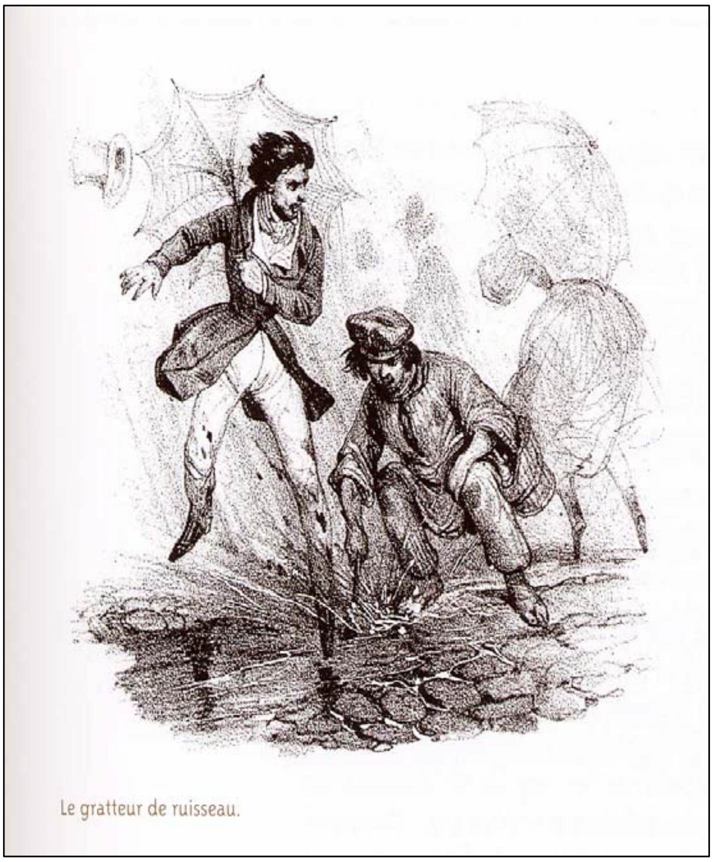
NOVATECH 2007

Workshop 5

Source Control: Managing Stormwater with a Water Balance Approach

A workshop of the **International Working Group SOCOMA**

(IWA/IAHR Joint Committee on Urban Drainage)



Workshop Organisers: **Gilles RIVARD (Aquapraxis) Sylvie BARRAUD (LGCIE –INSA)**

Sunday June 24th, 2007

NOVATECH 2007

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Recognition of adverse effects has led to a progression of evolving stormwater management strategies, each of which has attempted to minimize impact of urban runoff on the flow regime of receiving watercourses. While these efforts have resulted in reduction of some impact, research has shown that the current state of practice with respect to stormwater management is often not sufficient to mitigate the hydraulic and environmental impacts of land use change and urban development on water receiving bodies.

Examination of the premises behind current management strategies clearly reveals the need for a paradigm shift in stormwater management practice. While end-of-pipe solutions have been effective to a degree in reducing flood flow and water quality impacts, current science points to the need for a water balance approach that promotes additional source and conveyance controls to minimize the increase in runoff generation from urban landscapes and reduce impacts to receiving watercourses and the aquatic habitats that they support. The runoff volume control implied by this approach is often difficult or impossible to achieve only with end-of-pipe solutions and, in that context, source controls involving infiltration mechanisms become an essential component for the stormwater treatment train.

Based on invited presentations highlighting the practice in different parts of the world, different climates and various cultural contexts, this Workshop will examine their beneficial effects, the design criteria used for source control and the difficulties (technical, institutional and social acceptance) that can be encountered in their implementation. A panel discussion will provide a forum to discuss the implications of the new direction to be taken, addressing also the research needs that have been identified.

Timetable

Time slot	**Topic**	**Presenters**
9:00 am – 9:30 am	Welcome and overview of Water Balance approach and role of source control	Gilles Rivard Sylvie Barraud
9:30 am to 10:15 am	Germany	Heiko Seiker
10:15 am to 11:00 am	Brazil	Joel Goldenfum
11:00 am to 11:20 am	Coffee break	
11:20 am to 12:10 pm	Canada	Gilles Rivard
12:10 pm to 13:30 pm	Lunch	
13:30 pm to 14:15 pm	France	Bruno Tassin
14:15 pm to 15:00 pm	USA	Eric Strecker
15:00 pm to 15:20 pm	Coffee break	
15:20 pm to 16:10 pm	Australia	Grace Mitchell
16:10 pm to 17:00 pm	Panel discussion and forum	Sylvie Barraud

Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

Stormwater source control as a strategy for sustainable development: State of the practice and perceived trends

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ABSTRACT
The primary objective of the paper is to draw upon the experiences acquired in many parts of the world to provide an up-to-date summary of the state of the practice for source control techniques and approaches, in a sustainable development context. After a discussion of the prevailing context for urban drainage approaches, three main themes covering techniques and design criteria, institutional aspects and performance issues are discussed relative to source control implementation. The discussion is based on findings from the compilation and analysis of available literature, recently developed databases, the experience of the different members of the SOCOMA group and recent research on design methodologies that explicitly seek to better couple effective design and achievement of performance goals. The paper also discusses perceived trends in the selection, analysis, and implementation of source controls, highlighting the areas where knowledge is lacking and providing recommendations on needs for future research.

KEYWORDS
BMPs design criteria; BMPs effectiveness; integrated water management; Stormwater source control; sustainable development

INTRODUCTION
As one of the working groups of the IAHR/IWA Joint Committee, Specialist Group on Urban Drainage, SOCOMA (Source Control for Stormwater Management) provides an international forum to discuss and exchange information for all applicable structural or non structural measures concerning stormwater management before it enters a sewer system or a surface water body, close to the source. Conventional drainage systems in place today have developed since the 19th century with an implied objective to get the stormwater runoff out of the urban area as fast and efficiently as possible. This approach and the accelerated urban development

have in turn created problems of surcharging and flooding, which until recently were most often solved with end-of-pipe solutions (e.g. basins). However, it has been realized in the last 20 years that urban runoff pollution can be a significant problem and, given the desirability to take into account sustainable development principles, urban drainage approaches and criteria are now being re-examined in order to minimize the impacts of runoff in a more holistic and integrated way. From this perspective, source control techniques are perceived to be one important element that could help, by promoting control and infiltration as close to the source as possible, minimizing the hydrologic impacts of development. This change of paradigm (control near the source instead of rapid and efficient runoff conveyance) has however profound implications and it should not be viewed as a panacea or even, in some contexts, as more sustainable than traditional piped solutions.

This paper provides an overview of some of the key elements associated with the application of source control techniques. The first aspect concerns the general approaches of design and analysis that are now being reexamined in urban drainage. It is deemed important to put the approaches into perspective and to review the terminology that has been used in different parts of the world. Secondly, the techniques and the associated design criteria are discussed, highlighting the differences for particular regions or climates. A third section focuses on institutional aspects for implementation, followed by a discussion on the performance and effectiveness of the different techniques that have been developed. Finally, the areas where knowledge is lacking are presented, highlighting the needs for future research.

GLOBAL CONTEXT; EVOLVING URBAN DRAINAGE PARADIGM AND TERMINOLOGY

It is now widely recognized that rapid urbanization affects not only runoff quantity but also water quality, thereby producing significant hydrologic and ecological changes that can impact on streams, receiving waters and their habitats. Conventional pipe and curb systems, with their efficient ability to convey runoff rapidly to receiving waters, do not typically take into consideration these effects and new approaches have therefore been developed in recent years to address these concerns. Control and management near the source is now being promoted vigorously and it is viewed in many countries as comprising an appropriate suite of techniques facilitating the mimicry of natural processes and minimizing the hydrologic impacts.

This shift of paradigm has a significant impact on the way storm sewer systems are planned, designed, financed, operated and maintained. At the planning stage, it is now considered by many communities that water management considerations should be integrated at the very beginning of an urbanization project and, if possible, at the initial urban masterplanning stage, in order to take into account the potential benefits of water management and the potential uses in the city. This implies that a project based on source control for stormwater management will necessitate a multidisciplinary design group (engineers, urban planners, hydrologists, landscape architects, ecologists, sociologists, economists and people in charge of maintenance). Many experiences show the importance of such an approach but, in practice, consideration of source control measures is often difficult to include in the earliest stages of planning. For the design, it is recognized that there is not "one best" practice to be used in every situation and that every catchment must be evaluated for several variables in order to determine which measure is appropriate for that particular location. Decision problems are also associated with the evaluation of the effectiveness and sustainability of applied measures, which is still not very well defined due to a lack of long term in situ measurements and definitions as to how this should be assessed. However, databases are now being developed to help the designer in this respect (Strecker et al., 2004; Wild et al., 2002; EPA, 2002). Development and use of decision aiding tools and high performance simulation software, taking into account socio-economic, environmental and technical aspects are a main priority (e.g. DAYWATER project in Europe; Revitt et al., 2003).

Europe has generally followed the experiences of North America and Japan for the financing aspects of BMPs. Several examples are available in which regulatory obligations (especially in urban planning) and tax leverage has been used to implement source control policies. The weakness of the current approach is the lack of information about long term maintenance and control as the responsibility for this aspect is often transferred to individual owners. This could be viewed as an advantage for up-front costs (smaller regional basins or structures) or a disadvantage (potential problems for long-term maintenance and effectiveness). On the other hand, the concept of sustainable development has been, since its introduction in the 1980s, a central idea towards which evolving approaches to urban drainage have strived to adapt. Different definitions have been proposed (e.g. CIRIA, 2000; Maksimovic, 2000; Ellis et al., 2004) but the assessment of the degree of sustainability appears to have been mostly qualitative and subjective in nature; the use of robust sustainability indicators has not yet been developed. Moreover, stormwater control near the source is not necessarily any more or less sustainable than traditional piped solutions as it depends entirely on context as to which is likely to be the more sustainable. It is therefore unfortunate that in the UK, such systems are now known as ‘SUDS’ (Sustainable Urban Drainage Systems) – implying a sustainability ‘by definition’ and hence an automatic desirability in use. On the other hand, the US manual (WEF/ASCE, 1998), does not use the word ‘sustainable’ anywhere in the text.

Accepting the fact that the use of source control techniques can be beneficial in some contexts to reduce runoff-induced pollution, the basic question which remains is to specify to what extent the resulting drainage system will be sustainable. Potential sustainability criteria for stormwater management are presented by Crabtree (2000) (see also Revitt at al., 2003) under three major headings: Ecological Impact; Construction, Operation and Maintenance; and Social, Urban and Economic. Relevant issues are outlined for each of the categories, including the release of pollutants, use of material and energy, and health and safety, respectively.

One last general point is the terminology used in different countries. Source control is sometimes used as the equivalent of pollution prevention, encompassing measures designed to minimize the generation of, and entry of pollutants into, stormwater runoff, with emphasis on non-structural and semi-structural measures applied at or near source (Marsalek et al., 2001; CNRC, 2003). The same terminology is also used in other manuals to include on-site controls, which are usually structural in nature and applied at the individual lot level or on multiple lots that drain a small area (< 2 ha). Maybe a less confusing terminology would be to talk about generic source control, which would comprise pollution prevention (non-structural) and on-site controls.

It is also interesting to note the different names that have been used in different countries, often to describe similar techniques. In France, *Alternative techniques* (Azzout et al., 1994; CERTU, 2003) or *compensatory techniques* are used. In the US and Canada, we find BMPs, or Best Management Practices (which are not specific to source control measures), which has been translated in French as *Pratiques de Gestion Optimales* (PGOs) (CNRC, 2003); a global term which also emerged since the late 1990s is LID (Low Impact Development) (Prince

George's County, 1999). In the UK, the term Sustainable Urban Drainage (SUD) has been accepted in a number of publications (Wild et al., 2002). In Australia, there is WSUD (Water Sensitive Urban Design), which is used to describe a new approach to urban planning and design that aims to offer sustainable solutions for integrating land development and the natural water cycle.

TECHNIQUES AND DESIGN CRITERIA

Source control measures could be classified as non-structural or structural. Non-structural measures (also called in some guides and manuals Pollution Prevention measures or, confusingly, source control measures) include public education, awareness and participation, land-use planning and management of developing areas, modified use, releases and disposal of chemicals entering stormwater, development and enforcement of sewer ordinances, housekeeping practices and control of construction activities (CNRC, 2003; Revitt et al., 2003; UDFCD, 2002).

BMPs that could be used as structural measures for source control could be divided into 5 main categories : (1) vegetative systems (filter strip or buffer; grassed swales; green roofs); (2) Infiltration systems (soakaways, infiltration trenches or basins); (3) above or under ground storage facilities (detention/retention basins, wetlands, oversized pipes); (4) Road surfacing (porous paving or asphalt; reservoirs under roads); (5) Pre-treatment facilities (gross pollutant traps, litter baskets, sediment traps, oil and grit separators).

Technical design criteria to be adopted for stormwater BMPs and source control measures have evolved in the last 10 years to encompass the more holistic view that is now associated with stormwater management. These can be classified into 4 groups of general criteria (MOE, 2003; Maryland, 2000): (1) **water quality (**aquatic habitat, pollutant loading, temperature, recreation, groundwater contamination); (2) **erosion potential** (geomorphological characteristics and sensitivity, in-stream erosion); (3) **water quantity** (total and peak flows) and (4) **hydrologic cycle** (groundwater recharge, in-stream baseflow/low flow maintenance, surface and subsurface flow paths).

The unified sizing approach, using specific criteria for each category of concerns, is intended to manage the entire frequency of storms anticipated over the life of the stormwater management practice. Consequently, storms range from the smallest, most frequent events (which individually produce little runoff, but make up the majority of events and are responsible for the majority of groundwater recharge and impacts on water quality) up to the largest, very infrequent events that can cause catastrophic damages but for which most BMP facilities can provide little if any additional controls.

Revitt et al. (2003) give a good summary of techniques and of the particularities within different European countries. Swales and infiltration systems are widely used in Germany and innovative designs have been developed. Porous paving and reservoir structures under pavement are popular measures in France. Cold climate countries (Sweden, Denmark) have used retention ponds, ponds and infiltration systems. In the UK, filter drains, detention/retention basins and oil interceptors are very common. In the US, detention/retention ponds, grass filter strips and media filter are used commonly and represent the larger parts of the entries in the BMP database (Strecker et al., 2004). Porous paving are also used in the southern states.

The technical criteria for the current BMPs have been developed mostly in countries with temperate climates and there is an awareness that the BMPs themselves or, at least, the design criteria, should be modified for different types of climates. Particularities for cold climate countries are discussed in a number of publications (Barr (2001); CWP (1997); Maksimovic (2000); MOE (2003); Novotny et al. (1999); Revitt et al. (2003) ; Viklander et al. (2003)). There is a notable lack of knowledge on the urban runoff processes under winter and spring conditions in cold climate countries. BMP designs should be adapted for cold temperatures (i.e. ice on ponds), short growing seasons and snowmelt runoff. Maksimovic (2001) discusses specific problems with tropical climate, where larger rainfall rates, litter, sanitary conditions and diseases related to mosquitoes in standing water accumulations are important issues to consider.

INSTITUTIONAL AND PLANNING ISSUES

Much recent legislation around the world tends to point to a wider use of source control measures, in a global sustainable development context. For example, in France, a recent document has been issued by CERTU at the request of the Ministry of Ecology and Sustainable Development (CERTU, 2003). This guideline, which is a global document dealing with urban water management, recommends source control as the major principle of new stormwater systems and encourages source retention and infiltration. Many institutional and planning hurdles could however render more difficult than expected the application of this principle (Carré et al., 2004). Other considerations are:

- The effective implementation of storm water source control should be part of an integrated approach to storm water management but there are currently, in many countries, a large number of disparate institutional groups that have responsibility and/or interest in aspects of the urban water cycle. By partly transferring responsibilities for maintenance of the source control measures to individual home owners, there is an additional level of interaction that does not exist within conventional systems.
- To be effective, storm water source controls should be considered in any new development from the outset of the planning process. This is difficult and seldom occurs in practice as there is often no incentive to develop and implement alternative solutions.
- There are suggestions that increased public participation in the planning process may cause difficulties for regulatory bodies that need to maintain an independent, objective perspective.
- Contentious issues relating to adoption (and associated payment) of long term post-construction operation and maintenance costs of source control facilities as well as safety concerns over permanent water bodies in public open space are still widespread. There is evidence that housing associations and corporate estate management companies funded under annual service charges can provide more reliable O&M than local authorities.
- Regulations at various levels are diversely interpreted by the different local authorities (infiltration for example can be promoted in a region in order to reduce imperviousness or prohibited in another according to the “precautionary principle”).
- Even if it makes sense to consider that an integrated and multidisciplinary approach is necessary, most new projects are still based on technical aspects only. This is generally due to somewhat higher design costs or to the difficulty to effectively manage multidisciplinary projects (coordination of different services, different consulting agencies).

PERFORMANCE/EFFECTIVENESS ASSESSMENT

The most significant urban diffuse pollutants are sediments (including SS), oxygen demanding biodegradable organic materials, oils and hydrocarbons, pesticides, heavy metals, nutrients and fecal pathogens. Apart from possibly solids, it is far from certain whether the introduction of urban source controls will ever be able to reduce pollutant concentrations and loads to the equivalent recorded in the pre-development catchment. Irrespective of this, the major question is whether source controls can consistently (and in a long term perspective) reduce receiving water impacts to a lower level than conventional drainage systems. In this respect, there can be no doubt that any source control approach that prevents (or even attenuates) toxic contaminants from being incorporated into runoff discharges to receiving waterbodies will comprise cost-effective solutions.

General performance issues

- There is evidence of failure or performance below design expectations for infiltration basins/trenches and sand filters. Clogging, which compromises the hydraulic capacity of the system, is a major problem for infiltration or porous systems. The evidence for groundwater pollution below infiltration devices is nevertheless minimal but it clearly depends on the characteristics of the catchment; the possible contamination of underlying soil and groundwater is not yet entirely clear, particularly for sensitive conditions and long term operation.
- Pre-treatment measures are essential in most BMPs and will contribute to their longevity and sustainability.
- Retrofit technology is substantially more expensive (25 – 30%) than BMP installations for new developments
- Relatively little is known about optimum design limits and effects of hydraulic residence time for varying storm volumes on water quality performance for swales and storage facilities.
- Whilst vegetation coverage does play an important role in biofiltration and wetland pollutant removal, relatively little is known about the effects of vegetation type, rooting depth or height.
- For retention and detention basins, more information is needed on drawdown times and pollutant removal performance. In particular, data is lacking on the enhanced effects (if any) of extended drawdown times above 24 hours. In addition, the effects of controlled outlet discharge merit further investigation. Retention/detention basin design guidelines for consistent pollutant capture across the full range of expected storm events and for protection of downstream standards remain unclear.
- The long term performance, whole life costs and maintenance needs of most source controls are uncertain.
- For a number of source control measures, sludge removal and treatment could also be an important problem.
- Source controls are of limited effectiveness in dealing with floods. For the largest events, these systems will fail. Unfortunately, some of the systems will also be irreparably damaged by failure (unlike conventional piped systems which will usually return to normal functioning once the flood waters recede). This makes their implementation, even for flow control, subject to resistance when taken within the context of future climate change uncertainties.

Specific effectivenesses

Recent analyses of the US database have shown that BMP pollutant removal performance could be assessed by answering the following questions (Strecker et al., 2004): (1) How much stormwater runoff is prevented ? (e.g. hydrological source control); (2) How much of the runoff that occurs is treated by the BMP or not ? (e.g. bypass or overflow) and (3) Of the runoff treated, what is the effluent quality ? (or distributions of effluent quality). It is perceived that this approach provides a more robust and accurate characterization of BMP performance than percent removal, which is actually the usual parameter reported in most references. Based on the data contained in the US National BMP Database (www. bmpdatabase.org; Strecker et al., 2004), the EU DayWater project (www.daywater.org; Revitt et al., 2003) and a compilation of UK data sources (Ellis et al., 2005), it is possible to identify some broad quality performance characteristics for various source control types. The US database provides a good coverage for storage ponds (retention/detention basins, wetlands) and grass swales but has much less information for other biofiltration facilities (e.g filter strips) or for infiltration devices generally. The UK and European sources provide more comprehensive data for these source control types which can be usefully supplemented by reference to Australian data (Institution of Engineers, 2004). Based on these data sources, retention basins tend to demonstrate the best performance for most pollutant species, although there is considerable overlap in performance at low influent concentrations for all devices and pollutant groups with swale performance exhibiting the greatest sensitivity to influent concentrations. Some facilities such as swales have a tendency to accumulate pollutants such as bacteria over time.

RESEARCH NEEDS

Even if source control measures for urban drainage are gaining popularity in many countries, there are still many uncertainties attached to them in a widespread use. The perceived research needs are:

- Long term observation and monitoring, in order to follow the performance of the systems in terms of hydraulic and pollution risk but also in terms of people acceptance (users and personnel in charge of maintenance). For pollution risk, the conditions of groundwater contamination for the infiltration systems have to be especially considered (Ellis, 1997).
- Global modelling of source control systems in the longer term, integrating the continuous modification of the system structures (evolution of the land use of the catchment, evolution and prediction of clogging and its effect on performance).
- Performance indicators to qualify the sustainability of such systems in socio-economic, environmental and technical terms and development of more general efficiency criteria for source controls evaluation.
- Source controls whole life costs: wider studies on this topic can be useful in order to evaluate the relative sustainability of source controls approach with respect to other mitigation solutions.
- Definition of treatment trains for specific applications and of decision support systems to facilitate a global approach.
- BMPs should be adapted for different climate conditions (cold, humid tropical or arid) and much remains to be done in these areas. Appropriate design criteria should therefore be developed for these particularities.
- The majority of existing design guidelines emphasise single-site solutions for urban stormwater runoff control, whereas integrated catchment-wide approaches are required for diffuse pollution control under emerging European and North American legislation.

