WARWICK DISTRICT COUNCIL

TO: **Members – September 2019**

SUBJECT: **Utilising Green Barriers to Improve Local Air Quality**

REPORT BY: **Harry Williams, Community Partnership Team, Sustainability Projects Assistant.**

1.0 **Report Background and Aims**

Air pollution consists of air which contains substances that have harmful effects, including particulate matter, nitrogen dioxide, sulphur dioxide, and carbon monoxide. In recent years, there has been growing concern into the effects of air pollution in urban areas on human health and the environment. These effects are illustrated by the fact that pollutants are estimated to cause approximately 1.3 million deaths worldwide every year (World Health Organisation, 2012), and lead to cardiovascular and respiratory illnesses. Not only this, but according to GOV UK (2018), "poor air quality is the largest environmental risk to public health in the UK", and can cause asthma, hospital admissions related to respiratory/cardiovascular systems, and death.

Based on this, it is clear that poor air quality is a major issue and interventions are needed to improve the current situation. The use of vegetation in the form of green barriers, (a type of green infrastructure (GI)), has been proposed to improve local air quality as plants have the ability to absorb such chemicals through pores on their leaves. Not only this, but vegetation can disperse pollutants away from affected areas. These green barriers may include green walls, green roofs, hedges along the road side, and trees. However, there are multiple studies on this with mixed results.

Based on the above, this report aims to discuss the current understanding of how green barriers may contribute to improving urban air quality. The report will be laid out in key sections as follows. Section two will discuss in more depth the key types of green barriers, section three will look at how green barriers work in terms of deposition and dispersion and section four will look at further benefits of green barriers. Section five will consider the evidence regarding the effectiveness of green barriers, section six will look at case study examples, and section seven will discuss some practical issues regarding green barriers. Finally, section eight will present conclusions and recommendations of this reports findings.

It is hoped that this reports findings will be used to make a case for green barrier installation, and to improve the quality of life for residents in the District.

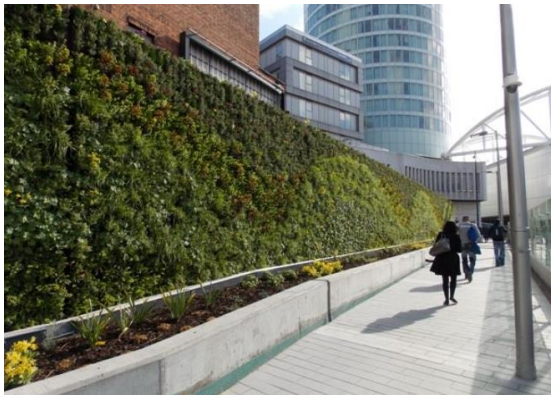
2.0 **Types of Green Barrier**

Green barriers are a type of GI, defined by Natural England as “a strategically planned and delivered network of high quality green spaces and other environmental features…It should provide ecological services and quality of life benefits needed to underpin sustainability.” There are several types of green barriers that can be used to improve air quality, listed as follows:

Green roofs: Green roofs are formed when vegetation is planted on any roof structure (GRPB). These may consist of either extensive or intensive types. Intensive roofs grow on deeper soil layers, require high levels of maintenance, and can be used to grow food or form gardens. By contrast, extensive roofs contain a shallower substrate layer, utilise low growing plants and are lower maintenance. Green roofs can also be grouped into further categories depending on their intended purpose, including: blue green roofs (to store rainwater), bio solar roofs (vegetation and solar panels) and biodiverse green roofs (EFB, 2019).

Green walls: Green walls consist of vegetation growing vertically upwards along a wall. Types of green wall may include: green facades (trellises and plants grown into planter boxes), bioactive facades (buildings with surfaces which encourage plants to grow where they would not usually), and living walls which are installed as a complete package and usually irrigated automatically by pumps.

Hedges and trees: These can also be used along road sides as a way of attempting to improve air quality if planted in the most beneficial places.



Green Wall, Birmingham New St Station.

