Plessey Semiconductors – Permit Variation Supporting Document

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For: Plessey Semiconductors Limited

Site: Roborough, Plymouth

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1. Introduction

1.1 Background

Plessey Semiconductors Limited (Plessey Semiconductors), a subsidiary of Haylo Ventures Limited, is a UK-based company that specialises in research into novel semiconductor products and their pilot-scale manufacture. Plessey Semiconductors is focussed on the development of microLEDs (micro light-emitting diodes), arrays of which can be used in a wide range of modern display technologies, including: televisions, smartphones and tablets, head-up displays, and Augmented Reality (AR) and Virtual Reality (VR) devices.

Plessey Semiconductor's principal research facility, which also serves as the company's headquarters, is located at Roborough near Plymouth. The site features a range of production, assembly, development and analytical equipment operating in ultra-clean environments. Plessey Semiconductors solely undertakes research activities and pilot-scale manufacturing processes; large-scale production is undertaken by third parties at dedicated fabrication plants.

The Roborough site has the capacity to produce microLED arrays on both 150mm and 200mm substrates, currently including both Silicon and Gallium Nitride on Silicon (GaN-on-Si) wafers, according to product requirements. At its maximum current throughput, the Roborough site can process around 17,000 substrate wafers per annum. Each wafer is subjected to an iterative series of process stages during which various materials – including metals, insulators, and semiconductors – are precisely deposited on the surface of the wafers and then selectively etched away. Repeated deposition and etching stages allow the orderly build-up of complex, layered electronic circuits, ultimately forming the desired microLED arrays. Each wafer, which can contain a number of microLED arrays, undergoes electrical and quality control testing following the fabrication process before being cleaved to yield the individual microLED devices. The devices are then mounted and packaged to form the finished product.

The processing stages involved in microLED manufacturing utilise a wide range of chemical reagents. As a result, the Roborough site is regulated as a Part A(1) chemicals installation by the Environment Agency (EA) under the terms of an Environmental Permitting Regulations 2016 (EPR) permit (Ref: EPR/BX1586IH). The site is currently permitted to undertake the following activities:

Fabrication of microelectronic circuits onto silicon wafers

Section 4.2 Part A(1)(b): Manufacturing activity which is likely to result in the release into the air of any hydrogen halide.

Fabrication of microelectronic circuits onto silicon wafers

Section 4.2 A(1)(c)(iv): Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements - gallium.

Effluent treatment plant.

Section 5.4 Part A(1)(a)(ii): Disposal of non-hazardous waste in a facility with a capacity exceeding 50 tonnes per day by physico-chemical treatment.

1.2 Proposed Variation

Devices based on the microLED technology are currently an active area of research and development as they offer a range of performance characteristics – such as high brightness, high operational durability and high energy efficiency – which would make them suitable for wide-scale adoption in consumer electronic display devices. Plessey Semiconductors is actively researching the use of novel substrate materials in microLED fabrication at the Roborough site and it is now intended to extend the production capabilities of the site to allow the pilot-scale manufacture of devices based on Gallium Arsenide (GaAs) substrate wafers. Semiconductors such as Aluminium Gallium Indium Phosphide (AlGaInP) when deposited on GaAs substrates may be used in the fabrication of LEDs with a broad colour emission palette, including red and orange wavelengths which have been difficult to achieve with current technologies.

The production of microLEDs based on Gallium Arsenide (GaAs) substrates will be complementary to the existing research and manufacturing processes at the Roborough site, which are based largely on Silicon substrates. There will be no change to the total number of substrate wafers that will be processed at the site each year. The relative levels of processing based on Gallium Arsenide and Silicon wafers have yet to be defined as these are contingent on the ongoing development of viable products based on the new Gallium Arsenide technology.

Much of the processing of the Gallium Arsenide wafers will be achieved using the existing equipment already installed at the Roborough site. However, the deposition of semiconductor layers on the Gallium Arsenide wafers will necessitate the addition of a pair of new production reactors dedicated to the new substrate materials. These two reactors, which will each have the same specification, will utilise the Metalorganic Chemical Vapour Deposition (MOCVD) technology to deposit layers of Aluminium Gallium Indium Phosphide on the Gallium Arsenide substrate. The new reactors will use a range of chemical reagents not currently stored or utilised in the installation, including Arsine (AsH_3), Phosphine (PH_3) and Trimethylindium ($In(Ch_3)_3$). Given this, it is considered that the new reactors will constitute a regulated activity under the Environmental Permitting Regulations, and that the addition of this activity necessitates a substantial variation to the site's environmental permit.

Table 1-1 below details the proposed variation to each listed activity and directly associated activity (DAA) at the Plessey Semiconductors site.

Table 1-1 Installation Activities and Directly Associated Activities (Proposed Changes Shown in Bold)

Listed Activities					
Activity Reference	**Schedule 1 References**	**Description of the Activity**	**Limits of Specified Activity**	**Description of Proposed Change**	**Document Reference of Proposed Changes**
AR1	Section 4.2 Part A(1)(b): Manufacturing activity which is likely to result in the release into the air of any hydrogen halide	Fabrication of microelectronic circuits onto silicon wafers	From receipt of wafers to despatch of product to electrical testing	The production of materials based on silicon substrates will reduce slightly as a consequence of the proposed variation. However, total site production will be unchanged from a maximum of approximately 17,000 wafers per annum (total of activities AR1, AR2 and AR10)	N/A
AR2	Section 4.2 A(1)(c)(iv): Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements – gallium	Fabrication of microelectronic circuits onto silicon wafers	From receipt of wafers to despatch of product to electrical testing		N/A
AR10	**Section 4.2 Part A(1)(c)(ii) (v))** **Unless falling within any other Section, any manufacturing activity (other than the application of a glaze or vitreous enamel) involving the use of, or the use or recovery of, any compound of any of the following elements – arsenic and indium**	**Fabrication of microelectronic circuits onto gallium arsenide wafers**	**From receipt of wafers to despatch of product to electrical testing**	**New activity added to installation permit**	**Section 2: Process Description**
AR3	Section 5.4 Part A(1)(a)(ii): Disposal of non-hazardous waste in a facility with a capacity exceeding 50 tonnes per day by physico-chemical treatment	Effluent treatment plant	From production of effluent to the point of discharge to the sewer	No change	N/A

Directly Associated Activities					
Activity Reference	**EPR Activity References**	**Description of the Activity**	**Limits of Specified Activity**	**Description of Proposed Change**	**Document Reference of Proposed Changes**
AR4	N/A	De-ionised water production	From receipt of mains water to input of de-ionised water to the production process	No changes proposed	-
AR5	N/A	Heat generation plant	Installed capacity less than 20MW	No changes proposed	-
AR6	**N/A**	**Storage and handling of raw materials**	**From receipt of raw materials to input to process**	**Gas handling systems will be extended to allow for the safe storage and handling of the new reagent gases**	**Section 3: Directly Associated Activities**
AR7	**N/A**	**Storage and handling of wastes**	**From production of waste to despatch from the permitted installation**	**Aqueous effluent from processes using GaAs wafers will be collected for off-site disposal**	**Section 9: Waste Management**
AR8	N/A	Surface water discharge	From collection to discharge either via a pipeline into a tributary of the River Plym, or into a soakaway	No changes proposed	-
AR9	Schedule 14 Solvent Emission Activity	Surface cleaning activities in accordance with Annex VII Part 1 of Directive 2010/75/EU	From receipt of solvent to collection of waste solvent or discharge to atmosphere	No changes proposed	-

1.2.1 Operating Techniques

Table 1-2 details the technical guidance referenced in the development of this permit variation application. All proposed variations contained within this document have been assessed against the appropriate technical guidance. With the exception of site plans, the information within this document should be viewed as supplementary to information previously submitted to the Environment Agency, as the majority of the installation will be unchanged by the proposed variation.

1.2.2 Improvement Conditions

An improvement programme was included as part of the installation's most recent permit variation (Table S1.3 in EPR/BX1586IH, as varied) in 2020. All required improvement conditions have already been satisfied by Plessey Semiconductors.

1.3 Permitting History

To date, there have been four variations to the permit, which was originally issued in 2004. The most recent variation, including a consolidation of the permit, was issued in 2020.

1.4 Substantiality of Change

Due to the addition of two new production reactors to expand the manufacturing capabilities of the Roborough site, a variation to the site's Environmental Permit is required. It is considered that the new reactors will constitute a regulated activity under the Environmental Permitting Regulations, as they will utilise chemicals not currently employed at the site and which are specifically prescribed in the Regulations, including Arsine (AsH_3) and Trimethylindium ($In(CH_3)_3$). As a result, it is considered that the addition of the new reactors necessitates a substantial variation to the site's environmental permit.

1.5 Guidance

The following guidance documents are considered the most applicable to the proposed activities and have been referenced in the preparation of this document.

Table 1-2 Applicable Technical Guidance to the Installation

Reference	Title
CWW BREF/ BATC	**Best Available Techniques (BAT) Reference Document for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (2016).**
WGC BREF/ BATC	Best Available Techniques (BAT) Reference Document for Common Waste Gas Management and Treatment Systems in the Chemical Sector (2022).

Please note that the WGC BATC document was published after the UK's exit from the European Union and is not legally enforceable in the UK. The UK BAT analogue of this guidance developed by Defra is currently at final draft stage and is also not currently enforceable, although this is expected in early 2026. The finalised CWW BATC document is thus the basis of the BAT assessment provided in this report. Reference to the WGC BATC document is limited solely to a consideration of the emissions to air from the new reactors.

1.6 Installation Boundary

The installation boundary will not change due to the proposed variation. The new layout for the installation is demonstrated in the figures provided in Appendix A in this application support document.

- Appendix A: Drawing A1 – Site Location and Boundary
- Appendix A: Drawing A2 – Site Layout and Proposed Revisions

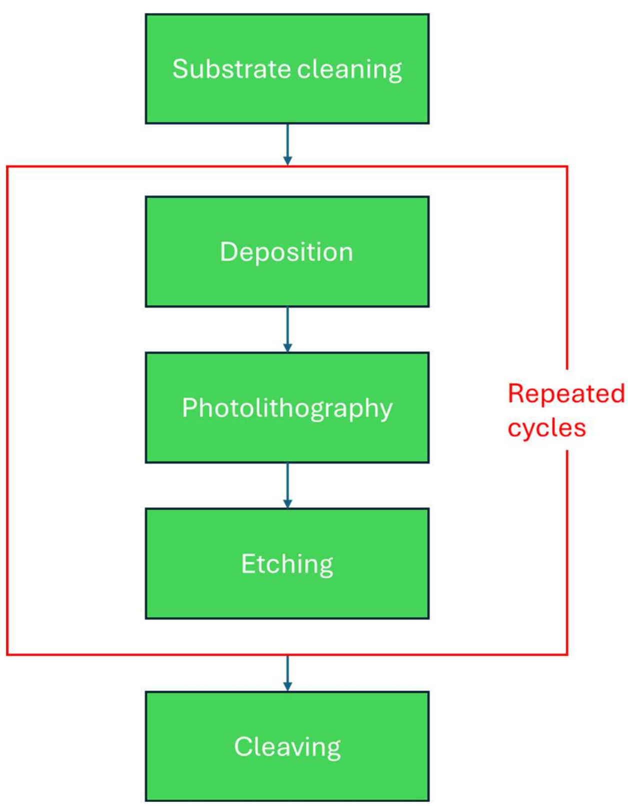
2. Process Description

2.1 Introduction

The manufacture of modern semiconductor products, such as microLEDs, involves a complex cycle of discrete processing steps to accurately create three dimensional electronic circuits on the surface of a suitable substrate medium. Repeated sequences of material deposition, photolithography and selective material removal allow for the gradual formation of the desired circuit conformations. Most commonly, Silicon substrates are used as the basis of the production process but, increasingly, alternative semiconductor materials are finding use in LED manufacture (such as Gallium Nitride and Gallium Arsenide) and these offer an enhanced range of product characteristics.

