter
Wetted perimeter of a triangular channel can be expressed as
$P = 2\ h\ (1 + z^2)^{1/2}$

Hydraulic Radius
Hydraulic radius of a triangular channel can be expressed as
$R_h = z\ h\ /\ 2\ (1 + z^2)^{1/2}$

Circular Pipe

Flow Area
Flow area of a circular pipe can be expressed as
$A = D^2/8\ (\Theta - \sin(\Theta))$



Where:
D = diameter of pipe
Θ = angle representing how full the culvert is in radians

Wetted Perimeter
Wetted perimeter of a circular pipe can be expressed as
$P = \Theta D/2$

Hydraulic Radius
Hydraulic radius of a circular pipe can be expressed as
$R_h = A/P$

Tables, nomographs, etc. may be used in lieu of calculations, provided the supporting documentation is included in the design report.

TABLE 4 - ROUGHNESS COEFFICIENTS (MANNING'S N) FOR OPEN CHANNEL FLOW

TYPE OF CHANNEL	n
Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble Masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.033
Grass (Sod)	0.030
Riprap	0.035
Grouted Riprap	0.030
Open Channels (Unlined) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Channels, not maintained, weeds & brush uncut	0.090
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street	
Curbing	0.014

Triangular Gutter Flow

The travel time for gutter flow can be estimated using an average velocity of the flow. The equation below can be used to determine the velocity in a triangular gutter section given the watercourse slope, gutter cross slope, and water spread. The gutter flow time shall be computed by dividing the distance from the point where the overland/initial flow reaches the street or gutter to the nearest inlet by the gutter velocity.

The gutter velocity is determined using the following equation:

Where: $\boldsymbol{V_g = 1.12\, S_x^{\,0.67} S^{\,0.50} T^{\,0.67}/n}$

V_g = velocity of flow in the gutter, ft/s.
S_x = street cross slope, ft/ft, use design value of 0.02 or 0.03.
S = street longitudinal slope, ft/ft.
T = spread of flow in the gutter = d/S_x, ft.
(4 feet max for streets without parking and 12 feet for streets with parking)
d = depth of flow in the gutter, ft.
n = Manning's "n" for pavement, use design value of 0.014.

(d). Pipe Flow. For ordinary conditions, a storm drain should be sized assuming that it will flow full or almost full for the design discharge. For non-pressure flow, the velocity can be determined using Manning's equation. For a circular pipe flowing full, the equation becomes the following:

Where: $V = 0.593\, D^{0.67} S^{0.50}/n$

V = mean velocity of flow, ft/s
n = Manning's roughness coefficient
D = Diameter of the circular pipe, (ft)
S = slope of the hydraulic grade line, decimal
Note that min. allowable velocity is 3.0 fps and max. 10.0 fps.

Pipe flow charts can be used to determine the velocity for either full or partially-full flow conditions provided documentation is provided in the design report.

Once the velocity has been determined, the time of concentration pipe flow can be computed from the following equation:

Where: $\mathbf{t_{pf}} = \boldsymbol{L/(60V)}$

t_{pf} = travel time, min
L = length which runoff must travel, ft
V = estimated or calculated velocity, ft/s

For circular pipes the travel time is usually calculated by assuming the pipe is full, where the hydraulic radius is one-fourth the pipe diameter. For pipe reaches where the HGL is above the crown of the pipe (pressure flow), travel time in the pipe shall be determined using the velocity calculated from the continuity equation:

Where: $\mathbf{Q = AV}$
A = cross-sectional area of the pipe in square feet
V = average pipe velocity in feet per second (fps)

In all cases, if the calculated velocity is less than 2.5 fps, then a value of 2.5 fps shall be used to calculate the travel time.

C. Limitations

The Rational Method is an adequate method for approximating the peak rate and total volume of runoff from a design rainstorm in a given catchment. The greatest drawback to the Rational Method is that it normally provides only one point on the runoff hydrograph. When the areas become complex and where sub-catchments come together, the Rational Method will tend to overestimate the actual flow, which results in oversizing of drainage facilities. The Rational Method provides no direct information needed to route hydrographs through the drainage facilities. One reason the Rational Method is limited to small areas is that good design practice requires the routing of hydrographs for larger catchments to achieve an economic design.

Another disadvantage of the Rational Method is that with typical design procedures one normally assumes that all of the design flow is collected at the design point and that there is no water running overland to the next design point. This being said, the Rational Method is adequate for analyzing most small storm sewer systems.

D. Alternate Design Basis – (TR-20/TR-55)

For watersheds greater than 20 acres and for drainage facilities that include storage, the SCS (currently NRCS) "Urban Hydrology for Small Watersheds" method, commonly referred to as TR-20/TR-55, shall be used for the basis of design. The design shall use the Type II, 10 yr-24 hour storm (3.15 inches). The use of software packages incorporating TR-20/TR-55 is encouraged.

(a). Introduction. The Natural Resource Conservation Service (NRCS) hydrologic method requires basic data similar to the Rational method: drainage area, a runoff factor, time of concentration, and rainfall. The NRCS approach, however, is more sophisticated in that it also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. Details of the methodology can be found in the NRCS National Engineering Handbook, Section 4, Hydrology. A typical application of the NRCS method includes the following basic steps:

1. Determination of curve numbers that represent different land uses within the drainage area.
2. Calculation of time of concentration to the study point.
3. Using the Type II rainfall distribution, total and excess rainfall amounts are determined.
4. Using the unit hydrograph approach, the hydrograph of direct runoff from the drainage basin can be developed.

The NRCS method can be used for both the estimation of stormwater runoff peak rates and the generation of hydrographs for the routing of stormwater flows. The simplified method can be used for drainage areas up to 2,000 acres. The NRCS method can be used for most design applications, including storage facilities, outlet structures, storm drain systems, culverts, small drainage ditches, open channels, and energy dissipators.

(b). Equations and concepts. The hydrograph of outflow from a drainage basin is the sum of the elemental hydrographs from all the sub-areas of the basin, modified by the effects of transit time through the basin and storage in the stream channels. Since the physical characteristics of the basin (shape, size, and slope) are constant, the unit hydrograph approach assumes that there is considerable similarity in the shape of hydrographs from storms of similar rainfall characteristics. Thus, the unit hydrograph is a typical hydrograph for the basin with a runoff volume under the hydrograph equal to 1 inch from a storm of specified duration. For a storm of the same duration, but with a different amount of runoff, the hydrograph of direct runoff can be expected to have the same time base as the unit hydrograph and ordinates of flow proportional to the runoff volume. Therefore, a storm that produces 2 inches of runoff would have a hydrograph with a flow equal to twice the flow of the unit hydrograph. With 0.5 inches of runoff, the flow of the hydrograph would be one-half of the flow of the unit hydrograph.

The following discussion outlines the equations and basin concepts used in the NRCS method:

1. Drainage area. The drainage area of a watershed is determined from topographic maps and field surveys. For large drainage areas, it might be necessary to divide the area into sub-drainage areas to account for major land use changes, obtain analysis results at different points within the drainage area, combine hydrographs from different subbasins as applicable, and/or route flows to points of interest.

2. Rainfall. The NRCS method applicable to the State of Michigan is based on a storm event that has a Type II time distribution. These distributions are used to distribute the 24-hour volume of rainfall for the different storm frequencies.

3. Rainfall-runoff equation. A relationship between accumulated rainfall and accumulated runoff was derived by the NRCS from experimental plots for numerous soils and vegetative cover conditions. The NRCS runoff curve number (CN) method is described in detail in NEH-4 (NRCS 1985). The following NRCS runoff equation is used to estimate direct runoff from 24-hour or 1-day storm rainfall:

Where: $\mathbf{Q = (P - I_a)^2 / (P - I_a) + S}$

Q = volume of accumulated runoff (in)
P = accumulated rainfall (potential maximum runoff) (in)
S = potential maximum retention of rainfall on the watershed at the beginning of the storm (in)
Ia = initial abstraction, including surface storage, interception, and evaporation

I_a is highly variable, but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

Where: $\mathbf{I_a = 0.2S}$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting S into the runoff equation gives:

Where: $\mathbf{Q = (P - 0.2S)^2 / (P + 0.8S)}$

S is related to the soil and cover conditions of the watershed through the curve number, CN. CN has a range of 0 to 100, and S is related to CN by the following equation:

Where: $S = 1000/CN - 10$

Figure 2 and Table 5 can solve for direct runoff (Q) and the rainfall (P) for a range of CN's and rainfall.

Figure 2
Solution of the NRCS Runoff Equation

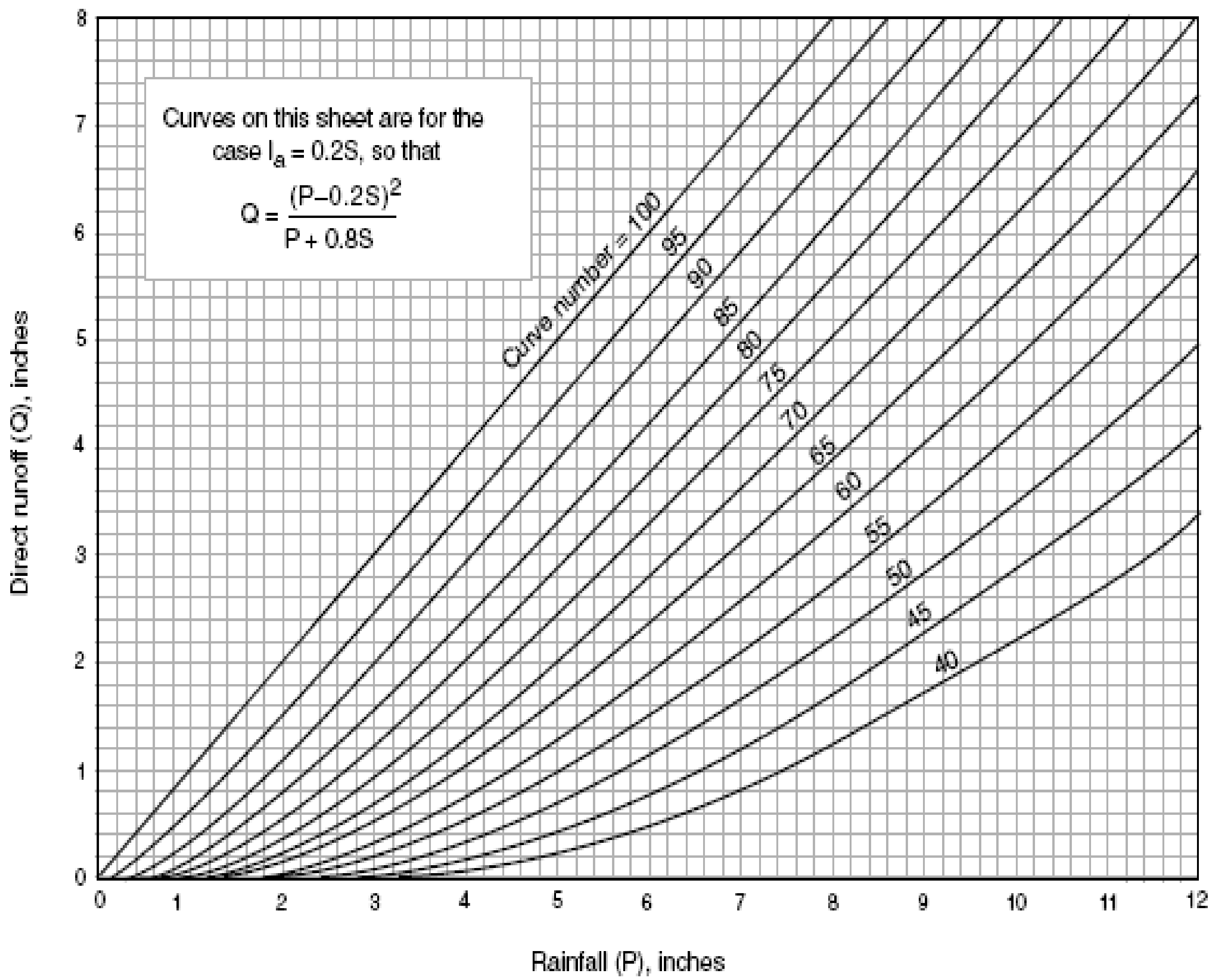


Table 5

Runoff Depth for Selected CN's and Rainfall Amounts[1]

	Runoff depth for curve number of:												
Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.10	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
2.0	.00	.00	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
2.5	.00	.00	.02	.08	.17	.30	.46	.65	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	.71	.96	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	1.01	1.30	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	.24	.44	.69	.98	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	.50	.80	1.14	1.52	1.92	2.35	2.81	3.28	3.78	4.30	4.85	5.41	5.76
7.0	.84	1.24	1.68	2.12	2.60	3.10	3.62	4.15	4.69	5.25	5.82	6.41	6.76
8.0	1.25	1.74	2.25	2.78	3.33	3.89	4.46	5.04	5.63	6.21	6.81	7.40	7.76
9.0	1.71	2.29	2.88	3.49	4.10	4.72	5.33	5.95	6.57	7.18	7.79	8.40	8.76
10.0	2.23	2.89	3.56	4.23	4.90	5.56	6.22	6.88	7.52	8.16	8.78	9.40	9.76
11.0	2.78	3.52	4.26	5.00	5.72	6.43	7.13	7.81	8.48	9.13	9.77	10.39	10.76
12.0	3.38	4.19	5.00	5.79	6.56	7.32	8.05	8.76	9.45	10.11	10.76	11.39	11.76
13.0	4.00	4.89	5.76	6.61	7.42	8.21	8.98	9.71	10.42	11.10	11.76	12.39	12.76
14.0	4.65	5.62	6.55	7.44	8.30	9.12	9.91	10.67	11.39	12.08	12.75	13.39	13.76
15.0	5.33	6.36	7.35	8.29	9.19	10.04	10.85	11.63	12.37	13.07	13.74	14.39	14.76

[1] Interpolate the values shown to obtain runoff depths for CNs or rainfall amounts not shown.

The runoff equation can be rearranged so the curve number can be estimated if rainfall and runoff volume are known. The equation then becomes (Pitt, 1994):

Where: $$CN = [1000/[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{1/2}]$$

P = rainfall (in)

Q_a = runoff volume (in)

(c). Runoff factor. The principal physical watershed characteristics affecting the relationship between rainfall and runoff are land use, land treatment, soil types, and land slope. The NRCS method uses a combination of soil conditions and land uses (ground cover) to assign a runoff factor to an area. These runoff factors, called runoff curve numbers (CN), indicate the runoff potential of an area. The higher the CN, the higher the runoff potential. Soil properties influence the relationship between runoff and rainfall since soils have differing rates of infiltration. Based on infiltration rates, the NRCS has divided soils into four hydrologic soil groups:

1. Group A Soils. Have a low runoff potential due to high infiltration rates. These soils consist primarily of deep, well-drained sands and gravels.

2. Group B Soils. Have a moderately low runoff potential due to moderate infiltration rates. These soils consist primarily of moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures.

3. Group C Soils. Have a moderately high runoff potential due to slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water or soils with moderately fine to fine texture.

4. Group D Soils. Have a high runoff potential due to very slow infiltration rates. These soils consist primarily of clays with high swelling potential, soils with permanently high water tables, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

Information on all of the soils in Michigan can be located in the NRCS Soil Survey publications, and can be obtained from the local NRCS offices for use in estimating soil type.

Consideration should be given to the effects of urbanization on the natural hydrologic soil group. If heavy equipment can be expected to compact the soil during construction, or if grading will mix the surface and subsurface soils, appropriate changes should be made in the soil group selected. Also, runoff curve numbers vary with the antecedent soil moisture conditions. Average antecedent soil moisture conditions (AMC II) are recommended for most hydrologic analysis. Areas with high water table conditions may want to consider using AMC III antecedent soil moisture conditions.

Tables with recommended curve numbers for a range of urban, cultivated agriculture, and other rural land uses are provided in Tables 6 - 7 and included in the land use definition menu in WINTR-55.

When a drainage area has more than one land use, a composite curve number can be calculated and used in the analysis. It should be noted that when composite curve numbers are used, the analysis does not take into account the location of the specific land uses, but sees the drainage area as a uniform land use represented by the composite curve number. Composite curve numbers for a drainage area can be calculated by using the weighted method.

The different land uses within the drainage basin should reflect a uniform hydrologic group, represented by a single curve number. Any number of land uses can be included, but if their spatial distribution is important to the hydrologic analysis, then subbasins should be developed, and separate hydrographs developed and routed to the study point.

Table 6 Runoff Curve Numbers for Urban Areas[1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas ar directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 7 Runoff Curve Numbers for Other Agricultural Lands[1]

Cover description: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

(d). Urban Modifications of the NRCS Method. Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for developed areas. For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur? The curve number values listed in the CN/land use tables are based on directly-connected impervious area. An impervious area is considered directly-connected if runoff from it flows directly into the drainage system. It is also considered directly-connected if runoff from it occurs as concentrated shallow flow that runs over pervious areas, and then into a drainage system. It is possible that curve number values from urban areas could be reduced by not directly connecting impervious surfaces to the drainage system, but allowing runoff to flow as sheet flow over significant pervious areas. The following discussion will give some guidance for adjusting curve numbers for different types of impervious areas.

1. Connected impervious areas. The CN's provided in the tables for the various land cover types were developed for typical land use relationships, based on specific assumed percentages of impervious area. These CN values were developed on the assumptions that:

    a. Pervious urban areas are equivalent to pasture in good hydrologic condition

    b. Impervious areas have a CN of 98, and are directly connected to the drainage system

DESIGN CRITERIA FOR STORM SEWERS

A. General Information
In general, all sewers shall be designed using the following criteria, with variations from such for special circumstances.

B. Hydraulic Calculations for Sizing Storm Sewer System Piping
Gravity storm sewers: The Rational Method or TR-20/TR-55, as appropriate, shall be used for calculating the contributing runoff for each basin towards the pipe run (inlet) in question. Manning's Formula shall be used for checking the existing or proposed pipe capacity.

For a storm-drainage system design using the Rational Method, the designer shall determine two different times of concentration, one for inlet spacing and one for pipe sizing. The difference between the two times is discussed in the following.

1. Inlet Spacing. The time of concentration, t_C, for inlet spacing is the time for water to flow from the hydraulically most-distant point of the drainage area to the inlet, which is known as the inlet time. This is the sum of the time required for water to move across the pavement or overland to the back of the curb to the gutter, plus the time required for flow to move through the length of the gutter to the inlet. For pavement drainage, if the total time of concentration to the upstream inlet is less than 5 min, a minimum t_C of 5 min should be used to estimate the intensity of rainfall. The time of concentration for the second downstream inlet and each succeeding inlet should be determined independently, the same as the first inlet. Travel time between inlets is not considered.

2. Pipe Sizing. The time of concentration for a point on a storm drain is the inlet time for the inlet at the upper end of the line plus the time of flow through the storm drain from the upper end of the storm drain to the point in question. If there is more than one source of runoff to a given

point in a storm-drainage system, the longest t_C is used to estimate the rainfall intensity, *I*. There can be an exception to this, for example, where there is a large inflow area at some point along the system, the t_C for that area may produce a larger discharge than the t_C for the summed area with the longer t_C. The designer should be aware of this possibility if joining drainage areas and determining which drainage area governs

A common mistake in urbanized areas is to assume travel velocities that are too slow. Another common error is to not check the runoff peak resulting from only part of the catchment. Sometimes a lower portion of the catchment or a highly impervious area produces a larger peak than that computed for the whole catchment. This error is most often encountered when the catchment is long or the upper portion contains grassy parkland and the lower portion is developed urban land.

Rational Method for Sizing Storm Sewer System:
The following step-by-step procedure should be used in conjunction with the "Rational Method Calculation Sheet" of these Standards. This procedure is for the average design situation and variations may be necessary to accommodate actual field conditions.

Columns 1 and 2: Determine design point (Inlet) locations and list. The design points should correspond to the sub-basins illustrated on a preliminary layout map.

Column 3: List basin areas "A" contributing runoff to this point (Inlet) that have not previously been analyzed. Subtract ponding areas that do not contribute to direct runoff

Column 4: Enter the runoff coefficient "C" for each basin area contributing to this inlet.

Column 5: Determine the "CA" value for each basin area contributing to this inlet.

Column 6: Enter the sum "∑CA" value based on the sum of the "CA" values associated with the drainage areas contributing to each design point.

Columns 7 through 34: Determine the time of concentration for each flow segment path traveling through the basin area contributing runoff to the inlet.

Column 35: Determine the total time of concentration for the basin area contributing runoff to the inlet.

Column 36: The average rainfall intensity to be applied to the basin under consideration is obtained from the total time of concentration from "Column 35" and the "Rainfall Intensity Duration Frequency Curves" shown in Fig. 1.

Column 37: Direct runoff from the tributary basins is calculated and tabulated hereby multiplying Columns 6 and 36 together.

Column 38: List the capacity of the pipe flowing full based on the pipe slope, size, and material using Manning's equation. This value should be equal or greater than the runoff contributing from the basin area called out in "Column 37".

Column 39: Include any remarks or comments that may affect or explain the design.

Rational Method Calculation Worksheet

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
						Time of Concentration													
Inlet						Overland Sheet Flow				Shallow Concentrated Flow				Open Channel Flow					
From	To	Area "A" (Acres)	C	CA	ΣCA	L (ft)	S (ft/ft)	"n"	t_{osf} (min)	L (ft)	S (ft/ft)	"n"	t_{scf} (min)	R (ft)	S (ft/ft)	Mannings "n"	Velocity (fps)	L (ft)	t_{ocf} (min)

Rational Method Calculation Worksheet Continued

(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)
Gutter Flow								Pipe Flow										
S_x (ft/ft)	S (ft/ft)	Mannings "n"	d (ft)	T (ft)	Velocity (fps)	L (ft)	t_{ocf} (min)	S (ft/ft)	Mannings "n"	D (ft)	Velocity (fps)	L (ft)	t_{pf} (min)	Total t_c (min)	I (in/hr)	Q_{Design} CIA (cfs)	Pipe Capacity (cfs)	Remarks

NRCS CN (TR-20/TR-55) Method Calculation Method

Pipe Capacity
Manning's Formula [$Q = A (1.49/n) R^{2/3} S^{1/2}$] shall be used to determine the pipe capacity. The "n" value shall be 0.015 or the pipe manufacturer's recommendation. Manning's "n" values, which are less than 0.013 shall require City Engineer approval and shall only be allowed if minor losses are accounted for.

Where: Q = Discharge (cu. ft./sec.)
A = Cross-sectional Area of Flow (sq. ft.)
n = Coefficient of Roughness
R = Hydraulic Radius (ft.)
S = Slope of Pipe (ft./ft.)

The hydraulic radius is calculated from the following equation:

Where: R = A / p
R = Hydraulic Radius (ft.)
A = Cross-sectional Area of Flow (sq. ft.)
p = Wetted perimeter (ft.)

Manning's Formula symbol values are provided in the following table. To find Q (discharge) multiply the last column value by $S^{1/2}$. To find the velocity use the following equation:

Where: V = Q/A
V = Velocity (ft./sec.)
Q = Discharge (cu. ft./sec.)
A = Cross-sectional Area of Flow (sq. ft.)

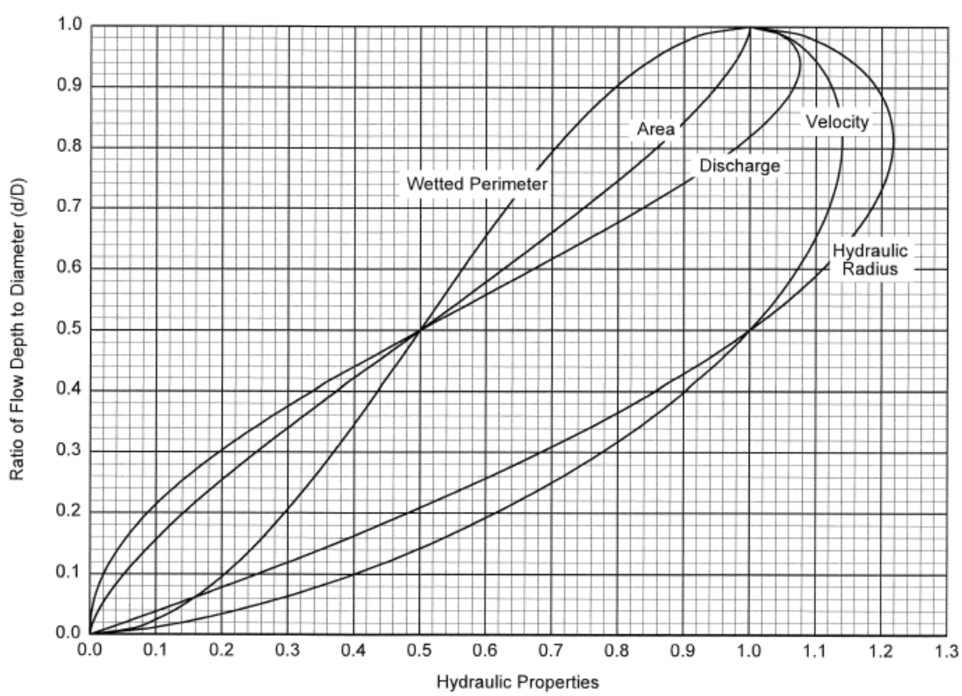
MANNING'S FORMULA SYMBOL VALUES (n = 0.015)
For Pipes Flowing Full

PIPE DIA. (INCHES) D	RADIUS (FEET) R	WETTED PERIMETER (FEET) P	AREA (SQ.FEET) A	HYDRAULIC RADIUS (FEET) R	$R^{2/3}$ (FEET)	A (1.49/N) $R^{2/3}$
8"	0.333	2.0944	0.34907	0.16667	0.30286	10.5014
10"	0.4167	2.6182	0.5455	0.20835	0.35145	19.0438
12"	0.500	3.14159	0.785398	0.250	0.39685	30.9610
15"	0.625	3.927	1.227	0.3125	0.46046	56.1220
18"	0.750	4.7124	1.767	0.37497	0.51999	91.2700
21"	0.875	5.49779	2.4053	0.4375	0.5763	137.6933
24"	1.000	6.2832	3.14159	0.500	0.62996	196.5882

PIPE DIA. (INCHES) D	RADIUS (FEET) R	WETTED PERIMETER (FEET) P	AREA (SQ.FEET) A	HYDRAULIC RADIUS (FEET) R	$R^{2/3}$ (FEET)	A (1.49/N) $R^{2/3}$
27”	1.125	7.0686	3.9761	0.5625	0.6814	269.1252
30”	1.25	7.8540	4.9087	0.62499	0.730999	356.4333
36”	1.50	9.425	7.0686	0.74998	0.82547	579.6018
42”	1.75	10.99557	9.62113	0.875	0.91483	874.3020
48”	2.00	12.5664	12.5664	1.000	1.000	1248.2624
54”	2.25	14.13717	15.9043	1.125	1.19324	1885.1129
60”	2.50	15.708	19.635	1.25	1.1604	2263.2558
66”	2.75	17.27876	23.7583	1.3750	1.2365	2918.1290
72”	3.00	18.8496	28.2743	1.50	1.3104	3680.3638
78”	3.25	20.4204	33.1831	1.625	1.38219	4555.9580
84”	3.50	21.9915	38.4845	1.745	1.4494	5540.7571
90”	3.75	23.5619	44.1786	1.875	1.5206	6673.0126

Hydraulic Properties of Circular Sewers
The hydraulic properties for partially full circular sections of pipe may be derived from the following graph:

Hydraulic Elements Graph



Hydraulic and Energy Grade Line, and Design Losses
Storm sewers shall be designed to convey the initial storm flow peaks without surcharging the sewer, and the final energy grade line shall be at or below the proposed ground surface. To ensure that this objective is achieved, the hydraulic and energy grade line shall be calculated by accounting for pipe friction losses and pipe form losses. Total hydraulic losses will include frictions, expansion, contraction, bend, and junction losses. The methods for estimating these losses are presented in the following sections.

(a) **Pipe Friction Losses:** The Manning's "n" values to be used in the calculation of storm sewer capacity and velocity are presented below.

Manning's "n" for Storm Sewers

Sewer Material Type	Manning's "n"
Concrete	0.013
Plastic	0.011
Corrugated Metal	0.024

(b) **Pipe Form Losses:** Generally, between the inlet and outlet the flow encounters a variety of configurations in the flow passageway such as changes in pipe size, branches, bends, junctions, expansion, and contractions. These shape variations impose losses in addition to those resulting from pipe friction. Pipe form losses are the result of fully developed turbulence and can be generally expressed as follows:

Where: $\mathbf{HL = K(V^2/2g)}$
HL = Head Loss (feet)
K = Loss Coefficient
$V^2/2g$ = Velocity Head (feet)
g = Acceleration of Gravity (32.2 ft/sec2)

Separate form losses attributable to pipe expansions and contractions, junctions and manholes, and at pipe outlets may be more specifically calculated in the following equations:

(i) **Expansion Losses:** Expansion in a storm sewer conduit will result in a shearing action between the incoming high velocity jet and the surrounding sewer boundary. Much of the kinetic energy is therefore dissipated by eddy currents and turbulence. The loss of head can be calculated as follows:

Where: $\mathbf{H_t = Ke\ (V_1^2/2g)\ [1 - (A_1/A_2)]^2}$
H_t = Head Loss (Feet)
Ke = Loss Coefficient
V1 = Pipe Velocity Upstream of Expansion (ft/sec)
A_1 = Pipe Cross-Sectional Area Upstream of Expansion (ft2)
A_2 = Pipe Cross-Sectional Area Downstream of Expansion (ft2)

(ii) **Contraction Losses:** The form loss of head due to contraction can be calculated as follows:

Where: $H_t = K_c (V_2^2/2g) [1 - (A_2/A_1)]^2$

H_t = Head Loss (Feet)
Kc = Loss Coefficient
V2 = Outfall Velocity (ft/sec)
A_1 = Pipe Cross-Sectional Area Upstream of Expansion (ft2)
A_2 = Pipe Cross-Sectional Area Downstream of Expansion (ft2)

(iii) **Junction and Manhole Losses:** A junction occurs where one or more branch sewers enter a main sewer, usually at manholes. The hydraulic design of a junction is in effect the design of two or more transitions, one for each flow path. Allowances should be made for head loss due to the impact at junctions. The head loss for a straight through manhole or at an inlet entering the sewer may be calculated from the general form loss equation, $H_j = K(V^2/2g)$, presented at the beginning of this section.

Other structure loss allowances should be made using the general form loss equation and an adjusted loss coefficient. Experimental studies have determined that the K value can be approximated as follows:

Where: $K_j = K_0 C_D C_d C_Q C_P C_B$

K_j = adjusted loss coefficient
K_0 = initial head loss coefficient based on relative manhole size.
C_D= correction factor for pipe diameter (pressure flow only)
C_d = correction factor for flow depth (non-pressure flow only)
C_Q= correction factor for relative flow
C_B= correction factor for benching
C_P = correction factor for plunging flow

* In some cases, the intent of the methodology is to compare the size of one pipe to another pipe (or to the size of the structure). In these cases an equivalent diameter is used, which is computed from the full area of the pipe or structure.

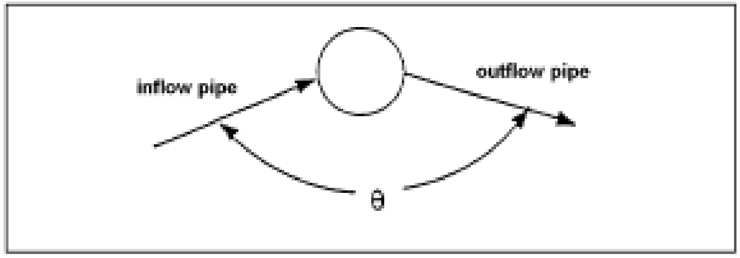
Relative Manhole Size

K_0 is estimated as a function of the relative structure size and the angle of deflection between the inflow and outflow pipes.

Where: $K_0 = 0.1(b/D_o)(1-\sin\theta) + 1.4(b/D_o)^{0.15} \sin\theta$

θ = the angle between the inflow and outflow pipes
b = structure diameter, (in)
D_o = outlet pipe diameter, (in)

Deflection Angle



Pipe Diameter

A change in head loss due to differences in pipe diameter is only significant in pressure flow situations when the depth in the structure to outlet pipe diameter ratio, d/Do, is greater than 3.2 otherwise C_D is set equal to 1.0. Therefore, it is only applied in such cases.

Where: $\mathbf{C_D = (D_0/Di)^3}$

Di = incoming pipe diameter, (in)
D_o= outgoing pipe diameter, (in)

Flow Depth

The correction factor for flow depth is significant only in cases of free surface flow or low pressures, when d/D_o ratio is less than 3.2 and is only applied in such cases. In cases where this ratio is greater than 3.2, C_d is set equal to 1.0. Water depth in the manhole is approximated as the level of the hydraulic gradeline at the upstream end of the outlet pipe. The correction factor for flow depth, C_d, is calculated by the following:

Where: $\mathbf{C_d = 0.5(d/D_o)^{0.6}}$

d = water depth in structure above outlet pipe invert, (in)
D_o= outlet pipe diameter, (in)

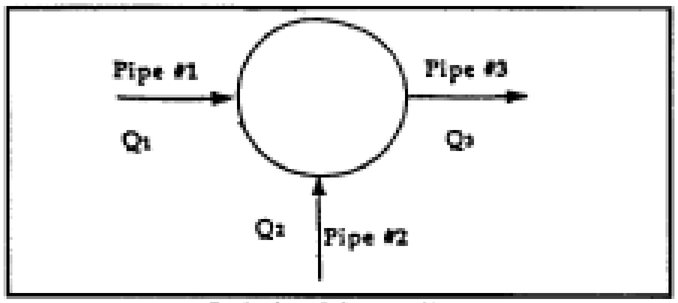
Relative Flow

The correction factor for relative flow, C_Q, is a function of the angle of the incoming flow as well as the percentage of flow coming in through the pipe of interest versus other incoming pipes. The correction factor is only applied to situations where there are three or more pipes entering the structure at approximately the same elevation. Otherwise, the value of C_Q is equal to 1.0. It is computed as follows:

Where: $C_Q = (1\text{-}2\sin\theta)(1\text{-}Q_i/Q_o)^{0.75} + 1$

C_Q = correction factor for relative flow
θ = the angle between the inflow and outflow pipes (degrees)
Q_i = flow in the inflow pipe, (ft3/s)
Q_o = flow in the outlet pipe, (ft3/s)

As can be seen from the equation, C_Q is a function of the angle of the incoming flow as well as the percentage of flow coming in through the pipe of interest versus other incoming pipes.



