INNOVATIVE ASSET MANAGEMENT

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CREATING A PROACTIVE DECISION SUPPORT ENVIRONMENT IN MANAGING ROAD TRAFFIC NOISE

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ABSTRACT

Properly designed decision support environments encourage proactive and objective decision making. The work presented in this paper inquires into developing a decision support environment and a tool to facilitate objective decision making in dealing with road traffic noise. The decision support methodology incorporates traffic amelioration strategies both within and outside the road reserve. The project is funded by the CRC for Construction Innovation and conducted jointly by the RMIT University and the Queensland Department of Main Roads (MR) in collaboration with the Queensland Department of Public Works, Arup Pty Ltd., and the Queensland University of Technology.

In this paper, the proposed decision support framework is presented in the way of a flowchart which enabled the development of the decision support tool (DST). The underpinning concept is to establish and retain an information warehouse for each critical road segment (noise corridor) for a given planning horizon. It is understood that, in current practice, some components of the approach described are already in place but not fully integrated and supported. It provides an integrated user-friendly interface between traffic noise modeling software, noise management criteria and cost databases.

Keywords: Road traffic noise, decision support tool, amelioration analysis, traffic noise modeling

1. INTRODUCTION

The purpose of road traffic noise management is to minimize environmental harm through cost effective measures undertaken in a proactive and informed manner. This can be achieved by creating a knowledge base for a given road segment and conducting comparative cost/benefit assessments of the alternative ameliorative treatments. One of the aims of the research project, funded by the CRC for Construction Innovation, is to develop a framework and a tool that could be used to facilitate this process of conducting comparative cost benefit assessments within and outside the road reserve. Presented in this paper is a description of the proposed proactive decision support environment and the framework.

The proposed decision support tool (DST) incorporates a number of distinct features. It facilitates the integration of a widely accepted traffic noise model, provides the cost database for alternative amelioration treatments within and outside the road reserve, incorporates the relevant noise amelioration criteria and generates reports. The software has an interactive user interface that enables the user to conduct cost/benefit analyses of feasible alternative amelioration options.

The decision support environment comprises of seven information and processing platforms, labeled as ‘zones’. Each of these zones may be regarded as a platform on which information is written to and read from. The seven zones are:

- Noise impact and code assessment zone
- Option identification zone
- Amelioration analysis zone
- Feasibility options zone
- Concept costing zone
- Benefit analysis zone
- Report generation zone

The proposed software is an interactive tool which is designed to provide various input and output reports, which will be stored for future use. The decision support comes in the way of filtering all possible options to provide feasible and reasonable options meeting noise amelioration criteria given in the guidelines to help the user and decision maker. A number of planning horizons may be tried out by changing predicted traffic, terrain and feature data to identify a number of alternative scenarios for a given road segment. Retaining such information would enable informed decisions on planning amelioration strategies through a number of stages.

2. THE DECISION SUPPORT FRAMEWORK

2.1 ZONE 1 – NOISE IMPACT AND CODE ASSESSMENT

Figure 1 illustrates the noise impact and code assessment zone, which represents the initiation of the decision support environment. In this zone, the road segment under investigation is identified and described in terms of both the traffic noise source details and the surrounding terrain and feature data. The parameters which define the traffic noise source are the speed, average annual daily traffic (AADT), vehicle composition and road surface type. The user would interactively input, store and upgrade this information for the road segment under investigation over a period of time. The intention is to map, upgrade and maintain an up-to-date knowledge base for any road segment which is identified as having traffic noise related issues.

