TOWN OF TOLLAND

DESIGN MANUAL

LOW IMPACT DEVELOPMENT
STORM WATER TREATMENT SYSTEMS
PERFORMANCE REQUIREMNTS
ROAD DESIGN
STORMWATER MANAGEMENT

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Acronym Dictionary

BMP	**B**est **M**anagement **P**ractices
BOD	**B**iological **O**xygen **D**emand
Cd	**C**a**d**mium
CGS	**C**onnecticut **G**eodetic **S**urvey
CN	runoff **C**urve **N**umber (see RCN)
CT DEP	**C**onnecticu**t** **D**epartment of **E**nvironmental **P**rotection
Cu	Copper
EPA	**E**nvironmental **P**rotection **A**gency
GRV	**G**roundwater **R**echarge **V**olume
IMP	**I**ntegrated **M**anagement **P**ractices
LID	**L**ow **I**mpact **D**evelopment
NPDES	**N**ational **P**ollutant **D**ischarge **E**limination **S**ystem
NRCS	**N**atural **R**esource **C**onservation **S**ervice
PAH	**P**olycyclical **A**romatic **H**ydrocarbons
PCB	**P**oly**C**hlorinated **B**iphenyls
RCN	**R**unoff **C**urve **N**umber (see CN)
Tc	**T**ime to **c**oncentration
TN	**T**otal **N**itrogen
TP	**T**otal **P**hosphorus
TSS	**T**otal **S**uspended **S**olids
WQF	**W**ater **Q**uality **F**low
WQV	**W**ater **Q**uality **V**olume
Zn	**Z**i**n**c

SECTION ONE

LOW IMPACT DEVELOPMENT
DESIGN MANUAL

Preamble – The Town of Tolland Watershed Areas

The Town of Tolland consists of approximately 25,000 acres (40 sq.miles). It is divided by Interstate I-84, with approximately two thirds of the land area being located north of I-84 and the other third south of I-84.

There are four main watersheds in town. The Willimantic River, The Skungamaug River, Gages Brook and Shenipsit Lake. A brief discussion of each area is provided below.

Willimantic River: The eastern 25% of the Town of Tolland is tributary to the Willimantic River. At the present time, approximately 75% of this watershed has an average impervious coverage of less than 5%. The remaining 25% of the land area has an average impervious coverage of 6.5%. The goal for the implementation of LID strategies in the Willimantic River watershed will be to keep the impervious coverage average less than 7% with the implementation of these regulations.

Skungamaug River: The water quality in this river is classified as B/A as determined by the CT DEP. According to the map entitled "Water Quality Classification Map of Connecticut" by James Murphy and prepared for the CT DEP in 1987 defines this rating as follows: May not be meeting Class A water quality criteria or one or more designated uses. The goal is Class A. For reference, designated uses for a Class A watercourse are potential drinking water supply, fish and wildlife habitat, recreational use, agricultural and industrial supply and other legitimate uses including navigation.

At the current time, there are portions of this watershed where the impervious coverage is approaching 10%. It is very important from a water quality standpoint to not exceed the 10% impervious coverage within a watershed. It has been shown by research in Prince George County, Maryland that water quality may become impaired without measures to effectively neutralize future increases of impervious coverage.

The implementation of LID strategies in this watershed will allow development to occur without increasing the effective impervious coverage within the watershed.

Shenipsit Lake: This lake is located in the northwest portion of the town and extends into the neighboring towns of Vernon and Ellington. Shenipsit Lake is a drinking water supply reservoir for the Towns of Vernon, Tolland and surrounding communities. This watershed is in pretty good shape with regard to the percent impervious coverage. Based upon Town of Tolland mapping, the average impervious area in the watershed for Shenipsit Lake is 4.5 to 6.5%.

The LID goal in the Shenipsit Lake watershed is to maintain the effective low impervious coverage for all future developments.

Gages Brook: Gages Brook is the headwaters of the Tankerhoosen River, which flows through the Town of Vernon. Gages Brook runs into to the Walker Reservoir, from which the Tankerhoosen River flows. Both watercourses are important to the Town of Vernon. In addition, the DEP Belding Wildlife Refuge is located a couple of miles downstream from the lake. Due to the proximity to I-84, a majority of the commercial and industrial development has occurred in this watershed in the past. The impervious coverage in this watershed is greater than 15%. A major water quality issue here is the discharge of storm water from a portion of I-84.

In this case, the implementation of LID for new development will prevent adverse changes in the water quality. On redevelopment sites, the retrofitting of LID storm water treatment systems will have the ability to slowly improve the water quality of the storm water runoff from these sites.

Aquifer Protection Areas: There are numerous aquifer protection areas, consisting of coarse-grained stratified drift, located within the three watershed areas discussed above. With the exception of the large aquifer along the Willimantic River, which is used for drinking water for the town water system, the other aquifer areas have not been developed into water supply systems at this time.

The LID goal for these aquifer protection areas will be to maintain their future ability to provide a water supply source for the town.

The Town of Tolland has prepared maps which show the limits of watershed areas as well as the impervious coverage within the drainage basins found in the town. These maps are found in Appendix A of this manual.

Chapter 1 – Introduction to Low Impact Development

A. Purpose of Manual

The primary purpose of this manual is to provide a legal framework for site design which incorporates Low Impact Development strategies into land development. This manual will provide techniques for land developers to maintain the integrity of natural site features into the development process, which will reduce or eliminate structural components of a storm water management system.

Some of the site features typically protected through the use of LID are wetlands, floodplains, forested areas, meadows, riparian buffers, soils and other unique site features.

There are many design features of LID, which will allow professional engineers in the development field to have flexibility in the development process. The various LID practices can be used alone or in series to maximize benefits to the site. In many cases, some type of structural drainage systems will also be required to be implemented on a site.

B. Storm Water Goals

The following are goals that can be achieved by the implementation of Low Impact Development Controls:

1. Preserve Open Space within developments -
   - Utilize the standards set forth is Section 170-38 of the Town of Tolland Zoning Regulations for Cluster or Open Space Subdivision designs.
   - Incorporate natural site elements (ridge lines, significant trees, permeable soils, open meadows, wetlands and streams) into the development project.
   - Maintain existing vegetation to the maximum extent possible by minimizing of land clearing and disturbance.
   - Increase natural landscape buffers at the limit of development to improve storm water management

2. Storm water Management -Consider storm water a resource to be reused and recycled
   - Incorporate decentralized storm water management systems in to the site design by treating storm water at its source.
   - Disconnect impervious areas and maintain sheet flow to the maximum extent possible.
   - Maintain pre-development Times of Concentrations for post-development runoff and maintain pre-development runoff volumes to maximum extent practical.

- Provide pollution prevention by modifying human activities to reduce the introduction of pollutants into the environment.
- Provide Water Quality treatment in accordance with Connecticut Department of Environmental Protection 2004 Storm Water Quality Manual.

3. Public Education and Outreach -
    - Provide education opportunities to the design and regulatory communities on the benefits of Low Impact Development.
    - Provide public outreach programs to educate the public community on the impacts of storm water.

C. Low Impact Development Benefits

The benefits of LID are achieved across the development board with the natural environment receiving the highest value. LID can not only benefit the environment, its use benefits the municipality and the developer.

1. Environmental Benefits -
    - Preserve trees and natural vegetation,
    - Protect the water quality by reducing sediment, nutrient and toxic loads to wetland and watercourse systems, not only on the site, but downstream areas also,
    - Reduce impacts to the local aquatic and terrestrial animals and plants,
    - Preserve the biological and ecological integrity of natural systems,

2. Municipality Benefits -
    - Protect regional flora and fauna
    - Balance Growth needs with environmental protection
    - Reduce municipal infrastructure and utility maintenance costs (roads, and storm water drainage systems)
    - Increase collaborative public/private partnerships on environmental protection

3. Developer Benefits -
    - Reduce land clearing and earth disturbance costs
    - Reduce storm water management costs
    - Reduce infrastructure costs (roads, storm water conveyance and treatment systems)
    - Increase quality of building lots and community marketability

4. Low Impact Development Findings

LID design strategies, such as Cluster or Open Space Subdivision Designs as specified in Section 170-38 of the Town of Tolland Zoning Regulations have been found to have significant environment and financial benefits in many parts of the country. Through the reduction in lot area, much more of the site can be preserved in its natural condition, thus providing benefits for wildlife, while improving the aesthetic benefits to the homeowners. Access roads are generally shorter and narrower, thus saving on the infrastructure and maintenance costs. It has been shown that lots and/or homes in a Conservation Subdivision have historically had higher retail values over time when compared to subdivisions built according to minimum zoning requirements.

LID storm water strategies have been proven to be extremely effective at maintaining pre-development hydrologic conditions, thus significantly reducing surface water discharges for post-development conditions. The basic LID concept is to incorporate storm water treatment as part of the development. This allows runoff to be handled as close to the source as possible and eliminate or minimize the end of pipe solutions, such as concentrated discharges and large detention basins. LID storm water systems have also been shown to remove significant pollutant loads commonly found in urban surface runoff. This research has been done by the Center for Watershed Protection, Wisconsin Department of Natural Resources and the University of New Hampshire Stormwater Center.

Chapter 2 – Storm Water Management Issues

What is Urban Storm Water Runoff? The 2004 Connecticut Stormwater Quality Manual by the CT DEP defines it as the following:

"Storm water runoff is a natural part of the hydrologic cycle, which is the distribution and movement of water between the earth's atmosphere, land and water bodies. Rainfall, snowfall, and other frozen precipitation send water to the earth's surfaces. Storm water runoff is surface flow from precipitation that accumulates in and flows through natural or man-made conveyance systems during and immediately after a storm event or upon snowmelt. Storm water eventually travels to surface water bodies as diffuse overland flow, a point discharge, or as groundwater flow. Water that seeps into the ground eventually replenishes groundwater aquifers and surface waters such as lakes, streams and oceans. Groundwater recharge also helps maintain water flows in streams and wetland moisture levels during dry weather. Water returned to the atmosphere through evaporation and transpiration to complete the cycle."

Most runoff starts out as overland flow (non-point source) but becomes a point source discharge. Point source discharges are a matter of concern under EPA's National Pollutant Discharge Elimination System (NPDES) permit program.

Why is Urban Storm Water Runoff a concern? Urban storm water runoff has been found to be both a point source and non-point source of pollution. Whether storm water flows from a pipe or as overland flow it can cause significant impairment of water quality in the receiving waters. Storm water runoff has also been shown to be the main source of excessive nutrient loading in natural watercourses.

As the percentage of impervious coverage (building, roads, driveways, and parking areas) increases within a watershed, there is a direct relationship with storm water issues.

A. Increased impervious coverage can have some of the following impacts on stream ecology according to the CT 2004 Storm Water Quality Manual:

1. **Hydrologic Impacts -**
   - Increased runoff volume
   - Increased peak discharges
   - Decreased runoff travel time
   - Reduced groundwater recharge
   - Reduced stream baseflow
   - Increased frequency of bankfull and overbank floods
   - Increase flow velocity during storms
   - Increase frequency and duration of high stream flows

2. **Stream Channel and Floodplain Impacts:**
    - Channel scour, widening and downcutting
    - Streambank erosion and increased sediment loads
    - Shifting bars of coarse sediment
    - Burying of stream substrate
    - Loss of poll/riffle structure and sequence
    - Man-made stream enclosures or channelization
    - Floodplain expansion

3. **Water Quality Impacts**:
    - Excess Nutrients (Nitrogen and soluble phosphorous)
    - Sediments
    - Pathogens
    - Organic Materials
    - Hydrocarbons
    - Metals
    - Synthetic Organic Compounds
    - Deicing Constituents
    - Trash and Debris
    - Thermal Impacts
    - Freshwater discharge to estuarine systems

All of these impacts not only affect the aquatic environment, but also affect the ability of people to use these areas for recreation, both active and passive. It is well documented that discharges of storm water have resulted in beach closures due to high bacteria and pathogen counts in the water.

B. A brief explanation for each type of pollutant and its affect on the environment is provided below -

1. **Nutrients:**

Non-point source runoff, such as from a lawn can have significant impacts on slow moving water bodies, such as lakes and ponds due to excessive nutrients. Excess nitrogen and phosphorous from lawn fertilizers do cause algae blooms and excessive plant growth in lakes and ponds. While nutrient loading may be seasonal in nature, the long term impacts can be significant. When the vegetation dies, available oxygen in the water is needed to enhance the decomposition process. The increased need of oxygen in the decomposition process is called the Biological Oxygen Demand (BOD). If the BOD increases significantly, then there is less available oxygen from the water for aquatic life. Excess nutrient loads can also increase the growth of epiphytes (small plants that attach themselves to other things) and increase the percentage of zooplankton and phytoplankton in the water. With increased plant growth, available light is reduced in the pond. Excess nutrients can also affect the types of plants found in an aquatic regime, thus allowing less desirable species to be dominant in the aquatic environment.

2. **Sediment:**

Sediment occurs as coarse and fine grained soil particles are washed off impervious surfaces or as erosion from active construction sites. Excessive sediment loads can smother the bottom dwelling aquatic life and change the bottom substrate in a stream. Very fine soil particles can remain suspended in the water column, thus making the water cloudy and turbid, which affects not only the water quality but the aesthetic qualities of the stream.   Many other pollutants, such as metals, hydrocarbons, pathogens and nutrients are attached to sediment particles and thus are conveyed to the reaching waters.

3. **Pathogens:**

Pathogens include viruses, bacteria and protozoa which can cause disease in human beings.   High levels of pathogens in water bodies can cause closures of recreational facilities.

4. **Organic Materials**:

Organic materials, such as leaves, grass clippings, discharges from failing septic systems have the following impacts on water quality; lower dissolved oxygen levels, algal growth, reduced clarity, fish kills and odors. While some natural deposition of organic matter will always occur, increased loading overtime can significantly impact water quality, again primarily in lakes and ponds. Discharges of partially treated effluent from septic systems contain nitrogen, phosphorous and pathogens, which as noted above will impact water quality.

5. **Hydrocarbons**:

The primary source of hydrocarbons is from deposition from automobiles.   Large impervious areas, such as parking lots, gas and vehicle service stations, roads and petroleum storage facilities will likely have high concentrations of hydrocarbons. The discharge of hydrocarbons to receiving waters are toxic to aquatic life at very low concentrations.

