APPENDIX B

LOW IMPACT DESIGN (LID) GUIDELINES FOR STORMWATER MANAGEMENT

LOW IMPACT DESIGN (LID) GUIDELINES
FOR STORMWATER MANAGEMENT

TABLE OF CONTENTS

LID DETAIL FIGURES

LOW IMPACT DESIGN (LID) GUIDELINES
FOR STORMWATER MANAGEMENT

I. BACKGROUND

Over the past decade, Low Impact Development (LID) has emerged as an innovative stormwater management approach with a basic principle that is modeled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls.

A. Overview of Traditional Development

Traditional development manages stormwater by conveying and treating stormwater in large, costly end-of-pipe treatment systems. This stormwater management method is based on resolving stormwater issues caused from traditional development. Historically, end-of-pipe treatment and control technologies have been the leading methods of stormwater control.

Currently, stormwater management plans address site design, source control, and pollution prevention strategies. These strategies more effectively address water quality and velocity issues that result from development as opposed to the standard end-of-pipe controls. Regulatory mandates still preserve the traditional centralized collection and treatment system of control. However, LID principles are being incorporated into regulatory mandates.

B. Overview of Low Impact Development

Unlike traditional development, Low Impact Development (LID) is based on the idea that undeveloped land does not present a stormwater runoff or pollution problem. LID is a source control option that minimizes stormwater pollution by recognizing that the greatest efficiencies are gained by minimizing stormwater generation. This most often translates to high rates of infiltration, vegetative interception, and evapotranspiration.

LID mimics a site's natural, or predevelopment, hydrology by using design techniques and best management practices (BMPs) that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID controls stormwater through integrated systems of decentralized, small, cost-effective features at individual construction sites, including:

- Open spaces
- Rooftops
- Streetscapes
- Parking lots
- Sidewalks
- Medians

These features represent some of the building blocks of LID. LID is a versatile approach that can be applied to new development, urban retrofits, redevelopment, and revitalization projects.

LID implementation is a process that conserves watershed resources, reduces impacts of development, and employs innovative BMPs to meet the stormwater objectives. It is not the use of BMPs alone. These practices, taken in aggregate, limit the observed onsite changes in hydrology resulting from development and present a comprehensive, efficient, and beneficial stormwater management approach.

II. PRACTICES AND PROCEDURES

The potential of LID is maximized when it is used in conjunction with other conservation and planning approaches. Programs like Smart Growth are the first step of the process. Smart Growth is a community planning process that follows specific principles that include:

- Taking advantage of compact building design
- Creating a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development towards existing communities
- Provide a variety of transportation choices
- Make development decisions predictable, fair, and cost effective
- Encourage community and stakeholder collaboration in development decisions

Smart growth practices can lessen the environmental impacts of development with techniques that reduce impervious surfaces and improved water detention. Before LID is implemented, decisions about where and how to develop within the watershed need to be evaluated to limit water quality impacts. Once these decisions are made, LID can then be used to mitigate the impacts of the development. Coordination and integrating LID with Smart Growth and other innovative land use approaches will limit conversion in land cover, preserve natural watershed areas, and maximize the management of stormwater runoff. In urbanized areas, LID can be coordinated with green building and redevelopment efforts and can be used to augment infrastructure projects by enhancing capacity. Retrofitting LID in urban locations provides opportunity to provide multiple environmental, social, and infrastructure benefits.

A. Advantages of LID

LID has numerous benefits and advantages over traditional stormwater management approaches. It is a more environmentally sound technology and economically sustainable approach to addressing the adverse impacts of urbanization. By managing runoff close to its source through intelligent site design, LID can enhance the local environment, protect public health, and improve community livability.

Stormwater programs require that a wide array of complex and challenging ecosystem and human health protection goals be addressed. Many of these goals are not being met by conventional stormwater management technology. Communities are challenged with funding the maintenance/expansion of stormwater infrastructure and restoring stream quality in watersheds that have already been densely developed. Relying on impervious reduction and/or conventional detention ponds to address these issues is not feasible, practical, or sustainable. LID provides a practical alternative in its emphasis on minimizing the changes to the local hydrologic cycle or regime.

1. Simple and Effective

Instead of large investments in complex and costly centralized conveyance and treatment infrastructure, LID allows for the integration of treatment and management measures into urban site features. This involves strategic placement of distributed lot-level controls that can be customized to more closely mimic a watershed's hydrology and water quality regime. The result is a hydrologically functional landscape that generates less surface runoff, less pollution, less erosion, and less overall damage to lakes, streams, and coastal waters.

2. Economical

LID costs less than conventional stormwater management systems to construct and maintain, in part, because of fewer pipes, fewer belowground infrastructure requirements, and less imperviousness. Additionally, space once dedicated to stormwater ponds can now be used for additional development to increase lot yields or be left as is for conservation. The greater use of on-lot multi-purpose landscaping and vegetation also offers human quality of life opportunities by greening neighborhoods and contributing to livability, value, sense of place, and aesthetics. Other benefits include enhanced property values and redevelopment potential, greater marketability, improved wildlife habitat, thermal pollution reduction, energy savings, smog reduction, enhanced wetlands protection, and decreased flooding.

3. Flexible

LID offers a wide variety of structural and nonstructural techniques to provide for both runoff quality and quantity benefits. It works in highly urbanized constrained areas, as well as open regions and environmentally sensitive sites. Opportunities to apply LID principles and practices are extensive since any feature of the urban landscape can be modified to control runoff and/or reduce the introduction of pollution. LID can be used to truly create customized watershed management designs.

B. Balanced Approach

LID is an advanced, ecologically-based land development technology that seeks to better integrate the built environment with the natural environment. LID principles and practices allow the developed site to maintain its predevelopment watershed and ecological functions.

C. Disadvantages of LID

Even though LID has been demonstrated as an attractive strategy, its application is limited and has not yet been fully integrated. Several barriers have generally slowed and hampered greater LID adoption. Bureaucratic inertia involving the entrenchment of prevailing conventional practices, institutional structures, and regulatory shortfalls are the prime barriers preventing a broad shift in stormwater management philosophy. In order to appropriately implement LID it is important to assess its role in water quality protection.

LID is one part of a toolkit that can be used to better manage natural resources and limit the pollution delivered to waterways. It is not independent of watershed planning, and to gain optimal benefits, LID needs to be integrated with appropriate land use programs. LID by itself will not deliver the water quality outcomes desired; it does provide enhanced stormwater treatment and mitigates excess volume and flow rates. However, if not integrated in a comprehensive fashion, LID techniques can end up as a series of uncoordinated innovative BMPs that have limited water quality benefit.

III. LID Methods

A. Bioretention

Bioretention devices (also known as rain gardens) incorporate mulch, soil and plants to retain stormwater and filter pollutants within it (see diagram below). Bioretention facilities (rain gardens) may range from simple shallow depressions to more complex designs, but all are structurally engineered to provide interception/capture, infiltration, filtration, storage, and water uptake by vegetation with respect to stormwater quantity control.

A recommended soil mixture of top soil (20-30%), leaf compost (20-30%) and coarse-grained sand (50%) produces an ideal filter media to maximize infiltration, filtration and storage (hydrologic loading) capacity. A key design aspect of a bioretention facility is its depressed bowl-shaped topography, creating a "ponding area". This ponding area allows for surface storage of runoff when the soil storage is at capacity; promotes evaporation; and allows sedimentation of particulate matter prior to infiltration. Further incorporation of an underdrain (or outlet) and surface overflow element allows the engineer to construct a bioretention facility that can handle the anticipated volume of storm water runoff in a given area. In fact, bioretention facilities can be designed to handle not only peak discharges (e.g. the "first flush" of spring thaw), but also the volumetric control of all storms by mimicking existing hydrologic conditions.
Stormwater treatment and retention are addressed in the sections below.

1. Stormwater Treatment

Bioretention devices, or cells, function by taking advantage of a variety of natural physical, biological, and chemical treatment processes. Stormwater treatment, or the reduction of pollutant loads in stormwater to receiving waters, is necessary for achieving regulatory water quality requirements.

Studies show that properly designed and constructed bioretention cells are able to achieve excellent removal of heavy metals. Typical reductions of more than 90% in copper (Cu), zinc (Zn), and lead (Pb) are documented. Removal efficiencies as high as 98% and 99% have been achieved for Pb and Zn. The mulch layer is credited with playing the greatest role in this uptake, with nearly all of the metal removal occurring within the top few inches of the bioretention system. Heavy metals affiliate strongly with the organic matter in this layer.

However, nutrient removal is not associated with the mulch layer. The likely mechanism for the removal of the phosphorus is its sorption onto aluminum, iron, and clay minerals in the soil. Phosphorus removals appear to increase linearly with depth and reach a maximum of approximately 80% by about 2 to 3 feet of soil depth. TKN (nitrogen) removal also appears to depend on soil depth but showed more variability in removal efficiencies between studies. Average removal efficiency for cell effluent is around 60%. Generally 70 to 80% reduction in ammonia was achieved in the lower levels of sampled bioretention cells.

Finally, nitrate removal is quite variable, with the bioretention cells demonstrating a production of nitrate in some cases due to nitrification reactions. Currently, the University of Maryland research group is looking at the possibility of incorporating into the bioretention cell design a fluctuating aerobic/anaerobic zone below a raised underdrain pipe in order to facilitate denitrification and thus nitrate removal.

Other pollutants of concern are also addressed by the bioretention cells. For example, sedimentation can occur in the ponding area as the velocity of the runoff slows and solids fall out of suspension. Field studies at the University of Virginia have indicated 86% removal for Total Suspended Solids (TSS), 97% for Chemical Oxygen Demand (COD), and 67% for Oil and Grease. Additional work with laboratory media columns at the University of Maryland has demonstrated potential bioretention cell removal efficiencies greater than 98% for total suspended solids and oil/grease.

An additional hydrologic benefit of the bioretention cell is the reduction of thermal pollution. Heated runoff from impervious surfaces is filtered through the bioretention facility and cooled; one study observed a temperature drop of 12°C between influent and effluent water. This function of the bioretention cell is especially useful in areas such as the Pacific Northwest where cold water fisheries are important.

2. Stormwater Retention

One of the primary objectives of LID site design is to minimize, detain, and retain post development runoff uniformly throughout a site so as to mimic the site's predevelopment hydrologic functions. Originally designed for providing an element of water quality control, bioretention cells can achieve quantity control as well. By infiltrating and temporarily storing runoff water, bioretention cells reduce a site's overall runoff volume and help to maintain the predevelopment peak discharge rate and timing.

B. Tree Box Filters

Tree box filters (Figure No. 14) are small bioretention areas installed beneath trees that can be effective at controlling runoff, especially when distributed throughout the site. Runoff is directed to the tree box, where it is cleaned by vegetation and soil before entering a catch basin. The runoff collected in the tree-boxes helps irrigate the trees.

Tree box filters are based on an effective and widely used “bioretention or rain garden” technology with improvements to enhance pollutant removal, increase performance reliability, increase ease of construction, reduce maintenance costs and improve aesthetics. Typical landscape plants (shrubs, ornamental grasses, trees, and flowers) are used as an integral part of the bioretention/filtration system. They can fit into any landscape scheme increasing the quality of life in urban areas by adding beauty, habitat value, and reducing urban heat island effects.
The system consists of a container filled with a soil mixture, a mulch layer, under-drain system and a shrub or tree. Stormwater runoff drains directly from impervious surfaces through a filter media. Treated water flows out of the system through an under drain connected to a storm drainpipe/inlet or into the surrounding soil. Tree box filters can also be used to control runoff volumes/flows by adding storage volume beneath the filter box with an outlet control device.

