“Comparing and contrasting the challenges and benefits of brownfield and greenfield sites for development.”
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Submitted for: Bsc (Hons) Architectural Design and Technology, Cardiff Metropolitan University

Declaration:

“I declare that this dissertation has not already been accepted in substance, or in part, for any degree and is not currently submitted in candidature for any degree. I further affirm that the substance of this work is entirely the result of my own independent research, except where otherwise stated.”

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1. Introduction

'We need to build more homes in this country so making sure that we re-use brownfield land is crucial. We want to bring life back to abandoned sites, create thousands more homes and help protect our valued countryside' (Gov.uk, 2017).

It is clear that Britain is in a housing crisis and that there is a need for more houses. It is estimated that there are over 66,000 hectares of brownfield sites in England alone (Sustainablebuild.co.uk, 2017) whilst the use of brownfield sites may bring advantages there are challenges too, therefore it would seem a relevant subject to discuss in this report.

The aim of this report is to consider brownfield and greenfield land classifications. The definition of both brownfield and greenfield sites will be explored. The report will also be investigating the use of the greenbelts, which surround the UK’s cities, and why it is important to maintain green open spaces. Case studies will be used throughout the report in order to give a clear understanding of each subject. The benefits and challenges involved with developing greenfield and brownfield sites will also be investigated, as brownfield site development seems more challenging and undesirable than greenfield site development. By looking at the challenges involved when developing brownfield sites, it may give an indication as to why there are so many in the UK. The development of greenbelt land will also be explored, as it seems a controversial topic.

1.1. Aim

To identify the benefits and challenges involved in brownfield development today.

1.2. Objectives

1. Establish whether all land is the same (exploring land classification used).
2. Investigate examples of developments on different types of land.
3. Discuss the benefits and challenges associated with developing different sites (benefits/challenges/advantages/disadvantages).
1.3. Evaluation of Sources

The use of secondary data will be used throughout the report in order to gain a broad range of information. 35.18% of the sources used are government websites or documents, or .org sites which are non-commercial, so are immediately considered credible as they have the weight of governmental institutions behind them, and their authors are employed as experts in their field.

A small number of sources are news articles which while current (2018) their credibility and reliability could be questionable. Fiona Harvey for example, is an award-winning environmental journalist who while working for the Guardian at present has previously reported for the Financial Times for a further 10 years, she has clearly got experience in writing about these issues but, caution must still be taken as some bias could be involved.

The majority of sources used in this report are current 44.44% being less than 3 years old, due to the fact that the topic is an important one and is consequently being continually reviewed, investigated and substantial new developments are in place. Those sources which are less current (10+ years old) still have a value due to the information gained being historical in nature. An example of this would be a source with information regarding the redevelopment of the London Olympic Park (Geocases2.co.uk, 2007). Sources, which are not historical but not immediately up to date; for example Foulds et al., 2014 may still be considered valuable but care must be taken in case information has changed slightly.

2. Land classifications

2.1. Brownfield sites

By definition, a brownfield site is an area of land, which has previously been built on or developed in some way and has become available for development, due to the building or site becoming derelict. Brownfield sites became more frequently used after the government set a national target in February 1998 to ensure 60% of all new developments were built on brownfield land (politics.co.uk, 2012).

There are four main types of brownfield site: vacant, derelict, contaminated and utilized. A vacant brownfield site is an empty site, for example, a site that may have
previously been built on and the building has now been knocked down. A derelict brownfield site is a site that still has a building on it in a state of disrepair as a result of being neglected. Having a contaminated site means the site may have been used for the production of harmful substances such as oils gases and asbestos and cannot be redeveloped until the site has been decontaminated, this is the most complicated, costly and time-consuming, as the site requires a lot of work before any construction work can begin. A utilized brownfield site is a site which is still in use but has potential to be redeveloped; this type of site can also be problematic as it may be required to re-house people as a result of the redevelopment (Legislation.gov.uk, 2017).

2.2. Greenfield sites

A greenfield site, in contrast to a brownfield site, is a piece of land which has never been previously been built on or developed hence the name ‘greenfield’ as it is effectively an untouched plot of land. Although greenfield sites are more frequently found in rural areas and have been previously used as agricultural land, they can also be found in urban areas although it is much less common. Greenfield land, which becomes available for development in urban areas, would probably be parkland or green belt land (Sustainablebuild.co.uk, 2017a).

2.3. Greenbelt land

Contrary to popular belief, green belt land is not necessarily always open countryside; greenbelt designation is an issue of policy and not always related to the wider countryside (Bahar, 2017). On the 27th of March 2012 the National Planning Policy Framework was published and in it states the importance of greenbelt land and how it also promotes the development of brownfield sites (National Planning Policy Framework, 2012). It promotes the development of brownfield sites as greenbelt designation reduces the amount of greenfield land available for development. Greenbelt land is an area of designated land surrounding large major cities; they separate cities and create development boundaries.

Green belt land has 5 main purposes:

1. To check the unrestricted sprawl of large built up areas.
2. To prevent neighbouring towns merging into one another.
3. To assist in safeguarding the countryside from encroachment.
4. To preserve the setting and special character of historic towns.
5. To assist in urban regeneration, by encouraging the recycling of derelict and other urban land.


