CITY OF CRYSTAL LAKE

Crystal Lake Watershed Stormwater Management Design Manual

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PURPOSE

The purpose of this document is to present guidance for the design of stormwater management systems within the Crystal Lake watershed. The overall goal of these guidelines is to protect the quantity and quality of water reaching Crystal Lake and also the shallow groundwater resource of the City of Crystal Lake and surrounding areas. Specific objectives are listed below.

- Allow no reduction in the quantity of water reaching Crystal Lake.
- Allow no water to reach Crystal Lake that will be of worse water quality than the existing water column quality in the lake.
- Protect the quality of the groundwater in the aquifers under the City of Crystal Lake.
- Ensure that stormwater infiltration designs are sustainable indefinitely.
- Provide a mechanism for long-term maintenance and, if necessary, repair of infiltration designs and the Crystal Lake Drainage District tile system.

BACKGROUND

The City of Crystal Lake is underlain by relatively unusual surficial geology that is a remnant of glacial activity tens of thousands of years ago. The movement of ice sheets across this area of northeastern Illinois and the flow of ice melt deposited a layer of sand and gravel whose thickness varies from tens to hundreds of feet (Figure 1.1). Groundwater typically lies from 10 to 40 feet below the ground surface within these permeable materials (Figure 1.2). An unsaturated zone of permeable materials exists above this groundwater "table" (the vadose zone). Precipitation infiltrates through surface soils and moves through this vadose zone to recharge shallow and deep aquifers.

Significant portions of the City of Crystal Lake also have artificial surface drainage systems in place in the form of field tiles for agricultural drainage and storm sewers for urban drainage (Figure 1.3).

The City of Crystal Lake has taken advantage of this high natural recharge potential to discharge stormwater into this vadose zone. This practice has helped to overcome natural surface drainage limitations in the relatively flat and potholed topography of the City. It also has helped to protect Crystal Lake from direct storm sewer discharges.

The City of Crystal Lake has invested heavily in the past to attain the protection of Crystal Lake. The development of the "Crystal Lake Watershed Resources Management Plan" by Bauer Engineering in 1975 was a far-sighted effort to analyze threats to Crystal Lake beneficial uses. The Plan also presented recommendations on how to address these threats. The principal concerns identified in the Plan were pollutants delivered from existing point sources and deterioration of the quantity and quality of water delivered to the lake as the result of new development in the watershed.

Crystal Lake is a very high quality mesotrophic lake fed mostly by shallow groundwater intercepted by field tiles. The existing water quality results from the fact that most of the lake's water supply is delivered indirectly through groundwater that has been filtered through glacial materials. Only about ten percent of the Crystal Lake watershed drains to the lake through storm sewers (Figure 1.3).

However, stormwater from existing land uses, particularly row crops, still results in poor water quality arriving upstream of the Lippold Wetland and Cove Pond wetland restorations. These two systems clean the water significantly but water reaching the lake from these two locations is well above the desirable in-lake concentration of 0.02 mg/l. Fortunately, high mineral and carbonate concentrations in the lake cause phosphorus to be precipitated before it can be used by algae. However, the buffering capability is not infinite and its limit is not currently known.

The lake also has experienced significant fluctuations in its water level due to variations in the quantity of groundwater it receives. These fluctuations are directly correlated with precipitation deficits below historic averages (Figure 1.4). Consequently, the three most significant concerns identified in the 1975 Watershed Plan (Bauer, 1975) were:

- Address existing water quality problem sources (principally discharges at that time from the sod farm (now Lippold Park) and Crystal Cove Pond);
- Address the threat to water quality of new surface discharges from development to Crystal Lake; and
- Address the threat to water levels from new development.

Crystal Lake and the Crystal Lake Park District have acted to address the existing water quality concerns by following Plan recommendations to convert Cove Pond and Lippold Park to wetland treatment units to retain runoff pollutants. The City of Crystal Lake also acted to adopt strict zoning regulations to limit the amount of impervious coverage in the Crystal Lake watershed to 5 to 20 percent (Figure 1.5). The City also enforced a policy of no new point source discharges to Crystal Lake. The zoning regulations were intended to be based in part on the natural infiltration rate of the soils above the highly permeable granular materials in the watershed. A comparison of the key recommendations of the Crystal Lake Resources Management Plan and these guidelines is presented in Appendix A.

Over the last 30 years, significant research and field experience have been accumulated on the character and treatment of urban stormwater runoff. The USEPA's Nationwide Urban Runoff Project studied the character of urban stormwater runoff in great detail across the country in the early 1980s. That effort also began to define the effectiveness of various Best Management Practices (BMPs) to control the pollutants in urban runoff to protect receiving water quality. More recently, a great deal of effort has been directed to define the effectiveness of low impact development (LID) techniques that attempt to control not only the quality of runoff but also to control the quantity of runoff by emphasizing reductions in impervious area and the interception, retention and infiltration of stormwater runoff.

Crystal Lake has long been in the LID business through its zoning ordinance and the use of stormwater infiltration using drywells. A 1979 report by the ISWS and the IEPA noted that the City has over 500 drywells, classified as Class V injection wells by the IEPA, in existence to manage stormwater. This was by far the largest number of any community in Illinois. Over the last five years, many parts of the country with highly permeable surficial geology are moving in the same direction as Crystal Lake. In the late 1990s, Washington State moved to require infiltration of stormwater from new development. Wisconsin adopted regulations in 2002 that also require infiltration where soils and geology are suitable. Kane County in northeastern Illinois requires retention and infiltration or filtration of the first 0.75 inches of runoff from new development.

FIGURE 1.1 - ISGS PROFILE

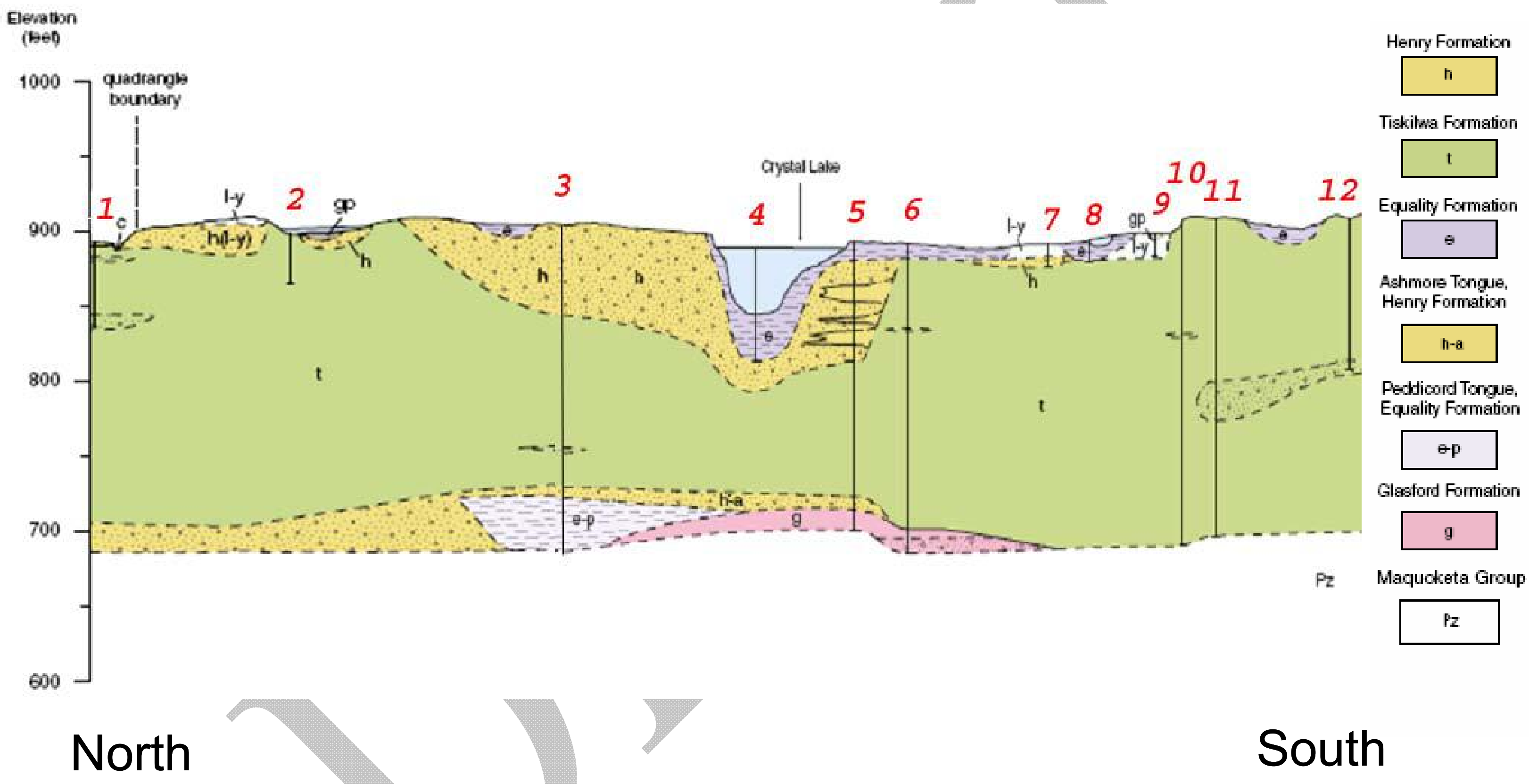


FIGURE 1.2 – CRYSTAL LAKE WATERSHED GROUNDWATER REGIME (ISWS, 1998)

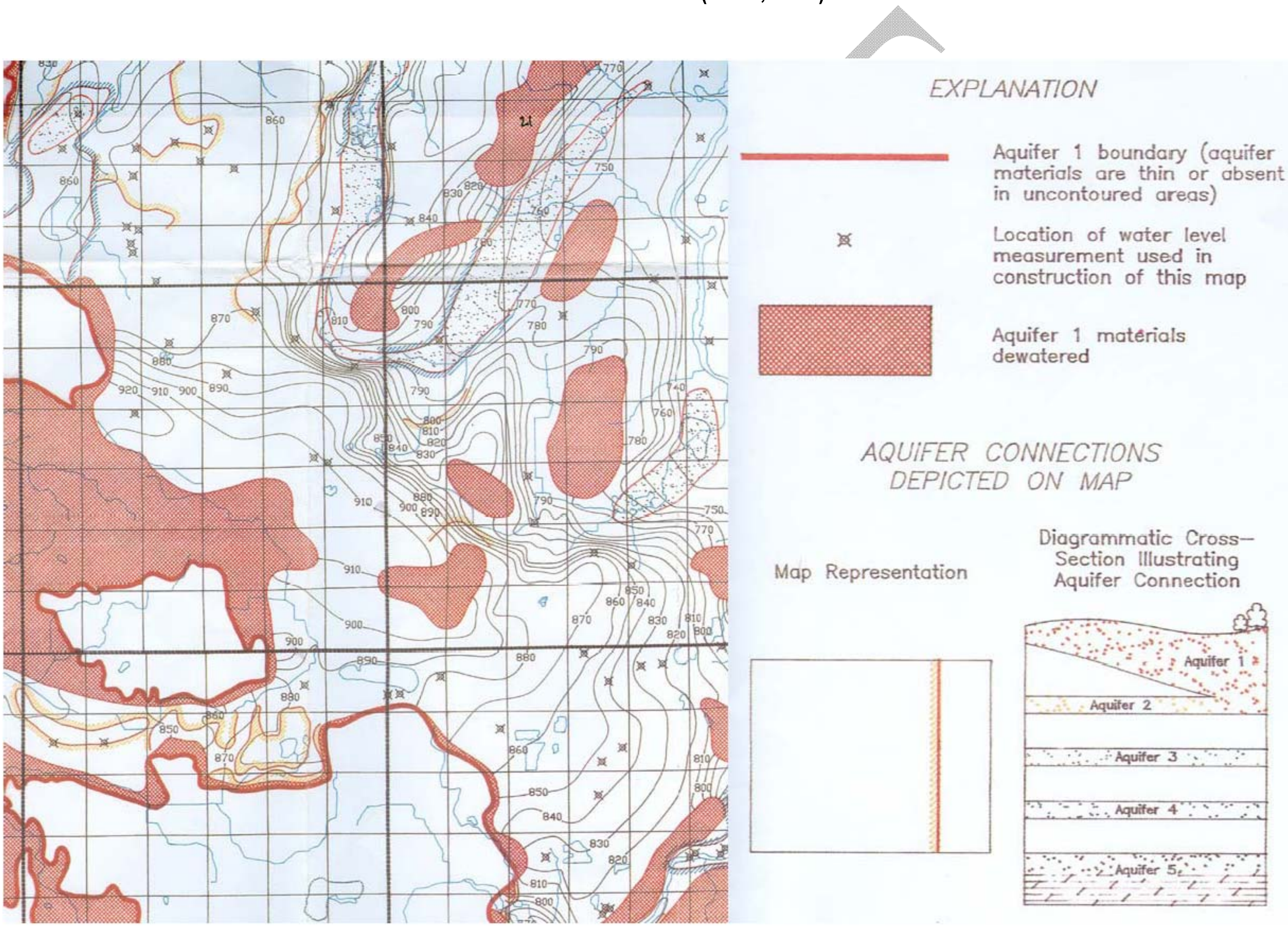
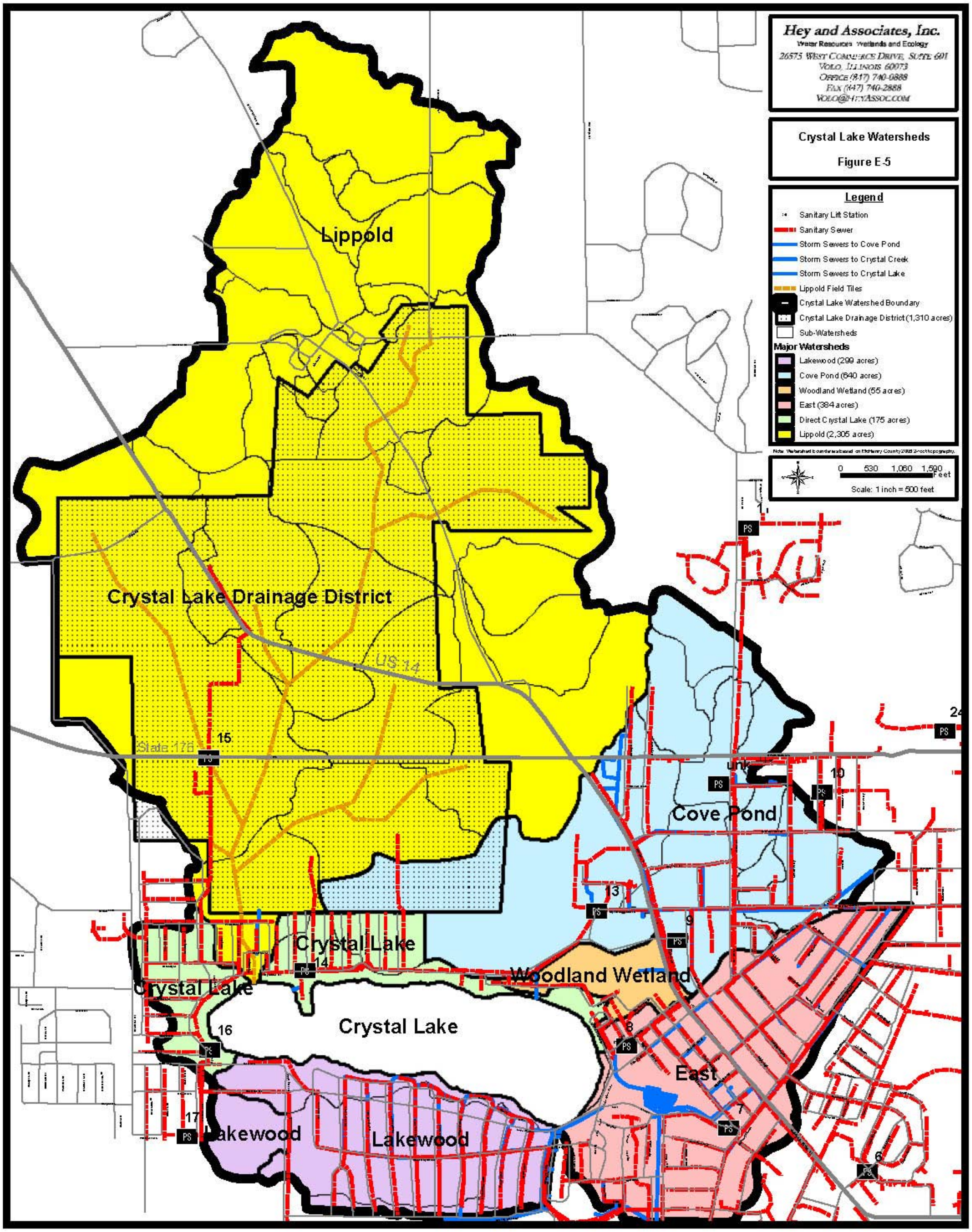
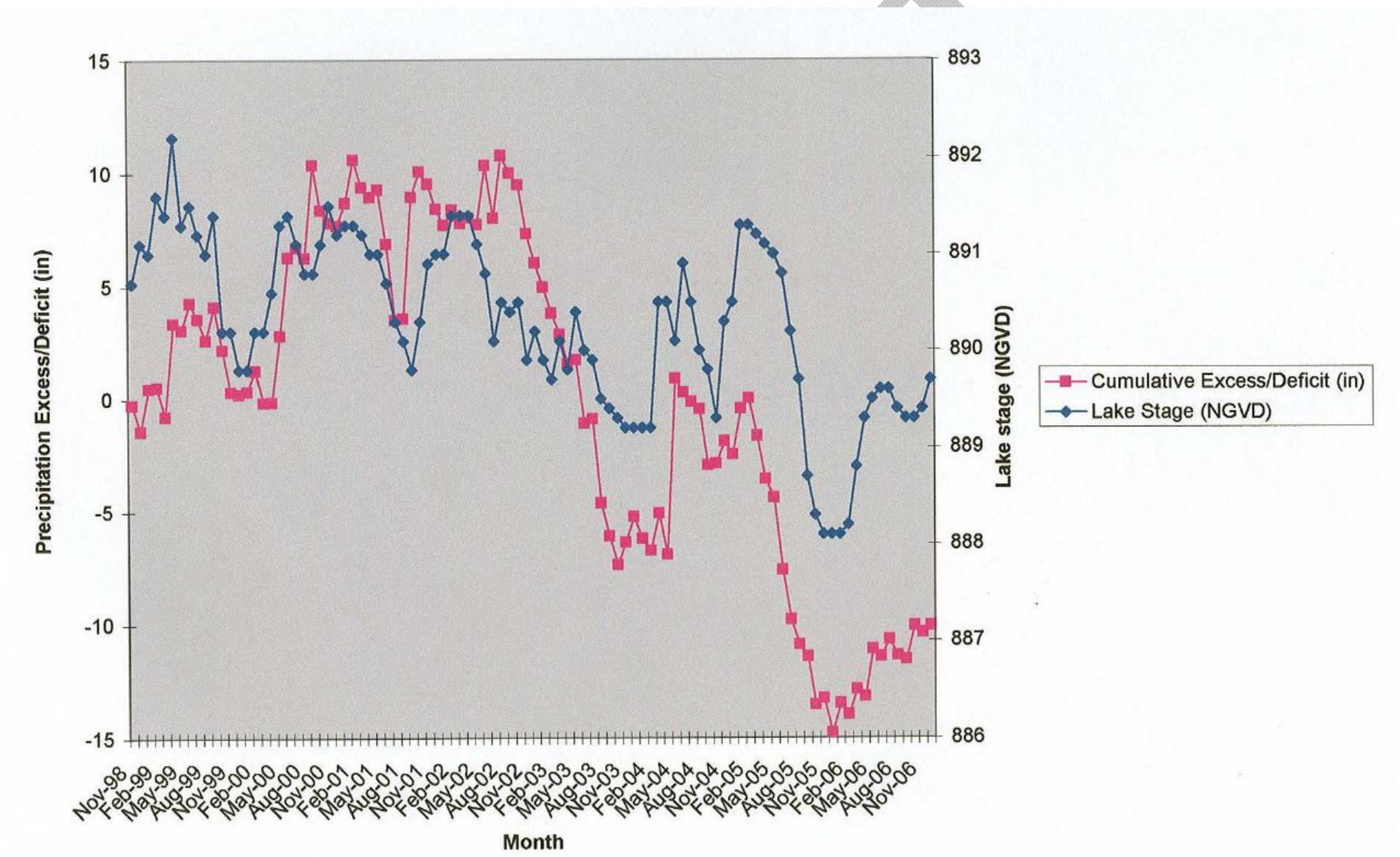


FIGURE 1.3 – TILE MAP



As a result of this extensive research and experience across the country, new design guidance is available to support development densities beyond the 5 to 20 percent originally stipulated to protect Crystal Lake. The City will use the guidance in this report as the basis for requests for densities beyond that currently allowed by ordinance. Developments that demonstrate compliance with these guidelines may be granted impervious coverage beyond the limits in the current zoning ordinance.

FIGURE 1.4 – CRYSTAL LAKE WATER LEVEL FLUCTUATIONS



CURRENT REGULATIONS

Zoning

The Crystal Lake Zoning Ordinance currently limits impervious coverage in zoning designations of "W" (Figure 1.5).

Crystal Lake Stormwater Ordinance

The Crystal Lake Stormwater Ordinance (CLSO) provides design regulations for both detention and infiltration basins. As previously mentioned, City policy is to prohibit new point source discharges in the Crystal Lake watershed, mandating infiltration to manage stormwater. Infiltration often is required in other portions of the City as well because of inadequate downstream drainage capacity and depressions that have no natural drainage outlet. The principal CLSO design criteria are as follows:

- Retention of 150 percent of the 100-year, 24-hour runoff volume
- The soil stratum proposed for infiltration must have a sustainable field measured infiltration rate of at least 0.5 in/hr
- The 100-year 24-hour event must infiltrate in no less than 72 hours
- The bottom of infiltration basins must be at least four feet above seasonally high groundwater
- Pretreatment water quality best management practices must be provided
- Class V injection wells must be at least 100 feet from any water supply well and 1000 feet from any public water supply well
- Class V injection wells must be at least 25 feet away from building foundations

The CLSO also contains a recommendation that new development minimize runoff volumes.

FIGURE 1.5 – ZONING CHART - Lot Area, Yard and Bulk Regulations

		Lot Size		Yards						Bulk					
		Area	Width	Front	Rear	Total Side	Minimum Side	Side Attributing Street	Abutting Res. Zone	Lot Coverage	F.A.R.	Height of Principal Use		Height of Accessory Use	
Zone	**Use**	Sq. Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	%	---	Ft.	St.	Ft.	St.
W	**Watershed Districts**														
W-1	Marsh Wetland	--	--	--	--	--	--	--	--	--	--	--	--	--	--
W-2	Farming	35 ac.	100	30	30	24	12	30	30	**5***	.10	25	3	60	3
W-3	Estate	15,000	100	30	30	24	12	30	30	**20***	.10	30	3	15	1
W-4	Estate	3 ac.	250	50	30	30	12	30	50	**20***	.10	30	3	15	1

DECLARATION OF INTENT

The Watershed Districts are areas zoned to maintain, protect, and preserve the water quality and natural recharge conditions of Crystal Lake which are located within the established boundaries as classified in the Crystal Lake Watershed Management Study and are to be consistent with the requirements of Table 1 of the Zoning Ordinance for "W-1", "W-2", "W-3", and "W-4" zoning districts.

DISTRICT RESTRICTIONS

A. All uses are subject to site specific analysis by the watershed consultant.
B. All uses, other than those identified as Principal Permitted Uses, shall be developed as PUDs and be consistent with the Comprehensive Land Use Plan.

PRINCIPAL PERMITTED USES

A. Apiary (bee keeping)
B. Farms and Farm House
C. Flower Garden/Greenhouse
D. Nursery or Orchards
E. Parks and Open Space
F. Single Family Dwellings on existing platted lots or parcels
G. Wild Life Preserves

CHAPTER 1.2 – CRYSTAL LAKE WATERSHED GROUNDWATER ENVIRONMENT

The Crystal Lake groundwater system is an interconnected system of soils overlying shallow aquifers located within glacial sand and gravel deposits (ISWS, 2000). Crystal Lake itself is a surface expression of a single shallow aquifer that extends from the lake to Ridgefield to the north (Figure 1.2). This aquifer ranges from several feet below the surface in wet periods to over ten feet below the surface in dryer periods. The level of this aquifer is controlled by the presence of the large CLDD farm tile network that covers most of the watershed of Crystal Lake (Figure 1.3). A similar network of aquifers also within sand and gravel deposits underlies the remainder of the City. A well-known example is Vulcan Lakes that is a former sand and gravel mine that exposed a large aquifer on the southeast corner of the City.

The shallow groundwater environment of Crystal Lake consists of an unsaturated zone (the vadose zone) overlying unconfined saturated aquifers. There also are deeper confined aquifers overlain by relatively impermeable layers of clay. A typical cross section of the Crystal Lake watershed and the complex series of interconnected aquifers located elsewhere in the City are shown in Figure 1.1 and Figure 1.2.

The introduction of stormwater runoff to these unsaturated and saturated zones by artificial means presents significant design problems. Under natural conditions, water would infiltrate through soils and then into the vadose zone and the CLDD tiles and flow to Lippold Park and the lake. The remainder (about 20 percent) would reach the saturated zone and move down gradient to Crystal Lake or recharge even deeper groundwater systems. This process allows seepage of water from depressions and significant contact time with vegetation and organic soil components.

