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Agenda item 14: Review of assessments for development of three new Regional Plans in accordance with Article 15 of the LBS Protocol for the biennium 2022-2023

Assessment of state of urban storm water management in the Mediterranean

UNEP/MAP
Athens, 2021

<u>**Note by the Secretariat**</u>

The 21st Meeting of the Contracting Parties to the Barcelona Convention COP21 (Napoli, Italy, 2-5 December 2019) adopted Decision IG.24/10 which endorsed the main elements for development/ update of six new Regional Plans related to the urban wastewater treatment, sewage sludge management, agriculture management, aquaculture management, storm water management in addition to updating the current Regional Plan for Marine Litter Management in the Mediterranean. COP21 also approved the way forward proposing the time frame for the development, negotiation and adoption of the six Regional Plans. With regard to the Regional Plan on Urban Storm Water Management, the Meeting approved submission of the new Regional Plan to COP 23 (December 2023). In preparation for the development of this Regional Plan, the Programme of Work (PoW) and Budget for the biennium 2020-2021, which was adopted in Decision IG.24/14, mandated MED POL in Activity 2.4.3.1(c) to undertake an “assessment of state of urban storm water management in the Mediterranean.”

To achieve this mandate, this assessment of the state of urban storm water management was undertaken with the aim to provide up-to-date information for elaborating the Regional Plan on Urban Storm Water Management in the Mediterranean. The assessment provides an overview of the urban storm water sector in the Mediterranean; state of play of urban storm water networks and discharged pollutants reaching the Mediterranean; impacts of significant aspects of the urban storm water management with focus on storm water management plans; risk management; design, operation and maintenance aspects; run-off water, sustainable design elements; availability of technical standards, and regulatory measures governing design, operation and maintenance of urban storm water networks in the Mediterranean. The assessment includes also an evaluation of current and potential level of implementation (or non-implementation) of proposed measures foreseen for the Regional Plan including recommendations for additional complementary measures and proposals to improve BAT and BEP for urban storm water management.

The assessment of state of urban storm water management in the Mediterranean was discussed during the Meeting on National Baseline Budget Methodologies, Assessments of new Regional Plans and Evaluation of National Action Plans under the LBS Protocol in April 2021. The Meeting agreed with the findings and recommendations of this assessment and requested the Secretariat to proceed with submission to the Meeting of the MED POL Focal Points further to incorporating a number of modifications.

The Meeting of the MED POL Focal Points is expected to review this updated draft assessment and to provide its comments with the aim of approval as a background information document for further elaborating the new Regional Plan for Urban Storm Water Management in the Mediterranean during the biennium 2022-2023.

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List of Abbreviations / Acronyms

BC	Barcelona Convention
BMP	Best Management Practice
CAMP	Coastal Area Management Programme
EC	European Commission
EU	European Union
GES	Good Environmental Status
GI	Green infrastructure
ICZM	Integrated Coastal Zone Management
LBS	Land Based Sources
LID	Low Impact Development
MEDPOL	Mediterranean Pollution Control and Assessment Programme
MSFD	Marine Strategy Framework Directive
PAH	Polycyclic Aromatic Hydrocarbons
p.e.	Population equivalent
SUDS	Sustainable Urban Drainage Systems
TSS	Total Suspended Solids
UNEP/MAP	United Nations Environment Programme / Mediterranean Action Plan
USW	Urban Storm Water
USWM	Urban Storm Water Management
WFD	Water Framework Directive
WWTP	Wastewater Treatment Plant

1. Overview of Urban Storm Water Characteristics and Impacts

1.1 Urbanized watersheds

1. As global populations rise and continue to migrate from rural to urban areas at increasing rates, land is converted from its natural state to urban environments, causing significant degradation to downstream water bodies (Carey et al., 2013; Paul & Meyer 2001; Brabec et al., 2002). The construction and development of urban cities has required the conversion of vegetated, pervious, “green” terrain to man-made, impervious, “grey” landscapes that disrupt the area’s natural hydrology (UACDC, 2010). Runoff volumes are attenuated during wet-weather events over undeveloped landscapes as much of the precipitation can collect in natural surface depressions, be intercepted by the vegetation, or infiltrate into the soil column of pervious areas, resulting in significant precipitation losses to evapotranspiration and infiltration (Paul & Meyer, 2001). However, in urban environments comprised of increased impervious area in the form of roadways, sidewalks, and building roofs, precipitation is incapable of penetrating the impervious surfaces and, thus, reduces the precipitation losses (Sun & Lockaby, 2012).

