INTEGRATED THINKING TO IMPROVE STORMWATER MANAGEMENT

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ABSTRACT

Urban catchment management has traditionally focused on the design and construction of infrastructure to reduce risks of flooding and provide basic water quality treatment. This approach has not only discouraged community involvement, but has also overlooked many opportunities to implement water-sensitive urban design to reduce impacts on the natural water cycle and help restore and enhance natural ecosystems within our towns and cities. To realise these more sustainable solutions, planners must look beyond their current models and give greater attention to multi-functional land use and environmental sustainability. It is proposed that catchments and development areas be delineated into ecosystem units to assess the potential environmental pressures within and between these units likely to follow land-use change. This knowledge can facilitate improved management of the location and design of urban developments, and the integration of urban design and stormwater management to enhance both the aesthetic and amenity value of the urban landscape, and the preservation of aquatic ecosystems.

Our ecosystem-based approach, focused on Environmentally Sensitive Area (ESA) mapping, has been employed at the 1:25 000-scale to provide a planning and modeling framework for Waitakere City’s Northern Strategic Growth Area (NOSGA). This 2200-ha study area, which may be significantly urbanised over the next 50 years, drains into the ecologically sensitive estuarine environments of the Upper Waitemata Harbour. The resulting map of ecological units and the associated management guidelines provide a basis for investigating development options, building stakeholders awareness of environmental issues and their impacts on development opportunities, and facilitating a more integrated approach to catchment management.

KEYWORDS

urban, stormwater, environmental sensitive areas, catchment management, ecosystems

1 INTRODUCTION

Sprawling residential suburbs comprising low to medium density single-unit housing characterize New Zealand’s urban landscape, and especially that of Auckland. This form of urban land cover comprises extensive areas of impervious surface and stormwater drainage systems that result in increased volumes of runoff, elevated peak flows, less sustained base flows (Herald, 2003), and increased channel erosion and sedimentation (Bledsoe and Watson, 2002). To cope with the increased storm flows and to reduce bank erosion, urban streams are often lined or piped to increase their hydraulic efficiency. These practices substantially modify the natural water cycle and result in widespread degradation of aquatic ecosystems within our urban environments.

However, there is now an international move towards Water Sensitive Urban Design (WSUD) that seeks not only to reduce impacts on the natural water cycle, but also to manage stormwater as a valued resource (Wong, 2001). The concept of WSUD is based on incorporating multiple stormwater management objectives into development plans with stormwater infrastructure not only reducing the risk of flooding and providing water treatment, but also providing aesthetic and amenity value to the urban landscape. To achieve these goals urban planners need to look beyond their current models and give greater attention to multi-functional land use, and environmental sustainability. Planners must adopt truly integrated approaches that are not discipline or function based, as is currently practised. Roading, water and drainage engineers must work together with urban and environmental planners to understand better the interrelationships between their respective fields of expertise. In other words, these practitioners must adopt an ecosystem-based approach to urban design that will ensure each component of the urban environment complements and supports the sustainability of the entire system. To bring these practitioners together von Haaren (2002) proposes the development of goals that promote cooperation, not
in the form of a rigid predetermined guideline, but rather as a system of “mandatory goals” specified for areas where the environment has an especially high value or vulnerability, and “desirable goals” where alternate objectives can be explored.

Environmentally sensitive area (ESA) mapping (Bastedo et al., 1984) provides an ecosystem-based framework for developing the “mandatory” and “desirable” guidelines proposed by von Haaren (2002), as well as providing a focus for communication with stakeholders and the community at large. The technique involves multidisciplinary analysis of landscape sensitivities, and involvement of local communities to establish values and priorities leading to the development of planning guidelines for sustainable land management. Following a demonstration of this technique by Professors Hans Schreier, of the University of British Columbia’s Institute for Resources and Environment, it was decided to trial the technique by creating an ESA map for the Northern Strategic Growth Area (NOSGA) of Waitakere City. The NOSGA represents the last major green fields development area in the city. This paper reports on work to date in this trial and its application to stormwater management.