C. Permeable Pavers, Permeable Asphalt, and Pervious Concrete

Most of the 'paving over' in developed areas is due to common roads and parking lots, which play a major role in transporting increased stormwater runoff and contaminant loads to receiving waters. Alternative paving materials such as permeable pavers, permeable asphalt, and pervious concrete can be used to locally infiltrate rainwater and reduce the runoff leaving a site (Figure No. 9 and 10). This can help to decrease downstream flooding and the thermal pollution of sensitive waters. Use of these materials can also eliminate problems with standing water, provide for groundwater recharge, control erosion of streambeds and riverbanks, facilitate pollutant removal, and provide for a more aesthetically pleasing site.

The effective imperviousness of any given project is reduced while land use is maximized. Alternative paving can eliminate the requirement for underground sewer pipes and conventional stormwater retention and detention systems. The drainage of paved areas and traffic surfaces by means of permeable systems is an important building block within an overall LID scheme that seeks to achieve a stormwater management system close to natural conditions.

1. Limitations

The following limitations must be observed for implementing permeable surfaces:

- Slopes greater than 6%. Can consider terracing.
- Not for use at locations with contaminated soil.
- Not for use in locations with high groundwater.

- Locations where there is a real likelihood of a spill. Can consider a filtration or wetland treatment prior to infiltration.

2. Installation of Permeable Surfaces

Permeable pavement in a stormwater management design is a part of a system, and not just a pavement in itself. The pavement supports traffic loading while allowing water to pass through the surface. Instillation techniques vary depending on traffic loading and soil permeability. Please consult with the City of Willits Stormwater Division prior to design and have a trained professional perform the work.

3. General Recommendations

- The EPA recommends permeability/ infiltration rate be 0.5"/hour. Some permeable pavements have been successful with an infiltration rate of 0.1"/hour.
- The depth to bedrock is recommended to be at least two (2) feet or greater.
- The depth to groundwater is recommended to be at least four (4) feet or greater.
- The bottom of the infiltration bed should be approximately level.
- Final pavement slope should be no greater than 5%.
- Use existing and available aggregate sources.

4. Maintenance and Repair

- Cracks can be repaired using crack sealant
- Regular cleaning can be completed by flush, jet wash, or vacuum sweeping (recommended twice per year).
- Do not use traditional seal coat treatments.
- Do not use salt or sand for de-icing (contamination of groundwater and reduced permeability)

D. Soil Amendments

Site preparation prior to the construction of residential units typically involves removing or stock piling the existing vegetation and topsoil. This has an immediate hydrologic impact because of the reduction in soil structure, pore space, organic content, and biological activity. After construction, a thin layer of topsoil is usually spread on the now very compacted subsoil and then the area is seeded or sodded.

The combination of soil compaction and loss of organic matter has several undesirable consequences:

- With the infiltration capacity of the site significantly reduced, rainwater more quickly runs off into local streams. This, in turn, tends to increase erosion, scouring, and the sediment load.
- The rate of groundwater recharge decreases.

- Due to the soil compaction and the loss of organic matter, the availability of subsurface water to plants is reduced.
- The increased volume and frequency of runoff carries pollutants with it that include pesticides, fertilizers, animal wastes and chemicals such as phosphorous and nitrogen.
- Homeowners now have to apply pesticides, fertilizers, and irrigation water in increasing amounts in order to maintain their landscapes.

However, soil additives, or amendments, can be used to minimize development impacts on native soils by restoring their infiltration capacity and chemical characteristics. After soils have been amended their improved physical, biological, and hydrological characteristics will make them more effective agents of stormwater management.
Soil amendments can include compost, mulch, and top soil. In addition, lime and gypsum offset any nutritional deficiencies and control acidity. A thorough soil analysis of the native soil is required to determine the optimum quantity for each component in order to obtain the maximum benefit from amending. Soil amendment components should generally be mixed and applied in the following manner:

- *Compost.* The amount of compost to be applied depends upon the organic content of the existing soil as well as the targeted amount of the proposed soil amendment. Compost typically has an organic content of 45-60% and is often used as the sole means of providing organic material to the soil profile. In soils that have organic contents of less than one percent, 8 to 13 percent by soil weight is a typical target of a proposed soil amendment with compost. As a general rule, a 2-to-1 ratio of existing soil to compost, by loose volume, will achieve the desired organics level. Locally available compost may be utilized if it is of high enough quality and available at a cost effective price.
- *Nutrients and Lime.* If the soil pH is below 6.0 the addition of pelletized dolomite is recommended, with application rates in the range of 50 to 100 pounds per 1000 square feet. Nitrogen requirements usually range from 2 to 8 pounds per 1,000 square feet, with slow release water-insoluble forms being the preferred method. Other soil additions may include sulfur and boron with the amount needed determined by soil analysis.
- *Gypsum*. Hydrated calcium sulfate ($CaSO_4 \bullet 2H_2O$) is sometimes applied to a soil in order to increase calcium and sulfur without affecting the pH, as well as to enhance a soil's structure in high clay content soils.

E. Green roofs

Green roofs (Figure No. 11), also known as vegetated roof covers, eco-roofs, or nature roofs, are multi-beneficial structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing, or detaining rainfall. They are constructed of a lightweight soil media, underlain by a drainage layer, and a high quality impermeable membrane that protects the building structure. The soil is planted with a specialized mix of plants that can thrive in the harsh, dry, high temperature conditions of the roof and tolerate short periods of inundation from storm events.

Green roofs provide stormwater management benefits by:

- Utilizing the biological, physical, and chemical processes found in the plant and soil complex to prevent airborne pollutants from entering the storm drain system.
- Reducing the runoff volume and peak discharge rate by holding back and slowing down the water that would otherwise flow quickly into the storm drain system.

Green roofs are not only aesthetically pleasing, but they also:

- Reduce city "heat island" effect
- Reduce CO_2 impact
- Reduce summer air conditioning cost
- Reduce winter heat demand
- Potentially lengthen roof life 2 to 3 times
- Treat nitrogen pollution in rain
- Negate acid rain effect
- Help reduce volume and peak rates of stormwater

F. Rain Barrels/Cisterns

Rain barrels and cisterns (Figure No. 13) are low-cost, effective, and easily maintainable retention and detention devices that are applicable to residential, commercial, and industrial sites to manage rooftop runoff. For residential applications a typical rain barrel design will include a hole at the top to allow for flow from a downspout, a sealed lid, an overflow pipe, and a spigot at or near the bottom of the barrel. The spigot can be left partially open to detain water or closed to fill the barrel. A screen is often included to control mosquitoes and other insects. The water can then be used for lawn and garden watering or other uses such as supplemental domestic water supply. Rain barrels can be connected to provide larger volumes of storage. Larger systems for commercial or industrial use can include pumps and filtration devices.

Stormwater runoff cisterns are roof water management devices that provide retention storage volume in above or underground storage tanks. They are typically used for water supply. Cisterns are generally larger than rain barrels, with some underground cisterns having the capacity of 10,000 gallons. On-lot storage with later reuse of stormwater also provides an opportunity for water conservation and the possibility of reducing water utility costs.

Site Constraints of LID Practices

	Bioretention	Dry Well	Filter/Buffer Strip	Swales: Grass, Infiltration, Wet	Rain Barrels	Cistern	Infiltration Trench
Space Required	Minimum surface area range: 50 to 200 ft² Minimum width: 5 to 10 ft Minimum length: 10 to 20 ft Minimum depth: 2 to 4 ft	Minimum surface area range: 8 to 20 ft² Minimum width: 2 to 4 ft Minimum length: 4 to 8 ft Minimum depth: 4 to 8 ft	Minimum length of 15 to 20 ft	Bottom width: 2 ft minimum, 6 ft maximum	Not a factor	Not a factor	Minimum surface area range: 8 to 20 ft² Minimum width: 2 to 4 ft Minimum length: 4 to 8 ft
Soils	Permeable soils with infiltration rates > 0.27 inches/hour are recommended. Soil limitations can be overcome with use of underdrains	Permeable soils with infiltration rates > 0.27 inches/hour are recommended	Permeable soils perform better, but soils not a limitation	Permeable soils provide better hydrologic performance, but soils not a limitation. Selection of type of swale, grassed, infiltration or wet is influenced by soils	Not a factor	Not a factor	Permeable soils with infiltration rates > 0.52 inches/hour are recommended
Slopes	Usually not a limitation, but a design consideration	Usually not a limitation, but a design consideration. Must locate downgradient of building and foundations	Usually not a limitation, but a design consideration	Swale side slopes: 3:1 or flatter Longitudinal slope: 1.0% minimum; maximum based on permissible velocities	Usually not a limitation, but a design consideration for location of barrel outfall	Not a factor	Usually not a limitation, but a design consideration. Must locate down-gradient of buildings and foundations
Water Table/ Bedrock	2- to 4-ft clearance above water table/ bedrock recommended	2- to 4-ft clearance above water table/ bedrock recommended	Generally not a constraint	Generally not a constraint	Generally not a constraint		2- to 4-ft clearance
Proximity to build foundations	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Minimum distance of 10 ft downgradient from buildings and foundations recommended	Not a factor		Minimum distance of 10 ft down-gradient from buildings and foundations recommended
Max. Depth	2- to 4-ft depth depending on soil type	6- to 10-ft depth depending on soil type	Not applicable	Not applicable	Not applicable		6- to 10-ft depth depending on soil type
Maintenance	Low requirement, property owner can include in normal site landscape maintenance	Low requirement	Low requirement, routine landscape maintenance	Low requirement, routine landscape maintenance	Low requirement		Moderate to high

Source: http://www.epa.gov/nps/lid/#guide

Hydrologic Functions of LID Practices

Hydrologic Functions	Bio Ret	Dry Well	Filter/ Buffer	Swale Grass	Rain Barrel	Cistern	Infilt. Trench
Interception	H	N	H	M	N	N	N
Depression Storage	H	N	H	H	N	N	M
Infiltration	H	H	M	M	N	N	H
G.W. Recharge	H	H	M	M	N	N	H
Runoff Volume	H	H	M	M	L	M	H
Peak Discharge	M	L	L	M	M	M	M
Runoff Frequency	H	M	M	M	M	M	M
Water Quality	H	H	H	H	L	L	H
Base Flow	M	H	H	M	M	N	L
Stream Quality	H	H	H	M	N	L	H

