WATER SENSITIVE DESIGN ASSESSMENT TOOL - A METHOD TO ATTAIN SUSTAINABLE DEVELOPMENT

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ABSTRACT

A new design tool has been developed that allows land developers to test proposed development form against principles of Water Sensitive Design (WSD). The new tool, called the 'WSD Assessment Tool', achieves sustainable development by enabling the development team to best practicably synthesize WSD principles for a proposed development.

The tool requires the user to enter a number of quantitative and qualitative attributes of the predevelopment and proposed development scenarios. The user can then test the proposed development against up to seven available site objectives. Site objectives have been derived in association with the latest WSD principles developed for Auckland Council's forthcoming Guideline Document 04. Outcomes from the tool are as 'Blue Stars' which indicate the degree of WSD inclusion and as output statements to the user. These statements detail the extent which the proposed development scenario achieves the queried site objective. If the proposed development does not achieve the site objective (less than three blue stars), the tool provides advice on how the proposed development may be improved.

This paper discusses the development of the WSD Assessment Tool. Information is also provided on the mechanics of how the tool operates, and how outcomes produced from the tool can be interpreted to enable improved inclusion of WSD principles within development form.

KEYWORDS

Water Sensitive Design, Land Development Assessment, Auckland Design Manual, WSD Assessment Tool, Land development, Low Impact Design.

PRESENTER PROFILE

Hayden is an Environmental Services Leader with Pattle Delamore Partners Ltd. With approximately 12 years of experience, he has extensive knowledge in the following fields; Stormwater quantity and quality management, flood assessment and management, Integrated Catchment Management Planning, Water Sensitive Design, and environmental monitoring.

1 INTRODUCTION

The Auckland Council has provided clear direction within the Proposed Auckland Unitary Plan that new urban development, and where appropriate, when intensification or redevelopment occurs within brownfield development, water sensitive design (WSD) principles are to be adopted (Auckland Council, 2013a).

With this new direction, appropriate guidance and tools to support land developers and their development teams are required. The Auckland Council have recently drafted the guideline document which is currently at pre-consultation stage and titled 'Water Sensitive Design Manual for the Auckland Region' (GD 04) (Auckland Council, 2014).

To support GD 04, an Excel based tool called the 'Water Sensitive Design Assessment Tool' has been developed. The principal objective of the WSD Assessment Tool is to provide a mechanism to allow developers to assess proposed development scenarios and determine if the principles of WSD have been successfully accommodated within the design. Whilst the WSD Assessment Tool provides an assessment that promotes multifaceted design outcomes, the primary aim of the WSD Assessment Tool is to achieve improved stormwater management outcomes.

The WSD Assessment Tool has been specifically designed for assessing developments 0.5 Ha or greater in size. Both greenfield and brownfield development can be assessed as well as a range of development densities. The specific development types discussed within the WSD Assessment Tool, and an associated WSD Assessment Tool user manual, are:

- Rural — residential (countryside living).
- Suburban development (<30% of dwellings are attached).
- Urban development (30-80% of dwellings are attached).
- Urban core development (>80% of dwellings are attached).

This paper discusses the development, functionality, and use of the WSD Assessment Tool and the associated WSD Assessment Tool user manual.

2 COMPONENTS OF THE WSD ASSESSMENT TOOL

The WSD Assessment Tool is comprised of two viewable Excel spreadsheets, consisting of:

- An input and output section.
- A detailed output report.

2.1 INPUT SECTION

The inputs section of the WSD Assessment Tool is where the user provides specific data that describes or evaluates the proposed development. Input data is divided into five key themes: Site Resources, Impact, Environment, Transport, and Post-development Land use and Treatment. All input fields within the WSD Assessment Tool need to be populated with data.

For the majority of information required by the WSD Assessment Tool, a dropdown menu is provided. These cells are coloured purple. For these cells, the user can select either: 'low', 'medium', 'high', or 'not applicable' for a given site attribute that describes the development. These selections commonly relate to the quantity or consideration of the given site attribute. Guidance regarding what qualifies a 'low', 'medium', 'high' result is provided within the WSD Assessment Tool user manual. This is discussed further in Section 6. For some site attributes, the user may provide either a yes or no answer. If a given site attribute is not applicable for the proposed development the user can select 'not applicable', e.g. if the proposed development does not have a stream.

The user is also required to provide numerical information. These are green cells within the WSD Assessment Tool. Commonly numerical information is used to determine the areas of different land uses found within the development.

To assess how development effects will be managed, the user is required to populate cells with land use details and treatment options data. Choices for these cells are prescribed within dropdown menus provided.

2.2 OUTPUTS SECTION

The output section displays results produced by the WSD Assessment Tool. Results are categorised into the site objectives assessed by the WSD Assessment Tool (discussed in Section 3). Results are presented in two ways:

- As blue star ratings (refer to Section 2.2.1) — a rating of one to six stars, or not applicable.
- As output statements — Statements that includes an output score and provides advice to improve the development design, if required.

Two levels of blue star rating are provided in the output section of the WSD Assessment Tool. These are:

- A single overall blue star rating. This blue star rating is the expected overall achievement that the development would attain in the proposed development form.
- Up to seven site objective blue star ratings.

2.2.1 BLUE STAR RATINGS

The visual rating of one to six blue stars is used to determine the level of integration of WSD principles in a proposed development.

Table 1 presents the differing definitions for each blue star rating.

Blue Star Rating	Definition
★	Non-Compliant. The development requires significant modification to integrate Water Sensitive Design principles.
★★	Partially non-compliant. The development requires minor modification to adequately integrate Water Sensitive Design principles.
★★★	Minimum standard. The development meets minimum standards for integration of Water Sensitive Design principles.
★★★★	Good Practice. The development integrates Water Sensitive Design principles well.
★★★★★	New Zealand Excellence. The development includes excellent integration of Water Sensitive Design principles and is an example of New Zealand excellence in WSD.
★★★★★★	World Leadership. The development includes outstanding integration of Water Sensitive Design principles and is an example of World Leadership in WSD.

Table 1: Blue Star Definitions

A minimum of three blue stars is required by the proposed development scenario to demonstrate adequate integration of WSD principles. Sections 4 and 5 discuss how the WSD Assessment Tool determines the quantity of blue stars that are prescribed to a proposed development scenario.

2.2.2 OUTPUT STATEMENTS

For each of the assessed site objectives, and output score and an output statement is displayed clarifying the blue star rating. If an assessed site objective blue star rating has less than six blue stars, the output statement will include recommendations for the user to consider. Recommendations are not to be regarded as the only means that a user can apply to improve a proposed development, but are given to prompt possible common missed opportunities that have been determined from professional experience obtained by the team who have produced the WSD Assessment Tool.

2.3 DETAILED REPORT

The detailed report allows the user to identify and assess WSD improvements for the proposed development.

The detailed report provides information, such as:

- The blue star ratings and the output statements.
- The result achieved for each individual site attribute.
- The overall result for each site objective.
- The score required to obtain the various blue star ratings.
- What contaminants are generated from the proposed development (Quality site objective) and what portions of the proposed development are deemed unmitigated (Quantity and Quality site objectives).
- What site attributes are given a higher weighting value than others (i.e. what site attributes are deemed as having a greater importance for achieving the given site objective).

By analysing the detail provided by this report, the user can easily identify what site attributes are key to achieving better blue star ratings and adjust the proposed development form to suit. By doing so, the proposed development will also improve the overall consideration of WSD principles within the design of the development.

3 SITE OBJECTIVES

The draft Water Sensitive Design Guideline Document (GD 04) prescribes four key principles for WSD approaches to land use planning and land development. These WSD principles are:

1. Promote inter-disciplinary planning and design.
2. Protect and enhance the values and functions of natural ecosystems.
3. Address stormwater effects as close to source as possible.
4. Mimic natural systems and processes for stormwater management.

These four WSD principles were analysed to develop seven key site objectives that conform to these principles and can alter the form in which land development can occur. These developed site objectives were then broken down further to identify site attributes

which the WSD Assessment Tool then assesses within a proposed development scenario. The seven site objectives used in the WSD Assessment Tool are:

- Water quantity management.
- Water quality management.
- Site resource integration.
- Ecological consideration, which can be further subdivided into:
    - Terrestrial ecology consideration.
    - Aquatic ecology consideration.
- WSD and urban design principle integration.
- WSD and transport orientated development consideration.

A discussion regarding each of the above site objectives is provided in the following sections.

3.1 WATER QUANTITY MANAGEMENT

Land development alters the hydrology of drainage catchments due to the addition of impervious surfaces and the disturbance of permeable areas (e.g. compaction from machinery, vegetation removal etc.). These changes increase the volume and peak flow of stormwater discharges. The WSD Assessment Tool evaluates water quantity management by assessing proposed land uses and water quantity controls provided.

3.2 WATER QUALITY MANAGEMENT

Reduced water quality can create a range of impacts to environmental, social, economic, and cultural outcomes. Land development affects water quality though the introduction of anthropogenic contaminants. Similar to water quantity management, the WSD Assessment Tool evaluates proposed land uses and stormwater management practices. Stormwater management practices available for the mitigation of water quality effects include source control measures (i.e. providing a development design that avoids a contaminant being generated), at-source control measures (which manage water quality effects close to the location which they are generated) and communal treatment facilities.

3.3 SITE RESOURCE INTEGRATION

Land development can allow for the preservation of site resources through:

- The creating of reserves for social enjoyment.
- Utilising stormwater treatment devices (stormwater management areas), or
- Retiring high risk areas (e.g. flood plains, steep erosion-prone soils).

The WSD Assessment Tool assesses site resource preservation by querying specific attributes within the proposed development layout. Attributes such as earthwork requirements and the allowance for and quantity of open space are key measures used.

3.4 TERRESTRIAL ECOLOGY CONSIDERATION

Terrestrial habitats are provided within developments by vegetated spaces, such as bush, forested areas, and general landscaped areas. It is important that a development not only provides vegetated spaces, but allows for a diverse assortment of vegetation types and achieves connectivity of vegetated spaces to areas external to the development. Vegetated spaces when maintained, enhanced or created may achieve the following terrestrial ecology outcomes:

- Ecological corridors for species to move through the wider landscape.

- Habitat and food sources for species within the site itself.
- A source of native seeds that animals or wind can disperse.
- A reduction in invasive weeds and the provision of ecological services on a broader level (i.e. maintenance of terrestrial biodiversity).

The WSD Assessment Tool assesses this site objective by determining the quantity and diversity of vegetated spaces and how they are linked to surrounding landscapes.

3.5 AQUATIC ECOLOGY CONSIDERATION

During land development, aquatic habitats (e.g. streams, lakes, or wetlands) are often retained, created or enhanced to:

- Satisfy regulatory (i.e. consenting) requirements.
- Meet regulations protecting them from modification (i.e. if specifically identified in policy or planning documents).
- Provide amenity value for the final development.
- Protect areas of risk that have been retired from development (i.e. within flood plains).

Improved aquatic ecology may be achieved through the creation, retention and/or enhancement of areas of aquatic habitat through:

- Migratory pathways for aquatic species to move through catchments.
- Habitat and food sources for aquatic species.
- Ecological services on a broader level (i.e. maintenance of aquatic biodiversity).

The WSD Assessment Tool assesses aquatic ecology consideration within a proposed development by querying the quality and quantity of habitats that are required by aquatic organisms. This specifically relates to the quality and connectivity of the waterway present, and the riparian margins.

3.6 WSD AND URBAN DESIGN PRINCIPLE INTEGRATION

Urban design principles are inherently focused towards community and people outcomes, whilst WSD principles are focused towards the protection and enhancement of natural resources. How urban design principles integrate with WSD principles is vital to a development providing the required services to the developments inhabitants and to manage environmental effects. To successfully integrate these two design principles, land development should promote, create and enhance social structure, built form, and environmental relationships within surrounding development and natural site features.

The WSD Assessment Tool determines the successful integration of these two design disciplines by evaluating specific development layout attributes with the aim of avoiding dominance of a single design discipline.

The primary resource for good urban design in the Auckland Region is the Auckland Design Manual (Auckland Council, 2013b). The Auckland Design Manual should be the primary guide for designing a development, with additional guidance contained in the future GD 04 and other documents. Lewis et al (2010) describes the successful integration of the two design disciplines in "The Integration of Low Impact Design, Urban Design, and Urban Form".

3.7 WSD AND TRANSPORT ORIENTATED DEVELOPMENT CONSIDERATION

Transport Orientated Development (TOD) is a land development design approach which

aims to provide growth around one or more transport nodes. TOD typically features compact and mixed-use activities configured around rail stations, interlaced by pedestrian amenities (Cervero and Sullivan, 2010).

Similar to urban design, the WSD Assessment Tool determines if integration of both TOD and WSD principles has been provided for in the proposed development design. Key indicators used by the WSD Assessment Tool to identify successful integration WSD and TOD principles are the inclusion of transport hubs and multimodal transport connectivity within a development, whilst also having regard to natural site features and site resource preservation.

4 SCORING AND WEIGHTING

To minimise the degree of ambiguity that could occur within the WSD Assessment Tool, input data is represented as a quantitative input whenever practicably possible, i.e. as a number or percentage. However, in some instances, qualitative input data can only be used. To enable the WSD Assessment Tool to characterise what value a qualitative input should entail (i.e. what does a 'low, 'medium', or 'high' result mean), and consequently calculate the correct number of blue stars and display the appropriate output statement, scoring and weighting calculations are carried out.

Scoring and weighting involves the assigning of two numbers (each number is between 1 and 5) against relevant site attributes measured within the WSD Assessment Tool.

Scoring is determined by assigning a number against the most optimal outcome, be it 'low', 'medium' or 'high' for a given site attribute. For example for the site attribute 'Vegetation species diversity provided within the post development scenario', a 'high' result is considered to be more favourable than a 'low' result. As such, the 'high' result is assigned a 5, whereas 'low' has been assigned a 1.

Similar to scoring, weighting is defined by analysing all site variables that are assessed for a given site objective and determining which site variable(s) are perceived to be more influential than others at achieving the given site objective.

Whilst scoring is only provided for qualitative site attributes, weighting is provided for all site attributes measured within the WSD Assessment Tool.

By multiplying the score number (that is dependent upon the input data entered by the user) and the weighting number, an output score for the site attribute is obtained. The sum of all output scores, that are associated to a given site objective, is then tested against scoring ranges (discussed in Section 5) to determine how many blue stars are achieved.

Site attributes used in the WSD Assessment Tool may be used in computations for multiple site objectives measured. In such instances, the score number and weighting number may differ between the site objectives measured.

All numbers applied to scorings and weightings within the WSD Assessment Tool were determined via multidisciplinary workshops. During these workshops, disciplines such as, stormwater engineers, planners, urban designers etc. provided feedback on what they believed scores and weighting numbers were for each site attribute. Feedback obtained during these workshops was averaged to provide the resultant scoring and weighting numbers that are applied within the WSD Assessment Tool.

5 SCORING RANGES

Once scores and weighting numbers are multiplied and all relevant output scores for a given site objective are summed, the resultant answer is assessed against scoring ranges.

Scoring ranges are prescribed margins (i.e. X score to Y score) from which the number of blue stars are assigned.

Figure one depicts how scoring ranges are applied within the WSD Assessment Tool.

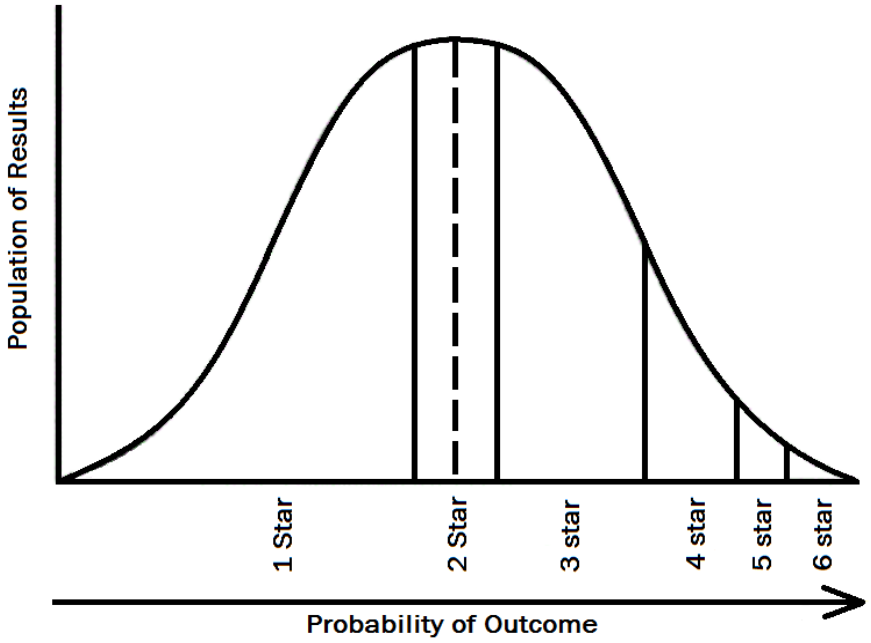

Figure One: Scoring Ranges

The probability of outcome has a negatively skewed distribution for the assignment of blue stars. This is attributed to the WSD Assessment Tool attempting to improve the development form from the current norm.

The assignment of scoring ranges (and calibration of the WSD Assessment Tool) was determined by applying the developed WSD Assessment Tool to a range of existing developments. A total of fifteen developments were specifically chosen for testing. Developments ranged from those considered by the WSD Assessment Tool project team as exemplars for WSD principle integration, to developments which were considered poor examples of WSD principle integration. By applying the required site attributes for the various developments, output scores were obtained from which margins for scoring ranges could then be determined.

It is expected that over time through greater usage of the WSD Assessment Tool, further analysis and refinement of the scoring ranges will be carried out.

6 INPUT SELECTION GUIDANCE

As some input information is based upon the user's personal opinion i.e. qualitative inputs, examples of 'appropriate' input selections are provided within the WSD Assessment Tool user manual.

For each development density assessed by the WSD Assessment Tool, examples of 'low', 'medium', and 'high' achievement are provided for each site attribute. The user compares these examples to their own development scenario to determine the most appropriate value to be inputted into the WSD Assessment Tool. By doing so, it ensures that the inputted information is accurate and consistent between tested development scenarios.

Figure two presents an example of the qualitative input interpretation provided within the WSD Assessment Tool user manual.

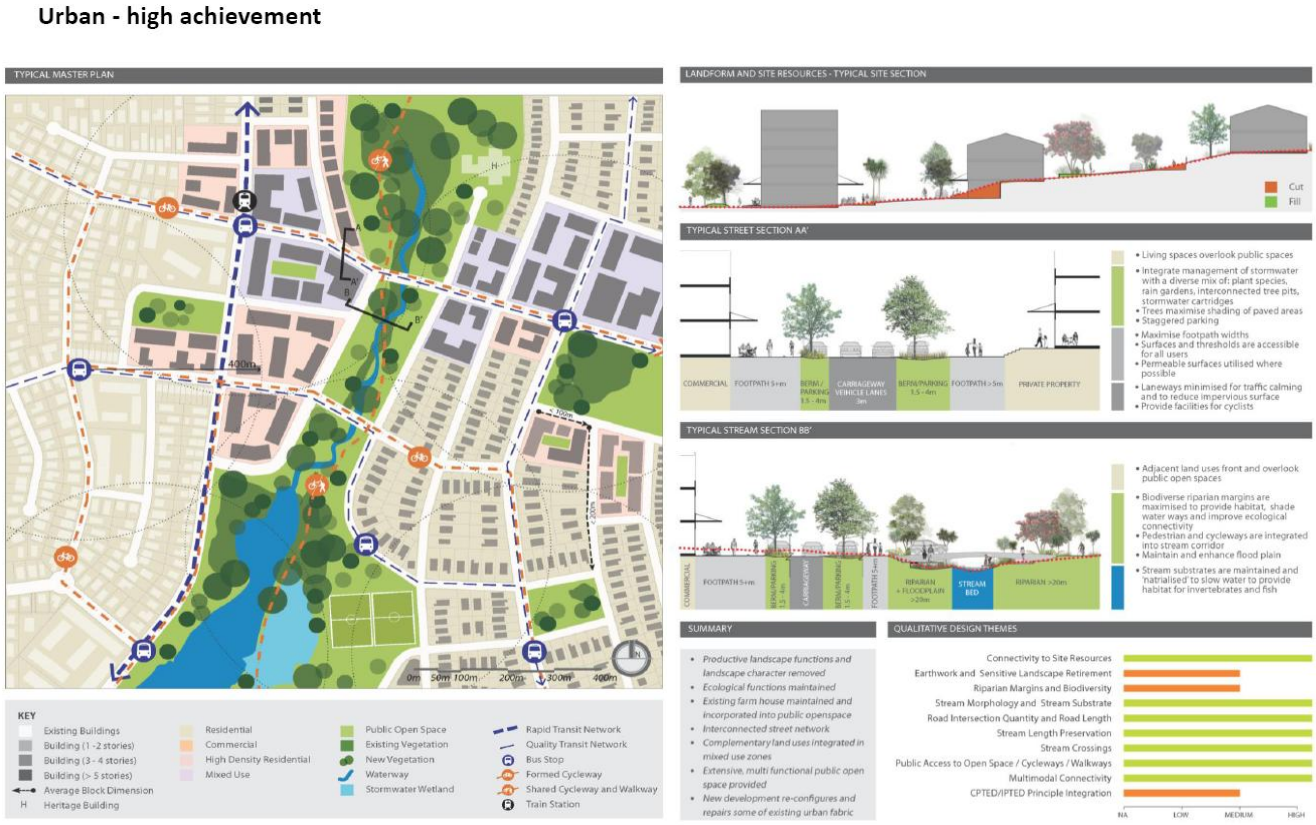

Figure Two: An example of qualitative input interpretation provided in the WSD Assessment Tool user manual.

7 CONCLUSIONS

The WSD Assessment Tool has been developed to assist land developers to test proposed development form against principles of WSD.

The tool comprises of two excel based spreadsheets. An associated user manual has also been developed to inform users on the functionality of the tool and how it is to be correctly used.

The focus of the WSD Assessment Tool is derived through the assessment of WSD principles that are contained within Auckland Council's future guidance document for Water Sensitive Design, GD 04. By providing this tool, it is anticipated that the quantity of land development that successfully integrates WSD principles would increase, thereby facilitating the achievement of related Auckland Unitary plan objectives.

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