TALLINN UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING
DEPARTMENT OF ENVIRONMENTAL ENGINEERING

Urban Stormwater Charging Strategy

Sademevee maksustamise strateegia

EKV70LT

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I have prepared the Master's thesis independently.

All papers of other authors, major opinions, and data originating from bibliographical and other sources have been referred.

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The thesis meets the requirements set to a Master's thesis

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THE INITIAL TASK

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- Tallinna sademevee strateegia aastani 2030, Tallinna õigusaktide register
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- United States Environmental Protection Agency stormwater charging related material
- National Association of Flood and Stormwater Management Agencies - Guidance for Municipal Stormwater Funding
- New England Environmental Finance Center - Stormwater Utility Fees (report)
- The Earth's Best Defence - Financing Stormwater Retrofits in Philadelphia and Beyond
- Other relevant information and examples of stormwater charging

Content of the thesis:

Objective of this thesis is to give an overview of different stormwater charging systems. It involves finding different methodologies used in different cities and present examples of how the cities are using these charging systems.

This thesis in needed because in Estonia there is no stormwater charging system implemented. The thesis is a good basis to better understand stormwater charging methods used in other countries and differences between charging systems

Explanatory letter:

Summary in English

The main goal of this thesis is to find out different stormwater charging methods and ways to calculate them. This thesis is needed because there is no stormwater charging system introduced in Tallinn as well in whole Estonia at the moment. This thesis can help to give an overview of different stormwater fee systems in different cities that Tallinn could use. Stormwater charge and credit systems examples can help to understand stormwater charging methodologies better and bring out the negative and positive sides. In addition to stormwater charging possibilities the thesis gives an overview of stormwater management practices and fee implementation considerations.

Resümee eesti keeles:

Antud lõputöö eesmärk on välja selgitada erinevaid sademevee maksustamise ja nende arvutamise võimalusi. Lõputöö teema on päevakohane, sest antud hetkel ei ole Tallinnas, ega ka Eestis tervikuna, veel sademevee maksustamist rakendatud. Antud lõputöö analüüsib ja annab ülevaate erinevatest sademevee maksustamise võimalustest, mida Tallinn ja ka teised Eesti asulad saaks sobiliku süsteemi valikul kasutada. Antud lõputöös käsitletud erinevate linnade maksustamise süsteemi ja soodustuste näited aitavad paremini maksustamise metoodikat ja erinevate metoodikate positiivseid ja negatiivseid külgi mõista. Lisaks sademevee maksustamise võimalusetele antakse antud lõputöös ka ülevaade sademevee äravoolu vähendamise võimalustest ning sademevee maksustamise süsteemi juurutamisest.

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Introduction

Over the time urbanisation has become more common due to this more areas have become artificial. Artificial areas restrain the infiltration of rainwater, due to that more rain becomes runoff. When there is an increased amount of stormwater runoff it can cause flooding which is a threat to property owners. Flooding can do damage to people's property. When the stormwater runoff runs on streets and other impervious surfaces it can collect pollutants and this can affect the receiving waters and can impose a threat to human health and fishes. Since the first few centimetres can be the most polluted it should be dealt with on site.

The stormwater systems need constant repairmen and improvement. All the leakages have to be eliminated especially when combined stormwater systems are used and new and better solutions for stormwater management should be applied. This means that the city needs extra resources because the city's budget is usually not enough and there are always issues with higher priority that should get more money than stormwater.

But getting more money to the Citys Budget is not the only goal. It is important to include citizens to the stormwater management, to use stormwater as a resource, to educate people and to reduce the load of stormwater in the sewage, regardless of whether the stormwater is directed to separate or combined sewers [1].

At the moment not many people are thinking when building a sidewalk or parking lot or any-other impervious surface how this affects rainwater runoff. Also not many think how they can contribute to helping more rainwater to infiltrate to the ground or how to decrease the amount of rainwater entering to the drainage. Many do not see a problem because there not involved and nobody has acquainted them with problems.

Stormwater has to be dealt with onsite and right away to increase the need to eliminate the consequences. One vital point in stormwater management is to involve people and to raise their awareness. In order to gain that informing people will usually not help. They will have to be motivated and educated in some way.

One way to influence people is to collect charges. Charges not only help to collect money to cover the costs for maintaining and improving stormwater systems but it can also be a good tool to motivate people to be more aware of the environment around them. Charging systems can have a Credit system added and this can influence people to use different stormwater management practices.

Tallinn is not charging the stormwater runoff but according to the stormwater strategy there are many things the City wants to do to eliminate problems and improve systems and for that the city needs extra resources. Since stormwater charges have not been collected in Estonia before it is important to find out different charging methodologies and examples of their implementation

Main examples in this thesis are from United States. There are approximately 600 stormwater utilities in the Country so a wide spectrum of examples can be found. To understand the United States examples better it's important to clarify the systems of measurement. 1 foot is 0.3048 meters (0.0003048 km), 1 inch is 0.0254 meters and 1 square foot is 0.0929 square meters. All the United States stormwater fees are in dollars.

The main goal of this thesis is to find out different charging possibilities and how they can be calculated. Give examples of the charging methodologies and credit systems used in other cities, introduce stormwater management practices and bring out fee implementation considerations.

1 Concepts

Stormwater is rainwater or water resulting from any form of precipitation that has fallen to a built-up area. If not drained properly it can cause inconvenience, damage, flooding and further health risks [3].

Sewage is waste material that is carried away from homes and other buildings in a system of pipes [50].

Detention basins are facilities that provide flow control. The ponds are usually earthen structures that are constructed by impoundment of a natural depression or excavation of existing soil [51].

Watercourses are natural or artificial channels where water flows [52].

Receiving waters can be a river, sea, stream, or other watercourse where treated wastewater is discharged [53].

Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) is the governing party of Convention on the Protection of the Marine Environment of the Baltic Sea Area.

Gross area (GA) is the total parcel area within the legally described boundaries except streets, medians, and sidewalks in the public right-of-way [24].

Impervious area (IA) is an area that is covered with material that restricts infiltration of water including semi-pervious surfaces such as compacted clay, most conventionally hard-scaped surfaces such as streets, driveways, roofs, sidewalks, parking lots, attached and detached structures, and other similar surfaces [24].

Urban tree canopy (UTC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. It intercepts rainfall that would otherwise run off of paved surfaces and be transported into local waters though the storm drainage system [25].

SCS Runoff Curve Number Method (NRCS-CN) is a method to estimate how much excess rainfall can be produced. The basis is the empirical relationship between the rainfall that is not converted into runoff and runoff properties of the watershed and the rainfall [26].

National Pollutant Discharge Elimination System (NPDES) is an Environmental Protection Agency's (EPA) program initiated to reduce and eliminate pollutants reaching water bodies of all types [29].

Storm Water Pollution Prevention Plan (SWPPP) is requirement of the NPDES that regulates water quality when associated with construction or industrial activities [70].

Equivalent Residential Unit (ERU) is a descriptive value based on the total gross area and the amount of impervious surface within each parcel [33].

Stormwater best management practices (BMPs) are activities or improvements that that reduce the quantity and improve the quality of stormwater runoff [2].

Southeast Metro Stormwater Authority (SEMSWA) is an independent governmental entity formed by formal agreement to provide stormwater management and maintenance for the City of Centennial [27].

Ordiance is a degree or law declared by a state or national government which applies only within its boundaries [94].

Helsinki Region Environmental Services Authority (HSY) is a municipal body that provides wastewater management and water services in Espoo, Helsinki, Kauniainen and Vantaa [96].

2 Sewers

In nature when rainwater falls to the surface some of this water evaporates, some runs off the surface and most of it infiltrates to the surface, more artificial surfaces in the cities means that less water is infiltrated and more becomes a runoff. As a result there is a more likely chance of floods and decrease in stormwater quality [3].

In order to collect the runoff caused by rainwater, cities have different drainage solutions. The main three sewer systems are combined sewers, separate sewers and partially separate sewer systems. Each of the system has good and bad sides to them which will be discussed below.

2.1 Combined sewers

Combined sewers are the networks of underground pipes that collected rainwater runoff, domestic sewer and industrial wastewater all to one place. When the weather is dry the sewage is sent by the sewer system to the wastewater treatment plant, which treats and discharges it into the recipient. Since the stormwater is also sent to the treatment plant there is unneeded waste of property owner's money, those who are paying for the stomwater collection. Stormwater and wastewater need different treatments. [9, 48]

When there are heavy rains or flooding the rain or snowmelt, can fill up a combined sewer. Since the sewers are designed with escape overflow pipes so the mixture of sewage and stormwater doesn't back up into buildings including homes. As a result the sewage is discharged to rivers, lakes, and coastal waters potentially harming public health and the environment [9].

2.2 Separate sewers

Separate sewerage system is a system where stormwater and sewage are in two separate sets of sewers. Stormwater is usually less polluted than wastewater so in separate systems they can be treated differently and in case of overflows sewage would not be affected of it. The sewage will be carried to the treatment plants in a closed system, while stormwater can be discharged to detention basins and watercourses. This means that in case of overflows, stormwater that is discharged to the environment would not be contaminated by sewage, which means that it is

more hygienic and the risk to public health is minimal. One of the advantages of this system is that it enables to reuse the stormwater [10].

Sewer separation has been used to eliminate overflows from combined sewers for over 50 years and it is getting more common. But there are some problematic points to this system. It is too disruptive, costly, and it may cause pollution to receiving waters because of increased discharge of untreated stormwater. The pollutants may come from rooftops, lorry loading bays, industrial sites and even from illegal connections to the surface water system. It is important, that the sewage network is carefully planned so the above mentioned problems as well as the local rainfall patterns are taken into account [10].

2.3 Partially separate sewerage system

Partially separate sewerage system is a system where the stormwater flows in a separate pipe system just like in separate sewage system. The difference between partly separate and separate sewage system is that the main collector has a segregation chamber that allows a certain amount of stormwater to the treatment plant. In case of heavy rains and flooding the overflows are discharged to the receiving body of water. In case of overflows the untreated stormwater is not mixed with wastewater so the wastewater is not discharged to the waterways. This is the best feature in this system and the good thing about this system is that it combines the good features of combined and separate sewage systems although the stormwater treatment together with wastewater is still questionable [11, 12].

3 Legislation

3.1 HELCOM

Estonia together with Denmark, the European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden are a part of Helsinki Commission (HELCOM), which main purpose is to protect Baltic Sea marine environment [14].

According to HELCOM Action plan the contracting parties have to prevent and eliminate pollution of the Baltic Sea from land-based sources by using best Environmental Practices and Best Available Technology. One of the important approaches is to reduce discharges from urban areas and municipal and domestic wastewater should be collected and treated before discharged to the waterbodies. Drainage and stormwater should never be led to wastewater treatment system. In order for that countries have to develop better sewage systems and they have to be maintained and renewed regularly [15].

Helcom Recommendation 23/5 sets more specific recommendations to the contracting parties concerning the proper management of stormwater. First and most importantly stormwaters quality must be dealt already in the source. Then the amount of stormwater entering the sewer systems should be minimized but this depends on the contamination of stormwater. But if the stormwater is contaminated it should be treated separately. In case of combined sewer systems, the aim is to decrease the overflow to the average of 10 times per year or limited to 10% of the total load conveyed to the sewerage system [16].

3.2 European legislation

The stormwater management is not clearly managed by the European Union directives. According to the Water Framework Directive Europe is aiming to promote sustainable use of water, while reducing or eliminating pollutants. The main goal is to achieve the "good status" of waterways [54].

Urban Wastewater treatment directives one key point is that the European Countries to take measures to limit the pollution of receiving waters from stormwater overflows under extreme situations, such as unusually heavy rain but this regulates only combined sewers [55].

3.3 Estonian legislation

In Estonia sewage, stormwater and drainage, wastewater treatment and collection systems are regulated by Public Water Supply and Sewerage Act. This act provides the rights and obligations of the state, local governments, water undertakings and clients. The local government can decide if the structures and equipment for transporting rain water, drainage water and other soil water, as well surface water are a part of a public water supply and sewerage system and the local government is in charge of making a public water supply and sewerage development plan [13].

According to the law it is allowed to collect money for the services of supplying water and discharging and treatment of wastewater, drainage water and also for leading off and treatment of rainwater, drainage water, as well other soil and surface water. So far the local governments have not charged this fee but according to the law they are allowed to do so. The charge for discharging and treatment of stormwater, drainage water and other soil and surface water may differ depending on whether it is being conducted to a combined sewer system or to stormwater pipes [13].

When we look at combined sewage Estonian Government has regulated stormwater discharge from combined sewage with sewage regulation where it is said that stormwater from combined sewage can be discharged to waterways in 1/4 ratio. The overflow should work only when there is one part wastewater and four parts stormwater in the sewage [1]. This means that when it foods the storwater together with sewage may be discharged to waterways.

3.4 United States Legislation

Many United States cities already have stormwater utility systems and the property owners are paying for the stormwater service. Since this paper has many examples how United States cities are collecting money for stormwater management it is important to introduce their legislation.

The Clean Water Act is the main legislation concerning waterways in The United States. Its main goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The long term goal is to eliminate polluted discharges to surface waters but at the moment the main goal is to achieve swimmable and fishable waters [47].

Since the main goal of the Clean Water Act is to limit pollutants to surface waters the volume of discharges tend to be secondary or not regulated at all. This is in the hands of state and local governments to regulate stormwater discharges [47].

The state agency can collect stormwater fees only when the state legislatures have authorized them to do so. When there is no authorization some state agencies are not able to create needed stormwater programs and in these states the stormwater programs are usually underfinanced and understaffed [47].

4 Situation in Tallinn

4.1 Precipitation

The annual precipitation in Estonia is 626 mm per year. The month with the highest monthly rainfall is August 79.1 mm (Figure 1) the average precipitation in a month is around 52 mm [83].

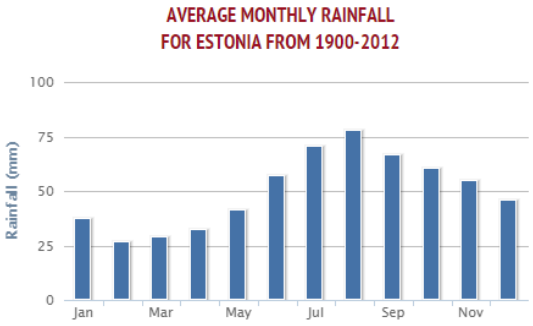


Figure 1 Estonia Precipitation Graph[83]

According to Estonia Wheather Service in Tallinn the annual precipitation is 704 mm per year, which means that the average precipitation in a month is around 58 mm (Figure 2) [84].