Relative Flow Effect

Plunging Flow

The correction factor for plunging flow, C_P, is calculated by the following:

Where: $C_P = 1 + 0.2\,[h/D_o][(h-d)/D_o]$

C_P = correction for plunging flow
h = vertical distance of plunging flow from flow line of higher elevation incoming pipe to the center of outlet pipe, (ft)
D_o = outlet pipe diameter, (ft)
d = water depth in structure above outlet pipe invert, (ft)

This correction factor corresponds to the effect of another inflow pipe or surface flow from an inlet, plunging into the structure, on the inflow pipe for which the head loss is being calculated. Using the notations in the above figure for the example, C_P is calculated for pipe # 1 when pipe # 2 discharges plunging flow. The correction factor is only applied when $h > d$, otherwise, the value of C_P is equal to 1.0. Additionally, the correction factor is only applied when a high elevation flow plunges into the structure that has both an inflow and outflow in the bottom of the structure.

Benching

The correction for benching in the structure, C_B, is obtained from Table 11-9. Benching tends to direct flows through the structure, resulting in reductions in head loss. For flow depths between the submerged and unsubmerged conditions, a linear interpolation is performed.

Benching Type Schematic

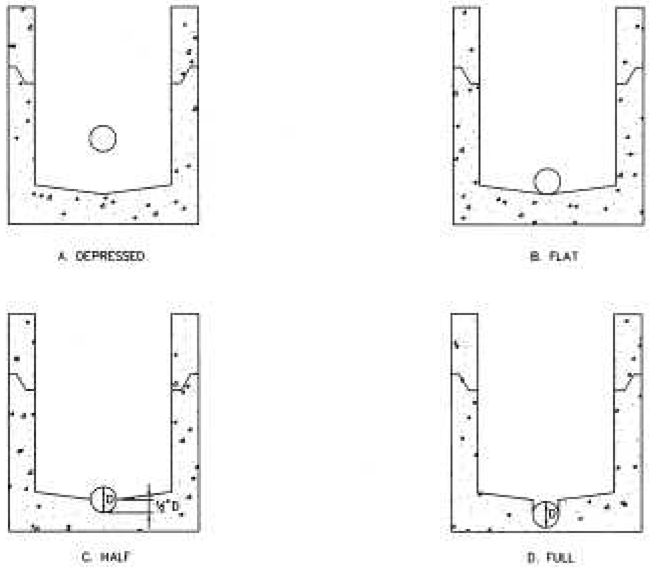


Table 11-9 Correction for Benching

Bench Type	Correction Factors, C_B	
	Submerged*	Unsubmerg-ed**
Flat floor	1.00	1.00
Half Bench	0.95	0.15
Full Bench	0.75	0.07
Improved	0.40	0.02

*pressure flow, $d/D_o > 3.2$
**free surface flow, $d/D_o < 1.0$

Summary

In summary, to estimate the head loss through a structure from the outflow pipe to a particular inflow pipe, multiply the above correction factors together to get the head loss coefficient, K_j. This coefficient is then multiplied by the velocity head in the outflow pipe to estimate the minor loss for the connection.

(iv) **Junction and Manhole Losses (Alternate Method):** An alternate method in calculating the head loss at a junction or manhole is as follows:

Where: $H_j = V_2^2/2g - K_j(V_1^2/2g)$

V = average flow velocity (ft/sec)
g = gravitational acceleration (32.2 ft/sec^2)
K_j = loss coefficient.

The coefficients for various junction configurations are presented in the "Energy Loss Coefficients Manhole and Junction" diagrams (Cases 1 - 3) below.

Subscripts 1 and 2 denote the upstream and downstream sections, respectively.

(v) **Bend Losses:** The head losses for bends, in excess of that caused by an equivalent length of straight pipe, may be expressed by the equation:

Where: $H_b = K_b V^2/2g$

H_b = Head Loss (Feet)
V = average flow velocity (ft/sec)
g = gravitational acceleration (32.2 ft/sec^2)
K_b = the bend coefficient.

The bend coefficient has been found to be a function of (a) the ratio of the radius of curvature of the bend to the width of the conduit, (b) deflection angle of the conduit, (c) geometry of the cross-section of flow, and (d) the Reynolds number and relative roughness.

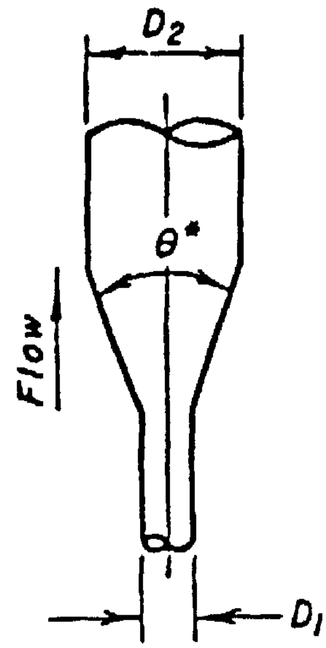
In most cases bend losses would not be incorporated into the design. Standard City of Marquette sewer design dictates that all sewer piping must be installed straight between structures. Special circumstances that may require the use of bends will require the approval of the City Engineer and Public Works Superintendent.

(c) **Storm Sewer Outlet Losses:** When the storm sewer system discharges into an open channel, additional losses occur at the outlet in the form of expansion losses. For a headwall and no wingwalls, the loss coefficient Ke = 1.0 and for a flared-end section the loss coefficient is approximately 0.5 or less.

Energy Loss Coefficient
Expansion and Contraction (Transitions)

Expansion K_e		
θ	$\frac{D_2}{D_1} = 3$	$\frac{D_2}{D_1} = 1.5$
10	0.17	0.17
20	0.40	0.40
45	0.86	1.06
60	1.02	1.21
90	1.06	1.14
120	1.04	1.07
180	1.00	1.00

- The angle is the angle in degrees between the sides
- of the tapering section.



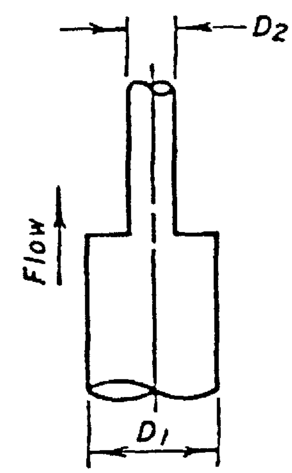
(i) Pipe Entrance from Reservoir

Bell-mouth $H_L = 0.04 \frac{V^2}{2g}$

Square-edge $H_L = 0.5 \frac{V^2}{2g}$

Groove end upstream for concrete pipe $H_L = 0.2 \frac{V^2}{2g}$

Contractions K_c	
$\frac{D_2}{D_1}$	K_c
0	0.5
0.4	0.4
0.6	0.3
0.8	0.1
1.0	0



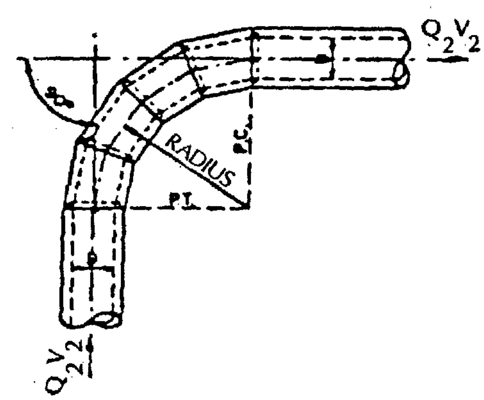
Reference: Linsley and Franzini "Water Resource Engineering," McGraw-Hill, 1964.

Energy Loss Coefficients
Bends

Case I Conduit on 90 degree curves	
θ	**K_b**
90	0.25
60	0.20
45	0.18
30	0.14

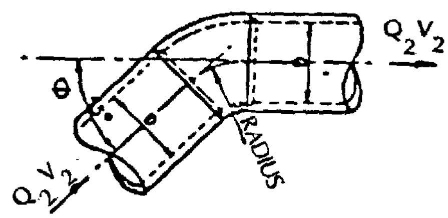
Note: Head loss applied at P.C. for length

$K_b = 0.25 \left(\frac{\theta}{90}\right)^{0.5}$



Case II Bends where radius of curve is equal to diameter of pipe	
θ	**K_b**
90	0.50
60	0.43
45	0.35
22 1/2	0.20

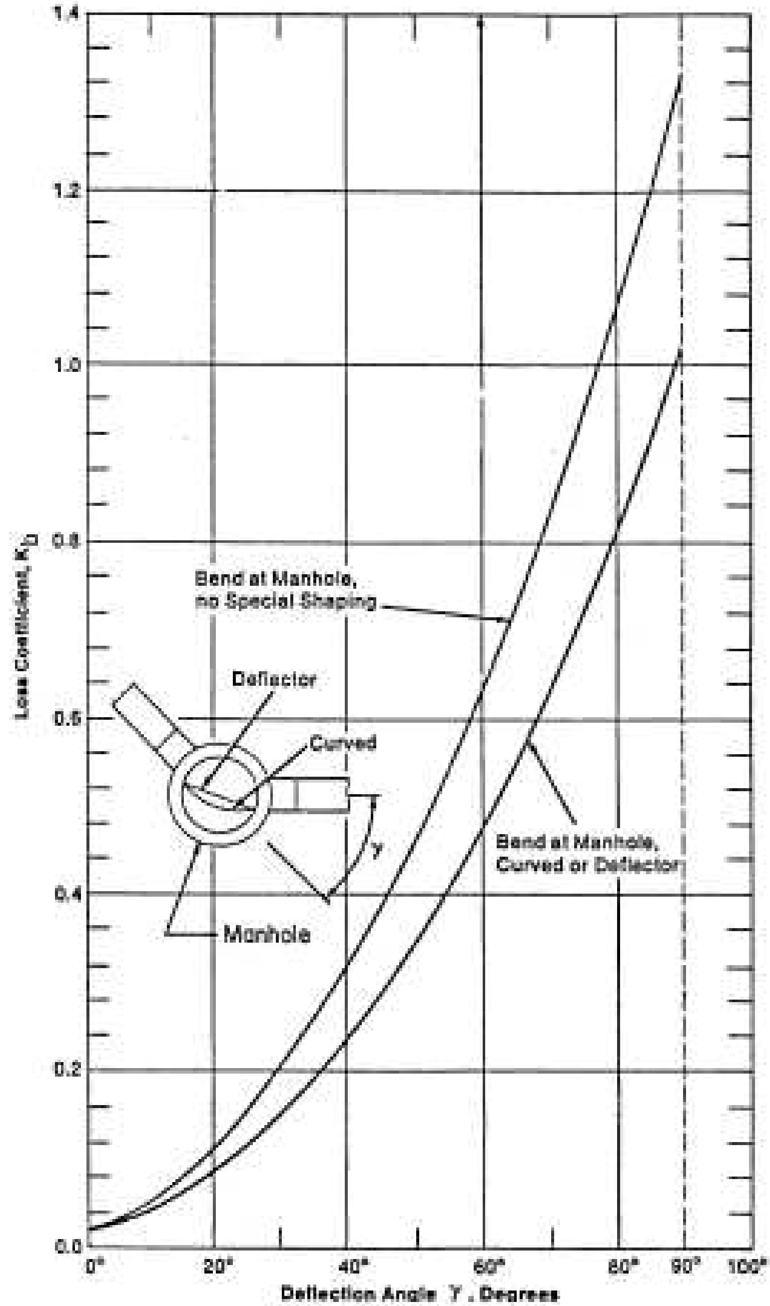
Note: Head loss is applied at beginning of bend



Reference: APWA Special Report No. 49, 1981

STORM SEWER ENERGY LOSS COEFFICIENT

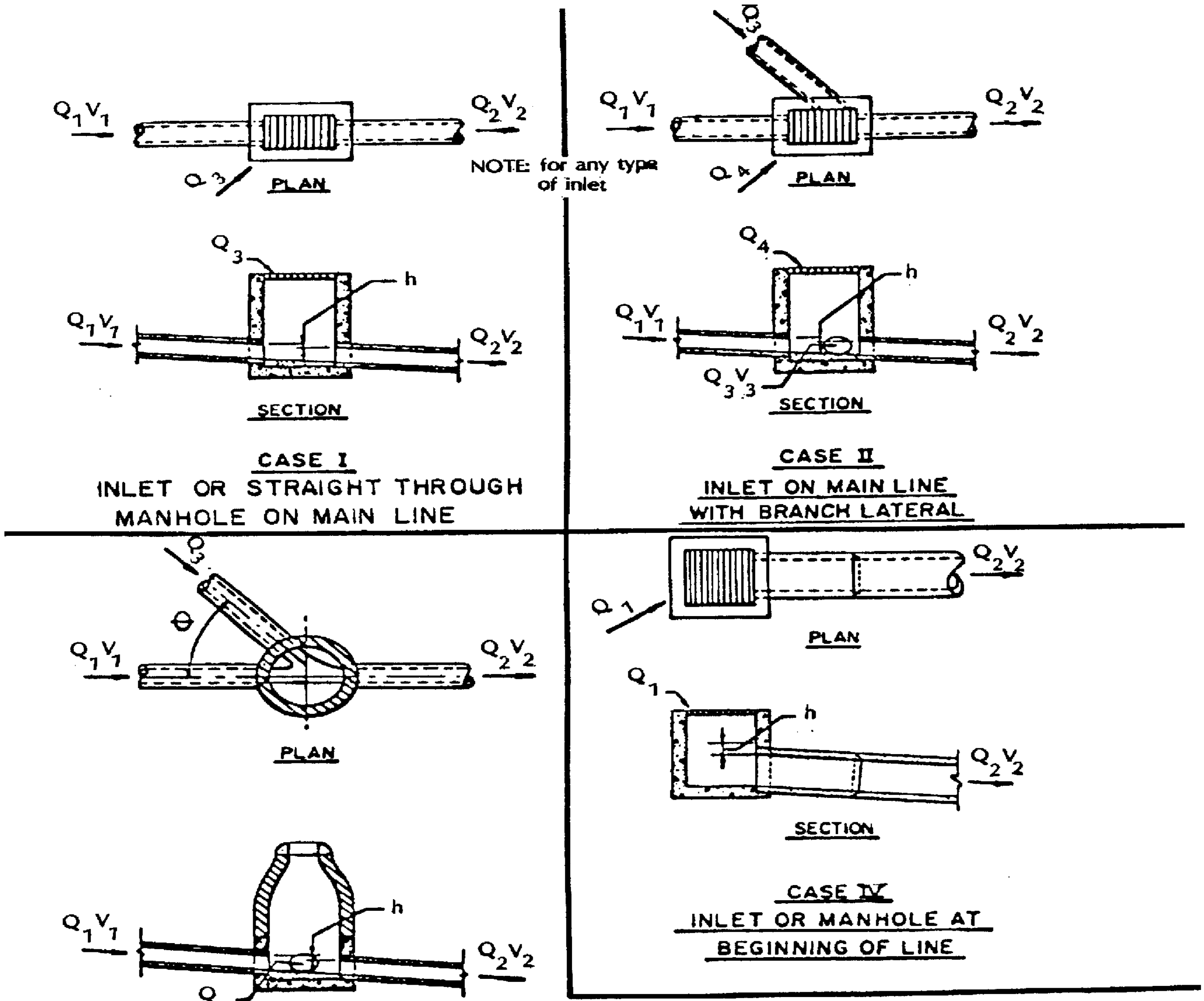
(BENDS AT MANHOLES)



NOTE: Head loss applied at outlet of manhole.

Reference: Modern Sewer Design, AISI, Washington D.C., 1980

Energy Loss Coefficients
Manhole and Junction



SECTION
CASE III
MANHOLE ON MAIN LINE WITH $\theta°$ BRANCH LATERAL

CASE NO.	K_j
I	0.05
II	0.25
IV	1.25

CASE III

$\theta°$	K_j
0	0.95
22 1/2	0.75
45	0.50
60	0.35
90	0.25

NO LATERAL - SEE CASE I

Reference: APWA Special Report No. 49, 1981

Water Surface and Energy Grade Line Calculations for a Storm Sewer

Pipe Material ____________________
Manning's "n" _____________________

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Station	Structure Type	Invert	Pipe Dia.	W.S. Elev	Pipe Shape	Area	¢	Velocity	Flow Rate	H_v	Energy Grade Line	S_f	Avg S_f	Length	H_f	H_b	H_j	H_t	Total Loss
		(ft)	(in)	(ft)		(ft^2)		(fps)	(cfs)	(ft)	(ft)			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)

Total Loss = ______

Water Surface, Hydraulic Grade Line, and Energy Grade Line Calculations for a Storm Sewer System:

The hydraulic grade line (HGL) and the energy grade line (EGL) are the last important features to be established relating to the hydraulic design of storm drains. The hydraulic grade line (HGL) aids the designer in determining the acceptability of the proposed system by establishing the elevations along the system to which the water will rise when the system is operating from a flood of design frequency.

In general, if the HGL is above the crown of the pipe, pressure flow hydraulic calculations are appropriate. Conversely, if the HGL is below the crown of the pipe, open channel flow calculations are appropriate. A special concern with storm drains designed to operate under pressure flow conditions is that inlet surcharging and possible manhole lid displacement can occur if the hydraulic grade line rises above the ground surface. Also of concern are localized flooding, joint displacement, and road structure subbase damage. Pressure flow design must assure the hydraulic grade line is 0.5 feet or more below the rim elevation of any drainage structure which may be affected. The energy grade line must also be at or below the rim elevation of any drainage structure which may be affected.

A design based on open channel conditions must be carefully planned as well, including evaluation of the potential for excessive and inadvertent flooding created when a storm event larger than the design storm pressurizes the system. As hydraulic calculations are performed, frequent verification of the existence of the desired flow condition should be made. Storm drain systems can often alternate between pressure and open channel flow conditions from one section to another.

The calculating of the HGL through the system begins at the system outfall with the tailwater elevation. If the outfall is an existing storm drain system, the HGL calculation must begin at the outlet end of the existing system and proceed upstream through this inplace system, then upstream through the proposed system to the upstream inlet. The same considerations apply to the outlet of a storm drain as to the outlet of a culvert.

For most design applications, the tailwater will either be above the crown of the outlet or can be considered to be between the crown and critical depth (dc). To determine the EGL, begin with the tailwater elevation or (dc + D)/2, whichever is higher, add the velocity head for full flow and proceed upstream to compute all losses such as exit losses, friction losses, junction losses, bend losses and entrance losses as appropriate.

The following step-by-step procedure should be used in conjunction with the "Water Surface and Energy Grade Line Calculations Calculation Sheet" of these Standards. The following procedure is based on full-flow conditions. If the pipe is flowing substantially full (i.e., greater than 80 percent), the following procedures can be used with minimal loss of accuracy. However, the designer is responsible for checking the assumptions (i.e., check for full flow) to assure that the calculations are correct.

(a) Columns 1 and 2: Determine stationing and the corresponding structure type that are proposed for the project. The structures planned for the project should correspond to the structures illustrated on a preliminary layout map.

(b) Column 3: List the center of the structure invert elevation for cases in which the piping diameter does not change. For cases where the pipe diameters change list the elevation at the ends of the structure with the corresponding stationing.

(c) Column 4: List the pipe diameter in inches for the corresponding stationing. Sizes of the storm sewer were determined during the calculation of the runoff volume and the pipe capacity during the preliminary design phases.

(d) Column 5: The starting water surface in most cases will be determined from the outlet and proceed upstream.

For subsequent calculations, the water surface elevation is calculated as follows:

$$W.S. = E.G. - H_V$$

This equation is used since the losses computed in "Columns 16 – 19" are energy losses, which are added to the downstream energy grade elevation. The velocity head is then subtracted to compute the water surface elevation (hydraulic grade line).

(e) Column 6: List the pipe shape. (Circular, Elliptical, etc.)

(f) Column 7: List the pipe area.

(g) Column 8: This equation is derived from Manning's equation by solving for velocity and converting to velocity head.

Where: $Ø = 2gn^2/2.21$
g = gravitational acceleration (32.2 ft/sec^2)
n = manning's coefficient of roughness

This value remains constant for this design since the n-value does not change.

(h) Column 9: Calculate the pipe velocity based on the flow rate from "Column 10" and the pipe area in "Column 7".

(i) Column 10: List the flow rates for each pipe. These were determined during the calculation of the runoff volumes.

(j) Column 11: Calculate the velocity head (H_V):

(k) Column 12: Calculate the Energy Grade Line (E.G.):
For the initial calculation, the Energy Grade Line is calculated as:

$$E.G. = W.S. + H_V$$

For subsequent calculations, the Energy Grade Line (E.G.) elevation is calculated as follows:

Add the total form loss in Column 20 to the energy grade at the downstream end to compute the energy grade at the upstream end.

E.G. (U/S) = E.G. (D/S) + TOTAL LOSS

(l) Column 13: Calculate the friction slope

Where: $Sf = ØH_V/R^{4/3}$

Ø = value from "Column 8"
H_V = velocity head value from "Column 11"
R = the hydraulic radius of the pipe. (ft)

(m) Column 14: Calculate the average friction slope (Avg. S_f)

This is the average value between S_f of the station being calculated and the Previous station. For the first station, Avg. $S_f = S_f$. The entries are placed in the next row since they represent the calculated losses between two stations.

(n) Column 15: List the length of the pipe between the stations/structures.

(o) Column 16: Calculate the friction head loss.

Friction loss H_f = (Avg. S_f)(L)

(p) Columns 17 – 19: Calculate the form losses for bends, junctions, manholes, and transitions (expansion or contraction) using equations previously discussed.

(q) Column 20: Sum all the form losses in Columns 16 through 19 and enter in Column 20.

CHECKLIST

To aid the designer and reviewer, the following checklist has been prepared:

1. Calculate the energy grade line (EGL) and hydraulic grade line (HGL) for all storm sewers.
2. Account for all losses in the EGL calculations including friction, outlet, form, bend, manhole, and junction losses. Provide all calculations in the Phase III Drainage Report.
3. Provide adequate protection at the outlet of all storm sewers into open channels.
4. Check for minimum pipe cover.
5. Check for adequate clearance with other utilities.

A. Grate and Inlet Capacity and Hydraulics

In many urban drainage systems, storm water enters the conveyance system through a catch basin or manhole curb inlet. Often these inlets are located along a gutter which is designed to convey overland flow to these inlets. It is important that the gutter and inlet be properly designed to adequately collect the storm water in order to minimize the potential flooding of the roadway, danger to pedestrians, and disruption of traffic.

In fact, the storm water inlet is an important element of the design in its own right. The hydraulics of flow into an inlet are based on principles of weir and orifice flow, modified by laboratory and field observation of entrance losses under controlled conditions. Inlets can be located at low points (sumps), directly upstream from street intersections and at intermediate locations as well. The spacing of these intermediate curb inlets depends on several criteria but is usually controlled by rate of flow and the permissible water spread toward the street crown. The type of road is also important since the greater the speed and volume of traffic, the greater the potential for hydroplaning. On the other hand, it is also considered acceptable practice to allow some periodic and temporary flooding of low volume streets.

The following diagram illustrates the importance of properly designed inlets. In the left-hand side of the figure the encroachment of the storm water into the street when the inlets are properly spaced is shown. The dashed line is the street encroachment with no carry-over from the upstream inlet and the solid line is encroachment with carry-over. In either case, these flows would not be very likely to disrupt traffic. However, the flow on the right-hand side shows pavement encroachment far into the street for the case with fewer inlets. This would obviously be a hazard to traffic and pedestrians.

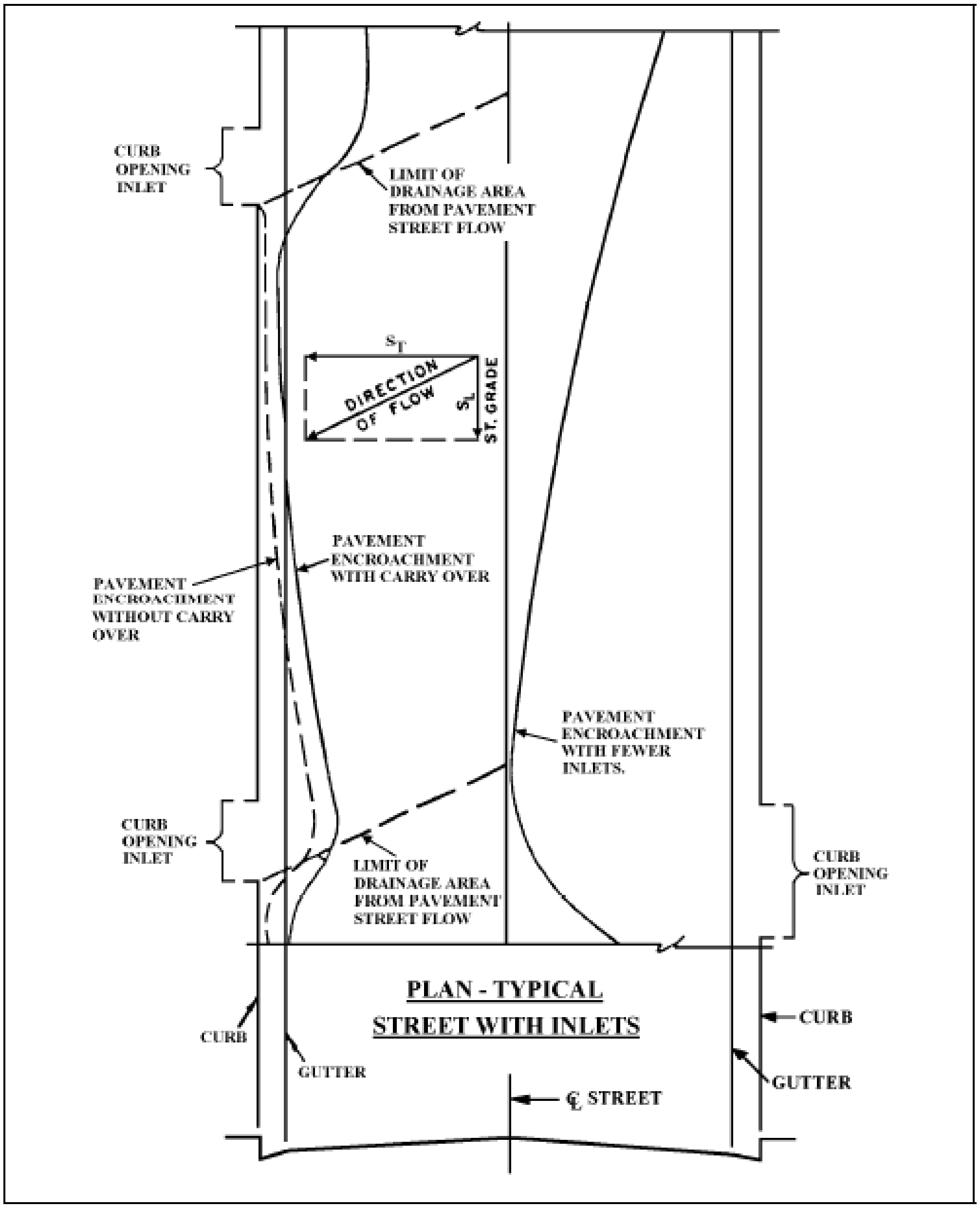


Diagram of Gutter and Pavement Flow Patterns (Wright, 1968)

Inlet interception capacity is the flow intercepted by an inlet under a given set of conditions. Under changed conditions, the interception capacity of a given inlet changes. The efficiency of an inlet is the percent of total flow that the inlet will intercept under a given set of conditions. The efficiency of an inlet changes with changes in cross slope, longitudinal slope, total gutter flow, and, to a lesser extent, pavement roughness.

Where: $\mathbf{Q_b = Q - Q_i}$

Q_b = Flow that is not intercepted by an inlet is termed carryover or bypass

Q = total gutter flow,ft3/s (m3/s)
Q_i = intercepted flow, ft3/s (m3/s)

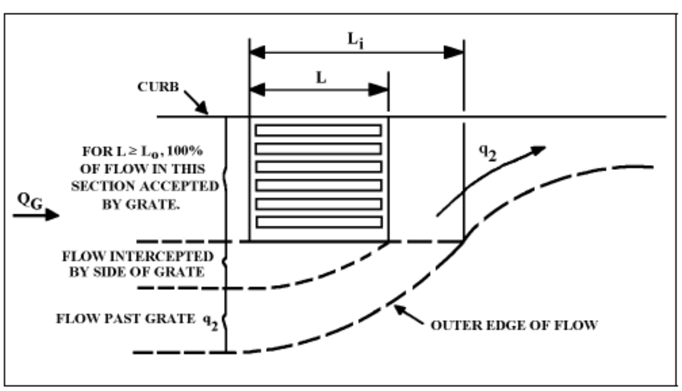
The interception capacity of all inlet configurations increases with increasing flow rates, and inlet efficiency generally decreases with increasing flow rates. Factors affecting gutter flow also affect inlet interception capacity. The depth of water next to the curb is the major factor in the interception capacity of both gutter inlets and curb-opening inlets. The interception capacity of a grate inlet depends on the amount of water flowing over the grate, the size and configuration of the grate and the velocity of flow in the gutter.

The City of Marquette uses a standard combination inlet consisting of a grate and a curb opening for runoff interception for all curbed streets. The interception capacity of a combination inlet consisting of a grate placed alongside a curb opening does not differ materially from that of a grate only. Interception capacity and efficiency are dependent on the same factors which affect grate capacity and efficiency. This inlet configuration has the added advantage of intercepting debris that might otherwise clog the grate and deflect water away from the inlet.

The interception capacity of a combination inlet consisting of a curb opening and grate is not appreciable greater than that of the grate alone. The capacity of a combined inlet on a continuous grade may be computed by ignoring the curb inlet and calculating the interception of the gutter inlet alone.

<u>Gutter Inlet Capacity Calculations</u>

A gutter inlet is an opening in the gutter through which water is admitted into the storm sewer system. The capacity of a gutter inlet decreases with an increase in longitudinal slope, and increases with an increase in transverse slope, grate length, width depression (described below) and grate efficiency. It has also been shown (Larson, 1948) that the capacity of a gutter inlet is increased by allowing a small percentage of the flow to bypass the grate (possible only on a continuous grade). This is achieved by the increased depth, and therefore an increase in the quantity of water captured. In order to intercept all the water, the grate length must be increased. As an example, an inlet grate with a constant transverse slope, S_T, may intercept 82% of the flow when the grate width is 50% of the total flow width. However, to capture the remaining 18% of the flow, the grate length must be doubled. This is shown qualitatively in the following figure where the grate length, L, would have to be extended to L_i to capture all of the flow Q_G.

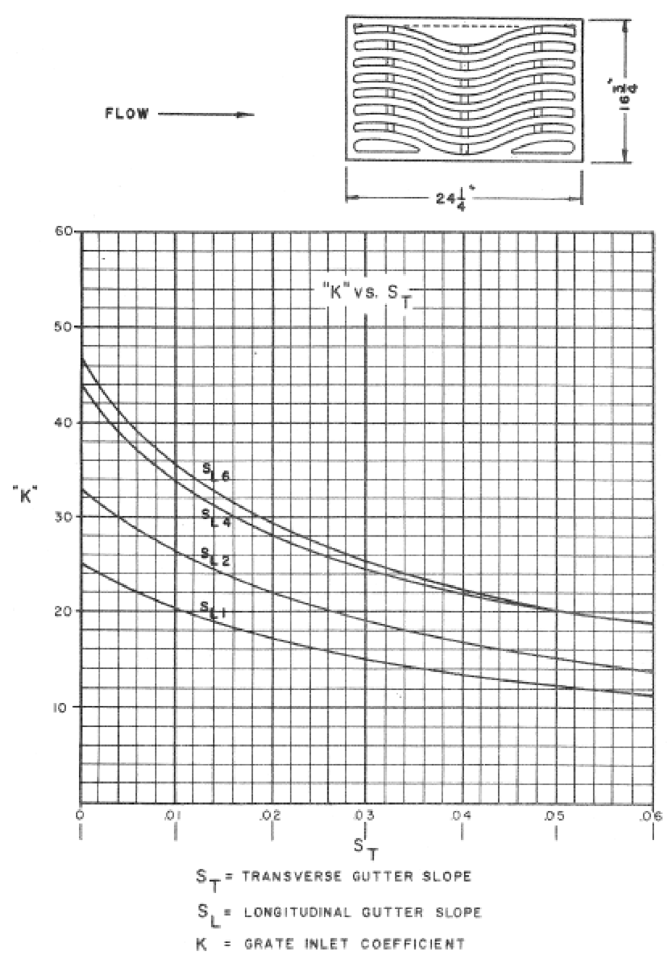


For inlets which are on a continuous grade, the capacity of a grate inlet may be easily calculated with a method developed by Neenah (1987). The discharge-depth relationship for a grate inlet is written as:

Where: $Q_i = K\, d^{5/3}$

Q_i = capacity of grate inlet (cfs)
K = coefficient dependent on the longitudinal slopes, S_L, transverse slopes, S_T, and grate configuration
d = depth of gutter flow (ft)

Graphs published by Neenah (Neenah, 1987) for many of their manufactured grates present K as a function of S_T and S_L. A typical chart published by Neenah is shown below. Each of these graphs published by Neenah is the result of 96 separate test points. The charts are applicable for Manning's roughness coefficient, *n*, between 0.013 - 0.014, and longitudinal slopes between 1 and 6 percent.