6. **Metals:**

Copper, zinc, lead, mercury and cadmium are all commonly found in storm water runoff.   The concentrations of metals in the runoff are directly tied to the percentage of impervious coverage and use.   Common sources of metals are vehicular exhaust, fossil fuel consumption, corrosion of galvanized and chrome-plated products, roof runoff, runoff from industrial sites and the application of deicing agents.   Not only are metals toxic to aquatic life, but they bioaccumulate in the environment and have the potential to contaminate drinking water supplies. As metal particles attach themselves to sediment, sediment build up on the bottom of a river can greatly impair the aquatic environment over the long term.

7. **Synthetic Organic Chemicals**:
Synthetic organic chemicals may also be found in urban storm water runoff at low concentrations. These chemicals come from pesticides, phenols, polycyclic aromatic compounds (PAHs), and polychlorinated biphenyls (PCBs). These compounds have varying levels of toxicity on aquatic organisms. The largest danger exists from the accumulation of these compounds in fish and shellfish. The primary source of pesticides is from lawns and landscape areas. Industrial sites are the most likely sources of PAHs.

8. **De-icing Constituents**:
The application of salt and other de-icing chemicals on roads, driveway and parking areas will result in the discharge of sodium chloride into storm water runoff during melt periods. High concentrations of sodium and chloride will adversely impact soil, water and vegetation. In addition, if the runoff has prolonged contact with metal surfaces, the rate of metal corrosion will increase, thus increasing the discharge of dissolved metals in the environment. Groundwater wells can be adversely impacted by high concentrations of salt and thus pose a health risk for human beings who consume the well water. Anti-freeze from automobiles is another source of deicing chemicals.

9. **Trash and Debris**:
Small particles of trash and other man-made materials can easily get washed off impervious surface during rainfall events. The primary impact of litter is that it detracts from the aesthetic value of water bodies. Litter can also harm wildlife thru the inadvertent ingestion of the material by animals or by clogging their environment. Sources of litter are found wherever human being has changed the landscape to suit their needs.

10. **Thermal Impacts**:
Impervious surfaces, such as roofs, and paved areas will warm up significantly on sunny days and hold onto the temperature increase. When rainfall lands on this surface, the water temperature of the runoff is significantly increased. Increased temperature of the runoff can elevate water temperatures in streams and other shallow water bodies. The increase in water temperature can exceed the tolerance limits for fish and invertebrates, thus lowering their survival rates. Elevated water temperatures will also contribute to decreased oxygen levels in the water.

11. **Freshwater Impacts**:
The discharge of freshwater storm water runoff into tidal areas can affect the salinity and hydroperiod of these environments. Species, which are more tolerant of these brackish conditions, such as Phragmites can thrive, thus crowding out native species.

C. Current Storm Water Management Philosophy

The primary goal of current storm water design simply involves conveying runoff from a development via the fastest means possible to a discharge point. A man-made outlet to reduce flow velocities might be installed prior to the discharge to a stream or maybe a man-made detention basin will be constructed. In either case, minimal, if any water quality treatment of the storm water occurs in this type of system. When detention basins are used to reduce the peak rate of runoff to pre-development rates, the post-development runoff volume is released over a much longer time period. This increase time of flow can have some of the adverse impacts on stream channel morphology as noted above.

All types of pollutants in the runoff are directly conveyed to reaching wetland or watercourse systems. Many of the impacts described above are likely to occur with this type of system.

Chapter 3 – Low Impact Development Overview

The Town of Tolland requires that Low Impact Development techniques be implemented on all development projects within the boundaries of the Town to protect high quality wetlands, watercourses, open water bodies and other sensitive areas from the impacts of point and non-point sources of storm water due to land development projects.

A. What is Low Impact Development?

Low Impact Development is an innovative storm water management approach that is modeled after nature itself. The goal of LID is to manage rainfall at the source using uniformly distributed decentralized micro-scale control measures. In other words, LID's goal is to mimic the site's pre-development hydrology thru the use of design measures, which can infiltrate, filter, and store, evaporate and detain storm water runoff at its source.

LID techniques are based upon the idea that storm water is a resource to be reused instead of something to get rid of as fast as possible. Storm water management systems which use LID concepts address this issue by creating cost effective landscape features at a lot level to handle runoff. The landscape features, known as Integrated Management Practices (IMPs) are the basic building techniques for the implementation of LID. Some of the common IMP practices are bioretention, rain gardens, infiltration trenches or drywells, vegetative swales, and rain cisterns.

LID techniques can be applied to new residential, commercial and industrial developments. LID can also be applied as a retrofit to existing site for redevelopment purposes.

B. The LID philosophy

LID is effective and simple to apply. LID uses the integration of treatment and management measures into the site features, instead of relying upon large, costly centralized conveyance and treatment systems. This system requires the strategic placement of small lot-level control measures that are customized to mimic the pre-development hydrology of the site.

LID is very cost effective. Because there are less structural components to LID systems, the installation cost is less as is the long term maintenance costs. As large detention basins are eliminated more of the site can be preserved or used for passive recreation. Quality of life issues are significantly improved with LID systems. Property values are enhanced; wildlife habitat is improved along with pollution reduction, better wetland protection and better flood protection.

LID is easy to work with. LID can be applied in heavily urbanized environments, as well as open areas and environmentally sensitive sites. LID storm water management systems use a variety of structural and non-structural systems to provide for both water quality and water quantity. LID is not a "one size fits all" solution to storm water issues. LID techniques can be modified to control and reduce the introduction of pollutants and is customizable for any development site.

LID is an environmentally sound approach to storm water issues. LID seeks to better integrate the built environment with the natural environment by using an ecologically-based land development technology. LID's practices and principles allow a developed site to maintain the pre-development ecological and watershed functions.

C. LID Principles

There are basic design principles associated with LID. Many of the principles require that land development professionals evaluate properties in a completely different manner in order to use LID systems.

1. The following are LID principles which affect the initial assessment of property and the type of use proposed.

- Define and locate Critical Resource areas, such as wetlands/watercourses, unusual forest features, and soils with moderate to high infiltrative capacities.
- Locate roads, driveways, parking areas, homesites and other buildings away from the Critical Resource areas.
- Retain native forest cover on undeveloped sites to the maximum extent practical.
- Use "site fingerprinting" to minimize areas cleared for development.
- Minimize impervious surfaces such as roads, driveways and parking areas.
- Consider the reduction of road widths while maintaining safe conditions for all vehicles and pedestrians.
- Consider the use of curvi-linear alignments for roads to permit roads to better fit the site, while reducing cuts and fills.
- Eliminate direct connection of impervious areas which convey runoff directly to wetlands or watercourses.
- Restore vegetation, both herbaceous and deciduous species on previously cleared areas. Vegetation captures rainfall and allows evapotranspiration and infiltration to occur.

2. The following are LID principles which are applicable to the design of the storm water control systems for a site.

- Reduce reliance on the use of traditional storm water collection and conveyance systems (catch basins, pipes and detention basins).
- Use small scale storm water management systems, such as bioretention, rain gardens, infiltration systems, rain cisterns, vegetated swales, permeable pavement and green roofs.

- Integrate storm water systems into the site design from the start of the design process; consider storm water a resource to be used as a benefit to the environment and to create aesthetically pleasing landscape areas.
- Create a site design that slow runoff from rainfall events and increases the amount of time that runoff stays on the site.
- Incorporate multiple LID treatment systems in treatment train to increase the effectiveness of the system, and create redundancy into the treatment train.

C. The Process of Low Impact Development

1. The following are the basic design principles to be applied on all development projects in the Town of Tolland.

- **Runoff Volume Control –** The pre-development volume is maintained by a combination of minimizing the site disturbance from the pre-development to the post-development condition and then providing distributed retention Best Management Practices (BMPs). Retention BMPs are structures that retain the runoff for the design storm event. A "customized" or detailed runoff curve number (RCN) evaluation is required to determine the required runoff volume. The storage required to maintain the pre-development volume may also be sufficient to maintain the pre-development peak rate.

- **Peak Runoff Rate Control –** Low impact development is designed to maintain the pre-development peak runoff discharge rate for the selected design storm events. This is done by maintaining the pre-development time of concentration and then using retention and/or detention BMPs (i.e. rain gardens, bioretention, and open drainage systems, etc.) that are distributed throughout the site. The goal is to use retention practices to control runoff volume, and, if these retention practices are not sufficient to control the peak runoff rate, to use additional detention practices to control the peak runoff rate.

- **Flow frequency Duration Control –** Since low impact development is designed to emulate the pre-development hydrologic regime through both volume and peak runoff rate controls, the flow frequency and duration for the post-development conditions will almost be identical to those for the pre-development conditions. The impacts on stream habitat due to erosion and sediment at downstream reaches can then be minimized.

- **Groundwater Infiltration Rates** - The pre-development infiltration rate shall be maintained for post-development conditions. As impervious coverage increases, the rate of infiltration of rainfall into the soil decreases. The goal is to use LID systems to infiltrate the same volume of water for post-development conditions which match the pre-development infiltration rate.

- **Water Quality Control –** Low impact development is designed to provide water quality treatment control for the duration storm runoff from impervious areas using retention practices. The storage required for water quality control is compared to the storage required to control the increased runoff volume. The greater of the two volumes is the required detention storage. Low impact development also provides pollution prevention by modifying human activities to reduce the introduction of pollutants into the environment.

2. Deviations from the above Low Impact Development requirements shall only be approved by the Planning and Zoning Commission upon an assessment by a professional engineer, with expertise in the implementation of Low Impact Development techniques and storm water treatment systems and shall meet the following criteria.

- The deviations will produce a compensating or comparable result in the storm water flow control and treatment that is in the public interest;
- The deviations contribute to and are consistent with the goal of achieving low effective impervious surface area within a development;
- The proposed development project offer reasonable assurances that low impervious surfaces will be achieved and maintained;
- The deviations do not threaten public health or safety;
- The deviations are consistent will generally accepted engineering and design practices;
- The deviations promote one or more of the following:
  a) Innovative site or housing design;
  b) Increased on-site stormwater retention using native vegetation;
  c) Retention of at least 60 percent of the natural vegetation conditions over the site;
  d) Improved on-site water quality beyond that required by current applicable regulations;
  e) Retention or re-creation of pre-development and/or natural hydrologic conditions to the maximum extent possible;
  f) The reduction of effective impervious surfaces to the maximum extent practical.
- The deviations do not allow density greater than what would otherwise be allowed under current regulations then in effect;

- The deviations do not present significantly greater maintenance requirements at facilities that will be eventually transferred to public ownership;
- There shall be submitted in conjunction with each such project, covenants, conditions and restrictions which will be binding upon the property all necessary native growth protection easements, impervious surface restrictions and such other critical features as the Planning and Zoning Commission may require.

Chapter 4 – Site Design Process

Residential – Commercial – Industrial

The following process shall be followed by any applicant for subdivision, site plan or special permit approval for a project in the Town of Tolland. The sample plans utilized in this section are generic in nature and are not purported to be in compliance with applicable Town of Tolland zoning and subdivision regulations and are simply shown for demonstration purposes. This process has been designed to assess the existing conditions of the land and to determine the optimum areas suitable for protection, development and the use of LID storm water techniques. The LID Design Process Outline summarizes the basic concepts of this procedure; the specifics will be explained within the body of Chapter 4.

LID Design Process Outline

Site Assessment

1. Acquire accurate topography

2. Perform soil analysis:
    - which soils comprise the site
    - what are infiltration rates

3. Determine hydrologic patterns & features:
    - all hydrologic features should be mapped along with existing drainage patterns
    - field verify

4. Identify:
    - Native Forest Vegetation
    - Wetlands & Riparian Areas
    - Flood Plains

Site Analysis

1. Map Requirements for all types of development
    - Areas to be protected from development
        - Wetlands
        - Watercourses
        - Riparian corridors
    - Slopes greater than 20% (as measured over 50')

- Soils with moderate to high infiltration potential
- Different types of vegetative cover
- Pre-development run-off patterns

Residential Development

1. Design Roads to:
    - reduce impervious coverage
    - minimize concentrated flow of stormwater
    - infiltrate stormwater
    - avoid sensitive areas
    - provide safe street system for all modes of transportation

2. Design Lots to:
    - minimize disturbance of natural soils and vegetation
    - place lots to provide space for dispersing stormwater and preserving open space
    - maximize opportunity for on-lot infiltration or bio-retention swales

Commercial/Industrial

1. Site Design
    - Site buildings and parking away from soils with greatest infiltrative capacity
    - maintain native vegetation in these areas, if possible
    - Reduce impervious coverage of parking area by:
        - utilizing compact diagonal parking spaces
        - shared parking
        - placing parking under building
        - use of pervious parking designs
    - Integrate bio-retention into parking lot islands or planter strips
    - Utilize pre-treatment of run-off to reduce pollutant loads, trap sediment particles, reduce flow velocities and protect groundwater with:
        - grass filter strips
        - sand filters

A. Site Assessment for Development Potential

1. Topography:

It is imperative to have an accurate topographic map of a development site. This information is crucial for the additional site assessments to be done below.

- A topographic map of the site and at a minimum 100' beyond the limits of the subject property shall be provided. The topographic mapping shall show contours at two (2) foot intervals. The topographic mapping shall be obtained by either a field topographic survey by a licensed land surveyor or from an aerial topographic mapping firm. Elevations for topographic maps shall be based upon Connecticut CGS monumentation.
- All slopes greater 20% as measured over a minimum of fifty (50) feet shall be determined and shown on the base map as required by the Town of Tolland Zoning and Subdivision Regulations.

2. Soils Analysis:

In order to fully utilize LID systems, a comprehensive understanding of the site soils is necessary. LID emphasizes the evaporation, storage, and infiltration of storm water in small, lot-scale systems, which are distributed throughout the site. Therefore, it is necessary to have not only the wetland soils determined by a Certified Soil Scientist, but also the upland soils on a parcel of land. It is also necessary to obtain preliminary infiltration rate data for the upland soil types. This information can be obtained from the National Resource Conservation Service at the website listed here.
(Website: www.websoilsurvey.nrcs/usda.gov/app/).

For sites with mixed soils or those sites with some previously disturbed soils, proposed impervious coverage should be located on the mixed or disturbed soils with the more permeable soils being preserved for infiltration.

