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# ACOUSTICS 2012

## On the diversity of urban waterscape

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In the last several hundred years the development of Sheffield has been shaped by waterways. In the recent city centre regeneration, starting in the 1990s, great efforts have been made to ensure that the reconnection with the rivers continues to be fostered and their role in the history of the city celebrated. Waterscapes and squares have been embedded into the city for its vibrancy with the respect of the history of Sheffield. This paper examines the soundscape with waterscape along the Gold Route formed in the city centre regeneration project. The changes of waterscape sound levels with frequency and time at different locations of the Gold Route are analysed. Comparisons have also been made between different water features along the Gold Route in terms of psychoacoustic parameters including loudness, roughness, sharpness, and fluctuation strength. A series of field questionnaire surveys in selected locations along the Gold Route have shown that water sounds are the most preferred sounds in the soundscape.

## 1 Introduction

The city's first settlement developed at the confluence of the Rivers Don and Sheaf, around the 12th century. With the role as a market town at this time, Sheffield had continued to be shaped by waterways. Sheffield's access to abundant natural resources made it an ideal centre for iron and steel industry, and the rivers contributed considerably to the production and industry of the city development. By the late 14th century Sheffield was famous for its metal knives and its role in this industry. Along with the industrial development in the 18th century, a large number of water powered mills along river banks and dams were developed. In the 18th century the Tinsley Canal was developed for connections for large steelworks. By the late 18th century all available sites on the rivers were developed. In the 19th century, Sheffield became the principal location in Britain for large steel works. In the 1980s of the last century, with the decline of the Sheffield steel industry, rivers lost their traditional function and became a forgotten part of the city. The character of the city in terms of the urban landscape was also changed by leaving redundant industrial buildings and vacant sites. In the recent city centre regeneration, starting in the 1990s, great efforts have been made to ensure that the reconnection with the rivers continues to be fostered and their role in the history of the city celebrated [1,2].

## 2 Gold Route and Waterscape

Under the regeneration of the Sheffield City Centre, waterscapes and squares were embedded into the city for its vibrancy with the respect of the history of Sheffield. Along the Gold Route, as shown in Figure 1, a diversity of waterscapes has been developed. Correspondingly, in Figure 2 the changes of waterscape sound levels with frequency and time at different locations of the Gold Route are shown. A series of field questionnaire surveys in selected locations along the Gold Route have shown that water sounds are the most preferred sounds in the soundscape, as shown in Figure 3 [3].



Figure 1: The Gold Route in Sheffield showing the waterscape and the city: 1. Sheaf Square; 2. Howard Street and Hallam Garden; 3. Millennium Galleries and Winter Garden; 4. Millennium Square; 5. Peace Gardens; 6. Town Hall Square and Surrey Street; 7. Barkers Pool.

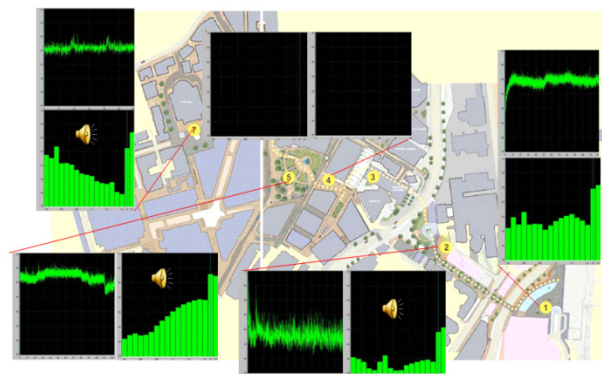


Figure 2: Changes of waterscape sound levels with frequency and time at different locations of the Gold Route, measured at 1m from each water feature.