Sademete hulk (mm) 1981-2010

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Aasta
Jõgeva	50	36	38	30	49	79	76	93	60	71	56	50	688
Jõhvi	45	33	39	32	49	83	81	103	74	82	65	50	736
Kihnu	37	29	30	30	34	58	65	66	62	64	58	45	578
Kunda	39	26	28	25	39	71	67	82	60	62	50	38	587
Kuusiku	62	43	43	34	44	74	82	89	69	87	71	64	766
Lääne-Nigula	54	36	37	33	36	58	71	87	68	78	73	56	688
Pärnu	60	44	44	37	37	73	79	79	67	83	75	67	746
Ristna	55	39	37	31	33	47	55	69	62	72	79	60	639
Ruhnu	43	29	33	29	36	58	65	71	59	68	57	46	603
Sõrve	43	30	31	28	33	52	64	66	56	70	67	47	587
Tallinn-Harku	56	36	37	32	36	64	84	86	67	78	70	57	704
Tartu-Tõravere	48	35	38	30	55	84	72	86	61	69	53	49	680
Tiirikoja	45	34	35	29	49	74	76	82	58	63	54	49	648
Türi	57	40	41	36	44	77	81	95	72	82	69	60	755
Valga	56	40	42	33	53	83	68	85	59	72	57	56	708
Viljandi	62	43	42	36	48	87	83	91	67	81	64	60	764
Vilsandi	47	30	34	28	31	48	49	68	64	70	70	51	585
Virtsu	52	36	36	31	30	52	66	74	64	73	67	51	628
Võru	46	34	36	30	52	84	80	86	62	64	51	47	665
Väike-Maarja	46	33	36	31	43	74	80	94	68	81	59	48	693
Keskmine	**50**	**35**	**37**	**31**	**42**	**69**	**72**	**83**	**64**	**74**	**63**	**53**	**672**

Figure 2 Precipitation in Tallinn [84]

As we can see in the Figure 1 the high peak of rain comes in the summer.

4.2 Legislation

Tallinn stormwater strategy until year 2030 (Tallinna sademevee strateegia aastani 2030) is a document where Tallinn has worked out a complete stormwater management plan that includes stormwater management practices and solutions to minimize stormwater impact [1].

The main goals of the strategy are:

- prevent and eliminate floods
- work out draining needs, solutions, workflows, bias and deal with excessive draining
- reduce harmful substances in stormwater and recipients, to improve and maintain conditions of waterbodies
- use stormwater as a resource
- gain stormwater systems sustainability, financing and economic efficiency

- minimize the negative impacts of construction [1]

The strategy agrees that without financing system for stormwater drainage it is hard to motivate onsite management of stormwater [1].

4.3 Sewage systems

Tallinn had brush drainage already in the 12th century. In the 16th and 17th century there was wood drainage that was mainly meant for draining stormwater. The wooden pipes were replaced with cast iron pipes in 1843 and after that the development of sewerage started. 1946 was the first time that three types of sewerage systems were explained - combined sewers, separate sewers and partially separate sewerage system but it was not until 1960 that the first separate sewer was built. By that time the street sewerage was approximately 165.6 km long. By 2008 the length of sewerage was approximately 800 km and the length of stormwater drainage system was 315 km. In 2010, 99.8% of houses in Tallinn were connected to the sewerage system [6].

The area of Tallinn is 157.28 km² where 74 km² is covered with sewerage. Out of the 74km² 44.8 km² has separate stormwater drainage and the rest 29.2 km² is combined sewerage. Tallinn sewer and drainage maps are shown in Appendix 1 [4, 5].

Large parts of Nõmme, Lilleküla, Merivälja, Pirita, Kose, Maarjamäe, Veskimetsa and Mõigu developed areas and some other areas do not have a sewerage system. Many local sewerage systems go through inadequate treatment systems and the treated water flows through exhaust pipes to Pirita River or to the sea. Also there is no stormwater drainage in Nõmme and Lilleküla and many parts of Tallinn still have combined sewerage [8].

4.4 Problems with stormwater runoff

One of the most problematic streets, which floods all the time is Tuukri Street. During heavy rains the water level on the street rises and makes it hard for the cars to move around. Also because of heavy rain basements and yards are flooded. The rain damages the cars and property (Figure 3).

Tuukri and Ahtri streets are connected to Härjapea pumping station. This region has historically been one of the lowest places in Tallinn. After the floods in 2004 pumps were added to the Härjapea station. This increased the capacity of the pumping station from 3600 to 8400 cubic meter per hour but this still did not fix the problem. Combined sewer is used in the centre of Tallinn so in order to prevent the floods in the future Tallinn should consider building a separate sewerage system in that area. This would take the load off the pumping station [1, 17].

Figure 3 Floods in Tuukri street [87]

Tuukri Street is not the only place in Tallinn that has a high risk of overfloods. The same risk is in Pirita Street, Merivälja street and A. H. Tammsaare street.

4.5 Stormwater fee

Tallinn has not implemented a stormwater fee system but according to Tallinn stormwater strategy until year 2030, Tallinn has a plan to collect money from landowners to cover the costs of stormwater collection. Tallinn and AS Tallinna Vesi have a contract where it is stated that Tallinn pays for stormwater collection, purifying and discharge to the environment and for the development of stormwater collection systems about 3,2 million euros a year, depending on the amount of stormwater. This would mean that each citizen in Tallinn should pay about 8 euros a year to cover these costs. In addition there are several investments that Tallinn is planning to make according to Tallinn stormwater strategy until year 2030 [1].

5 Funding sources

There are many ways a city can collect money for stormwater management. The most common ways to fund stormwater management are discussed below.

5.1 Taxes

Tax revenue (e.g., property, income, and sales) contributes a large sum of money to municipal general funds. Through this communities fund their public works, including stormwater management. General funds are stable, staying the same from year to year and may be used by the local governments for any legal purpose. Since the money is going to one place how the money is used depends on how the priorities are set in the government. For example stormwater management programs are often not considered as a priority when compared to other public services such as public safety, schools, and social services. This general fund financing system is not transparent if we look at the total cost of stormwater management because the costs are dispersed across general fund departmental budgets. This may lead to a situation where stormwater management does not get enough money. [18].

The way the tax is calculated is not related to the costs of stormwater generated by individual properties. Property taxes are calculated based on an assessment of the value of land, and this not related to the stormwater runoff. Also some properties where a lot of stormwater runoff is generated may be freed from the tax. This means that taxes may not be the best solution for collecting money for stormwater management [18].

5.2 Fees

Fees are usually charged in exchange for a particular governmental service which the fee payer gets in exchange. This means that fees are voluntary. When the payers do not want to use the service the government is providing then they usually can withdraw the agreement and stop paying the fee. The amount of the fee charged is directly related to the actual cost of the service.

Although the fee is voluntary it is still gives stable revenue ensuring that the capital improvements and operations that are planned in advance can be done [19].

5.3 Service fees

Service fees are designed to reflect how each property is impacting stormwater service demands and thus the cost of providing facilities and operational and support activities [19].

Stormwater user fee rates are based upon the conditions of properties that affect the peak rate of runoff, total volume discharged, and pollutant loadings on receiving waters. Stormwater rates may also be based on the amount impervious area or gross area of properties and numerical factors that reflect the intensity of development. Stormwater user fee is quite flexible and easily tailored to individual situations and coordinated with other funding methods. [19].

Stormwater fees can be a good way to cover the costs of stormwater management if they are thoroughly planned and thoughtfully implemented. When the fees are hastily established they can cause more harm than good [31].

Stormwater fee structure must be built up so that those who create the most runoff pay the most. For example those properties that have the most impervious area like commercial and industrial facilities pay higher fees than residential and other small properties which usually have less impervious area [31].

5.4 Stormwater utilities

Stormwater utility is a mechanism to fund the cost of services directly related to the implementation of stormwater programs. Stormwater utilities generate revenues through user fees for services related to the control and treatment of stormwater [18].

It is a stable source of funding that gives more possibilities to address needs to the stormwater managers. This gives a better system for collecting money. The fee is calculated on actual runoff impact. This means that it is not calculated based on property value and even the tax-exempt properties have to pay it. Another good thing about this mechanism is that through this it is possible to direct people towards becoming more environmentally conscious by rewarding them.

This is possible when for example the fees are based on impervious surfaces or a system of credits is added to the mechanism [20].

The main challenge is to get public acceptance to the fee because usually the public is against new fees and taxes, especially when they do not see the need for it, so it is very important to communicate the need and goal of the fee. Another challenge may be to find the best solution how the fee is calculated and from whom it is collected from. The cost of developing and implementing utilities depends on the size of a community or the complexity of processes employed [19, 20].

The utility approach has been identified in a number of analyses as the most equitable and effective approach to stormwater financing [20].

5.5 Service Fee Credits and Discounts

One way to accommodate stormwater rates to local circumstances is to add credit adjustments to service fees. Discounts and credits give the property owners an opportunity to reduce the cost of their stormwater fees by using green infrastructure techniques that limit impervious cover and reduce the stormwater runoff generated. One of the main goals of stormwater management should be to manage the stormwater on site and credits and discounts help to direct property owners to that direction. If less water enters the sewer system the less money is spent on treatment, maintenance, and operation expense [19, 31].

There are many possibilities for reducing fees but it is important that there is a balance between the base charge and the type of incentive used. To achieve this the goals for stormwater management have to be set and after that it can be decided how to credit private property owners. Some of the most well-known stormwater management goals have been brought out in Table 1 [31].

Discounts can be given for stormwater quantity reduction or for impervious surface reductions or they can be given based on particular practices, such as rain gardens, green roofs or tree canopy. Credit amounts vary based on the practice and the goals the municipality has for private stormwater management (Table 1) [31].

Table 1 Stormwater fee discounts [31].

Goal of Discount	Mechanism for Fee Reduction	Process for Implementation
Reduce Imperviousness	Percent fee reduction Per-square-foot credit	-Percent reduction in imperviousness -Square feet of pervious surfaces
On-site Management	Percent fee reduction Quantity/Quality credits (performance based)	-List of practices with various credits -Total area managed
Volume Reduction	Percent fee reduction Performance-based quantity reduction	-Rercent reduction in imperviousness Performance-based -Total area managed -Practices based on pre-assigned performance values
Use of Specific Practices	Percent fee reduction One time credit	-List of practices with various credits

5.6 Impact fees

Impact fees are used when for example a new development has a measurable and certain impact on existing infrastructure and there is a need for additional resources to maintain an adequate service level. Money collected with this fee must be used only for specific projects, if not they must be returned to the developer [19].

5.7 Special fees

Special fees can be included under the scope of a stormwater utility or adopter separately. These fees are appointed to those who need special services which costs are not included in the usual fee or to those who cause the need for regulatory measure. Regulatory activities can be related to public health, safety, and welfare. One example of special services is inspections. The cost of inspections will be placed on certain property owners so the general taxpayer or utility ratepayers are not affected by it. Special fees provide only a small amount of revenue but enhance the equity of cost apportionment [19].

5.8 Conclusion

Taxes tend to be not well received among property owners and the money usually goes to general funds. This means that the collected money may not be used for stormwater management but may be used to fund those public services that get higher priority like public safety, schools, and social services.

When stormwater utility fees are charged, the money is used for stormwater management. This means that the money is going to a place it is supposed to go. There is a steady cash flow to the utility fund to develop and maintain the stormwater systems. There is a possibility to add credits and discounts to the fees to direct the property owners to handle the stormwater onsite. When this is accomplished the load to the drainage is reduced and this means that the costs for maintenance should decrease as well. Also Credits can be included to the stormwater fees to give discounts to those who green infrastructure techniques that limit impervious cover and reduce the stormwater runoff generated.

According to the observation, we can conclude that the fee system is better than taxes, especially the stormwater utility system. Other fees like impact or special fees will not be discussed in detail. Now let us look more closely how to build up a fee system.

6 Stormwater fee structure

It is important to figure out on what to base the stormwater fee on and from whom the fee should be charged. Often residential and non-residential properties fees are calculated differently and charged different rates. This is because usually non-residential properties have more impervious area than residential buildings so they are responsible of producing more stormwater runoff.

Stormwater fees can be based on:

- Impervious area
- A combination of impervious and gross area
- Impervious area and the percentage of imperviousness
- Gross property area and the intensity of development.
- Runoff coefficient

Other fee computation methods:

- Flat fee
- Equivalent Residential Unit (ERU)
- Tier systems (TIER)
- Residential Equivalency Factor (REF)

6.1 Impervious Area

Stormwater rate structure based only on impervious area means that the costs are based on each property's contribution of runoff to the system. This system is widely used and considered fair, because it is easily understandable by the general public. There have been numerous studies proving that the impervious coverage is the key factor influencing peak stormwater runoff [19].

The problem with impervious area service fees are that the fee is usually applicable only to developed properties but stormwater management should look ahead and consider future growth. Other than that the fee is quite stable and takes into account property alterations [19].

Most impervious area rate structures include simplified single-family residential fees often applied as flat-rate charges. And in some cases the ranges of impervious area are used as billing unit [19].

Impervious area service fees can be calculated by dividing the amount of impervious area on each parcel by an equivalent unit or a range value to determine the number of billing units and multiplying a charge per unit. It is based on a single parameter that can be accurately measured and there is possibility to add modifying factors to the fee calculation but it's not that flexible in its application to specific properties [19].

The fee can be calculated like this:

$$Stormwater\ Charge = Rate \times Property's\ Impervious\ Area \text{ [71]} \quad (1)$$

6.2 Impervious Area and Gross Area

Gross area and impervious coverage influence amount, peak rate, and stormwater discharged to public sewerage systems. This stormwater rate methodology is not as common as taking into account only the impervious area or the gross area [19].

This methodology is quite easy to understand. It is consistent with the public's general understanding of hydrology and impervious and gross areas impact to stormwater runoff.

In the service fee calculation the mix of impervious and gross area has to properly reflect the significance given to each parameter. This can be achieved in at least two ways [19]:

1. Applying weighting factors to gross and impervious areas - this should be consistent with the local hydrologic conditions, patterns of development, program requirements, balance of stormwater quantity and quality program costs, and the community's perceptions [19].
2. Allocating certain costs of service to each parameter - Units of cross-area may be charged a basic rate, with a surcharge applied to units of impervious coverage [19].

Alternatively, the cost of service may be apportioned between impervious and gross area like this - 80 percent of total stormwater cost of service might be allocated to impervious area and 20 percent to gross area [19].

Residential flat-rate charge can be used with this methodology, when we use a sample of residents to determine how much gross and impervious area there usually is in the community [19].

There is a possibility to get more revenue with this rate structure than the impervious area approach because it can charge both undeveloped and developed properties. The revenue stream depends on the weighting factors or allocation of costs and rates assigned. This approach is flexible thanks to weighting factors or allocating costs to impervious and gross area [19].

Because the rate is based on gross area and impervious area, the property owner cannot do much to change the amount of service fee. That is why credits and discounts must be added to this approach. The credits and discounts have to guide property owners in that direction so that the stormwater management goals can be achieved [19].

For the fee calculation, we need to know both the impervious area and gross area data. The gross area on each property might be divided by a billing unit increment and multiplied times a charge per unit. The same can be done to the impervious area. Then the two sub-totals have to be added together to get the fee. Credits and discounts can be added to both impervious and gross parameters [19].