Green Roof, London, United Kingdom

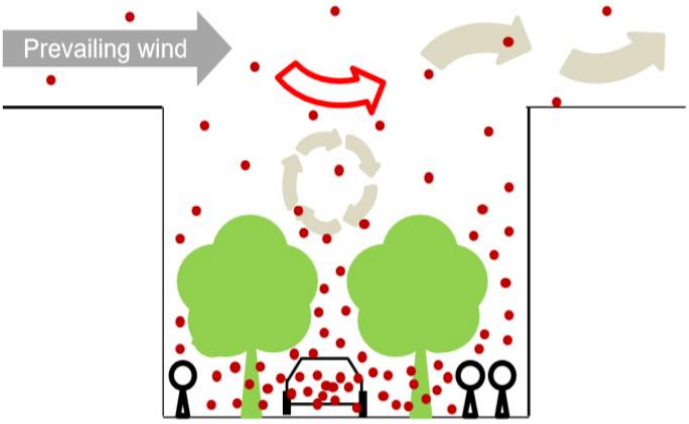
3.0 **How Green Barriers Work**

There are two mechanisms through which green barriers improve local air quality. Dispersion is the major mechanism, where the speed and distance that pollutants travel is altered before they cause harm to people. As the pollution travels away from the original concentrated area, the level of pollution is diluted. Alternatively, deposition also removes a lesser amount of pollution from the air. When falling on a plants leaf, the pollutant is taken up by the plant and removed from the air.

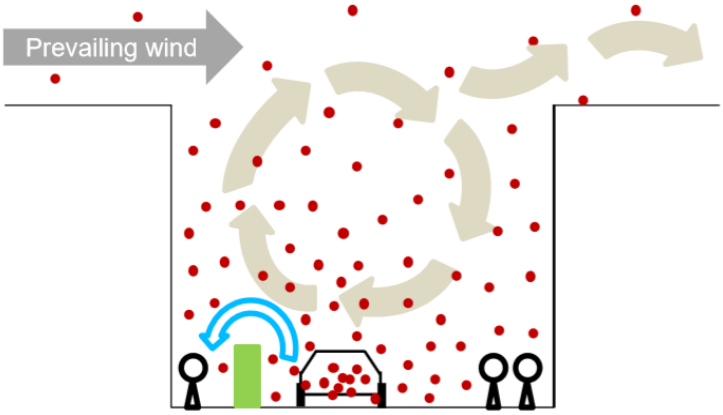
To maximise the benefit of green barriers, the appropriate green barrier must be used in the correct place. This depends on whether the given environment is a street canyon or open road. Street canyons are comprised of a road with buildings on each side. Open roads may have buildings on one side with open space on another, or detached single storey buildings may be present on both sides. See table below (Adapted from Greater London Authority, 2019):

Street Canyons		Open Roads	
Scenario Where air quality at the street level is better than the air quality above surrounding buildings (little traffic):	**Appropriate Green Barrier** Use a dense avenue of trees to protect the street from the above polluted air.	**Scenario** Where the priority is to protect people at the road side, e.g. cyclists and pedestrians.	**Appropriate Green Barrier** Use hedges and green walls to act as a barrier to pollutants.
Scenario Where air quality at the street level is poorer than the air above:	**Appropriate Green Barrier** Add green space to one side of the street canyon if possible, or add hedges/green walls between vehicles and people.	**Scenario** Where the priority is to protect people further away, e.g. children in playgrounds which border the street.	**Appropriate Green Barrier** Combine hedges and a dense row of trees to provide a tall barrier of vegetation. This offers protection over a greater distance.

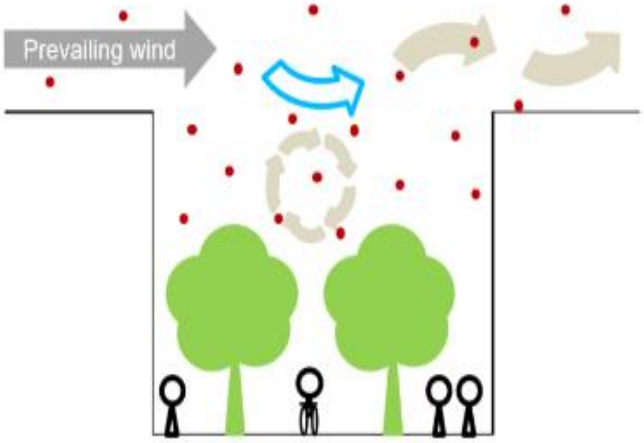
Street Canyons



Where there are high volumes of traffic, it is often the case that street level air is worse than the air above. Densely packed trees may trap this air so their usage should be avoided. However, widely spaced trees may be used although there will be little impact on air quality.