2.4. Amberfield sites

In 2015 the Royal Institute of Chartered Surveyors (RICS) released their Residential Policy, which called for the government to introduce an Amberfield land classification. An Amberfield classification would be a means of identifying land, which is ready to be developed. The land could be greenfield land of low quality and not in any greenbelt designation or it could be brownfield land which has been dealt with accordingly and is ready for development. By introducing this new classification, it would be a clear way to advertise land, which can be developed immediately at lower costs than complicated brownfield and greenfield sites (RICS Residential Policy, 2015). If brownfield landowners were able to develop their sites into Amberfield sites, they would be much more attractive to potential buyers and developers. If Amberfield classification were to be introduced, it would effectively fast track the development of housing and reduce the current housing shortage (RICS Residential Policy, 2015).

3. Land classification – Case studies

3.1. Cardiff Bay – Brownfield development

In 1987 the Cardiff Bay Development Corporation was set up to regenerate the huge brownfield site to the south of the city centre (Geowilmington.weebly.com, 2016). There were a total of 5 docks opened between 1830 and 1907. The docklands were used as a major iron exporter; coal was also exported from the dock due to the amount of coal being mined in the South Wales valleys, which are just north of the city. The docks were so successful that the owner John Crichton-Stuart, 3rd Marquess of Bute was at the time the richest man in the world (Caerphilly.gov.uk, 2013) (figure 1). However, after the Second World War most of the industry in the South Wales area declined so much that the docks were made redundant by the early 1980s and eventually closed and the whole site became derelict (figure 2).
Figure 1: Cardiff Docks in its heyday 1900s (Fluidr.com, n.d.)

Figure 2: Cardiff Docks derelict 1980s (Revitalizationnews.com, 2017).
As part of the British government’s Urban Development Programme to regenerate deprived areas of inner cities, the corporation was set up to redevelop the 1,100 hectares of derelict docklands of Cardiff and Penarth. The five main aims and objectives of the regeneration project were:

1. To promote development and provide a superb environment in which people will want to live, work and play.
2. To reunite the city centre of Cardiff with its waterfront.
3. To bring forward a mix of development, which would create a wide range of job opportunities and reflect the hopes and aspirations of the community.
4. To achieve the highest standard of design and quality in all types of development and investment.
5. To establish the area as a recognised centre of excellence and innovation in the field of urban regeneration.

(Cardiff Harbour Authority, 2017)

One of the biggest changes the Cardiff Bay Development Corporation wanted to make was to build a 1.1km long barrage connecting Cardiff docks to Penarth. The proposed barrage was estimated to cost £220million, which began construction in 1994 and was completed by 1999 (Cardiff Harbour Authority, n.d.). At the time there were many people opposing the plans as they thought it could result in major flooding and the loss of habitat for wading birds and migrating wildlife (Crockett, 2017).

When the Cardiff Bay Development Corporation stopped work in March 2000 it had completed many of its aims and objectives and is estimated to have created 16,750 new jobs, 4,800 new housing units, 695,000m² of new non-residential developments, it opened 79 hectares of open space for the public, and it built 42km of new or upgraded roads (Cardiff Harbour Authority, 2017a). These figures were made possible due to the vast number of shops, bars restaurants, office blocks, and flats, which were built as a result of making an artificial freshwater lake due to the barrage being built. Cardiff Bay is now a tourist hot spot as well as a place of work and home for many people.
Later in 2004, the Millennium Centre, a music and arts centre was opened, and in 2006 the Senedd, the home of the National Assembly for Wales was opened. Both of which have large architectural significance becoming attractions in their own rights. Other attractions include the Techniquest science centre and the Dr Who Experience (Urban Strategies, 2014) (Figure 3).

![Figure 3: Cardiff Bay as it is today (Doug Taylor, n.d.)](image)

The Cardiff Bay redevelopment is thought of as being highly successful as a result of all of the jobs and tourism it now brings. In 2014 Urban Strategies was charged with creating a plan to complete the regeneration of Cardiff Bay as a world-class tourism and leisure destination (Urban Strategies, 2014).

3.2. Plasdŵr – Greenfield Development

The Cardiff local development plan 2006-2026 states the need for a significant number of new homes, due to the city’s growth. Independent population forecasts suggest the need for 41,100 new homes in this 20-year period. There will be new developments across most of the city (figure 4). Approximately 65% of the new dwellings will be provided on brownfield sites and 35% are to be provided on greenfield sites. Providing this many brownfield sites for development is very important although it is also important to provide greenfield sites as well. Greenfield sites are generally used for affordable housing, as they are less challenging to work on, this is why it is important to provide greenfield sites for development (Cardiff Local Development Plan 2006-2026, 2013).
Some of the first large-scale developments have begun, plans for a modern ‘garden city’ have been approved, and construction work began on 1,200 homes in 2017. Situated in the North West of Cardiff, amongst Danescourt, St Fagans, Fairwater and Radyr (Figure 5); the development as a whole will contribute 6,680 new homes (including affordable housing) to the required 41,100 deemed necessary by the Local Development Plan. Offices, shops, schools, pubs restaurants and health centres will also be built on 331.3 hectares of greenfield land. The development known as Plasdŵr, is proposed to be a model for sustainable living. With an estimated cost of around £2 billion. In order for the development to be a sustainable ‘garden city,’ there are plans to encourage walking and cycling; all new roads will also include cycle lanes. Due to the scale of the development, it has been split into nine phases, the first of which has begun already. The dates have been given for the first three phases, which are planned to be finished by 2029; dates for the later phases have not yet been set (Plasdwr.co.uk, 2017).
Existing electrical and gas infrastructure already exists on the Plasdwr site, there are water mains crossing the development area and a new waste strategy will be developed (irma.net, 2014), as this is all in place it makes the development process simpler and faster.

