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# Carbon Management Plan
# Annual Report 2016/17

University of Nottingham

# Carbon Management Plan Annual Report 2016/17

**Contents**

**Executive Summary**

This annual report provides an update on our investments and performance in reducing emissions of carbon dioxide ($CO_2$) against the University's targets over the past 12 months[1].

The University's CMP[2] was refreshed in 2015/17 and includes targets for reductions in emissions of $CO_2$ from energy consumption. It identifies the principal areas of energy use and our investment programmes to improve energy efficiency, reduce consumption and generate energy from lower carbon and renewable energy sources.

**In 2016/17 our Scope 1 and 2[3] carbon dioxide emissions have shown an absolute reduction of 7% or 3,914t from 2015/16 and down 19,628 t from 2009/10 baseline of 67,998 t CO2.**

**In the programme's seventh year the University continued investment of £3.04m in projects across all areas of the CMP. Since 2010 our CMP has now invested in excess of £18.2m, with estimated annual savings in the region of 13,601 tonnes of $CO_2$.**

Over the past year investments have continued to focus on energy and carbon intensive buildings and processes across our campuses. These have covered a range of areas, including boilers and chillers upgrades and replacement, lighting upgrades and the continuation of insulation and double glazing projects along with energy saving fume cupboard upgrades. Continued action at the Medical School with further glazing projects and the final chiller replacement has delivered the total annual carbon savings of 3,516 t CO2 along with energy cost savings of £405K. The new 800kW combined heat and power (CHP) at our Sutton Bonington Campus completed first full reporting year of operation and achieved annual savings of 1,230t CO2.

The University will continue to deliver its capital program to 2020 along with continued expansion in energy intensive research activity. The CMP will therefore continue to invest in the existing estate and new build projects continue to meet the very highest sustainability standards. For example, The GlaxoSmithKline Carbon Neutral Laboratory of Sustainable Chemistry has achieved a BREEAM[4] rating of Outstanding and a LEED[5] rating of Platinum. As a result, future projects will seek to achieve significant carbon reduction targets, realise financial benefits and improve resilience aligned with the University's Global Strategy 2020.

As Jubilee campus continues with rapid expansion carbon emission will continue to increase disproportionately, 15% this year, compared to other campus reduction. This will be amplified over this next year or so as the research energy intensives engineering buildings, Advanced Manufacturing, RAD and the Power Electronics are commissioned.

[1] The scope of our plan includes all of the University's UK assets, with the exception of the University of Nottingham Innovation Park and East Midlands Conference Centre ltd assets along with any temporary energy supplies which are excluded from the reported figures.

[2] www.nottingham.ac.uk/about/values/environment/carbonmanagement.aspx

[3] Scope 1 combustion of Natural Gas. Scope 2 'Grid' supplied Electricity consumption

[4] http://www.breeam.com/

[5] http://www.usgbc.org/leed

## 1 Introduction

This is the seventh annual report on our Carbon Management Plan (CMP) and covers the financial year 2016/17. It provides details on progress achieved and performance improvements made against targets.

The CMP was originally approved in December 2010 and was updated in 2016. Over the seventh year of the plan the University has invested £3.04 m in projects across all areas of the CMP, with predicted annual savings totalling £179k and 928 tonnes of $CO_2$. So far the CMP has resulted in investments in excess of £18.2m, with estimated annual savings of 13,601 tonnes of $CO_2$.The report provides an update on energy and carbon dioxide ($CO_2$) emissions arising from Scope 1 and 2 sources, $CO_2$ reduction projects approved and installed, $CO_2$ savings, financial performance and the programmes of work planned for the next 12 months.

## 2 Carbon Management Plan – objectives and targets

The CMP was approved by the University in December 2010 and updated in July 2016 with the main areas of investment to be centred on:

1. Improvements in energy efficiency of buildings, including insulation, heating & lighting
2. More efficient use of existing equipment
3. Generation of energy from small/medium scale renewable energy systems
4. Major infrastructure upgrades to replace existing plant to reduce energy cost, carbon emissions while at the same time improving system resilience.

The programme includes a number of specific investment projects and more generic programmes to deliver $CO_2$ reductions. These focus on the areas of energy saving and energy efficiency for Scope 1 (predominantly gas combustion in boilers) and Scope 2 (electricity use) emissions.

