Impacts of Climate Change on Urban Infrastructure & the Built Environment

A Toolbox

Tool 4.2: Overview of an Option Screening Tool

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Contents

1. Introduction

1.1 Background

This document gives details one of a number of tools developed to assist Councils, and others, in taking account of long-term climate change effects in their on-going asset development and management, with the broad aim of making urban infrastructure more resilient to climate change effects.

The tool described is embodied within a 'Toolbox' comprising of various reference and guidance documents, and software tools designed to assist in assessing asset development needs and solutions that will lead to more resilient urban infrastructure in the face of increasingly extreme weather events [see Toolbox Overview].

The tool is designed to aid in the screening and short-listing of risk reduction measures prior to a more formal assessment of the short-listed options. It is intended to add structure to a wide ranging consideration of alternatives in a brainstorming context.

To date the tool has been developed to assist in screening risk reduction options or adaptations (collectively referred to simply as "options") in the context of fluvial and marine flood risk, or in the context of landslide risk. However the structure and operation of the tool can be used in a multitude of other contexts, if the requisite content is added.

Illustrations of the use of the tool are taken from a flood risk case study on the Buller River [Keenan, 2011] and a landslide risk study for Karori in Wellington [Oldfield, 2011].

Designing and developing infrastructure to be more resilient to climate change effects does not require fundamentally different solutions, rather designs need to be made taking account of changing climate-related effects. Detrimental climate change effects influence design through increased 'loading' requirements, and add to other uncertainties because the rate and magnitude of the changes in climate are not known with certainty. Increased uncertainty means that making the 'correct' design choice in any particular context is more challenging that it would otherwise be.

1.2 Purpose of Tool

The Options Screening Tool is specifically designed to assist in the identification of plausible risk reduction measures, and the short-listing of these prior to a more formal

assessment of options. Options can also be screened against sustainability and other guiding principles when faced with an uncertain future.

1.3 Obtaining this Tool

Contact the authors of this report for information about obtaining and using this Tool.

2. Overview of the Option Screening Tool

The Option Screening Tool described here operates on a long list of generic measures or adaptation options which may be used, in different contexts, to manage the risks from natural hazards. To date, the software application is limited to flood and landslide risk reduction. However, it is envisaged that the same approach could be applied to other hazards.

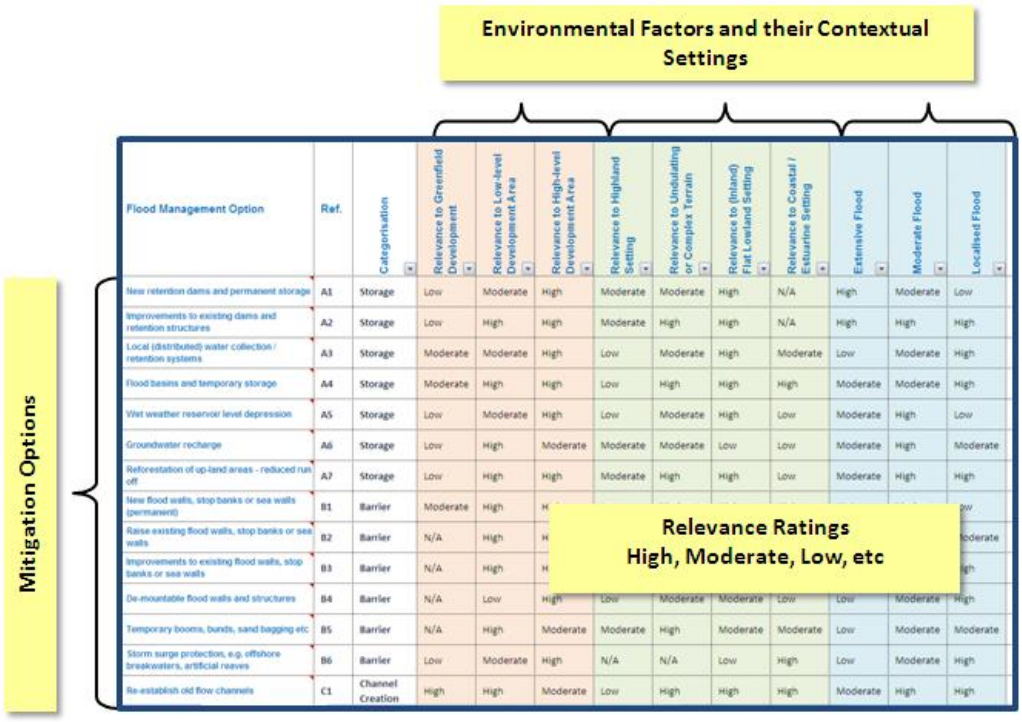
The basic aim of the screening process is to identify the options that are most relevant to the characteristics of the location of interest. In order to achieve this, the alternative adaptation options are given a pre-defined rating in terms of their relevance to a number of different generic location-type characteristics. Location types are characterised by three different 'Environmental Factors', each of which has three or four alternative 'Contextual Settings'. The characteristics of a location are specified by choosing the combination of Contextual Settings for each of the three Environmental Factors that best describe the location.

Screening is performed iteratively by gradually filtering out the options that are rated as least relevant to the chosen Contextual Settings for the location of interest. Options may also be screened against four attributes for a desirable solution, namely – Affordability, Protection Capability, Sustainability and Adaptability. Pre-set ratings, similar to the relevance ratings, are provided for each of the attributes associated with each option. The short-listed options can then be combined, if required, to form schemes. The short-listed options or schemes developed in this way can then be taken forward for further assessment, possibly using one of the other tools in the toolbox [see Tool 4.5, for example].

The Screening Tool is designed to be used by a single user allocated to the task, or in a group brainstorming context. In this report, the tool is presented and illustrated for its application to flood risk mitigation, but the same processes apply in screening and short-listing landslide risk reduction measures.

2.1 Basis of the Screening Process

Central to the screening process is a two-dimensional matrix or table of relevance ratings for each risk reduction option. The generic risk reduction options are listed down the left-hand side of this matrix, and the location 'Contextual Settings' are listed across the top. The relevance ratings within in the matrix, indicate how relevant an options is ("High", "Moderate", etc.) to a particular Contextual Setting, see Figure 2.1.