2 ENVIRONMENTALLY SENSITIVE AREA MAPPING

The main objective of ESA mapping is to facilitate proactive land use and catchment planning through delineation of land units determined by their environmental value and vulnerability to development for which management, development and protection guidelines are developed. The environmental value and vulnerability of land units to development is termed their sensitivity. Sensitive areas may be those at risk of degradation by development such as streams, wetlands and undisturbed natural areas with high species diversity, or they may be areas where natural hazards such as flooding or land instability directly constrain land development.

Land or ESA units in a landscape are delineated according to their biotic, abiotic and cultural make-up. Respective biotic, abiotic and cultural components are scored according to their perceived sensitivity through consultation with stakeholders. A set of “mandatory” and “desirable” guidelines for the management, development and protection of these units is also developed through consultation. These guidelines must take into account the environmental value and vulnerability of the respective land unit and its vulnerability from, and impact on, other units within the larger environment. Typically, the discrete ecological units are then categorized into three ESA classes according to their environmental sensitivity. These classes represent: those areas where mandatory rules stipulate no development; areas where alternate development options may be considered under strict regulatory control; and those where less rigid planning controls are required. The key to successful application of this ecosystem-based approach to land management is that the interactions between, as well as within, ecological units are fully considered. Through this approach, areas suitable for different forms of land development and stormwater management are identified and their impacts on other environmentally sensitive ecosystem units foreseen. This ESA approach to land management can facilitate truly integrated urban planning.

Development of an ESA assessment comprises a number of steps.

- consulting with stakeholders to determine the sensitivities of most concern;
- assembling spatial datasets for key abiotic, biotic, and cultural factors used to delineate environmentally sensitive units;
- prioritizing environmental units in terms of their environmental importance or constraint to development;
- developing mandatory and desirable management guidelines for each environmentally sensitive unit.

GIS technologies lend themselves to the compilation of ESA maps and associated databases.

| Table 1 | Factors underlying assessment of environmental sensitivity. |
Abiotic | Biotic | Cultural
---|---|---
Size, shape | Productivity | Historic uniqueness or significance
Geological hazard potential/terrace sensitivity | Ecological importance or function | Aesthetic value or intrinsic appeal
Geographic position/adjacency | Faunal habitat dependence | Cultural significance
Fragility/vulnerability | Connectivity | Public health and safety
Typicalness, representativeness | Diversity | Educational value
Naturalness | | Scientific value

3 WAITAKERE CITY NORTHERN STRATEGIC GROWTH AREA (NOSGA)

The Hobsonville-Whenuapai area (Northern Strategic Growth Area), in northeastern Waitakere City (Figure 1) is 2200 ha in area and mainly comprises flat to rolling land with minimal steeper areas, apart from the coastal edge and banks along inland waterways. The three main catchments comprise grassed channels in their headwaters leading into incised gully areas with variable amounts of native and exotic vegetation on the stream banks, giving way to mangroves and ecologically sensitive estuarine environments at the stream outfalls. The Upper Waitemata Harbour is a largely enclosed water body with limited tidal flushing.

While the existing land use is primarily pastoral farming, horticulture and lifestyle blocks, there are two significant areas of development associated with the Hobsonville and Whenuapai air bases. The first of these is to be decommissioned, while the future of the second is presently uncertain.

Higher hills and ridges are underlain by moderately hard Miocene age Waitemata Group sandstones, siltstones and mudstones (Kermode, 1986). The flat terraces and flat to undulating relict terraces comprise Quaternary alluvial silts, clays and sands derived from the surrounding hills, with some organic rich lenses. Soft alluvial silts and clays occupy floodplain areas. A significant area of peat occurs within Whenuapai airbase.