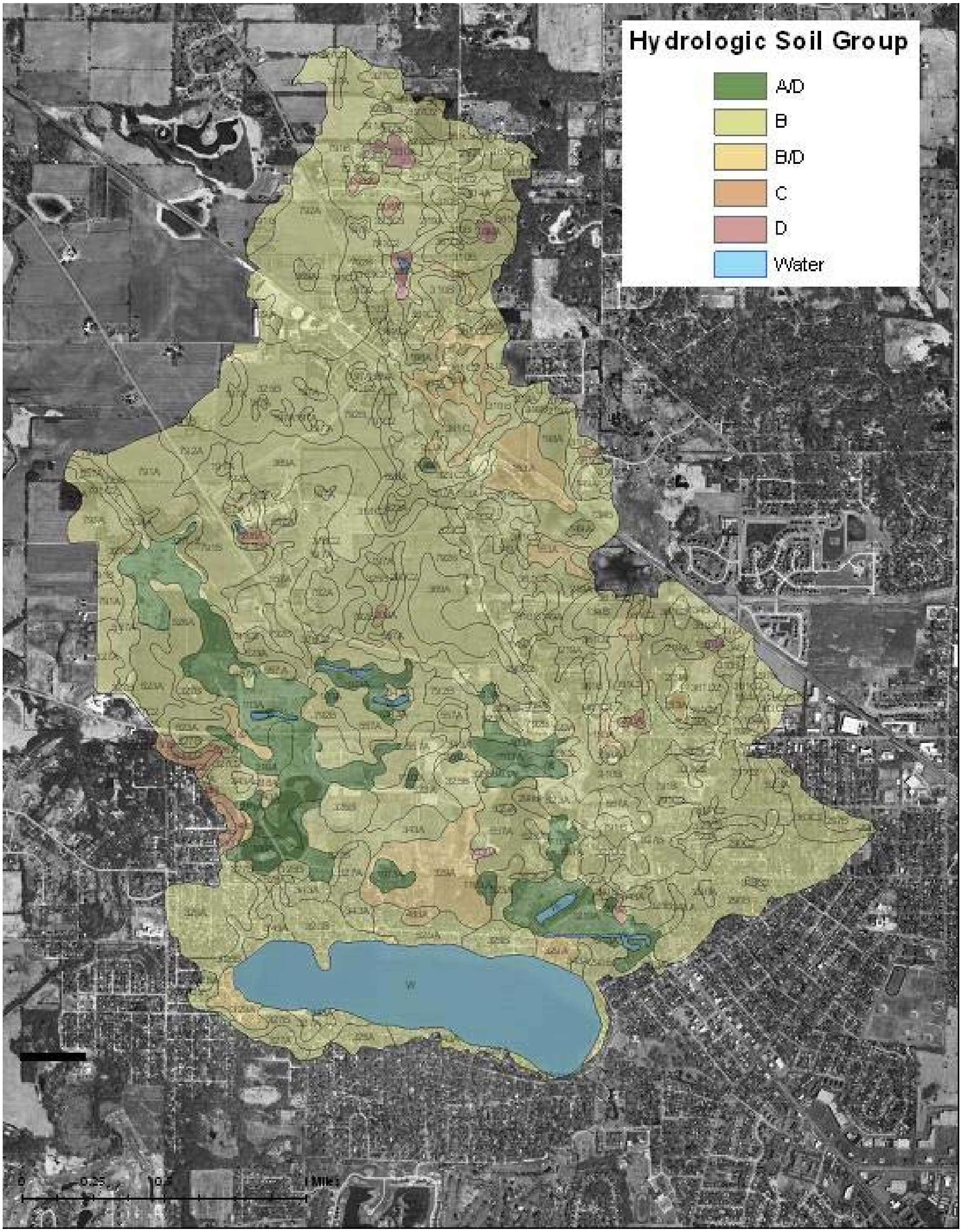
According to NRCS data, the infiltration rate of surface soils in the Crystal Lake watershed is rapid and varies from about 2 inches per hour to 6 inches per hour with subsoils at 20 inches per hour in many areas (NRCS, 2002) (Figure 1.6).

When development occurs, a significant portion of these soils is replaced with pavement and another significant portion can be compacted by earth moving activities even if they are intended to remain pervious areas. The net result of development is an increase in runoff volume due to reduced infiltration and a decrease in the area available for infiltration.

The natural soil infiltration rates of more than 1.0 inch per hour are fast enough to infiltrate the runoff from the 100-year, 24-hour storm over a 70 percent impervious site in afew days. To ensure that all runoff will continue to infiltrate, engineered infiltration basins are recommended to sustain the natural infiltration process.

The high iron and calcium concentrations of soils in the watershed act to remove phosphorus from stormwater runoff. Engineered designs must consider how the natural cleansing action of the soils and vegetation will be sustaineded. They also must plan for how new pollution threats such as soil erosion and urban runoff pollutants will be managed. Only then can this enhanced infiltration take place and stormwater runoff be introduced to shallow groundwater and ultimately Crystal Lake. The sustainability of these engineered systems must also be considered since, like natural systems, these infiltration designs are not always self-cleansing.

FIGURE 1.6 – NRCS SOILS MAP



CHAPTER 1.3 – STORMWATER MANAGEMENT IN THE CRYSTAL LAKE WATERSHED

DESIGN CRITERIA

As previously stated, the goal for stormwater management in the Crystal Lake watershed is to enhance the quantity and quality of groundwater reaching Crystal Lake. Chapter 1.1 presented specific stormwater management objectives. Chapter 1.2 presented the groundwater system that must be protected. The minimum requirements of the CLSO also must be met by new development. The result of these goals, objectives and regulations is to establish design criteria for management of stormwater runoff from new development in the watershed

These design criteria are as follows.

1. At least 95 percent of the annual stormwater runoff volume from new development should be infiltrated to protect the quality of water reaching Crystal Lake.
2. Prior to infiltration, all stormwater runoff should receive treatment as necessary to remove constituents that could pollute Crystal Lake. Pre-treatment ystems should be designed to discharge a total phosphorus concentration of no more than 0.10 mg/l prior to infiltration.
3. The volume of stormwater retention in an infiltration basin should never be less than that required for a surface discharge design.
4. Where no surface discharge or safe, deed restricted emergency overflow is available, the volume of a retention basin should be increased by 50 percent as a factor of safety. This increase should be obtained by expanding the area of the basin not its depth.
5. The maximum feasible portions of the pervious area of new development should be devoted to stormwater management.

Figure 1.7 shows the minimum amount of storage needed for detention or retention assuming a surface release. Figure 1.8 shows the portions of the Crystal Lake watershed that are unsuitable for surface discharge for events smaller than10-year, 24-hour recurrence under any circumstance. Figure 1.8 also shows the areas where events larger than 2-year, 24-hour recurrence may be discharged as surface runoff assuming downstream flooding will not be worsened. The basis for this design criteria is presented in Figure 1.9. Figure 1.9 shows that over 90 percent of the average annual surface runoff volume is generated by events less than the 2-year, 24-hour rainfall of 3.04 inches. For the 10-year, 24-hour rainfall event or 4.47 inches, the volume is 95 percent. These design criteria are intended to strike a balance between the need for safe, reliable low-maintenance surface discharge of stormwater and the need to protect the groundwater quantity and quality reaching Crystal Lake.

The maximum feasible pervious site area should be deed restricted and dedicated to storm water quality and quantity management in the Crystal Lake watershed. For highly impervious land uses this may require virtually all open space to be devoted to stormwater management. Floodprone and wetland areas may be counted for this purpose if they are integrated into the stormwater management plan.

DESIGN APPROACH

Figure 1.10 highlights the site development planning and stormwater management design process in the Crystal Lake watershed. The process guides developers to first evaluate the stormwater management capabilities of their sites before finalizing a land plan.

This is intended to prevent unrealistic expectations regarding density and land uses. The vast majority of sites in the Crystal Lake watershed have excellent infiltration capabilities but many have significant downstream drainage constraints. The highly permeable geology of the Crystal Lake watershed resulted in very poorly defined surface flow conveyance. However, some locations in the vicinity of Route 176 may have high groundwater that could make it impossible to meet the safe separation distance from the bottom of the infiltration basin without significant engineering.

The numerous depressions where runoff collects also present a challenge for new development. If they are within a development's boundaries, then 100-year, 24-hour storage must be conserved. If they are downstream, the development must manage its stormwater to prevent increases in off-site flood elevations.

Figure 1.10 points out the need for sites that propose significant impervious coverage to manage stormwater immediately where it falls. Minimization of first flush runoff volume, rather than pipes is recommended. The remaining stormwater is then collected in pre-treatment BMPs to remove total phosphorus to a maximum annual average of 0.10 mg/l. Only after these significant pre-treatment efforts is water allowed to be infiltrated through the vegetation and soil of the infiltration facility bottom and allowed to enter groundwater and the CLDD tile to Crystal Lake.

FIGURE 1.7 – DETENTION SIZING CHART (McHenry County, 2004)

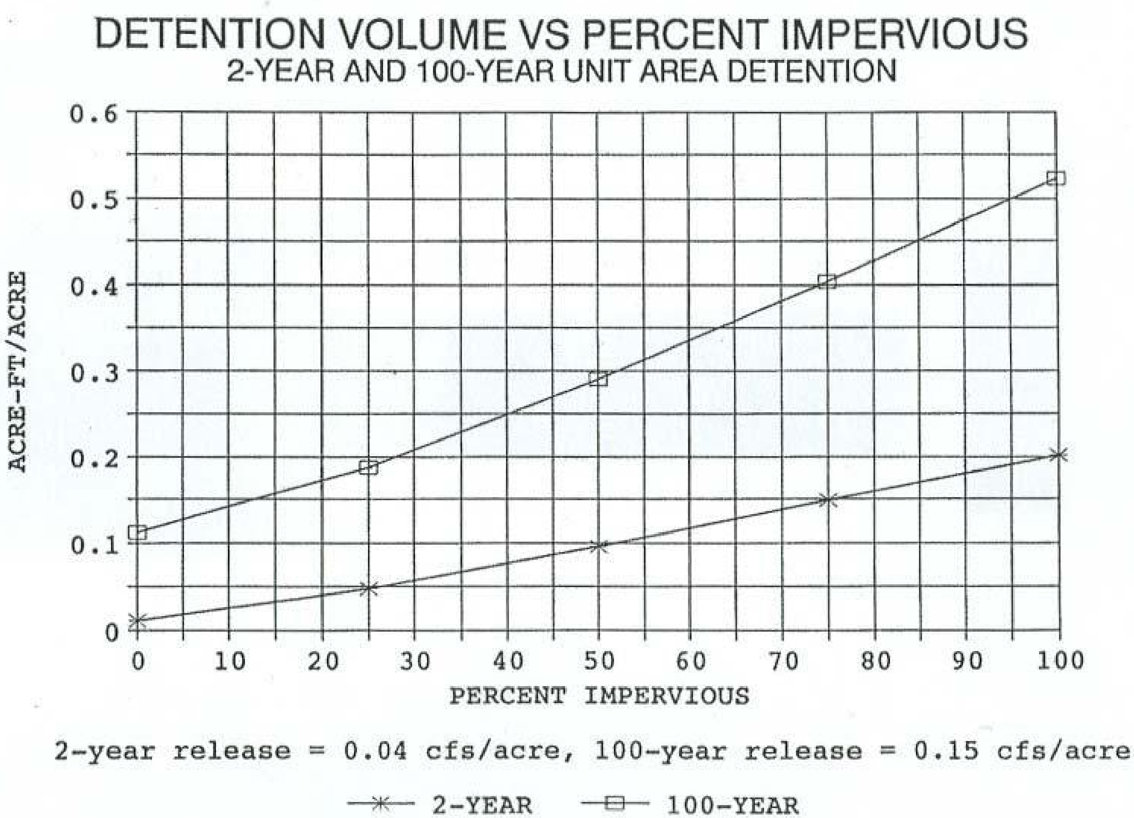


FIGURE 1.8 – INFILTRATION GUIDANCE

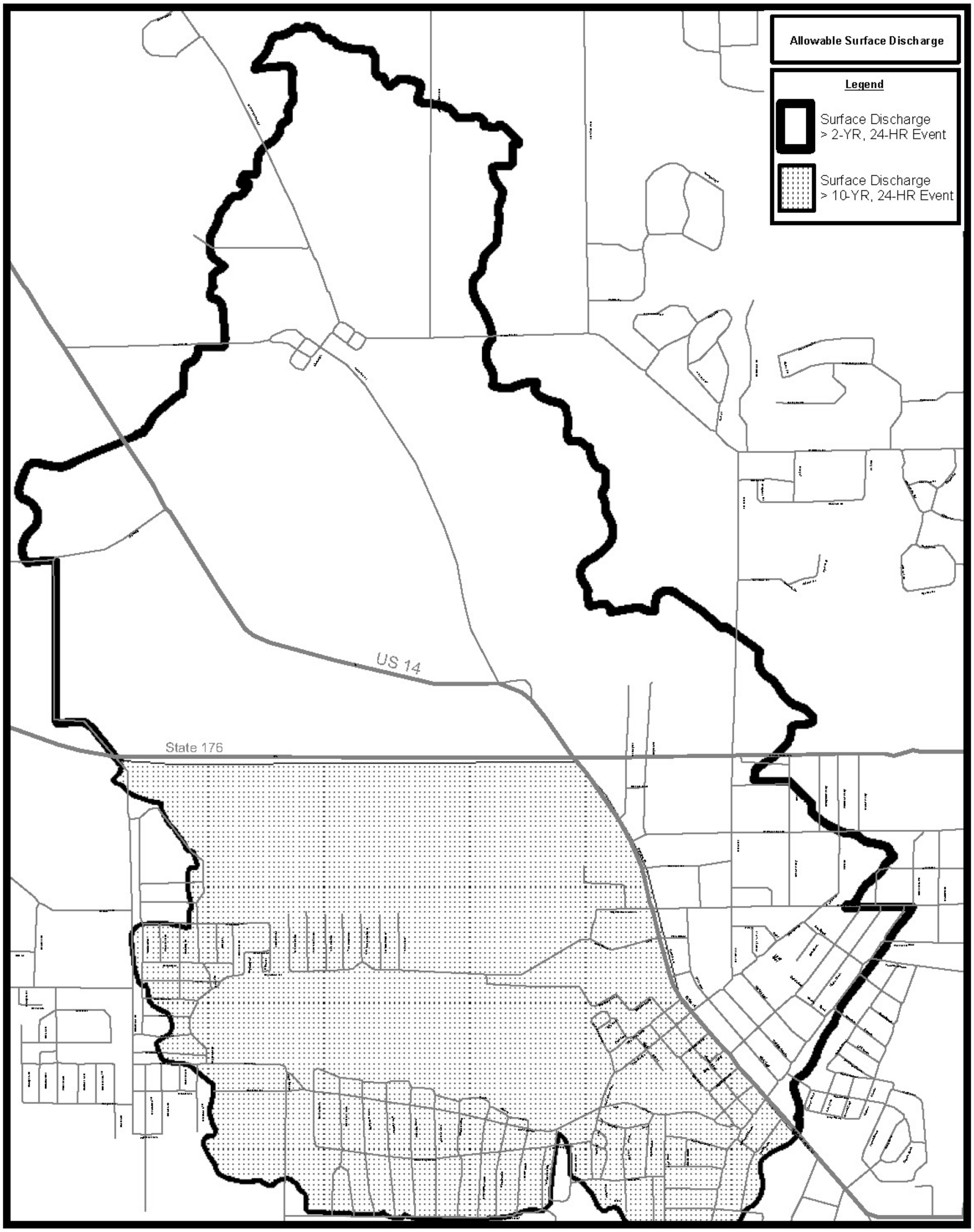


FIGURE 1.9 – ANNUAL RUNOFF VOLUME VERSUS EVENT PRECIPITATION (NIPC, 2000)

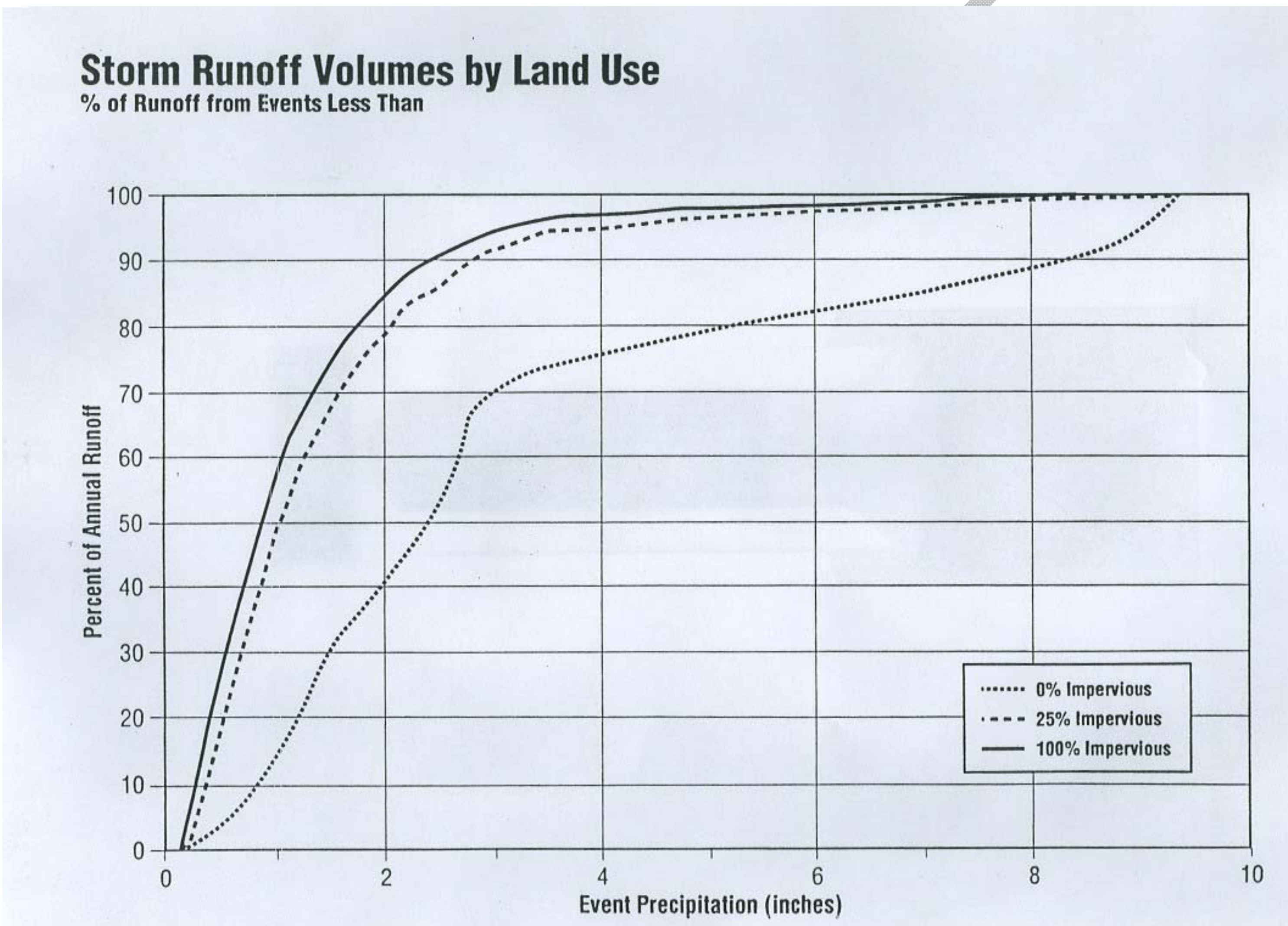


FIGURE 1.10 – STORMWATER MANAGEMENT DESIGN GUIDANCE

I. SITE EVALUATION FOR STORMWATER MANAGEMENT

- Assess Infiltration Requirements
- Evaluate Infiltration Feasibility
    - Screening
    - Soil Boring
    - Field Infiltration Rate Tests
- Define Other Development Constraints
    - Floodprone
    - Wetland
    - Other Code Requirements

II. PREPARE PRELIMINARY LAND PLAN

- Calculate Stormwater Runoff Quantities
- Calculate the Regulatory Floodprone Volumes
- Dedicate Pervious Areas for Stormwater Management
- Draft Trial Land Plan

III. SITE EVALUATION FOR STORMWATER QUALITY MANAGEMENT

- Identify Water Quality Threats
    - Roofs (Class I)
    - Roads and Parking (Class II and Class III)
    - Landscaped areas (Class II)
    - Materials Storage (Class III)
- Identify Potential Best Management Practices (sequential treatment)
    - First flush stormwater management (Class III)
    - Pre-treatment facilities (Class II and Class III)
    - Infiltration basins (All Classes)

IV. PREPARE PRELIMINARY STORMWATER MANAGEMENT PLAN

- Calculate Storage Needed
- Calculate Infiltration and Surface Release Rates
- Size First Flush Systems and Overland Conveyance Routes
- Select and Size Pre-treatment BMPs
- Size Infiltration and Retention Systems

V. REVISE PRELIMINARY LAND PLAN TO REFLECT STORMWATER MANAGEMENT REQUIREMENTS AND PROCEED TO PRELIMINARY PLAT

CHAPTER 2.1 – SITE EVALUATION AND FIELD TESTING REQUIREMENTS

Site evaluation is required before an infiltration system can be designed. The site evaluation process for determining the optimal location of an infiltration system should be a four-step procedure. The process entails: 1) performing the initial screening of the site; 2) obtaining soil borings; and 3) field testing of infiltration rates. All results must be summarized in an infiltration site evaluation report that is the fourth step.

STEP 1: INITIAL SCREENING

The initial screening identifies the potential locations for infiltration practices within a development. The screening process is used to evaluate infiltration capability of a site and to determine the number and location of field tests.

The following information should be provided in the site evaluation phase.

1. Site topography from the site-specific survey of the existing property or the existing one-foot topographic mapping from the City of Crystal Lake's Engineering Department.
2. Site soil infiltration capacity characteristics as defined in NRCS County soil surveys.
3. Local depth to groundwater from the NRCS soil survey or other available data. Use seasonally high groundwater information where available.
4. Regional groundwater data from the 1998 ISWS report "Ground-Water Studies for Environmental Planning McHenry County, Illinois."
5. Existing private wells within 100 feet and existing public wells within 1000 feet of the property from City files.
6. Existing municipal well 5 and 10-year recharge zones within 100 feet of the property.
7. Floodprone areas (Required under submittal requirements of the CLSO).
8. Wetlands (Required under submittal requirements of the CLSO).
9. Surficial geology, if applicable, from regional ISGS reports.

After all of the above information has been collected, it shall be submitted to the City as part of the Soil and Site Evaluation Report as described in Step 4. The initial screening is used to identify potential sites for infiltration practice placement. These areas then need to be field evaluated through steps 2 and 3 below.

STEP 2: SOIL BORINGS

Soil borings confirm the feasibility of infiltration designs, refine the location of infiltration practices and provide data to select the type of infiltration device to be used. The number of soil borings required is based on the size of the development and by the size of the infiltration devices. Table 2.1 presents the recommended number of borings based on development size.

Soil borings are required at the location of proposed infiltration devices. Information submitted to the City during this phase of the screening process shall include, at a minimum:

1. The name of the professional and firm who collected the data, and the date the data was recorded.
2. A scaled map of the entire site showing the location of all soil borings taken on the property.

3. The location of all wells within 100 feet of the development site, and public wells within 1,000 feet of the development site.

4. Soil boring logs shall be submitted for each boring. Boring method and sample collection method shall be described. The boring logs shall contain the following data, at a minimum:

   a. Surface elevation of boring in NGVD

   b. Site topography at one-foot contour interval

   c. NRCS textural description of each strata encountered and at what depth

   d. Water content and porosity of each strata

   e. Groundwater level during and after drilling

   f. Grain size analysis (D_{10}, D_{60}, D_{90}) for strata where infiltration is proposed and immediately adjacent strata

   g. Borings shall extend at least five feet below the elevation at which groundwater is encountered

   h. Each boring shall be a minimum of 2-inches in diameter

5. If native soils are proposed for infiltration without disturbance, then soil profile descriptions written in accordance with the *Field Book for Describing and Sampling Soils* by the USDA, NRCS, 1998 also are required. Additionally, the description for each soil horizon or layer shall include the following information:

   a. Thickness, in inches or feet

   b. Munsell soil color notation

   c. Soil mottle or redoximorphic feature color, abundance, size and contrast

   d. USDA soil textural class with rock fragment modifiers

   e. Soil structure, grade size and shape

   f. Soil consistence, root abundance and size

   g. Soil boundary

   h. Occurrence of saturated soil, groundwater, bedrock or disturbed soil

All soil boring data shall be submitted to the City as part of the Soil and Site Evaluation Report. The soil borings data should show that the required infiltration parameters are available for the location of each infiltration device. Next, detailed field-testing must be performed to determine the design infiltration rate.

TABLE 2.1 MINIMUM NUMBER OF SOIL BORINGS

Development Size (ac)	Probable Infiltration Basin Size (ac)	Number of Borings [1]
< 5	0.5	2
5 – 20	0.5 – 2	3
> 20	> 2	1 Boring for every 10 acres of development

[1] All borings to be located at site of proposed infiltration device.

TABLE 2.2 NUMBER OF FIELD INFILTRATION TESTS

Size of Proposed Retention Basin (ac)	Number of Infiltration Tests [1]
< 0.5	2
0.5 – 1.0	3
> 1.0	3 plus 1 for each additional 10,000 s.f. of basin

[1] All tests to be performed at the proposed infiltration device location

STEP 3: FIELD INFILTRATION RATE TEST PROCEDURES AND METHODS

Field testing to determine design infiltration rates is essential. The complex nature of surficial geology makes actual site data necessary for the development of design parameters. Field testing must quantify sustainable infiltration rates. Infiltration designs must be highly reliable and self-sustaining. The failure of an infiltration device may create an unsolvable drainage problem since surface discharge is not available or would cause flooding downstream. For this reason, good design data, based on appropriate field-testing, is essential. It is the design engineer's responsibility to ensure that the infiltration system will be able to meet and sustain the design infiltration rate.

For infiltration trenches and infiltration basins, infiltration tests shall be performed as described below. Table 2.2 presented the number of tests required depending on the size of the proposed infiltration device.

Determination of Field Infiltration Rate

Infiltration testing will generally be one of two methods. For sites where soils with suitable infiltration rates are within a few feet of the surface, single-ring infiltration testing should be used. The procedures for the single-ring test are modified from Bouwer 1978 and 2001. A double-ring method or the actual single ring method of Bouwer also may be used. Where deeper strata are intended to be used after excavation, well permeameter methods patterned after the USBR guidance (7300-89) should be used (USBR, 1990). Post-construction testing typically will be by the single-ring infiltrometer method.