The CMP provided a baseline of $CO_2$ emissions; sets emission reduction targets; and mapped out a 5 year investment programme implemented to deliver environmental performance improvements and carbon & financial savings[6]. The CMP targets and objectives set in the 2010 CMP are:

| | Baseline 2009/10 | Target 2014/15 | Target 2020 |
|---|---|---|---|
| Total $CO_2$ emissions p.a. | 68,000 tonnes | 54,000 tonnes | 41,000 tonnes |

These represented reductions from the 2009/10 of 20% on $CO_2$ emissions by 2014/15.

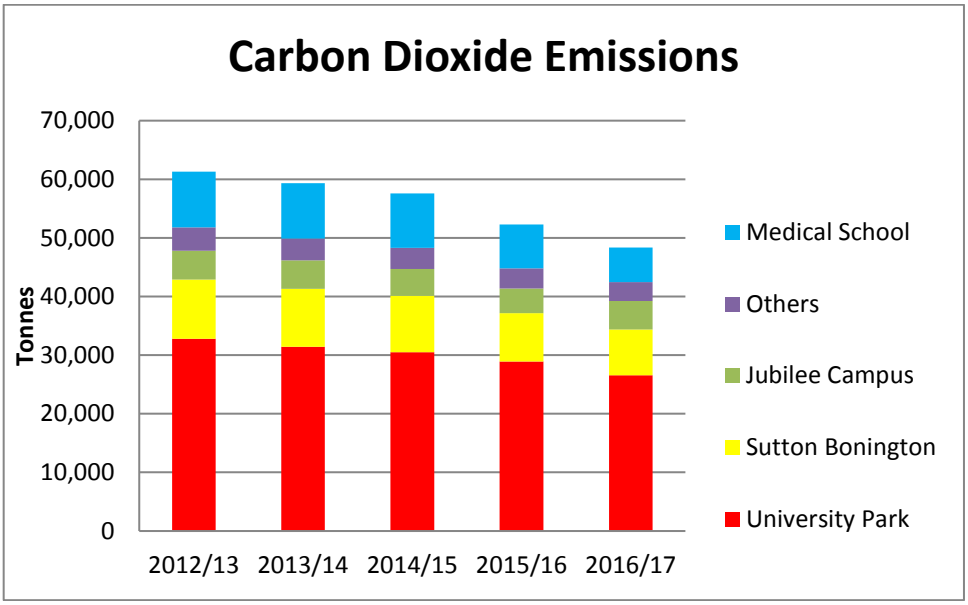
We will continue to prioritise the most energy and carbon intensive buildings and achieve a better understanding of what contributes to our significant 'out of hours' baseload. Continued development of energy strategies for each campus with the overall aim of reducing carbon emissions, improving financial sustainability, system resilience and student experience and where possible, deliver income generation via government feed in tariffs.
Assets of commercial subsidiary companies of the University at Innovation Park and East Midlands Conference Centre ltd are excluded from reported figures consistent with previous annual reports.

[6] www.nottingham.ac.uk/about/documents/carbonmanagementplan2011.pdf

## 3 Performance achieved

### 3.1 Carbon dioxide emissions (Scope 1 and 2)

In 2016/17 carbon dioxide emissions fell by 3,914 tonnes following continued investment in projects as detailed in section 4. The National Grid has continued to reduce its $CO_2$ emissions associated with power generation through the increasing proportion of renewable energy and gas fired power stations supplying the grid with a corresponding reduction in the use of coal fired plant. However the 3 year percentage site reductions shown below at Sutton Bonington (19%) and Medical School (36%) show the full operating year impact of significant investment at these sites when compared with others.




| CO2 Emission factor [4] | 2011/12 | 2012/13 | 2013/14 | 2014/15 | 2015/16 | 2016/17 |
|---|---|---|---|---|---|---|
| Electricity Kg/kWh | 0.541 | 0.484 | 0.494 | 0.462 | 0.412 | 0.352 |
| Natural Gas Kg/kWh | 0.204 | 0.184 | 0.185 | 0.184 | 0.184 | 0.184 |