Soils within the NOSGA are mostly poorly draining clayey soils, although comparatively well-drained, tephradervied soils with high water-holding capacities exist within the terrace and lowland areas (Jessen, 1983). These are not only the better soils for agricultural production, but may also provide opportunities for on-site storm water management under urban land uses.

Groundwater resources within the NOSGA are locally important, but in general both the Waitemata Group sediments and the overlying alluvial sediments have relatively low transmissivities. Recharge is believed to occur primarily in the areas where Waitemata Group is exposed, in the upper catchment (ARC, 1995). Geotechnical constraints to urban development centre mainly on shallow land sliding in the vicinity of streams, and coastal land instability (Tonkin & Taylor, 2001b). Some areas, such as uncontrolled landfills, scrap yards, service stations, and parts of the airbases, are undoubtedly contaminated. The wide variety of land uses present in the NOSGA suggests various types of potential site contamination, ranging from petroleum hydrocarbons, to solvents, pesticides and faecal contamination (Tonkin & Taylor, 2001a).

The primary ecological values of the area centre on the coastal environment, including remnant indigenous bush, mangroves, and salt marshes of regional and national significance. A significant wetland occurs in the lower Waiaorohia catchment, and a wetland mosaic exists in the upper Totara catchment (Kingett Mitchell, 2001). Waitakere City Council has already identified Managed Natural Areas with high native biodiversity, and Restoration Natural Areas, which have less significant indigenous populations, but the potential for rehabilitation. Native fish still inhabit many of the streams (Moore, 2002), despite the degradation of riparian
margins and adjacent land uses. Apart from the coastal margins, landscape values within the NOSGA are generally not high when compared with regional or national norms (Brown, 2001).

4 DEVELOPMENT ISSUES

The NOSGA has the potential to accommodate 40 000 people, within the next 50 years, although regional policy-makers intend that 70% of population growth in this period will be accommodated within existing urban areas. Because of the sensitivity of the Upper Waitemata Harbour ecosystem, it is essential that future development consider the long-term health of both the marine and onshore environments. Over the past two decades the local marine environment has become increasingly affected by urban development, especially the increased sediment loads from poorly managed construction sites, and heavy metals and hydrocarbons associated with road runoff (Vant et al., 1993).

A proposed new motorway that traverses the southern portion of the NOSGA is a major driver of future development. Currently, the NOSGA is immediately outside the Auckland Metropolitan Urban Limit. Construction of the motorway is causing re-examination of the optimal location for this boundary. Despite the urgency for planning this motorway extension, the 50-year time frame for development of the NOSGA has been seen by Waitakere City as an opportunity to develop innovative environmental management and catchment rehabilitation strategies that assure the future of the Harbour and create healthy terrestrial environments. In particular, the City Council wishes to

- foster and put in place a high-quality vision for the future of the NOSGA;
- build on the special advantages of the peninsula, particularly the character of the foreshore and cliff top environments;
- ensure best practice for urban design;

Figure 1  
Waitakere City’s Northern Strategic Growth Area
• meet community needs for locally based employment, community and cultural facilities, open spaces and access to the foreshore;

• recognise the sensitivity of the Upper Waitemata Harbour and provide sustainable water management based on the principles of the City’s Water Cycle Strategy for sustainable water management.

5 ESA MAP FOR THE NORTHERN STRATEGIC GROWTH AREA

Base data for the ESA map was obtained through a series of consultancies, many of which produced map outputs at 1:25 000 or similar (Table 2).

Table 2 Spatial data used to prepare the ESA map for the NSGA.