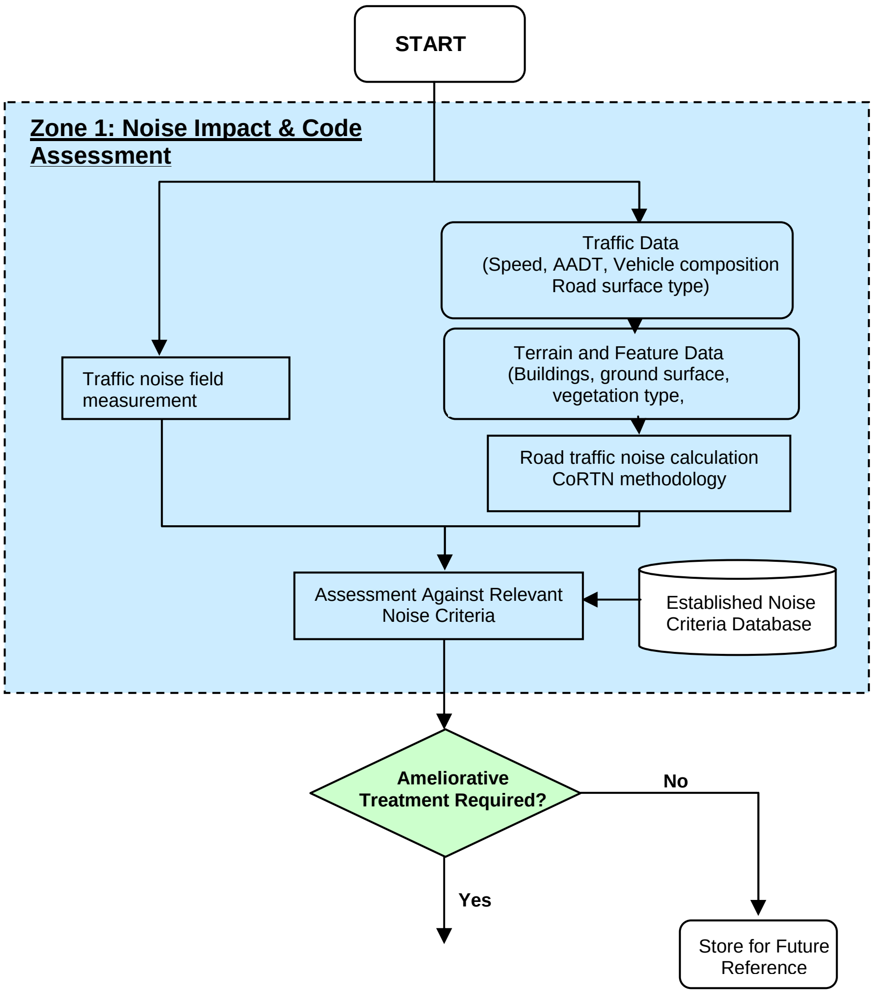

Figure 1 – Flow chart of the noise impact and code assessment zone

The terrain and feature data are represented by three dimensional models in a form typical of an AutoCAD file that contain spatial information for the road and the environment surrounding the road segment. The terrain and feature data includes topography, vegetation type, building property, road and road reserve boundaries. Although not stored in the database, the terrain and feature data is stored in a directory of which the path is recorded so that it is possible to easily access such files at the appropriate stages of the assessment/evaluation process.

The noise impact and code assessment zone of the DST is also designed to provide a user interface to call or launch the commercially available road traffic noise modeling software. The road traffic modeling software can access the terrain, feature and traffic data of the road segment and surrounding environment in DXF format. When executed, the modeling software is used to calculate (based on the CoRTN methodology (GBDoT, 1988) the noise level in the environment surrounding the road segment from which the traffic noise emanates. The output noise level data which is associated with various receivers (residences, schools, hospitals, etc) in the surrounding environment is stored via the user interface in the database.

As shown in Figure 1, zone1 also facilitates storing traffic noise field measurement data for the road segment. This would enable the user to retrieve and compare the corresponding noise levels simulated by the modeling software with the field measurements. Provided the difference between the measured and simulated noise levels are within acceptable limits, the simulated noise levels are considered as reliably representing the noise impact.

Having established the noise impact on the surrounding environment, the decision support framework facilitates the code assessment. This is to determine whether the receivers are exposed to a noise level that exceeds the external noise criteria permissible by the guidelines. The external noise criteria are a set of limiting noise levels that receivers (private residences, schools, etc) can be exposed to without the need for ameliorative treatment. External noise criteria vary from country to country and within Australia from state to state (Berglund, 1999; QDMR, 2000; NSWRTA, 2001). As shown in Figure 1, the established noise criteria database provides a user interface for the decision maker to establish the need for intervention by the road authority. If the receivers are exposed to a noise level that exceeds the external noise criteria then ameliorative treatment is required.

If ameliorative treatment is not required at present, the decision support tool facilitates retaining all such information generated in order to reach this decision for future reference. However if ameliorative treatment is deemed necessary then further analysis is required and the decision maker needs to identify a number of alternative ameliorative options which are feasible and preferable. The Zone 2 - ‘option identification’ platform is designed to achieve this objective.

