Procedure		Document No.	2792
Document Title	**Monitoring Program – Waste**		
Area	HSE	**Issue Date**	23 August 2017
Major Process	Environment	**Sub Process**	Checking
Authoriser	Jacqui McGill – Asset President Olympic Dam	**Version Number**	17

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1 SCOPE

This Monitoring Program (MP) describes environmental monitoring activities undertaken by BHP Billiton Olympic Dam Corporation Pty Ltd (ODC) for the purpose of quantifying any change in the extent or significance of impacts of the Olympic Dam operation on soil and groundwater from waste facilities, assessing the performance of the control measures employed to limit these impacts, and meeting relevant legal and other requirements.

This MP addresses a number of distinct elements of waste monitoring. For each element, the MP sets out some background information, the purpose of the monitoring and the deliverables which are produced as a result of the monitoring. The MP also includes a description of the methods for measuring achievement of **compliance criteria** and the movement of trends towards **leading indicators** (where applicable).

This MP addresses the monitoring of **environmental aspects** such as the release of contaminants to land and groundwater from site waste facilities, which through their interaction with the environment have the potential to cause impacts. The process of quantifying any change in the extent or significance of impacts of the Olympic Dam operation on groundwater is described in the Groundwater Monitoring Program.

The definition of waste within this MP is any solid, liquid or gas (or combination thereof) that is left over, surplus or an unwanted by-product from business or domestic activity, regardless of economic value. Olympic Dam produces a number of solid and liquid waste streams, some of which are characterised by significant metal concentrations, low-level radioactivity and/or low pH values. The facilities to manage these waste streams are described in Table 1-1.

Table 1-1: Summary of Olympic Dam waste management facilities

Waste management facility	Facility description	Waste stream(s)
Tailings Storage Facility (TSF)	Three cells (Cells 1, 2, 3) totalling 190 hectares (ha) in area and 28.5-30m in height	Miscellaneous hazardous and **low-level radioactive wastes** (**LLRW**).
	One cell (Cell 4) totalling 190ha in area and 27 metres (m) in height	Tailings slurry from the metallurgical plant. Miscellaneous hazardous and **LLRW**.
	One cell (Cell 5 East) totalling 260 ha in area and 11 m in height	Tailings slurry from the metallurgical plant. Miscellaneous hazardous and **LLRWs**.
Evaporation Ponds (EPs)	Five ponds (EP 1, 2, 3, 4 and 5) comprising 8 cells and totalling an area of 144 ha. The ponds range in depth from 4.2 to 5.5 m	Excess liquor from the TSF and the metallurgical plant.
Mine Water Disposal Pond (MWDP)	One cell totalling 35 ha in area and up to 3 m in depth	Excess saline groundwater pumped from the mine dewatering system.
Site sewage ponds	One clay and HDPE lined primary lagoon and one lined evaporation pond. This facility was updated during FY15.	Sewage
Olympic Village sewage ponds	One HDPE lined primary lagoon, four anaerobic ponds and two evaporation ponds. The facility was upgraded during FY13.	Sewage
Resource Recovery Centre (RRC)	Landfill.	Industrial and general solid wastes which are not practicable or cost-effective to reuse or recycle.
	Designated recycling storage areas.	Recoverable materials for reuse and recycling.
Pilot Plant	Laboratory waste and PPE storage	Laboratory waste and PPE

Waste management facility	Facility description	Waste stream(s)
	area.	
Temporary contaminated waste storage area	Approved LLRW temporary storage area adjacent to the RRC.	Contaminated plant and equipment not suitable for disposal in the TSF or landfill.
Permanent contaminated waste disposal facility	Approved contaminated waste disposal facility.	Contaminated plant and equipment not suitable for disposal in the TSF or landfill.

1.1 Responsible ODC personnel

ODC employs a Statutory Radiation Safety Officer acceptable to the Radiation Protection Division of the Environment Protection Authority (EPA), to establish, maintain and fulfil the requirements of this MP, thereby fulfilling its obligation with respect to clause 2.10.1(d) of the Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005) (MC 2.10.1d, MC 2.10.1f). ODC also employs other staff with the necessary experience and qualifications to fulfil the requirements of this MP.

1.2 Review and modification

This MP is reviewed annually. Major changes or amendments following the review are documented in the Environmental Management Program Targets, Actions and Major Changes document.