Typical Inlet Grate Capacity Chart (Neenah, 1987)

The maximum allowable depth, d, in the above equation may be obtained from the nomograph below or the following equation:

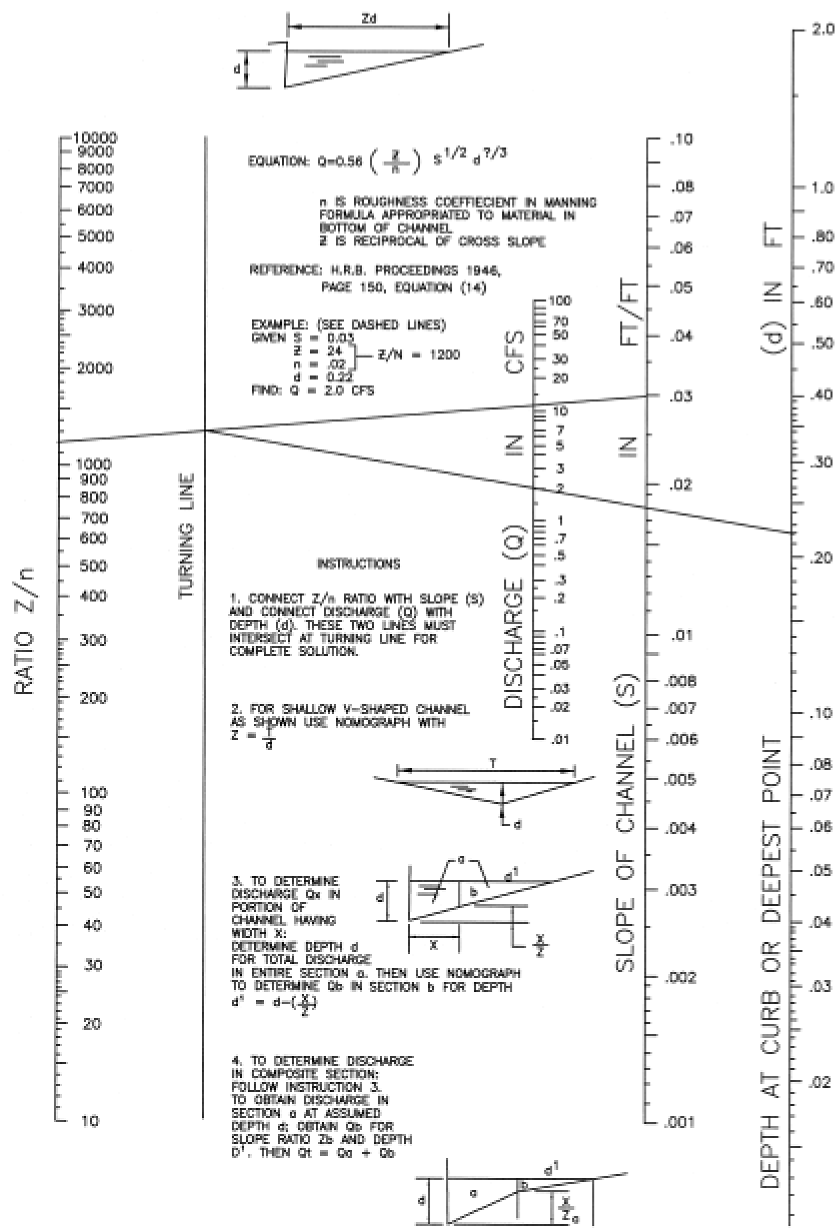
Where: $\mathbf{d = [\,1.79 Q_G n S_T / S_L^{1/2}]^{3/8}}$

Q_G = Gutter Flow (cfs)

n = Manning's Roughness Coefficient

S_T = Transverse Slope (ft/ft)

S_L = Longitudinal Slope (ft/ft)



Gutter Flow Nomograph

The spread of the flow in the street can be determined from the following equation based on the depth of the flow at the gutter.

Where: $\mathbf{T = d/S_T}$

T = Spread Width of the Flow (ft)
d = Depth of the Flow at the Gutter (ft)
S_T = Transverse Slope (ft/ft)

For a sump condition, the capacity of the combination inlet depends upon the depth of water at the curb, the opening length and the height of the curb opening. In this case the grate opening can be ignored in the calculations with the assumption that the area is clogged. The inlet will act as a weir until the entrance is submerged. When the depth is greater than 1.4 times the curb opening height, the inlet will operate as an orifice. The flow is indeterminate for the intermediate region.

The weir coefficient for a curb inlet is less than the usual coefficient because experimental measurements for determining the coefficients were taken in the curb and not in the inlet, and because there is a drawdown in the water surface between the point where the measurements are made and the weir. The weir location for a depressed curb inlet is at the edge of the gutter while the weir length is dependent on the width of the depression and the curb opening length. For a non-depressed curb inlet, the weir location is at the lip of the opening and the corresponding length is equal to the inlet length. The weir coefficient for depressed curb inlets and those without depression are approximately equal. For a depressed curb inlet which acts as a weir, the equation for the interception capacity is as follows:

Where: $\mathbf{Q_i = C_w(L + 1.8W)d^{1.5}}$ **for** $\mathbf{(d \leq h + a/12)}$

Q_i = Discharge Rate into the Inlet (cfs)
$\mathbf{C_w}$ **=** 2.3
W = Width of the Depression (ft)
a = Depth of the Depression (inches)
h = Curb Opening Height (ft)
d = Depth of Water Above Grate Top for Weir Flow (ft)
L = Length of the Opening (ft).

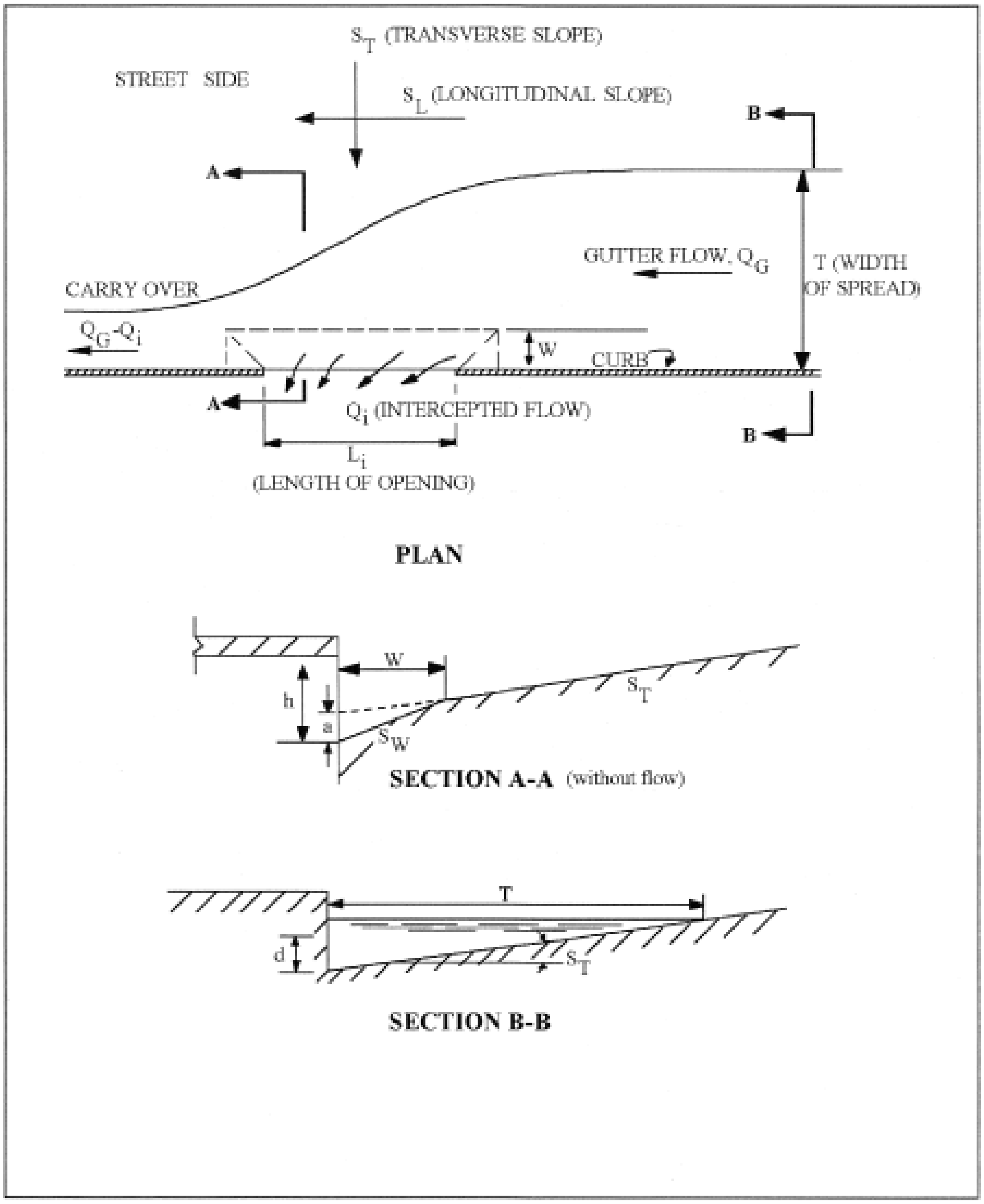
For a curb inlet without depression which acts as a weir (W=0), the equation for the interception capacity is per the following equation:

Where: $\mathbf{Q_i = C_w L d^{1.5}}$

A depressed curb inlet acts as an orifice when the depth exceeds 1.4h. The interception capacity for this condition is per the following equation:

Where: $\mathbf{Q_i = 0.67A_g[2g(d - h/2)]^{0.5}}$ **for** $\mathbf{(d \geq 1.4h)}$

Q_i = Discharge Rate into the Inlet (cfs)
A_g = Area of the Opening equal to hL (sft)
h = Curb Opening Height (ft)
d = Depth of Water Above Grate Top for Orifice Flow (ft)
L = Length of the Opening (ft)
g = 32.2 fps



Plan View and Notation Used for Curb Inlets (Bauer and Woo, 1964)

D. Curb Inlet and Grate Design Criteria

The design criteria and methods for the design of storm water inlets are presented in this section. This information will aid in inlet selection and spacing. Listed below are some general requirements which must be considered prior to inlet selection:

1. The inlet should have sufficient capacity to intercept storm water from the gutter.

2. The inlet should be designed so as to control the ponding of flow.
3. The inlet should be able to pass small debris (e.g. leaves) while screening out larger, harmful debris (e.g. branches of trees).
4. The inlet should have sufficient strength to resist traffic loadings.
5. Inlet grates should not be hazardous to bicycles.
6. Use inlets where required and where the flow capacity dictates.

The following is a list of some general criteria for the design of storm water curb inlets and grates:

Return Period: The curb inlets should be designed for a ten (10) year return period.

Encroachment: The spread, top width or encroachment of storm water into the street should be less than 4 feet for streets without parking; and less than 12 feet or a maximum depth of 0.36 feet for a street with parking.

Minimum Gutter Slope: The minimum longitudinal slope of the gutter, S_L, is 0.5%,

Minimum Transverse Slope: The minimum transverse slope of the street, S_T, is 1%.

Inlet Locations: Inlets should be placed at all low points in the grade of the gutter and at intersections to prevent storm water from flowing across traffic lanes and crosswalks. In addition, inlets should be placed when the top width (see above) or the flow depth exceeds the maximum allowable limits.

Spacing of Inlets: Inlets should be spaced so as to capture the flow from the drainage area contributing to the inlet plus any storm water not intercepted by the stream inlet (carryover) less any flow intentionally bypassed. Using the rational method to calculate the flow from the contributing drainage area the flow in the gutter can be written as:

Where: $\mathbf{Q_G = CiA + Q_C}$

Q_G = Flow Rate in Gutter at the inlet location (cfs)
Q_C = Carryover from upgrade inlet (cfs). (Q_C is zero for the first inlet)
C = Runoff Coefficient
A = Drainage area (acres)
i = Rainfall intensity (inches/hr)

The capacity of the inlet Q_i which is a function of the longitudinal and transverse slopes and inlet geometry can be determined by using the appropriate equations or figures as discussed previously in these standards. The depth of flow used in these equations or figures is determined by using the criteria presented above. If the spacing is to be the maximum distance apart, the inlet capacity is found by the following equation:

Where: $\mathbf{Q_i = Q_G - Q_b}$

Q_i = Capacity of the inlet
Q_b = Flow Bypassed by this Inlet (cfs). (This could be zero for 100% efficiency)

The length between inlets is given by the following equation:

Where: $L = 43{,}560\,(Q_i + Q_b - Q_C)/Ciw$

L = Distance Between Inlets (ft)
w = Width of Contributing Area (ft) (assumed to be a constant)
i = Rainfall intensity (inches/hr)
C = Composite Runoff Coefficient for Contributing Area
Q_i = Capacity of the inlet
Q_b = Flow Bypassed by this Inlet (cfs)
Q_C = Carryover from upgrade inlet (cfs)

The spreadsheet on the following page has been included to aid in the computations for a storm water collection system and inlet spacing.

Neenah Foundry Company's Inlet Grate Capacities

The Neenah Foundry Company has a computer program available for Inlet Grate Capacities. The program allows the user to evaluate grate efficiencies under differing flow conditions. Two separate sub-programs are present. One evaluates inlet capacities, where the parameters of flow, longitudinal and transverse slopes, plugging factor and grate selection are input. The program then displays the depth of flow onto the pavement, and the amount of flow captured by the individual grate being evaluated. The program has the capability of evaluating a compound gutter section where the transverse slope of the gutter is greater than the transverse slope of the pavement.

The second sub-program evaluates an inlet at low points, i.e. sump conditions. The free open area of the grate and the wetted perimeter are input and a graph of head vs. flow is generated for both weir and orifice flow (Neenah, 1990). The program and supporting documentation can be obtained from the Neenah Foundry Company, Product Engineering Department, P.O. Box 729, Neenah, Wisconsin, 54957; (414) 725-7000.

COMPUTATION SHEET FOR INLET SPACING

Inlet Location			**Roadway and Gutter Data**							**Inlet Data**			**Contributing Area Data**			**Inlet Spacing**			
Inlet Number	Station	Road or Street	Inlet Type and Condition	Trans. Slope S_T (%)	Longit. Slope S_L (%)	Manning's Roughness Coefficient n	Depth of Flow d (ft)	Top Width T (ft)	Flow Rate Q (cfs)	Depression Width W (ft)	Depression Depth a (in)	Inlet Capacity Q_i (cfs)	Width W (ft)	Composite Runoff Coefficient C	Rainfall Intensity i (in/hr)	Upgrade Carryover $Q_C=Q_G-Q_i$ (cfs)	Inlet bypass Q_b (cfs)	$Q_i+Q_b-Q_C$ (cfs)	Inlet Spacing L (ft)

Drainage Structure and Storm Sewer Piping Design Standards

A. Layout of Storm Sewers

The term drainage structure refers to all types of storm manholes and catch basins. Drainage structures are sized and located to limit the spread of water on traffic lanes to tolerable widths as specified in these standards.

Combination inlets (grate and curb opening) will be used on all catch basins located along the curb and gutter of all City of Marquette streets. All grates used on the combination inlets shall be bicycle safe when used on roadways that allow bicycle travel.

All new main line storm sewers on street projects should be located outside the pavement area if feasible. Manholes are utilized to provide entry to underground storm sewers for inspection and cleanout. Catch basins can be used as manholes when entry to the system can be provided at the catch basin inlet, so the benefit of extra storm water interception can be achieved with minimal additional cost.

Manholes should not be located in traffic lanes; however, when it is impossible to avoid locating a manhole in a traffic lane, care should be taken to ensure it is not in the normal vehicle wheel path.

Manholes will be required whenever there is a change in size, direction, elevation, grade, at a junction of two or more sewers, the upstream dead end, at points where pipe material changes, or at distances not greater than the following:

(a) 400 feet, for mains 36 inches in diameter or less, and
(b) 500 feet, for mains greater than 36 inches in diameter

The required manhole size is as follows:

DRAINAGE STRUCTURE - MANHOLE SIZE	
SEWER DIAMETER	**MANHOLE DIAMETER**
12" to 18"	4'
21" to 36"	5'
42" to 48"	6'
54" and larger	See MDOT Std. Details

Larger manhole diameters or a junction structure may be required when sewer alignments are not straight through or more than one sewer line goes through the manhole. Care must be exercised in not introducing too many sewer leads into conventional manholes at or near the same elevation or having large sewers, such as a 36-inch and a 42-inch entering or leaving at the same elevation. In these cases the structural integrity is seriously weakened and either a large manhole or a special design should be used. The outside diameters shall be a minimum of one (1) foot of each other.

Catch basins shall be located when required for storm interception based on the spread requirements, runoff volume, and grate/curb inlet capacity. In general catch basins shall also be located as follows:

- At the radius return of street intersections when drainage is required to go around corners.
- At locations where significant ponding may occur, such as sag vertical curves in depressed sections, it is recommended practice to place supplemental catch basins on either side of the low point in the sag.

Where changes in size occur for all storm sewer mains, the pipe shall be constructed with the crown of the pipes matching.

B. Minimum Size

The minimum nominal size of all drainage (storm) sewer mains, excluding lateral connections, shall be twelve inches (12") in diameter.

C. Minimum and Maximum Velocities

Minimum design velocities for gravity and low pressure sanitary sewers shall be three (3) feet per second, and a maximum design velocity shall be ten (10) feet per second with the pipe flowing full.

D. **Allowable Minimum Pipe Slopes**

Minimum Pipe Slopes Necessary to Ensure a 3 ft/sec Velocity

Pipe Diameter	Percent Slope (ft/ft x 100)		
	n = 0.013	*n* = 0.014	*n* = 0.015
12	0.435	0.505	0.579
15	0.323	0.375	0.430
18	0.253	0.294	0.337
21	0.206	0.239	0.275
24	0.173	0.200	0.230
27	0.148	0.171	0.196
30	0.128	0.149	0.171
36	0.101	0.117	0.134
42	0.082	0.095	0.109
48	0.069	0.079	0.091
54	0.059	0.068	0.068
60	0.051	0.059	0.068
66	0.045	0.052	0.060
72	0.040	0.046	0.053

All storm sewer piping shall be laid at a constant slope between structures. Curvilinear storm sewer mains shall not be allowed.

E. Vertical and Horizontal Alignment
The sewer grade shall be such that a minimum cover is maintained to withstand AASHTO HS-20 loading on the pipe. Piping placed under roadways designated as a truck route will comply with AASHTO HS-25 loading. The minimum cover depends upon the pipe size, type and class, and soil bedding condition, but shall be not less than three (3) feet at any point along the pipe. Sometimes, however, a grade conflict between other sewers or water distribution systems may occur requiring the depth to be less than 3 feet. In this case extra strength pipe or special trench backfill procedures must be employed. The "Design Manual - Concrete Pipe" from the Concrete Pipe Association is a good reference for pipe strength class and load requirements.

The minimum clearance between storm sewer and water main, either above or below, shall be eighteen (18) inches between the outside of the water main and the outside of the sewer main.

The minimum clearance between storm sewer and sanitary sewer, either above or below, shall also be eighteen (18) inches.

Storm sewers shall be laid at least six (6) feet horizontally from all water mains and sanitary sewer mains. The distance shall be measured from edge to edge of the piping.

F. Maintenance Access
Manholes that are not located within a public street, public alley, dedicated public easement, or driveway section shall be provided with direct access for maintenance vehicles. The access drive shall be an all-weather surface, such as asphalt or concrete paving, adequate gravel base or turf block, and shall be capable of supporting maintenance vehicles weighing up to 14 tons.

Storm sewers shall not be located in rear yards except in unusual circumstances with the permission of the City Engineer and Public Works Superintendent. When storm sewers are allowed in rear yards, a parallel rear yard drainage system will be installed, and maintained by the developer or owner(s) as a private system until it outlets to a public system.

G. Edge Drain, Underdrain, and Building Lateral Piping and Connections
Select fittings and connection methods used in the underdrain system to prevent separation of the pipes. Secure approval from the Engineer for connection methods before underdrain installation begins. Mechanically fasten all connections between the underdrain and outlet pipes with aluminum blind rivets, stainless steel selftapping screws or interlocking parts. Do not penetrate the inside diameter of the pipe with the self-tapping screws by more than 1⁄8 inch. Wrap all fittings with geotextile blanket and seal the geotextile to the outlet pipe with waterproof tape.

H. Bedding, Haunching, and Initial Backfill
Embedment materials for bedding, haunching, and initial backfill shall meet City of Marquette, Michigan Department of Environmental Quality, and State of Michigan Transportation requirements based on the type of soil encountered and potential groundwater conditions. Haunching of the embedment materials will be done by industry and construction standards.

STORM SEWER MATERIALS

A. General Information

All piping materials, manholes, and appurtenances furnished for public storm sewers shall comply with the latest applicable national standards, such as the American Society for Testing and Materials (ASTM), American National Standards Institute (ANSI), State of Michigan Department of Transportation, or other representative standards organizations. Some products are specified with more than one applicable reference standard for such items as testing, installation, or supplementary material specifications.

The following materials listed are not all-inclusive. Developers and Consulting Engineers must familiarize themselves with the City of Marquette Standard Specifications and Standard Details to find all requirements and specifics.

B. Types of Sewer Pipe
Product description, materials testing, field testing and installation techniques shall be governed by the City of Marquette Standard Specifications and Standard Details.

Reinforced Concrete Pipe (RCP) in accordance with ASTM C-76, C-506, or C-507 is the material acceptable for use in storm sewer construction within City of Marquette right-of-way, or dedicated public easements. The minimum class of pipe shall be Class II; however, the actual depth of cover, live load, and field conditions may require structurally stronger pipe. Refer to the current State of Michigan Standard Specification for Construction for additional details.

If cover is less than three (3) feet, use C-76, Class IV for all pipe, Class IV pipe shall be used for all cross-drains between catch basins, including the leads to the manhole.

Corrugated HDPE smooth interior dual wall pipe (12 inch through 30 inch) in accordance with the requirements of ASTM D4101 for virgin material shall be impact modified copolymer polypropylene. Pipe shall have a minimum pipe stiffness of 46 psi when tested in accordance with ASTM D2412. Pipe diameters from 12 inch through 30 inch installed in traffic areas (AASHTO H-25 or HS-25 loads) must have at least three foot of cover over the pipe crown.

Underdrain perforated pipe shall be Smooth-Wall PVC Plastic with 1/8 inch to 3/16 inch perforations, AASHTO M 278 or as an option, (ABS) pipe meeting ASTM D 2751, SDR 35, with
perforations meeting AASHTO M 278, may be furnished for pipes 6 inches in diameter and smaller.

Underdrain corrugated plastic tubing shall conform to AASHTO M 252 for polyethylene (PE) tubing or ASTM F 949 for (PVC) tubing. The perforations for both PE and PVC tubing must conform to AASHTO M.

Perforated pipe and tubing used for underdrains shall be wrapped in geotextile.

C. Storm Sewer Joints
All concrete pipe shall have flexible rubber compression gaskets conforming to
ASTM C 443.

RCP sizes over twenty-four (24) inches shall have the joints wrapped with a geotextile blanket. Use geotextile with a minimum width of thirty-six (36) inches and center it on the joint.

Corrugated HDPE smooth interior dual wall pipe (12 inch through 30 inch) shall be joined with a gasketed integral bell & spigot joint and shall be watertight according to the requirements of ASTM D3212.

Spigot shall have two gaskets meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gaskets are free from debris.

All pipe manufacturers regardless of the accepted pipe material, shall have successfully performed and passed MDOT's MTM 723 "*Michigan Test Method for Water Tightness Testing of Culvert and Sewer Joints up to 24"inches in Diameter."*

D. Storm Sewer Drainage Structures

All catch basins or manholes functioning as catch basins or inlets will be provided with a two (2) foot deep sump.

Construct precast reinforced concrete units according to the State of Michigan Department of Transportation Standard Plans/Specifications or as detailed on the project plans/specifications. All precast reinforced manhole sections will conform to ASTM C 478 requirements. Seal the structure joints with Butyl rubber sealant meeting AASHTO M 198.

E. Manhole and Catch Basin Frames and Castings

Standard manhole frames and castings shall have a vented cover as manufactured by East Jordan Iron Works Catalog Number 1040. All drainage structure manholes will have a frame opening of twenty-four (24) inches in diameter.

Two (2) foot diameter catch basins located in the curb line will require MDOT Type L or K frames and castings. East Jordan Iron Works Cat. No. 7056 or equal will be accepted.

F. Deflection Testing for Flexible Pipe

A mandrel test is required for all flexible pipe per ASTM 2321. Requirements will meet or exceed what is required for sanitary sewer piping as called out in the City of Marquette Standard Specifications.

STORM SEWER – CULVERT
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL AND REQUIRED INFORMATION

A. General Information

The function of a culvert is to convey surface water under a highway, railroad, or other embankment. In addition to the hydraulic function, the culvert must carry construction, highway, railroad, or other traffic and earth loads. The culvert also provides for the movement of ecological connectivity. Therefore, culvert design involves hydraulic, structural, and ecological design considerations.

Ecological connectivity refers to the ability of a landscape to support the movement of energy, organisms, and materials (Bates et al. 2003). This can include the migration of fish, movement of sediment and debris, and the capacity of a stream to handle changes in hydrology. With regards to fish passage and road culverts, it is the linkage between the upstream and downstream reaches.

A careful approach to culvert design is essential, both in new land development and retrofit situations, because culverts often significantly influence upstream and downstream flood risks, floodplain management and public safety. Culverts can be designed to provide beneficial upstream and downstream conditions and to avoid negative visual impact. The following standards will provide the hydraulic aspects of culvert design. Numerous resources are available for the structural and ecological aspects of culvert design and should be referenced when conditions permit.

B. Information Required for Design

The hydraulic design of a culvert essentially consists of an analysis of the required performance of the culvert to convey flow from one side of the roadway (or other kind of embankment, such as a railroad) to the other. The designer must select a design flood frequency as specified below, estimate the design discharge for that frequency, and set an allowable headwater elevation based on the selected design flood and headwater considerations. The culvert size and type can be selected after the design discharge, controlling design headwater, slope, tailwater, and allowable outlet velocity have been determined.

The design of a culvert includes a determination of the following:

- Impacts of various culvert sizes and dimensions on upstream and downstream flood risks, including the implications of embankment overtopping.

- How will the proposed culvert/embankment fit into the relevant major drainageway master plan, and are there multipurpose objectives that should be satisfied?

- Alignment, grade, and length of culvert.

- Size, type, end treatment, headwater, and outlet velocity.

- Amount and type of cover.

- Public safety issues, including the key question of whether or not to include a safety/debris rack.

- Pipe material.

- Type of coating (if required).

- Need for fish passage/ecological connectivity measures, in specialized cases.

- Need for protective measures against abrasion and corrosion.

- Need for specially designed inlets or outlets.

- Structural and geotechnical considerations, which are beyond the scope of this chapter.

DETERMINATION OF RUNOFF QUANTITIES

A. General Information

Culvert drainage systems shall be designed for a peak runoff for a 25 year – 24 hour intensity rainfall frequency when crossing under major streets, and 10 year – 24 hour rainfall intensity frequency when crossing under minor streets and other locations. Sufficient capacity shall be provided in the culvert piping to take fully developed upstream tributary drainage into the system. When a storm sewer is designed to provide capacity for upstream tributary areas, the hydraulic gradient shall remain in the pipe.

Culverts shall be checked for the effects of the 100 year – 24 hour storm. No flooding of building structures shall result from the 100-year design flow.

B. Design Basis

Runoff quantities shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel when fully developed. The quantity of runoff which is generated as the result of a given rainfall intensity may be calculated by methods previously discussed in these standards.

HYDRAULIC DESIGN

A. General Information

Culverts experience 2 major types of flow: Flow with inlet control and flow with outlet control. Under outlet control, all of the culvert parameters including the headwater depth, type of inlet, cross sectional area, slope, roughness, length and tail water elevation influence the culvert size and capacity. Under inlet control the capacity of the entire culvert is limited by the capacity of the inlet, headwater depth, type of inlet, and cross sectional area.

In general, culverts shall be hydraulically designed in accordance with the U. S. Department of Transportation's latest publication, "Hydraulic Charts for the Selection of Highway Culverts."

General guidelines in selection of culvert size are as follows:

- Headwater depth for design discharge shall not exceed a height greater than 1 ½’ below the edge of the shoulder of a road.

- In general maximum allowable headwater above the crown of a culvert shall not be greater than 5’.

- Headwater depth for the design discharge shall not cause water to rise above the top of approach channels which are adjacent to improved land or above the established floodplain easements.

- Headwater depth at design discharge shall cause no flooding of existing or proposed building structures.

- Outlet velocities shall be calculated. If outlet velocities equal or exceed erosive velocities of channel lining, then riprap or some other form of energy dissipation device shall be placed at the culvert outlet.

B. Hydraulic Design Basis

All culvert designs are to include an analysis to determine whether inlet or outlet control conditions govern for both major and minor storm runoff conditions. The following procedure is to be applied:

- Compile design data, including design discharge, allowable headwater, and proposed culvert cross section (to determine slope, length, flowline and velocity).

- Design culvert assuming inlet control, using trial culvert type and size. Apply the proper design nomographs and repeat until the allowable headwater condition is achieved.

- Design culvert assuming outlet control, beginning with the adequate culvert design for inlet control. Compute H (Head) from the proper design nomograph and TW (Tail Water) from open channel hydraulics to determine HW (Headwater). The HW must satisfy the allowable headwater conditions.

- Design appropriate outlet protection based on outlet velocity and tail water depth.

C. Design Criteria

All culvert designs are to be based on the following criteria:

(1) **Size**

(a) Culvert design size shall be based upon the following:

(i) Runoff volumes for the appropriate design storm.

(ii) Required capacity based on roadway classification and allowable street overtopping, as prescribed in Section 7.10, “Street Drainage,” of these standards.

(b) Culverts shall be at least 18 inches in diameter or height, with the exception of driveway culverts along roads with roadside drainage swales, which shall be at least 12 inches in diameter or height.

(2) **Inlet and Outlet Sections**

(a) All culverts shall be designed with headwalls and wingwalls, or flared end sections at the inlet and outlet. Flared end sections are allowed only on pipe culverts with diameters of 42 inches (or equivalent) or less.

(b) Erosion protection, such as rip-rap, boulder energy dissipators, or adequate vegetation, shall be provided at the inlet or outlet where required to mitigate potential scouring or erosive flow conditions. The Engineer shall propose the erosion protection to be used, subject to approval by the City Engineer.

(3) **Slope and Velocity**

(a) Culvert slopes shall be designed so that neither silting nor excessive velocities resulting in scour can occur. The minimum design velocity for minor storm conditions shall be 2 feet per second, to provide for self-cleansing of the culvert.

(b) The maximum culvert velocity is dictated by the channel conditions at the outlet, and the amount of erosion protection or energy dissipation that can be provided to prevent scour or damage.

(4) **Allowable Headwater**

(a) The maximum headwater / diameter (HW/D) ratio for the 100-year design flows shall be 1.5, and 1.0 for the 10-year design flow. These HW/D ratios are to be applied to culverts at street crossings, and should not be applied to outlets from detention ponds or private driveways.

(b) Ponding above the top of a culvert is not permitted if such ponding could potentially cause property or roadway damage, culvert clogging, saturation of critical embankments, detrimental debris deposition, erosion, or inundation of existing or future utilities, structures, or buildings.

(5) **Trash Racks**

(a) The installation of a trash rack over a culvert entrance shall be provided as required by the City Engineer where there exists the potential for debris clogging of the culvert or where there is a safety hazard concern for the possibility of people (especially children) being carried into the culvert.

(b) Trash racks shall be designed to maintain adequate culvert hydraulics, considering the potential for debris buildup and blockage which may render the culvert ineffective. Careful design considerations are to be applied, including without limitation application of the following standards:

(i) Materials: All trash racks shall be constructed with smooth steep pipe, having an outside diameter of at least 1 ¼ inches. Trash rack ends and bracing shall be constructed with steel angle sections. All trash rack components shall have a corrosion protective finish.

(ii) Design: Trash racks shall be designed without cross-braces, to minimize debris clogging, and be able to withstand the full hydraulic load of a completely plugged trichroic based on the highest anticipated depth of ponding. The trash rack shall be hinged and removable for maintenance purposes.

(iii) Bar Spacing: Bar spacing shall provide a maximum clear opening of 6 inches. The longitudinal slope of the trash rack shall be no steeper than 3:1, horizontal to vertical. The entire trash rack shall have a clear opening at least three times the culvert opening area.

(c) Hydraulics: Use the following equation to compute hydraulic losses through trash racks:

HT=0.11 * (TV/D)2 * (sin A)

Where: HT = Head Loss through the Trichroic (feet)
T = Thickness of Trichroic Bar (inches)
V = Velocity normal to Trichroic (fps)
D = Center-to-Center Spacing of Bars (inches)
A = Angle of Inclination of Trichroic with Horizontal
The velocity normal to the trichroic shall be computed considering the rack to be 50 percent plugged.

(C) Structural Design

The structural design of culverts shall conform to accepted structural engineering practices, design standards and standard specifications, any methods and criteria recommended by the manufacturer for a specific culvert type, and for conditions found at the construction site. As a minimum, all culverts shall be designed to withstand an AASHTO HS-20 traffic loading.

STORM SEWER – OPEN CHANNEL
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL INFORMATION

A. Background

With enough precipitation all areas of land will create storm water runoff. This runoff increases in amount as an area is more urbanized and contains more impervious surfaces such as roads, parking lots, building roofs, driveways, etc. and runoff must be handled and controlled responsibly by all entities that own and/or control the land creating and conveying storm water runoff.

In instances where ditches, swales or other open channel conveyances are possible and can be utilized safely, the City encourages their use. Open channels are generally cheaper to build, easier to maintain and more environmentally friendly. Runoff moves slower in an open channel versus a pipe, which helps lower the peak flash flows in the City's storm water system. Also channels allow infiltration and exfiltration, remove sediment from the runoff and channel vegetation helps to further slow and filter the flow.

B. Intent of Design

This design standard section for open channel flow design is intended for man-made channels, swales or ditches. For natural water conveyances such as streams or rivers that may need their surface profiled the designer shall model the surface water using the Corps of Engineers model Hydrologic Engineering Center's River Analysis System (HECRAS). The City Engineer shall make the final determination as to when and if the use of HECRAS is required.

For most applications, design of man-made open channels shall utilize Manning's equation for steady flow as explained further in this section. However, if it is determined by the City Engineer that the man-made open channel is major and flooding of the channel could jeopardize nearby assets and/or structures, he may again require the use of HECRAS to model the flooded water surface boundary of the proposed channel and nearby areas.

C. Related Design Standard Sections

Other design standards related to Open Channel Flow Design are: Storm Sewer and Storm Sewer/Culverts. These standards should be consulted because often open channels will connect to or flow into storm sewers and culverts. The transition to culverts and storm sewers can restrict flow and cause water in an open channel to rise and lead to undesired flooding.

Runoff flows discussed later in this section shall be calculated as shown in the Storm Sewer Design Standard.

TECHNICAL INFORMATION

A. Channel Linings

The three main classifications of open channel linings are vegetative, flexible, and rigid. Vegetative linings include grass with mulch, sod, and lapped sod. Rock riprap is a flexible lining, while rigid linings are generally concrete.

1) Vegetative

Vegetation is the most desirable lining for an artificial channel. It stabilizes the channel body, consolidates the soil mass of the bed, checks erosion on the channel surface, and controls the movement of soil particles along the channel bottom. Conditions under which vegetation may not be acceptable, however, include but are not limited to:

a. Flow conditions in excess of the maximum shear stress for bare soils
b. Standing or continuous flowing water
c. Lack of regular maintenance necessary to prevent domination by taller vegetation
d. Lack of nutrients and inadequate topsoil
e. Excessive shade
f. Velocities

Proper seeding, mulching, and soil preparation are required during construction to assure establishment of a healthy growth of grass. Soil testing may be performed and the results evaluated by an agronomist to determine soil treatment requirements for pH, nitrogen, phosphorus, potassium, and other factors. In many cases, temporary erosion control measures are required to provide time for the seeding to establish a viable vegetative lining.