Infiltrometer Test Method

The single-ring infiltrometer method consists of driving a 12-inch open cylinder 24 inches long partially into the ground, filling the ring with clean water, and then observing the water level drop over time (Figure 2.1). Water is added to the ring as needed to restore the liquid level. The test should be performed so that the total change in water level per time interval is less than 12 inches. The cumulative volume infiltrated during timed intervals is plotted versus elapsed time. The test is performed over several hours until a steady state infiltration rate develops.

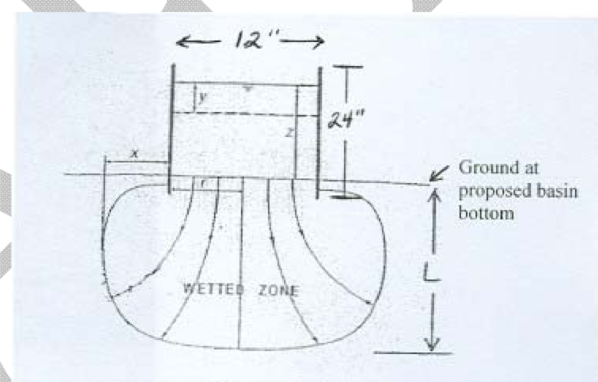


Figure 2.1
z = ~ 20-24 inches
y = maintain after 12 inches drop

FIGURE 2.1 - SINGLE RING INFILTROMETER

z = ~ 20-24 inches

y = maintain after 12 inches drop

Test Site

- The soil strata to be tested should be based on the soil borings data and the proposed basin bottom.
- The test requires an area of approximately 3 by 3 m (10 by 10 ft) accessible by a truck.
- The test site should be nearly level, or a level surface should be prepared.

- The test may be set up in an excavated pit if needed to reach the stratum to be tested.

Placing the Infiltration Ring

The cylinder is driven straight down to a depth of about 2-4 inches into the ground. The soil is packed against the inside and outside of the cylinder to achieve good soil-cylinder contact. A plate or flat rock is placed on the soil inside the cylinder for erosion prevention when adding the water.

Adding Water and Measurement

The cylinder is filled to the top with clean water, and clock time is recorded. The decline is measured at regular intervals with a ruler, and clock time is recorded. Water is allowed to lower about 12 inches before refilling. This procedure is repeated for several hours or until steady state infiltration rate has been reached. The last decline *y* is measured and clock time is recorded to obtain the time increment Δt for *y*.

Calculations

Table 2.3 presents an example of tabulated water level drops and infiltration rate calculations for a single-ring infiltration test.

The corresponding downward flow rate, or flux i_w in the wetted area below a cylinder of radius *r*, is then calculated as:

$$i_w = \frac{ir^2}{\pi(r + x)^2}$$

where *x* is the distance of lateral wetting from the cylinder wall (Fig. 2.1). For Crystal Lake, *x* should be assumed to equal one-half *r*. The rate, *i*, is calculated from the last measurement in the test ($y/\Delta t$).

The depth *L* of the wet front at the end of the test is calculated from the total accumulated declines y_t of the water level in the cylinder as:

$$L = \frac{y_t \pi r^2}{n\pi(r + x)^2}$$

where *n* is the fillable porosity of the soil. For the Crystal Lake watershed, a value of 0.2 to 0.3 would be typical. Darcy's equation can be used to calculate the downward flow in the wetted zone:

$$i_w = \frac{K(z+L)}{L}$$

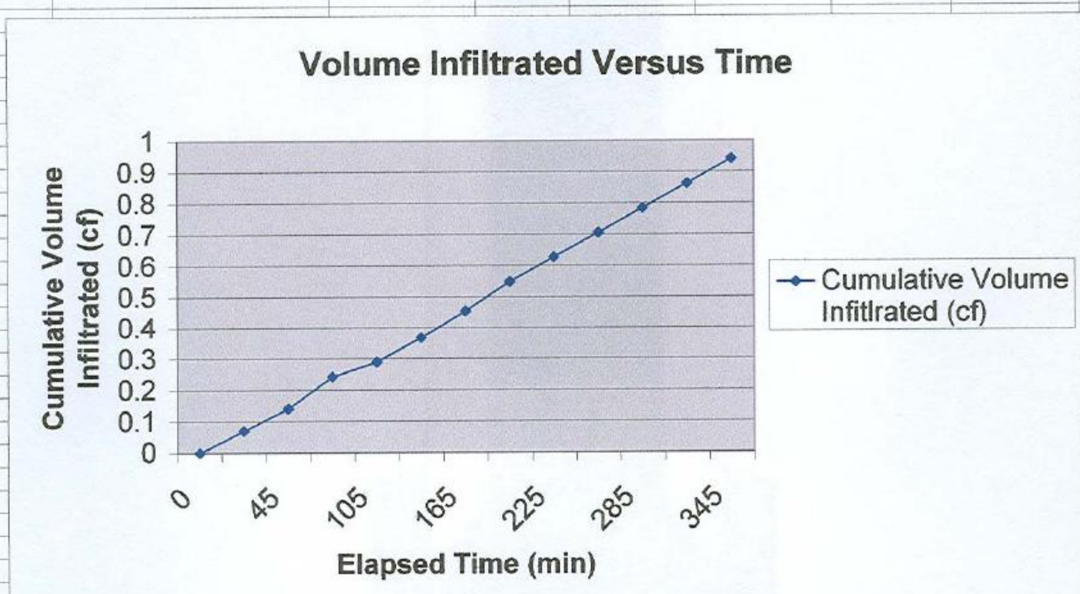
where *z* is the average depth of water in the cylinder during the last water-level decline. To solve for *K*:

$$K = \frac{i_w L}{(z + L)}$$

This calculated value of *K* is used as an estimate of long-term infiltration rates in infiltration devices. It does not consider clogging of the surface of the device or restricting layers below the infiltration stratum.

TABLE 2.3 – SINGLE RING INFILTROMETER INFILTRATION RATE DETERMINATION

Table 2.3 Single Ring Infiltrometer Infiltration Rate Determination								
12-inch infiltrometer		0.785	cf/ft of drop					
Time	Elapsed Time (minutes)	Water Decline (feet)	Cumulative Volume (cf)					
0	0	0	0					
15	15	0.09	0.07065					
30	45	0.09	0.1413					
30	75	0.13	0.24335					
30	105	0.06	0.29045					
30	135	0.1	0.36895					
30	165	0.11	0.4553					
30	195	0.12	0.5495					
30	225	0.1	0.628					
30	255	0.1	0.7065					
30	285	0.1	0.785					
30	315	0.1	0.8635					
30	345	0.1	0.942		in = yn/tn	=0.1/(30*60)=	0.000056	fps
					z = 0.05	ft		
Total	345	1.2	0.942		yt = 1.2	ft		



iw=in*3.14*(r)^2/(3.14*(r+0.5r)^2	=3.14*(0.5)^2/(3.14*(0.5+0.25)^2=	0.0000244	fps
L=yt*3.14*r^2/(n*3.14*(r+0.5r)^2	=1.2*3.14*(0.5)^2/(0.2*3.14*(0.5+0.25)^2=	2.67	ft
K=iw*L/(z+L)	=0.0000244*2.67/(0.05+2.67)=	0.000024	fps

Well Permeameter Method

For sites where deeper strata are intended to be used for infiltration after excavation, well permeameter methods patterned after the USBR guidance at 7300-89 should be used (USBR, 1990). Other methods to determine hydraulic conductivity may be acceptable after review by the City. This method may not be applicable in the Crystal Lake watershed because of groundwater separation requirements and Class V Injection Wells are not recommended.

Summary of Method

The method consists of measuring the rate at which water flows out of a well under a relatively constant gravity head. The coefficient of permeability of the soil is calculated using (1) the relatively constant flow rate which is reached after a period of time, (2) the average height of water in the well for the period when flow rate is measured, and (3) the radius of the well.

The method is used to determine the average coefficient of permeability for soil in its natural condition. The permeability results are used in appropriate equations for calculating approximate seepage rates for design of infiltration devices. Although the test is usually performed in auger holes, it can also be used in test pits.

Interferences

Proper use of the test requires soil characteristics which allow excavation of a well of reasonably uniform dimensions with the soil sufficiently undisturbed to allow unrestricted outward flow of water from the hole for the strata to be tested. Test results are adversely affected by using dirty water.

Augers

Hand augers suitable for excavating permeability test holes. Power-driven augers may be used if it is determined that disturbance of soil around the well is no more than for a hand auger.

Soil Logs

Prior to performing field permeability tests for a seepage investigation, exploratory borings should be made at appropriate intervals and logs of the borings should be prepared to show a representative soil profile. Soil classifications of the different strata encountered should be recorded as described earlier in Chapter 2.1.

Size of Test

For a low water table condition (see Condition I, Figure 2.2), the depth of the well may be of any desired dimension provided the ratio of water height h in the well to well radius is greater than 1. To fulfill theoretical considerations in development of the equations for high water table conditions (Condition II, Figure 2.2), the ratio of water height h in the well to well radius should be greater than 10. A practical well diameter is usually 6 to 8 inches. Normally, the water surface elevation in the well and the well bottom should correspond to the elevations of the proposed infiltration basin water surface and bottom of the stratum to be used for infiltration, respectively. Test results would then provide an average permeability for the soils in the design stratum. For pervious soils, well size is limited by the ability to maintain a continuous supply of water at the desired relatively constant head level.

Soil Permeability in Test Pits

The well permeameter test method also can be adapted for use in test pits in a low water table condition if the ratio of water depth to pit radius is greater than 1, and sand or gravel backfill is used to prevent soil in the sides of the pit from sloughing. In this case, calibration of backfill is not necessary since dimensions of a test pit of regular shape can be found by averaging linear measurements. If a rectangular pit is used, the effective cylindrical radius for use in permeability calculations can be determined from the pit dimensions.

Excavation of the Test Well

Wells for permeability tests should be prepared carefully to cause as little disturbance to surrounding soil as possible. Where moisture content of the soil is high, the wall of the hole can become smeared and outward flow of water restricted.

If it is apparent that the wall of the well is smeared, the walls should be scraped or scratched with improvised tools to remove the smeared surface. Remove any loose soil from the bottom of the well.

Depth of the Well

Depth measurements in the well should be measured (and recorded) from an NGVD datum.

Performing the Test

Gradually fill the well with water to an elevation equivalent to one-half the proposed maximum water depth in the infiltration basin. As the water level in the well falls, record the change in elevation with time. After the water level has fallen one-foot, it should be replenished. This should continue until the test is completed. In general, dry soil at the start of the test absorbs water at a comparatively high rate. However, as the moisture content of the soil increases around the well, the rate generally decreases and usually stabilizes. It is this constant rate after stabilization that is used to compute permeability. As records of water discharge from the reservoir and time are made, plot a curve of accumulative flow versus time (Table 2.4).

Test Duration

Minimum duration for the test is the time required to obtain a steady-state infiltration rate.
However, in order to avoid discontinuing a test prematurely, it must be continued for at least 2 hours from the starting time so the slope can be determined over a period of 2 to 3 hours. The test must be conducted without allowing more than a 12 inch drop until the test has been completed.

Calculations

Computing Coefficient of Permeability – The following equations are used to calculate the coefficient of permeability, for the well permeameter test. The proximity of a water table or impervious soil layer within a distance of less than three times that of the water depth in the well (measured from the water surface) will enable the water table to be classified as Condition I or II. as illustrated on Figure 2.3. Table 2.4 shows sample calculations.

Low Water Table – When the distance from the water surface in the test well to the ground-water table, or to an impervious soil layer is greater than three times the depth of water in the well, a low water table condition exists as illustrated by Condition I (Figure 2.2). For determination of the coefficient of permeability, the Condition I equation should be used.

High Water Table – When the distance from the water surface in the test well to the ground-water table, or to an impervious layer, is less than three times the depth of water in the well but below the bottom of the well, a high water table condition exists as illustrated by Condition II. Condition II shows a high water table with the water table below the well bottom, and the Condition II equation in Figure 2.3 should be used.

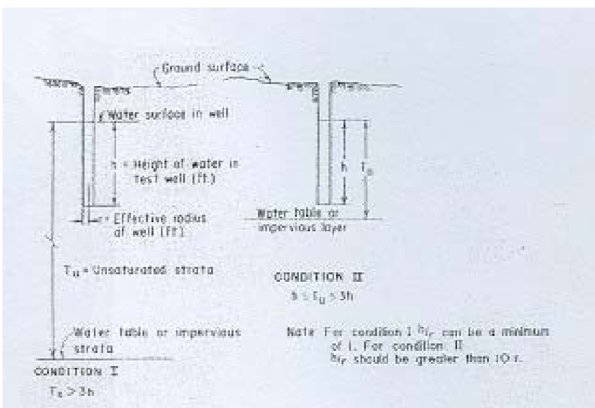


FIGURE 2.2 – WELL PERMEAMETER WATER DEPTH CONDITIONS

(Relationship between depth of water in test well and distance to water table in well permeamter test.)

Condition I:

$$k_{20} = \frac{qV}{2\pi h^2}\left\{ \ln\left[\frac{h}{r} + \sqrt{\left(\frac{h}{r}\right)^2+1}\right] - \frac{\sqrt{1+\left(\frac{h}{r}\right)^2}}{\frac{h}{r}} + \frac{1}{\frac{h}{r}} \right\}$$

Condition II:

$$k_{20} = \frac{qV}{2\pi h^2}\left[\frac{\ln\left(\frac{h}{r}\right)}{\frac{1}{6} + \frac{1}{3}\left(\frac{h}{T_u}\right)^{-1}}\right] \qquad (5)$$

where:

k_{20} = coefficient of permeability at 20 °C

h = height of water in the well

r = radius of well

q = discharge rate of water from the well for steady-state condition (determined experimentally, see example, fig. 7)

$V = \frac{\mu_T \text{ viscosity of water at temp. } T \text{ (see fig. 9)}}{\mu_{20} \text{ viscosity of water at } 20\ °C}$

T_u = unsaturated distance between the water surface in the well and the water table

FIGURE 2.3 – CALCULATION OF FIELD HYDRAULIC CONDUCTIVITY FROM WELL PERMEAMETER DATA

Design Infiltration Rate

Field infiltration rates from the single-ring or the well permeameter test are an indication of actual infiltration device performance. The water depth in the test and depth of wetting front into the soil stratum should be similar to actual design conditions. Elements that may cause actual infiltration rates to be less than the measured infiltration rate include, but are not limited to soil variability over the bottom of the infiltration device, actual construction procedures, variability in construction materials, clogging due to fines during construction, and clogging over time due to stormwater pollutants that escape pretreatment and biological growth.

To avoid the need for test pits at a larger scale to confirm field infiltration results, a factor of safety approach is recommended.

- For field permeability greater than 2 in/hr (4.6 x10^{-5} fps), a rate of 2 inches should be used.
- For rates less than 2 in/hr, the actual field permeability be used.
- Field permeability less than 0.5 in/hr requires explanation why the design will meet the CLSO criteria of 0.5 in/hr (gradient, engineered media, etc.).

STEP 4: SOIL AND SITE EVALUATION REPORT

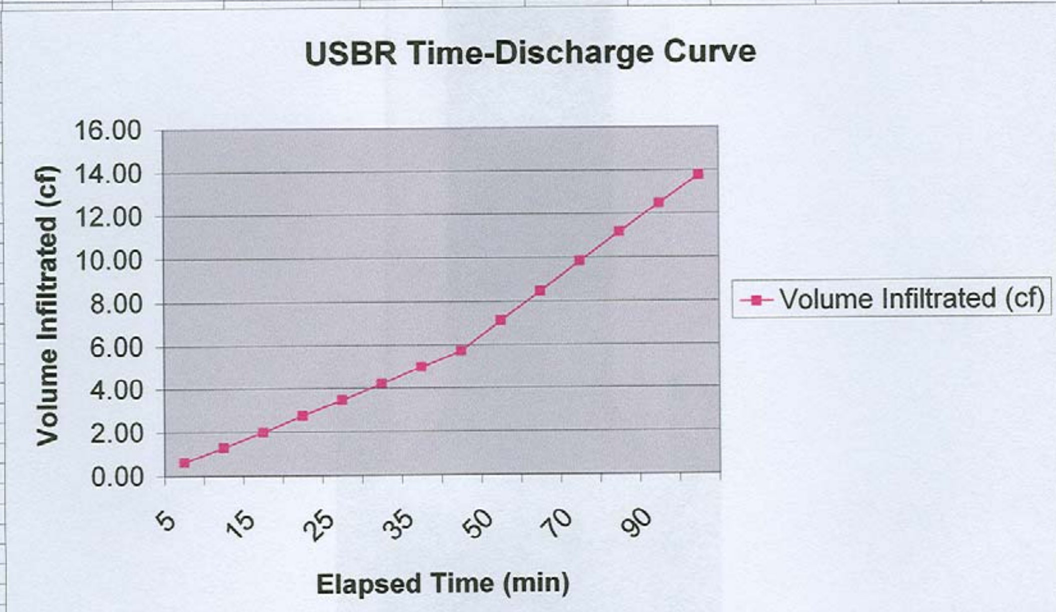
A Soil and Site Evaluation Report shall be submitted to the City for approval before the design of the pretreatment and treatment BMP is completed. The report shall contain all information outlined above in Steps 1, 2, and 3. It also shall present the time versus infiltration rate results graphically and field observations of all tests. A field determined infiltration rate shall be calculated for each test hole.

TABLE 2.4 – INFILTRATION RATE DETERMINATION FROM WELL PERMEAMETER TEST

Table 2.4 Infiltration Rate Determination from Well Permeameter Test

Well Diameter	8.5 inches	Water Volume per Foot		0.394	cf		
Well Depth	15 feet						
Screen Length	10 feet						
Groundwater Depth	20 feet						

Time (min)	Elapsed Time (min)	Water Decline (ft)	Volume Infiltrated (cf)	Cumulative Volume Infiltrated (cf)				
		0						
5	5	1.6	0.63	0.63				
5	10	1.7	0.67	1.30				
5	15	1.8	0.71	2.01				
5	20	1.9	0.75	2.76				
5	25	1.8	0.71	3.47				
5	30	1.9	0.75	4.21				
5	35	2	0.79	5.00				
5	40	1.9	0.75	5.75				
10	50	3.5	1.38	7.13				
10	60	3.4	1.34	8.47	Slope =	(13.79-11.19)/(100-80) =	0.0022	cfs
10	70	3.5	1.38	9.85				
10	80	3.4	1.34	11.19				
10	90	3.3	1.30	12.49				
10	100	3.3	1.30	13.79				



K20 = (qV/(2*3.14*h^2))*(ln(h/r))/(0.167+0.33*Tu/h)

q =	0.0022	cfs
V =	1	for 20o
h =	11	ft
r =	0.35	ft
Tu	16	ft

K20 = (0.0015)(1)(ln(11/0.08)/((6.28*(11)^2(0.167+0.33(16/11)) = 0.000015 fps

CHAPTER 3.1 – NEED FOR PRETREATMENT

INTRODUCTION

Under the CLSO (Section 3.174-6 (4)(q)(3)) pretreatment of stormwater runoff is required before discharging to an infiltration system. The purpose of pretreatment is two-fold:

- To reduce suspended sediment to prevent clogging of the infiltration system.
- To minimize the discharge of pollutants into the groundwater, where they could reach local drinking water supplies and down gradient water resources such as Crystal Lake.

SOIL CLOGGING

Soil clogging is caused by physical, biological and chemical processes. Physical processes include the accumulation of inorganic and organic suspended sediments in the runoff water. Suspended sediment can include silt and clay washed off the land surface. Particles in runoff can move into the infiltration media filling the pore spaces that allow water movement, and form a clogging layer preventing efficient water movement. Biological processes involve either the deposition of organic matter on the infiltration media surface or the development of micro-organisms within the media. Chemical clogging results from chemical reactions that result in precipitation of calcium carbonate and other scales within the top layer of the soil media. The best approach to prevent clogging is to remove the materials that cause the clogging before the water enters the infiltration system.

POTENTIAL GROUNDWATER CONTAMINATION

Stormwater runoff has been documented to contain a variety of pollutants at dilute but potentially important concentrations (USEPA, 1983). Table 3-1 summarizes the potential pollutants that have been found in urban runoff.

In addition to these pollutants, bacteria, herbicides, pesticides, and chloride (from road salt) also are found.

PRE-TREATMENT EFFECTIVENESS

Research and demonstration projects over the last 30 years have documented the effectiveness and design criteria for pre-treatment Best Management Practices (BMPS). The following BMP technologies have all been demonstrated to remove 70 to 90 percent of total suspended solids and total phosphorus from stormwater (USEPA, 1999) when properly designed.

- Wet Detention Basins
- Wetland Detention Basins
- Bio-Retention Basins

Each of these BMPs can produce an average annual effluent concentration of less than 0.10 mg/l total phosphorus (ASCE, 2005).

TABLE 3.1 – POLLUTANT CONCENTRATIONS IN URBAN RUNOFF

Constituent	Median Concentration (mg/l)	90 Percentile (mg/l)
TSS	141-224	424-671
BOD_5	10-13	17-21
COD	73-92	157-198
Total-P	0.37-0.47	0.78-0.99
Soluble-P	0.13-0.17	0.23-0.30
TKN	1.68-2.12	3.69-4.67
NO_2 & NO_3	0.76-0.96	1.96-2.47
Total copper	0.38-0.48	0.104-0.132
Total lead	0.161-0.204	0.391-0.495
Total zinc	0.179-0.226	0.559-0.707

Source: National Urban Runoff Study (NURP), USEPA (1983)

CHAPTER 3.2 – PRETREATMENT REQUIREMENTS

PRETREATMENT REQUIREMENTS

Pretreatment is required before any stormwater runoff can be discharged to an infiltration system (Section 3.174-6q(3) of the CLSO). Several levels of pretreatment have been established based on expected impervious coverage and automobile traffic levels. Impervious areas translate to larger volumes of runoff and automobiles are a principal source of metals, oil and grease. Table 3-2 summarizes the land cover types and the type of pretreatment that should be applied.

- Category I - Land cover that generates little or no pollutants.
- Category II - Land uses and activities that generate limited pollutants, but must be treated for removal of suspended sediments and pollutants before discharge to an infiltration device.
- Category III - Land uses and activities that generate know stormwater pollutants and must be treated for removal of suspended sediment and pollutants prior to discharge to an infiltration device.

Category II and III pretreatment facilities should be designed to produce an annual average total phosphorus concentration of less than 0.10 mg/l in their effluent.

TABLE 3.2 – LAND COVER/BMP SOLUTIONS

Category	Runoff Source	Appropriate Pre-Treatment BMPs
I	Rooftops	No pre-treatment
II	Less than 30 percent impervious area with ADT < 5000 vehicles/day and no storage of pollutants	Wet Basins Wetland Basins Bio-Retention
III	Impervious areas > 30 percent or ADT > 5000 vehicles/day or storage or application of pollutants	Volume Reduction Wet Basins Wetland Basin Bio-Retention

INTRODUCTION

Additional measures are needed to ensure that the quality and quantity of runoff reaching infiltration basins from Class III sites will not pollute groundwater or Crystal Lake. These measures are best added as part of the site design process.

FIRST FLUSH TREATMENT

The stormwater collection and conveyance system of Class III sites must incorporate sustainable measures to remove pollutants from the fitst flush of stormwater runoff before it even reaches pre-treatment facilities. These site design measures are intended to provide a first step to minimize pollutant transport. The key measures are to:

- Minimize impervious surfaces,
- Route impervious surfaces across pervious surfaces (infiltration strips) before collection,
- De-centralize flows to dissipate energy, and
- Use vegetated swales instead of storm sewers and concrete channels.

After volume reduction measures have been applied stormwater is routed to pre-treatment facilities and then of infiltration basins. These are the same measures recommended in the Crystal Lake Stormwater Ordinance in Section 3.174-6 (Table 3-3). However, within the Crystal Lake watershed these measures are mandatory for Class III sites.

MINIMIZATION OF IMPERVIOUS SURFACES

The minimization of impervious surfaces results in less site less runoff volume that is generated for pre-treatment and infiltration. This can help to reduce the size of pre-treatment facilities and sustain their performance and the life of infiltration basins. Techniques include permeable pavement (Figure SD-1), site design to minimize road lengths (Prince George's County Department of Environmental Resources, 2000; NIPC, 2003), green roofs, rain barrels and rain gardens (Figure SD-2).

VEGETATED SWALES

Vegetated swales are an alternative to storm sewers. Unlike storm sewers though, they transport water more slowly and allow for filtering, settling, infiltration, evapotranspiration and soil-water contact. With careful site design, vegetated swales can provide at least some of the stormwater conveyance for new development. The design criteria for vegetated swales in the Crystal Lake watershed are summarized below.

Length	>200 feet
Bottom Width	> 3.0 feet
Sideslopes	3:1 or flatter
Slope	<1.0 percent
Shape	Parabolic or trapezoidal
Velocities	
1-year	<1.0 fps
10-year	<2.0 fps
100-year	<5.0 fps
Vegetation	Unmowed grass from seed at a height > 8 inches or native plants (see Table 3.7).

A typical residential swale is shown in Figure SD-3.

TABLE 3.3 – CLSO RUNOFF VOLUME REDUCTION HIERARCHY

3.174-6: Paragraph 1

An applicant shall choose a strategy to meet the release rate requirements that minimizes the increase in runoff volumes and rates from the development and addresses the water quality treatment requirements of this Ordinance. The applicant shall use appropriate best management practices as presented in the Technical Reference Manual and consider the following hierarchy in preparing a drainage plan suitable for the development site:

a. Conservation of natural resource features of the development site (e.g. floodplains, wetlands, Isolated Waters of McHenry County, prairies and woodlands);
b. Conservation of the existing natural streams, channels and drainageways;
c. Minimizing impervious surfaces created at the site (e.g. narrowing road width, minimizing driveway length and width, clustering homes and shared driveways);
d. The use of natural landscaping as an alternative to turf grass;
e. The use of open vegetated channels, filter strips, and infiltration to convey, filter, and infiltrate stormwater runoff;
f. Conservation of the natural infiltration and storage characteristics of the site (e.g. disconnection of impervious cover and on-lot bioretention facilities);
g. Structural measures that provide water quality and quantity control;
h. Structural measures that provide only quantity control and conveyance.