It should be noted that as a result of operational activities or through optimisation of sample design some existing monitoring sites may be lost and others added (where possible) to maintain the integrity of the sampling program. Access restrictions can result in some sites occasionally being unable to be monitored.

Figure 1-1 : Location of Olympic Dam waste management facilities

2 DETAILED PROCEDURE

2.1 Tailings storage facility

2.1.1 Background

Tailings generated from the hydrometallurgical plant are pumped as a slurry from the tailings disposal surge tanks to the TSF. The tailings are discharged onto the TSF cells via spigot off-takes from the tailings distribution pipework located at the crest of the perimeter embankments of each cell of the TSF. Other miscellaneous hazardous or **LLRW** are also delivered to the TSF as a solid, slurry or liquid.

External perimeter embankments of the TSF are constructed using clayey soil, sand, crushed rock and tailings. The outer face is covered with rock armouring for erosion protection and the crest is covered with a crushed road base material to provide a trafficable surface. The design, construction and operation of the TSF ensure stability under seismic loading, minimise seepage of liquor as far as practicable and minimise erosion on the outer face.

2.1.2 Purpose

- Monitor the operation and performance of the TSF to identify potential for adverse **environmental impact** on soil and groundwater quality.
- Monitor the pond areas on TSF cells to minimise the area of available habitat, reducing the overall attractiveness of the TSF to migratory birds.

2.1.3 Deliverable(s)

- Monitoring data showing the size and location of the supernatant liquor ponds in each TSF cell on a monthly basis (EPA 31543.500-433).
- Monitoring data showing the rate of rise of tailings in each TSF cell.
- Monitoring data showing the pore pressures within tailings adjacent to the external walls of the TSF.
- A review of the water balance on an annual basis (EPA 31543.500-435).

2.1.4 Method

The monitoring of tailings deposition is conducted in accordance with the TRS Operation, Maintenance and Surveillance Manual (BHP Billiton, 2014) and the Tailings Retention System Management Plan (BHP Billiton, 2015).

The TRS Management Plan incorporates:

- Detailed description of the TRS;
- Production Plan;
- Tailings Storage Plan;
- Liquor Management Plan;
- Monitoring and Surveillance Plan;
- Licensing Plan;
- Decommissioning and Closure Plan.

A detailed estimate of the location and area of the supernatant liquor pond in each TSF cell is carried out monthly. Quarterly and annual aerial imagery, provides accurate pond area calculations and pond locations (EPA 31543.500-433).

The rate of rise of tailings is determined using tailings deposition records and quarterly surveys of the tailings beach at the perimeter of each TSF cell prior to each tailings embankment raise.

Piezometers are monitored to assess the pore pressures within the tailings adjacent to the TSF embankments. Piezometers are monitored every two months or more frequently as required. Piezometers used include standpipe and vibrating wire piezometers. Additional or replacement piezometers are installed from time to time as required. The locations of existing piezometers are shown in Figure 2-1 and Figure 2-2.

It is noted that pore pressures vary depending on the location and depth of the piezometers and over the life of the facility as the height of the tailings beach is progressively increased. Pore pressures are monitored and reviewed on a regular basis by operations personnel and during the annual desktop geotechnical review and operational review by an independent tailings consultant. Any abnormal trends identified by operations personnel or the tailings consultant are investigated and, where required, additional slope stability analysis is carried out to confirm compliance with ANCOLD guidelines.

An annual water balance is calculated from monthly data for the TSF to assess the ongoing liquor disposal requirements. Data used includes estimates of tailings production and average tailings slurry density, daily volumes of supernatant liquor decanted to the EPs, daily records of rainfall and pan evaporation, flows into and within the EPs and daily liquor levels in the EPs (EPA 31543.500-435).

An annual operational audit and desktop geotechnical review is performed for the TSF by an independent tailings consultant.