Flood Management Option	Ref.	Categorisation	Relevance to Greenfield Development	Relevance to Low-level Development Area	Relevance to High-level Development Area	Relevance to Highland Setting	Relevance to Undulating or Complex Terrain	Relevance to (Inland) Flat Lowland Setting	Relevance to Coastal / Estuarine Setting	Extensive Flood	Moderate Flood	Localised Flood
New retention dams and permanent storage	A1	Storage	Low	Moderate	High	Moderate	Moderate	High	N/A	High	Moderate	Low
Improvements to existing dams and retention structures	A2	Storage	Low	High	High	Moderate	High	High	N/A	High	High	High
Local (distributed) water collection / retention systems	A3	Storage	Moderate	Moderate	High	Low	Moderate	High	Moderate	Low	Moderate	High
Flood basins and temporary storage	A4	Storage	Moderate	High	High	Low	High	High	High	Moderate	Moderate	High
Wet weather reservoir level depression	A5	Storage	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low
Groundwater recharge	A6	Storage	Low	High	Moderate	Moderate	Moderate	Low	Low	Moderate	High	Moderate
Reforestation of up-land areas - reduced run off	A7	Storage	Low	High	High	Moderate	High	High	Low	Moderate	High	High
New flood walls, stop banks or sea walls (permanent)	B1	Barrier	Moderate	High	H							ow
Raise existing flood walls, stop banks or sea walls	B2	Barrier	N/A	High	H							oderate
Improvements to existing flood walls, stop banks or sea walls	B3	Barrier	N/A	High	H							gh
De-mountable flood walls and structures	B4	Barrier	N/A	Low	High	Low	Moderate	Moderate	Low	Low	Moderate	High
Temporary booms, bunds, sand bagging etc	B5	Barrier	N/A	High	Moderate	Moderate	High	Moderate	Moderate	Low	Moderate	Moderate
Storm surge protection, e.g. offshore breakwaters, artificial reaves	B6	Barrier	Low	Moderate	High	N/A	N/A	Low	High	Low	Moderate	High
Re-establish old flow channels	C1	Channel Creation	High	High	Moderate	Low	High	High	High	Moderate	High	High

Figure 2.1: Schematic of option screening matrix (top few lines only)

The Environmental Factors and their Contextual Settings represent the dominant characteristics of a location in determining the level of risk involved, for example topography is one of three Contextual Settings used in assessing flood risk reduction options, and slope is one of the three Contextual Settings used for landslides.

Each of the three Environmental Factors has three or four alternative contextual settings[1]. For example, in assessing flood mitigation options, the Environmental Factor "Topography" has contextual settings of "Highland", "Complex", "Flat Lowland" or "Coastal/Estuarine". In assessing landslide options, the Environmental Factor "Slope" has Contextual Settings of "High", "Moderate" or "Low" Slope. The user selects the setting for each of the Contextual Settings that best describes the location of interest.

[1] Further Environmental Factors and/or Contextual Settings can be added to refine the assessment of options, but the appropriate option relevance ratings will need to be supplied

Relevance ratings of "High", "Moderate", "Low", "N/A" or "User" are used to indicate how relevant a particular option is to a particular Contextual Setting. In a flooding context, for example, the option "Re-instate old flow channels" is more relevant in a "Flat Lowland" setting than in a "Highland" setting. Thus, if a location of interest is described as "Flat Lowland" the flood mitigation option "Re-instate old flow channels" will be displayed with a relevance rating of "High" for the Topography Contextual Setting.

A setting of "N/A" is used when an option is not relevant to a particular Contextual Setting. The setting "User" is used in a few instances when a generic rating cannot be pre-determined, leaving it up to the User to decide how relevant the option is for the specific location of interest.

The overall Option Screening process involves a number of steps, which would normally be undertaken iteratively, but for clarity are listed here sequentially. A schematic illustration of the process is shown in Figure 2.2 and outlined below.

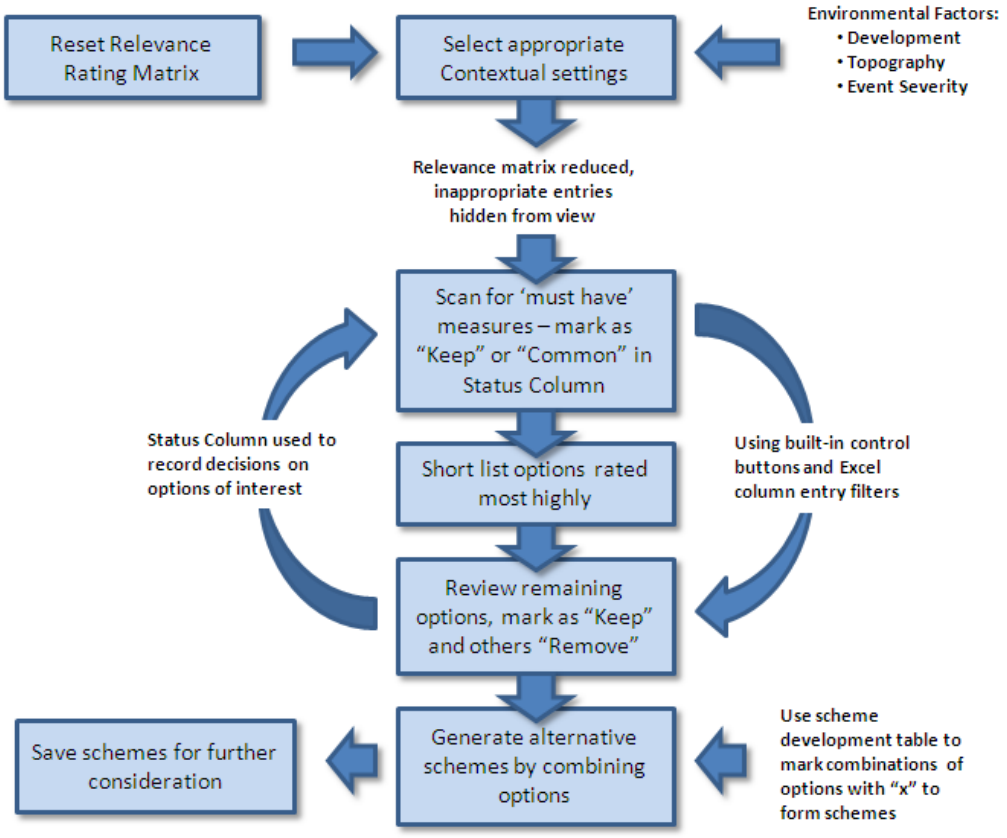


Figure 2.2: Schematic of the screening process

Step 1. First reset the screening matrix to re-instate the full list of options and default settings[2]. Then, select the Contextual Settings for each of the Environmental Factors that best describe the location of interest. Use the embedded control buttons to hide columns in the screening table that are not relevant to the chosen Contextual Settings.