Sodding should be staggered to avoid seams in the direction of flow. Lapped or shingle sod should be staggered and overlapped by approximately 25 percent. Staked sod is usually only necessary for use on steeper .slopes to prevent sliding.

2) Flexible

Rock riprap including rubble is the most common type of flexible lining. It presents a rough surface that can dissipate energy and mitigate increases in erosive velocity. These linings are usually less expensive than rigid linings and have self-healing qualities that reduce maintenance. They typically require use of filter fabric and allow the infiltration and exfiltration of water. The growth of grass and weeds through the lining may present maintenance problems. The use of flexible lining may be restricted where space is limited, since the higher roughness values create larger cross sections.

3) Rigid

Rigid linings are generally constructed of concrete and used where smoothness offers a higher capacity for a given cross-sectional area. Higher velocities, however, create the potential for scour at channel lining transitions. A rigid lining can be destroyed by flow undercutting the lining, channel head cutting, or the buildup of hydrostatic pressure behind the rigid surfaces. When properly designed, rigid linings may be appropriate where the channel width is restricted. Filter fabric may be required to prevent soil loss through pavement cracks.

Under continuous base conditions when a vegetative lining alone would be appropriate, a small concrete pilot channel could be used to handle the continuous low flows. Vegetation could then be maintained for handling larger flows.

B. Hydraulic Terms

1) Energy of Flow

Flowing water contains energy in two forms - potential and kinetic. The potential energy at a particular point is represented by the depth of the water plus the elevation of the channel bottom above a convenient datum plane. The kinetic energy (in feet) is represented by the velocity head. $V^2/2g$. Figure OP-F1 illustrates open channel energy concepts and equation OP.E1 is the energy equation.

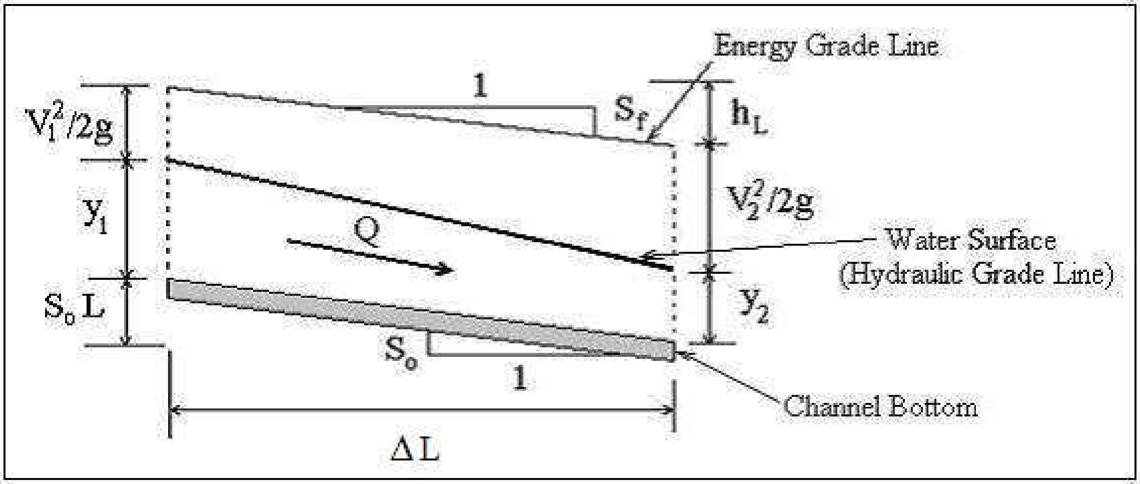


Figure OP-F1 Energy in Open Channel Flow

$$S_oL + V_1^2/2g + y_1 = V^2/2g + y_2 + h_L \quad \text{(OP.E1)}$$

Where: d = *depth* of flow above streambed (ft)
V = mean velocity of flow (ft/s)
Z = vertical distance from datum (ft)
g =acceleration due to gravity (32.2 ft/s^2)
h_L = head loss (ft)

The slope (gradient) of the total energy grade line is a measure of the friction slope or rate of energy head loss due to friction. The total head loss for a length of channel is the product of the length and friction slope (h_L = S x L). Under uniform flow, the energy line is parallel to the water surface and streambed.

2) Steady and Unsteady

Flow in open channels is classified as either steady or unsteady flow. Steady flow occurs when discharge or rate of flow at any cross section is constant with time. In unsteady flow, the discharge or rate of flow varies from one cross section to another with time.

3) Uniform and Non-Uniform Flow

Uniform flow exists when the channel cross section, roughness, and slope are constant; and non-uniform or varied flow exists when the channel properties vary from section to section.

4) Froude Number

The Froude number is the ratio of the inertial force to that of gravitational force, expressed by the following equation

$$Fr = v / (gD)^{1/2}$$

Where: v = mean velocity of flow (ft/s)

g = acceleration due to gravity (32.2 ft/s^2)

D = hydraulic depth (ft) - defined as the cross sectional area of water normal to the direction of channel flow divided by free surface width.

5) Critical Flow

Critical flow is defined as the condition for which the Froude Number is equal to one. At that state of flow, the specific energy is a minimum for a constant discharge. By plotting specific energy head against depth of flow for a constant discharge, a specific energy diagram can be drawn as illustrated in Figure OP-F2. Also, by plotting discharge against specific energy head we can illustrate not only minimum specific energy for a given discharge per unit width, but also maximum discharge per unit for a given specific energy.

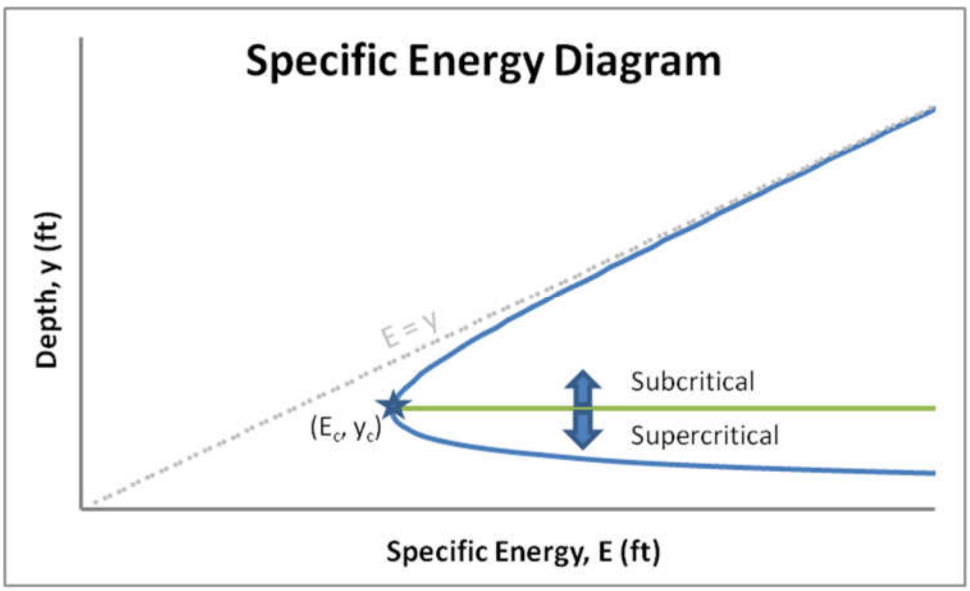


Figure OP-F2 Definition Sketch of Specific Energy

6) Subcritical Flow

When the Froude Number is smaller than l, the state of flow is defined as subcritical or tranquil flow, and surface waves propagate upstream as well as downstream. Control of subcritical flow depth is always downstream.

7) Supercritical Flow

When the Froude Number is larger than 1, the state of flow is defined as supercritical or rapid flow, and surface disturbance can propagate only in the downstream direction. Control of supercritical flow depth is always at the upstream end of the critical flow region.

C. Trapezoidal Channel Equations

For a given discharge, slope, and channel roughness, maximum velocity implies minimum cross sectional area. From Manning's equation, if velocity is maximized and area is minimized, wetted perimeter will also be minimized. The best hydraulic section therefore, simultaneously minimizes area and wetted perimeter.

For ease of construction, most channels are built with trapezoidal cross-sections. Therefore, this chapter deals with computing .the best hydraulic section for trapezoidal section channels.

Equations

Given that the desired side slope, M to one, has been selected for a given channel, the minimum wetted perimeter (P) exists when:

$$P = 4y(1+M^2)^{1/2} - 2My \qquad \text{(OP.E2)}$$

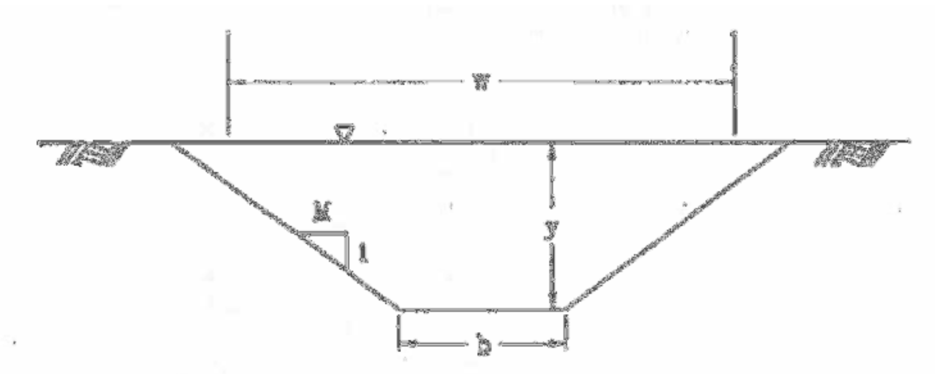


Figure OP-F3 - Trapezoidal Channel - Definition of Variables

From the geometry of the channel cross-section and the Manning equation, design equations can be developed for determining the dimensions of the best hydraulic section for a trapezoidal channel.

The depth of the hydraulic section is defined by:

$y = C_M(Qn/(S^{1/2}))^{3/8}$

Where: $C_M = [\{k+2(M^2+1)^{1/2}\}^{2/3}/ 1.49(k+M)^{5/3}]^{3/8}$

The associated bottom width is: $b = ky$
The cross-sectional area of the resulting channel is: $A=by+My^2$
Table OP-T1 lists values of C_M and k for various values of M.

Table OP –T1

Values of C_M and k for determining bottom width and depth of best hydraulic section for a trapezoidal channel.

M	C_M	k
0/1	0.790	2.00
0.5/1	0.833	1.236
0.577/1	0.833	1.155
1/1	0.817	0.828
1.5/1	0.775	0.606
2/1	0.729	0.472
2.5/1	0.688	0.385
3/1	0.653	0.325
3.5/1	0.622	0.280
4/1	0.595	0.246
5/1	0.522	0.198
6/1	0.518	0.166
8/1	0.467	0.125
10/1	0.430	0.100
12/1	0.402	0.083

D. Nomographs

Nomographs for obtaining direct solutions to Manning's Equation are presented in Figures OP-F4 and OP-F5. Figure OP-F4 provides a general solution for the velocity form of Manning's Equation, while Figure OP-F5 provides a solution of Manning's Equation for trapezoidal channels.

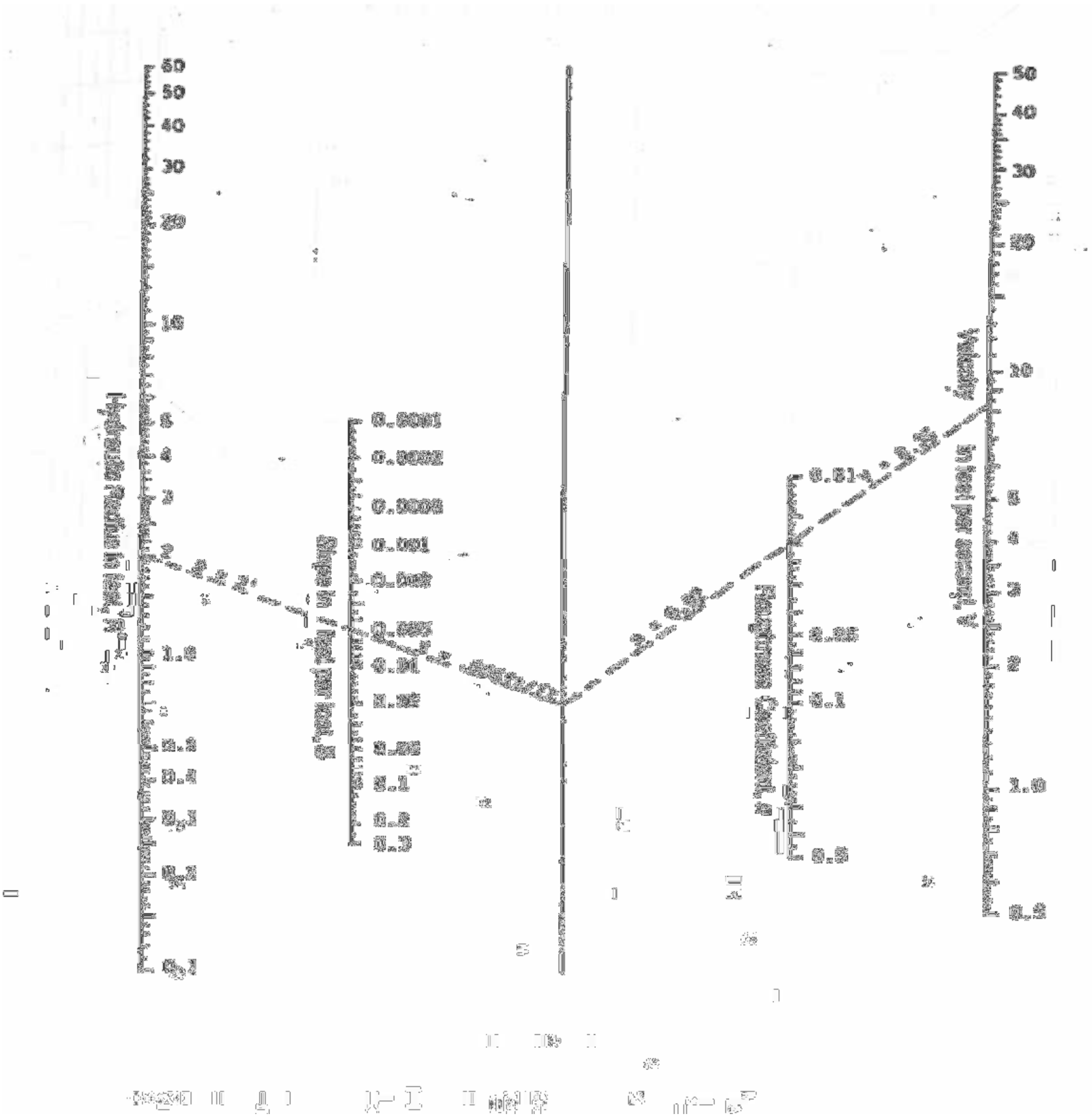


Figure OP-F4

Nomo graph for the Solution of Manning's Equation

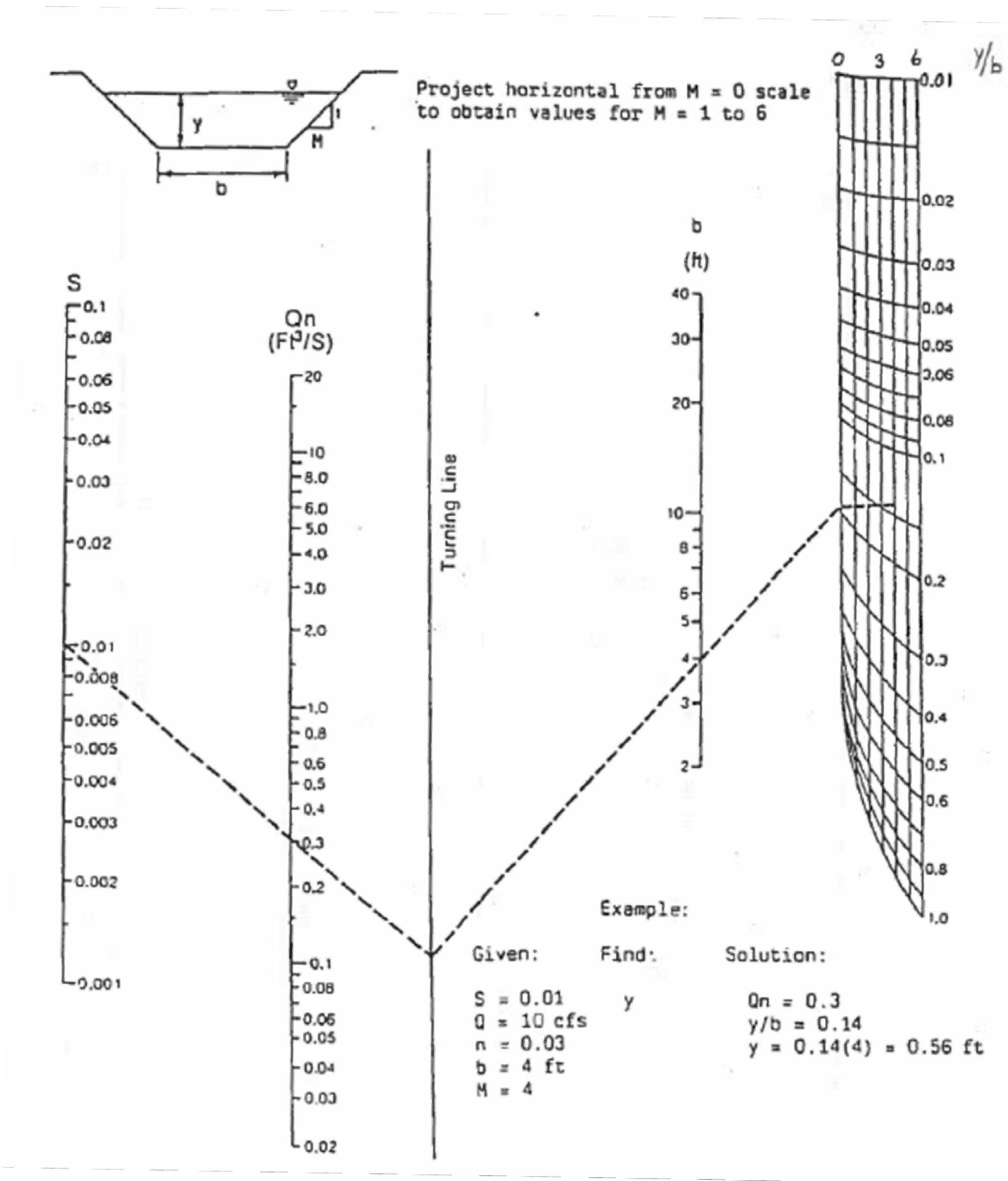


Figure OP-F5

Solution of Manning's Equation for Trapezoidal Channels

E. Critical Depth

Critical depth depends only on the discharge rate and channel geometry. The general equation for determining critical depth is expressed as:

$$Q^2/g=A^3/T \qquad \text{(OP.E3)}$$

Where: Q = discharge rate for design conditions (cfs)

g = acceleration due to gravity (32.2 ft/sec^2)

A = cross-sectional area (ft^2)

T = top width of water surface (ft)

A trial and error procedure is needed to solve equation OP-E3.

Semi-empirical equations (as presented in Table OP·T2) or section factors (as presented in Figure OP·T3) can be used to simplify trial and error critical depth calculations. The following equation from Chow (1959) is used to determine critical depth with the critical flow section factor, Z:

$$Z = Q/ (g)^{1/2} \qquad \text{(OP.E4)}$$

Where: Z = critical flow section factor

Q = discharge rate for design conditions (cfs)

g = acceleration due to gravity (32.2 ft/sec^2)

The following guidelines are presented for evaluating critical flow conditions of open channel flow:

1. A normal depth of uniform flow within about 10 percent of critical depth is unstable and should be avoided in design, if possible.
2. If the velocity head is less than one-half the mean depth of flow, the flow is subcritical.
3. If the velocity head is equal to one-half the mean depth of flow, the flow is critical.
4. If the velocity head is greater than one half the mean depth of flow, the flow is supercritical.
5. If an unstable critical depth cannot be avoided in design, the least type of flow should be assumed for the design.

Table OP-T2 Critical Depth Equations for Uniform Flow in Channel Cross Sections

Channel Type*	Semi-Empirical Equation[b] for Estimating Critical Depth	Range of Applicability
Rectangular[c]	$y_c = (Q^2/gb^2)/3$	N/A
Trapezoidal	$yc = 0.81(Q^2/gM^{0.75}b^{1.25})^{0.27}-(b/30M)$	$0.1<0.5522(Q/b^{2.5})<0.1$ use rectangular channel equation
Triangular[c]	$y_c = (2Q^2/gM^2)^{1/5}$	N/A
Circular[d]	$yc = 0.325(Q/D)^{2/3} + 0.083D$	$0.3 < y_c /D < 0.9$
General[e]	$A^3/T = Q^2/g$	N/A

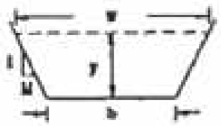
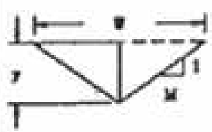
*See Figure OP-T3 for channel sketches

[b]Assumes uniform flow with the Kinetic energy coefficient equal to 1.

[c]Reference: French (1985)

[d]Reference: USDOT, FHWA, HDS-4 (1965)

[e]Reference: Brater and King (1976)

Section	Area A	Wetted Perimeter, P	Hydraulic Radius, R	Top Width, W	Critical Depth Factor, Z
 Trapezoid	$by + My^2$	$b + 2y\sqrt{M^2 + 1}$	$\frac{by + My^2}{b + 2y\sqrt{M^2 + 1}}$	$b + 2My$	$\frac{[(b + My)y]^{1.5}}{\sqrt{b + 2My}}$
 Rectangle	by	$b + 2y$	$\frac{by}{b + 2y}$	b	$by^{1.5}$
 Triangle	My^2	$2y\sqrt{M^2 + 1}$	$\frac{My}{2\sqrt{M^2 + 1}}$	$2My$	$\frac{\sqrt{2}}{2} My^{2.5}$

Open Channel Geometric Relationships for Various Cross Sections

Table OP-T3

Froude Number

The Froude Number, Fr, calculated by the following equation, is useful for evaluating the type of flow conditions in an open channel:

$$Fr = v/(gA/T)^{1/2} \quad \text{(OP.E5)}$$

Where: Fr = Froude number (dimensionless)

v = velocity of flow (ft/s)

g = acceleration due to gravity (32.2 ft/sec^2)

A = cross-sectional area of flow (ft^2)

T = top width of flow (ft)

If Fr is greater than 1.0, flow is supercritical; if it is under 1.0, flow is subcritical. Fr equals 1.0 for critical flow conditions.

F. Rip Rap Design

The following procedure is based on results and analysis of laboratory and field data (Maynord, 1987; Reese, 1984; Reese, 1988). This procedure applies to riprap placement in both natural and prismatic channels and has the following assumptions and limitations:

1. Maximum side slope is 2: 1
2. Maximum allowable velocity is 14 feet per second

If significant turbulence is caused by boundary irregularities, such as installations near obstructions or structures, this procedure is not applicable.

Procedure

Following are the steps in the procedure for riprap design.

1. Determine the average velocity in the main channel for the design condition. Use the higher value of velocity calculated both with and without riprap in place. Manning's n values for riprap can be calculated from the equation:

$$n = 0.0395\,(d_{50})^{1/6}$$

Where: n = manning’s roughness coefficient for stone rip rap

d_{50} = diameter of stone for which 50 percent, by weight, of the gradation is finer (ft)

2. If rock is to be placed at the outside of a bend, multiply the velocity determined in Step 1 by the bend correction coefficient, Cb, given in Figure OP-F6 for either a natural or prismatic channel. This requires determining the channel top width, W, just upstream from the bend and the centerline bend radius, R_b.

3. If the specific weight of the stone varies from 165 pounds per cubic foot, multiply the velocity from Step 1 or 2 (as appropriate) by the specific weight correction coefficent, Cg, from Figure OP·F7.

4. Determine the required minimum d_{30} value from Figure OP-F8 which is based on the equation:

$$d_{30}/D = 0.193Fr^{2.5}$$

Where: d_{30} = diameter of stone for which 30 percent, by weight, of the gradation is finer

D = depth of flow above stone (ft)

Fr = Froude number (see equation OP-E5), dimensionless

v = mean velocity above the stone (ft/s)

g = acceleration due to gravity (32.2 ft/sec^2)

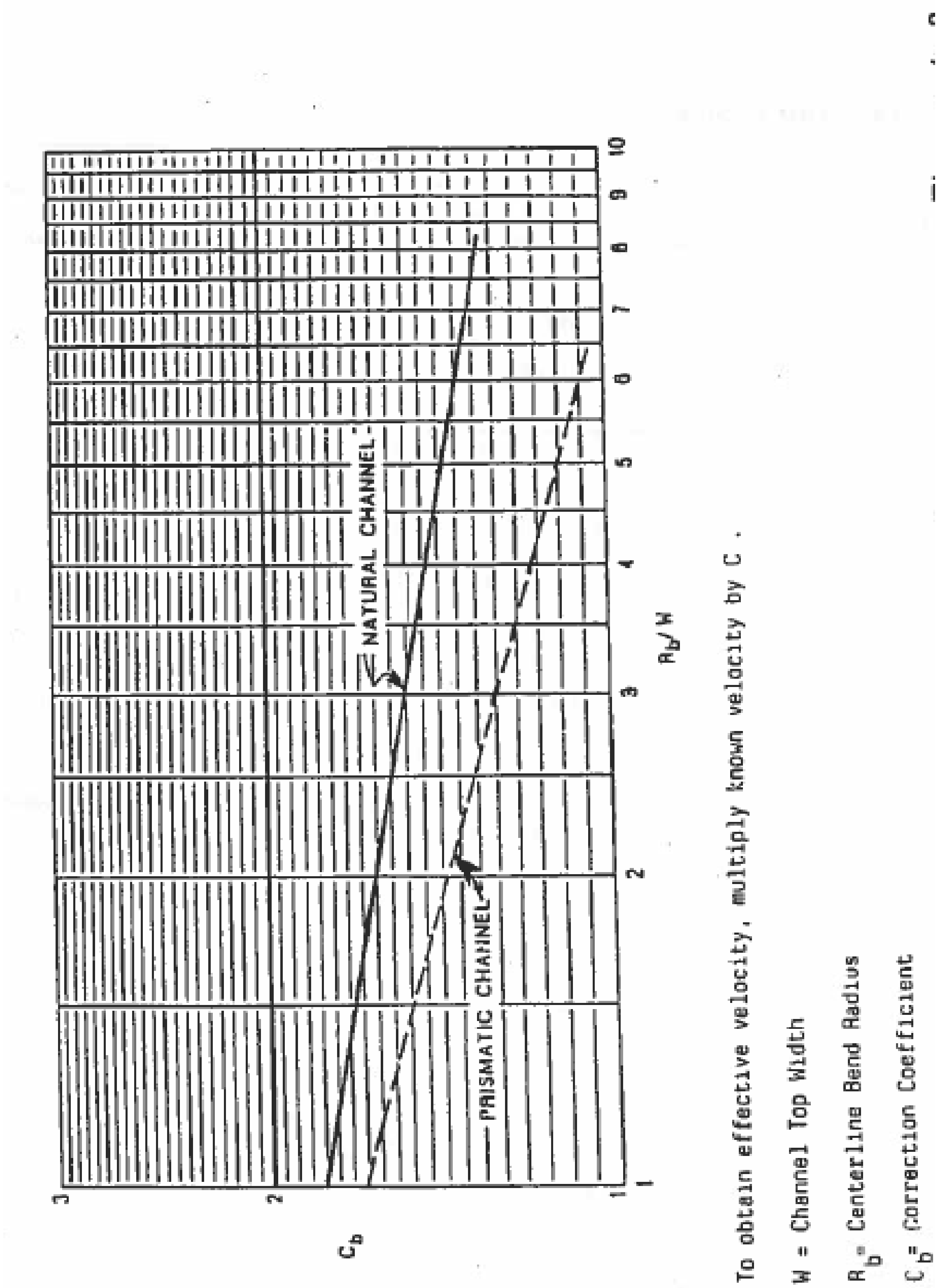


Figure OP-F6

Rip Rap Bend Correction Coefficient

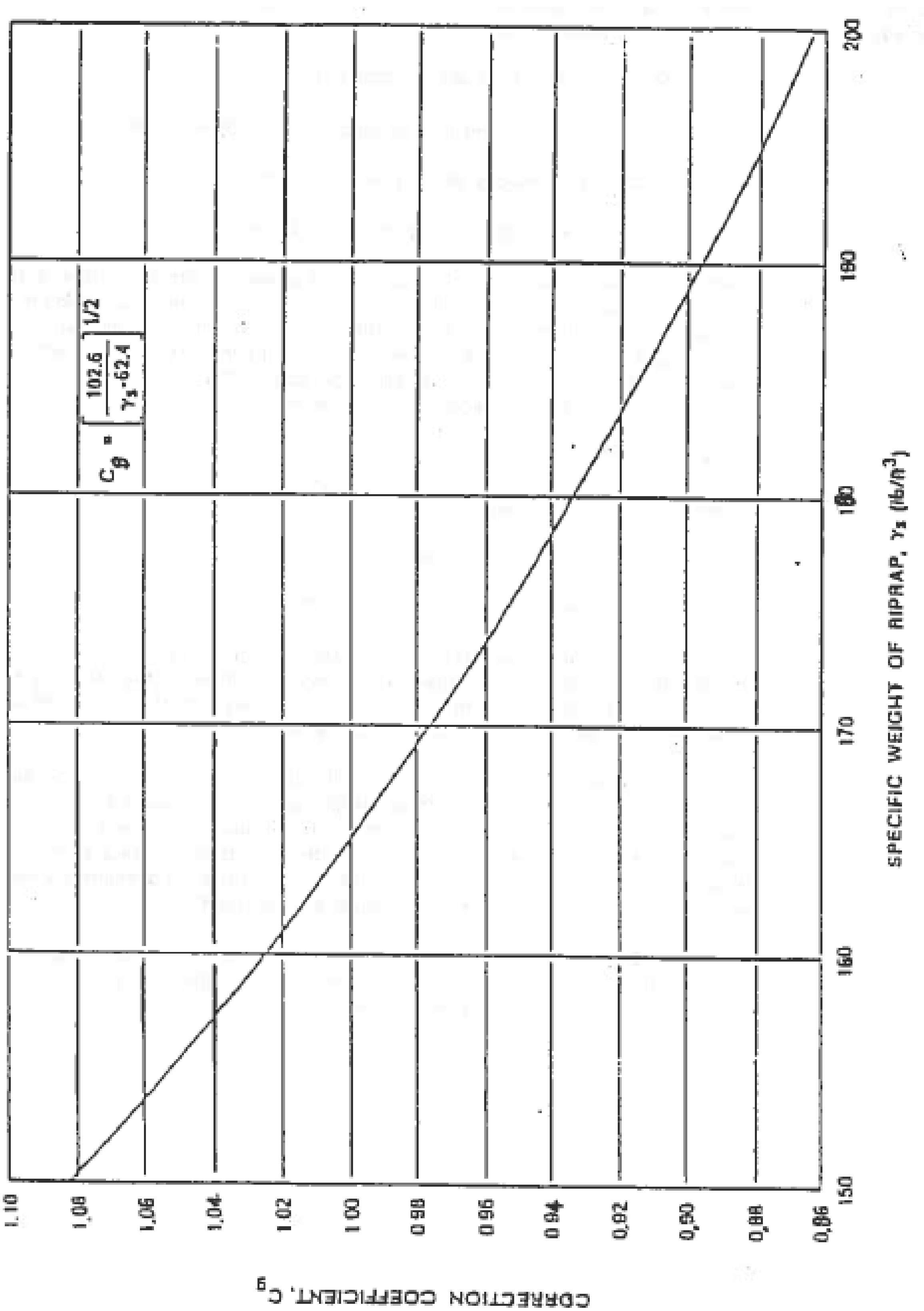


Figure OP-F7

Rip Rap Lining Specific Weight Correlation Coefficient

5. Determine available riprap gradations. A well graded riprap is preferable to uniform size or gap graded. The diameter of the largest stone, d_{100} should not be more than 1.5 times the d_{50} size. Blanket thickness should be greater than or equal to d_{100} except as noted below. Sufficient fines (below d_{15}) should be available to fill the voids in the larger rock sizes. The stone weight for a selected stone size can be calculated from the equations:

   $w = 0.5236\ SW_s\, d^3$

   Where: w = stone weight (lbs)

   d = selected stone diameter (ft)

   $SW_s =$ specific weight of stone (lbs/ft^3)

   Filter fabric or a filter stone layer should be used to prevent turbulence or groundwater seepage from removing bank material through the stone or to serve as a foundation for unconsolidated material. Layer thickness should be increased by 50 percent for underwater placement.

6. If d_{85}/d_{15} is between 2.0 and 2.3 and a smaller d_{30} size is desired, a thickness greater than d_{100} can be used to offset the smaller d_{30} size. Figure OP·F9 can be used to make an approximate adjustment using the ratio of d_{30} sizes. Enter the y-axis with the ratio of the desired d_{30} size to the standard d_{30} size and find the thickness ratio increase on the x-axis. Other minor gradation deficiencies may be compensated for by increasing the stone blanket thickness.

7. Perform preliminary design, ensuring that adequate transition is provided to natural materials both up and downstream to avoid flanking and that toe protection is provided to avoid riprap undermining.

