European Commission

NWRM

Natural Water Retention Measures

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Service contract n°07.0330/2013/659147/SER/ENV.C1

Case Study

Fornebu

Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID	*Norway_01*			
Application Name	**Fornebu**			
Application Location	Country:	Norway	Country 2:	
	NUTS2 Code			
	River Basin District Code			
	WFD Water Body Code			
	Description		*Fornebu is a 340 ha brownfield redevelopment of the old Olso airport*	
Application Site Coordinates	Latitude: 59 54 7 WGS84		Longitude: *10 37 45 WGS 84*	
Target Sector(s)	Primary:	Urban		
Implemented NWRM(s)	Measure #1:	*U3 Permeable surfaces*		
	Measure #2:	*U4,6 Swales and Filter strips*		
	Measure #3:	*U10 Detention Basins*		
	Measure #4:	*U11 Retention ponds*		
Application short description	Fornebu is a brownfield development project with a focus on sustainable stormwater management and green infrastructure.			

II. Policy context and design targets

Brief description of the problem to be tackled	*The old Oslo airport at Fornebu was a brownfield site in need of redevelopment. The urban planning challenge was to redevelop the site in a sustainable manner supporting both residential and industrial uses while encouraging environmental responsibility*			
What were the primary & secondary targets when designing this application?	Primary target #1:	Regulation of hydrological cycle and water flow		
	Primary target #2:	Flood control and flood risk mitigation		
	Secondary target #1:	Self-regulation of water by filtration / storage / accumulation by ecosystems		
	Secondary target #2:	Natural assimilation (purification) of effluents through dilution, dispersion, and physic-chemical processes		
	Remarks			
Which specific types of pressures did you aim at mitigating?	Pressure #1:	Other non EU-Directive (specify)	*Norwegian government commitment to environmental sustainability*	
	Remarks			
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	Other non EU-Directive (specify)	*1.3 Storm Overflows*	
	Impact #2:	Other non EU-Directive (specify)	*Community (sustainable built environment)*	
	Remarks	The Fornebu development was motivated primarily by national as opposed to European priorities.		
Which EU requirements and EU Directives were aimed at being	Requirement #1:			

addressed?	Remarks
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	The Fornebu project in a national-level initiative aimed at restoring a brownfield site and providing a sustainable multi-use built environment centred around sustainable urban drainage systems and other green infrastructure.

III. Site characteristics

Dominant Land Use type(s)	Dominant land use	*124*
	Secondary land use	*121*
	Other important land use	*111*
	The old airport has been converted to a mixture of residential and industrial land use with a focus on green space and natural storm water management.	
Climate zone	cool temperate moist	
Soil type	*Very little natural soil remained as a result of the old airport at Fornebu; more than 200,000 cubic metres of contaminated soil have been removed.*	
Average Slope	nearly level (0-1%)	
Mean Annual Rainfall	600 - 900 mm	
Mean Annual Runoff	300 - 450 mm	
Average Runoff coefficient (or % imperviousness on site)	0.5 - 0.7	40 - 60%
	Remarks	
Characterization of water quality status (prior to the implementation of the NWRMs)	*Water quality was degraded prior to brownfield redevelopment. There is significant local pollution related to the old airport. Pollutants include oil, PAHs, heavy metals and de-icing chemicals.*	
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	*Positive way:* Access to funds for implementation did not seem to be a problem at this site.	
	Negative way: Multiple levels of government made it challenging to start project implementation.	

IV. Design & implementation parameters

Project scale	Large (e.g. watershed, city, entire water system)	*Fornebu is a 340 ha brownfield redevelopment*
Time frame	Date of installation/construction (MM.YYYY)	*Started 2002, planned completion 2015*
	Expected average lifespan (life expectancy) of the application in years	Unknown/not specified
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1.Statsbygg (Norwegian Directorate of Public Construction and Property)	Land owner with primary responsibility for design and implementation of brownfield redevelopment.
	2.City of Oslo	Secondary land owner
	3.Municipality of Baerun	Municipality, typically responsible for infrastructure and green space
The application was initiated and financed by	The application was initiated and financed by Statsbygg	
What were specific principles that were followed in the design of this application?	Environmental responsibility and a need to balance competing demands were the key guiding principles behind the redevelopment plan. The plan was to develop a functional, multi-use urban area with recreational, residential and industrial areas. The development had to be acceptable to the general Norwegian public as well as area residents and administrators.	
Area (ha)	Number of hectares treated by the NWRM(s).	*340*
	"Treated areas" do not have a clearly interpretable meaning for the Fornebu case study as the NWRM and other green infrastructure are part of an overall development plan for the whole 340 ha site.	
Design capacity	The systems were designed based on flows expected with a 1 year return period for channels and a 20 year return period for detention ponds. The average runoff was based on estimates of daily summer rainfall between 1957 and 1995. The wet ponds had design criteria of 230 m^3 per effective hectare.	

Reference to existing engineering standards, guidelines and manuals that have been used during the design phase	*Reference*	*URL*
	1.	
	2.	
	3.	
	4.	
	5.	

Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?	The availability of the entire brownfield site for redevelopment greatly simplified the development of a master plan incorporating sustainable urban drainage features. While there were challenges with communication between different levels of government, these were resolved. The Statsbygg commitment to sustainable urban environments and substantial financial investment allowed this project to be implemented.