The fee can be calculated like this:

$$Stormwater\ Charge\ = (Gross\ Area\ Rate\ \times\ Gross\ Area\ of\ Property)\ +\ (Impervious\ Area\ Rate\ \times\ Impervious\ Area\ of\ Property)\ [22] \quad (2)$$

6.3 Impervious Area and Percentage of Impervious Coverage

The amount of impervious area and impervious percentage are used under this rate, to calculate service fees. The percentage of imperviousness is calculated by using gross area. In this approach the impervious area of the property is charged a rate that depends on the percentage of imperviousness of the property. Usually each square foot of impervious area is charged more as the percentage of imperviousness increases. Under this methodology underdeveloped lands are often not charged [19].

Properties may be divided into several classes based on their percentage of imperviousness and different rates per impervious area can be applied for each class. Proportionately higher values are applied as the percentage of impervious coverage increases. This rate concept is quite flexible on how the classes of imperviousness are defined and the schedule of rates assigned. Modifying factors can also be applied. Better overview of the classes in the table below (Table 2) [19].

Table 2 Annual Rate and Percentage of Impervious Coverage [19]

Impervious Percentage	Annual Rate/100 square foot of Impervious Area
1-10%	$ 0.50
11-20%	$ 1.35
21-30%	$2.00
31-40%	$2.70
41-50%	$3.35
51-60%	$4.00
61-70%	$4.70
71-80%	$5.40
81-90%	$6.00
91-100%	$7.70

When the property has 12,000 square foot (1114.84 square metres) area where 3,000 (278.71 square metres) is impervious (25%) then the fee can be calculated like this:

$$Fee = \frac{impervious\ area}{100} \times annual\ rate \text{ [19]} \quad (3)$$

With this calculation we get how much one property has to pay in a year. When we look at the example it is 60 dollars in a year and 5 dollars in a month [19].

This benefits single-family residences as they will probably see a lower bill under this rate structure. On the other hand intensely developed commercial properties would have to bear a

much higher proportion of cost of service. Of course the rates must be well thought out to ensure that appropriate allocations of cost of service result [19].

In this approach it should be considered that a lot of data has to be gathered and stored and necessary calculations have to be made. This approach requires a database and a system to be thought out, in order to easily calculate the imperviousness percentage. But these developments are not significantly greater than for other methodology options. But the revenue capacity of this type of rate structure is greater than most of the other methodology options, especially if higher progressive schedule is used [19].

The one thing has to be considered with this methodology is that this approach may not motivate property owners to reduce impervious areas in their property. It may not be cost-effective for them to do so, so Credit programs should be added [19].

The Impervious Area and Percentage of Impervious Coverage methodology generates a lot of revenue per square meter because of the very heavy weighting applied to the percentage of imperviousness results in much higher charges for intensely developed properties. [19].

6.4 Gross Area and Intensity of Development

This rate is based on the gross area of each property and its intensity of development. Intensity is measured by the percentage of the property covered by the development area [33].

When this method is applied to every parcel the gross area has to be determined for all residential and non-residential properties and an intensity of development rating is assigned to all. Many communities have decided to apply a simplified service fee to one or more categories of single-family residential parcels. If a flat-rate residential charge is not used then all residential properties are typically assigned to one or two of the intensity of development categories. This depends on how the residential development is divided. When the residential development is very even, only one category of residential intensity of development is needed but when the sizes of residential properties vary then more categories are needed. Non-residential properties are categorized into five to ten groups ranging from “undeveloped” to “very heavily developed” [19].

Similar properties are grouped together and given the same classification. This means that all apartments might be classified as multi-family residents with intensity of development factor equal to .65 although individual ranging can be from .50 to .85. The gross area is the controlling element of rate calculation for all parcels in this classification [19].

Calculation of service fees can be structured in several ways. With a simplified residential charge the service fee compares conditions on non-residential properties to a defined average specified for residential properties. This approach allows service charges to undeveloped as well as to developed properties [19].

This methodology is quite fair but the methodology requires a careful explanation to the community. For example the terminology has to be explained and simplified. This methodology does not need that much data then the other options. Gross area information can be taken from databases or maps and the intensity of development factor has to be assigned for each property using aerial photographs. Some additional work has to be done so that the undeveloped properties would be charged as well [19].

This rate methodology puts greater proportion of the cost of service onto residential and other lightly developed properties than the methodologies based on impervious area, although the differences has decreased as the housing sizes have increased. The overall revenue capacity can be increased when the undeveloped properties are charged as well. This approach is relatively stable and insensitive to external influences and quite flexible because it is possible to define categories and assigning intensity of development factors. But it has to be considered that a lot of engineering judgement is involved in determining the intensity of development of a parcel [19].

6.5 Runoff coefficient

This methodology is similar to density of development but more closely associated with the physical characteristics of properties. The information needed to calculate this fee, are basic physical characteristics of land like slope, soil type, land use and the properties size. Undeveloped parcels may also be charged depending on the properties slope variables and soil characteristics [33].

Runoff coefficients are charged as a fee per unit of area or as an adjustment factor to impervious surface area to modify the final charge based on a parcel's runoff characteristics [33].

According to Estonian Standard EVS 849:2013, the runoff coefficients can be assigned like shown in Table 3.

Table 3 Runoff Coefficients [93]

Area of	Runoff Coefficient
Roof	0.9
Asphalt or Concrete Surfaces	0.8
Tight joint paver	0.8
Joint sand paver	0.7
Gravel or crushed stone	0.3
Grass	0.2
Lawn, Gardens	0.15
Bare soil	0.1
Forest	0.05

In this case the weighted runoff coefficients are calculated to each area and then added up. Then the sum of weighed runoff coefficients is divided by the total parcel area. Then we get the final runoff coefficient and the fee can be calculated like this [67]:

$$Fee = Rate \times Runoff\ Coefficient \text{ [67]} \quad (4)$$

6.6 Flat fee

Flat fee charges categories of consumers a flat fee. Flat fee means that the cost of stormwater services is divided equally. All properties pay the same rate [59]. Flat rate helps to simplify the administration of the billing system, can help to reduce costs and the maintenance of information is simpler [19].

Some examples how flat fees can be charged:

Impervious area methodology – Flat fee can be applied to all single-family residences and the typical single-family impervious area might be used to determine charges to other properties [19].

Impervious area and gross area methodology – Flat fee can be applied to residential properties where a sample of residences can be used to determine how much gross and impervious area is typical to a given community [19].

6.7 Equivalent Residential Unit

Equivalent Residential Unit (ERU) method is based on the average amount of impervious surface on a residential parcel, or the ERU Area Unit. Each property is assessed to determine how many ERUs it has by dividing the properties amount of impervious area by the ERU area. A fee assessment rate per ERU is established and all properties are assessed according to that [49].

$$ERU\ Area = \frac{total\ residential\ impervious\ area}{total\ number\ of\ residential\ parcels}\ [49] \quad (5)$$

$$Number\ of\ ERUs\ per\ parcel = \frac{total\ parcel\ impervious\ area}{ERU\ Area}\ [49] \quad (6)$$

$$Total\ fee = nr\ of\ ERUs\ \times ERU\ rate\ [49] \quad (7)$$

All the properties may be charged a rate per ERU or the procedure may be modified. Single-family parcels are often charged one ERU regardless the number of ERU-s they may have. Or one ERU is charged to properties up to a maximum size. All other properties can be charged the total number of ERUs associated with their parcel [49].

6.8 Tier

Tier system means that fees or factors are based on categories. Tiers can be based on numerical factors, such as magnitude of impervious area or water use, or categorical factors, such as land-use type or water meter size. Tier system can be applied to all properties or to selected property types such as commercial properties. For example tier system can charge a flat fee for various ranges of impervious area (Table 4) [49].

Table 4 Tier System [49]

Tier	Impervious Area	Monthly fee
Residential 1	200-1500	1.30
Residential 2	1501-3000	2.60
Residential 3	3001-4500	3.90
Residential 4	4501-6000	5.20
Residential 5	>6000	6.50
Other	1 ERU = 1500 Square Feet Iimpervious Area	1.30/ERU

6.9 Residential Equivalency Factor

Residential Equivalency Factor (REF) is defined as the ratio of runoff volume generated by one acre of land relative to the runoff volume of generated by one acre of neighbourhood residential land [62]. Parcels can be placed into categories and REF can be assigned to each category [61]. The ways categories are made and the way REF is assigned can differ but one way is shown in Table 5.

Table 5 REF categories [62]

Land Use	REF
Rural residence	0.6
Neighbourhood residential	1.0
Commercial	1.4
Industrial	2.1
Public/Institutional	1.0
Park/Open space	0.4
Agricultural	0.4

Fees can be calculated like this:

$$Rate\ per\ acre = REF\ \times Base\ rate \text{ [62]} \quad (8)$$

7 Stormwater management practices

There are many management practices handling stormwater runoff. These solutions can be worked into stormwater management methodologies so that they provide discounts and credits to those properties that use them. These solutions can help the property owners to deal with the first few centimetres of rain onsite. This is a vital point in stormwater management because the water that is infiltrated on site will not enter the stormwater drainage pipes, which mean that there is a smaller chance for overflows and less money is needed for the management of stormwater pipes. The more people handle the stormwater on site the less the stormwater drainage pipes are used. These practices can help to improve the quality of stormwater or to increase the amount of rain entering the stormwater drainage. This gives people a chance to be involved in stormwater management.

Some of the management practices that property owners can use are explained below.

7.1 Rain Gardens

Rain gardens are specially designed garden beds, which filter stormwater runoff from surrounding areas. They are used to stop excess stormwater, nutrients, rubbish and sediment from polluting our waterways, bays and oceans. Stormwater is soaked through the plants and filter media so that the sediment and toxins are trapped and the nutrients are used by the plants [37].

7.1.1 Green roofs

A green roof is a garden that sits on top of a roof (Figure 4). It consists of a waterproof layer, a drainage system and plants. This solution reduces energy consumption by adding an extra layer of insulation reduces the volume of runoff and reduces outside building temperatures [38].

Figure 4 Green roof [1]

Green roofs require careful planning of the design, implementation and maintenance. The weight it adds to the roof has to be considered. The plants for the roof have to adapt to the drought, high winds and uncertain weather conditions [38].

7.1.2 Porous paving

Porous paving is designed so that the water can soak through the paving into the ground (Figure 5). This solution reduces the volume of stormwater runoff and pollutants entering waterways and benefits nearby plants and trees by allowing air and water to reach the roots [39].

Figure 5 Permiable Paver [85]

Before selecting a paving system, it is important to figure out the traffic type, frequency, existing soil type, location, aesthetic preference and cost. Porous paving types are loose gravel, structural gravel, grass, masonry pavers or engineered pavers [39].

7.1.3 Infiltration raingarden

An infiltration rain garden is a trench filled with gravel designed to receive stormwater directly from a downpipe or runoff from surrounding hard surfaces such as a driveway or paving (Figure 6). It has layers of soil for filtration, gravel for drainage, and plants that can tolerate both extreme wet and dry conditions. This system helps to protect waterways by reducing stormwater [40].

Figure 6 Infiltration Garden[86]

7.2 Wet ponds

Wet ponds usually look like a usual pond but actually, they are specially designed to manage stormwater (Figure 7). They contain a permanent pool of water that is a minimum of three feet deep (about 0,9 m). The outlet structure is above water

Figure 7 Wet pond [88]

level so the pond stays full. When there are heavy rains and the water level rises below the outlet level only then there is a discharge. Eventually the normal water level in the pond is restored. Wet ponds help to improve water quality [41].

7.3 Urban Tree Canopy

Urban tree canopy is the layer of leaves, branches, and stems of trees that cover the ground for rain (Figure 8). This option provides a good stormwater management function by intercepting rainfall that would otherwise runoff from paved surfaces into local drainage system. This option also reduces the urban heat island effect, reduces heating/cooling costs, lowers air temperatures, reduces air pollution, increases property values, provides wildlife habitat, and can improve quality of life [25].

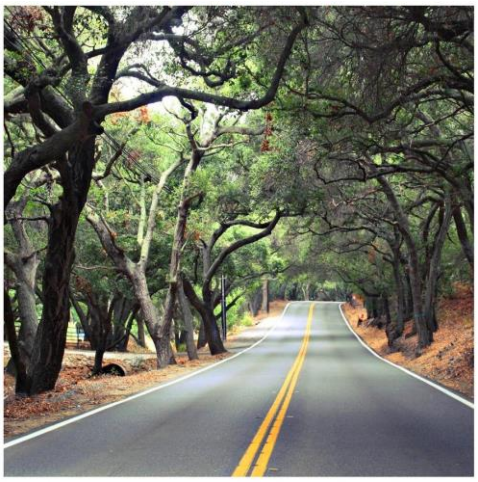


Figure 8 Tree Canopy [89]

7.4 Rainwater harvesting

Rainwater harvesting is a process of collecting, filtering, storing and using stormwater for irrigation or other purposes. Rainwater can be collected from roofs and stored inside special tank (Figure 9). The collected stormwaterwater can be purified if needed and used as a drinking water. The collected water can be used inside the house for laundry, toilet flushing or for watering the garden or washing the car [42]. Those areas that have a lot of rain and those who have little can both benefit from this solution.

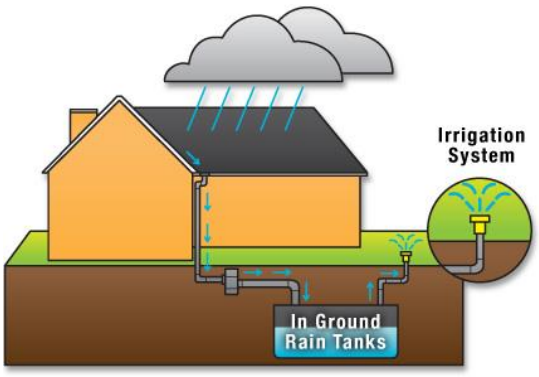


Figure 9 Rainwater Harvesting Tank [90]

7.5 Detention basin

Detention ponds store stormwater runoff for a short period of time to reduce the peak rate of runoff to a stream or sewer (Figure 10). The runoff is released at predetermined rate to the storm sewer or stream. The ponds are usually earthen structures constructed by natural depression or excavated to existing soil. The runoff is released through pipes or other outlet structures when the level of runoff rises [60].

They help to control flooding, provide some water quality benefits and reduce streambank erosion. They are generally ineffective at removing pollutants but when the detention time is extended and the solids have time to settle will increase the water quality. [60]

Figure 10 Detention Basin [91]

8 Implementation Considerations

In order for the implementation to be successful, it is important to follow four main tracks of activity – Public, Program, Finance and Database.

Public - In public involvement, there are several things that have to be thought out. Public involvement have to be planned out and information process, make a public involvement process, carry out the implementation campaign and monitor utility implementation and customer service. It is important to remember that there may be several publics in a local community so it is important to address them all [19].