2. The water cycle is short-circuited in urban areas, resulting in a larger percentage of precipitation being converted to runoff, which has been hydraulically designed to be channel water swiftly downstream through extensive storm water collection systems (Bedient et al., 2013). Additionally, these grey landscapes generate urban pollutants such as heavy metals, E. coli, oil and grease, nutrients, pharmaceuticals, and suspended sediments that are picked up by storm water flows and carried downstream, without mitigation that would have naturally been provided in undisturbed landscapes by vegetation and infiltration (Steinman et al., 200;, UACDC, 2010). As a result, the flow regimes of stormflows from urban watersheds are characterized by increased total runoff volumes, greater peak flows, flashier hydrographs with rapidly rising and receding flows, and poorer water quality (Walsh et al., 2005; May et al., 2006). These effects are expected to escalate with climate change. A comparison showing the typical proportions of precipitation conversion to runoff, shallow and deep infiltration, and evapotranspiration in urban and natural environments is presented in Figure 1.

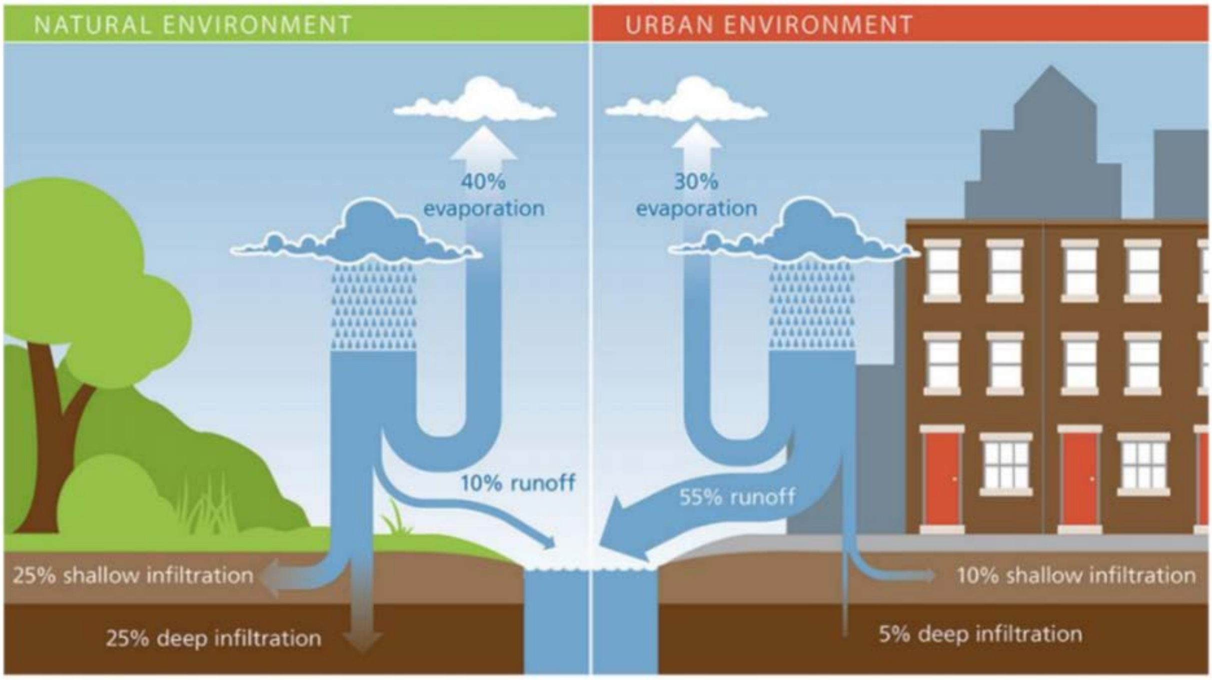

Figure 1: hydrologic comparison of urban versus natural watersheds (www.phila.gov/water/wu/storm water)