3.3. Cardiff Greenbelt
Cardiff, the capital city of Wales, is the most populated urban area in Wales and has been subject to a vast amount of development in recent years. Gradually development has eaten into the surrounding open green land to the north and west of
the city. Cardiff naturally has its own borders with Caerphilly mountain to the north of the city, with Leckwith Escarpment situated on its western border and the Severn Estuary meeting Cardiff Bay to the south of the city, all of which are areas which are of natural beauty and all play a part in people’s perception of the city. As the development continues due to the demand of the growing city it puts these surrounding areas at risk of being built on and developed. It is considered that the designation of a greenbelt will assist the management of future urban growth (Cardiff Local Development Plan 2006-2026, 2013a). The designation of a strict green belt zone would be the only policy able to protect Cardiff’s surrounding picturesque areas, which help define the city and in turn, would keep its identity. However, as it stands today there is only what is known as a proposed greenbelt (sometimes known as a green wedge), which is acting as a green belt for the duration of the Local Development Plan. There is only one piece of green belt land in Wales and that’s situated to the East of Cardiff separating the city from Newport. The green belt was put in place here to prevent the two cities merging and in order to maintain their own identities. Although there are designated special landscape areas already in place surrounding Cardiff they are not enough to completely prevent development in the way that a designated green belt would (Figure 6).
Figure 6: Map showing designated and proposed green belt land, as well as areas of special landscape (Cardiff Local Development Plan 2006-2026, 2013a).

4. The benefits and challenges involved in the development of different sites.

4.1. Challenges involved with developing brownfield sites

Although there are many benefits from building on brownfield land, and development is encouraged, there are many problems associated with redeveloping these sites due to the developments that already exist on the site. As brownfield sites don’t only consist of land there are many challenges involved with their development.

Before redevelopment can begin, brownfield sites require assessments by many different experienced environmental consultants. Ground condition surveys are carried out in order to determine whether the ground is contaminated, if the ground is not contaminated development can commence. Vacant brownfield land is the simplest to redevelop, as it is theoretically a site, which has already been prepared for development. Once the existing construction work has been completely deconstructed and the appropriate ground condition surveys have been carried out,
then it is ready to be built upon. A vacant brownfield site is effectively the end product of the derelict, contaminated and utilized brownfield sites.

4.1.1. Challenges associated with derelict brownfield land

A derelict site still has old building work on it; in order for the site to be redeveloped the demolition of the existing building work must take place. Prior to the demolition work, the principal contractor must produce a health and safety plan and any demolition work about to take place must comply with the Construction (Design and Management) Regulations.

4.1.2. Challenges associated with utilized brownfield land

Utilized brownfield sites are often the most controversial as the demolition of occupied buildings must take place. Many of the tenants of houses, which require being demolished object resulting in an often costly and time-consuming process. In many cases, it results in developers paying up to 10% more than a building’s current market value depending on circumstances. A compulsory purchase order is often used which forces homeowners to sell their properties if it obstructs a regeneration development or if it is in the public’s interest (HomeOwners Alliance, 2017).

In 2014 a homeowner in Aberystwyth, West Wales refused to give up her home in order for a multimillion-pound shopping development to be built, she was the only resident on the street of 12 houses not willing to sell. As a result, a compulsory purchase order was issued as it was in the public’s interest to build the shopping complex as it would boost the town trade by between £1.6 and £3.5 million a year and create 295 new full-time jobs (BBC News, 2014).

4.1.3. Challenges associated with contaminated brownfield land

“Contaminated land” is any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that – (a) significant harm is being caused or there is a significant possibility of such harm being caused; or (b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused (Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, 2012).
In the UK there is a substantial legacy of historical land contamination involving a vast array of substances. All land has some sort of substance present, some occur naturally, and some are as a result of human pollution. And on some land, these substances are more concentrated. It is estimated that around 300,000 hectares of soil are contaminated with toxic elements in the UK (Cahill, 2016). Contaminated land is legally defined where substances could either cause significant harm to people, property or protected species, or if it could cause significant pollution to surface water such as lakes and rivers, land is also classed as contaminated if there is potential harm to people as a result of radioactivity (Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance, 2012). Local authorities can only define a site as contaminated if all of these conditions are met, there are many instances where land is contaminated in some way but does not meet the legal requirements of The Environmental Protection Act 1990: Part 2A, these sites are then unfortunately overlooked. Contaminated land is usually caused by waste products of factories, mines, oil refineries or even landfill sites. Contaminated land can also be classed as a special site if it affects drinking water due to surface water being contaminated. This could be due to the land previously having been used for activities involving certain industrial activities such as making explosives, if the site has been used to dispose of waste acid tars, or if the Ministry of Defence has owned the site, or if the site has been used for nuclear activities. If the site has been identified as a special site then it is regulated by the Environment Agency in England, or by Natural Resources Wales, in Wales.

To determine whether the land is contaminated the local authority or environment agency will conduct land inspections. The land is examined for various purposes, they could decide to look into it if the land is sold, is proposed for development or if the land is known to have been polluted.

The Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance was put into place in order to reduce the amount of contaminated land in the country. The aim of the report is to identify and remove unacceptable risks to human health and the environment, to ensure that contaminated land is made more suitable for its current use, and to ensure that the burdens faced by individuals, companies, and society as a whole are proportionate, and compatible with the idea of

Part 2A states the two main ways contamination tests are conducted, it also states that it is the local authority’s responsibility to determine where the contaminated areas of land are. Firstly, a strategic inspection takes place; this is carried out prior to visiting the sites to make an initial assessment on whether or not specific areas of land could have been contaminated at some point. This then identifies areas of land, which may be contaminated, and what they could potentially be contaminated by. After identifying where to conduct more in depth on site examinations, a more detailed inspection takes place. Ground condition surveys are then taken, and appropriate risk assessments are formed. Having then had strategic and detailed inspections conducted it then needs remediating. Where land is determined to be contaminated local authorities must provide remediation methods to high standards, which results in decontamination of the land, so it is designated fit for purpose. In Wales only around 3% (203 sites) of contaminated land is dealt with due to Part 2A, 93% (5,506 sites) of contaminated land is dealt with through the planning process, and around 3% (209 sites) are dealt with under voluntary action. Between 2001 and 2013, 5,922 contaminated sites were dealt with (Naturalresources.wales, 2016).

What is remediation?
Remediation is the process involved in the cleaning of the ground; it is the process that takes place to reverse the effects of land contamination to an extent where the ground is made suitable to use without environmentally harmful risks. There are numerous methods intended for the removal of contaminants. Remediation is needed in areas, which have been legally identified as contaminated land by Part 2A.

Every contaminated site is different therefore each and every remediation method must be tailored specifically to each site. The appropriate method is assigned to the given site based on the results formed from the detailed inspection; it takes into consideration the chemicals, minerals and biological factors affecting the site (Tyagi, 2007).
Phases of remediating a site

There are four phases involved in remediating a contaminated site. The first phase is known as a site walk over, having identified a potentially contaminated site after looking at historical maps to identify the site’s former uses; a site visit takes place in order to identify potential contaminants and a detailed report is then written. The site walk takes place in order to identify any visible signs of contamination such as spilt oil; the amount of plant growth is also taken into consideration (Lustreconsulting.com, 2017).

If there is still thought to be a potential contamination following the site walk, phase two commences; this involves another site visit in order to conduct a more in-depth analysis. Soil samples are taken to identify the concentration of each individual contaminant. The number of soil samples taken depends on the potential severity of the contamination report produced by phase one. Having analysed the samples taken it is then decided if the site is contaminated. Once the site is classed as contaminated the appropriate remediation techniques can be considered (Lustreconsulting.com, 2017) (see below).

Having completed phase two and identifying the site as contaminated a Remedial Options Appraisal is assigned, this gives the different remediation treatments available for the site and once the method is chosen remediation can begin. Phase four happens once the remediation itself is completed. Following the remediation, soil samples are then taken on site to provide assurance that the site is no longer contaminated (Lustreconsulting.com, 2017).

Methods of remediation

Physical treatment

The physical treatment of contaminated land includes anything that involves actual groundwork. There are many different types of physical treatment available for remediation; one form is known as pump and treat (Tyagi, 2007), this is the most common form of remediation, this form of treatment involves using a vacuum pump to bring the contaminated soil or groundwater out for further treatment above ground or off site.
Thermal treatment

Thermal treatment is where contaminated soil is heated up to remove pollutants; contaminants are exposed to extreme heat to dry out the soil and pollutants (burn off pollutants). There are two types of thermal treatment, high temperature that is between 320 to 560ºC and low temperature, which heats the soil between 90 and 320ºC (soilutions.co.uk, n.d,b). It can reduce the concentration of the contaminant making it much less harmful. Thermal treatment is most commonly used to reduce the amount of fossil fuels in soil. Heat treated contaminants can often be reused as they are only separated from the soil rather than being degraded which happens in other forms of remediation.

Chemical treatment

Chemical remediation is the process of using naturally occurring non-toxic chemicals to degrade chemicals, which are harmful to the environment. Chemical remediation can only treat naturally occurring chemicals. One form of widely used chemical remediation is soil flushing, soil flushing is the process of running a chemical solution through contaminated soil, it is flushed through via the use of injection wells, it is an effective yet costly process. Soil washing is another method, the process takes place off site and separates the contaminated soil from the uncontaminated soil, and it is then required to treat the contaminated soil separately or dispose of it. Chemical leaching is very similar as it also extracts the soil and is treated off site, the process then differs as instead of separating the contaminated soil and the uncontaminated soil it uses inorganic chemicals such as acids to remove contaminants. Chemical leaching is often used along-side soil washing to reduce the amount of soil, which needs to be disposed of (Tyagi, 2007).

Bioremediation

Bioremediation is a natural process that comprises of improving and controlling the ground to decrease the number of contaminants to a level, which is no longer classed as contaminated ground. Remediation methods, which involve physical and chemical applications, are often expensive and can produce secondary pollutants into the environment (Hattan, et al, 2003). The use of bioremediation is good for eradicating organic pollutants such as oils and gases. Bioremediation is thought of as the most economical and eco-friendly option for complete remediation, it is however,
a time-consuming method. There are two specific types of bioremediation, bioremediation with bacteria and enzymes, which is most commonly used, and bioremediation with fungi.