- Test pits shall be excavated in those areas deemed suitable for infiltration practices. A log of the soil layers shall be obtained, along with textural or grain size analysis of the soil layers. The location of test pits and their logs shall be determined by a Professional Engineer, licensed to practice in the State of Connecticut or a Certified Soil Scientist. Depths to mottling (soil staining), groundwater and bedrock shall be observed in the test pits. In extremely coarse grained soils, such as natural sand and gravels, it may be difficult to determine the depth of groundwater in the soil; therefore, 4" PVC monitoring pipes should be installed in order to measure maximum ground water levels during the wet season (February 1 to May 31). A few percolation tests shall be performed at varying depths to determine the infiltration rate of the "B" Horizon and the "C" Horizon.

- Once a preliminary site design has been prepared and determined to be feasible, additional soil testing may be necessary to verify the infiltrative capacities of the soils. This testing may entail deep test holes, percolation tests and/or permeability tests.

3. Hydrologic Patterns And Features:

Since LID revolves around the pre-development hydrologic cycle, it is very important to understand the existing hydrologic processes, patterns and physical features (streams, wetlands, native soils, vegetation) that can influence the site hydrology.

- The initial hydrologic assessment should map prominent hydrologic features such as seeps, springs, drainage swales and isolated depression storage areas. Existing drainage patterns shall be determined on the base map and verified in the field. Field observations shall be made regarding existing drainage patterns, the presence of erosion and deposition patterns. All of the hydrologic features should be shown on the base map.

4. Native Forest And Soil Conservation Areas:

One of the principal design concepts for LID is the conservation of forest land and the use of native soils for storm water management. By the protection of forest land and native soils, the following LID objectives can be met: (1) reducing total impervious area; (2) increasing storm water storage, infiltration and evaporation; and (3) providing potential areas for the dispersion of storm water.

- Generalized forest types should be determined in the field by a qualified environmental consultant. Dominant deciduous and evergreen tree species by class shall be determined and noted on the plans. Notations shall be made as to the density of the trees and canopy coverage. The average type of the forest cover shall be determined. There are three types of vegetative cover: old field/shrub; early succession and mature hardwood.

5. Wetland And Riparian Management Areas:

Wetlands and watercourses are generally environmentally sensitive areas. Wetlands, in particular provide a myriad of functions to improve the quality of water which flows through them prior to reaching an open water system. Wetlands are capable of trapping sediments and organic debris, filtration and/or uptake of soluble pollutants via the vegetative matrix.

- Wetland soils and watercourses (both intermittent and permanent) shall be determined in the field by a Certified Soil Scientist. Wetland and watercourse boundaries shall be delineated in the field by numbered flagging. Delineated wetland/watercourse flags shall be located by a licensed land surveyor and shown on the base map.

Refer to Town of Tolland Inland Wetlands and Watercourse Regulations; Effective date: February 20, 2007 for more detail about inland wetlands and watercourses.

- A relative assessment of the quality of each wetland system on the site shall be performed by a Certified Soil Scientist or Environmental Consultant using protocols established by the Army Corp of Engineers.
- Riparian zones are those areas adjacent to streams, lakes and wetlands that support native vegetation species, which are adapted to saturated or moderately saturated soil conditions.
    - Where mature vegetation exists on stable land forms, these riparian systems can perform the following functions:

        - Dissipate stream energy and erosion associated with high flow events;
        - Filter sediment, capture bedload, and aid in floodplain development;
        - Improve flood water retention and groundwater recharge;
        - Develop diverse pond and channel characteristics that provide habitat necessary for fish and other aquatic life to spawn, feed and find refuge from flood events;
        - Provide vegetation litter and nutrients to the aquatic food web;
        - Provide habitat for a high diversity of terrestrial and aquatic biota;
        - Provide shade and temperature regulation;
        - Provide adequate soil structure, vegetation, and surface roughness to slow and infiltrate storm water delivered as precipitation or low velocity sheet flow from adjacent areas.

It is important to protect these riparian corridors in order to maintain the functions noted above.

6. Floodplains:

While development is unlikely to occur with defined floodplains, it is important to acknowledge these areas for the environmental benefits that they provide and ensure that they are incorporated into the design process. Some of the important functions, which floodplains provide are (a) the connection between the stream channel, floodplain, and off channel habitats; (b) mature vegetative cover and soils; and (c) pre-development hydrology that supports the above functions, and flood storage.

- The location of the 100 year flood boundaries should be taken from Floodplain Mapping as prepared by the Federal Emergency

Management Agency for the Town of Tolland and added to the base map. The flood mapping is also available on line at http://www.fema.gov/hazard/flood/index.shtm. If necessary, the limits of 100 year flood boundaries shall be verified in the field by a licensed land surveyor.

B. Site Analysis Process:

1. **Residential Development**

For residential development projects, the process of site assessment and analysis shall be done in compliance with the Town of Tolland Subdivision Regulations and be supplemented by the following standards as necessary. Once all the base mapping has been collected and combined into a readable format, then the development process can begin. In general, the following sequence shall be utilized to assess a property to be developed using LID principles.

- 1. Determine those environmentally sensitive areas to be protected from development - Wetlands, watercourses, lakes, ponds, riparian corridors and flood plains
- Determine and delineate those 20% slopes as required by the Town of Tolland Zoning Regulations.
- Determine and delineate those soil areas which have moderate to high infiltration rates. These areas should be reserved for LID infiltration practices for post-development runoff.
- Delineate the different vegetative cover types on the site. Highlight those areas of special characteristics or environmental sensitivities. As an example, a large grove of mature White Pines in the middle of a hardwood forest would be an unusual feature that should be noted. Large and very mature hardwood trees with a DBH greater 42” shall be noted on the plan.
- Determine and define the Pre-development runoff patterns on the site in order to provide a preliminary understanding of the sites’ drainage patterns and the ultimate discharge points.

Once the above areas have been clearly delineated on the base, the remaining areas would become the available buildable area. This is not to say that development cannot extend beyond the defined buildable area, it is however a starting point to develop environmentally sensitive plan.

Figure 1 – Schematic View of Site Analysis as taken from the document entitled “Low Impact Development – Technical Guidance Manual for Puget Sound” January 2005 shows how the above process will work.

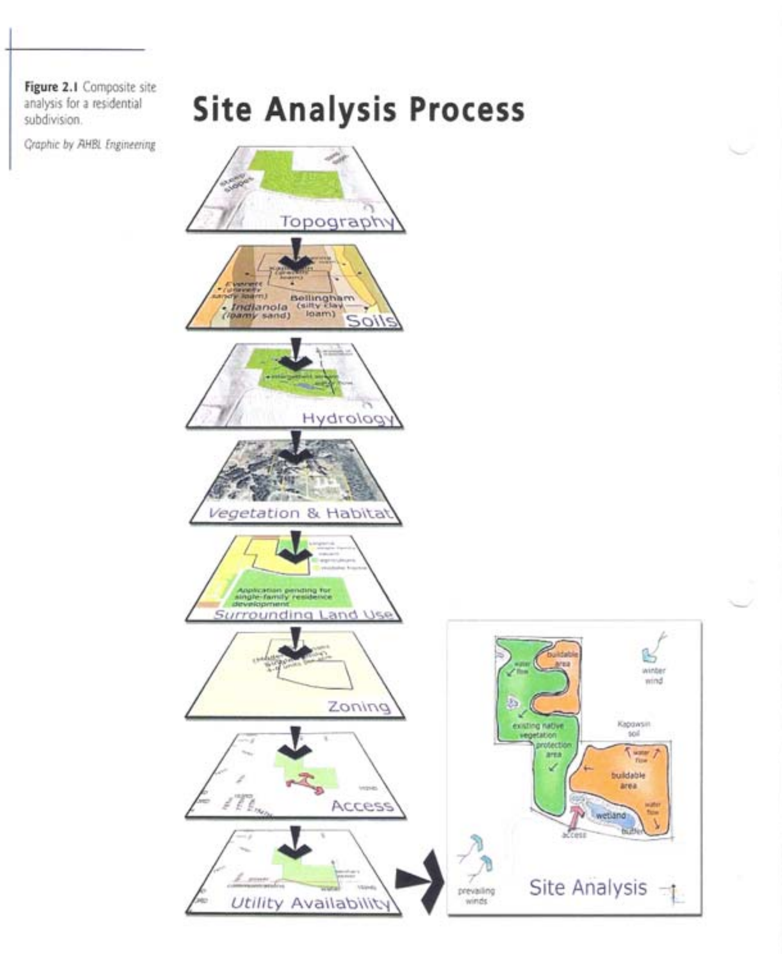


Figure 1 - Schematic View of Site Analysis

Now that the initial buildable area has been defined, it is time to develop Conceptual Site Plans for the land. For residential development, there are two main issues which drive the site design. The first is the applicable zoning, which defines minimum lot size, lot frontage and lot shape. The second is the design of the road access system.

2. Roads

In the utilization of LID, the design objectives for roads are:

- Reduce total impervious area by reducing the overall road network coverage
- Minimize or eliminate effective impervious area and concentrated flows on impervious surfaces by reducing or eliminating structural conveyance systems (curb/gutter, catch basin/pipe).

- Infiltrate and slowly convey storm flows in roadside bioretention cells and swales, and through possibly permeable pavement systems.
- Design the road network in such a manner as to minimize site disturbance, avoid sensitive areas, and reduce the fragmentation of the landscape.
- Create a street system and utilize Open Space to promote a system, which encourage walking, biking and access to other public improvements, such as transit station and services.
- Provide for safe and efficient access for emergency vehicles, especially fire.

Figure 2 below shows how simply a Curvilinear road alignment can improve a subdivision design versus a standard Grid road alignment.

Figure 2 – Typical Grid & Curvilinear Road Alignments

Note: This sketch is for demonstration purposes only and is not in compliance with Town of Tolland Land Use Regulations.

Figure 3 below shows a Hybrid road plan, which incorporates the best aspects of both a Grid and Curvilinear Road design into a new design. In conjunction with a Cluster or Open Space subdivision design, a hybrid road network can provide many of the environmental benefits which are part of a LID design.

You will notice that the Hybrid plan shown in Figure 3 shows that there are many opportunities to create storm water treatment systems close to the source of the road, utilizing LID techniques, such as rain gardens, bioretention, infiltration and vegetated swales.

Figure 3.2 Hybrid, or open space, road layout.

Graphic by AHBL Engineering

Figure 3 – Open Space or Hybrid Road alignment

Note: This sketch is for demonstration purposes only and is not in compliance with Town of Tolland Land Use Regulations.

The use of loop roads as shown in Figure 3 is a great way to implement basis LID principles. The use of loop roads will minimize the amount of impervious road coverage per residential unit, provide for an adequate turning radius for emergency vehicles, provide for two access points for traffic, and allow for the creation of a bioretention facility in the center of the loop, while providing a visual landscape break for the homes around the loop.

The green space between the homes will allow for storm water conveyance along vegetated swales, thus increasing the Time of Concentration and meeting one of the basis LID hydrologic goals, in addition to providing pedestrian access within the development.

Road widths and cul-de-sac designs shall conform to the requirements found in the Town of Tolland Design Manual.

Driveways are another source of impervious coverage within a residential development that can be significantly reduced by LID techniques. The use of common driveways to serve two adjacent lots can reduce the impervious area by 50% over two individual driveways. If common driveways are not feasible, then common entrances at the road could be utilized. The use of common entrances will help in the reduction of impervious area on the site. Runoff from driveways can also be directed into on-site bioretention systems or vegetated swales along the road, thus "disconnecting" the driveway impervious coverage from the road.

The current Town of Tolland Zoning Regulations shall be utilized to design all residential developments utilizing LID techniques. Section 170-37: Density, Lot size and other dimensional requirements shall be used for standard single family development. Section 170-38: Development Options shall be used for Cluster or Open Space subdivision designs. In order to achieve the LID goals, it is strongly recommended that single family subdivisions use Section 170-38 to create environmentally sensitive designs. The potential increases in Open Space allowable under Section 170-38 can achieve many of the LID storm water management goals through the simple preservation of undisturbed forest land.

Figure 4 shows how LID design concepts can easily be incorporated into residential site design. The top design consists of a standard type of residential development that will require the clearing and disturbance of the majority of the site area. Minimal areas are set aside for protection.

In contrast, the LID design shown on the bottom shows significant areas to be preserved and how LID storm water concepts are created within the actual development, instead of being regulated to the end of the storm water pipe.

Figure 5 shows an enlargement of a typical lot in a residential development and how LID storm water concepts can be placed on an individual lot. The implementation of LID storm water concepts require that the design engineer or landscape architect look at land in a totally different way than currently happens.

3. Residential Building Lots

Irregardless the density and size of building lots for proposed residential use, the following objectives shall be implemented for LID projects:

- Minimize lot disturbance
- Place lots to provide for space for dispersing storm water and preserving open space.
- Orient lots and building to maximize the opportunity to create on-lot infiltration systems, bioretention swales to convey runoff to bioretention cells or other LID systems.
- Locate lots adjacent to preserved open space to improve the privacy and aesthetics of each lot.

Figure 4 – Conventional & LID Residential Design Concepts

Note: This sketch is for demonstration purposes only and is not in compliance with Town of Tolland Land Use Regulations.

Figure 2.2 Large lot composite site analysis.
Graphic by AHBL Engineering

Figure 5 – Sketch showing incorporation of LID storm water measures on a single family lot

4. **Commercial Lots and Parking** Commercial land uses pose a whole different challenge during the design phase. Commercial projects inherently have large, continuous impervious areas due to building roofs and parking. There are several major storm water issues associated with commercial parking areas. The first is the volume of runoff from the site increases significantly for post-development conditions versus pre-development due to the amount of impervious coverage. The peak runoff rate becomes significantly higher due to shorter times of concentration on the site. Lastly, there are very high pollutant loads due to the automobile traffic on the parking area, in particular the stopping and starting of a vehicle. As a result of the automobile traffic, the concentrations of petroleum hydrocarbons, and trace metals (zinc, copper, cadmium and lead) are much higher from a commercial parking lot when compared to other land uses.
There are several non-technical and LID techniques which can used to improve the storm water conditions for commercial parking and buildings.

