Reducing non point source pollution in the urban environment

Photo: Hardrainproject.com

M. Michele Montano
(CPP) LA652 – Doug Delgado
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Photo: http://www.oilgoneeasy.com/oil_spill_blog/nonpoint-source-pollution-2

1. Introduction

In the past couple of decades, municipal governments have been held increasingly accountable for controlling pollutants washed into the storm water systems and discharged into the waterways. Pollutants found in urban stormwater runoff come from a variety of sources, unlike the pollution from industrial and sewage treatment plants, which are treated before being discharged into surface waters. As water moves through the urban environment it transports both natural and man made pollutants into the surrounding rivers, wetlands, lakes, coastal waters, and sometimes even finds its way into groundwater. Not limited to the discharge from stormwater events, wind, landscape irrigation, improper disposal of trash, yard waste and septic systems also contribute to pollution in our urban runoff. (CWPU, 2009)

Runoff in the urban environment from both storm generated and dry weather flows have been shown to contribute significant amounts of pollutants into surface waters throughout the country. In 1987 amendments were made to the Clean Water Act, which directed the Environmental Protection Agency to comply with regulations that required municipal separate storm sewer systems serving populations of 100,000 or more to meet requirements in the National Pollutant Discharge Elimination System (NPEDS). (CWPU, 2009)

Identified as one of the main causes of water quality degradation, urban runoff discharge from municipal storm drains have been known to help cause public health risks and safety concerns. Potentially containing a combination of pollutants like trash and debris, bacteria, viruses, sediments, oil and grease, metals, nutrients, sediments, and an assortment of toxic chemicals. These contaminants have been documented to have negatively impacted the quality of receiving and coastal waters, public health and related biota. Urban runoff pollution is not only a problem during rainy seasons, it is also a problem that is occurs throughout the year due to the variety of urban water use. (LA LID Manual, 2011)

The problems faced by urban streams, lakes, estuaries, aquifers, and other water bodies due to inadequately controlled or treated runoff is extremely troubling. Changes in flow, increased sedimentation, higher water temperatures, lower numbers of dissolved oxygen, the degradation of aquatic ecosystems and habitat, loss of fish and other aquatic populations, degraded water quality, increased levels of nutrients, metals, hydrocarbons, bacteria, are all factors that have contributed to the degraded water system we have now. (EPA, 2005)

“The *National Water Quality Inventory: 2000 Report to Congress* identified urban runoff as one of the leading sources of water quality impairment in surface waters (USEPA, 2002b). Of the 11 pollution source categories listed in the report, “urban runoff/storm sewers” was ranked as the fourth leading source of impairment in rivers, third in lakes, and second in estuaries.” (EPA, 2005)

1.1. What is Point Source pollution?

During 1972-1987 the EPA and the national program to abate and control water pollution, focused on controlling pollution from traditional point sources, which are generally fixed locations or permanent facilities from which pollutants are released States along with the EPA have regulated these point sources through the National Pollutant Discharge Elimination System (NPEDS) permit program established by section 402 of the Clean Water Act (CWA).

1.2. What is Non Point Source Pollution?

Considered one of the most influential sources of contamination in the nations waterways, non point source pollution was ranked 77 of 127 according to a nationwide study. Heavy metals, toxic chemicals, organic compounds, pesticides, pathogens, nutrients, sediments, and salts are some of the most prevalent contaminants found in urban stormwater runoff. Many of the substances are found to be carcinogenic, and have been proven to lead to reproductive and developmental problems associated with long-term exposure. Short-term exposure to pathogens not only makes one ill but it can also be fatal. Collected in urban sewer systems, runoff is generally not treated prior to entering our waterways, transporting contaminants into surface water bodies used as our sources of drinking water. Serving 20 percent of the population, combined sewer systems allow contaminants to be discharged untreated into our waterways during heavy storm events (EPA, 2001).

As water flows across the landscape, it carries with it all of the “residues” from the surrounding environment, augmented by different contaminants from a variety of land uses. Agricultural lands generally contain enriched nutrients and sediments; highly developed urban areas have been shown to contain rubber fragments, heavy metals, sodium and sulfates. (Tong & Chen, 2002) It is safe to assume that there is a strong correlation between land use types and the quality and quantity of water. (Gburek and Folmar, 1999). Evapotranspiration, infiltration, interception, absorption, and percolation can help to modify land surface characteristics, water balance, hydrologic cycle, and surface water temperature (LeBlanc et al., 1997). Consequently runoff amounts, stream / groundwater flow, and natural processes in the receiving water bodies are all adversely affected. It is then fairly safe to deduce that land use types affect the quantity and quality of water (Gburek & Folmar, 1999).

2. How do urbanized areas increase water pollution?

Urban landscapes are dominated by impervious surfaces made up of roads, walkways, parking lots, buildings and structures of all shapes and sizes. Much of the exposed soil is compacted and will not allow infiltration. During storm events water is conveyed across the surface rapidly picking up toxins as it travels through the sewer network and into the ocean. The urban runoff conveys oil, gasoline, automotive fluids, hydrocarbons, sediments, pesticides, nutrients and a whole host of other pollutants through the city and into the waterways.(EPA, 2001)

As this toxic composition makes its way through the city and into the waterways it carries with it chemical constituents and pathogenic organisms that greatly impair water quality. “The actual threat to groundwater quality from recharging urban runoff is dependent on several factors, including soil type, source control, pretreatment, solubility of pollutants, maintenance of recharge basins, current and past land use, and depth to groundwater. Studies by EPA (EPA 1983) and the U.S. Geological Survey (USGS 1995) indicate that all monitored pollutants stayed within the top 16 centimeters of the soil in the recharge basins.” (CWPU, 2009)

Conventional approaches generally address flooding issues, and the conveyance of water as out from the city into drainage systems and channels lined with concrete. This approach has been known to result in habitat loss, a reduction in groundwater, and its impacts to the natural systems have been catastrophic in some cases. The increase in runoff volume and speed results in increased pollution, stream bank erosion, and increased flooding problems downstream, because the focus of the solutions is to move water out of the city as quickly as possible, without addressing the use of runoff. (CWPU, 2009)

The following table shows the impact of human activity on the quality of our various water bodies.

Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Agriculture (48%) [a]	Agriculture (41%) [a]	Municipal point sources (37%)[a]
Hydrologic modifications (20%)	Hydrologic modifications (18%)	Urban runoff/storm sewers (32%)
Habitat modifications (14%)	Urban runoff/storm sewers (18%)	Industrial discharges (26%)
Urban runoff/storm sewers (13%)	Misc. nonpoint source pollution (14%)	Atmospheric deposition (24%)

[a]Values in parentheses represent the percentage of assessed river miles, lake acres, or estuary square miles that are classified as impaired. States assessed 19% of stream miles, 43% of lakes, ponds, and reservoirs, and 36% of square mileage of estuaries.
[b] Excluding unknown, natural, and "other" sources.

Photo: EPA, 2005

2.1. Development's Role

Land development and construction have significantly altered the landscape; in doing so it has altered natural drainage patterns contributing to erosion and removal of existing vegetation, as well as distributing large amounts of sediment into the storm water runoff (LA LID Manual, 2011).

Roads, highways and bridges convey contaminants from vehicles, construction, and maintenance. These contaminants contribute significant amounts of pollutants directly into our waterways (EPA, 2005). The reduction of native vegetation due to development, loss of pervious surface, and loss of vegetation decreases the ability of our natural environment to filter contaminants. Degraded water starts to become obvious within a watershed area after impervious cover reaches 10-20%. (EPA, 2001)

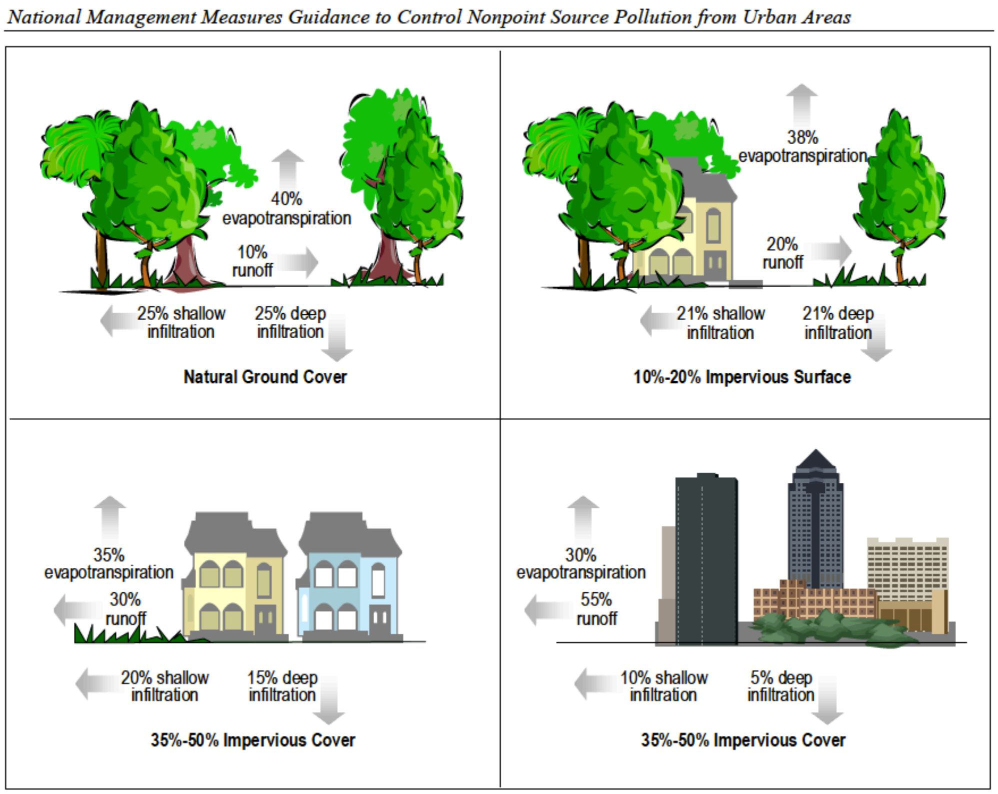
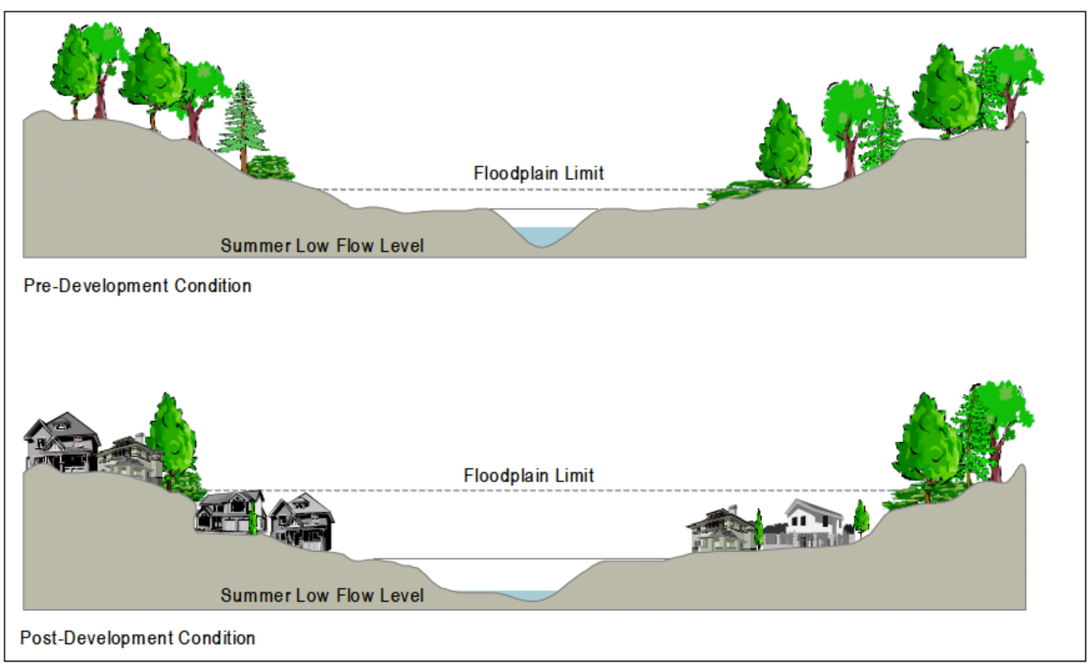


Photo: EPA, 2005



The photo above depicts the response of stream geometry to urbanization
Photo: EPA, 2005

2.2. Types of pollutants & Changes in the natural systems

Runoff pollution is that associated with rainwater or melting snow that washes off roads, bridges, parking lots, rooftops, and other impermeable surfaces. As it flows over these surfaces, the water picks up dirt and dust, rubber and metal deposits from tire wear, antifreeze and engine oil that has dripped onto the pavement, pesticides and fertilizers, and discarded cups, plastic bags, cigarette butts, pet waste, and other litter. These contaminants are carried into our lakes, rivers, streams, and oceans. (EPA, 1995) Pollutants transported through our waterways adhere to sediment and degrade water quality, harming aquatic life, impeding photosynthesis, respiration, growth and reproduction.