H = High M = Moderate L = Low N = None

Source: http://www.epa.gov/nps/lid/#guide

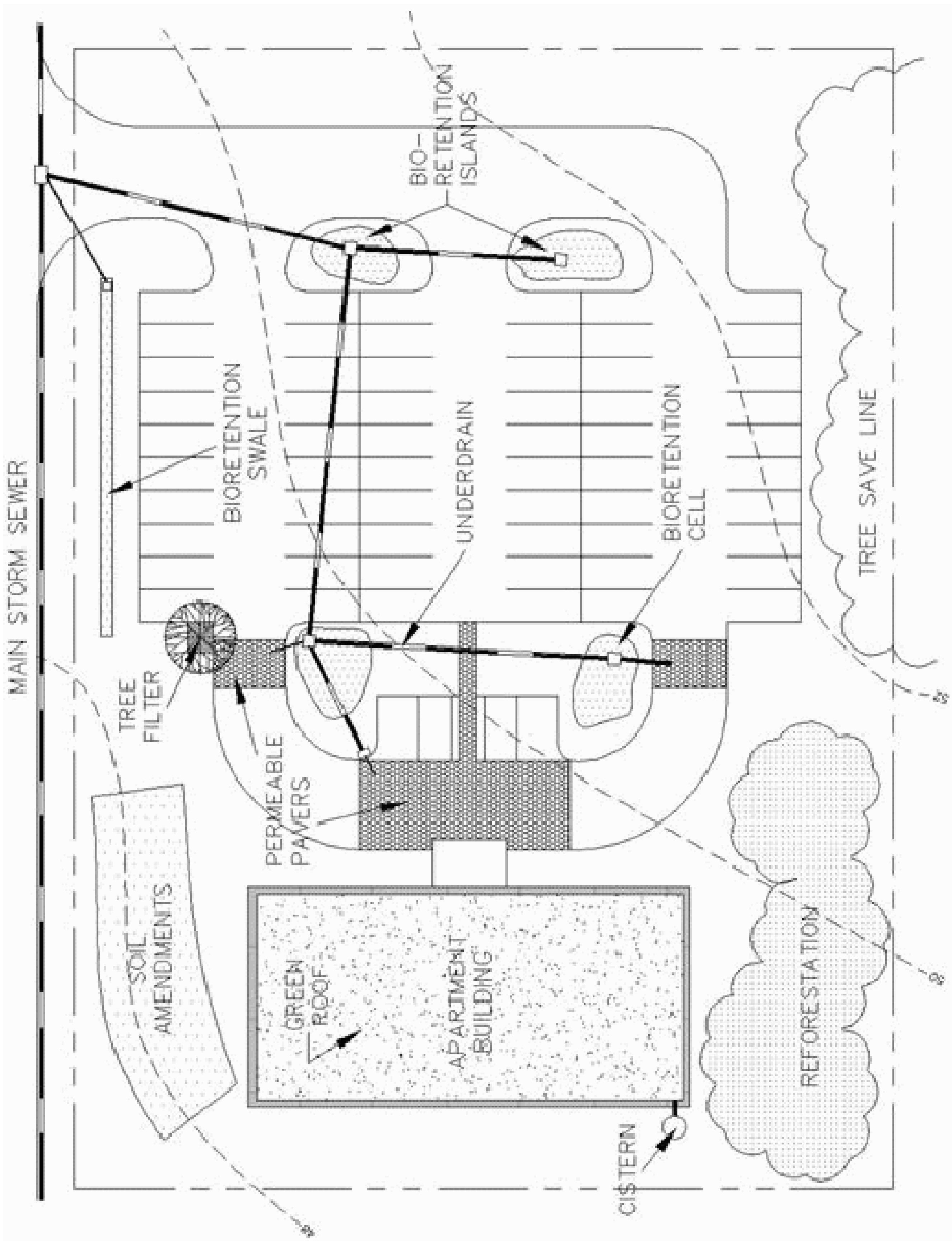
Reported Pollutant Removal Efficiency of LID Practices

PMP	TSS	Total P	Total N	Zinc	Lead	BOD	Bacteria
Bioretention	-	81	43	99	99	-	-
Dry Well	80-100	40-60	40-60	80-100	80-100	60-80	60-80
Infiltration Trench	80-100	40-60	40-60	80-100	80-100	60-80	60-80
Filter/Buffer Strip	20-100	0-60	0-60	20-100	20-100	0-80	-
Vegetated Swale	30-65	10-25	0-15	20-50	20-50	-	Neg.
Infiltration Swale	90	65	50	80-90	80-90	-	-
Wet Swale	80	20	40	40-70	40-70	-	-
Rain Barrel	NA	NA	NA	NA	NA	NA	NA
Cistern	NA	NA	NA	NA	NA	NA	NA

Source: CRC, 1996; Davis et al. 1997; MWCG, 1987; Urbonas & Stahre, 1993; Yousef et al., 1985; Yu et al., 1992; Yu et al., 1993.

Source: http://www.epa.gov/nps/lid/#guide

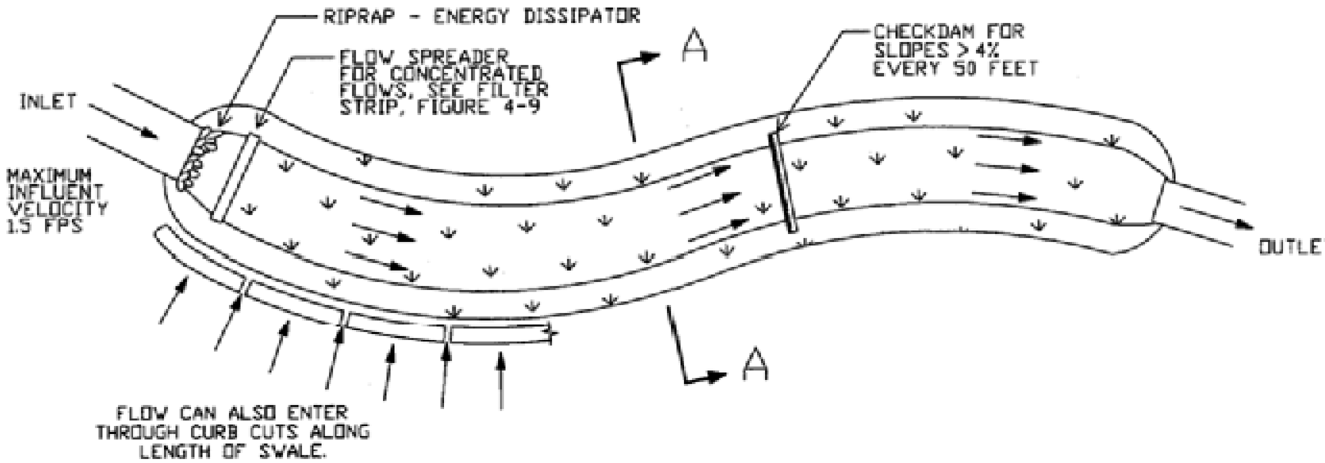
Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 – City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-1 Plot Date: Sep 29, 2009 at 10:40

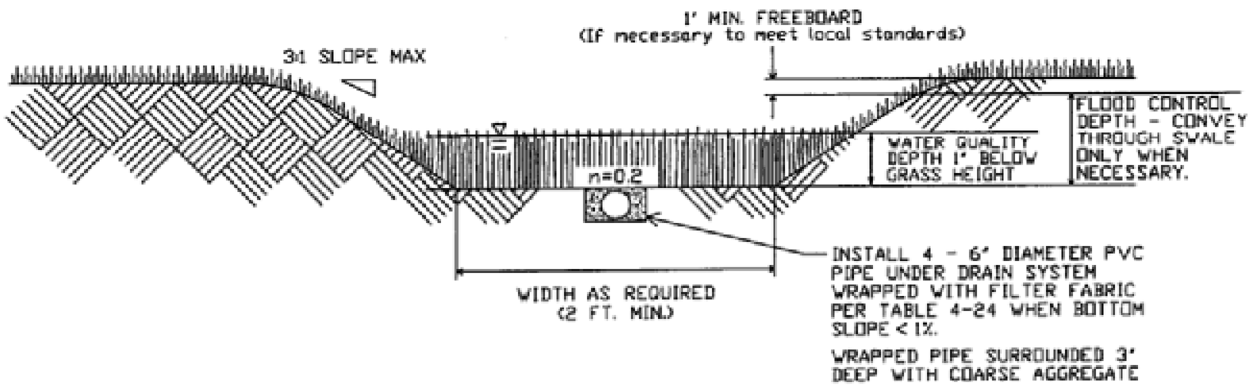


CITY LAYOUTS
EXAMPLE L.I.D.

STD. NO.
1

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: Thomas M Mannatt	DATE: OCT 2009





NOTES:

1. An energy dissipator and flow spreader should be installed at the entrance to the swale to reduce velocity and evenly distribute flows across the swale.
2. Maximum allowable side-slope 3:1.
3. Grass height maintained in accordance with design specifications. Design grass height between 4 to 6 inches.
4. Flow height to be one-inch below design grass height for water quality design storm flow (2 year - 6 hour storm). Use a Mannings roughness coefficient of 0.2 to design for water quality flow through the swale vegetation.
5. n value above water quality height determined based on type of vegetation used. Typical value: 0.035
6. If the swale bottom slope exceeds 4% or soils very permeable, install check dams every 50 feet to slow the velocity to prohibit scouring and promote infiltration.
7. If the swale bottom slope is less than 1% install under drain system to prevent standing water.
8. Flows in excess of water quality volume should be diverted around the swale. If necessary for swale to convey flood waters, provisions shall be made to ensure conveyance in accordance with City or County Standards. Provide 1 ft. freeboard if necessary for flood control.

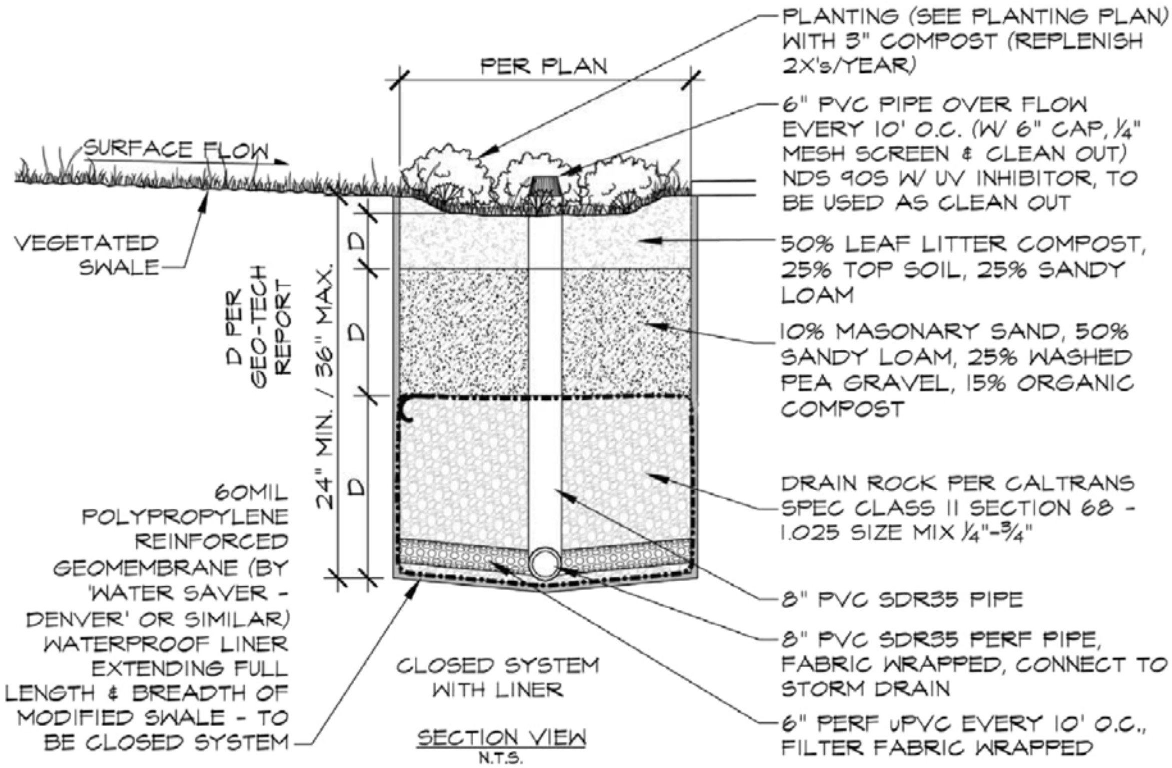
CITY OF WILLITS

VEGETATIVE SWALE

STD. NO. 2

SCALE: NONE | DRAWN: CFB | CHK: MGK | APPVD: Thomas M Mannatt | DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-2 Plot Date: Sep 29, 2009 at 10:40