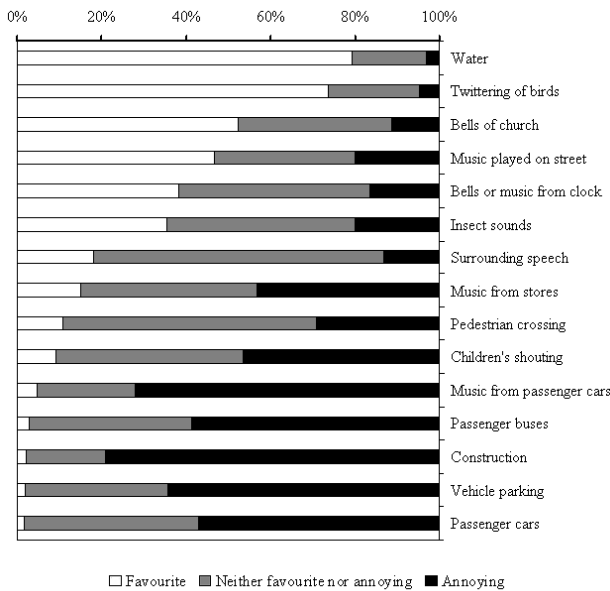


Figure 3: Sound preference evaluation based on surveys in Barkers Pool and Peace Gardens.

### 2.1 Barkers Pool

Figure 4 shows the change of soundscape when moving away from the water feature in the Barkers Pool, in terms of spectrum and dynamic range. It is interesting to see the richness of soundscape within a relatively short distance, giving a considering scope of soundscape design.

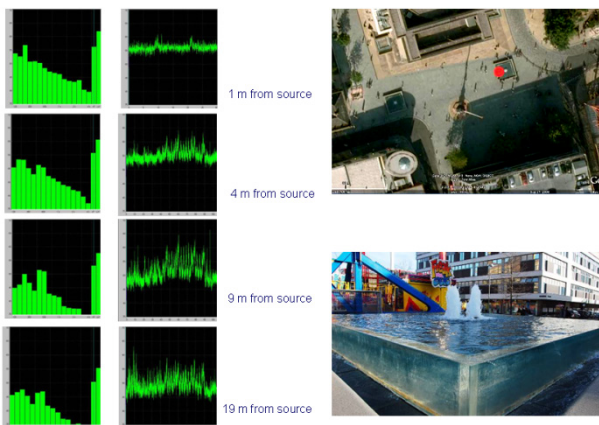


Figure 4: Change of soundscape when moving away from the water feature in the Barkers Pool.

### 2.2 Peace Gardens

Similar to Barkers pool, the change of soundscape is shown in Figure 5 when moving away from the main fountain in the Peace Gardens. Correspondingly, a soundscape map can be developed, overlapping sound field from different sources, as shown in Figure 6 as an example. To further analyse soundscape maps, comparisons on spectrum would be useful, as demonstrated in Figure 7. It is important to note that the first noticed sound may not be the loudest one, as can be seen in Figure 8 from the results of a large scale field survey.

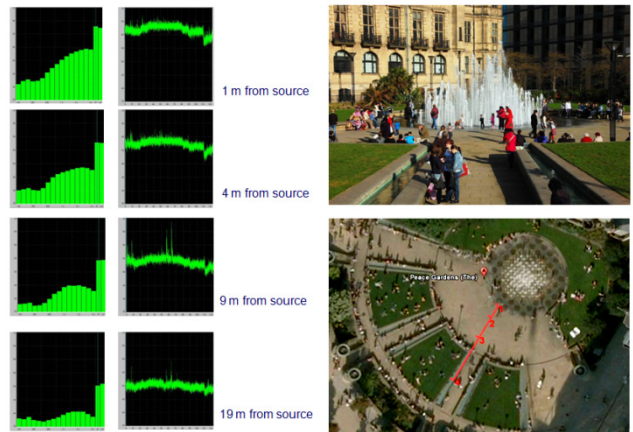


Figure 5: Change of soundscape when moving away from the main fountain in the Peace Gardens [Plan from googlemap].

