ENGINEERING DESIGN MANUAL

PART III – DRAINAGE

TOWN OF NORTHLAKE

ENGINEERING DESIGN MANUAL

PART III - DRAINAGE

Incorporating the

TOWN OF NORTHLAKE LOCAL CRITERIA SECTION

and the

NCTCOG – *integrated* Storm Water Management (*iSWM*™)
Design Manual for Site Development
(2006 Edition)

This document consists of the regional *i*SWM™ Manual prepared by the North Central Texas Council of Governments and the Town of Northlake Local Criteria Section. The Local Criteria Section adopts by reference the applicable *i*SWM™ sections that are required by the Town's storm water management program and includes additional design criteria that are not included in the *i*SWM™ Manual. The remaining *i*SWM™ sections and criteria are available for technical reference, utilization by developers for enhancement of land development projects, and potential future adoption by the Town, as needed.

Table of Contents

TOWN OF NORTHLAKE LOCAL CRITERIA SECTION

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Why a Town of Northlake Storm Water Management Design Manual is necessary

This design manual is needed to create policies and criteria for storm water facilities within the Town of Northlake and its extraterritorial jurisdiction. The primary motivation for this manual is to guide the community in drainage policy and criteria so that new development does not increase flooding, erosion, and/or water quality problems.

This manual is intended to provide a guideline for the most commonly encountered storm water or flood control designs in the Town of Northlake. It can also be used as a guide for watershed master plans and for design of remedial measures for existing facilities. This manual was developed for users with knowledge and experience in the applications of standard engineering principles and practices of storm water design and management. There will be situations not completely addressed or covered by this manual. Any variations from the practices established in this manual must have the approval of the Town. Close coordination with the staff of the Town is recommended and encouraged during the planning, design and construction of all storm water facilities. This Storm Water Management Design Manual is adopted and becomes effective on May 13, 2010.

Relationship of Town of Northlake Manual to Regional *integrated* Storm Water Management (*iSWM*™) Manual

The Town of Northlake hereby adopts and incorporates herein the regional *iSWM*™ Manual (2006 Edition), developed by the North Central Texas Council of Governments (NCTCOG), the same as if same is set forth fully herein, with such clarifications and modifications as are indicated in this "Local Criteria Section". The *i*SWM™ manual was prepared for the 16-county region and includes sections that are not being adopted or are being modified by the Town of Northlake. The digital version of both manuals are included on the Town of Northlake website (http://www.town.northlake.tx.us/). Copies of these documents can be downloaded from the websites or ordered from the respective agencies for the cost of reproduction.

Precedence of Town of Northlake Local Criteria

The requirements contained within this Town of Northlake Local Criteria section shall take precedence over conflicting provisions that may be contained in the *integrated* Storm Water Management Manual approved by the North Central Council of Governments. Please note that the *i*SWM™ Manual's requirements for Streambank Protection and Water Quality Protection are encouraged by the Town but not currently required.

Notes and Abbreviations

Notes and abbreviations used in the Local Criteria Section:

1. Town-Town of Northlake
2. References are made to the Regional *i*SWM™ Manual for Site Development, 2006

Contact Information

Contacts for the Town of Northlake Storm Water Management Design Manual can be reached at the Public Works Department at: 940-648-3290 or at the website: http://www.town.northlake.tx.us/.

References

integrated Storm Water Management Design Manual for Site Development, 2006 Edition. NCTCOG, Arlington, TX.

integrated Storm Water Management Design Manual for Construction, December, 2003. NCTCOG, Arlington, TX.

Note: Additional references are included in individual chapters or appendices.

GOALS AND OBJECTIVES OF THE TOWN OF NORTHLAKE STORM WATER MANAGEMENT PROGRAM

1. Establish and implement drainage policy and criteria so that new development does not create or increase flooding problems, cause erosion or pollute downstream water bodies.

2. Facilitate the continuation of comprehensive watershed planning that promotes orderly growth and results in an integrated system of public and private storm water infrastructure.

3. Minimize flood risks to citizens and properties and stabilize or decrease streambank and channel erosion on creeks, channels, and streams.

4. Improve storm water quality in creeks, rivers, and other water bodies, remove pollutants, enhance the environment and mimic the natural drainage system to the extent practicable in conformance with the Texas Pollutant Discharge Elimination System (TPDES) permit requirements.

5. Support multi-use functions of storm water facilities for trails, green space, parks, greenways or corridors, storm water quality treatment, and other recreational and natural features, provided they are compatible with the primary functions of the storm water facility.

6. Encourage a more standardized, integrated land development process by bringing storm water planning into the conceptual stages of land development.

TOWN OF NORTHLAKE STORM WATER POLICY STATEMENTS

1. All development within the Town of Northlake Town Limits or Extra-territorial Jurisdiction (ETJ) shall include planning, design, and construction of storm drainage systems in accordance with this Storm Water Management Design Manual as well as Planning Commission Rules and Regulations.

2. Conceptual, Preliminary and Final Drainage Studies and Plans may be required for proposed developments within the Northlake Town Limits or its ETJ, in conformance with this Storm Water Management Design Manual. Specific submittal requirements depend on the complexity of the project and requirements of the Unified Development Code (UDC). Drainage Studies are required only as a part of a "Concept Plan" as defined by the UDC. The checklists for each stage of this three-tier process are included in the *i*SWM™ Manual.

3. All drainage related plans and studies shall be prepared and sealed by a Licensed Professional Engineer with a valid license from the State of Texas. The Engineer shall attest that the design was conducted in accordance with this Storm Water Management Design Manual.

4. For currently developed areas within the Town of Northlake with planned re-development, storm water discharges and velocities from the project should not exceed discharges established by procedures presented in this manual but also shall not exceed discharges and velocities from current (existing) developed conditions, unless the downstream storm drainage system is designed (or adequate) to convey the future (increased) discharges and velocities.

5. All drainage studies and design plans shall be formulated and based upon ultimate, fully developed watershed or drainage area runoff conditions. In certain circumstances where regional detention is in place or a master plan has been adopted, a development may plan to receive less than ultimate developed flow from upstream areas with the approval of the Town. The rainfall frequency criteria for storm water facilities, as enumerated within this Storm Water Management Design Manual shall be utilized for all drainage studies and design plans.

6. Proposed storm water discharge rates and velocities from a development shall not exceed the runoff from existing, pre-development conditions, unless a detailed study is prepared that demonstrates that no unacceptable adverse impacts will be created. Adverse impacts include: new or increased flooding of existing structures, significant increases in flood elevations over existing roadways, unacceptable rises in base flood elevations or velocities, and new or increased stream bank erosion or increased occurrence of nuisance flows.

7. If a proposed development drains into an improved channel or storm water drainage system designed under a previous Town of Northlake drainage policy, then the hydraulic capacities of downstream facilities must be checked to verify that increased flows, caused by the new development, will not exceed the capacity of the existing system or cause increased downstream structure flooding. If there is not sufficient capacity to prevent increased downstream flooding, then detention or other acceptable measures must be adopted to accommodate the increase in runoff due to the proposed development.

8. Storm water runoff may be stored in detention and retention basins to mitigate potential downstream problems caused by a proposed development. Proposed detention or retention basins shall be analyzed both individually and as a part of the watershed system, to assure compatibility with one another and with the Town's storm water management master plans for that watershed (if available). Storage of storm water runoff, near points of rainfall occurrence, such as the use of parking lots, ball fields, property line swales, parks, road embankments, borrow pits and on-site ponds is desirable and encouraged.

9. Alternatives to detention or retention for mitigation of potential downstream problems caused by proposed development include: acquisition of expanded drainage easements, ROW, or property owner agreements; downstream channel and/or roadway bridge/culvert improvements or stream bank erosion protection; and financial contributions to the Town Storm Water Program for future improvements. These alternatives will be considered by the Town on a case-by-case basis.

10. All proposed developments within the Northlake Town Limits or its ETJ shall comply with all local, county, state and federal regulations. All required permits or approvals shall be obtained by the developer.

11. The policy of the Town is to avoid substantial or significant transfer of storm water runoff from one basin to another and to maintain historical drainage paths whenever possible. However, the transfer of storm water from basin to basin may be necessary in certain instances and will be reviewed and a variance can be made by the Town in accordance with established variance procedures. TCEQ approval may be required for significant transfer of storm water.

12. Town Maintenance - The Town will provide for perpetual maintenance, in accordance with adopted Town maintenance standards, of all public drainage facilities (those facilities located within dedicated easements, rights of way and constructed to Town standards). Access shall be provided and dedicated by the developer to all public storm water facilities in developments for maintenance and inspection by the Town.

13. Private Maintenance- Private drainage facilities (those facilities entirely on private property) include those drainage improvements which are located on private property and which handle only private water. Private drainage facilities may also include detention or retention ponds, dams, and other storm water controls which collect public water, as well as drainage ways not constructed to Town standards but which convey public water. Such facilities must be designed in accordance with sound engineering practices and reviewed and inspected by the Town. An agreement for perpetual maintenance of private drainage facilities serving public water shall be executed with the Town prior to acceptance of the final plat. This agreement shall run with the land and can be tied to commercial property or to an owner's association, but not to individual residential lots. Access shall be provided by the developer/owner to all private drainage facilities where there may be a public safety concern for inspection by the Town.