Types of runoff pollution:

Sediment**:** The disturbance and clearing of land creates large amounts of sediment, which is transported to surface waters. These sediment deposits accumulate around bridge structures, road pavements, and drainage ditches not only weakening them, but also preventing sunlight from reaching aquatic plants, clogging fish gills, suffocating organisms, as well as devastating spawning grounds and nursery areas. (EPA, 1995)

Oils and Grease**:** “Oils and grease are leaked onto road surfaces from car and truck engines, spilled at fueling stations, and discarded directly onto pavement or into storm sewers instead of being taken to recycling stations. Rain and snowmelt transport these pollutants directly to surface waters.” (EPA, 1995)

Heavy Metals**:** Heavy metals not only come from vehicles, they can also come from natural sources, such as rocks, salt, sand, and vegetation. Heavy metals are known to be toxic to aquatic life and can likely pollute ground water. (EPA, 1995)

Debris**:** “Grass and shrub clippings, pet waste, food containers, and other household wastes and litter can lead to unsightly and polluted waters. Pet waste from urban areas can add enough nutrients to estuaries to cause premature aging, or ‘eutrophication’." (EPA, 1995)

Road Salts**:** Considered to be a major pollutant in both urban and rural areas, road salts can produce high concentrations of sodium and chloride in ponds, lakes, and bays causing changes in water composition and avoidable fish kills. (EPA, 1995)

Fertilizers, Pesticides, and Herbicides**:** Runoff from fertilizers, pesticides, and herbicides that are transported into our waterways without filtration can lead to algal blooms, excessive plant growth, and eutrophication. Not only do they alter the water quality, they are harmful to both humans and wildlife. (EPA, 1995)

The table below is a summary of case studies, which link urbanization to hydrological impacts of streams.

Case Study	Location	Documented Impacts	Inferred Impacts
East Meadow Brook	Nassau County, NY	– Increased peak flows	Flooding, habitat loss, erosion, channel widening, streambed alteration
Holmes Run Watershed	Fairfax, VA	– Frequent flooding – Severe streambank erosion – Sedimentation	Flooding, habitat loss, erosion, channel widening, streambed alteration
Kelsey Creek	Bellvue, WA	– Degradation of designated uses – Decreased base flow – Loss of fish populations	Habitat loss, channel widening
Patuxent River System	Maryland	– Increased instream sediment load – Changes in morphology of urban channels	Habitat loss, erosion, channel widening
Peachtree Creek	Atlanta, GA	– Increased bankfull events – Decreased base flow	Flooding, habitat loss, erosion, channel widening, streambed alteration
Pheasant Branch Basin	Middleton, WI	– Stream incision – Increase in bankfull events – Sedimentation	Flooding, habitat loss, erosion, channel widening, streambed alteration
Pipers Creek	Seattle, WA	– Increased peak flows – Loss of fish populations – Aesthetic degradation	Flooding, habitat loss, erosion, channel widening, streambed alteration
Several creeks	Dekalb County, GA	– Stream enlargement – Stream incision – Increased sediment transport	Habitat loss, erosion, channel widening, streambed alteration
Valley Stream, Pines Brook, Bellmore Creek, and Massapequa Creek	Nassau County, NY	– Decreased base flow	Habitat loss

Photo: EPA, 2005

2.3. Impervious Surfaces increases & conveys pollutants

Impervious surface is a reference to surface area that cannot be penetrated by water. Precipitation falling on to an impervious surface is not infiltrated into the soil, it either runs off into a pervious area where it is then infiltrated, or it continues traveling through a network of impervious surfaces until it is conveyed into a ditch, a storm drain network, a stream, lake, wetland, or other type of receiving body of water (EPA, 2005).

Impervious areas do not allow for natural infiltration, which helps to filter pollutants before reaching the groundwater, and also helps to slow down the rate of travel as water moves on the surface (EPA, 2001).

Impervious cover can generally be organized into three main categories:

- Roofs - Impervious cover created by buildings and built structures
- Transport systems – Impervious cover created by parking lots, roads, sidewalks, etc…

- Recreational facilities – Impervious cover created by playgrounds, basketball/tennis courts, swimming pools, etc…
  (EPA, 2005)

Streets have the capacity to increase the velocity of water flow because of it's smooth impervious surface, and can in fact increase even more greatly with depth contributing to erosion in areas without the protection of vegetation, further increasing flooding in low lying areas, and sedimentation in surface water bodies. Sediment deposited into streams increases the turbidity, transport pathogenic bacteria and viruses, and decrease the capacity of reservoirs. Sediment is also known to "smother" aquatic species, decrease biodiversity, and destroy habitat through erosion. So, because of the impervious nature of urban environments, aquifers are no longer being recharged (EPA, 2001).