- **Design Engineers and Landscape Architects shall apply the following suggestions in the design of commercial parking facilities in the Town of Tolland.**

    - Provide 20 to 30 percent of the overall parking spaces as compact spaces versus standard spaces. This change can reduce impervious coverage, especially in large parking areas, such as for shopping centers and retail strip malls.
    - If the land area permits, utilize diagonal parking spaces as stated in Section 170-105 with a one-way aisle. This change can reduce impervious area by 5 to 10% as the aisle width will be reduced from 24’ to a maximum of 18’ (60 degree spaces).
    - Encourage shared parking agreements with adjacent or nearby properties (walking distance) that serve land uses with non-competing hours of operation. An example of this is use of a parking area for an office building after 5 pm for an adjacent retail use which stays open to 9 or 10 pm.
    - Where feasible and not cost prohibitive, place parking under a building. This will help reduce the total impervious area on a site.
    - Use permeable pavement, grass pavers or other non-impervious systems for overflow parking that is only needed for certain times of the year. An example of this is found at the West Farm Shopping Mall in Farmington.
    - Integrate bioretention into parking lot islands or planter strips distributed throughout the parking area to infiltrate, store and slowly convey storm water flows to other facilities, if needed.

4. **Industrial Lots.**. Industrial land uses, such as warehousing, manufacturing facilities, bulk storage facilities pose many storm water issues due to the large extents of impervious required for truck maneuvering, loading, storage and the building themselves. In addition to the large impervious areas, the pollutant loads are very high, especially petroleum hydrocarbons and metals. Industrial sites are generally considered “hot spots” due to the higher than average pollutant loads which can result from these sites. While LID storm water techniques can be used on industrial site, care must be taken to ensure that groundwater under the site is no adversely affect by the concentrated pollutant loads on these sites.

The LID site analysis process and general design principles shall be applied to the design of industrial sites. In the design of storm water treatment systems for industrial sites, pre-treatment of runoff from the impervious areas shall be applied. Pre-treatment systems can include grass filter strips and sand filters. Grass filter strips are very effective at trapping sediment particles and reducing flow velocities. Underground sand filter are very effective in the trapping of petroleum hydrocarbons.

Once runoff has been pre-treated, it shall be conveyed to bioretention systems or broad vegetated swales.

Chapter 5 – Overview of Hydrologic Cycle and the design of LID systems in the Town of Tolland:

A. There are five key elements of the hydrologic cycle. Each one will be briefly described below.

1. Precipitation and Design Storm Events: Precipitation data, both for rain and snow are used for storm water design. Storm events occur on a random basis; however their frequency of occurrence can be predicted by statistical methods. Smaller, more frequent storms are most commonly used in the design of storm water systems for most residential, commercial and industrial uses. Storage volume for peak runoff control is very dependant upon the rainfall distribution during an event.
2. Rainfall Abstraction: this is the physical process of interception of rainfall by vegetation, evaporation from land surfaces & upper soil layers, evapotranspiration from plants, infiltration of rainfall into the soil surface and surface storage within natural depressions. Rainfall abstraction can be estimated as a depth of water on a site. When the rainfall abstraction is removed from the total rainfall, the remaining amount is runoff.
3. Runoff: this is the amount of water which is left over after the rainfall abstraction is removed. Under natural conditions, 10% to 30% of the annual rainfall will become runoff. As impervious cover increases, rainfall abstractions decrease, while runoff increases. Significant changes in runoff cause increased erosion, flooding, reduced groundwater recharges and are responsible for the reductions in water quality.
4. Time of Concentration: this is the time it takes for a drop of water from the hydraulically most distance point to reach the watershed outlet. As impervious area increases and drainage paths are altered, the time of concentration is shortened. A primary LID goal is maintaining the pre-development time of concentration.
5. Groundwater recharge: A significant portion of the rainfall abstraction will infiltrate into the soil and therefore contribute to groundwater recharge. As the shallow groundwater table is connected to streams, it can provide baseflow during low rainfall times. By maintaining the base flow to the stream, the biological habitat of streams is maintained in an optimum condition.

B. Town of Tolland Design Standards for LID storm water systems:

1. For the determination of required total storage volume for Bioretention, Filtration, Infiltration, Level Spreaders, and permeable pavement, the 1” rainfall event shall be utilized. The required storage volume shall be the Water Quality Volume (WQV) as defined in the 2004 Storm Water Quality Manual (The Manual) by the CT DEP in section 7.4.1. In addition to this calculation, the Groundwater Recharge Volume (GRV) shall be calculated in accordance with the requirements in Section 7.5.1 of The Manual,

however the Groundwater Recharge Depth value for this calculation shall be taken from the table on page 39 of this manual. The GRV is part of the total WQV for a site and may be subtracted from the WQV as long as the infiltration used will infiltrate the entire GRV.

2. If a vegetated swale is to be used for treatment of the water quality volume, then the swale must be sized in accordance with the Water Quality Flow (WQF) as defined in Section 7.4.2 of The Manual. These systems are designed to treat the WQV without infiltration being a component of the treatment. Structural by-pass systems are required for this type of treatment system, so that flows in excess of the WQF can be routed around the treatment system. The WQF shall be calculated according to the procedures outlined in Appendix B of The Manual.

3. For stream channel protection, the peak rate of post-development runoff must be reduced to 50% of the pre-development peak rate for a two-year storm event. For the Town of Tolland, the two-year storm equates to 3.2" in a 24-hour period.

4. For non-structural or structural conveyance system, the ten-year storm event shall be used for sizing purposes. For the Town of Tolland, the ten year storm equates to 4.8" in a 24-hour period.

5. If storm water detention is still necessary after the implementation of LID strategies and techniques. The detention systems shall be sized for the ten-year (4.8") and twenty five-year (5.5") storm events. Emergency spillways and overflow channels shall be capable of handling the one hundred-year (6.9") storm event.

The document entitled " Low-Impact Development Design Strategies – An Integrated Design Approach" as prepared by Prince George's County, Maryland Department of Environmental Resources, Programs and Planning Division, June 1999" is hereby appended to this design manual. This document provides design information on the various types of LID storm water systems, in addition to procedures for performing the necessary hydrologic analyses necessary for the implementation of LID.

The 2004 Storm Water Quality Manual as prepared by the Connecticut Department of Environmental Protection shall be used for the design of storm water treatment systems, such as storm water wetlands, wet ponds and extended wet ponds to name a few.

C. Storm Water Credits:

As Low Impact Development is based upon sensitive site design, storm water credits can be obtained that will reduce the required Water Quality Volume (WQV) and Groundwater Recharge Volume (GRV) as these volumes are directly tied to the extent of impervious coverage on a site. There are six categories when storm water credits can be obtained.

Credit 1 - Natural Area Conservation
Credit 2 - Disconnection of Rooftop Runoff
Credit 3 - Disconnection of Non-rooftop Runoff
Credit 4 - Sheet Flow to Buffers
Credit 5 - Open Channel Use
Credit 6 - Environmentally Sensitive Development

Summary of Storm Water Credits

Storm Water Credit	**Water Quality Volume**	**Groundwater Recharge Volume**	**Channel Protection**
Natural Area Conservation	Reduce site area	No credit. Use as receiving area	Forest/meadow CN for natural areas
Disconnection of Rooftop Runoff	Reduced 'R' value in WQV equation	No credit.	Longer Tc, CN credit
Disconnection of Non-Rooftop Runoff	Reduced 'R' value in WQV equation	No credit.	Longer Tc, CN credit
Sheet Flow to Buffers	Subtract contributing site area to BMP	Reduced GRV	CN credit
Open Channel Flow	May meet WQV	Meets GRV	Longer Tc, No CN credit
Environmentally Sensitive Development	Meets WQV	Meets GRV	No CN credit Tc may increase

Each type of storm water credit is described below:

1. Natural Area Conservation Credit:

A storm water credit is given when natural areas are conserved at development sites, thereby retaining pre-development hydrologic and water quality characteristics. A simple WQV credit is granted for all conservation areas permanently protected under fee simple setasides or conservation easements.

Under the credit, the design engineer can subtract the conservation areas from the total site area when computing the water quality volume. The volumetric runoff coefficient, R is still based upon the percent impervious cover for the entire site. As an additional incentive, the post-development curve number for all natural areas permanently protected can be assumed to be wood in good condition when calculating the total site CN.

Criteria for Natural Area Credit:

a. The area shall not be disturbed during the construction process.
b. It shall be protected from having the limits of disturbance clearly shown on all construction or mitigation plans and shall be delineated in the field.
c. It shall be located within an acceptable conservation easement or other enforceable instrument that provides perpetual protection of the area.
d. It shall be located on the development project site.

2. Disconnection of Rooftop Runoff Credit:

A credit is given when rooftop runoff is disconnected and then directed to a pervious area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland flow and filtering or the installation of bioretention areas on single family lots. If the rooftop is adequately disconnected, the roof area can be deducted from the total impervious cover in the WQV calculation.

Criteria for Disconnection of Rooftop Runoff Credit:

a. Rooftop cannot be within a designated hotspot.
b. Disconnection shall cause no basement seepage.
c. The contributing area of the roof top to each disconnected discharge point (gutter pipe) shall not exceed 500 square feet.
d. The length of the "disconnection" shall be 75' or greater.
e. Dry wells, rain gardens or similar devices may be utilized to compensate if the disconnection length is less than 75'.
f. In residential developments, disconnections will only be credited, when the lot area is greater than 40,000 square feet.
g. The entire vegetative disconnection shall be on an average slope of 5% or less.
h. The disconnection must drain continuously through a vegetated channel, swale or a filter strip to a property line or BMP.
i. Downspouts must be at least 10' away from the nearest impervious surface to discourage "re-connections".
j. For those rooftop draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be taken, not both.

Rooftop Disconnection Compensation Storage Volume Requirement per discharge point draining 500 square feet of rooftop

Disconnection Length Provided	**0-14 ft.**	**15-29 ft.**	**30-44 ft.**	**45-59 ft.**	**60-74 ft**	**>75 ft.**
%WQV Treated by Disconnect	0%	20%	40%	60%	80%	100%
% WQV Treated by Storage	100%	80%	60%	40%	20%	0%
Max. Storage Volume	36 cu.ft.	28.8 cu.ft.	21.6 cu.ft.	14.4 cu.ft.	7.2 cu.ft.	0 cu.ft.

3. Disconnection of Non Rooftop Runoff Credit:

Credit is given for practices that disconnect surface impervious cover by directing it to pervious areas where infiltration into the soil can occur or surface filtering by overland flow. This credit can be obtained by grading to encourage infiltration and filtering or the installation of bioretention systems on single family lots. The "disconnected" areas can be subtracted from the impervious are when computing the WQV.

Criteria for Disconnection of Non Rooftop Runoff Credit:

a. Runoff cannot come from a designated hotspot.
b. The maximum contributing impervious flow path shall be 75'.
c. The disconnection shall drain continuously through a vegetated channel, swale or filter strip to property line or BMP.
d. The length of the "disconnection" must be equal to or greater than the contributing length.
e. The entire vegetative "disconnection" shall be on an average slope of 5% or less.
f. The surface impervious area to any one discharge location cannot exceed 1,000 square feet.
g. The hydrologic disconnections is encouraged on relatively permeable soils (Hydrologic Soil Group A and B)
h. If the site cannot meet the required disconnect length, a spreading device, such as a French drain, rain garden, gravel trench or other storage device may be needed for compensation.
i. For those rooftop draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be taken, not both.

4. Sheet Flow to Buffer Credit:

This credit is given when storm water is effectively treated by a natural buffer to a stream or forested area. Effective treatment is achieved when pervious and impervious area runoff is discharged to a grass or forested buffer via overland flow. The use of a filter strip is also recommended to treat overland flow in the green space of a development site. This credit includes subtracting the area draining by sheet flow to a buffer from the total area in the WQV calculation and the area draining to the buffer contributes to the GRV requirement.

Criteria for Sheet flow to Buffer Credit:

a. The minimum buffer width shall be 50 feet as measured from bankfull elevation or the centerline of the buffer.
b. The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces.
c. Runoff shall enter the buffer as sheet flow. Either the average contributing overland slope shall be 5% or less, or a level spreader device shall be used where sheet flow can no longer be maintained.
d. This credit is not available if rooftop or non rooftop disconnection has already been provided.
e. Buffers shall remain unmanaged other than routine debris removal.
f. Buffers shall be protected by an acceptable conservation easement or other enforceable instrument that provides perpetual protection of the area.

5. Grass Channel Credit:

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (<1”). Use of a grass channel will automatically meet the GRV for impervious areas draining into the channel. However, the GRV for impervious areas not draining to grass channels must still be addressed. If the swale is designed to the following criteria, the grass channel will meet the WQV as well.

Criteria for Grass Channel Credit:

a. The maximum flow velocity for runoff from the one-inch rainfall shall be less than or equal to 1.0 fps.
b. The maximum flow velocity for runoff from the ten-year design event shall be non erosive.
c. The bottom width shall be 3’ minimum and 8’ maximum.
d. The side slopes shall be 3:1 or flatter.
e. The channel slope shall be less than or equal to 4.0%.
f. The credit is not applicable if the rooftop disconnection has already been provided.

6. Environmentally Sensitive Development Credit:

Credit is given when a group of environmental site design techniques are applied to low density residential developments. The credit eliminates the need for structural practices to treat both the GRV and the WQV, and is intended for use on large lots (>1 acre).

Criteria for Environmentally Sensitive Development Credit.

For Single Lot Development

a. Total site impervious cover is less than 15%.
b. Lot size shall be at least 2 acres.

c. Rooftop runoff is disconnected in accordance with the criteria listed above and grass channels are used to convey runoff versus curb and gutter.

For Multiple Lot Development

a. Total site impervious cover is less than 15%.
b. Lot size shall be as least two acres if clustering techniques are not used.
c. If clustering techniques are used, the average lot shall not be less than 40,000 square feet, which is the minimum lot size as identified in the Town of Tolland Zoning Regulations.
d. Rooftop runoff is disconnected in accordance with the criteria listed above
e. Grass channels are used to convey runoff versus curb and gutter.
f. A minimum of 25% of the site is protected in natural conservation areas.
g. The design shall address WQV, GRV and Channel Protection flows for all roadway and connected impervious surfaces.

Chapter 6 – Pollution loads and renovation analysis

One of the most significant issues of storm water from development project is the amount of typical pollutants from projects which have many adverse impacts on receiving waterways and the environment in general.