| **CO2 Emissions( tonnes)** | | | | | | | | Change |
|---|---|---|---|---|---|---|---|---|
| | | **2011/12** | **2012/13** | **2013/14** | **2014/15** | **2015/16** | **2016/17** | **2015/16 to 2016/17** |
| University Park | | 37,578 | 32,814 | 31,424 | 30,490 | 28,898 | 26,573 | -8.0 |
| Sutton Bonington | | 9,964 | 10,103 | 9,876 | 9,637 | 8,244 | 7,791 | -5.5 |
| Jubilee Campus | | 5,430 | 4,892 | 4,855 | 4,295 | 4,247 | 4,877 | 14.8 |
| Others | | 4,161 | 3,994 | 3,731 | 3,612 | 3,425 | 3,199 | -6.6 |
| Medical School | | 10,289 | 9,519 | 9,446 | 9,285 | 7,470 | 5,930 | -20.6 |
| **Total** | | **67,422** | **61,322** | **59,332** | **57,319** | **52,284** | **48,370** | -7.5 |

[4] Our emission factor for grid consumed electricity includes Scope 1 and 2 emissions associated with power generation but does not include scope 3, i.e. those associated with transmission and distribution losses and are obtained from DEFRA.

### 3.2 Electricity

Overall 'Grid' imported electricity consumption increased 2.7% over the last 12 months compared to 2015/16 due to four substantial new buildings that were added to the Estate (GSK Sustainable, Chemistry, David Ross Sports village, Jubilee Conference centre and the Ingenuity building) However Sutton Bonington Campus continued to see reductions (34% total) in electrical use following the first full years operation of the CHP plant contributing significantly to the 2,000 t CO2 carbon reduction for this site. It was also pleasing to see slight reductions in electrical use at the Medical school despite the installation of the new Electrical powered Chillers due in part to other efficiency measures and decommissioning of the roof top cooling towers.

### 3.3 Natural Gas

Consumption of natural gas reduced by 1%, over the last 12 months due mainly to the large reduction (48% total) in steam use at the Medical School following the first full years operation of the high efficiency chillers and other system and fabric improvements. Other sites saw a small reduction in natural gas consumption with the exception of Sutton Bonington which had a 16% increase in consumption due to the installation of the gas fired CHP plant and Jubilee Campus up 29% due to additional buildings.

Further details and a full breakdown of electricity and fossil fuel usage campus by campus and major buildings can be found in the University's 2016/17 Energy Report.

### 3.4 Targets for scope 1 and 2 emissions

Our 2015 Carbon Management Plan target was 51,000 tonnes, a reduction of 17,000 tonnes plus an additional 3000 tonnes to offset impact of new buildings. Our total programme savings at the end of 2016/17 now stand at 13,601 t CO2 per annum from 2009/10.
Since the publication of the CMP in 2010 the University has exceeded its estimated growth plan, however carbon emissions have reduced by 19,628 t $CO_2$ with the help from the National Grid de-carbonising power generation. This will continue to have a significant influence on our performance and ability to meet Carbon targets. The challenge over the period to 2020 will be to continue to identify and implement cost effective carbon reduction initiatives to achieve absolute reductions in emissions offsetting continued growth in new buildings and increased intensive energy consumption from research. It is clear that to achieve our targets we need to continue to invest in large scale carbon reduction projects to decarbonise our power and heating needs. As the National power grid continues to de-carbonise more emphasis will be required on reducing carbon emissions associated with heat supply to our buildings which is currently predominately from combustion of natural gas.

## 4 Carbon projects

### 4.1 Carbon Management Plan projects

A summary of carbon saving projects installed in 2016/17 together with totals for investment in previous years is given below. Projects are grouped into the main CMP themes together with their financial and carbon performance.