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Source Control:

Managing Stormwater with a Water Balance Approach

NOVATECH 2007

Introduction and general context
Introduction et contexte général

SOCOMA – Gilles Rivard – Sylvie Barraud

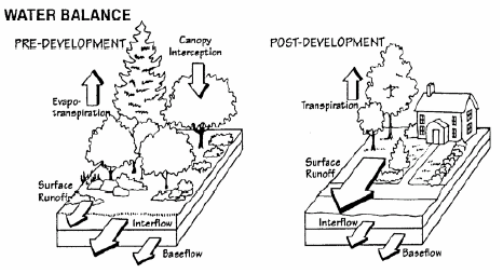
IWA/IAHR Urban Drainage Joint Committee

LYON

Lyon - France , 24 – 28 JUIN 2007

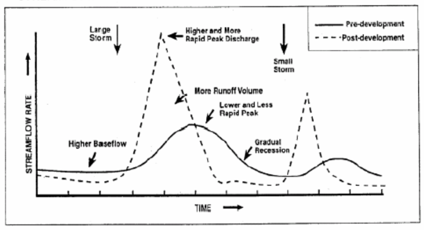
GENERAL IMPACTS OF URBAN DEVELOPMENT

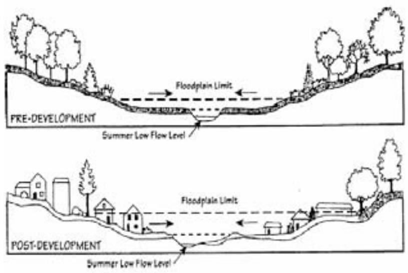
- Modifications to runoff volumes and water quality



- Surcharge and flooding

STREAMFLOW





- Degraded watercourses (erosion - SSOs - CSOs)

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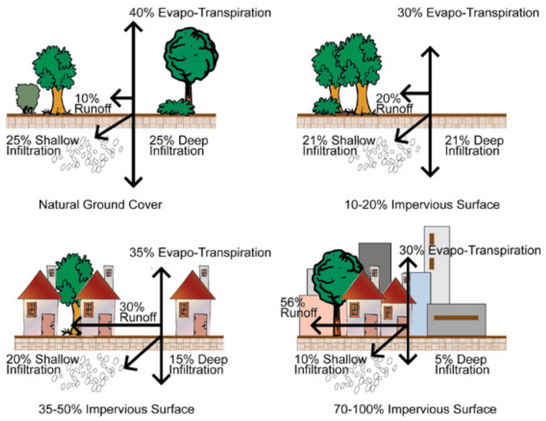
GENERAL IMPACTS OF URBAN DEVELOPMENT

Modifications to the hydrologic regime and on the water balance

Increase of peak **discharges** and runoff **volumes**

Historically – control of runoff volumes has been neglected

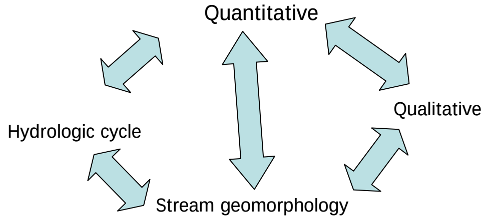
Volume control should be integrated in a Water Balance Approach



GENERAL IMPACTS OF URBAN DEVELOPMENT

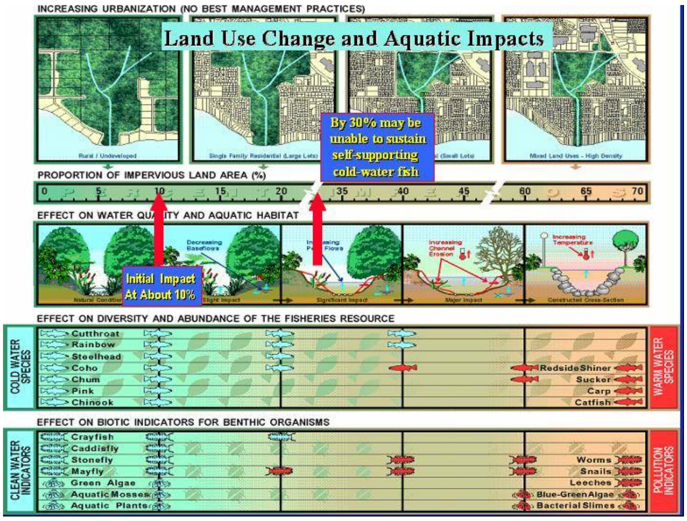
Different types of impacts

- Quantitative (discharges, runoff volumes, velocity of runoff)
- Qualitative
- Watercourse erosion (related to a degradation of the water quality)
- Hydrologic cycle (Groundwater and baseflows)



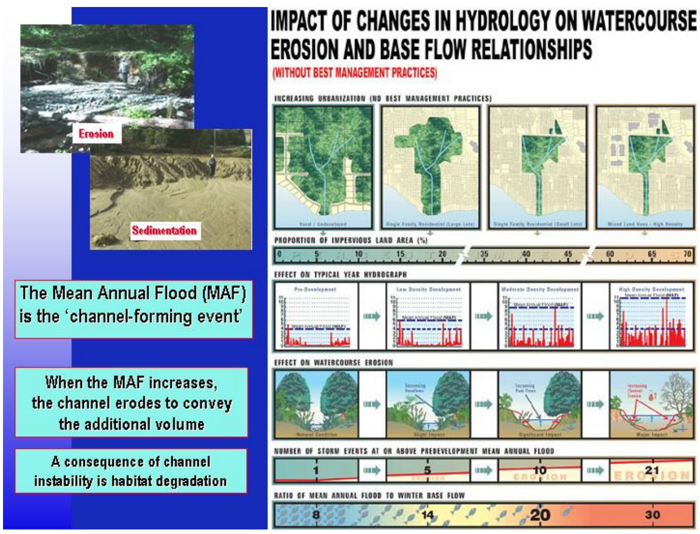
Inter-relation of the different types of impacts

GENERAL IMPACTS (Quantity)



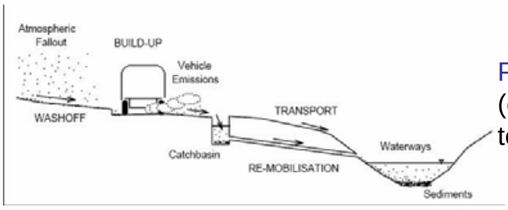
British Columbia, Canada

GENERAL IMPACTS (Quantity)



British Columbia, Canada

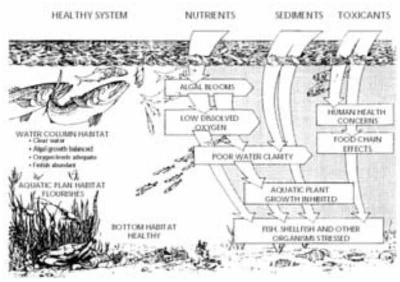
GENERAL IMPACTS (Quality)



Physical parameters
(discharges, solids, temperature, …)

Chemical parameters
(organic matter, nutrients, heavy metals, chloride, pesticides, Hydrocarbons, …)

Microbiological parameters
(bacteria and viruses)



GENERAL IMPACTS (Quality)

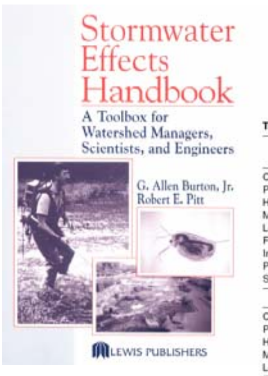


Table 2.5 Typical Urban Area Pollutant Yields (lb/acre/year or kg/ha/yr)[a]

Land Use	Total Solids	Suspended Solids	Chloride	Total Phosphorus	TKN	NH_3	NO_3 plus NO_2	BOD_5
Commercial	2100	1000	420	1.5	6.7	1.9	3.1	62
Parking lot	1300	400	300	0.7	5.1	2.0	2.9	47
High-density residential	670	420	54	1.0	4.2	0.8	2.0	27
Medium-density residential	450	250	30	0.3	2.5	0.5	1.4	13
Low-density residential[b]	65	10	9	0.04	0.3	0.02	0.1	1
Freeways	1700	880	470	0.9	7.9	1.5	4.2	NA[b]
Industrial	670	500	25	1.3	3.4	0.2	1.3	NA
Parks	NA[c]	3	NA	0.03	NA	NA	NA	NA
Shopping center	720	440	36	0.5	3.1	0.5	1.7	NA

Land Use	COD	Lead[d]	Zinc	Chromium	Copper	Cadmium	Arsenic
Commercial	420	2.7	2.1	0.15	0.4	0.03	0.02
Parking lot	270	0.8	0.8	NA	0.06	0.01	NA
High-density residential	170	0.8	0.7	NA	0.03	0.01	NA
Medium-density residential	50	0.05	0.1	0.02	0.03	0.01	0.01
Low-density residential[e]	7	0.01	0.04	0.002	0.01	0.001	0.001
Freeways	NA	4.5	2.1	0.09	0.37	0.02	0.02
Industrial	200	0.2	0.4	0.6	0.10	0.05	0.04
Parks	NA	0.005	NA	NA	NA	NA	NA
Shopping center	NA	1.1	0.6	0.04	0.09	0.01	0.02

[a] The difference between lb/acre/year and kg/ha/yr is less than 15%, and the accuracy of the values shown in this table cannot differentiate between such close values.
[b] The monitored low-density residential areas were drained by grass swales.
[c] NA = Not available.
[d] The lead unit area loadings shown on this table are currently expected to be significantly less than shown on this table, as these values are from periods when leaded gasoline adversely affected stormwater lead quality.
[e] The monitored low-density residential areas were drained by grass swales.

Data from Bannerman et al. (1979, 1983); Madison et al. (1979); EPA (1983); Pitt and McLean (1986).

GENERAL IMPACTS (Quality)

Mean Pollutant Concentration Generated by Different Land Uses

Land Use	Primary Indicators		Secondary Indicators					Metals					
	TSS (mg/L)	TP (mg/L)	BOD (mg/L)	COD (mg/L)	TKN (mg/L)	TDS (mg/L)	TN (mg/L)	Cd (ug/L)	Cr (ug/L)	Cu (ug/L)	Pb (ug/L)	Ni (ugL)	Zn (ug/L)
Forested wetland	19.0	0.2	4.1	29.4	0.6	52.0	1.1	0.5	2.8	5.3	3.0	4.7	22.9
Cropland and Pasture	19.2	0.2	4.2	29.7	0.6	52.0	1.1	0.5	2.9	5.4	3.1	4.7	23.5
Upland forest	19.7	0.2	4.3	30.4	0.7	52.0	1.1	0.5	2.9	5.6	3.2	4.7	24.8
Urban open	20.0	0.2	4.4	30.7	0.7	52.0	1.1	0.5	2.9	5.7	3.2	4.7	25.4
Communication and utilities	20.7	0.2	4.6	31.7	0.7	52.0	1.2	0.5	3.0	6.0	3.4	4.8	27.5
Low-density Residential	22.1	0.2	5.0	33.4	0.8	52.0	1.2	0.5	3.1	6.5	3.8	4.8	31.2
Medium-density residential	30.5	0.2	7.5	43.5	1.1	52.0	1.7	0.6	3.8	9.7	6.1	5.0	59.4
Institutional	41.9	0.3	11.3	56.7	1.5	52.0	2.4	0.6	4.5	14.7	9.9	5.3	112.9
High-density residential	47.7	0.3	13.3	63.1	1.7	52.0	2.7	0.7	4.9	17.3	12.0	5.4	145.9
Multifamily residential	47.7	0.3	13.3	63.1	1.7	52.0	2.7	0.7	4.9	17.3	12.0	5.4	145.9
Commercial	54.2		15.7	70.1	2.0		3.1	0.7	5.3	20.4	14.5	5.5	188.7
Highways	57.8		17.0	74.0	2.1	1.3	3.3	0.7	5.5	22.1	16.0	5.5	214.6
Industrial	57.8		17.0	74.0	2.1	1.3	3.3	0.7	5.5	22.1	16.0	5.5	214.6

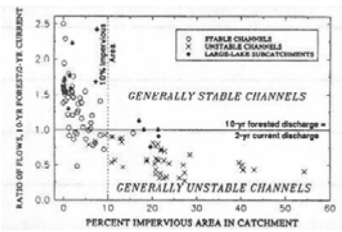
Risk to Fish Habitat by Increase in TSS

European Commission		Canada	
TSS – mg/L	Risk Level	TSS – mg/L	Risk Level
<25	Not harmful	<25	Very low risk
25-80	Somewhat diminished yield	25-100	Low risk
80-400	Unlikely to support fisheries	100-200	Moderate risk
>400	Only poor fisheries	200-400	High risk

GENERAL IMPACTS (Stream erosion)

Increase of erosive forces

Secondary impacts on habitats and water quality



Visible impacts at 10 % imperviousness

MINIMIZING THE IMPACTS OF URBAN DEVELOPMENT

2000s : Stormwater management redefined with new context

- Sustainable development
- Management taking into account ecological & social systems (acceptable cost)
- Improved understanding of stormwater runoff effects on receiving waters
- Desirable approach to consider urban water in an integrated way
- Watershed management & urban management

MINIMIZING THE IMPACTS OF URBAN DEVELOPMENT

Trends in urban drainage

- Shift of paradigm

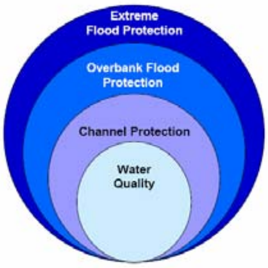
  Mimicry of natural processes and minimizing total hydrological impacts vs Rapid and efficient runoff

- Treatment train instead of simple curb and gutters systems
- Control of complete range of rainfall
- Volume control
- Use technical solutions for other purposes (landscape, playground, water reuse, ...)

MINIMIZING THE IMPACTS OF URBAN DEVELOPMENT

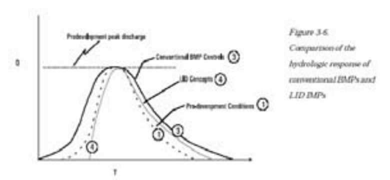
Enlargement of design criteria

General groups of design criteria

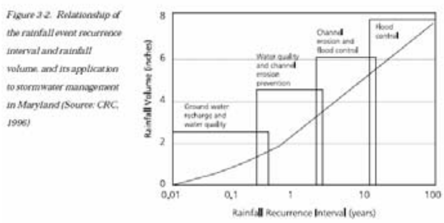


- Water quality
- Erosion potential
- Water quantity
- Hydrologic cycle (Groundwater – baseflows)
- Water perception and usual population practices

MINIMIZING THE IMPACTS OF URBAN DEVELOPMENT



- Control of runoff volumes

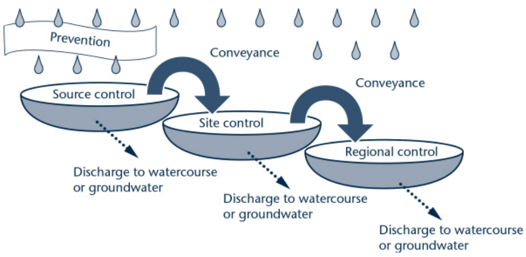


Importance of source control for these 2 aspects

- Control of complete range of rainfall or Design / simulation with long series)

CONTROL FRAMEWORK

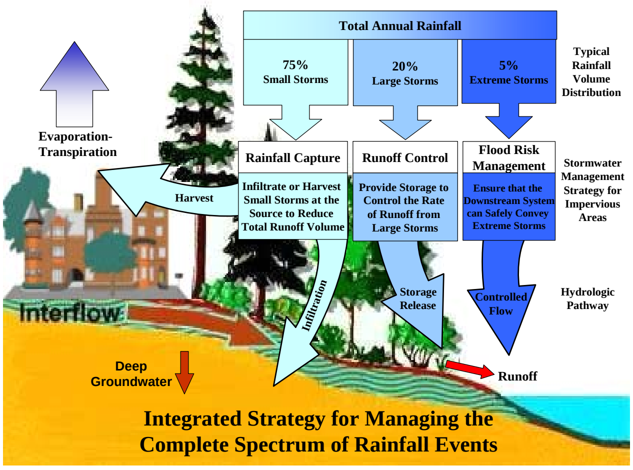
Treatment train approach



- Stormwater runoff
- Pollution Prevention
- Source Control
- On-site (lot-level) Controls
- Conveyance Level Controls
- End-of-pipe Controls
- Receiving Waters

CONTROL FRAMEWORK

Complete range of rainfall – Water Balance Approach



British Columbia (Canada) - 2003

CONTROL FRAMEWORK

From TRADITIONAL to → INTEGRATED:

- Drainage Systems → Ecosystems
- Reactive (Solve Problems) → Proactive (Prevent Problems)
- Engineer-Driven → Interdisciplinary Team-Driven
- Protect Property → Protect Property *and* Habitat
- Pipe and Convey → Mimic Natural Processes
- Unilateral Decisions → Consensus-Based Decisions
- Local Government Ownership → Partnerships with Others
- Extreme Storm Focus → Rainwater Integrated with Land Use
- Peak Flow Thinking! → Volume-Based Thinking!

Source control and infiltration techniques become essential in a Volume-Based thinking

EXAMPLES – SOURCE CONTROL

Non-structural or structural

5 General categories for structural measures

- Vegetative / soil systems
- Infiltration systems
- Above or under ground storage
- Road surfacing
- Pre-treatment facilities

EXAMPLES – SOURCE CONTROL

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EXAMPLES – SOURCE CONTROL

More of that green stuff...

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INSTITUTIONAL AND PLANNING ISSUES

Institutional and planning difficulties

- Integration with different institutional groups – maintenance responsibility at lot level ?
- Incentives to develop alternative solutions
- Conflicts with other building and design requirements
- Increased public participation – good or bad ?
- Long-term maintenance
- Diverse interpretation of regulations
- Multidisciplinary design team

PERFORMANCE AND EFFECTIVENESS

General performance issues

- Clogging for infiltration systems and sand filters
- Pre-treatment measures are essential
- Retrofit is more expensive than BMPs for new developments
- Role of vegetation type in bioretention/wetlands
- Optimum design limits
- Long-term performance
- Sludge removal and treatment
- Effectiveness for floods
- Social acceptance and shift of practices (design, maintenance, ...)

PERFORMANCE AND EFFECTIVENESS

Specific effectivenesses

- Usual parameter : percent removal
- More robust and accurate approach (Strecker, 2004):
  - How much stormwater runoff is prevented ?
  - How much of the stormwater runoff is treated ?
  - Of the runoff treated, what is the effluent quality ?
  - Does the BMP control discharges such that streams are protected ?

PERFORMANCE AND EFFECTIVENESS

International databases

- US National BMP database (www.bmpdatabase.org)

  Storage ponds / grass swales

- EU DayWater project (www.daywater.org)

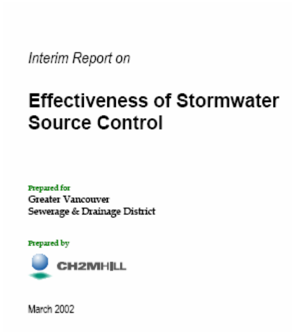
  Biofiltration / Infiltration devices

- UK data sources (Ellis et al., 2005)

FR OTHU (infiltration)

http://www.graie.org/othu/
(Barraud et al., 2001)

....



Interim Report on

Effectiveness of Stormwater Source Control

Prepared for
Greater Vancouver
Sewerage & Drainage District

Prepared by
CH2MHILL

March 2002

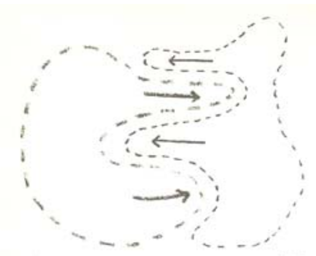
IMPLEMENTATION

- Different types of climates
  - Cold climate – Winter and spring conditions, ice, short growing season
  - Tropical climate – larger rainfall rates, litter, sanitary conditions, diseases (mosquitoes)
  - Arid or semi-arid climate – Groundwater recharge, infiltration rates

THE FUTURE ...