<table>
<thead>
<tr>
<th>Abiotic</th>
<th>Biotic</th>
<th>Cultural</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 5-m contours and digital elevation model</td>
<td>• Indigenous ecosystems</td>
<td>• Potentially contaminating land uses</td>
</tr>
<tr>
<td>• Slope</td>
<td>• Significant trees</td>
<td>• Heritage sites</td>
</tr>
<tr>
<td>• Permanent watercourses</td>
<td>• Vegetation classes</td>
<td>• Landscape values</td>
</tr>
<tr>
<td>• Surficial geological materials</td>
<td>• Potential restoration areas</td>
<td>• Landscape sensitivity to development</td>
</tr>
<tr>
<td>• Soils</td>
<td>• Fish species distribution</td>
<td>• Key landscape features</td>
</tr>
<tr>
<td>• 100-yr floodplain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Geotechnical constraints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Orthophotographic coverage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the basis of this information, and considering the generalised ESA assessment factors (Table 1), three ESA classes for the NOSGA were defined as follows:

**ESA Class 1** – those areas of land with the highest ecological values that would be threatened by development, and areas where natural hazards are unavoidable, such as floodplains. These areas are recommended to be excluded from development.

**ESA Class 2** – areas of land that provide actual or potential ecological linkages, low-grade hazards to development, areas with a significant number of important but small features or present opportunities for mitigation of the effects of development. Development can proceed in these sensitive areas, subject to negotiation and documented management recommendations.

**ESA Class 3** – the remaining land not included in Classes 1 or 2. These are areas where urban development would normally be expected to proceed, subject to management recommendations.

Prioritised rules were created (Table 3) to define areas of similar environmental sensitivity within the NOSGA. Each area was rated according to the maximum score, or priority, incurred by applying the entire set of land classification rules. Intersections of each of the rules with rules of lower priority were explored to determine if these intersections should define separate ESA units. No such intersections were found to be significant. The final ESA map of c. 200 polygons (Figures 2 and 3) was prepared by eliminating small polygons, and manually altering some boundaries to maximise simplicity, acknowledging uncertainties in boundaries in the underlying maps. We overlaid point data, including heritage sites, and designated trees, but the spatial incidence of these sites did not justify delineating separate ESA polygons.

A linked MS Access database is being prepared, containing information specific to each polygon, by overlaying the final set of polygon boundaries over each of the constituent data layers. Linked into the GIS, this database
will allow the map to be queried interactively. The database provides a complete abiotic, biotic, and cultural profile for each ESA unit, including ESA number, class type, area and a description of key issues and management guidelines. These guidelines, which take into account sensitivities of adjacent or downstream polygons, include information on the suitability of the polygon for development, stormwater management practices, restoration, and weed control.

<table>
<thead>
<tr>
<th>ESA Class</th>
<th>Rule definition</th>
<th>Score</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Management Status = protected</td>
<td>20</td>
<td>Existing protected natural area</td>
</tr>
<tr>
<td></td>
<td>Vegetation = outstanding, significant</td>
<td>19</td>
<td>Valued indigenous vegetation</td>
</tr>
<tr>
<td></td>
<td>Ecological zone = wetland</td>
<td>18</td>
<td>Scarce wetland habitat</td>
</tr>
<tr>
<td></td>
<td>Floodplain 100 yr = true</td>
<td>17</td>
<td>Long-term flood hazard</td>
</tr>
<tr>
<td></td>
<td>Geotech zone = C</td>
<td>16</td>
<td>Coastal land instability</td>
</tr>
<tr>
<td></td>
<td>District Plan Soil = 4 AND (Geotech zone = B OR Landscape feature = primary) AND (stream order &gt;1 OR stream drains direct to Upper Waitemata Harbour)</td>
<td>15</td>
<td>Principal drainage and ecological corridor</td>
</tr>
<tr>
<td></td>
<td>Ecological zone = mudflat, shellbank</td>
<td>14</td>
<td>Sedimentation area</td>
</tr>
<tr>
<td></td>
<td>Ecological zone = mangel</td>
<td>13</td>
<td>Coastal mangrove</td>
</tr>
</tbody>
</table>