NOTES:

1. LONGITUDINAL SLOPE TO D.I. TO A MINIMUM OF 0.5% AND MAXIMUM OF 4%. RECOMMENDED SLOPE IS 1%-2%
2. ALL SOIL PROFILES TO BE Ph 6.0-6.5 AND DRAIN AT A MIN. OF 5" PER HOUR (NOT TO EXCEED 10" PER HOUR)
3. SOIL TO BE PLACED IN 6" LIFTS AND NO MACHINE COMPACTION.
4. ALL SOIL SHALL BE VERIFIED AS TO FERTILITY, Ph AND DRAINAGE BY SOIL LAB & MUST BE FIELD TESTED, IN MOCK UP, BY CONTRACTOR AND APPROVED BY L. ARCH.
5. SUPPLEMENTAL IRRIGATION TO BE PROVIDED, SEE IRRIGATION PLAN
6. ALL PERF PIPES TO BE RIGID TYPE, WRAPPED IN FILTER FABRIC (MIRIAFI FILTER FABRIC OR EQUAL)

C / SW-6 **CENTER ISLAND BIORETENTION SWALE**

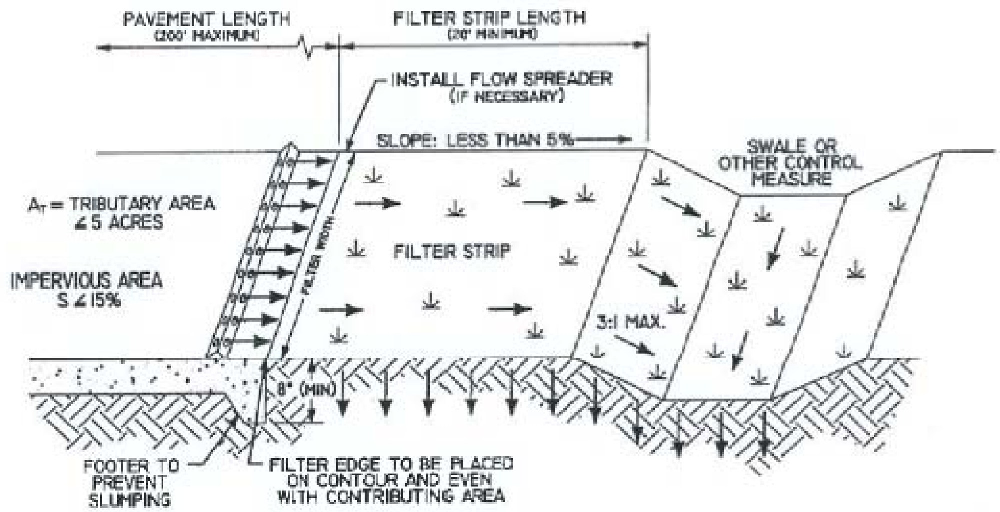
NOT TO SCALE

CENTER ISLAND BIORETENTION SWALE

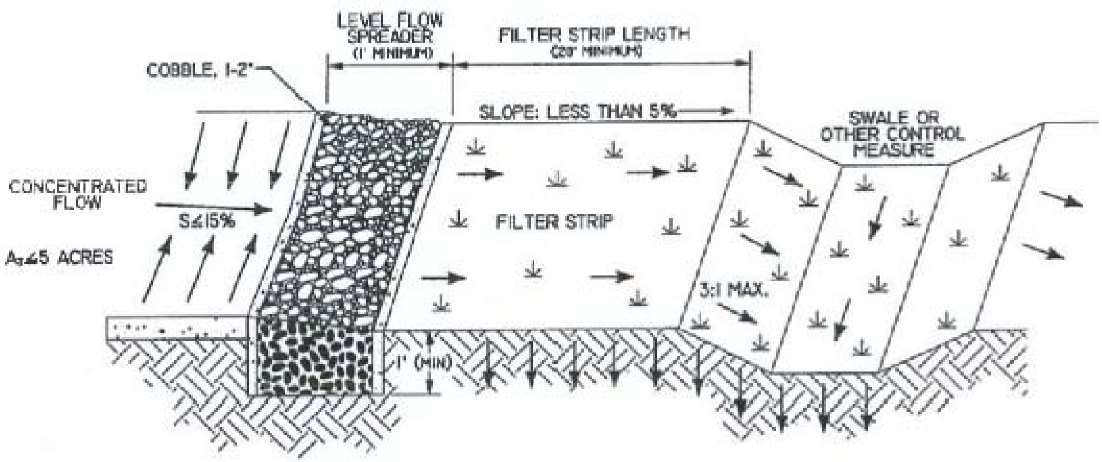
STD. NO. **3**

SCALE: NONE | DRAWN: CFB | CHK: MGK | APPVD: Thomas M Marriott | DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-3 Plot Date: Sep 29, 2009 at 10:40



ONSITE FLOW CONTROL



CONCENTRATED FLOW CONTROL

NOTES:

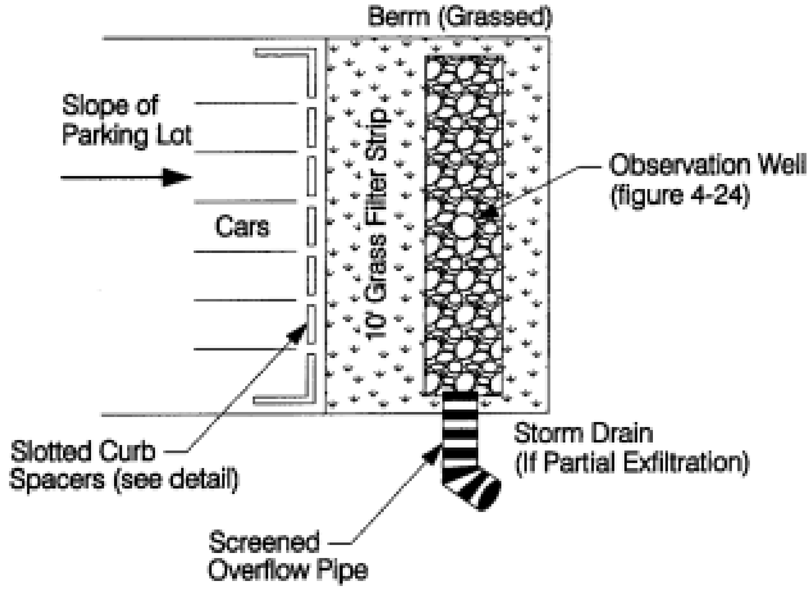
1. Maximum contributing drainage area 5 acres.
2. Maximum slope of contributing area 15%.
3. Situate upstream edge of filter on contour to prevent channelization.
4. Install a level spreader at top edge of filter.
5. Slope of filter should be as level as possible yet permit drainage, not to exceed 5%.
6. Minimum length of filter for grass or turf 20 feet, for forested (shrubs and trees) 50 feet.
7. Filter to be as wide as contributing area.
8. Grass height maintained in accordance with design specifications.
   Design grass height between 4 to 6 inches.
9. Flow height to be one-inch below design grass height for water quality volume or flow.

FILTER STRIPS

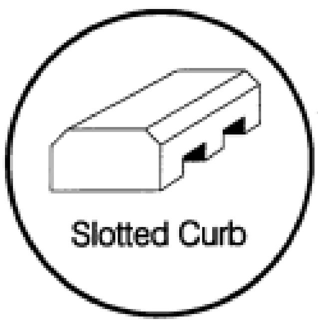
STD. NO.
4

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: [signature]	DATE: OCT 2009