1.2 Downstream effects of urban storm water

3. Urbanized watersheds have produced consistent, often drastic negative effects on downstream water bodies including increased urban pollutant, nutrient, and suspended sediment loads; flashier hydrographs; reduced biotic integrity; and altered stream geomorphologies (Paul & Meyer 2001; Walsh et al., 2005; UACDC, 2010). Uncontrolled storm water runoff has many cumulative impacts on humans and the environment including:

a. Flooding - Damage to public and private property;
b. Eroded Streambanks - Sediment clogs waterways, fills lakes, reservoirs, kills fish and aquatic animals;
c. Widened Stream Channels - Loss of valuable property;
d. Aesthetics - Dirty water, trash and debris, foul odours;
e. Fish and Aquatic Life - Impaired and destroyed;
f. Impaired Recreational Uses - Swimming, fishing, boating;
g. Threatens Public Health - Contamination of drinking water, fish/shellfish;
h. Threatens Public Safety - Drownings occur in flood waters;
i. Economic Impacts – Impairments to fisheries, shellfish, tourism, recreation related businesses;
j. Increased cost of Water and Wastewater Treatment - Storm water pollution increases raw water treatment costs and reduces the assimilative capacity of waterbodies;
k. Excess storm water causes flooding and damage that is difficult and costly to clean up.

4. Urban stormflows generally have warmer temperatures and higher nutrient pollutant levels that often destroy downstream aquatic ecosystems through a naturally occurring process called eutrophication (Carpenter et al., 1998; Hall et al., 1999). As a result of increasing global urbanization and land-use alterations, this process has become accelerated beyond its natural rates, termed cultural eutrophication (Steinman et al., 2009; Anderson et al., 2002; Carey et al., 2013). When excess amounts of nitrogen and phosphorus are carried downstream, simple photosynthetic organisms, most prominently algae and plankton, quickly uptake the nutrients and experience excess growth, called blooms (Elser, 2012; Leitz, 1999).

1.3 Urban storm water pollution

5. Urban pollutants in storm water sewers are generated by an assortment of human activities and strongly associated with increases in impervious land cover, which occur as a result of urbanization (EPA, 1993; Brabec et al., 2002; Sun & Lockaby, 2012). Common urban pollutants and their primary sources include sediment, from erosion and construction sites; oil, grease, and toxic chemicals from industrial uses and motor vehicles; pesticides and nutrients from lawns and gardens; detergents from laundromats and car washing; viruses, bacteria and nutrients from pet waste and sewage; road salts from highways and transportation operations; heavy metals from roof shingles, motor vehicles, and industry; and also thermal pollution from dark impervious surfaces such as streets and rooftops (Carpenter et al., 1998; EPA, 1993). Pollutants come from one of two types of sources: point and non-point. Point sources are those that discharge waste, such as sewage or storm water, from a single point and are regulated by the EPA in the NPDES program (EPA, 1993). Non-point sources have non-discrete or multiple points discharging pollutants as a result of sheetflow flowing over urban surfaces during storm events. Non-point sources generally require more robust, BMP solutions to mitigate as they are more complex to contain (Hoos et al., 2000; Davis & Masten, 2009; Carpenter et al., 1998).

6. Urban Nutrient Sources of N and P in storm water runoff include residential fertilizers, atmospheric deposition, vehicle emissions, point source discharges of municipal and industrial waste, laundry or cleaning detergents, pet waste, yard litter, and suspended sediment and particulate matter (Carpenter et al., 1998, Davis and Masten, 2009; EPA1993).

2. Assessment of state of play of management practices in Urban Storm Water in support of the proposed main elements for the Regional Plan

7. The information on the state of play of management practices in urban storm water in the Mediterranean was collected in part through a survey questionnaire developed specifically for that purpose[1] (included in Annex I); videoconference meetings arranged with responsible agencies, as well as further to an in-depth review of existing documents and country reports (included in Annex III).

8. Information was structured to assess the current level of implementation of key aspects related to urban storm water management (USWM) at national level in relation to the main elements of the Regional Plan for Urban Storm Water Management including availability of storm water management plans, establishment of separate collection systems for surface water run-off, measures for combined collection systems, promoting sustainable urban drainage systems, incorporating management schemes of storm water into ICZM, and maintenance of storm water systems. Specific aspects related to risk management; development and efficiency of currently operating combined or separate collection systems and their infrastructure; and related regulatory measures governing design, construction and maintenance, including availability of a related technical standards, manuals/guidance, studies and data were addressed.