Many of the production processes involve the modification of the surface of the semiconductor substrates at near-atomic scales. As a result, and in order to avoid product defects and process waste, semiconductor products are manufactured in enclosed systems located in clean room environments to avoid potential contamination from the factory environment. The formation of finished products may require hundreds of processing steps, which means that the overall manufacturing process may take in excess of a fortnight to complete .

The following schematic provides a high-level outline of the key processing stages undertaken at the Roborough site. The manufacturing process is largely the same whether using Silicon or Gallium Nitride on Silicon substrates, as at present, and the schematic is also relevant to the operation of the site once Gallium Arsenide substrates are added to the installation.



MicroLEDs are manufactured from thin discs of pure substrate materials, also termed 'wafers', which have a diameter of 150mm or 200mm depending on the requirements of the production process. Following cleaning of a wafer, which may utilise concentrated acids, alkalis or solvents to provide a contaminant-free surface to the substrate, it is then either manually loaded into the processing plant or placed along with a small number of other wafers in a transfer box ('FOUP') which will facilitate easy and contamination free transfer of the substrates between process stages, which require different equipment to achieve.

Thereafter, the principal process stages are as follows:

Deposition

Deposition is a generic term referring to a series of methods which result in the growth of thin films of semiconductors or metals on the surface of the substrates. These methods are generally achieved in sealed chambers which may be evacuated or filled with an inert gas to prevent the oxidation of the deposited materials that would result if they were exposed to air.

Semiconductor layers are generally formed by Chemical Vapour Deposition (CVD) in which gaseous precursor materials are heated to the point of decomposition in the chamber, with the resultant chemicals reacting on the surface of the substrate wafers to form chemically bound thin films of semiconductors. Careful adjustment of the temperature, flow rate and mixture of precursor gases allow the creation of deposited layers with specific physical and electrical properties.

Metallic elements are deposited via the simpler Physical Vapour Deposition (PVD) process, also known as sputtering. In PVD, the substrate wafer is held in a chamber also including a heated metallic source, which is heated to very high temperature until it partially vaporises. The metallic vapour will ultimately condense on the substrate to form a thin film.

Both CVD and PVD processes are already in operation at the Roborough installation.

Photolithography

This is a photographic process used to transfer a circuit pattern onto the surface of the substrate wafers. The first stage involves the application of a solution of a light sensitive material, or photoresist, to the substrate and then drying to form a thin layer. Subsequently, high intensity light is projected onto the substrate via a reticle, which partially obscures the light, allowing some areas of the surface to be masked and some areas exposed, in accordance with the required circuit design. The exposure to light causes a chemical change in the photoresist, rendering the exposed portion susceptible to removal by dissolution.

Etching

Following partial removal of the photoresist and drying, the substrate wafers may then be etched, which removes the deposited semiconductor materials that are not protected by the photoresist. Two forms of etching are used at the Roborough installation:

- wet etching, which uses an aggressive chemical solution (e.g. buffered hydrofluoric acid) to remove the deposited materials; and
- dry etching, which uses a focussed plasma to accurately remove the semiconductor material.

Following the etching process, the residual photoresist is then removed in a process known as stripping, to leave the substrate coated with an initial, patterned layer of semiconductor on its surface. Repeated cycles of deposition, photolithography and etching allow the controlled build-up of complex circuit designs.

2.2 Metalorganic Chemical Vapour Deposition (MOCVD)

As has been identified, much of the installation will be unaffected by the proposed variation, but the introduction of production based on Gallium Arsenide substrate wafers will require the installation of two new Metalorganic Chemical Vapour Deposition (MOCVD) reactors to the FAB3 fabrication area of the plant. These reactors will be dedicated to the deposition of Aluminium Gallium Indium Phosphide (AlGaInP) on the Gallium Arsenide substrate, to facilitate the manufacture of a new range of microLED products.

MOCVD is a well-established technology in LED manufacture and is a variant of the CVD technology that utilises metalorganic compounds (such as Trimethylindium (TMIn)) in addition to other precursor gases (e.g. Arsine) to produce semiconductor layers whose composition and physical properties can be accurately adjusted to meet specific product requirements.

The MOCVD process uses precursor gases and metalorganic compounds dispersed in a non-reactive carrier gas and contained within a sealed chamber at reduced pressure. The chamber is held at elevated temperatures, so upon entry to the chamber, the precursor gases pyrolyse to form a mixture of atomic species and gaseous decomposition products such as methane. Further gas phase reactions may occur under these conditions to produce a complex range of semiconductor chemicals, including Indium Phosphide and Gallium Arsenide.

The substrate wafer is held on a susceptor plate within the chamber at a controlled and reduced temperature, and, as a result, the elements formed from the decomposition of the precursor gases, along with the gas-phase reaction products, will adsorb on the surface of the substrate and become bound. Precise control of the precursor gas mixture, flow rate and temperature allows for the deposition and accumulation of specific semiconductor materials. Other chemicals used in the reactor will include Disilane and bis(cyclopentadienyl)magnesium (Cp_2Mg), which will be used to add intentional impurities ('dopants') to the semiconductor layers to modify their electrical properties.

The MOCVD technology is already used at the Roborough installation for the deposition of Gallium Nitride (GaN) layers on Silicon substrate wafers.

2.3 Proposed Variation

Two new reactors will be installed in FAB3 to allow the deposition of materials on Gallium Arsenide wafers. Both reactors will be Aixtron G10-AsP units, which will be installed at the northern end of FAB3, with the approximate installation area shown in Appendix A (Drawing A-2). The new reactors will process batches of wafers but production cycles will be operated continuously, as with the existing processes operated across the site.

Each new reactor includes a wafer handling station, operator tables, a control system and local storage for spares, tools, wafer storage boxes and pods. As a result, the installation of the two new reactors will necessitate the relocation of a maintenance cleaning bench, a solvent cleaning bench and a wafer box washer to new locations towards the south of the FAB3 area. Some currently redundant equipment, including two existing PVD tools and one CVD tool will be decommissioned and removed from the installation as part of the proposed variation.

Precursor gases will be provided to the new reactors from the existing gas storage area in SUB-FAB3, with new dedicated gas storage cabinets and gas lines added for the provision of the new precursor materials. As with the existing gas handling systems, extensive leak detection will be utilised and the gas process panel will automatically shut-down the gas cabinets, with all valves failing safe, in the event of a leak being detected.

Cooling water for the reactors will be provided from the existing FAB3 process cooling water system, which has sufficient capacity to accommodate the new reactors. Cooling water is supplied at around 2°C to 4°C, with biocides and corrosion inhibitors dosed into the system when required. The internal pipework of the reactors is fabricated from stainless steel to prevent corrosion.

The exhaust gases from the reactors will be extracted using a main process pump, used to pump the process chamber down to a low pressure. Each reactor will be equipped with its own pump, mounted within the main frame of the reactor. A pumping line takes the exhaust from the pump and passes it through the floor to SUB-FAB3, which is where the associated abatement systems are to be installed. Further details of the abatement systems are provided in Section 5 (Emissions to Air).

The Aixtron G10-AsP reactors and the abatement systems are fully-integrated and interlocked systems; the reactor cannot run unless the abatement system is also operational. Sensors constantly relay data to both systems and in the event of a failure or loss of control the systems will automatically shut down.

Documented procedures for intentional and emergency process shutdowns have been provided by the reactor manufacturer and are being integrated into the Plessey Semiconductors management systems to ensure shutdowns are undertaken in a controlled manner by trained personnel. Start-up is also part of the same documented procedures. If a shutdown is initiated automatically due to an emergency condition being activated, then the equipment will be recovered in a controlled manner, and there are documented procedures in place for recovery from this type of failure.

3. Directly Associated Activities

As demonstrated in Table 1.2, the Stationary Technical Unit (STU) at the Roborough installation consists of the activities undertaken at the site which are directly referenced in the Environmental Permitting Regulations, i.e. the semiconductor manufacturing processes (which are regulated as chemicals manufacturing) and the on-site Effluent Treatment Plant (which is regulated as a non-hazardous waste treatment activity).

The installation also contains a series of Directly Associated Activities (DAAs), which include the other activities carried on at the site that both have a direct technical connection to the STU and that could have an effect on the environmental impact of the site as a whole.

Only the DAAs at the Roborough site which are anticipated to change due to this proposed variation are described further in this section, with the remainder being unaffected by the change.

3.1 Raw Material Storage and Handling (AR6)

There will be new raw material storage introduced on the site; cylinders of the precursor gases arsine, phosphine and disilane will be held in dedicated gas cabinets in the FAB3 area. A gas cabinet can hold two speciality gas bottles and a nitrogen gas bottle. The cabinets will have an 'auto-changeover' function, to allow a seamless switch from the empty gas bottle to a full one. The nitrogen is used to purge the gas lines when the cylinder change is required.

Speciality gas stock will be held in the gas cylinder compound, which is located on the North roadway and the flammable gases are held in a separate area of the compound, away from other gases. Please note that due to their inherent hazard ratings, the inventory of both arsine and phosphine stored at the site will be limited to the two small cylinders of each held in gas cabinets.

The metal organic materials (such as Trimethylindium and Trimethylgallium) will be held in the DI plant room, until they are required for use at the new reactors. Metal organics will be delivered in sealed drums and undergo careful inspection on delivery.

Hydrogen is held in a dedicated trailer, located along the North roadway, adjacent to the gas cylinder compound. The gas is fed into the hydrogen system and purified before being passed to the reactors.

Nitrogen is supplied from an on-site nitrogen plant located next to the hydrogen purification plant. The nitrogen is passed through a purifier before being used in the reactors.

The expected quantities of raw materials consumed by the installation following this variation are detailed in Table 8-1.

3.2 Waste Storage and Handling (AR7)

The proposed variation is not expected to increase the quantities of waste generated onsite significantly as there will be no change to the total number of substrate wafers processed per annum and many of the processes utilised at the site will be unaffected by the proposed variation.

New waste streams will be produced following the variation as a consequence of the substitution of a fraction of the Silicon wafers currently processed at the site by Gallium Arsenide wafers. New wastes will include:

- Scrap Gallium Arsenide wafers. Plessey Semiconductors has a specific procedure for the disposal of scrap wafers, which will be extended to incorporate the new substrate material to be used. As will the current waste, scrap Gallium Arsenide wafers will be collected at the point of production in the manufacturing areas in plastic 150mm and 200mm boxes; broken wafers will be collected in sharps bins for safety. Wherever possible, Silicon-derived wastes and Gallium Arsenide wastes will be segregated. The contractor selected for the management of scrap wafers offers both safe and secure disposal in full compliance with relevant waste management legislation.