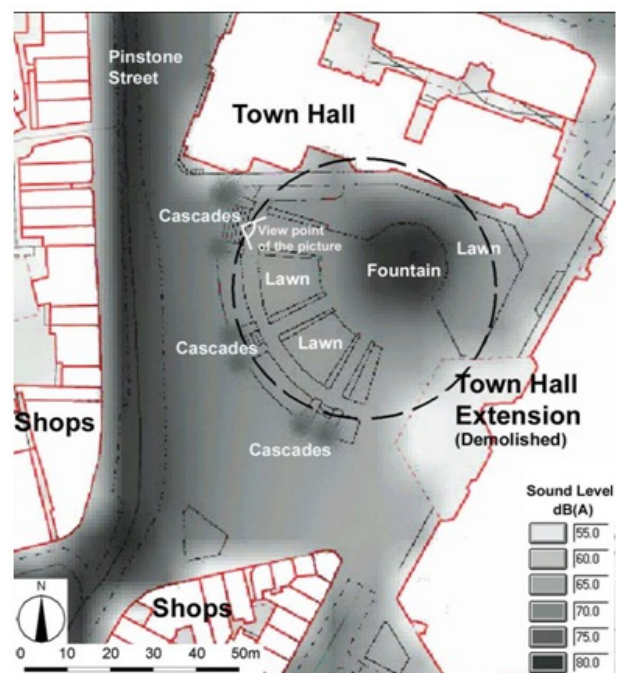


Figure 6: An example of soundscape map in the Peace Gardens.

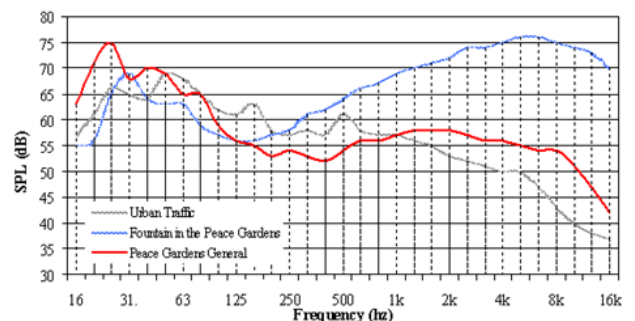


Figure 7: Spectrum comparison between different sounds in the soundscape of the Peace Gardens.

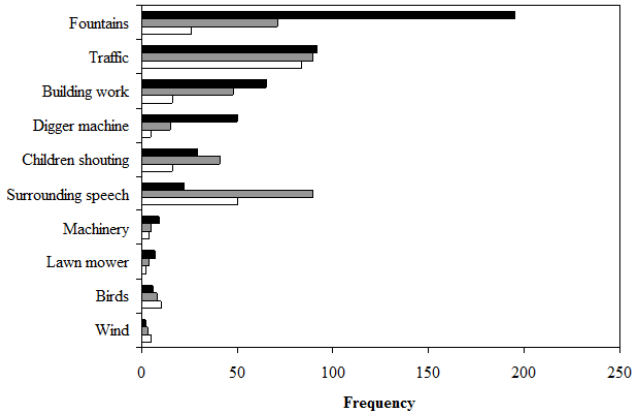


Figure 8: Notice-ability of different sounds in the soundscape of the Peace Gardens.

### 2.3 Millennium Square

While sound of water features are normally pleasant and will attract people’s attention from unwanted sounds such as traffic, silent water features in the Millennium Square, as shown in Figure 9, with their significant visual effect, could also play a similar role. Because of the low sound level, people often turn their attention to such water features to try to hear the sound and thus, the attention could be attracted, leading to effective attention masking.



Figure 9: Silent water features in the Millennium Square.

### 2.4 Howard Street

The water features as shown in Figure 10 have relatively large dynamic ranges and the spectra are also rather different from other water features along the Gold Route. Together with the visual effects, the water features great enhanced the richness and diversity of the waterscapes and soundscapes of the Gold Route.



Figure 10: Water features in the Howard Street.

## 2.5 Sheaf Square

Sheaf Square provides interesting and enjoyable soundscapes. There is a number of water features and the measurements (see Figure 11) show that they vary considerably in terms of spectrum and dynamic process, as can be seen in Figures 12 and 13. It is very interesting to note that the steel barrier reduces noise from the busy road efficiently as shown in Figure 14 and also, generate pleasant water sounds. It is a very successful soundscape element.



Figure 11: Plan of the Sheaf Square [based on googlemap], showing a range of water features, and the measurement points: 1, Steel barrier; 2, Medium cascade; 3-6, Big fountain (1,3,5,10m); 7, Small cascade L1; 8, Small cascade L3.

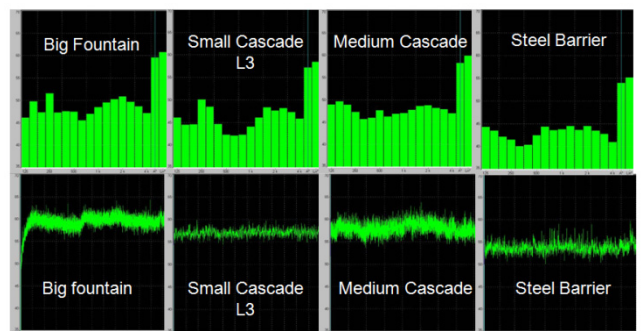


Figure 12: Changes of sound levels with frequency and time at different locations of the Sheaf Square, measured at 1m from each water feature.