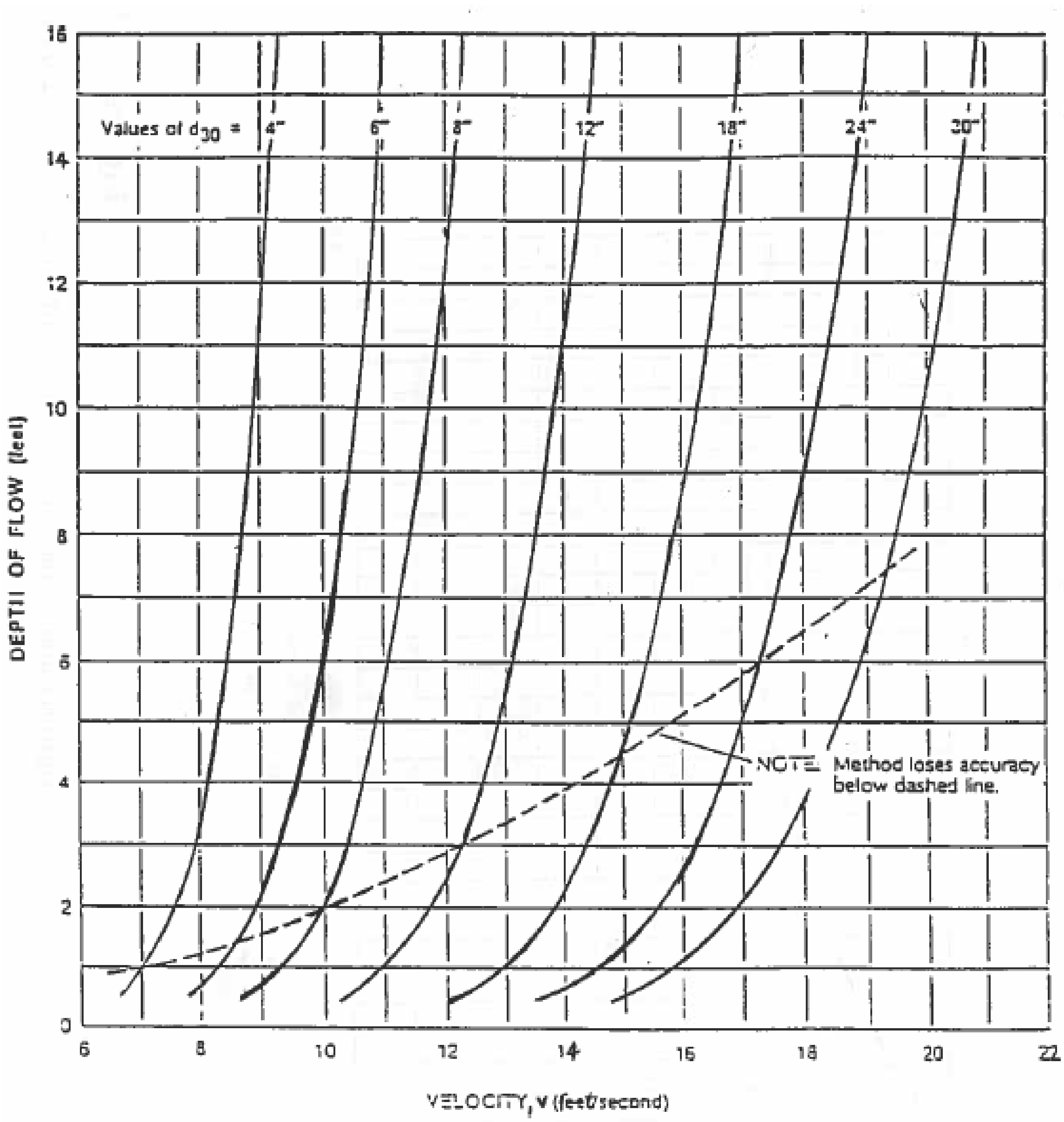


Figure OP-F8

Rip Rap Lining d_{30} Stone Size as a Function of Mean Velocity and Depth

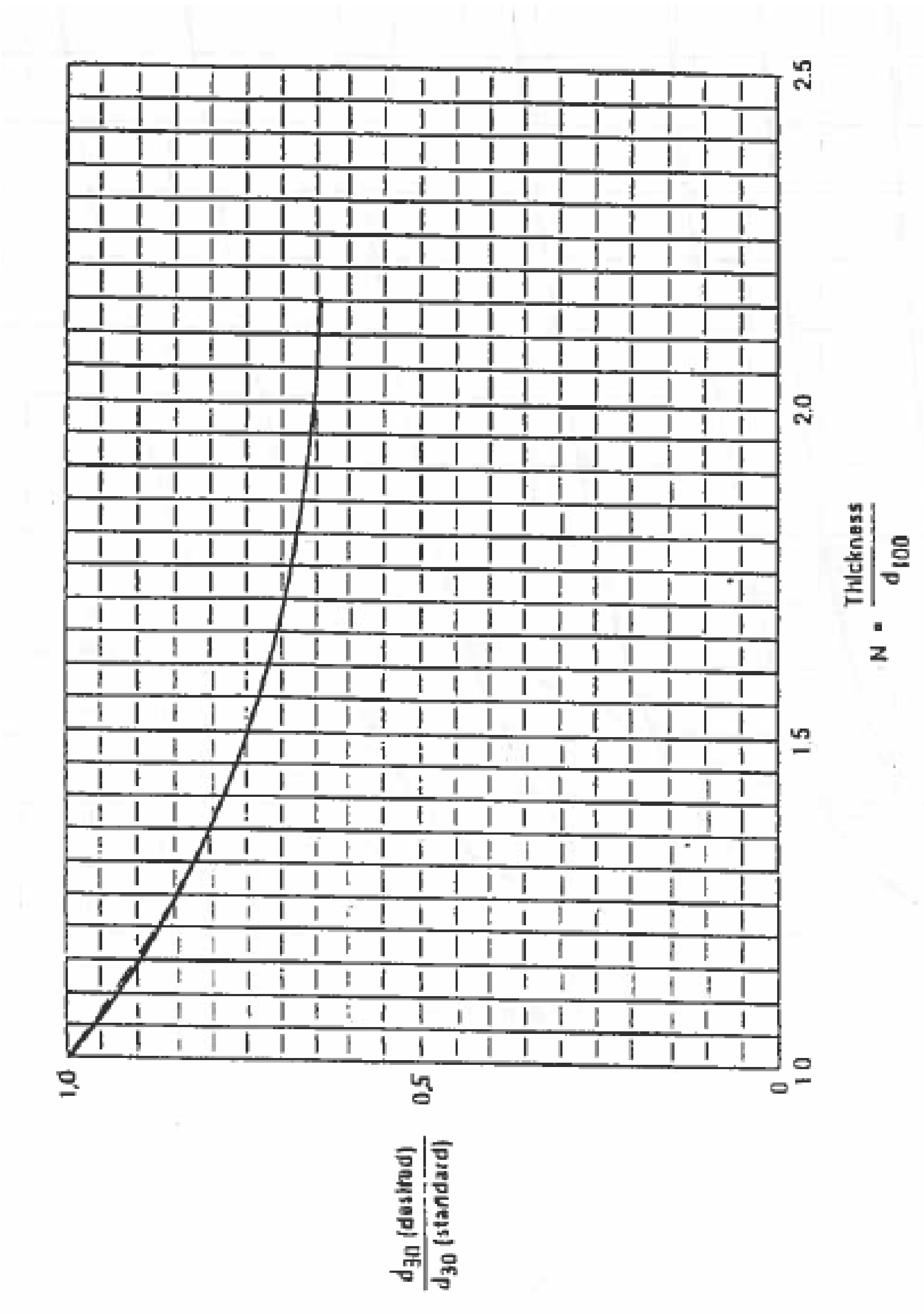


Figure OP-F9

Rip Rap Lining Thickness Adjustment for d_{85}/d_{15} = 2.0 to 2.3

G. Energy Dissipater Design

When energy becomes high in an open channel, standard channel lining materials may be inadequate. In this case energy dissipaters will be necessary. For energy dissipation design, we send the designer to Federal Highway Administration (FHWA) Publication No. FHWA-NHI-06-086 July 2006. "Hydraulic Engineering Circular No. 14, Third Edition" For information and guidance, the first chapter of this document is shown below.

First time designers should become familiar with the recommended energy dissipater design procedure that is discussed in this section.

1) Energy Dissipater Design Procedure

   The designer should treat the culvert, energy dissipater, and channel protection designs as an integrated system. Energy dissipaters can change culvert performance and channel protection requirements. Some debris-control structures represent losses not normally considered in the culvert design procedure. Velocity can be increased or reduced by changes in the culvert design. Downstream channel conditions (velocity, depth, and channel stability) are important considerations in energy dissipater design. A combination of dissipater and channel protection might be used to solve specific problems.

Dissipator Type	Froude Number[7] (Fr)	Allowable Debris [1] Silt/ Sand	Boulders	Floating	Tailwater (TW)
Flow transitions	na	H	H	H	Desirable
Scour hole	na	H	H	H	Desirable
Hydraulic jump	> 1	H	H	H	Required
Tumbling flow[2]	> 1	M	L	L	Not needed
Increased resistance[3]	na	M	L	L	Not needed
USBR Type IX baffled apron	< 1	M	L	L	Not needed
Broken-back culvert	> 1	M	L	L	Desirable
Outlet weir	2 to 7	M	L	M	Not needed
Outlet drop/weir	3.5 to 6	M	L	M	Not needed
USBR Type III stilling basin	4.5 to 17	M	L	M	Required
USBR Type IV stilling basin	2.5 to 4.5	M	L	M	Required
SAF stilling basin	1.7 to 17	M	L	M	Required
CSU rigid boundary basin[8]	< 3	M	L	M	Not needed
Contra Costa basin	< 3	H	M	M	< 0.5D
Hook basin	1.8 to 3	H	M	M	Not needed
USBR Type VI impact basin[4]	na	M	L	L	Desirable
Riprap basin	< 3	H	H	H	Not needed
Riprap apron[8]	na	H	H	H	Not needed
Straight drop structure[5]	< 1	H	L	M	Required
Box inlet drop structure[6]	< 1	H	L	M	Required
USACE stilling well	na	M	L	N	Desirable

[1]Debris notes: N = none, L = low, M = moderate, H = heavy
[2]Bed slope must be in the range 4% < S_o < 25%
[3]Check headwater for outlet control
[4]Discharge, Q < 11 m^3/s (400 ft^3/s) and Velocity, V < 15 m/s (50 ft/s)
[5]Drop < 4.6 m (15 ft)
[6]Drop < 3.7 m (12 ft)
[7]At release point from culvert or channel
[8]Culvert rise less than or equal to 1500 mm (60 in)
na = not applicable.

Table OP-T4

The energy dissipater design procedure, illustrated in Figure OP-F10, shows the recommended design steps. The designer should apply the following design procedure to one drainage channel/culvert and its associated structure at a time.

Step 1.

Identify and Collect Design Data. Energy dissipaters should be considered part of a larger design system that includes a culvert or a chute, channel protection requirements (both upstream and downstream), and may include a debris control structure. Much of the input data will be available to the energy dissipater design phase from previous design efforts.

a. Culvert Data: The culvert design should provide: type (RCB, RCP, CMP, etc); height, D; width, B; length, L; roughness, n; slope, S_o; design discharge, Q; tailwater, TW; type of control (inlet or outlet); outlet depth, y_o; outlet velocity, V_o; and outlet Froude number, Fr_o.

b. Transition Data: For most culvert designs, the designer will have to determine the flow depth, y, and velocity, V, at the exit of standard wingwall/apron combinations.

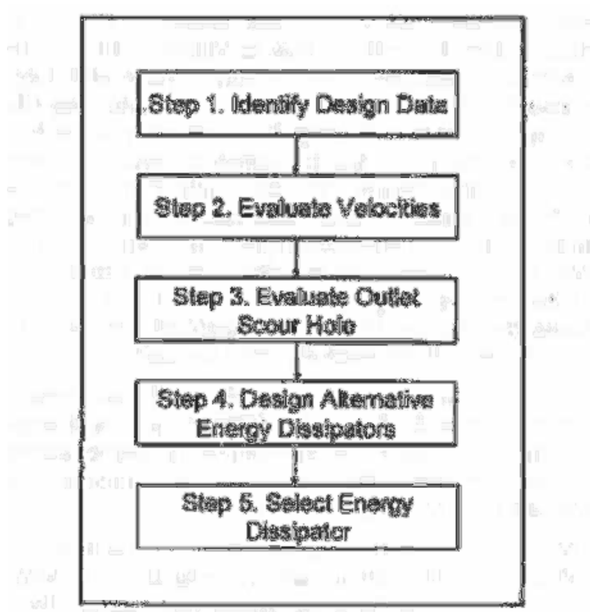


Figure OP-F10

c. Channel Data: The following channel data is used to determine the TW for the culvert design: design discharge, Q; slope, S_o; cross section geometry; bank and bed roughness, n; normal depth, y_n = TW; and normal velocity, V_n. If the cross section is a trapezoid, it is defined by the bottom width, B, and side slope, Z, which is expressed as 1 unit vertical to Z units horizontal (1V:ZH). HDS 4 (Schall, et al., 2001) provides examples of how to compute normal depth in channels. The size and amount of debris should be estimated using HEC 9 (Bradley, J.B., et al., 2005). The size and amount of bedload should be estimated.

d. Allowable Scour Estimate: In the field, the designer should determine if the bed material at the planned exit of the culvert is erodible. If it is, the potential extent of scour should be estimated: depth, h_s; width, W_s; and length, L_s. These estimates should be based on the physical limits to scour at the site. For example, the length, L_s, can be limited by a rock ledge or vegetation. The following soils parameters in the vicinity of planned culvert outlets should be provided. For non-cohesive soil, a grain size distribution including D_{16} and D_{84} is needed. For cohesive soil, the values needed are saturated shear strength, S_v, and plasticity index, PI.

e. Stability Assessment: The channel, culvert, and related structures should be evaluated for stability considering potential erosion, as well as buoyancy, shear, and other forces on the structure. If the channel, culvert, and related structures are assessed as unstable, the depth of degradation or height of aggradation that will occur over the design life of the structure should be estimated.

Step 2.

Evaluate Velocities. Compute culvert or chute exit velocity, V_o, and compare with downstream channel velocity, V_n. If the exit velocity and flow depth approximates the natural flow condition in the downstream channel, the culvert design is acceptable. If the velocity is moderately higher, the designer can evaluate reducing velocity within the barrel or chute or reducing the velocity with a scour hole (step 3). Another option is to modify the culvert or chute (channel) design such that the outlet conditions are mitigated. If the velocity is substantially higher and/or the scour hole from step 3 is unacceptable, the designer should evaluate energy dissipaters (step 4). Definition of the terms “approximately equal,” “moderately higher,” and “substantially higher” is relative to site-specific concerns such as sensitivity of the site and the consequences of failure. However, as rough guidelines that should be re-evaluated on a site-specific basis, the ranges of less than 10 percent, between 10 and 30 percent, and greater than 30 percent, respectively, may be used.

Step 3.

Evaluate Outlet Scour Hole. If the size of the scour hole is acceptable, the designer should document the size of the expected scour hole for maintenance and note the monitoring requirements. If the size of the scour hole is excessive, the designer should evaluate energy dissipaters (step 4).

Step 4.

Design Alternative Energy Dissipaters. Compare the design data identified in step 1 to the attributes of the various energy dissipaters in Table OP-T4. Design one or more of the energy dissipaters that substantially satisfy the design criteria. The dissipaters fall into two general groups based on Fr:

1. Fr < 3, most designs are in this group

2. Fr > 3, tumbling flow, USBR Type III stilling basin, USBR Type IV stilling basin, SAF stilling basin, and USBR Type VI impact basin

Debris, tailwater channel conditions, site conditions, and cost must also be considered in selecting alternative designs.

Step 5.

Select Energy Dissipaters. Compare the design alternatives and select the dissipater that has the best combination of cost and velocity reduction. Each situation is unique and the exercise of engineering judgment will always be necessary. The designer should document the alternatives considered.

GENERAL CITY REQUIREMENTS FOR DESIGN

A. Channel Geometry

1) Generally channel side slopes should be 1V:3H or flatter. The channel should be shaped to allow for the use of mowing equipment.

2) Channel freeboard near a road should be 1.5 feet below the edge of the road shoulder for runoff from the 50 year- 24 hour storm.

3) Channel grades shall be 0.3 percent minimum. In extenuating circumstances slopes of 0.1 percent may be allowed.

B. Hydraulic Analysis

The hydraulic analysis of a channel determines the depth and velocity at which a given discharge will flow in a channel of known geometry, roughness and slope. The depth and velocity of flow are necessary for the design or analysis of channel linings and drainage structures. The depth determines the water surface profile which then defines the extent of possible flooding

The computation of water surface profiles requires cross sections at representative locations throughout the channel reach. When a channel is fairly straight and uniform, cross sections may be taken at regular intervals. Cross section frequency should increase to define transitional elements of a channel such as: the cross sectional area increasing or decreasing, channel or overbank roughness changes, or marked breaks in bottom slope. When an abrupt change in cross section occurs, such as at bridges or other man made or natural restriction, several cross sections should be used to describe the change, regardless of the distance.

Cross sections must be taken perpendicular to the direction of the estimated center of mass of flow. In some instances, this direction may differ materially from that of the normal flow in the channel. Every effort should be made to obtain cross sections that accurately represent the channel geometry at all stages.

Under steady state, uniform flow conditions channel capacity shall be computed using Manning's Equation:

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$, where

Q = rate of flow, cubic feet per second
n = Manning's roughness coefficient (see table)
A = Cross sectional area of flow, square feet
P = Wetted perimeter, feet
R = Hydraulic radius = A\P, feet
S = Slope of channel (feet/feet)

"n" values for use in the Manning's equation can be obtained from the following table:

Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble Masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.033
Grass (Sod) Unmowed	0.030
Heavy Riprap	0.035
Grouted Riprap	0.030
Open Channels (Unlined) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Channels, not maintained, weeds & brush uncut	0.090
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100

Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street	
Curbing	0.014

C. General Method of Verifying Capacity of Designed Open Channel

1) Select typical cross section for each channel reach to be designed.
2) Calculate the cross sectional area, wetted perimeter and the hydraulic radius.
3) Assign Manning's "n" roughness value from table to each cross section.
4) Calculate discharge using Manning's equation and slope for each section. Alternately, nomographs and flow charts for different shaped channels are available from credible institutions and can be used if provided for City review and approved. Also the designer can choose to use HECRAS at his/her discretion.
5) Verify the calculated discharge is greater than or equal to the design flow for each section.
6) If calculated discharge is lower than design flow, re-engineer as appropriate to accommodate expected runoff. Repeat the above steps as necessary.

D. Design flows

Open channels, ditches, swales etc. shall be designed to carry the 50 year storm for the time of concentration of the location of the channel. Also a check shall be made at each section to verify that the flow resulting from the 100 year storm does not flood any adjacent houses or buildings.

E. Erosion control for channels

There are both permanent and temporary erosion control measures used to construct drainage channels. The designer shall design and show on the Contract Drawings both types of erosion control measures to be applied in the establishment of open flow channels. Check dams or other engineered methods to slow erosive flow and settle sediment shall be used in channels for temporary measures.

The table below shows guidelines for permanent stabilization treatments for various channel grades. The designated treatment for all situations should include installation in the channel bottom and at least 4 feet up both sides. The soil type should be considered for borderline situations. The lesser treatment can be used for cohesive soils, while the higher level treatment should be used for non-cohesive soils.

Permanent Stabilization Treatments for Various Channel Grades	
Channel Bottom Treatment	**Channel Grade**
Seed and Mulch*	0.3% to 0.5%
Standard Mulch Blanket*	0.5% to 1.5%
Sod*	1.5% to 3.0%
Turf Reinforcement Mat or Cobble	3.0% to 6.0%
Specific Design Required**	Greater than 6.0%

* When within 200 feet of a waterway or Lake Superior, the minimum permanent channel treatment will be mulch blanket for channel grades 0.5% or less and sod for channel grades between 0.5% and 3.0%. Also depending on the area the City may require sod outright as determined by the City Engineer.
** Designer may consult MDOT Standard plans R-32 or R-46 as appropriate.

JURISTICTION AND LAND CONSIDERATIONS

Open channel design on private developments will be evaluated using this design standard section during the site plan review process.

All channels that are to be maintained by the City shall be located on City owned land, within a drainage easement or within a street right of way. The minimum drainage way easement width for an open channel shall be the top of the drainage way plus 10 feet on both sides. Additional easement shall be provided for maintenance equipment ingress and egress if needed.

The water surface boundary edge for both the 50 year storm and 100 year storm shall be shown in plan view of proposed drawings of open channel design.

References:

Chow, V. T., ed. 1959. Open Channel Hydraulics. McGraw hill Book Co. New York

French, R. H.1985. Open Channel Hydraulics. McGraw Hill Book Co. New York

Federal Highway Administration.1989. Bridge Waterways Analysis Model twSPRO). User's Manual, FHWA IP·89027.

Harza Engineering Company. 1972. Storm Drainage Design Manual. Prepared for the Erie and Niagara Counties Regional Planning Board. Har2a Engineering Company, Grand Island, N. Y.

Maynord, S. T. 1987. Stable Riprap Size for Open Channel Flows. Ph.D. Dissertation. Colorado State University, Fort Collins, Colorado.

Morris, J. R. 1984. A Method of Estimating Floodway Setback Limits in Areas of Approximate Study. In Proceedings of 19B4 International Symposium on Urban Hydrology. Hydraulics and Sediment Control. Lexington, Kentucky: University of Kentucky.

Peterska, A. J. 1978. Hydraulic Design of Stilling Basins and Energy Dissipaters. Engineering nomograph No. 25. U. S. Department of Interior, Bureau of Reclamation, Washington, D.C.

Reese, A. J. 1984. Riprap Sizing, Four Methods. In Proceedings of ASCE Conference on Water for Resource Development. Hydraulics Division, ASCE. David L. Schreiber, ed.

Reese, A. J. 1988. Nomographic Riprap Design. Miscellaneous Paper HL 88-2. Vicksburg, Mississippi: U.S.Army Engineers, Waterways Experiment Section.

U. S. Department of Transportation,Federal Highway Administration.1973. Design Charts for Open Channel Flow. Hydraulic Design Series No.3 Washington D.C.

U. S. Department of Transportation, Federal Highway Administration. 1983. Hydraulic Design of Energy Dissipaters for Culverts and Channels. Hydraulic Engineering Circular No. 14. Washington D.C.

U. S. Department of Transportation,Federal Highway Administration. 1984. Guide for Selecting Manning's Roughness Coefficients For Natural Channels and Flood Plains. FHWA-TS-84-204. Washington, D.C.

U. S. Department of Transportation,Federal Highway Administration.1986. Design of Stable Channels with Flexible Linings. Hydraulic Engineering Circular No. 15. Washington D.C.

Wright-McLaughlin Engineers. 1969. Urban Drainage Criteria Manual. Vol 2. Prepared for the Denver Regional Council of Governments. Wright-McLaughlin Engineers, Denver, Col.

North Carolina Department pf Natural Resources and Community Development. 1988. Erosion and Sediment Control Planning and Design Manual.

STORM SEWER
RETENTION, DETENTION AND STORM WATER TREATMENT SYSTEMS
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL INFORMATION

A. Background

Urbanization in the City of Marquette creates impervious surfaces on individual parcels and impervious surfaces generate greater storm water runoff. Runoff from these parcels combine to produce large amounts of flow that requires storm water infrastructure to convey it downstream safely. This conveying infrastructure consisting of pipes, culverts and bridges that are maintained by the City. Building and maintaining storm water infrastructure requires careful allocation of funds.

The amount of funding to build and maintain storm water infrastructure is directly related to the quantity of flow needed to be conveyed. As flow increases so does the size of pipes, culverts and bridge spans needed to convey it. Larger pipes, culverts and bridge spans cost more. Smaller pipes, culverts and bridge spans cost less. The most common way to reduce runoff and subsequent cost is by the use of onsite detention and retention basins.

A detention basin is defined as an impoundment which temporarily detains storm water runoff and releases the impounded water at a controlled rate over a specified period of time. By temporarily storing runoff water, peak flows can be affectively lowered, which reduces flooding, decreases erosion to open channels and waterways, and allows for smaller downstream design capacities in the city storm water infrastructure.

A retention basin is defined as an impoundment that retains all of the runoff from a specified storm. Water leaves a retention basin very slowly by infiltration, evaporation and vegetative transpiration. Retention basins are the ultimate way to lower runoff flows and volumes from a site.

This guideline provides the design standards the City will recognize and require for design of detention and retention basins.

While the primary function of detention and retention basins is to reduce peak flows and volumes of storm water, they also provide an added benefit of removing impurities from runoff. Impurities can also be removed by systems specifically engineered for the task such as manufactured treatment units, underground infiltration, bio-retention, rain gardens and vegetated swales.

In 1994 the City of Marquette enacted an ordinance that created the city's Stormwater Utility. The Utility charges each parcel in the City a user fee that is based on the amount of pervious and impervious area on the parcel. This fee can be reduced or eliminated using the items described in this design guideline.

A section at the end of this guide will outline how the use of various sized detention and retention basins that mitigate runoff flows, and storm water treatment systems that remove impurities can be used to reduce the City of Marquette Storm Water Utility fee for any given parcel.

B. Intent of Design

This guideline will describe the procedure for designing detention and retention basins. Design of storm water treatment systems will not be discussed but will be evaluated in the final section of this guide according to their surface area.

The City realizes that the design of detention and retention basins can be a very involved process. The designer must gather very specific information about a drainage area in order to analyze a dynamic weather event and derive useful numbers for basin design. The U. S. Conservation Service has formalized a procedure to lead the designer through the process. This City of Marquette design guideline will be centered on this procedure.

The U. S. Soil Conservation Service Technical Release Number 55 (TR55) Urban Hydrology for Small Watersheds is time tested and recognized as an industry standard. This release provides instruction and forms that allow for hand calculations needed to determine detention and retention basin design. TR55 software with fillable forms is also available for free on the internet that will perform the calculations for the user once appropriate data is entered.

Other computer software such as TR20, HECRAS, EPA SWMM or HydoCad can also be used. In most instances, the City will also allow the user to determine peak flows using the Rational Method which can then be used in basin design. However, the designer should be aware that the Rational Method almost always estimates larger conservative flows which then consequentially result in bigger basins.

C. Related Design Standard Sections and Ordinance

Other City design standards related to Detention and Retention Design are: Storm Sewer and Storm Sewer/Culverts, Open Channel Flow and Storm Water Management. The City of Marquette Storm Water Utility Ordinance can also affect design. All of these documents should be consulted.

Retention and detention basins and storm water treatment unit facilities within private developments may also be evaluated when a project is going through the site plan review process.

REQUIREMENTS FOR DESIGN

A. Data Required to Determine Runoff Flow and/or Volume

1) A map or maps with contours showing the drainage area feeding a basin using a scale that adequately shows the land use and/or pervious and impervious surfaces. If the site is small (less than 10 acres) the scale of the map(s) should be 1”=30’ or finer with 1’ contours. If the site is large (greater than 10 acres) map(s) with a scale of 1”=100’ with 2’ contours is acceptable.

2) Runoff Curve Numbers. Different land uses are assigned unique runoff curve numbers. These numbers can be found in tables 6 & 7 starting on page 80 of the storm sewer design standards.

3) Soil type. All of the soil types with their respective boundaries as determined by the Natural Resources Conservation Service (NRCS) need to be shown on the maps described above. The hydrologic group of the soil is needed for the calculations.

4) The design storm(s) to be used to determine runoff volume and peak flows.

5) Rainfall distribution type for Marquette, Michigan is II.

6) The percent of the drainage area that is a pond or swamp.

Calculations using the above data are used to determine basin size and/or basin outlet peak flow.

B. Basin Configuration

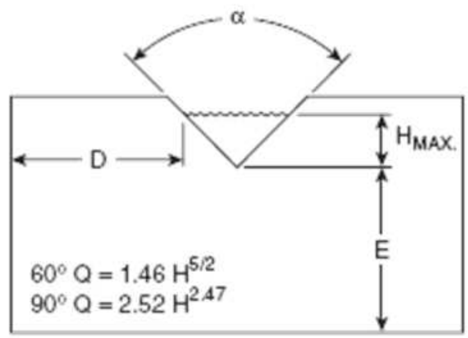
For the purposes of this design guideline, a basin constructed of earthen materials shall be assumed. Basins constructed of other materials such as concrete, HDPE or bedded stone can be used. However, the designer should consult the City Engineering Department before starting design. If the basin, by mutual consent of both the land owner and the city, is to be turned over to the City, the designer needs to work closely with the City Engineering Department throughout the design process.

Requirements of earthen basin configuration follow:

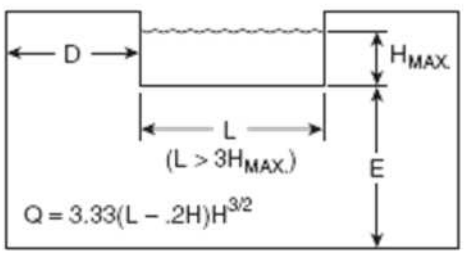
1) Side slopes of basin shall be 1 vertical on 3 horizontal or flatter so that, if desired, they can be mowed.
2) The inlet to the basin shall be protected from erosion. The inlet transition to the bottom of the basin shall be rip rap, stone, or on bigger basins, a concrete pad that can be cleaned of sediment using the bucket of a loader or a shovel.
3) The main outlet shall be controlled using an orifice (or orifices if perforations are used), a weir, pipe or other controlling feature. An engineered emergency

overflow shall also be used for the basin. Depending on the velocity of flow over the overflow, special treatment such as rip rap, concrete or an engineered structure may be necessary.

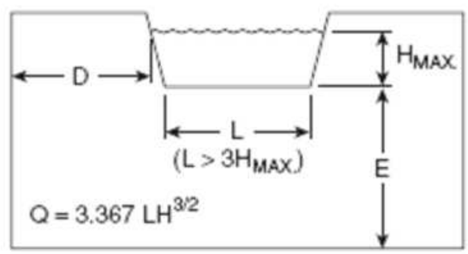
The following equations can be used for the types of weirs shown:



(a)



(b)

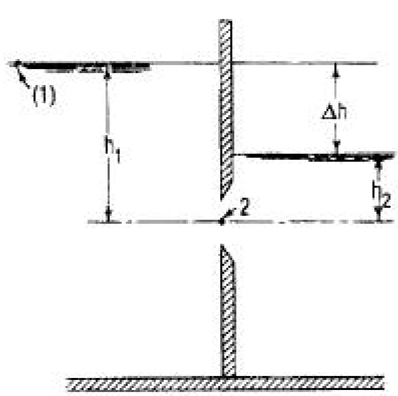


(c)

Q is in ft^3/sec, H and L are in feet.

Or the following equation can be used for a sharp crested vertical orifice :

$$Q = Ca\sqrt{2g\,\Delta h}$$



Where Q is in ft^3/sec. Dh is in feet. C = 0.6. And a is the cross sectional area of the orifice in ft^2. Use g = 32.2 ft/sec^2. Also use h_1 for Dh if orifice is not submerged.

4) Generally, the bottom and sides of the basin shall be grass. Other vegetation such as native plants, flowers and wetland plants and trees may be allowed if desired for landscaping design.
5) To the furthest extent possible, a basin should be 3 to 4 times as long as it is wide. This ratio allows for maximum settlement time of solids while keeping the flow or current through the basin to acceptable levels that do not stir up previously deposited materials.
6) At least one foot of freeboard shall be used in the design of any retention/detention basin.
7) For privately owned basins, it is the responsibility of the land owner to investigate all rules, regulations and laws pertaining to the placement of a fence around the retention/detention pond.

C. Design Flows and Volumes

The most important parameters needed to size a detention basin are the design runoff flow and basin outlet flow. Basins can be sized using these flows by following procedures and forms found within the TR55 document. Retention basins require just the runoff volume for sizing. If designing for the control or elimination of peak outlet flow, basins tend to be large and can comprise 5 to 10% or more of a site depending on amount of impervious surface. These larger basins can be used to lower the City of Marquette storm water utility fee.

The City of Marquette Storm Water Utility Ordinance allows for the elimination of part or all of the parcel's storm water utility fee if a detention or retention basin servicing the parcel meets certain requirements. For detention basins, the ordinance states:

> "Any detention basin permit issued pursuant to this section shall be supported by a certification of a professional engineer that runoff rates from the parcel for a 100-year, 24-hour duration storm event will not exceed a 10-year, 24-hour duration storm event for an equivalent undeveloped parcel." In other words a basin needs to store the difference between the flows of a 100 year, 24 hour *post developed* storm and a 10 year, 24 hour *pre-developed* storm in order to reduce the storm water utility fee by 85%.

And for retention basins:

> "Any retention basin permit issued pursuant to this section shall be supported by a certification of a professional engineer that the basin volume is capable of holding the runoff from the parcel from a 100-year, 24-hour event." If this is achieved, the storm water utility fee is reduced 100% and goes to zero for the parcel.

A designer may also design a treatment facility with the aim of higher water quality. Facilities for water treatment tend to be smaller than basins. The ordinance contains the following two paragraphs:

> "Manufactured stormwater treatment units. Manufactured stormwater treatment units, if approved and installed, shall reduce the stormwater fee charged to a lot through the use of the water quality factor. For a manufactured stormwater treatment unit to be approved, it must remove, at a minimum, 80 percent of total suspended solids (TSS) annually. Proof of 80 percent TSS removal shall be provided by an independent third party for review. The water quality factor shall be 0.5 if the unit can treat 100 percent of the peak flow from a post-developed ten-year, 24-hour storm. The water quality factor for the lot shall be proportionally increased to 1.0 maximum at the discretion of the city engineer for units that treat less than the peak flow from a ten-year, 24-hour storm."

and

> "Constructed stormwater treatment system. Other treatment systems such as detention basins, retention basins, bio-swales, rain gardens, etc., are encouraged and may qualify for lower stormwater fees through the assignment of a smaller water quality factor. Water quality factors for various types of treatment methods are listed in the city stormwater design standards. Final determination of the water quality factor shall be made by the city engineer."

The method for determining the Water Quality Factor (WQF) can be found at the end of this guideline section.

MAINTENANCE

All retention and detention basins and manufactured or constructed treatment units shall be cleaned and maintained regularly. A maintenance agreement found at the end of this document must be signed by the land owner for any basin or facility that decreases the parcel's Storm Water fee. If the City finds that a basin or manufactured or constructed treatment unit are not maintained, the storm water utility fee for that parcel shall be adjusted accordingly (See Maintenance Agreement Form).

JURISTICTION AND LAND CONSIDERATIONS

All retention and detention basins to be owned and maintained by the City shall be located on City owned land, within a drainage easement, or within a street right of way. The border of the easement shall be, at a minimum, 10 feet outside of the top of the bank of the basin. A minimum 20 foot wide access easement shall be provided for maintenance equipment ingress and egress if needed.

STORM WATER UTILITY USER FEE REDUCTION

The owner of the parcel where a basin or treatment facility is constructed may be eligible for a reduction of the parcel's stormwater utility fee. In order to receive this reduction, a

"Storm Water Utility Fee Reduction Request" application must be filled out and submitted to the City of Marquette Engineering Department for approval. As part of the application process, a maintenance agreement for the basin or facility must be signed by the parcel owner and submitted with the application. These forms can be found in this section, on the City website www.mqtcty.org, or at the Municipal Service Center.