It would be wise to make an economic analysis of how property owners will be affected by different stormwater fee models. This can help to get public acceptance quicker, reduce complaints and helps to find the best stormwater fee system for different property groups [82].

Customer assistance and outreach campaigns are also very important. It is crucial to explain the need and the desired outcome of the fee to the property owners and to involve them to the stormwater management plans in the early stages. The public should also be educated by introducing environmental and infrastructural effects of stormwater and the beneficial impacts of stormwater management practices [82].

Program - In here, it is important to assess the basic problems the implementation process may have, define needs and goals, establish program priorities, define implementation period, find out the costs of the implementation process, and finally figure out the steps for implementation [19].

Finance – The legal and financial basis for the stormwater program are set up. Legal parameters of the revenue options are examined, the policies that govern the revenue program are explored, the rate structure factors are examined, determine the needed revenues [19].

A good plan for the Credit program has to be thought out. This has to motivate property owners to the make the effort to deal with the first few centimetres of rain on site and to reduce the amount of rainwater entering the drainage system and to improve the quality of rainwater.

At the same time fees should not be so expensive that they would harm customer's economic viability, but high enough to collect revenues to stormwater management. When the residential customers have much of the cost burden then the stormwater fees can quickly lose traction and

support. This happened in Detroit where the residential stormwater fees left many of city's low-income families unable to pay their monthly water bill. On the other hand, the stormwater fee has to provide enough capital to maintain and enhance existing stormwater infrastructure. When the fee is too low, like it was in the District of Columbia where single-family homes were charged so that it covered only a fraction of the District's actual infrastructure, the fee does not justify itself [31, 82].

Database – The database needs and needs for fields have to be determined, the whole process how the data is stored and displayed have to be thought out, also how to get the bill to the end customer, and how the system should be maintained [19].

A lot of information from different sources has to be provided to the property owners. A web site where the property owner can find all the necessary information is vital. The system should give an overview of all the data gathered from the properties and all the information about the fee formation. The property owners and utility provider should be able to manage all the data in the information system [82].

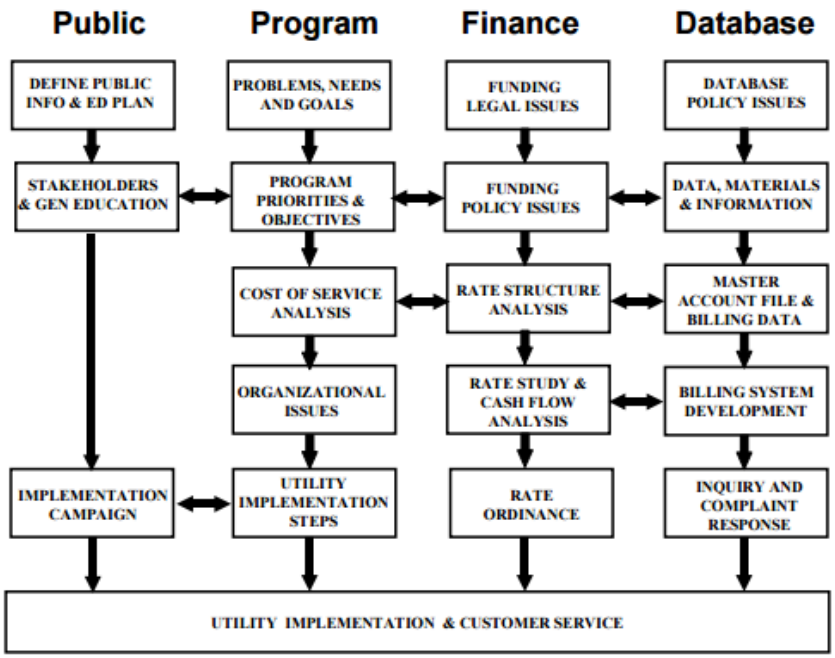


Figure 11 Utility Implementation Approach [19]

All these points are closely related to each other like shown in Figure 11. The details of each point have to be well thought out and at the same time it is important, to see the big picture and not forget the main goal.

9 Solutions used in different cities

9.1 Philadelphia, Pennsylvania, United States

9.1.1 Precipitation

The weather in Philadelphia is quite warm. The annual precipitation in Philadelphia is about 1055 mm. The month with the highest monthly rainfall is August 117 mm (Figure 12) [28].

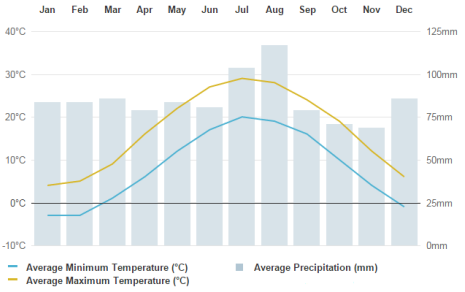


Figure 12 Philadelphia Precipitation Graph [92]

9.1.2 Stormwater regulations

Pennsylvania enforces the Clean Water Acts standards by issuing permits that regulate combined sewer overflows and stormwater runoff in areas with separate sewer systems. It also requires counties to develop stormwater management plans for local watersheds. To comfort the challenges of stormwater runoff and meet the regulatory requirements, Philadelphia Water developed regulations to ensure a modern and effective stormwater management program. Requirements have four main components [46]:

1. Water Quality – Remove pollutants from stormwater and reduce the volume of water entering sewers [46].
2. Channel Protection - Protect stream banks by minimizing the rate of erosion from stormwater runoff [46].
3. Flood Control - Manage the rate of runoff from a property to prevent localized flooding [46].
4. Public Health and Safety Release Rate requirements - Manage the rate of runoff from a site located in an area where known flooding has occurred due to constraints in the sewer network [46].

9.1.3 Sewer system

Philadelphia has two types of sewer systems – combined and separate, in total the pipes are 4828 km long the total area of Philadelphia is 367 km^2. About 60% of Philadelphia's sewered area is served by combined sewer system (Figure 13) [23].

Figure 13 Philadelphia Sewer Map [23]

9.1.4 Flooding

When there are heavy rains the system is overload about 85 times per year. This is caused by the stormwater runoff from the impervious areas [21].

From the USA states the chance for a flood is the highest in Pennsylvania. During the past century there have been several serious floods and the increasing percentage of impervious surface areas is not making matters easier. Stormwater is also carrying significant amounts of pollutants washed from impervious surfaces and altered land surfaces. Although stormwater management cannot eliminate flooding during such severe rainfalls it is even more important that the stormwater management has been well figured out [44].

9.1.5 Stormwater fee

Before 2010 the stormwater fee was charged based on the amount of water used on the parcel. This was measured with the water meter. This system does not have a clear overview of the stormwater volume on the property because those who use a lot of water may not have that much rainwater runoff in their property. Because of that there was a situation where properties with small water meter diameter but large impervious areas paid low stormwater fees, even though they generated relatively large amounts of stormwater. On the other hand properties with little impervious area but large amounts of water usage were overpaying for their stormwater management. This system did not help the property owners to manage stormwater on their property because the fee was not connected to the actual amount of stormwater produced in their property. In order for them to decrease the fee they would have had to use less water but this, although a good thing was not helping to reduce the discharged stormwater in any way [21].

9.1.6 Non-residential fee

In 2010 Philadelphia started to implement a new stormwater rate structure. With this system the non-residential customers have to pay a monthly stormwater fee based on the impervious area on

their parcel. The new parcel-based stormwater billing system is based on parcels' gross area and impervious surface area. 80 percent of the city's stormwater fee is based upon a property's impervious area, and the remaining 20 percent based upon the property's gross area. This means that the amount of money paid by the property owner is directly related to the stormwater runoff generated on that area. Those owners who had little impervious area but large amounts of water usage will pay less than they did before [21].

The monthly parcel-based fee for non-residential properties is the sum of an impervious area (IA) charge and a gross area (GA) charge, according to the following formula [21]:

$$Stormwater\ Charge = (Gross\ Area\ Rate \times Gross\ Area\ of\ Property) + (Impervious\ Area\ Rate \times Impervious\ Area\ of\ Property) \quad [22] \qquad (9)$$

9.1.7 Residential fee

Philadelphia has a lot of residential properties (450 000) this means that a detailed analysis for each of these properties would be administratively complex. That is the reason why the City has chosen not to implement the same level of detail as to non-residential properties. Instead all residential properties have been combined and treated as a single land parcel with the total costs of 80/20 calculation divided equally among all households [31]. This means that all residential parcels pay flat fee with the same monthly GA/IA charge which can create inequities because the parcels are different in size [30].

9.1.8 Credits

One good thing with this stormwater system is that it is fairer to Philadelphia's property owners but the main goal has been to reduce the stormwater generated on their property. This can be done if the property owner installs storwater retrofits. Property owner can get credit by reducing the impervious area where the entire first few centimeters of runoff is managed onsite. This gives the property owner a reduction in the Impervious Area portion of the monthly stormwater fee. When the stormwater fee credit is approved, the fee reduction is fixed for a four-year period. The property owner can re-apply for the credit, based on a showing that the retrofit has been properly inspected and maintained and remains fully functional. In order to qualify for the credits non-residential or Condominium parcel has to have at least five-hundred (500) square feet of gross area and its water, sewer, and SWMS accounts are not past due [21, 24].

Here are some credit examples that Philadelphias Water Department are offering:

9.1.8.1 Impervious Area Stormwater Credit

To be eligible for IA Credit the property owner must establish the management of first inch of runoff from impervious areas on a property. This can be achieved by [24]. :

1. Infiltration
2. Detention and slow release
3. Volume reduction and filtration

9.1.8.2 Impervious Area Reductions (IARs) Credit

- Tree Canopy Cover – A new or existing tree canopy extends over or is close proximity ground level impervious area on a parcel. In this case a portion of impervious area may be deducted from total billable IA [24].
- Roof Leader/Downspout Disconnections – Downspout is disconnected and then directed to a pervious area which allows infiltration. In this case certain requirements have to be met and it has to be approved by the Philadelphia Water Department [24].
- Pavement Disconnections – Pavement runoff is directed to a pervious area which allows infiltration. This can be used for driveways or narrow pathways. The disconnected impervious areas are deducted from the total IA [24].
- Green Roofs – Green roof is installed on a building. All the requirements must be met and since it is not a zero discharge system the excess runoff must be discharged to the storm sewer, combined sewer or receiving water body. In this case the IAR is calculated based on the area of the green roof [24].
- Porous Pavement – Porous pavement is installed on a property so that it does not create any concentrated infiltration areas. Porous pavement systems can be considered disconnected when they receive only direct rainfall and are underlain by a cruched infiltration bed that is at least 8 inches deep [24].

9.1.8.3 Gross Area Stormwater Credit

There are two options to get GA Credit:

1. Management of the first inch on runoff – GA Credit is automatically achieved when a parcel is approved for IA Credit with the management of the first inch on runoff.

When an area gets IA Credit it will usually receive a GA Credit as well for the land area underneath the IA [24].

2. GA Credit Based on NRCS-CN – Customer must demonstrate a NRCS-CN that is below of certain Curve Number that represents the runoff potential for a particular soil and ground. This is applicable only to the open space of the parcel [24].

9.1.9 Calculation of Charges with Credits

1. IAR Criteria – The total areas that meet the IAR criteria must be subtracted from the billable IA [24].
2. Non-surface discharge areas without NPDES Credits for areas of a property that do not discharge stormwater to a surface water body [24]. :
    a. IA Credit - 80% maximum credit factor is applied to the parcel's IA square footage that is managed [24].
    b. GA Credit (GA underneath the IA) - 80% maximum credit factor is applied to the square footage of IA Managed [24].
    c. GA Credit (GA minus IA) - up of 80% may be applied, as applicable for open space areas [24].
3. Non-surface discharge areas with NPDES Credits for areas of a property that do not discharge stormwater to a surface water body and the property has an active NPDES permit for industrial stormwater discharge activities [24]. :
    a. IA Credit - 87% maximum credit factor is applied to the parcel's IA square footage that is managed [24].
    b. GA Credit (GA underneath the IA) - 87% maximum credit factor is applied to the square footage of IA Managed [24].
    c. GA Credit (GA minus IA) - up of 87% may be applied, as applicable for open space areas [24].
    d. Not eligible for GA or IA credits - 7% credit for both the IA and GA square footage [24].
4. Surface discharge areas without NPDES Credits for areas of a property that discharge stormwater to a surface water body [24] :
    a. IA Credit - 90% maximum credit factor is applied to the parcel's IA square footage that is managed [24].

b. GA Credit (GA underneath the IA) - 90% maximum credit factor is applied to the square footage of IA Managed [24].
c. GA Credit (GA minus IA) - maximum of 90% may be applied to open space areas [24].

5. Surface discharge areas with NPDES Credits for areas of a property that discharge stormwater to a surface water body and the property has an active NPDES permit or industrial stormwater discharge activities[24] :
    a. IA Credit - 97% maximum credit factor is applied to the parcel's IA square footage that is managed [24].
    b. GA Credit (GA underneath the IA) - 97% maximum credit factor is applied to the square footage of IA Managed [24].
    c. GA Credit (GA minus IA) - maximum of 97% may be applied for open space areas [24].

The final billable IA and GA are calculated as the total IA and GA minus any applicable IA and GA credits. Then IA and GA charges are calculated based on the Final IA and GA square footage and the fixed rates of IA and GA [24].

9.1.10 Implementation

Philadelphia had a plan to phase in parcel-based stormwater fee in four years so that by 2014 the billing system would be replaced (Table 6). This gave the property owners time to adjust to the new system and make necessary steps to get credit against their fees [21].

Table 6 Phase-In Schedule [22]

Year	Meter Based Charge	Parcel Based Charge
7/1/10 to 6/30/11	75%	25%
7/1/11 to 6/30/12	50%	50%
7/1/12 to 6/30/13	25%	75%
7/1/13 forward	0%	100%

Philadelphia was also helping and informing their customers by:

- Adding specialized customer service

- Advanced notification letters
- Conceptual design assistance
- Workshops and meetings
- Online web viewer and tools
- Created a Commercial Customer Service Unit
- Continued outreach [43].

Philadelphia has its own system to store stormwater charge information called PWD's Stormwater Map Viewer. All the gathered information about the parcel can be found in one place. This makes the information management easier and more understandable for people. An example of the system can be found in Appendix 2[45].

9.2 Adams County, Colorado, United States

9.2.1 Precipitation

The annual precipitation in Adams County is about 377.19 mm. The month with the highest monthly rainfall is May 55.88 mm (Figure 14) [35].