As the amount of impervious surface increases, water that once use to percolate into the soil now travels across the surface into drains, and channels that convey the water out as quickly as it came it. As water is washed rapidly across the urban landscape it scours the surface of a various kinds of pollutants, unfiltered, and unfettered, gleaning automotive fluids, cleaning solvents, toxic or hazardous chemicals, detergents, sediment, metals, pesticides, nutrients, food waste, oil and grease. Not only does it transport water out, it is also conveying potentially harmful pollutants that were deposited onto our roads and urban surfaces, and will eventually be deposited into the receiving water bodies contaminating the water (LA LID Manual, 2011)

There is a linear relationship between the amount of impervious surfaces in a give area and the amount of runoff generated. Annual stormwater runoff can increase 2-16 times the predevelopment amount depending on the percentage of impervious cover (Schueler, 1994). Impervious cover as low as 10% has the ability to destabilize a stream channel, raise water temperature, reduce water quality, and reduce biodiversity (Schueler, 1995). One study found that connected impervious levels between 8-12% was representative of a threshold region where minor changes in urbanization could result in major changes in the condition of the stream (Wang et al., 2001)

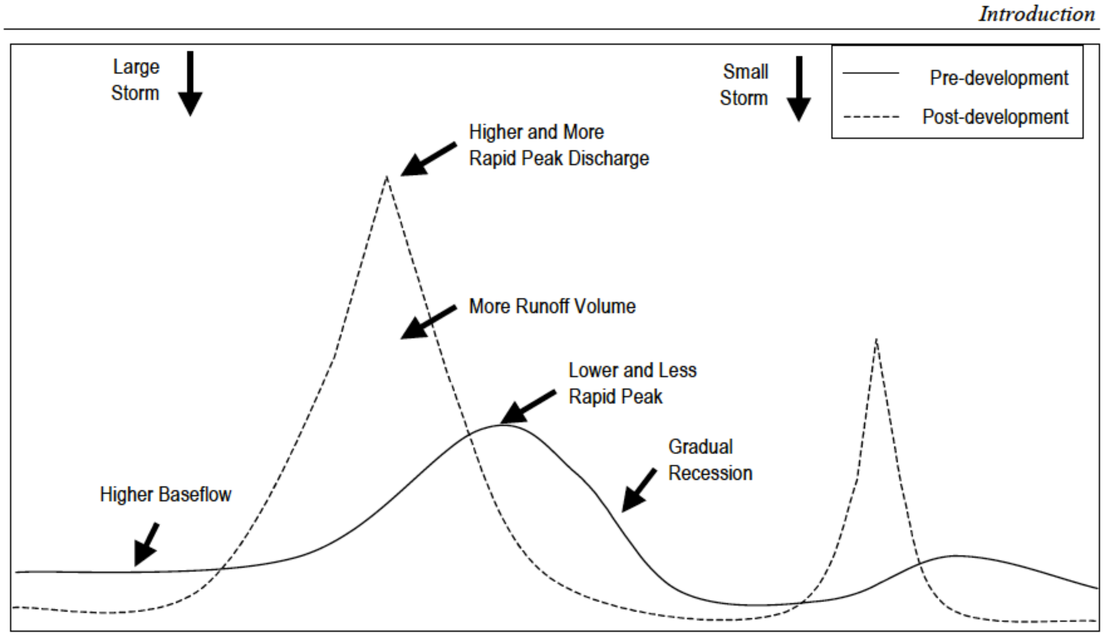


Figure 0.5: Changes in stream flow hydrograph as a result of urbanization (Schueler, 1987).

Photo: EPA, 2005

3. What are the negative impacts of water pollution?

Stormwater pollution affects human, aquatic, and plant life. Potentially harmful bacteria, viruses, soil particles, debris, oil, grease, and chemical compounds have been found in coastal waters and surface water bodies from coast to coast (LA LID Manual, 2011).

Leachate from storage tanks, pesticides, cleaning solvents, toxic chemicals, oil and grease from parking lots, and leaking petroleum are all transported into water bodies and receiving water by urban runoff. Algal blooms are created due to leaking septic tanks, and fertilizer constituents conveyed from lawns and golf courses. Disturbances of the soil due to construction, allows for silt to wash from storm channels into receiving waters, making them muddy, cloudy, and inhospitable to aquatic organisms. Artificial surfaces in our urban landscape deposit heavy metals, which are toxic to aquatic organisms, into the runoff as it flakes, erodes, dissolves, or decays (LA LID Manual, 2011).

3.1. Human Health

In 1999, a study was conducted to investigate possible health effects of swimming in Santa Monica Bay was done by the Santa Monica Bay Restoration Project, the Environmental Protection Agency (EPA), and then Governor of California Pete Wilson (Hale, 1999). The results indicated that individuals who swam near storm drain outlets have a greater risk in developing various illnesses, as opposed to those who swam at least 400 yards away from the same drains (Hale, 1999). These pollutants have a large impact on the natural aquatic habitat (LA LID Manual, 2011)

3.2. Water Supply

In the Piedmont eco-region of North Carolina, Lenat and Crawford (1994) discovered that agricultural lands had the highest concentrations of nutrients. There were higher levels of nitrogen, phosphorous, and fecal coliform bacteria in areas where there was poultry production within the Georgian Upper Oconee Watershed, noted by Fisher et. Al (2000). Bolstad and Swank (1997) discovered that changes in land use corresponded to the change in water quality in a study that was done in Western North Carolina along Coweta Creek. In an earlier study done in 1990, Tong discovered that urban development had caused many significant changes in flood runoff and water quality. Some of the main factors altering the hydrological system is our change in land use patterns and management practices, and because of this, it has forever altered runoff patterns (Mander et al., 1998), surface water supply yields (Wu and Haith, 1993), and quality of receiving water (Changnon and Demissie, 1996)(Tong and Chen, 2002).

3.3. Sediment

In the United States significant sources of water pollution have been created by excessive erosion, transport, and deposition of sediment in surface waters. Sediment is known to cause imbalances in temperature, filling interstitial spaces of spawning gravels, impairs sources of fish food, fills rearing pools, and greatly reduces habitat structure in stream channels. Sediment can also alter the taste and smell of drinking water, and block intake structures (USEPA, 2002).

19 percent of the Nation's 3.6 million miles of rivers and streams were surveyed in *The National Water Quality Inventory: 2000 Report to Congress*. The report found that 39 percent of the surveyed water sources were impaired by various pollution sources. Accounting for 31 percent of the impaired waters in the United States, sediment was found to be the second leading cause of impairment. It was also found to be the primary transporter of pollutants such as organic components, metals, ammonium ions, phosphates, and toxic organic compounds (EPA, 2005).

3.4. Habitat & Wildlife

While much of the pollution can be treated before it enters the surface water bodies, there are some wastes that cannot be filtered, such as feces from pets (EPA, 2005). If not disposed of properly, it can potentially wash into water bodies near by carried through our storm drain system. Because storm drains are not usually connected to a filtration system, they wash directly into our streams and lakes becoming significant sources of pathogens in surface water (EPA, 2005). Pet waste uses up oxygen, and sometimes releases ammonia. The combination of lower oxygen levels, ammonia and a change in water temperature can be catastrophic to fish and aquatic life. Pet waste also contains nutrients, parasites, bacteria, and viruses that can pose health risks to both humans and wildlife (EPA, 2005).