As discussed in Chapter 2, there are eleven categories of common pollutants associated with land development. For residential developments, the pollutants of most concern are Total Suspend Solids (TSS), Total Nitrogen (TN), Total Phosphorous (TP), Zinc (Zn), Copper (Cu) and to a slightly lesser degree Cadmium (Cd), and petroleum hydrocarbons. Total suspended solids can be discharged during the site disturbance phase of a development if the erosion control measures are not adequate. Impervious surfaces, such as roads, driveways and parking spaces are sources of TSS after development is complete. Total Nitrogen and Total Phosphorous are found due to atmospheric deposition on impervious surfaces as well as the application of fertilizers to lawns. Automobile movements, stopping and starting of the engine are the sources of zinc, copper and cadmium on the impervious surfaces. The source for petroleum hydrocarbons is oil drops from automobiles and trucks.

In order to accurately access the changes in pollutant loading for development, a pollutant loading analysis must be prepared. This analysis must be prepared by a Licensed Professional Engineer in the State of Connecticut. The Schueler Method is used to calculate the annual pollutant load for the average annual rainfall in a community for the range of pollutants being evaluated for a particular land use.

Schueler Equation or Simple Equation:

$L = [(P*Pj)*Rv/12]*C*A*2.72$ Where;

- L = Storm Pollutant Export (lbs on an annual basis)
- P = Rainfall Depth (inches) (48" avg. per year)
- Pj = Percent of rainfall becoming runoff, Use Pj = 0.9
- Rv = Volumetric Runoff Coefficient Rv = 0.05 + 0.009 (I)
- I = Percent of Site Impervious Coverage
- C = Flow weighted mean concentration of pollutants in urban runoff (mg/l)
- A = Area of Development (acres)
- 12 = Conversion Factor
- 2.72 = Conversion Factor

The purpose of preparing a pollution loading analysis is to document the changes in loading from the pre-development conditions after development. All types of treatment systems have the ability to remove some measure of the post-development pollutant load. A storm water treatment system for pollutant renovation needs to consist of several treatment systems in series. This type of system is called a treatment train.

Another reason to use multiple systems in line is to provide for redundancy in the system to enhance the pollutant removal.

A lot of research on the pollutant removal abilities of many times of treatment systems has been done. A lot of this research has been performed by Roger Bannerman at the Wisconsin Department of Natural Resources, Robert Pitt, P.E. at the University of Alabama, the Center for Water Protection in Maryland and most recently by the University of New Hampshire Stormwater Center under the direction of Robert Roseen, PhD to determine the pollutant removal rates for various structural and non-structural treatment systems for the most commonly found storm water pollutants. The determination of the treatment removal rate is the most critical choice the professional engineer will make in this analysis. Pollutant removal rates for various treatment systems will be discussed in more detail below.

The following tables provide mean concentrations of Total Suspended Solids, Total Nitrogen and Total Phosphorous for various land uses as found in the report entitled "The National Stormwater Quality Database, Version 1.1; A compilation and Analysis of NPDES Stormwater Monitoring Information; September 4, 2005" by Alex Maestre and Robert Pitt, Department of Civil and Environmental Engineering, The University of Alabama and the Center for Watershed Protection.

Table 1:

All pollutant concentrations are provided as mg/l.

Land Use Description	**TSS**	**TN**	**TP**
Large lot subdivision (1 unit/5-10 ac.)	60	2.1	0.38
Low density residential (1unit/5ac or 2units/ac)	60	2.1	0.38
Medium density residential (2-8 units/ac)	60	2.1	0.30
High density residential (8+ units/ac)	60	2.1	0.30
Commercial	58	2.6	0.25
Industrial	80	2.1	0.23
Institutional (schools, churches,	--	--	---
Military institutions, etc)	58	2.0	0.27
Open urban land	50	1.3	0.25
Transportation	99	2.3	0.25
Extractive	350	1.5	0.5
Deciduous forest	90	1.5	0.10
Evergreen forest	90	1.5	0.10
Mixed forest	90	1.5	0.10
Brush	90	1.5	0.38
Wetlands	0	1.5	0.38
Beaches	0	1.5	0.10
Bare ground	1000	1.5	0.38
Row & garden crops	357	2.92	1.00
Cropland	357	2.92	1.00
Orchards,.vinyards/horticulture	357	2.92	1.00
Pasture	145	2.2	0.38
Feeding Operations	145	2.2	0.38
Agricultural building, breeding &	---	---	---
Training facilities	145	2.2	0.38

The following tables break down the most common land uses and their associated pollutants loads based upon research in Anne Arundel County, Maryland utilizing 50 years of rainfall records. It is important note the percentage of directly connected impervious area versus the percentage of disconnected impervious area for each particular land use. The third column in the table is the total average impervious coverage in percent for that particular land use. The designing engineer must calculate the relative percentages of directly connected versus disconnected impervious area for a particular land use for a development project.

Table 60. Urban Land Use Categories Used in Anne Arundel County, Maryland

Description	Note	Average percentage of Impervious areas	TSS (mg/L)	Total P (mg/L)	Total N (mg/L)	Comments
High density residential	Rv = 0.34, 47% pervious, 39.9% dir con imp, and 13.1% dis con impervious	53	60	0.3	2.1	Rv and CN calculated using 50 yrs of BWI rains and concentration factors from MD and VA MS4 data
Medium density residential	Rv = 0.23, 62.3% pervious, 24.2% directly con imp, and 13.5% disconnected impervious	37.8	60	0.3	2.1	Rv and CN using 50 yr BWI rain and concentration factors from MD and VA MS4 data
Low density residential	Rv = 0.14, 79.6% pervious, 14.9% dir con impervious, and 5.5% disconnected imp.	20.4	60	0.38	2.1	1 unit/5 ac to 2 units/ac. Calc Rv and CN using 50 years BWI rains and concentration factors from MD and VA MS4
Ultra low den residential	Rv=0.09, 90.4% pervious, 5.6%directly con imp and 4% discon impervious	9.6	60	0.38	2.1	1 unit/5 to 10 ac, calc 50 yr, concentration factors from MD and VA MS4 data
Freeways and other main roads with paved drainage	Rv = 0.41, 49.5% pervious, 50.5% dir con impervious.	50.5	99	0.25	2.3	Calc using 50 yrs of BWI rains and concentration factors from national MS4 data
Commercial (shopping centers)	Rv=0.72, 8.3% pervious, and 91.7% dir con imp.	91.7	58	0.25	2.6	50 yr of BWI rains and concentration factors from MD and VA MS4 data
Institutional (schools, churches, military, etc.)	Rv=0.49, 36.4% pervious, 61.3%dir con imp, and 2.3%discon imp.	63.6	57.9	0.35	1.57	Calculated from 50 yr BWI rains and concentration factors from national average institutional MS4 data.
Industrial (medium)	Rv=0.52, 16.7% pervious, 62.8% dir con imp, and 20.5% discon con imp.	83.3	80	0.23	2.1	CN calc using 50 yr BWI rain and concentration factors from MD and VA MS4 data.
Open urban area	Rv=0.08, 95.1% pervious and 4.9% dir con impervious.	4.9	70	0.12	1.5	CN calc from 50 yr BWI rains and concentration factors from national average urban open area MS4 data

Description	Note	TSS (mg/L)	Total Phosphorus (mg/L)	Total Nitrogen (mg/L)
Fallow	Straight Row. Concentration factors from prior regional data	107	1.3	4.4
Row Crops	Straight Row, small grain. Concentration factors from prior regional data	357	1	2.92
Row and garden Crops	Straight Row. Concentrations factors from prior regional data	357	1	2.92
Orchards, vineyards, horticultural	Concentration factors from prior regional data	357	1	2.92
Pasture or Range	Concentration factors from prior regional data	145	0.38	2.2
Feeding operations	Continuous forage, poor. Concentration factors from prior regional data	145	0.38	2.2
Woods or Forest Land	Deciduous forest (woods, good). Concentration factors from prior regional data	90	0.1	1.5
Woods or Forest Land	Evergreen forest (woods, good condition). Concentration factors from prior regional data.	90	0.1	1.5
Woods or Forest Land	Mixed forest (woods, good). Concentration factors from prior regional data.	90	0.1	1.5
Farmsteads	Agricultural buildings, breeding and training facilities	163	0.38	2.2
Brush	Herbaceous, fair.	90	0.38	1.5
Extractive		1000	0.38	1.5
Wetlands		0	0.38	1.5
Beaches		0	0.1	1.5
Bare ground		1000	0.38	1.5

For the concentrations of typical metals and petroleum hydrocarbons in storm water, the following concentrations shall be used as shown in Table #2 below:

Table #2

Water Quality Characteristics of Urban Runoff. All concentration as mg/l.

Land Use Category	**Zinc**	**Copper**	**Cadmium**	**Petroleum Hydrocarbons**
Forest/Rural	0	0	0	0
Agriculture/Pasture	0	0	0	0
Low-Density Residential	0.161	0.026	0.004	3.5*
Medium-Density Residential	0.176	0.047	0.004	3.5*
High-Density Residential	0.218	0.033	0.003	3.5*
Commercial	0.156	0.037	0.003	3.5*
Industrial	0.671	0.058	0.005	3.5*
Highways	0.156	0.037	0.003	3.5*

Note: Pollutant concentrations for Zinc, Copper and Cadmium were taken from NRUP (1983), Horner et al (1994) and Cave et al (1994) as analyzed and presented by Terrene Institute 1996.
* Note: Concentrations for petroleum hydrocarbons were taken from the New York State Stormwater Management Design Manual of August 2003 and represent a mean concentration value.

A. Calculation steps to perform a pollution loading analysis:

Pre-Development Conditions:

1. Determine percentage of different land use coverage on site. I.E. Forest, meadow, bare soils, impervious, etc. by acre.
2. Calculate total site area in acres to each sub-watershed design point.
3. Determine pollutant concentration per land use from above tables.
4. Determine average annual rainfall amount for each sub-watershed area.
5. Calculate Volumetric Runoff Coefficient
6. Calculate pollutant loads on an annual basis for pre-development conditions for each sub-watershed design point.

Post-Development Conditions:

1. Determine percentage of different land use coverage for each post-development sub-watershed areas to each discharge point. If project consists of single type of land use, i.e., low density residential, use total area of proposed lots for this type of land use. Calculate area and percentage of impervious cover of roadways, and parking areas separately.
2. Compile areas and percentage of impervious coverage for each sub-watershed area.
3. Determine pollutant concentration per land use from above tables.
4. Calculate Volumetric Runoff Coefficient.
5. Calculate pollutant loads on an annual basis for post-development conditions for each sub-watershed area to each treatment system (design point).
6. Calculate pollutant loads for undisturbed areas downgradient of each treatment system.

B. Renovation Analysis:

As noted above, the choice of a storm water treatment system is very important from a water quality point of view. Most conventional storm water treatment systems consist of standard catch basin with no or 24" deep sumps, followed by a dry detention pond. For Low Impact Development systems, the professional engineer must choose specific systems to address the water quality issues on a particular site.

A LID treatment choice greatly depends upon how much runoff is treated at its source, by disconnection, diversion to rain gardens, or bioretention facilities prior to be conveyed to larger treatment facilities.

The types of Storm water treatment practices are divided into two categories, Primary Treatment Practices and Secondary Treatment Practices. Secondary Treatment Practices are those systems whose primary function is not water quality control. The following information, reproduced from the 2004 Connecticut Storm Water Quality Manual outlines the various practices.

Summary of Storm Water Treatment Practices

Primary Treatment Practice Practice	**Secondary Treatment**
Stormwater Ponds	Conventional Practices
Micropool Extended Detention Pond	Dry Detention Pond
Wet Pond	Underground Detention Facilities
Wet Extended Detention Pond	Deep Sump Catch Basins
Multiple Pond System	Oil/Particle Separators
Pocket Pond	Dry Wells
Stormwater Wetlands	Permeable Pavement
Shallow Wetlands	Vegetated Filter Strips/Level
Spreaders	
Extended Detention Wetlands	Grass Drainage Channels
Pond/Wetland System	
Infiltration Practices	
Infiltration Trench	**Innovative/Emerging Technologies**
Infiltration Basin	Catch Basin Inserts
Filtering Practices	Hydrodynamic Separators
Surface Sand Filter	Media Filters
Underground Sand Filter	Underground Infiltration Systems
Perimeter Sand Filter	Alum Injection
Organic Filter	
Bioretention	
Water Quality Swale	
Dry Swale	
Wet Swale	

"The National Pollutant Removal Performance Database, Version 3, September 2007" by The Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043 (www.cwp.org and www.stormwatercenter.net) and current research from the University of New Hampshire Stormwater Center (www.unh.edu/erg/cstev) shall be used to determine the appropriate pollutant removal rates for various structural and non-structural treatment systems.

Median pollutant removal rates for typical storm water treatment systems as taken from the "National Pollutant Removal Performance Database, Version 3;

September 2007. A copy of this summary document is appended to the end of this design manual.

Median Pollutant Removal Efficiencies (percent)

	List of Pollutants				
Type of Treatment System	**TSS**	**TP**	**TN**	**Cu**	**Zn**
Dry Pond	49	20	24	29	29
Wet Pond	80	52	31	57	64
Wetlands	72	48	24	47	42
Filtering Practices	86	59	32	37	87
Bioretention	59	5	46	81	79
Infiltration	89	65	42	86	66
Open Channel	81	24	56	65	71

Once the pollution loads have been calculated, the next step is to apply the appropriate removal rate for the treatment device in a treatment train. This procedure will be used for each pollutant under analysis. The following example shows how the removal analysis shall be performed for TSS removal.

Design Example:
Post-development pollutant loads
TSS = 1250 lbs
Treatment Devices:
Catch Basins with 24" sumps – 20% TSS removal rate
Stormwater wetlands – 76% TSS removal rate
Water Quality Swale – 81% TSS removal rate
Removal by catch basin = 1250 * 0.20 = 250 lbs
Removal by storm water wetlands = (1250 – 250) * 0.76 = 760 lbs
Removal by water quality swale = (1250 – 250 – 760) * 0.81 = 194.4 lbs
Total TSS removed = 250 + 760 + 194.4 = 1204.4 lbs
Total Percent TSS removed = (1204.4/1250) * 100 = 96.35%, thus complying with DEP goal of 80% TSS removal from post-development runoff.

To calculate the total post-development loads, the remaining pollutant load discharged from a treatment system will be added to the naturally occurring pollutant downgradient of the treatment system to determine the total annual pollutant load at a point on the property perimeter.