| Project theme | Project description | Investment cost £ | Estimated annual savings | |
|---|---|---|---|---|
| | | | Financial £ | $CO_2$ tonnes |
| Improvements to building fabric, glazing and insulation | Double glazing and insulation to Medical school SW, Chemistry NE, Physics NE and North Lab remaining | 2,070,000 | 20,378 | 135 |
| Laboratories: Continuation of Fume Cupboard works | Upgrade of fume cupboard controls, with full VAV with PIR auto sash closure in North wing Chemistry. | 110,000 | 23,467 | 143 |
| Medical school Chilled water | Additional 3rd Chiller to compliment 'Turbocor' Electric chillers | 325,000 | 63,500 | 357 |
| Boiler Replacements and controls | Replacement of old inefficient boilers for more efficient models in halls of residence, along with improved controls and BMS sensors | 343,641 | 48,049 | 199 |
| Controls, heating upgrades, insulation pump motor drives. | Segregation of heating circuits, pipework insulation, controls to Medical School and installation of new inverter drives to pumps etc. | 174500 | 22050 | 83 |
| Lighting upgrades | LED replacement lighting in Medical School and halls of residence. | 19,782 | 2129 | 9.9 |
| **Total for 2016/17** | | **3,042,923** | **179,623** | **928** |
| | | | | |
| Total for 2015/16 | | 4,388,205 | 399,792 | 1616 |
| Total for 2014/15 | | 2,863,391 | 433,325 | 2,021 |
| Total for 2013/14 | | 2,136,070 | 339,793 | 1,390 |
| Total for 2012/13 | | 2,806,613 | 219,481 | 1,522 |
| Total for 2011/12 | | 1,489,937 | 350,467 | 2,028 |
| Total for 2010/11 | | 1,509,361 | 666,424 | 4,096 |
| **Total for 7years** | | **18,236,500** | **2,155,580** | **13,601** |

## 4.2 Project overview and updates

Our strategy to invest in areas of the University that are energy and carbon intensive has continued through 2016/17 and a full schedule of projects is included in Appendix 1 and provides details of type, location and capital spend with calculated annual energy, financial and carbon savings.

Improving the thermal performance of our buildings has continued with a number of significant insulation projects carried out. Several large buildings including the Medical School and Chemistry have continued to see single glazing replaced with double glazing improving the thermal performance of the building and improving the comfort for occupants.

We have continued to deliver investment in the laboratory fume cupboard efficiency programme with further works to reduce fan speeds with full variable speed extracts to deliver reduced electricity use and, as a consequence, reduced gas from space heating.

The replacement of old plant, both chillers and boilers, has resulted in improved efficiency across the estate and this rolling programme will continue over coming years. This year's installations included replacement water heaters to Ancaster and Cripps halls of residence along with boiler replacements in the Arts centre, Hemsley, Sir Peter Mansfield and Hugh Stewart House.

The Medical School received an additional 3rd Chiller to complement the installation of 2 high-efficiency chillers that replaced the aging steam absorption units. This switch from steam generated cooling to electrical systems has led to a significant reduction in gas (which is used to generate steam). The system was fully commissioned November 2016 and along with other projects over the last 3 years has reduced steam consumption in this first full year of reporting by almost 50% The combination of projects has seen steam consumption drop from 25,295MWh to 13,484MWh resulting in an annual cost saving of £405K and carbon reduction of 3,516 t CO2

## 4.3 Renewable energy projects

Small and medium scale renewable energy projects are financially supported by UK legislation through initiatives such as the Feed in Tariffs (FITs) and Renewable Heat Incentive (RHI). These programmes promote widespread uptake and provide income from generation to accredited technologies including photovoltaics (PV), wind, biomass, solar thermal and ground source heat pumps (GSHP). Below is a summary of the University's renewable energy generation in the last 12 months.

| Building | Technology | Annual Production (kWh) |
|---|---|---|
| Dearing | PV | 7,699 |
| Business School North | PV | 13,365 |
| Computer Sciences | PV | 6,421 |
| Derby Hall | PV | 46,496 |
| Lincoln Hall | PV | 39,369 |
| Si Yuan Chinese Studies | PV | 7,952 |
| Aerospace Technology | PV | 10,800 |
| Environmental Education Centre | PV | 15,517 |
| Sustainable Research Building | PV | 5,274 |
| Ingenuity Centre (TEC) | PV | 2,868 |
| Riverside Sports Pavilion A | PV | 18,183 |
| The Barn | PV | 3,333 |
| Sustainable Chemistry | PV | 205,223 |

| | | |
|---|---|---|
| George Green Library | PV | 31,716 |
| Orchard Hotel | PV | 7,485 |
| Veterinary School | PV | 123,705 |
| **Total** | | **552,774** |
| Si Yuan Chinese Studies | Solar thermal | 2,284 |
| Geospatial | Biomass | 51,580 |
| BioEnergy | Biomass | 150,650 |
| **Total** | | **204,514** |

These installations have saved 231 tonnes of Carbon by displacing electricity that would have been provided by the 'Grid'

### 4.4 Audits and feasibility studies

A significant amount of work has been carried out looking at the long term energy strategies of both University Park and Sutton Bonington campuses due to their energy intensive activities. At Sutton Bonington the mixed blend includes the installation of the CHP scheme, photovoltaic (PV) array. Further details and update is shown below.