| 2         | Land use = landfill-controlled/uncontrolled, panel beaters, scrap yard, service station, timber yard, vehicle workshop | 12    | Potentially contaminated site |
|           | Peatland | 11    | Peatland |
|           | Rural land use capability class = 4 AND (Geotech zone = B OR Landscape feature = primary) AND stream order =1 AND stream does not drain direct to Upper Waitemata Harbour. | 10    | Secondary drainage and ecological corridor |
|           | Rural land-use capability class = 2 | 9     | Higher value soils |
|           | Vegetation = managed | 8     | Managed vegetation area |
|           | Vegetation = exotic, restoration | 7     | Valued vegetation site |
|           | Landscape value = moderate, moderate-high, high OR landscape sensitivity = high | 6     | High landscape risk |
|           | Revegetation priority = high, moderate | 5     | Revegetation area for ecological connectivity |

| 3         | Landscape value = low, low-modern AND landscape sensitivity = moderate, moderate/high | 4     | Moderate landscape risk |
|           | Topographic feature/high point = true | 3     | Topographic feature |
|           | Secondary/potential feature & linkage area | 2     | Secondary feature or linkage |
|           | Landscape value = low, low-modern AND landscape sensitivity = low, low-moderate | 1     | Low landscape risk |

6 ESA MAPPING AND STORMWATER MANAGEMENT

The concept of water-sensitive urban design (WSUD) seeks to reduce the impact of development on the natural water cycle by managing stormwater as a valued resource, and by integrating good stormwater management
practices and urban design to protect the health of aquatic ecosystems (Wong, 2001). As an initial stage in this process, development of an ESA map provides a basis for clarifying and communicating many of the issues that will determine the location and form of appropriate land development, the performance criteria of stormwater management practices and the availability of natural ecosystem services important when integrating stormwater management and urban design.

The NOSGA ESA condenses many layers of relevant data into a single map, easily understood and accessible to planners, policy makers and the wider community. For example, areas of high-value aquatic habitat are identified in terms of their species composition, location and sensitivity as well as their relationship with other components of the landscape. It is therefore possible to link ecosystem units or components of the landscape in terms of their hydrological function and habitat requirements to ensure they are not impacted by modifications to the natural water cycle. Areas of opportunity, such as soils suitable for managing stormwater through infiltration have been delineated, as have areas where development should be restricted due to unstable slopes and natural flooding. Planning goals and associated priorities can now be developed that will determine both the location and form of land development. Performance specifications in terms of stormwater management practices can be developed to ensure protection and enhancement of aquatic ecosystems. For example, areas of highly valued vegetation, riparian corridors and unstable slopes may be defined as areas of no development, while less sensitive areas and those where development is likely to impact on highly sensitive ecosystem units may be zoned for development under strict development controls. Other areas of low sensitivity unlikely to impact on more sensitive areas may be zoned for development under less stringent controls, but still adhering to the overall goal of WSUD. Having collapsed all relevant information into a single system, with a clear set of prioritised goals, it is then possible to implement WSUD more clearly. Decisions on best management practices with regard both to the location, form and function of land development, and to stormwater management can be integrated to reduce impacts on the natural water cycle and ensure sustainability of urban aquatic ecosystems.

![Figure 2](image-url)  
**Figure 2** ESA units of Waitakere City’s the Northern Strategic Growth Area
7 CONCLUSION

Urban planners need to move away from traditional development models and implement water-sensitive urban design concepts that integrate urban design and stormwater management. This would not only enhance the aesthetics and amenity value of the urban landscape, but also preserve the health of aquatic ecosystems. To realise this goal it is important to adopt an ecosystems approach to land management whereby the interactions within and between ecosystem units are fully considered during the planning process. ESA mapping and analysis is being trialled as a tool to achieve this goal for the NOSGA of Waitakere City. The ESA map delineates and classifies ecosystem units according to their environmental sensitivities and has provided a basis for developing planning goals for the NOSGA. The ESA assessment collapses many layers of relevant data into a single map that has provided a focus for planners and engineers to gain a common understanding of development issues and likely impacts on the environment. Although the ESA methodology is most often applied to green field situations, it should also prove a valuable tool for planning areas of urban renewal.

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