FIGURE SD-1 PERMEABLE PAVEMENT

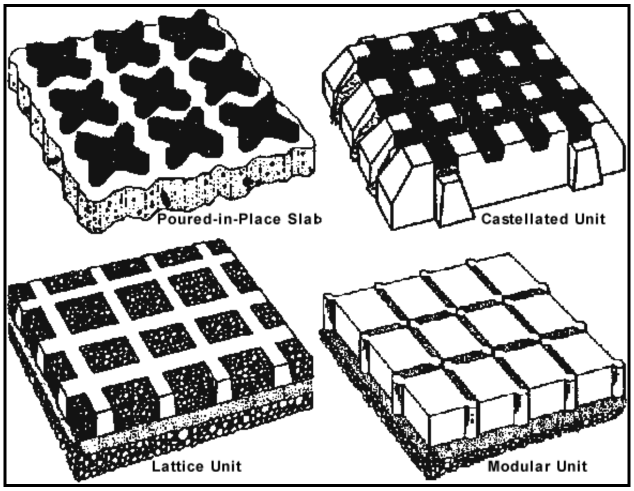


FIGURE SD-2 RAIN GARDEN

FIGURE SD-3 VEGETATED SWALE

REFERENCES

Northeastern Illinois Planning Commission, Urban Stormwater, Best Management Practices guidebook, 2000.

Northeastern Illinois Planning Commission, Conservation Design Manual, 2003

Prince George's County Maryland, Department of Environmental Regulation, Low Impact Development Guidance, 2000.

Center for Watershed Protection, Better Site Design, 1998

Low Impact Development Center, Site Design Tools, 2007

University of Wisconsin Extension, Designing Bio/Infiltration Best Management Practices for Stormwater Quality Improvement, 2006

Pitt, R., Design of Grassed Swales, 2005.

WET BASINS

PURPOSE

This chapter presents the methods, criteria, and details for analysis and design of wet pre-treatment basins.

A wet basin is defined as a constructed stormwater pond that retains a permanent pool of water with designed dimensions, inlets, outlets and storage capacity. It is constructed to collect, detain, and pretreat stormwater runoff before releasing the runoff into an infiltration facility.

The primary purpose of this best management practice is to serve as a pretreatment device to remove suspended solids and other associated pollutants such as nutrients, some metals, and organics, before the stormwater flows to the final infiltration system. Figures WB-1 and WB-2 illustrate a typical plan and cross-sectional view of a wet basin.

DESIGN CRITERIA

The primary design factors that determine a wet basin's treatment efficiency is the surface area and volume of the permanent pool. If the pool volume is large enough, most runoff events will only displace resident water in the basin. This allows additional time for pollutant settling between events.

The design of a wet basin should include a permanent pool with a sediment forebay and a main pool. Live storage volume above the permanent pool volume also should be provided for additional water quality treatment.

TABLE 1 REMOVAL EFFICIENCIES FROM WET DETENTION PONDS

Parameter	Percent Removal	
	Schueler, 1992	Hartigan, 1988
Total Suspended Solid	50-90	80-90
Total Phosphorus	30-90	
Soluble Nutrients	40-80	50-70
Lead	70-80	
Zinc	40-50	
Biochemical Oxygen Demand or Chemical Oxygen Demand	20-40	

1 hydraulic residence time varies
2 hydraulic residence time of 2 weeks

Source: Schueler, 1992 & MD DEQ, 1986.

FIGURE WB-1 WET BASIN PLAN

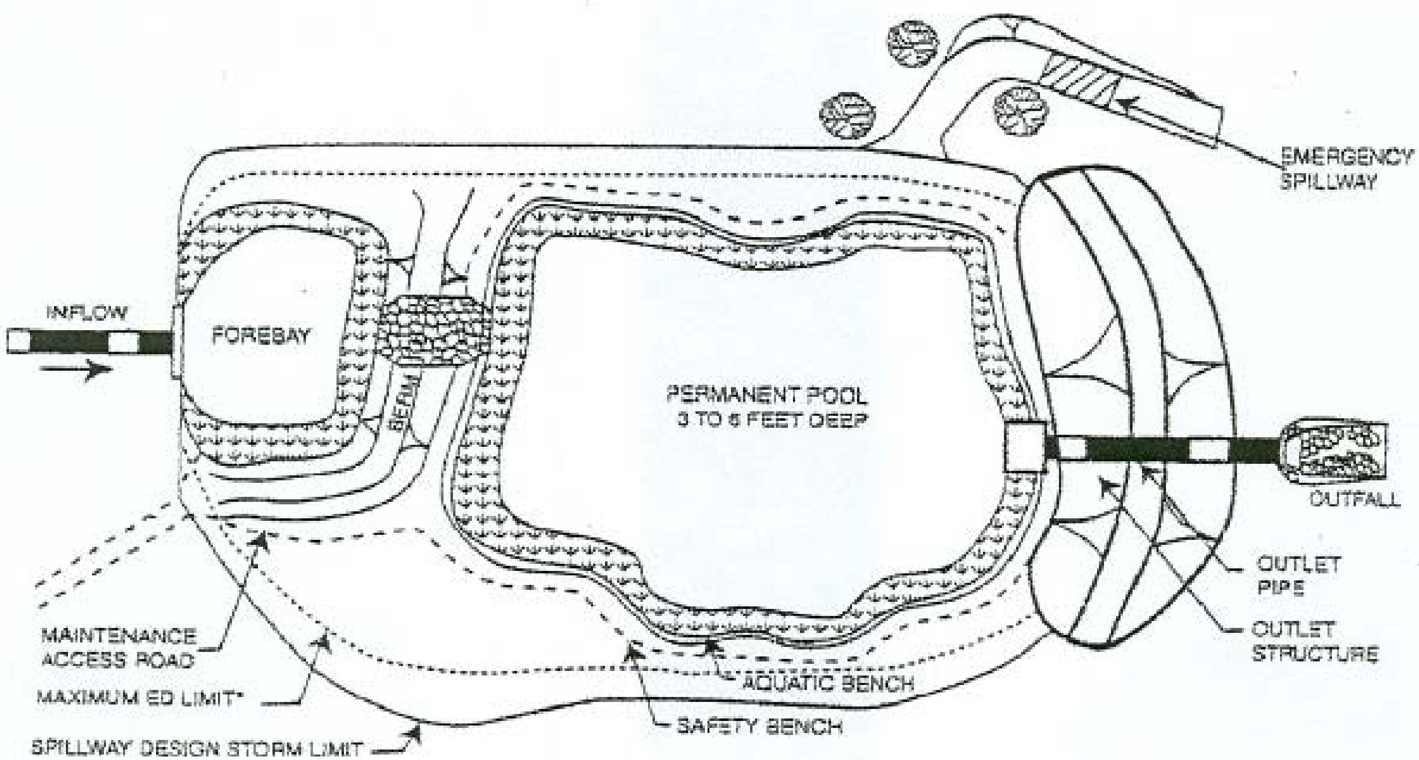
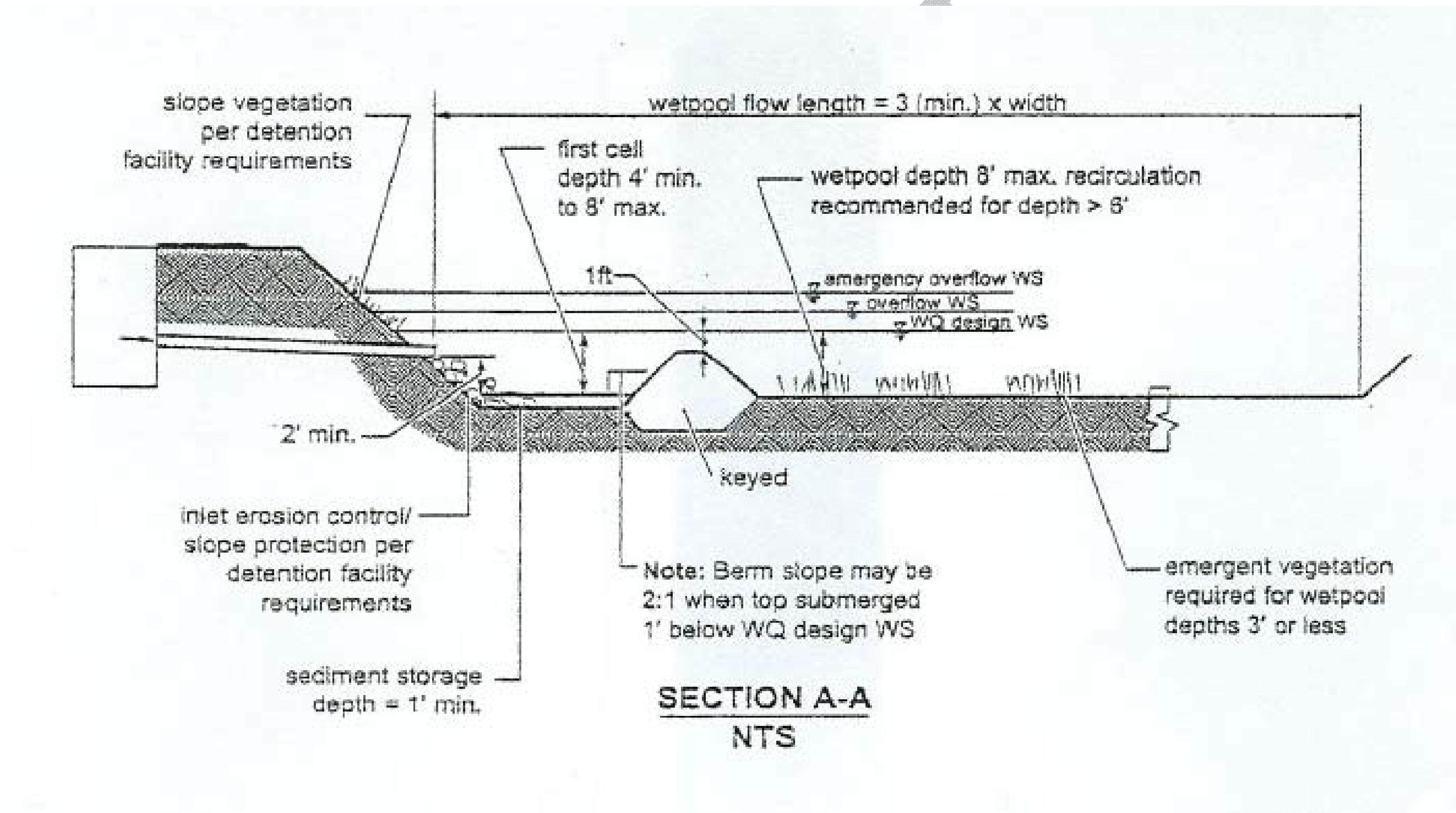


FIGURE WB-2 WET BASIN SECTION



Basin Design

To achieve its water quality goals, basin design must incorporate a number of design features. These include, but are not limited to, the design of: the permanent pool volume, the live storage volume, the surface size and pond shape, pond depth, inlet and outlet structure design, slope stability, and safety. Each design criteria will be discussed in the following sections.

Design Storm

The total storage volume for water quality control should be based on the runoff from the 2-year, 24-hour event as summarized below.

- Design Rainfall: 3.04 inches

  (2-year, 24-hour, Bulletin 70 Tabular Northeast Section)
- Antecedent Moisture Condition: Type II
- Rainfall Distribution: 3rd Quartile Huff (Use median values)

RCN Selection

In addition, designers should use the runoff curve number (RCN) for the next higher NRCS hydrologic soil group for all pervious areas that will be mass graded for with-project runoff calculations. The increased RCN will not be required if the pervious areas are disked to offset compaction before planting or if native landscaping is used. Wet basins should use an RCN of 95.

Volume

Both pool and live storage volume should be based on the 2-year, 24-hour runoff volume with no release. Figure 3.1 also may be used to calculate 2-year storage volume.

Permanent Pool Versus Live Storage

The permanent pool volume should be equal to the design volume for live storage.

Soils

Soil permeability data should be used to determine if the soil is capable of maintaining a permanent pool. This will help the designer to establish the feasibility of wet detention and if compaction or a liner will be required to hold water.

Depth to Groundwater

The seasonally high groundwater level should be below the proposed bottom of the basin. If it is determined during testing that the separation distance is not available, special precautions will be necessary to prevent movement of pollutants to groundwater.

Configuration

The avoidance of short-circuiting and the promotion of plug flow (i.e. the potential of stormwater moving through the basin as a unit, displacing the "old" water in the basin with incoming flows) are very important design considerations. Design features that encourage plug flow include the following:

- Dissipating energy at the inlet,
- Providing a length-to-width of at least 3 to 1 ratio,
- Dividing the wet basin into two cells in series rather than a single basin,
- Maximizing the flowpath length between inlet and outlet to enhance treatment by increasing water residence time.

Surface Area

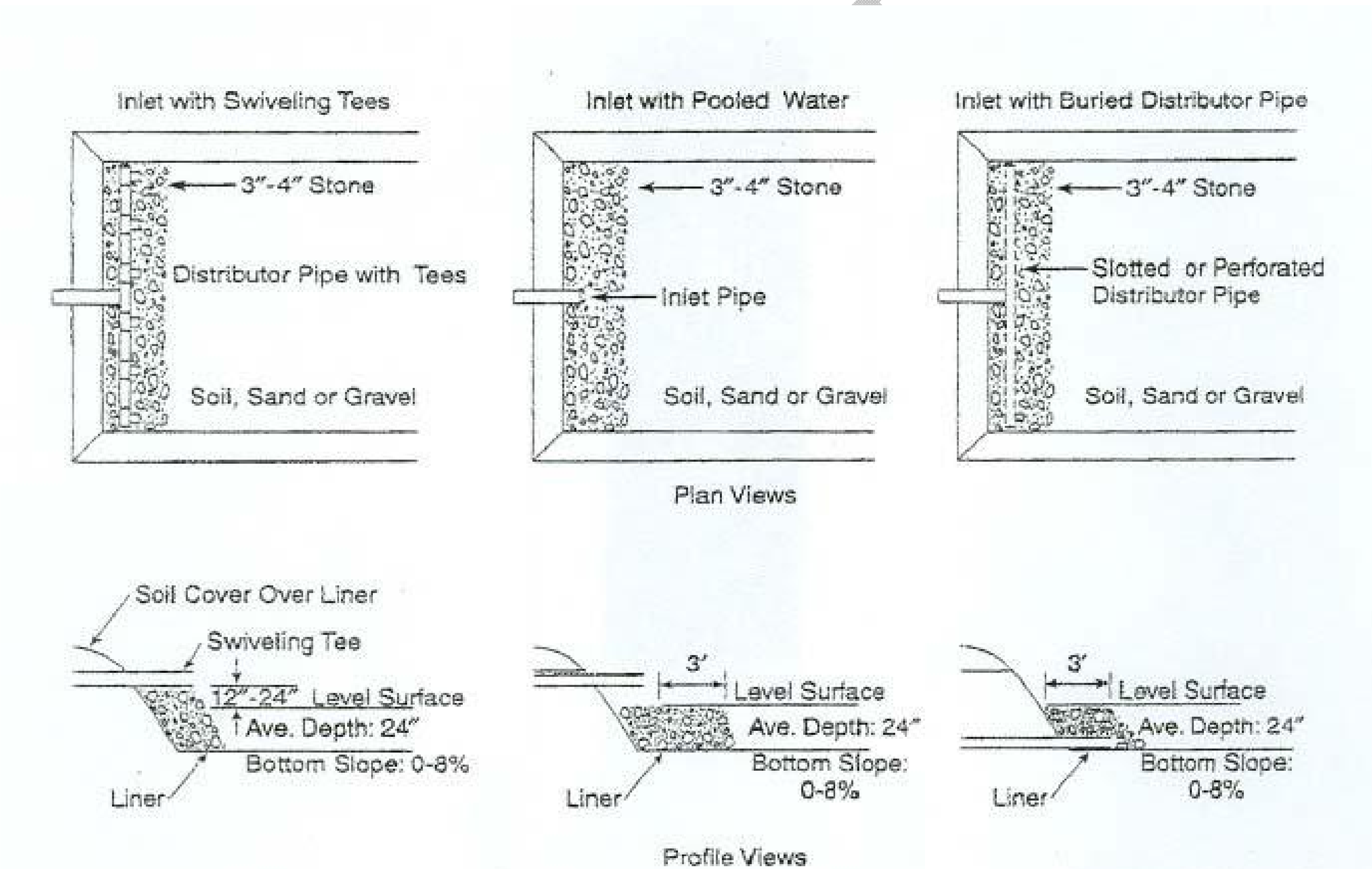
Research has demonstrated that to attain significant (greater than 80 percent) removal of most pollutants in urban stormwater, a wet basin should not have a hydraulic loading rate of more than one inch/day as an annual average. Table 3.3 shows the effect of this design criterion on the normal water level area of a wet basin size as percent impervious area increases.

TABLE 3.4 – WET BASIN SIZE VERSUS IMPERVIOUS AREA

Percent Impervious	Typical Annual Yield (in)	Basin Size (ac/ac of watershed)
30	12	0.040
40	14	0.045
50	16	0.050
60	18	0.055
70	19	0.060
80	20	0.065

The basin size is the area at normal water level of the basin in relationship to the total contributing area to the wet basin.

FIGURE WB-3 ENERGY DISSAPATORS



Sediment Forebay Design

A sediment forebay located at the inlet should be incorporated into the design of the wet basin. The forebay is designed to trap large particles so that the useful life of the main pond is protected. Concentrating sediment accumulation in a smaller area should make it easier to remove. The following guidelines shall be used in conjunction with the site constraints to determine the surface area, depth, and volume of the sediment forebay:

Surface Area – 10% of the permanent pool surface area recommended

Depth – Minimum of 4 feet

Volume – Calculated from design surface area and depth

Inlet Energy Dissipation

The detention basin inlets should be directed to the sediment forebay. The inlets should be designed to prevent scouring and re-suspending settled bottom sediments. The use of rip-rap, stone, or manhole sections can be effective in stabilizing inlets. Figure WB-3 shows several energy dissipation designs.

Outlet Release Rate

Although there is no specific release rate required from wet basin pre-treatment, it is important that flow be detained to allow time for pollutant removal. The design release rate from wet basin pre-treatment should be 0.10 cfs/acre. However, no pipe or orifice outlet should be less than 4 inches.

Outlet Design

Single pipe outlets shall have a minimum inside diameter of 12 inches. Where an orifice plate is used to control discharge, it shall have a minimum diameter of 4 inches to prevent plugging. Figure WB-3 shows several possible outlet designs.

Other outlet designs also may be effective. These include weirs and level spreader designs also may be used (Figure WB-4).

All culvert and weir outlets should discharge into an energy dissipater section before releasing into the infiltration basin as shown in Figure WB-3.

Safety Shelf

A safety shelf shall extend a minimum of 8 feet from the edge of the permanent pool, with a slope of 10H:1V or flatter where water depths exceed three feet. The maximum depth of water over the shelf shall be 3.0 feet.

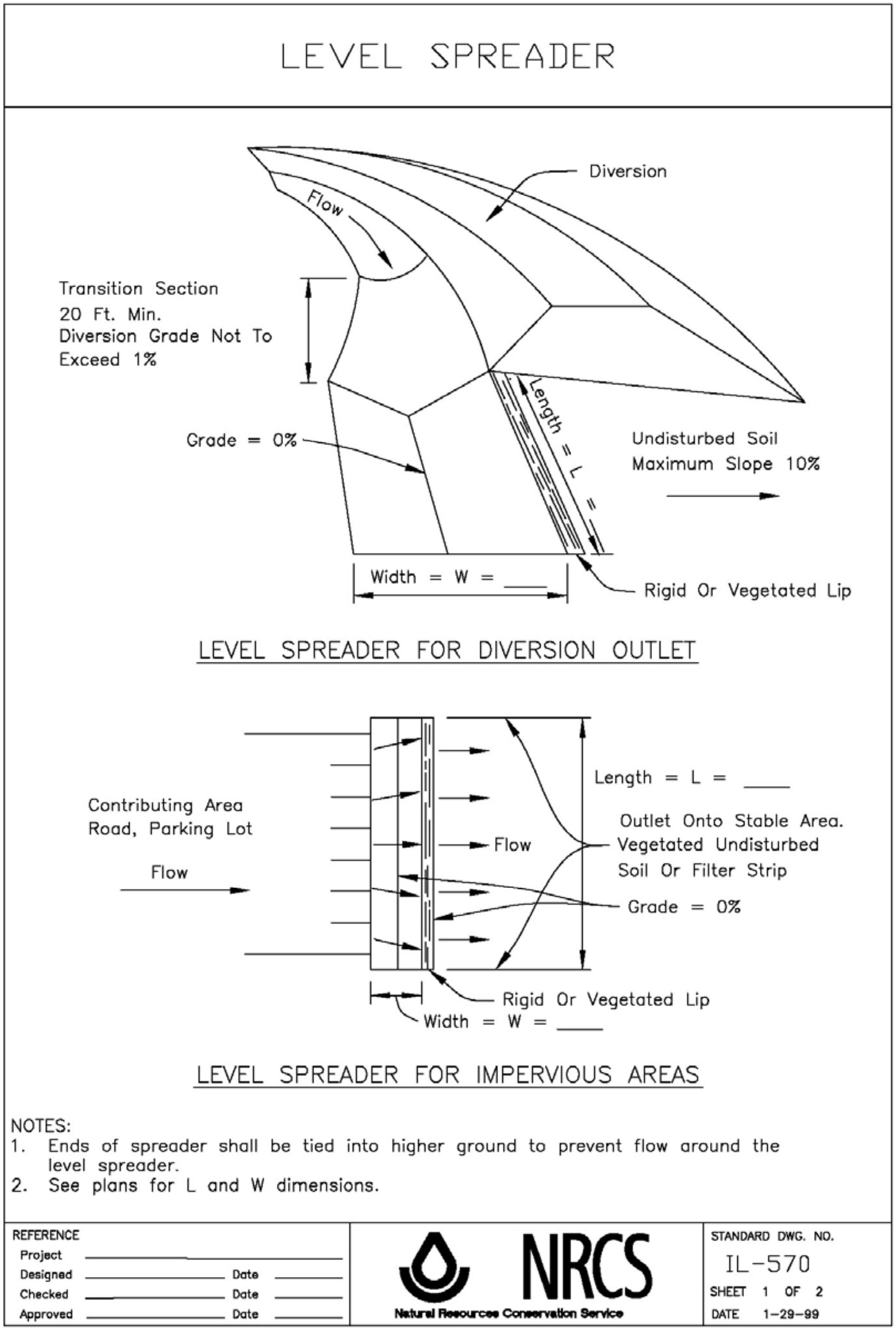
Side slopes below the safety shelf in the permanent pool area should be 3H:1V or flatter.

All interior side slopes above the permanent pool safety shelf shall be 4H:1V or flatter.

Liner

A liner may be needed to hold a permanent pool of water in the very permeable soils of Crystal Lake. Liner designs must be submitted by a licensed geotechnical engineer who shall certify their performance. Caly liners are preferred. Synthetic liners will only be approved in extreme circumstances.

INSERT FIGURE WB-4 LEVEL SPREADER



Embankments

Earthen embankments should be designed to address potential risk and structural integrity issues such as seepage and saturation. All should meet the following criteria:

- The base of the embankment shall be stripped of all vegetation, stumps, topsoil and other matter. Stripping shall be a minimum of 6 inches.
- For embankments where the permanent pool is ponded 3 feet or more against the embankment, the designer should evaluate the structural integrity of the design.
- All embankments shall be constructed with non-organic soils and compacted to prevent leakage. No tree stumps, or other organic material shall be buried in the embankment. The constructed embankment height shall be increased as necessary to account for settling.
- Any pipes extending through the embankment shall be bedded and backfilled with embankment or equivalent soils. The bedding and backfill shall be compacted in lifts and to the same standards as the original embankment.
- Measures such as anti-seep collars shall be taken to minimize seepage along any conduit buried in the embankment.

Overflow Design

Since wet pre-treatment basins are designed for the 2-year event, an overflow spillway is needed to control the location where flows overtop the wet basin and flow to the infiltration device.

The overflow spillway should be sized to pass the 100-year, 24-hour discharge to the wet basin at a depth not to exceed 0.5 feet above the spillway elevation.

The overflow spillway must be armored across its full width. Generally, vegetation over geotextile is preferred. However, the designer should evaluate the need for rip rap or other hard surface stabilization based on specific circumstances.

Freeboard

The design of the wet basin shall ensure the top of the embankment, after settling, is a minimum of one vertical foot above the flow depth in the overflow spillway required to safely pass the 100-year, 24-hour storm.

Access

Access and maintenance should be provided and extend to both the wet basin inlet and outlet structures. An access ramp should be provided to the bottom of the first cell unless all portions of the cell can be reached by a backhoe from the banks of the basin.

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WETLAND BASINS

PURPOSE

This chapter presents the methods, criteria, and details for analysis and design of wetland basins for treatment of stormwater runoff.

A wetland basin is defined as a shallow depression designed to treat stormwater through physical, chemical and biological processes associated with hydric soils and emergent aquatic plants. These processes include absorption, adsorption, filtration, microbial transformation (biodegradation), precipitation, sedimentation, uptake by vegetation and volatilization.

Pollutants removed by wetland basins include sediment, oxygen demanding substances, nutrients, metals, pesticides, hydrocarbons and trash or debris. In addition, wetlands provide wildlife habitat, aesthetic appeal and educational and passive recreational opportunities. Figures WL-1 and WL-2 illustrate a typical plan and cross-sectional view of a wetland basin.

DESIGN CRITERIA

To function effectively, a wetland basin needs to be properly designed, installed and maintained. Constructed wetlands are effective at removing suspended solids and the pollutants that absorb to solids and dissolved nutrients.

The design of a wetland basin is based on hydraulic loading rate and mass loading rate.

Basin Design

The most important design factors for wetland basins include hydrology and hydroperiod, soil suitability, depth to groundwater, configuration, water level control and hydraulic and mass loading rates. Each design parameter is discussed below.

Design Hydrology

The total wet and live volume for wetland basin design for water quality treatment should be the 2-year, 24-hour storm event.