A. Using a Retention or Detention Basin

The Storm Water Utility specifies how the fee shall be reduced if detention or retention basins are sized using the *post-developed* 100 year-24 hour storm. However, further determination is needed if a partial fee reduction is to be granted allowing for basin sizes derived from smaller storms.

The Storm Water Utility ordinance prescribes that runoff from the 100 year-24 hour *post-developed* storm that is stored in a retention pond receives a 100% reduction of the storm water fee. Using this reference point, ratios to runoff depth of statistically smaller storms can be determined to reduce the fee.

Smaller storm runoff depths from a typical urban property are listed in the table below and in Table 2-1 of the U.S. Conservation Service Technical Release 55 (TR55). An average urban property in TR55 has a runoff curve number (RCN) of about 70. Rainfall amounts and runoff depths for a RCN of 70 for 10yr, 25yr, 50yr and 100yr are shown below. The ratio of *post-developed* runoff depth for a given storm versus *post-developed* runoff from the 100 year storm is used to determine the reduction of the Storm Water Utility fee as shown in the following table:

Storm 24 Hour	2 year	10 year	25 year	50 year	100 year
Rainfall Amount (Inches)	2.25	3.25	3.75	4.25	4.5
Runoff Depth (RCN 70)	0.35	0.86	1.17	1.50	1.67
Ratio to 100 Year	0.210	0.515	0.701	0.898	1.00
Fee Reduction (retention)	20%	50%	70%	90%	100%
Fee Reduction (detention)*	17%	43%	60%	77%	85%

* Maximum reduction for a qualified *detention* pond is 85%. *Detention* pond fee reductions are determined by multiplying the *retention* pond fee reductions by 85%.

For example: a *retention* facility sized for the 25 year *post-developed* storm would see a fee reduction of 70%.

Also for example: a *detention* facility sized for the *post-developed* 50 year storm would see a fee reduction of 77%.

B. Using a Treatment Facility

The Storm Water Utility Ordinance allows for the reduction of the utility fee through the use of a *water quality factor* (WQF) when a parcel owner constructs a storm water treatment facility such as a bio-retention area, rain garden or other landscaped means of cleaning the parcel runoff before it leaves the site.

The factor will be based on the ratio of treatment facility area to the impervious area that drains to it. The reduction of the fee through the use of a WQF for any parcel will be capped at 50%. See the following examples that further describe WQF determination.

As a point of clarification, the City recognizes the positive aspects of using rain barrels and encourages their use. They are an environmentally friendly use of water. However, the City's Storm Water Utility is based on runoff flows and volumes from precipitation, and the volume of a rain barrel is very small compared to runoff from a storm. So no water quality fee reduction is assigned to the use of rain barrels.

WATER QUALITY FACTOR DETERMINATION FOR CONSTRUCTED WATER TREATMENT FACILITY

WQF= 1−(AxBx0.5*)

**A AND B ARE BOTH A MAXIMUM OF 1. SO OVERALL WQF IS CAPPED AT 0.6.*

A=(AREA OF FACILITYx2**/IMPERVIOUS AREA DRAINING TO FACILITY)

A IS ALLOWED A MAXIMUM VALUE OF 1

***THE AREA OF FACILITY IS MULTIPLIED HERE BY TWO. THIS IS BASED ON THE CONCEPT THAT A FACILITY THAT IS HALF THE SIZE OF THE IMPERVIOUS DRAINING TO IT IS AN EFFECTIVE MEANS OF IMPROVING WATER QUALITY. BY MULTIPLYING BY 2 THE "A" FACTOR IN THE EQUATION CAN BE 1 IN THIS SITUATION.*

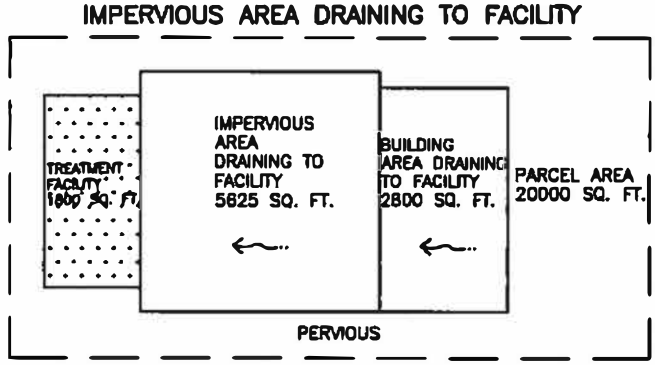
B=(IMPERVIOUS AREA DRAINING TO FACILITY/TOTAL IMPERVIOUS AREA ON SITE)

THIS ACCOUNTS FOR THE RATIO OF AREA DRAINING TO FACILITY TO TOTAL IMPERVIOUS ON SITE.

PERVIOUS AREA NOT CONSIDERED WHEN CALCULATING WQF BECAUSE PERVIOUS AREA NOT CONSIDERED A SIGNIFICANT DETERMENT TO WATER QUALITY.

EXAMPLE 1

IMPERVIOUS AREA DRAINING TO FACILITY



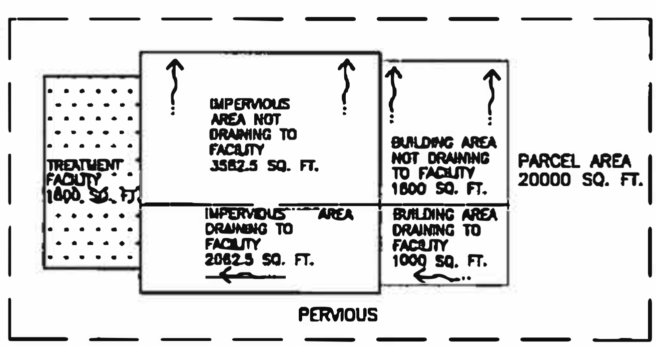
A=(1800X2/8425) = 0.4273

B=(8425/8425) = 1

WQF=1−(0.4273x1X0.5) = 0.79

EXAMPLE 2

PARTIAL IMPERVIOUS AREA DRAINING TO FACILITY



A=(1800x2/3062.5) = 1.1755 USE ALLOWED MAXIMUM OF 1

B=(3062.5/8425) = 0.3635

WQF=1−(1x0.3635X0.5) = 0.81

CITY ENGINEER'S OFFICE
MARQUETTE, MICHIGAN
300 WEST BARAGA AVE., MARQUETTE, MI 49855
PHONE (906)228-0440

WATER QUALITY FACTOR
DETERMINATION FOR TREATMENT FACILITY
1"=60"
11/9/15

STORM SEWER
STORM WATER MANAGEMENT AND WATER QUALITY
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL INFORMATION

A. Background

Initial development of a parcel of land alters the landscape by removing areas of vegetation and replacing them with impervious surfaces such as buildings, parking lots, sidewalks, etc. These impervious surfaces introduce a barrier to the natural process of water infiltration into the soil from precipitation and snow melt. The water from rain and snow melt collects into surface runoff which in turn creates high peak flows, large volumes of runoff and degradation of water quality due to pollutants.

Increasingly higher peak flows from numerous developments combine and require larger and larger downstream infrastructure to handle the water and prevent flooding. Operation and maintenance of this infrastructure is a financial burden on a municipality that grows as the storm system capacity increases. Increasingly larger flows eventually discharge to natural waterways, where the additional water creates higher waterway velocities, resulting in stream bed down cutting and stream bank erosion.

A second issue with urban runoff is the warming of lakes and streams. Runoff from hot roofs, pavement and concrete is substantially warmer than the ground water table that normally feeds a natural water body. When storm water runoff reaches lakes and streams the overall water temperature of the water body increases. This temperature increase changes the aquatic environment and promotes algae growth. The change in aquatic environment and algae growth decreases oxygen levels and bio-organisms die off.

A third issue with urban runoff is pollution. Petroleum products, salt, sand, herbicides, pesticides, animal waste and fertilizer are all found in urban runoff water. These pollutants can be toxic to aquatic organisms. Nutrients from animal waste and fertilizer become food for algae that along with the warmer water cause deadly algae blooms. Algae blooms starve the water body of oxygen and kill aquatic organisms.

As an urban area develops, storm water runoff increases and produces problems for a municipality.

Early on, the State of Michigan and the Michigan Department of Transportation recognized the legal issues with storm water runoff. These issues eventually led to a Supreme Court case and a legal precedent was set.

The legal precedent concerning the drainage of Michigan surface waters was established by the Michigan Supreme Court in 1906 in **Tower vs. Township of Somerset**, 143 Mich. 195, 201. The three resulting rules from this precedent case are:

A. “The owner of a lower or servient estate is obligated to receive surface water from the upper or dominant estate in its natural flow”
B. “The owner of the lower or servient estate may not fill his lands in such a way as to retard the natural flow of surface water or cause it to impound upon the upper owner’s land”
C. “The owner of the dominant estate has no right to divert, concentrate, or increase the velocity of the natural surface water. Public authorities do not have the right to divert surface water that would, in the natural state, disperse over a large area and cast such in concentrated form upon the lands of the abutting owner to his damage without compensation to him”.

In essence a developer has a legal obligation to receive the natural flow of water into the development and then control how and where storm water runoff leaves the site.

B. Storm Water Solutions

This design standard provides best management practices (BMPs) and other tools that can, and in some instances must be used to address the problems created by development storm water runoff. These BMPs and tools are used during the planning, design and construction of a development and can significantly reduce the harmful affects of urban storm water runoff leaving a site development.

BMPs are **absolutely critical** during construction to control erosion and prevent sedimentation from leaving the site and damaging adjacent property, water bodies and City infrastructure. These same BMPs (especially the vegetative BMPs) can also be used in the permanent design of a project. A good source listing of applicable BMPs can be found on the State of Michigan web site: http://mdotcf.state.mi.us/public/design/englishstandardplans/ and click on Road Plans then R-96-E Soil Erosion and Sedimentation Control Measures.

C. Related Design Standard Sections

Other City design standards related to Storm Water Management and Water Quality are: “Retention, Detention and Storm Water Treatment Systems”, “Storm Sewer”, “Storm Sewer-Culverts” and “Storm Sewer-Open Channel”. Retention, Detention and Storm Water Treatment System is the standard most related to this section and should be used to help address storm water management and water quality.

PLANNING AND DESIGN PROCESS

A. Initial Site Evaluation

Municipal zoning typically regulates where man-made structures and infrastructure can and can not be placed on a parcel. Designers are familiar with ordinances that require set backs, regulate parking lot dimensions, require adjacent parcel buffering and restrict certain land uses. However, while still honoring zoning requirements, decisions can be made in the early stages of development planning that will result in better management of storm water quantity and quality. The following items, when considered and utilized, will help a designer initially layout a site early in the process of design. A well thought out initial layout will result in a higher quality development with water runoff benefits to both the development and the adjacent neighborhood.

1) Site topography. If the slope and elevation change across the site is large, it can play a significant role in locating the building, parking lot, landscaping and storm water BMPs. The designer should strongly consider locating the building at the highest elevation of the site followed by the parking lot with the final storm water BMPs at the lower elevations. Regardless of the placement or order of these items, very careful attention is needed when designing how water enters, flows through and eventually leaves the site.

2) Floodplain. Construction of buildings in a floodplain is almost always disallowed. In the rare instance when a building is allowed in a floodplain, the finished floor must be above the 100 year flood. Through the permitting process, the Michigan Department of Environment Quality (MDEQ) and the U.S. Army Corps of Engineers (USACOE) carefully monitor construction activities in a floodplain. They look to ensure that construction of structures and earth moving activities do not result in a net loss of volume in any floodplain area. However, some land uses on a site within a floodplain such as snow storage, landscaping and retention and detention basins are often allowed.

3) Lakes and Streams. Direct untreated discharge of storm water runoff into a water body has immediate and long term harmful affects and should be minimized. Whenever possible a strip of undisturbed land should be left adjacent to both sides of a waterway. This undisturbed land, called a riparian buffer, should be 25 foot wide with 50 or 100 feet preferable. In addition, the MDEQ, USACOE and Marquette County may require a permit for development near water.

4) Downstream Flow Capability. If downstream pipes, culverts and bridges are not large enough to carry additional flows, then retention or detention basins shall be used to lower peak flows to prevent flooding.

5) Groundwater Depth. Shallow groundwater determines the lowest usable floor elevation of a building. It can also determine how deep retention or detention basins can be constructed. Once a basin encounters ground water, further excavation adds no additional water storage volume.

6) Soil or Water Contamination. Where soil or water contamination is present or nearby the designer may not want to infiltrate water in way that would increase the spread of the contamination. A storm water basin up-gradient or over

contamination would need an impervious liner so migration of the underlying contamination is not accelerated.

7) Soils. On-site soils vary from sandy soils with high infiltration rates to clayey soils with very low infiltration rates. High and low infiltration rates influence where basins or storm water treatment practices are located, which in turn affect where buildings and parking lots are placed. Soil borings with soil classification can be extremely useful in determining the soil makeup of a site.

B. Preliminary Design

Once the initial site evaluation is done, preliminary design can begin. Listed below are some important steps that should be used in preliminary design:

1) Building finished floor. One of the most important decisions of any development relative to storm water is the proposed elevation of a building's finished floor. Several examples of building finished floors being set too low can be found in the City. In these examples the ground, or in some instances, the driveway is sloped toward the building and water runs into basements, crawl spaces, garages and sometimes to the finished floor itself. Generally, it is best if the finished floor elevation is set so parking lots, drives and adjacent landscaping areas slope away from any building. There is little that can be done after a building is constructed too low, to correct the problem. When there is a solution, it is often very expensive.

2) Building shape and size. Cost, function and aesthetics are considered paramount in any development. However, the designer should also attempt to minimize the overall footprint of the building to only what is needed. Methods to minimize building footprints include utilizing basements and additional stories. In addition, the shape of the building can be designed to better match the topography of the site. An "L" shaped footprint may fit into a corner of a site better as opposed to a square or rectangular shape requiring extensive earthwork. Large pervious areas should be planned near and around the building and the runoff from the building should be sent to the pervious areas instead of directly to concrete or asphalt surfaces.

3) Parking lot. Lay out the parking lot with the fewest spaces necessary. Often a minimum number of spaces is required by local zoning codes. If the amount required by zoning is more than the development needs, consider asking the planning commission for a variance.

Group the parking spaces together in clusters to minimize the amount of maneuvering lanes needed. Furthermore, if the development has significant elevation change across the site, multiple clusters may be better than one large lot. This will allow the clusters to be tiered on different levels so that mass earth moving is not needed to "flatten" the site.

Overall, try to match the proposed parking lot surface to the existing topography as much as possible while allowing for the thickness of pavement and gravel and still meeting reasonable grades that service the development.

4) Storm water BMPs. While laying out the development, allow for areas in, around and in between the building, parking lots and sidewalks for storm water BMPs. Rain gardens, bioswales, retention and detention areas strategically placed can be very effective in handling storm water. These areas can also be used for landscaping that make the development more aesthetically pleasing. If parking lot islands and landscaping areas around the building and parking lot were already planned for landscaping, lower these areas to accept runoff and serve a double purpose. Whenever possible send runoff from parking lots into areas of infiltration.

C. Final Design

Once a preliminary layout of the site is complete the final design can begin. In final design, provisions must be placed on-site to direct and control storm water. Unless all of a development's storm water is retained on site, some will eventually have to leave the property.

The property owner of any development has important legal responsibility to handle surface water on site. As was mentioned earlier regarding storm water legal precedent, natural drainage flow into, out of, and through a site must be accommodated. In other words, any surface flow that has always entered the site must be accepted. Flow leaving the site must be discharged at the same location as discharged prior to development with no increase in water velocity.

To help address this situation the City requires, at a minimum, that the flow rate from a *post-developed* 24 hour-10 year storm be less than or equal to the flow rate that historically left the site during a *pre-developed* 24 hour-10 year event.

The City does not allow flow to leave the site as sheet flow over a right of way line. Runoff can be sent into the City storm system via pipe or approved channel. If the owner chooses to send storm water runoff into the City system, he or she may do so as long as the added flow (from 24 hour-10 year storm) does not exceed 90% of the downstream system's capacity. In instances where downstream capacity is insufficient, peak flow mitigation will be required to the extent that downstream capacity of 90% is maintained.

Regardless of the City requirements to control water leaving the property, the owner may opt to mitigate the flow of runoff leaving the site. Controlling water runoff quantity or quality may make the property eligible for a reduction of its Storm Water Utility fee. See standard design section "Retention, Detention and Storm Water Treatment Systems" and the City's Storm Water Utility Ordinance.

Below are items required to be used and items to be considered during final design that will address storm water accommodations in a way that promotes water quality and quantity issues.

The City of Marquette requires the parcel owner to direct storm water in a controlled way to the City's storm water system. This is almost always done with storm water piping. First however, the designer should consider the following practices that treat and reduce runoff.

1) Native plants. Native plants are acclimated to the area climate. Consequently they are better equipped to tolerate the hydrologic cycles of the seasons. Because they tolerate local hydrologic cycles better, they often need far less irrigation and watering than non-native plants. This leaves the soil and root systems in a better state to infiltrate and accept runoff in rain gardens, bio-swales and other storm water BMPs.

2) Landscaping. Instead of large areas of lawn, consider landscaping with native plants that grow close to the ground over these spaces. Decorative grasses, flowers, low profile shrubs such as juniper can be used that require less fertilizer and irrigation than do landscaping plants often found at landscaping suppliers. In addition, the areas don't need to be mowed.

3) Snow storage. Instead of allocating areas of the parking lot for snow storage, design for and designate pervious areas such as retention or detention basins or other infiltration areas to receive the plowed snow. This practice will help with removing pollutants from the runoff, keep sand from filling the catch basins and lessen runoff flow.

4) Infiltration areas (bio-swales, bio-retention, washed stone beds, etc.). Whenever possible send runoff into infiltration areas. Once this is done though, thought must be given to controlling where the water will overflow. This overflow can go to another area of the development or to the City storm water system. Unless an infiltration area is a retention basin, overflow to the City system must be directed to a controlled point such as a man hole, catch basin, culvert or ditch in the City right of way.

5) Retention and detention basins. See the City Design Guideline: "Retention, Detention and Storm Water Treatment Systems" for direction in using these storm water BMPs. The City strongly encourages their use.

6) Porous pavements. The storm water industry is constantly adding new innovations for porous parking lot surfaces. Porous concrete and asphalt mixes are being introduced as are paving blocks that allow infiltration through the parking surface. Some of the paving blocks even allow grass to grow in the interstices spaces of the blocks.

The City of Marquette off street parking ordinance forbids parking lot runoff from traveling over a property line. Unless 100% is retained on site, water must be sent into the City storm water system as long as there is capacity. Most often a development will utilize catch basins and piping to send water to city infrastructure. Below are some requirements for storm water infrastructure on site and in City controlled land such as a right of way:

1) Catch basins must have sumps that are 2 feet deep. Sumps catch material that settles out before it enters the city system. There need to be enough catch basins so their aggregate inlet capacities match design flow.

2) Storm piping in the City right of way must be reinforced concrete and a minimum of 12 inch diameter.

3) Sometimes drives do slope toward a building such as a loading dock or the entrance to an underground parking facility. In this instance a trench drain should be installed just outside the door or entrance and piped to the storm water system. Building codes require all floor drains inside of a structure be piped to the sanitary sewer system.

4) If other means of sending water into the City storm water system are proposed, they will be evaluated during the Site Plan review process.

REGULATION AND ORDINANCES

By ordinance, the City of Marquette maintains a Storm Water Utility where every parcel of land pays a utility fee except where certain storm water provisions are provided by the land owner. See the “Retention, Detention and Storm Water Treatment Systems” design guideline and the City ordinance for details as these may weigh in on development decisions.

The City of Marquette requires a permit be issued prior to tapping into the City’s storm sewer system.

Depending on proximity to lakes, streams or floodplains, work on a parcel may require a permit from the Michigan Department of Environmental Quality an/or the U.S. Corps of Engineers.

Development projects require site plan review. See ordinance 80.62, “Site Plans”.

Projects may also require the developer to obtain a permit from Marquette County for Soil Erosion and Sediment Control.

Stormwater Utility Fee Reduction Application

Please check or fill in all boxes. Write N/A if not applicable.

Step 1. Owner of Parcel

Property Owner Name	
Street Address	
City, State Zip	
Home or Cell Phone	
Work Phone	
E-mail	

Step 2. Parcel Info

Property Street Address	
City, State Zip	
Property Identification Number (PIN)	

Step 3. Which type of fee reduction are you applying for?

Choose one of the following:

- ☐ Retention Basin (go to step 4)
- ☐ Detention Basin (go to step 4)
- ☐ Constructed Stormwater Treatment Facility (go to step 6)
- ☐ Manufactured Stormwater Treatment Unit (go to step 10)

Step 4. Retention or Detention Basin

For consideration of Storm Water Utility fee reduction using a retention or detention basin, a site plan of the parcel stamped and signed by a licensed engineer in the State of Michigan must be submitted that shows or meets the following:

- Site plan shall be 24 inches by 36 inches or smaller with 1' contours at a scale of 1"=30' if site is less than 10 acres. Sites greater than 10 acres can use a scale of 1"=100' with 2' contours. Multiple sheets shall be used if site can not fit on single sheet.
- Address of parcel
- Stamp and signature of the licensed Engineer in the State of Michigan who created the site plan.
- Date of site plan creation.
- North arrow.
- Property lines with dimensions.
- All impervious surfaces including: buildings, parking areas, drives, patios, sidewalks, etc.
- Retention or detention basin

- All on site and adjacent storm water infrastructure (pipes, catch basins, manholes, ditches)
- Streams, rivers, ponds within 100' of property line.
- Cross section or sections of basin.
- Pre-development and Post-development runoff peak flows on site.
- Volume of basin.

☐ A site plan meeting all of the above is included with this application.

Step 5. Stormwater Calculations

In addition to the site plan, storm water calculations stamped by a licensed engineer registered in the State of Michigan shall be submitted that follow the requirements of the City of Marquette design standards "Retention Detention and Stormwater Treatment".

☐ Stormwater Calculations following the City of Marquette design standards stamped and signed by a licensed Engineer registered in the State of Michigan are included with this application.

Go to step 12.

Step 6. Constructed Stormwater Treatment Facility

What type of treatment facility is constructed on site?

☐ Bio-retention basin
☐ Rain Garden
☐ Infiltration basin
☐ Other (describe)

Step 7. Is Parcel a Residential Property?

Choose one of the following:

☐ Property is not residential (go to step 8)
☐ Property is multifamily residential with more than 4 living units (go to step 8)
☐ Property is residential with 4 living units or less (go to step 9)

Step 8. Multifamily or Non-residential Property

For consideration of Storm Water Utility fee reduction using a constructed storm water treatment facility on a parcel that is non-residential or multifamily, the following must be submitted:

A site plan of the parcel stamped by a licensed engineer in the State of Michigan must be submitted that shows or meets the following:

- Site plan shall be 24 inches by 36 inches or smaller with 1' contours at a scale of 1"=30' if site is less than 10 acres. Sites greater than 10 acres can use a scale of 1"=100' with 2' contours. Multiple sheets shall be used if site can not fit on single sheet.
- Address of parcel
- Stamp and signature of the licensed Engineer registered in the State of Michigan who created the site plan.
- Date of site plan creation.
- North arrow.
- Property lines with dimensions.
- All impervious surfaces including: buildings, parking areas, drives, patios, sidewalks, etc.
- Storm water treatment facility shape, size and type.
- All on site and adjacent storm water infrastructure (pipes, catch basins, manholes, ditches)
- Streams, rivers, ponds within 100' of property.
- Cross section or sections through facility.

Either on the plan or on a separate document the following areas need to be measured, calculated, titled and listed:

- ➢ All impervious surfaces on site including: buildings, parking areas, drives, patios, sidewalks, etc.
- ➢ The portion of the above listed impervious surfaces that drain to the treatment facility.
- ➢ The area of the treatment facility.
- ➢ Pre-development and Post-development runoff volumes from site for 10, 25, 50 & 100 year-24 hour storm.

☐ A site plan meeting all of the above along with area information is included with this application.

Go to step 12.

Step 9. Residential Property

For parcels that are residential with four living units or less, a legible, scaled site plan of the parcel is still required. However the parcel owner, an engineer or designee can generate the site plan. As an option to aid the creation of the site plan, the parcel owner can purchase from the City Engineering Department a printed scaled map of the parcel showing 2' contours with or without an aerial photo background for a fee that is determined by the current City Fee Schedule.

The site plan must show:

- Site plan shall be any size that can show the entire site using a scale of 1"=30'.
- Address of parcel
- Date of site plan creation.
- North arrow.
- Property lines with dimensions.
- Topography represented by 2' contours
- All impervious surfaces including: buildings, parking areas, drives, patios, sidewalks, etc.

- Storm water treatment facility shape, size and type.
- All on site and adjacent storm water infrastructure (pipes, catch basins, manholes, ditches)
- Streams, rivers, ponds within 100’ of the property.

Either on the plan or on a separate document the following areas need to be measured, calculated, titled and listed:

- All impervious surfaces on site including: buildings, parking areas, drives, patios, sidewalks, etc.
- The portion of the above listed impervious surfaces that drain to the treatment facility.
- The area of the treatment facility.

☐ A site plan meeting all of the above along with area information is included with this application.

Go to step 12.

Step 10. Manufactured Stormwater Treatment Unit

For consideration of Storm Water Utility fee reduction using a manufactured storm water treatment facility on a parcel, the following must be submitted:

A site plan of the parcel stamped by a licensed engineer registered in the State of Michigan must be submitted that shows or meets the following:

- Site plan shall be 24 inches by 36 inches or smaller at a scale of 1”=30’. Multiple sheets shall be used if site can not fit on single sheet.
- Address of parcel
- Stamp and signature of the licensed Engineer registered in the State of Michigan who created the site plan.
- Date of site plan creation.
- North arrow.
- Property lines with dimensions.
- Topography represented by 2’ contours or smaller interval
- All impervious surfaces including: buildings, parking areas, drives, patios, sidewalks, etc.
- Location of treatment unit.
- All on site and adjacent storm water infrastructure (pipes, catch basins, manholes, ditches)
- Streams, rivers, ponds within 100’ of project property line.

Either on the plan or on a separate document the following areas need to be measured, calculated, titled and listed:

- All impervious surfaces on site including: buildings, parking areas, drives, patios, sidewalks, etc.
- The portion of the above listed impervious surfaces that drain to the treatment unit.
- Peak flow from 2, 5 or 10 year-24 hour post development storm event.

Documentation of third party independent study showing the design storm the unit is sized for and that 80% of total suspended solids are removed by the treatment unit, for the design storm.

☐ A site plan meeting all of the above along with area information is included with this application.

Step 11. Stormwater Calculations

In addition to the site plan, storm water calculations stamped by a licensed engineer in the State of Michigan shall be submitted that follow the requirements of the City of Marquette design standards "Retention Detention and Stormwater Treatment".

☐ Stormwater Calculations following the City of Marquette design standards stamped and signed by a licensed Engineer registered in the State of Michigan are included with this application.

Step 12. Maintenance Agreement

A Stormwater Maintenance Agreement must also be signed and submitted in order to be considered for a fee reduction. This agreement form can be found at the Community Development or Engineering departments or on the City website.

☐ I have signed and included the Stormwater Maintenance Agreement

Step 13. Signed Application

"By signing this application, I certify that I am the owner (or authorized representative of the owner) of the parcel for which fee reduction has been requested. I have read the completed application and understand its terms and conditions. I further certify that the completed application and attached documents are factual and represent the conditions of the parcel. Also I grant the City of Marquette permission to enter the parcel for the sole purpose of conducting periodic inspections of the stormwater basin or treatment facility".

Signature of Property Owner	
Date	

Step 14. Submit Application, Maintenance Agreement and other Documents

Application, site plan, storm water calculations and maintenance agreement must be submitted to:

City of Marquette Engineering
Department 300 W. Baraga Ave.
Marquette, Michigan 49855

City of Marquette Storm Water Utility

Retention, Detention, Water Quality or Treatment Unit Maintenance Agreement

This maintenance agreement, made this ______ day of ___________ 20_____, by and between ______________________________ (hereafter referred to as the Owner) and the City of Marquette (hereafter referred to as City), provides as follows:

WHEREAS, the Owner has possession of real estate in the City of Marquette, Michigan with the tax identification number of_________________ (Hereafter referred to as the Property); and,

WHEREAS the Owner has provided on the Property a certain storm water control pond or water quality treatment facility (hereafter referred to as the System); and,

WHEREAS the Owner has provided an "as-built" plan (Exhibit A) that has been approved by the City; and,

WHEREAS the placement of this System allows for consideration of City Stormwater Utility fee reduction per section _______________ of City Code; and,

WHEREAS the Owner of the Property has agreed to maintain the System in accordance with the terms and conditions hereafter set forth.

NOW, THEREFORE, for and in consideration of the mutual covenants and undertaking of the parties, the parties hereby agree as follows:

A. Storm Utility Fee Reduction Application
The Owner shall fill out and comply with the items in the Storm Water Utility Fee Reduction Application.

B. System Maintenance
The Owner agrees to maintain using the applicable practices as set forth in exhibit B of this document, the System such that it performs as designed and constructed. Maintenance shall include all pipes and channels to and from the System along with structures and landscaping.

C. Inspection and Repairs
The Owner shall inspect the System annually and after every heavy rain using Exhibit B. Repair and maintenance shall be performed immediately on any items found deficient.

The City shall inspect system periodically to confirm compliance with this agreement.

The Owner grants permission to the City to enter the Property and to inspect all aspects of the System whenever the City deems necessary. Upon inspection, if the City finds repairs or maintenance is needed, the City will direct the Owner in written letter to perform the necessary work to bring the System back into compliance.

The Owner shall make all required repairs within 30 days of receipt of the directive letter and notify the City in writing of said repairs. If the work is not complete within 30 days, the City will reevaluate the function of the System and may rescind some or all of the Storm Water Utility fee reduction. After the fee is rescinded, the Owner may still make the necessary repairs but will have to reapply for any fee reduction.

The Owner shall repair and clean the City stormwater infrastructure arising from any failure of the System.

D. Indemnification and Responsibility

The Owner herby agrees that it shall save, hold harmless, and indemnify the City and its employees and officers from and against all liability, losses, claims, demands, costs, and expenses arising from, or out of, default or failure by the Owner to maintain the System in accordance with the terms and conditions set forth herein, or from acts of the Owner arising from, or out of, the inspection, construction, operation, repair or maintenance of the System.

This maintenance agreement shall be a covenant that runs with the land and shall inure to the benefit of and shall be binding upon the parties hereto, their respective successors and assigns, and all subsequent owners of the property.

Upon execution of this Maintenance Agreement, the Agreement, Exhibit A and Exhibit B shall be recorded as one document at the Owner's expense in the Register of Deeds Office of Marquette County, Michigan. A copy of the Agreement showing the Liber and Page shall be provided to the City.

The Owner can by written letter to the City Engineer terminate this agreement. Termination of this agreement will return the Storm Water Utility fee to a non-reduced value.

In Witness Where of, the Owner has caused this Maintenance Agreement to be signed in its names by a duly authorized person.

____

Signature of Owner

____

Typed Name of Owner

____

Signature of Authorized City Official

Exhibit A

As Built Plan of Treatment Facility

Attach 8.5” by 11” As-Built Plan of Facility with Label “Exhibit A”

Exhibit B

Minimum Maintenance Standards for Stormwater Treatment Facilities

1. Retention and Detention Basins
    a. Maintain Vegetation
        i. Vegetation shall be healthy and as originally designed. Repair or replace plants as necessary.
    b. Sediment Removal
        i. Remove sediment if it covers more than 10% of basin bottom. Restore basin to original as-built elevations.
        ii. Remove all debris from basin whether natural or litter.
    c. Inlets and outlets
        i. Verify inlets and outlets are completely free of sediment and debris. Clean as necessary.
        ii. Repair any damage to inlets and outlets.
        iii. Repair any erosion near outlet or inlet.
    d. Emergency Overflow
        i. Repair and clean emergency overflow. Verify it will function as designed.
    e. Erosion
        i. Correct and stabilize any erosion.
2. BioSwale, BioRetention and Rain Garden (Facility)
    a. Flowpaths
        i. Clean and repair flow paths into, through and out of facility.
        ii. Replace any vegetation that has died and was planted when facility was constructed.
        iii. Remove any weeds and invasive species growing in the facility. Invasive species include but are not limited to: Purple Loosestife, Garlic Mustard, Spotted Knapweed, Reed Canary Grass, and Giant Hogweed.
        iv. Correct and stabilize any erosion in facility.
3. Storm Water Treatment Units
    a. Cleaning per Manufacturer's Requirements and Recommendations
        i. Remove sediment from grit chamber at least annually.
        ii. Remove all floating litter and debris from floating chamber.
        iii. Clean inlet and outlet and verify they are functioning.

STREET INFRASTRUCTURE
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL AND REQUIRED INFORMATION

A. General Information
This chapter of the City of Marquette Engineering Department General Guidelines for Street and Utility Design Standards outlines the minimum design criteria and design procedures to aid in the preparation of construction plans and specifications for municipal streets. While the standards described here are for public City streets, they are also recommended for application to private streets in new subdivisions, since the various design principles for moving traffic, providing access, and providing maintainable street pavements are pertinent to all streets.

These design guidelines are intended to supplement rather than replace existing engineering standards and requirements, including but not limited to the City of Marquette Code of Ordinances, City of Marquette Master Plan, AASHTO "A Policy on Geometric Design of Highways and Streets" (Green Book), the Manual of Uniform Traffic Control Devices (MUTCD), AASHTO "Guidelines for Geometric Design of Very Low-Volume Local Roads", and Michigan Department of Transportation Uniform Criteria for Major Streets requirements.

The primary objective of these standards is to ensure the safe and efficient movement of motor vehicles, bicycles, and pedestrians; and to be cognizant of future maintenance costs to sustain desired levels of service.

B. Variations
Variations in design from these documents shall be considered a special circumstance. Special circumstances shall require that the City of Marquette Engineering and Public Works Departments approve the variation in concept prior to final design. Approval shall be based on established engineering standards and professional judgment, with the safety of all street users being of paramount importance. Variations shall include, but not be limited to, geometric configuration, materials of construction, and methods of construction.

STREET CLASSIFICATIONS
All streets are classified as Arterial, Collector, Local streets, or Alleys. These classifications relate to the function of the streets. Lower order streets function primarily as access to individual lots, and higher order streets function primarily for the purpose of mobility (expeditious movement of people and goods). Each classification used must conform to the City Master Plan and meet all of the criteria for the specific classification. New streets not shown on the City Master Plan shall be classified by the anticipated traffic volumes, functionality and based upon a Transportation Impact Study (TIS).