Step 2. Scan the full list of options for any that might be considered as 'must have' options in any viable solution. These should be marked as "Common" in the "Status" column.

Step 3. Successively hide options with the lowest relance ratings using the Excel column-filter facility, until a manageable number of options are left. Alternatively, select the options that are rated as "High" for all three of the chosen Contextual Settings directly. This can be achieved using one of the embedded control buttons.

Step 4. Review the options that remain, mark any that are not practical for whatever reason as "Remove" in the Status column and any that should be retained as "Keep". At this stage it may also be considered prudent to quickly scan the rejected options to see if any should be retained, despite having a lower rating. It is usual, for example, to "Keep" the "Maintain Current Status Quo" as an option for comparative purposes.

Step 5. Seek to refine the short-listed options further using the four Attribute ratings and / or through team discussion. Mark any further options to be retained as "Keep" in the Status column. The Status column can now be used to shortlist the options to be retained, rather than use the column filters, and is achieved by selecting all options marked as "Keep" or "Common" in the Status column.

Step 6. The shortlisted options may now be combined to form alternative schemes. This is achieved by marking all the options that are to be included within a particular scheme with an "X" in the appropriate cell of the Scheme Development Table. Any "Common" options would be expected to exist in each of the schemes. The possible exception is the Maintain Current Status Quo option which may form a separate Scheme in is own right. Once the different schemes have been created, a summary table of schemes and their associated option combinations can be generated for reporting purposes.

2.2 Brief Guidance on Use

The overall framework within which the Option Screening Tool is intended to be used is shown in Figure 2.3.

[2] The user can temporarily over-write relevance factors to suit a specific location of interest. These temporary changes need to be removed for subsequent studies.

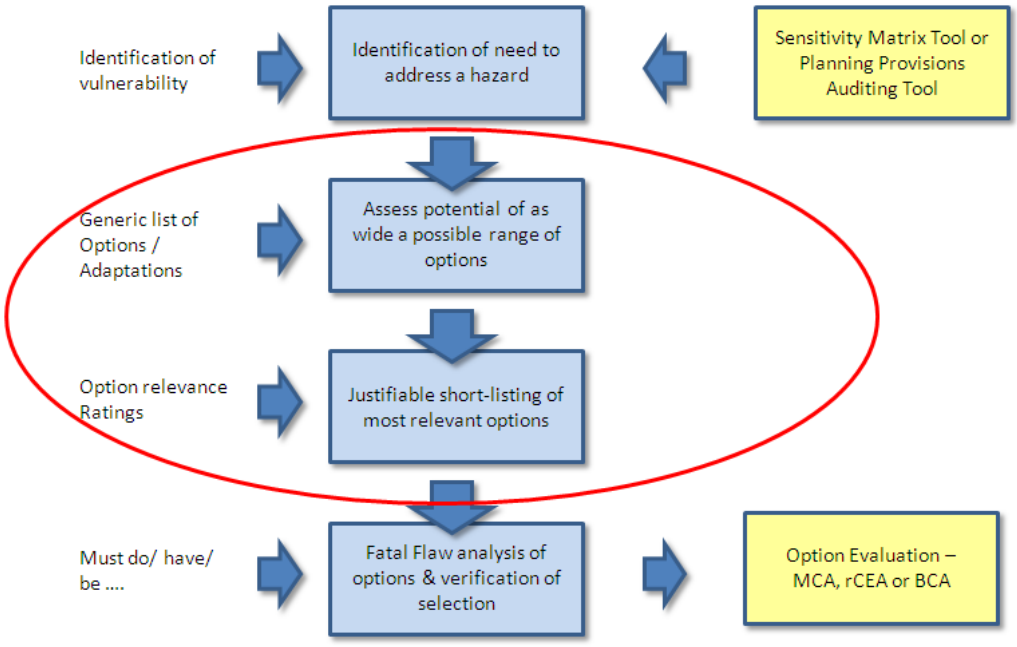


Figure 2.3: Generalised MCA decision tool framework

The screening tool is not designed to rank options directly, and should not be used to develop preferences amongst options. The tool is intended to be used for early stage identification and screening of a wide range of potential solutions. Further information and study will always be required to ensure that selected options are viable and not fatally flawed in terms of their affordability, consentability, buildability etc.

Relevance factors should only be taken as a guide to the selection of possible options for further consideration. Option relevance ratings are intended to be generic to a finite number of natural hazard situations. However, because they are generic, there is a possibility that individual ratings may not be appropriate in any particular situation. If this is the case, relevance factors can be overridden by the user.

2.3 Data Needs

The basic data needs for the Screening Process are as follows:

a) An understanding of the site or location and its vulnerability to the natural hazard of concern;

b) At least a general appreciation of which options might be effective for the situation being considered, which are technically feasible, and ones that might be acceptable to the local community;

c) Access to expert knowledge to guide or verify the shortlisting of options.

2.4 Outputs Generated to Aid Decision Making

Figure 2.4 shows an example screen shot of the screening matrix for a particular set of Contextual Settings ("Low-level Development", "Flat Lowland" and "Moderate Flood" hazard).

Flood Management Option	Ref.	Categorisation	Affordability	Protection Capability	Sustainability	Adaptability	Relevance to Low-level Development Area	Relevance to (Inland) Flat Lowland Setting	Moderate Flood	Overall Rating	Option Status	Scheme 1	Scheme 2	Scheme 3	Scheme 4	Scheme 5	Scheme 6	Scheme 7	Scheme 8	Scheme 9	Scheme 10
Re-establish old flow channels	C1	Channel Creation	User	High	High	Moderate	High	High	High	9	Keep		X								
Removal of confining structures or embankments	D1	Channel Clearance	High	Low	High	Low	High	High	High	9	Keep			X							
Rip-rap / rockwall / revetments protection	H1	Stabilisation	Moderate	High	Low	Moderate	High	High	High	9	Keep				X						
Maintain Current Status Quo	K2	Maintenance	High	Low	User	N/A	High	High	High	9	Keep	X									
Administrative controls e.g. by-laws	L1	Administration	High	High	High	High	High	High	High	9	Common		X	X	X						
Planning/building restrictions and land titles	L3	Administration	High	High	High	High	Moderate	High	High	8	Common		X	X	X						
Investigations, surveying, monitoring and modelling	O1	Investigation	High	N/A	N/A	High	High	High	High	9	Common		X	X	X						

Figure 2.4: Example of screening matrix following screening of options

In this example, two administrative type options, the Maintain Current Status Quo option and three other options rated "High" for all three Contextual Settings have been shortlisted. Four schemes are developed from combinations of these options, using the Scheme Development Table shown on the right-hand side of Figure 2.4. A summary of the schemes generated from the spreadsheet application is shown in Table 2.1.

Table 2.1 Tabular summary of schemes developed from short-listed options

Ref	Scheme Description
Scheme 1	Maintain Current Status Quo
Scheme 2	Re-establish old flow channels; administrative controls e.g. by-laws; planning/building restrictions and land titles; investigations, surveying, monitoring and modelling.
Scheme 3	Removal of confining structures or embankments; administrative controls e.g. by-laws; planning/building restrictions and land titles; investigations, surveying, monitoring and modelling.
Scheme 4	Rip-rap / rockwall / revetments protection; administrative controls e.g. by-laws; planning/building restrictions and land titles; investigations, surveying, monitoring and modelling.

Further details of the structure and content of the Option Screening Tool are given in Section 3.

2.5 Assumptions and Limitations

The overriding assumption in applying the Option Screening Tool is that natural hazard locations can be characterised by a relative small number of Contextual Settings and that the relevance ratings are sufficiently generic and applicable to these Contextual Settings.

It is possible to add Contextual Settings if it is considered necessary to improve the characterisation of different location types. However, the relative simplicity of the tool is one of its strengths. Adding complexity may prove counter-productive; rather, the tool should be used only as a guide. The selections provided by the tool should always be carefully reviewed and adjusted according to the actual hazard situation and verified through stakeholder consultation.

A further important consideration in applying this Tool is that any selection of adaptation options needs to satisfy both local conditions and the wider regional situation. This is especially true when considering flood mitigation options. The reason is because many risk reduction and adaptation options applied in a local situation will have a wider impact. A stopbank provided to protect a township may cause additional flooding further upstream or downstream. Using flood basins in the upper catchment to reduce flooding in the lower catchment will clearly have an impact in the upper catchment, which itself needs consideration.

3. How to Apply the Decision Tool

The application and use of the Option Screening Tool is illustrated using the Buller River Case Study [see: Toolbox Overview and Keenan, 2011]. The presentations and descriptions given here are provided to offer insights into the application of the Tool; they are not intended to represent a definitive selection of options for the Buller River. The explanations are brief and are not intended to form the function of a User Guide. Some additional schematics describing the content of the main Option Screening worksheet are given in Appendix A. For more detailed information please contact the authors of the Tool.

3.1 Tool Structure and Content

The spreadsheet application comprises of a series of worksheets with embedded macros provided to assist the option selection process, see Figure 3.1. The first worksheet gives guidance on the use of the Tool. There are three other sheets: the master Options Screening sheet, a sheet for generating a tabular output of the hazard adaptation schemes generated from the shortlisted options, and a sheet containing default settings used to reset the screening matrix for a new study.

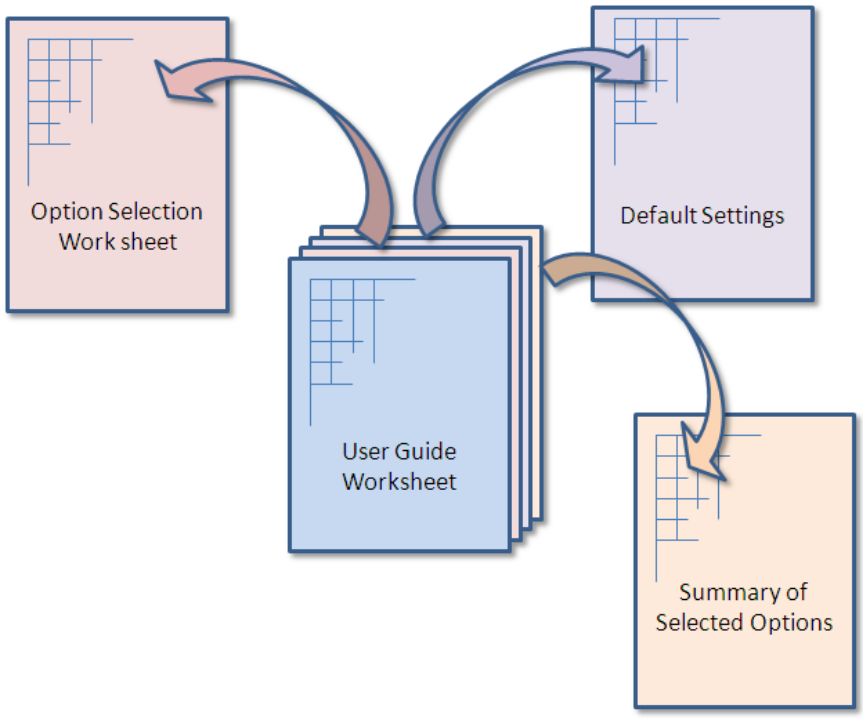


Figure 3.1: Structure of the Option Screening Tool

3.2 Selecting the Contextual Settings

The full Option Screening Matrix is first expanded to reveal all the different Options, and all the different Contextual Settings. The Contextual Settings that best describe the new location of interest are then chosen using the three selection boxes shown in Figure 3.2. Once the selection is made, the command buttons may be used to hide the unwanted columns in the Screening Matrix.

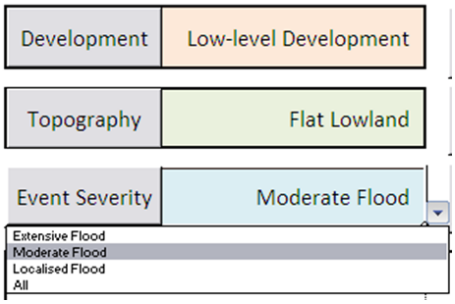


Figure 3.2: Selection of contextual settings

Next, all Options which are not rated as "High" relevance for a particular, or for all, Environmental Factors can be hidden from view using the MS Excel column filters. Figure 3.3 shows the column Filter for the "Development" Environmental Factor set to display only the "High" rated entries. This can be repeated for the other two Environmental Factors.

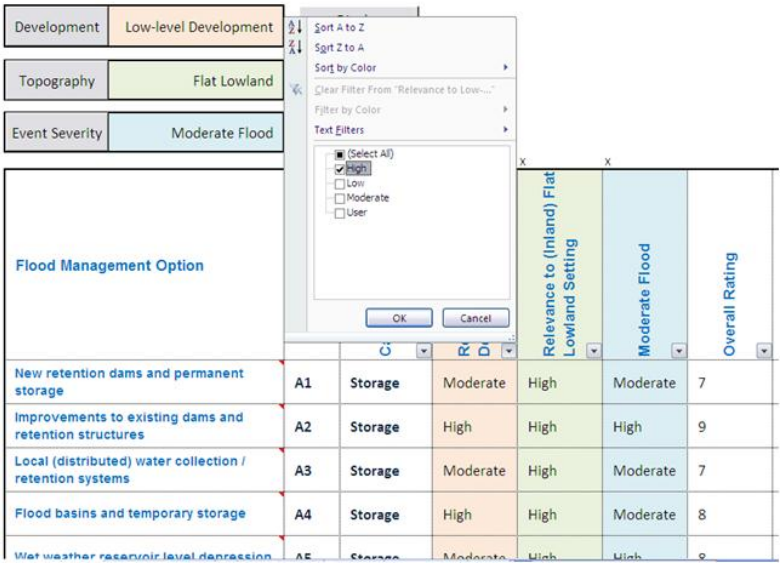


Figure 3.3: Filtering of options

Figure 3.4 shows the shortlisted Options that are rated "High" relevance for the Contextual Settings given in Figure 3.2. The last but one column on the right-hand side provides a numeric score for each option. These scores can also be used to filter or refine the selection of options. The column on the far right of Figure 3.3 is the "Status" column, provided for the User to record the options selected and marked as "Keep" or "Common".

The shortlisted options rated with a "High" relevance are summarised in Figure 3.4. Four options are marked as "Keep" in the Status column and two are marked as "Common". Note that there is no restriction to only select options that are rated as "High"; any option may be selected for further consideration.

Flood Management Option	Ref.	Categorisation	Relevance to Low-level Development a	Relevance to (Inland) Flat Flood Setting	Moderate Flood	Overall Rating	Option Status
Improvements to existing dams and retention structures	A2	Storage	High	High	High	3	
Reforestation of up-land areas - reduced run off	A7	Storage	High	High	High	3	
Raise existing flood walls, stop banks or sea walls	B2	Barrier	High	High	High	3	
Improvements to existing flood walls, stop banks or sea walls	B3	Barrier	High	High	High	3	
Re-establish old flow channels	C1	Channel Creation	High	High	High	3	Keep
Optimise flood pathway alignments	C2	Channel Creation	High	High	High	3	
Divert river channel	C4	Channel Creation	High	High	High	3	
Removal of confining structures or embankments	D1	Channel Clearance	High	High	High	3	Keep
Commercial gravel extraction	D5	Channel Clearance	High	High	High	3	
Improvements to existing tunnels and culverts	E2	Tunnels	High	High	High	3	
Drainage channels and causeways	G1	Drainage	High	High	High	3	
Rip-rap / rockwall / revetments protection	H1	Stabilisation	High	High	High	3	Keep
Improved maintenance of flood protection assets	K1	Maintenance	High	High	High	3	
Maintain Current Status Quo	K2	Maintenance	High	High	High	3	Keep
Administrative controls e.g. by-laws	L1	Administration	High	High	High	3	Common
Behavioural modifiers, financial incentives	L4	Administration	High	High	High	3	
Weather and flood prediction warning systems	M2	Civil Defence	High	High	High	3	
Investigations, surveying, monitoring and modelling	O1	Investigation	High	High	High	3	Common
Education and publicity	O2	Investigation	High	High	High	3	
Further Consultation	O3	Investigation	High	High	High	3	
Long-term infrastructure planning	O4	Investigation	High	High	High	3	

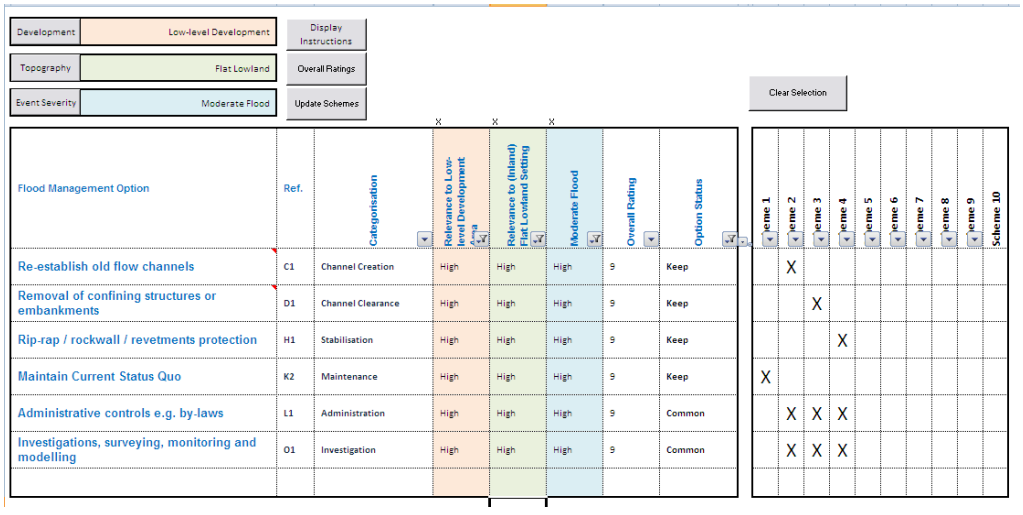
Figure 3.4: Shortlist of options rated `High' relevance

Option attributes (i.e. Affordability, Protection Capability, Sustainability and Adaptability) can be used to further refine the option shortlist. In Figure 3.5, entries with "High" Sustainability and "High" Adaptability have been selected as these two Attributes are important for solutions which offer resilience to climate change effects.

Flood Management Option	Ref.	Categorisation	Affordability	Protection Capability	Sustainability	Adaptability	Relevance to Low-level Development Area	Relevance to (Inland) Flat Lowland Setting	Moderate Flood
Local (distributed) water collection / retention systems	A3	Storage	High	Low	High	High	Moderate	High	Moderate
Reforestation of up-land areas - reduced run off	A7	Storage	High	Moderate	High	High	High	High	High
Sustainable Urban Drainage Systems (SUDS)	G2	Drainage	Moderate	Moderate	High	High	Moderate	Moderate	Moderate
Stabilise river channels, riparian planting	H2	Stabilisation	High	Moderate	High	High	High	Moderate	Moderate
Raise asset	J1	Asset Developme	User	Moderate	High	High	High	High	Moderate
Managed retreat	J4	Asset Developme	User	High	High	High	High	High	Moderate
Flood resilient & flood tolerant buildings / structures	J6	Asset Developme	High	Moderate	High	High	Moderate	High	High
Administrative controls e.g. by-laws	L1	Administrat ion	High	High	High	High	High	High	High
Land use management & zoning	L2	Administrat ion	High	High	High	High	Moderate	High	High
Planning/building restrictions and land titles	L3	Administrat ion	High	High	High	High	Moderate	High	High
Long-term infrastructure planning	O4	Investigatio n	High	High	High	High	High	High	High

Figure 3.5: Assessment of option attributes

The column filter on the Status Column may now be used to shortlist the options chosen by the User for further consideration, as shown in Figure 3.6.



Flood Management Option	Ref.	Categorisation	Relevance to Low-level Development Area	Relevance to (Inland) Flat Lowland Setting	Moderate Flood	Overall Rating	Option Status	eme 1	eme 2	eme 3	eme 4	eme 5	eme 6	eme 7	eme 8	eme 9	Scheme 10
Re-establish old flow channels	C1	Channel Creation	High	High	High	9	Keep		X								
Removal of confining structures or embankments	D1	Channel Clearance	High	High	High	9	Keep			X							
Rip-rap / rockwall / revetments protection	H1	Stabilisation	High	High	High	9	Keep				X						
Maintain Current Status Quo	K2	Maintenance	High	High	High	9	Keep	X									
Administrative controls e.g. by-laws	L1	Administration	High	High	High	9	Common		X	X	X						
Investigations, surveying, monitoring and modelling	O1	Investigation	High	High	High	9	Common		X	X	X						

Figure 3.6: User-selected shortlist of options

The spreadsheet table on the right side of Figure 3.6 is the Scheme Development matrix, and is used to indicate how the shortlisted options combine to make up a number of alternative schemes. The user enters an "X" in the appropriate cell of the Scheme Development Table against each option that is to be included in each scheme.

In Figure 4.6 the two common Options are included in all Schemes except the one containing "Maintain Current Status Quo" which stands on its own as Scheme 1. This Scheme will be used as a reference against which the performance of the other Schemes, 2 to 4, can be compared. Schemes 2 to 4 each contain the "Common" Options and one of the other selected options.

3.3 The Next Steps

The Options Screening Tool provides a means of exploring a wide choice of adaptation options within the context of high uncertainty presented when considering the effects of climate change. It provides a structured and traceable means of selecting potential solutions. This is achieved through successive refinement of the choice of options that have the desired features for the location's conditions, including the effects of climate change.

Having shortlisted options or schemes, these can be investigated in more depth and their relative performance and economics explored with other Tools in the Toolbox [see Tool 4.5, for example].

A final cautionary note:

This Tool is not intended to provide an end in itself. Although this Tool provides a means of shortlisting options, the selection of options should not been seen as an entirely linear process. It is entirely possible that options initially rejected may later be deemed to have potential and re-introduced later in the assessment of options. Similarly, a shortlisted option may subsequently be found to be impractical, possibly necessitating significant modifications or replacement by another option.

4. References

Keenan, N. (2011) Toolbox Case Study – Buller River Flood Hazard, MWH Report no. Z1823603.

Oldfield, S.G. (2011) Toolbox Case Study – Wellington Landslide Hazard, MWH Report no. Z1823604.

Appendix A: Worksheet Descriptions

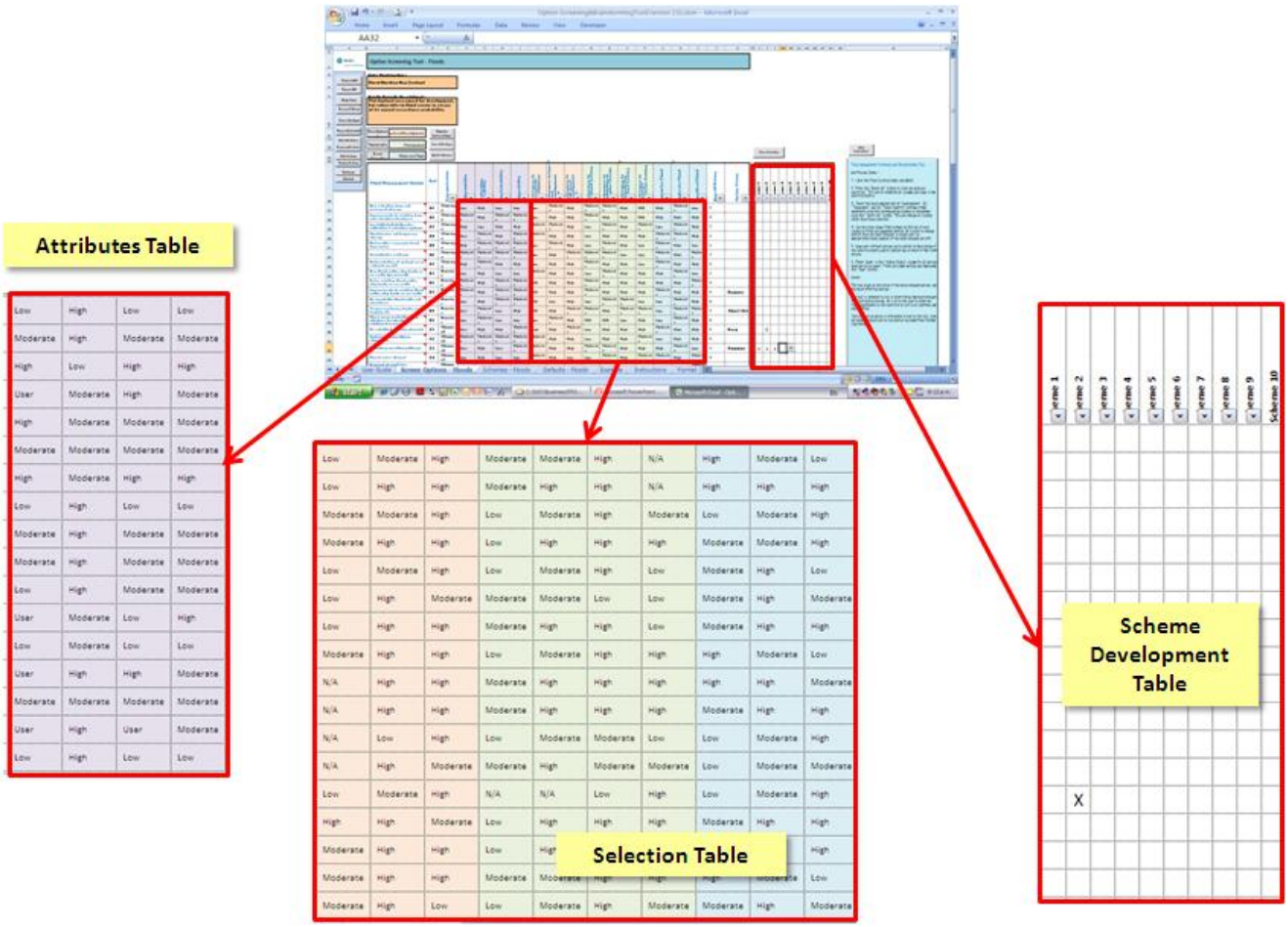


Figure A1: Attribute, screening and scheme development tables

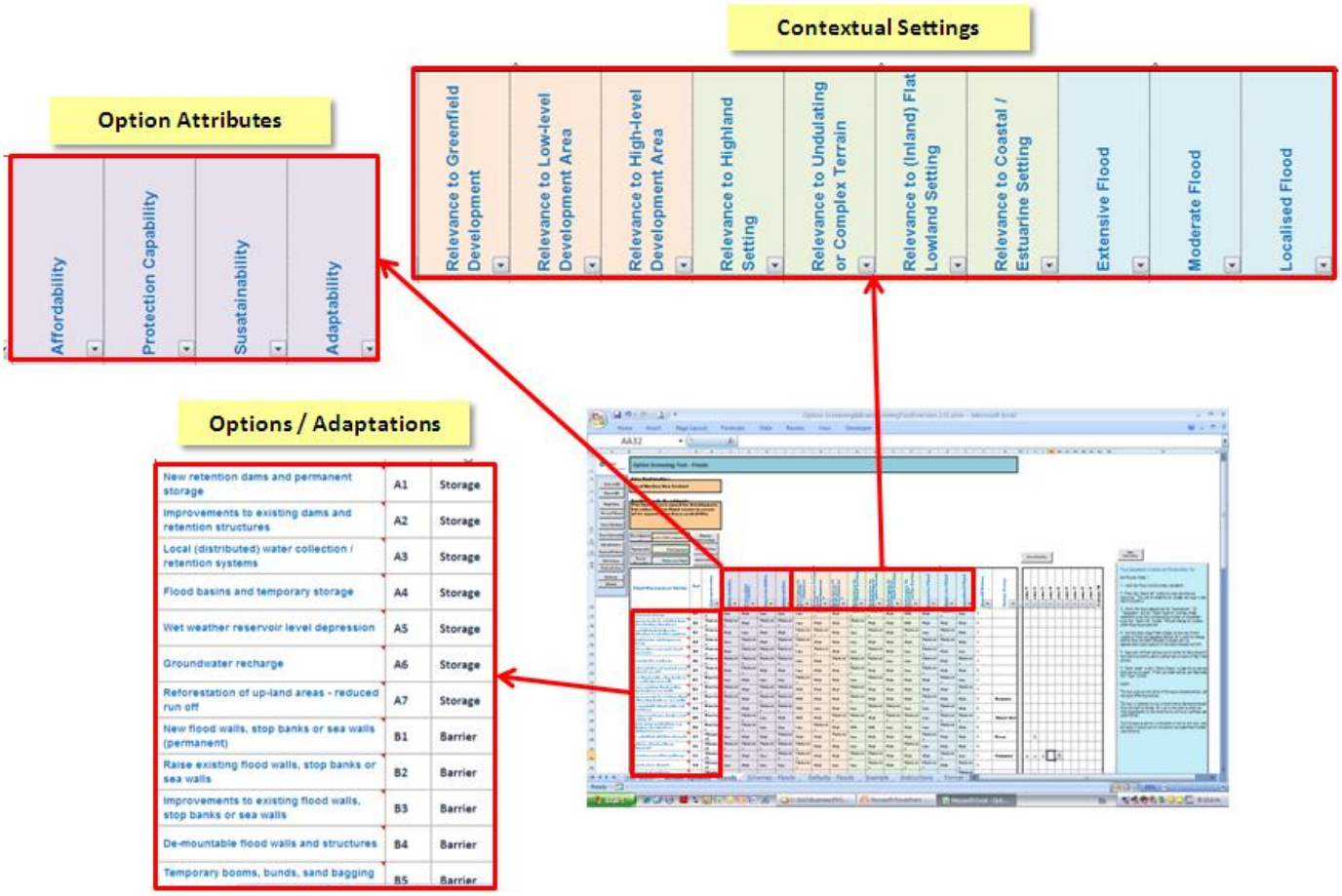


Figure A2: Attribute, contextual settings and options / adaptations lists

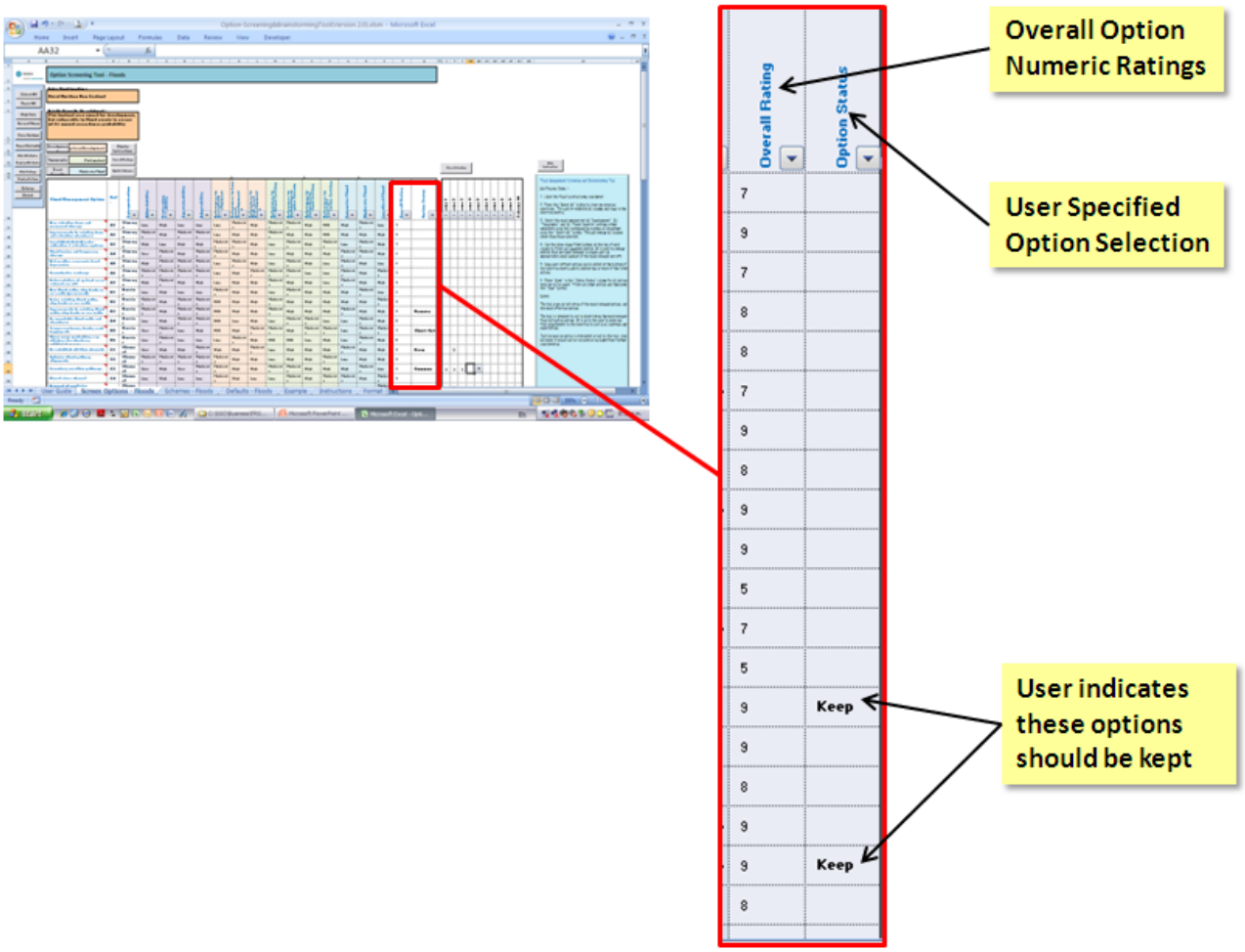


Figure A3: Option numeric rating and option selection status

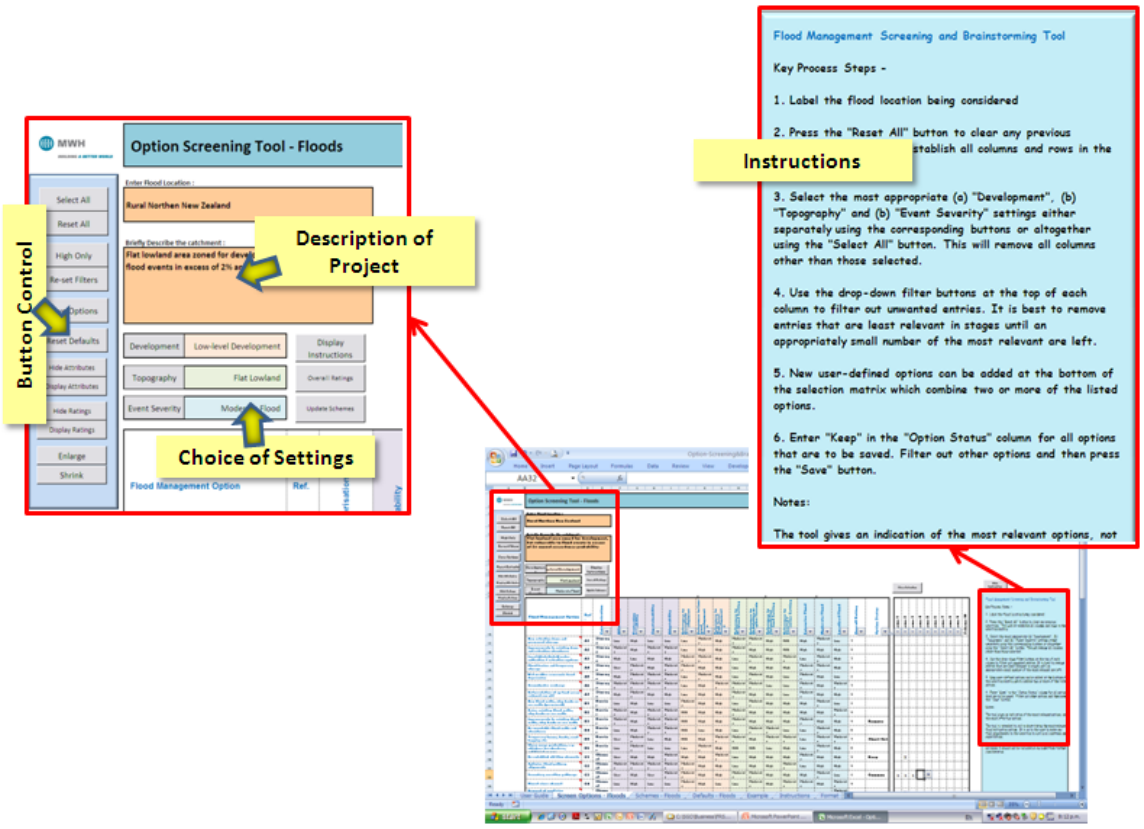


Figure A4: User controls and instructions.