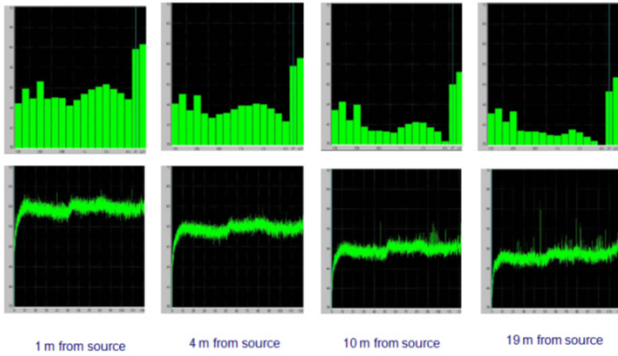


Figure 13: Change of soundscape when moving away from the main fountain in the Sheaf Square.

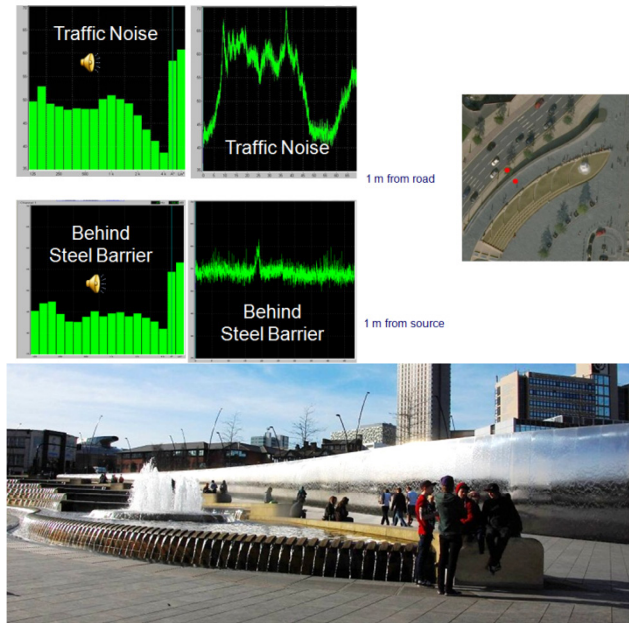


Figure 14: Comparison between sound levels on the road side and behind the barrier, Sheaf Square. [Plan from googlemap]

### 3 Psychoacoustic factors

Comparisons have also been made between different water features along the Gold Route in terms of loudness (Figure 15), roughness (Figure 16), sharpness (Figure 17), and fluctuation strength (Figure 18). The results show again the diversity of soundscape, as can also be seen in Table 1. In Figures 15-18 and Table 1 the data of traffic noise measured in the Sheaf Square are also shown, and there are generally considerable differences compared to those of the water features.

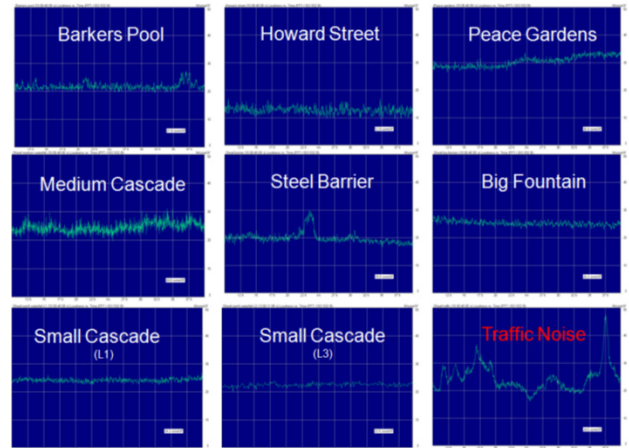


Figure 15: Comparison of loudness vs time between different water features on the Gold Route.