- Effluent from the aqueous processing of Gallium Arsenide wafers (e.g. from wafer cleaning and wet etching processes) will be collected in IBCs located adjacent to the point of production. This effluent will be collected for safe off-site treatment and disposal by competent waste management contractors. Samples of the effluent will be taken for analysis while the Gallium Arsenide manufacturing process is established. The sampling will be used to assess the suitability for the treatment of the effluent in the on-site Effluent Treatment Plant.
- Spent absorption columns from the new reactor abatement systems (see Section 5). Once the absorption medium in the system is depleted, individual absorber columns will removed from the abatement system and stored on-site pending return to the equipment provider for emptying and refilling. It is assumed that the spent absorption medium, which will have removed the toxic and reactive components of the MOCVD reactor exhaust gases, will be a hazardous waste.

All waste storage conditions, locations and expected generated quantities following this variation are detailed in Section 9.

4. Management

4.1 Environmental Management System (EMS)

The activities undertaken at the Roborough installation are operated in accordance with an Environmental Management System (EMS) which is certified to meet ISO14001:2015 standards. The site's EMS certificate of registration has been included as Appendix C.

Plessey Semiconductors also operates to the following international standards:

- Quality Management System ISO 9001:2015;
- Energy Management Framework ISO 50001; and
- Occupational Health and Safety ISO 45001:2018.

The systems are currently being updated to reflect the recent sale of Plessey Semiconductors to Haylo Labs Limited in August 2025. While Plessey Semiconductors remains as the operator of the installation, the composition of the senior management team responsible for the EMS has changed to reflect the new ownership structure.

In general, the site will continue to use the same management procedures and techniques as presently, since the large majority of the activities operated will not change following this proposed variation. New procedures and work instructions will be added to explicitly address the changes made to the site, namely the addition of two new MOCVD reactors and associated gas handling and abatement systems. Work is also underway in preparation for the update to the ISO14001 standard in 2026.

4.2 Senior Leadership Commitment

Responsibility for the environmental, quality and safety management of Plessey Semiconductors lies with the site's senior leadership team. The revision to the leadership team, following the recent purchase of Plessey Semiconductors to Haylo Ventures Limited, does not affect its commitment to the continual improvement of the environmental performance at the Roborough site, and the provision of adequate financial and human resources to ensure its safe and sustainable operation.

The quality, environmental and health and safety management systems are reviewed on a regular basis through meetings which are attended by members of the senior management team.

4.3 Environmental Policy

The Environmental Policy outlines the organisations approach to its effect on the environment.

Plessey is committed to protecting the environment and the health and safety of its employees. To achieve this, Plessey have set the following policy aims:

- Comply with all legal and regulatory EHS requirements applicable to their operations
- Identify the environmental aspects of the company activities to reduce or eliminate actual and potential risks, prevent pollution and reduce waste in order to protect the environment
- Provide a safe and healthy working environment for their employees and prevent work related injuries and ill health by eliminating hazards and reducing risk
- Aim to continually improve the EHS performance of the company by setting objectives and targets and supporting programmes

- Communicate with all parties working for or on behalf of the company in order to raise their awareness and understanding of the EHS systems and process
- Provide interested parties with relevant and appropriate information
- Ensure these aims are achieved by the use of appropriate procedures and management systems that will be systematically monitored, audited, reviewed and improved.

4.4 Organisation

Responsibility for the ongoing operation of the EMS lies with the Quality, Environmental, Health and Safety Manger, with support from the leadership team. The team will be responsible for the delegation of environmental responsibilities to individual staff members, as required by their specific roles at the site.

The leadership team comprises of:

- CEO
- CTO
- COO/CFO
- People and Corporate Affairs officer
- Partnership, Product & Technology Director
- Director of Programmes
- Operations Director

The quality, environmental and health and safety management systems are reviewed on a regular basis through meetings which are attended by member of the senior management team.

4.5 Environmental Aspects and Impacts

As part of the EMS, all elements of the business that interact with the environment have been assessed, both directly (through on-site process) and indirectly (through the use of externally sourced materials, goods and services and sale of products). These interactions are the site's environmental Aspects and Impacts, which are recorded in an Environmental Aspects and Impacts Register.

The aspects have been systematically assessed to determine their overall environmental significance. This assessment takes into account both the likelihood and the potential severity of the occurrence of each aspect to create an overall risk profile for the environment, for the business and for interested parties, including the local community and other stakeholders.

The register is subject to regular review to ensure its continued relevance to the operations at the site and to the legislative and regulatory requirements to which the business is subject. The review process is also triggered by the occurrence of any significant environmental incident or by any planned substantive change to the site, such as the proposed variation to production operations which is the subject of this permit application.

4.6 Objectives and Targets

Building on the risk profile for the installation identified in the Environmental Aspects and Impacts Register, a range of Objectives and Targets are established for the installation. Environmental Objectives represent the long-term aims of the business (e.g. the minimisation of energy and raw material uses), with the principal objectives summarised in the Environmental Policy as its key commitments. The EMS also includes a range of Environmental Targets, which are the specific and measurable expression of the Objectives and how progress of the site against the Objectives will be monitored. The most important targets for the sustainable operation of the business are reinforced in the EMS as Key Performance Indicators (KPIs), which are the focus of careful and ongoing management control.

The EMS objectives, targets and KPIs are reviewed as part of the regular review of the system by the senior leadership team and environmental manager. Areas identified by the EMS review and target setting process as presenting risk of non-compliance are prioritised as action items in an improvement programme and included in the site's capital expenditure programme where necessary.

4.7 Operational Procedures

A range of procedures have been developed and implemented as part of the EMS for the identification, assessment and management of the most significant operational aspects of the activities undertaken on the site. These procedures are designed to facilitate and monitor the safe, efficient and sustained operation of the site, and to support its ongoing progress against the defined Objectives and Targets. The procedures are revised to explicitly address the environmental aspects of the site's operation as it changes and are currently being updated to reflect the proposed changes to the site.

Procedures have also been developed to ensure that the personnel responsible for any activities with the potential for significant environmental impact are both qualified and competent to carry out their duties. Following the issue of the varied permit for the Plymouth installation, the procedures will be revised and extended to specifically address the requirements of the new equipment to be installed at the site.

4.8 Competence, Resources and Training

Plessey assesses the training and development needs for its staff as part of the performance review process, and all employees receive training relevant to their job role. Line managers are responsible for ensuring employees receive appropriate training, with refresher training provided as the site and legislation relevant to its operation evolve. Records of training are kept for all employees.

Procedures have also been developed to ensure that the personnel responsible for any activities with the potential for significant environmental impact are both qualified and competent to carry out their duties. Following the issue of the varied permit for the Roborough installation, the procedures will be revised and extended to specifically address the requirements of the new equipment to be installed at the site.

4.9 Communication and Engagement

All staff receive training on communication, which includes: when to communicate, who to communicate with and how to communicate. All information communicated in regard to the EMS is documented.

4.10 Maintenance

All manufacturing and plant systems are subject to routine maintenance and there are documented procedures covering maintenance and inspection activities; the maintenance procedures are either time or run count controlled. All maintenance is carried out by suitably trained facilities or equipment engineers. Some maintenance procedures for the new reactors and the associated abatement system will require vendor support, as these particular tasks require specialist knowledge of the systems.

4.11 Accidents and Incidents

The Aspects and Impacts Register extends explicitly to the consideration of accidents and incidents at the site with the potential to result in significant environmental aspects.

An Accident Risk Assessment has been carried out to evaluate the changes to the site's risk profile following the installation of the new reactors and accounting for the use of new process reagents.

4.12 Non-compliance and Complaints

Written procedures for the handling, investigating and reporting of actual and potential non-compliance with regulatory requirements are defined within the EMS, along with formal mechanisms for the management of complaints relating to the operation of the installation, should these arise.

4.13 Monitoring

Monitoring is undertaken at the site in line with the current permit. Further details of the monitoring that will be undertaken at the site following the proposed variation are provided in Section 13 of this application support document (Monitoring).

4.14 Records

Procedures in the EMS identify and control the collection, retention and disposal of documents and evidence. The controlled documentation will include the environmental manual, register, procedures and other primary documentation as part of the system. Individual copies of these documents will be identified and issued to company personnel as appropriate. All documentation will be subject to review by the senior leadership team to ensure its continued relevance.

The document management system is web based and all documents are held on this system. Approval of new and amended documents is through electronic sign-off. Previous revisions of documents are also accessible. Hard copies of documents are stamped by the quality department, any copy not having a stamp is deemed as uncontrolled.

4.15 Audit and Review

Internal audits are carried out an all aspects of the quality, environmental and health and safety management systems. There are also third-part audits completed every six months by a contracted auditing company.

5. Emissions to Air

5.1 Emissions Abatement

The MOCVD process to be operated in the two new FAB3 production reactors utilises carefully controlled flows of ultrapure precursor gases (e.g. Arsine and Phosphine), along with metalorganic compounds (such as Trimethylindium) dispersed in a non-reactive carrier gas (Hydrogen).

As the MOCVD process involves the controlled deposition of ultrathin semiconductor layers on substrate wafers, the reactors will not use large quantities of the precursor gases. However, as a number of the precursor gases are inherently toxic, careful extraction and abatement of the MOCVD exhaust gases will be required both to control potential health and safety risks for process operators and to minimise any potential environmental effects the gases may have.

The exhaust gases from each of the two new MOCVD reactors will be abated using a two-stage abatement system provided by CS CLEAN SOLUTIONS GmbH, a well-established technology provider to the semiconductor industry. The two stages are as follows:

1. A CS CLEAN CLEANSORB PRIMELINE absorption system.

   The CLEANSORB system features an enclosure containing a pair of refillable stainless steel absorber columns. Each absorber column will be packed with a bespoke absorption medium provided by the equipment provider which is designed to chemically react with the reactive materials in the MOCVD exhaust gases (i.e. the toxic precursor gases) to form a solid residue which is retained within the column. CS CLEAN SOLUTIONS can provide different absorber media tailored to the specific precursor gases being used by the MOCVD process.

   The two columns will be run in a duty-standby arrangement to ensure that abatement capacity is always available to the production process. Multiple integrated sensors will monitor the duty absorber column for breakthrough of reactor exhaust gases into the abated gas flow, which would indicate that the reactivity of the absorbed medium has been depleted. At this point the exhaust gas flow will be transferred automatically to the second, standby absorber column so that the MOCVD reactor can continue to run without interruption. The absorption system will be interlocked with the MOCVD reactor and is designed to fail safe so that the reactor can only be operated if suitable abatement capacity is available.

   The depleted absorber column will be purged with nitrogen gas for safety and can then be removed manually by an operator with a new column installed in its place. The depleted column will then be collected and returned to the equipment provider. The spent absorption medium will be disposed of as waste and the column will be refilled with the reactive absorption medium and returned to Plessey Semiconductors for reuse.

2. A CS CLEAN PCS EXO Plasma Conversion System

   Following the treatment of the reactor exhaust gases in the CLEANSORB system, the residual exhaust gases from the MOCVD reactor will largely consist of the carrier gas, Hydrogen, along with any non-reactive reaction products of the MOCVD process such as Methane. While these gases do not have a significant environmental impact, they are flammable and hence need to be removed from the exhaust prior to discharge.

   The exhaust from the CLEANSORB system will thus be ducted into a PCS plasma system for further abatement. The plasma system features two complementary combustion stages, a plasma discharge to ignite the exhaust gas and then a heated combustion chamber in which the exhaust gases mix with air to complete the combustion process. The energy required to maintain the consistent temperature required in the combustion chamber is derived from the hydrogen and methane content of the waste gas, so the operational and environmental cost of the system will be minimal in practice.