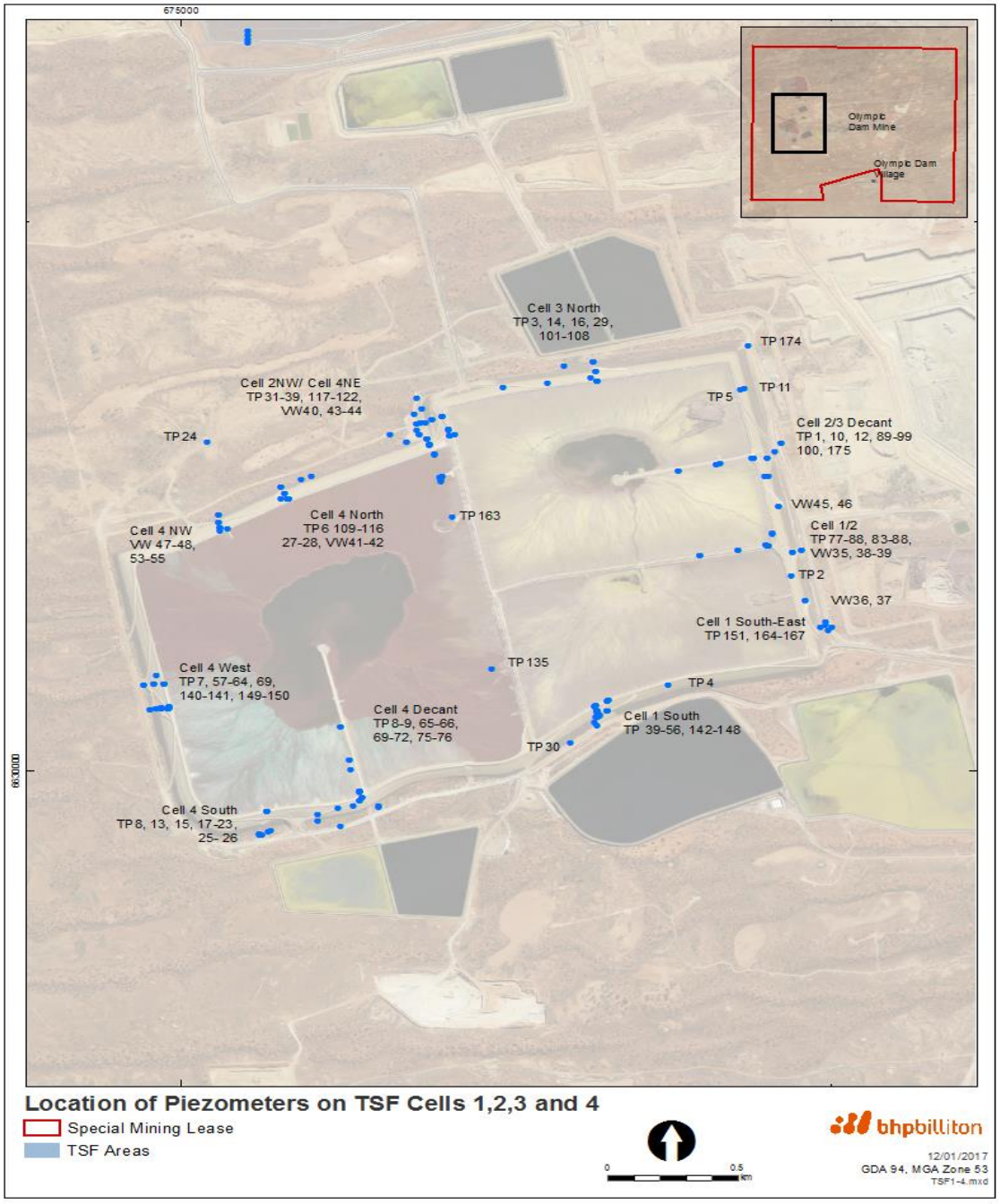

Figure 2-1: Location of piezometers on TSF Cells 1, 2, 3 and 4

Figure 2-2: Location of piezometers on TSF Cell 5 East

2.2 Evaporation ponds

2.2.1 Background

ODC operates five EPs. Their principal function is the storage and evaporation of surplus tailings liquor decanted from the TSF.

The crests of the EPs are profiled so that there is a uniform cross fall from the outer edge to the inner edge of each cell and a constant level is maintained around the perimeter of each cell. A bund is included on the outer edge as a contingency to contain any liquor that overtops the ponds due to wind and wave action.

Liquor evaporates and concentrates in the evaporation cells, resulting in precipitation of solids, principally iron sulphate. Precipitation of solids can be reduced by circulation of liquor through the pond and this is currently being implemented on a number of the EPs. EP1, EP2 and EP3A were taken out of service due to a high level of precipitated solids resulting in inadequate freeboard for their continued operation. The walls of EP1 and EP2 have been raised by two metres and the EPs have been returned to service.