<u>Low Impact Development Performance Standards for the Town of Tolland:</u>

Ground Water Recharge Volume

NRCS Hydrologic Soil Group	Avg. Annual Recharge	Groundwater Recharge Depth (D)
A	18”/year	0.60”
B	12”/year	0.35”
C	6”/year	0.25”
D	3”/year	0.10”

General Description of Soil Types:
A – Gravels, sand, loamy sand or sandy loam
B – Silty loam
C – Sandy clay loam
D – Clay, silty clay loam, sandy clay, silty clay

Pollutant Removal Efficiencies

Pollutant Type	Removal Rate to be Achieved
Total Suspended Solids	80%
Total Nitrogen	35%
Total Phosphorous	50%
Zinc	65%
Copper	65%
Cadmium	65%
Petroleum Hydrocarbons	80%

Chapter 7 – Maintenance and Enforcement

In order to maximize the benefits of LID, it is extremely important to ensure that the treatment systems on individual lots are maintained in an appropriate condition. The method to do this is by the use of a Maintenance Covenant or Agreement. The maintenance agreement must spell out the type and frequency of necessary maintenance of LID storm water systems. In addition, there must be clear enforcement provisions to ensure that the storm water systems are maintained and not eliminated on an individual lot. A sample agreement is found in the document entitled " Low-Impact Development Design Strategies – An Integrated Design Approach" as prepared by Prince George's County, Maryland Department of Environmental Resources, Programs and Planning Division, June 1999" which is hereby appended to this design manual.

Glossary

Bankfull discharge: Stream discharge that fills the channel to the top of the banks and just begins to spread onto the floodplain. Bankfull discharges occur on average every 1 to 1.5 years in undisturbed watersheds and are primarily responsible for controlling the shape and form of natural channels.

Bioretention: On-lot retention of storm water through the use of vegetated depressions engineered to collect, store, and infiltrate runoff.

BMP: Best Management Practice; is a practice or combination of practices that are the most effective and practical means of controlling point or non-point source pollutants at levels compatible with environmental quality goals.

Buffer: A vegetated zone adjacent to a stream, wetland, or shoreline where development is restricted or controlled to minimize the effects of development.

Cluster Development: Buildings concentrated in specific areas to minimize infrastructure and development costs while achieving the allowable density. This approach allows the preservation of natural open space for recreation, common open space, and preservation of environmentally sensitive features.

Curbs: Concrete or bituminous concrete barriers on the edge of streets used to direct storm water runoff to an inlet or storm drain and to protect lawns and sidewalks from vehicles.

Denitrification: Reduction of nitrate (commonly by bacteria) to di-nitrogen gas.
Design storm: A rainfall event of specific size, intensity, and return frequency that is used to calculate runoff volume and peak discharge rate.

Detention: The temporary storage of storm water to control discharge rates, allow for infiltration, and improve water quality.

Dry Well: Small excavated trenches filled with stone to control and infiltrate rooftop runoff.

Effective Impervious Area (EIA): Subset of total impervious area that is hydrologically connected via sheet flow or discrete conveyance to a drainage system or receiving body of water. For impervious areas in residential development to be considered ineffective, the runoff must be dispersed through at least 100’ of native vegetation using approved dispersion techniques.

Erosion: The process of soil detachment and movement by forces of wind and water.

Evapotranspiration: Collective term for the processes of water returning to the atmosphere via interception and evaporation from plant surfaces and transpiration through plant leaves.

Exfiltration: Movement of soil soil from an infiltration integrated management practice to surrounding soil.

Filter Strips: Bands of closely-growing vegetation, usually grass, planted between pollution sources and downstream receiving waterbodies.

Hot Spot: A storm water hot spot is an area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water.

Hydrologically functional landscape: Term used to describe a design approach for the built environment that attempts to more closely mimic the overland and subsurface flow, infiltration, storage, evapotranspiration, and time of concentration characteristic of the native landscape of the area.

Impervious Area: A hard surface that prevents or retards the entry of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow.

Infiltration: The downward movement of water from the land surface into the soil.
Level Spreader: An outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope to prevent erosion.

Low Impact Development: The integration of site ecological and environmental goal and requirements into all phases of urban planning and design from the individual lot level to the entire watershed.

Nitrification: Process in which ammonium is converted to nitrite and then nitrate by specialized bacteria.

Non-Point Source Pollution: Water pollution caused by rainfall or snowmelt moving both over and through the ground and carrying with it a variety of pollutants associated with human land uses. A non-point source is any source of water pollution that does not meet the legal definition of point source in Section 502(14) of the Federal Clean Water Act.

NPDES: National Pollutant Discharge Elimination System: a regulatory program in the Federal Clean Water Act that prohibits the discharge of pollutants into surface waters of the United States without a permit.

Open Space: Land set aside for public or private use within a development that is not built upon.

Permeable: Soil or other material that allows the infiltration or passage of water or other liquids.

Recharge Area: A land area in which surface water infiltrates the soil and reaches the zone of saturation or groundwater table.

Riparian Area: Vegetated ecosystems along a waterbody through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding.

Runoff: Water from rain, melted snow, or irrigation that flows over the land surface.

Site Fingerprinting: Development approach that places development away from environmentally sensitive areas (wetlands, steep slopes, etc.), future open spaces, tree save areas, future restoration areas, and temporary and permanent vegetative forest buffer zones. Ground disturbance is confined to areas where structure, roads, and rights-of-way will exist after construction is complete.

Swale: An open drainage channel designed to detain or infiltration storm water runoff.

Time of Concentration: Time that surface runoff takes to reach the outlet of a sub-basin or discharge area from the most hydraulically distant point in that drainage area.

Total Impervious Area (TIA): Total area of surfaces on a developed site that inhibit infiltration of storm water. The surface include, but are not limited to, conventional asphalt or concrete roads, driveways, parking lots, sidewalks or alleys, and rooftops.

Watershed: The topographic boundary within which water drains to a particular river, stream, wetland or body of water.

Wet Pond: A storm water management pond designed to detain urban runoff and always contain water.

Zero-lot-line Development: A development option in which side yard restrictions are reduced and the building abuts a side lot line. Overall unit-lot densities are therefore increased. Zero-lot-line development can result in increased protection of natural resources, as well as reduction in requirements for roads and sidewalks.

List of References

1. **LOW IMPACT DEVELOPMENT -** Technical Guidance Manual for Puget Sound, January 2005 (Puget Sound Action Team – Washington State University Pierce County Extension.)
2. **NATURAL APPROACHES TO STORMWATER MANAGEMENT –** Low Impact Development in Puget Sound, March 2003 (Puget Sound Action Team)
3. **2000 MARYLAND STORMWATER DESIGN MANUAL, VOLUMES I & II –** Prepared by the Center for Watershed Protection and the Maryland Department on the Environment; Water Management Administration as amended.
4. **2000 MARYLAND STORMWATER DESIGN MANUAL – VOLUME II, STORMWATER DESIGN APPENDICES –** Prepared by Maryland Department of the Environment as amended.
5. **LOW-IMPACT DEVELOPMENT DESIGN STRATEGIES –** An Integrated Design Approach – Prepared by Prince George's County, Maryland; Department of Environmental Resources; Programs and Planning Division, June 1999
6. **LOW-IMPACT DEVELOPMENT HYDROLOGIC ANALYSIS –** Prepared by Prince George's County, Maryland; Department of Environmental Resources; Programs and Planning Division, July 1999.
7. **2004 CONNECTICUT STORMWATER QUALITY MANUAL –** Prepared by the Connecticut Department of Environmental Protection.
8. **NATIONAL POLLUTANT REMOVAL PERFORMANCE DATABASE FOR STORMWATER TREATMENT PRACTICES, 2ND EDITION, MARCH 2000 –** Prepared by Rebecca Winer, Center for Watershed Protection for EPA Office of Science and Technology In Association with TetraTech, Inc.
9. **NATIONAL POLLUTANT REMOVAL PERFORMANCE DATABASE, Version 3;** September 2007 by the Center for Watershed Protection.
10. **2005 DATA REPORT – UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER –** Authored by Dr. Thomas Ballestero, Dr. Robert Roseen and James Houle.
11. **CONSERVATION DESIGN FOR STORMWATER MANAGEMENT – A Design Approach to Reduce Stormwater Impacts from Land Development and Achieve Multiple Objectives Related to Land Use –** A joint effort between the Delaware Department of Natural Resources and Environmental Control and the Environmental Management Center of the Brandywine Conservancy – September 1997.
12. **LOW IMPACT DEVELOPMENT MEMORANDUM – CITY OF SAMMAMISH, WASHINGTON,** November 1, 2006; Re: Low Impact Development Ordinance and 2005 King County Surface Water Design Manual Background Summary.

13. **Presentation by Larry Coffman "Developing LID Regulations"** as presented at the 2nd National Low Impact Development Conference, March 12 – 14, 2007 in Wilmington, NC.
14. **Pembroke Woods: Lessons Learned in the Design and Construction of an LID Subdivision –** by Michael Carr, P.E., President, Ecosite, Inc.
15. **Promoting Low Impact Development in Puget Sound through Regulatory Assistance and other measures** by Bruce Wulkan, Puget Sound Action Team**.**
16. **The integration of Low Impact Development and Conservation Design: The New Castle County, Delaware, Experience** by Michael Carr, P.E. (Principal Engineer, Ecosite, Inc.), John Gaadt, AICP (Principal Planner, Gaadt Perspectives, LLC) and George Haggerty (Assistant Manager, Department of Land Use, New Castle County, Delaware).
17. **ORDINANCES & REGULATIONS – Puget Sound Online by the Puget Sound Action Team.**
    - I. Island County Stormwater Code – Low Impact Development Requirements
    - II. Issaquah Stormwater Management Policy for LID
    - III. Lacey Zero-Effect Drainage Discharge Ordinance
    - IV. Olympia LID Strategy for Green Cove Basin
    - V. Pierce County LID Regulations
    - VI. Snohomish County Reduced Discharge Housing Demonstration Program
    - VII. Tumwater Zero Effect Development Ordinance
    - VIII. Washington State Department of Transportation, LID in the Highway Runoff Manual

SECTION TWO

Design manual

Road Design
Storm Drainage
Driveway

The following design provisions apply to the extension of existing Town Roads and the construction of new roads, which ultimately would be accepted by the Town of Tolland. The intent of this set of specifications is to provide a generally accepted minimum standard for the materials and construction of such projects. Under unusual circumstances the Design requirements can be modified w/ joint consent of P&Z and Town Engineer.

I. Road Design

A. Classification of Streets.

Streets and Roads in the Town of Tolland shall be classified into 4 major groups related to the levels of service provided. Under almost all circumstances new roads and extensions to existing roads will be done on Residential and Neighborhood Roads; however Collector Roads may be involved in intersection design and associated activities.

1. An **Arterial Road** would provide the highest levels of service and is predominantly used for the regional transport of traffic from one population center to another, with little or no intra-town utilization. Interstate 84 is the arterial road in the Town of Tolland.

2. A **Collector Road** generally provides for a lesser level of service than the Arterial Road and functions as a conveyance for traffic traveling from town to town or population cluster to cluster. Generally the traffic is predominated by through traffic rather than homes or businesses located along its length. All State Routes; Old Stafford Road, Goose Lane, Old Post Road, Grant Hill Road, Browns Bridge Road, Grahaber Road, and Buff Cap Road shall be considered Collector Roads. Design speeds and level of service would be higher than local Residential and Neighborhood Roads.

3. A **Residential Road** will provide balanced access to both homes and business located along its length and through traffic on a neighborhood to neighborhood scale. Design speed would generally be less than 30 mph and the level of service would be considered modest. Roads already in service and not listed above as well as principal roads within a proposed subdivision would be considered Residential Roads.

4. The classification of **Neighborhood Roads**. New roads that provide essentially access only to homes within single neighborhood that meet the design criteria specified would be considered Neighborhood Roads. These may include dead end roads without future interconnection potential, and other roads that will not create inter-neighborhood short cuts. Design speeds are to be low, 20 to 25 mph. The applicant must satisfy the Commission that a road proposed as a Neighborhood Road will meet the criteria established to insure its scaled down function.

B. Street Right of Way Width.

1. **Collector Roads**. In subdivisions located along sections of State Routes that are not monumented and defined by CT. DOT Right of Way Surveys, the town shall request that the front property line be established at least 30' from the centerline of the existing traveled way, not withstanding other property information indicating that the property line is actually further from the centerline of the traveled way. This would be communicated to the CT. Dept. of Transportation, who would either accept or decline the proposed Right of Way line.

   - In subdivisions along monumented and defined sections of State Routes, the street line shall be as established by the CT. DOT Right of Way Survey.

   - In subdivision along Collector Roads with local jurisdiction, the street line for new lots shall be established at least 30' from the existing traveled way, not withstanding other property information indicating that the property line is actually further from the centerline of the traveled way.

2. **Residential Roads and Neighborhood Roads**. In subdivisions along existing Residential Roads the minimum street line shall be established at least 25' from the existing traveled way, not withstanding other property information indicating that the property line is actually further from the centerline of the traveled way.

   - For all new Residential and Neighborhood Roads the minimum Right of Way width shall be 50'. The paved surface of the road shall be centered in the right of way.

B. Intersections.

1. Proposed intersections of new roads with other new roads or existing roads shall be located not closer than 350' from other intersections on collector road, 250' from other intersections on residential roads and 150' from other intersections on neighborhood roads. This distance shall be measured from the centerline / centerline of one intersection to the centerline / centerline of the other. In cases where intersecting roads are of different classifications, the higher level of service shall control the offset distance.

2. Proposed intersections of Residential and Neighborhood Roads with Collector Roads shall be generally meet at right angles or radial to the curvature of the Collector Road if appropriate. In no case shall such an intersection be greater than 5° from the right angle line or radial line. This line of approach shall extend at least 50’ along the centerline of the subordinate street before any other changes of horizontal alignment can be included in the design.

3. Proposed intersections of Residential and Neighborhood Roads with other Residential or Neighborhood Roads shall be generally meet at right angles or radial to the curvature of the intersected road if appropriate. In no case shall such an intersection be greater than 30° from the right angle line or radial line.

4. No intersections shall be approved where the intersected street’s centerline grade exceeds 8%. The intersecting street’s centerline grade shall not exceed 3% within 75’ of the point of intersection.

5. Intersecting streetlines shall be constructed to provide a minimum 25’ transition radius. Intersecting paved surfaces shall provide transition radii of 20’ and 25’ feet for Neighborhood and Residential Roads respectively, regardless of the classification of the intersected street. Adequate lines of sight at proposed intersections shall be provided. Improvements to existing conditions such as grading, vegetation removal and easements enabling maintenance of such features shall be provided by the applicant as needed to provide sightlines of 350’, 250’ and 150’ for intersections with collector, residential and neighborhood roads. Should the intersection be made with roads of different classifications, the longer distance shall prevail.