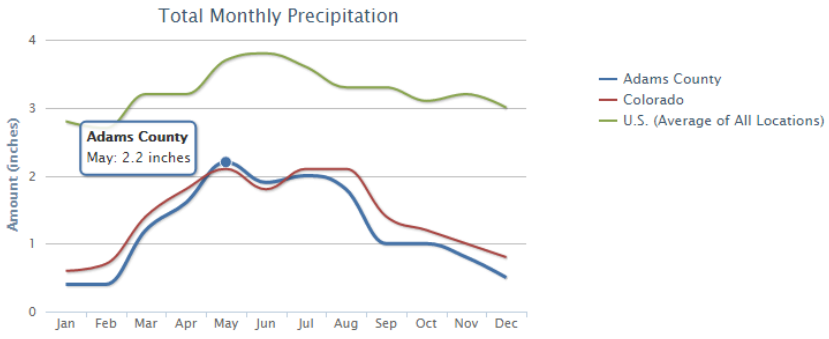


Figure 114 Adams County Precipitation Graph [35]

9.2.2 Stormwater regulations

Adams County Stormwater Utility was established in 2012 [56].

The purposes of the Stormwater Utility Policy are:

- Provide effective management and financing of storm sewer systems.
- Reduce the damaging effects of stormwater runoff
- Improve the public health, safety, and welfare of citizens through stormwater management
- Authorize the establishment and implementation of a master plan for storm drainage
- Establish reasonable stormwater service charges based on each properties contribution

- Encourage and facilitate urban water resources management techniques

9.2.3 Sewer system

Approximately 27, 000 properties are provided public drainage which is about 257 square miles (665.63 square kilometres) [56].

9.2.4 Stormwater fee

Adams County chose an impervious area rate methodology to calculate the fee. This methodology was chosen because there is a direct connection between the amount of stormwater generated and the amount of impervious area. The fee is charged from all developed areas, including but not limited to mobile home lots, single family homes, commercial properties, and non-taxed parcels [57].

The rate structure is a flat rate charge per square foot of billable impervious area on each developed parcel in the service area. All properties that have up to 1,000 square feet of impervious area will be charged a minimum fee. Properties under 100 square feet are not charged. The billable impervious area goes up to 100,000 square feet [57].

Calculation of the fee:

First the total amount of impervious area has to be added up – the area of roof, driveway, patio, and sidewalk. Then the fee is calculated like this [56]:

$$Fee = Total\ Impervious\ Area \times Rate \text{ [56]} \quad (10)$$

For example when the rate per square foot is 0.00167 per month and impervious area is 1,000 square feet the fee for the property is 1.67 per month [57].

9.2.5 Credits

The Adams County aims to encourage technical design and maintenance of stormwater best management practices to reduce the impact of surfaces. Grants will be granted only to non-single family properties. The credit is given on water quality and quantity basis. Additional credit may be granted to properties that do self-maintenance this means that a property stores or treats strormwater run-off from other properties or maintains stormwater infrastructure. Each credit is granted for three years [58].

The table below describes which property with what kind of activity can get credits. The maximum Credit percentage and calculation of the credit is shown there as well (Table 7).

Table 7 Requirements and Calculation of Credits [58]

Outcome	Typical BMPs	Eligible Properties	Maximum Credit	Calculation
Improvements in water quality **Reductions in water quality**	Detention Basins -- Retention Ponds	Non-single family properties In special circumstances, single family properties	60%	Credit = 60% X (proportion of impervious area for which 1 inch of runoff is treated) Cannot exceed 100% of property fee.
Improvements in water quality	Activity	Non-single family properties	25%	Credit = 25% X (proportion of equivalent impervious area for which 1 inch of runoff is treated)
Improvements in water quality	Channel protection	Non-single family properties	25%	Credit = 25% X (proportion of impervious area that drains to channel)
Improvements in water quality	NPDES permit	Non-single family properties	25%	Credit = 25% X (proportion of impervious area covered under permit)
Improvements in water quality	Stormwater pollution prevention plan	Non-single family properties	25%	Credit = 25% X (proportion of impervious area covered under SWPPP
Reduction in utility's maintenance costs	Self-maintenance activities	Non-single family properties In special circumstances, single family properties	5%	Credit = 5% X (proportion of impervious area that drains through maintained portion of the system)

In general, these three credit types can be granted at once but the maximum credit for water quality and quantity is 60%. That is because it is estimated that about 40% of the impervious area are roads and since the County is responsible for maintaining and operating of roads drainage systems, 40% of the costs will stay the same. This means that some of the fee paid will be used to maintain obligations outside the property boundaries [58, 63].

9.3 City of Monroe, North Carolina, United States

9.3.1 Precipitation

Average annual precipitation is 1192 mm. The month when it rains the most is August 131 mm (Figure 15) [32].

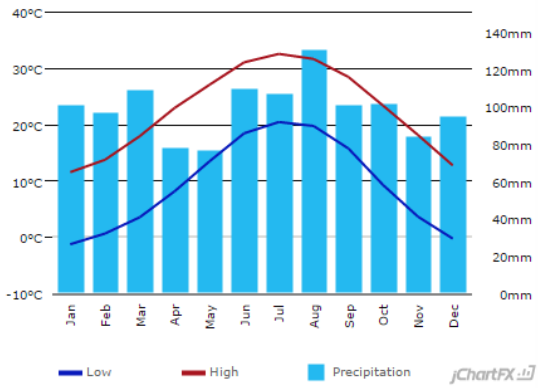


Figure 12 City of Monroe Precipitation Graph [32]

9.3.2 Stormwater regulations

The City has issued National Pollutant Discharge Elimination System (NPDES) Phase II stormwater permit. This program requires that the city implements the six main elements [66]:

1. Public education and outreach
2. Public involvement
3. Illegal discharge detection and elimination
4. Construction site runoff control
5. Post-construction site runoff control
6. Pollution prevention and good housekeeping [66]

As a result the City developed a stormwater program and established a stormwater utility. The utility provides the city the right to collect rates, fees and charges for stormwater services [66].

9.3.3 Stormwater fee

The monthly stormwater fee is based on the number of equivalent residential units (ERU) which has been calculated for each individual parcel. ERU is the average amount of impervious surface in a single-family residential property and in City of Monroe this has calculated to be 2,618 square feet and the billing unit rate is $4.50.

Monthly fee is calculated like this:

$$Monthly\ fee = Billing\ unit\ rate\ \times ERU\ [65] \quad (11)$$

9.3.3.1 Residential fee

Single-family residential properties are grouped into three tier system based on the amount of the impervious surface each property has. Each tier is assigned an ERU value and a fee based on this

value. For other residential properties, the ERU value is assigned based on the categorization of the residential unit (Table 8).

Table 8 Residential Fee [65]

Description	ERU	Fee
Single family detached		
0-2,010 (Tier 1)	0.7	3.15 per month
2,011-3,289 (Tier 2)	1.0	4.50 per month
3,288 – (Tier 3)	1.4	6.30 per month
Other residential units		
Town homes	0.5	2.25 per month
Condominiums	0.5	2.25 per month
Multifamily	0.6	2.70 per month

9.3.3.2 Non-residential fee

For non-residential properties, ERU is calculated by dividing the total impervious surface area of the property with one ERU. Each of these ERU values is then multiplied by the monthly billing unit rate (Table 9).

Table 9 Non-Residential Fee [65]

Description	ERU	Fee
Non-residential properties		
1 ERU per 2,618 square feet of impervious area	varies	4.50 per ERU per month

$$Total\ ERU = \frac{Total\ Impervious\ Area}{1\ ERU} \quad [65] \qquad (12)$$

9.3.4 Credits

9.3.4.1 Facility Credits

Credits can be associated with the construction, operation, and maintenance of privately owned Stormwater Facilities witch benefit the city. Credits may be applied to the property where the Stormwater Facility is located. Single-Family residential lands can get the credit only when the Stormwater Facility subject to the credit is wholly owned and it is proved that the activity reduces the stormwater management burden caused by each customer [66].

Stormwater Facility that controls onsite stormwater runoff – The first few centimetres of stormwater has to be managed on site in addition to the 2-year, 10 year, and 24 hour design storm events. The maximum credit is 20% [66].

Stormwater Facility that controls runoff from offside (upstream tributary area) – The maximum credit is 30%. The credit percent's are given according to the size of the parcel (Table 10) [66].

Table 10 Upstream Credit Percent [66]

Upstream Tributary Area for which Stormwater is Controlled by Stormwater Facilities	Controlling 1 inch of rain & 2 year Storm	Controlling 1 inch of rain & 2 year & 10 year Storm	Controlling 1 inch of rain & 2 year & 10 year & 25 year Storm
Less than 1 acre	0%	0%	0%
Between 1 and 10 acres	5%	10%	15%
Greater than 10 acres	10%	20%	30%

When the Customer is controlling both onsite and offsite runoff with an upstream area greater than 10 acres for the 25-year, 24-hour or larger design storm event would be eligible for a maximum stormwater Fee credit of 50 percent.

9.3.4.2 NPDES Industrial Stormwater Permit Credit

Customers holding NPDES Industrial Stormwater permits will qualify for this credit when they are performing activities that help the city to comply with specific requirements included in its NPDES MS4 Phase II Permit. The amount of credit will be calculated case-by-case but will not exceed 15%. This credit together with Stormwater Facility Credit can give up to 65 percent credit [66].

9.3.4.3 Stormwater Education Credit

A stormwater education credit is available to public or private schools. To qualify teachers must teach the approved course material to all students of a grade level in a school year. When the material is taught to at least one classroom the credit will go into effect and remain in effect until the end of school year. The credit for this is 15 percent and the curriculum has to be approved. This credit together with Stormwater Facility Credit can give up to 65 percent credit [66].

9.4 City of Anderson, South Carolina, United States

9.4.1 Precipitation

Average annual precipitation is 1122 mm. The month when it rains the most is August 110 mm (Figure 16) [68].

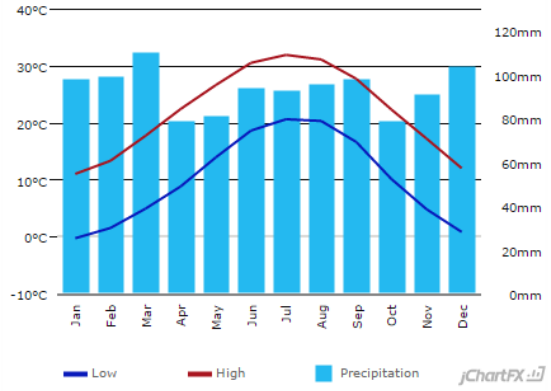


Figure 13 City of Anderson precipitation Graph [68]

9.4.2 Stormwater regulations

The City of Anderson has designed a Stormwater management plan to reduce the pollutants from the Small Municipal Separate Storm Sewer System to protect water quality and satisfy the requirements of the Clean Water Act [34].

The city has conducted an Ordiance which main purposes are [69]:

- ensure the protection, maintenance, and enhancement of water quality
- ensure the short term and long term public health, safety, and general welfare of the citizens
- minimize the property damage of increased stormwater runoff and pollutant loads
- properly manage stormwater runoff by insuring a functional drainage system
- reduce the effects of development on land, stream channel erosion
- maintain water quality standards
- enhance the local environment associated with the drainage system
- reduce local flooding
- maintain the maximum extent practical pre-developed runoff characteristics of the area in terms of flow rate
- volume and pollutant concentration
- flooding, erosion and drainage impacts [69].

9.4.3 Stormwater fee

Each parcel of land has to pay a monthly stormwater utility fee. The fee for residential and non-residential properties is calculated differently. For residential properties, the fee system is

simpler and based only on Equivalent Residential Unit (ERU). However, non-residential properties fee is calculated based on ERU and Runoff Coefficient. There is also a minimum charge to accommodate all additional public runoff that does not originate from private property. This means that a properties fee can go below this charge [64].

9.4.4 Residential fee

Each residential property is equal to one ERU. This means that the charge assigned to one ERU is the monthly charge [64].

9.4.5 Non-residential fee

The monthly non-residential fee is calculated based on ERU and Runoff Coefficient that relates impervious area to the intensity of development or land use of a parcel. The Runoff Coefficients assigned to different uses of land are descried in Table 11 [64]:

Table 11 Runoff Coefficient [64]

Land	Runoff Coefficient
Church	0.60
Commercial	0.80
Industrial	0.80
Institutional	0.65
Multi-Family Residential	0.70
Parking	0.80
Public/Parks & Recreation	0.25
Single Family Residential	0.40
Undeveloped/Vacant	0.20

Calculation of non-residential fee:

$$Fee = \frac{Nonresidential\ parcel\ area}{Average\ residential\ parcel\ area} \times \frac{Nonresidential\ runoff\ coefficient}{Average\ residential\ runoff\ coefficient} \times Equivalent\ residential\ unit \quad [64] \qquad (13)$$

Where the average residential parcel area (0.4 acres) and the average residential runoff coefficient (0.4) has been calculated by the City of Anderson [64].

9.4.6 Credits

Credits will only be considered for properties that are classified as undeveloped or vacant. This means that the undeveloped property in not altered from its natural state by construction or installation of improvements like buildings, structures, or other impervious surfaces, or witch has less than 1% of its property covered by impervious surfaces. Stormwater fee credits will be provided only by request [64].

In case of credits, the fee is calculated like shown in the Table 12.

Table 12 Credit Calculation[64]

Parcel Area (acres)	Monthly Stormwater Fee Calculation
0 < parcel area ≤ 0.8	Minimum fee (1 ERU)
0.8 < parcel area ≤ 10	Fee is calculated with the equation
10 < parcel area ≤ 20	$50 + 1 ERU
20 < parcel area ≤ 30	$50 + 2 ERU
30 < parcel area ≤ 40	$50 + 3 ERU
> 40 acres	$50 + 4 ERU

9.5 City of Centennial, Colorado, United States

9.5.1 Precipitation

Average annual precipitation is 349 mm. The month when it rains the most is July 41 mm (Figure 17) [72].

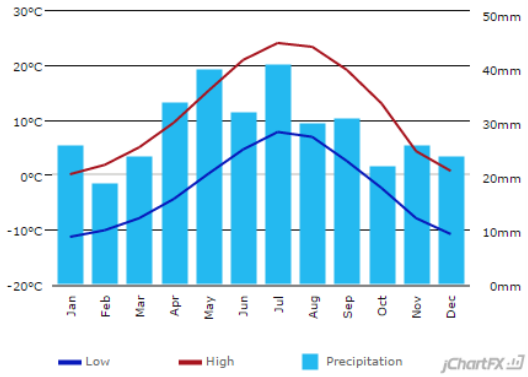


Figure 17 City of Centennial precipitation Graph [72]

9.5.2 Stormwater regulations

In the City of Centennial the stormwater services are managed by the Southeast Metro Stormwater Authority (SEMSWA). Drainage and flood control facilities are managed by the SEMSWA as well [71].

SEMSWA is using an integrated approach to meet the requirements of NPDES stormwater permit. The minimum control measures in the stormwater management program are [74]:

- Public outreach and education
- Public participation
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention/Good housekeeping [74]

9.5.3 Stormwater fees

Stormwater fee calculation in different for single-family residences and non-singe family properties.

9.5.3.1 Single-Family Residences

Single-Family residences will pay the fee based on impervious area. The impervious areas are divided into Tiers and fee is assigned to each Tier (Table 13) [71].