As with the CLEANSORB system described previously, the PCS plasma system will be interlocked with the new MOCVD reactors so that the reactors will not be able to operate if either of the abatement systems are offline.

The new abatement equipment will be installed in SUB-FAB3, immediately beneath the two new MOCVD reactors in FAB3. A general exhaust will be fitted on each module of the reactors, through which exhaust gases will be pumped using a process pump. These extracts feed into one main line which passes through the floor and from there connects to the CS CLEAN abatement system described above. Following abatement, the treated exhaust from the reactors will be ducted into the existing FAB3 pyrophoric exhaust system. The final release point, denoted emission point A3 in the current Environmental Permit, is a 22m high stack located at the northeast corner of the main production building. The stack location is identified in Appendix A to this document (Drawing A-2).

5.2 Emissions Benchmarking

Installations falling under the scope of the EPR are expected to utilise BAT to minimise their impact on the environment. BAT means the techniques which are the best for preventing or minimising their emissions and impacts on the environment, provided that they are commercially available to an operator. Techniques include both the technology used and the way the installation is designed, built, operated, maintained and decommissioned.

For each industrial sector falling under EPR, the European Union has published a BAT Reference (BREF) document that identifies the relevant technologies, and an associated BAT Conclusions (BATC) document which summarises the indicative standards and the BAT-Associated Emission Levels (BAT-AELs) which an installation should achieve.

Of the BAT documents issued by the EU and remaining legally enforceable following the UK's exit from the EU, only the Common Waste Water and Waste Gas Treatment (CWW) BREF and BATC documents are relevant to the Roborough installation. A further BATC document for use in the chemicals sector – Common Waste Gas Management and Treatment Systems in the Chemical Sector (WGC) – was issued in 2022, but as this followed the UK's exit from the EU it cannot be applied to regulated chemicals installations in the UK.

A UK-specific BATC document based on the WGC BATC document is currently being finalised by Defra. While this document cannot currently be used as the basis of BAT determinations and emissions benchmarking, BAT-AELs which are provided in this document have been considered where they are relevant to the new reactors to be added to the installation.

5.3 Channelled Emissions to Air

The Roborough installation currently features 16 point sources through which channelled emissions are released to air. The proposed variation will not increase this number of emission points as the two new MOCVD reactors and their associated abatement systems will exhaust to atmosphere via emission point source A3, which provides the exhaust from the existing FAB3 Pyrophoric extraction system.

There are currently no Emission Limit Values (ELVs) defined in the installation's environmental permit for this emission point and no monitoring requirements are stipulated.

Table 5.1 – Current Installation Air Emission Point and Applicable ELVs

Emission Point	Source	Parameter	Limit (mg/m^3)
A3	FAB3 pyrophoric extract	No parameters set	No limit set

Details of the proposed MOCVD reactors and process gases to be used have been provided to the abatement equipment provider, CS CLEAN SOLUTIONS GmbH, who have provided guaranteed emission concentrations for the reactors following abatement. These emission concentrations are provided below in Table 5.2.

There are no BAT-Associated Emission Levels defined in the CWW BAT Conclusions document for any of the substances that will be released from the new MOCVD reactors.

Table 5.2 – Guaranteed post-abatement emission levels for the proposed MOCVD reactors

Substance	Guaranteed emission concentration	BAT-Associated Emission Level
Arsine (AsH_3)	0.05 ppm	None defined
Phosphine (PH_3)	0.1 ppm	
Disilane (Si_2H_6)	5 ppm	
Trimethylindium ($In(CH_3)_3$)	0.1 mg/m^3 (as indium)	
Trimethylgallium ($Ga(CH_3)_3$)	3 mg/m^3 (as gallium)	
Trimethylaluminium ($Al_2(CH_3)_6$)	2 mg/m^3 (as aluminium)	
Bis(cyclopentadienyl) magnesium ($Mg(C_5H_5)_2$)	3 mg/m^3 (as magnesium)	

The concentrations specified are for the gases released directly from the CS CLEAN SOLUTIONS abatement system. Substantially lower concentrations will be experienced at the release from the FAB3 pyrophoric extraction system since the emissions from the new reactors will be diluted by the other process gas streams captured by this system.

5.4 Impact Assessment

While there are no monitoring requirements specified in the Roborough installation's Environmental Permit for the FAB3 pyrophoric extraction system (emission point A3), Plessey Semiconductors does undertake annual emissions monitoring for this source. Given this monitoring data, and the specifications of the new reactors and their abatement systems, it is therefore possible to calculate the expected emissions from the FAB3 exhaust following the proposed variation. Using this data, an air quality assessment has been undertaken to evaluate the significance of the emission to air. This was undertaken using the Environment Agency's (EA's) H1 software tool.

This assessment was undertaken as per the guidance provided by the EA which can be found at:

https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

5.4.1 Assessment Overview

The H1 assessment incorporates two screening stages which are used to evaluate the environmental significance of an emission of a substance. The assessment considers both the long- and short-term potential impacts. The stages of a H1 impact assessment are outlined below:

Stage 1: Evaluates the environmental concentration of each substance being released to air. This is known as the process contribution (PC). The PC is set against defined environmental assessment levels (EALs). If the PC is evaluated as insignificant, meaning it is <1% of the EAL in the long-term, or <10% in the short-term, the contribution can be screened out. If it is higher than these values, then the impact is evaluated in Stage 2. As this assessment is across all emission points, each substance will only be screening at Stage 1 if the cumulative total of the PCs for a substance is below the limit.

Stage 2: Allows for the context of the impact to be accounted for by taking into account background concentrations of the substances that are present. From this, the predicted environmental concentration (PEC) can be calculated. The PEC is assessed to be insignificant if it is <70% of the EAL in the long-term, and <20% of the EAL minus the background concentrations in the short-term. In that case the contribution can be screening out. If not, the impact would need to be evaluated further, for example via detailed dispersion modelling. As with Stage 1, only substances whose PEC, calculated from the cumulative PC, is below the limit shall be screened.

Further modelling: As the H1 is a conservative assessment tool, it does not demonstrate the spatial or temporal variations of emissions around an emissions source, which are key to demonstrating the significance of an impact. Instead, the H1 tool only shows if an emission can be considered insignificant. Therefore, when the H1 assessment does not allow emissions to be screening out, more detailed modelling is required to be conducted (e.g. air dispersion modelling or a D1 assessment). This is required to evaluate the significance of an impact.

5.4.2 Emission Data

The inputs selected as part of the assessment are denoted in the table below. Data regarding release concentrations was gathered through the most recent onsite monitoring of the stacks. It was deemed appropriate to use monitored concentration instead of ELVs due to the significant differences between the values. Data regarding the additional release concentrations from the proposed reactor were calculated from data provided by the manufacturer.

The new substances from the new process that have been included within the H1 assessment are summarised below:

- Arsine
- Phosphine
- Disilane
- Trimethylindium
- Trimethylgallium
- Trimethylaluminum; and
- Bis(cyclopentadienyl)magnesium.

Existing monitoring data are available for release points A3 and A6, the pyrophoric extraction systems for FAB3 and FAB8 respectively, which are summarised below in Table 5.3.

The emission points are summarised in Table 5.3 below. The flow rate and efflux velocity has been taken from the most recent monitoring data available (2024).

Table 5.3: Emission Points Summary

Emission Point	Associated Activity	Flow Rate (m^3/hr)	Efflux Velocity (m/s)	Stack Height (m)
A3	FAB3 Pyrophoric Extract	10,833	5.2	22
A6	FAB8 Pyrophoric Extract	27,740	13.0	22

The flow from the FAB3 exhaust will increase to a total of 11,397m^3 per hour following the proposed variation as a consequence of the additional gas flow from the new reactors and their associated abatement systems.

The assessed release concentrations for each emission point are summarised below in Table 5.4 and 5.5. The data for emission point A3 include both the existing monitored emissions and the contribution from the new reactors.

Table 5.4: Release Concentrations for A3

Substance	Concentration (mg/m^3)
Arsine	0.00318
Phosphine	0.0265
Disilane (Si_2H_6)	0.178
Trimethylindium (TMIn)	0.00024
Trimethylgallium (TMGa)	0.0071
Trimethylaluminum (TMAl)	0.0047
bis(cyclopentadienyl)magnesium (Cp_2Mg)	0.0071

Table 5.5: Release Concentrations for A6

Substance	Concentration (mg/m^3)
Arsenic	0.00033
Phosphorous	0.01542

5.4.3 Effective Release Height

The impact of nearby buildings must be considered when assessing the risk of emissions to atmosphere. The methodology identified by the UK Government: Air emissions risk assessment for your environmental permit - GOV.UK (www.gov.uk) states that the effective height of release should be treated as 0m if emissions are actually released at a point that's either:

- Less than 3 metres above the ground or building on which the stack is located
- More than 3 metres above the ground or the building, but less than the height of the tallest building within a distance that's 5 times 'L'

'L' is the lowest of either:

- the height of the building
- the greatest width between 2 points at the same height of the building (for example between 2 opposing corners of a roof)

For this assessment, L = the height of the building.

When the effective height of release is more than 3 metres above the ground or building, but less than 2.5 times the building's height, it should be estimated by the following steps:

1. Take the actual height of release.
2. Subtract the height of the tallest building within a distance 5 times L (this can be the building where the emissions are coming from, if it's the tallest).
3. Multiply the figure that's left by 1.66.

When the actual stack height is more than 2.5 times the building height, the actual stack height can be treated as the effective height of release. This methodology has been used to calculate the effective release height for the release points; these heights can be seen in the table below:

Table 5.6: Effective stack heights

Emission Point	Stack Height (m)	'L' (m)	Effective Height of Release (m)
A3	22	16	9.96
A6	22		9.96

5.4.4 Operating Mode

The operating mode allows for the scaling of emission based on the duration of operation across a year. The scaling only has an effect on the long-term PC. It does not make any alterations to short-term PC that is calculated. As a worst-case scenario, it has been assumed that the two emission points operates consistently all year round. As such, an operating mode percentage of 100% has been used.

5.4.5 H1 Impact Assessment Results

As described previously, the screening stages associated with a H1 impact assessment involve comparing the PCs against the EALs for each substance. Table 5.7 below shows the EALs for each evaluated substance as per EA guidance.

As a conservative approach, all Arsine has been measured as Arsenic due to having a lower EAL.

There is no specific standard for assessment of Phosphorous, and so the Phosphorous has been measured against the Phosphine EAL.

It is noted that there is no published or appropriately robust EAL for Si_2H_6, TMIn, TMAl, TMGa, or Cp_2Mg.

Table 5.7. Substance Environmental Assessment Levels

Substance	Long Term EAL (µg/m_3)	Short Term EAL (µg/m_3)
Arsenic	0.006	-
Phosphine	42	-

5.4.6 Long Term Impacts

The tables below provide the results of the H1 assessment to evaluate long term impacts.

Table 5.8. Long Term Impacts Stage 1

Substance	Stage 1	
	PC (µg/m₃)	% PC of EAL
Arsenic	0.00042	7%

Table 4.1 Long Term Impacts Stage 2

Substance	Stage 2		
	PC (µg/m₃)	Background Concentration (mg/m³)	Total % PEC of EAL (Limit 70%)
Arsenic	0.00042	0.0007	19%

All substances were screened during Stage 2 and may therefore be deemed to be insignificant.