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CHAPTER 1 – STORM WATER MANAGEMENT SYSTEM PLANNING AND DESIGN

Chapter 1 of the *i*SWM™ Manual provides a foundation for *integrated* Storm Water Management in terms of basic philosophy, principles, definitions, and land development site planning and design practices. It should therefore be utilized for general guidance throughout the development process. Water Quality and Streambank Protection Volume controls are not adopted by Town of Northlake at this time. Other exceptions are summarized below. All references to *i*SWM™ site plans are modified to refer to Town of Northlake storm water management plans.

Section 1.1 – Storm Water Site Planning

ADOPTED WITH MODIFICATIONS

Depending on the complexity of the project or submittal requirements as dictated in the Unified Development Code (UDC), storm water management plans may be prepared and submitted to the Town of Northlake in the progressive planning stages of a land development project with the Conceptual Site Plan and Preliminary and Final Plats. The Conceptual Site Plan is an important consideration in that it allows the developer and their design engineer to propose a potential site layout and gives Town staff the opportunity to comment on a storm water management plan concept prior to significant planning and design effort on the part of the design engineer.

Section 1.1.2 – *integrated* Storm Water Management (*i*SWM™) Site Plans

ADOPTED WITH MODIFICATIONS

The Town of Northlake does not currently require water quality (Section 1.2.3 of *i*SWM™) or streambank protection volume mitigation (Option4 of Section 1.2.4 of *i*SWM™).

Section 1.1.2.2 – Applicability

ADOPTED WITH MODIFICATIONS

Storm Water Management plans are required for all new Town of Northlake subdivisions. At this time the Town of Northlake does not require Storm Water Management plans for land disturbing activities or increases in impervious areas.

Section 1.1.3 – Developer Steps to Prepare an *i*SWM™ Site Plan

ADOPTED WITH MODIFICATIONS

See Local Criteria Section 1.1 for a description of Town of Northlake requirements.

Conceptual Storm Water Management Plan (*i*SWM™ 1.1.3.5)

In general, the engineer and planner will follow the conceptual storm water management plan guidelines as presented in Section 1.1.3.5 of the *i*SWM™ Manual, as applicable to Northlake. **Water quality and streambank protection requirements and credits are not currently part of the Town of Northlake criteria**.

Preliminary Storm Water Management Plan (*i*SWM™ 1.1.3.6)

A preliminary drainage study and storm water management plan will accompany a preliminary plat submitted for development review, and shall generally include the information listed in Section 1.1.3.6 of the *i*SWM™ manual as applicable to Northlake. The study will include a downstream assessment of properties that could be impacted by the development. These studies will include adequate hydrologic analysis to determine the existing, proposed, and fully-developed runoff for the drainage area that is affected by the proposed development and will include hydraulic studies that define the

"adequate outfall" (as defined in *i*SWM™ Section 2.1.9.2). The development storm water management plan shall address existing downstream, off-site drainage conveyance system(s); and shall define the discharge path from the outlet of the on-site storm water facilities to the off-site drainage system(s) and/or appropriate receiving waters. See Section 2.1.9 of the *i*SWM™ Manual ("Downstream Hydrologic Assessment") for guidance on the details of this downstream assessment. As a minimum, the Town of Northlake requires assessment of the 2-, 10-, 25- and 100- year 24- hour events. This preliminary drainage study and storm water management plan will include:

1. A topographical map of the entire watershed (not just the area of the proposed development) generally not smaller than 1"=200' (or other such scale approved by the Town), delineating the watershed boundary(s) and runoff design point(s), existing and proposed land use and zoning, and the size and description of the outfall drainage facilities and receiving streams.
2. Computation tables showing drainage areas, runoff coefficients, time of concentration, rainfall intensities and peak discharge for the required design storms for both existing and proposed (ultimate development) conditions and at all design points for each component of the storm water system (streets, pipes, channels, detention ponds, etc.).
3. Any proposed changes to watershed boundaries (i.e. by re-grading, where permissible by Texas Water Code). If significant changes to watershed boundary are made, more extensive analyses of downstream impact and mitigating detention will be required and a variance obtained from the Town.
4. FEMA Flood Hazard Areas, if applicable.
5. In addition any required Corps of Engineer's Section 404 permits, Conditional Letters of Map Revision (CLOMR), Letters of Map Revision (LOMR) or other permits relating to lakes and streams required by any federal, state or local authorities. These must be documented in the Drainage Study.
6. Detailed off-site outfall information. This shall include the presence of existing or proposed drainage structures, bridges or systems; documentation of existing versus proposed developed site as well as ultimate runoff, identification of downstream properties which might be impacted by increased runoff, and proposed detention or other means of mitigation. Downstream impacts shall generally be delineated to a point where the drainage from the proposed development has no impact on the receiving stream or on any downstream drainage systems within the "zone of influence"(as defined in *i*SWM™ Section 2.1.9.2).
7. Report with technical documentation.

Final Storm Water Management Plan (*i*SWM™ 1.1.3.7)

A Final Drainage Study and Storm Water Management Plan for development of all or a portion (i.e. phase one or phase two, etc.) of the overall development shall be prepared and submitted to the Town of Northlake. This submittal shall generally include the information listed in Section 1.1.3.7 of the *i*SWM™ manual as applicable to Northlake, including:

1. Conformance with the Preliminary Storm Water Management Plan and Study.
2. Submission of detailed drainage calculations and detailed design plans.
3. The submission of a cover sheet signed by the Town indicating the approval of the detailed construction drawings for the proposed development is sufficient to clear a plat drainage study comment.
4. Final drainage studies shall be approved based on the submission of a signed cover sheet and drainage map with calculations from the approved engineering construction drawings. Where Town approval of construction plans is not required, the above information required for preliminary drainage studies, as well as construction plans for any drainage improvements, prepared according to criteria in the current Town of Northlake plan review checklists, shall be submitted.

5. Note that unless specifically approved in a Floodplain Development Permit issued through the Town, no work may be performed in the FEMA regulatory floodway without a FEMA-approved Conditional Letter of Map Revision (CLOMR). No development activities may occur in the FEMA regulatory floodplain without an approved Floodplain Development Permit.

Section 1.1.4 – Local Community Plan Review Responsibilities

FOR GUIDANCE

Section 1.1.5 – Local Government Responsibilities during Construction and Operation

ADOPTED WITH MODIFICATIONS

The Town of Northlake Process includes:

Construction Phase

1. Pre-construction Meeting - Where possible, a pre-construction meeting shall occur before any clearing or grading is initiated on the site. This step ensures that the owner-developer, contractor, engineer, inspector, and plan reviewer can be sure that each party understands how the plan will be implemented on the site.
2. Periodic Inspections - Periodic inspections during construction by Town of Northlake representatives. Inspection frequency may vary with regard to site size and location; however, monthly inspections are a minimum target.
3. Final Inspection - A final inspection is needed to ensure that the construction conforms to the intent of the approved design. Prior to accepting the infrastructure components, issuing an occupancy permit, and releasing any applicable bonds, the Town of Northlake will ensure that: (a) temporary erosion control measures have been removed; (b) storm water controls are unobstructed and in good working order; (c) permanent vegetative cover has been established in exposed areas; (d) any damage to natural feature protection and conservation areas have been mitigated; (e) conservation areas and buffers have been adequately marked or signed; and (f) any other applicable conditions have been met.
4. Record Drawings - Record drawings of the structural storm water controls, drainage facilities, and other infrastructure components will be provided to the Town of Northlake by the developer.

Maintenance

1. Maintenance Plan - If private maintenance is planned, a maintenance plan, prepared by the developer, will outline the scope of activities, schedule, costs, funding source, and responsible parties. Vegetation, sediment management, access, and safety issues will be addressed.
2. Ongoing Maintenance – it will be clearly detailed in the Final Storm Water Management Plan which entity has responsibility for operation and maintenance of all structural storm water controls and drainage facilities (see Town of Northlake Policy Statements regarding maintenance).
3. Annual Inspections - Annual inspections of private storm water management facilities will be conducted by the owner and the results will be provided to the Town of Northlake.

Section 1.1.6 – *i*SWM™ Site Plan Design Tools

FOR GUIDANCE

Section 1.2 – *integrated* Planning and Design Approach

ADOPTED WITH MODIFICATIONS

In general, the Town of Northlake currently follows the flood control and streambank protection components of the *integrated* planning and design approach. Streambank protection is a requirement in Northlake, but there is not a standard requirement to provide extended release detention for the streambank protection volume. Post construction water quality protection is not currently a standard requirement in Northlake. However, the Town encourages land developers to consider the use of post construction water quality measures.

Section 1.2.1 – Introduction

ADOPTED

Section 1.2.2 – Downstream Assessment

ADOPTED WITH MODIFICATIONS

The downstream assessment described in Section 2.1.9 of the *i*SWM™ Manual will include the necessary hydrologic and hydraulic analyses to clearly demonstrate that the limits of the Zone of Influence (Refer to *i*SWM™ Section 2.1.9.2) have been identified, and that along the drainage route to that location, these parameters are met:

- No new or increased flooding of existing insurable (FEMA) structures (habitable buildings).
- No significant (0.1') increases in flood elevations over existing roadways for the 2-, 10-, 25- and 100-year floods.
- No significant rise (0.1') in 100-year flood elevations, unless contained in existing channel, roadway, drainage easement and/or R.O.W.
- No significant increases (maximum 5%) in channel velocities for the 2-, 10-, 25- and 100-year floods. Post-development channel velocities cannot be increased above pre-development velocities, if they exceed the applicable maximum permissible velocity shown in *i*SWM™ Table 4.4-2. Exceptions to these criteria will require certified geotechnical/geomorphologic studies that provide documentation those higher velocities will not create additional erosion. If existing channel velocities exceed six (6) feet per second, no additional increase in velocities will be allowed.
- No increases in downstream discharges caused by the proposed development that, in combination with existing discharges, exceeds the existing capacity of the downstream storm drainage system.
- For watersheds of 100 acres or less at any proposed outfall, the downstream assessment may use the ten percent rule of thumb (as delineated in section 2.1.9.2 of the *i*SWM™ Manual) or a detailed study in order to determine the Zone of Influence.
- For all other watersheds, the Zone of Influence will be defined by a detailed hydrologic and hydraulic analysis.