2.2 ZONE 2 – OPTION IDENTIFICATION

Figure 2 illustrates the functionality of the ‘option identification’ zone. The purpose of the zone 2 is to identify all the amelioration options that could potentially be used to reduce the noise level at the receivers that exceed the noise criteria.

The proposed decision support framework facilitates possible treatments not only within the road reserve but also outside the road reserve as given in Figure 2. The user is presented with the ‘inventory of all possible treatment options’. Possible options are derived from two databases as shown, which satisfy a set of guidelines outlining internal and external criteria. This is an interactive process where the experience and know how of the decision maker plays a major role in ruling out options which are not practicable, already in place or fully exhausted. At this stage the treatment options are separated according to whether they are applied within or outside the road reserve. This is mainly due to the fact that the current guidelines of many road authorities recommend amelioration strategies, such as treatment to building envelopes, as the last resort. However the proposed decision support framework facilitates a combination of external and internal criteria to achieve the desired outcome. This approach is desirable when all amelioration options within the road reserve have been fully or partially exhausted.

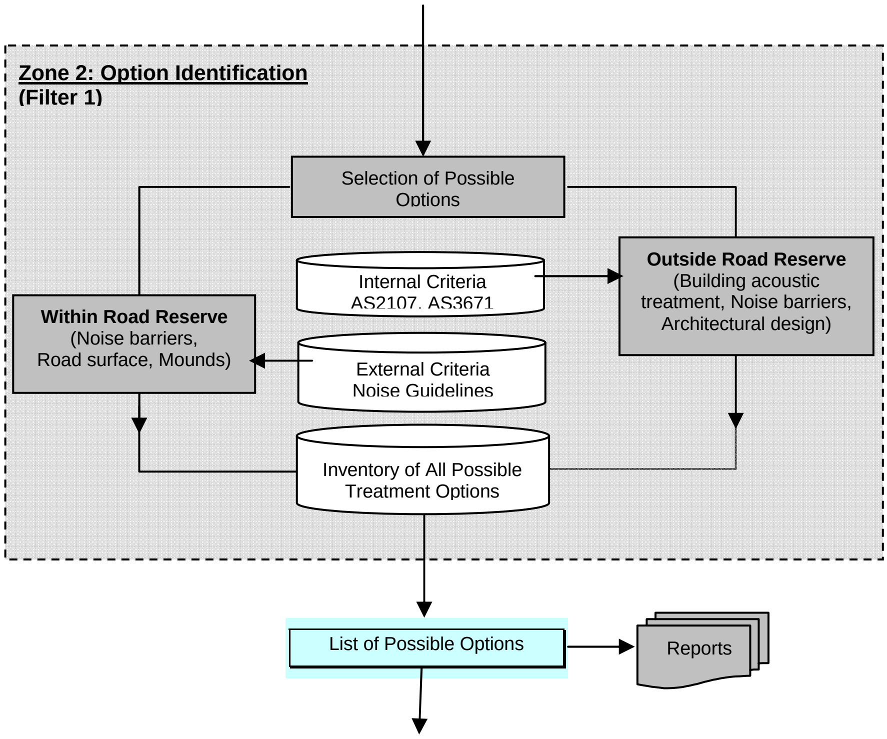

Figure 2 – Flowchart of the option identification zone

Treatment options that are applied outside the road reserve include treatments to the building envelope and/or screens/fences. The purpose of treating the building envelope is to reduce the internal noise only. The Australian standard (AS3671, 1989) provides a procedure for determining appropriate treatments that correspond to the noise reduction required. Accordingly by following this procedure it would be possible to identify from the initially selected treatment options those that could reduce the internal noise level to the allowable level set by the relevant criteria. At this point the treatment options that were considered unsatisfactory would be discarded.

The internal noise criteria, like the external noise criteria also vary from country to country (Berglund *et. al*., 2001; AS2107, 2000). At the time of writing, in Australia the state road authorities had not explicitly defined their own internal noise criteria or adopted internal noise criteria given in the Australian standard (AS2107, 2000). The values given in the AS2107, like those established by the World Health Organization [Berglund, 1999, De Silva & Douglas, 2004], recommend very low internal noise levels that would be difficult and costly to achieve.