2.2.2 Purpose

- Monitor the operation and performance of the EPs to confirm that they are operating as designed, and to prevent adverse impact on soil and groundwater quality.
- Monitor the liquor inventory in the EPs to assess the evaporation capacity of the ponds and assist in liquor management within the TRS.
- Monitor the liquor depth in EPs to confirm minimum depths that reduce the overall attractiveness of EPs to wading birds.

2.2.3 Deliverable(s)

- Monitoring data showing the liquor level in each cell of the EPs.
- Monitoring data showing the overall (solids and liquor) inventory in the EPs.
- Monitoring data showing the minimum pond depth for operational EPs.
- Results of a liquor balance for each EP cell.

2.2.4 Method

EP levels are measured using a combination of laser, radar and manual survey measurements, depending on the level of solids build-up in the cell and access provisions in each cell (e.g. stilling wells or jetty). EPs are inspected and liquor levels recorded daily. Stored volume (liquor and solids) is calculated from daily liquor level measurements to enable freeboard and overall EP (solids and liquor) inventory to be determined.

Minimum pond depth for operational EPs is measured on a monthly basis to monitor compliance.

A liquor balance is performed to highlight cells with potential significant leaks by comparison of the apparent evaporation from each cell of each EP.

2.3 Mine water disposal pond

2.3.1 Background

Water pumped from the Olympic Dam underground workings originates predominantly from the Tent Hill aquifer, which is fractured in its lower sections and yields water into the mine ventilation shafts, decline, haulage shafts and drill holes. The ore-body and its host rocks generate little or no groundwater flows into the workings.

Water collected from the mine is pumped to the mine water settling ponds to let the slimes and fine particles settle. Water levels of the ponds are monitored via Citect. Settled sludge is removed and disposed of to the TSF and the settled water is reused on-site for dust suppression, soil conditioning during construction and underground mining activities or is discharged to the MWDP for subsequent evaporation and recharging of the Andamooka Limestone aquifer (BHP Billiton, 2013).

2.3.2 Purpose

To provide data related to the operation and performance of the MWDP.

2.3.3 Deliverable(s)

- Records of ground water levels in the vicinity of the MWDP.
- Records of quantities of water disposed of into the MWDP.

2.3.4 Method

Water levels and quantities disposed of into the MWDP pond are monitored in Citect and Ajenti and captured in the Mine Water Balance.

2.4 Site and Olympic Village sewage ponds

2.4.1 Background

Olympic Dam operates two separate sewage facilities. The onsite sewage facility consists of a lined primary lagoon and a smaller lined evaporation pond. The facility at Olympic Village consists of a lined primary lagoon and six anaerobic ponds. Their principal function is to contain and facilitate the anaerobic treatment of sewage from the metallurgical plant, mine and Olympic Village.

2.4.2 Purpose

Monitor the operation of the sewage ponds to minimise impact on soil and groundwater quality.

2.4.3 Deliverable(s)

- Records of pond levels and pond wall condition.

2.4.4 Method

Sewage ponds are monitored regularly to identify potential for adverse **environmental impact**. Pond walls are inspected for any abnormalities and pond levels are measured and recorded. Samples are also taken quarterly to ensure sewer ponds are operating effectively.

2.5 Resource Recovery Centre

2.5.1 Background

Industrial and general waste materials generated at Olympic Dam are managed through the Resource Recovery Centre (RRC), which is located north-west of the smelter and south of the quarry (see Figure 1.1).

Dedicated areas within the RRC allow waste streams to be segregated and certain items to be reused or recycled. Recovered material is cleaned and undergoes a formal radiation clearance procedure before leaving the site.

Material which cannot be reused or recycled is disposed of to the landfill facility, which is also located within the RRC. At the landfill face, waste materials are deposited and covered with clean fill material to facilitate containment of waste. The RRC is enclosed on all sides by either a mesh fence topped with strands of barbed wire or a bund. This is designed to restrict unauthorised access and function as a secondary litter containment control.

Hazardous waste unsuitable for disposal within the **Special Mining Lease** (SML) is transported off-site to an appropriate waste depot for further treatment, recycling or disposal, as discussed in section 2.6.