Section 1.2.3 – Water Quality Protection

FOR GUIDANCE

Post construction water quality protection is not currently a standard requirement in Northlake. However, the Town encourages land developers to consider the use of post construction water quality measures.

Section 1.2.4 – Stream Bank Protection
ADOPTED WITH MODIFICATIONS

Streambank protection is a requirement in Northlake, but there is not a standard requirement to provide extended release detention for the streambank protection volume.

Section 1.2.5 – Flood Control
ADOPTED

Section 1.2.6 – *integrated* Watershed Planning
FOR GUIDANCE

Section 1.3 – *integrated* Site Design Practices
ADOPTED WITH MODIFICATIONS

This section provides general guidance for potentially reducing costs of storm water infrastructure construction and the negative impacts of development on flooding, stream stability and water quality. Numerous examples of *integrated* site design practices are included. Town of Northlake exceptions to this guidance are summarized below:

Section 1.3.4 – *integrated* Site Design Credits
FOR GUIDANCE

This section is not adopted by the Town of Northlake at this time. The Town of Northlake will be evaluating and developing an incentive program for preserving open space, incorporating natural drainage features, and providing special water controls in ways that improve and protect water quality. These incentives may take the form of additional flexibility in development standards or reductions in storm water utility fees that may apply after development.

Section 1.4 – *integrated* Storm Water Controls
FOR GUIDANCE

Section 1.4 and Chapter 5 of the *i*SWM™ Manual contain summaries, discussions and examples of storm water controls that can be implemented in land development to meet the goals of protecting water quality, minimizing streambank erosion, and reducing flood volumes. Although primarily oriented toward water quality issues, these storm water controls bring additional and valuable benefits for flood control and streambank protection. Many of the listed storm water control features and techniques enhance the aesthetics and value of land developments, as well as providing a drainage function, and are recommended for use in Northlake, when applicable.

Special storm water controls are not required for water quality treatment by the Town of Northlake at this time unless downstream conditions dictate. Although not mandated, the use of these storm water controls are recognized as inherently valuable for application in overall storm water management. The Town of Northlake encourages developers to use water quality storm water controls and will evaluate any proposed controls based on this section.

CHAPTER 2 – HYDROLOGIC ANALYSIS

Section 2.1 – Estimating Runoff

Section 2.1.1 – Introduction to Hydrologic Methods

ADOPTED WITH MODIFICATIONS

Water quality volume and stream bank protection volume applications are encouraged by the Town but not specifically required at this time. USGS and TxDOT equations are only allowed with the approval of the Town.

Table 2.1.1-1 – Only hydrograph methods may be used to compute design discharges for design of bridges with over 100 acres in contributing drainage area.

Table 2.1.1-2 – See modified version of Table 2.1.1-2 below (differences from *i*SWM™ Manual are in bold type).

Table 2.1.1-2 Constraints on Using Recommended Hydrologic Methods

Method	Size Limitations[1]	Comments
Rational	0 – 200 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems.
Modified Rational[2]	0 –200 acres	Method can be used for estimating runoff volumes for detention planning and conceptual design. **However, basin sizes larger than 25 acres must utilize a hydrograph routing method for final design**.
Unit Hydrograph **(SCS)**[3]	**Any Size**	Method can be used for estimating peak flows and hydrographs for all design applications.
Unit Hydrograph **(Snyder's)**[4]	> 100 acres	Method can be used for estimating peak flows and hydrographs for all design applications.
TXDOT Regression Equations[5]	10 to 100 mi^2	Method can be used for estimating peak flows for rural design applications **for comparison purposes only**.
USGS Regression Equations[5]	3 – 40 mi^2	Method can be used for estimating peak flows for urban design applications **for comparison purposes only**.
*i*SWMTM Water Quality Protection Volume Calculation[6]	Limits set for each Structural Control	Method used for calculating the Water Quality Protection Volume (WQv)

[1]Size limitations refer to the drainage basin for the storm water management facility (e.g., culvert, inlet). **These do not necessarily apply to master drainage plans**.
[2]Where the Modified Rational Method is used for conceptual sizing the engineer is cautioned that the method could underestimate the storage volume.
[3]This refers to SCS routing methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.
[4]This refers to the Snyder's routing methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.
[5]Use only with approval of TOWN.
[6]Not currently required by TOWN OF NORTHLAKE.

Section 2.1.2 – Symbols and Definitions

ADOPTED

Section 2.1.3 – Rainfall Estimation

ADOPTED WITH MODIFICATIONS

The rainfall intensities listed in the *i*SWM™ Manual for Denton County will be used throughout Northlake and its ETJ.

Section 2.1.4 – Rational Method

ADOPTED

Section 2.1.4.3 – Equations
ADOPTED

Section 2.1.4.4 – Time of Concentration
ADOPTED

Section 2.1.4.6 – Runoff Coefficient (C)
ADOPTED

Section 2.1.5 – SCS Hydrologic Method
ADOPTED

Section 2.1.5.2 – Application
ADOPTED WITH MODIFICATIONS

Town of Northlake allows the hydrograph routing method for subdrainage areas of any size but will not allow the Simplified Method, except as approved by TOWN. Figure 2.1.6-1 presents a sample computation sheet for presentation of unit hydrograph method results. This form should be completed even if the computations are performed on acceptable computer programs HEC-1 or HEC-HMS.

BY: DATE: CK'D: DATE:	LOSS RATE METHOD STREAM ROUTING		COMPUTATION SHEET HYDROLOGY BY UNIT HYDROGRAPH METHOD								SHEET 1 OF 1 SUBWATERSHED MAJOR WATERSHED JOB/FILE NO.:
ANALYSIS POINT	SUBWATER-SHED AREA (AC)	WATERSHED AREA (AC)	UNIT HYDROGRAPH COEFFICIENTS				PEAK DISCHARGES (CFS)				COMMENTS
			SCS METHOD		SNYDER'S METHOD						
			C_N	Lag (HR)	C_p	T_p (HR)	Q2	Q10	Q25	Q100	
1	2	3	4	5	6	7	8	9	10	11	12
REMARKS, SKETCHES AND COMPUTATIONS											

Figure 2.1.6-1 Computation Sheet – Hydrology by Unit Hydrograph Method

Section 2.1.5.7 – Simplified SCS Peak Runoff Rate Estimation
ADOPTED WITH MODIFICATIONS

Town of Northlake will not allow the simplified SCS method except as approved by the Town.

Section 2.1.5.8 – Example Problem 1
ADOPTED WITH MODIFICATIONS

Town of Northlake will not allow the simplified SCS method except as approved by the Town.

Section 2.1.6 – Snyder's Unit Hydrograph Method
ADOPTED

Section 2.1.6.2 – Application
ADOPTED WITH MODIFICATIONS

Figure 2.1.6-1 presents a sample computation sheet for presentation of unit hydrograph method results. This form should be completed even if the computations are performed on acceptable computer programs HEC-1 or HEC-HMS.

Section 2.1.6.3 – Urbanization Curves
ADOPTED WITH MODIFICATIONS

An alternative method to determine Snyder's Lag is to determine the time of concentration (travel time) by the methodology described in Section 2.1.5.6 and multiply this time of concentration by 0.6.

Section 2.1.7 – Modified Rational Method
ADOPTED

Section 2.1.7.2 – Design Equations
ADOPTED WITH MODIFICATIONS

An exception to the *i*SWM™ Method is that only "C" coefficients presented in *i*SWM™ Table 2.1.4-2 are allowed for use in the Modified Rational Method. The remaining methodology is allowed.

Section 2.1.8 – USGS and TxDOT Regression Methods
ADOPTED WITH MODIFICATIONS

The regression methods used in this Section will only be used for comparison of the reasonableness of other approved determinations, not for final results or design unless specifically approved by the Town.

Section 2.1.9 – Downstream Hydrologic Assessment
ADOPTED

Section 2.1.10 – Water Quality Protection Volume and Peak Flow
ADOPTED

Section 2.1.11 – Streambank Protection Volume Estimation
ADOPTED

Section 2.1.12 – Water Balance Calculations

ADOPTED

References

ADOPTED

CHAPTER 3 – HYDRAULIC DESIGN OF STREETS AND CLOSED CONDUITS

Section 3.1 – Storm Water Street and Closed Conduit Design Overview

Section 3.1.1 – Storm Water System Design

ADOPTED

Section 3.1.2 – Key Issues in Storm Water System Design

ADOPTED

Section 3.1.2.3 – Street and Roadway Gutter

FOR GUIDANCE

Section 3.1.2.4 – Inlets and Drains

FOR GUIDANCE

Section 3.1.2.5 – Closed Conduit Systems (Storm Drains/Sewers)

FOR GUIDANCE

Section 3.1.3 – Design Storm Recommendations

ADOPTED WITH MODIFICATIONS

The design storms presented in *i*SWM™ are replaced by the design storms required by Town of Northlake as follows:

Storm Sewer System

The design storm is a minimum 25-year for the closed conduit systems in residential and commercial areas and for thoroughfares. The 100-year storm is the design storm for the combination of the closed conduit and surface drainage system.