The decision support tool provides access to the relevant sections of the Australian Standard (AS2107, 2000), which are stored in the internal criteria database. Provisions are made to determine the necessary construction category of the building envelope to achieve desired reduction of noise trough transmission losses at the building façade. The type of construction used in the noise sensitive building could then be assessed to determine if it was equivalent to or could be realistically upgraded to be equivalent to the construction category required. If the construction category of the building envelope was found to be unsuitable for treatment then this option would have to be discarded.

Treatment options that are applied inside the road reserve include road resurfacing, noise barriers and mounds. The user interface also provides selective access to the relevant road authority noise guidelines. The user is able to determine, based on the guidelines, if the selected treatment option is potentially suitable for the application. All the treatments, both within and outside the road reserve options that have been found to be potentially capable of satisfying the noise reduction required, are then stored in an inventory so they can be further evaluated at a later stage.

Before beginning the amelioration analysis the user is able to display a list of the possible treatment options. At this stage the user is able to discard any options considered unsuitable. It is also possible to generate a report describing the treatment options and the reasons why they have either been accepted or discarded.

2.3 ZONE 3 – AMELIORATION ANALYSIS

The functionality of 'Zone 3 - amelioration analysis', as illustrated in Figure 3, is to determine if the preferred treatment options identified in Zone 2 are technically viable to achieve the relevant noise criteria. The decision support tool makes provisions for technical validation of preferred amelioration options within the road reserve, outside the road reserve and the combination of both. The commercially available traffic noise models can be called upon to model and analyse preferred treatment options within the road reserve which include the provision of noise barriers, road surface treatments, earth mounds, etc. The provision is made available through specifically developed software based on the Australian Standards (AS3671, 1989; AS2107, 2000) to deal with preferred treatment options outside the road reserve, such as provision of screens and treatment to building envelopes etc.

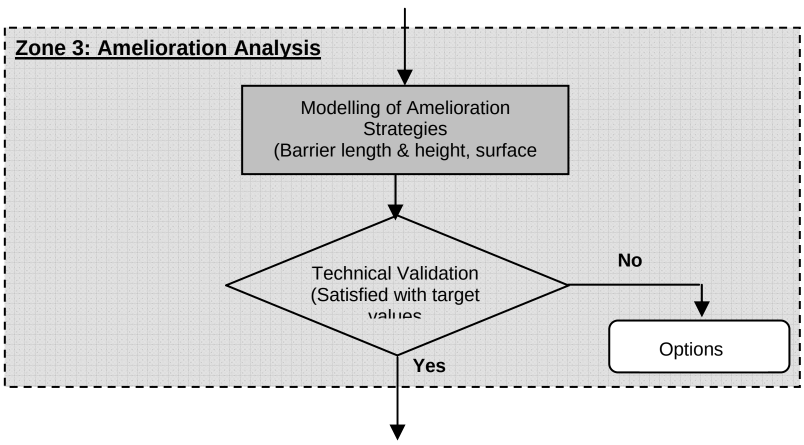

Figure 3 – Flowchart of the amelioration analysis zone

In this stage the traffic noise impact assessment model developed in zone 1 can be called upon to incorporate preferred treatment options. The model is executed for each preferred option and the predicted environmental noise levels at the sensitive receivers are compared to the target reduced noise levels. Interactively, by a process of iteration, the amelioration treatment parameters are varied and the models re-run until the predicted noise levels are lower than or equal to the target values.

Outside the road reserve amelioration strategies include; erecting screens, maintaining closed windows, sealing facades, acoustic/thermal insulation and improving façade elements such as solid core doors and double glazing (De Salis *et. al*., 2002).

The software for outside road reserve treatments has capabilities in evaluating composite noise transmission losses through the building envelope. The user is able to select the target values based on; the internal noise criteria set by state road authorities or in the absence of such criteria, the Australian Standards (AS2107, 2000) or international bodies such as the World Health Organization (Berglund *et. al.*,1999), the room type (living or sleeping).

Having selected the appropriate internal noise criteria and knowing the external noise levels the target reduction is established. The user is then able to try out different acoustic treatments to building façade elements until either the internal noise level is equal to, or lower than, the target value or it is found that it is not possible to sufficiently reduce the noise level. The user is also able to select the number of buildings of this type that would require similar treatment. This process can be repeated for each different building type that is exposed to a noise level that exceeds the external noise criteria.

The noise level data and the design parameters for each amelioration strategy that was found to be capable of satisfying the target noise levels are then stored using the user interface.