Bioremediation can take place on site or off site. By treating contaminants on site, it can minimise the disruption to the localised natural environment, on site treatment is however very limiting and will only work on some types of soil and isn’t very effective, it can only really reduce the harmfulness of the contaminants rather than completely dispose of them. When bioremediation takes place off-site the soil needs to be excavated, which affects the local environment quite significantly. Off-site it is possible to maximise efficiency by altering the temperature to aid the bacteria, it is also much easier to enhance the amount of oxygen available to the bacteria resulting in faster degrading times.

Bioaugmentation is where a certain bacterium can degrade a certain contaminant and so the bacteria are placed in the contaminated soil specifically to get rid of one contaminant. This can be a very time-consuming process as finding out which bacteria degrades each pollutant has many variants, for example, the bacteria may be able to degrade the contaminant but not at the PH level of the soil. Bioaugmentation can take place on or off site (soilutions.co.uk, n.d).

**Bioremediation with enzymes and bacteria**

Microorganisms are found everywhere and have an ability to break down and absorb contaminants quickly. There are two types of bacteria; aerobic, which requires oxygen to grow and anaerobic which doesn’t require oxygen. Aerobic bioremediation can be up to 100 times more efficient than anaerobic bioremediation, which is why it is much more commonly used (Ahlet & Peters, 2001). The efficiency of aerobic bioremediation can also be improved by adding nutrients and ensuring the bacteria have access to lots of oxygen to stimulate growth, this is known as biostimulation.

Biosparging is a form of bioremediation with bacteria, which can take place on or off site and involves the use of natural microorganisms. This form of remediation can only be used to break down natural pollutants, it is another form of aerobic bacteria which benefits from the having access to air. Many factors affect the effectiveness of the success of biosparging. The use of air injectors can increase the efficiency of this
process. Different soil types make a lot of difference when trying to control biosparing remediation, the temperature, acidity level, and iron content also affect the process (Tyagi, 2007).

Bioremediation with fungi
Contaminants such as pesticides, synthetic dyes and wood preservatives can be degraded with the use of fungi (Pointing, 2001). It is however, less often used than bioremediation with bacteria, as it is less effective.

Excavation
Excavation and the disposal of contaminated soil must be the simplest forms of remediation, the process involves digging up the contaminated land and disposing of it off site. An expensive landfill tax results in this simple method being rarely used instead the development of other remediation technologies has taken place in order to find cost-effective alternatives (soilutions.co.uk, n.d,a).

Heavy metal removal
The removal of heavy metals such as lead, arsenic and mercury is essential as they are toxic to all living organisms, if plants grew on contaminated land which contained heavy metals there would be the possibility that it could enter the food chain so once identified must be removed as efficiently and effectively as possible (Adriano, 1992). The remediation of sites contaminated by heavy metals is very complicated, there are a number of different ways of dealing with it and these include both on and off-site procedures. One method of remediating land of heavy metal contamination is known as solidification and stabilization. Solidification is a physical process, it turns liquid materials into solids by using cement and silicates to harden them, and this is the most cost-effective way of dealing with heavy metals. This form of solidification is normally performed on site and once the metals turn to solid they must be removed and mixed with sand or gravel the mixture is then washed and put into moulds. Each type of contaminant is then disposed of (Tyagi, 2007). Another technique of remediating heavy metals is known as isolation and confinement, these methods are often used once the harmfulness is reduced to an acceptable level. This method involves creating barriers out of steel or concrete containing the contaminated area to a regulated area, so it cannot spread or get into the water board, once areas are
contained they can either be extracted or be left and monitored depending on the severity of the contamination (Mulligan et al. 2001). Mechanical separation is where contaminants are separated inorganically the main advantage of using this method is that it is cost effective and is able to remediate large amounts at a time making it a fast method of dealing with the metals. The extraction of heavy metals from contaminated sites can also be attained by using chemicals such as inorganic acids, organic acids, chelating agents and oxidizing agents these are used through the soil washing method where any of these chemicals are dissolved into water and washed through the soil off site (Tyagi, 2007).

4.1.3.1. Case Study – Contaminated land in Wales

The following graph (Figure 7) shows the very wide array of contaminants found at contaminated sites in Wales between 2003 and 2013, the most common contaminants were benzo(a)pyrene, lead and arsenic, all of which were found at over 60% of determined contaminated sites (naturalresources.wales, 2013).

Figure 7: Graph showing contaminants found at 175 reported sites in Wales between 2003 and 2013 (Naturalresources.wales, 2016).
One of the most common contaminants found in Wales is lead; lead is a heavy metal and can be very harmful to the environment. Lead pollution can be found as a result of agriculture and mining, nearly half a million tons of lead ores were mined in central Wales alone, when lead was mined in Wales the processing methods were very inefficient and as a result vast quantity of lead was lost to the environment resulting in the contamination of land (Davies, 1987). Lead mines are found all over Wales, in the Caerphilly area of South Wales and the more major mines of Llynwernog in central Wales and Llangynog to the north, there were also mines on the Llyn Peninsula and the St Elvis mine in Pembrokeshire (Davies & Berwick, 2017). The volume of lead mined throughout Wales would explain why there are so many lead-contaminated sites.