Runoff from the design closed conduit storm must be contained within the permissible spread of water in the gutter. The 100-year storm flow must be contained within the ROW. Adequate inlet capacity shall be provided to intercept surface flows before the street ROW capacity is exceeded. Note: The capacity of the underground system may be required to exceed the 25-year design closed conduit storm in order to satisfy the 100-year storm criteria.

Enclosed drainage systems for all street types shall be designed to contain the 25-year storm. The 25-year flow must not exceed curb depth. 100-year flows shall be contained within drainage easement and/or ROW. Safe overflow routing with supporting calculations shall be provided and indicated on plans. Grading plans must accommodate the necessary capacities to contain the 100-year flow within the street right-of-way or drainage easements.

The closed conduit HGL must be equal to or below the gutter line for pipe systems and one (1) foot or more below top of curb at inlets. For situations where no ROW exists, the 100 year HGL must be below finished ground. The 100-year HGL will be tracked carefully throughout the system and described in the hydraulic calculation tables (Fig. 3.2.4-4) in the construction drawings.

Roadway ditches shall be designed to convey the 100-year storm within the limits of the 4:1 ditch and within the ROW or easement.

Driveway culverts shall be installed at all driveways to allow the storm drainage to pass underneath the driveway. The Driveway culvert shall be designed to convey the 100-year storm.

Sump Inlets

In sag or sump conditions, the storm drain and sump inlets should be sized to intercept and convey the 25-year storm, provided that a positive overflow is provided for the remainder of the 100-year storm. When the overflow route is between residential lots or otherwise constricted, the positive overflow structure must be concrete or other acceptable non-earthen structure with a minimum bottom width of 6 feet extending from the sump inlet to the storm sewer outfall. If the upstream pipe already conveys more than 25-year peak discharge, then the downstream pipe must have at least the same capacity from sump to outfall, and an inlet must still be installed at sump to allow for emergency overflow. In the event that a structural overflow is not practical, then the underground system must be sized to convey the 100-year storm.

Section 3.2 – On-Site Flood Control System Design

Section 3.2.1 – Overview

ADOPTED WITH MODIFICATIONS

The portion of Section 3.2.3 dealing with Flow Spread Limits is an exception to the *i*SWM™ requirements. Portions of Sections 3.2.5, 3.2.6 and 3.2.7 are specific Town of Northlake requirements rather than the *i*SWM™ requirements. The forms presented herein will be used to document all closed conduit calculations even if calculations are actually performed on an acceptable computer program unless otherwise approved by the Town.

Section 3.2.1.2 – General Criteria

ADOPTED WITH MODIFICATIONS

Flow Spread Limits

The requirements for the Town of Northlake's typical urban street sections are presented in Table 3.1.3-1 below. Rural street sections are not shown because those street sections are non curbed and drainage is taken to roadway ditches.

Table 3.1.3-1 Typical Street Sections and Storm Sewer Criteria

Street Type	Back to Back Width (ft)	Section Type	Closed Conduit Design Storm	Inlet Type	
				Recessed or Non-Recessed	Depressed or Non-Depressed
Local Residential (L2U-U)	31	Parabolic	25 yr	Non-Recessed	Depressed
Local Collector (C2U-U)	37	Parabolic	25 yr	Non-Recessed	Depressed
Minor Arterial – Undivided (M2U-U)	41	Parabolic	25 yr	Recessed	Depressed
Minor Arterial – Undivided (M4U-U)	51	Parabolic	25 yr	Recessed	Depressed
Minor Arterial – Divided (M4D-U)	28/28*	Straight Crown	25 yr	Recessed	Depressed
Principal Arterial - Divided (P6D-U)	40/40*	Straight Crown	25 yr	Recessed	Depressed

* Each Side

Must use roadway sections as approved by Town of Northlake. See the Engineering Design Manual and the "Standard Construction Details" for drawings of these sections. Permissible spread of water for a 10-year frequency event will be limited to the following:

Local Residential – Six inch (6") depth of flow at curb or no lanes completely clear.
Collector – One traffic lane to remain clear down the center of the pavement.
Minor Arterial – One traffic lane in each direction to remain clear.
Principal Arterial – One traffic lane in each direction to remain clear.

Section 3.2.2 – Symbols and Definitions

ADOPTED

Section 3.2.3 – Street and Roadway Gutters

ADOPTED

Section 3.2.4 – Storm Water Inlets

ADOPTED

Section 3.2.5- Grate Inlet Design

ADOPTED WITH MODIFICATIONS

Grate inlets on grade are not permitted by the Town of Northlake.

Section 3.2.6 – Curb Inlet Design

ADOPTED WITH MODIFICATIONS

Curb inlets on grade **without depression** are not permitted by the Town of Northlake.

Section 3.2.6.2 – Curb Inlets in Sumps

ADOPTED WITH MODIFICATIONS

In order to accommodate the standard curb inlet configuration presented in Northlake's "Standard Construction Details", the following supplement to Section 3.2.4.1 of *i*SWM™ from Hydraulic Engineering Circular 22 by FHA (August, 2001) is presented.

The weir for a depressed curb-opening inlet is at the edge of the gutter and the effective weir length is dependent on the width of the depressed gutter and the length of the curb opening. The weir location for a curb-opening inlet that is not depressed is at the lip of the curb opening and its length is equal to that of the inlet.

The equation for the interception capacity of a depressed curb-opening inlet operating as a weir is:

$$Q_i = C_w (L + 1.8\ W)\ d^{1.5} \qquad (4\text{-}28)$$

where:

C_w = 1.25 (2.3 In English Units)
L = length of curb opening, m (ft)
W = lateral width of depression m (ft)
d = depth at curb measured from the normal cross slope, m (ft), i.e., d = T S_x

The weir equation is applicable to depths at the curb approximately equal to the height of the opening plus the depth of the depression. Thus, the limitation on the use of equation 4-28 for a depressed curb-opening inlet is:

$$d \leq h + a/(1000) \qquad (d \leq h + a/12, \text{ in English units}) \qquad (4\text{-}29)$$

where:

h = height of curb-opening inlet, m (ft)
a = depth of depression, mm (in)

Section 3.2.7 – Combination Inlets

ADOPTED WITH MODIFICATIONS

Combination inlets on grade are permitted only by Town approval.

Section 3.2.8 – Closed Conduit Systems

ADOPTED WITH MODIFICATIONS

Materials

Only reinforced concrete pipe is allowed within public rights of way in the Town of Northlake.

HDPE/CPVC pipe is permitted for use in private developments only.

In selecting roughness coefficients for concrete pipe, consideration will be given to the average conditions at the site during the useful life of the structure. The 'n' value of 0.015 for concrete pipe shall be used primarily in analyzing old sewers where alignment is poor and joints have become rough. If, for example, concrete pipe is being designed at a location where it is considered suitable, and there is reason to believe that the roughness would increase through erosion or corrosion of the interior surface, slight displacement of joints or entrance of foreign materials. A roughness coefficient will be selected which in the judgment of the designer, will represent the average condition. Any selection of 'n' values below the minimum or above the maximum, either for monolithic concrete structures, concrete pipe or HDPE, will have to have written approval of the Town.

The following recommended coefficients of roughness are listed in Table 3.2.8-3 and are for use in the nomographs contained herein, or by direct solution of Manning's Equation.

Table 3.2.8-3 Manning's Coefficients for Storm Drain Conduits*	
Type of Storm Drain	**Manning's n**
Concrete Pipe (Design n = 0.013)	0.012-0.015
Concrete Boxes (Design n = 0.015)	0.012-0.015
*NOTE: Actual field values for conduits may vary depending on the effect of abrasion, corrosion, deflection, and joint conditions.	

Full or Part Full Flow in Storm Drains

All storm drains shall be designed by the application of the Continuity Equation and Manning Equation either through the appropriate charts or nomographs or by direct solutions of the equations as follows:

$Q = A\ V$, and

$Q = \frac{1.486}{n} A\ r^{2/3}\ S_f^{1/2}$, where

Q = Runoff in cubic feet per second.

A = Cross-sectional area of pipe or channel.

V = Velocity of flow.

n = Coefficient of roughness of pipe or channel.

r = Hydraulic radius = $\frac{A}{P}$

S_f = friction slope in feet per foot in pipe or channel.

p = Wetted perimeter.

The size of pipe required to transport a known-quantity of storm runoff is obtained by substituting known values in the formula. In practice, the formula is best utilized in the preparation of a pipe flow chart which interrelates values of runoff, velocity, slope and pipe geometry. With two of these variables known or assumed. The other two are quickly obtained from the chart. A pipe flow nomograph for circular conduits flowing full graphs is shown in *i*SWM™ Figure 3.2.16. Nomographs for flow in conduits of other cross-sections are available in TxDOT Hydraulic Design Manual, dated March 2004, Chapter 6, Section 2. For circular conduits flowing partially full, graphs are presented in *i*SWM™ Figure 3.2-18a.