Multi-disciplinary : Communication

Integration of different disciplines for common objectives



Exchange of information and data

Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

Current situation and perspectives in Brazil

Situation actuelle et tendances au Brésil

Dr Joel Avruch Goldenfum
IPH/UFRGS
BRAZIL

Workshop 5

Source Control:

Managing Stormwater with a Water Balance Approach

Current situation and perspectives in Brazil

La situation actuelle et les tendances en Brésil

Dr Joel Avruch Goldenfum

IPH/UFRGS

BRAZIL

Brazilian Basins

8.511.965 km²

190.000.000 inhabitants

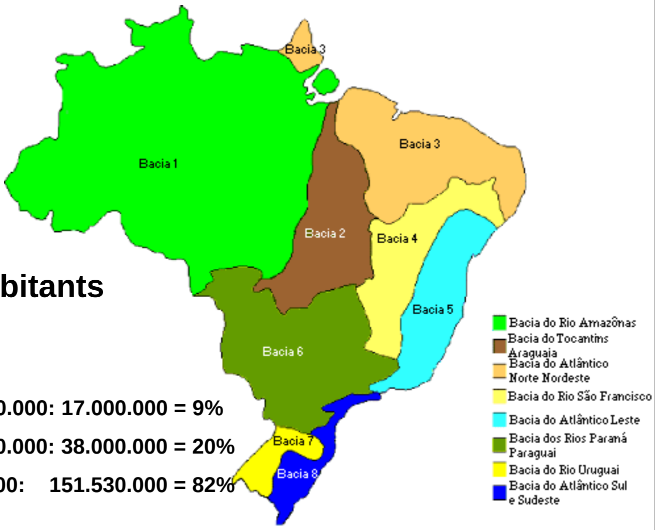
80 % urban:

5.564 cities and towns

2 cities (0,04%) > 5.000.000: 17.000.000 = 9%

14 cities (0,25%) > 1.000.000: 38.000.000 = 20%

1.594 cities (29%) > 20.000: 151.530.000 = 82%



Difficulties – developing countries

Climatic and socioeconomic conditions

- Intense rainfall
- greater capacity to generate runoff
- greater erosive capacity
- proliferation of vectors/carriers of tropical diseases
- precarious public works (cleaning-inspection services)
- technically outdated, ill-planned storm drainage systems
- data deficiency

N O V A T E C H 2 0 0 7

Difficulties – developing countries

Climatic and socioeconomic conditions

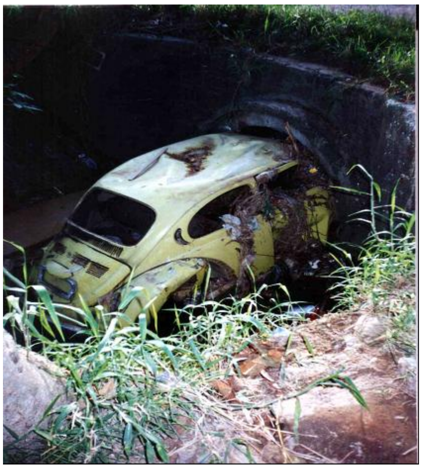
- Uncontrolled urban expansion

N O V A T E C H 2 0 0 7

Difficulties – developing countries

Climatic and socioeconomic conditions

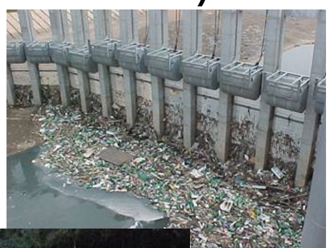
- Obstructions (“solid waste”)



Difficulties – developing countries

Climatic and socioeconomic conditions

- Water quality issues (and solid waste)



Difficulties – developing countries

Climatic and socioeconomic conditions

- Institutional and political issues

- Lack of legal instruments

  +

  difficulty to approve new legislation

  - costs to prevent and solve inundation problems are paid by the public sector
  - strong opposition from developers

- Urban planning restrictions - lack of appropriate public or private spaces

Difficulties – developing countries

Climatic and socioeconomic conditions

- Institutional and political issues

- Not enough articulation among the several public organs
- Legal conflicts among Cities, State and Union:
  - Soil use regulation: municipal
  - Environment protection,polution control, public health and security: States and Union
- Measures developed in the city frequently with no agreements with neighbouring towns
- Trend: macrozonig urban directives introduced by the towns with incentive of the States

Difficulties – developing countries

Climatic and socioeconomic conditions

- lack of knowledge and technical information

Opposition

by the population
by the designers
by the public managers

Perspectives for improvements

- Significant increase on:
  - Scientific and technical publications
  - talks on drainage compensatory approach
- Changes in curricula:
  - Engineering Schools
  - Architecture Schools

URBAN WATER MASTER PLANS IN BRAZIL

- Belo Horizonte – Urban Master Plan (1996): impermeabilization compensed by detentions (30 l/m2 of impermeabilized area).
- Porto Alegre – Urban Master Plan (2000): acknowledgement of urbanization effects on flow and of flow control reduction necessity to be regulated by DEP
- Guarulhos Constrution directives (2000): detentions to control floods for areas bigger than 1 ha.
- Urban drainage Master Plans:
  - Porto Alegre (2000)
  - Curitiba Metropolitan Area (2000)
  - Caxias do Sul (2001)
  - Flores da Cunha (2003)

São Paulo

Curitiba

Belo Horizonte

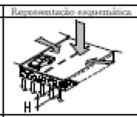
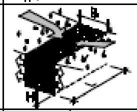
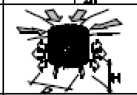
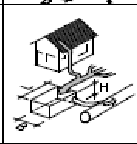
Natal

Porto Alegre

N O V A T E C H 2 0 0 7

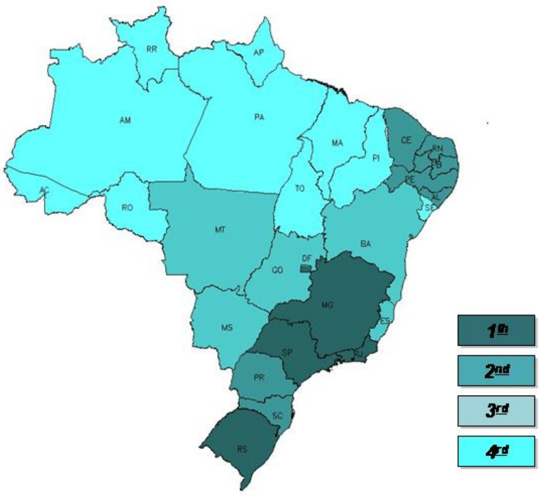
Trends for Regulation

- Urban Drainage Master Plans
- Local regulations in the cities
- Technical studies and guielines

Dispositivo	Representação esquemática	Fórmulas para pré-dimensionamento
Pavimento permeável		$H = \frac{V_{max}}{\eta}$; $V_{max} = \left(\sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2} - \sqrt{\frac{c}{60}}\sqrt{q_S}\right)^2$
Trincheira de Infiltração		$H = \left[\frac{k_1(k_2-\sqrt{\eta})}{\eta - k_2^2}\right]^2$; $k_1 = \sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2}$; $k_2 = \sqrt{\frac{c}{60}}\sqrt{\gamma}\sqrt{q_S}$; $\beta = \frac{C.A}{B.L}$; $\gamma = \frac{2L}{L.B} = \frac{2}{B}$
Vala de Infiltração		$H = V_{max} = \left(\sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2} - \sqrt{\frac{c}{60}}\sqrt{q_S}\right)^2$; $\beta = \frac{C.A}{B.L}$
Poço de Infiltração		$H = \left[\frac{k_1(k_2-\sqrt{\eta})}{\eta - k_2^2}\right]^2$; $k_1 = \sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2}$; $k_2 = \sqrt{\frac{c}{60}}\sqrt{\gamma}\sqrt{q_S}$; $\gamma = \frac{4}{D}$; $\beta = \frac{4.C.A}{\pi.D^2}$
Micro-reservatório		$V_{max} = \left(\sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2} - \sqrt{\frac{c}{60}}\sqrt{\gamma}\sqrt{H}\sqrt{q_S}\right)^2$; $\beta = \frac{C.A}{B.L}$; Infiltrante: $H = \left[\frac{k_1(k_2-\sqrt{\eta})}{\eta - k_2^2}\right]^2$; $k_1 = \sqrt{\frac{a}{60}}\sqrt{\beta}T^{b/2}$; $k_2 = \sqrt{\frac{c}{60}}\sqrt{\gamma}\sqrt{q_S}$; $\gamma = \frac{2(L+B)}{L.B}$; Estanque: $H = V_{max}$; $\sqrt{\gamma}\sqrt{H} = 1$
Bacia de Detenção		$H = V_{max} = \left(\sqrt{\frac{a}{60}}\sqrt{C}T^{b/2} - \sqrt{\frac{c}{60}}\sqrt{q_S}\right)^2$; $q_S = q_{pre} + \alpha K_{sat}$; Leito impermeável: $q_S = q_{pre}$; Bacia de infiltração: $q_S = \alpha K_{sat}$

V_{max} = volume de dimensionamento (mm) η = porosidade do material de enchimento do dispositivo

Research – numerical and analytical



Research - experimental

- São Carlos - USP

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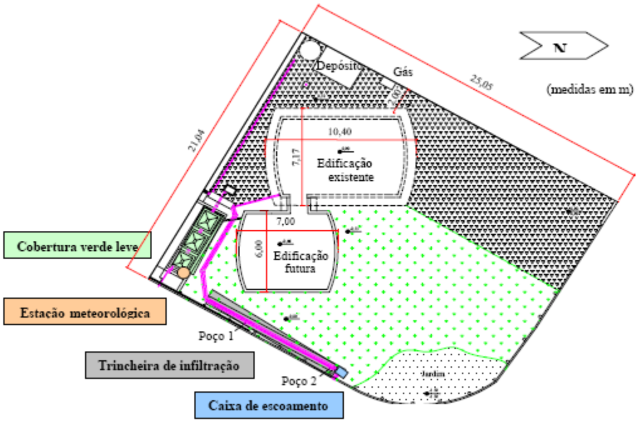
Research - experimental

- São Carlos - USP

lote.



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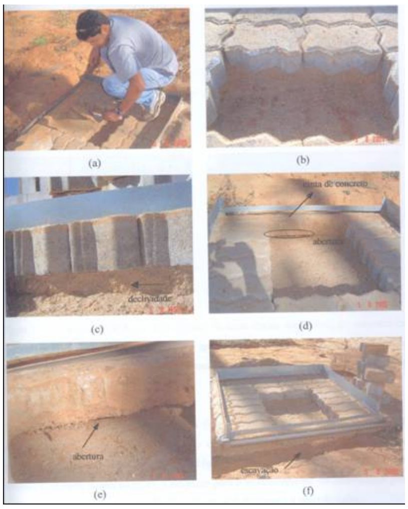
Research - experimental

- Brasília - UnB



Research - experimental

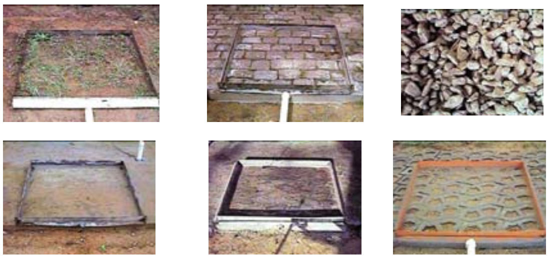
- Porto Alegre – IPH/UFRGS

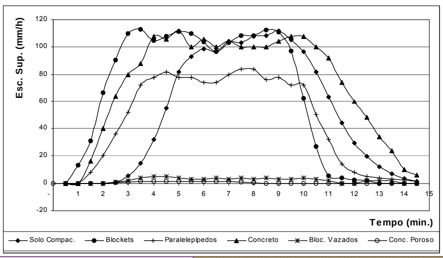
Research - experimental

- Porto Alegre – IPH/UFRGS

Research - experimental

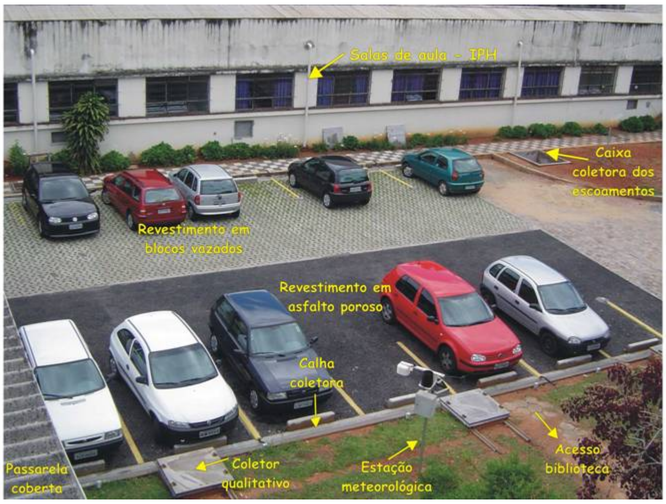
- Porto Alegre – IPH/UFRGS





Research - experimental

- Porto Alegre – IPH/UFRGS



Research - experimental

- Porto Alegre – IPH/UFRGS

Proposal for Future improvements

Administrative actions:
- Integration among administrative organizations
- Long term planning – PDDrU
- Law enforcement

Education:
-Technical information for designers
- General information for decision makers
- Environmental education for general public

Academia:
- Research
- Product development
- Teaching: undergrad, post-grad, extension
- Experimental Studies
- Association with other sectors
- Educative Campaigns

Questions for discussion

Sustainability

Education
Capacity Building

Knowledgement Transfer and Adaptation


Thank You !!
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Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

Current situation and perspectives in France

Situation actuelle et tendances en France

Bruno Tassin & Jean-Claude Deutsch
CEREVE – ENPC
France

Workshop 5

Source Control:

Managing Stormwater with a Water Balance Approach

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France - Stormwater Management or Urban management ?

Version1

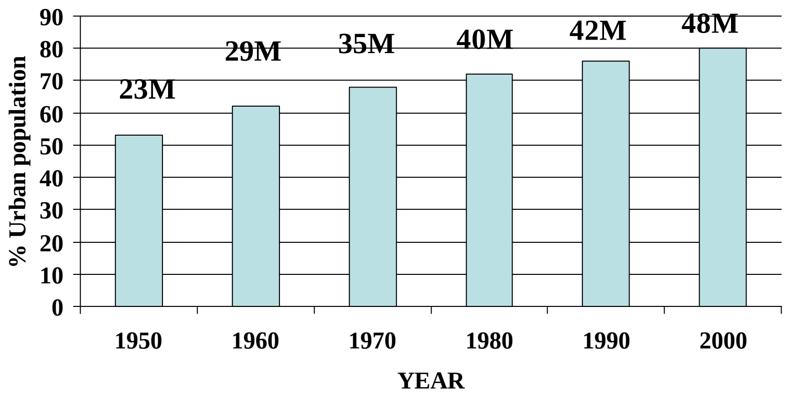
J.C. DEUTSCH & B.TASSIN

CEREVE

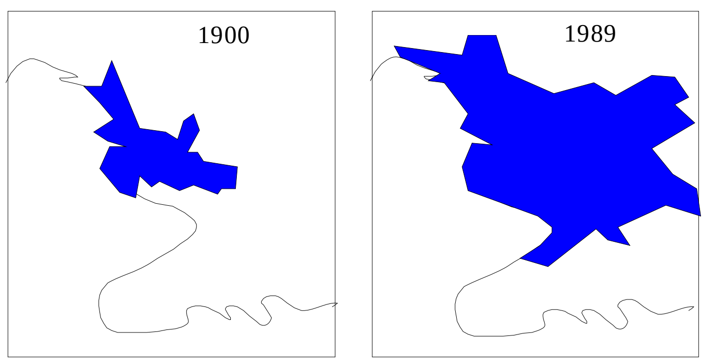
Historical context

- XIX century sanitary approach
- Building sewer network: combined in the centre of cities, separate in the suburbs
- Rise of urban population during the fifties

Historical context



Historical context



MARSEILLE

Historical context

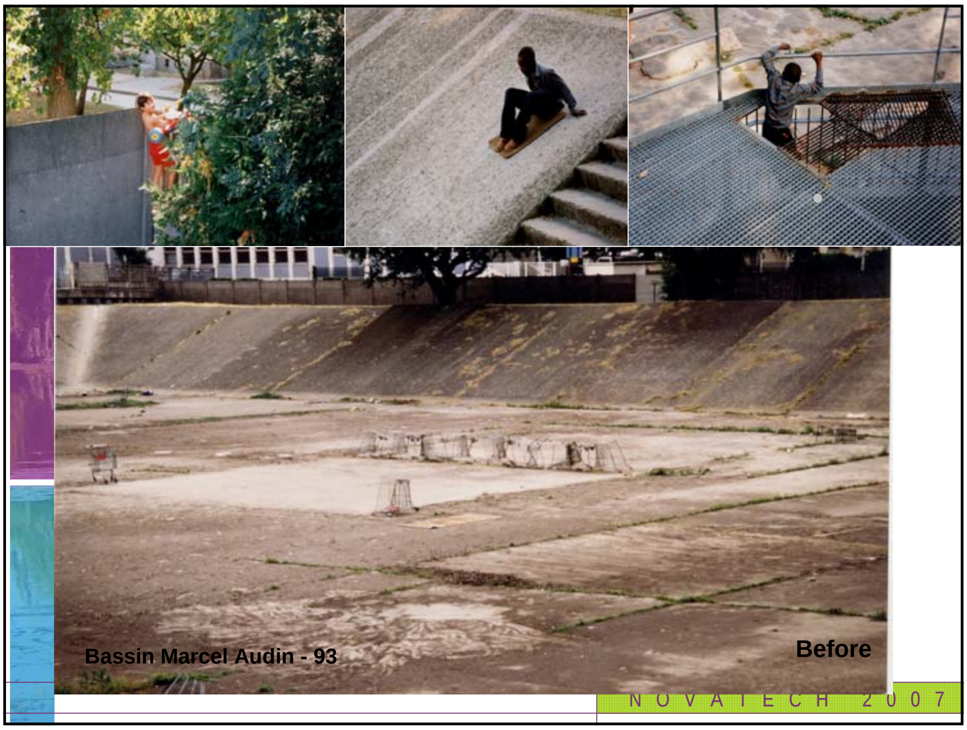
- Sixties: Are new cities compatible with stormwater run-off ?
- 1972 : Severe urban flooding in Paris area
- End of pipe solution last victory:
  building of 3 m diameter stormwater pipe
- 77/284 INT on sewer system design

Historical context

1980-1990 : the rise of BMP'S

- Generalisation of the concept of stormwater storage


1st generation
3rd generation
2nd generation


Bassin Marcel Audin - 93
Before
NOVATECH 2007

NOVATECH 2007

Bassin Marcel Audin - 93

NOVATECH 2007

Bassin Marcel Audin - 93

DEA Seine St Denis (93)

Beaumont / Oise (95) – source : Guide SAUL

Val Maubuée – Marne la vallée (77) - Réalisation Sauveterre

RER Lognes Mandinet (77) (Photo Sauveterre)

Historical context

1980-1990: the rise of BMP'S

- Generalisation of the concept of stormwater storage
- Shift toward source control solutions (mainly according to hydraulic aspects)
  - Feasibility studies on porous pavements
  - Assessment of stormwater storage on flat roofs
  - Is it useful to convince people not to have gutters on their house ?

Craponne (69)

Bruges (33)

N O V A T E C H 2 0 0 7

Portes des Alpes (69) /

IUT A Villeurbanne (69) /

ZAC du Chêne (69)

Square with a soakaway - Bordeaux Region (33)

Source Ecosedum : www.ecosedum.com

Historical context

1990 – 2007+

- Characterisation of urban run-off pollution
- Water law of 1992:
  - Responsibility of local communities
  - Stormwater run-off zoning

Technical context

Main approach

- Risk management
- Interactions between urban techniques
- Integrated approach through water management planning and urban management planning

Organisational context

- 36 000 local communitites
- 6 water agencies
- Private management:
  - water supply (85 % of the population)
  - wastewater collection (45 % of the population)

Sewerage and drainage funding system

- Wastewater collection and treatment: separate budget in local communities
- Stormwater collection and treatment: local general municipal budget with the help of the State or counties
- Water agency

Regulation context

- Design of a water management program for local communities (water law 1992)
- Possibility for local community to tax surface of new constructions to fund stormwater run-off control (water law 2006)
- Possibility to reduce tax by building rainwater harvesting and reuse systems (water law 2006)

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Technical recommendations

1994, 1997

2003

CERTU

LA VILLE & SON ASSAINISSEMENT

Ministère de l'écologie et du développement durable

General recommandations

Written by Universities, associations (GRAIE, EURYDICE)

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BMP’s use

Structural approach

- Porous pavements
- Retention and infiltration basins, swales, trenches, pits
- Use of urban area to store/infiltrate stormwater
- Green roofs
- Water harvesting between rainwater retention and stormwater reuse

BMP’s use

Non-structural approach

- Drainage annex in local planning document (Plan Local d’Urbanisme)
- Public awareness to urban stormwater run-off problems through local public information and consultation groups (Université populaire de l’eau, OHU, …)
- Stakeholders awareness through the organisation of specific information events (GRAIE technical sessions, …)

Research

Main development axes

- What are the phenomena involved in BMP's behaviour, their performance and their impact on:
  - Environment :
    - water bodies: surface & groundwater
    - sediment and sludge management
  - Social and economical
    - transfer of expenses between citizens, local communities and operating societies
    - social acceptance of new approaches
  - Health (not much !)

Main Research Tools

- Development of observatories and on site measurements (OTHU, OPUR, SAP)
  - OTHU http://www.graie.org/othu/
  - OPUR http://www.enpc.fr/cereve/opur/
  - SAP

Main Research Tools

- Development of models
  - Pollution transfer/retention, infiltration, small scale hydro meteorological modelling, urban vulnerability to floods, …
  - Integrated models
    - Linking hydrological models on urban, semi-urban and rural areas
    - Hydrological modelling taking into account small scale climatology and infiltration
    - Modelling BMP's and sewer networks at the same time
    - Modelling the quality of urban wet weather discharges and stormwater run-off at different scales

Main Research Tools

- Development of decision support system (construction of indicators, use or development of multicriteria methodology, Computer tools)

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Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

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Balance Approach - Update on the Australian Scene

Situation actuelle et les tendances en Australie

Dr V. Grace Mitchell
with input from Dr Tim Fletcher
Monash University, Melbourne, Australia

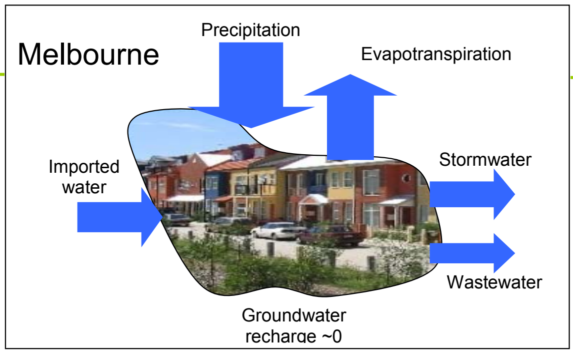
Source Control: Managing Stormwater with a Water Balance Approach - Update on the Australian Scene

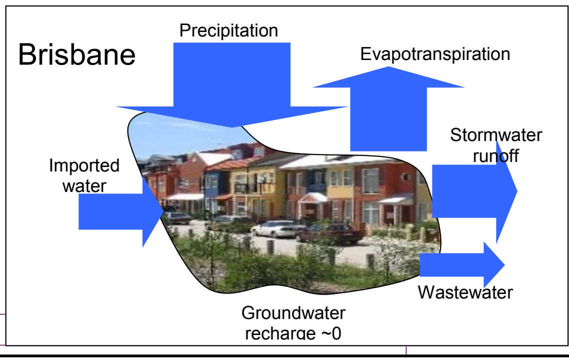
La situation actuelle et les tendances en Australie

Dr V. Grace Mitchell with input from Dr Tim Fletcher

Monash University, Melbourne, Australia

Lyon - France , 24 – 28 JUIN 2007





What does Stormwater 'Source Control' mean in Australia?