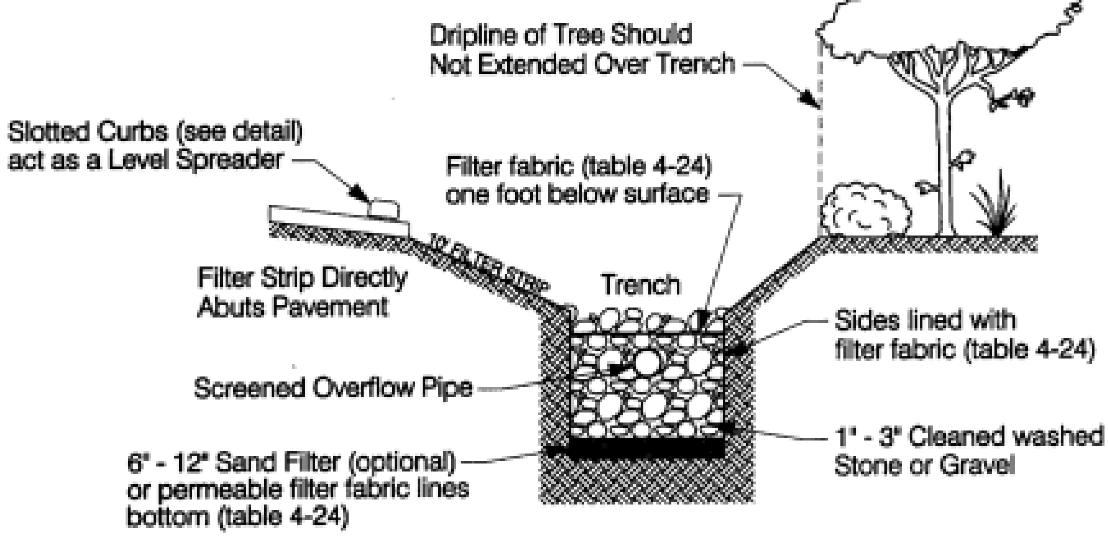
Top View



Detail

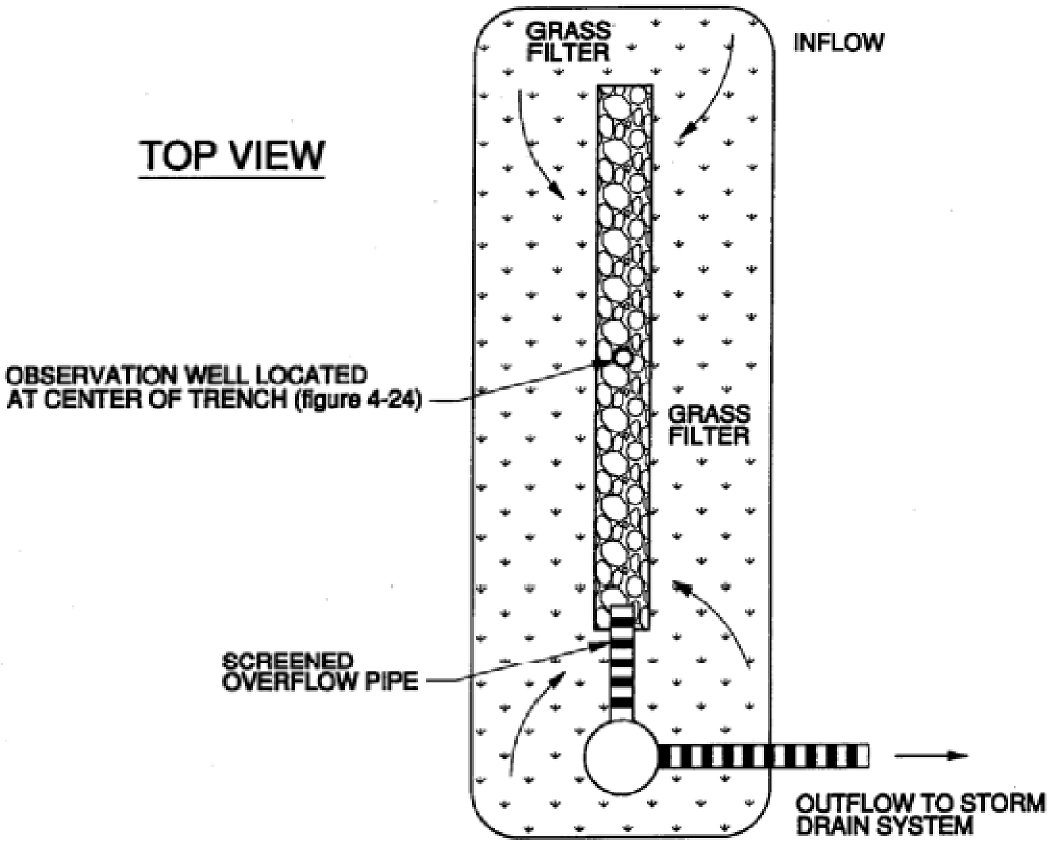


Side View

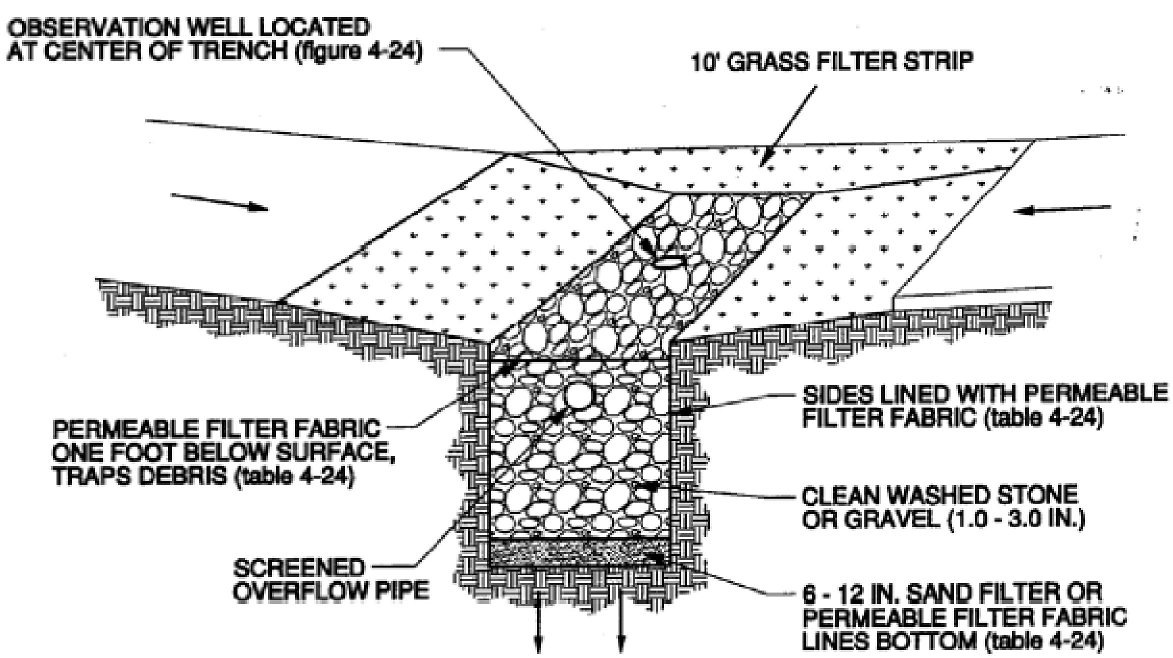


CITY OF WILLITS	**PARKING LOT PERIMETER TRENCH**				STD. NO. 5
	SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD:	DATE: OCT 2009

TOP VIEW



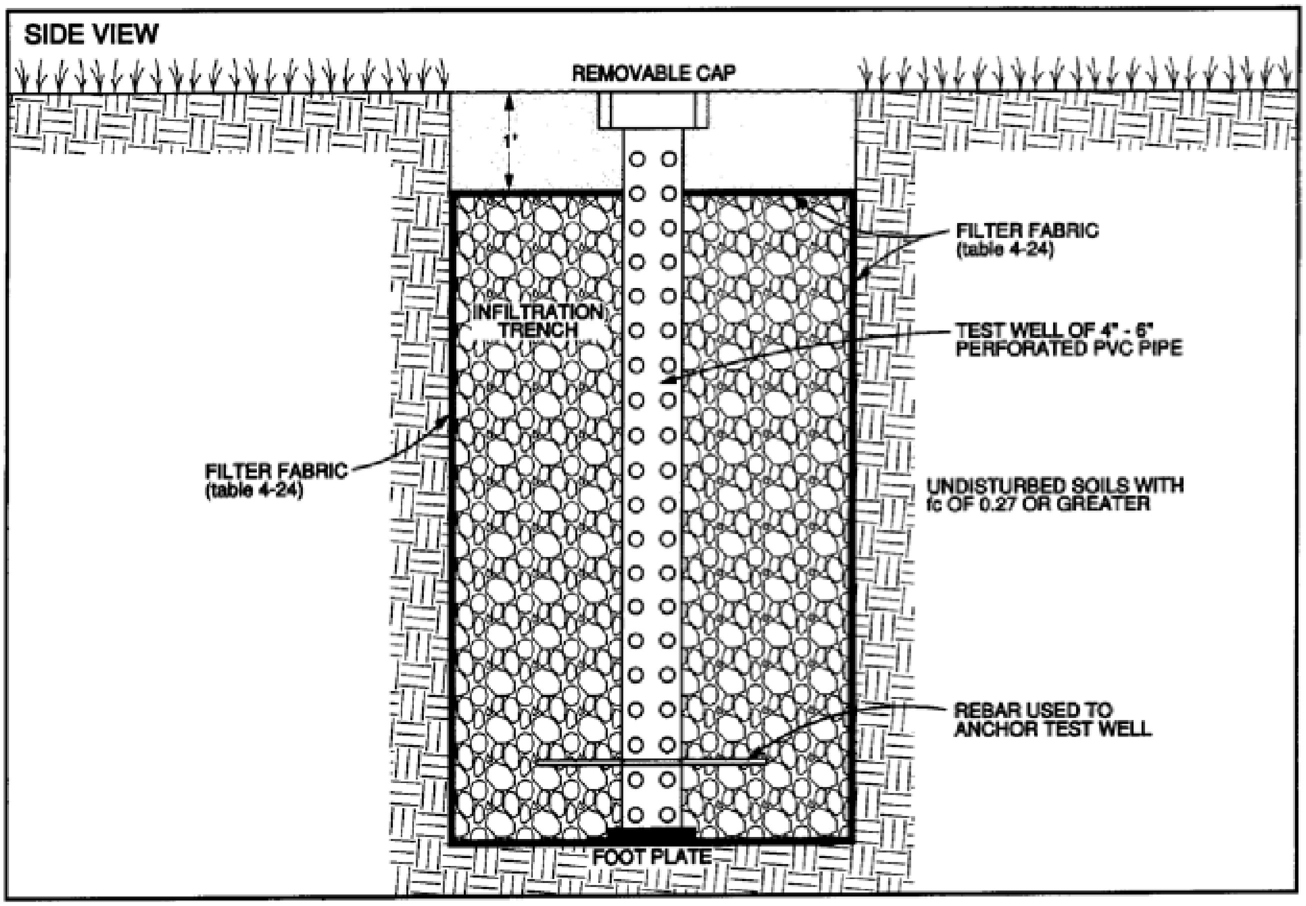
SIDE VIEW



MEDIAN STRIP TRENCH

STD. NO. **6**

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: Thomas M Mannatt	DATE: OCT 2009

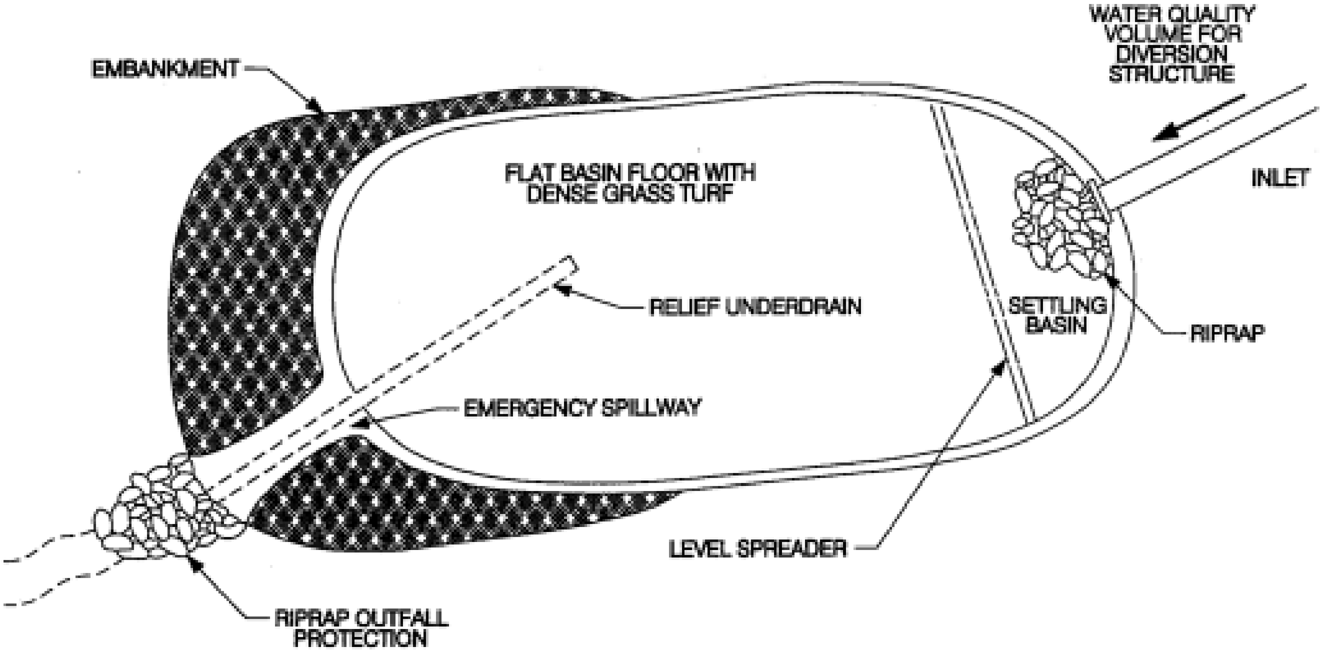


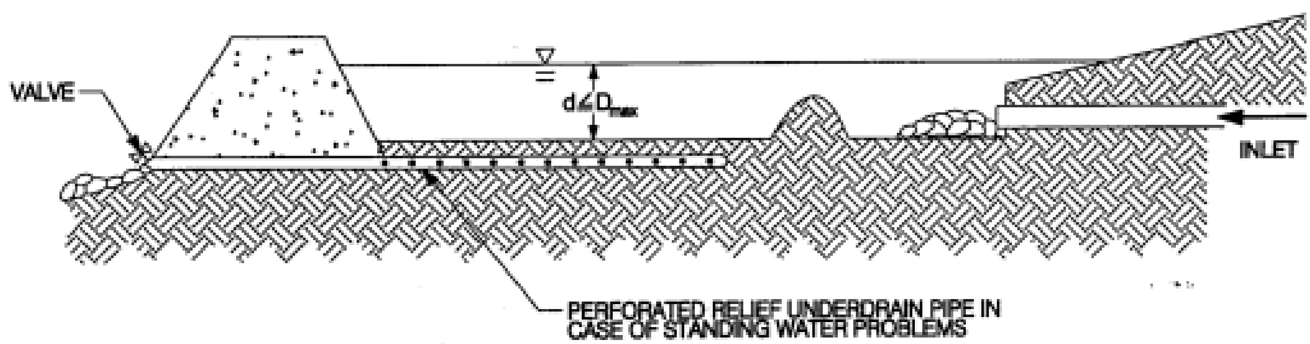
TYPICAL OBSERVATION WELL AND FILTER FABRIC PLACEMENT

STD. NO. 7

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: Thomas M Marnatt	DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-7 Plot Date: Sep 29, 2009 at 10:40