Hydraulic Gradient and Profile of Storm Drain

In storm drain systems flowing full (or partially full as discussed above) all losses of energy through resistance with flow in pipes, by changes of momentum or by interference with flow patterns at junctions, must be accounted for by accumulative head losses along the system from its initial upstream inlet to its outlet. The purpose of accurate determinations of head losses at junctions is to include these values in a progressive calculation of the hydraulic gradient along the storm drain system. In this way, it is possible to determine the water surface elevation which will exist at each structure. The rate of loss of energy through the storm drain system shall be represented by the hydraulic grade line. Since the hydraulic grade line measures the pressure head available at any given point within the system.

The hydraulic grade (HG) line shall be established for all storm drainage design in which the system operates under a head. In open channels, the water surface itself is the hydraulic grade line. The

hydraulic grade line is often controlled by the conditions of the sewer outfall; therefore, the elevation of the tailwater pool must be known. The hydraulic gradient is constructed upstream from the downstream end, taking into account all of the head losses that may occur along the line. *i*SWM™ Section 3.2.8.10 provides a table of coincident design frequencies to assist with tailwater determination. The hydraulic gradient shall begin at the higher of the tailwater pool or depth of flow in the pipe at the downstream end.

All head losses shall be calculated as if the storm drain system is in a sub critical flow regime whether the system is flowing partially full or surcharged. Hydraulic calculations shall reflect partially full pipe where appropriate. Supercritical flow is allowed in main lines only with the approval of the Town. If the system is in supercritical regime the section should be marked "SUPERCRITICAL FLOW." The presence of supercritical regime should be confirmed by analyzing from downstream as well as upstream.

The friction head loss shall be determined by direct application of Manning's Equation or by appropriate nomographs or charts as discussed in the first paragraph of this subsection. Minor losses due to turbulence at structures shall be determined by the procedure described in Section 3.2.8.11 of the *i*SWM™ manual. All HG calculations will be carried upstream to the inlet.

The hydraulic grade line shall in no case be above the surface of the ground or street gutter for the design storm. Allowance of head must also be provided for future extensions of the storm drainage system. In all cases the maximum HGL must be 12" below top of curb at any inlet.

Section 3.3 – General Design and Construction Standards

LOCAL CRITERIA SECTION ONLY

Utilities

In the design of a storm drainage system, the engineer is frequently confronted with the problem of crossings between the proposed storm drain and existing or proposed utilities such as water, gas and sanitary sewer lines. The Town of Northlake prefers a minimum of 2 feet of clearance with all conflicting utilities. All utilities in the vicinity of a proposed storm drain shall be clearly indicated on both plan and profile sheets.

Single Family Lot Grading

All single family lots shall be graded such that the lots are higher than the street. Lots shall be graded to allow all drainage towards public rights of way or drainage easements. Lots shall be graded to avoid lot to lot drainage.

Headwalls, Culverts, and Other Structures

For headwalls, culverts and other structures, Standard Construction Details adopted by the Town of Northlake shall be used. The appropriate detail sheets for non-standard structures should be included in any construction plans. All headwalls and culverts should be extended to or beyond the street right-of-way. Sloped headwalls shall be used to the greatest extent possible.

Roadway Ditch Design & Driveway culverts

In the rural typical sections, ditches along the sides of the road will convey storm drainage.

Driveway culverts shall be installed at all driveways to allow the storm drainage to pass underneath the driveway. Minimum pipe size for the driveway culvert shall be 18" and shall be reinforced concrete pipe.

Unless otherwise approved by the Town, all headwalls on all driveway culverts shall be sloped headwalls per the City standard sloped headwall.

Roadway ditches shall utilize the Manning's n values as shown in *i*SWM™ adopted table 4.4-2. Values shall be in the "Minor Natural Streams" range from 0.030 to 0.050.

Roadway ditches shall be analyzed for capacity with the rougher of two Manning's n values and analyzed for velocity with the smoother of the two Manning's n values.

Minimum Pipe Sizes and Depths

Minimum pipe sizes are 24" diameter for mains and 18" diameter for inlet leads. Minimum pipe size for lead lines to sag inlets shall be 24". Minimum depth of storm sewer from outside top of conduit to top of curb/pavement is 24 inches.

Pipe Connections and Curved Alignment

Prefabricated wye (45-degree or 60-degree) connections supplied by the pipe manufacturer are required. Manholes are required at Tee intersections. Pipes with beveled joints or "radius" shall be used when pulled joints exceed manufacturer limits. However, designers should use bends or large radius curves where practical. When field connections or field radii must be used, all joints and gaps must be fully grouted with a collar to prevent voids and cave-ins caused by material washout into the storm drain.

Inlets

Curb inlets shall be 10, 15 or 20 feet in length and shall have depressed openings. Recessed inlets shall be provided on minor arterials and principal arterials as described in Table 3.1.3-1. Proposed inlet lengths greater than 20 feet must be approved by the Town. Care should be taken in laying out inlets to allow for adequate driveway access between the inlet and the far property line.

Due to excessive clogging, grate inlets are not allowed on public storm drain except as specifically approved by the Town.

Streets

To minimize standing water, the minimum street grade shall be 0.50%. Along a curve, this grade shall be measured along the outer gutter line. The minimum grade along a cul-de-sac or eyebrow gutter shall be 0.50%. Alternatively, elbows may be designed with a valley gutter along the normal outer gutter line, with two percent cross slope from curb to the valley gutter. The minimum grade for any valley gutter shall be 0.50%. Where a crest or sag is designed on a residential street, a PVI shall be used instead of a vertical curve where the total gradient change is no more than one percent ($\Delta \leq 1.0\%$).

Flow in Driveways and Intersections

At any intersection, only one street shall be crossed with surface drainage and this street shall be the lower classified street. Where an alley or street intersects a street, inlets shall be placed in the intersecting alley or street whenever the combination of flow down the alley or intersecting street would cause the capacity of the downstream street to be exceeded. Inlets shall be placed upstream from an intersection whenever possible. Surface drainage from a 25-year event may not cross any street classified as a thoroughfare or collector. Not more than 5.0 cfs in a 25-year event may be discharged per driveway at a business, commercial, industrial, manufacturing, or school site. Also, not more than 5.0 cfs may be discharged in a 25-year event from a street intersection with a major collector or arterial. In all cases, the downstream storm drainage system shall be adequate to collect and convey the flow and inlets shall be provided as required.

The cumulative flows from existing driveways shall be considered and inlets provided as necessary where the flow exceeds the specified design capacity of the street.

Storm Drain Outfall Considerations

In the design of outfalls, the engineer should consider discharge flow conditions, conduit size and shape, existing and future site conditions, soil characteristics, and flow conditions of the receiving stream.

The outfall flowline should match the flowline of the receiving stream. Because of height restrictions, it is sometimes necessary to terminate the conduit at the floodplain fringe and have a channel extend to the stream flowline. Outfall velocities should not exceed the following:

Channel Material	Mean channel Velocity (fps)
Fine Sand	2.0
Course Sand	4.0
Fine Gravel	6.0
Clay	6.0
Grass-lined channel (Slope < 5%)	6.0
Concrete	15.0

Velocities which exceed this amount shall be treated with erosion control to a point where the velocity slows to the above values. In addition, outfalls with velocities of 9 to 15 fps shall have engineered energy dissipaters. Outfall velocities exceeding 15 fps shall not be permitted.

Storm Drain Access Points

Manholes shall be located at vertical changes in grade and no greater than 500' apart in storm drain lines less than 6' in diameter or height and no greater than 1,000' apart in larger conduits.

Storm Drain Profiles

All storm drain lines shall be profiled.

Storm Drain Velocity

Storm drain velocities shall not be less than 2.0 fps (assuming uniform open channel flow), nor greater than 15.0 fps under pressure flow.

Section 3.4 – Easements for Closed Conduit Systems

LOCAL CRITERIA SECTION ONLY

Minimum easement requirements for storm sewer pipe shall be as follows:

Table 3.4-1 Closed Conduit Easements

Pipe Size	Minimum Easement Width Required
36" and under	15 Feet
42" through 54"	20 Feet
60" through 66"	25 Feet
72" through 102"	30 Feet

The outside face of the proposed storm drain line shall be placed at least five (5) feet off either edge of the storm drain easement. The proposed centerline of overflow swales shall normally coincide with the centerline of the easement.

Box culverts shall have an easement width equal to the width of the box plus twenty (20) additional feet. The edge of the box should be located at least five (5) feet from either edge of the easement.

Drainage easements will generally extend beyond an outfall headwall to provide for velocity dissipation devices and an area for maintenance operations. Drainage easements along a required outfall channel or ditch shall be provided until the flowline reaches an acceptable outfall.

References

ADOPTED WITH MODIFICATIONS

Texas Department of Transportation, March 2004, Hydraulic Design Manual, Austin, Texas.

CHAPTER 4 – HYDRAULIC DESIGN OF CULVERTS, BRIDGES, OPEN CHANNELS, AND DETENTION STRUCTURES

Section 4.1 – Storm Water Open Channels, Culverts, Bridges, and Detention Structure Design Overview

Section 4.1.1 – Storm Water System Design

ADOPTED

Section 4.1.2 – Key Issues in Storm Water System Design

ADOPTED

Section 4.1.3 – Design Storm Recommendations

ADOPTED WITH MODIFICATIONS

Roadway Culvert Design

100-year storm for fully developed watershed conditions.

Bridge Design

100-year storm for fully developed watershed conditions.