- Structural techniques:
  - Sediment basins
  - Bioretention swales and basins
  - Sand filters
  - Swale/buffer systems
  - Constructed wetlands
  - Ponds
  - Infiltration systems
  - Rainwater tanks
- Non-structural techniques:
  - Town and Strategic Planning
  - Pollution Prevention Procedures
  - Education and Participation Programs
  - Regulatory Controls
  - Incentive Programs

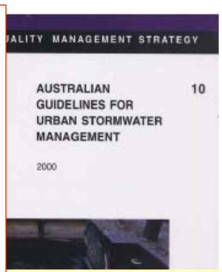
National Policy Setting

- National Water Initiative
  - agreed to and signed at the 25 June 2004 meeting of the Council of Australian Governments (COAG)
  - One of its multiple aims is:

    "better and more efficient management of water in urban environments, for example through the increased use of recycled water and stormwater."

National Water Quality Management Strat

- Gui Sto Ma



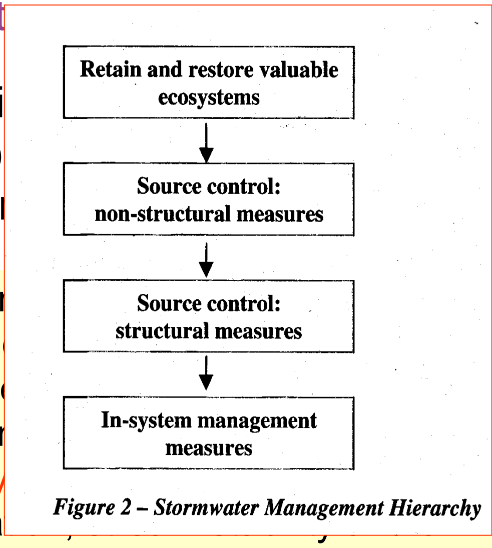
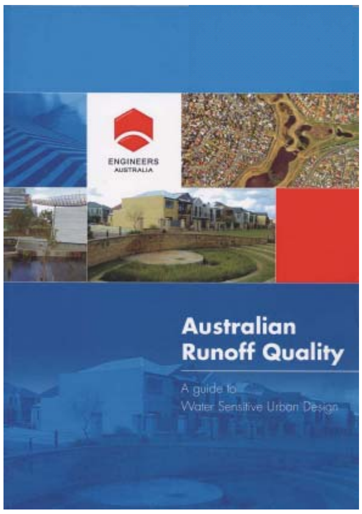


Figure 2 – Stormwater Management Hierarchy

Urba ... agement challeng ... nd drainage manag ... ality (litter, nutrie ... d aquatic ecosy ... , riparian vegeta ... ronmental flows).

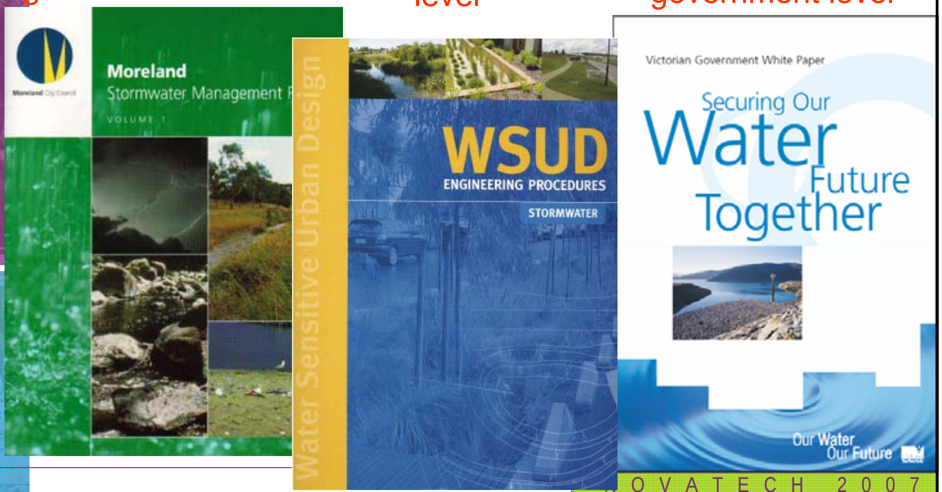
National Guidelines - ARQ

- Australian Runoff and Quality (ARQ)
  - Final version released in 2006
  - Focus on stormwater source control
  - Also covers broader context of urban water system



State level policy, regulation, guidelines… e.g. Victoria

Local government level ↔ Water authority level ↔ State government level



Progress on the structural techniques front

- Landscape integration
- Integration with water supply management
- Scale considerations

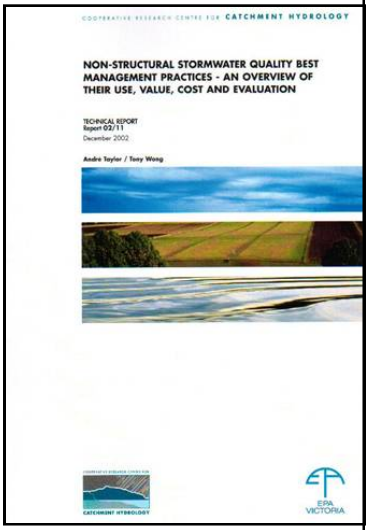
Victoria Park, Sydney (Landcom)

Street bioretention system

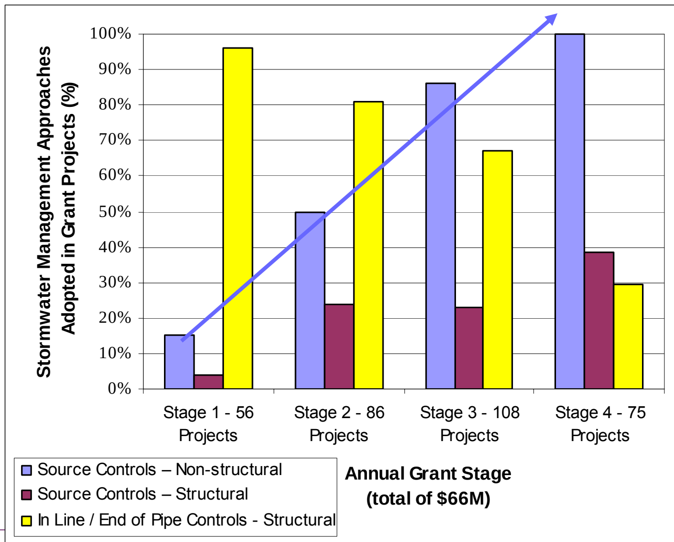

Baltusrol Estate
(Australand)
Victoria Harbour, Melbourne
Docklands
(Lend Lease)

Trends in the Use of Non Structural Measures

- Research has found non-structural measures are:
  - already widely used in Australia;
  - increasing in use; and
  - set to become more widely used if Australian urban water management programs mature like those overseas.



Type of Stormwater Projects Funded in NSW *(Source: Taylor & McManus, 2002)*

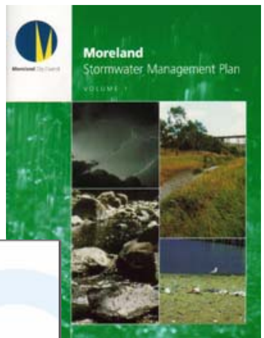


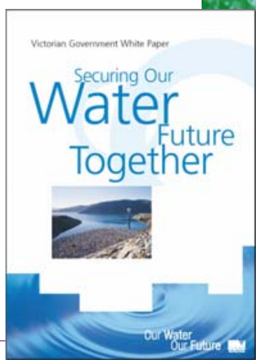
Education & Participation Programs

clearwater
SUPPORTING SUSTAINABLE MANAGEMENT OF URBAN STORMWATER

Strategic Planning & Institutional Controls

- Many levels
  - National
  - State
  - Local government
  - Water authority



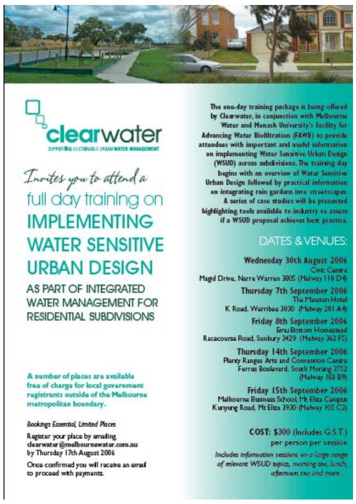


Clause 56 – Residential subdivision provisions in Victoria

- Sets out requirements for the design and assessment of residential subdivisions in urban areas throughout the state
  - new provisions introduced on 9 Oct 2006
- The urban stormwater management system must:
  - Meet BMP guidelines for stormwater quality
  - Ensure no detrimental downstream impacts (pre-development flows)

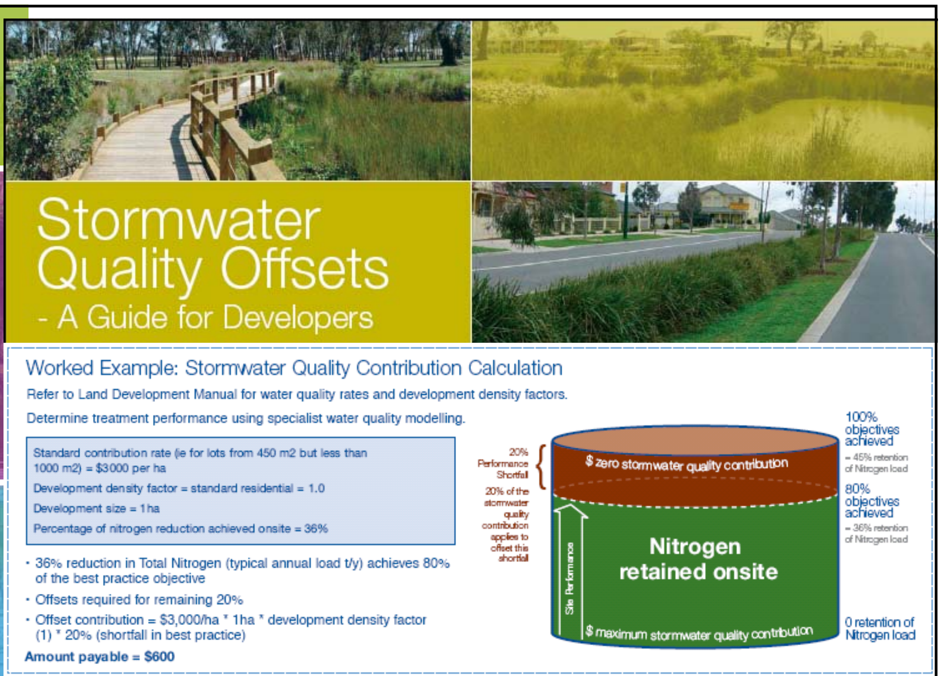
Clause 56 – Residential subdivision provisions in Victoria

- Consequences:
  - Local management of stormwater quality
  - Training/capacity building…



Melbourne Water's Stormwater Quality Offsets Strategy

- If a developer cannot meet stormwater quality standards within their development
  - provides a mechanism to pay an offset to Melbourne Water
  - $$ to provide water quality treatment elsewhere in the catchment
- Nitrogen is the offset "currency" as it is the critical pollutant load for Port Phillip Bay



Intersection with other urban water drivers

- Ten years of drought in much of Australia
- Pressure on water supplies
- Shifting of priorities to harvesting stormwater:
  - Rainwater tanks at lot scale
  - Stormwater harvesting at catchment scale
- Larger scale water balance in play

Rainwater tank subsidies

- Available in most urban areas
- Differing “rules” depending on location
- Usually vary depending on tank size and end uses

Rainwater Tank Rebates
Fact Sheet January 2007

The Victorian Government has increased incentives under the Water Smart Gardens and Homes Rebate Scheme.

The scheme rewards residential customers connected to a mains water supply for purchasing water-saving devices and services, thereby reducing their water consumption.

Households purchasing and installing a water tank from 1 January 2007 are now eligible for a rebate of up to $1000.

Water tanks can save up to 40,000 litres per household per year.

The rebate is based on the size of the tank and requires the tank to be connected to toilet and/or laundry facilities as follows:

Rainwater Tanks, 2000 – 4999 litre capacity, connected to toilet and/or laundry	$500 rebate
Rainwater Tanks, 5000+ litre capacity, connected to toilet **or** laundry	$900 rebate
Rainwater Tank 5000+ litre capacity, connected to toilet **and** laundry	$1000 rebate

Example: Royal Park Wetland Stormwater Reuse System

- Designed to supply 74 ML/y of irrigation
- Also stormwater quality improvement for environmental protection
- Are monitoring it to evaluate its multi purpose performance

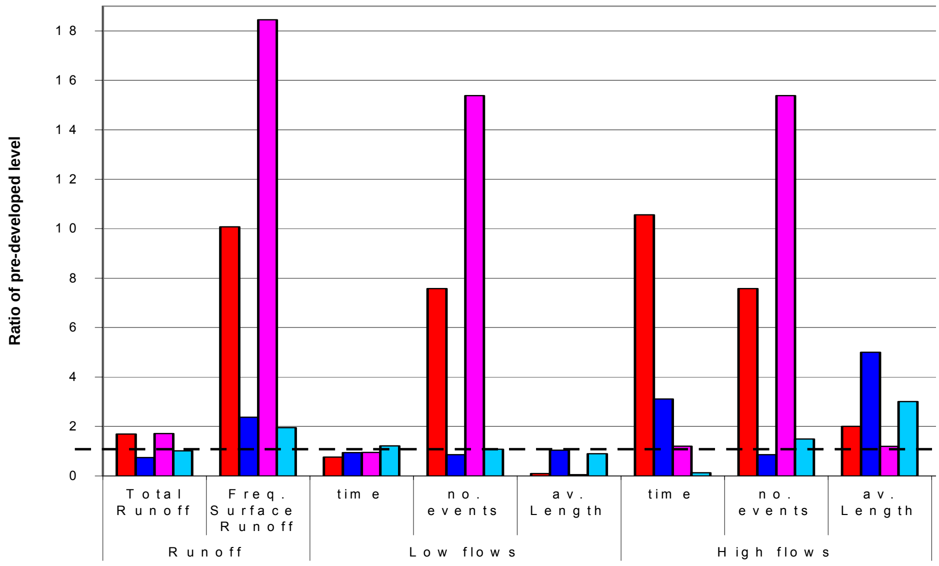
Environmental Flows

- Are rainwater tanks and stormwater as a tool to maintain environmental flows?
- Desktop study examined the impacts of stormwater harvesting on a suite of hydrologic and water quality indicators
  - ecological impacts

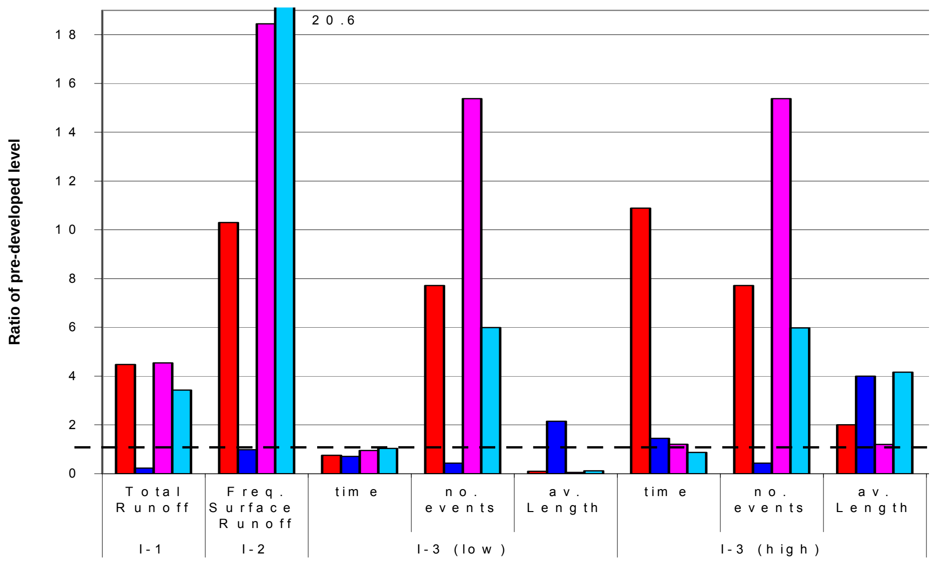
Indicators

Category	Indicator (and abbreviated name)	Analysis time step	Unit
Runoff	Total runoff	daily	ML/yr
	Frequency of surface runoff	daily	times/yr
Flow Spells	Duration (total time of low flows)	daily	days/yr
	Average length of low-flow spells	daily	days in a row (average/yr)
	Number of low-flow events	daily	events/yr
	Duration (total time of high flows)	daily	days/yr
	Average length of high-flow spells	daily	days in a row (average/yr)
	Number of high-flow events	daily	events/yr
Peak Flow	Q1month	hourly	m^3/sec
	Q3month	hourly	m^3/sec
	Q1year	hourly	m^3/sec
	Q1.5year	hourly	m^3/sec
	Q5year	hourly	m^3/sec
Flow Duration Curve	Integral of the flow duration curve	hourly	Integral of curve
Pollutant Loads	Total Suspended Solids (TSS) load	daily	kg/ha/yr
	Total Nitrogen (TN) load	daily	kg/ha/yr
	Total Phosphorus (TP) load	daily	kg/ha/yr

Low Density: 14% Impervious



High Density: 70% Impervious



Summary

- No shortage of policies and guidelines
- Progress in:
  - Experience with successful implementation
  - Capacity building in the water industry
  - Linking stormwater with the rest of the urban water balance
- Research:
  - Very active in many fronts in Australia!

Point for discussion

- What is the "burden of proof" in terms of source control performance before the tool/technique is integrated into policies/regulations/guidelines?
  - i.e. how much knowledge is enough to get on and advocate changes in on-ground practice?

Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

Managing Stormwater with a Water Balance Approach
United States of America

Gestion des eaux pluviales avec une approche de gestion de l'Eau équilibrée
Situation actuelle et tendances aux Etats-Unis

Eric Strecker
GeoSyntec Consultants
Portland, OR, US

Managing Stormwater with a Water Balance Approach- United States of America

Eric Strecker
GeoSyntec Consultants
Portland, OR

Stormwater
"More Sustainable" Strategy

1. Hydrological Source Control
2. Pollutant Source Control
3. On-site Treatment, close to the source
4. Regional Treatment Systems
5. Stream Stabilization/Function Restoration

Probably need to do all (no silver bullets!) in many if not most cases

Presentation Overview

- Flood Control and Watershed Management
- BMPs – What do we know about their performance
- Unit Processes Approaches to BMP Design and Selection
- Low Impact Development – How Low is it?
- Examples

Themes

- Getting more science and science-based engineering into Urban Watershed Planning
  - Move away from “Ready Fire Aim” (or really “Ready, Fire, Oops Missed”)
- Retrofitting Urban Watersheds is tough
- New Development and Re-Development requirements are only a part of the solution
- Regional Approaches are part of the solution

Re-Thinking

- Flood Control solutions and design standards
- Water Quality Protection and BMPs/Design Standards/Approaches
- Stream Integrity Protection
- How the above interact

Typical Flood Control Approach

- Pick a big precipitation event
- Assign a peaky shape to it (not its actual shape)
- Assume that the watershed is saturated
- Drop storm on the watershed all at once (not the way it occurs)
- Route Storm Down System
- Size up and harden the system (no vegetation allowed)

Flood Design Event Use Results

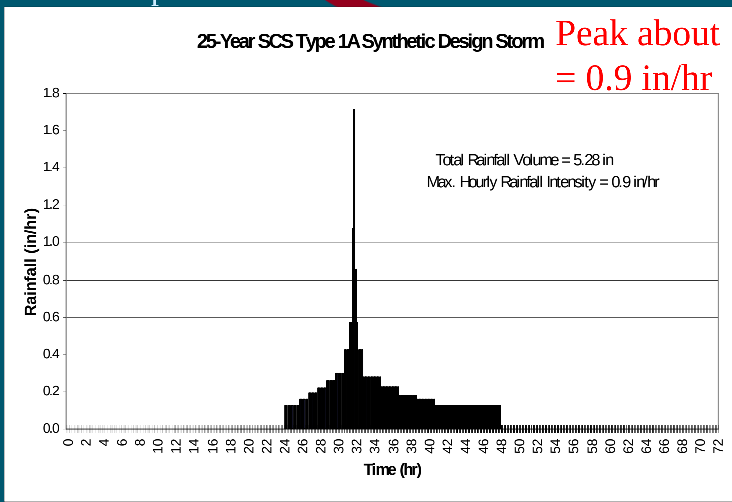
- 50 year precipitation event turned into 100 to 500+ year design flow
  - $$$$$
  - Smooth channels required to convey storm (e.g. forget habitat)
- Over-design in least developed areas
  - Pavement not affected much by saturation
  - Peaky shape affects undeveloped areas more
  - Result is more over-design in least developed areas

Hard to Change

- Litigation Fears
- “We have always done it this way”
- Other methods (e.g. continuous simulations) with long-term precipitation records take more time, data and thought