2.4 ZONE 4 – FEASIBILITY OF OPTIONS

All the treatment options that were technically viable of reducing the noise level to the target value are presented in the form of a list to the user in the feasibility of options zone.

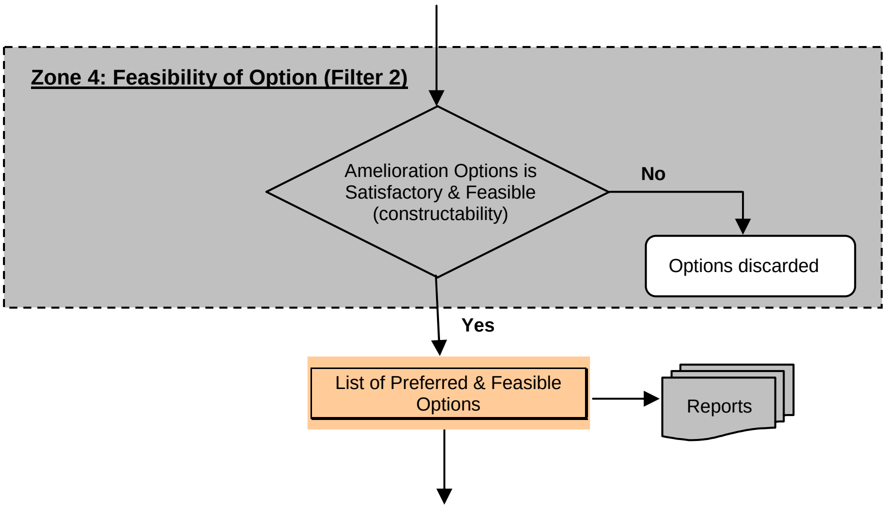

Figure 4 – Flowchart of the feasibility of options zone

The user is then able to narrow down satisfactory and feasible options with due consideration to technical viability and constructability. In order to make a final decision as to whether or not an option is selected, the decision maker is required to draw on information that may not necessarily have been available within the decision support environment. This type of information might be based on reasons that are social or political in nature and are only known to each respective decision making body.

The treatment options that do not pass through these selection criteria may be discarded. The selected treatment options are then stored and are available for concept costing to determine cost/benefit ratios. It is also possible to generate a report describing the treatment options and the reasons why they have either been discarded or considered as preferred and feasible as shown in Figure 4.

2.5 ZONE 5 – CONCEPT COSTING

The cost of implementing the selected preferred and feasible treatment options is evaluated in the 'Zone 5 - concept costing' illustrated in Figure 5. This zone provides a cost database for standard noise treatments both within and outside the road reserve.

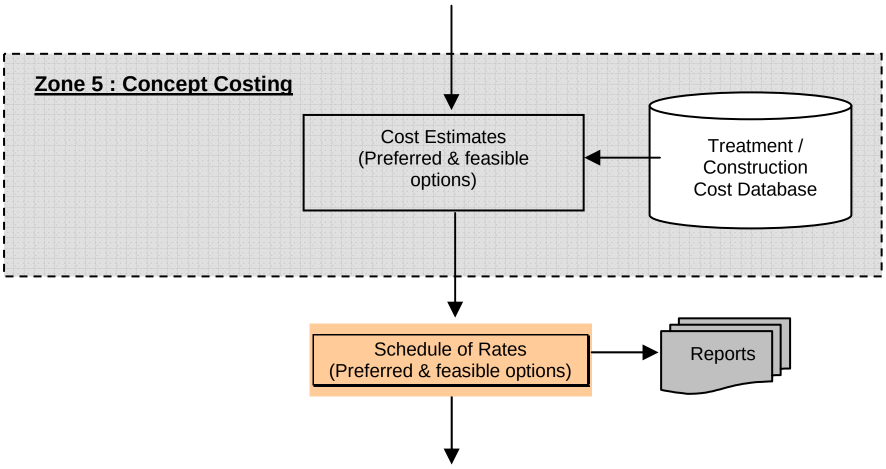

Figure 5 – Flowchart of the concept costing zone

At this stage each selected treatment option is conceptually developed and the technical details are available for proper cost estimates. The concept design of the treatment option has been developed to the extent that parameters such as the length, height and material type have been determined. Reasonable cost estimates and therefore the schedule of rates can be established for each option based on the cost database.