GEOMETRIC DESIGN CRITERIA

A. Roadway Pavement Width
The roadway pavement width consist of the area between the face of curbs used for vehicular traffic and parking and in some cases those areas that incorporate the use of bike lanes.

Traffic and parking lane widths shall conform to the City of Marquette Master Plan and the Michigan Department of Transportation Uniform Criteria for Major Streets. Bicycle lanes shall follow the requirements as set forth in the City of Marquette Complete Streets Policy and the National Association of City Transportation Officials Urban Bikeway Design Guide.

B. Horizontal Alignment

1. Horizontal Curves
   Minimum curve radii with and without super elevation are shown in the AASHTO "A Policy on Geometric Design of Highways and Streets" publication for the various classifications of streets.

2. Super Elevation

   a. Local low volume streets may have the super elevation minimized or in some cases negated due to the existing conditions.

   b. Super elevation is allowed on all other streets if required to maintain the design speed along curves.

   c. Super elevation must be designed to show length, transition, and crown runoff.

   d. Super elevation shall extend uniformly from the flow line of the gutter on the high side of the street to the lip of the gutter on the low side of the street, keeping the standard slope of the gutter on the low side unchanged.

   e. All streets not super elevated shall be crowned at 2 percent for those with longitudinal slopes of 2 percent or greater and crowned at 3 percent for those streets with a longitudinal slope of less that 2 percent.

   f. Inverted crowns are not allowed on City streets.

3. Sight Distance
   Sight distance on horizontal curves shall be determined from AASHTO "A Policy on Geometric Design of Highways and Streets" publication for the various classifications of streets and speeds. See Table B-1.

4. Compound Curves
   Care should be used in the design of compound curves. Their use should be avoided where the curves are sharp. Compound curves with large differences in curvature introduce the same problems that arise with a tangent approach to a circular curve. Where compound curves must be used, the radius of the flatter curve should not be more than 50 percent greater than the radius of the sharper curve.

5. Reverse Curves
   Avoid abrupt reversals in reverse curve alignments by providing enough tangent distance between the curves to ensure adequate super elevation transition for both

curves and sufficient distance for adequate signing. Refer to the AASHTO A Policy on Geometric Design of Highways and Streets publication

6. Broken-Back Curves
   Avoid “broken-back” curves (short tangent sections between two curves in the same direction). Use of spiral transitions, compound curves or a single longer curve is preferable because they provide some degree of continuous super elevation. When broken-back curves are necessary, there should be a tangent distance of at least 400 ft between the curves, depending on the design speed.

7. Curves With Small Deflection angles (10^o or Less)
   To reduce the appearance of kinks in the street, minimum lengths of curve shall be designed with minimum arc lengths as shown in Table A-1.

Table A-1 Centerline Arc Lengths

Street Classification	Minimum Centerline Arc Length (ft.)
Arterial	400
Collector	300
Local	100

8. Horizontal curves on Vertical Curves
   For driver safety, horizontal curves shall not begin near the top of a crest vertical curve nor near the bottom of a sag vertical curve.

C. Vertical Alignment

1. Vertical Curves
   Vertical curves shall be designed to the current AASHTO “A Policy on Geometric Design of Highways and Streets” publication based on sight distance criteria and design speed.

2. Grade
   The minimum vertical grade on any new street or roadway shall be 0.50 feet per 100 feet and the maximum grade on any street or roadway shall be 8.0 feet per 100 feet of length. Existing roadways will be determined on a case by case basis.

3. Driveway Approaches
   The maximum grade on new driveway approaches shall be ten (10) percent for low volume commercial or residential generators. The maximum grade new on driveway approaches shall be two (2) percent for major commercial traffic generators. Driveway approaches on existing roadways will be determined on a case by case basis.

4. Vertical Clearance
   Vertical clearance above a roadway is a minimum of 13.5 feet.

5. Stopping Sight Distance
Stopping sight distance on vertical crest curves shall be determined from AASHTO “A Policy on Geometric Design of Highways and Streets” publication for the various classifications of streets and speeds. See Table C-1.

Table C-1 Stopping and Passing Sight Distance

Design Speed (Mph)	Stopping Sight Distance (feet)	Passing Sight Distance (feet)
20	125	800
25	150	1000
30	200	1100
35	250	1300
40	275	1500
45	325	1650
50	400	1800
From AASHTO “Green Book” Table III-1, Table III-5 and Table VII-3		

D. Intersections

Intersections shall be designed to provide for the safety of motorists, pedestrians, and bicyclists. This section is based on criteria from the Institute of Transportation Engineers Traffic Engineering Handbook and AASHTO’s A Policy on Geometric Design of Highways and Streets.

By their nature, intersections are conflict locations. Vehicles, pedestrians, and bicycles all cross paths. Each crossing is a conflict point. Intersections contain many conflict points.

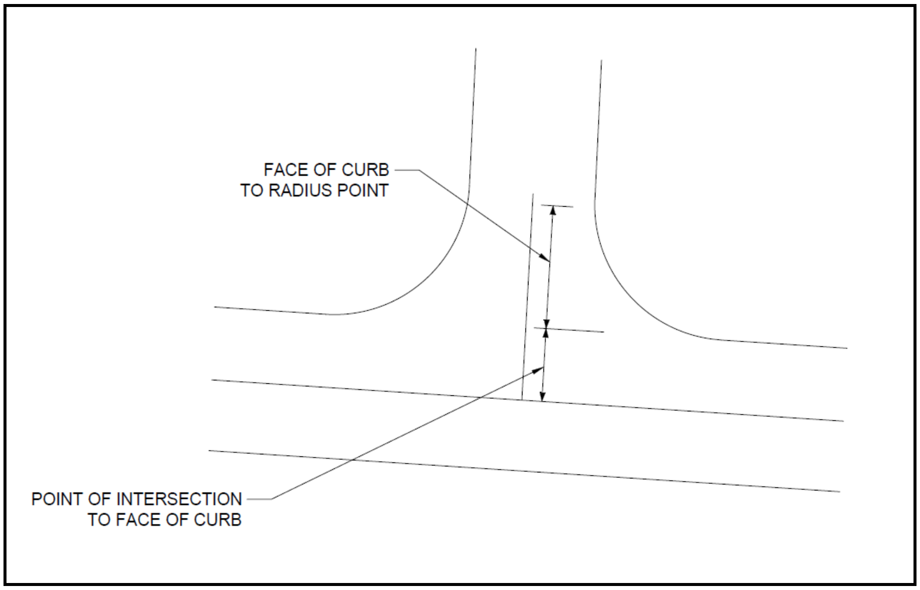
The basic design of intersections includes the following objectives:

- Minimize points of conflict;
- Simplify areas of conflict;
- Limit conflict frequency; and
- Limit conflict severity.

1. Intersection Angle and Tangent Length
Street intersections are to be designed with their centerlines at right angles. The Minimum centerline tangent length at the intersection is to be equal to the width of the cross street (measured from the point of intersection to the face-of-curb) plus the radius of the round corner (measured at the face of curb). Additional tangent length may be required at expanded intersections, major streets, and arterials. See Figure D-1 for clarification.

2. Intersection with Existing Curve
For those existing situations where a proposed street will intersect a existing curved street due to the development the proposed street will intersect the curve radially. This situation is not ideal and should be avoided if possible.

FIGURE D-1
MINIMUM CENTERLINE TANGENT LENGTH AT INTERSECTION



2. Intersection Offset

   a. Two streets intersecting opposite sides of a cross street are to have the same points of intersection or else their centerlines are to be separated by a minimum of 120 feet for local streets.

   b. Full access intersections of local streets with major streets should be kept to a minimum, and such intersections shall be at least 500 feet apart, measured between centerlines, and shall be farther apart where turn pockets dictate longer spacing. The need for left-turn storage may require a greater distance. Pedestrian access to transit and adjacent commercial uses should be considered in major street intersection spacing.

3. Lane Alignment
All lanes shall be in alignment through each intersection, with a maximum of a 2-foot shift in a hardship situation only, subject to approval by the City Engineer. This may be waived if it is shown that offset left turning lanes promote increased visibility and safety for the turning movements.

4. Angle of Intersection
Crossing roadways should intersect at 90 degrees whenever possible. In no case Shall they intersect at less than 80 degrees or more than 100 degrees.

5. Pavement Cross Slopes
   a. Maximum grade across intersections along local and two-lane sub-collector and two-lane collector streets shall not exceed 8 percent and along arterial

streets and greater shall not exceed 5 percent.

b. The pavement cross slopes at intersections of major streets and those through streets should be given special considerations to avoid an uncomfortable ride at higher speeds. Drainage patterns should be directed away from the higher classification street around the curb returns toward the lower classification street. Preference for a comfortable ride should be given to the higher classification or through street when ever possible.

c. Special attention should be given to signalized intersections where high speeds are possible on both crossing roadways.

6. Curb Return Radius

a. Curb return radius should accommodate the expected amount and type of traffic and allow for safe turning speeds at intersections.

b. Curb return radius shall be installed in accordance with Table D-1.

Table D-1 Curb Return Radius

	Local	Collector	Arterial
Local	20 ft.	25 ft.	30 ft.
Collector	25 ft.	25 ft.	30 ft.
Arterial	30 ft.	30 ft.	30 ft.

The above radii may be adjusted based on traffic volumes/patterns, intensity of large vehicle uses and the needs of specific land uses/truck routing. Radii within the downtown are to be determined on a case by case basis.

7. Clear Vision Triangle (Clear Zone)

a. For safety and visibility purposes, a **clear vision** triangle shall be maintained at street intersections and where driveways intersect streets. The distances along the legs of the **clear vision** triangle shall be measured from the tangent intersection point along the curb lines or along the edge of the driving surface for driveways. For each intersection, the length of the legs of the triangle shall be determined by the classification of the roadways which form the intersection in accordance with Table D-2. The higher classification will determine the

Table D-2 Clear Vision Triangle Leg Lengths

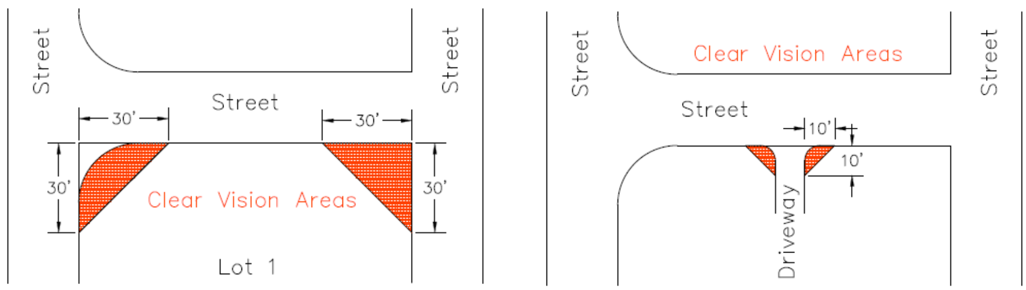
Commercial Driveways	10 feet
Local street	35 feet
Collector street	50 feet
Arterial street	70 feet

(Code of Ordinances City of Marquette, Michigan – Section 2-99. Definitions)

Clear vision triangle leg lengths may be increased due to existing conditions or per the recommendation of the City Engineer. Clear vision triangle lengths within the downtown are to be determined on a case by case basis.

The following figure illustrates the sight distance geometrics.

FIGURE D-2
TYPICAL CLEAR VISION TRIANGLE



b. Sight Distance Triangles and Easements. All clear vision triangles must be shown on the street plan/profile plans. All clean vision triangles must be within the public right-of-way or a sight distance easement. If the line of sight crosses onto private property, a "Sight Distance Easement" shall be dedicated to provide the required sight distance. The easement or right-of-way shall be dedicated to the City of Marquette, however, maintenance shall be noted on the final plat as the responsibility of a private entity such as the property owner or the home owners association.

c. Sight Obstructions. Any object within the clear vision triangle and/or sight distance easement more than 30 inches above the flowline elevation of the adjacent street shall constitute a sight obstruction, and shall be removed or lowered. Such objects include but are not limited to berms, buildings, parked vehicles on private property, cut slopes, hedges, trees, bushes, or mailbox clusters. Mailboxes must not pose a fixed object hazard for vehicles and pedestrians. Parked vehicles shall be considered an obstruction for design purposes. The city may limit parking to protect visibility. In no case shall any permanent object encroach into the line-of-sight of any part of the clear vision triangle. Trees are permitted if pruned up to 8 feet.

Clear vision triangle lengths within the downtown are to be determined on a Case by case basis.

8. Horizontal Curves
Intersections on horizontal curves should be avoided. The curvature adds an extra element of complexity to the highway information that must be processed by the driver, thereby increasing the hazard. It also complicates the geometric design elements of sight distance, channelization and super elevation.

9. Roundabouts
   Roundabouts may be permitted by the City in intersections where three or more streets converge. Roundabouts shall be of sufficient size to allow truck turning movements to occur. Roundabouts shall be designed to acceptable standards per State and Federal guidelines.

10. Exclusive Left Turn Lanes
    Left turn lanes are specified as needed by an access plan and warrant. Warrants will be reviewed and approved by the City Engineer. The City of Marquette Police Department will review and issue a traffic control order. The Designer shall use the criteria in the AASHTO Green Book to determine whether an exclusive left turn lane is warranted and/or these guidelines.

    a. Warrants for Signalized Intersections
       A separate left turn lane shall be required if one of the following criteria is met:
       i. The left turn design volume is at least 20 percent of total approach volumes, or
       ii. The left turn design volume exceeds 100 vph in peak periods, or
       iii. Refer to Table D-3 for the intersection capacities assuming various left turn treatments.

Table D-3
Rule-of-Thumb Intersection Capacities Assuming Various Exclusive Left Turn Movements

Case I: No Exclusive Left-Turn Lanes

Assumed critical signal phases*	2
Left-turn volumes	Critical major approach:** ≤ 125 veh/hr Critical minor approach: ≤ 100 veh/hr

Planning-level capacity (veh/hr), sum of critical approach volumes***		Number of basic lanes,**** major approach		
		2	3	4
Number of basic lanes, minor approach	1	1,700	2,300	—
	2	2,400	3,000	—
	3	—	—	—

Case II: Exclusive Left-Turn Lane on Major Approaches Only

Assumed critical signal phases	3
Left-turn volumes	Critical major approach: 150-350 veh/hr Critical minor approach: ≤ 125 veh/hr

Planning-level capacity (veh/hr), sum of critical approach volumes		Number of basic lanes, major approach		
		2	3	4
Number of basic lanes, minor approach	1	1,800	2,100	2,300
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]

[illegible]		[illegible]		
		[illegible]	[illegible]	4
[illegible]	1	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

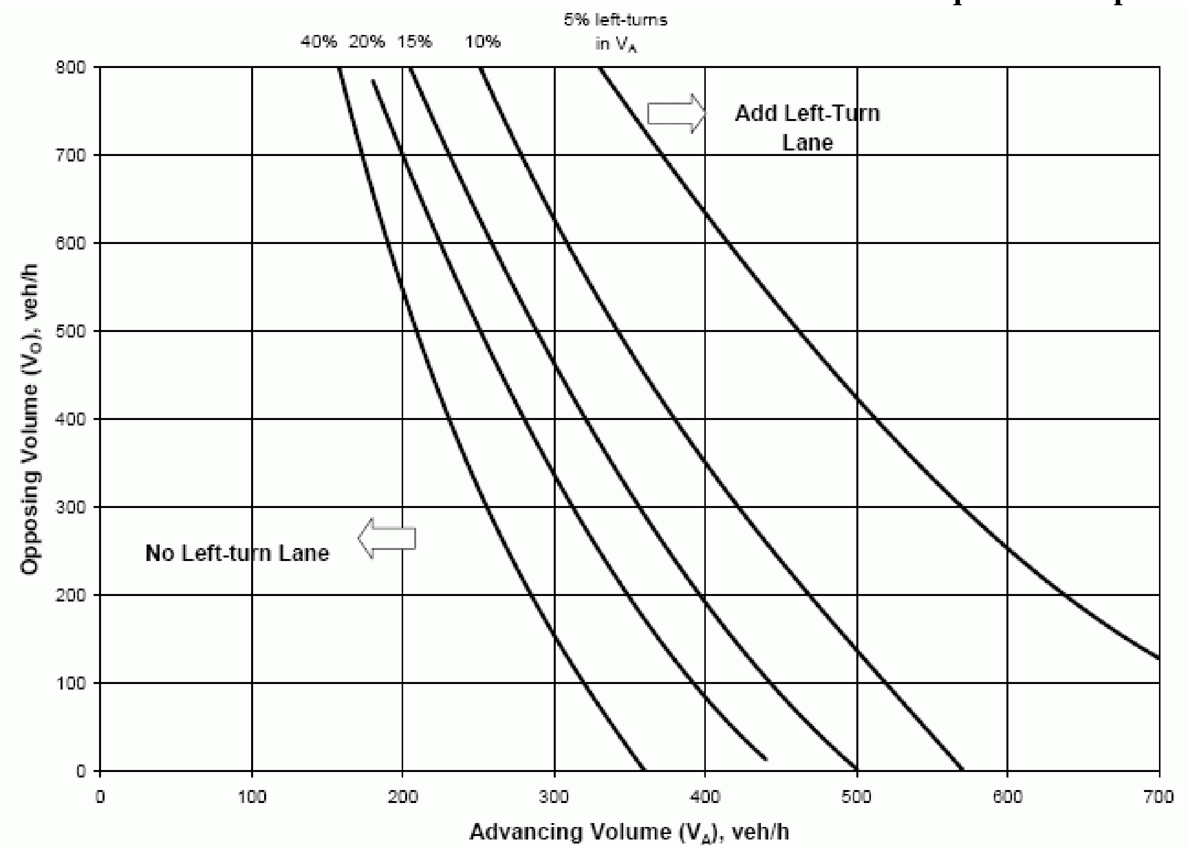
[illegible]

[illegible]

[illegible]

b. Warrants for Unsignalized Intersections
Left turn lanes may be required at approaches to intersections for which the combination of through, left, and opposing volumes exceeds warrant guidelines as called out in Fig. D-3. The City Engineer will determine which peak hours to consider in the evaluation.

Figure D-3
Left Turn Lane Guidelines for Two-Lane Roads less than or equal to 40 mph



The following data is required for left hand turn lane assessment:

Opposing Volume (veh/hr) - VO - The opposing volume is to include only the right-turn and through movements in the opposite direction of the left turning vehicle.

Advancing Volume (veh/hr) - VA - The advancing volume is to include the right-turn, left-turn and through movements in the same direction as the left turning vehicle.

Operating Speed (mph) - The greatest of anticipated operating speed, measured 85th percentile speed or posted speed.

Percentage of left turns in VA

Left turn lane is not needed for left turn volume less than 10 vph. However, criteria other than volume, such as crash experience, may be used to justify a left turn lane.

The appropriate trend line is identified on the basis of the percentage of left-turns in the advancing volume, rounded up to the nearest percentage trend line. If the advancing and opposing volume combination intersects above or to the right of this trend line, a left-turn lane is appropriate.

c. Design Criteria

Left turn lanes shall be designed to provide the following functions:

i. A means for safe deceleration outside the high speed through lane.

ii. A storage length long enough for left turning vehicles so that signal phasing can be optimized and intersection delay minimized.

iii. A means of separating movements at unsignalized intersections to reduce left turn impacts on other flows.

E. Design Vehicles

The design vehicle is the largest type of vehicle typically expected to be accommodated on the street. At intersections, the most important attribute of design vehicles is their turning radius, which in turn influences the pavement corner radius and therefore the size of the intersection. Lane width, another feature related to the design vehicle, has some impact on intersection design, but less than turning radius. The design vehicle may also affect the choice of traffic control device and the need for auxiliary lanes.

Typical design vehicles used for intersection design are:

• P - Passenger car; includes vans and pickup trucks.
• S-BUS-40; 84-passenger school bus.
• SU - Single-unit truck.
• WB-40 - Tractor/Semitrailer combination with an overall wheelbase of 40 ft.
• WB-50 - Tractor/Semitrailer combination with an overall wheelbase of 50 ft.
• WB-55 - Tractor/Semitrailer combination with an overall wheelbase of 55 ft.
• WB-65- Tractor/Semitrailer combination with an overall wheelbase of 65 ft.
• P/T- Recreational vehicle, car, and camper trailer.

In addition to Table E-1, consider the following guidelines when selecting a design vehicle:

1. Minimum Designs. The SU and/or school bus design vehicles are generally the smallest vehicles used in the design of local intersections. This design reflects that, even in residential areas, garbage trucks, delivery trucks, and school buses will be negotiating turns with some frequency.

2. Recreational Areas. Recreational areas typically will be designed using the SU design vehicle. This reflects that service vehicles are typically required to maintain the recreational area. Under some circumstances the passenger car with a trailer (P/T) may be the appropriate design vehicle (e.g., campground areas, boat launches).

Table E-1

Selection of Design Vehicle at Intersections (Functional Classification)

For Turn Made		Design Vehicle
From	**Onto**	
Arterial	Arterial	WB-65
	Collector	WB-55
	Local	WB-50
	Local (Residential)	SU
Collector	Arterial	WB-55
	Collector	WB-55
	Local	WB-50
	Local (Residential)	SU
Local	Arterial	WB-50
	Collector	WB-50
	Local	SU
	Local (Residential)	SU
Local (Residential)	Arterial	SU
	Collector	SU
	Local	SU
	Local (Residential)	SU

E. Street Materials and Pavement Thickness

1. Pavement Design
   Effective pavement design is one of the more important aspects of project design. The pavement is the portion of the street which is most obvious to the motorist. The condition and adequacy of the street is often judged by the smoothness or roughness of the pavement. The pavement life is substantially affected by the number of heavy load repetitions applied, such as single, tandem, tridem and quad axle trucks, buses, tractor trailers and equipment. A properly designed pavement structure will take into account the applied loading. Other factors to consider are existing subgrade soils, climate, drainage, proper material compaction, etc.

   a. Pavement design for collector and arterial streets shall reflect the increased traffic volume and higher axle loads and shall be subject to review and approval by the City Engineer.

   b. Local streets shall consist of 12 inches of City of Marquette modified subbase, 4 inches of compacted MDOT 21A aggregate base, and 330 pounds per square yard (3 inches) of MDOT superpave bituminous mixtures constructed in two lifts; 165 lbs/syd (1 ½ inches) leveling and 165 lbs/syd (1 ½inches) top course.

   c. Additional engineered soils may be required for areas consisting of undesirable soil conditions in the subgrade. Soil borings will be required for identification of existing soils and to aid in the design of the pavement structure.

   d. HMA mixture type and binder selection will be per MDOT's Local Agency Programs Hot Mix Asphalt (HMA) Selection Guidelines. Previous experience and performance shall permit variations from these guidelines upon approval of the City Engineer.

e. Curb and Gutter – All streets and roadways shall include concrete curb and gutter. As a general rule all streets will require the use of MDOT C-2 or F-2 curb and gutter. Rolled curb, MDOT D-2 may be allowed on new developments where multiple lots are planned due to the unknown location of the driveways. Bituminous curb will not be allowed.

Concrete shall meet the requirements for Grade P1 Concrete or Grade S2 Concrete as specified in the MDOT 2012 Standard Specifications for Construction Section 601, "Portland Cement Concrete Pavements". All curbing will incorporate the use of fiberglass fibers as specified by the City Engineer.

The reinforcing steel used in the curbing must be epoxy coated and the materials must meet the requirements as set forth in the MDOT 2012 Standard Specifications for Construction Section 905, "Steel Reinforcment".

f. The required HMA mixture for collector and arterial streets with grades 8% or greater will be high stress. The appropriate High Stress binder grade must be identified in the HMA application estimate table. Other applications that may require a High Stress HMA mixture can be found in the MDOT Hot Mix Asphalt Mixture Selection Guidelines.

g. The AASHTO "Mechanistic-Empirical Pavement Design Guide" (M-E Design Guide) will be the preferred method in the analysis of pavement structure design.

F. Cul-De-Sacs

1. Cul-de-sacs shall be constructed at the termini of permanent dead-end streets if the placement of a through street is not feasible due to topography. Maximum cul-de-sac length shall be as defined in City Code of Ordinances Chapter 85 – Subdivision Ordinance. Cul-de-sacs may be allowed on local low volume streets only.

2. Cul-de-sac pavement areas will be constructed with same materials as specified for streets.

3. Cul-de-sacs will incorporate the use of a landscape center island. Where practical this center island will be designed as a depression to accept storm water runoff from the surrounding pavement and development area to provide storm water control and water quality enhancement.

G. Sidewalks

1. Sidewalk Width

a. Sidewalk width will be as set forth in the City of Marquette Master Plan and the City Code of Ordinances Chapter 85 – Subdivision Ordinance for various street classifications.

b. The placement of sidewalks adjacent to the back of the curb is not desirable and should be used only if the existing terrain dictates or the existing right of way width is the restricting factor. If allowed the width of a contiguous sidewalk shall be measured from the back of the curb.

c. Sidewalk widths are intended to be clear widths. Where fire hydrants, street furniture, or other above ground appurtenances reduce such width, additional sidewalk shall be constructed around the obstacles.

2. Sidewalk Locations

a. Sidewalk location will be as set forth in the City of Marquette Master Plan and

the City Code of Ordinances Chapter 85 – Subdivision Ordinance for various street classifications.

3. Sidewalk Materials

a. Sidewalks shall consist of concrete. Asphalt sidewalk will not be allowed.

b. Concrete shall meet the requirements for Grade P1 Concrete or Grade S2 Concrete as specified in the MDOT 2012 Standard Specifications for Construction Section 601, "Portland Cement Concrete Pavements". All concrete sidewalks shall be paved with a single course of concrete. Sidewalks through driveways shall be six (6") inches thick. All other walks shall be four (4") inches thick. Sidewalk ramps shall be six (6") inches thick.

4. Sidewalk Design

a. Sidewalks will be designed to have a maximum cross slope of 2%.

b. Sidewalk ramps shall conform to ADA requirements. Sidewalk Detectable Warnings shall be placed at all street intersections and commercial/industrial driveways. Sidewalk Detectable Warning details shall conform to ADA requirements, MDOT Specifications, MDOT Detail R-28-E, and City of Marquette Specifications.

Warning details shall apply to all construction or reconstruction of streets, curbs, or sidewalks. Detectable warnings shall extend the full width of the curb/sidewalk ramp. They shall be located so that the edge nearest the curb or street is 6" to 8" from the back of curb line.

5. Sidewalk Buffer Area

a. Sidewalks alongside roadways shall be separated by planting strips consisting of natural vegetation or landscaping that create a buffer area. Planting buffers (also referred to as planting strips, landscape strips, landscape buffers, and nature strips) are generally considered to be an effective separation treatment between walkways and streets in all types of settings. Areas of high pedestrian traffic may not be suitable for vegetation and may require other treatments such as stamped concrete pavement or pervious pavement applications.

b. The added separation of a planting buffer helps a pedestrian feel more comfortable when walking along the street. The buffer area also provides space for streetlights, fire hydrants, utility boxes, and bike racks. Other advantages of buffer areas include an area for drainage runoff, aesthetic enhancement, and tree planting.

c. Materials and objects placed in the buffer area will be governed by the City of Marquette Code of Ordinances.

d. The landscape strip or buffer area width shall be per the City of Marquette Master Plan and City of Marquette Code of Ordinances.

H. Pavement Markings

1. Striping Plans

Roadway signs and markings shall conform to standards specified in the Manual of Uniform Traffic Control Devices (MUTCD). Signs and striping plans shall be included with all improvement plans and shall be approved by the City Engineer, Traffic Engineer, and Public Works Superintendent.

a. Striping plans are required for all projects that will modify, add to, or delete existing roadway signs and/or markings.

b. All striping is to be in epoxy, unless otherwise approved.

c. Plans shall show existing striping, signs, and pavement markings as lightly shaded and new striping, signs, and pavement markings as bold.

d. Intersection striping plans at existing and proposed facilities are to provide details for a minimum of 150’ at each leg of intersection.

2. Traffic Control Pavement Markings

a. Standard pavement arrows for indicating turn movements and lane markings shall be required at all major arterial or collector intersections or per the direction of the City Engineer.

b. Stop bars are placed behind the curb ramp or ramp landing, whichever applies and shall be located to allow adequate stopping sight distance. For collector, arterial, or those streets that intersect a collector or arterial a 24 inch stop bar will be required. All other streets a 12 inch stop bar will be required if a stop sign is present.

c. Intersections with low traffic volumes may only require the use of a stop sign if warranted.

3. Crosswalks Markings

a. Crosswalks at controlled intersections shall be a minimum of 8 feet wide or 2 feet wider than the sidewalk or pathway entering the intersection.

b. At Signalized Intersections - Install marked high visibility crosswalks on all approaches. Certain unique intersections with high pedestrian activity may be considered for high visibility crosswalks. High visibility crosswalk standard for the City is the perpendicular ladder hatching option as called out in the MUTCD.

c. At Stop Sign Controlled Approaches - Install parallel line crosswalks and/or a stop bar if recommended by the City. Intersections with low traffic volumes may only require the use of a stop sign if warranted.

d. At School Zones or Safe Routes to School Designated Sidewalks - Install marked high visibility crosswalks on all approaches. High visibility crosswalk standard for the City is the perpendicular ladder hatching option as called out in the MUTCD.

e. At Business Districts - Install marked high visibility crosswalks on all approaches. High visibility crosswalk standard for the City is the perpendicular ladder hatching option as called out in the MUTCD. Specialized cross walk aesthetic design will require the approval of the Planning Commission and shall meet all the requirements of the MUTCD.

TRANSPORTATION IMPACT STUDY CRITERIA
ENGINEERING DESIGN GUIDELINES AND STANDARDS

GENERAL AND REQUIRED INFORMATION

A. General Information
This section contains the policies and guidelines necessary for the preparation of Transportation Impact Studies (TIS) for development proposals. The guidelines exist to ensure consistent and proper traffic planning and engineering practices when land use actions are being considered. The guidelines provide for a standard process, set of assumptions, set of analytic techniques, and presentation format to be used in the preparation of the TIS.

B. Applicant Responsibility
The responsibility for assessing the traffic impacts associated with an application for development approval rests with the developer. The City of Marquette serves in a review capacity. The assessment of these impacts shall be contained within a TIS report as specified herein. It shall be prepared under the supervision of, and sealed by, a Licensed Professional Engineer in the State of Michigan with experience in traffic engineering and transportation planning/engineering.

C. City Responsibility
The City and its engineering staff, or when requested, the Planning Commission, shall serve in a review capacity. The City can use the findings of the impact study to suggest or require roadway improvements, changes to site design, and/or operational improvements. The applicant shall revise and resubmit the study as necessary to address review comments provided to the applicant by the City or other affected agencies

D. Capacity and Safety Issues
Development of property has a direct impact on transportation, including vehicular, transit, bicycle, and pedestrian traffic. In order to meet capacity and safety needs as they relate to the traffic generated from a particular land use, specific improvements can be made. The goal of the TIS is to address the traffic related issues that result from the new development and to determine the improvements required such that appropriate levels of service are safely maintained. The competing objectives of vehicular movement, pedestrians, bicyclists, and others must be balanced in the development review process. A balanced combination of elements is needed to provide streets that serve all transportation modes. The TIS will provide information and guidance as plans are developed and decisions made for the approved plan.

REQUIREMENTS AND CRITERIA

A. Scope Meeting Purpose
The purpose of the scoping meeting is to determine the parameters for the study of traffic impacts for a specific development project, and to document those parameters. The parameters determined in the scoping meeting represent general agreement between the City and the consulting engineer, but they may not be all-inclusive. The City retains the right to require any additional information and/or analysis to complete an evaluation of the proposed development project.

B. Meeting Setup and Content.

The Applicant is required to contact the City in writing to arrange for a Scoping Meeting to discuss the TIS requirements and determine the base assumptions. It is incumbent upon the Applicant to bring a completed Traffic Impact Study Compliance Form, Transportation Impact Study Base Assumptions Form and a complete Pedestrian Analysis Worksheet (included at the end of this section as Attachments “A”, “B”, and “C”) to the meeting and be prepared to discuss the following:

1. Previous TIS prepared for the site, if any;
2. Location of the site;
3. Proposed access and its relationship to adjacent properties and their existing/proposed access;
4. Preliminary estimates of the site's trip generation and trip distribution at build-out;
5. Identification of proposed year of build-out;
6. Trip adjustment factors proposed, if any;
7. Approved and proposed developments in the study area, and the associated committed roadway improvements;
8. Anticipated roadway improvements to be provided by the Applicant;
9. Phasing plan proposed;
10. Potential bicycle and pedestrian connections to the nearest attraction (existing or imminent) within 1320’ of the site. This distance may be increased up to 1.5 miles for residential projects near existing or proposed school sites.
11. Special analysis needs.

C. Results of Meeting

The Scoping Meeting shall conclude with the City and Applicant in mutual agreement with regard to determining the level of detail and extent to which the TIS will need to address each of the following:

1. Study area for the impact analysis;
2. Other developments within the study area;
3. Existing intersection counts;
4. Intersections to be studied in detail;
5. Background traffic volume forecasts;
6. Location of the nearest bicycle and pedestrian facilities and
7. Special analysis needs. (Non traditional peak hour volumes for some uses, neighborhood impacts, access management plans, etc.)

D. Documentation after Meeting

The signed scoping meeting agreement and all attachments shall be inserted into the TIS.

LEVELS OF ANALYSIS

For an Individual Site Transportation Impact Study, the following levels of analysis apply: (These categories are intended as guidelines and may be revised, when warranted, by the City Engineer.)

A. Full TIS.

A full TIS shall be required if one or more of the following conditions occur:

1. Vehicular Traffic

a. The site generated traffic exceeds 1,000 trips/day and/or 100 peak hour trips, or
b. New high volume access is requested for an arterial street.

2. Pedestrian Traffic
Paved pedestrian facilities exist or will be constructed on, or adjacent to, the site; or, the proposed use will generate any new pedestrian traffic.

3. Bicycle Traffic
Paved bike lanes or paths exist or will be constructed on, or adjacent to, the site; or, the proposed use will generate any new bicycle traffic.

B. Intermediate TIS.
An Intermediate TIS may be considered if all of the following requirements are met:

1. Vehicular Traffic
   a. Daily vehicle trip-end generation is between 501 and 1000 inclusive, or the peak hour trip generation is between 51 and 100, and
   b. No high volume access onto arterials is being requested, and
   c. The Level of Service (LOS) of the adjacent facility when the development is completed equals or exceeds the minimum allowable LOS standard established for that facility.

2. Pedestrian Traffic
Paved pedestrian facilities exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new pedestrian traffic.