5.4.7 Short Term Impacts

The table below provides the results of the H1 assessment undertaken to evaluate short term impacts.

Table 4.2 Short Term Impacts Stage 1

Substance	Stage 1	
	PC (µg/m₃)	% PC of EAL
Phosphine	0.124	0.3%

All substances were screened during Stage 1 and may therefore be deemed to be insignificant.

5.4.8 Conclusions

The H1 assessment demonstrates that the emissions to air from the new MOCVD reactors will have an insignificant environmental impact.

6. Emissions to Water

6.1 Surface Water

The proposed variation to the activities at the Roborough site will not lead to any change in the emissions from the installation to surface water. All proposed variations to the installation including the two new MOCVD reactors, the associated air emissions abatement equipment and the storage areas for the new raw materials used in the process will be contained internally within the FAB3 area of the main production building.

As at present, uncontaminated surface water runoff from the majority of the site's buildings, roads and yard areas will be discharged via an 800 m underground pipeline to a tributary of the River Plym. Surface water run-off from an area at the north of the site will continue to be discharged to ground via a soakaway.

6.2 Sewer, Effluent Treatment Plant or Other Transfers Off-site

As noted previously, effluent from production processes involving the aqueous treatment of Gallium Arsenide wafers, including substrate cleaning and wet etching activities, will be collected in drums and IBCs at the point that it is generated within the production building. Following the proposed variation, samples of the effluent will be taken and sent for analysis so that the suitability of the effluent for treatment in the on-site effluent treatment plant can be evaluated. Pending the completion of that evaluation, the collected effluent will be sent for off-site treatment and disposal by appropriately trained and competent third-party waste contactors.

As at present, all aqueous effluent arising from the treatment of Silicon substrate wafers will continue to be routed to the on-site effluent treatment plant for treatment, before being discharged to sewer for final treatment at the Emesettle treatment works operated by South West Water. Given the proposed change from Silicon wafers to Gallium Arsenide wafers for a small fraction of the site's production output, and the associated diversion of effluent to off-site waste disposal described above, the total volume of the effluent discharged to sewer from the installation may reduce slightly following this proposed variation. Other than this, there will be no further change to the effluent produced by the installation.

The operation of the on-site Effluent Treatment Plant and its ongoing effectiveness is currently under review by Plessey Semiconductors. Changes to its operation are not proposed in this permit variation application but are possible in 2026, subject to an additional application for variation to the site's environmental permit.

7. Emissions to Land

Surface water run-off from an area at the north of the Roborough installation is currently discharged to ground via a soakaway and this will not change as a consequence of the proposed variation. Fugitive emissions to land may occur only in the event of accidental losses (spills, leaks, etc) but these will be prevented, as at present, by the use of appropriate pollution prevention measures and careful management of raw material/waste storage, handling and utilisation.

7.1 Updated Assessment of Site Condition

An assessment has been undertaken of the risk to the condition of the Roborough site posed by the new substances to be used following the proposed variation. The assessment has followed the methodology defined in EC Commission Guidance concerning baseline reporting (2014/C 136/03) [1].

Table 7.1 provides Stages 1 to 3 of this risk assessment.

Table 7.1. Risk Assessment for New Hazardous Substances to be Used at the Roborough Installation

Stage	Activity	Response
1	Identify which hazardous substances are used, produced or released at the installation and produce a list of these hazardous substances	A complete list of the new materials to be used at the installation are provided in Section 8 below. All new materials are considered to be Relevant Hazardous Substances. The proposed variation will not change the quantities or usage of the other raw materials used at the site, as the majority of the installation will be unaffected. The risk assessment for these remains unchanged.

[1] https://eur-lex.europa.eu/legal-content/EN/ TXT/PDF/?uri=CELEX:52014XC0506(01)&from=EN

Stage	Activity	Response
2	Identify which of the hazardous substances from Stage 1 are ‘relevant hazardous substances’. Discard those hazardous substances that are incapable of contaminating soil or groundwater. Justify and record the decisions taken to exclude certain hazardous substances.	The new materials to be used in the installation following the proposed variation are: • gaseous compounds (Arsine, Phosphine and Disilane), which will disperse in the event of accidental losses; or • volatile and pyrophoric liquids (metalorganic compounds) which decompose immediately in contact with the air. Consequently, given their chemical and physical nature, none of the new substances to be used at the site are considered capable of contaminating soil or groundwater. Control mechanisms implemented at the site relating to the storage, utilisation and disposal of these materials further mean that the risk of uncontrolled releases of the substances to the environment is very low.
3	For each relevant hazardous substance brought forward from Stage 2, identify the actual possibility for soil or groundwater contamination at the site of the installation, including the probability of releases and their consequences, and taking particular account of: • the quantities of each hazardous substance or groups of similar hazardous substances concerned; • how and where hazardous substances are stored, used and to be transported around the installation; • where they pose a risk to be released; • In case of existing installations also the measures that have been adopted to ensure that it is impossible in practice that contamination of soil or groundwater takes place.	Not applicable – there are no new Relevant Hazardous Substances which are considered capable of contaminating soil or groundwater and all substances are screened out at Stage 2.

It is not considered that the additional raw materials to be used at the Roborough site following the proposed variation will represent any risk of land or groundwater contamination.

8. Raw and Auxiliary Materials

Plessey Semiconductors currently utilise a range of raw materials to support the manufacturing of semiconductor undertaken at the installation. The majority of the raw materials consumed at the installation will not be altered following the proposed variation to the site and are not considered further here. Table 8-1 below lists the additional raw materials to be used at the installation in the two new MOCVD reactors.

8.1 Raw Material Selection

The production of microLEDs on Gallium Arsenide substrates will involve the use of specific raw materials, including arsine, phosphine, a range of metal organic substances, and carrier gases such as hydrogen. The careful selection of these materials is essential to ensure optimal device performance. All gases and chemicals are selected based on industry-recognised best-known methods, and process recipes are optimised to maximise gas efficiency.

Due to the nature of the operations at this facility, the use of certain hazardous substances, including arsine and phosphine has been deemed necessary. The proposed reactors are intended to expand the site's manufacturing capabilities and will require these materials, which are handled in small quantities and under controlled conditions.

Plessey Semiconductors selects, purchases and manages raw materials in line with the requirements of the formalised systems for quality and environmental management that are implemented at the site (see Section 4). The site only purchases raw materials from reputable, auditable suppliers and specifies the quality control procedures that suppliers must utilise to ensure that the raw materials provided to the site are within defined quality standards.

The selection of raw materials at the site is carefully controlled by senior management in line with relevant legislation and the material selection process is regularly reviewed as part of ongoing environmental and cost control, with long-term objective being the demonstration of sustainable production techniques.

Due to the nature of the semiconductor manufacturing industry, the materials and methods used at the installation are reasonably established, therefore alternative materials and methods are limited.

8.2 Raw Material Inventory

As at present, the site will continue to maintain an up-to-date inventory of raw materials consumed for inclusion in the EMS. The inventory is an essential requirement of process management, production scheduling and stock control.

Arsine and Phosphine are both named substances under the Control of Major Accident Hazards (COMAH) Regulations and several of the metal organic compounds to be used in the new production process are classed as pyrophoric substances. As a result, careful inventory management will be employed by Plessey Semiconductors to ensure that the site's inventory of these materials, and of all other relevant hazardous materials, is maintained at all times below lower-tier COMAH thresholds, both individually and in aggregate.

Inventories of Arsine and Phosphine will be limited to two small gas cylinders for each compound. Plessey Semiconductors has entered an arrangement for the storage of additional gas volumes at a third-party, off-site warehousing facility, which is regulated under the COMAH regulations. Careful monitoring of material storage and utilisation will be undertaken, and stock will only be transferred to the Roborough installation from the off-site warehouse upon full depletion of the on-site inventory.

The consumption and specification of raw materials are reviewed periodically by the business and under the Plessey Semiconductors Quality Policy:

- Meet customer requirements and strive to exceed customer expectations
- Setting SMART quality objectives
- Maintaining a management system that meets the requirements of international standards and facilitates the delivery of quality products and solutions
- Maintain the effectiveness of the quality management system; and
- Involve all employees in the process of continuous improvement

Reviews of raw material specification and utilisation additionally take into account good practice environmental options, client requirements, legislative requirements, cost effectiveness, and the COSHH (Control of Substances Hazardous to Health Regulations 2002, as amended). In line with the requirements of COSHH, safety data sheets (SDS) are stored electronically onsite, so that the appropriate information is available to all operators in the safe utilisation, storage and disposal of the materials. Periodic checks are undertaken to ensure that the SDS information is up-to-date.

Table 8-1. New Raw Materials to be Used at the Roborough Installation

Raw Material	Description	Typical Annual Usage	Maximum Amount on Site	Environmental Fate of Material	Hazards	Alternatives
Arsine	Used for electronic component manufacture (Aluminium Gallium Indium Phosphide semiconductor layers)	100kg	Two 27kg X47 gas cylinders. (No cylinders held on stock at Roborough site)	Hazardous waste disposal (spent absorber columns) & air emissions	H220: Extremely flammable gas. H280: Contains gas under pressure; may explode if heated. H330: Fatal if inhaled. H373: May cause damage to organs through prolonged or repeated exposure. H410: Very toxic to aquatic life with long lasting effect	None given current semiconductor processing technologies
Phosphine	Used for electronic component manufacture (Aluminium Gallium Indium Phosphide semiconductor layers)	350kg	Two 22kg X47 gas cylinders. (No cylinders held on stock at Roborough site)	Hazardous waste disposal (spent absorber columns) & air emissions	H232 - May ignite spontaneously if exposed to air. H314 - Causes severe skin burns and eye damage. H220 - Extremely flammable gas. H280 - Contains gas under pressure; may explode if heated. H330 - Fatal if inhaled. EUH071 - Corrosive to the respiratory tract	None given current semiconductor processing technologies
Trimethylindium (TMIn)	Used for electronic component manufacture (Aluminium Gallium Indium Phosphide semiconductor layers)	10kg	550 gram vessel. 3 x stock	Hazardous waste disposal (spent absorber columns) & air emissions	H250 Catches fire spontaneously if exposed to air. H314 Causes severe skin burns and eye damage.	None given current semiconductor processing technologies

Raw Material	Description	Typical Annual Usage	Maximum Amount on Site	Environmental Fate of Material	Hazards	Alternatives
Trimethylgallium (TMGa)	Used for electronic component manufacture (Aluminium Gallium Indium Phosphide semiconductor layers)	10kg	3.8kg vessel. 3 x stock	Hazardous waste disposal (spent absorber columns) & air emissions	H250 Catches fire spontaneously if exposed to air. H260 In contact with water releases flammable gases which may ignite spontaneously. H314 Causes severe skin burns and eye damage	None given current semiconductor processing technologies
Trimethylaluminium (TMAl)	Used for electronic component manufacture (Aluminium Gallium Indium Phosphide semiconductor layers)	10kg	1 x 600 gram vessel. 3 x stock	Hazardous waste disposal (spent absorber columns) & air emissions	H250 Catches fire spontaneously if exposed to air. H260 In contact with water releases flammable gases which may ignite spontaneously. H314 Causes severe skin burns and eye damage.	None given current semiconductor processing technologies
Disilane	Used for electronic component manufacture (doping of semiconductor layers to modify electrical properties)	100kg	2 x 12kg X20 gas cylinder. No cylinders held on stock	Hazardous waste disposal (spent absorber columns) & air emissions	Extremely flammable gas. May form explosive mixtures with air. Contains gas under pressure; may explode if heated. May displace oxygen and cause rapid suffocation. Harmful if inhaled. Causes serious eye irritation. Causes skin irritation. May cause allergy or asthma symptoms or breathing difficulties if inhaled	None given current semiconductor processing technologies

Raw Material	Description	Typical Annual Usage	Maximum Amount on Site	Environmental Fate of Material	Hazards	Alternatives
Bis(cyclopentadienyl)magnesium (CP_2Mg)	Used for electronic component manufacture (doping of semiconductor layers to modify electrical properties)	100 grams	50 gram vessel. 2 x stock	Hazardous waste disposal & air emissions	H228 Flammable solid. H250 Catches fire spontaneously if exposed to air. H261 In contact with water releases flammable gases. H314 Causes severe skin burns and eye damage.	None given current semiconductor processing technologies

8.3 Minimisation of Raw Material Use

The efficient use of raw materials is a key element of process control. An integral part of the day-to-day supervision of production (both manual and via automated control systems) and of the planned maintenance programme is the monitoring of the process to ensure that the installation operates effectively and efficiently with minimal process losses.