The concept costing module of the DST has a user interface through a pull down form where relevant items can be selected and the quantity entered in by the user. A schedule of rates similar to a bill-of-quantities is produced by the software giving the total cost of the treatment option including general costs such as project management, survey/design and service relocation etc.

The user also has the option to evaluate the costs in terms of present value or discounted future values. Such an option provides the user with the possibility of comparing a series of treatments developed over a number of planning horizons that aim to satisfy immediate needs only with a one off treatment or that aims to satisfy both present and future needs through a number of stages.

It is also possible for the user to generate a report that details the cost estimates for each of the preferred and feasible treatment options in terms of either present or future values.

2.6 ZONE 6 – BENEFIT ANALYSIS

The benefit of a treatment option depends on the perspective of who is to receive the benefit as well as on how it is measured. Accordingly there are many different ways to measure benefit. For this reason, a number of different measures of benefit are presented to the user in the benefit analysis zone. The possibility of using a measure that includes a weighted combination of measures is also being investigated.

Although at this stage the exact measures of benefit have not been determined it is envisaged that they will include; the average cost per household, the cost per decibel reduced and the increase in the value of exposed households resulting from the reduction in noise level evaluated using hedonic pricing methods (Morrison, 2002; Nijland *et.al*., 2003).

In a similar interactive fashion to that of zone 4, the decision maker will be able to select from the range of measures those that are most appropriate for the given application. In addition the user is also able to generate a report detailing the cost and the selected measures of benefit for each of the preferred and feasible treatment options.

At this stage it may be found that an option although preferred and feasible is not financially reasonable. Although such an option would not be included in the final report, the results associated with the option could be stored for future reference as given in Figure 6.

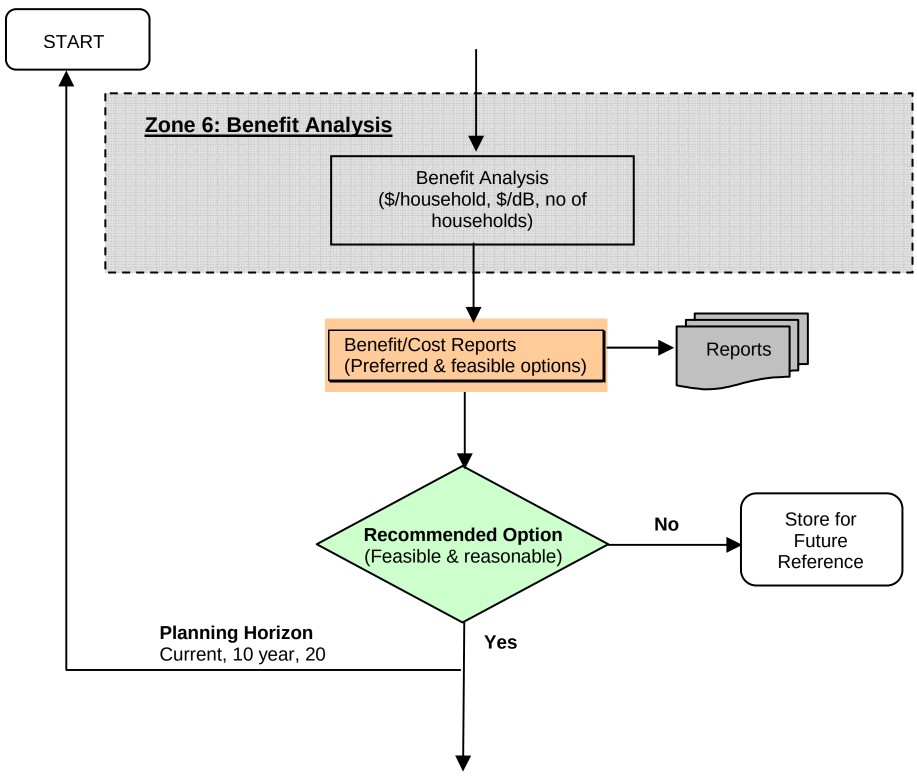

Figure 6 – Flowchart of the benefit analysis zone for different planning horizons

At this stage it is also possible to assess the feasible and reasonable treatment options at planning horizons such as 10 or 20 years into the future. The process is the same as for assessing treatment options in the current planning horizon where the user again follows the procedures from Zone 1 to Zone 6 as discussed in this paper.