Notes:

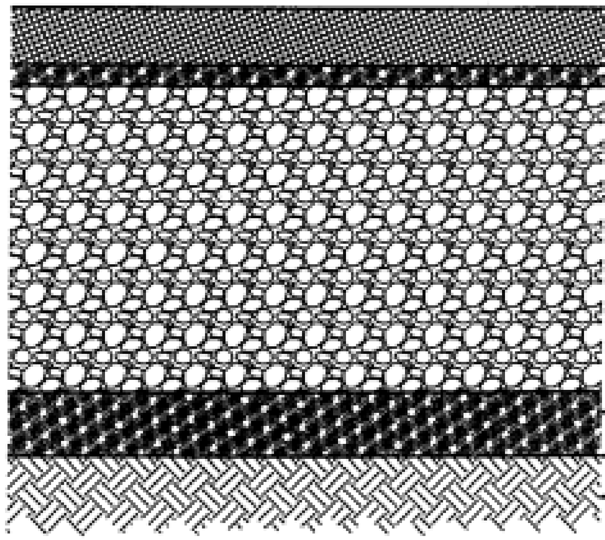
1. A settling basin with a total volume of 10 to 20 percent of the design infiltration volume should be placed at the inlet to the infiltration basin to allow coarse sediment to settle, reducing the frequency of clogging the basin.
2. The infiltration basin should drawdown within 72 hours for basins constructed in soils with acceptable infiltration rates, and 24 to 48 hours for soils with marginal infiltration rates. Basins are to completely dry between storm events.
3. At least 3:1 side slopes for safety and for ease of mowing (4:1 slopes are preferred).
4. An infiltration basin can also be excavated (typically 2 to 6 feet) as long as the bottom of the basin is 2 to 4 feet above the seasonally high ground water table.
5. A perforated relief underdrain with a valve is installed to provide drainage in the event of system failure.

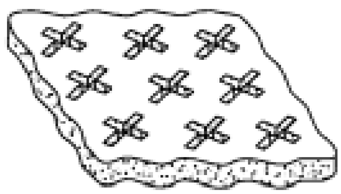
INFILTRATION BASIN

STD. NO. 8

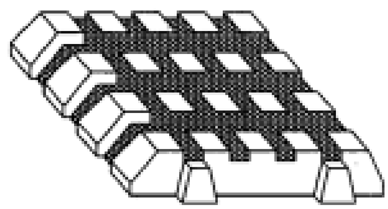
SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: [signature]	DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-8 Plot Date: Sep 29, 2009 at 10:40

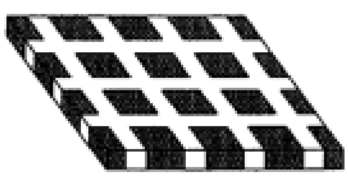




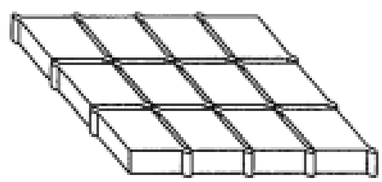
POURED-IN-PLACE SLAB



CASTELLATED UNIT



LATTICE UNIT

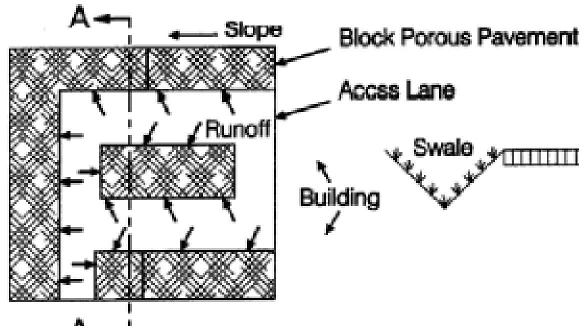


MODULAR UNIT

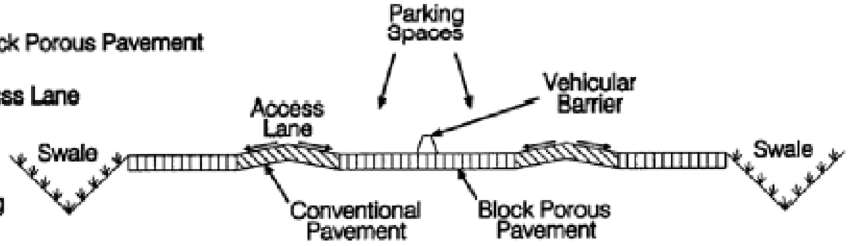
NOTES:

1. SITES SUITABLE FOR PAVING BLOCKS ARE:
   - LOW-USE PARKING AREAS SUCH AS OVERFLOW PARKING AREAS OF LARGE COMMERCIAL CENTERS.
   - RESIDENTIAL DRIVEWAYS, WALKWAYS, PATIOS, ETC.
2. RUNOFF SHOULD NOT BE DIVERTED INTO PAVING BLOCKS TO AVOID EXCESSIVE PONDING ON THE PAVEMENT SURFACE AND POTENTIAL CLOGGING FROM SEDIMENT-LADEN RUNOFF.

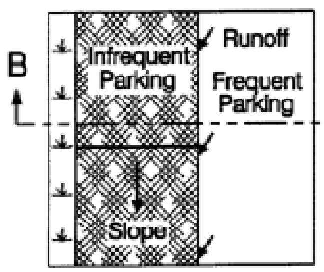
CITY OF WILLITS	PAVING BLOCKS			STD. NO. 9
	SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: [signature]	DATE: OCT 2009



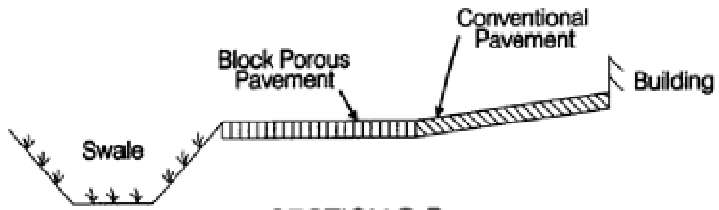
PARKING LOT



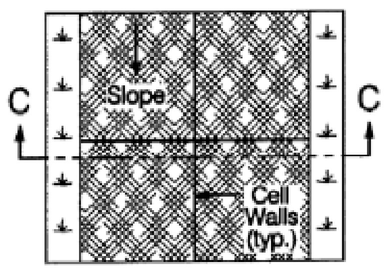
SECTION A-A



PARKING LOT

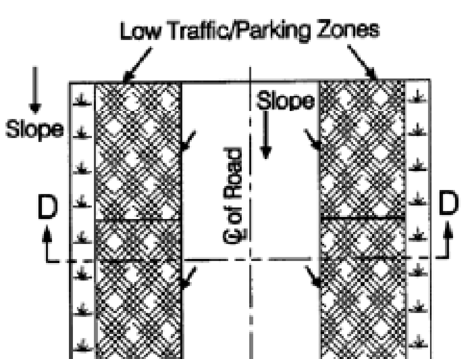


SECTION B-B

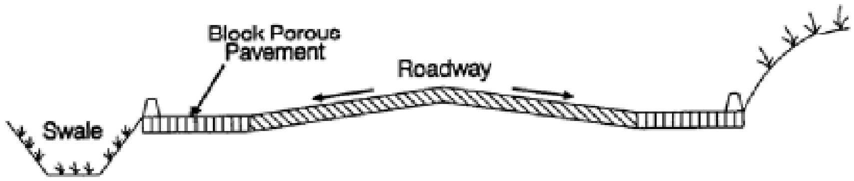


PARKING LOT

SECTION C-C



STREET OR ROAD



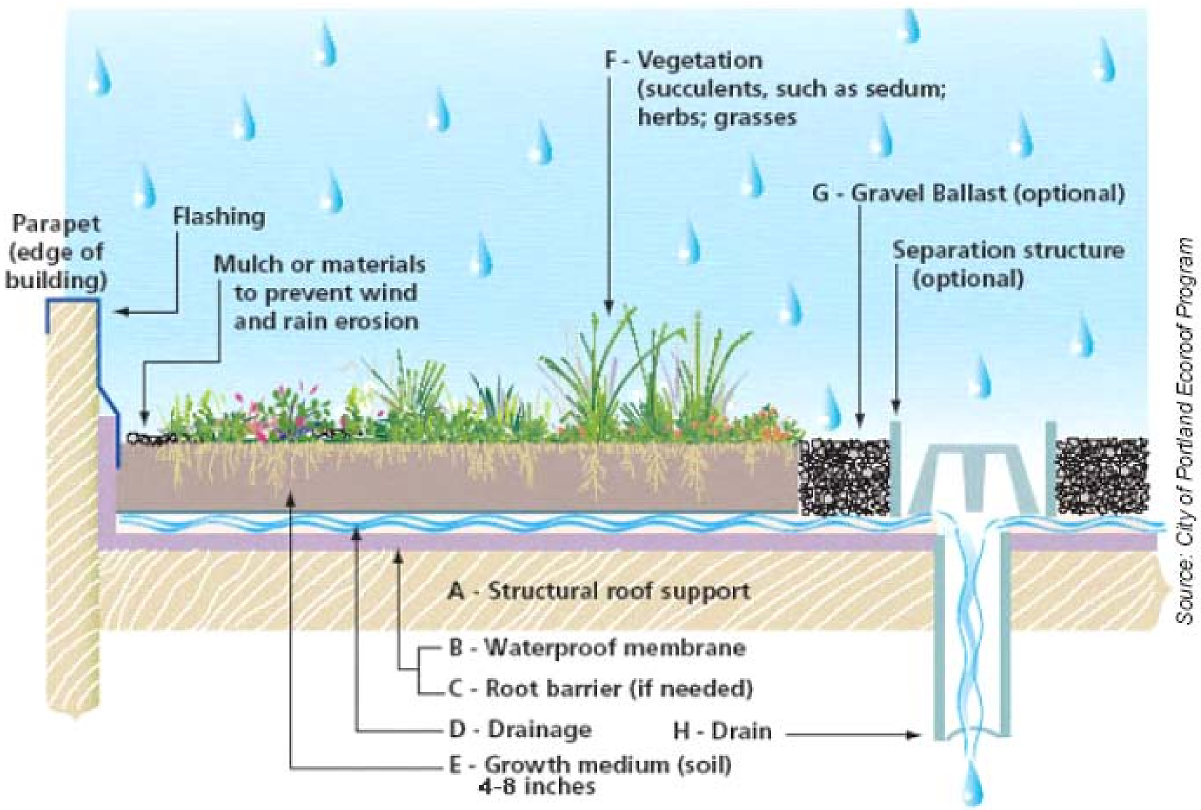
SECTION D-D

TYPICAL APPLICATIONS OF BLOCK POROUS PAVEMENT

STD. NO. 10

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD:	DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-10 Plot Date: Sep 29, 2009 at 10:40