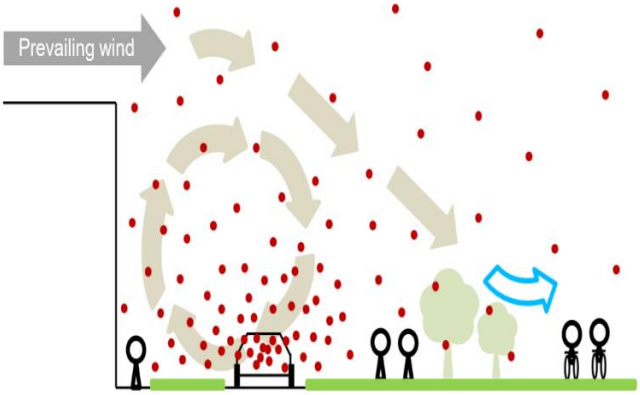


On busy roads where there are high levels of air pollution at street level, hedges can be used to reduce contact with cyclists and pedestrians.

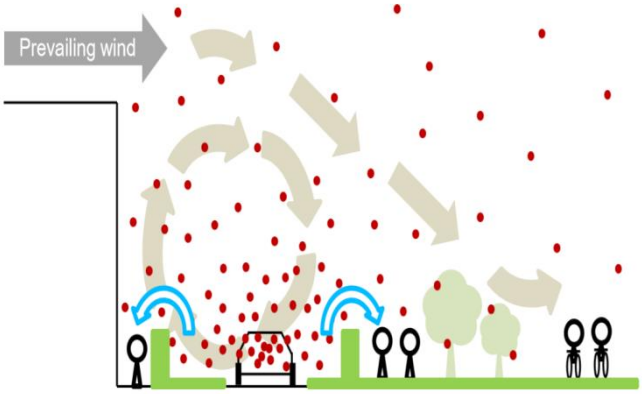


If air above street level is more polluted (e.g. roads with little traffic), densely packed trees can have a positive effect as a clean air 'zone' is created on the street level. This is because air from higher up is prevented from being dispersed downwards.

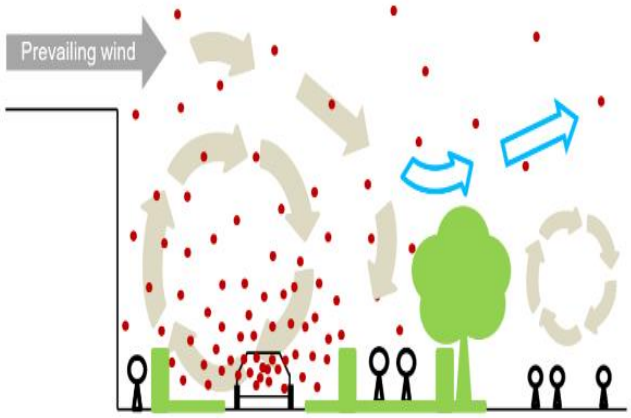
Open Roads



If there is open space near a road side, pollutants can disperse away from their original source making them less concentrated. If trees are in parkland/open spaces, they can help dilute polluted air.



Hedges act as barriers between people on the roadside and those in open spaces. Where hedges are close to buildings, pollutants travel further from the road source to pedestrians, providing protection. Hedges next to open spaces help to disperse polluted air over and away from the open space.



If the people who require protection are a large distance away from the road, green barriers such as trees are required to reduce levels of air pollution.

All diagrams are taken from Greater London Authority, 2019.