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below: ⇩	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control	*The entire Fornebu master plan had a goal of runoff attenuation and control. The channels are designed to deal with flows of 1.25 $m^3 s^{-1}$ while the detention ponds are designed to handle a flow of 2.75 $m^3 s^{-1}$*		
Peak flow rate reduction	*Reductions in peak flow rates can be expected so long as design criteria are not exceeded and that all water storage features are not full. Thus, the NWRM at Fornebu can be expected to reduce peak flow rates for small to medium size storms.*		Large qualitative improvement
Impact on groundwater			
Impact on soil moisture and soil storage capacity	*Extensive use of swales and soakaways will lead to improvements in soil moisture status and soil storage capacity compared to traditional impervious urban features. It is hard to make a "before / after" comparison in this case as the data do not exist and the change in land use is too large.*		
Restoring hydraulic connection	*The new Fornebu will have much better hydraulic connectivity compared to the old airport.*		*Large qualitative improvement*
Water quality Improvements	*Overall water quality is expected to improve over and above baseline conditions. Ponds are designed to remove 70-90% of suspended solids, 55-65% of total phosphorus, a maximum of 40% of total nitrogen, 45% of zinc and 65% of copper.*	*% removal*	*SS 70-90%* *Total P 55-65%* *Total N 40%* *Zn 45%* *Cu 65%*
WFD Ecological Status and objectives			
Reducing flood risks (Floods Directive)			
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	*There is no mention in the available literature of other European Directives as guiding documents in the Fornebu project.*		
Soil Quality Improvements	*Overall soil quality in Fornebu has been improved, primarily due to the removal of approximately 200,000 m^3 of*		

	contaminated soil .This improvement is not related to green infrastructure, but to brownfield remediation.		
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	The direct societal benefits of the brownfield regeneration at Fornebu include more living space in Oslo and a more sustainable urban environment.		
Financial costs	***Total:***		*Unknown / Not specified*
	Capital:		
	Land acquisition and value:		*Presumably minimal as land was already owned by Statsbygg*
	Operational:		*Unknown / Not available*
	Maintenance:		*Unknown / Not available*
	Other:		*Unknown / Not available*
Were financial compensations required? What amount?	*Was financial compensation required: No*		
	Total amount of money paid (in €):		
	Compensation schema:		
	Comments / Remarks:		
Economic costs	*Actual income loss: Unknown / Not available*		
	Additional costs: Unknown / Not available		
	Other opportunity costs: Unknown / Not available		
	Comments / Remarks:		
Which link can be made to the ecosystem services approach?	A key focus of the Fornebu project is the amenity value of green infrastructure for sustainable stormwater management. The greenspace in Fornebu offers recreational and other amenity values. Water-related ecosystem services include flood protection and security, wastewater services and improved coastal status due to a reduction in polluted runoff.		

VII. Monitoring & maintenance requirements

Monitoring requirements	The Fornebu project is still in the implementation stage. Monitoring requirements could not be determined from the available literature.
Maintenance requirements	A similar level of maintenance as is needed for similar green infrastructure in other cities will be needed.
What are the administrative costs?	Unknown / Not available

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	Assessment criteria are based mostly on engineering design criteria and expected benefits estimated from

	modeling.
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	Unknown / Not available
How cost-effective are NWRM's compared to "traditional / structural" measures?	Unknown / Not available
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	Fornebu, like most of northern Europe, experiences freezing conditions throughout the winter months. Adapting Green Infrastructure and urban NWRM to deal with ice and snow is an ongoing challenge.
What is the standard time delay for measuring the effects of the measures?	*n/a*

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Achieving god communication between the different actors and levels of government was one of the key challenges in implementing the Fornebu project.
What were the main enabling and success factors?	The main enabling and success factors are related to the commitment of Statsbygg, to a sustainable, multi-use redevelopment of the Fornebu brownfield so as to support recreational, residential and industrial land use.
Financing	There is not a lot of documentation available about financing, however, it appears that most of it came from the Norwegian government or other state agencies.
Flexibility & Adaptability	It is unclear how flexible or adaptable Fornebu is to changing baseline conditions. Climate change may have both negative and positive effects. Warmer temperatures would reduce the problems associated with snow and ice. Changing precipitation patterns could alter the effectiveness of the Green Infrastructure for stormwater management.
Transferability	Fornebu provides a model for brownfield redevelopment and shows that sustainable urban drainage systems can be integrated into a multi-functional urban landscape.

X. Lessons learned

Key lessons	The Fornebu project showed that brownfields can be successfully re-developed as sustainable multi-function urban areas supporting a range of recreational, residential and industrial land uses.

XI. References

Source Type	*Scientific Article*		
Source Author(s)	Svein Ols Åstebol. Thorkild Hvitved-Jcobsen, Øyvind Simonsen		
Source Title	Sustainable stormwater management at Fornebu – from an airport to an industrial and residential area of the city of Oslo, Norway		
Year of publication	2004		
Editor/Publisher	Science of the Total Environment 334-335 239-249		
Source Weblink			
Key People		*Name / affiliation*	*Contact details*
	1.		
	2.		
	3.		
	4.		