- Design Rainfall: 3.04 inches (2-year, 24-hour, Bulletin 70 Tabular Northeast Section)
- Antecedent Moisture Condition: Type II
- Rainfall Distribution: 3rd Quartile Huff (Use median values)

The wetland basin should use an RCN of 90. In addition designers should use RCNs for the next higher NRCS hydrologic soil group for all pervious areas that will be mass graded. If the pervious areas are disked after mass grading to offset compaction or planted with native landscaping no increase in pervious RCN is required.

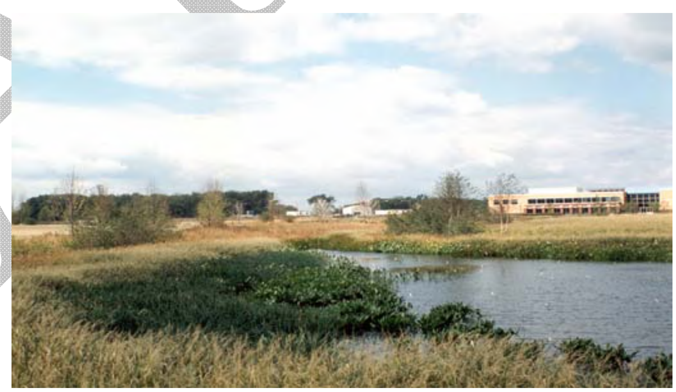


TABLE 2 PERFORMANCE OF STORM WATER WETLANDS

Pollutant	Removal Rate
Total Suspended Solids	67%
Total Phosphorus	49%
Total Nitrogen	28%
Organic Carbon	34%
Petroleum Hydrocarbons	87%
Cadmium	36%
Copper	41%
Lead	62%
Zinc	45%
Bacteria	77%

Source: CWP, 1997.

FIGURE WL-1 WETLAND BASIN PLAN

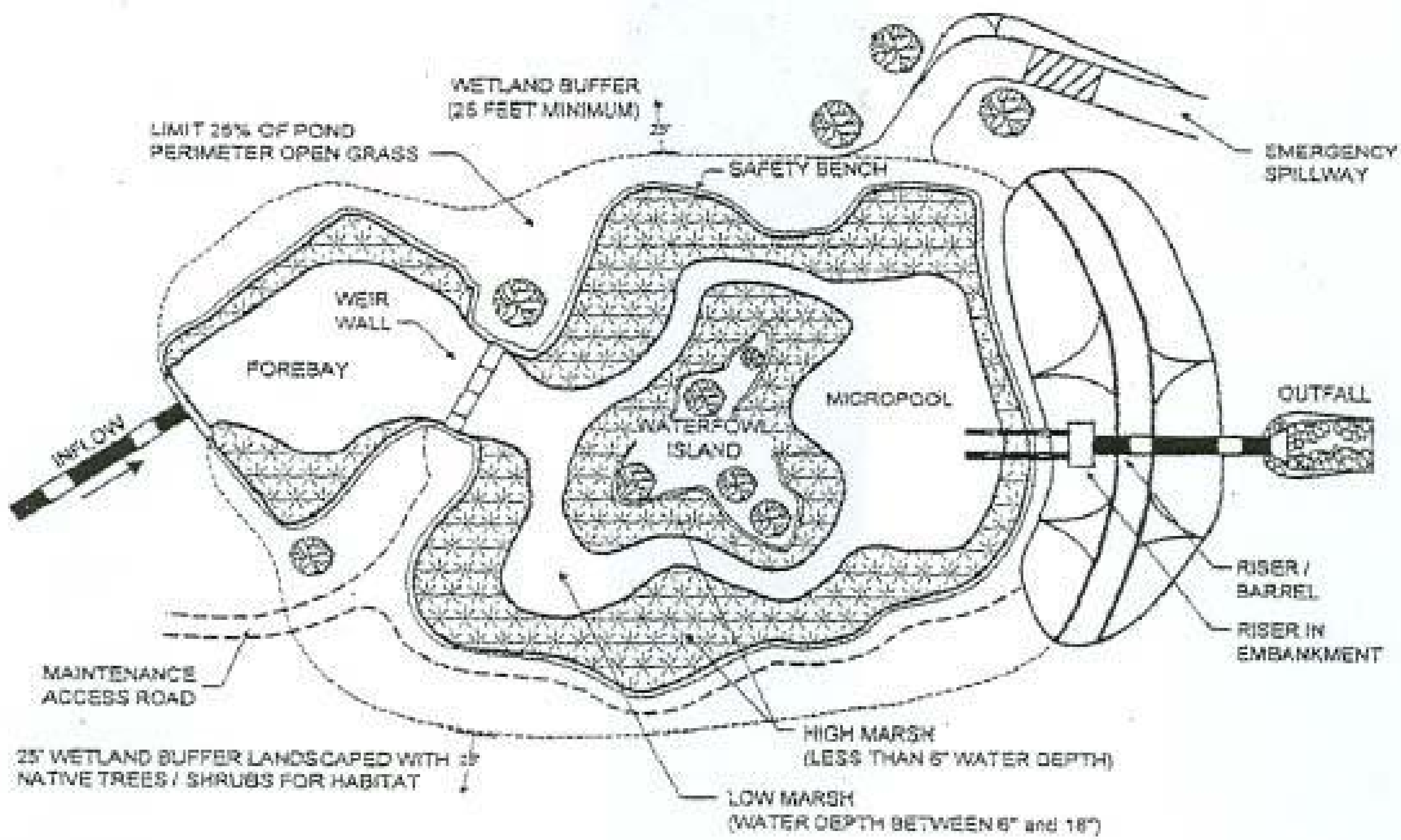
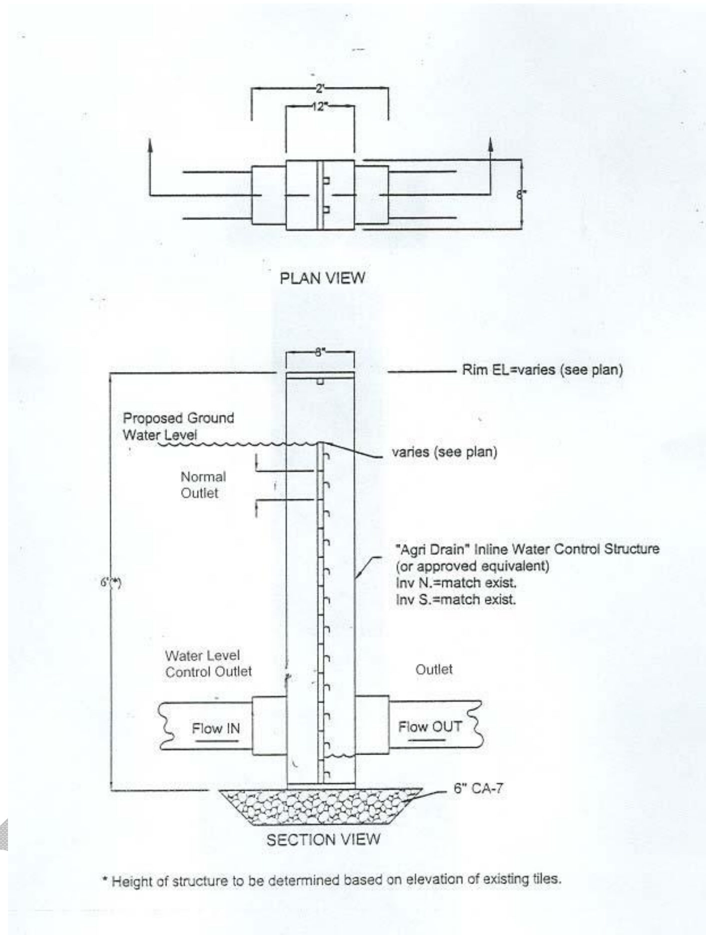
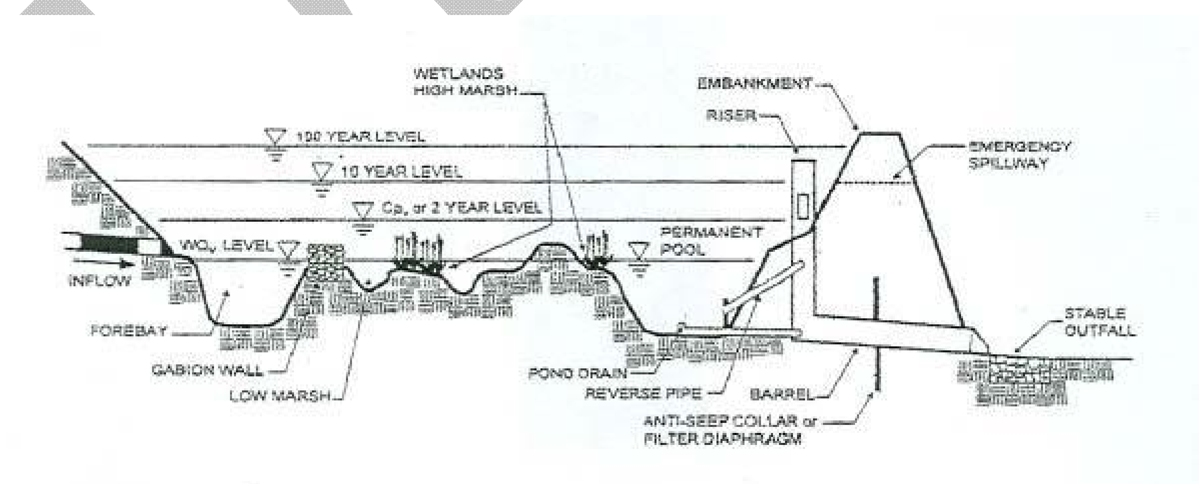


FIGURE WL-2 WETLAND BASIN SECTION





Storage

The total live design volume of the wetland basin should be equal to the volume of runoff from a 2-year, 24-hour event under full development. The amounts of "wet" storage should be based on design wetland depth.

Surface Area

Research has demonstrated that to attain significant (greater than 80 percent) removal of most pollutants in urban stormwater, a wetland basin should not have a hydraulic loading rate of more than one inch/day as an annual average. Table 3.5 shows the effect of this design criterion on wetland basin size as percent impervious area increases.

TABLE 3.5 – WETLAND BASIN SIZE VERSUS IMPERVIOUS AREA

Percent Impervious	Typical Annual Yield (in)	Basin Size (ac/ac of watershed)
30	12	0.040
40	14	0.045
50	16	0.050
60	18	0.055
70	19	0.060
80	20	0.065

Depth

Shallow wetland basin normal water depths are necessary to promote the growth and propagation of wetland plants and improve the efficiency of pollutant removal. Deeper water reduces vegetation growth and the effective contact time with both vegetation and soils.

The recommended wetland basin depths are between 6 inches and one foot.

Design Grades

The wetland bottom should be flat. Sideslopes should be 4 to 1 or flatter. It typically will be necessary to over-excavate by 12 inches for topsoil placement in the bottom of the wetland.

Soils

For the wetland basin to function, the soils in the basin must retain water to support wetland vegetation and provide active exchange sites for adsorption of pollutants. The site-specific soil investigation in the *Site Evaluation and Field Testing* section should provide this information.

Since hydric soils will not be present, typically it will be necessary to import topsoil or organic soils to provide an appropriate wetland substrate.

Minimum topsoil specifications are no more than 20% clay and at least 50% organic. The soil should be free of all woody or inorganic debris. A sample specification is presented in Figure WL-3.

Liner

A liner may be needed to hold a permanent pool of water in the very permeable soils of Crystal Lake. Liner designs must be submitted by a licensed geotechnical engineer who shall certify their performance. Caly liners are preferred. Synthetic liners will only be approved in extreme circumstances.

Configuration

Wetland configuration is determined by depth and size. The effectiveness of several removal mechanisms, such as sedimentation, adsorption and microbial transformation are enhanced when the wetland possess high surface area to volume ratios. As with wet basins, designing the wetland basin with multiple cells promotes better performance.

To prevent short-circuiting, a length-to-width ratio of at least 3 to 1 is recommended.

Sediment Forebay Design

A sediment forebay located at the inlet should be incorporated into the design of the wetland basin. The forebay is designed to trap large particles so that sediment may be more easily removed, thereby lengthening the useful life of the wetland. The following guidelines shall be used in conjunction with the site constraints to determine the surface area, depth, and volume of the sediment forebay:

- **Surface Area** – 10% of the permanent pool surface area recommended
- **Depth** – Minimum of 3 feet
- **Volume** – Calculated from design surface area and depth

Inlet Energy Dissipation

The detention basin inlets should be directed to the sediment forebay. The inlets should be designed to prevent scouring and re-suspension of settled bottom sediments.

The use of rip-rap, stone, or manhole sections can be effective in stabilizing inlets (Figure WB-3).

Outlet Design

The ability to control water level is essential to the establishment and maintenance of wetland basins. The first consideration of outlet design is the need to be able to lower water levels to 6 inches to a foot below wetland grade. Figure WL-2 shows a typical detail of such a design. Without water level control it is difficult to establish wetland vegetation. Once wetland vegetation is established, water levels can be raised to normal design levels.

Single pipe outlets shall have a minimum inside diameter of 12 inches. Where an orifice plate is used to control discharge, it shall have a minimum diameter of 4 inches to prevent plugging. Figure WB-4 shows several possible outlet designs.

Other outlet designs also may be effective. These include weirs and level spreader design (Figure WB-3).

All culvert weir outlets should discharge into an energy dissipator before releasing into the infiltration basin as shown in Figure WB-6.

Overflow Design

Since the wet basins are designed for the 2-year event, an overflow spillway is needed to control the location where flows overtop the wetland basin and flow to the infiltration device.

The overflow spillway should be sized to pass the 100-year, 24-hour discharge to the wetland basin at a depth not to exceed 0.5 feet above the spillway elevation.

The overflow spillway must be armored across its full width. Generally, vegetation over geotextile is preferred. However, the designer should evaluate the need for rip rap or other hard surface stabilization based on specific circumstances.

Embankments

Earthen embankments should be designed to address potential risk and structural integrity issues such as seepage and saturation. All should meet the following criteria:

- The base of the embankment shall be stripped of all vegetation, stumps, topsoil and other matter. Stripping shall be a minimum of 6 inches.

- For embankments where the permanent pool is ponded 3 feet or more against the embankment, the designer should evaluate the structural integrity of the design.
- All embankments shall be constructed with non-organic soils and compacted to prevent leakage. No tree stumps, or other organic material shall be buried in the embankment. The constructed embankment height shall be increased as necessary to account for settling.
- Any pipes extending through the embankment shall be bedded and backfilled with embankment or equivalent soils. The bedding and backfill shall be compacted in lifts and to the same standards as the original embankment.

Measures such as anti-seep collars shall be taken to minimize seepage along any conduit buried in the embankment.

Freeboard

The design of the wetland basin shall ensure the top of the embankment, after settling, is a minimum of one vertical foot above the flow depth in the overflow spillway required to safely pass the 100-year, 24-hour storm.

Access

Access and maintenance should be provided and extend to both the wetland basin inlet and outlet structures. An access ramp should be provided to the bottom of wetland basin unless all portions can be reached by a backhoe from the banks of the basin.

Vegetation and Planting

Vegetation is a defining component of all wetlands. In general, wetland species that have a large stem surface area per unit bed area will provide the greatest opportunity for stormwater contact and microbe growth. Dense-growing species will reduce flow velocity and increase sedimentation and filtration. The tolerance of some species to water level fluctuations may be relatively narrow, and the selection of vegetation must take this sensitivity into account. Likewise, designers should select plants adapted to the local environment, commercially available, fast growing and requiring little maintenance. Table 3.6 outlines recommended species for planting in a wetland basin.

The sideslopes of the wetland basin also should be planted in low-maintenance native plants. Table 3.7 presents suitable species by anticipated water level. A typical wetland planting specification is included on Figure WL-1.

TABLE 3.6 - WETLAND BASIN BOTTOM PLANT LIST (Hey and Associates, 2007)

Forbs	
Scientific Name	**Common Name**
Acorus calamus	sweet flag
Alisma subcordatum	common water plantain
Asclepias incarnata	marsh milkweed
Boltonia latisquama	false aster
Caltha palustris	marsh marigold
Chelone glabra	white turtle head
Eupatorium maculatum	joe pye weed
Eupatorium perfoliatum	common boneset
Iris virginica shrevei	blue flag
Mentha arvensis	wild mint
Mimulus ringens	monkey flower
Penthorum sedoides	ditch stone crop
Rumex orbiculatus	great water dock
Sagittaria latifolia	common arrowhead
Scutellaria lateriflora	mad-dog skullcap
Graminoids	
Scientific Name	**Common Name**
Calamagrostis canadensis	blue joint grass
Carex aquatilis var. altior	long-bracted tussock sedge
Carex comosa	bristly sedge
Carex lacustris	common lake sedge
Eleocharis erythropoda	red-rooted spike rush
Juncus effusus	common rush
Leersia oryzoides	rice cut grass
Scirpus cyperinus	wool grass
Scirpus fluviatilis	river bulrush
Scirpus pungens	chairmakers rush
Scirpus validus creber	great bulrush
Sparganium eurycarpum	common bur reed
Cover Crop	
Scientific Name	**Common Name**
Echinochloa crusgalli	barnyard grass

Table 3.7 – WETLAND BASIN SIDESLOPE PLANT LIST

Mesic Prairie Buffer Seed List > 12" Above NWL		Wet Mesic Plant List NWL – 12"	
Forbs		**Forbs**	
Scientific Name	**Common Name**	***Scientific Name***	**Common Name**
Aster laevis	smooth blue aster	*Allium cernuum*	noddng wild onion
Aster nova-angliae	New England aster	*Anemone canadensis*	meadow anemone
Baptisia leucantha	white false indigo	*Asclepias incarnata*	swamp milkweed
Coreopsis tripteris	tall coreopsis	*Aster novae-angliae*	New England aster
Desmodium canadense	showy tick trefoil	*Eupatorium maculatum*	joe pye weed
Echinacea pallida	pale purple coneflower	*Eupatorium perfoliatum*	common boneset
Echinacea purpurea	purple coneflower	*Gentiana andrewsii*	bottle Gentian
Eryngium yuccifolium	rattlesnake master	*Helianthus grosseserratus*	sawtooth sunflower
Heliopsis helianthoides	ox-eye sunflower	*Helenium autumnale*	sneeze weed
Lespedeza capitata	round-headed bush clover	*Liatris spicata*	marsh blazing star
Liatris pychnostachya	prairie blazingstar	*Physostegia virginiana*	obedient plant
Liatris spicata	marsh blazingstar	*Pycnanthemum virginianum*	common mountain mint
Monarda fistulosa	wild bergamot	*Silphium perfoliatum*	cup plant
Parthenium integrifolium	wild quinine	*Sisyrinchium angustifolium*	stout blue-eyed grass
Penstemon digitalis	smooth penstemon	*Solidago graminafolia*	grass leaved golden rod
Petalostemum purpureum	purple prairie clover	*Teucrium canadense*	germander
Ratibida pinnata	yellow coneflower	*Verbena hastata*	blue vervain
Rudbeckia hirta	black-eyed Susan	*Veronia fasciculata*	ironweed
Rudbeckia subtomentosa	sweet black-eyed Susan	*Veronicastrum virginicum*	Culver's root
Silphium integrifolium	rosinweed	*Zizia aurea*	golden alexanders
Silphium terebinthinaceum	prairie dock	**Graminoids**	
Solidago rigida	stiff goldenrod	*Carex annectins var. xanthocarpa*	small yellow fox sedge
Verbena hastata	blue vervain	*Carex scoparia*	lance-fruited oval sedge
Zizia aurea	golden alexanders	*Carex vulpinoidea*	brown fox sedge
Grasses		*Elymus virginicus*	Virginia wild rye
Andropogon gerardii	big bluestem	*Hierochloa Odorata*	sweet grass
Andropogon scoparius	little bluestem	*Juncus dudleyi*	Dudley's rush
Bouteloua curtipendula	side-oats grama	*Panicum virgatum*	switch grass
Elymus canadensis	Canada wild rye	*Scirpus atrovirens*	dark green bulrush
Panicum virgatum	switch grass	*Spartina pectinata*	prairie cord grass
Sorghastrum nutans	Indian grass	**Cover Crop**	
Cover Crop		*Avena sativa*	seed oats
Lolium multiflorum	annual rye	*Lolium multiflorum*	annual rye

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BIO-RETENTION FACILITIES

PURPOSE

This chapter presents the methods, criteria, and details for analysis and design of a bio-retention facility for water quality benefits.

A bio-retention facility (BRF) is a specially designed detention and filtration area for the treatment of stormwater runoff. The BRF is excavated and back-filled with an engineered sand mix for filtration and then overed with a sand-compost mix and planted. The BRF has tiles installed to underdrain it to the final infiltration basin. Stormwater is treated by a variety of physical, chemical and biological processes as it percolates through the vegetation and engineered soil.

BRFs are designed to remove low concentrations and quantities of petroleum hydrocarbons, total suspended solids (TSS), heavy metals, and nutrients from stormwater. Figures BRF-1 and BRF-2 illustrate a typical plan and cross-sectional view of a bioretention facility.

BRFs can require significant maintenance and are best applied only to Class III impervious areas.

DESIGN CRITERIA

A BRF is designed so that runoff from small events will flow smoothly across the entire width of a densely-vegetated area and infiltrate through engineered soil and into underdrains. BRF sizing is based on several variables, including the design flow and tributary area. Key design parameters are size, depth of engineered soil, underdrain considerations and specifications for soils and vegetation. Design procedures for sizing BRFs are summarized below.

Design Hydrology

The geometry of the BRF should be based on the volume and rate of flow expected from its watershed. BRFs should be designed for the runoff volume from a 1-year, 24-hour event.

The smaller design event is related to the dynamic ability of the BRF to both settle and filter runoff prior to infiltration.

TABLE 1 LABORATORY AND ESTIMATED BIORETENTION

Pollutant	Removal Rate
Total Phosphorus	70%-83% [1]
Metals (Cu, Zn, Pb)	93%-98% [1]
TKN	68%-80% [1]
Total Suspended Solids	90% [2]
Organics	90% [2]
Bacteria	90% [2]

Source: [1]Davis et al. (1998)
[2]PGDER (1993)

FIGURE BS-1 WATER QUALITY SWALE PLAN

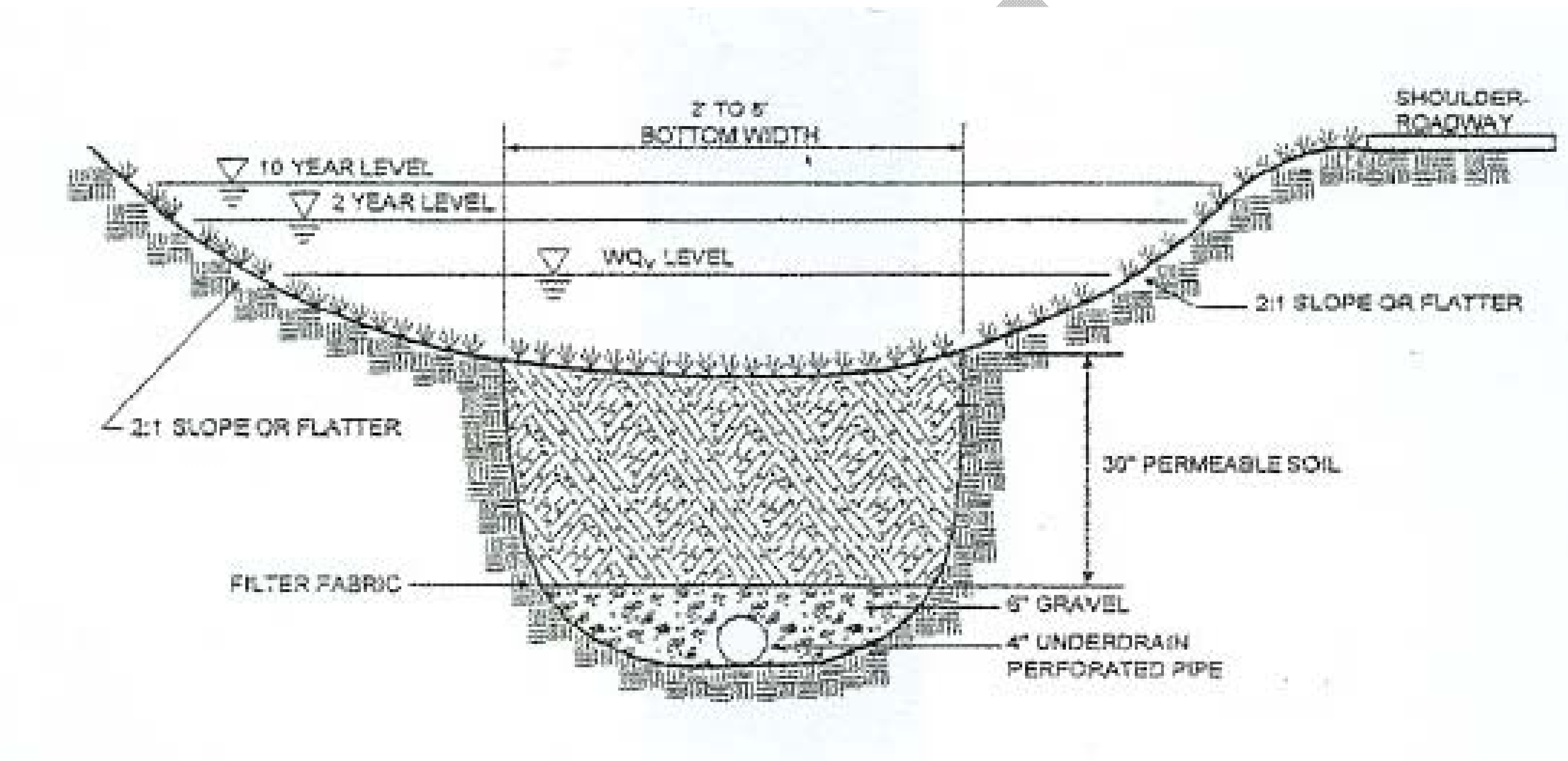
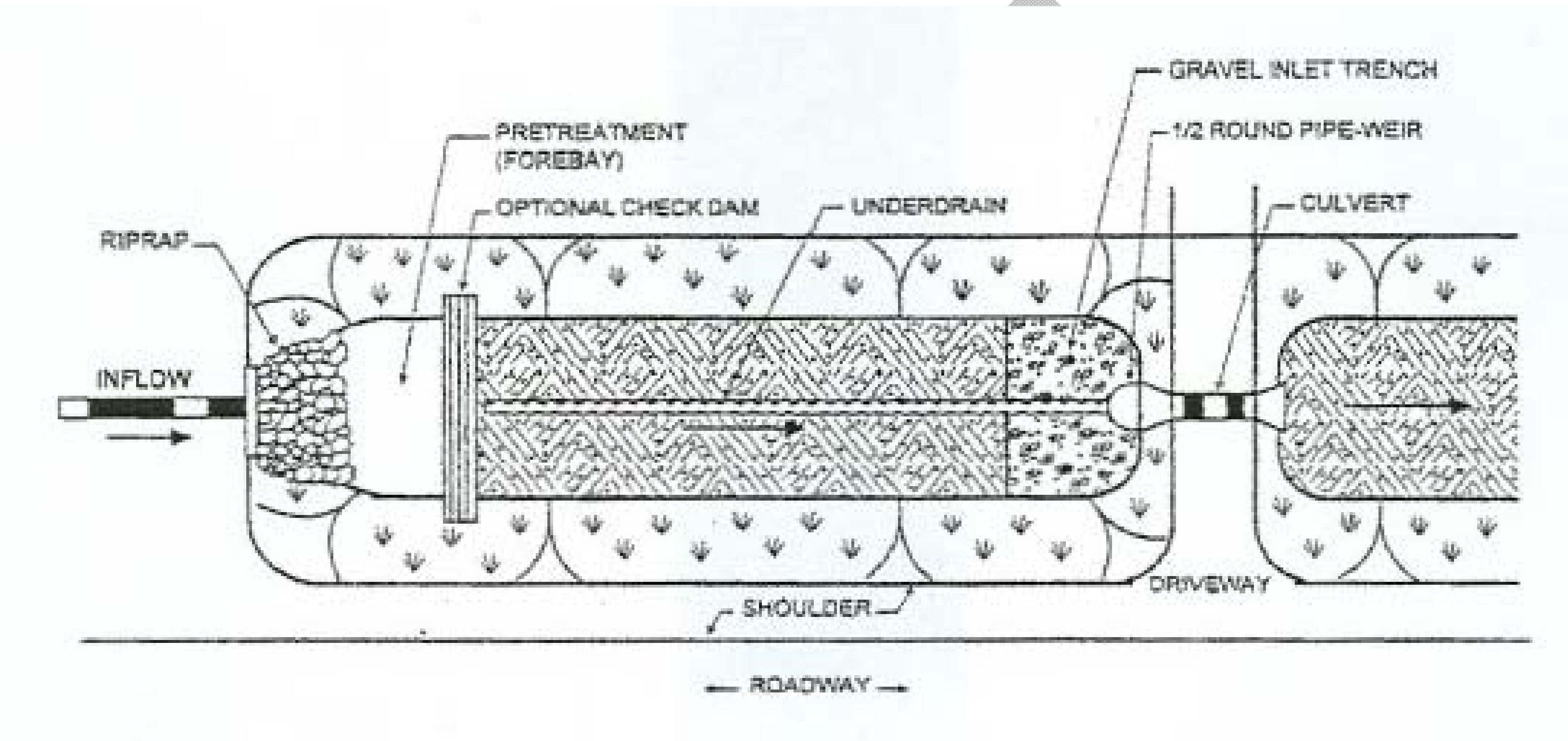


FIGURE BS-2 WATER QUALITY SWALE SECTION



BRF Slope

The BRF should only have enough slope to facilitate even distribution of incoming runoff across the entire surface of the BRF. In no event shall slopes greater than one percent be acceptable.