C. Roadway Specifications

1. The following criteria will be incorporated in the design of proposed roads and extensions of existing roads. Collector Road information is provided for comparison only, new construction of a collector is unlikely.

	CL radius	*design speed*	*max/min grade*	*travel width*
Collector	*400’ min.*	*30mph*	*8% / 1%*	*28’*
Residential	*250’ min.*	*25mph*	*8% / 1%*	*24’*
Neighborhood	*175’ min.*	*20mph*	*8% / 1%*	*22’*

The Commission may modify the width of pavement if Town staff recommends such a reduction will not negatively impact public safety or emergency response.

2. **Cul-de-sacs**

Dead end roads that do not double back upon themselves shall terminate in a cul-de-sac either centered along the alignment of the road or offset to one side. Cul-de-sacs may be circular or elliptical in shape so long as the pavement radii permit the continuous turning movements for the largest fire fighting vehicle used by the Town of Tolland. An island may be placed in the center of the cul-de-sac to permit the creation of a LID storm water treatment systems, such as a bioretention facility. The minimum pavement width shall conform to the appropriate road width shown in the table above. The design of all cul-de-sacs must be approved by the Town Engineer, the Director of Public Works, the Fire and Police Departments. The street line and pavement line shall have transition radii of 15'and 25' respectively to link to the conventional portion of the road.

D. Road Grades –

1. Minimum one percent (1%); except in transition areas between grades.

2. The maximum road grade shall be eight percent (8%). The Commission may waive the requirement to a maximum of 10% where the applicant has demonstrated that such an increase will reduce the environmental impact of cutting and/or filling the slope. The applicant must clearly document the following conditions are met in order to use a maximum grade of 10.0% for a road.

   a) The proposed road must closely follow the existing contours on the site.
   b) The grading limits as defined in the section below must be reduced by at least 40% from those grading limits associated with a road grade of 8.0% in the same alignment.
   c) The total volume of cut and fill material must be reduced by at least 50% from the total volume of cut and fill associated with a road grade of 8.0% in the same alignment.

The new road and existing rights-of-way shall only be cleared of existing vegetation as outlined in the VPPP to provide for safety, drainage and construction.

E. Street Grading and Improvement –

1. Streets shall be related appropriately to the topography. Local roads shall be curved wherever possible, to avoid conformity of lot appearance. All streets shall be arranged to obtain as many as possible of the building sites at, or above, the grades of the streets. Grades of streets shall conform as closely as possible to the original topography. A combination of steep grades and curves shall be avoided. Specific standards are contained in these Regulations.

2. Horizontal and Vertical Alignment shall be designed to minimize large cut and fill construction. New roads shall be provided with a "snow shelf" with a width of 5' adjacent to the traveled way. The grade of the snow shelf shall not exceed 12 horizontal to 1 vertical. Grading beyond the shelf, shall not exceed 3 horizontal to vertical. All cut and fill slopes shall be provided with a minimum of 4" of topsoil and shall be seeded to grass or other acceptable vegetation to stabilize the embankment.

F. Other Standards –

1. Neighborhood Roads shall be constructed in a manner to maintain slower traffic speeds. Long straight sections between curves shall not be permitted. Straight alignments or curves with a radius > 400' shall be broken into smaller sections not exceeding 500'. These breaks may be curvature with a centerline radius of 175', or other methods for "traffic calming" as approved by the Town Engineer.

2. Neighborhood roads shall be constructed in such a manner as to follow the existing contours, minimize excessive cuts and fills (>6' at the centerline of the road), and provide for horizontal and vertical geometry which will encourage slower vehicular speeds.

3. Both Neighborhood and Residential Roads shall have a 3' wide white pavement stripe painted along both sides of the road 10' from the centerline of the traveled way. No centerline marking will be permitted. Special markings and signage at intersections and at specific traffic calming devices shall be at the direction of the Town Engineer.

4. The town reserves the right to require traffic calming measures on Residential Roads, if due to geometry, proximity to Collector Roads, and other factors it is likely that design speeds may be exceeded. These may include one or more of the following: changes to vertical profile such as speed tables and raised cross walks; changes to horizontal alignment such as chicanes, roundabouts and restricted intersection; or textural changes to the travel surface.

II. Road Construction.

Connecticut Department of Transportation Form 814A is included by reference to these specifications, for matters concerning material specification, method of measure and project administration. The Town of Tolland reserves the right to further modify provisions in 814A to provide for the best interest of the community.

A. **Town Engineer -** In all matters pertaining to highway construction and design, the Town Engineer shall be the final judge as to proper practice.

B. **Construction Procedure -** The Contractor shall notify the Public Works Coordinator and the Town Engineer at the beginning and end of each phase of the construction and shall not proceed with the next step until the Public Works Coordinator and the Town Engineer have inspected the work. It will be the responsibility of the applicant's engineer to make periodic detailed inspections of the project to insure compliance with the Town Highway specification and approved plans.

C. **Specifications**

1. Excavation shall not be made below subgrade except where rock or stone is encountered or removal of unstable material is directed by the Town Engineer. When ledge rock is encountered, this material shall be over excavated to a depth

of not less than six (6) inches below subgrade unless otherwise directed. Material removed below grade shall be replaced with approved material, thoroughly compacted or as otherwise directed.

2. Springs or seepage water encountered shall be reported to the Public Works Coordinator. The contractor shall keep the excavation free from water at all times by pumping or by any other means that may be necessary. The Town reserves the right to require underdrain installation as required by field conditions.

3. Fills shall not be started until the area has been inspected and approved by the Town Engineer and the Public Works Coordinator. Only material from excavation or borrow pits approved by the Town Engineer shall be used as fill. Laboratory certification that materials to be used meet the minimum requirements of CT. DOT 814a may me required. Fills shall be placed in 10-inch to 12-inch layers and compacted with a 3-wheel power roller weighing 8 to 12 tons or other suitable equipment approved by the Public Works Coordinator. Compaction must be such that no creeping or weaving appears ahead of the roller on the final rolling. No stone over 5 inches in its greatest dimension shall be placed within 12 inches of the elevation of the subgrade.

4. All streets shall be graded the entire width of the right of way with side slopes as indicated on the provision discussed elsewhere in this document. Any exception to this procedure shall be at the discretion of the Town Engineer. Finished pavement surfaces shall provide a 3/8" per foot cross slope from the centerline to the edge.

5. Embankment fill for the construction of roads, parking lots, sidewalks, etc. Shall be constructed in accordance with Section 2.03.01 & 2.02.03 of the CT DOT Form 816 (Embankment and Disposal of Surplus Material), as revised.

D. Materials

1. **Preparation of the Subgrade -** The rough subgrade shall be cleaned of all loose or foreign material and reshaped if rutted. Approved materials shall be added to meet the established grades and standard cross sections. Shaping and compacting, as directed by the Public Works Coordinator, shall be done with blade graders and a 3-wheel power roller weighing 8 to 12 tons or equivalent vibratory compactor. The finished surface shall be smooth and even and shall not vary more than one-half (1/2) inch from the standard cross section or established grade. Any deviations from this cross section and grade shall be corrected by cutting or filling, followed by repeated rolling until a well compacted surface is obtained.

2. **Construction of the Subbase -** The subbase shall be gravel or crushed stone, constructed according to Connecticut Highway Department Specification M.02.02. The compacted thickness of the subbase shall be as 12". Under unusual circumstances the Town Engineer may require additional depth of subbase material. All drainage and utilities buried within the paved area shall be installed and tested prior to installation of the subbase.

3. **Construction of the Base -** The base shall consist of processed aggregate, a minimum compacted depth of 6”, complying with Connecticut Highway Department Specification M-05.01 and shall be constructed in accordance with Connecticut Highway Department Specification 3.04. The processed aggregate shall be compacted with a 3-wheel roller weighing 8 to 12 tons or an equivalent vibratory compactor. Rolling shall proceed in a longitudinal direction beginning 12 inches back of the gutter line and proceeding toward the center. Sufficient overlap with the inside roller wheel shall be maintained to avoid any unrolled areas. Rolling shall be continued until the material is well compacted and does not creep ahead of the roller.

4. **Two Course Bituminous Concrete Pavement -** No pavement shall be placed until any manhole frames, gate valves and similar devices have been installed at the finished pavement elevation. The first course shall be a bituminous concrete binder complying with Connecticut Highway Department Specifications 4.06 and M.04.01 Class I. For Residential Roads and Neighborhood Roads, the binder course shall be one and one-half (1 1/2) inches minimum thickness after compaction. The second course shall be a bituminous concrete complying with Connecticut Highway Department Specifications 4.06 and M.04.01 Class II. For Residential Roads and Neighborhood Roads, the minimum compacted thickness shall be one and one-half (1 1/2) inch. Both courses shall be compacted with a ten (10) ton tandem roller and self-propelled pneumatic tire roller as per Connecticut Highway Department Specifications 4.06.03-9. If the second course of pavement is delayed in its installation, the Town Engineer may require that the binder course shall be mechanically swept and a tack coat provided. Paving shall not be done between November 1^{st} and April 1^{st} without the consent of the Town Engineer.

III. Stormwater Drainage.

A. All subdivisions proposals of 5 lots or more on existing roads and any subdivision with new roads and./or extensions of existing roads shall provide a storm water analysis and treatment system in accordance with the Town of Tolland Low Impact Development Manual, September 2007 The Town Engineer shall approve the type and size of the proposed storm water conveyance and treatment system.

Storm drainage shall be provided and designed in accordance with the following standards:

Class of Drainage	Watershed Area	Design Frequency
In Road Drainage System		10 years
Minor Cross Culverts (Intermittent streams with watershed areas with less than 100 acres)		25 years
Intermediate Cross Culverts (Perennial streams with watershed areas with less than 200 acres)		50 years
Large Cross Culverts (Perennial streams and Rivers with watershed with areas greater than 200 acres)		100 years

Note: For Intermediate and Large Cross Culverts, the backwater condition shall not extend more than 100’ upstream from the inlet of the cross culvert, but in no case shall cross a property line onto land not under the applicant’s control.

B. Drainage Structures, Catch Basins and Stormwater Piping -

1. The minimum size for all storm drains shall be 15 inches diameter and the minimum grade shall be 1.0%. All stormwater piping under pavement shall be class IV RCP and shall have at least 30” of cover. Drainage piping not located under the pavement such as outfalls, underdrains or other similar applications may be smooth walled corrugated plastic, ADS N-12, HDPE or equal. Backfill and cover requirements for these pipe applications may vary depending on conditions and shall be approved by the Town Engineer.

2. Pipe and drainage structures shall be installed within the subdivision to facilitate crossing of existing wetlands and watercourses and to provide street drainage within the subdivision. Proposed discharge points and piping located outside of the street right of way shall be located within an easement area allowing the Town access for maintenance. All discharge points and the adjacent land shall additionally be encumbered with an unrestricted Right to Drain in favor of the Town. Drainage easements will generally be 30’ in width and extend a minimum of 20’ beyond the discharge point.

3. Catch basins shall be pre-cast concrete or site built masonry structures built in accordance with CT. DOT 814a and shall be provided at all significant changes of vertical and horizontal pipe alignment, at all low points and at intervals not exceeding 300 feet along the road. Drainage piping shall not cut across the centerline of the roadway when connecting basins along a curve, unless the Town Engineer approves such an alignment for environmental reasons. In general piping shall be located on the "cut" side of the road to facilitate the placement of an underdrain in the same trench system. Piping that must cross from one side of the road to the others shall cross at right angles to the road alignment.

4. Bridges, box culvert, deep manholes and other special structures shall be designed in accordance with good engineering practice and shall be subject to the approval of the Town Engineer. No structures shall be backfilled or covered until inspected and approved by the Public Works Coordinator or his agent.

C. Curbing –

1. Mountable curbs also called "Cape Cod Curbs" shall be provided along all new roads and extensions of existing roads to direct storm water runoff. Curbing shall be constructed of Bituminous Concrete and shall provide a minimum reveal of 4".

2. Curbing may be eliminated for roads if the grades are less than 5% and the development calls for off-road LID storm water conveyance systems, such as vegetated swales as recommended by the Town Engineer and approved by the Planning and Zoning Commission. The Town Engineer may recommend to reduce or eliminate the requirement for curbing for other unique or special conditions

IV. Miscellaneous Items.

A. Underground Utilities – Underground Utilities shall be provided along all new roads and extensions of existing roads wherever possible. Underground utilities shall be placed in the snow shelf.

B. Sidewalks - Sidewalks where required by the commission shall meet the following criteria:

type of walk	subbase	base course	surface treatment
stone dust path	na	8" gravel	4" stone dust
bituminous walk	8" gravel	4" process gravel	3" Class 2 Bituminous Concrete
concrete walk	na	6" process gravel	4" 3000 # Reinforced Concrete

C. Public Water and Sewer - Public Water and Sewer shall be sized and installed in accordance with the current standards utilized by the utility providing the service. All work shall be inspected and tested prior to placement of roadway base materials. Trenches shall be thoroughly compacted to eliminate settling.

D. Road and Property Monumentation - Prior to acceptance of the completed road by the Town of Tolland, the Right of Way shall be marked in the field with 36" tall reinforced concrete monuments set at all points of curvature and tangency. Monuments shall generally be set flush to the ground surface. Property corners shall be marked with iron pins or pipes with a minimum diameter of 5/8" and length of 36". Property corners shall generally be set flush to the ground surface. A Land Surveyor licensed by the State of Connecticut shall certify that the pins and monuments have been set to the standards of an A-2 Survey.