Table 13 Single-Family Residence fees [71]

Impervious Area (Square Feet)	2016 Fee
100 – 2,000	$53.98
2,001 – 2,900	$72.36
2,901 – 3,900	$94.16
3,901 – 7,500	$126,30
7,501 – 50,000	$274.42

9.5.3.2 Non-Single Family Properties

This fee applies to Commercial, Governmental, Non-Profit, Condo & Townhome Properties. Fees are based on a percentage of impervious area each property has. Condos and townhomes may pay a prorated share of the costs due for the entire condo/townhome complex (Table 14) [71].

Table 14 Non-Single Family Properties [71]

% Impervious of Property	2016 Annual Rate/1,000 Square Feet of Impervious Area
Less than 2%	No Fee
2% - 40%	$18.52
41% - 70%	$28.49
71% - 100%	$38.47

Fee is then calculated according to the formula:

$$Fee = Rate \times Property's\ Impervious\ Area \text{ [71]} \quad (14)$$

So if the property has an impervious area of 24,000 feet and the percentage of impervious area is between 41% and 70% then the fee is 28.49×24=683.76/year [71].

9.5.4 Credits

There are two types of credits Self-Maintenance Annual Credit and Grant Program Credit that reduce the stormwater fee.

9.5.4.1 Self-Maintenance Annual Credit

Some properties may have the capability to maintain regional stormwater systems. In this case the property owner relives SEMSWA of the responsibility to use public resources for this portion of the stormwater system. To qualify the property owner must provide maintenance of regional stormwater facilities that would otherwise be maintained by SEMSWA. Property owner must have an approved Maintenance Agreement detailing maintenance schedules and thresholds, responsibilities and have maintained such systems before and has a budget to continue [73].

The credits will be calculated case-by-case basis but may not exceed 50% because the annual fee payed by the property owner covers more than maintenance, and there are no discounts to the other services provided by the SEMSWA. The annual credit will apply to the property owner as long as the property owner maintains the regional stormwater facility and complies with the approved maintenance plan [73].

9.5.4.2 Grant Program Credit

Property owners who built their stormwater facilities before 2007 can apply for this credit. In 2007 water quality capture volume and flow control detention requirements were set for all developments and redevelopments. Those property owners who built their stormwater facilities before 2007 and who wish to upgrade their stormwater facilities to meet the quantity and quality goals can apply for this credit. Non-single family residential properties who want to upgrade their facilities may be eligible. To qualify property owners must own the existing stormwater facility and must address an existing or future need for detention or water quality treatment. [73].

This credit would assist property owners with the costs of upgrading stormwater facilities. The funds budgeted will be determined during each budget cycle. Funds will be give funds on a first come, first serve basis but may need a priority system when the need exceeds the funds [73].

9.6 Thief River Falls, Minnesota, United States

9.6.1 Precipitation

Average annual precipitation is 501 mm. The month when it rains the most is July 87 mm (Figure 18) [77].

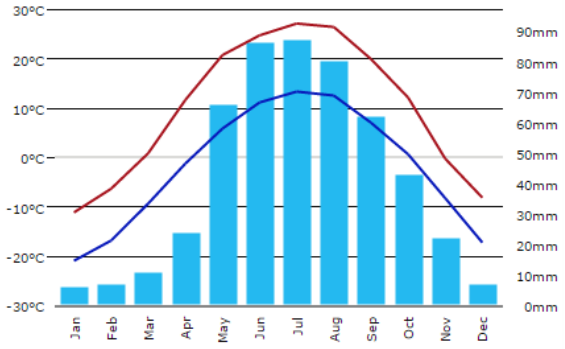


Figure 18 Thief River Falls precipitation Graph [77]

9.6.2 Stormwater regulations

The City has established a Stormwater Utility to collect charges that are used to improve, establish, enlarge, replace, repair, maintain and operating the system [75].

9.6.3 Stormwater fee

The stormwater fee is based on Residential Equivalency Factor (REF). Parcels are divided into categories and REF has assigned to each category (Table 15) [76].

Table 15 Residential Equivalency Factor [76]

Land Use Classification	REF
Single Family	1
Manufactured Home	1
Multi-Family Residential (the impervious area only)	2.5
Multi-Family Residential (entire parcel of land)	1.5
Commercial/Industrial (the impervious area only)	2.5
Commercial/Industrial (entire parcel of land)	1.5
Schools, Churches, Institutions (the impervious area only)	2.5
Schools, Churches, Institutions (entire parcel of land)	1.5
City-Owned Land	0
Vacant, Vegetative, and Unimproved Land	0

Fee is calculated like this:

$$Fee = REF \times Size\ of\ Parcel\ (acres) \times Fee\ Per\ Acre \quad [76] \tag{15}$$

The fee per acre is set by the City to be $7.50/acre/month [76].

9.6.3.1 Single-Family Residences

All single-family residential parcels are considered to be 1/3 acre in size and the monthly fee is smaller as well $2.50/month [76].

9.6.4 Credits

Larger commercial, industrial or institutional parcels will have their charges reduced by receiving a 50% credit for the second 5 acres and an 80% credit for the balance of parcel size over 10 acres. So for 21 acre development area fee is calculated like this:

$$5\ acres + (50\%)\ 5\ acres + (20\%)\ 11\ acres = 9.7\ acres \tag{16}$$

$$Fee = 9.7\ acres \times REF \times Fee\ per\ Acre \quad [76] \tag{17}$$

9.7 Horry County, South Carolina, United States

9.7.1 Precipitation

Average annual precipitation is 501 mm. The month when it rains the most is August 155 mm (Figure 19) [78, 79].

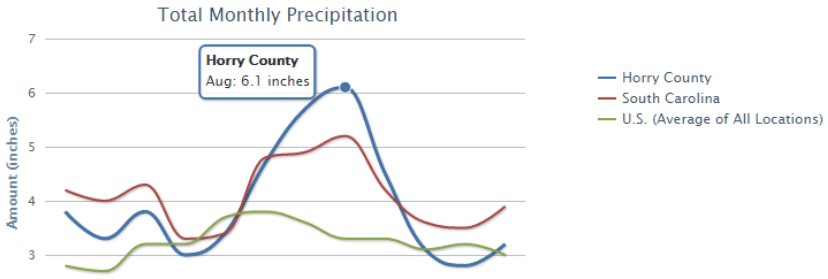


Figure 19. Thief River Falls precipitation Graph [79]

9.7.2 Stormwater regulations

The Horry County has established a stormwater management utility that is responsible for stormwater management programs throughout the unincorporated county, and its goal is to provide the management, protection, control, regulation, use, and enhancement of stormwater systems and facilities. The stormwater utility should establish a fund to manage stormwater like rentals, rates, charges, fees. All revenues must be placed in the stormwater management fund and all expenses of the utility should be financed from the fund [81].

9.7.3 Stormwater fee

Stormwater utility fees are paid by each property owner in Horry County. The fee is based on how much one property uses the drainage system – the gross area and the intensity of development of each property. Single-Family properties are billed differently than other properties [81].

9.7.3.1 Single-Family Residences

Single-family homes, townhomes and condominiums are charged a flat fee that is equal to 1 ERU. The single family fee is shown in the table below (Table 16) [81]:

Table 16 Single-Family Stormwater Fee [81]

Property Type	Gross area (square feet)	Development Intensity Factor	ERU	Monthly Fee per ERU	Fee
Single-Family Residences	20,000	0.25	1	$2.45	$2.45

9.7.3.2 Other developed and undeveloped lands

All developed and undeveloped lands are assigned a development intensity factor reflecting the overall development intensity of the property ranging from 0.01 for undeveloped land to 0.95 to very heavily developed land. Each 20,000 square feet is billed. The parcel's impervious percentage will be used to assign a development intensity factor to the parcel (Table 17) [81].

Table 17 Assignment of Development Intensity Factor to Developed Lands [80]

Impervious Percentage	Development Intensity Factor
90% - 100%	0.95
75% - 89.9%	0.80
55% - 74.9%	0.65
30% - 54.9%	0.40
10% - 29.9%	0.20
1% - 9.9%	0.05
Less than 1%	0.01

The development intensity factor assigned to undeveloped land is shown in Table 18:

Table 18 Assignment of Development Intensity Factor to Undeveloped Lands [80]

Total Land Areas	Development Intensity Factor
Up to 12 acres	0.01
12.1 – 100 acres	0.001
100.1 – 1,000 acres	0.0001
Above 1,000 acres	0.00001

Billing is done by ERUs that represent the average gross area and development intensity factor for a typical single family residential property and the calculation of the fee is done like this:

$$Fee = \frac{Property\ Gross\ area}{Gross\ area\ of\ one\ ERU} \times \frac{Development\ Intensity\ Factor}{Development\ Intensity\ Factor\ of\ 1\ ERU}\ [81] \quad (18)$$

An example of non-residential fee calculations (Table 19):

Table 19 Example of Non-Residental Stormwater Fee [81]

Propery Type	Gross area (square feet)	Development Intensity Factor	ERU	Monthly Fee per ERU	Fee
Commercial	95,832	0.40	7.66	$2.45	$18.77

9.7.4 Credits

9.7.4.1 Existing watershed districts

Properties those are located in a watershed district are already paying a watershed district millage for certain storm drainage services. All of these properties will have the amount of their watershed district millage for that property deducted from their computed stormwater service charge. If the watershed district millage is larger than its computed stormwater service charge, that property will not be charged a stormwater service charge [80].

9.7.4.2 Freshwater wetlands

All properties except single-family properties may receive a credit for those portions of the property that are classified as freshwater wetlands. The proportion of the property will be treated similar to the river and marsh areas and is deducted from the property's total land area in computing its stormwater service charge. This credit remains in effect as long as the conditions are met [80].

9.7.4.3 On-site detention and retention facilities

All developed land, except single-family properties, that have on-site detention or retention facilities may receive a credit. The stormwater utility service charge credit should be proportional to the reduced costs realized by the stormwater management utility, but should not be related to the cost of such services and activities to the person or entity providing same [80].

9.8 Helsinki, Finland

9.8.1 Precipitation

The annual precipitation is 688 mm, 57.3 mm per month. The month when it rains the most is October when the average rainfall is 73mm (Table 20) [95].

Table 20 Hesinki Precipitation [95]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Precipitation mm (in)	56 (2.2)	42 (1.7)	36 (1.4)	44 (1.7)	41 (1.6)	51 (2)	68 (2.7)	72 (2.8)	71 (2.8)	73 (2.9)	68 (2.7)	66 (2.6)	688 (27.1)

9.8.2 Stormwater regulations

According to Finnish Water Supply and Sewer act the local government is obligated to make a water resources development plan. Helsinki development plan has listed the priority activities [96]:

1. Stormwater should be infiltrated on site.
2. When stormwater cannot be infiltrated the peak rate of runoff has to be reduced by slowing down the stormwater.
3. Third option is to slow down the stormwater by directing the water through open system that allows some of the water to be infiltrated along the way.
4. Fourth option is that the stormwater is discharged through pipes to waterways.
5. And the last option is to direct the stormwater through combined sewage system to the treatment plant [96]

Helsingi, Espoo, Kauniainen and Vantaa have created union of municipalities called Helsinki Region Environmental Services Authority (HSY). HSY has to ensure water and sewer service this includes the stormwater management [96].

9.8.3 Stormwater fee

The stormwater fee is divided into two different parts. First there is a user fee that is charged together with wastewater and it is based on how much water is used per cubic litre of water. The second part is a basic rate. In this case the stormwater fee is calculated based on a formula [97]:

$$Basic\ rate = Service\ factor \times Property\ type\ factor \times Fixed\ rate \text{ [97]} \quad (19)$$

There are different service factors to different services because this formula is used to calculate wastewater and water fee as well. For stormwater the factor is 0.2 [97].

Property type factors can be found in Table 21:

Table 21 Property type factors [97]

The basic rate property types and their factors (p)	
Detached or semi-detached house	3.0
Terraced or linked house	2.7
Block of flats	2.5
Industrial building	2.2
Commercial building	2.0
Office building	1.8
Public building	1.6
Sports and exercise halls	1.3
Warehouses, industrial warehouses and car parks	1.0
Special cases (parks, fields, tunnels, fountains, etc)	0.5

The fixed rate is based on thetotal area that has been divided to categories (Table 22):

Table 22 Fixed basic rate [97]

Total area	Payment category	Total area used to calculate the basic rate (m²)	EUR/month (without tax)
0-100	A	100	1.56
101-250	B	175	2.73
251-350	C	300	4.68
351-500	D	425	6.63
501-1000	E	750	11.70
1001-2000	F	1500	23.40
2001-4000	G	3000	46.80
4001-7000	H	5500	85.80
7001-10000	I	8500	132.60
>10000	J	15000	234.00

9.8.4 Credits

There is no credit system for stormwater fees.

9.9 Baden-Württemberg, Germany

9.9.1 Precipitation

The annual rainfall is 674 mm. The month with the highest rainfall is June when the average rainfall is 89 mm (Figure 20) [99].

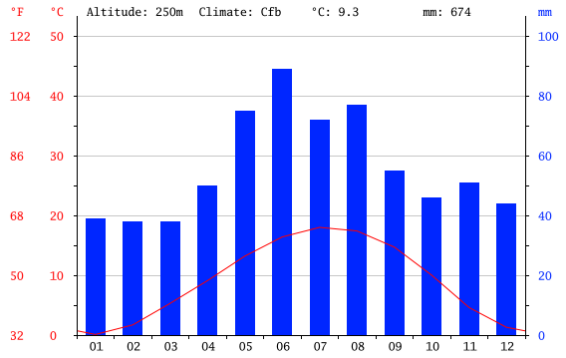


Figure 20 Baden-Württemberg precipitation graph [99]

9.9.2 Stormwater regulations

Baden-Württemberg is a federal state of Germany with a total area of 35,751 km², where 4 % is urban area [98].

The main principles of Water Act for Baden-Württemberg are:

- Water savings and efficiency on a property
- Water protection of chemicals
- Flood protection
- Adapting to climate change [98]

9.9.3 Stormwater fee

Administrative Court of Baden-Württemberg introduced a separate stormwater fee in 2010. The fee is based on runoff coefficient and each area is calculated separately and then added up (Table 23) [100].

Table 23 Runoff Coefficient [100]

	Area of	Runoff coefficient
Roof surfaces		
	Starndard roof	0.9
	Gravel packing roof	0.6
	Green roof	0.3
Open Spaces		
	Impervious (asphalt, concrete, ect)	0.9
	Paved or gravelled area where water can get through	0.3
	Parks and vegetation areas	0

Stormwater fee is calculated based on a formula:

$$Fee = Total\ area_1 \times Runoff\ coefficient_1 \times Rate + \cdots + Total\ area_n \times Runoff\ coefficient_n \times Rate\ [100] \quad (20)$$

9.9.4 Credits

Stormwater fee can be reduced when property owners:

- use building materials with increased infiltration capacity
- unseal surfaces
- retention of precipitation water through cisterns or rain barrels from 1 m³ storage volume
- infiltrate rainwater on the property
- drain rainwater into streams or ditches

When one or more conditions are met the area that is affected by the credit is subtracted from the charged area [100].