4.0 **Further Benefits of Green Barriers**

In addition to improving air quality in local areas, green barriers have numerous other benefits which come with their installation, for example:

- **Managing surface water:** due to impermeable surfaces in urban areas, flooding is often an issue. Green roofs help to control/absorb flows of water and can contribute to flood control.
- **Urban cooling:** Both green roofs and walls help to cool building exteriors and internal rooms. This occurs through insulation, shading, albedo and evapotranspiration.
- **Biodiversity:** Depending on type of vegetation, structure and setting, green roofs can provide habitats for species such as birds, invertebrates and bats.
- **Noise reduction:** Growth media and soils help to absorb noise, creating sound barriers.
- **Health and wellbeing:** Intensive green roofs allow green space for people to relax whilst extensive green roofs improve health and wellbeing through noise reduction and air quality improvement.
- **Carbon storage:** Vegetation and soil has the potential to store carbon as organic matter. Depending on the depth of the growing medium, green roofs can store a considerable amount of organic carbon permanently. It is estimated that an extensive green roof, including vegetation and substrate can store **375g of carbon for every square metre**.

5.0 **Studies Regarding the Effectiveness of Green Barriers**

There are several studies showing mixed results in terms of the effectiveness of green barriers in reducing air pollution and improving air quality. This is important because to make recommendations to stakeholders, evidence of effectiveness needs to be strong. Some studies have been listed below to give an idea of whether using green barriers to combat air pollution would be useful to Warwick District Council.

One high profile study, undertaken in 2012 by Pugh et al in the journal of Environmental Science and Technology has shown that vegetation (green walls) in street canyons can reduce NO2 (nitrogen dioxide) by 40% and PM (particulate matter) by 60%. Additionally, the study showed that vegetation can continue reduce pollutant levels even if the original source of pollution is removed, this being importance since some pollutants have long atmospheric lifetimes. Clearly, this suggests that green barriers can have a significant impact on pollution in urban areas.

Additionally, the European Commission has given evidence from a study undertaken by Churkina et al (2017). According to the paper, it is possible for volatile organic compounds (VOCs), such as isoprene and monoterpenes from vegetation (trees in this case), to reduce air quality. Within the paper, two study years in the summer of 2006 and 2014, were examined for the impact of trees on air quality. On average, the presence of vegetation was thought to be responsible for 12% of the ozone present. However, since trees can both increase and reduce pollutants, the overall effect is complicated with pollutants both being reduced and enhanced.

Alternatively, the University of Surrey has referenced a study published in Atmospheric Environment. This illustrated that where there are buildings near to the roadside, hedges can have a much greater impact on producing air pollution than trees. This is because trees can end up trapping air pollution on the street level. It was found that in the study undertaken in Guildford, roads that only had hedges cut the levels of black carbon by 63%. In contrast, there was no reduction in air quality along roadsides with just trees. This strong evidence for the use of hedges in street canyons could be useful for Warwick District Council's next steps of implementation.

To back up the effectiveness of green barriers, ivy along the A38 in Birmingham was used and when compared to ivy from a nursery, the results clearly showed that the plants exposed to the road had always captured more particulates. Similarly, Forest Research completed a study regarding this topic to investigate the impact of vegetation on particulate matter 10 levels. They found that by using grassland, sycamore maple and Douglas fir that 90 tonnes per year of particulate matter was captured. This was modelled to show that 2 deaths and 2 hospital admissions could be avoided annually, showing significant benefits of vegetation usage due to the health issues that can be avoided.

6.0 **Green Barriers and Air Quality: Case Studies**

Some organisations and councils have implemented green barriers, with several doing so to improve air quality. This is significant because these case studies may mirror the effectiveness of such green infrastructure if Warwick District Council were to use a similar approach. Notable examples below include installations in Birmingham, Southampton, London and Manchester.

Birmingham, United Kingdom: When Birmingham New Street station was redeveloped, ecology was considered an important component of the project to improve. Initially, in 2012, a 325 meter squared green wall was proposed by Network Rail and has a result of advice from ecologists. However, in 2017 this wall was removed due to the plants exhausting nutrients from their soil. Due to this, a new wall has now been installed by Biotecture with a hydroponic system and 16,000 plant species. This was done with the aim of improving air quality due to the presence of diesel trains and the resulting NOx. Species in the new wall include Heucheras and Armenia to provide colour in the spring and summer, with Pachysandra and Euonymus acting as ever green plants over winter. Maintenance post completion is undertaken by Biotecture who are contracted to do so.