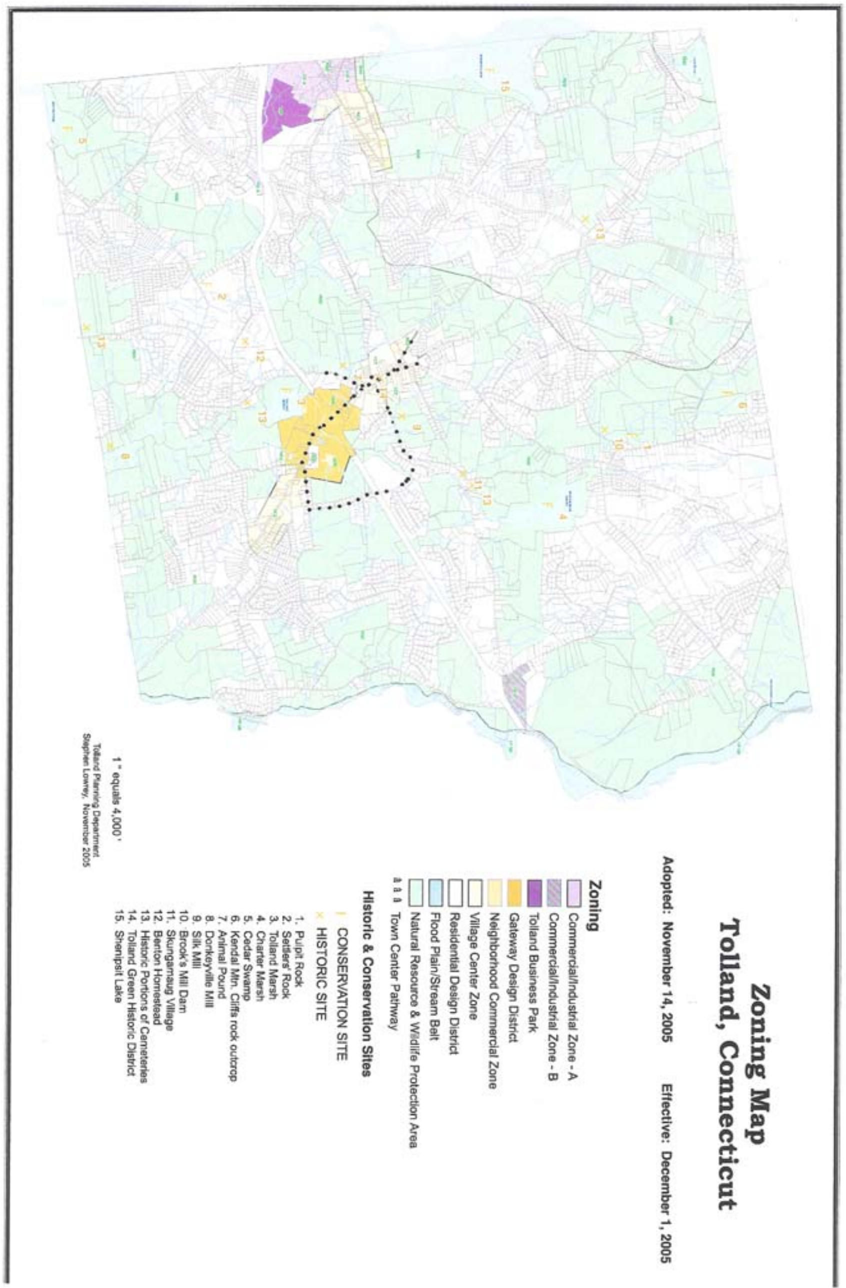
E. "As-Built" Plans - A Plan and Profile "As-Built" survey shall be prepared and submitted to the Town Planner showing all the physical feature of the new road including surface and subsurface infrastructure within and adjacent to the Right of Way. Elevations shall be specified but finished contour lines are not required.

F. Sedimentation and Erosion Control - Sedimentation and Erosion Control measures shall be detailed in the proposed design consistent with local and state regulations. All Erosion and Sedimentation Control Plans shall be prepared in accordance with the 2002 Guidelines for Soil Erosion and Sediment Control as prepared by the State of Connecticut as may be amended in the future. The Town reserves the right to require additional measures beyond those specified on the approved plans, if field conditions indicate that such measures are necessary to prevent the erosion and subsequent siltation of downstream areas.

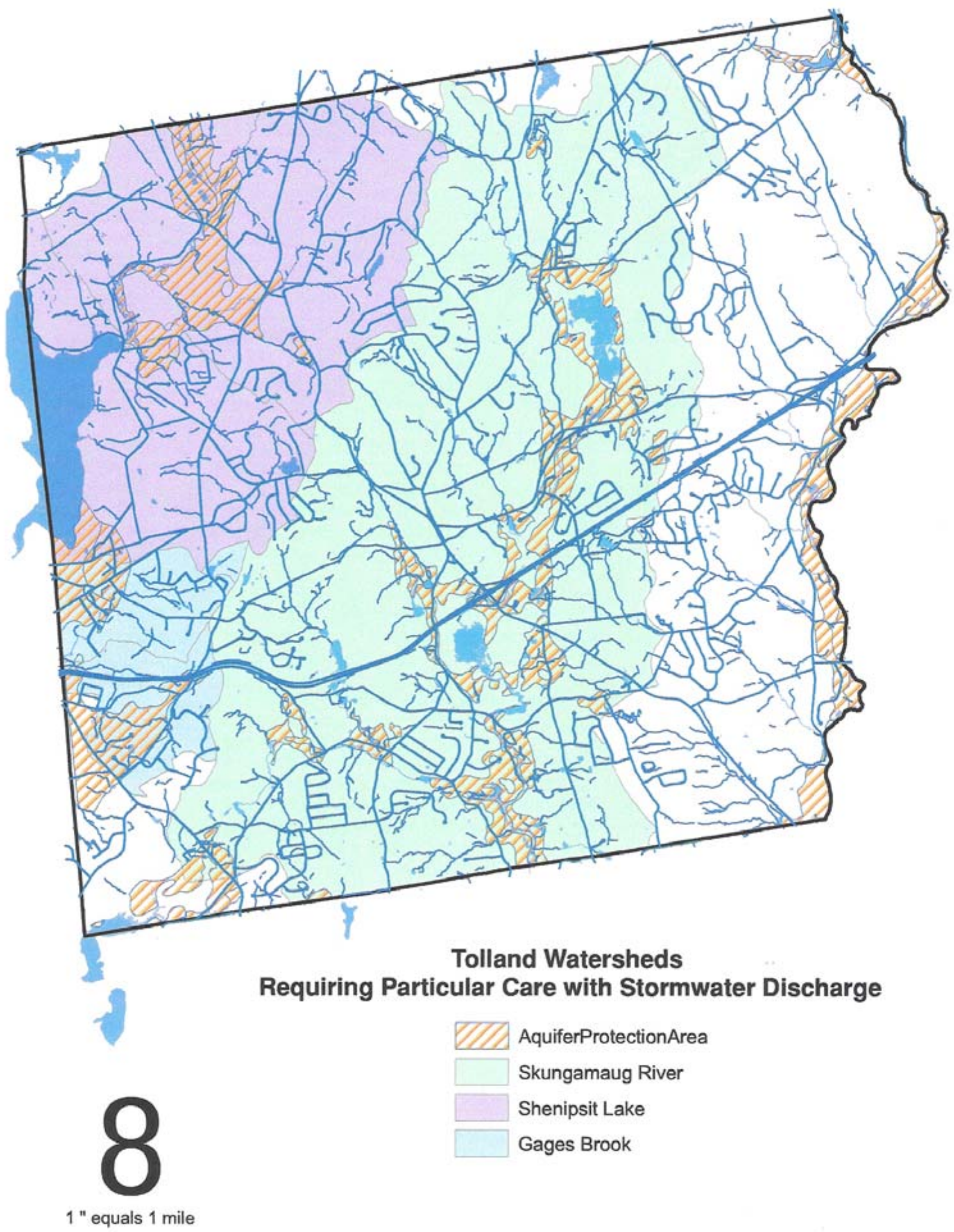
G. Guide Rails - Corrugated metal beam rail may be required on fill sections of roads where the vertical difference from the edge of the snow shelf to the toe of the slope exceeds 5' and the overall slope is 3 horizontal to 1 vertical. Alternatively the commission may require that the slope section be extended to eliminate or reduce the requirement for guide rail.

APPENDIX A
TOWN OF TOLLAND MAPPING
MAP 1 – ZONING MAP
MAP 2 – WATERSHED MAP
MAP 3 – IMPERVIOUS COVERAGE MAP

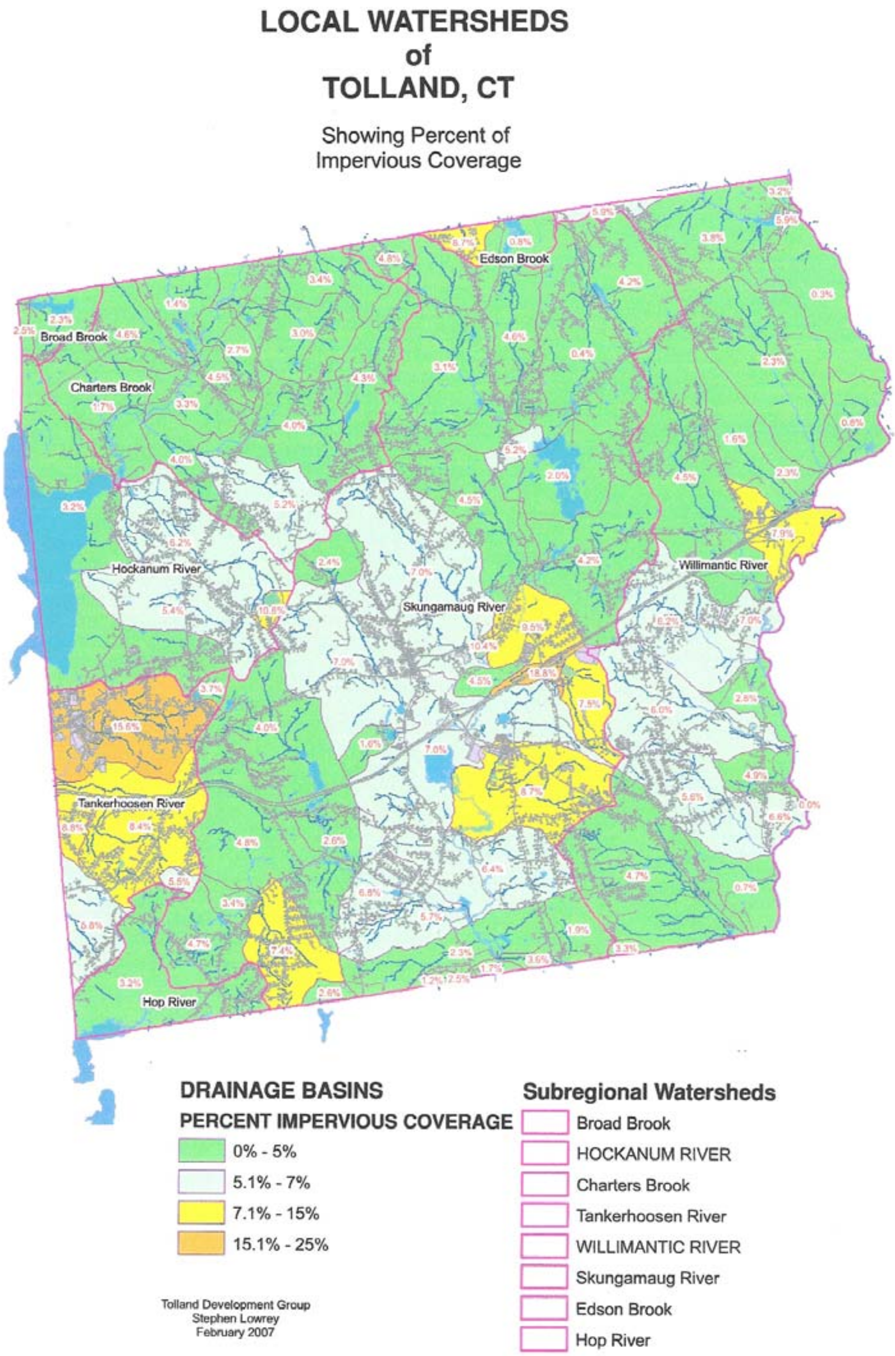
MAP 1


Zoning Map
Tolland, Connecticut
Adopted: November 14, 2005
Effective: December 1, 2005
Zoning
Commercial/Industrial Zone - A
Commercial/Industrial Zone - B
Tolland Business Park
Gateway Design District
Neighborhood Commercial Zone
Village Center Zone
Residential Design District
Flood Plain/Stream Belt
Natural Resource & Wildlife Protection Area
Town Center Pathway
Historic & Conservation Sites
CONSERVATION SITE
HISTORIC SITE
1. Pulpit Rock
2. Settlers' Rock
3. Tolland Marsh
4. Charter Marsh
5. Cedar Swamp
6. Kendal Mtn. Cliffs rock outcrop
7. Animal Pound
8. Donkeyville Mill
9. Silk Mill
10. Brook's Mill Dam
11. Skungamaug Village
12. Benton Homestead
13. Historic Portions of Cemeteries
14. Tolland Green Historic District
15. Shenipsit Lake
1" equals 4,000'
Tolland Planning Department
Stephen Lowrey, November 2005

MAP 2


Tolland Watersheds
Requiring Particular Care with Stormwater Discharge
AquiferProtectionArea
Skungamaug River
Shenipsit Lake
Gages Brook
8
1 " equals 1 mile

MAP 3


LOCAL WATERSHEDS
of
TOLLAND, CT
Showing Percent of
Impervious Coverage
Edson Brook
Broad Brook
Charters Brook
Hockanum River
Willimantic River
Skungamaug River
Tankerhoosen River
Hop River
DRAINAGE BASINS
PERCENT IMPERVIOUS COVERAGE
0% - 5%
5.1% - 7%
7.1% - 15%
15.1% - 25%
Subregional Watersheds
Broad Brook
HOCKANUM RIVER
Charters Brook
Tankerhoosen River
WILLIMANTIC RIVER
Skungamaug River
Edson Brook
Hop River
Tolland Development Group
Stephen Lowrey
February 2007

APPENDIX B

Low-Impact Development Design Strategies
An Integrated Design Approach
Prepared by:
Prince George's County, Maryland
Department of Environmental Resources
Programs and Planning Division
June 1999

http://www.lowimpactdevelopment.org/pubs/LID_National_Manual.pdf

APPENDIX C

Low-Impact Development Hydrologic Analysis
Prepared by:
Prince George's County, Maryland
Department of Environmental Resources
Programs and Planning Division
July 1999

http://www.lowimpactdevelopment.org/pubs/LID_Hydrology_National_Manual.pdf

APPENDIX D

National Pollutant Removal Database
Version 3
Prepared by:
Center for Watershed Protection
September 2007

http://www.cwp.org/PublicationStore/special.htm