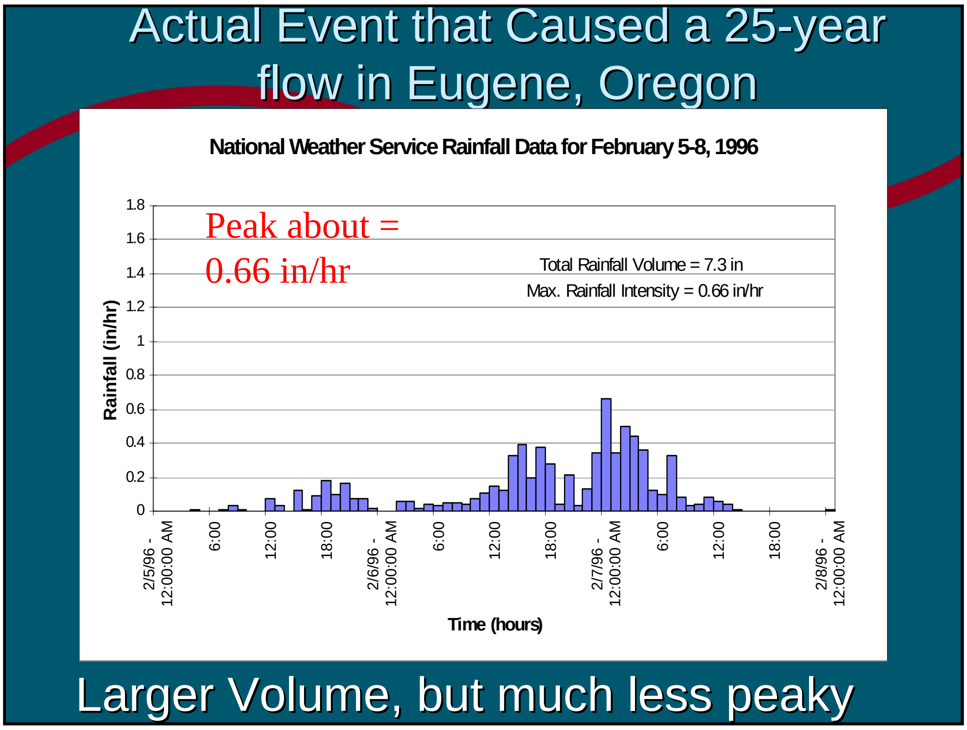
Traditional Approach - Design Storm based upon:

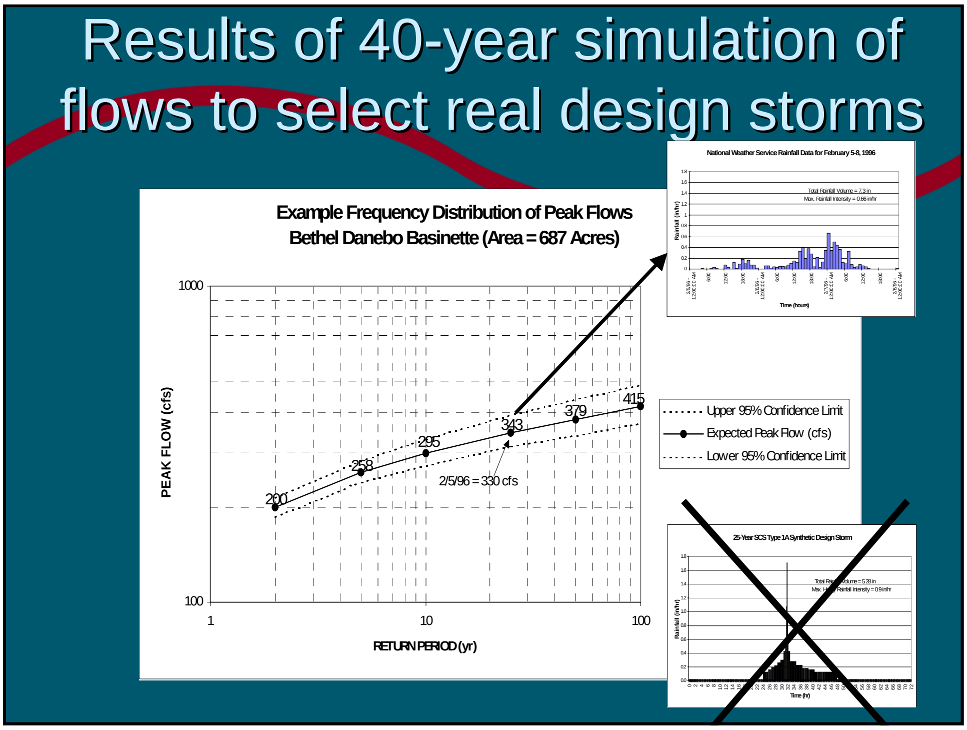
- rainfall depth return period,
- conservative shape, and applied with
- assumption of saturation



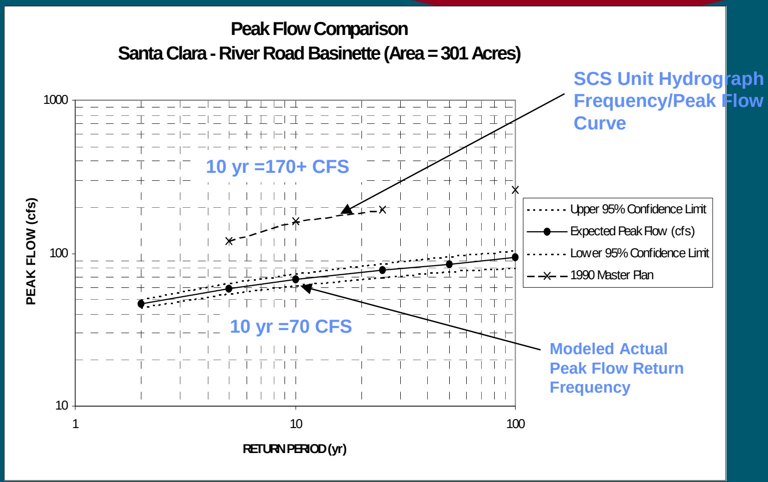
Peak about = 0.9 in/hr

What is the resulting return period of flows?


Actual Event that Caused a 25-year flow in Eugene, Oregon
National Weather Service Rainfall Data for February 5-8, 1996
Peak about = 0.66 in/hr
Total Rainfall Volume = 7.3 in
Max. Rainfall Intensity = 0.66 in/hr
Rainfall (in/hr)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
2/5/96 - 12:00:00 AM
6:00
12:00
18:00
2/6/96 - 12:00:00 AM
2/7/96 - 12:00:00 AM
2/8/96 - 12:00:00 AM
Time (hours)
Larger Volume, but much less peaky


Results of 40-year simulation of flows to select real design storms
Example Frequency Distribution of Peak Flows
Bethel Danebo Basinette (Area = 687 Acres)
PEAK FLOW (cfs)
1000
100
1
10
100
RETURN PERIOD (yr)
200
258
295
343
379
415
2/5/96 = 330 cfs
Upper 95% Confidence Limit
Expected Peak Flow (cfs)
Lower 95% Confidence Limit
National Weather Service Rainfall Data for February 5-8, 1996
25-Year SCS Type 1A Synthetic Design Storm

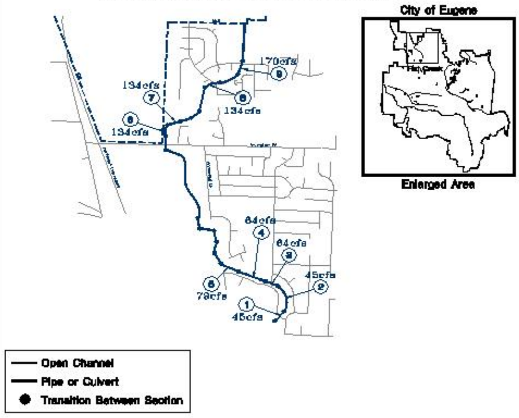
Comparison of Predicted Peak Flows from Traditional SCS Unit Hydrograph Method vs. Actual Rainfall Data/Continuous Simulation



Traditional SCS method based projects

9 projects, $550,000

Flat Creek Drainage System
Capital Improvements Proposed in 1990 Master Plan
Using 10-year SCS Synthetic Design Storm

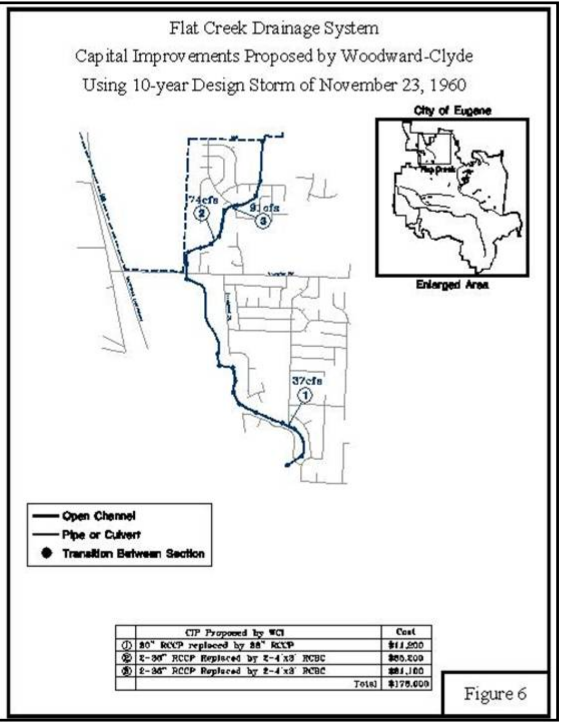


	CIP Proposed in 1990 Master Plan	Cost
1	30" RCCP replaced by 4'x3' RCBC	$27,300
2	open channel replaced by 2-36" RCCP	$175,400
3	30" RCCP replaced by 2-3'x3' RCBC	$31,600
4	existing channel expansion	$9,100
5	existing channel expansion	$8,900
6	existing channel expansion	$21,000
7	3-43"x27" CMP replaced by 2-6'x3' RCBC	$87,100
8	2-36" RCCP replaced by 2-4'x3' RCBC	$81,100
9	58"x36" and 24" CMP replaced by 2-5'x3' RCBC	$117,100
	Total	$553,600

Figure 7

Use of real storms has resulted in fewer and smaller capacity based projects (e.g. more $ for Water Quality and Natural Resources)

3 projects, $178,000

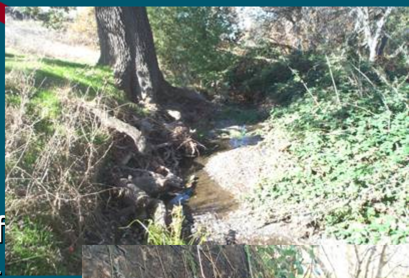


Stream Erosion

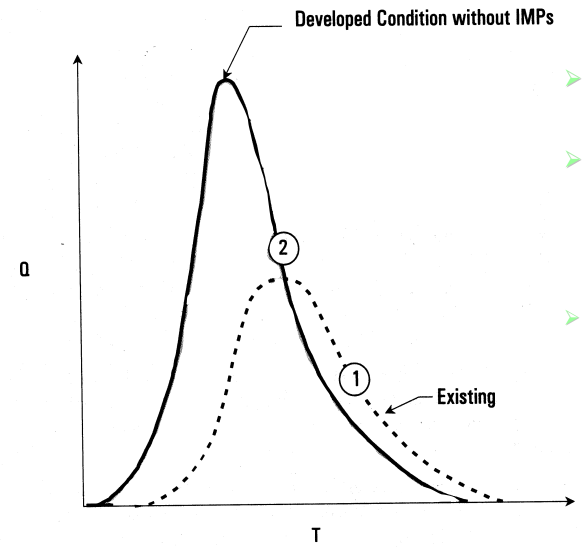
- Becoming a larger concern in US-Hydromodification
- Cause is change in energy (more runoff) and reduction in sediment supply (often ignored)
- Efforts to control via design storms have failed (cause even more damage)
- Volume control combined with Flow-Duration and instream controls is the solution

Hydromodification

- Increases peak flow and runoff volume
- Decreases time of concentration
- Increase the number of runoff events and long-term flow duration
- Intensifies sediment transport and erosion processes

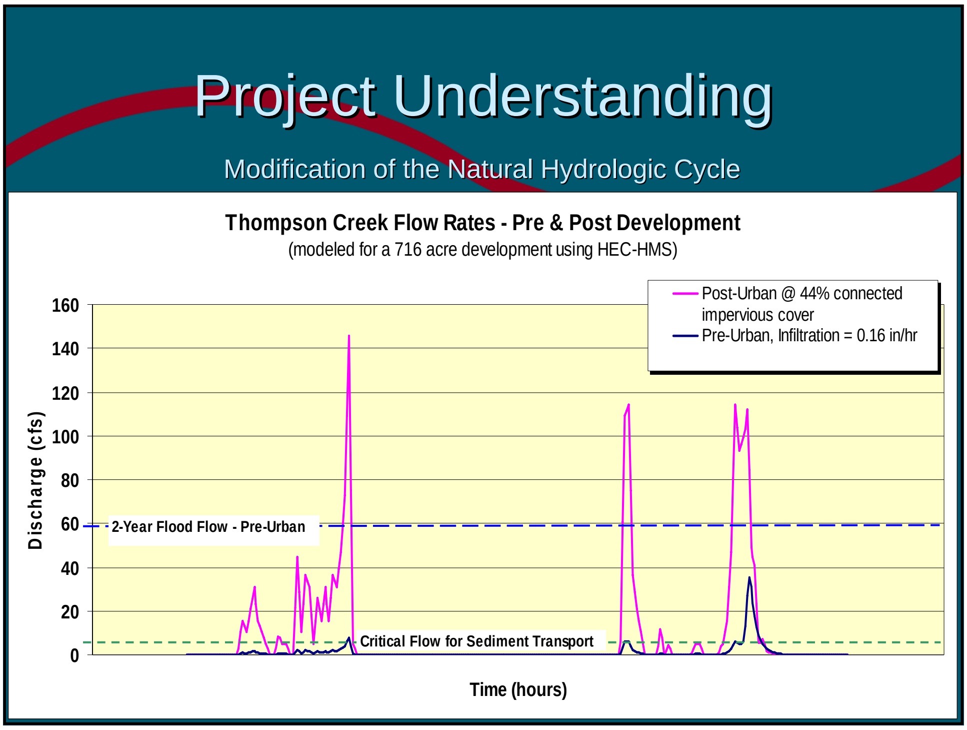


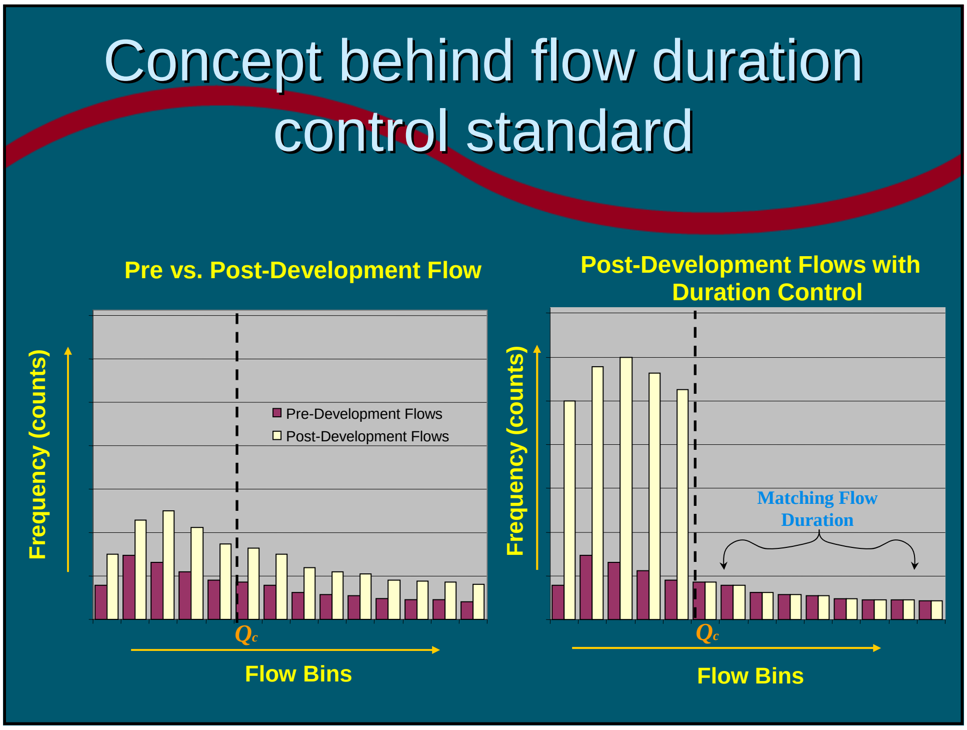
Flood Design Based Hydrologic Changes



- **Pre-development (Curve 1),**
- **Post-development with no controls (Curve 2)**
- 40 to 60 percent increase in peak flow implied

(Source: Adapted from Prince Georges County, Low Impact Development Hydrological Analysis , 2000)

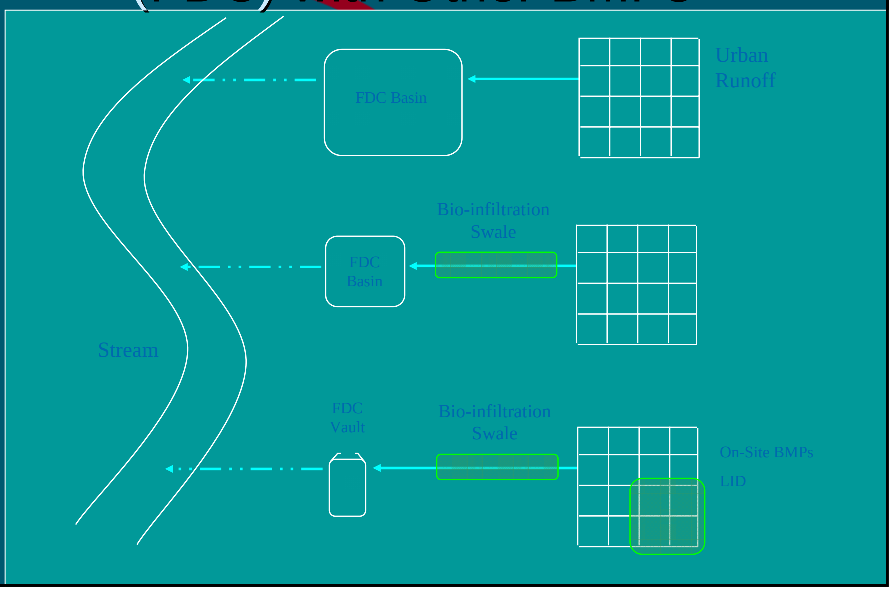

Project Understanding
Modification of the Natural Hydrologic Cycle
Thompson Creek Flow Rates - Pre & Post Development
(modeled for a 716 acre development using HEC-HMS)
Post-Urban @ 44% connected impervious cover
Pre-Urban, Infiltration = 0.16 in/hr
2-Year Flood Flow - Pre-Urban
Critical Flow for Sediment Transport
Discharge (cfs)
160
140
120
100
80
60
40
20
0
Time (hours)


Concept behind flow duration control standard
Pre vs. Post-Development Flow
Pre-Development Flows
Post-Development Flows
Frequency (counts)
Qc
Flow Bins
Post-Development Flows with Duration Control
Matching Flow Duration
Frequency (counts)
Qc
Flow Bins

On-Site Options

- Use site design techniques to reduce runoff flow and volume
  - Decrease impervious surface area
  - Disconnect impervious areas
  - Promote infiltration
- Select treatment BMPs that reduce volume
  - swales, detention areas, bioretention, green roofs

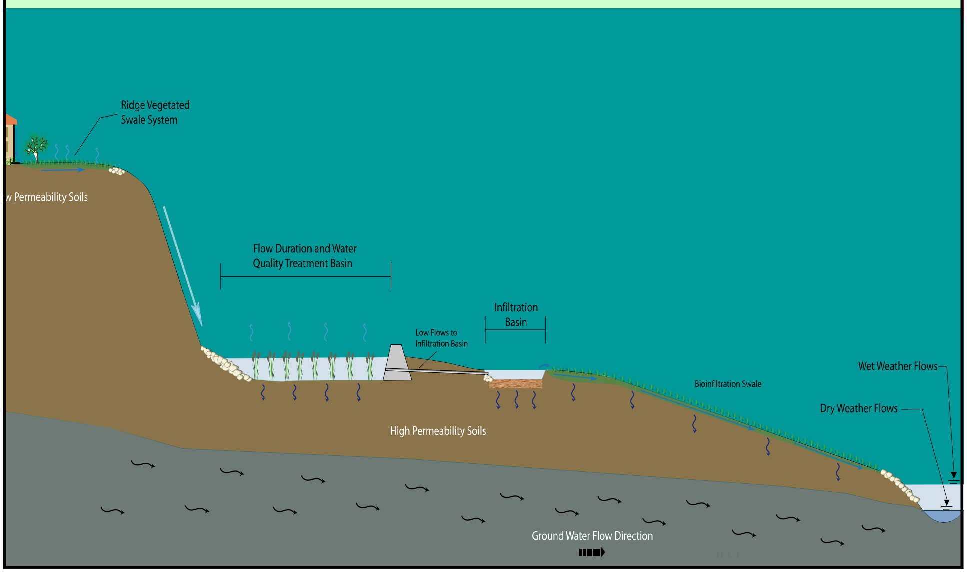
Integrating Flow Duration Control (FDC) with Other BMPs



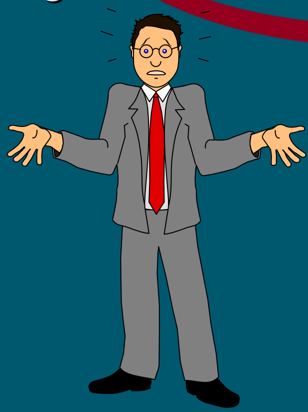
Off-Site and In-Stream Options

- Off-site (regional)
  - Regional detention basins
  - Bypass pipelines
- In-stream
  - Grade controls
  - Bank stabilization
  - Flood plain/channel restoration

Combined Control Concept for Ridge-type Development



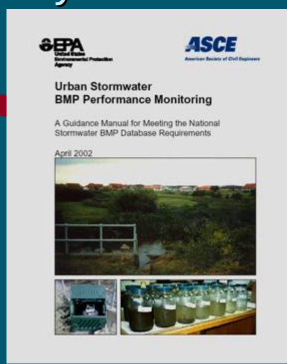
Understanding and Applying Knowledge of Performance of Best Management Practices



We have come along way!