Although there are many old mines situated throughout Wales most of them are contained in the land surrounding them however contaminants can be easily distributed by flooding, this can threaten gardens crops cattle and potential development sites. Many old mines are located in river catchment areas, if rivers with old mines in their catchments were to flood contaminants such as metal sediments could be carried and distributed across floodplains. Summer of 2012 experienced the most rain since 1912 resulting in severe flooding across Wales. The main rivers affected by the flooding were the river Leri, the Rheidol, the Clarach and the Ystwyth all of which drain towards Aberystwyth in Mid Wales. As the flooding went samples were taken from the banks of the rivers and the areas of land which had flooded, high levels of lead were found with most not conforming to EU guidelines, the Clarach floodplain samples were found to be 10 times higher than the safety limit for industrial land, with one individual sample measuring 82 times over the EU guidelines (Foulds et al., 2014).

Five months later it was reported that cattle in the flood-affected areas had been getting ill having been eating food produced on the Clarach floodplain. Blood samples were taken from the cattle and all had lead levels, which were too high for human consumption (Peel, 2014).

As a result of floods and freak weather comparable to the flood in the summer of 2012 contaminants which are carried in river sediments could find their way into housing plots agricultural land and peoples vegetable patches. This clearly breaches
Part 2A as it could cause significant harm to humans, wildlife and farm animals. This identifies the importance of remediating sites even when there seems to be no immediate risk of them causing harm.

![Figure 8: Map showing concentrations of Lead down river from former mines after the 2012 flooding in Wales (Foulds et al., 2014).](image)

The map shows how much the floods affected the land and how big the contaminated area is, lead is found naturally in rocks at a concentration of between 15 and 70mg/kg (Part 2A, TGS). Almost all of the samples taken found the concentration to be over 100mg/kg.

4.1.3.2. Case study - London Olympic Park

“The 2012 Olympic and Paralympic Games, their infrastructure and investment have created the most important strategic regeneration opportunities in London for the next 25 years.” (Bernstock, 2016).
In 2005 London won its bid to host the 2012 Olympic and Paralympic games, one of the key deciding factors in London winning its bid was that it was it wanted to be a sustainable and environmentally friendly games. They wanted to design innovative buildings, which were run using renewable energy sources and used very little energy so that the buildings could be built using materials, which require little energy to be produced. They also wanted to build the park on a 350-hectare area of land located in Stratford East London, which was a severely degraded and contaminated area. The site was formerly used as landfill, factories a gas works and various other industrial activities, the site was desperately in need of redevelopment (Geocases2.co.uk, 2007).

Due to the various industrial activities, which took place on the site the site was extremely contaminated, over 3,500 independent samples were taken resulting in over 5 million chemical test results. Contaminants of greatest concern included heavy metals such as arsenic and lead, as well as oil and tar. Throughout the project, around 2.2 million square meters of soil was excavated of which 764,000 square metres were treated by soil washing treatments, chemical remediation treatments and forms of bioremediation treatments. It is estimated that around 80% of all the excavated soil was reused on site (Forestry.gov.uk, n.d.).

As a result of the redevelopment and remediation of the contaminated former industrial site environmental quality has improved all across all of East London. There are now habitats for plants and animals, and vastly improved air quality (Forestry.gov.uk, n.d.).

After the games in 2016 the London Local Development Corporation published the ‘Ten Year Plan.’ It's the continuation of development for the London Olympic Park; it sets out aims and how they plan to achieve them. For the housing on the former Olympic site, they aim to build 2,500 zero carbon homes excluding the ones built for the Olympics (Olymicopolis), and they aim to build two modern new schools. For jobs and businesses, they aim to generate 13,000 new jobs for local people. The Development plan also states that it wants to become a tourist destination, which in turn will create more jobs and attract more investment, and to carry on its sporting legacy by hosting 15 major sporting events by 2018. And for the environmental aspect, they aim to retain their Green Flag status (Ten Year Plan, 2015/16).


4.1.4. Why don’t people want to develop brownfield sites?

Due to the number of different problems associated with redeveloping brownfield sites the cost is much greater than the cost of developing greenfield sites. And although it is estimated that there is enough brownfield land in the UK to build 1.5 million new homes on, even though this figure seems like an obvious way to benefit the housing crisis all of the sites would need to be dealt with in order to be redeveloped, which is a costly and time-consuming process. It is however, easier to get planning permission to redevelop a site than to build on greenfield land, the planning process is however, one of the few things that are easier to deal with compared to the planning process of a greenfield development (Full Fact, 2017). It is hard to object plans for buildings on brownfield sites, as a precedent has been set.

The government or local authorities have previously covered the cost of remediating land for redevelopment in order to encourage developers to build on brownfield sites and meet the set targets of brownfield site development. But in 2013 the Department for Environment, Food and Rural Affairs (DEFRA) had cut funding for remediation from £17.5m in 2009 to £2m in 2013 and planned to phase it out completely by the end of 2017 (Harvey, 2016). By doing this it would deter developers from redeveloping brownfield sites, as it wouldn’t be economically viable. This would particularly discourage development in poor areas, as it would be impossible to produce affordable housing on previously developed land, these are the areas, which most desperately need redevelopment. By reducing the amount of funding for site remediation they do not only reduce the number of brownfield sites being developed but they also increase the health risk produced by contaminated sites across the country.