Engineered Soils

The media of a BRF includes three distinct layers – the top compost-topsoil layer, the middle engineered soil media, and the bottom gravel storage layer (as illustrated in Figure BS-1).

1. Engineered Soil Layer

A thin compact-topsoil layer should be installed on the surface of the BRF area. The layer should be 8 inches in depth and consist of the following mix of City approved material:

- 40-50 percent compost
- 40-50 percent sand
- 10-20 percent clay

Testing results shall be submitted to the City to ensure that the final mix is free from pollutants and has at least a 2 percent iron content.

2. Engineered Filtration Media

Below the soil layer, a layer of engineered filtration media shall be placed. The engineered filtration media shall have a void ratio of at least 30 percent.

Filtration Media

The filtration media component shall be AASHTO-M-6 or ASTM-C-33 sand (0.02 to 0.04 inch diameter).

The depth of the filtration media should be at least 1.5 feet after placement.

3. Gravel Drainage Layer

A gravel drainage layer shall be installed below the engineered filtration layer. The gravel shall be of IDOT CA-4 as specified in the *Standard Specifications for Road and Bridge Construction* (2002). Gravel shall be washed and the thickness of this layer should be at least two inches above and below the underdrain. The entire surface of the BRF between the filtration media and the gravel drainage media shall be covered by geotextile as shown in Table 3.7.

Depth to Groundwater

BRFs are similar to infiltration basins. The depth from the bottom of the top of the BRF to the groundwater table shall be at least four feet. Soil borings are needed to establish that the depth to the groundwater table.

Surface Area and Configuration

The following geometric criteria should be followed.

1. *Size*

   The BRF surface area should be no less than 3.0 percent of contributing watershed.

2. *BRF Storage and Depth*

   BRFs should have a live storage depth equal to the volume of runoff from the 1-year, 24-hour event for its contributing watershed.

   The total below-grade depth of the BRF shall be at least 3 feet as described earlier.

3. *Shape*

   The BRF shape shall be determined by flow distribution requirements. It is important that flow be evenly distributed over the BRF so that sections are not overloaded. As described in the following sections flow distribution shall be added to ensure even spreading of incoming stormwater. It is likely that a rectangular shape with the long axis receiving the distributed flow will be necessary.

Side slopes within the treatment area should be 3H:1V or flatter whenever possible, but shall not be steeper than 2H:1V.

Flow Velocity

The maximum flow velocity into the BRF for runoff events up to the 1-year 24-hour flow events shall not exceed 0.5 feet per second. The maximum velocity for the 100-year event should never exceed 2 feet per second.

Flow Spreading and Energy Dissipation

A flow spreader shall be used at the inlet of a swale to dissipate energy and evenly spread runoff as sheet flow over the swale bottom.

Underdrains

Underdrains are required to collect the treated runoff from the BRF and to transport the flow to the downstream infiltration system.

Underdrains must meet the following criteria:

- Underdrains should be made of PVC perforated pipe (SDR 35), laid parallel to the swale bottom and backfilled and bedded as described above.
- The underdrain pipe must be 4 inches or greater in diameter.

TABLE 3.8 – FILTER FABRIC MATERIAL REQUIREMENTS

Geotextile Property	Value	Test Method
Grab Tensile Strength, N	800 min.	ASTM D4632
Puncture Strength, N	300 min.	ASTM D4833
Apparent Breaking Elongation, Percent	30 min.	ASTM D4632
Apparent Opening Size, μm	300 max.	ASTM D4751
Permittivity, S-1	1.35 min.	ASTM D4491

Freeboard

A minimum of 6 inches freeboard shall be provided above the 1-year, 24-hour water level.

Access

Maintenance access to BRFs shall be provided.

Planting Requirements

Vegetation shall be established throughout the entire treatment area of the swale subject to the following provisions:

- Seeding is best performed in spring (mid-March to June) or fall (late September to October). Irrigation is required during the first summer following installation if seeding occurs in spring or summer.
- Acceptable grass seed mixes for the area are listed in Table 3.8. As an alternative to these mixes, a horticultural or erosion control specialist may develop a seed specification tailored to the site.
- Above the design treatment elevation, either a typical lawn seed mix or landscape plants may be used. Acceptable grasses and groundcovers are presented in Table 3.8. Native plant species are preferred.

Overflow Design

Since the BRFs are designed for the 1-year event, an overflow spillway is needed to control the location where flows overtop and flow to the infiltration device.

The overflow spillway should be sized to pass the 100-year, 24-hour discharge to the BRF at a depth not to exceed 0.5 feet above the spillway elevation.

The overflow spillway must be armored across its full width. Generally, vegetation over geotextile is preferred. However, the designer should evaluate the need for rip rap or other hard surface stabilization based on specific circumstances.

Embankments

Earthen embankments should be designed to address potential risk and structural integrity issues such as seepage and saturation. All should meet the following criteria:

- The base of the embankment shall be stripped of all vegetation, stumps, topsoil and other matter. Stripping shall be a minimum of 6 inches.
- For embankments where the permanent pool is ponded 3 feet or more against the embankment, the designer should evaluate the structural integrity of the design.
- All embankments shall be constructed with non-organic soils and compacted to prevent leakage. No tree stumps, or other organic material shall be buried in the embankment. The constructed embankment height shall be increased as necessary to account for settling.
- Any pipes extending through the embankment shall be bedded and backfilled with embankment or equivalent soils. The bedding and backfill shall be compacted in lifts and to the same standards as the original embankment.

Measures such as anti-seep collars shall be taken to minimize seepage along any conduit buried in the embankment.

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CHAPTER 4.1 – STORMWATER INFILTRATION

DESIGN PRINCIPLES

As previously discussed, infiltration of stormwater runoff is the policy of the City of Crystal Lake for the Crystal Lake Watershed. Infiltration maintains groundwater recharge, which is essential to maintaining flow to Crystal Lake. Infiltration in combination with pre-treatment BMPs also maximizes water quality protection for Crystal Lake and its aquifer.

The following principles expand upon the regulatory requirements for the design of stormwater infiltrations systems for Crystal Lake.

- Infiltration designs must be sustainable.
- Groundwater quality must not be degraded.
- Groundwater quantity must not be reduced.
- Upstream and downstream properties shall not have their base flood elevations (BFE) increased from new development.
- Adequate precious area must be provided to ensure that if the infiltration area fails it can be replaced in-kind.

ALLOWABLE INFILTRATION DEVICES

Infiltration systems within the Crystal Lake watershed shall be only infiltration basins. While there are a number of practices that provide for infiltration of stormwater, not all are sustainable or provide for water quality treatment. The approach to infiltration shown in Figure 4-1 is an example of a stormwater management system in the Crystal Lake watershed to meet the above design principles.

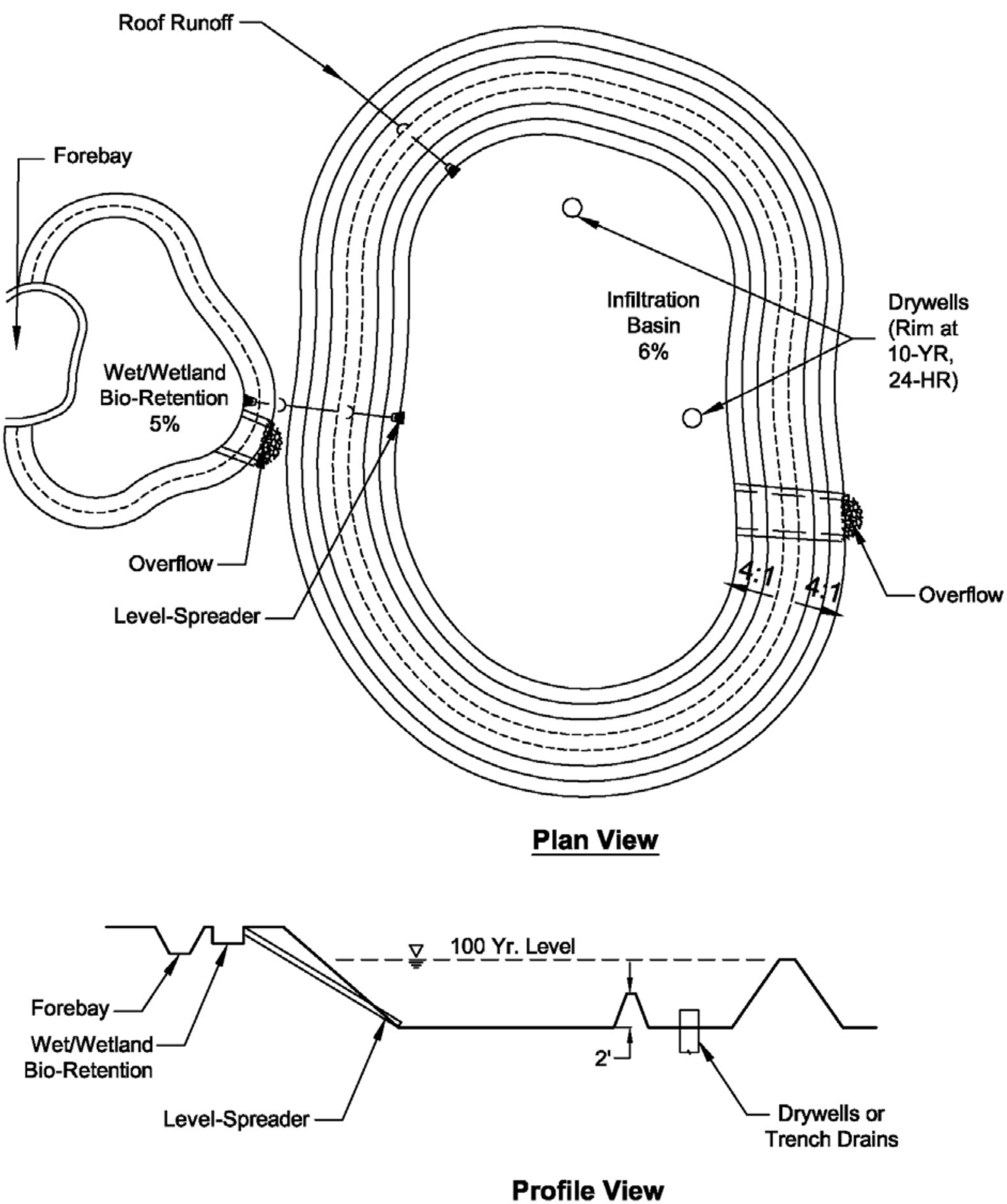
The recommended system allows for routine maintenance to assure sustainability and follows a sequential approach (treatment train) to water quality treatment.

The use of Class V Injection Wells for infiltration is not recommended in the Crystal Lake watershed due to their lack of ability to treat stormwater pollutants and problems with maintenance.

Any structure deeper than it is wide for the purpose of delivering stormwater to subsurface unsaturated or saturated zones is a Class V Injection well (IEPA, 1974).

Class V Injection Wells have been shown to provide little to no water quality treatment capability (WDNR, WSDOT, 1995). Typically, these wells discharge water below the surface soil layer into a zone with subsoils that have limited capacity to filter and absorb pollutants. When injection wells clog, they cannot be restored through routine maintenance as other surface infiltration systems can. Therefore, Class V Injection Wells are not recommended as an allowable infiltration practice in the City of Crystal Lake.

FIGURE 4.1 – COORDINATED STORMWATER MANAGEMENT PLAN



GENERAL DESIGN GUIDANCE FOR ORDINANCE PROVISIONS

The following is a summary of the sections of the CLSO that address the design requirements of infiltration systems:

Use of Infiltration Basin for Detention (3.174-6 (4)(q)) :

"Infiltration basins may be used as detention facilities subject to the following:

(1) The basin must be designed to dewater within 72 hours following the end of the 100-year, 24-hour storm.

(2) The underlying soils must have a sustainable infiltration rate of at least 0.5 inches per hour as determined by a geotechnical engineer in a sealed opinion. Column drains may be used to access more permeable substrate if designed by a geotechnical engineer in a sealed opinion.

(3) Pretreatment facilities for runoff must be provided to prevent loss of infiltration capacity.

(4) Direct infiltration (i.e. column drain) must be at least 100 feet away from any water supply wells and 1000 feet away from a public water supply well. Direct infiltration (drywells or trenches) structures must be at least 25 feet away from a building foundation unless a suitable design is produced by a licensed engineer and approved by the Enforcement Officer.

(5) Runoff from the areas that have water quality concerns or subject to frequent winter deicing must not be routed directly to the infiltration facility.

(6) The bottom of the infiltration basin must be at least four (4) feet above the seasonal high groundwater elevation.

(7) Infiltration basin design shall provide for storage of 150% of the storage volume for the 100-year, 24-hour storm."

Water Quality Requirements (3.174-2 (2)):

The development shall provide water quality treatment for runoff from increased impervious areas to minimize impacts of post construction stormwater runoff on water quality. The site development plan shall include a description of the water quality protection measures incorporated into the site design. The following treatment methods shall be evaluated and incorporated in the following order to reduce pollution and stormwater volumes to the maximum extent practicable:

"a. Sedimentation facilities, (basins and traps), followed by infiltration basins followed by column drains, if necessary.

b. If infiltration is infeasible, then use wetland detention facilities."

Within the Crystal Lake watershed all pretreatment facilities shall be designed to produce a total phosphorus effluent quality of no more than 0.10 mg/l as an annual average.

Dewatering

The 72-hour drawdown time following the 100-year, 24-hour event typically will require an infiltration rate of 0.75 inches per hour as shown in Figure 4-2. Drawdown is interpreted to mean no standing water deeper than two inches over 75 percent of the infiltration basin.

Infiltration Rate

Generally, the test procedures of Chapter 2 result in a field measured infiltration rate that combines the permeability and gradient expected in the infiltration basin. This is because the tests are intended to be performed at the average head in the infiltration basin.

Infiltration rate is a function of the permeability of the strata where groundwater will be infiltrated and the gradient (or head) available.

Pre-treatment Facilities

Figure 4-1 and Chapter 3 describe site design and pre-treatment BMPs. As shown, it is important to assign and size BMPs based on the characteristics of the watershed they will treat. Figure 4-1 shows a treatment train approach to sequentially address first solids, then nutrients, then any remaining pollutants such as oil and grease before runoff is introduced to the infiltration basin.

Well Separation

It is important that each infiltration design evaluate potential effects on neighboring water supplies. The concern about Class V Injection Wells reflects the need for a cautious approach to disposal of stormwater runoff underground.

Areas of Water Quality Concern

Developers who follow the design example of Figure 4-1 will have avoided direct discharge of runoff to groundwater through the recommended treatment train approach. Chapter 3 discussed classification of watersheds based on pollutant risk. This also is reflected in Figure 4-1.

Groundwater Separation

Groundwater separation ensures that sufficient gradient is available for infiltration. It also ensures that there will be an unsaturated zone for temporary storage of runoff in void spaces (typically 20-30 percent of the soils under the infiltration basin bottom above the groundwater table). It prevents saturation of the basin bottom which could lead to clogging and prevents death of vegetation on the basin bottom. The separation also applies to trenches and drywells.

Volume Factor of Safety

The 150 percent factor of safety applies to retention basins where no surface outlet is available and where no safe emergency overflow route is protected. In these rare circumstances, additional volume is required as a factor of safety. The additional storage volume is intended to offset uncontrollable factors such as clogging of the infiltration surface, trenches or drywells, frozen ground and runoff greater than the 100-year event. Since no safe overflow is available, these circumstances must be addressed in the retention basin design. Several design conditions may work to reduce the final storage where required. The design approach for a basin without a surface outlet on a safe, protected emergency overflow route is as follows:

1. Calculate storage required for the 100-year, 24-hour event (7.58 inches of rainfall) using the field determined infiltration rate from Chapter 2 and a design methodology to calculate storage consistent with the CLSO.
2. Add 50 % to the volume obtained in Step 1.
3. Using Figure 1.7, calculate the storage required as though a surface outlet were available.
4. Design the basin volume for the larger of Step 2 or 3.

Compensatory storage may be used to offset the 50% portion of safety volume but not the base storage volume of Step 1. If compensatory storage is proposed to offset the factor of safety, a 100-year event critical duration analysis of the with-project condition should be performed to demonstrate that the final basin design is large enough.

CHAPTER 4.2 – INFILTRATION BASINS

INFILTRATION BASINS

PURPOSE

This chapter presents the methods, criteria, and details for design of infiltration basins.

Infiltration basins temporarily store and infiltrate stormwater runoff into permeable soils and groundwater. With proper design, infiltration basins also can provide water quality treatment, removing many nutrients and pollutants while recharging the groundwater.

Figures IB-1 and IB-2 illustrate a typical plan and cross-sectional view of an infiltration basin.

Infiltration basins can be very effective to route runoff to groundwater recharge. However, when not properly designed and maintained, infiltration basins have a high failure rate due to premature clogging of the basin. To prevent premature failure, pretreatment is essential for the continued function of the basin. Figure 4-1 presented a typical design for infiltration in the Crystal Lake watershed. It presents the significant pre-treatment measures needed to sustain the infiltration function.

DESIGN CRITERIA

The design of an infiltration basin is based on the infiltration rate of the soil and the volume of runoff from the tributary area. A discussion and guidance for key design parameters follows.