Southampton, United Kingdom: Southampton City Council and Balfour Beatty are currently in the process of completing a living wall project to improve air quality on Millbrook Roundabout which is due to be completed in October 2019. Like Network Rail's project in Birmingham, this project is also being completed by Biotecture as a hydroponic living wall without needing soil. The foundations and frame of the wall are being installed by Balfour Beatty, and Biotecture is responsible for designing and positioning the wall. At the time of writing this report, the cost of the project was requested from Southampton City Council but will require completion of a freedom of information request.

Manchester, United Kingdom: Manchester City Council and Transport for Greater Manchester are funding a project surrounding hedges and playground air pollution – the "Protecting Playgrounds" project. The project will be delivered by the charity, Groundwork, who aim to ensure strong and green communities are maintained (e.g. ensuring good health, poverty alleviation and improving people's skills). Four schools that currently have no barrier other than mesh or railings between the playground and main road are completing the study. It is hoped that students will play an active part in being trained to measure air quality, and learn about new cleaner travel routes. Findings of this study will be published in late 2019.

London, United Kingdom: In West Minster, the city council is trialling living moss benches which have become known as the CityTree, originally designed by Green City Solutions in Germany. The designers state that the technology is capable of removing such as nitrogen dioxide and particulate matter by 30%. According to the Green City Solutions website, installation of a CityTree is completed through a location analysis where the optimal location can be pinpointed. Maintenance of the CityTree is achieved through generating real time data, which is then provided to service teams so they can take appropriate maintenance steps. In terms of cost, each unit used in West Minster costs approximately £17,600. It may be useful to contact West Minster City Council to find out the cost of maintenance.

7.0 **Practical Considerations**

In addition to cost and maintenance mentioned above, there are several practical considerations which must be considered by Warwick District Council before the implementation of any green barriers can take place. These are presented in the tables below adapted from Greater London Authority (2019):

Species Considerations	
Effect of seasons	Evergreen plants are most advantageous as they act as a pollutant barrier all year round. However, species most suitable for the given area must be used.
Allergens, stress resistance and invasiveness	Vegetation must be resistant to local pollutants, salt, drought and turbulence. Invasive species and those producing allergens should not be used.
Leaf deposition surface	Deposition is an important factor despite the role of dispersion. Large, waxy and/or hairy leaves should be used if suitable for the local area.
Volatile organic compound emissions (VOCs)	As climate warms, certain species may release increased VOCs. These species should be avoided.

Considerations of Physical Vegetation Characteristics to Act as Barriers between Emissions and People	
Height	A minimum height of 2m for hedges and green walls should be used to protect people in the surrounding area. A barrier of **H metres** can protect a downwind distance of **(3H)-3** metres..
Thickness/Density	Barriers intended to protect against roadside emissions should be as thick and dense as possible. The thicker and denser the barrier, the less air flow through it and the more air flow over it.
Safety	When barriers are installed, guidance must be followed to ensure sight lines, vision splays and safety provisions for cyclists, pedestrians and drivers are maintained.
Installation and Maintenance	Barriers must be installed and maintained to sufficient standards to ensure success.

*****In regard to the height consideration, if a barrier of 5m was installed, the downwind distance protected against pollution would be (3 X 5) - 3 = 12m.

8.0 **Conclusions and Recommendations**

To conclude, there is certainly strong evidence that green barriers can work to combat air pollution in local areas, especially through dispersion. However, the appropriate type of green barrier must be used in order to ensure that air pollution is not unintentionally increased or trapped in an urban area (e.g. under a tree canopy), resulting in a reduction in air quality.

Case studies have shown that the installation of green barriers by various organisations is a fairly recent type of infrastructure to use, and that some results of the effectiveness are not available, and will be published towards the end of 2019. It is also the case that costs have

been hard to obtain, so further follow up is required. This includes both installation and maintenance cost. It should also be remembered that every green barrier installation is different so costs vary on a case by case basis, still, it would be useful to have a rough idea of the cost of some existing projects. Therefore, Warwick District Council should make further contacts with supplier companies and other councils before proceeding with any projects.

The final important point to take away is that there are multiple practical considerations of green barrier installations which must be considered before any project is given the go ahead. This is important to ensure the green barrier used provides the best results for its intended purpose in a given area. Warwick District Council must therefore ensure that the area proposed for the green barrier installation is appropriate, and that the chosen type of barrier will function effectively in this area.