Although lots of local planning authorities intend on promoting sustainable developments and prioritising the development of brownfield sites only 27% of English councils outside of London have set local targets for the development of brownfield sites (Sinnett et al., 2014). It is stated in the National Planning Policy Framework that sites must be viable and deliverable in order for them to be developed, as there are so many ways around the development of more complex brownfield sites it often discourages developers.
4.1.5. Benefits of developing brownfield land

Although there are many challenges involved in developing brownfield land there is also a high reward. By developing brownfield sites in urban areas, it means lots of new housing will be near jobs and shops, this would reduce the demand on public transport and ease congestion, as people would be able to commute by walking or cycling this would also improve their health. Another benefit of the further development to inner cities would be that roads and utilities would already be available, unlike building on greenfield site where new infrastructure would need to be created. As a result of inner city development cities would look more modern and less worn out, larger companies may be more attracted to older cities again if city centres were regenerated. Older derelict city centres would be less attractive as building maintenance costs would be high and less economical. By redeveloping inner cities people would be less likely to travel to out of town shopping centres which would also reduce the impact of transport. It would also take the pressure off greenbelt land and the greenfield sites around the outskirts of cities resulting in many environmental and ecological benefits. Smaller developers would be more attracted to the sites as larger greenfield sites maybe too expensive due to their size. This would however, depend on the state of the brownfield site (a brownfield site may need demolition work, or remediating). As brownfield sites have many constraints such as size it promotes innovative design (Planning and Building Control Today, 2017).

One of the biggest challenges involved in brownfield site development is the process of remediation. Although the process of remediation may seem like a disadvantage to developers due to the cost and time consumption, it has many environmental and social advantages. By remediating sites, it reduces the amount of contaminated land, as a result of this there will be a lower risk to cattle and crops situated near to contaminated sites, there will also be fewer homes with contaminated gardens. Events such as the flooding in Mid Wales in 2012 (see case study – 4.1.3.1) will also have less of an impact on wildlife if there were less contaminated areas of land. If contaminated sites weren’t going to be used for the development of new buildings then it may not be financially viable to remediate the contaminated land, as a direct result of brownfield land development there is a significant reduction in contaminated land.
Brownfield sites are often situated in desirable city centre spaces and can be developed into expensive homes; although the cost of redevelopment is high brownfield development only takes place if it's financially viable. Once the redevelopment takes place it cleans up the look of the area and can increase the value of neighbouring properties (Cielap.org, 2017).

There are also benefits to a Brownfield development. It is quite common that existing infrastructure (such as services and roads) is already in place, meaning the total cost of the project could be less, and occupancy can happen a lot faster. Developers looking for a quick turnaround may also much prefer going down the brownfield route as greenfield Sites are notoriously slow for gaining planning permission from councils, due to them being new sites.

In 2016 Campaign to Protect Rural England (CPRE) commissioned Glenigan a construction analyst to compare the speed of residential development of brownfield sites to greenfield sites, having received planning permission. 1,040 developments, which had already received planning permission, were analysed over three years, 696 of the sites were brownfield and 296 were classed as greenfield. It was found that on average both types of sites took 29 weeks to start work having been granted planning permission. However, once the work started it was found that on average the brownfield sites took 63 weeks to complete and the greenfield sites took 92 weeks to complete. The results found that brownfield sites were consistently faster for all sizes of sites (Cpre.org.uk, 2016). Therefore, building on brownfield sites will reduce the housing shortage faster than developing greenfield sites. The cost of construction on a brownfield site development would as a result be lower than that of the development of a greenfield site.
Although the report states that the development is faster beyond the planning permission stage, prior to that the process of preparing the site for development may be much more time-consuming as there are many potential problems to solve in order to make a brownfield site suitable for development.

Brownfield sites may be faster to develop due to the existing infrastructure, which is already in place as a result of previous developments. Another reason might be because the site is more developed than a greenfield site at the planning permission stage due to the deconstruction of derelict buildings and remediation which has taken place on the brownfield site in order to get it to stage where construction can begin.

4.2 Benefits and challenges involved with developing greenfield land

Similar to brownfield sites, greenfield sites also have many advantages and disadvantages when it comes to their development. One of the main reasons people want to develop greenfield sites is that they have fewer constraints and more flexibility when it comes to design, as there tends to be more space and fewer restrictions from existing buildings and infrastructure. There also maybe fewer people in the immediate area who are able to oppose the planning permission of more extravagant designs, the sites are developed from scratch meaning they can be tailored perfectly to clients and developers' needs (Barbourproductsearch.info, 2018).
Greenfield sites are often thought of as a blank canvas, this makes greenfield site development most attractive to people designing their own homes, and to developers wanting to make completely new housing cul-de-sac's and estates, whereas brownfield site development may be more attractive to developers with a much bigger budget and are able to redevelop much bigger housing and commercial complexes.

For small-scale residential developments, clients and developers may decide that greenfield sites are the best option as it would be easier to meet the clients’ needs rather than having to work around existing buildings and infrastructure.

The development of greenfield sites can have a very negative impact on the environment, once the land is developed it is very rarely put back to its original state. Once the development of greenfield land begins there is an immediate impact on the natural habitats of animals and plants, the natural habitats may also be used for agricultural purposes in which case there would be a loss of production and employment. In England farmland occupies around 70% of the land, and is the country’s largest industry. If more farmland were to be built on it would have an immediate negative impact on the economy (Fawcett, n.d). As greenfield land is undeveloped there is a lack of infrastructure, new electricity lines, sewage works, and new roads would need to be built, the number of people using existing roads in the areas of development would also increase resulting in more heavily congested roads (Sustainablebuild.co.uk, 2017).