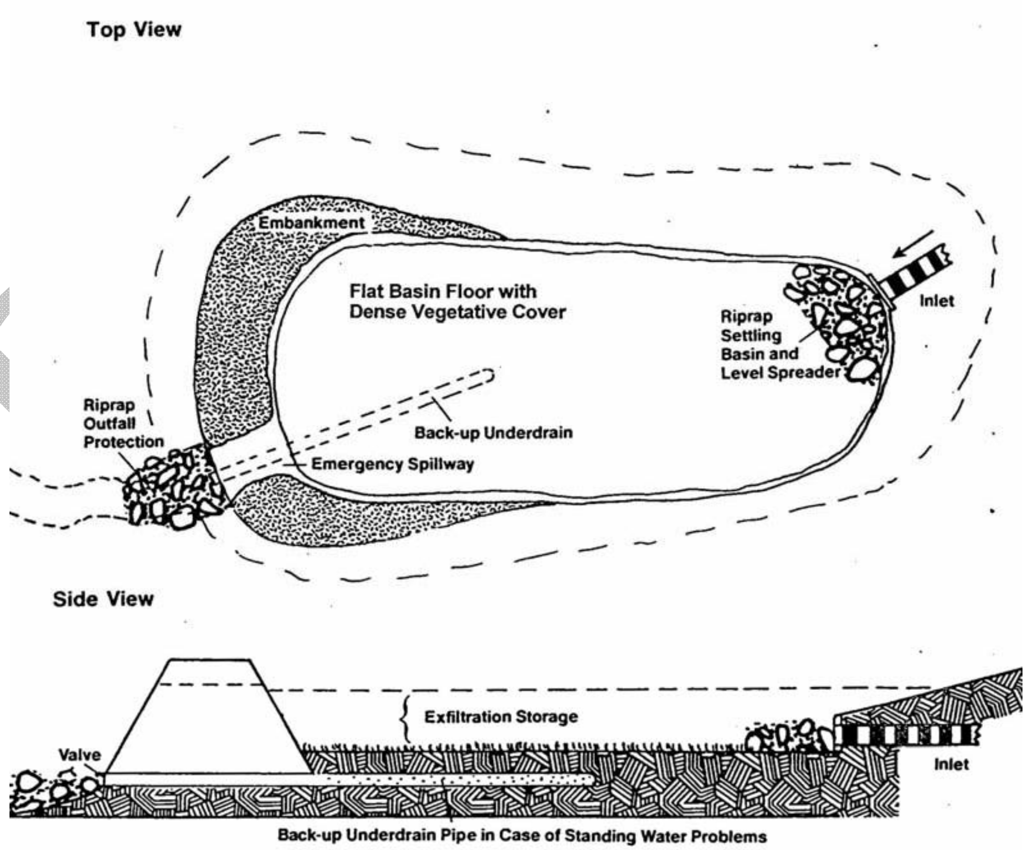


FIGURE IB-1 INFILTRATION BASIN PLAN

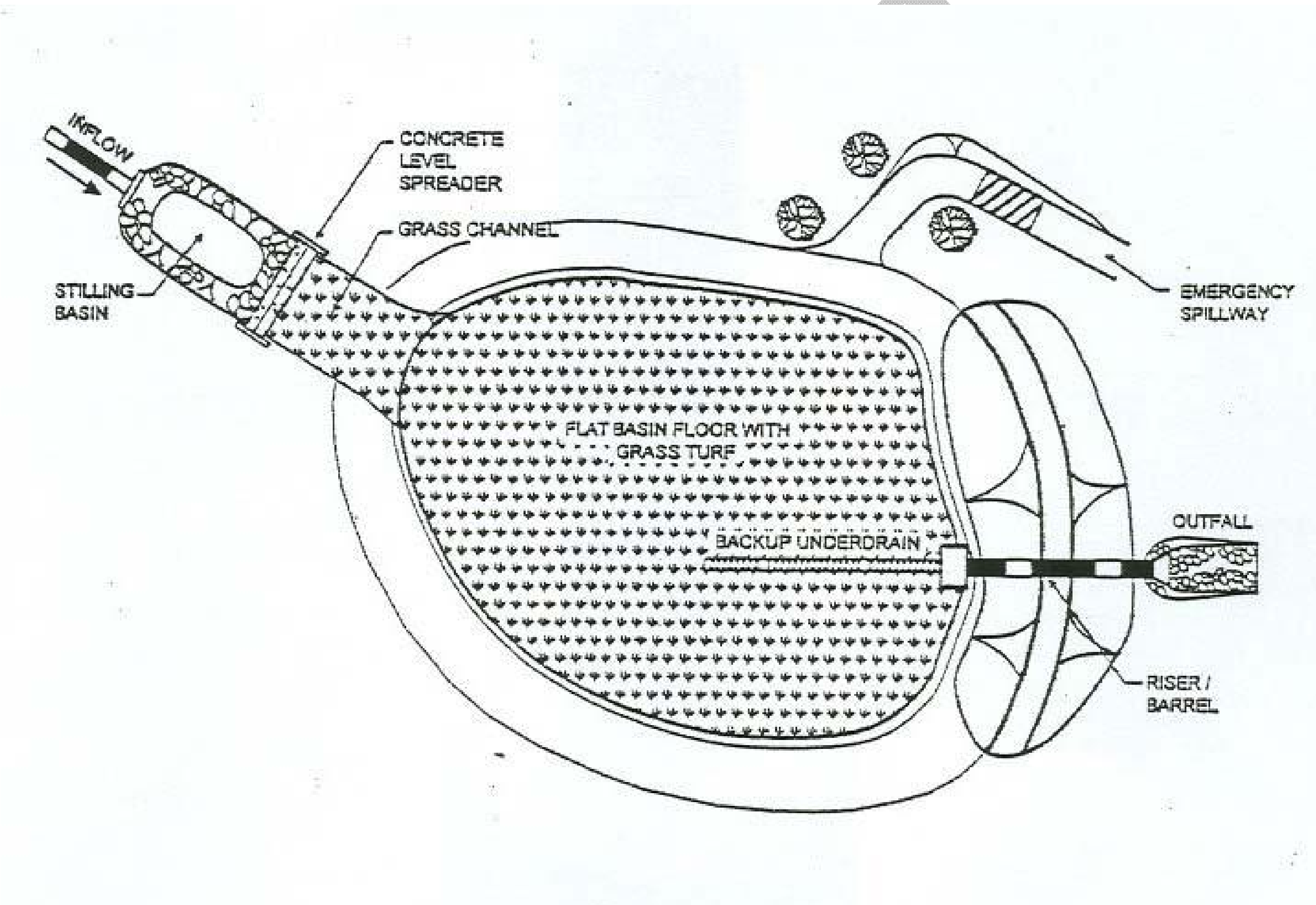
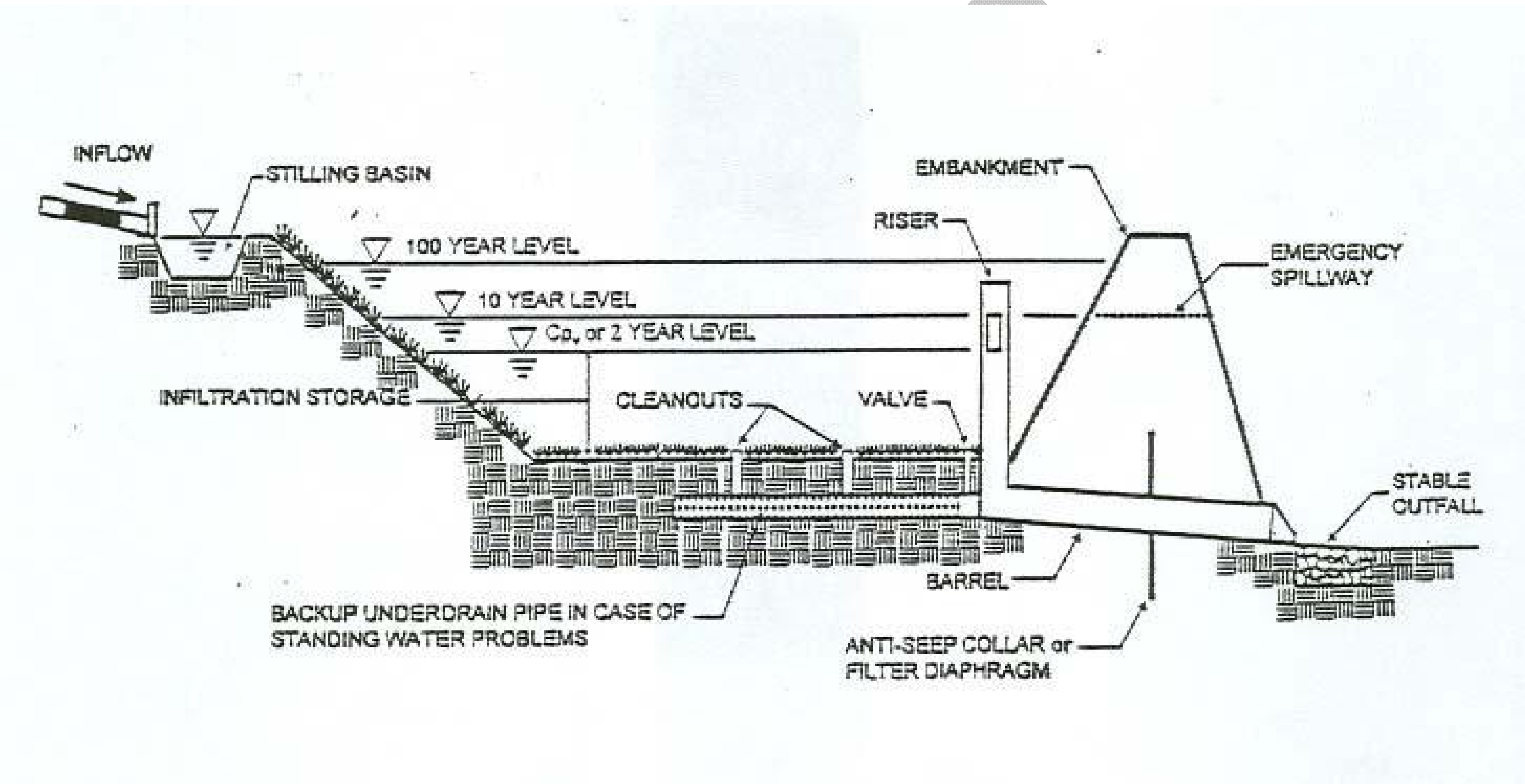


FIGURE IB-2 INFILTRATION BASIN SECTION



Pretreatment

The design of pre-treatment facilities was discussed in Chapter 3.

Design Storm

The hydrologic design parameters used to determine infiltration detention basin volume are listed below.

- Design Rainfall: 7.58 inches
  (100-year, 24-hour, Bulletin 70 Tabular Northeast Section)
- Antecedent Moisture Condition: Type II
- Rainfall Distribution: 3rd Quartile Huff
  (Use median values)

In addition, designers shall use the runoff curve number (RCN) for the next higher NRCS hydrologic soil group for all pervious areas that will be mass graded for with-project runoff calculations. The increased RCN will not be required if the pervious areas are disked to offset compaction before planting or if native landscaping is used.

Stormwater management basins shall use the following RCNs:

- Normally dry: 85
- Wetland bottom: 90
- Wet bottom: 95

Soils

To be suitable for infiltration, underlying soils should have a sustainable infiltration rate (permeability x gradient) of 0.5 inches per hour or greater. Chapter 2 discussed the process for evaluating suitable soils for permeability.

Depth to Groundwater

The depth to seasonally high groundwater must be at least 4 feet below the bottom of the infiltration basin as required by the CLSO. Data from the Soil and Site Evaluation report (Chapter 2) should document groundwater levels.

Configuration

All infiltration basins must be flat on the bottom with stable side slopes. Side slopes of 3:1 or flatter are required for ease of maintenance and safety.

Drain Times

The basin should drain within 72 hours. The infiltration rate at the average design depth in the basin and the permeability obtained from tests performed at the site should be used in the design calculations.

Gradient

Darcy's law states that infiltration rate, q, equals permeability times gradient. Gradient was discussed in Chapter 2. For infiltration basins gradient is equal to the depth of water stored in the basin above the bottom of the basin plus the depth of the wetting front below the basin divided by the depth of the wetting front (Bouwer, 2001). Referring to Figure 2.1:

$$q = \frac{(z + L)}{L}$$

where q = unit infiltration rate

z = depth of water in basin

L = depth of wetting front

The depth of the wetting front changes rapidly as water infiltrates through the infiltration basin. At a porosity of 20 percent and the minimum separation of 4 feet above groundwater (or a relatively impermeable structure) storage of 9.6 inches under the bottom of the basin is available. However, with a ratio of infiltration basin area to contributing watershed of 10 percent, 1 inch of watershed runoff is equal to 10 inches of runoff over the basin. This volume of runoff would be delivered in the first few hours of the design runoff event. It is apparent that for larger events the depth of the wetting front will increase rapidly. At typical maximum water depths in the basin of 4 feet the gradient will rarely exceed (4 + 4)/4 = 2. At greater groundwater separation the gradient will tend to approach 1.

Infiltration Basin Calculations

The procedure for the design of an infiltration basin volume is summarized in the following section. The following data are needed for the calculations:

1. The contributing watershed and its hydrologic parameters,
2. The field infiltration rate at different water depths in the basin based on permeability from field testing results obtained in accordance with the guidelines specified in Chapter 2: *Site Evaluation and Field Testing Requirements*, and, design gradient and,
3. Calculation of any compensatory storage requirements.

The above data are then used in the following calculations.

Step 1 – Volume Using Design Infiltration Rate

The design release rate for infiltration basins shall be based on actual field testing as summarized in Chapter 2. The design infiltration rate should be the lowest field infiltration rate determined from field tests. A stage-discharge relationship should be developed using field permeability testing data, the design gradient and the area of the basin to be used for infiltration. The retention volume then is calculated in the usual manner using a methodology specified in the CLSO.

Step 2 – 150 Percent Volume Factor of Safety

After a retention volume has been calculated using the field infiltration rate, a factor of safety may need to be applied to that volume.

The factor of safety is necessary when the retention basin has no surface discharge or lacks a safe, protected overflow for events larger than the 100-year recurrence. For this situation, the volume calculated in Step 1 is multiplied by 1.5 and this becomes the design volume. This design volume must still be compared to the McHenry County minimum recommended infiltration volume as described in Step 3.

Step 3 – McHenry County Minimum Infiltration Basin Volume

The McHenry County Technical Reference Manual states that infiltration designs should not have a design volume less than that required at a surface release of 0.15 cfs per acre at high water for the 100-year, 24-hour event. The calculation of minimum storage can be made as described in Section 3.174 – 6, (2)1, 3 and 4. Figure 1.7 may be used to calculate the minimum county storage for development smaller than 10 acres.

Step 4 – Required Storage

The required storage for a retention basin that does not have a surface discharge on a safe emergency overflow is the larger of the volume computed in Step 2 and Step 3.

Step 5 – Compensatory Storage

If the development is required to provide compensatory storage as described in the CLSO at 3.174-6 3h, 4 m, and 3.174-7, it may be used to offset the 50 percent factor of safety volume if a 100-year event critical duration analysis shows no off-site impacts. The critical duration analysis should show that the basin will not overflow for any 100-year events.

Step 6 - Drawdown Time

The drawdown time for the 100-year 24-hour runoff volume must be less than 72 hours as required by section 3.174-6.4.q (1) of the CLSO.

Drawdown Time (hr) =
Runoff Volume (ac-ft) x Design Discharge (cfs)

Design discharge should be based on the same stage-discharge relationship used in Step 1.

If the drawdown time is greater than 72 hours, the design must be modified until a drawdown time of less than 72 hours is achieved or a variance must be requested.

Appendix B contains a design example that incorporates the above guidelines.

Step 7 - Groundwater Mounding

Groundwater mounding refers to the accumulation of water beneath an infiltration facility faster than it can move laterally. A mound of water actually can form as groundwater builds a head to be able to flow horizontally through the subsoils. A groundwater mounding calculation must be submitted for each infiltration design.

Engineered Soils

The media of a BRF includes three distinct layers – the top compost-topsoil layer, the middle engineered soil media, and the bottom native sand and gravel storage layer.

1. Engineered Soil Layer

A thin compact-topsoil layer should be installed on the surface of the infiltration basin bottom area. The layer should be 6 inches in depth and consist of the following mix of City approved material:

- 50 percent compost
- 40 percent sand
- 10 percent clay

Testing results shall be submitted to the City to ensure that the final mix is free from pollutants and has at least 2 percent iron content.

2. Engineered Filtration Media

Below the soil layer, a layer of engineered filtration media shall be placed. The engineered filtration layer shall be one foot deep.

The filtration media component shall be AASHTO-M-6 or ASTM-C-33 sand (0.02 to 0.04 inch diameter).

3. Native Soil Drainage Layer

The engineered filtration media shall be separated by filter fabric meeting the specifications of Table 3.7 The native soil layer shall be inspected and certified free from clogging prior to installation of the fabric, filtration media or engineered soils.

Drywells

Drywells meeting the following design criteria may be added to the bottom of the infiltration basin to provide an emergency outlet for maintenance and repair.

The rim of the drywell shall be at the elevation of the 2-year, 24-hour event. The drywell must be no more than four feet wide and no more than three feet deep and in any event cannot be classified as a Class V Injection Well. No more than two drywells can be used within the infiltration basin. Drywells shall be filled with CA-5 and shall have an open grate structure.

Basin Inlets

Erosion protection is required at the inlet. Riprap aprons or other energy dissipaters help to reduce velocities and spread flows. The inlet should discharge at the basin floor.

Emergency Spillways

In the event of failure or in the instance of an extreme event, a non-erosive overflow channel should be provided to safely pass flows that exceed the storage capacity of the basin to a stabilized downstream area or watercourse. Dry wells and injection wells are not allowed as a means of direct release to the groundwater.

Access

Adequate access should be provided to an infiltration basin facility for inspection and maintenance.

Setbacks

Minimum setback requirements for infiltration basin facilities are as follows:

- From a property line – 10 feet
- From a building foundation – 25 feet
- From a private well – 100 feet
- From a public water supply well – 1,000 feet
- From drain tiles – 50 feet

Planting Requirements

Plant species native to Illinois are biologically and aesthetically more valuable than non-native species and may provide a longer-lived, stable system for infiltration. Table 3.4 and 3.5 in Chapter 3 include examples of native species that should be employed.

CONSTRUCTION CRITERIA

The greatest concern for the sustainable operation and performance of an infiltration basin is premature clogging of the basin. Premature clogging is often a result of poor construction techniques or improper control of sediment during construction. The following construction guidelines should help to minimize the problem.

- The infiltration basin should not be used for erosion control during construction.
- Partially excavate the basin during dry periods, using only light earth-moving equipment or equipment with over-sized tires. Leave a "sacrificial" layer 1 to 2 feet deep to be excavated. After the development is stabilized, complete the excavation. The infiltration site should be deep-tilled and leveled after excavation.
- Seed vegetation immediately after construction.
- Any sediment that has accumulated in the basin must be removed after construction.
- The basin should not be placed in operation until upland areas are stabilized.

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CHAPTER 4.3 – INFILTRATION TRENCHES AND DRYWELLS

INFILTRATION TRENCHES AND DRYWELLS

PURPOSE

This chapter presents the methods, criteria, and details for design of infiltration trenches and drywells.

An infiltration trench is defined as an excavated trench filled with stone aggregate used to capture and allow infiltration of stormwater runoff into the surrounding soils from the bottom and sides of the trench. It is typically 2 to 10 feet deep, often lined with a sand base, a protective layer of filter fabric on the sides, and filled with coarse aggregate. In the Crystal Lake watershed, trench drains and drywells are not recommended.

They are constructed to provide a sustainable route to infiltrate stormwater in the event the infiltration basin clogs or as the primary route to infiltration in specific designs.

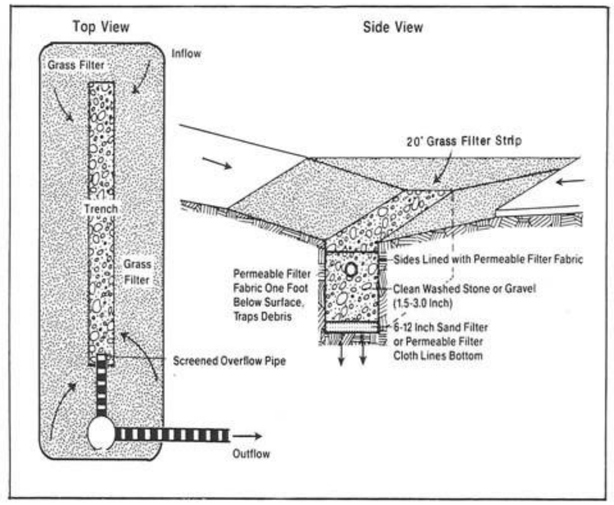
Figure IT-1 illustrates a typical cross-sectional view of a drywell and Figure IT-2 shows an infiltration trench.

Infiltration trenches or drywells are needed to provide a sustainable route for runoff to infiltrate but they have a higher maintenance level than infiltration basins.

The potential role of infiltration trenches and drywells is shown in Figure 4-1.

DESIGN CRITERIA

The following sections present the guidance for the design, sizing, construction criteria, and operation and maintenance for infiltration trenches and drywells.



Median Strip Trench Design

Size

The following criteria provide guidance for the sizing of a drywell or infiltration trench.

The design infiltration rate should be based on the field tests described in Chapter 2 and the sealed opinion of the engineer who prepared the tests. The following formula presents the upper bound for design infiltration rates once field testing has been completed.

The discharge for a drywell of radius r with hydraulic conductivity K and depth of water from the bottom of the drywell to the average surface ponding depth D would be

$$Q = \frac{2 * \pi * K * D^2}{\ln(2 * D / r) - 1}$$

Trench drains should be designed assuming they will provide 20 percent of the recharge rate of a drywell of equal width and length.

FIGURE IT-1 DRYWELL DETAIL

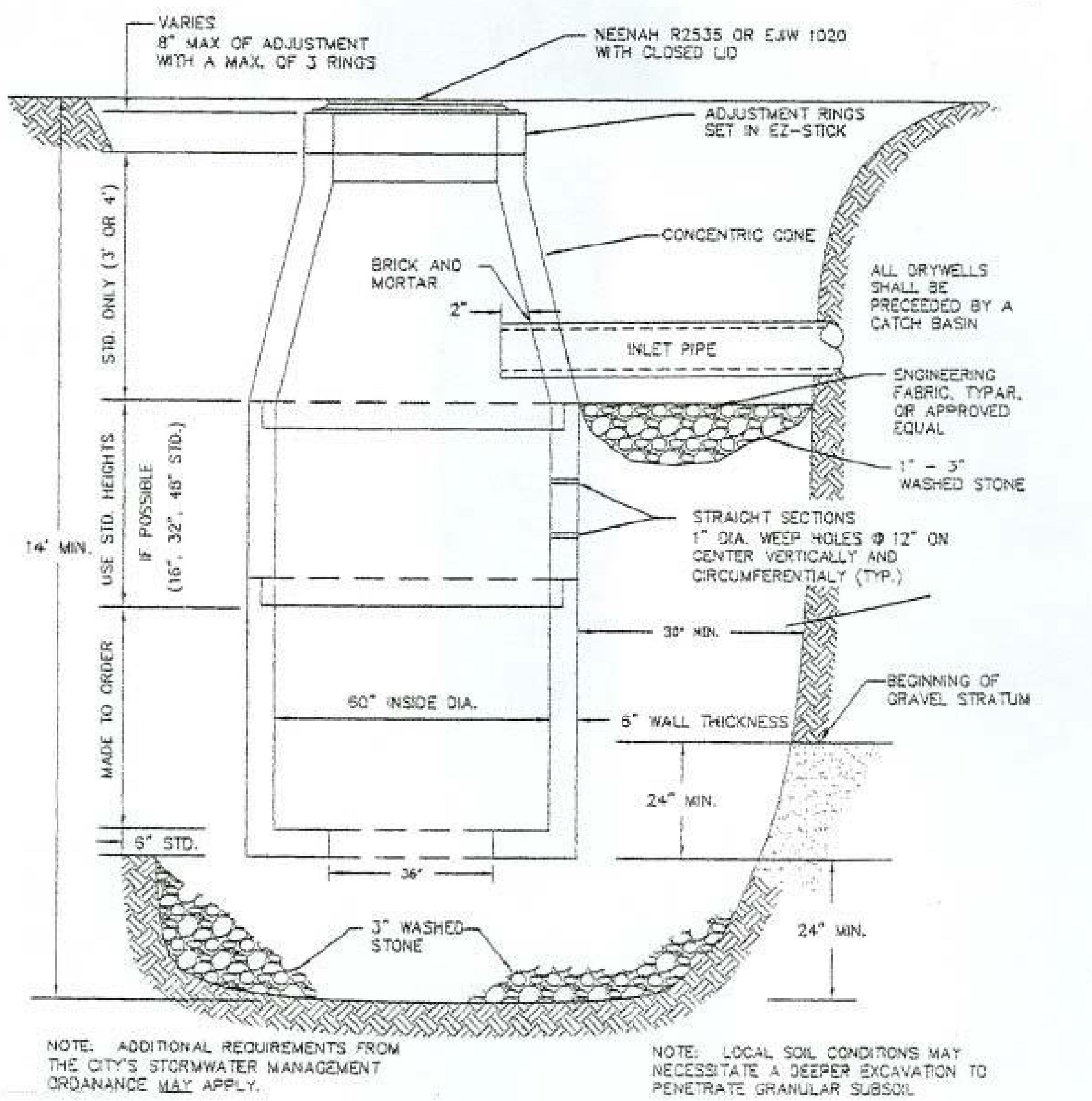
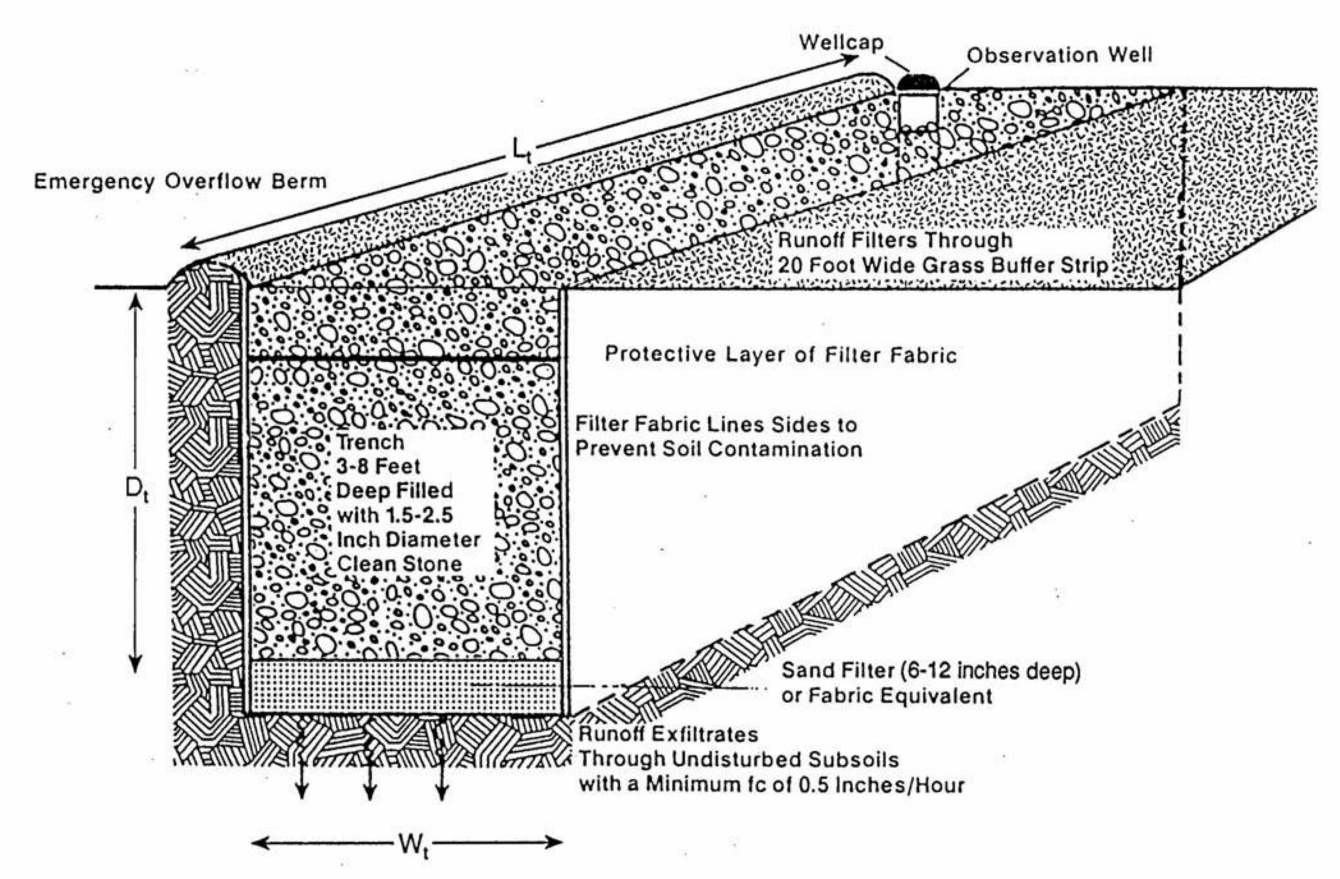


FIGURE IT-2 INFILTRATION TRENCH DETAIL



Design Storm

The key hydrologic design parameters used to determine minimum infiltration trench or drywell size are listed below.

- Design Rainfall: 7.58 inches
  (100-year, 24-hour, Bulletin 70 Tabular Northeast Section)
- Antecedent Moisture Condition: Type II
- Rainfall Distribution: 3rd Quartile Huff
  (Use median values)

In addition, designers shall use the runoff curve number (RCN) for the next higher NRCS hydrologic soil group for all pervious areas that will be mass graded for with-project runoff calculations. The increased RCN will not be required if the pervious areas are disked to offset compaction before planting or if native landscaping is used.

Detention/retention basins shall use the following RCNs:

- Normally dry: 85
- Wetland bottom: 90
- Wet bottom: 95

Where the infiltration trench is to be used as a pre-treatment BMP, the design even is the 2-year 24-hour rainfall.

Infiltration Rate

Chapter 2 presented the methodology for field determination of infiltration rate and permeability. Once permeability has been determined, it can be used to calculate the size of infiltration trenches or drywells.

Depth to Groundwater

Soil borings are needed to establish that the depth to seasonally high groundwater as described in Chapter 2. The bottom of the trench or drywell should be at least 4 feet above groundwater. The bottom of the trench or drywell is defined as the surface at the top of the native soil where infiltration will occur.

Configuration

Generally, trench depths should be between 2 and 10 feet, to provide for easier maintenance. The width of a trench should be less than 25 feet. The trench must be wider than it is deep to prevent the device from being classified as a Class V injection well (Appendix D).

The bottom slope of a trench should be flat across its length and width to evenly distribute flows, encourage uniform infiltration through the bottom, and reduce the risk of clogging. A series of trenches rather than one long trench will provide a better flow pattern. This configuration also reduces the rate of clogging, since the first trench will receive and trap the heaviest sediment loads.

Drywell diameter should be at least 3 feet. Again, the depth of a drywell below the surface of the infiltration basin should be less than or equal to its diameter.

Aggregate Material

Stone aggregate should be used to fill the trench or drywell. The stone aggregate used should be washed, bank-run gravel, 1.5 to 2.5 inches in diameter with a void space of about 40% (IDOT Grade CA 3). Aggregate contaminated with soil shall not be used. A porosity value (void space/total volume) of 0.40 should be used in calculations, unless aggregate specific data exist.