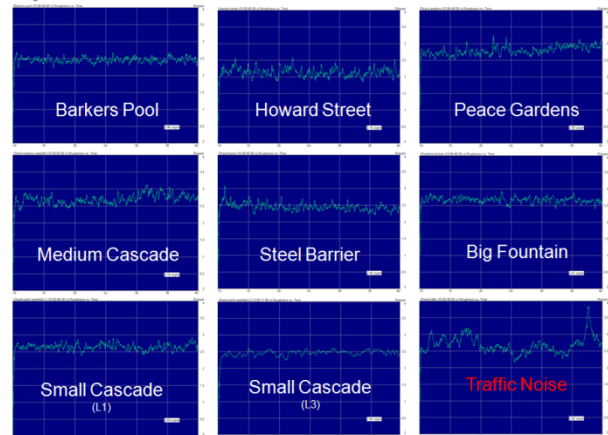


Figure 16: Comparison of roughness vs time between different water features on the Gold Route.

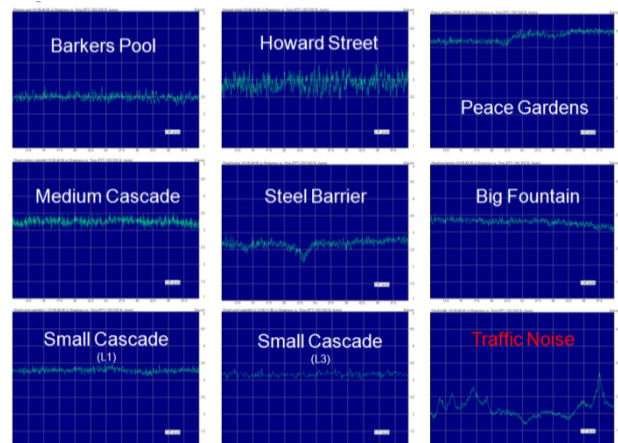


Figure 17: Comparison of sharpness vs time between different water features on the Gold Route.

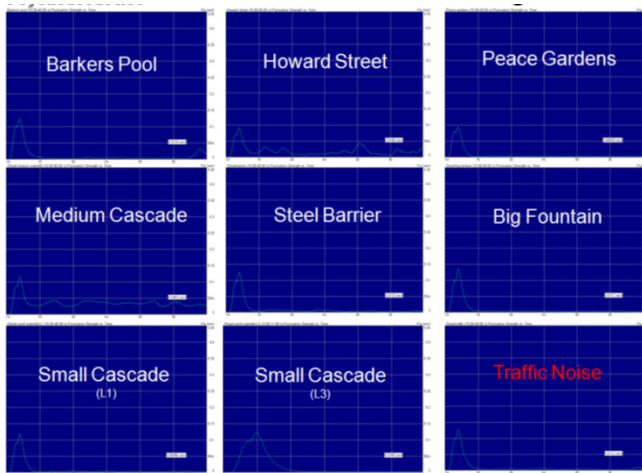


Figure 18: Comparison of fluctuation strength vs time between different water features on the Gold Route.

Table 1: Comparison of psychoacoustic factors between different water features on the Gold Route.

Water	Psychoacoustic indices	Fluctuation Strength vacil	Loudness (FFT/ ISO 532 B) soneGF	Roughness asper	Sharpness (FFT/ ISO 532 B, Aures) acum
Barkers Pool		0.0125	21.8	2.46	2.50
Howard Street		0.0198	12.8	2.14	2.91
Peace Gardens		0.00829	30.4	2.80	4.32
Medium Cascade		0.0363	24.6	2.70	3.26
Steel Barrier		0.0110	19.9	2.45	2.67
Big Fountain		0.0111	25.2	2.67	3.29
Small Cascade(L1)		0.00956	24.2	2.64	3.29
Small Cascade(L3)		0.0189	22.5	2.45	3.17
Traffic Noise		0.0112	24.6	2.69	2.17

## 4 Conclusions

Through the systematic review of the current progress in soundscape, the complexity as well as potentials of soundscape research and practice has been demonstrated. The current research works in soundscape are still at the stage of describing and identifying the problems, and they tend to be fragmented and focused on only a few special cases. Thus, although considerable work has been carried out, further research is still needed in more facets, and practical implementation of the research work is yet to start. The case studies on the Sheffield Gold Route demonstrate the great potential of creating good soundscapes.

## Acknowledgments

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## Reference

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