**1MWe Ground-based PV Array**

A detailed business case for a PV array located on land at Sutton Bonington is being developed with calculations showing potential for a 6500m$^2$ array that would generate an annual yield of 870,000kWh of electricity or about 7% of the Sutton Bonington demand. This is estimated to achieve annual cost saving of £85,000 and a carbon saving of around 309t $CO_2$. Over the 25 year life of the panels the system is expected to save in excess of £3m in electricity cost and over 5000 t CO2.
Combined with the existing CHP plant on certain days of the year the campus could be self-sufficient in electrical power. CHP and solar PV have a good output synergy as PV provides power peak around the middle of the day/ early afternoon when heating demand reduces and the CHP usually reduces output as heating demands are met, hence maintaining a good electrical generation balance for the site. The latest options are on land around the Diary farm with the preferred location being adjacent to the rear service road that runs between the Diary farm and Station road. Other options include a split locations on land near the trail bore hole research although there may be issues with planning as permission has already been granted for research use.

**University Park Low Carbon Energy Centre**

Development of a low carbon energy centre to be located in the former CHP building behind the boiler house (adjacent to the Life Sciences building) could achieve significant fuel cost savings and reduction in $CO_2$. A business case has been prepared for consideration and is due for update (Nov 2017) to reflect the latest energy cost, carbon intensities and availability of suitable engines to suit our high temperature heat network. It is proposed that this £3.5m scheme will utilise gas-fired CHP plant along with high efficiency gas-fired boiler plant with aim of reducing energy costs, carbon emissions while at the same time improving overall system resilience of the district heating system that serves around 20 buildings across University Park. The system will be designed to fully integrate with future low carbon heat/ energy sources as and when they become available and includes upgrade of the main University Park electrical sub-station.
A 2.3MW CHP installed capacity along with a new high efficiency back up boiler has been identified has the best 'fit' solution. The fully costed business case with energy cost and carbon intensities identified overall cost saving of around **£683k** along with annual carbon savings of **798 t $CO_2$**. This compares with **£413k** and **2,304 t CO2** only 18 months ago when the feasibility study was commissioned and shows how sensitive CHP schemes are to the 'National Grid' de-carbonising and increasing price differential between purchased electricity and gas. The project is currently in the design/ Tender stage with a fully cost scheme expected by the end of 2017.

**University Park Electrical loads**

Studies are currently underway to understand where the significant overnight baseloads are located and how these may be reduced. The load varies cross University Park as would be expected with Science and Engineering accounting for almost 40% mainly due to equipment/ processes that operate year round. Further understanding is still required and various department have been asked to submitted equipment schedules detailing power rating and likely operating profiles.

## 5 Future carbon management and investment programmes

At this mid-term position, with a refreshed and updated the CMP to continue to deliver the depth and range of carbon projects needed to deliver our institutional targets. This includes continuing with plant replacement, glazing and insulation projects and at the same time continue on site with major investments such as continuation of the Sutton Bonington low carbon energy strategy. We will continue to take an evidence-based and targeted approach and further investments in energy and carbon intensive buildings. There will be further investment in the Medical School and a focus on heat delivery to buildings served by the district heat network on the University Park campus. An options appraisal for an energy strategy to cover the expansion of Jubilee Campus is being developed to look at options for low carbon energy sources to serve a number of buildings at the north end of the campus from a common plant room. Whilst there is likely to be significant further development on acquired sites the appraisal assumed the development of the 'bonded warehouse' site whilst the future plans of that site are considered.
Investment over the next 5 years on various carbon reduction programmes is expected to reach £11m and is likely to include large scale building fabric upgrades.

The programme continues the focus on investment in the CMP's main areas based

- Large and small scale Plant/ infrastructure replacements
- Laboratory fume cupboard efficiency upgrades
- Campus wide low carbon generation strategies
- Staff and student engagement
- Continued improvements to existing building fabric to reduce heat losses
- Review renewable energy strategies following recent reduction in Government feed in tariffs.