After development, daily activities can cause a discharge of pollutants in runoff that can have harmful effects on water quality and habitat (EPA, 2005). The changes in the landscape with the introduction of roads and channels increases velocity and volume, eroding stream banks, steep slopes, and areas with little to no vegetation (EPA, 2005). The destruction of the riparian buffer, which accounted for a large portion of wildlife habitat has led to increases in water temperature, stream bed scouring, and downstream sedimentation of stream bed substrates (EPA, 2005)

3.5. Ocean

Not only runoff contributes to non point source pollution, but marina and boating activities also play a part in the degradation of oceans. Chemicals used to repair and maintain boats can spill into the water, or make their way into the water bodies as runoff. Spilling fuel, discharge uncombusted fuels from engines, poorly maintained sanitary waste systems all leads to an increase in bacteria and nutrient levels (NOAA, 2008). 75 million gallons of petroleum makes its way into North America's oceans, and 10 percent comes form human activity, mostly from non point source pollution (Rabalias, 2003).

4. Reducing Pollution Creation through policy

Federal agencies have created plans to control and treat stormwater runoff before it reaches receiving waters amidst growing public concern over the effects of contaminated runoff on water quality (LA LID Manual, 2011). Urban runoff management programs have also been developed and implemented by federal, state, regional, and local governments. All play key roles in helping to establish and maintaining those programs. Team approaches are recommended in order to overlap key responsibilities and authorities, and also to help ensure that everyone functions cooperatively (EPA, 2005)

State programs play a big part in this approach to runoff management, by interpreting and coordinating federal mandates for implementation at the local level, and establishing state performance standards and design criteria for runoff mitigation. Not only do states typically take the lead in research, technical assistance, and public education programs, they generally allow the local jurisdictions to take care of management while they retain oversight and enforcement responsibilities in order to ensure consistency statewide (EPA, 2005). The federal governments role in NPSP management programs is to develop broad urban runoff guidance along with state, regional, and local governments.

While fitting the needs and attributes to a region, regional authorities generally share some of the duties of state agencies. They provide the necessary link between local communities and the state, and work to establish region based performance standards and design criteria to control runoff. By implementing the watershed approach, developing watershed plans, ensuring consistency of stormwater planning, and in mitigating situations that impact communities downstream regional authorities become the focal point in coordinating issues and interests amongst communities within the region (EPA, 2005).

The integration of local management planning with land use and regional watershed plans, floodplain management, wastewater planning is trending amongst cities, states and regional agencies involved with the daily administrative, operational, and technical aspects of runoff management. Enforcing compliance, performing inspections, identifying and removing prohibited connections, and coordinating funding are all to be considered when moving forward with regulation (EPA, 2005).

4.1. Existing Policies & Laws

4.1.1. Clean Water Act

Congress established the Nonpoint Source Management Program on 1987, under section 319 of the Clean Water Act (CWA), to address nonpoint source pollution by identifying waters affected by runoff pollution and implementing management programs to control it. These programs recommend the use of best management practices (BMPs) to mitigate polluted runoff, and to reduce the amount that reaches surface waters (EPA, 1995).

The Federal Clean Water Act is the prime instrument used for control of non point source pollution. The State of California General Plan Law (CGPL) for Municipalities and the California Environmental Quality Act (CEQA) are other programs that help to control pollution from stormwater. Under the Federal Clean Water Act, each city in the nation is issued a stormwater permit through the National Pollutant Discharge Elimination System (NPDES) program. The goal is to stop polluted discharges from entering the storm drain system and into receiving and coastal waters. In California, the State Water Resources Control Board (SWRCB) through its nine regional boards administers the NPDES stormwater permitting program (LA LID Manual, 2011).

The amendments made to The Federal Clean Water Act in 1987 helped the NPDES program to establish a framework for regulating stormwater discharges from municipal, industrial, and construction activities. The main objectives of the program are to prohibit non-stormwater discharges, and to reduce the discharge of pollutants to the MEP statutory standard (LA LID Manual, 2011).

4.1.2. National Pollution Discharge Elimination System

The National Pollution Discharge Elimination System (NEPDS) is the primary regulatory tool in the management of state water quality standards. Designed to meet water quality standards, NPEDS permits are issued by an authorized state or EPA and contain discharge limits and national technology based effluent regulations (EPA, 2007). In 1987 Congress amended the CWA in order to take a closer look at national efforts on mitigating non point source pollution (EPA, 2007).

A National Pollutant Discharge Elimination System (NPEDS) is required for construction sites with 5 or more acres of disturbed land because they are considered point sources of pollution under section 402 of the CWA. NPEDS also regulates discharges from industrial activities, discharges from municipal separate sewer systems serving populations of over 100,000 and discharges identified by the EPA or a state as needing an NPDES permit because of water quality violations. Other regulations are being developed by the EPA, which may include discharges from municipal separate sewer systems serving populations of less than 100,000 and discharges associated with commercial operations, light industries, and construction sites of less than 5 acres (EPA, 1995).

4.1.3. Coastal Zone Management Act and Reauthorization

A comprehensive management program was developed to protect and mange coastal water resources in 1972, called The Coastal Zone Management Act (EPA, 1995). As of today 29 states have federally approved coastal management programs. Amendments were made in 1990 through The Coastal Zone Act Reauthorization Amendments (CZARA), which charged coastal states and territories with developing upgraded programs to protect coastal waters from runoff pollution (EPA, 1995). The Environmental Protection Agency (EPA) and National Oceanic and Atmospheric Administration (NOAA) are charged with overseeing this program. CZARA applies to both stormwater runoff from roads that serve populations of less than 100,000 and also to construction sites in the 29 states and territories where less than 5 acres are disturbed (EPA, 1995).

4.1.4. Intermodal Surface Transportation Efficiency Act

The Intermodal Surface Transportation Efficiency Act (ISTEA) conceived in 1991, also known as “ice tea”, addresses the planning and development of highway systems, and transportational enhancements. One approach is to mitigate the pollution from highway runoff. States are capable of using a portion of their federal funding allotment for the mitigation of NPSP, and BMP’s in order to prevent contaminated runoff from reaching surface waters (EPA, 1995).