Open Channel Design

100-year storm for fully developed watershed conditions

Energy Dissipation Design

100-year design for fully developed watershed conditions.

Storage (Detention Basin Design)

2-year, 10-year, 25-year and 100-year storm for the critical storm duration (i.e. 3 hour, 6 hour or 24 hour duration) that results in the maximum (or near maximum) peak flow. Analysis should consider both existing watershed plus developed site conditions and fully developed watershed conditions.

Section 4.2 – Culvert Design

Section 4.2.1 – Overview

ADOPTED

Section 4.2.2 – Symbols and Definitions

ADOPTED

Section 4.2.3 – Design Criteria

ADOPTED WITH MODIFICATIONS

Town of Northlake requires a 100-year design storm for fully developed watershed with headwater (HW – upstream WSEL) 1’ below the adjacent curb. Only reinforced concrete culvert structures are acceptable.

Section 4.2.4 – Design Procedures

ADOPTED

Section 4.2.4.4 – Nomographs

ADOPTED WITH MODIFICATIONS

Nomographs are not allowed by the Town of Northlake for final sizing of culverts with drainage areas greater than 10 acres. The use of nomographs for culverts with drainage areas greater than 10 acres requires approval of the Town. The reference for nomographs is FHWA HDS-5. A backwater analysis using HEC-RAS is required for culverts with areas greater than 10 acres.

Section 4.2.5 – Culvert Design Example

ADOPTED WITH MODIFICATIONS

This procedure is acceptable for preliminary sizing of all culverts and final sizing of culverts with drainage areas of 10 acres or less unless approved by the Town.

Section 4.2.6 – Design Procedures for Beveled-Edged Inlets

ADOPTED WITH MODIFICATIONS

This procedure is acceptable for preliminary sizing only.

Section 4.2.7 – Flood Routing and Culvert Design

FOR GUIDANCE

Section 4.3 – Bridge Design

Section 4.3.1 – Overview

ADOPTED

Section 4.3.2 – Symbols and Definitions

ADOPTED

Section 4.3.3 – Design Criteria

ADOPTED

Section 4.3.3.2 – Freeboard

ADOPTED WITH MODIFICATIONS

In all cases the minimum allowable freeboard between the low cord on a bridge and the fully developed 100-year water surface elevation is 2'.

Section 4.3.4 – Design Procedures

ADOPTED WITH MODIFICATIONS

Backwater analysis will be required using HEC-RAS for any proposed bridge to determine accurate tailwater elevations, velocities, headlosses, headwater elevations, profiles and floodplains affected by the proposed structure. If the current effective FEMA model is a HEC-2 model, the engineer has the option to either use that model, or convert to HEC-RAS for analysis of proposed conditions.

Section 4.4 – Open Channel Design

ADOPTED WITH MODIFICATIONS

Normal Depth (Uniform Flow) vs. Backwater Profile Depths:

For uniform flow calculations, the theoretical channel dimensions, computed by the slope-area methods outlined in the *i*SWM™ manual, are generally to be used only for an initial dimension in the design of an

improved channel. Exceptions will be for small outfall channels (with the approval of the Town) meeting the following criteria:

1. Drainage area 10 acres or less.
2. Completely contained on the development site ;
3. No nearby downstream restrictions (no significant backwater effects).
4. Flow conditions consistent with uniform flow assumption.

The Town of Northlake requires a HEC-RAS backwater/frontwater analysis on any proposed open channel with a drainage area greater than 10 acres to determine the actual tailwater elevations, channel capacity and freeboard, and impacts on adjacent floodplains. If the current effective FEMA model for the stream is a HEC-2 model, the engineer has the option to either use that model, or convert to HEC-RAS for analysis of proposed conditions.

Supercritical Flow Regime

Supercritical flow will not be allowed except under unusual circumstances, with special approval of the Town. However, for lined channels the analysis should include a mixed-flow regime analysis, to make sure no supercritical flow occurs. Town of Northlake requires that the computed flow depths in designed channels be outside of the range of instability, i.e. depth of flow should be at least 1.1 times critical depth.

Channel Transitions or Energy Dissipation Structures or Small Dams

A HEC-RAS model is a standard requirement for design of channel transitions (upstream and downstream), energy dissipation structures, and small dams. A backwater analysis will be required by the Town, to determine accurate tailwater elevation, headlosses, headwater elevations and floodplains affected by the proposed transition into and out of an improved channel, any on-stream energy dissipating structures, and small dams (less than 6 feet). If the current effective FEMA model for the stream is a HEC-2 model, the engineer has the option to either use that model, or convert to HEC-RAS for analysis of proposed conditions. For larger dams, a hydrologic routing will be required, as well as hydraulic analysis, to determine impacts of the proposed structure on existing floodplains and adjacent properties.

Section 4.4.1 – Overview
ADOPTED

Section 4.4.2 – Symbols and Definitions
ADOPTED

Section 4.4.3 – Design Criteria
ADOPTED

Section 4.4.3.1 – General Criteria
ADOPTED WITH MODIFICATIONS

Earthen Channels

The Town of Northlake encourages the preservation of natural drainageways or use of constructed vegetated or permeable channels designed to create a more natural environment.

1. An earthen channel shall have a trapezoidal shape with side slopes not steeper than a 4:1 ratio and a channel bottom at least six (6) feet in width. Roadway ditches in rural paving sections are allowed to have a ‘V” ditch”.
2. One (1) foot of freeboard must be provided, within drainage easements, above the 100-year fully developed water surface elevation at all locations along channels.

3. The side slopes and bottom of an earthen channel shall be smooth, free of rocks, and contain a minimum of six (6) inches of topsoil. The side slopes and channel bottom shall be re-vegetated with grass or other acceptable vegetative material. No channel shall be accepted by the Town until a uniform (e.g., evenly distributed, without large bare areas) vegetative cover at least 2" in height with a density of 70% has been established.
4. Each reach of a channel requiring vehicular access for maintenance must have a ramp. In general, reaches with maintenance access ramps should be located between bridges or culverts but individual situations may vary. Ramps shall be at least ten (10) feet wide and have 15% maximum grade. Twelve-foot (12') width is required if the ramp is bound by vertical walls.
5. Minimum channel slope is 0.0020 ft/ft unless approved by the Town. Minimum slope for roadway ditches is 0.0050 ft/ft.
6. Erosion protection to be provided at upper limits of improvements and outfall to the receiving stream.
7. All improved earthen channels shall include either "Composite Low Flow" channel or "Trickle" channel. Criteria for each of these channels is as follows:
   a. Low Flow Composite Channels-
      1) Drainage area greater than 300 acres.
      2) Minimum design discharge - 2% of fully developed 100 year peak discharge.
      3) Maximum depth - 5 feet. Maximum side slope 4:1 (H:V).
      4) Minimum bottom width- 8 feet unless approved by the Town.
      5) Lined with riprap or gabions if design velocity exceeds 5 feet/second (also see *i*SWM™ sections 4.4.3 and 4.4.4).
      6) Some meanders in alignment acceptable as long as width of shelf between top of bank of low flow channel and toe of slope of main channel is not less than 10 feet. Minimum lateral slope of shelf is 1%.
   b. Trickle Channels-
      1) Drainage area less than or equal to 300 acres.
      2) Design discharge - 2% of fully developed 100 year peak discharge.
      3) Concrete or permeable armor such as gabions, mat or interlocking block-lined.
      4) Minimum bottom width- 8 feet unless approved by the Town.
      5) Maximum depth -5 feet. Maximum side slope dependent on type of lining.
8. The following guidelines shall be considered for buffer areas or zones along natural or constructed earthen channels:
   a. A minimum erosion control setback on each side of natural channels based on a 4:1 (H:V) slope from the bottom of the bank to the natural ground adjacent to the bank plus an additional 15 feet. See Figure 4.4.3-1.
   b. Include adjacent delineated wetlands or critical habitats.
   c. Other buffer widths will be considered if supported by specific engineering and environmental studies.
9. Landscaping shall be installed to allow earthen channels to evolve into a more natural environment. Tree or shrub plantings will be required to enhance habitat of channels by providing shade once mature plant growth has been reached. Mature plantings must be considered in setting design Manning's "n" values.

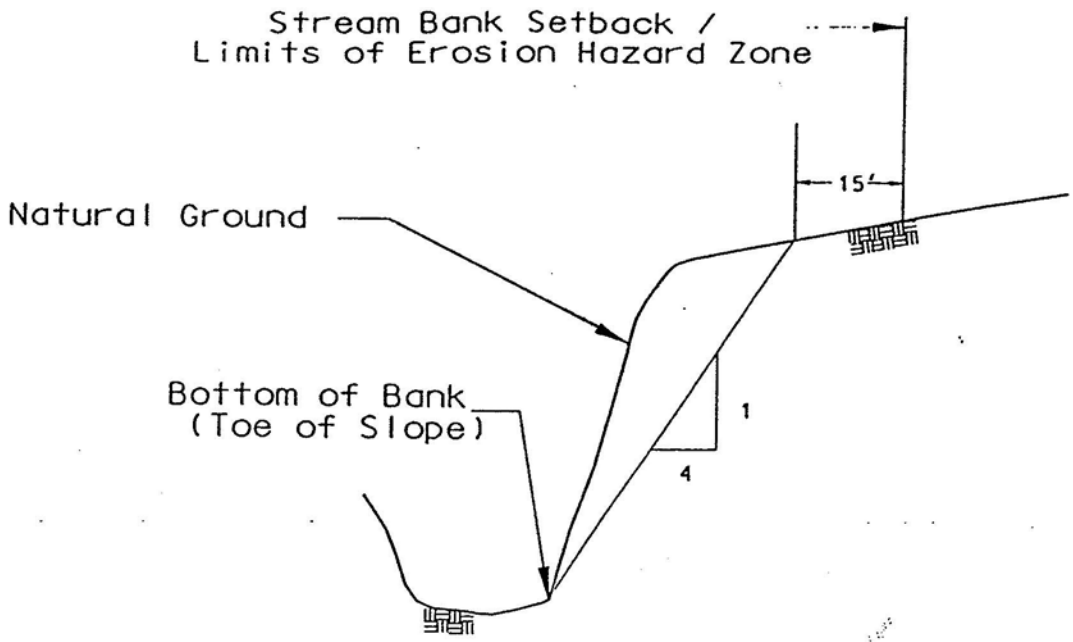

Figure 4.4.3-1 Minimum Erosion Control Setback

Lined Channels

In general, lined channels are discouraged and must have approval of the Town.