3. Bicycle Traffic
Paved bike lanes or paths exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new bicycle traffic.

C. Transportation Memorandum.
A Traffic Memorandum, in lieu of a more detailed study, may be considered if all the following requirements are met:

1. Vehicular Traffic
   a. Daily vehicle trip-end generation is less than or equal to 500, and/or the peak hour trip generation is between 21 and 50. and
   b. Any new access requests are for local streets or minor collector streets only.

2. Pedestrian Traffic
Paved pedestrian facilities exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new pedestrian traffic.

3. Bicycle Traffic
Paved bike lanes or paths exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new bicycle traffic.

D. No TIS Required.
Upon submittal of a Traffic Impact Study Compliance Application, Traffic Impact Study Base Assumptions Worksheet, and the Pedestrian Analysis Worksheet (Attachments "A, B. and C") by the Applicant and written acceptance by the City Engineer, the TIS requirement may be waived if all of the criteria below are satisfied:

1. Vehicular Traffic
   a. The daily vehicle trip-end generation is less than 200 and/or the peak hour trip generation is less than 20 vph;
   b. There are no additional proposed minor or major street intersections on major collectors, or arterial streets;
   c. If the property is being redeveloped, the increase in the number of vehicular trips for the proposed use does not exceed the trip generation from the existing use by more than 20 peak hour trips or 200 daily trip ends;
   d. Any change in the type of traffic to be generated (i.e. the addition of new truck traffic) does not adversely affect the traffic currently planned for and accommodated within, and adjacent to, the property;
   e. The scale or use of the proposed development or redevelopment is not likely to cause less than acceptable levels of service on the adjacent public streets, accesses, and intersections; and
   f. The proposed development or redevelopment is not in the vicinity of a street or intersection with a history of safety and/or accident problems.

2. Pedestrian Traffic
   Paved pedestrian facilities exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new pedestrian traffic.

3. Bicycle Traffic
   Paved bike lanes or paths exist or will be constructed on, or adjacent to, the site; or, the proposed use will not generate any new bicycle traffic.

STUDY PARAMETERS

A. Summary
The Summary shall be provided as a condensed, stand-alone document. Maps and tables required or provided in individual sections of the report shall be placed in the Summary in the order described and provided in the text of the report. Individual sections of the report may be referenced only as necessary to document a source of information.

B. Project Description
A description of the proposed project shall include the type of land use and size of the proposed project (number of dwelling units or building square footage), proposed phasing, and anticipated completion date. A figure depicting the proposed site plan shall also be included, and the proposed vehicular access locations will be described. This figure shall provide the following:

1. Surrounding street roadway arterial classification
2. Number of existing and proposed travel lanes
3. Existing and proposed street width
4. Existing and proposed right-of-way dimensions

5. Existing and proposed multi-use driveways and site access points (with turning movements)
6. Traffic control
7. Speed limits
8. Existing and proposed access
9. Locations of parks, schools, activity centers, and other notable destinations within ¼ mile of the project edge, and identify sidewalks, bike routes, lanes, or paths that would be used to get from the project to each destination. Also identify how pedestrian and bicycle access is provided within the project site to facilities at the boundaries.

Similar access information for adjacent properties shall be provided as well, if available, on the same map. The data presented in this report shall be identical in every respect to the site plan submitted for development approval. For situations where a site plan does not exist, a prototypical site roadway and access system should be assumed for purposes of the study. Subsequent updates will be necessary when a site plan becomes available. This section will also include a description of how pedestrian and bicycle travel will be accommodated within the proposed site plan.

C. Analysis Horizons

Three study horizons are required for a Full TIS analysis: the existing (current), the short range (short range build-out) and the long range (20 year). It may be acceptable for the short range and long range horizons to be identical for some large projects.

1. Existing Horizon: The intent of completing an analysis of the existing (current) study horizon is to establish a baseline of traffic conditions.

2. Short Range Horizon: The intent of the short range planning horizon is to investigate the immediate impacts of the completed, proposed project on the existing and Committed roadway network. The short range planning horizon year is defined as one year after the full occupancy of the project. If the project is proposed to occur over multiple phases, each phase shall be evaluated for impacts one year after the occupancy of that phase for the short range analysis.

3. Long Range Horizon: The third planning horizon is the long range planning horizon. It shall be based on the current Regional Transportation Plan 20-year planning horizon and related modeling if available. If not available, the current counts shall be increased by application of a growth rate established by the City or as approved by the City Engineer. The intent of the long range planning horizon is to evaluate the implications of the fully developed proposed project on the long-range traffic condition.

D. Study Area

The limits of the transportation network study area shall be defined for all levels of TIS analysis. The limits of the transportation network to be studied shall be based on the size and extent of the application for development approval, the existing and future land uses, and traffic conditions on and near the site. The study area generally contains the major streets and intersections within one mile of the project. This may be increased or decreased, at the discretion of the City Engineer. The exact limits of the study area are to be based on good engineering judgment, and an understanding of existing and future land use and traffic conditions at and around the site. The limits of the study area shall be agreed upon at the Scoping Meeting.

The concerns related to specific land use actions on specific studies vary greatly, at a minimum, the factors to be considered for the establishment of the limits of the study area should include:

1. Full TIS

a. All adjacent streets, intersections, and High-Volume Driveways.
b. Nearest offsite major intersection(s).
c. Offsite collector and arterial links within the study area that have impacted intersections as defined in items e and f below.
d. Internal public roads, including establishing the road classification.
e. Additional offsite major intersections where:
   i. The project contributes a 10 percent impact (during either the A.M. or P.M. peak hour) to any approach leg of the intersection where the intersection is operating at a level of service of C or better in the Short Range Horizon, unless otherwise approved by the City Engineer, or
   ii. The project contributes a 5 percent impact (during either the A.M. or P.M. peak hour) to any approach leg of the intersection where the intersection is operating at a level of service of D or worse in the Short Range Horizon, unless otherwise approved by the City Engineer.
f. Additional offsite minor intersections where the project contributes a 30 percent increase in volume (during either the A.M. or P.M. peak hour) to any approach leg of the intersection where any existing leg of the intersection is currently operating at a level of service of E or worse.
g. Pedestrian and bicyclist destinations (existing or imminent) within 1320 feet of the site.
h. Access to the most direct transit facility or transit route (existing or imminent) within 1,320 feet of the site.
i. Any pedestrian routes within 1-1/2 miles of a school (residential land uses only).

2. Intermediate TIS

a. All adjacent streets, intersections, and High-Volume Driveways;
b. The nearest offsite major intersection(s) only if:
   i. The project contributes a 10 percent impact (during either the A.M. or P.M. peak hour) to any approach leg of the intersection where the intersection is operating at a level of service of C or better in the Short Range Horizon, unless otherwise approved by the City Engineer, or
   ii. The project contributes a 5 percent impact (during either the A.M. or P.M. peak hour) to any approach leg of the intersection where the intersection is operating at a level of service of D or worse in the Short Range Horizon, unless otherwise approved by the Local Entity Engineer.
c. Offsite collector and arterial links within the study area that have impacted intersections as defined in item b above.
d. Internal public roads, including establishing the road classification;
e. Pedestrian and bicyclist destinations (existing or imminent) within 1320 feet of the site.

f. Access to the most direct transit facility or transit route (existing or imminent) within 1,320 feet of the site.
g. Any pedestrian routes within 1-1/2 miles of a school (residential land uses only).

3. Traffic Memorandum

a. All adjacent streets, intersections, and High-Volume Driveways;
b. Internal public roads, including establishing the road classification;
c. Continuity and adequacy of pedestrian and bike facilities adjacent to the site.
d. Access to the most direct transit facility or transit route adjacent to the site.

E. Evaluation Elements

1. Full TIS. The key elements of the project impact assessment shall be specified by the City Engineer from the following list:

a. Conformity with the adopted Transportation Master Plan, including any adopted access plans.
b. Peak hour link volume and level of service of streets adjoining development;
c. Peak hour intersection and driveway level of service;
d. Appropriateness of access locations;
e. Location and requirements for turn lanes or acceleration/deceleration lanes at accesses or intersections, including recommendations for taper lengths, storage length, acceleration/deceleration lengths, and other geometric design requirements per City or MDOT requirements;
f. Sight distance evaluations and recommendations (intersection, stopping, passing);
g. Multi-modal opportunities;
h. Continuity and adequacy of pedestrian and bike facilities to the nearest attraction (existing or imminent) within the study area;
i. Recommended traffic control devices for intersections which may include two way stop control, four way stop control or yield signs, school flashers, school crossing guards, crosswalks, traffic signals or roundabouts.
j. Traffic signal and stop sign warrants.
k. Progression analysis for signalized intersections.
l. Appropriateness of the existing roadway signing and striping.
m. Safety and accident analysis.
n. Other items as requested by the City Engineer and agreed to in the Scoping Meeting.
o. Neighborhood and public input issues.

2. Intermediate TIS. At a minimum, the following issues should be considered for submittal of an Intermediate TIS:

a. No Long Range Horizon is required as part of this study.
b. Conformity with the adopted Transportation Master Plan, including any adopted access plans.
c. Peak hour link volume and level of service of streets adjoining development;
d. Peak hour intersection and driveway level of service;
e. Appropriateness of access locations;
f. Location and requirements for turn lanes or acceleration/deceleration lanes at accesses or intersections, including recommendations for taper lengths, storage length, acceleration/deceleration lengths, and other geometric design requirements per City or MDOT requirements;
g. Sight distance evaluations and recommendations (intersection, stopping, passing);
h. Continuity and adequacy of pedestrian and bike facilities to the nearest attraction

(existing or imminent) within the study area;

i. Recommended traffic control devices for intersections which may include two way stop control, four way stop control or yield signs, school flashers, school crossing guards, crosswalks, traffic signals, or roundabouts.

j. Traffic signal and stop sign warrants.

k. Progression analysis for signalized intersections.

l. Appropriateness of the existing roadway signing and striping

m. Safety and accident analysis.

n. Other items as requested by the City Engineer and agreed to in the Scoping Meeting.

o. Neighborhood and public input issues.

3. **Traffic Memorandum.** At a minimum, the following issues should be considered for submittal in a Traffic Memorandum:
   a. No Long Range Horizon is required as part of this study.
   b. Peak hour link volume and level of service for streets adjoining development;
   c. Peak hour driveway level of service;
   d. Appropriateness of access locations;
   e. Location and requirements for turn lanes or acceleration/deceleration lanes at the access, including recommendations for taper lengths, storage length, acceleration/deceleration lengths, and other geometric design requirements per City or MDOT requirements;
   f. Sight distance evaluations and recommendations (intersection, stopping, passing);
   g. Continuity and adequacy of pedestrian and bike facilities within the study area;
   h. Appropriateness of the existing roadway signing and striping.
   i. Other items as requested by the City Engineer and agreed to in consultation with the Applicant's Traffic Engineer.
   j. Neighborhood and public input issues.

TRAFFIC ANALYSIS

A. Analysis Time Periods

The TIS shall analyze the traffic peak hours. Peak hours generally occur during both the morning and afternoon weekday peak hours, typically between 7:00 a.m. to 9:00 a.m. and 4:00 p.m. to 6:00 p.m. respectively. Due to project specifics, peak hours may be the mid-day weekday (schools require an analysis of the peak period during the school start-up and school let-out), or can occur on a weekend (park events, shopping centers, church facilities).

In any case, these volumes shall be no more than one year old (from the date of application submittal). The source(s) of each of the existing traffic volumes shall be explicitly stated (MDOT counts, new counts by Applicant, City counts, etc.) Summaries of current traffic counts shall be provided. The City may require the use of seasonal adjustment factors depending on when data was collected and if the project is considered to be in an affected area. (i.e. Tourism)

B. Intersection Level of Service

Level of Service (LOS) shall be computed for the peak hour, typically morning and afternoon for un-signalized and signalized intersection according to latest edition of Highway Capacity Manual, or using the latest version of Highway Capacity Software (HCS), SYNCHRO, RODEL, or other software acceptable to City.

C. Traffic Forecasts

Traffic forecasts shall be provided for both the Short Range Forecast Year and the Long Range Forecast Year. The report shall include complete documentation of trip generation calculations including Institute of Transportation Engineers (ITE) Trip Generation (latest published edition) use code(s) or an alternative basis of trip generation and the rationale for using the alternative.

1. Short Range Forecast Year Analysis. The short range forecast year analysis shall be Total Traffic at the time of anticipated completion and occupancy of each phase of the development and at the time of completion and occupancy of the entire development. Total traffic for additional developments planned for the area will be provided by the City to consider in the calculation of Added Traffic.

2. Long Range Forecast Year Analysis. The Traffic Impact Analysis shall include an analysis of the potential worst-case long-range impacts to the local transportation system identified in the City's Transportation Plan. The forecast year shall be the forecast year of the Transportation Plan or an alternate year approved by the City Engineer. The Traffic Impact Analysis shall include a prediction of whether any phase of the proposed development will change the long-range transportation needs identified in the Transportation Plan and the extent to which traffic from the proposed development contributes to the long-range improvement needs.

3. Trip Generation. Trip generation should be calculated from the latest data contained within the Institute of Transportation Engineers' Trip Generation Manual. Other industry publications may be approved by the City. Data limitations, data age, choice of peak hours (for the land use or adjacent street traffic), choice of independent variables, and choice of average rate versus statistically significant modification should be discussed in the study when appropriate. When data is not available for a proposed land use or a modification is proposed, the Applicant must conduct a local trip generation study following procedures prescribed in the ITE Trip Generation Manual and provide sufficient justification for the proposed generation rate. This rate must be approved by the City prior to its use in the written study. See Table C-1 for examples of common trip generation rates.

Table C-1 Common Trip Generation Rates

Land Use	Base Unit	Rates		
		AM Peak	ADT	ADT Range
Residential				
Single Family Home	per dwelling unit	.75	9.55	4.31-21.85
Apartment Building	per dwelling unit	.41	6.63	2.00-11.81
Condo/Town Home	per dwelling unit	.44	10.71	1.83-11.79
Retirement Community	per dwelling unit	.29	5.86	
Mobile Home Park	per dwelling unit	.43	4.81	2.29-10.42
Recreational Home	per dwelling unit	.30	3.16	3.00-3.24
Retail				
Shopping Center	per 1,000 GLA	1.03	42.92	12.5-270.8
Discount Club	per 1,000 GFA	65	41.8	25.4-78.02
Restaurant (High-turnover)	per 1,000 GFA	9.27	130.34	73.5-246.0
Convenience Mart w/ Gas	per 1,000 GFA		845.60	578.52-1084.72

Pumps				
Convenience Market (24-hour)	per 1,000 GFA	65.3	737.99	330.0-1438.0
Specialty Retail	per 1,000 GFA	6.41	40.67	21.3-50.9
Office				
Business Park	per employee	.45	4.04	3.25-8.19
General Office Bldg	per employee	.48	3.32	1.59-7.28
R & D Center	per employee	.43	2.77	.96-10.63
Medical-Dental	per 1,000 GFA	3.6	36.13	23.16-50.51
Industrial				
Industrial Park	per employee	.43	3.34	1.24-8.8
Manufacturing	per employee	.39	2.10	.60-6.66
Warehousing	1,000 GFA	.55	3.89	1.47-15.71
Other				
Service Station	per pump	12.8	168.56	73.0-306.0
City Park	per acre	1.59	NA	NA
County Park	per acre	.52	2.28	17-53.4
State Park	per acre	.02	.61	.10-2.94
Movie Theatre w/Matinee	per movie screen Saturday	89.48 (PM Peak)	529.47	143.5-171.5
Day Care Center	per 1,000 GFA	13.5	79.26	57.17-126.07

Source: Institute of Transportation Engineers (ITE). Trip Generation.

4. Adjustments to Trip Generation. Trip-making reduction factors may be used after first generating trips at full ITE rates or pre-approved rates from other professional sources. These factors fall into two categories, pass-by trips and internal site trips.

a. Pass-by Trips: Typical trip generation rates are derived from counts taken at the driveways of the various land uses. For many land uses, not all of the trips generated at the driveway represent new trips added to the roadways. This is due to “pass-by” trips. Pass-by trips are made by traffic already using the adjacent roadway and enter the site as an intermediate stop on the way from another destination. The trip may not necessarily be “generated” by the land use under study, and thus, not a new trip added to the transportation system. This pass-by factor should be taken into account in devising a trip generation estimate.

b. Internal Site Trips: The method of developing a trip generation estimate must also take into consideration the fact that some of the trips counted at stand-alone sites are actually made within a multi-use development, by vehicle or by an alternate mode such as walking. The most common example of this trip-making occurs at multi-use developments that include both residential and shopping areas. Some of the residents’ work trips and shopping trips are made to the on-site shopping area. These trips are internal to the multi-use site. Because they are captured on-site, a capture rate is used. A capture rate is a percentage reduction in traditionally developed trip forecasts to account for internal trips. The reduction may be applied to the total trips estimated, just as is the pass-by percentage reduction. The ITE has found that multi-use developments could reduce trip generation estimates by 24%.

5. Trip Distribution and Assignment. Trip distribution must be documented in the TIS. It may be based on the professional engineer's judgment applied to one or more of the following: regional traffic volume projections, gravity model, market analysis, existing traffic flows, or applied census data. Regardless of the basis of the estimates, the procedures and rationale used in determining the trip distributions must be fully explained and documented.
The project traffic will be assigned to the roadway system according to the trip distribution established above. The resulting project site generated traffic and total site traffic will be depicted on figures for each analysis horizon. These figures will include peak hour traffic volume information, plus daily traffic volume information.

6. Crash Analysis. A three-year accident record shall be collected for adjacent roadways and intersections within the study area. Based on existing traffic volumes, an accident rate for accidents per million vehicle miles of travel for links and accidents per million vehicles at intersections shall be calculated by year. Geometric deficiencies for high-accident locations shall be identified. As part of the analysis, the applicant shall identify problems that currently exist and how the proposed improvements will mitigate these problems.

7. Sight Distance Analysis. Sight distance analysis shall be conducted to insure the appropriate length of visible roadway is provided. The three most common types are sight distance, stopping sight distance, and passing sight distance. Intersection sight distance shall analyze approach sight triangles, departure sight triangles. Obstructions to view within these triangles shall be indicated. Due to the variation of topography, location, speed of the roadway, etc., other sight criteria may need to be addressed in accordance with sight specific requirements.

8. Other items as requested by the City. In the initial required scoping meeting with the City staff, specific additional issues might be raised which require further analysis. Additional concerns might include cut through traffic and residential quality-of-life concerns, truck/bus traffic estimates and pavement design, routes to schools, emergency routes, etc.

PROJECT TRAFFIC IMPACTS

A. Significant Negative Impacts

This section applies primarily to vehicular related impacts associated with the proposed project. A project is defined as significantly impacting a study intersection or roadway link when one of the following criteria is satisfied:

1. Exceeding Maximum Traffic Volume. When the project's (land use action) traffic causes the estimated traffic to exceed the established maximum traffic volumes (Table A-1, Table A-2) allowed for the specific classes of roadways;

Table A-1 Level of Service (LOS) Threshold Volumes for Various Roadway Types

Roadway Type	LOS A	LOS B	LOS C	LOS D	LOS E
2-Lane Arterial (w/left turn lane)	11,000	12,800	14,700	16,500	18,300
2-Lane Collector	6,000	7,500	9,000	10,500	12,000
2- Lane Local	1,200	1,400	1,600	1,800	2,000

Notes:
1. The volumes are total daily volumes in both directions (ADT).
2. The above threshold volumes for preliminary planning purposes only. If available, the results of detailed level of service analyses will typically have priority over the levels of service derived from this table. In that case this table can be used by the analyst for providing additional considerations for recommending the appropriate general roadway type for the specific condition being analyzed.
3. Local street level of service thresholds are based upon “Neighborhood Traffic Related Quality-of-Life Considerations” which assumes a standard suburban neighborhood, 40-foot roadway width, and 25 mile per hour speed limit with normal speed violation rates.
4. All volumes are approximate and assume ideal roadway characteristics.

The City usually strives to maintain service levels on City facilities at the transition between LOS C and LOS D. Anything below LOS D can be considered unacceptable conditions.

Table A-2 Qualitative Description of Level Service for Roadway Segments

Level of Service	Interpretation
A	Low volumes; primarily free-flow operations. Density is low, and vehicles can freely maneuver within the traffic stream. Drivers can maintain their desired speeds with little or no delay.
B	Stable flow with potential for some restriction of operating speeds due to traffic conditions. Maneuvering is only slightly restricted. The stopped delays are not bothersome, and drives are not subject to appreciable tension.
C	Stable operations; however, the ability to maneuver is more restricted by the increase in traffic volumes. Relatively satisfactory operating speeds prevail, but adverse signal coordination or longer queues cause delays.
D	Approaching unstable traffic flow, where small increases in volume could cause substantial delays. Most drivers are restricted in their ability to maneuver and in their selection of travel speeds. Comfort and convenience are low but tolerable.
E	Operations characterized by significant approach delays and average travel speeds of one-half to one-third the free-flow speed. Flow is unstable and potential for stoppages of brief duration. High signal density, extensive queuing, or progression/timing are the typical causes of the delays.
F	Forced-flow operations with high approach delays at critical signalized intersections. Speeds are reduced substantially, and stoppages may occur for short or long periods of time because of downstream congestion.

2. **Exceeding the LOS standard.** When the added project traffic causes any portion of an intersection to exceed the LOS standard (Table A-3 and Table A-4);
   a. All signalized intersections in the City should maintain LOS C. Exceptions to this

policy are that lower service levels shall be permitted at any location where the existing LOS does not meet this standard and in which case the LOS cannot be worsened any further.

b. All unsignalized intersections must maintain LOS C. If the LOS degrades below LOS C, an evaluation of the need for traffic signalization shall be undertaken according to standard Manual of Uniform Traffic Control Devices (MUTCD) signal warrants. If signals are not initially warranted, the location shall continue to be monitored for signal warrants on a regular basis.

Table A-3 Level of Service Criteria for Signalized Intersections

Level of Service	Average Control Delay (sec/veh)	General Description (Signalized Intersections
A	≤ 10	Free Flow
B	> 10 - 20	Stable Flow (slight delays)
C	> 20 - 35	Stable Flow (acceptable delays)
D	> 35 - 55	Approaching unstable flow (tolerable delay, occasionally wait through more than one signal cycle before proceeding)
E	> 55 - 80	Unstable Flow (intolerable delay)
F	> 80	Forced Flow (jammed)

Source: Highway Capacity Manual (HCP).

Table A-4 Level of Service Criteria for Unsignalized Intersections

Level of Service	Average Control Delay (sec/veh)
A	0 - 10
B	> 10 - 15
C	> 15 - 25
D	> 25 - 35
E	> 35 - 50
F	> 50

Source: Highway Capacity Manual (HCP).

PEDESTRIAN AND BICYCLE IMPACT EVALUATIONS

A. Pedestrian and Bike Facility Demand

The TIS shall provide in sufficient detail the project's proposal to provide pedestrian and bicycle connections within the site to the local off-site pedestrian and bicycle destinations. Pedestrian and bike facility demand shall be identified and related items for discussion during the Scoping Meeting should include:

1. School routing plans per the MUTCD between the project and all schools within 1-1/2 miles of the project boundary.
2. The demand for pedestrian and bike facilities to serve high pedestrian activity areas within the land use.
3. The need for links of bicycle or pedestrian facilities to neighboring land uses or attractions (trails, etc.) within 1320' (or greater if applicable to unique pedestrian oriented destinations) of the project site;

4. Existing and proposed sidewalk width, separation from traffic, and space available for trees, transit stops (if any), or other related elements (if any).
5. Geometric improvements and recommended traffic control devices to accommodate pedestrians and bicyclists;
6. Existing and proposed pedestrian and bike facilities shall be evaluated for compliance with the following elements:
   a. Directness. Walking distance to destinations like transit stops, schools, parks, and commercial or activity areas should be direct. Measurement of directness is the ratio of the Actual distance to a destination via a sidewalk or pathway divided by the Minimum distance characterized by a grid street system.
   b. Continuity. The sidewalk/walkway system should be complete, without gaps. The pedestrian corridor should be integrated with the activities along the corridor and should provide continuous access to destinations.
   c. Street Crossings. Safety and comfort is essential while crossing streets, intersections and mid-block crossings. Factors that affect the LOS include: number of lanes to cross, crossing delay for pedestrians, signal indication, cross-walks, lighting, raised medians, visibility, curb ramps, pedestrian buttons, convenience, comfort, and security.
   d. Visual Interest and Amenity. Pedestrians/bicyclists enjoy visually appealing environments that are compatible with local architecture and include street lighting, landscaping, bicycle racks, and benches.
   e. Security. Pedestrians should be visible to motorists, separated from motor vehicles and bicycles, and under adequate street lighting.
   f. Surface Condition. Pedestrian facilities should be free from obstructions, cracks, and interruptions.

MITIGATION MEASURES

When a project's vehicular impacts are determined to not meet the minimum acceptable level of service standard, the TIS shall include feasible measures, which would mitigate the project's impacts. The mitigation measures are intended to be *in addition to* the minimum required improvements necessary to meet the City's standards and codes.

A. Mitigation Improvements and Considerations for Vehicular Traffic

Examples of vehicular traffic considerations and improvements include: road widenings, turn lanes, acceleration and deceleration lanes, intersection improvements, traffic control, design-speed adjustments, modifications to access points and truck routes. Design basis shall generally be ITE, AASHTO, MDOT, NCHRP or other nationally accepted standards.

B. Mitigation Improvements and Considerations for Pedestrian/Bicycle Traffic

Examples of pedestrian and bicycle considerations and improvements include: safe, comfortable, and convenient pedestrian services, shorter blocks, tree-lined sidewalks, smaller corner radii, well-defined crosswalks, median refuges, bike lanes, on-street parking and shared-use path connections. Also, design elements that lead to low traffic speeds on local streets should be considered. Design basis shall generally be ITE, AASHTO, MDOT, NCHRP or other nationally accepted standards.

TIS ACCEPTANCE AND APPROVAL

When a TIS is submitted to the City Engineer for review, the developer will submit all of the appropriate applications as defined in these guidelines. Once all City staff TIS review comments have been satisfactorily addressed, the City Engineer will issue a letter documenting that the TIS has been accepted and approved by the City.

REFERENCES

Trip Generation, 7th Edition, Institute of Transportation Engineers, 2003

Trip Generation Handbook, Institute of Transportation Engineers, March 2001

Highway Capacity Manual, Transportation Research Board. 2000

A Policy on the Geometric Design of Highways and Streets, *5*th edition, 2004, American Association of State Highway and Transportation Officials.

Larimer County Urban Area Street Standards, April 1, 2007

Special Exception Application Procedures Manual, Town of Leesburg, July 2010

Traffic Impact Study Design Guidelines, City of Draper, June 2012

Unified Development Code, *Article 3*, City of Cheyenne, April 2012

NCHRP Report 599, National Cooperative Highway Research Program, 2008 Transportation Research Board

General Plan Update, City of St. Helens, August 2010

Standards & Specifications for the Design and Construction of Public Improvements, City of Dacono, March 2012

ATTACHMENT A
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY COMPLIANCE APPLICATION

Compliance with the Transportation Impact Study Criteria Section of the City of Marquette Engineering Design Guidelines and Standards

Choose one of the two options below:

__ This proposed development **Does Not Meet** any of the levels of analysis identified in the **Transportation Impact Study Criteria** that would require a Traffic Impact study to be submitted in conjunction with this application.

__ This proposal **Meets** at least one of the levels of analysis identified in the **Transportation impact Study Criteria** that would require a Traffic Impact Study t be submitted in conjunction with this application. **A Traffic Impact Study Base Assumptions Worksheet** and a **Pedestrian Analysis Worksheet** are attached for appropriate review.

The above is based on a projected daily trip generation of _________ vehicles per day (VPD) and a site peak hour trip generation of ________ vehicles per hour (VPH).

I hereby certify that all the above statements are true.

____

Certifier's Name, Print and Sign

______________ ______________________

Date **Phone Number**

ATTACHMENT B
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY BASE ASSUMPTIONS WORKSHEET

TRAFFIC IMPACT STUDY BASE ASSUMPTIONS WORKSHEET				
Project Name				
Project Location				
Project Size				
Study Area Boundaries	North:		South:	
	East:		West:	
Study Years	Short Range :		Long Range:	
Future Traffic Growth Rate				
Study Intersections	1. All Access Drives		2.	
	3.		4.	
	5.		6.	
	7.		8.	
Time Period For Study	AM: 7 – 9	PM: 4 – 6	Sat. Noon	
Trip Generation Rates (If adequate ITE *Trip Generation Manual* data is not available, trip generation procedures shall be approved by the City.)				
Trip Adjustments Factors (Subject to Approval)	Pass By:		Captive Market:	
Overall Trip Distribution (attach sketch)	North	South	East	West
Mode Split Assumptions				
Committed Roadway Improvements				
Other Traffic Studies				
Areas Requiring Special Study (i.e. Signal Progression, passenger car equivalents, accident analysis, etc.)				
Date: Transportation Engineer:				

ATTACHMENT C
CITY OF MARQUETTE
TRANSPORTATION IMPACT STUDY
PEDESTRIAN ANALYSIS WORKSHEET

		DESTINATION						
		Rec.	Res.←	Inst.	Ofc/Bus.	Com.	Ind.	Other (Specify)
Origin (project land use)	Recreation							
	1) Residential							
	Institution (school, church, civic)							
	Office/Business							
	Commercial							
	Industrial							
	Other (specify)							

INSTRUCTIONS:
Identify the pedestrian destinations within 1320' (1.5 miles for schools) of the project boundary in the spaces above. The pedestrian quality of service for the facility/corridor linking these destinations to the project site will be based on the directness, continuity, types of street crossings, walkway surface condition, visual interest/amenity, and security of the selected route(s).

← 12 Dwelling units or more.

____

Date:

____

Transportation Engineer's Name, Print and Sign

ATTACHMENT D
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY SCOPE AGREEMENT

CONTACT INFORMATION

Consultant Name: ______________________________
- Company: ______________________________
- Telephone: ______________________________
- Email: ______________________________

Applicant/Rep: ______________________________
- Company: ______________________________
- Telephone: ______________________________
- Email: ______________________________

PROJECT INFORMATION

Project Name: ______________________________

Project Address: ______________________________

Application Type: Rezoning ☐ Special Exception ☐ Site Plan ☐

Project Description: (Include details on land use, acreage, access, etc. Attach additional sheets if necessary)

Proposed Use(s): Residential ☐ Commercial ☐ Mixed Use ☐ Other ☐ ____________

Trip Generation

ITE Code	Land Use	**Variable** (SQ FT / EMPS / STUDENTS / SEATS)

Total (In/Out) Peak Hour Trip Generation

<100 ☐ 100-499 ☐ 500-999 ☐ 1,000 + ☐

ATTACHMENT D
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY SCOPE AGREEMENT

TRAFFIC IMPACT ANALYSIS ASSUMPTIONS

STUDY YEARS

Current Year: ____________ Build Out Year: ______________ Design Year: _____________

STUDY AREA BOUNDARIES

(Shall extend to the point at which site-generated traffic is 15% or less of total roadway volume, excluding site traffic. Attach map)

North [ ]

West [ ] East [ ]

South [ ]

EXTERNAL FACTORS THAT COULD AFFECT PROJECT

(Planned road improvements, approved nearby development)

[ ]

EXISTING TRAFFIC DATA TO BE UTILIZED

(Historical, Town Forecasts)

[ ]

TRIP DISTRIBUTION (Attach Graphic)

Road Name:	% of distribution N	S	E	W

Annual Vehicle Trip Growth Rate: ___________ %

Additional Notes:

[ ]

ATTACHMENT D
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY SCOPE AGREEMENT

Peak Period to be Analyzed:

(Check all that apply) AM ☐ PM ☐ SAT ☐ SUN ☐

Peak Hour of Generator: ____________________ AM ☐ PM ☐

Study Intersections

1. ______________________________ at ______________________________
2. ______________________________ at ______________________________
3. ______________________________ at ______________________________
4. ______________________________ at ______________________________
5. ______________________________ at ______________________________
6. ______________________________ at ______________________________
7. ______________________________ at ______________________________
8. ______________________________ at ______________________________
9. ______________________________ at ______________________________
10. ______________________________ at ______________________________

TRIP ADJUSTMENT FACTORS

Internal Capture: NO ☐ YES ☐ If Yes _______% Land Use: _____________

Pass By: NO ☐ YES ☐ If Yes _______% Land Use: _____________

Software Methodology: Synchro ☐ HCS ☐ Other ☐ _______________

Traffic Signals Proposed or Affected:
(Identify intersection and analysis software to be used in analysis)

Other Mitigation Proposed:

Existing Background Traffic Studies to be Utilized:

Additional Analysis Required:

☐ Queuing ☐ Merging ☐ Actuation / Coordination ☐ Bike / Pedestrian

☐ TDM Measures ☐ Other ____

Total Number of Pages of Scoping Agreement, Including Attachments: _____________

ATTACHMENT D
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY SCOPE AGREEMENT

IN ADDITION TO THE SCOPE OF STUDY SPECIFIED IN THIS DOCUMENT, ALL TRAFFIC IMPACT ANALYSES SUBMITTED TO THE CITY OF MARQUETTE SHALL COMPLY WITH THE PROVISIONS OF THIS SECTION.

AGREED

______________________________ _______________

APPLICANT OR ITS REPRESENTATIVE SIGNATURE DATE

PRINT NAME

COMPANY

TRANSPORTATION ENGINEER SIGNATURE DATE

PRINT NAME

COMPANY

CITY OF MARQUETTE REPRESENTATIVE SIGNATURE DATE

PRINT NAME

CITY OF MARQUETTE REPRESENTATIVE SIGNATURE DATE

PRINT NAME

ATTACHMENT D
CITY OF MARQUETTE
TRAFFIC IMPACT STUDY SCOPE AGREEMENT

IN ADDITION TO THE SCOPE OF STUDY SPECIFIED IN THIS DOCUMENT, ALL TRAFFIC IMPACT ANALYSES SUBMITTED TO THE CITY OF MARQUETTE SHALL COMPLY WITH THE PROVISIONS OF THIS SECTION.

AGREED

______________________________ ______________
APPLICANT OR ITS REPRESENTATIVE SIGNATURE DATE

____
PRINT NAME

____
COMPANY

______________________________ ______________
TRANSPORTATION ENGINEER SIGNATURE DATE

____
PRINT NAME

____
COMPANY

______________________________ ______________
CITY OF MARQUETTE REPRESENTATIVE SIGNATURE DATE

____
PRINT NAME

______________________________ ______________
CITY OF MARQUETTE REPRESENTATIVE SIGNATURE DATE

____
PRINT NAME