The processes use small quantities of raw materials, with the new reactors each scheduled to operate three process runs a day, requiring approximately require 950g of phosphine and 250g of arsine in total. Given current estimates of production using the Gallium Arsenide substrate wafers, it is expected that approximately 350kg of phosphine and 108kg of arsine will be used per annum.

The estimated consumption of TMGa, TMAl and TMln would be much lower with only around 10kg per year of each material used with the exception of CP_2Mg which would be 100 grams per year.

Opportunities to reduce the quantity of raw materials used in the installation's process are limited due to already small quantities of raw materials being consumed and process recipes already optimised to ensure gases are used at the most efficient flow rate to provide the required product specifications.

Optimisation techniques are employed within the Plymouth installation to reduce or eliminate process loss, including:

- Monitoring of raw materials usage (including any associated energy usage);
- Process-wide quality control inspections to minimise product rejects;
- Monitoring of the production of waste materials, reject product, maintenance waste, etc;
- Preventative and reactive maintenance of processing equipment, when applicable, in accordance with good practice requirements.

8.4 Water Use

The water usage for the new MOCVD reactors will be minimal and the overall water consumption of the installation is not forecast to change increase significantly following the proposed variation.

Water will be used in the cooling circuit of the reactors to regulate the temperature of the process chamber in a controlled fashion. Cooling water will be sourced from the main FAB3 recirculating process cooling water system. The return loop cooling water is passed through heat exchangers and a chiller unit located externally to the main process building, none of which will be changed as part of the variation.

9. Waste Management

9.1 Waste Management

A range of hazardous and non-hazardous waste streams are produced at the Roborough installation. Plessey Semiconductors has designated areas around the installation for storing the different waste streams produced and have defined operating procedures to dictate how different wastes should be managed. The current waste handling and management procedures will remain following the proposed variation, with minor amendments made to reflect the new wastes arising from the use of an additional substate material (Gallium Arsenide) and associated reagents. Silicon-derived wastes and gallium arsenide wastes will be segregated wherever practicable.

The production of waste is an inevitable feature of manufacturing processes due to deviations in process control, such as equipment breakdown or malfunction, as a result of operator error or due to deviations away from the required standards of product quality. This is compounded by the use of the Roborough installation for research, new product innovation and pilot-scale manufacturing activities which will have higher than typical waste production rates as a new production methodology is established.

Plessey Semiconductors actively follows the principles of the Waste Hierarchy to prevent the generation of waste and, where that is not possible, to seek avenues for the recovery and recycling of the wastes produced by the site. Wastes are segregated as far as is practicable and there are separate waste streams for plastic, aluminium, stainless steel, mild steel, copper, wood, paper and cardboard. These waste streams are recycled through licenced waste companies.

In order to maximise the efficient operation of the Installation, and hence maximise process efficiency, Plessey Semiconductors utilises a number of key operational measures including:

- Clear staff responsibilities relating to waste management;
- Use of intelligent automated control systems to maintain high levels of process control;
- Operation of detailed quality management and environmental management systems to reinforce the high standards of process control;
- Preventative maintenance of key items of processing plant; and
- Training of plant operators to recognise circumstances where waste may arise and to take prompt action to prevent this.

The relative proportion of waste production compared to overall production is a Key Performance Indicator (KPI) for the installation. Consequently, all waste streams are reviewed by the installation’s Nominated Manager against the Waste Hierarchy to determine whether improvements can be made. For example, review of segregation methods is regularly undertaken to identify if further segregation is feasible to improve recycling rates.

The Plessey installation’s Nominated Manager is also responsible for:

- Maintaining records of all wastes sent off-site including all necessary evidence to demonstrate compliance with Duty of Care legislation (e.g., Consignment Notes);
- Assessing the compliance history of all waste contractors used;
- Maintaining information on waste contractors used including Waste Management Licenses and Exemptions;

- Arranging periodic checks on waste contractors to help ensure continued compliance; and
- Arranging waste uplifts.

9.2 Waste Records

Waste transfer notes are kept on site and only approved contractors are utilised for off-site waste recycling, reuse or disposal activities; these records include the nature, origin and volume of the transferred waste. Before any contractor is used, their carrier certification and Waste Management Licences are checked and recorded. In this regard, Plessey Semiconductors is fully compliant with the requirements of Duty of Care legislation.

9.3 Waste Storage

All waste awaiting removal from the site is stored in designated waste storage areas. As far as is practicable, these areas are located close to the points at which the waste is generated to reduce handling and the risk of spillages or other losses.

All hazardous wastes generated by the Plessey installation are stored in suitable and secure containers to prevent the contents escaping. Each container is clearly marked, identifying its contents and its hazardous nature. Non-hazardous wastes are typically stored in waste bins or skips. Scrap wafers are collected in the manufacturing area in plastic 150 and 200mm boxes and broken wafers are collected in sharps bins. The material is then passed to the stores area for transfer into metal barrels.

It has been determined that the installation's current waste storage areas are of sufficient capacity following the proposed variation, as minimal increase in waste generation are expected. These areas are regularly inspected, and all non-conformities (such as leaking containers or de-segregation of waste streams) are reported, investigated and corrected. These review procedures are formalised in the site's EMS to ensure ongoing application to the waste handling undertaken at the site.

9.4 Waste Segregation

Specific areas within the installation are designed for waste handling in which waste streams arising from the installation will be appropriately and safely managed. The specification and locations of these areas around the installation take account of the BAT requirements for waste management which prioritises segregation of the wastes produced at the site to maximise the potential for their reuse, recovery or recycling.

While several of the waste streams that are produced by the installation cannot be recycled at present, waste segregation is still undertaken to ensure that these materials can be recycled when appropriate recycling facilities and markets become available. Wastes from the ongoing manufacture of products based on Silicon substrates will be segregated from the analogous wastes based on the proposed Gallium Arsenide substrates.

Plessey Semiconductors staff are technically competent to manage waste treatment activities and will be trained to ensure that appropriate levels of waste segregation are maintained following the proposed variation.

9.5 Waste Inventory

As well as maintaining a detailed inventory of the raw materials used in the installation (See Section 8), Plessey Semiconductors also maintains an inventory of the wastes produced by the installation and has provided an initial quantification of the inventory based on the expected performance of the site following the proposed variation. The inventory includes both hazardous waste and non-hazardous waste arising from the installation.

The Waste Inventory has information on the characterisation of the wastes produced by the installation, their origin, an approximate quantification and details of their storage and handling arrangements and a description of their fate once they leave the installation. The inventory will be updated and maintained for inclusion in the site's EMS once the proposed site variation is complete.

The manufacturing processes utilised in the Roborough installation are necessarily variable as they relate to manufacture of new technologies. Therefore, waste production is not consistent or readily predictable. However, Plessey Semiconductors reviews collected waste data at regular intervals against the context of the collection period. With limits, given the novel nature of the processes employed at the installation, this analysis is beneficial for assessing performance trends, in the optimisation of process control and in the identification of waste prevention opportunities.

Three principal waste streams will result from the operation of the new MOCVD reactors and Table 9.1 below details the source, character and destination of these wastes. The existing wastes produced at the site will be largely unchanged or slightly decreased in volume following the proposed variation and are not detailed further.

The data in the table are estimates for a full year of operation of the installation following the commissioning of the new MOCVD reactors and the associated utilisation of Gallium Arsenide substrates.

Table 9-1. Predicted Post-Variation Waste Inventory (New Waste Streams Only)

Waste Stream	Storage Location	Description	Source	Quantity	Fate of Materials	Storage Conditions
Hazardous Wastes						
Waste Gallium Arsenide wafers	Within FAB3 near production equipment	Waste Gallium Arsenide wafers	FAB3: May be generated at any point during the production cycle and subsequent QA processes	800 wafers per annum	Sent for secure disposal	Plastic boxes at point of production and then in metal drums externally. Broken wafers to be stored in sharps bins.
Aqueous effluent	Hazardous waste storage area between pillars B1 and C1	Aqueous effluent derived from the wet treatment of Gallium Arsenide wafers	FAB3: Substrate cleaning and wet etching processes	$100m^3$ per annum	Treatment and disposal by licensed third-part waste contractors	IBCs used internally for collection of effluent at point of production. Bunded external area for IBC storage pending collection.
Spent absorber columns	North end of the site pending collection	Spent absorber columns from the new MOCVD reactor abatement systems	Abatement systems for new MOCVD reactors	20 columns per annum	Columns returned to equipment provider for emptying and refill. Spent absorption medium to be disposed of as hazardous waste.	Spent columns are gathered and palletised pending collection

Note 1: Quantities are estimates following initial commissioning of the new MOCVD reactors and may be subject to change.

Note 2: As a precautionary approach, it has been assumed that the new waste streams produced following the proposed variation will be classified as hazardous. Initial sampling and assessment of the wastes will be undertaken to verify this classification once the new manufacturing equipment has been commissioned and qualified in operation.

10. Energy

10.1 Introduction

The activities undertaken at the Roborough installation are operated in accordance with an Energy Management Framework which is certified to meet the standards defined by ISO 50001:2018. The minimisation of energy consumption is a key management focus for the business.

Plessey Semiconductors has defined an energy policy, which is endorsed by the site's Senior Management Team. The policy commits the business to:

- Comply with all relevant regulatory and other requirements applicable to the business and the energy management system.
- Embrace sustainable innovation and responsible energy management.
- Engage and educate employees on sustainable practices.
- Continually monitor and analyse energy consumption to minimise waste.
- Incorporate sustainable design principles in facility expansion.
- Collaborate with suppliers for the procurement of energy-efficient products.
- Continually review and improve the performance of the energy management system by implementing energy efficient technologies and practices and setting objectives and energy targets.

The Roborough installation currently operates a range of measures to maximise energy efficiency, including:

- The use of automated control systems;
- A range of building and infrastructure energy efficiency design measures; and
- The use of established and widely implemented quality control procedures and work instructions aimed at the minimization of waste production, with attendant energy savings.

10.2 Predicted Energy Consumption

Primary energy at the site is obtained from natural gas and electricity.