Project Approach - A Scientifically Rigorous BMP Data Collection and Analysis Effort

- Development of protocols for collection and reporting of BMP performance information
- Establishment of data base
- Establishment of standard techniques for data collection, storage, reporting, and analysis (guidance document)
- Conduct data analysis and exploration



- Disseminate data and findings: www.bmpdatabase.org:
  - ✓ **Flat File Database**
  - ✓ **Guidance Manual**
- Promote technically based BMP selection and design improvements

Distribution of Current Studies

Total Structural	219
Total Non-Structural	28
Total BMPs	247

Total Numbers of BMPs by Category

BMP CATEGORY	NUMBER OF BMPS
Structural	
Biofilter	59
Detention Basin	26
Hydrodynamic Device	23
Infiltration Basin	1
Media Filter	38
Percolation Trench/Well	1
Porous Pavement	5
Retention Pond	37
Wetland Basin	15
Wetland Channel	14
Non-Structural	
Maintenance Practice	28

BMP TOTALS BY STATE/COUNTRY

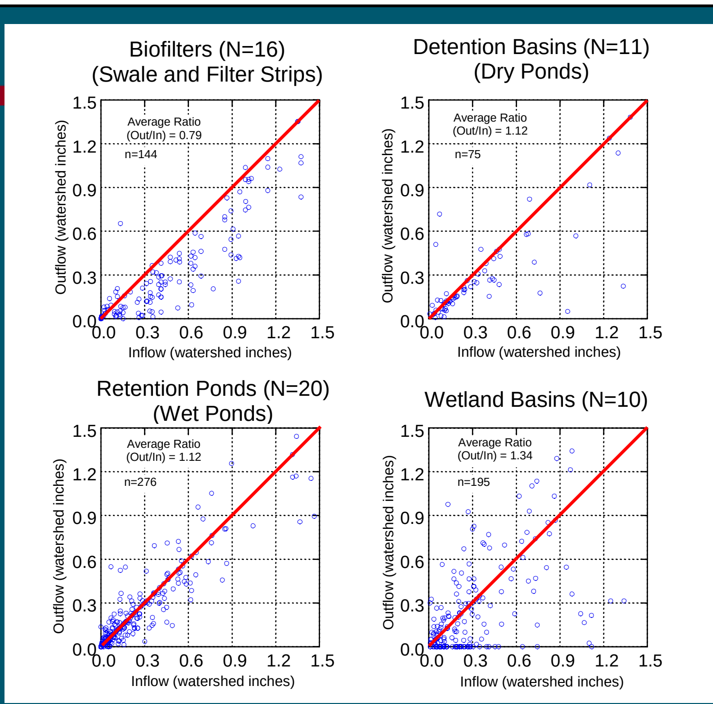
STATE	NUMBER OF BMPS
Domestic	
AL	13
CA	**41**
CO	4
FL	24
GA	2
IL	5
MD	5
MI	5
MN	7
NC	6
NJ	3
OH	1
OR	3
TX	19
VA	29
WA	20
WI	10
International	
Sweden	1
Canada	1

Recommended Measures of BMP Performance

- How much stormwater runoff is prevented? ("hydrological source control")
- How much of the runoff that occurs is treated by the BMP or not ("hydraulic performance")?
- Of the runoff treated, what is the effluent quality? ("concentration characteristics achieved")
- *Does the BMP address downstream erosion impacts?*

Percent Removal is <u>Very Problematic</u> and SHOULD NOT be used as a performance measure for BMPs.

Runoff Volume Control



- ET losses
- Infiltration

Runoff Volume Control

Consider "credit" for volume reduction in design requirements

BMP Type	Mean Monitored Outflow/Mean Monitored Inflow for Events Where Inflow is Greater Than or Equal to 0.2 Watershed Inches
Detention Basins	**0.70**
Biofilters	**0.62**
Media Filters	1.00
Hydrodynamic Devices	1.00
Wetland Basins	0.95
Retention Ponds	0.93
Wetland Channels	1.00

Lake George Field Study Evaluation Vortechs model 11000

Runoff Event #	TSSin (mg/L) Interpolated	TSSin (mg/L) Arithmetic	TSSout (mg/L) Interpolated	TSSout (mg/L) Arithmetic	% Reduction Interpolated	% Reduction Arithmetic
1	987.48	693.52	263.18	205.98	73%	70%
2	128.73	88.57	59.23	59.18	54%	33%
3	1040.04	882.42	337.87	486.75	68%	45%
4	213.73	225.42	359.14	388.08	-68%	-72%
5	1673.57	1217.53	71.39	102.84	96%	92%
6	535.16	603.54	70.14	85.23	87%	86%
7	180.81	132.22	29.76	34.88	84%	74%
8	2491.55	2202.78	35.41	35.47	99%	98%
9	89.99	76.60	31.98	33.14	64%	57%
10	1047.02	2257.46	37.08	31.22	96%	99%
11	439.45	344.86	16.57	13.83	96%	96%
12	445.19	291.58	17.36	14.91	96%	95%
13	1156.16	674.94	44.72	37.91	96%	94%
Averages	802.2215	745.4954	105.6792	117.6477	87%	84%

(Winkler and Guswa 2002)

- Is an average of 100+ mg/l TSS acceptable performance?

Percent Removal Use Results

- BMPs improperly “rejected”
- BMPs improperly “accepted”
- “Daisy-Chaining” BMPs and applied % removals at each step that highly over predicts performance
- Improper use of TSS as the sole indicator of performance
- Etc. Etc.

Analysis Findings

Results of the analyses of the now expanded database have reinforced the initial finding that BMPs are best described by:

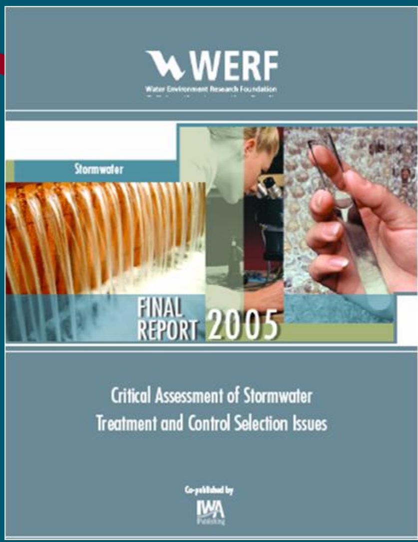
1. how much they reduce runoff volumes [Hydrological Source Control Performance],
2. how much of the runoff that occurs is treated (and not) by the BMP (e.g., bypass or overflow) [Hydraulic Performance],
3. of the runoff treated, what effluent quality (concentrations and toxicity potential) is achieved? [Water Quality Performance]
4. And does the BMP reduce downstream erosion impacts [Physical Stream Impact Performance]

Analysis Findings Cont.

- These Basic BMP performance description elements can be utilized to more accurately:
  - ✓assess the concentrations that BMPs are able to achieve (concentration TMDLs),
  - ✓assess effects on total loadings (TMDLs),
  - ✓estimate the frequency of potential exceedances of water quality criteria or other targets, and
  - ✓develop other desired water quality performance measures.

Unit Processes Based Approach

- Use the "best information" available to provide guidance on the selection and use of stormwater water quality controls
- Develop stormwater controls selection and evaluation methodology for use by practitioners
  - NCHRP – Highway Specific
  - WERF – Urban Environment



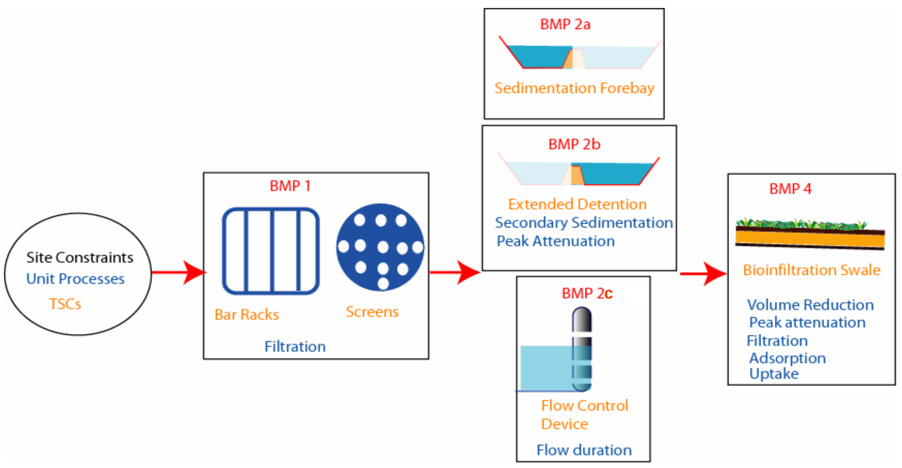
Using the Integrated Treatment Process Design Approach - Summary

- Characterize area conditions and goals and objectives
- Identify Fundamental Unit Process Categories (FPCs) and associated Treatment System Components (TSCs)
- Formulate design alternatives
- Critically assess alternatives and select most feasible alternatives
- Size/configure the facility

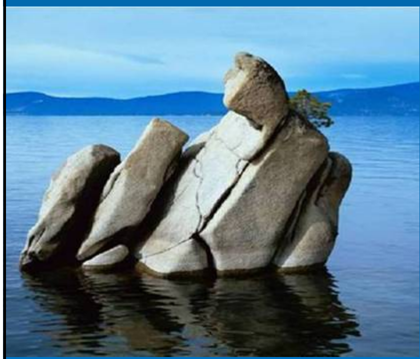
Design Standards

- Typically have focused almost entirely on "Size of Storm" for runoff treatment with no or little requirements for addressing pollutants/parameters of concern
- Rarely have design standards development efforts started with the questions:
  - What are the pollutants and parameters of concern?
  - Will/can/how will my design standards for new and re-development address those concerns?

Alternative 1 – TSS, Trash and Debris and Dissolved Copper, and Stream Erosion



Tahoe Basin BMP Evaluation and Feasibility Study



Eric Strecker, Jim Howell,
Marc Leisenring, Andi Thayumanavan

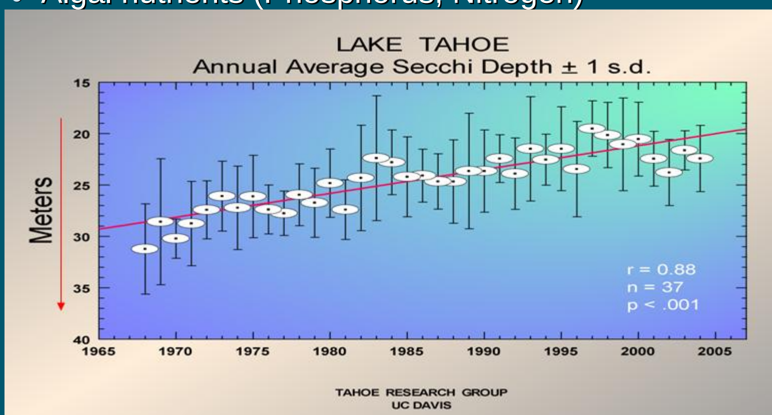
GeoSyntec Consultants
Portland, Oregon

Dave Roberts
Lahontan Regional Water Quality Control Board

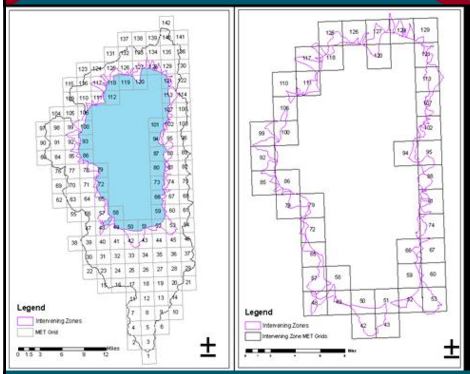
John Reuter
University of California
Davis, California

Water Quality Issues

- Decline in water clarity at about 1- ft/year
- Major pollutants of concern
  - Suspended sediments (fine particulates, <10 µm)
  - Algal nutrients (Phosphorus, Nitrogen)

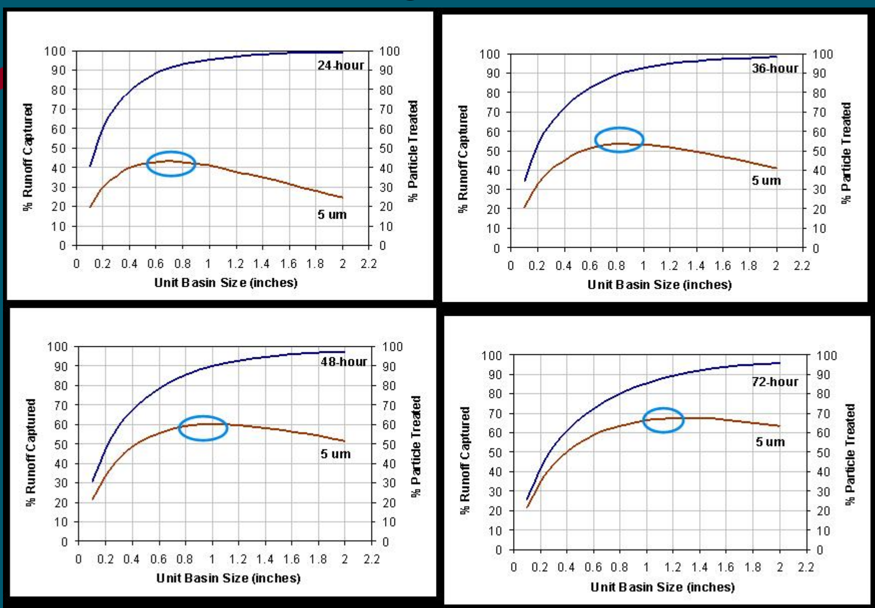


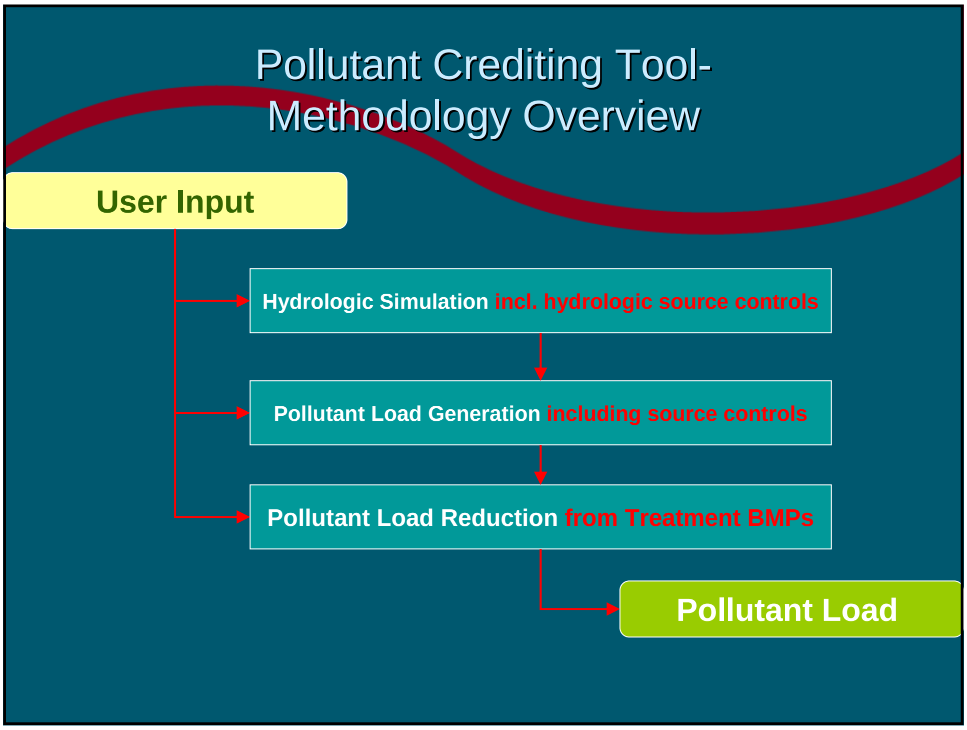
Continuous SWMM modeling Together with BMP Effluent Performance to Assess BMP Performance at a Project Scale



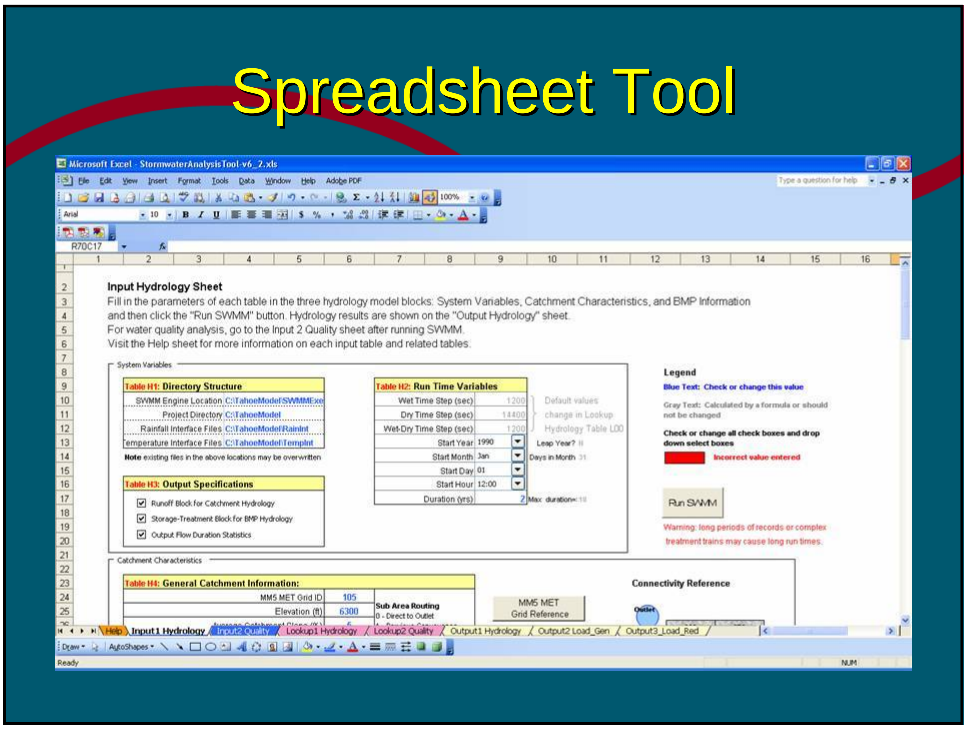
- How much runoff is evapotranspirated or infiltrated? Hydrological Source Control
- How much runoff is treated (and not)?
- What is effluent quality of treated runoff?
- Evaluations included:
  - Assessed effects of residence time
  - Evaluated 20 alternate sizing criteria (0.1” to 2”)
  - Generated performance curves for percent runoff captured as well as percent particle treated

Effect of Sizing and Residence Time





Pollutant Crediting Tool-
Methodology Overview
User Input
Hydrologic Simulation incl. hydrologic source controls
Pollutant Load Generation including source controls
Pollutant Load Reduction from Treatment BMPs
Pollutant Load

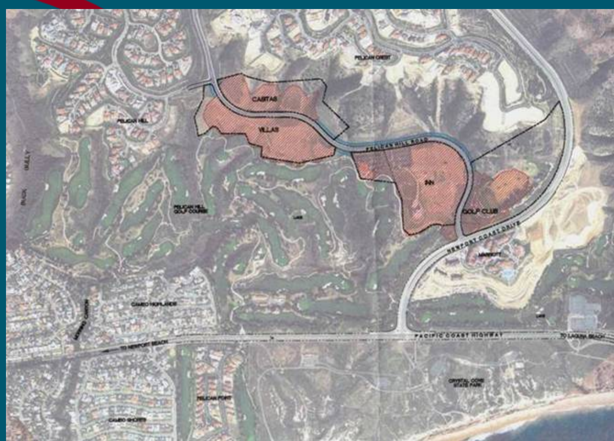


Spreadsheet Tool
Microsoft Excel - StormwaterAnalysisTool-v6_2.xls
Input Hydrology Sheet
Fill in the parameters of each table in the three hydrology model blocks: System Variables, Catchment Characteristics, and BMP Information
and then click the "Run SWMM" button. Hydrology results are shown on the "Output Hydrology" sheet.
For water quality analysis, go to the Input 2 Quality sheet after running SWMM.
Visit the Help sheet for more information on each input table and related tables.
Table H1: Directory Structure
Table H2: Run Time Variables
Table H3: Output Specifications
Table H4: General Catchment Information
Legend
Run SWMM
Connectivity Reference

West-Coast Applications of Low Impact Development (LID) Techniques and Their Applicability

Example Project Overview

- New club house and restaurant and relocation of the golf course operations
- A new hotel, restaurant, & spa located where existing club house and golf operations area
- Tourist-serving fractionalized ownership condominiums



Re-development and New Development

Client Specified Desired Project Water Quality and Hydrology Goals

- No changes in pre/post in hydrology
  - No increase in runoff volume
  - No increase in **infiltration**
- Show an improvement in water quality
- No irrigation runoff
- Eliminate all runoff to Morning Canyon

Why These Goals?

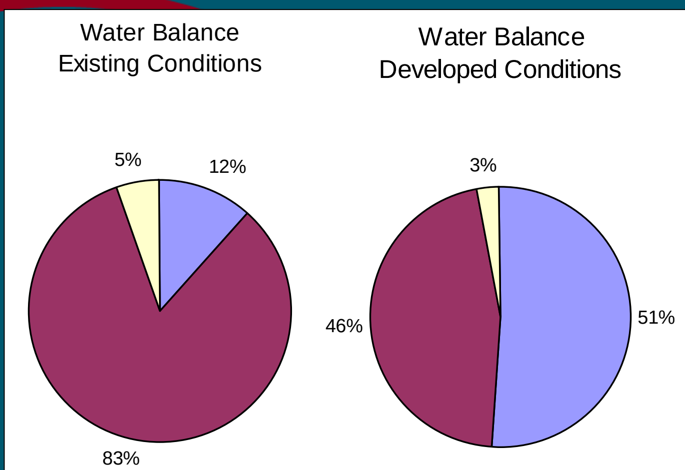
- Project drains to a State defined “Area of Special Biological Significance” – Crystal Cove
- Morning Canyon has had erosion problems from increased runoff
- Seeps downstream of the site are a concern
- Client wanted quick permitting process and environmental community acceptance

No Change in Hydrology!

- Manage the “ET” Sponge
- Necessitated a detailed analysis of
  - precipitation,
  - runoff,
  - shallow soil soaking and drying, and
  - deeper infiltration

  to ascertain what conditions to match

Pre- and Post-Hydrology No BMPs



About 83% Evapotranspiration

Pre-Development!