Conclusion

Different taxations and fees will not be warmly welcomed by the public so it is very important to carefully consider what kind of fee collecting method should be used. The best practice is to form a stormwater utility. In that case, the money collected will be used for stormwater management.

There are many ways to build up a stormwater charging system. This thesis has tried to give an overview of the main methodologies used. Almost all of the mentioned charging methodologies are good either they are based on impervious area, a combination of impervious and gross area, impervious area and the percentage of imperviousness, gross property area and the intensity of development or runoff coefficient as long as they are directly related to the amount of runoff generated in one property. However, the difference between these methodologies can come from how difficult they are to understand, how difficulty the fee is calculated and how complicated is the implementation.

Since the methodologies and ways the fees can be calculated can all be modified to the cities needs, it is hard to point out the best solutions but things that need to be considered are weather it is possible to gather the needed data, where and how the data can be stored and how much money the City is willing to invest in this system. Because the more data is needed the bigger and complex the information system should be made and the more it will cost.

The methodology can be mixed with other feeing systems like flat fee, Equivalent Residential Unit (ERU), Tier systems (TIER) and Residential Equivalency Factor (REF). These systems help to simplify the charging system or can provide a general fee for a certain property type. Also it is wise to combine a credit system with the charging methodology because the methodology itself may not be as motivating to the property owners to increase the amount of stormwater runoff entering the drainage systems.

Credits should be given to the property owners based on stormwater management practices. Credit system has to be thought out by the city and it should motivate the property owners to

deal with the first few centimetres of rain or to improve its quality. It is important to make people more aware of how their actions can affect strormwater runoff.
Many stormwater changing systems can be found in the United States. The examples given here are based on the stormwater charging methodologies to give better understanding how the methodologies can be used.

There are usually different charging systems for residential or single-family properties. A simplified system is used to reduce the amount of data needed or to simplify the system for the majority. This may cause inequality because property sizes and the amount of impervious areas may differ but a complex stormwater system may not justify itself or it may need more resources than it can give back.

Some of the stormwater charging methodologies can be more complex than others. For example impervious and gross area methodology, runoff coefficient and development intensity factor may not be as well understood by the property owners as impervious area methodology. But this does not mean that they are not good.

When we look at the credit systems then Philadelphia and Adams County have quite good credit system that can help to involve property owners and motivate them to reduce impervious area or improve the stormwater quality. Other example cityes and regions have credit system for very limited property types or regions.

When implementing a stormwater fee system it is important to define goals, what the fee system has to meet, take into consideration how public is affected; think of the whole implementation process, financial and legal aspects and needs for the database. All of these aspects have to be well thought over and it is important to realize that they are closely linked together.

Kokkuvõte

Tavaliselt ei suhtu inimesed maksudesse ja tasudesse hästi, mistõttu on väga oluline, et oleks hästi läbimõeldud, millist maksustamise süsteemi kasutada. Kõige parem viis on luua sademevee kommunaalteenus. Sellisel juhul läheb raha, mis on maa omanikelt kogutud, otse sademevee haldamisse.

Sademevee maksustamise loomiseks on palju erinevaid võimalusi. See töö analüüsib ja annab ülevaate põhilistest metoodikatest, mida mujal maailmas sademevee maksustamiseks kasutatakse. Kõik töös uuritud maksustamise metoodikad on head, olenemata sellest kas nad põhinevad kõvakattega pindade arvestamisega, on kombinatsioon kõvakattega pindadest ja kogupinnast, kõvakattega pindadest ja kõvakattega pindade protsendist, kogupinna ja arendamise intensiivsusest või äravoolutegurist. Peamine on, et nad on otseselt seotud kinnistul kujuneva sademevee äravooluga. Nende metoodikate erinevus seisneb keerulises ja kui keeruline on tasu arvutada, samuti, kui lihtsalt läheb selle metoodika kasutusele võtmine.

Kuna metoodikad sademevee maksustamiseks on iga linna ja regiooni jaoks sobivaks muudetavad, siis on keeruline välja tuua parimat metoodikat. Millega tuleks siiski arvestada, on algandmete kogumise keerukus, andmete hoiustamine ning kui palju raha linn või regioon on valmis kulutama, et süsteemi kasutusele võtta. Mida rohkem andmeid on vaja, seda mahukam ja keerukam infosüsteem tuleb luua ja seda rohkem ta maksab.

Metoodikaid on võimalik kombineerida teiste tasustamise võimalustega nagu fikseeritud tasu, Ekvivalente elamu ühik, rea süsteem ja Elamu ekvivalente faktor. Need aitavad lihtsustada tasustamise süsteemi, pakkudes üldist tasu kindla kinnisvara tüübi ees. Samuti on hea kasutada maksusoodustusi tasustamise metoodikaga koos, sest metoodika ise ei motiveeri kinnisvara omanikke tegema samme, et vähendada sademevee sattumist kanalisatsiooni.

Soodustusi tuleks anda erinevate sademevee vähendavate või sademevee kvaliteeti tõstvate tegevuste eest. Soodustused tuleb läbi mõelda linna poolt ja nad peaksid olema motiveerivad, et kinnisvara omanikud oleksid valmis esimest paari sentimeetrit immutama või parandama sademevee kvaliteeti.

Antud töös toodud näidetele on aluseks võetud erinevad maksustamise metoodikad, et luua parem arusaamine, kuidas antud metoodikaid on võimalik kasutada.

Tavaliselt on elamurajoonid või ühepere elamud maksustatud lihtsustatud süsteemi alusel. Lihtsustatud süsteem on kasutusel, et vähendada vajalike andmete mahtu või lihtsustada süsteemi arusaadavust kinnisvara omanikele. See võib tekitada ebavõrdsust, sest kinnisvara suurus ja kõvakattega alad võivad olla kinnisvarade lõikes erinevad. Kui aga kasutada keerulist maksustamist nende elamute puhul siis see maksustamine ei pruugi ennast ära tasuda.

Mõned sademevee maksustamise süsteemid võivad olla keerukamad kui teised. Näiteks kombinatsioon vett mitte läbilaskvast pinnasest ja kogupinnast; äravoolu koefitsient; ja kogu maaala ja arendamise intensiivsus ei pruugi olla nii hästi arusaadavad metoodikad kinnisvara omanikele kui ainult vett läbilaskva pinnase metoodika. Kuid see ei ole ainuke aspekt millele tuleb tähelepanu pöörata.

Philadelphia ja Adamsi Maakond on loonud head soodustuse süsteemid, mis aitavad kaasata kinnisvara omanikke ja motiveerib neid kõvakattega pindasid vähendama või parandama sademevee kvaliteeti. Teised linna ja maakonna näited omavad väga piiratud soodustusi, mis kehtivad ainult teatud kinnisvarale või kindlale regioonile.

Enne sademevee maksustamise süsteemi kasutusele võtmist on oluline teha kindlaks eesmärgid, mida soovitakse saavutada. Tuleb arvestada, kuidas inimesed on sellest maksust mõjutatud, vaadata tervet protsessi, sealhulgas finants- ja juriidilisi küsimusi ning andmebaasi vajadusi. Kõik need aspektid peavad olema põhjalikud läbi mõeldud ning on oluline aru saada, et kõik on tihedalt üksteisega seotud.

References

1. Tallinna sademevee strateegia aastani 2030, Tallinna õigusaktide register [WWW] https://oigusaktid.tallinn.ee/?id=3001&aktid=123505 (28.12.2015)
2. Stormwater Management Terms & Definitions [WWW] http://sp.mdot.ms.gov/Environmental/Stormwater%20Resources/Stormwater%20Management%20Terms%20And%20Definitions.pdf (09.05.2016)
3. Urban Drainage, David Butler and John W. Davies, 3rd edition, Spon Press, 2011, USA and London
4. Eesti Entsüklopeedia [WWW] http://entsyklopeedia.ee/artikkel/tallinn3 (20.03.2016)
5. Eesti Ekspress [WWW] http://ekspress.delfi.ee/kuum/tallinna-vesi-savisaar-pakub-imelikku-arvestust?id=69075139 (20.03.2016)
6. Tallinna kommunaalmajandus 1940-2011, Robert Nerman, Küllike Kaplinski , Tallinna Komunaalamet, 2012
7. Historical Perspectives of Urban Drainage, Steven J. Burian and Findlay G. Edwards, [WWW] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.492.8829&rep=rep1&type=pdf (21.03.2016)
8. Tallinna linna üldplaneering, [WWW]http://www.tallinn.ee/est/ehitus/Tallinna-linna-uldplaneering (21.03.2016)
9. Combined Sewer Systems: Down, Dirty, and Out of Date, John Tibbetts, 2015, [WWW] http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1257666/ (22.03.2016)
10. Separate Sewers, [WWW] http://www.sswm.info/content/separate-sewers (27.03.2016)
11. Reoveekanalisatsioonisüsteemid, torustikud, pumbajaamad, sademevee ülevoolud, puhastusseadmed, väljalask suublasse, Indrek Salis , 2007, [WWW] www.ttu.ee/public/e/ehitusteaduskond/Instituudid/Keskkonnatehnika_instituut/Oppetoo/operaatorikool/SlaidSalis4.ppt (05.05.2016)
12. Engineering Articles - What is Sewerage System & Disposal of Sewage, [WWW] http://www.engineeringarticles.org/what-is-sewerage-system-disposal-of-sewage/ (28.03.2016)

13. Riigi Teataja - Ühisveevärgi ja -kanalisatsiooni seadus, [WWW] https://www.riigiteataja.ee/akt/123122014023?leiaKehtiv (31.03.2016)
14. European Commission, Our Oceans, Seas and Coasts, [WWW] http://ec.europa.eu/environment/marine/international-cooperation/regional-sea-conventions/helcom/index_en.htm (8.04.2016)
15. HELCOM Baltic Sea Action Plan, 2007, [WWW] http://www.helcom.fi/Documents/Baltic%20sea%20action%20plan/BSAP_Final.pdf (8.04.2016)
16. Reduction of Discharges From Urban Areas by The Proper Management of Storm Water Systems, [WWW] http://www.helcom.fi/Recommendations/Rec%2023-5.pdf (8.04.2016)
17. Tallinna Vesi, [WWW] http://www.tallinnavesi.ee/est/Ettevote/uudised/429 (9.04.2016)
18. United States Environmental Protection Agency - Paying for Green Infrastructure Financing Options and Resources for Local Decision-Makers, [WWW] http://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100LPA6.txt (10.04.2016)
19. National Association of Flood and Stormwater Management Agencies - Guidance for Municipal Stormwater Funding, [WWW] http://www.epa.ohio.gov/Portals/35/storm/Guidance-Manual-Version-2X-2.pdf (16.04.2016)
20. New England Environmental Finance Center - Stormwater Utility Fees, [WWW] http://efc.muskie.usm.maine.edu/docs/StormwaterUtilityFeeReport.pdf (17.10.2016)
21. The Earth's Best Defence - Financing Stormwater Retrofits in Philadelphia and Beyond, [WWW] https://www.nrdc.org/sites/default/files/StormwaterFinancing-report.pdf(25.04.2016)
22. World Energy Solutions - Philadelphia Stormwater Charges, [WWW] http://www.rworldenergy.com/water-conservation/Philadelphia-Stormwater-Charges.shtml(25.04.2016)
23. Philadelphia Water - Stormwater Management, [WWW] http://www.phillywatersheds.org/watershed_issues/stormwater_management (25.04.2016)

24. City of Philadelphia Stormwater Management Regulation Compliance, [WWW] http://rrstormwater.com/city-philadelphia-stormwater-management-regulation-compliance (25.04.2016)
25. Watershed Forestry Resource Guide – Urban Tree Canopy, [WWW] http://forestsforwatersheds.org/urban-tree-canopy/ (25.04.2016)
26. SCS Runoff Curve Number Method, [WWW] http://www.professorpatel.com/curve-number-introduction.html (25.04.2016)
27. Southeast Metro Stormwater Authority - Stormwater Management Manual, [WWW] http://www.semswa.org/uploads/FileLinks/067f0d8e59624789b2717637e6d4543a/SEMSWA_SMM_revised_August_2012_.pdf (17.05.2016)
28. Average Annual Precipitation by City in the United States, [WWW] https://www.currentresults.com/Weather/US/average-annual-precipitation-by-city.php (26.04.2016)
29. Town of Normal Storm Water Credit Manual, [WWW] https://www.normal.org/DocumentCenter/Home/View/415 (26.04.2016)
30. Stormwater Management Service Charge: GA/IA Rate Methodology, [WWW] http://www.phillywatersheds.org/sites/default/files/PWD%20Stormwater%20Rate%20Methodology_V1.pdf (26.04.2016)
31. Managing Wet Weather with Green Infrastructure - Municipal Handbook, Funding Options, [WWW] https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_funding.pdf (26.04.2016)
32. U.S Climate Data, [WWW] http://www.usclimatedata.com/climate/monroe/north-carolina/united-states/usnc0458/2016/1 (13.05.2016)
33. Rate Structure Options, [WWW] http://www.lanecounty.org/Departments/PW/WMD/EnvironServices/Documents/4%20Rate%20Structure%20Options%20v2.docx (29.04.2016)
34. City of Anderson Stormwater Management – Stormwater Management Plan, [WWW] http://cityofandersonsc.com/stormwater/plan.pdf (15.05.2016)
35. Adams County Weather, [WWW]http://www.usa.com/adams-county-co-weather.htm (09.05.2016)

36. Roheline katus kui miniaed, [WWW]http://www.kodujaehitus.ee/index.php?id=295 (30.04.2016)
37. Melborne Water - What is a raingarden, [WWW] http://www.melbournewater.com.au/getinvolved/protecttheenvironment/raingardens/Pages/What-is-a-raingarden.aspx (30.04.2016)
38. Melborne Water - Green roofs, [WWW] http://www.melbournewater.com.au/getinvolved/protecttheenvironment/raingardens/Documents/GreenRoof.pdf (30.04.2016)
39. Melborne Water - Porous paving, [WWW] http://www.melbournewater.com.au/getinvolved/protecttheenvironment/raingardens/Documents/Porous%20paving.pdf (30.04.2016)
40. Melborne Water - Building an infiltration raingarden, [WWW] http://www.melbournewater.com.au/getinvolved/protecttheenvironment/raingardens/Documents/Infiltration.pdf (01.05.2016)
41. Managing Stormwater, [WWW] http://nemo.udel.edu/manual/Chap5Web.pdf (01.05.2016)
42. Conserve Enegry Future - What is Rainwater Harvesting?, [WWW] http://www.conserve-energy-future.com/Advantages_Disadvantages_Rainwater_Harvesting.php (01.05.2016)
43. ASCE-Philadelphia - Parcel Based Billing For Stormwater, [WWW] http://asce-philly.org/images/archive/2010/2010-03-11-ASCE-ChristopherCrockett.pdf (01.05.2016)
44. Pennsylvania Environmental Council - Stormwater BMP Manual, [WWW] http://pecpa.org/wp-content/uploads/Stormwater-BMP-Manual.pdf (02.05.2016)
45. Stormwater Water - Stormwater Retrofit Guidance Manual, [WWW] http://www.phila.gov/water/PDF/SWRetroManual.pdf (02.05.2016)
46. Philadelphia Water - Why are Stormwater Regulations important?, [WWW] http://www.pwdplanreview.org/stormwater-101/regulations (02.05.2016)
47. National Research Council - Urban Stormwater Management in the United States, [WWW] https://www3.epa.gov/npdes/pubs/nrc_stormwaterreport.pdf (02.05.2016)