4.2. Federal Programs & Funding

4.2.1. Section 319 Grant Program

Section 319 of the CWA, EPA awards funds to states and eligible tribes to implement NPS management programs. These funds can be used for projects that address nonpoint source related sources of pollution, including Hydromodification. (EPA, 2007)

4.2.2. Clean water state revolving fund (CWSRF)

An innovative way to fund environmental projects is through the Clean Water State Revolving Fund (CWSRF). EPA provides grants or “seed money” to capitalize state loan funds. The states then make loans to individuals, communities and to other high priority water related activities. As loans are paid back, new loans are made. Projects funded with a loan through this program, generally cost less that what it would have if it were funded through the bond market. Just recently, states have begun to

4.2.3. Total maximum daily loads

Under section 303(d) of the CWA, states are required to compile a list of impaired waters that fail to meet any of their applicable water quality standards. This list, called a 303(d) list, is submitted to Congress every 2 years, and states are required to develop a Total Maximum Daily Load (TMDL) for each pollutant causing impairment for water bodies on the list. (EPA, 2007)

4.2.4. Water quality certification

Section 401 of the CWA requires that any applicant for a federal license or permit to conduct any activity that may result in any discharge into navigable waters must obtain a certification from the state or tribe in which the discharge originates that the discharge will comply with various provisions of the CWA, including sections 301 and 303. The federal license or permit may not be issued unless the state or tribe has granted or waived certification. The certification shall include conditions, e.g. effluent limitations or other limitations necessary to assure that the permit will comply with the states or tribes water quality standards or other appropriate requirements of state or tribal law. Such conditions must be included in the federal license or permit. (EPA, 2007)

4.2.5. National estuary program

The National Estuary Program (NEP) established by the CWA and the Federal Insecticide, Fungicide and Rodenticide Act help to control roadway pollution. The focus of NEP is on point source and runoff, especially high-priority estuaries. The pesticides program regulates pesticides, which can be a threat to both ground and surface waters (EPA, 1995). Under the National Estuary Program, states work together to evaluate water quality problems and their sources, collect and compile water quality data, and integrate management efforts to improve conditions in estuaries. To date, 28 estuaries have been accepted into the program. Estuary programs can be an excellent source of water quality data and can provide information on management practices. (EPA, 2007)

4.2.6. Safe drinking water act

In an attempt to improve and maintain the quality of drinking water, Congress passed The Safe Drinking Water Act (SDWA) in 1974. Its purpose is to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and now requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. It is especially important for urban fringe areas to maintain or improve the quality of surface and ground waters that are used as drinking water sources. This act calls for states to develop Source Water Assessment Reports and implement Source Water Protection Programs. Low or no interest loans are available under the Drinking Water State Revolving Fund (SRF) Program (EPA, 2007).

4.2.7. Wildlife habitat incentives program

The Wildlife Habitat Incentives Program (WHIP) is a voluntary program authorized by the farm security and investment act of 2002 (Farm Bill). The program enables landowners, and operators the ability to improve wildlife habitat while working alongside federal, state, and tribal organizations to improve both terrestrial and aquatic habitats.

NRCS and the participants work together to create a wildlife habitat development plan that include a cost sharing type of agreement, continued assistance after habitat development includes monitoring, review of management guidelines, and technical advice. Dam removal projects can also use WHIP funds. (EPA, 2007)

5. Water Pollution Management, Prevention & Mitigation

The first thing one must do is to establish a reference condition in order to create a basis for comparison. The reference should characterize the undisturbed natural systems but it is also important to understand that if there is impairment there must be an understanding of how it all occurred before undergoing costly efforts to mitigate anthropologic inputs. There are two types of reference conditions to keep in mind site specific and regional.

Site-specific conditions are generally determined from one or more locations in a watershed or stream in areas where there are discharges occurring. Regional reference conditions are established from unimpaired sites within a relatively homogeneous region and habitat type. Omerink (1987) developed a way in which to interpret spatial patterns in data by creating an ecoregional framework based on land surface form, soil, and potential natural vegetation which can then be used to help develop a reference condition for a relatively homogeneous region.

Water pollutant loads can be estimated through the use of models. Models are used to estimate storm water pollutant loads in receiving water bodies, enabling watershed managers to target specific areas for non point source pollution control. (EPA, 2005) In order to help watershed managers determine how to meet water quality standards water quality models are used to identify impacts from runoff. Because of the complexity of the calculations computers are generally used. Models are available for all different types of water bodies, and most models couple quantity and quality parameters, but some consider them separately. (EPA, 2005)

In an attempt to emulate and preserve the natural hydrologic cycle altered by urbanization the watershed approach consists of a series of Best Management Practices (BMP's) designed to filter pollutants, reduce velocity, and volume of urban runoff before reaching water bodies. (CWPU, 2009) The ability of the watershed approach to be applied to both large scale and small-scale watersheds is a key element in its success. The flexibility of its application allows it to work regardless of objectives, priorities, actions, timing and resources. (EPA, 2005) Ideally individual measures should be combined considering the potential source of the pollution, purpose, cost, operational and maintenance requirements of the measures, vulnerability of the source waters, the public approval and the communities desire for safety. (EPA, 2001)

5.1 Management / Prevention Measures

5.1.1. Management

"Comprehensive planning is an effective nonstructural tool to control nonpoint source pollution. Where possible, growth should be directed toward areas where it can be sustained with minimal impact on the natural environment (Meeks, 1990). Poorly planned growth and development have the potential to degrade and destroy natural drainage systems and surface waters (Mantel et al., 1990)."