There are two main differences between the cost/benefit assessment of the treatment options for current and future planning horizons. The first is that the traffic data and terrain data used in Zone 1 would be measured for current assessment where as predicted in case of the future planning. The second difference is that in Zone 5 the future values would be given as present values so they could be directly compared with treatment options developed for the current planning horizon.

2.7 ZONE 7 – REPORT GENERATION

In Zone 7 a final report is generated for all the feasible and reasonable treatment options. The report includes cost estimates and benefit analyses for current and future planning horizons as given in Figure 7.

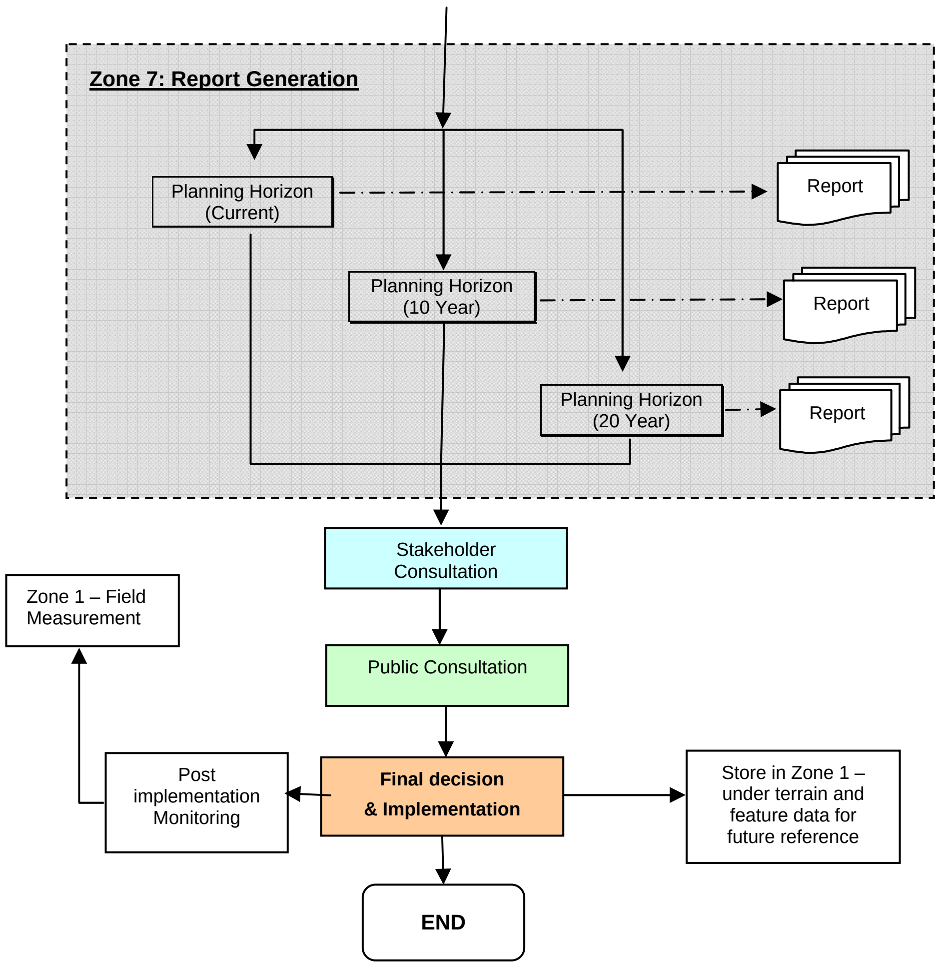

Figure 7 – Report generation zone

The report can then be made available for stakeholder and public consultation before the final decision can be taken and implemented. All the information in the report is then stored in Zone 1 under terrain and feature data for future reference. Once the treatment option has been implemented post implementation monitoring is carried out and the results are stored in Zone 1 under field measurement data again for future reference.

3. CONCLUSIONS

A decision support framework is proposed to encourage a proactive traffic noise management strategy.

Decision support software is currently being developed to incorporate the proposed framework.

The proposed decision support framework and the tool incorporate noise amelioration, both, within the road reserve and outside the road reserve such as architectural treatments to building envelopes.

When developed the proposed framework and the tool will be tested and calibrated using four trial sites located in Queensland.

Software is designed to integrate commercially available traffic noise models, capabilities in evaluating composite noise transmission losses through different building envelopes and cost/benefit analysis of alternative amelioration options to support decision making.

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