A 6-inch layer of clean, washed sand should be placed on the bottom of the trench or drywell to encourage drainage and prevent compaction of the native soil while the stone aggregate is added.

Filter Fabric

The infiltration trench or drywell should be lined on the sides and top by an appropriate geotextile filter fabric that prevents soil migration but has greater permeability than the parent soil. The top layer of filter fabric is located 1 foot from the top of the trench and serves to prevent sediment from passing into the stone aggregate. Since this top layer serves as a sediment barrier, it will need to be replaced more frequently and must be readily separated from the side sections.

The top surface of the infiltration trench above the filter fabric is typically covered with pea gravel. It can easily be removed and replaced should the device begin to clog. Alternatively, the trench can be covered with permeable topsoil and planted with grass in a landscaped area.

The filter fabric should meet the requirement in Natural Resources Conservation Service Material Specification 592 Geotextile Table 1 or 2, Class 1, with an equivalent opening size of 30 for non-woven and 50 for woven fabric.

Observation Well

An observation will must be installed in every infiltration trench and should consist of a perforated PVC pipe, 4 to 6 inches in diameter, extending to the bottom of the trench. The observation well will show the rate of dewatering after a storm, as well as provide a means of determining sediment levels at the bottom and when the filter fabric at the top is clogged and maintenance is needed. It should be installed along the centerline of the structure, flush with the ground elevation of the trench. A visible floating marker should be provided to indicate the water level. The top of the well should be capped and locked to discourage vandalism and tampering.

CONSTRUCTION CRITERIA

The greatest concern for the continual functionality and performance of an infiltration trench is premature clogging of the trench. Premature clogging is often a result of poor construction techniques or improper control of sediment during construction. The following construction guidelines will help minimize the problem.

- Before any construction begins, divert stormwater runoff and construction traffic away from the site of the trench.
- Trench construction should not begin until the upland site is stabilized or runoff diverted and should not be used as part of the construction site erosion control plan.
- Excavate the trench using a backhoe or trencher with oversized tires to prevent compaction. Do not use bulldozers or front-end loaders. Each trench section should be dug, filled with rock and covered before a new section is dug.
- After the trench is dug, roughen or scarify the bottom and sides to restore infiltration capacity that may have been compromised by rainfall or smearing of the soil surface during digging.
- Cover the trench bottom with 6 inches of clean sand. Place a geotextile filter fabric on the sides and one foot below the top of the trench, overlapping it at the seams to prevent soil fines from entering the stone aggregate. The fabric should be flush with the walls.
- Clean, washed, 1.5- to 3.0-inch stone aggregate should be placed in the trench in lifts and lightly compacted with a plate compactor. Using unwashed stone will result in premature clogging from the stone's heavy sediment load.

- Place filter fabric horizontally over the aggregate approximately 1 foot below the surface, and then cover it with permeable topsoils or with larger aggregate.
- Sediment control after construction is critical. Sodding the upland areas and the vegetative buffer will speed up the stabilization of the area. If upland areas are seeded, the area must be inspected regularly until it is well established. (Refer to NRCS Technical Guide #342 *Practice Standards and Specifications for Critical Area Planting.)*

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CHAPTER 5 – SOIL EROSION AND SEDIMENT CONTROL

INTRODUCTION

The Crystal Lake Stormwater Ordinance (CLSO) and Stormwater NPDES requirements already place stringent standards on development to manage erosion. The management of erosion in the Crystal Lake watershed is particularly important because of the potential for erosion to cause the failure of infiltration devices. It is also critical that infiltration devices be protected from erosion until a watershed is completely stabilized. The following guidance expands on the requirements of Chapter 3.174-5 of the CLSO.

DESIGN CRITERIA

Temporary Sediment Basins

The CLSO requires that sediment basins for disturbed areas greater than 2 acres be sized for the 2-year, 24-hour runoff volume from the developed site for both live and wet storage. For most sites this amounts to about 0.1 to 0.2 acre-feet of both wet and live storage for each acre tributary to the sediment basin or 0.2 to 0.4 acre-feet of total volume per acre. It is anticipated that for many sites the pre-treatment basin will be utilized for temporary sediment control.

Where infiltration basins are being used this number should be even larger. Temporary sediment basins with wet storage for the 2-year, 24-hour event and live storage for the 10-year, 24-hour event should be used. This will increase the live storage to about 0.3 to 0.4 acre-feet per acre of development and total storage to about 0.4 to 0.6 acre-feet per acre.

All temporary sediment basins should be equipped with a perforated riser. The riser should be wrapped with filter fabric with a pore space of 0.1 mm or less. Such a riser may need frequent maintenance for cleaning or replacement of the fabric.

Infiltration through the bottom of the temporary sediment basin is encouraged. It is unlikely that significant infiltration can be sustained due to clogging with fines but while it is available it can help to prevent discharge to the infiltration basin downstream.

Floc Logs

The use of floc logs at the inlets to the temporary sediment basin is strongly encouraged. Figure EC-1 shows a temporary sediment basin with both floc logs and a perforated riser installed. Floc logs work to add a chemical flocculant to incoming stormwater. The flocculant causes small sediment particles to coagulate and settle more quickly. These particles settle to the bottom of the sediment basin and are not transported downstream.

CONSTRUCTION CRITERIA

Construction techniques can be critical to protecting the infiltration device as well. In particular the sequence of construction activities can help to ensure infiltration will be protected. Figure 5-1 presents the recommended construction sequence for the Crystal Lake watershed.

It is recommended that the infiltration basin be graded only after the temporary sediment basins are in place with perforated risers functional. The infiltration basin should be graded to within two feet of finished grade. A double row of silt fence should be added at the toe of slope for the basin and the space between fences covered with fabric meeting the specifications of Table 3.7. The fabric should then be covered with one to two inches of washed sand or straw bales.

Once the entire site is stabilized, the final grading of the infiltration basin can commence. The straw bales (or sand) and fabric is removed. The basin is then graded to its final elevation and engineered soil is added.

The use of the infiltration basin itself as a temporary sediment basin is strongly discouraged. This is likely to lead to fines blocking the soils void spaces and ruining infiltration performance over time.

REFERENCES

NRCS Illinois Urban Manual 2002

McHenry County, Technical Reference Manual for the McHenry County Stormwater Ordinance, 2004

FIGURE 5.1 –CONSTRUCTION SEQUENCE

1. File stormwater NPDES permit with the IEPA at least 30 days prior to beginning work,
2. Install silt fence.
3. Construct temporary sediment basins. Wet or wetland BMPs can be used as temporary sediment basins.
4. Install perforated risers and floc logs.
5. City inspection and signoff.
6. Strip topsoil.
7. Stockpile topsoil and complete additional erosion control for the pile.
8. City inspection and signoff.
9. Begin mass grading.
10. Add additional soil erosion and sediment control as needed. In particular the CLSO requirement for stabilization within 14 days of temporary or permanent cessation of grading must be met and will be vigorously enforced by the City.
11. Partially excavate infiltration basin and add fabric and sand cover.
12. City inspection of infiltration basin.
13. Permanent site stabilization.
14. City inspection.
15. Finish infiltration basin construction.
16. City inspection.

CHAPTER 6 – MONITORING AND MAINTENANCE PROVISIONS FOR STORMWATER MANAGEMENT SYSTEMS

INTRODUCTION

Storm water management facilities can only serve their purpose in the long term if they are properly maintained. A major problem with infiltration systems designed for artificial recharge is clogging of the infiltration surfaces. Basin bottoms, wall of trenches and dry wells are all subject to clogging caused by physical, biological and chemical processes (Baveye et al. 1998). Even with pre-treatment, eventually all infiltration systems will require some form of maintenance.

To help ensure that storm water facilities are maintained in the future, the City of Crystal Lake Stormwater Management Ordinance (CLSO) requires a maintenance plan. The maintenance plan, will become part of the stormwater permit and documents the responsibilities for maintaining the storm water facility and authorizes access to the property by the community for inspection purposes. If the responsible party should fail to meet their maintenance responsibilities, the permit authorizes the city to complete necessary maintenance work and charge costs back to the responsible party through special assessment.

Within the Crystal Lake watershed there is another even more serious maintenance concern that must be addressed – the Crystal Lake Drainage District (CLDD) farm tile network.

THE CLDD TILE

Maintenance of the CLDD must be assured. There are several options available for this. The City of Crystal Lake must take the lead on this with the assistance and cooperation of McHenry County in the unincorporated area and the CLDD.

Stormwater Utility

A stormwater utility could be formed by the City of Crystal Lake to provide funds not only for tile maintenance but also BMP maintenance, general drainage maintenance, and flooding and water quality improvement generally. Such a utility could encompass the entire City or just a specific watershed such as the Crystal Lake watershed.

This approach would probably require that all components of the drainage network be dedicated to the City. At present all drainage components not within public road right of way are privately maintained in Crystal Lake.

The formation of a utility is authorized in Illinois. A formal need assessment, cost estimate and financing plan are needed to justify cost assessed similar to any other utility.

Special Service Area

Crystal Lake could establish a special service area to fund tile maintenance and public stormwater management improvements. This would again require that the tile and critical stormwater components be place in public ownership.

CLDD Tax Assessment

The CLDD is an active drainage district incorporated under the Illinois Statutes. Although active, it does not assess any taxes. The CLDD could begin to assess taxes to maintain and replace the tile it manages. This focuses the solution on all property owners within the district including properties that have not yet developed. The CLDD also has specific responsibilities that go beyond simple tile maintenance under Illinois statutes that may conflict with Crystal Lake water quality protection objectives.

Escrow, Bonding, Letter of Credit

New development, at a minimum, should establish a dedicated funding mechanism during construction for repair or replacement of the tile. This again appears to require that the tile be placed in a municipal easement. This approach also does not address how upstream or downstream maintenance issues will be funded.

Property Owners Association

All new development must clearly indicate how long term maintenance of the CLDD tile will be handled through property owner's associations or similar organizations. Funding levels should be sufficient to replace the tile immediately and once every 50 years thereafter.

COMPONENTS OF A STORMWATER SYSTEM MONITORING AND MAINTENANCE PLAN

A stormwater monitoring and maintenance plan needs to address how the system will be monitored to assure the practice is functioning in accordance with the initial approved design and what maintenance activities will be performed on a routine basis to assure the systems performance. The plan must include an inspection schedule that is appropriate to the system and the inspections must be performed by a qualified professional who will certify the condition of the system at the time of the inspection. The licensed engineer who designed the stormwater infiltration system should prepare the stormwater monitoring and maintenance plan. A stormwater monitoring and maintenance plan should include the following components:

- System Description
- Monitoring Schedule
- Minimum Maintenance Requirements

SYSTEM DESCRIPTION

Infiltration basins are designed to reduce runoff volumes from a site after development by intercepting the runoff and allowing it to slowly seep (infiltrate) into the underlying soil and groundwater. Pretreatment of the runoff is required to reduce sedimentation in the basin and prevent the risk of groundwater pollution, depending on the land use of the drainage area served by the basin. The stormwater monitoring and maintenance plan needs to include a detailed description of the stormwater system and each of its components including:

- Conveyance system to move stormwater to the system
- System to pre-treat the stormwater before entering the infiltration system
- Infiltration system

The system description needs to document the design capacities of each system component; safety factors used in the design and define action limits when the reduced performance of the system indicates the need for maintenance.

MINIMUM MAINTENANCE REQUIREMENTS

Each stormwater system will have its own unique monitoring and maintenance requirements. Requirements will vary with the pre-treatment and infiltration devices used. However, all stormwater management systems will have common monitoring and maintenance tasks. The minimum maintenance requirements for various devices are described in this chapter. Individual site designs may require additional site specific monitoring and maintenance requirements that should be identified by the design engineer.

The following section outlines a sample monitoring and maintenance plan for a stormwater management system similar to Figure 4-1.

SAMPLE MONITORING AND MAINTENANCE PLAN

Responsible Parties

Legal and financial responsibility for inspection, monitoring and maintenance for the stormwater management system at (Subdivision or Address) rests with (Name, Address and Phone Number of Responsible HOA or Party).

Inspections, as described later in this plan, will be performed by (Name of Party Responsible for Inspections).

Maintenance, as described later in this plan, will be the responsibility of (Name of Party Responsible for Maintenance).

Documentation of these responsibilities is contained in (Name of Subdivision) Homeowners covenants and Restrictions dated (Date) (or equivalent document). A copy of this document is attached.

Stormwater System Description

The stormwater system for the (Subdivision or Property) includes:

- Catch basin/vault spill collectors
- Sediment collection pools
- Outlet structures
- Overflow structures
- Wetland detention pretreatment
- Infiltration basin
- Trench drains/drywells

An exhibit that presents the stormwater management system design as-constructed is enclosed.

Inspections and Schedule

Routine Inspections and Housekeeping

Routine housekeeping should be performed monthly from March through November. Activities will include removal and disposal of litter from the landscaped areas and any materials floating on the surface, removal of any materials clogging inlets and outlets and maintenance of vegetated areas through reseeding damaged areas, mowing and removal of tree seedlings.

Inspection and Report Schedule

The inspection schedule by system component is described in Tables 6.1 through 6.5. The (Name) Homeowners Association (or Owner) has contracted for these services as described above.

TABLE 6.1 WET/WETLAND BASIN INSPECTION AND MAINTENANCE

Maintenance Component	Frequency (per year)	Defect	Conditions When Maintenance Is Needed	Date of Inspection	Results Expected When Maintenance Is Performed	Date of Maintenance
General	Monthly March-November	Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.		Trash and debris cleared from site.	
	Summer	Nuisance Vegetation and Noxious Weeds	Any nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations.		Eradication of nuisance vegetation and noxious weeds by mowing and herbiciding.	
	Summer	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants. (Coordinate removal/cleanup with local water quality response agency if severe spill).		No contaminants or pollutants present.	
	Summer	Rodent Holes	Any evidence of rodent holes in dams or berms, or any evidence of water piping through dam or berm via rodent holes.		Rodents eliminated and dam or berm repaired.	
	Summer	Beaver Dams	Dam results in flooding of portions of stormwater management system		Facility is returned to design function by trapping of beavers and removal or dams under state regulations.	
	Summer	Insects	Wasps and hornets interfere with maintenance activities.		Insects destroyed or removed from site.	
	Summer	Tree Growth and Hazard Trees	Tree Growth does not allow maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). Dead, diseased, or dying trees are present.		Remove hazard trees to not hinder maintenance activities.	

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
Side Slopes of Basin	Spring/Fall	Erosion	Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.		Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass compaction. If erosion is occurring on compacted berms, a licensed civil engineer should be consulted to resolve source of erosion.	
Storage Area	Fall	Sediment	Accumulated sediment that exceeds 50% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.		Sediment cleaned out to meet pond design shape and depth; pond reseeded if necessary to control erosion.	
Basin Berms	Spring/Fall	Settlement	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement if it exceeds one foot.		Berm is restored to the design elevation.	
	Spring/Fall	Piping	Discernable water flow through basin berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.		Piping eliminated. Erosion potential resolved.	
Emergency Flow	Spring	Emergency Overflow/ Spill-way	Tree growth and erosion on spillway Inadequate vegetative cover Geotextile exposed Soil exposed in area five square feet or larger.		Rocks and pad depth are restored to design standards. Trees removed Erosion repaired and stabilized. Vegetation replaced.	

TABLE 6.2 VAULT AND CATCH BASIN INSPECTION AND MAINTENANCE

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
Storage Area	Annual	Debris and Sediment	Accumulated sediment depth exceeds 50% of the capacity of the storage area or is within 6 inches of outlet invert.		All sediment and debris removed from storage area.	
	Annual	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility.		All joint between tank/pipe sections are sealed.	
	Annual	Vault Structure shows Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than ½-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound.		Vault replaced or repaired to design specifications and is structurally sound.	
Manhole	Annual	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.		Manhole is closed.	
	Annual	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.		Cover can be removed and reinstalled by one maintenance person.	
	Annual	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust or cracks.		Ladder meets design standards. Allows maintenance person safe access.	

TABLE 6.3 CONTROL STRUCTURE INSPECTION AND MAINTENANCE

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
General	Annual	Trash and Debris (Includes Sediment)	Material depth within 6 inches of outlet invert.		Control structure invert is not blocked. All trash and debris removed.	
	Annual	Structural Damage	Structure is not securely attached to manhole wall.		Structure securely attached to wall and outlet pipe.	
			Structure is not in upright position (allow up to 10% from plumb).		Structure in correct position.	
			Connections to outlet pipe are not watertight and show signs of rust.		Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.	
			Any holes – other than designed holes – in the structure.		Structure has no holes other than designed holes.	
Orifice Plate	Annual	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.		Plate is in place and works as designed.	
	Annual	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.		Plate is free of all obstructions and works as designed.	
Emergency Overflow	Annual	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow.		Plate is free of all obstructions and works as designed.	
Catch Basins	Annual	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.		No trash or debris located immediately in front of catch basin or on grate opening.	
			Trash or debris (in the basin) that exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.		No trash or debris in the catch basin.	
			Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.		Inlet and outlet pipes free of trash or debris.	
			Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).		No dead animals or vegetation present within the catch basin.	

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
	Annual	Sediment	Sediment (in the basin) that exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe. Measured from the bottom of basin to invert of the lowest pipe into or out of the basin.		No sediment in the catch basin.	
	Annual	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than ¼ inch (Intent is to make sure no material is running into basin).		Top slab is free of holes and cracks.	
			Frame not sitting flush on top slab, i.e., separation of more than ¾ inch of the frame from the tob slab. Frame not securely attached.		Frame is sitting flush on the riser rings or top slab and firmly attached.	
		Basin Walls/Bottom	Grout fillet has separated or cracked wider than ½ inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.		Pipe is regrouted and secure at basin wall.	
		Settlement /Misalignment	If failure of basin has created a safety, function, or design problem.		Basin replaced or repaired to design standards.	
		Contamination and Pollution	Oil sheen present		No pollution present.	
Catch Basin Cover		Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.		Catch basin cover is closed.	
		Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)		Cover can be removed by one maintenance person.	
Ladder		Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.		Ladder meets design standards and allows maintenance person safe access.	

TABLE 6.4 INFILTRATION BASIN INSPECTION AND MAINTENANCE

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
General		Trash & Debris	Any trash and debris which exceed 5 cubic feet per 1,000 square feet (this is about equal to the amount of trash it would take to fill up one standard size garbage can). In general, there should be no visual evidence of dumping. If less than threshold, all trash and debris will be removed as part of next scheduled maintenance.		Trash and debris cleared from site.	
		Noxious Vegetation	Any nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations.		Eradication of nuisance vegetation and noxious weeds by mowing and herbiciding.	
		Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants. (Coordinate removal/cleanup with local water quality response agency if severe spill).		No contaminants or pollutants present.	
		Rodent Holes	Any evidence of rodent holes in dams or berms, or any evidence of water piping through dam or berm via rodent holes.		Rodents eliminated and dam or berm repaired.	
Storage		Clogging	Water ponding in infiltration pond after rainfall ceases and 72 hours time allowed for infiltration. (A percolcation test pit may be needed to confirm basin is working.)		Sediment is removed and/or facility is cleaned so that infiltration system works according to design. Top layers of soil and vegetation may need to be replaced.	
Rock Filters		Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.		Gravel in rock filter is replaced.	
Side Slopes of Pond		Erosion	Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment		Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
Emergency Overflow Spillway and Berms		Tree Growth	Tree Growth does not allow maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). Dead, diseased, or dying trees are present		Remove hazard trees to not hinder maintenance activities.	
		Piping	Discernable water flow through basin berm. Ongoing erosion with potential for erosion to continue. (Recommend a Geotechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.		Piping eliminated. Erosion potential resolved.	
		Erosion	Eroded damage where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.		Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass compaction. If erosion is occurring on compacted berms, a licensed civil engineer should be consulted to resolve source of erosion.	
Pre-settling Ponds		Facility filled with sediment and/or debris	50% of work of designed sediment trap depth filled with sediment.			

TABLE 6.5 DRYWELL AND TRENCH INSPECTION AND MAINTENANCE

Maintenance Component	Frequency	Defect	Conditions When Maintenance Is Needed	Inspection Date	Results Expected When Maintenance Is Performed	Maintenance Date
Debris	Every 3 months	Clogging due to obstructions	Ensure drywells or trenches are free of debris and obstructions. Remove any debris from on top of or around drywell and grate. Remove grate and inspect drywell for debris and sediment build-up. Debris needs to be removed immediately.		Drywell or trench free of debris	
Sediment	Every 3 months	Clogging	Anytime that standing water is noticed in a drywell or swale more than 24 hours after an event has ceased, a visual inspection is warranted. When standing water is observed, the inspector should be aware of sediment accumulation. Care should be taken to note the depth of the sediment. If it appears that the sediment is increasing with depth at each inspection, this may be a sign that the system is not functioning properly; stormwater may be ponding and spilling, carrying sediment laden stormwater into the drywell, rather than infiltrating at the design rate.		No sediment accumulation interfering with infiltration	
Illicit Discharge	As needed		If any of the following are observed, in addition to the sod and topsoil being affected and requiring replacement, if it is evident that discharge was made directly into the drywell, the drywell and affected surrounding drain rock must be replaced as soon as possible: oil, sheen, spilled paint, burned area due to battery acid, multi-colored appearance of antifreeze, brown to black fuel oil, or any other materials that may be deemed deleterious to water quality. Sod, topsoil and drain rock removed must be handled and disposed of in a manner consistent with a hazardous material.		Restoration of system	
Structural Damage	Annually		Inspect metal frame and grate, adjustment rings, mortar or any other visible parts of the drywell structure. The metal frame and grate should sit flush on the top ring.			

APPENDIX

TABLE A-1: COMPARISON OF CRYSTAL LAKE RESOURCES MANAGEMENT PLAN AND CRYSTAL LAKE WATERSHED GUIDANCE DOCUMENT

TABLE A-2: COMPARISON OF BAUER RECOMMENDATIONS AND DRAFT CRYSTAL LAKE WATERSHED DEVELOPMENT GUIDANCE DOCUMENT

Table A-1: Comparison of Crystal Lake Resources Management Plan and Crystal Lake Watershed Guidance Document

Bauer Report Design Criteria	Status	Draft Crystal Lake Guidance Document				
1. Drainage from all impervious areas shall discharge to pervious surfaces at controlled rates to prevent erosion	Not accomplished	Recommended				
2. Natural ground cover or grass shall be used to cover all pervious surfaces receiving stormwater	Not accomplished	Recommended				
3. Grassed swales are preferred over storm sewers to collect drainage from development.	Not accomplished	Recommended				
4. Runoff from all impervious areas shall be routed over pervious areas wherever possible to allow infiltration	Not accomplished	Recommended				
5. The 1-year, 1-hour (about 0.5 inch of runoff) event shall be infiltrated before flow reaches a detention facility.	Not accomplished	Recommended				
6. Drainage systems shall be designed to manage the 100-year event of critical duration.	Crystal Lake Stormwater Ordinance	Recommended				
7. Retention basins shall be designed to recharge the 100-year event design storage volume within five days (about 0.05 inches per hour).	Crystal Lake Stormwater Ordinance	Recommended				
8. Maximum ponding depth of the 100-year event shall be three feet in the retention basin.	Not accomplished	Four feet recommended				
9. Grassed swales shall be used for conveyance wherever possible with design velocities less than 2 feet per second. No direct storm sewer discharges shall be allowed.	Not accomplished	Recommended				
10. Retention basins should be normally dry with grassed bottoms.	Not accomplished	Recommended				
11. The bottom of retention basins shall have a minimum free draining depth from groundwater of ten feet.	Crystal Lake Stormwater Ordinance Calls for 4 feet	Four feet recommended to be consistent with CLSO				
12. The design infiltration rate shall be based on the least permeable stratum through which infiltration will take place.	Not accomplished	Recommended				
13. No new septics shall be allowed.	City is Planning Sanitary Sewer	Recommended				
14. Sanitary sewers shall be leak tight or force mains.	Included in City Sewer Design	Recommended				

Table A-2: Comparison of Bauer Recommendations and Draft Crystal Lake Watershed Development Guidance Document

Bauer Watershed Development Objectives	Status	Draft Crystal Lake Guidance Document	Rationale	Explanation
No direct discharge of stormwater to the lake from new development and elimination of existing direct discharges to the lake where possible	Policy but not ordinance	Recommended		
No diversion of water out of the Crystal Lake watershed	Policy but not ordinance	Recommended		
All stormwater to be infiltrated to preserve recharge rates to the lake	Policy but not ordinance	Recommended for runoff events less than 2 years north of 176 and 10 years south for 24-hour duration	Serious concern for need to provide positive drainage during larger events to downstream properties where it can be done safely	Recommended approach still results in infitlration of over 95 percent of annual stormwater runoff
Surface and subsurface phosphorus concentrations to the lake should be less than 0.05 mg/l and preferably as low as 0.01 mg/l	Not accomplished	Special pre-treatment measures recommended to attain maximum feasible of 0.10 mg/l prior to infiltration basin	It is not possible to reliably and cost effectively remove total phosphorus in stormwater to 0.05 mg/l based on research over last 25 years. Best Management Practices can reliably attain 0.1 mg/l prior to infiltration. After infiltration actual discharge to groundwater will be less than 0.05 mg/l	Research and demonstration over the last 25 years has documented the effectiveness of properly desinged BMPs to remove solids and phosphorus from stormwater runoff. The Bauer report did not specify pre treatment approached but relied on general vegetaton-soil properties.
Impervious surface to be limited to 20 percent	Crystal Lake Zoning Ordinance Requirement	Pre-treatment of runoff followed by mandatory infiltration. No impervious limitation.	The Bauer recommendation is unsupported. Bauer stated 20 percent impervious is all that can be safely infiltrated in 120 hours at 0.6 to 2.0 inches per hour. At 0.6 inches per hour 70 percent impervious site can infiltrate in about 72 hours.	The ability of pre-treatment facilities, especially combined with pervious conveyance systems, to remove phosphorus to below 0.1 mg/l as an annual average. Even the undersized (due to space constraints) Lippold and Cove Pond consistently have attained this over the last five years.