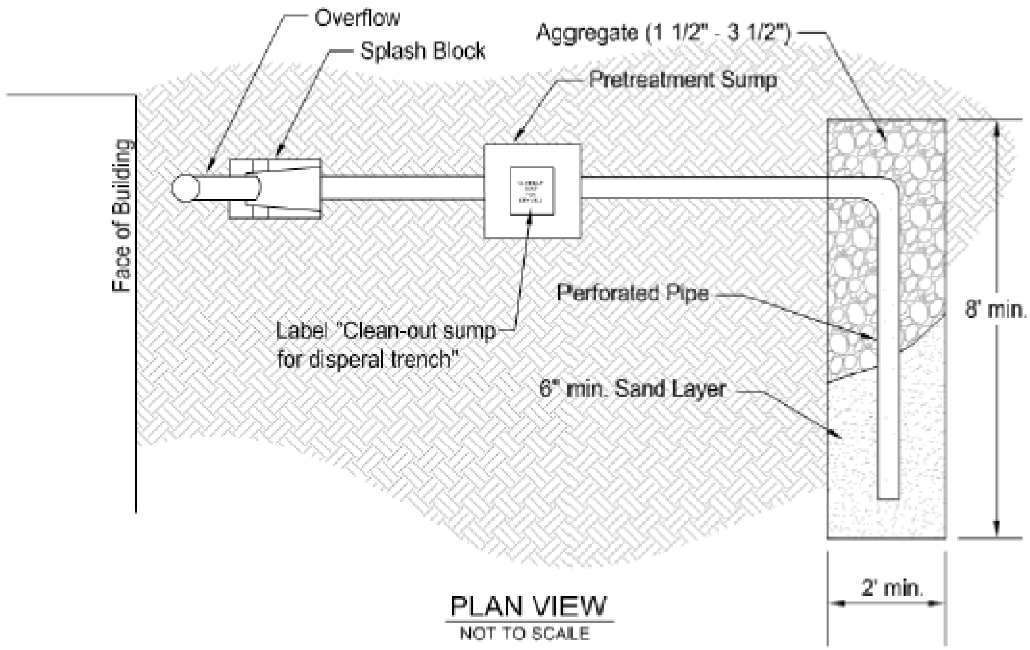


GREEN ROOF DETAIL

STD. NO.
11

SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD:	DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-11 Plot Date: Sep 29, 2009 at 10:40



PLAN VIEW
NOT TO SCALE

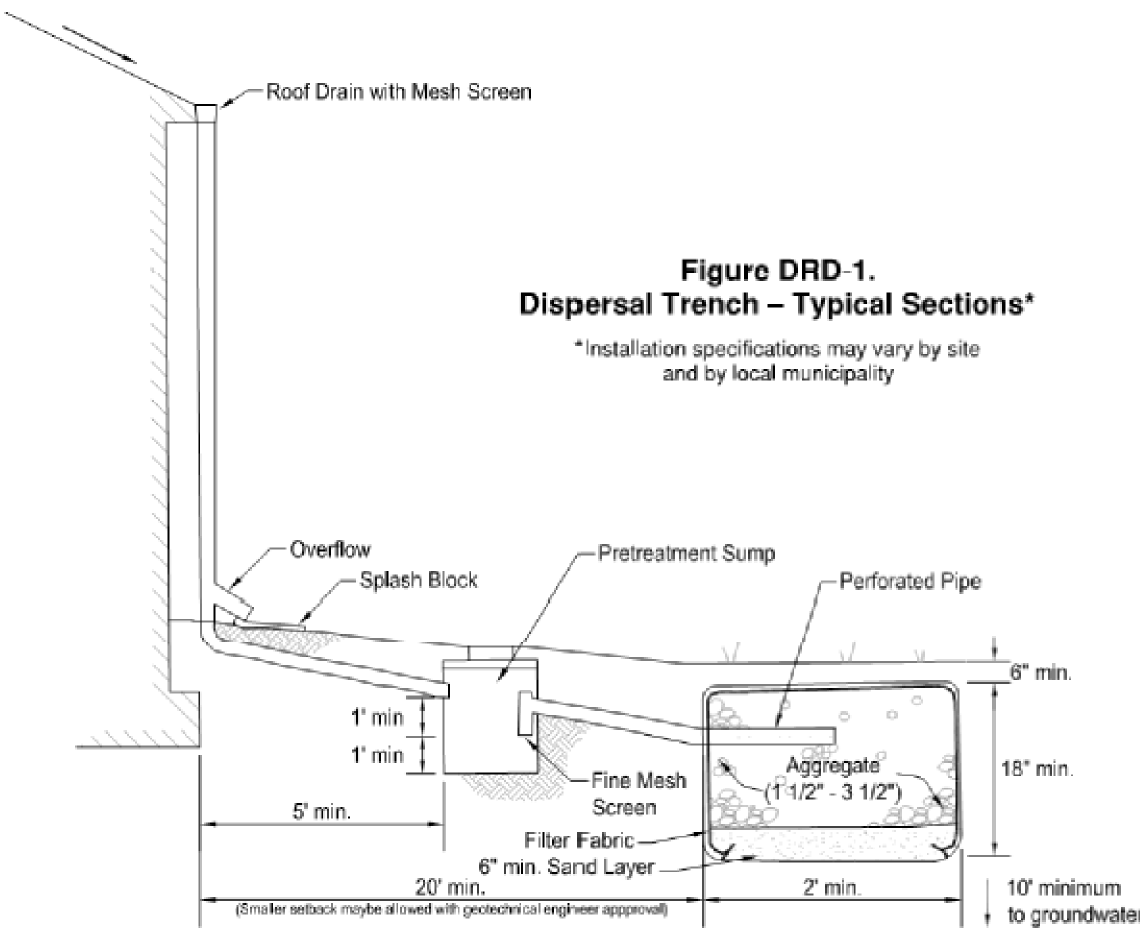


Figure DRD-1.
Dispersal Trench – Typical Sections*

*Installation specifications may vary by site and by local municipality

CROSS-SECTION
NOT TO SCALE

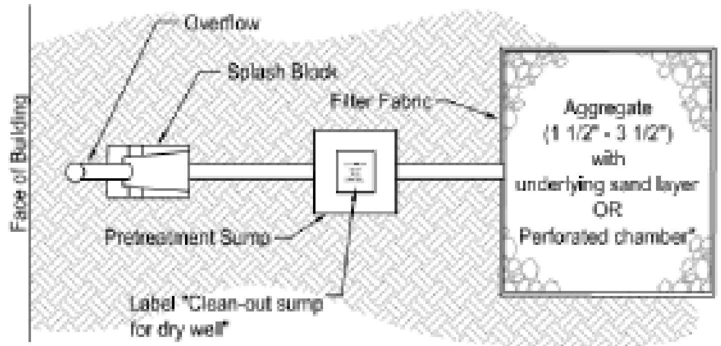
SHEET 1 OF 2

DISCONNECTED ROOF DRAINS

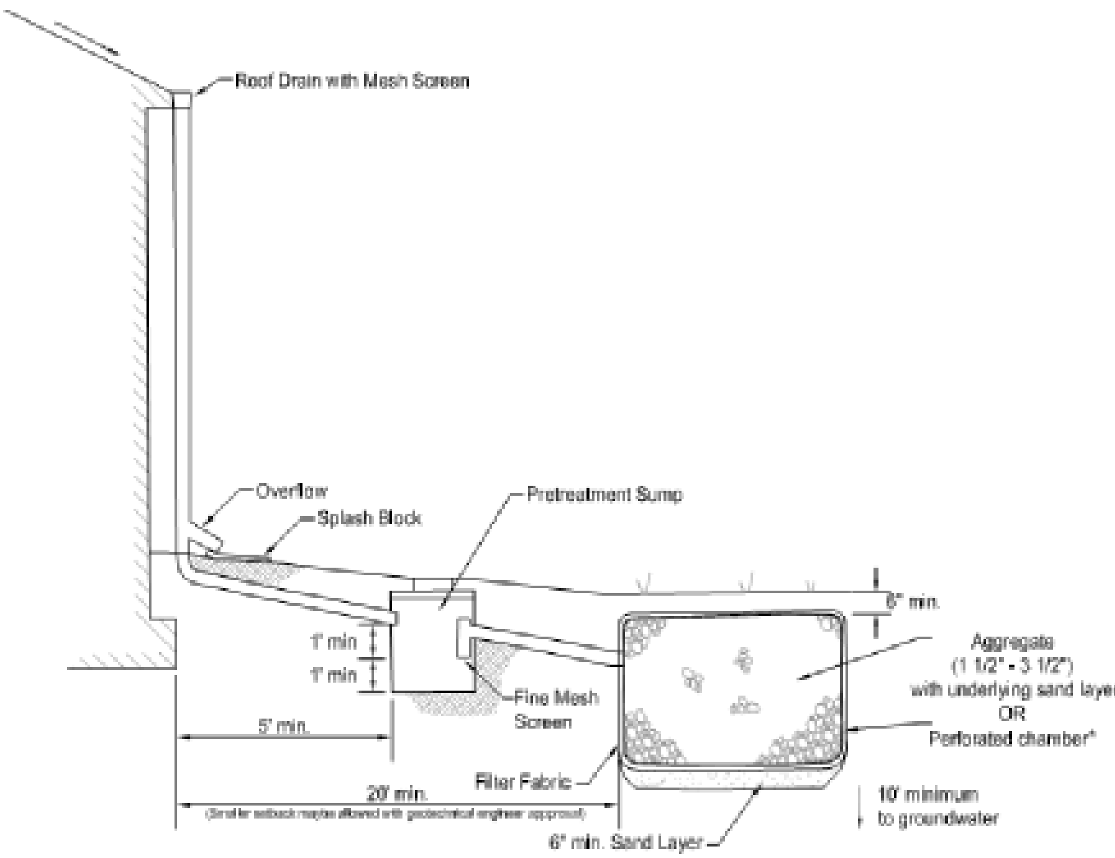
STD. NO. 12

SCALE: NONE | DRAWN: CFB | CHK: MGK | APPVD: | DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064\01064-09-001 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-12 (1) Plot Date: Sep 29, 2009 at 10:40