Evaluated "Standard" LID Approach

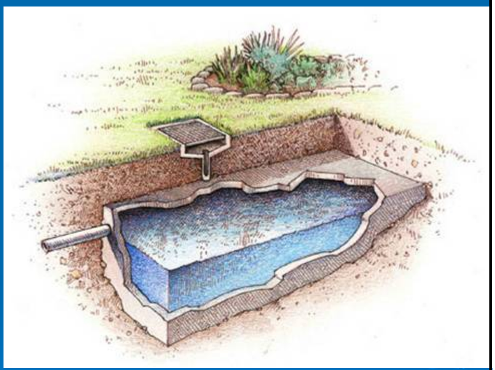
- How much of the site would we have to have in biofiltration areas to meet goals?

  With:
  - Various depths of amended, moisture holding soils and
  - Limited infiltration.
- Result: 30% of site would have to be in bioswales to meet project goals!

Plan B

stormwater treatment system includes:

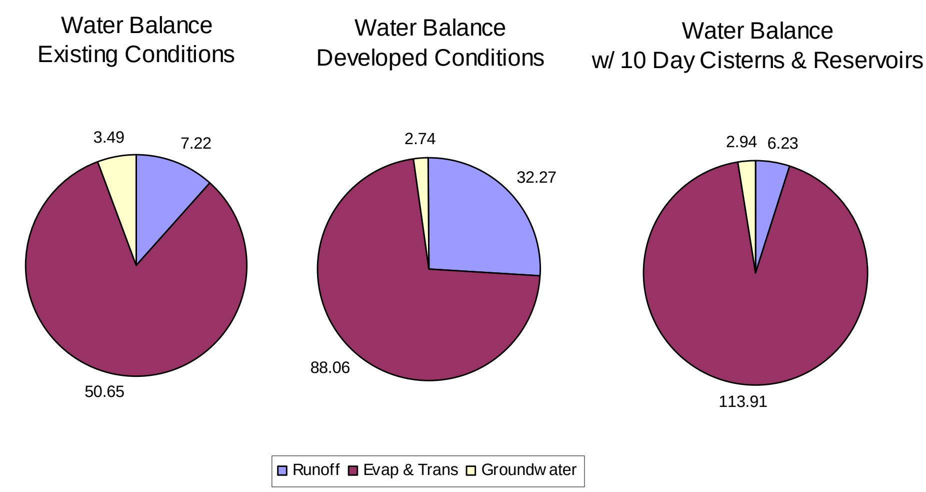
- Biofiltration
- Cisterns to capture runoff from all developed areas of the project of the equivalent of 1.26" of rainfall over the project impervious areas.
- Use of the irrigation storage reservoirs to store the cistern outflow from all area of the Project



What to do with the water?

Golf Course (of course)!

Water Balance for All Years Modeled



Average Annual TSS & Nutrient Loads

Modeled Area	Site Conditions	Modeled Constituent - Loads			
		TSS (tons)	TP (lbs)	TKN (lbs)	Nitrate-N (lbs)
Pelican Point Project Area (49.7 acres)	Existing	0.903	6.30	48.5	10.6
	Developed w/o PDFs	2.51	25.7	197	32.6
	Dev w/ PDFs	0.410	4.94	33.8	7.02
	% Change	-55%	-22%	-30%	-34%

Summary

- "Low Impact Development" applied to Southern California

Solving problems:

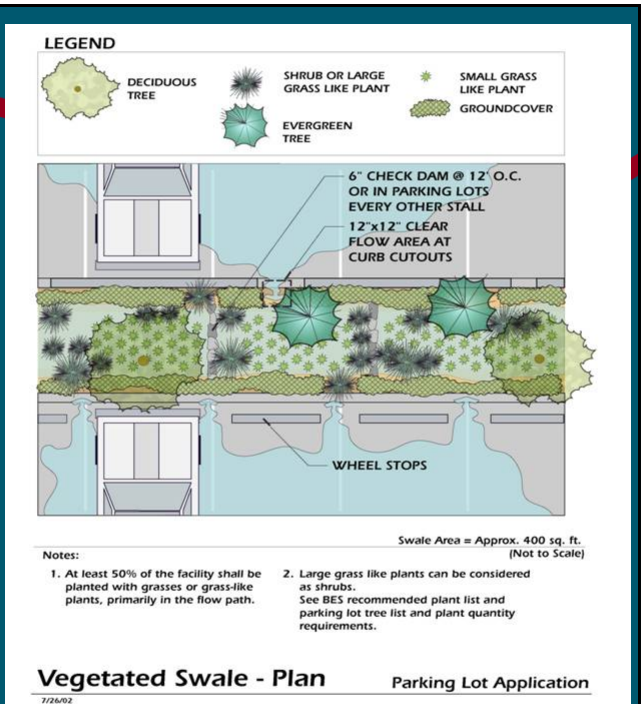
More focus on maximizing "hydrological source control":

1. Evapotranspiration first
2. Infiltration next
3. Pollutant Source Control
4. Treatment

Village Homes

Village Homes, Davis, CA. Project has no stormwater pipes; most of the runoff infiltrates (in poor soils). Built almost 30 years ago. Saved about $1,000 per lot in 1970s.

City of Portland - Simplified Approach Parking Lot Swales



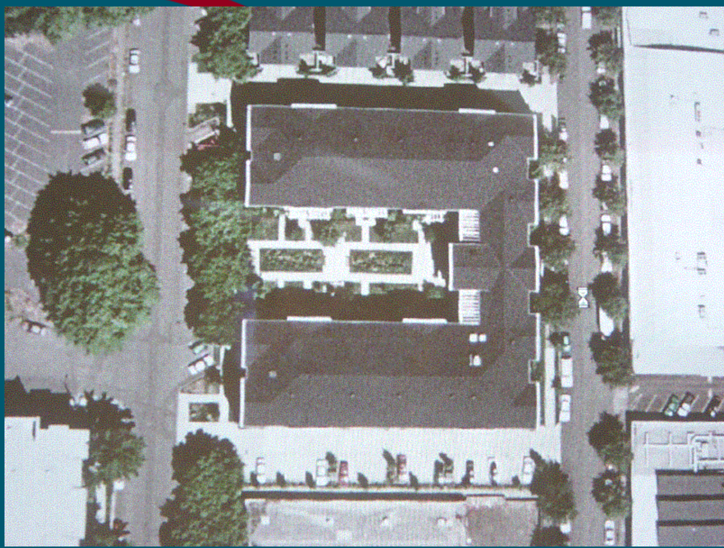
Buckman Heights Apartments

Inland Empire Utilities Agency – Ontario, CA


Inland Empire Utilities Agency – Ontario, CA
Parking Lot BioSwale


Sacramento County
Stormwater Quality Improvement Project
Sand Bed Profile
(Top of bed to be horizontal)
GRASSY SWALE
WEIR
SAND LAYER
GEOTEXTILE FABRIC
GRAVEL LAYER
DRAINAGE MATTING
IMPERMEABLE LAYER
PERFORATED 6" PVC - schedule 40 pipe

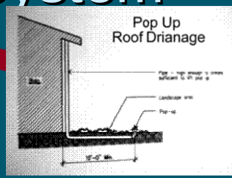
Portland Buckman Heights Apartments – Stormwater Planters



Buckman Heights Apartments

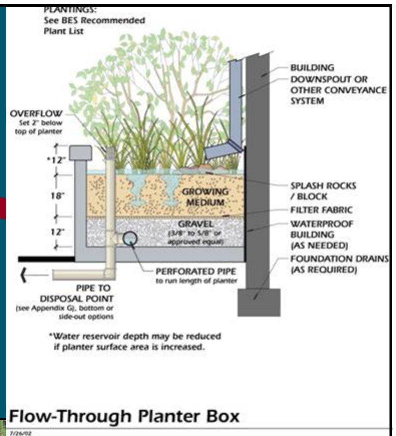
Figure I.6.12

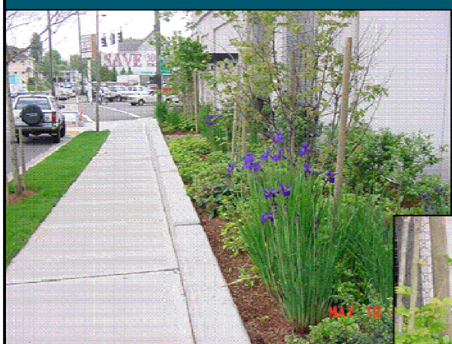
Apartment Courtyard Biofiltration System



Runoff is directed to center planter and either infiltrates or overflows into small inlets

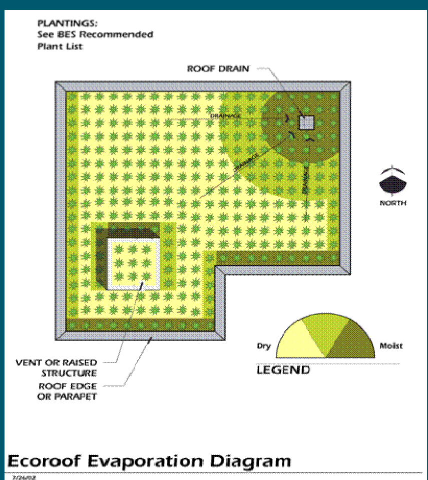
Hydrological Source Control –Stormwater Planter Boxes

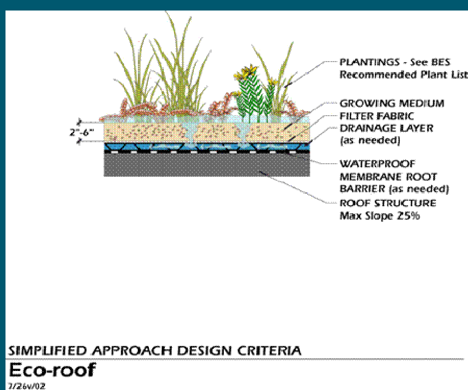


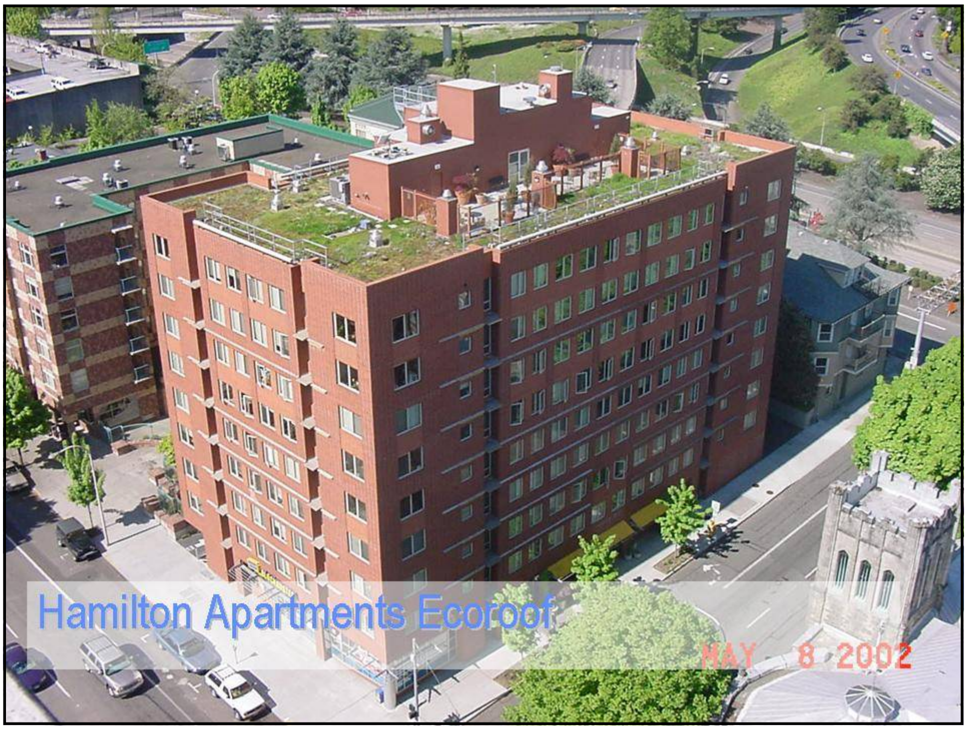


Roofs – Good Looking?

City of Portland -Simplified Approach

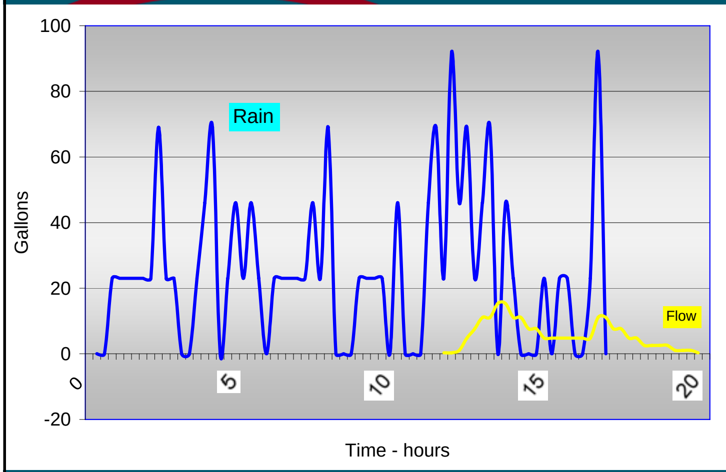





Hamilton Apartments Ecoroof
MAY 8 2002


Hamilton Apartments Ecoroof
MAY 8 2002

Hamilton Ecoroof westside rainfall and runoff June 28-29, 2002 storm event 0.73"

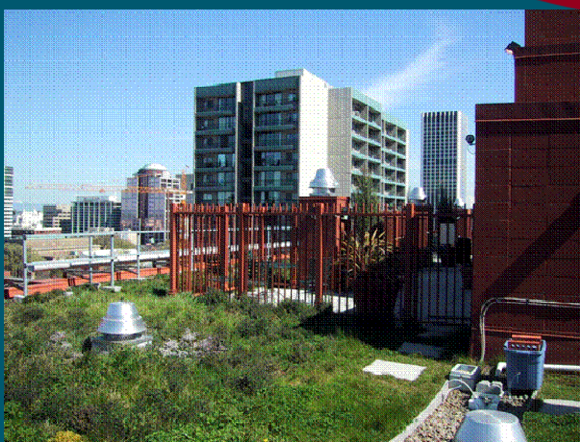


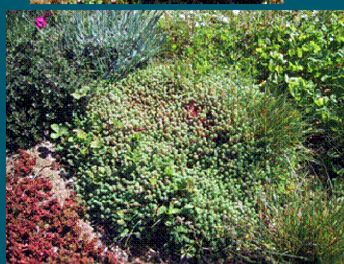
Hydrological Source Control-

ET Losses

- **Total catchment 3,692 sf, ecoroof 2,690 sf, * impervious surfaces 527 sf, pavers on sand base 475 sf**
- ***If the 239 gallons of rainfall from the impervious surfaces is removed then no runoff would have occurred**

Portland Roof



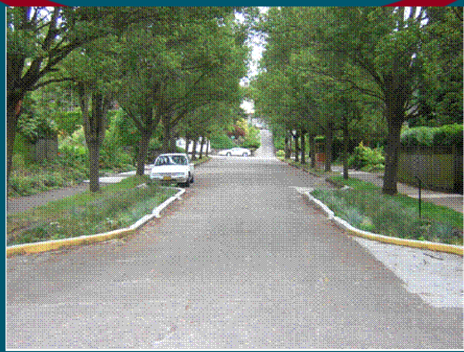



"Flat Curbs" to allow water to sheet flow into swales
City of Seattle


About $1 Million for 1 block

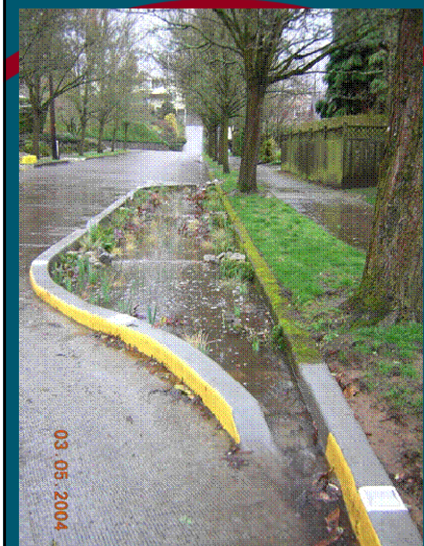
Portland Version of Green Streets

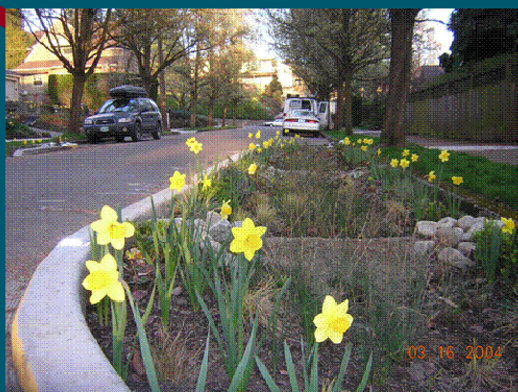
Before



After

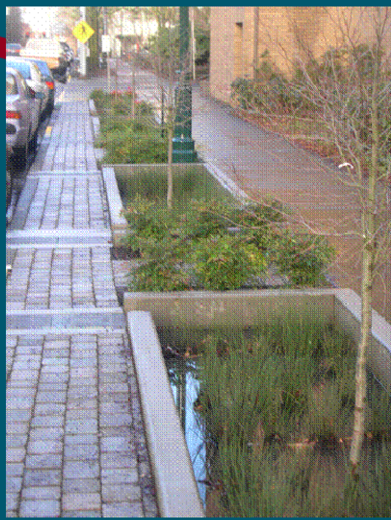
Portland Version of Retro-fit Green Streets





About $30,000

Portland Ultra Urban Biofiltration



Conclusions

Workshop 5 : Source Control: Managing Stormwater with a Water Balance Approach

Experience with stormwater source control in Germany

Experience en matière de gestion des eaux pluviales à la source en Allemagne

Heiko Sieker
IPS
Germany

THE STORMWATER EXPERTS.
INGENIEURGESELLSCHAFT
PROF. DR. SIEKER MBH

Experiences with Stormwater Source Control in Germany

Pre Conference Workshop,
Novatech, Lyon, June 2007

Heiko Sieker, IPS

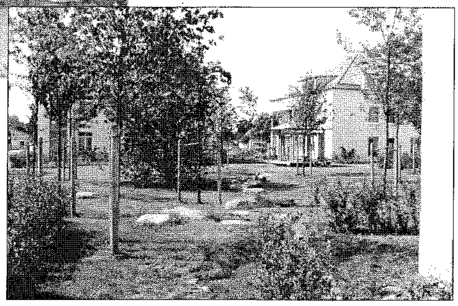
Contents

- Stormwater Management (SWM) in Germany
- Project Examples
- New stormwater regulation in Germany based on a water balance approach !?

Paradigm shift regarding stormwater in the last 10-15 years

From Discharge

towards
source control



SWM in Germany

- New SW-related regulations on **national level**
  - §1a WHG (German Water Act)
    - "Keep runoff in the catchment"
    - Introduced after the big floods in 1993/1995 at the Rhine
  - §7a WHG: Emission standards for waste water treatment incl. stormwater
    - Until 2000: Common engineering practice (technical rules)
    - Since 2000: Best available technology (BAT)
  - Under development for 2008: definition of BAT for SWM
- SW-regulations on **federal level**
  - In 10 of 16 federal states, stormwater infiltration is obligatory for new developments
  - North Rhine Westfalia (biggest state):
    regulation (ordinance) for stormwater treatment

North Rhine Westphalian regulation on stormwater treatment

- Regulation defines basic standards
- Extended treatment based on imission standards
- Principle: stormwater should be infiltrated if possible (§51a)
- If discharge necessary, treatment depending on land-use
  - Unpolluted stormwater
    - E.g. roofs in residential areas (non-metal), sidewalks, ...
    - No treatment necessary
  - Stormwater with minor pollution
    - E.g. roofs in commercial areas, residential roads,
    - Treatment necessary
  - Heavily polluted stormwater
    - Main roads, highways, runways on airports, ...
    - To WWTP or adequate treatment
- Decentral treatment has priority over end-of-pipe-treatment
- Infiltration over topsoil is treatment!