- Electricity is supplied to the site from the National Grid. The new prime users of electricity to be installed at the site as part of the increase in the site's capabilities will be the:
    - Two Aixtron G10-AsP MOCVD reactors
    - Two-stage CS CLEAN SOLUTIONS abatement system associated with each reactor
- Natural gas is supplied to the site on a non-interruptible contract. There will be no new prime users of gas to be installed at the site as part of the proposed variation. The second stage of the CS CLEAN SOLUTIONS abatement system will utilise the hydrogen in the reactor exhaust gases as fuel.

It is expected the two proposed reactors and their associated abatement systems will use approximately 350kWh/day of electricity in total. Predicated energy data are provided in Table 10.1, based on an estimated 300 days of operation per annum.

Table 10.1. Expected Annual Energy Consumption Associated with the Additional Processing Equipment

Energy Source	Annual Energy Consumption (MWh)		
	Delivered	Primary	% of Total (Primary)
Electricity from public supply	105	252	100
Natural Gas	0	0	0
Total	**105**	**252**	**100**

Note: An average thermal efficiency of 41% has been assumed for the public supply of electricity, equating to a primary: delivered ratio of 2.4.

Based on converting the primary energy consumption values by standard emission factors (2025 factors provided by the UK government[2]), the CO_2 emissions associated with the proposed additional activities undertaken with the installation activities are estimated in Table 10.2.

Table 10.2. Expected Annual CO_2 Emissions Associated with the Additional Processing Equipment

Energy Source	Annual Emissions of CO_2 (tonnes)
Electricity from public supply	44.6
Natural Gas	0
Total	**44.6**

Conversion factors used:

- Delivered electricity = 177 kg/MWh
- Natural gas = 203 kg/MWh

The use of the additional process equipment to be installed at the site (dedicated to the deposition of materials on Gallium Arsenide wafers) will result in a reduction in the utilisation of other existing equipment at the site (dedicated to the processing of Silicon wafers), since the total number of wafers to be processed at the site will not increase. The overall energy consumption of the site may also not increase.

The site has installed half-hourly meters to measure energy consumption accurately and this will continue following the proposed variation, to allow the evaluation of the efficiency of production processes using Gallium Arsenide substrates.

[2] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2025

11. Odour Risk Assessment

11.1 Introduction

The Roborough installation utilises a wide range of chemicals in its research and manufacturing activities, many of which have the potential to cause an environmental impact without the use of appropriate process design, pollution control systems and process management to minimise their emissions.

As a result, the installation has been designed to minimise the potential of emissions to air, which will necessarily also minimise the potential for the creation of unacceptable odour beyond the boundaries of the site. Measures for emissions control include:

- The storage of all chemicals in appropriate containment systems, with extraction provided for the main process gas store to reduce the risk associated with leaks from the primary storage containers;
- The use of all process chemicals in enclosed equipment located within the main production building;
- The extraction of process gas emissions to appropriate abatement systems. The two production areas at the site, FAB3 and FAB8, each feature three discrete process exhaust systems (for solvent emissions, acid gas emissions and releases of pyrophoric materials) and a wide range of abatement plant to minimise the emissions from these 6 exhaust systems;
- The use of leak detection and fail-safe devices for the site's gas transfer systems to ensure that the potential for fugitive losses to the environment is minimised.

The nearest residential properties and other sensitive receptor locations are located in close proximity to the site, around 30m east of the site boundary and beyond the A386 main road. Despite the proximity of the receptors, the control systems utilised have meant that the site has never been the subject of odour complaints in its 20-year operational history.

11.2 Proposed variation

A small number of additional raw materials will be used at the Roborough site, as has been detailed in Section 8 (Raw Materials) of this document. As with the materials currently used at the installation, the hazardous nature of the materials to be used following the proposed variation (particularly Arsine and Phosphine) means that their storage, in-process utilisation and disposal will be subject to careful operational control so that the potential for their emission to air will be minimised. The new abatement systems proposed for use in the installation have been described in Section 5 (Emissions to Air) of this document.

As a result of the emissions control systems currently used at the site and the new abatement to be added as part of the proposed variation, the potential risk of the new processes and chemicals leading to an off site odour impact is considered to be low and no further assessment is considered applicable at this time.

Members of Plessey Semiconductors' environmental management team undertake daily site walkabouts of the site to assess its operation and to provide a qualitative appraisal of its environmental impacts. Particular emphasis will be given during commissioning of the new MOCVD reactors to confirm that there is no significant odour resulting from the revised installation activities. If odorous emissions are identified, a suitable olfactory monitoring and minimisation programme will be implemented, to be undertaken by Plessey Semiconductors at suitable frequencies.

12. Noise and Vibration

12.1 Background

The Plessey Semiconductors installation is located off Tamerton Road, around 500m north of the centre of Roborough village, with Plymouth city centre around 6km further to the south. The installation is in a mixed-use area with both industrial units and residential properties in close proximity. The site is bounded by the A386 main road to the east with Tamerton Road to the south and an industrial estate to the southwest. Playing fields lie to the immediate west of the site, with open land, a logistics warehouse and Roborough House to the north.

The nearest sensitive receptors, including both residential properties and Roborough Recreation Hall, are distributed along the eastern edge of the A386 around 30m from the site boundary. To the southwest of the site boundary the closest residential development is located approximately 50m from the site boundary.

12.2 Existing Noise Environment

The manufacture of microLEDs is an iterative process, requiring dozens of repeated production steps conducted on batches of semiconductor wafers, with the processing of a single product batch lasting more than a fortnight in total. As a result, the Plessey Semiconductors installation operates 24 hours a day and year-round.

The majority of noise generating plant at the installation, including: reactors, abatement plant, analytical equipment and gas handling and exhaust systems, are located internally within the main production building. External noise sources include an enclosed plant room which is located along the eastern edge of the roof of the production building, an effluent treatment plant, and the exhaust fans associated with the site's principal air emission points, which are situated at the northeastern corner of the site building. Transient noise generating activities, relating to the deliveries of materials to the site and the subsequent removal of waste and product materials from the site, also occur externally but these are limited to normal daytime hours wherever possible.

Following the installation of the plant room on the roof of the installation in 2023, an assessment was undertaken by Plessey Semiconductors to evaluate the site's impact on the noise environment experienced at the closest sensitive receptor locations. The assessment concluded that the existing noise environment was dominated by traffic noise from the A386 main road, which lies between the receptors and the Plessey Semiconductors site, and that noise from the installation was controlled to an adequate degree.

12.3 Future Noise Environment

The proposed variation will result in the addition of two new MOCVD reactors at the site, which will be placed internally towards the northern end of the FAB3 fabrication area within the main production building, as shown in Appendix A (Drawing A-2). The gas extraction systems and associated abatement equipment for the reactors will be placed beneath the reactors in SUB-FAB3. Given the internal location of the new equipment, the contribution of the new equipment to external noise is expected to be minimal.

Other existing equipment will either be relocated within FAB3 to create room for the installation of the new reactors or will be decommissioned and removed from the site. The new reactors will not have higher noise emissions than the plant they replace and there will be no new externally-located equipment installed as part of the variation.

The intention of the proposed variation is to allow the manufacture of products based on Gallium Arsenide substrates in addition to the current products based on Silicon substrates. Despite this expansion of the site's production capabilities, the overall manufacturing output of the Roborough installation will not increase and will remain limited to approximately 17,000 processed wafers per annum. As a result, the proposed variation is expected to have minimal effect on the site's overall noise impact.

As at present, members of Plessey Semiconductors' environmental management team undertake daily site walkabouts of the site to assess its operation and to provide a qualitative appraisal of its environmental impacts. Particular emphasis will be given during commissioning of the new MOCVD reactors to confirm that there is no significant noise resulting from the revised installation activities. Additional environmental noise monitoring and assessment will be undertaken by Plessey Semiconductors during plant commissioning to provide quantitative confirmation of this conclusion.

13. Monitoring

13.1 Emissions to Air

The Roborough installation has sixteen discrete emission points through which channelled emissions to air are released, designated emission points A1 through to A16. The current Environmental Permit for the site defines a range of Emission Limit Values for these emission points and also specifies monitoring requirements, where necessary, to demonstrate that the emissions are being controlled to an adequate degree.

The proposed addition of two new MOCVD reactors to the installation will not result in any additional air emission points. Following abatement, the emissions from the reactors will be ducted to the existing pyrophoric gas extraction system in FAB3 and will be released to atmosphere via the existing exhaust stack for this system, designated as emission point A3. The location of this stack is shown in Appendix A (Drawing A-2). The existing permit does not specify any current monitoring requirements for this emission point.

Following the commissioning of the new MOCVD reactors, Plessey Semiconductors will undertake emissions monitoring of the release to air from emission point A3 to demonstrate the adequate functioning of the FAB3 pyrophoric process exhaust ventilation systems and of the new reactor abatement systems. It is anticipated that monitoring will be undertaken at three-monthly intervals during the commissioning period, but this interval will be contingent upon the successful progress of the reactor commissioning programme and will therefore be subject to change.

Thereafter, once normal operation of the reactors is established, air emissions monitoring will be undertaken to demonstrate compliance with any ELV stipulated in the site's PPC permit. The monitoring undertaken during commissioning will determine the need for ongoing monitoring.

Table 13.1 – Proposed Air Emission Monitoring Requirements

Emission Point	Substance	Frequency	Standard
A3 – FAB3 pyrophoric exhaust system	Arsenic	Three monthly during commissioning. Frequency during normal plant operation to be determined	BS EN 14385
	Phosphorus		

13.2 Emissions to Surface Water

The proposed variation will not affect the emissions to surface water from the installation, which consist solely of clean surface water run-off and which are discharged to emission point W1, ultimately leading to an unnamed tributary of the River Plym. The site's existing Environmental Permit does not specify any monitoring requirements for this discharge and no monitoring is proposed following the variation to the site.

13.3 Emissions to Sewer

Aqueous process emissions from the installation are routed to the on-site effluent treatment plant (ETP), which is a regulated activity included in the Environmental Permit. Following neutralisation in the ETP, the process effluent is then released to the public foul sewer where it undergoes final treatment in the Emesettle treatment works operated by South West Water.

Monitoring requirements for the discharge to sewer are established in the Trade Effluent Discharge Consent for the installation issued by South West Water (consent reference T4726/0674).

The proposed variation to the regulated activities at the Roborough installation is not predicted to result in any significant change to the effluent produced at the site. As a result, no changes are proposed to the existing monitoring of emissions to sewer.

13.4 Emissions to Groundwater

Clean surface water run-off from an area at the northern end of the installation is discharged to ground via a soakaway, designated as emission point L1 in the site's Environmental Permit. No monitoring requirements are specified in the permit in relation to this emission, which will not be affected by the proposed variation to the installation.

13.5 Environmental Monitoring

Given that the proposed variation to the installation is not predicted to give rise to any adverse environmental impact, no environmental monitoring (i.e. beyond the installation boundary) is proposed.

14. BAT Assessment

The following table shows the Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector (CWW) BAT Conclusions which are applicable to the proposed variation. An assessment of the compliance of the new plant to be added to the installation with these BAT requirements is provided.