1. Channels shall be trapezoidal in shape and lined with reinforced concrete (or flexible lining material as approved by the Town). Side slopes shall generally be no steeper than 2:1 unless approved by the Town as appropriate for the lining material. The lining shall extend to and include the water surface elevation of the 100 year fully developed storm plus one foot freeboard.
2. The channel bottom must be a minimum of 8' in width. (A minimum bottom width of 6 feet for overflow structures of storm sewer system sumps or where access is not a concern).
3. The maximum water flow velocity in a lined channel shall be fifteen (15) feet per second except that the water flow shall not be supercritical in an area from 100' upstream from a bridge to 25' downstream from a bridge. Hydraulic jumps shall not be allowed from the face of a culvert to 50' upstream from that culvert. In general channels having supercritical flow conditions are discouraged (See Section 4.4).
4. Whenever flow changes from supercritical to subcritical channel protection shall be provided to protect from the hydraulic jump that is anticipated (see comment in Item 3).
5. The design of the channel lining shall take into account the super elevation of the water surface around curves and other changes in direction.
6. A chain link fence six (6) feet in height or other fence as approved by the Town may be required on each side of a lined channel.
7. The Town may require a geotechnical study and /or an underground drainage system design option prior to approval of concrete lined channels.

Soil Retention Blankets

Soil Retention Blankets will be required on all earthen side slopes and bottoms.
Excellent guidance is provided by the Texas Department of Transportation (TxDOT) concerning synthetic blankets and mats for use as slope protection and flexible channel liners. Annually, these products are tested and a list of acceptable products is published. It is recommended that applications in the project area be limited to those products on TxDOT's approved list. The current list is available at www.dot.state.tx.us/services/maintenance/erosion_control.htm. Most of these systems are proprietary and should be installed per the manufacturer's recommendations.

A soil retention blanket (SRB) is used for short and/or long-term protection of seeded and sodded slopes, ditches, and channels. SRB's can be manufactured out of wood, straw or coconut fiber mat, synthetic mat, paper mat, jute mesh or other material. The SRB shall be one of the following classes and types:

- Class 1. "Slope Protection"
  - Type A. Slopes 4(h):1(v) or flatter – Clay soils
  - Type B. Slopes 4(h):1(v) or flatter – Sandy soils
  - Type C. Slopes steeper than 4(h):1(v) – Clay soils
  - Type D. Slopes steeper than 4(h):1(v) – Sandy soils

- Class 1. "Flexible Channel Liner"
  - Type E. Shear Stress < 2 lbs./sf
  - Type F. Shear Stress < 4 lbs./sf
  - Type G. Shear Stress < 6 lbs./sf
  - Type H. Shear Stress < 8 lbs./sf
  - Type I. Shear Stress < 10 lbs./sf
  - Type J. Shear Stress < 12 lbs./sf

- Mulches 6:1 or flatter slopes
  - Clay or Tight Soils
  - Sandy or Loose Soils

Section 4.4.3.2 – Velocity Limitation

ADOPTED WITH MODIFICATIONS

Channel Velocities

Maximum allowable:

Lined Channels – Maximum velocities = 15 fps. (Exceptions can be granted by the Town, with justifiable, technical reasons)

Grass Lined Channels – Maximum velocities = 6 fps. Higher values can be justified by a sealed geotechnical study/analysis of soil type and conditions.

Section 4.4.4 – Manning's n Values

ADOPTED

Section 4.4.5 – Uniform Flow Calculations

ADOPTED

Section 4.4.6 – Critical Flow Calculations
ADOPTED

Section 4.4.7 –Vegetative Design
ADOPTED

Section 4.4.8 – Stone Riprap Design
ADOPTED

Section 4.4.8.1 – Introduction
ADOPTED WITH MODIFICATIONS

The "Method # 2" procedure in *i*SWM™ for stone riprap design is adopted by the Town of Northlake. Please note that Equation 4.4.16 in the *i*SWM™ Manual is INCORRECT and should be expressed as $T_0' = T_0*(1- (Sin^2\phi/Sin^2\theta))^{1/2}$. A properly designed geotextile is required under the bedding layer. Regardless of computed thickness the minimum allowable riprap thickness is 12 inches.

The Town of Northlake may allow grouted stone riprap as an erosion control feature. However, the design thickness of the stone lining will not be reduced by the use of grout. See the U.S. Army Corps of Engineers design manual ETL 1110-2-334 on design and construction of grouted riprap.

Section 4.4.8.2 – Method # 1: Maynard & Reese
FOR GUIDANCE

Section 4.4.8.3 – Method # 2: Gregory
ADOPTED

Section 4.4.8.4 – Culvert Outfall Protection
ADOPTED

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Section 4.4.9 – Gabion Design
ADOPTED

Section 4.4.10 – Uniform Flow - Example Problems
ADOPTED

Section 4.4.11 – Gradually Varied Flow
ADOPTED

Section 4.4.12 – Rectangular, Triangular and Trapezoidal Open Channel Design
ADOPTED

Section 4.5 – Storage Design
ADOPTED WITH MODIFICATIONS

Storm water detention is not a standard requirement in Northlake, but shall be provided to mitigate increased peak flows in Northlake waterways in specific circumstances. The purpose of the mitigation is to minimize downstream flooding impacts or streambank erosion from upstream development. In some instances, detention may be shown to exacerbate potential flooding conditions downstream. Therefore,

the “Zone of Influence” criteria (**Reference Section 2.1.9.2 of *i*SWM™) shall be applied in addition to these criteria.**

The Owner of any property upon which a Detention Facility is required to be developed, constructed, or used in order to satisfy the Town of Northlake’s requirements for drainage, shall be required to indemnify, defend and hold harmless the Town of Northlake, its officers, employees, and agents from any direct or indirect loss, damage, liability, or expense and attorneys’ fees for any negligence whatsoever, arising out of the design, construction, operation, maintenance, condition, or use of the “Detention Facility,” including any non-performance of the foregoing, in form and substance as required by the Uniform Development Code.

“Dry” Detention Basins

1. Detention Basins shall be required when downstream facilities within the “Zone of Influence” are not adequately sized to convey a design storm based on current Town criteria for hydraulic capacity. Detention basins may not be required if downstream improvements that will result in sufficient hydraulic capacity are proposed by the Town within a relatively short period of time.
2. Calculated proposed storm water discharge from a site shall not exceed the calculated discharges from existing conditions, unless sufficient downstream capacity above existing discharge conditions is available.
3. The Modified Rational Method is allowed for planning and conceptual design for watersheds of 200 acres and less. For final design purposes the Modified Rational Method is allowed only for watersheds of 25 acres and less (see Table 2.1.1-2).
4. Detention Basins draining watersheds over 25 acres shall be designed using a detailed unit hydrograph method acceptable to the Town of Northlake. These include Snyder’s Unit Hydrograph (>100 acres) and SCS Dimensionless Unit Hydrograph (any size). The SCS method is also allowed for basins with watersheds less than 25 acres (see Table 2.1.1-2).
5. Detention Basins shall be designed for the 2-year, 10-year, 25-year and 100-year storm for the critical storm duration (i.e. 3-hour, 6-hour, or 24-hour storm duration) that results in the maximum (or near maximum) peak flow.
6. Detention Basins shall be designed with access for tracked earthwork equipment with a 10-foot crown width on any embankment.
7. Earthen (grassed) embankment slopes shall NOT exceed 4:1. Concrete lined or structural embankment can be steeper with the approval of the Town.
8. A calculation summary shall be provided on construction plans. For detailed calculations of unit hydrograph studies, a separate report shall be provided to the Town for review and referenced on the construction plans. Stage-storage-discharge values shall be tabulated and flow calculations for discharge structures shall be shown on the construction plans.
9. An emergency spillway shall be provided at the 100-year maximum storage elevation with sufficient capacity to convey the fully urbanized 100-year storm assuming blockage of the closed conduit portion outlet works with six inches of freeboard. Spillway requirements must also meet all appropriate state and Federal criteria.
10. Design calculations will be provided for all spillways.
11. All detention basins shall be stabilized against significant erosion and include a maintenance plan.
12. State rules and regulations regarding impoundments shall be observed including 30 TAC Chapter 299, Dams and Reservoirs (TCEQ).
13. In accordance with Texas Water Code §11, all surface impoundments not used for domestic or livestock purposes must obtain a water rights permit from the TCEQ. A completed permit for the proposed use, or written documentation stating that a permit is not required, must be obtained. All detention facility designs shall include a landscaping plan.
14. Detention ponds shall maintain a minimum slope of 0.5% on the bottom to avoid silt build up.