9. Summary findings of current state of plan of the main elements proposed in line with the proposed measures in Decision IG.24/10 for development of the new Regional Plan for Urban Storm Water Management as well as recommendations for additional measures to be addressed in the Regional Plan on Urban Storm Water Management are presented below:

2.1 Availability of storm water management plans

10. Due to difficulties in ensuring flood control and meeting environmental quality standards for waters bodies in urban agglomerations along the Mediterranean, there is a lack of a systematic approach for developing urban storm water management plans. These plans typically address how urban storm water quantity and quality should be managed to protect ecological, social/cultural and economic values. Urban storm water management plans are used to assist decision making to ensure that remedial measures (structural and non-structural) in existing developed areas are undertaken in a cost-effective, integrated and coordinated manner, and that decisions in relation to areas of new expansion (including redevelopment) are made with the implications for storm water impacts taken into account in order to achieve the quality goals for water bodies. Urban storm water management plans include risk management (storm water quantity, quality, public health/safety, environmental impacts, etc.) and information on location of land-based activities. These plans are usually prepared for a local government area, or a catchment area (occasionally for high priority sub-catchment area), and sometimes for a larger territory such as a regional government area.

11. Urban storm water management (USWM) plans have been developed to a various extent across the Mediterranean. This ranges from major cities having USWM Plans to smaller municipalities where such plans are non-existent, or at best are under preparation. USWM Plans in the Mediterranean mostly include only flooding control segments, i.e., no pollution control, while segments on risk management and information on location of land-based activities are covered only on a basic level.

12. In some cases, it is found that some elements of the USWM plans are incorporated into Urban Plans but only to a limited extent, such as collection systems layout, principles and recommended techniques regarding flood and pollution control management, as well as principles on how to achieve environmental water quality goals for water bodies.

13. Along the Mediterranean urban planning and storm water management are typically under municipal governance, where storm water management is usually the responsibility of the same utility or authority that manages drinking water and wastewater systems. Thus, in addition to practical

[1] Questionnaire distributed to Countries participating in the EU-funded Water-Environments-Support in the ENI Southern Neighborhood Region (WES) Project

challenges related to design, construction and maintenance, developing and implementing USWM plans, including sustainable urban drainage systems (SUDS) solutions, necessitates reframing storm water management from a technical problem handled solely by engineers at these water utilities, to a broader sustainability issue integrated into wider urban planning practices, by including other municipal departments, e.g. urban planners, ecologists and landscape architects (Serrao-Neumann et al. 2017). Furthermore, public participation should be promoted by involving citizens taking responsibility for reducing storm water runoff and associated pollution whereby measures are located on their private properties (Bohman et al. 2020).

2.2 Establishment of separate collection systems for surface water run-off

14. A separate storm water sewer system is a collection of structures, including retention basins, ditches, roadside inlets and underground pipes, designed to gather storm water from built-up areas and discharge it, with or without treatment, into local water bodies, e.g. streams, rivers, coastal waters (National Research Council. 2009). Separate collection prevents the overflow of sewer systems and treatment stations during rainy periods and the mixing of the relatively little polluted surface run-off with chemical and microbial pollutants from municipal wastewater. Separate storm water systems allow for design of sewers and treatment plants that consider the volume of the wastewater only, while surface run-off and rainwater can be reused after a simplified treatment (e.g. for landscaping or agriculture).

15. Most major urban centres in Mediterranean have both storm and sewage water collection systems. Typically, these are combined systems in city centres and old districts, and separate collection systems in new or recently developed districts. Separate collection systems for newly of re-developed areas have been applied in some Mediterranean cities, as a desired or prescribed option, as early since the 1970s, while in most of the cities separate systems are very limited in extent and have been implemented only in recent years. Separate collection systems are typically implemented in different land-use areas, i.e. urban, industrial and commercial areas (Chesa, 2016). Storm water treatment measures in separate collection systems are commonly not implemented and storm water is discharged untreated (World Bank, 2011), and if applied, storm water treatment is generally limited to screening, detention basins and sand filters, oil separation or alternatively absorption type of devices like biofilters (Sauri et al. 2017). If applicable (in relation to soil and hydraulic characteristics), storm water from roofs and other waterproofed surfaces commonly have on-site disposal, without treatment if not susceptible to leaching of dangerous substances. Otherwise, if storm water is likely to be polluted, adequate treatment measures have to be implemented prior to disposal into water bodies or public sewage systems (PTUA, 2006). In addition, the first rainwater can be sent to the “black network” only if this injection is compatible with the treatment systems in place. When discharge from separate collection systems is used for aquifer recharge, typically via injection to groundwater level, treatment measures are implemented with a focus on removal of sediments.

16. Separate collection systems are commonly implemented in industrial and commercial areas. Where space permits, detention basins and sand filters have been used to treat the “first flush” run-off that generally contains higher concentrations of contaminants. Oil separators or alternatively absorption type devices such as activated carbon or compost leaf filters have also been used, mostly in industrial areas, to remove hydrocarbons or other organic contaminants.

17. In addition, there are Mediterranean cities which have some segments where sewer systems are inadequate or non-existent or even may have some illegal cross-connections whereby untreated wastewater reaches the storm water system and consequently water bodies.

18. Even though, separate collection systems are foreseen by the proposed measures of the Regional Plan, or already included in the urban planning instruments in force, they should be complemented with (currently commonly missing) technical standards and manuals/guidance related to design in order to ensure application of the following principles:

a. Use of multiple storm events, i.e. “design storm” or high intensity storm events for flood control and “moderate-sized storm,” or every day rain event for pollution control as the common usage of single “design storm” cannot adequately capture the variability of rain and how that translates into runoff or pollutant loadings; and thus is not suitable for addressing the multiple objectives of urban storm water management, i.e. flood and pollution control;

b. Incorporate aspects related to climate change impacts, including extreme hydrological patterns and their impacts on influent flow; and
c. Impose “hydraulic invariance” principle which aims at restoring the natural water cycle by promoting on-site disposal (PTUA, 2006).

2.3 Measures for combined collection systems

19. Combined collection systems are sewer networks designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of their wastewater to a wastewater treatment plant (WWTP), where it is treated and then discharged to a water body (National Research Council, 2009). During periods of heavy rainfall, however, the wastewater volume in a combined collection system can exceed the capacity of the sewer system or treatment facilities, for which reason the combined collection systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers or coastal waters. These storm water overflows from combined collection systems contain not only storm water but also all sorts of untreated pollutants, e.g. human and industrial waste, toxic materials, and debris. These storm water overflows are considered major water pollution concerns for the majority of coastal cities that have predominantly combined collection systems implemented (Milieu, 2016). In most cases, these overflow events are causing short-term pollution. These shortcomings of combined collection systems are typically remediated by installing storm water treatment tanks to ensure the adequate capacity of the system (for absorption of the peak flow) during an intense rain events, or alternatively introducing SUDS solutions; and thus, reducing the risk of flooding and pollution from combined collection systems.

20. In coastal urban agglomerations along the Mediterranean which have combined collection systems, implemented treatment measures (if existent) consist of storm water treatment tanks which include decantation and filtering. On the other hand, industrial areas typically have simple pre-treatment measures implemented to some extent prior to connection to a combined collection system.

21. Furthermore, combined collection systems throughout Mediterranean have storm water overflow mechanism installed by default, which is a common key concern during intense rain events where system capacity system is exceeded, leading to uncontrolled discharge of untreated sewage into surface waters or groundwater. These events are common occurrence in case of the under-capacitated old and poorly maintained systems. In addition to overflows, leakage from combined collection systems may occur frequently due to various forms of malpractice, e.g. illegal cross-connections, surcharge of water in sewers, blockages and sometimes collapse of the conduits.

22. In addition to proposed measures by the Regional Plan, a variety of measures can be recommended (Milieu, 2016) with the aim of reducing the occurrence and impacts of storm water overflows and associated floods and pollution. These range from end-of-pipe solutions such as building water storage capacity to optimising the use of the waste water treatment plant and sewer system (e.g. using sewer networks for additional storage and optimising pumping operations); to reduction of clean storm water entering a sewer system (e.g. de-connecting impervious areas from combined sewer systems); or alternatively green infrastructure as potentially cost-effective measures to reduce storm water (e.g. retention basins, infiltration trenches). In addition, it would be valuable to close the knowledge gaps by gathering comparable information across the Mediterranean on the extent of storm water overflows from combined collection systems, which should include inventory of the locations of overflow structures, inventory of functioning of the overflow structures, inventory of sewage storage capacity structures (e.g. starting with agglomerations of more than 100,000 p.e.), with the aim of acquiring better understanding of the occurrence of storm water overflows and their impacts on the quality of receiving water bodies.

2.4 Promoting Sustainable Urban Drainage Systems (SUDS)

23. There is an emerging consensus that urban storm water runoff should be managed via alternative control measures, typically referred as SUDS, which are designed to mimic the natural functions of pre-development hydrology (Barbosa et al. 2012). These sustainable storm water solutions aim to minimize the impervious cover by promoting infiltration, ponding and harvesting of storm water runoff. Furthermore, in this decentralized management approach, storm water runoff and pollution are primarily controlled by measures located near the source to strive towards well-integrated measures that perform multiple functions, including flood protection, pollution removal and groundwater recharge, as well as recreation, biodiversity and urban aesthetics.

24. Sustainable Urban Drainage Systems (SUDS) have achieved mainly a moderate to high level of awareness in both, designers and planners. Despite many arguments in favour, implementation of SUDS in the Mediterranean however is still very rare and is typically limited to small-scale public projects; although there are cities with high level of implementation. SUDS solutions usually complement traditional (piped) sewerage networks. SUDS approach initially received attention as early as the 1970s when it was piloted in small-scale public projects, while from the year 2000 onwards, it is becoming increasingly convenient to adopt decentralised, small-scale SUDS solutions for drainage of storm water.

25. Throughout the Mediterranean, there is a similar situation where a community typically shares the cost of discharging storm water from private land via the sewerage network, but this is not the case for alternative techniques, for which costs have to be borne by the developer. Hence, even if alternative techniques are relatively inexpensive, they represent an additional cost (installation and maintenance) and they often take up valuable real estate land. As a result, despite the arguments in favour of SUDS techniques, they have not yet been widely adopted by cities, mainly because they commonly require additional financial resources and greater land area for implementation in comparison to traditional counterparts (Patouillard and Forest. 2011). A possible solution to overcome this aspect in cost could be the creation of a tax credit for sanitation, which would allow local authorities to tax storm water management, with an exoneration for those who treat storm water on their own land.

2.5 Incorporating management schemes of storm water into ICZM

26. Integrated Coastal Zone Management (ICZM) is a resource management system following an integrative, holistic approach and an interactive planning process in addressing the complex management issues in the coastal area. In order to promote this integrated management approach, the ICZM Protocol under the Barcelona Convention has been developed and adopted in 2008 by ten countries and the EU in the Mediterranean basin. One of UNEP MAP’s Regional Activity Centres (PAP/RAC) has been established in order to encourage the adoption of ICZM Protocol within national legislative framework, and additionally to ensure the implementation of key aspects of the ICZM Protocol by establishing the Coastal Area Management Programme (CAMP) in all Mediterranean Countries going back to the early 1990s. It is believed that CAMP will allow the countries to better manage their coastal zones, as well as to deal with the emerging coastal environmental challenges, such as the climate change. Storm water management represents one of the key aspects of the ICZM; and thus, USWM schemes are typically integrated into ICZM plans.

27. ICZM plans commonly incorporate USWM schemes, which typically promote sustainable management practices such as pollution control at the product level; separation of waste streams at source, for different land-use areas, i.e. industrial areas; internal recycling and pre-treatment prior connection to public (combined) collection systems; reuse and recycling of storm water (e.g. from roofs); and protection of storm water runoff damage due via improved flood control (PAPRAC, 2007)

28. Integrated Coastal Zone Management (ICZM) plans have been developed from 1990 onwards in pilot coastal areas in several Mediterranean countries; a number of which with the support of UNEP-MAP. Yet, these plans rarely include more than basic principles on USWM.

2.6 Maintenance of storm water systems

29. Proper maintenance of storm water collection systems aims at keeping storm water networks and infrastructure clean and fully functioning for discharge of storm water, which ensures prevention of flooding or pollution due to malfunction or storm water overflows during rainfall.

30. An adequate maintenance is implemented with various levels of scrutiny across the Mediterranean, ranging from fully adequate maintenance where actions are performed on a regular basis, and in a pro-active fashion, with only occasional oversights in some of areas – typically small municipalities, to moderately adequate maintenance where actions are frequently taken irregularly, and reactively rather than pro-actively, while some of small local communities may not have enough skilled professional staff to stimulate efficient operation of water-related utilities, to poorly implemented maintenance where service is irregular, inadequate and insufficient, leading to frequent malfunctioning of the sewer networks, as well as intermittent operation of wastewater treatment plants.

31. Ensuring regular and pro-active cleaning and maintenance service of urban storm water structures is a prerequisite for sustaining the efficiency of the urban storm water systems and preventing the occurrence of floods and pollution associated with malfunction of the system during intense rain events. Hence, these services should minimally include road maintenance, street sweeping, storm-drain maintenance, storm water hotline response, and landscape and park maintenance. In addition, a performance monitoring, i.e. continuous, flow-weighted sampling methods which require flow and water quality data, should be implemented at key urban storm water structures (National Research Council, 2009)

3. Recommendations for additional measures to be addressed in the Regional Plan on Urban Storm Water Management

32. An understanding of urban watershed hydrology and water quality, including the quantity and movement of storm water runoff, sources and locations of contaminants, and the degree of downstream water body impairment is required to effectively design and plan Green Infrastructure (Carey et al., 2013; Lathrop et al., 1998; UACDC, 2010). In that respect, it is important that governmental agencies, city public works, and geological survey agencies, work together to provide these understandings by conducting field hydrologic and water quality monitoring studies that model and quantify downstream pollutant levels and stormflow volumes to estimate overall contaminant loads across land-areas and regions (Leitz, 1999). After an assessment of human and natural factors, such as city climate and location and urbanization rates, land-use, and the observed water quality conditions, storm water pollution reduction goals and more effective storm water management strategies can be created (EPA, 1993; NRC, 2008). In order for implemented Green Infrastructure to provide solutions to urban runoff in cities, particular care must be taken on a community-specific basis in designing management strategies. For example, in densely populated urban environments, incorporating retention strategies involving the infiltration of large volumes of runoff may not be economically feasible compared to other alternatives, such as water storage (Bedient et al., 2013). Once an effective management plan is derived, an interdisciplinary collaboration between city planners, community leaders, engineers, scientists, and builders must be completed to implement Green Infrastructure measures as many developed cities include pre-existing grey infrastructure.

3.1 Best management practices (BMPs)

33. In order to begin solving the complex issue of urban storm water pollution, cities are developing and implementing storm water management plans that are unique to each location. In many cases, systemic changes from current city infrastructures to designs including more BMPs are being implemented. BMPs include conserving natural areas and vegetation, reducing hard and/or impervious surface cover, and retrofitting urban areas with Low Impact Development (LID) features that effectively hold and treat storm water instead of conveying it downstream with no treatment (NRC, 2008). An increasingly popular BMP technique is Green Infrastructure (GI), which mimics the natural water cycle by harvesting, infiltrating, and evapo-transpiring storm water, while promoting climate

regulation and ecological functioning, such as sediment retention and nutrient cycling that is lost in urban “grey” landscapes (UACDC, 2010). As such, city planners have worked to incorporate Green Ifrastructure, such as green roofs, bioretention facilities, and porous pavements, into city design schemes due to their effectiveness in reducing and mitigating storm water and providing economy and aesthetic enhancements to communities and their citizens’ life quality (Tzoulas et al., 2007).

3.2 Storm water quality testing

34. Storm water carries a variety of dissolved constituents and particulate matter from both anthropogenic and natural sources. For monitoring purposes, pollutants are categorized into physical, chemical, and biological subgroups (Caltrans, 2013). Physical characteristics are based upon physical properties of the storm water itself, such as temperature, turbidity, conductivity, total suspended solids, pH, and biological oxygen demand. Chemical characteristics are based upon chemical constituents of the water that can be specifically measured (EPA, 1993). Typically, they can be split into dissolved and suspended fractions via filtering methods in lab analyses. Examples of common chemical storm water pollutants include metals and nutrients (NRC, 2008). Biological characteristics of storm water include the properties that relate to any living materials within the water and its toxicity to living organisms (Caltrans, 2013). Storm water samples are typically tested for indicator bacteria such as total coliforms, fecal coliforms, and E. coli that correlate the degree of pathogenic activity and toxic effects from the storm water (EPA, 1993). Mediterranean countries are recommended to develop their storm water testing procedures and standards.

4. Conclusions

35. The urban storm water management in the Mediterranean is experiencing a good improvement in separating collected waters and implementing novel practices that aim at restoring natural water cycle, though there are scopes for further improvement. There is a high need for robust legal framework and governance structure with distinct accountability maps for strict implementation of the available legislation aiming to minimize environmental impacts. Further research, more importantly field hydrologic and water quality monitoring, is needed to assess the effectiveness of novel management practices developed across the globe, and to evaluate the conditions for replicability and transferability of available BMPs and BEPs to the Mediterranean. Sustainable Urban Drainage Systems should be considered as the overarching conceptual framework underlying any development of urban storm water systems. Creating a Mediterranean long-term vision of the sector is key to effectiveness of management practices in reducing and mitigating storm water and providing environmental enhancements to cities and their citizens’ life quality. These aspects should be reflected in the new Regional Plan on Urban Storm Water Management.

36. With regards to the Regional Plan for Urban Storm Water Management, emphasis in the proposed measures should be given to developing management plans which would ensure flood and pollution control by committing to separate collection systems and utilisation of novel management practices which mimic the natural water cycle. For parts of urban areas with pre-existing combined collection systems, the scope will be aimed at reducing the risk of overflows through installing storm water treatment tanks as well as reducing environmental impacts through improving efficiency of treatment facilities, ensuring regular cleaning and proper maintenance of the system, and improving energy efficiency. For newly-developing or land-use changing parts of urban centres, separate collection of storm water runoff as well as introduction of innovative techniques that effectively hold and treat storm water instead of conveying it downstream with no treatment should be given preference. Sustainable design in the form of green infrastructure such as bioswales, wetlands, retention ponds, porous pavements, recharge of aquifers, etc., should be given priority when developing city management strategies, taking into account on a city-specific basis the need for these design schemes. Improvement of availability of data, various studies, manual/guidance, and technical standards, as well as adoption of all of these novel management practices along with effective collaboration at all levels with all the stakeholders will enhance efficiency of urban storm water management in the region. Introduction of best management practices should be pursued. Adoption of supporting legal and institutional measures should be ensured as part of the regulatory measures

introduced by the Regional Plan in order to ensure the effective implementation of urban management plans measures.

Annex I
Survey Questionnaire for State of the Play on USWM in the Mediterranean

Introduction

An assessment template was prepared in order to obtain feedback of countries about storm management practices. The template reflects the main elements on proposed measures for the Regional Plan on Urban Storm Water Management. The Survey questionnaire is presented below.

Survey Questionnaire

Main elements of the Regional Plan on USWM - **proposed measures** - **additional measures**	**What to assess** - **current level of implementation or (non-implementation) of proposed measures** - **impacts on the Mediterranean**	**State of play of USWM (network and infrastructure)**
a) develop storm water management plans, including: - risk management - info on location of land-based activities To add: - categorisation of recipient water bodies	- Extent to which USWM Plans are developed and implemented in coastal cities? - Do USWM Plans include risk management? - Do USWM Plans provide info on location of land-based activities, i.e. sources of pollution? - Do USWM Plans provide categorisation of recipient water bodies, i.e. aimed water quality?	
b) establish separate collection systems for run-off water, under specific conditions	- Extent to which separate collection systems are implemented in coastal cities? - Extent to which separate collection systems are implemented in different land-use areas, i.e. urban, industrial, commercial? - Extent to which adequate storm water treatment measures are implemented in separate collection systems?	
c) in combined collection systems, install storm water treatment tanks - with decantation and filtering	- Extent to which storm water treatment measures are implemented in combined collection systems?	
d) promote sustainable design - such as green infrastructure - for small medium cities	- To which extent sustainable design has been recognized and implemented by relevant stakeholders (designers, planners)?	
e) incorporate management schemes of storm water run-off into ICZM plans	- Are there any ICZM plan developed, that incorporated management schemes of storm water run-off?	
f) ensure proper maintenance - clean USW system to prevent floods during rain events To add: - maintain storm water treatment facilities to sustain their efficiency and prevent malfunction	- Extent to which maintenance is adequately applied: (i) on collection system, (ii) on storm water treatment facilities?	

Manual / Guidance development	**What to assess**	**State of play**
a) integrating storm water management	- Availability of manual / guidance on integrating storm water management in native language?	
b) storm water management plans	- Availability of manual / guidance on storm water management plans in native language?	
c) structural controls - storage - use - infiltration	- Availability of manual / guidance related to structural controls in native language?	
d) non-structural best management practice: - maintenance - awareness	- Availability of manual / guidance related to non-structural best management practice in native language?	
Studies that may be undertaken	**What to assess**	**State of play**
a) evaluate locations of effluent points of USW outlets	- Availability of evaluation reports for locations of effluent points of USW outlets?	
b) prepare drainage features plans to illustrate geographic pattern of drainage	- Availability of drainage feature plans that illustrate geographic pattern of drainage?	
Additional issues in focus	**What to assess**	**State of play**
e) measures related to pollution reduction and prevention from run-off originating in contaminated sites (e.g. industrial or commercial areas) and constructed infrastructure (e.g. parking, pavements)	- Extent to which USW network and treatment facilities are implemented in: contaminated sites and constructed sites?	
h) availability of qualitative and quantitative data for run-off (i.e. in different areas characterized by different pollutants loads)	- Extent to which USW systems have monitoring program implemented? - Availability of USWM related data for recipient water bodies? - Availability of USWM related data for USW network and treatment facilities, i.e. flow regime control, water quality control? - Availability of USWM related data that estimate effects of regulated storm water beyond traditional pollutants, i.e. changes in stream flow, streambank erosion, and habitat alterations caused by storm water runoff? - Availability of meteorological data needed for design process of USW network and treatment facilities?	

Annex II
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