Table 14-1 BAT Conclusions Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector

BAT Conclusion	Description	Assessment
Environmental management systems		
BAT 1	In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features:	See Section 4 Management. The installation currently operates an EMS accredited to ISO14001 standard which will be extended to include the new reactors. I) Section 4.2 II) Section 4.3 Environmental Policy III) Sections 4.2, 4.6 4.7 IV) Sections 4.2-0. V) Section: a) 4.13 b) 4.10 c) 4.14 Records d) 4.15 VI) Section 4.2 Senior Leadership Commitment VII) Section 4.3 Environmental Policy VIII) X IX) Section 4.9 X) See BAT 13 XI) N/A XII) Section 8 XIII) Section 11 Section 12

	I. commitment of the management, including senior management; II. an environmental policy that includes the continuous improvement of the installation by the management; III. planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment; IV. implementation of procedures paying particular attention to: a) structure and responsibility; b) recruitment, training, awareness and competence; c) communication; d) employee involvement; e) documentation; f) effective process control; g) maintenance programmes; h) emergency preparedness and response; i) safeguarding compliance with environmental legislation; V. checking performance and taking corrective action, paying particular attention to: a) monitoring and measurement (see also the Reference Report on Monitoring of Emissions to Air and Water from IED installations – ROM); b) corrective and preventive action; c) maintenance of records; d) independent (where practicable) internal or external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained; VI. review of the EMS and its continuing suitability, adequacy and effectiveness by senior management; VII. following the development of cleaner technologies; VIII. consideration for the environmental impacts from the eventual decommissioning of the plant at the design stage of a new plant, and throughout its operating life; IX. application of sectoral benchmarking on a regular basis; X. waste management plan (see BAT 13).	

BAT Conclusion	Description	Assessment
	Specifically for chemical sector activities, BAT is to incorporate the following features in the EMS: XI. on multi-operator installations/sites, establishment of a convention that sets out the roles, responsibilities and coordination of operating procedures of each plant operator in order to enhance the cooperation between the various operators; XII. establishment of inventories of waste water and waste gas streams (see BAT 2). In some cases, the following features are part of the EMS: XIII. odour management plan (see BAT 20); XIV. noise management plan (see BAT 22)	
BAT 2	In order to facilitate the reduction of emissions to water and air and the reduction of water usage, BAT is to establish and to maintain an inventory of waste water and waste gas streams, as part of the environmental management system (see BAT 1), that incorporates all of the following features: I. information about the chemical production processes, including: (a) chemical reaction equations, also showing side products; (b) simplified process flow sheets that show the origin of the emissions; (c) descriptions of process-integrated techniques and waste water/waste gas treatment at source including their performances; II. information, as comprehensive as is reasonably possible, about the characteristics of the waste water streams, such as: (a) average values and variability of flow, pH, temperature, and conductivity; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. COD/TOC, nitrogen species, phosphorus, metals, salts, specific organic compounds); (c) data on bioeliminability (e.g. BOD, BOD/COD ratio, Zahn-Wellens test, biological inhibition potential (e.g. nitrification)); III. information, as comprehensive as is reasonably possible, about the characteristics of the waste gas streams, such as:	There shall be minimal change to the forms of water used onsite following this proposed variation, see Section 8.4. Inventories of waste gas streams and waste water have been given in Sections 5 and 6, respectively. The variation will not lead to any substantive change in the emissions of waste water. All inventories are contained within the site's EMS.

BAT Conclusion	Description	Assessment
	(a) average values and variability of flow and temperature; (b) average concentration and load values of relevant pollutants/parameters and their variability (e.g. VOC, CO, NOX, SOX, chlorine, hydrogen chloride); (c) flammability, lower and higher explosive limits, reactivity; (d) presence of other substances that may affect the waste gas treatment system or plant safety (e.g. oxygen, nitrogen, water vapour, dust).	
Monitoring		
BAT 3	For relevant emissions to water as identified by the inventory of waste water streams (see BAT 2), BAT is to monitor key process parameters (including continuous monitoring of waste water flow, pH and temperature) at key locations (e.g. influent to pretreatment and influent to final treatment).	Waste water streams have been given in Section 6. There will be minimal change to the waste water streams following the proposed variation.
BAT 4	BAT is to monitor emissions to water in accordance with EN standards with at least the minimum frequency given below. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	Section 13
BAT 5	BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using an appropriate combination of the techniques I – III or, where large amounts of VOC are handled, all of the techniques I – III I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment; II. optical gas imaging methods; III. calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements. Where large amounts of VOCs are handled, the screening and quantification of emissions from the installation by periodic campaigns with optical absorption-based techniques, such as Differential absorption light detection and ranging (DIAL) or Solar occultation flux (SOF), is a useful complementary technique to the techniques I to III.	The proposed variation will not affect the use of solvents at the site or their point source or diffuse emissions.

BAT Conclusion	Description	Assessment
BAT 6	BAT is to periodically monitor odour emissions from relevant sources in accordance with EN standards.	See Section 11. No emissions of odour are expected from the proposed reactors.
Emissions to water		
BAT 7	In order to reduce the usage of water and the generation of waste water, BAT is to reduce the volume and/or pollutant load of waste water streams, to enhance the reuse of waste water within the production process and to recover and reuse raw materials.	See Section 8.4. The water usage for the reactors will be minimal.
BAT 8	In order to prevent the contamination of uncontaminated water and to reduce emissions to water, BAT is to segregate uncontaminated waste water streams from waste water streams that require treatment	Only effluent generated by onsite processes will be allowed to enter the proposed treatment system. No rainwater or other surface water will be allowed to mix with the process effluent stream. Once treated, effluent sent to the site's trade effluent drainage system will be kept segregated until it reaches sewer.
BAT 9	In order to prevent uncontrolled emissions to water, BAT is to provide an appropriate buffer storage capacity for waste water incurred during other than normal operating conditions based on a risk assessment (taking into account e.g. the nature of the pollutant, the effects on further treatment, and the receiving environment), and to take appropriate further measures (e.g. control, treat, reuse).	The proposed variation will not affect the production of waste water by the site.
BAT 10	In order to reduce emissions to water, BAT is to use an integrated waste water management and treatment strategy that includes an appropriate combination of the techniques in the priority order given below. a) Process-integrated techniques b) Recovery of pollutants at source c) Waste water pretreatment d) Final waste water treatment	The proposed variation will not affect the production of waste water by the site.

BAT Conclusion	Description	Assessment
BAT 11	In order to reduce emissions to water, BAT is to pretreat waste water that contains pollutants that cannot be dealt with adequately during final waste water treatment by using appropriate techniques	The proposed variation will not affect the production of waste water by the site.
BAT 12	In order to reduce emissions to water, BAT is to use an appropriate combination of final waste water treatment techniques. **Technique** *Preliminary and primary treatment* a) Equalisation b) Neutralisation c) Physical separation, e.g. screens, sieves, grit separators, grease separators or primary settlement tanks *Biological treatment (secondary treatment) e.g.* d) Activated sludge process e) Membrane bioreactor *Nitrogen removal* f) Nitrification/denitrification *Phosphorus removal* g) Chemical precipitation *Final solids removal* h) Coagulation and flocculation i) Sedimentation j) Filtration (e.g. sand filtration, microfiltration, ultrafiltration) k) Flotation	Current effluent treatment plant only requires pH correction for the installation to remain compliant with their trade effluent consent.
Waste		
BAT 13	In order to prevent or, where this is not practicable, to reduce the quantity of waste being sent for disposal, BAT is to set up and implement a waste management plan as part of the environmental management system (see BAT 1) that, in order of priority, ensures that waste is prevented, prepared for reuse, recycled or otherwise recovered.	Waste procedures will be largely unchanged following the proposed variation. Section 9 details the new waste streams expected following the proposed variation. Appropriate procedures and management practices will be adopted for these wastes.

BAT Conclusion	Description	Assessment
BAT 14	In order to reduce the volume of waste water sludge requiring further treatment or disposal, and to reduce its potential environmental impact, BAT is to use one or a combination of the techniques given below. a) Conditioning b) Thickening/dewatering c) Stabilisation d) Drying	The proposed variation will not affect the production of waste water by the site.
Emissions to air		
BAT 15	In order to facilitate the recovery of compounds and the reduction of emissions to air, BAT is to enclose the emission sources and to treat the emissions, where possible.	All emissions to air from the new process equipment at the site will be abated. See Section 5.
BAT 16	In order to reduce emissions to air, BAT is to use an integrated waste gas management and treatment strategy that includes process-integrated and waste gas treatment techniques.	All emissions to air from the new process equipment at the site will be abated. See Section 5.
BAT 17	In order to prevent emissions to air from flares, BAT is to use flaring only for safety reasons or non-routine operational conditions (e.g. start-ups, shutdowns) by using one or both of the techniques given below. a) Correct plant design b) Plant management	Flaring will not be required or utilised by the site.
BAT 18	In order to reduce emissions to air from flares when flaring is unavoidable, BAT is to use one or both of the techniques given below. a) Correct design of flaring devices b) Monitoring and recording as part of flare management	Flaring will not be required or utilised by the site.
BAT 19	In order to prevent or, where that is not practicable, to reduce diffuse VOC emissions to air, BAT is to use a combination of the techniques given below. *Techniques related to plant design*	The proposed variation will not affect the use of solvents at the site or their point source or diffuse emissions.

BAT Conclusion	Description	Assessment
	a) Limit the number of potential emission sources b) Maximise process-inherent containment features c) Select high-integrity equipment d) Facilitate maintenance activities by ensuring access to potentially leaky equipment *Techniques related to plant/equipment construction, assembly and commissioning* e) Ensure well-defined and comprehensive procedures for plant/equipment construction and assembly. This includes using the designed gasket stress for flanged joint assembly f) Ensure robust plant/equipment commissioning and handover procedures in line with the design requirements *Techniques related to plant operation* g) Ensure good maintenance and timely replacement of equipment h) Use a risk-based leak detection and repair (LDAR) programme i) As far as it is reasonable, prevent diffuse VOC emissions, collect them at source, and treat them	
BAT 20	In order to prevent or, where that is not practicable, to reduce odour emissions, BAT is to set up, implement and regularly review an odour management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements I. a protocol containing appropriate actions and timelines; II. a protocol for conducting odour monitoring; III. a protocol for response to identified odour incidents; IV. an odour prevention and reduction programme designed to identify the source(s), to measure/estimate odour exposure, to characterise the contributions of the sources, and to implement prevention and/or reduction measures.	No odour nuisance is expected at sensitive receptors.
BAT 21	In order to prevent or, where that is not practicable, to reduce odour emissions from waste water collection and treatment and from sludge treatment, BAT is to use one or a combination of the techniques given below.	The proposed variation will not affect the production of waste water by the site.

BAT Conclusion	Description	Assessment
	a) Minimise residence times b) Chemical treatment c) Optimise aerobic treatment d) Enclosure e) End-of-pipe treatment	
BAT 22	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to set up and implement a noise management plan, as part of the environmental management system (see BAT 1), that includes all of the following elements: I. a protocol containing appropriate actions and timelines; II. a protocol for conducting noise monitoring; III. a protocol for response to identified noise incidents; IV. a noise prevention and reduction programme designed to identify the source(s), to measure/estimate noise exposure, to characterise the contributions of the sources and to implement prevention and/or reduction measures.	See Section12. No noise nuisance is expected at sensitive receptors.
BAT 23	In order to prevent or, where that is not practicable, to reduce noise emissions, BAT is to use one or a combination of the techniques given below. a) Appropriate location of equipment and buildings b) Operational measures c) Low-noise equipment d) Noise-control equipment e) Noise abatement	No noise nuisance is expected at sensitive receptors.

Appendix A: Drawings

Appendix B: EMS Certificate

Appendix C: Non-Technical Summary