One of the biggest challenges involved with the development of greenfield sites is that many people object to it. People often object to new developments near their homes because it may result in a loss of light to their properties, it may reduce the amount of privacy as new houses may overlook gardens, it may result in the loss of views, all of which could potentially reduce the value of existing properties. People may also object for environmental reasons, as a result of new developments it might be necessary to cut down a significant number of trees, and the damage of the natural environment could be a reason for people wanting to oppose developments (Richmond.gov.uk, 2014). If there was plans to develop an area with cultural or architectural value, and the heritage of an area were to be demolished then there would be grounds to object.
A more complex way of objecting is known as the creation of precedent, if a development takes place it is very difficult for planning authorities to oppose a similar development on a similar site, in a similar location, and if one is objected then it is very difficult for them to approve another of similar characteristics. Therefore, if a new big development was proposed it could result in further developments happening and whilst one new development may be acceptable, a number of new developments may not be. An example of this would be if a family home was replaced with flats, if it were to be approved then the same thing could happen to lots of other family homes, this would then result in the character of the area being changed.

4.3. Benefits and challenges with greenbelt land

The green belt policy has many benefits for urban and rural areas. Designated rural areas are not allowed to be built on unless in exception for buildings which have an agricultural use. Although some development projects are approved, the National Planning Policy Framework states that local planning authorities should only allow planning permission to buildings of agricultural or forestry use. The extension of buildings in a designated greenbelt area would be approved as long as it does not result in disproportionate additions over and above the size of the original building. The replacement of a building is allowed only if the new building is in the same use and not significantly bigger than the one it replaces. If there is limited affordable housing for local community needs under policies set out in local plans. Outdoor facility development is allowed as long as it preserves the openness of the green belt for example, a cemetery or outdoor sports facility. The partial or redevelopment of brownfield land is acceptable and encouraged within green belts as long as the redevelopment does not have a greater impact on the openness of the green belt. Various other types of development are accepted in green belts as long as the preserve the openness of the area, these developments include, mineral extraction, engineering operations, local transport infrastructure, and development brought forward under community right to build order.

There is an argument that greenbelt land should be available to be developed. Designated green belts do not prevent urbanisation as effectively as they should do, as they prevent cities from growing outwards naturally they distribute development into more rural areas resulting in more people having to commute further, causing
congestion and further pollution. Greenbelts are meant to improve air quality, however, here it is clear that it is effectively making people travel in cars, which in turn creates more pollution (Figures 10 and 11).

Figure 10: Greenbelt designated areas surrounding London (Urbanist Architecture Ltd, 2017)
Another argument is that only 6.8% of the UK is actually built on or developed; these figures include allotments, parks, gardens and sporting pitches. If these are all removed, then the figure drops to only 2.27%. This figure seems very low compared to the 15% of the UK which is designated greenbelt land (Politics-greenbelt.org.uk, 2016).

The greenbelt land itself mostly has no ecological value or agricultural purpose, and the majority of it is low-quality scrubland (Wiles, 2014). This then seems very drastic designating such vast amounts of space around major cities as there is a housing shortage and properties in inner cities are so expensive. By building on 25% of greenbelt land inside the M25 this would allow for around one million new homes to be built (Urbanist Architecture, 2017), if that amount of greenbelt land were to be built on, that number of new homes would significantly reduce the severity of the housing crisis.
5. Conclusion

To conclude, it is clear that the need for housing, and mainly affordable housing, in the UK is at an all-time high, and that whilst in an ideal world all available brownfield sites would be developed before eating away at anymore countryside, this is not always possible.

Currently, only 2.27% of the UK is built upon, whilst this figure may seem very low, it doesn't, however, mean that greenfield sites all over the country need developing. Although this figure does seem low, it is important that it is kept as low as possible: Greenfield development can be kept to a minimum by prioritising the development of brownfield sites.

Brownfield development is clearly the most environmentally friendly as it regenerates urban areas, cleans the land, which was previously toxic which then benefits wildlife, farmland, crops and cattle, and reduces the risk of drinking water becoming contaminated. Contaminated sites are often only remediated if there is a financial gain, therefore, most sites are only remediated if they are required for development, this gives another benefit of developing brownfield sites over greenfield sites. Unfortunately, brownfield development is not always possible due to the costs involved in preparing sites for development (remediation, demolition etc.), as this is the case, affordable housing is most often built on greenfield sites as there are no additional development costs. Whilst there is clearly a need for the development of greenfield sites in order to meet housing needs set by local planning departments it is very important to build on areas of land in the appropriate place.

Greenbelt land is crucial in order to maintain valuable countryside and maintain good air quality in the UK's biggest cities. However, it would make sense to develop the vast amounts of very-low-quality greenbelt land and replace the greenbelt designation with land of a higher quality within close proximity, as it is more important to protect high-quality countryside with good agricultural assets in order to be as sustainable as possible.

Due to the many challenges and additional costs involved in the development of brownfield sites, it would seem that developers would prefer to use greenfield sites for developments. The general public would seem to favour the development of
brownfield sites as the development of greenfield sites near existing houses has mainly negative impacts. The development of brownfield sites near existing houses has mainly positive impacts.
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