48. Green Wei - How CSOs (combined sewer/water systems) work, why they're bad, [WWW] http://greenwei.com/blog/how-csos-combined-sewerwater-systems-work-why-theyre-bad/ (05.05.2016)
49. An Analysis of Trends in U.S. Stormwater Utility & Fee Systems, [WWW] https://vtechworks.lib.vt.edu/bitstream/handle/10919/53704/Kea_K_T_2015.pdf?sequence=1 (05.05.2016)
50. Merriam Webster – Sewage, [WWW] http://www.merriam-webster.com/dictionary/sewage (06.05.2016)
51. Susdrain - Component: Detention basins, [WWW] http://www.susdrain.org/delivering-suds/using-suds/suds-components/retention_and_detention/Detention_basins.html (06.05.2016)
52. Merriam Webster – Watercourse, [WWW] http://www.merriam-webster.com/dictionary/watercourse (06.05.2016)
53. Mimi Environment - Receiving waters, [WWW] http://en.mimi.hu/environment/receiving_waters.html (06.05.2016)
54. Delivering more effective stormwater management in the UK and Europe – lessons from the Clean Water Act in America, [WWW] http://documents.irevues.inist.fr/bitstream/handle/2042/25225/1697_081ashley.pdf?sequence=1 (07.05.2016)
55. EUR-lex - Urban wastewater treatment, [WWW] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=URISERV%3Al28008 (07.05.2016)
56. Adams County Colorado Government - Stormwater Utility, [WWW] http://www.co.adams.co.us/index.aspx?NID=1073 (08.05.2016)
57. Adams County Colorado Government – Stormwater Utility Policy Manual, [WWW] http://www.co.adams.co.us/DocumentCenter/View/7146 (08.05.2016)
58. Adams County Colorado Government – Stormwater Utility Credit Eligibility Report, [WWW] http://www.co.adams.co.us/DocumentCenter/View/5708 (08.05.2016)
59. Ottawa - Water, Wastewater and Stormwater Rate Structure Review, [WWW] http://ottawa.ca/en/residents/water-and-environment/water-and-sewer-bills/water-wastewater-and-stormwater-rate-structure (09.05.2016)

60. Dauphin County Conservation District - Best Management Practices Fact Sheet Detention Ponds, [WWW] http://www.dauphincd.org/swm/BMPfactsheets/Detention%20Basin%20fact%20sheet.pdf (09.05.2016)
61. Thief River Falls – Storm Water, [WWW] http://www.citytrf.net/index.asp?SEC=793E63F5-01BA-454F-9DA1-B0309D6A9407&Type=B_BASIC (09.05.2016)
62. City of Hanover - Stormwater Utility Report, [WWW] http://www.hanovermn.org/vertical/sites/%7B16C6D2AE-89FC-4A97-9E92-3449C8A9165C%7D/uploads/%7B2F5278A2-7A69-4D5F-A856-66085D51EC61%7D.PDF (9.05.2016)
63. Adams County - Stormwater Utility Credit Program Analysis, [WWW] http://www.co.adams.co.us/DocumentCenter/View/5707 (11.05.2016)
64. Anderson Stormwater Management - Stormwater Utility Fee Manual, [WWW] http://www.cityofandersonsc.com/stormwater/documents/SW2f.pdf (12.05.2016)
65. City of Monroe - Stormwater Utility Fee Explanation, [WWW] http://engineering.monroenc.org/wp-content/uploads/StormwaterUtilityFeeExplanation.pdf (13.05.2016)
66. City of Monroe - Stormwater Utility Credit and Adjustment Manual, [WWW] http://engineering.monroenc.org/wp-content/uploads/2014/11/StormwaterUtilityCreditandAdjustmentManual.pdf (13.05.2016)
67. City Of Greeley - Stormwater Fee Worksheet, [WWW] http://greeleygov.com/docs/default-source/construction-standards/stormwater/stormwater-fee-worksheet.pdf?sfvrsn=5 (14.05.2016)
68. U.S Climate Data, [WWW] http://www.usclimatedata.com/climate/anderson/south-carolina/united-states/ussc0006/2016/1 (15.05.2016)
69. City of Anderson – Stormwater Management Ordiance, [WWW] http://cityofandersonsc.com/stormwater/documents/SW2a.pdf (15.05.2016)

70. What is a SWPPP and Does Your Project Need One?, [WWW] http://www.rinconconsultants.com/about-us/blog/bid/95681/What-is-a-SWPPP-and-Does-Your-Project-Need-One (15.05.2016)
71. Southeast Metro Stormwater Authority - How Stormwater Fees Are Calculated, [WWW] http://www.semswa.org/how-stormwater-fees-are-calculated.aspx (17.05.2016)
72. U.S Climate Data, [WWW] http://www.usclimatedata.com/climate/centennial/wyoming/united-states/uswy0031 (17.05.2016)
73. The Southeast Metro Stormwater Authority - Credit Policy, [WWW] http://www.semswa.org/uploads/FileLinks/f229a4de7bde4894a517504c51abc289/CREDIT20POLICY_Reduced.pdf (18.05.2016)
74. The Southeast Metro Stormwater Authority - Regulatory Mission, [WWW] http://www.semswa.org/regulatory-mission.aspx (18.05.2016)
75. Thief River Falls - Public Utilities, [WWW] http://thiefriverfallsmn.govoffice3.com/vertical/sites/%7BF0A915C0-82C2-43FC-93FF-B561AD75910F%7D/uploads/53UtilitiesSewers.pdf (18.05.2016)
76. Thief River Falls - Stormwater, [WWW] http://www.citytrf.net/index.asp?SEC=793E63F5-01BA-454F-9DA1-B0309D6A9407&Type=B_BASIC (18.05.2016)
77. U.S Climate Data, [WWW] http://www.usclimatedata.com/climate/thief-river-falls/minnesota/united-states/usmn0733 (18.05.2016)
78. South Carolina Average Precipitation County Rank, [WWW] http://www.usa.com/rank/south-carolina-state--average-precipitation--county-rank.htm?hl=Horry&hlst=SC (19.05.2016)
79. Horry County Weather, [WWW] http://www.usa.com/horry-county-sc-weather.htm (19.05.2016)
80. Horry County, South Carolina - Code of Ordinances - Stormwater Management Utility, [WWW]https://www2.municode.com/library/sc/horry_county/codes/code_of_ordinances?nodeId=COOR_CH17.7STMA_ARTISTMAUT (19.05.2016)
81. Horry County – Stormwater, [WWW] http://stormwater.horrycounty.org/AboutUs/StormwaterUtilityFee.aspx (19.05.2016)

82. STORMWATER FEES An Equitable Path to a Sustainable Wastewater System, [WWW] https://www.spur.org/sites/default/files/publications_pdfs/SPUR_Stormwater_Fees.pdf (20.05.2016)

83. The World Bank - Average precipitation in depth, [WWW] http://data.worldbank.org/indicator/AG.LND.PRCP.MM/countries/1W-EE?display=map (28.12.2015)

84. Estonian Weather Service - Precipitation (mm) 1981-2010, [WWW]http://www.ilmateenistus.ee/kliima/kliimanormid/sademed/?lang=en (28.12.2015)

85. LA Stormwater - Permeable Pavements (or Porous Pavement Systems) [WWW]http://www.lastormwater.org/green-la/low-impact-development/residential-solutions/permeable-pavements-or-porous-pavement-systems/ (01.05.2016)

86. Handiman - Create a Raingarden, [WWW]http://www.handyman.net.au/create-raingarden (01.05.2016)

87. ERR.ee - Fotod: paduvihm ujutas taas Tuukri tänava üle, [WWW]http://uudised.err.ee/v/eesti/24da529b-df68-4441-b7c6-27663cf1b9d0 (8.04.2016)

88. Stormwater Retention, [WWW]https://webpages.uidaho.edu/larc380/new380/pages/retBasin.html (01.05.2016)

89. Deviant Art, [WWW]http://juliabohemian.deviantart.com/art/Tree-Canopy-180077500 (01.05.2016)

90. 7 Important Reasons for Rainwater Harvesting, [WWW]http://listaka.com/7-important-reasons-for-rain-water-harvesting/ (01.05.2016)

91. J&D Civil Engineers, LLC – Stormwater Management, [WWW]http://jdcivilengineers.com/stormwater.html (09.05.2016)

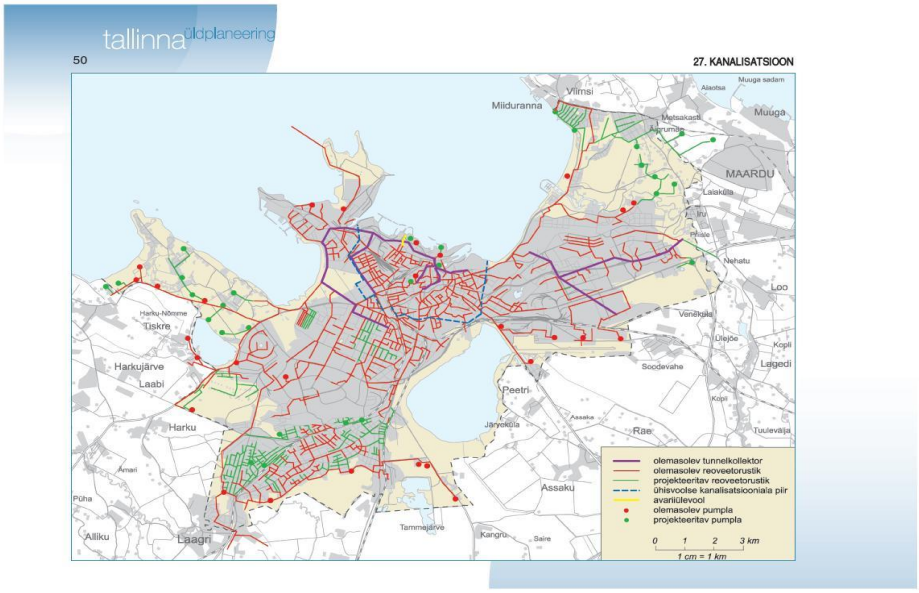
92. BBC - Weather Philadelphia, [WWW]http://www.bbc.com/weather/4560349 (26.04.2016)

93. Mõniste valla ühisveevärgi ja -kanalisatsiooni kasutamise eeskiri [WWW] https://www.riigiteataja.ee/akt/422072014002.txt (31.05.2016)

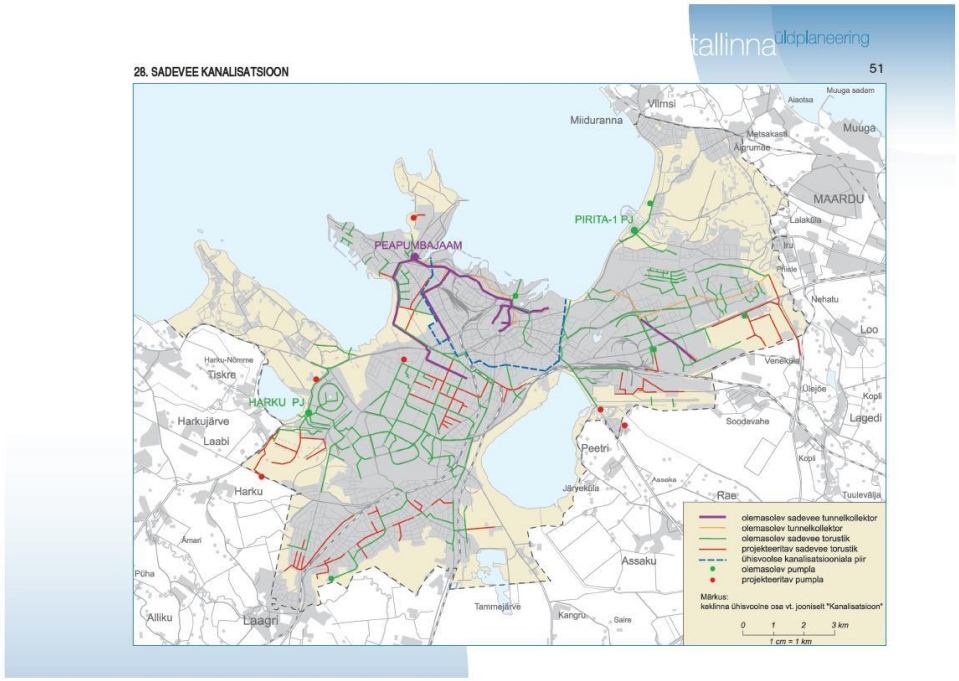
94. Business Dictionary [WWW]
http://www.businessdictionary.com/definition/ordinance.html (31.05.2016)
95. Rainfall/ Precipitation in Helsinki, Finland [WWW]
http://www.helsinki.climatemps.com/precipitation.php (31.06.2016)
96. Ülevaade sademevee (sh liigvee) äravoolu maksustamise alustest ja praktilistest rakendustest Euroopa Liidus ja mujal. Tallinn: Tallinna Tehnikaülikooli Keskkonnatehnika Instituut, 2010.
97. HSY's water services rates as of 1 January 2016 [WWW]
https://www.hsy.fi/sites/Esitteet/EsitteetKatalogi/water-services-rates-2016.pdf (29.05.2016)
98. Analysis of urban pollution sources and balancing of emissions from urban areas in the state of BadenWürttemberg (Germany), [WWW]
http://documents.irevues.inist.fr/bitstream/handle/2042/35719/32902-232WAN.pdf?sequence=1 (28.05.2016)
99. Climate Graph, [WWW] http://en.climate-data.org/location/6363/#climate-graph (28.05.2016)
100. Spanned wastewater fee: Frequently Asked Questions (FAQ)
https://translate.google.ee/translate?hl=et&sl=de&tl=en&u=http%3A%2F%2Fwww.baden-baden.de%2Fmam%2Ffiles%2Fumwelt%2Fentsorgung%2Fgesplittete_abwassergeb%C3%BChr_-_fragen_und_antworten.pdf (28.05.2016)

Appendix 1

Tallinn sewer map [8]:



Stormwater drainage in Tallinn [8]:



Appendix 2

PWD's Stormwater Map Viewer [45]: