

EVALUATING OPTIONS FOR WATER SENSITIVE URBAN DESIGN IN THE MEDIJANA MUNICIPALITY

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Summary: *The research presented in the paper deals with the analysis of the natural and man-made conditions available in the General Regulation Plan (GRP) for the territory of the central municipality Medijana in Niš, Serbia. The research result is a preliminary zoning of the studied area from the perspective of application of nine Water Sensitive Urban Design (WSUD) elements. The zoning is performed based on eight constraints for implementation of the individual WSUD elements at the subdivision and allotment scales. The information that is not present in the GRP, but required for the assessment of the natural conditions is obtained and studied from the other available data sources. The result of the research may serve as a guideline for the start of WSUD principles implementation in the urban planning and design process and documents for the local authorities in Serbia.*

Keywords: *WSUD approach, WSUD elements, urban planning and design, General Regulation Plan, Medijana.*

1. INTRODUCTION

The development of integrated stormwater management has started in the 1980s as an answer to the adverse effects of urbanization, industrialization, socio-economic and physical changes in the urban catchments [1]. Initially started in Australia [2], nowadays practiced in the most of the developed countries [3], one of the approaches is known as the Water Sensitive Urban Design (WSUD). It includes measures aimed at surface water and groundwater quality protection, and pluvial flood risk management. The measures contribute to reducing the pressure from the traditional stormwater systems, both in terms of pollution loads and flow volumes. The WSUD elements alone or combined in a 'treatment train' are integrated in the urban environment through the urban planning and design activities on the local level.

Institutional implementation of WSUD approach in Serbia is limited due to the lack of an established planning framework, procedures and standards. In order to encourage

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WSUD implementation in the Serbian cities, we aim to highlight the possibilities of WSUD measures implementation for a diverse range of WSUD elements at the subdivision and allotment scales in the case of Medijana, a central municipality of the City of Niš. The WSUD elements implemented in this paper are based upon the WSUD Technical Guidelines [4], while the possibility of their application is evaluated with respect to the specific local conditions.

2. METHODOLOGY

Table 1 lists nine WSUD elements and the constraints that we use to assess their feasibility for implementation .

Table 1. Site constraints for the WSUD elements [4].

Element label	WSUD element	Constraint label							
		C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8
		Steep site	Shallow bedrock	Low permeability soils	High permeability soils	High water table	High sediment input	Land availability limitation	Hydraulic head loss limitation
E1	Vegetated Swales	c	m	✓	✓	m	m	c	✓
E2	Vegetated Filter Stripes	c	m	✓	✓	m	m	c	✓
E3	Sand filters	m	m	✓	m	c	c	m	c
E4	Bioretention Systems	c	m	✓	m	c	c	c	c
E5	Permeable Pavements (infiltration)	c	c	c	✓	c	c	c	c
E5	Permeable Pavements (detention)	c	m	✓	m	c	c	c	c
E6	Infiltration trenches	c	c	c	✓	c	c	m	c
E7	Infiltration basins	c	c	c	✓	c	c	c	✓
E8	Rainwater Tanks	✓	✓	✓	✓	✓	✓	c	✓
E9	Landscape Developments	✓	m	✓	✓	m	m	c	✓

Key: c- constraint may preclude the use of this WSUD; m- constraint may be overcome with appropriate modification to design; ✓- generally not a constraint.

We use a flexible spatial unit in evaluation of the studied area and perform an analysis at the subdivision and allotment scales grouped across the land use categories of the

Medijana General Regulation Plan (GRP) [5], because this level offers an appropriate background for our study. The grey cells in Table 1 are filled in after the initial assessment of natural conditions in the area. These cells represent constraints that we do not take into consideration for further evaluation due to: 1) constraint absence in the studied area (C-1), 2) the detail site investigation required for the assessment (C-6), and 3) impossibility to deal with the constraint prior to the technical design phase (C-8). We examine the constraints C-2 to C-5 based on data from the Republic Hydrometeorological Service of Serbia (RHSS) groundwater station network [6], and a selection of the geotechnical sampling results. For the definition of the shallow bedrock depth we use 1.8 m, as recommended in [7].

3. RESULTS AND DISCUSSION

Figure 1 shows the GRP Medijana border, the studied part of the GRP, and the main traffic infrastructure. The locations of the soil boreholes (B) and groundwater stations (GWS) are also shown in Figure 1.












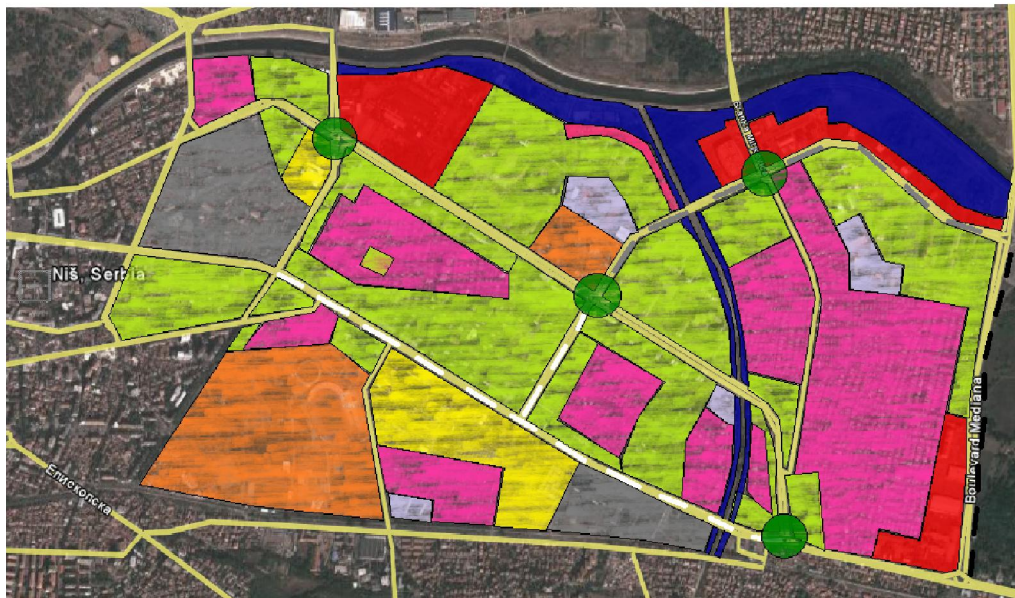
Figure 1. GRP Medijana border [5] (dashed line), the studied part (the inner dashed line), groundwater stations (filled circles) and soil borehole locations (empty circles).

According to the vertical soil profiles found in data for the GWS and soil boreholes, the shallow bedrock is not present in the studied area. Consequently, we exclude constraint (C-2) for the WSUD elements. The typical vertical soil profile in the East and Northeast section of the GRP has low permeable soils approximately 1.5 m in depth, while in the West and Southwest, the upper soil layer of 0.5-1 m is moderately permeable. The applicability of the WSUD elements E5, E6 and E7 is limited in the East and Northeast section of the GRP, according to the constraint C-3. The groundwater table ranges from 2.0 m-2.5 m below terrain at all soil borehole locations. The shallowest level (-1.6 m) is recorded at the GWS7. Therefore, if the other design conditions require the element depth to be greater than 1.6 m, the infiltration trenches and basins (E6 and E7), are not

suitable for the sites by the Nišava River. With these remarks on applicability of the WSUD elements (E5, E6 and E7) in regard to the constraints C-3 and C5, we use the land availability (C-7) as the leading factor for selection of the WSUD elements in the studied area. The range of the WSUD elements available may be applied in the following sub areas, as shown in Figure 2: 1) the streets that have a single or double greenery belts (including Boulevard Nemanjica, Vizantijski Boulevard, Boulevard Mediana, and Sremska Street), and roundabouts; 2) publicly owned land (riverfront of the Nišava River, the Cair park, the Sveti Sava park, Healthcare Facilities, Schoolyards etc.); 3) residential developments (Krive Livade and Duvanište multi-storey housing areas, Duvanište private housing area, and private housing as a part of the Krive livade area); 4) commercial and service developments (Mercator shopping mall, Zona 1, 2 and 3 shopping centers, and Niš-ekspres); 5) driveways / access ways on public or private property (throughout the whole area).

Key to prevailing land use

 Multi-storey housing	 Healthcare facility	 Commercial activity
 Individual housing	 School	 Riverfront
 Mixed housing	 Park and recreation facility	 Roundabout



Key to potential WSUD elements













 E3, E4, E6, E8, E9	 E3, E9	 E3, E8	 E1, E2
 E4, E5, E6, E8, E9	 E8, E9	 E4, E9	 E2, E4
 E3, E4, E5, E6	 E1, E2, E4	 E4, E9	 E3

Figure 2. Zoning of the studied area in respect to the land use and potential WSUD element application as labelled in the Table 1.

We studied the application of the individual WSUD elements, according to the WSUD planning and selection guide in [4]. The zones with prevailing land use are shown in Figure 2, as well as potential the WSUD elements:

E1) Vegetated Swales. The most applicable in the existing parks, and along median stripes, E1 can also substitute kerb and gutters along the Mediana Boulevard.

E2) Vegetated Filter Stripes. We use E2 in conjunction with E1, E4, E6 and E7.

E3) Sand filters. Aimed for high density housing areas (in Krive livade and Duvanište), service stations (along Vizantijski Boulevard, Niš-ekspres), and healthcare facility.

E4) Bioretention Systems. The larger scale devices are appropriate for streetscapes with side planter boxes (including Boulevard Zorana Djindjica, Branka Krsmanovica Street, Sremska Street, Blagoja Parovića Street, including roundabouts), large open spaces (Parks: Čair and Sveti Sava, Nišava riverfront, and open spaces in multi-storey housing blocks). On the small scale, systems are appropriate at the level of individual lots (‘rain gardens’).

E5) Permeable Pavements. Due to suitability on small scale, E5 is identified as suitable for small car parks, paving within individual housing areas and low traffic streets. E6) Infiltration Trenches. E6 may be combined with E5 in the small scale car parks, in the areas where C-3 and C-5 do not apply. E7) Infiltration Basins. We cannot recommend the element without detailed site evaluation due to C-3 and C-5.

E8) Rainwater tanks. E8 is appropriate for all residential and commercial areas with appropriate roofing materials (excluding asbestos, copper, lead, or tar based painted roofs). E9) Landscape Developments. E9 is appropriate for retrofitting existing landscape areas within existing residential, commercial areas, parks and open spaces. It should be limited to small scale features, due to local climate conditions.

The suggested elements would lead to more attractive streetscapes, open spaces and sustainable urban landscapes.

4. CONCLUSION

The evaluation of the WSUD approach in the case of the Medijana municipality in the city of Niš is undertaken to promote new urban planning and design approach which would integrate best practice of stormwater management in the early phase of planning process. The study has revealed that the WSUD approach implementation requires a deeper analysis of the specific natural conditions (climate, geology and soil, groundwater) on one side, and social, economic and urban conditions on the other. The former requires engagement of the engineers and an investigation program, while the latter needs less resources, since majority is analysed and already present in the GRP. Consequently, further action towards the implementation of WSUD approach would require two parallel activities: 1) Hydrologic, hydraulic, and pollutant study of the local conditions, and 2) Study of the legal framework and institutional capacity requirements for the key stakeholders included in the process, including an opinion survey of the private property owners.

Our local government declare the commitment to sustainable water management, water conservation, surface water quality improvement, ground water protection, etc. This requires a range of new solutions at both the institutional and planning level in Serbia. As a principle, all urban plans and documents at the local level should include the water saving projects with stormwater treatment measures and vice versa. Since the WSUD approach is a novelty for the urban planning practice in Serbia, the first step might be a preparation of the WSUD Guidelines with defined legislation and policy framework for a pilot city, which would provide the WSUD approach the tools and resources necessary to deliver the sustainability goals to the ground.

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МОГУЋНОСТИ ПРИМЕНЕ WSUD ПРИСТУПА НА ПРИМЕРУ ОПШТИНЕ МЕДИЈАНА

Резиме: У оквиру овог истраживања су анализирани природни и створени услови обухваћени Планом генералне регулације (ПГР) подручја централне градске

општине Медијана у Нишу, Србија. Резултат истраживања представља прелиминарно зонирање изучаваног подручја са становишта могућности примене девет карактеристичних WSUD (Water Sensitive Urban Design) елемената. Зонирање је обављено поштовањем осам ограничења за примену појединачних WSUD елемената на нивоу блокова и мањих просторно-функционалних целина. Подлоге које нису део ПГР-а а тичу се ограничења у погледу природних чинилаца и потребне су за разматрање, надокнађене су информацијама добијеним из других расположивих извора. Добијени резултати могу послужити јединицама локалне самоуправе као смернице за уградњу WSUD приступа у процес урбанистичког планирања и пројектовања у нашим условима.

Кључне речи: *WSUD приступ, WSUD елементи, урбанистичко планирање, ПГР Медијана.*