## 6 Financial requirements

CMP projects continue to be assessed for financial and carbon performance and submitted for approval, having initially gone through a energy/carbon working group. Funding for CMP projects is provided from CMP capital, revenue expenditure, Salix finance and grant contributions and loans.

### 6.1 Salix Finance

The University continues to utilise its Salix Finance revolving green fund and has used it to invest more than £894K in carbon saving projects to date and will continue to invest these ring fenced savings into further carbon saving projects.

## Appendix 1 – Carbon Management Plan projects 2016/17

| Carbon Management Plan 2016/2017 committed projects | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Investment cost | Estimated Annual Savings | | | Payback period | Cost per Tonne of CO2 |
| | | | (incl VAT) | Financial | $CO_2$ | Energy | | |
| Project | Location | Technology description | £ | £ | tonnes | kWh | (years) | |
| **Double Glazing and Cladding** | Medical School SW Elevation | | 800,000 | 13,933 | 69 | 461,500 | 57.4 | 11594 |
| | Chemistry NE/remain NW Elevation | | 980,000 | 3,500 | 32 | 172,000 | 280.0 | 30625 |
| | Physics NE elevation | | 200,000 | 1,080 | 10 | 54,500 | 185.2 | 20000 |
| | North Lab glazing phase 2 | | 90,000 | 1,865 | 24 | 125,786 | 48.3 | 3750 |
| | | | | | | | | |
| **Lighting upgrades** | Medical School | LED Lighting | 12,250 | 1,165 | 6 | 15,685 | 10.5 | 2042 |
| | Halls of Residents WC and corridors | LED Lighting plus PIR | 7,532 | 964 | 3.3 | 9637 | 7.8 | 2282 |
| | | | | | | | | |
| **Chiller replacement** | Medical School 3rd Chiller | Turbocor Chillers | 325,000 | 63,500 | 357 | n/a | 5.1 | 910 |
| | | | | | | | | |
| **Boiler Replacement** | Cripps Hall | water heaters | 78,000 | 877 | 8 | 43,850 | 88.9 | 9615 |
| | Ancaster | water heaters | 63,000 | 579 | 5 | 28,939 | 108.8 | 11768 |
| | Exchange Building | water heaters | 3769 | 96 | 1 | 4789 | 39.4 | 4254 |
| | Arts Centre | condensing Boilers | 22,500 | 1,195 | 11 | 59,754 | 18.8 | 2035 |
| | Farm Offices/ Demo hall | condensing Boilers | 4,250 | 115 | 1 | 5,748 | 37.0 | 3997 |
| | Food hall/ Café | condensing Boilers | 3,560 | 154 | 1 | 7,694 | 23.1 | 2501 |
| | Hugh Stewart House | condensing Boilers | 18,000 | 395 | 4 | 19,753 | 45.6 | 4926 |
| | David Wilson House | condensing Boilers | 3,400 | 37 | 0 | 1,869 | 91.0 | 9833 |
| | Sir Peter Mansfield centre | condensing Boilers | 38,500 | 1,390 | 13 | 69,475 | 27.7 | 2995 |
| | Sherwood hall north block | water heaters | 3,850 | 94 | 1 | 4,693 | 41.0 | 4434 |
| | Hemsley | heating | 18,000 | 828 | 8 | 41,400 | 21.7 | 2350 |
| | Newark hall | water heaters | 22,300 | 740 | 7 | 36,996 | 30.1 | 3258 |
| | | | | | | | | |
| **BMS, controls & metering** | Medical Sch CT presuurisation, controls remaining | heating controls | 29,500 | 6,250 | 22 | 89,467 | 4.7 | 1341 |
| | Main Boiler House burner controls 2 | conontrols/ inverter | 34,125 | 16,100 | 136 | 670,000 | 2.1 | 251 |
| | Medical Sch Steam valves and BMS | controls | 142,000 | 15,800 | 61 | 225,748 | 9.0 | 2328 |
| | | | | | | | | |
| **Fume Cupbords** | Chemistry North Wing B52/remian B46 Fume Cupboards | Full VAV system/ auto sash | 110,000 | 23,467 | 143 | 558,654 | 4.7 | 769 |
| **Water leak/ mains repairs/ replace** | | | 33,400 | 25,500 | 5 | n/a | 1.3 | 7422 |
| | | | | | | | | |
| | **Summary** | **YTD £** | **3,042,936** | **179,623** | **928** | | | **3279** |