SWM in Germany

- Stormwater regulations on **municipal level**
  - Drainage statutes may limit or demand use of public sewer systems
  - Most of German cities have a stormwater fee
    - Average (2003) 0,80 €/sqm/year
    - Berlin (2007): 1,65 €/sqm/year
- Technical rules
  - Mainly by German Water Association (DWA)
  - A138 (2000): Guideline for Stormwater infiltration
  - A100 (2006): Guideline for Masterplanning

Stormwater source control is considered in German regulations

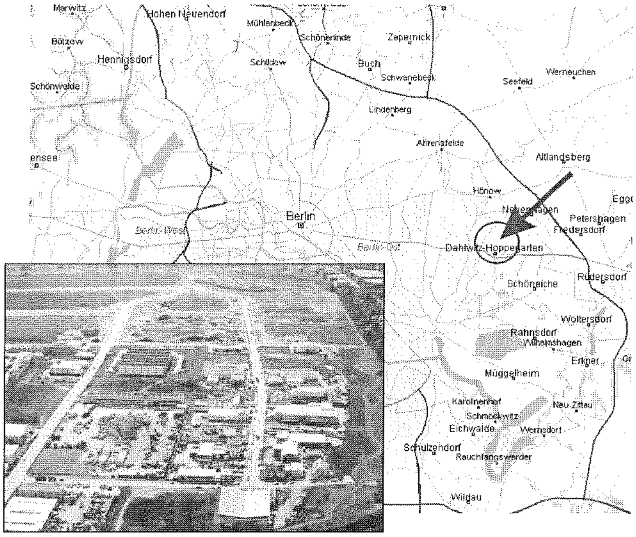
Problems / Contradictons

- Lip services
  - In most regulations, a need for source control is stressed ...
  - ... but concrete rules are sometimes missing or are weak
- Stormwater fee
  - On one hand a good motivation for source control
  - On the other hand: municipalities/water companies don't want to loose clients
- Standards for CSO-treatment is based on assumption, that emissions should not be greater than from a comparable separated system (without treatment)
- On-going discussion about what is the "Best Available Technology" for stormwater treatment

Project examples

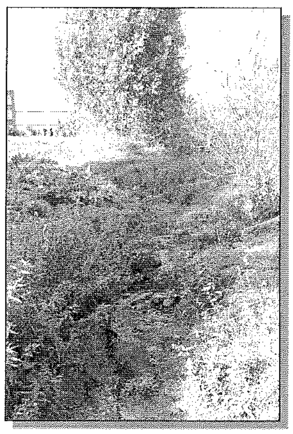
- Many (thousands!) good examples for stormwater source control available
- Three examples
  - Commercial site in Berlin-Hoppegarten
  - Residential area Berlin-Rummelsburg
  - Emscherregion

Example No.1: Commercial Site Hoppegarten

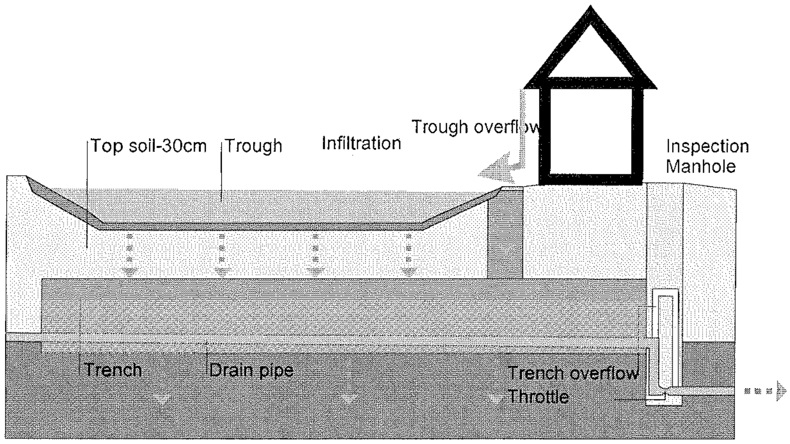


Commercial Site Hoppegarten

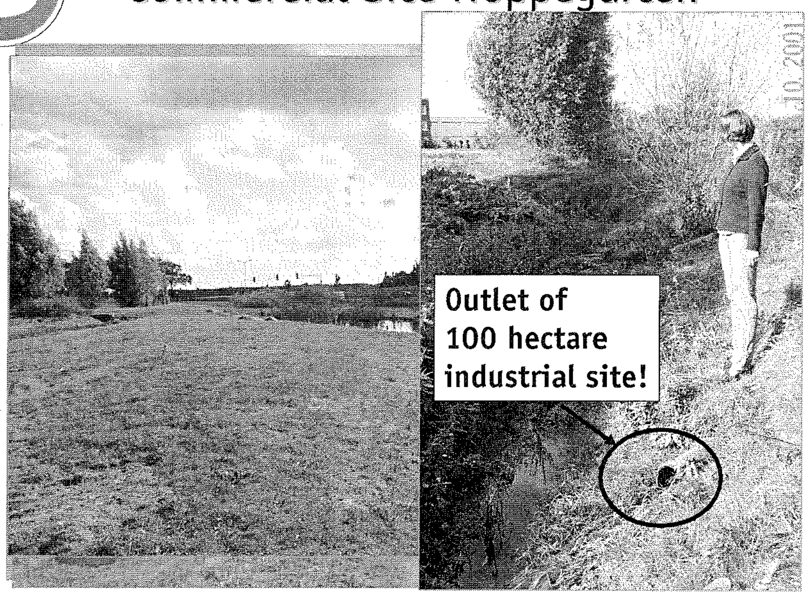
- Difficult hydrological conditions
  - Very small receiving water
  - max. Discharge 40 l/s for 100 hectare development
  - One year design storm for 100 hectare: 10-15 m^3/s
  - Retention necessary
- Difficult geological conditions
  - Glacial soils: poor infiltration capacity
  - Swampy parts with high groundwater tables
  - Storm water infiltration not possible



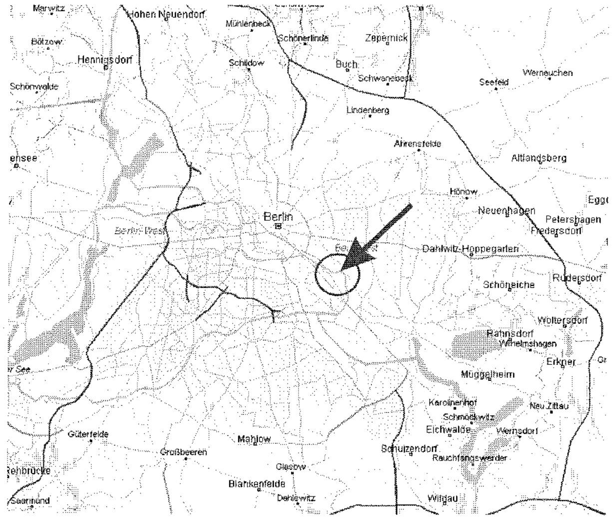
Solution: Trough-Trench-System



Commercial Site Hoppegarten



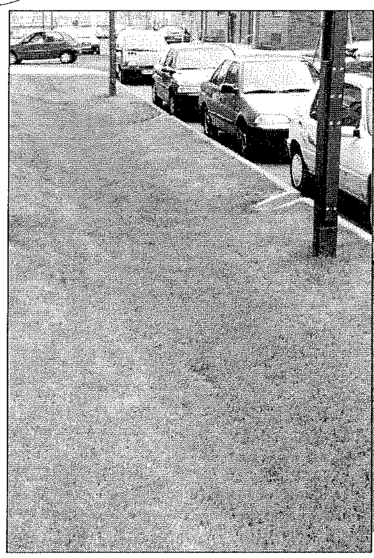
Example No.2: Residential Area Rummelsburg

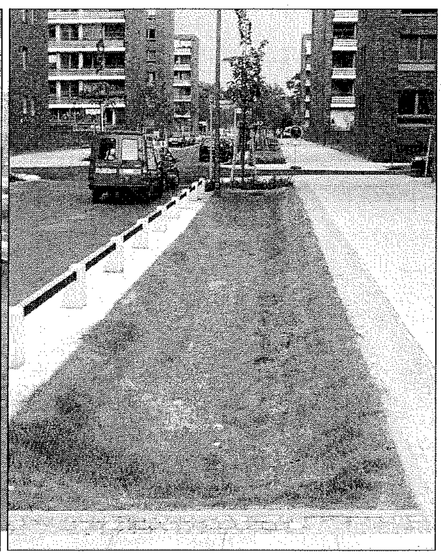


Residential Area Rummelsburg

Stormwater Management on Private Properties

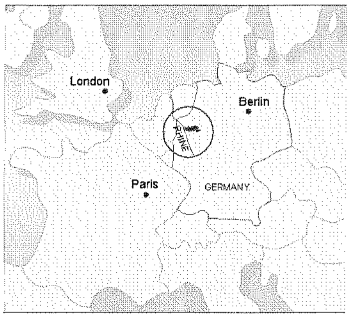
Stormwater Management in Public Areas

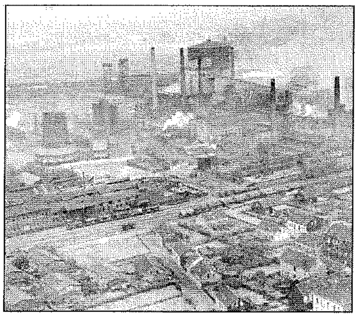




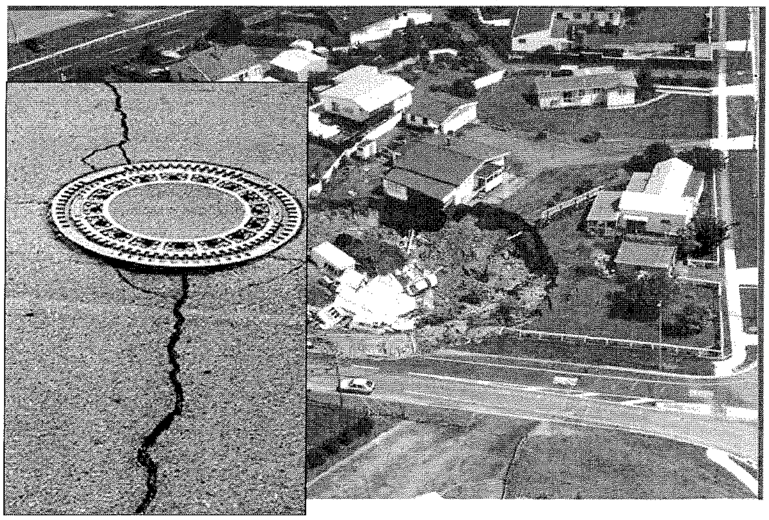
Example No.3: Emscher Region

- Tributary of the river Rhine in Western Germany.
- Length: 84 km, Catchment area: 865 km^2
- Densely populated: 2.3 million inhabitants
- Long tradition in steel industry and coal mining

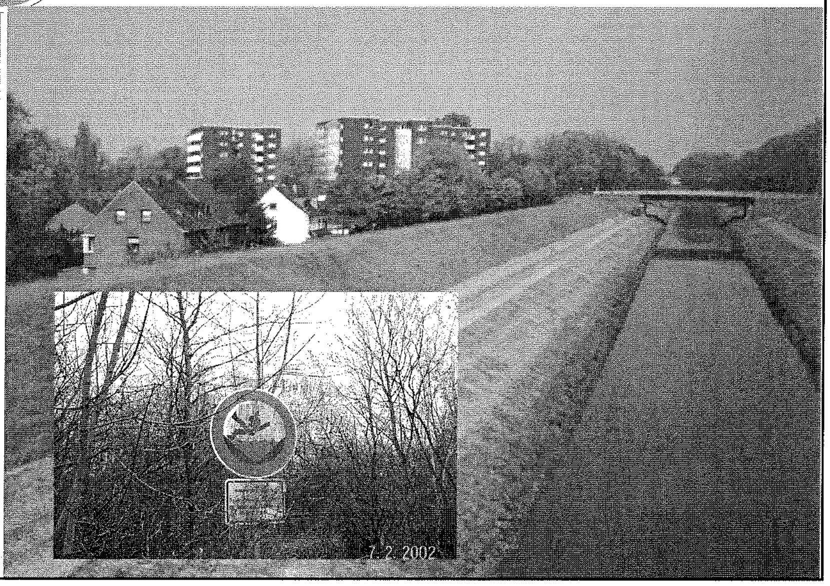




Subsidence caused by Mining



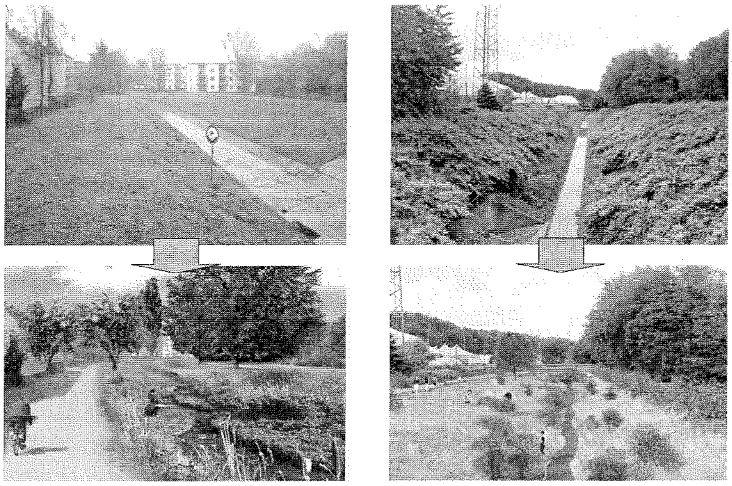
The Emscher System



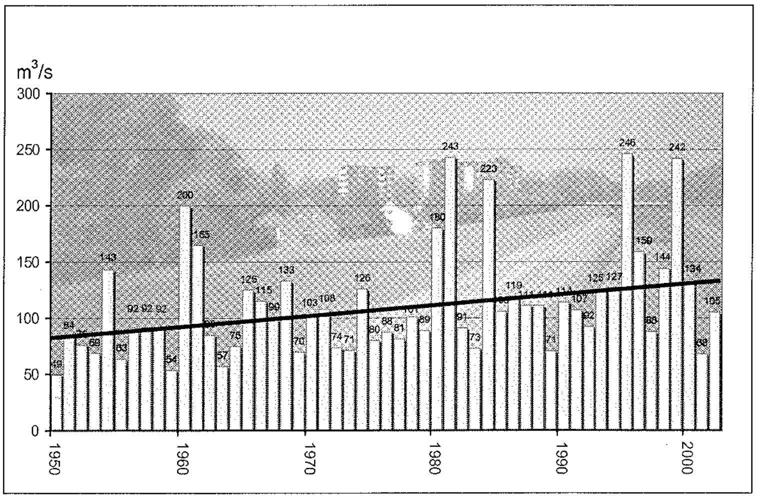
Emscher Rehabilitation Project

- Ceasing of mining activities in the 1980's subsidence stopped some year later
- In 1990's chance for rehabilitation was given
- Estimated project duration ~ 30 years
- Budget: ~ 4.5 Billion €
- Measures
  - Decentral WWTP
  - Combined Sewers
  - CSO and retention ponds
  - River rehabilitation

Emscher Rehabilitation Project

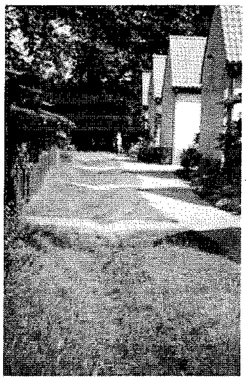


Problem of Flood Peaks

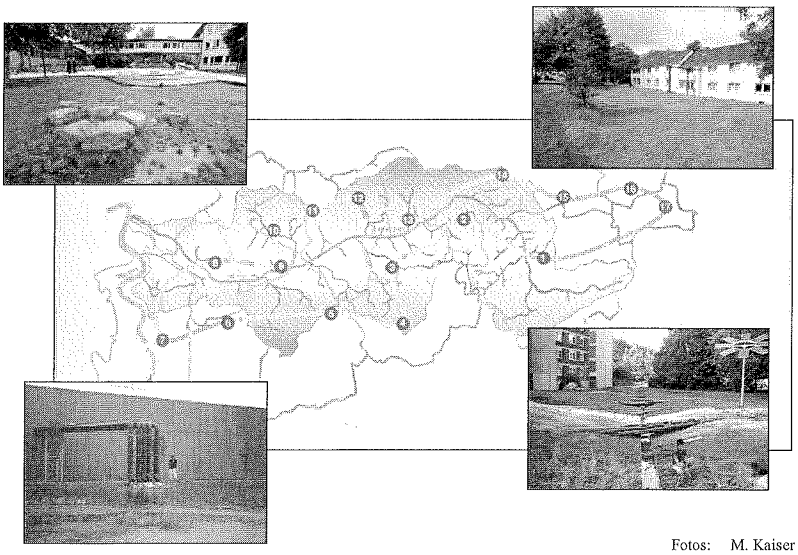


"The Rainwater Route"

- Many pilot projects for USWM since the 1990's
- Subsidized by Emschergenossenschaft and the Ministry of Environment of the Federal State



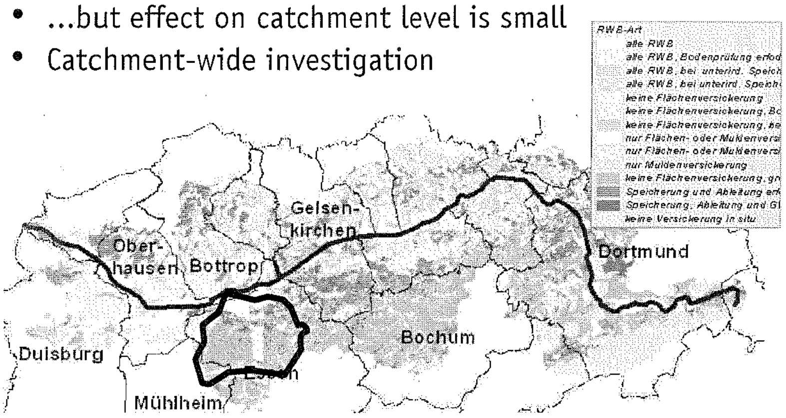
"The Rainwater Route"



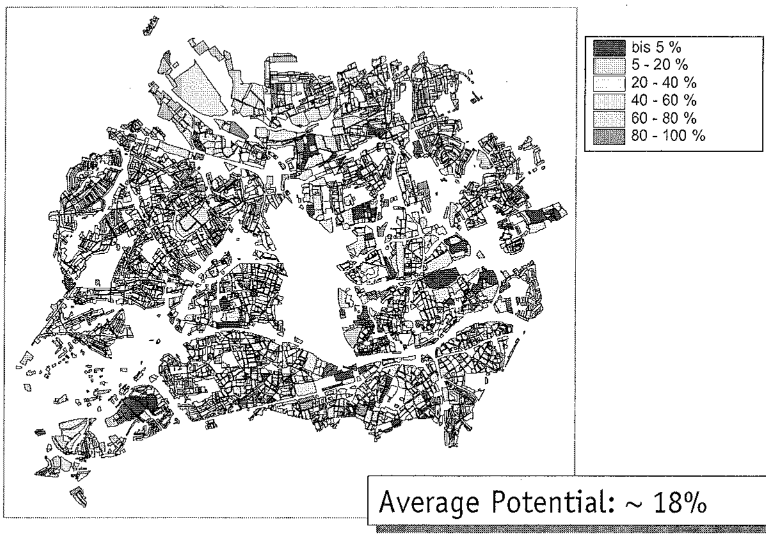
Fotos: M. Kaiser

Stormwater Management Information System (SMIS)

- Pilot projects are good for demonstration...
- ...but effect on catchment level is small
- Catchment-wide investigation



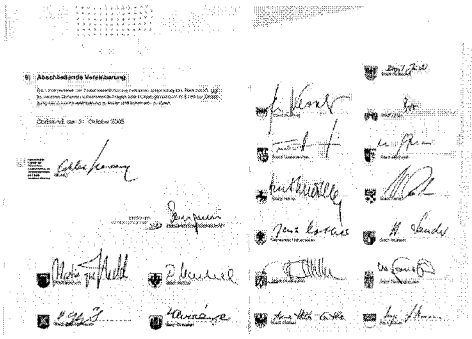
Potentials for Disconnection



Average Potential: ~ 18%

Project "15/15"

- Target 15% disconnection in 15 years
- Contract between Emschergenossenschaft, Federal State Ministry and 17 municipalities
- "Storm Water Convention" was signed in Oct. 2005

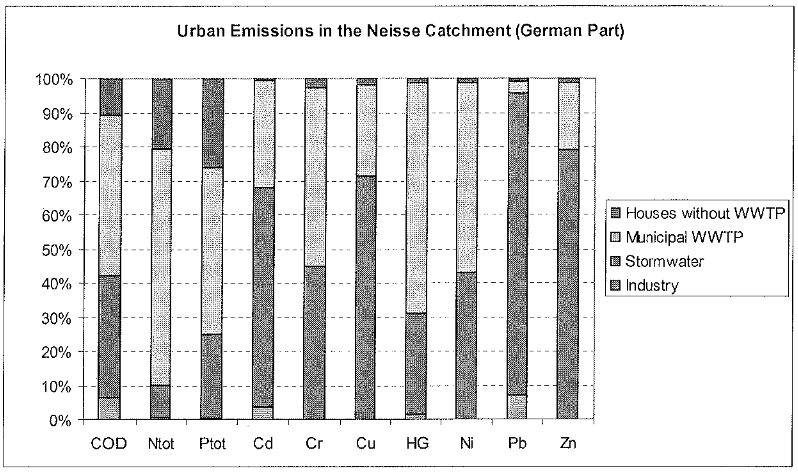


Actual situation

- Although
  - Many successful pilot projects
  - BMP/SUDs are common practice for new developments
  - Potentials for catchment-wide application are given
  - From technical point of view decentralized urban stormwater management systems are ready to use
  - Political support
- Still
  - Resistance e.g. from drainage departments
  - Hard to switch the daily practice

Job for the next years:
to overcome the administrative obstacles

EU Water Framework Directive



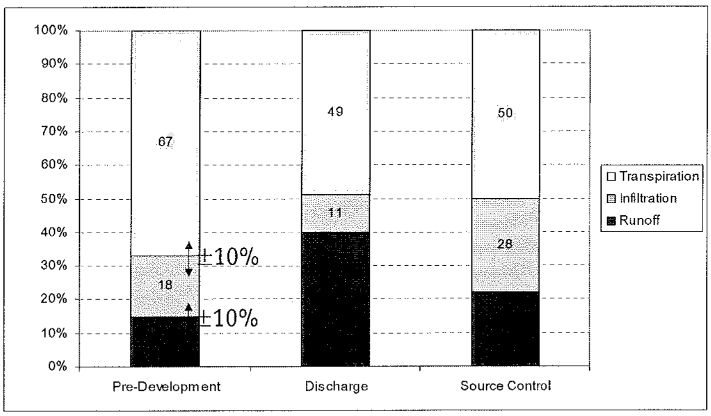
New stormwater regulation

- Change of the constitution in 2006:
  Regulation for water treatment is not any longer federal but national task
- Ministry of the Environment wants to define the Best available technology (BAT) for stormwater management until 2008
- Status quo of discussion
  - Definition of BAT only for new developments
  - Objectives instead of measures
  - Main criteria
    - Suspended solids
    - TOC, N, P , petroleum-derived hydrocarbon
  - Treatment schemes based on land-use
  - Infiltration if possible/Water balance approach

Water balance approach

- Alternative to the demand for infiltration
- Principle: „objectives instead of measures“
- Objective: Keeping up the natural water balance
- Suggested procedure (for new developments)
  - Calculate natural water balance
  - Calculate post-development natural water balance
  - Criteria:
    - Difference of infiltration +- 10%
    - Difference of runoff +- 10%
    - Difference of evapotranspiration +- 20%

Water balance



Thank you for your attention!