Development and land disturbance can be directed away from ecologically sensitive areas just by making accurate informed planning decisions. Utilizing land use designations and zoning laws can protect riparian corridors, wetlands, and other sensitive areas. (EPA, 2005)

Riparian buffers and wetlands not only have the capability of mitigating pollution, they attenuate the release of sediment into stream channels, and are also cost effective when compared to the cost of building and maintaining structural controls. Critical to maintaining surface water quality is the conservation and preservation of lakes, streams, and wetlands. Riparian buffers alongside stream banks not only provide protection for the stream ecosystem, but also help to stabilize, and prevent stream bank erosion. (Holler, 1989) Well-developed riparian vegetation has also been shown to slow the increase of suspended solids in stream channels. (Holler, 1989) (EPA, 2005)

Management programs use management measures to guide the development of the program. Performance expectations are established, and actions are taken to mitigate the non point source pollution. (EPA, 2005) Management measures are designed to address a particular issue, and the implementation of these management measures can help to minimize and control hydromodification, control pollutants, manage instream and riparian habitat restoration. (EPA, 2001) It is important to remember that the most effective stormwater pollution prevention plans combine the measures and consider the land use conditions, soil, and precipitation. (EPA, 2001)

Program and administrative indicators can be evaluated for their effectiveness once they have been established and management practices have been implemented. This evaluation involves reassessing conditions in the watershed in order to determine whether the implemented practices were effectively reducing non point source pollution. This evaluation can also identify additional opportunities for restoration, and can be used to help guide future watershed initiatives. (EPA, 2005)

Initially viewed as a response to flood control, urban stormwater management is now being linked to resource strategies. Growing concerns about water quality and the impacts of stormwater runoff have led water agencies to look at different approaches and their benefits. (CWPU, 2009)

Key management measures for roads, highways, and bridges include the following:

- Protect areas that provide important water quality benefits or are particularly susceptible to erosion or sediment loss.
- Limit land disturbance such as clearing and grading and cut fill to reduce erosion and sediment loss.
- Limit disturbance of natural drainage features and vegetation.
- Place Bridge structures so that sensitive and valuable aquatic ecosystems are protected. Prepare and implement an approved erosion control plan. Ensure proper storage and disposal of toxic material.
- Incorporate pollution prevention into operation and maintenance procedures to reduce pollutant loadings to surface runoff.
- Develop and implement runoff pollution controls for existing road systems to reduce pollutant concentrations and volumes.
  (EPA, 1995)

5.2. Mitigation techniques

Draining parking lots, driveways, and walkways into landscaped zones with permeable soils, surfaces and dry wells are a few of the methods used to recharge ground water through infiltration. Infiltration allows for the natural filtration of pollutants from the water as it travels through the soil substrate and into the aquifer. (CWPU, 2009) It is important to note that the watershed approach will not be able to prevent all urban runoff from reaching waterways, it is an attempt at managing the pollutants that are scoured from the urban landscape as water travels through the conveyance systems created to move it out. (CWPU, 2009)

5.2.1. LID

A relatively new stormwater management approach directed at achieving this goal is the use of Low Impact Development (LID). Within the past 10 years, LID practices have received increased attention and implementation, becoming a leading practice for stormwater pollution prevention. Starting in Chicago with its green alleys program in 2006, other cities have followed with the creation of their own LID manual green streets programs. In recognition of this, recent action by the RWQCB, SWRCB, and US EPA have prioritized the use of LID as the preferred approach to stormwater management, including for the purpose of water quality compliance. (LA LID Manual, 2011)

Low Impact Development (LID) is a stormwater strategy that addresses the issue of increased pollutant loads in the waterways due to stormwater runoff. LID is made up of a collection of site design approaches and Best Management Practices (BMPs) that encourages the use of natural systems for infiltration, evapotranspiration, and reuse. These LID techniques are effective in removing nutrients, bacteria, and metals while reducing the volume and intensity of the stormwater flows. These systems can be applied onsite and are made to mimic predevelopment drainage characteristics. Rain gardens, green roofs, rain barrels, and bio retention ponds are other options available when infiltration is not possible. (LA LID Manual, 2011)

5.2.2. BMP's

The incorporation of best management practices (BMPs) in building and site-development codes should be encouraged. The proper maintenance of rights-of-way, control of chemical and nutrient applications, street cleaning or sweeping, storm drain cleaning, use of alternative or reduced de-icing products, and equipment washing can all help to reduce the pollutant content in the stormwater runoff. (EPA, 2001)

It is important to note that sitting BMPs for storm water drainage wells require minimum setbacks from surface waters, drinking water wells, or the water table. Storm water drainage wells may also be prohibited from areas of critical concern. Available design BMPs for storm water drainage wells include sediment removal devices (such as oil/grit separators or filter strips), oil and grease separators, and pretreatment devices such as infiltration trenches or wetlands (described above). Maintenance of these BMPs is crucial to their performance. Management measures related to operation include spill response, monitoring, and maintenance procedures. Source separation, or keeping runoff from industrial areas away from storm water drainage wells, involves using containment devices such as berms or curbs (see the fact sheets on vehicle washing and small quantity chemical use for more information on these devices). (EPA, 2001)

5.2.3. Constructed Wetlands

Constructed wetlands have typically less diversity than natural wetlands. Wetlands are as efficient as wet ponds at removing pollutants, and its maintenance requirements are similar to those of wet ponds. (EPA, 2001) Designed to treat stormwater runoff, constructed wetlands contain more aquatic vegetation with a smaller open water area that wet ponds. Constructed wetlands are extremely effective in mitigating agricultural runoff by capturing water, and holding it for infiltration, and filtering the water as it percolates into the groundwater.

5.2.4. Decreasing impervious surfaces

Minimizing connected impervious areas reduces stormwater flow and volume. Directing flow away from roads, roofs, sidewalks and parking lots and into grassed or vegetated areas will help to ensure that the water is contained and slowly infiltrated. Concrete grid pavement is used when extra support is needed, it is placed on a sand or gravel base with void spaces filled with sand, gravel, or grass. Stormwater flows through the voids and down into the groundwater. (EPA, 2001)

5.2.5. Construction mitigation

Not only should construction be planned to correspond with low rainfall in order to minimize any erosion factor, it should also be staged to reduce soil exposure. Other measures that need to be taken prior to the start of construction activities include sediment traps and basins, sediment fences, wind barriers, sediment, chemical, and nutrient control. (EPA, 2001) Construction entrance pads and vehicle washing also help to keep sediment and soil on site.