"Wet" Detention Basins and Amenity Ponds

Wet detention basins maintain a permanent pool with additional storage capacity to detain storm water. Amenity ponds may or may not include this additional storage. The depth of a wet or amenity pond is generally seven (7) to ten (10) feet to prevent algal growth, although lesser depths are possible with artificial mixing. The objective is to avoid thermal stratification that could result in odor problems or recycling of nutrients. Gentle artificial mixing may be needed in small ponds because they are effectively sheltered from the wind. If properly designed, constructed, and maintained, wet ponds will not only reduce peak storm water flows, but also improve water quality and can be an attractive feature of a development.

Below are guidelines for wet detention basins in addition to those presented under "Dry" Detention Basins.

1. Must be appropriately aerated according to normal pool size unless specifically approved by the Town.
2. Provisions shall be made to ensure that normal water surface elevation is maintained through the use of ground wells or the Town water supply unless surface water supply can be justified based on drainage area to pond. (general requirement is 12 acres of drainage area for every acre-foot of normal pool storage).
3. Ten-foot (10') wide maintenance access shall be provided with a slope of 6:1 or flatter.
4. A debris filter must be provided for all outlet structures.
5. Design shall provide adequate capacity for trapped sediment for five (5) years.
6. To minimize short-circuiting, the inlet and outlet should be placed at opposite ends of the pond or baffling shall be installed to direct the water to the opposite end before returning to the outlet. Dead space should be avoided.
7. To limit water loss by infiltration through the bottom of the pond either an artificial liner or a clay liner may be used. Natural material may be used if a geotechnical report is provided to assure it will not leach out the bottom or sides of the pond.
8. Reference *i*SWM™ Section 5.2.21 "Storm Water Ponds" for additional guidance on the design of Wet Ponds. The water quality and streambank protection criteria described in this *i*SWM™ section are not currently required by the Town.
9. Detention ponds shall maintain a minimum slope of 0.5% on the bottom to avoid silt build up.

Section 4.5.1 – General Storage Concepts
ADOPTED

Section 4.5.2 – Symbols and Definitions
ADOPTED

Section 4.5.3 – General Storage Design Procedures
ADOPTED

Section 4.5.4 – Preliminary Detention Calculations
ADOPTED

Section 4.6 – Outlet Structures
ADOPTED

Section 4.7 – Energy Dissipation

Section 4.7.1 – Overview

ADOPTED WITH MODIFICATIONS

Channel Transitions, Energy Dissipation Structures, or Small Dams

A backwater analysis is required by the Town of Northlake, using HEC-RAS, to determine accurate tailwater elevation and velocities, headlosses, headwater elevations, velocities and floodplains affected by the proposed transition into and out of 1) An improved channel, 2) Any on-stream energy dissipating structures, and 3) Small dams (less than 6 feet). If the current effective FEMA model for the stream is a HEC-2 model, the engineer has the option to either use that model, or convert to HEC-RAS for analysis of proposed conditions. For larger dams, a hydrologic routing will be required, as well as hydraulic analysis, to determine impacts of the proposed structure on existing floodplains and adjacent properties.

Exceptions may be granted for small outfall channels (with the approval of the Town) with drainage areas of 10 acres or less and no nearby downstream restrictions.

Examples of Open Channel Transition Structures

Details and Specifications and application guidance for Harris County Flood Control District Straight Drop Structure and Bureau of Reclamation Baffled Chute (Basin IX) can be found in the Harris County Flood Control District Policy Criteria & Procedure Manual (See references section for description). A computer program associated with FHWA Hydraulic Engineering Circular No. 14 is "HY8Energy" dated May 2000. This program provides guidance in the selection and sizing of a broad range of energy dissipaters including some of those listed in Chapter 4 of the *i*SWM™ manual.

Section 4.7.2 – Symbols and Definitions

ADOPTED

Section 4.7.3 – Design Guidelines

ADOPTED

Section 4.7.4 – Riprap Aprons

ADOPTED

Section 4.7.5 – Riprap Basins

ADOPTED

Section 4.7.6 – Baffled Outlets

ADOPTED

Section 4.7.7 – Grade Control Structures

ADOPTED

Section 4.8 – Easements for Open Channels and Detention Ponds

LOCAL CRITERIA SECTION ONLY

Drainage Easement Criteria:

1. Drainage easements are required for both on-site and off-site public storm drain channels and ponds. Results of a backwater hydraulic analysis (plus freeboard) will determine easement requirements.

Buffer zones must also be provided for access and to guard against nuisances created from natural erosion processes. Also see Item 6 below.

2. Floodway/Drainage easements shall be provided on-site along FEMA streams with delineated floodways. Floodway easements shall encompass the entire area of the floodway shown on the Effective FEMA Flood Insurance Rate Map.
3. Drainage easements shall include a minimum of ten-foot (10') margin on both sides beyond actual top of bank for improved earthen channels. Retaining walls are not permitted within or adjacent to a drainage easement in order to reduce the easement width.
4. Natural creeks shall have a dedicated drainage easement encompassing the 100-year fully developed floodplain plus ten (10) feet on each side of this floodplain. The minimum finished floor elevation for lots impacted by natural creeks shall be a minimum of two (2) feet above the fully developed 100 year water surface elevation.
5. Concrete Lined Channels and Gabion Lined Channels shall have drainage easements dedicated to meet the requirements of the width of the channel, the one-foot freeboard above the 100 year fully developed water surface elevation, and any access routes. The minimum finished floor elevation for lots adjacent to Concrete Lined and Gabion Lined Channels shall be a minimum of two (2) feet above the fully developed 100 year water surface.
6. All detention and retention structures shall be located within drainage easements. Maintenance shall be provided by the developer/land owner. The Town of Northlake provides maintenance only on regional detention facilities. The limit of the easement shall include all freeboard as stated in Section 4.5 plus any access route around the perimeter of the facility.
7. The entire reach or each section of any drainage facility must be readily accessible to maintenance equipment. Additional easement(s) shall be required at the access point(s) and the access points shall be appropriately designed to restrict access by the public.

References

ADOPTED WITH MODIFICATIONS

Harris County Flood Control District, October 2004, Policy, Criteria and Procedure Manual for Approval and Acceptance of Infrastructure, Houston, Texas.

U.S. Army Corps of Engineers, August, 1992, Design and Construction of Grouted Riprap, ETL 1110-2-334.

U.S. Army Corps of Engineers, July 1991/June 1994, Hydraulic Design of Flood Control Channels, EM 1110-2-1601.

U.S. Department of the Interior Bureau of Reclamation , Hydraulic Design of Stilling Basins and Energy Dissipaters, January 1978, Engineering Monograph No. 25.

CHAPTER 5 - STORM WATER CONTROLS
FOR GUIDANCE ONLY

Chapter 5 of the *i*SWM™ Manual contains an exhaustive discussion and detailed examples of storm water controls that can be implemented in land development to meet the goals of protecting water quality, minimizing streambank erosion, and reducing flood volumes. It is an excellent planning and design resource document and has valuable design examples that the Town of Northlake encourages local developers to consider in their site planning. Although it is primarily oriented toward water quality issues, these storm water controls bring additional and valuable benefits for flood control and streambank protection. Many of the listed storm water control features and techniques enhance the aesthetics and value of land developments, as well as providing a drainage function.

Since the Town of Northlake is currently emphasizing the streambank protection and flood control components of the *integrated* storm water management approach, Chapter 5 of the *i*SWM™ Manual is being adopted for design guidance, technical reference, and applicable features that can be implemented in local developments and redevelopments. The Town of Northlake does not mandate the use of any of these storm water controls, but recognizes the inherent values of their application in overall storm water management.

Therefore the Town of Northlake adopts for design guidance and technical reference ONLY all sections of Chapter 5.

*i*SWM™ APPENDICES

Appendix A **Rainfall Tables for North Central Texas**
Adopted

Appendix B **Hydrologic Soils Data**
Adopted

Appendix C **Federal, State and Regional Regulations and Programs**
Adopted

Appendix D **Dams and Reservoirs in Texas**
Adopted

Appendix E ***i*SWM™ Worksheets and Checklists**
Adopted

Appendix F **Landscaping and Aesthetics Guidance**
Adopted

Appendix G **Storm Water Computer Models**
Adopted with Modifications

In addition to Storm Water Computer Models listed in Appendix G of the *i*SWM™ Manual, the Town of Northlake accepts appropriately applied versions of the following computer models.

1. STORMCAD by Haestad Methods and GeoPac by Bentley for analysis and design of storm sewer.

2. Gabion Design Programs by Maccaferri:

   a. Macra 1 for Channel Design

   b. GawacWIN for Retaining Wall Design

3. SWFHYD (formerly NUDALLAS) by Fort Worth District, U.S. Army Corps of Engineers for hydrologic routing studies (use only where model currently exists).

4. AdICPR (Advanced Interconnected Pond Routing) by Streamline Technologies, Inc. for complex hydrograph routing particularly detention ponds in series.

5. InfoWorks by Wallingford for complex dynamic hydrologic and hydraulic modeling.

Appendix H **Storm Water Control Design Examples**
Adopted