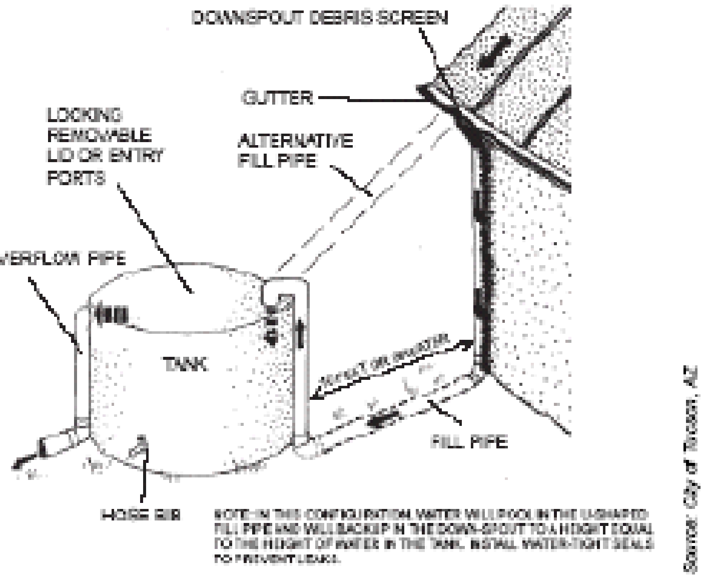
PLAN VIEW
NOT TO SCALE

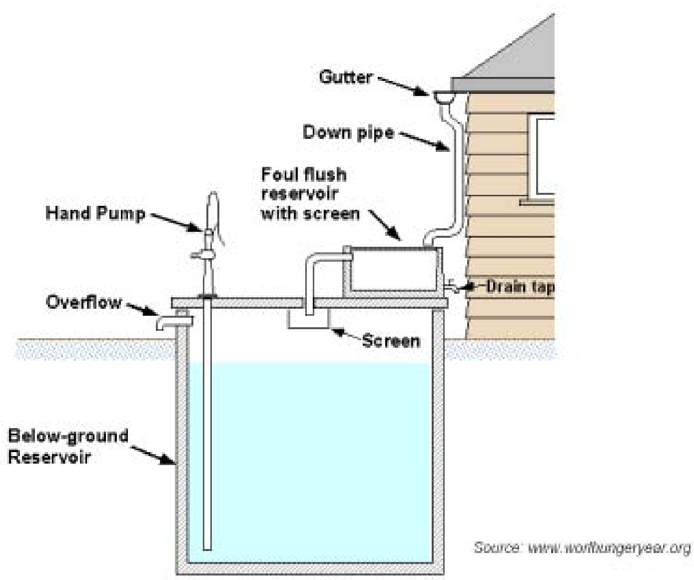


CROSS-SECTION
NOT TO SCALE

SHEET 2 OF 2

CITY OF WILLITS	DISCONNECTED ROOF DRAINS			STD. NO. 12
	SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: [signature]	DATE: OCT 2009





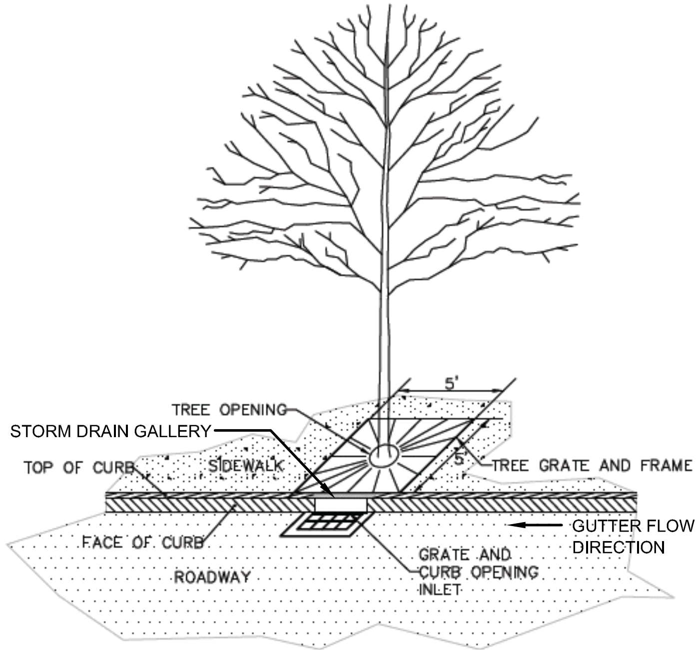
RAINWATER CATCHMENT

STD. NO.

13

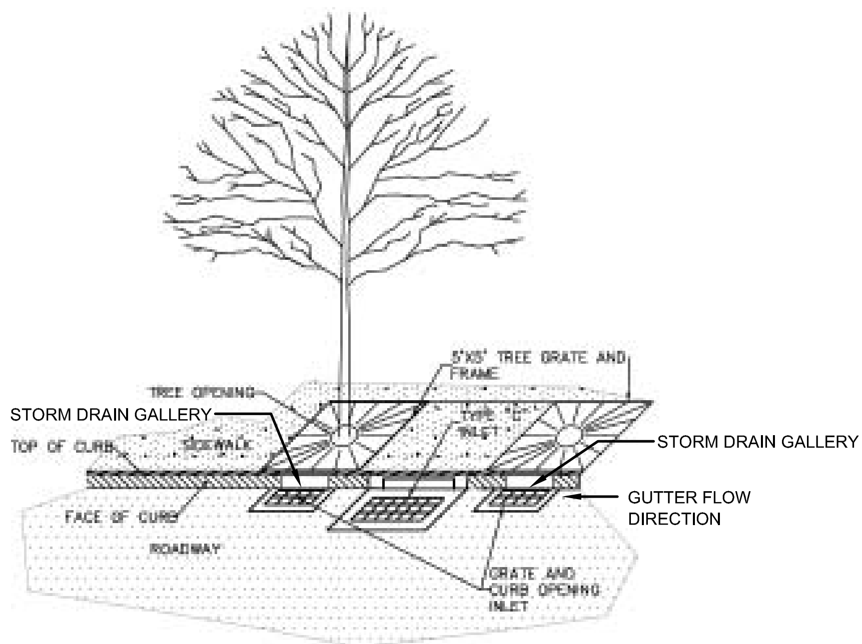
SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: Thomas M Mannatt	DATE: OCT 2009

Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-13 Plot Date: Sep 29, 2009 at 10:40



SCHEMATIC AT GRADE

N.T.S.



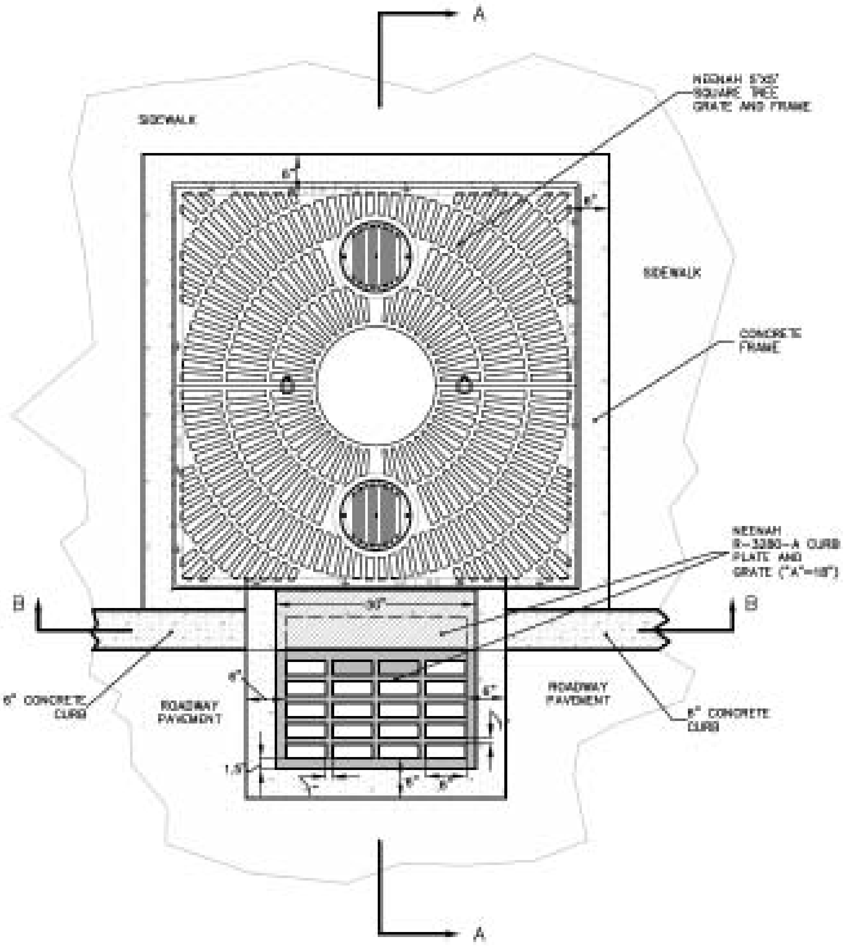
SCHEMATIC AT SAG CONDITION

N.T.S.

SHEET 1 OF 3

TREE BOX FILTER				STD. NO. 14
SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD: Thomas M Mannatt	DATE: OCT 2009

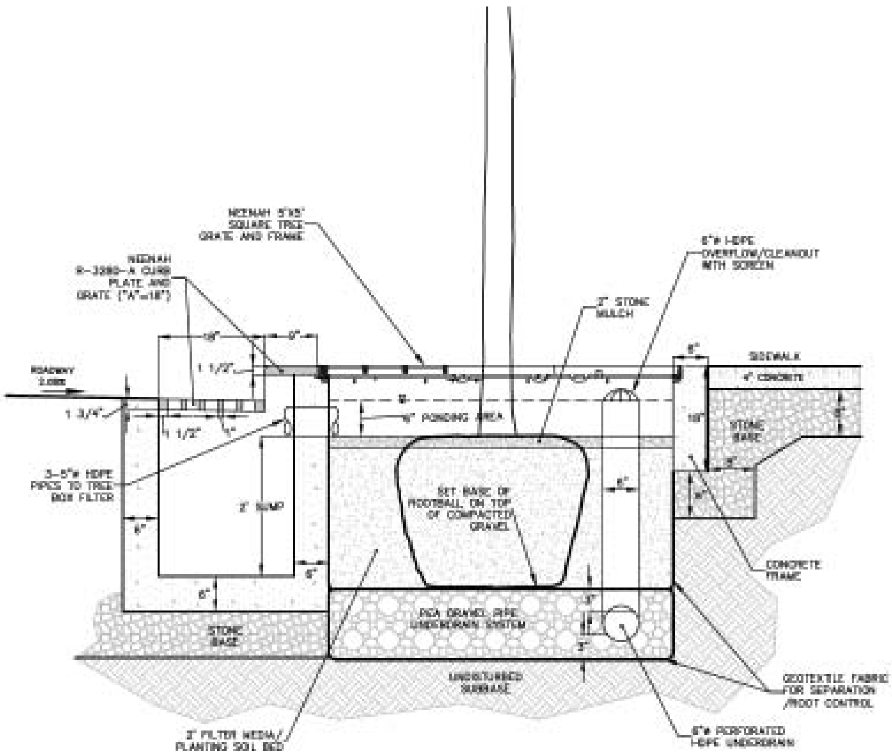
Path: \\srosvr1.corp.w-and-k.com\PROJECTS\01064 - City of Willits\01064-09-001 Willits City Standards\CAD 01064-09-001\dwg\WillitsLID-Details.dwg Layout Name: FIG-14 (1) Plot Date: Sep 29, 2009 at 10:40



ROADSIDE TREE BOX FILTER (PLAN VIEW)

N.T.S.

CITY OF WILLITS	TREE BOX FILTER			STD. NO. 14
	SCALE: NONE	DRAWN: CFB	CHK: MGK	APPVD:	DATE: OCT 2009



NOTE: CONCRETE 28 DAY MINIMUM COMPRESSIVE STRENGTH = 3000 psi

ROADSIDE TREE BOX FILTER CROSS SECTION AA

N.T.S.

SHEET 3 OF 3

CITY OF WILLITS	TREE BOX FILTER	STD. NO. 14
SCALE: NONE	DRAWN: CFB	CHK: MGK
APPVD: *(signature)*	DATE: OCT 2009	