5.2.6. Infiltration

Infiltration is one of the goals of stormwater management. By allowing the stormwater runoff to percolate into the groundwater, and is filtered naturally. The biological decomposition properties of the soils, plant roots, and microorganisms all work to remove pollutants prior to the water recharging the groundwater. Infiltration BMPs include infiltration basins, infiltration trenches, infiltration galleries, drywells, bioretention (without the under drain), and permeable pavement. Infiltration allows for peak flow management, pollutant removal, groundwater recharge, and flood control. There are certain conditions that are not suitable for infiltration, such as sites with the wrong soil properties. Proximity to building foundations and other infrastructure, geotechnical hazards, and hazardous sites are also examples of locations that would not be suitable for infiltration. (LA LID Manual, 2011) Recharge basins should be designed to minimize physical, chemical, or biological clogging, and need to be periodically excavated in order to maintain its infiltration capacity. By developing a groundwater management plan in order to protect the quantity and quality of the groundwater. (CWPU, 2009)

Infiltration basins and trenches are generally long, narrow stone filled excavated trenches 3-12 feet deep. Runoff is stored within the basin or in voids between the aggregate and is slowly infiltrated into the soil matrix where it is filtered on its way down into the water table. It is recommended that infiltration should be combined with a “pre-treatment practice” such as a swale or sediment basin in order to prevent clogging. Infiltration systems have the potential to remove up to 70-98 percent of the contaminants in the water. (EPA, 2001)

5.2.7. Vegetated open channels & detention/retention ponds

Many times, wet ponds are developed as water features in a community, not only do they increase the value of the adjacent property they are also functional. Storm water ponds (wet ponds) are made up of a permanent pond, and a zone of wetland vegetation where contaminants are removed through biochemical processes. Other than maintaining the landscape periodically, only an annual inspection of the outlets Storm water pond and shoreline is required. Vegetation should be harvested every 3 to 5 years, and sediment should be removed every 7 to 10 years. Wet ponds can achieve 40 to 60 percent phosphorus removal and 30 to 40 percent total nitrogen removal. (EPA, 2001)

6. Conclusion

The benefits from urban runoff management include the reduction of stormwater pollution, improved flood protection, an increase in water supply through groundwater recharge, improved wildlife habitat, and an increase of open space. Groundwater recharge and storm water retention sites can be designed to provide additional benefits to wildlife habitat, parks, and open space. Underground infiltration facilities not only store runoff, they have the ability to release water gradually to the aquifer while allowing the unimpaired use of the surfaces above them. Or the captured water can be used as a source of irrigation water. (CWPU, 2009)

If land use changes in the future, the levels of contaminants will be changed accordingly. Hence, future land development and management should be considered with care. This is especially the case if the land is going to be changed to agriculture or impervious urban lands. With a better land-use planning, we may be able to curtail some of the water quality problems. (Tong and Chen, 2002)

References:

U.S. Environmental Protection Agency (USEPA). (February 2003). *Protecting Water from Urban Runoff.* EPA-841-F-03-003. *U.S.* Environmental Protection Agency, Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (November 2005). *National Management Measures to Control Nonpoint Source Pollution from Urban Areas.* EPA-841-B-05-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

National Resources Defense Council (NRDC) (2011) *After the Storm: How Green Infrastructure Can Effectively Manage Stormwater Runoff from Roads and Highways*

National Oceanic and Atmospheric Administration (NOAA) (March, 2008)
Non Point Source Pollution: Marinas and Boating Activities.
http://oceanservice.noaa.gov/education/kits/pollution/09activities.html

U.S. Environmental Protection Agency (USEPA). (1997). *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls*. EPA 841-B-96-004. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (1998). *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures: Urban*. EPA 841-B-00-007. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (July 2007). *National Management Measures to Control Nonpoint Source Pollution from Hydromodification.* EPA 841-B-07-002. *U.S.* Environmental Protection Agency, Washington, DC.

City of Los Angeles. (June 2011). *City of LA LID Handbook Draft: Development Best Management Practices Handbook.* Los Angeles, CA.

U.S. Environmental Protection Agency (USEPA). (August 1995). *Controlling Nonpoint Source Runoff Pollution from Roads, Highways and Bridges.* EPA-841-F-95-008a. U.S. Environmental Protection Agency, Washington, DC.

State of Texas. (November 2003). *Draft Texas Nonpoint Source Pollution Assessment Report and Management Program,* SFR-68/04. TX.

Farrell-Poe, Kitt. (January 1995). *Non Point Source Pollution*. Utah State University. UT.
Garrison, Noah. Hobbs, Karen. Natural Resources Defense Council (NRDC). (2011)

Rooftops to Rivers II: Green strategies for controlling stormwater and combined sewer overflows. Washington, DC.U.S. Environmental Protection Agency (USEPA). (August 2011).

Healthy Watersheds
Initiative: National Framework and Action Plan. EPA 841-R-11-005. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Levine, Larry. Natural Resources Defense Council (NRDC). (2012). *Financing Stormwater Retrofits in Philadelphia and Beyond.* Washington, DC.

U.S. Environmental Protection Agency (USEPA). (January 1992). *Managing Non Point Source Pollution.* U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (August 1987). *Nonpoint Source Pollution: The Nation's Largest Water Quality Problem.* EPA-841-F-96-004A. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (1987). *Non Point Source Pollution Control: A Guide.* EPA-841-B-87-111. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (July 2003). *National Management Measures to Control Nonpoint Source Pollution from Agriculture.* EPA 841-B-03-004. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (July 2007). *National Management Measures to Control Nonpoint Source Pollution from Hydromodification.* U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (November 2005). *National Management Measures to Control Nonpoint Source Pollution from Urban Areas.* EPA-841-B-05-004. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (USEPA). (February 2003). *Protecting Water Quality from Urban Runoff.* U.S. Environmental Protection Agency, Washington, DC.

Natural Resources Defense Council (NRDC). (2011). *Community Responses to Runoff Pollution.* Washington, DC.

U.S. Environmental Protection Agency (USEPA). (November 2005). *Source Water Protection Practices Bulletin: Managing Storm Water Runoff to Prevent Contamination of Drinking Water.* EPA-816-F-01-020. U.S. Environmental Protection Agency, Washington, DC.

Tong, Susanna. Chen, Wenli. (April 2002). *Modeling the relationship between land use and surface water quality.* Department, University of Cincinnati, Cincinnati, OH

U.S. Environmental Protection Agency (USEPA). (November 2005). *Source Water Protection Practices Bulletin: Managing Storm Water Runoff to Prevent Contamination of Drinking Water.* EPA-816-F-01-020. U.S. Environmental Protection Agency, Washington, DC.