2.5.2 Purpose

Monitor the disposal and recovery of industrial and general wastes to identify opportunities to minimise the use of natural resources.

2.5.3 Deliverable(s)

- Records of quantities of general and industrial waste disposed of to landfill.
- Records of quantities of material recovered for reuse and recycling.

2.5.4 Method

Waste materials generated across site are collected by the waste management contractor in a dedicated vehicle for recovery or disposal. At the time of collection, the vehicle operator records the quantity of the material and collection location, where appropriate. In cases where material is delivered

to the RRC by operations personnel, the quantity, type and source of the material is recorded at the RRC office before being placed in storage for recovery or disposed of to landfill.

The waste management contractor manages the processes associated with the reception, storage, recovery and disposal of waste materials and the control and operation of the RRC facilities.

Olympic Dam maintains systems to record quantities of industrial and general waste generated, quantities recovered for reuse or recycling and quantities disposed of to landfill. The waste management contractor is responsible for maintaining such records, which are entered into an electronic register. These include:

- cardboard collected;
- general waste collected; and
- materials sent off-site for recycling.

A landfill audit is conducted if any improvement opportunities have been implemented that will affect the waste handling and disposal on site. The audit will be used to determine the composition of waste disposed of to landfill. Wastes from different areas of the plant are separated into various predetermined categories and volumes of each category are recorded. The audit results can be used to assess the performance of reuse and recycling initiatives and to identify new opportunities for reuse or recycling.

The quantities of wastes collected are compared to relevant regulatory guidelines such as prohibited waste to landfill according to schedule 4 of the Environment Protection (Waste to Resources) Policy 2010 under the Environment Protection Act 1993, and appropriate management actions are undertaken to ensure compliance with the relevant storage criteria. The storage of waste tyres will be assessed annually to ensure storage is according to the **Built Environs Section Guideline No. 13 – General Guidelines for Rubber Tyre Storage**, issued by the South Australian Fire Authorities Community Safety Department, revision date 28 July 2014.

2.6 Miscellaneous hazardous wastes

2.6.1 Background

Miscellaneous hazardous wastes such as laboratory chemicals, process chemicals and process waste materials are generated on an ongoing basis at Olympic Dam and require appropriate disposal.

Olympic Dam maintains systems and processes to control and administer the disposal of hazardous waste. Designated HSE personnel provide advice on the disposal of hazardous wastes and authorise waste disposal within the SML, primarily to the TSF. Hazardous waste unsuitable for disposal within the SML is transported off-site to an appropriate waste depot for further treatment, recycling or disposal. For off-site disposal, hazardous waste categorised as listed waste (within the meaning of the **Environment Protection Act**) is transported by an EPA licensed transporter to an EPA licensed waste depot in accordance with EPA guidelines for waste transport and tracking (EPA 1301. (S-27) (S-28)).

2.6.2 Purpose

- Provide data to assist in the management of miscellaneous hazardous wastes in an appropriate manner.

2.6.3 Deliverable(s)

- Records of categories, quantities and location of hazardous waste materials disposed of within the SML.
- Records to provide evidence that listed waste is appropriately managed, specifically:
    - that listed waste is stored, contained and treated in a manner that does not cause environmental harm or nuisance or present risks to human health and safety;
    - that all listed waste storage containers are of a suitable strength and durability, are clearly marked and contain appropriate safety warnings;
    - that all listed wastes do not contact soils or stormwater, and that measures to prevent and recover spillages are implemented as necessary.

2.6.4 Method

Olympic Dam maintains systems to record categories, quantities and location of hazardous waste materials disposed of within the SML. The waste management contractor is responsible for maintaining such records, which are entered into an electronic register.

The location, type and quantity of hazardous waste disposed of to the TSF are recorded on the register.

The transport of hazardous waste off-site is documented through the EPA waste transport and tracking system as required, providing assurance to regulators that wastes are managed appropriately.

2.7 Low-level radioactive waste

2.7.1 Background

There are two general forms of radioactive waste produced at Olympic Dam being: waste process material, process residues or samples that contain radionuclides from the orebody and plant equipment or materials that have been contaminated with radionuclides from the ore body. Each of these categories is managed differently.

Materials that contain radionuclides are generally disposed of in the TSF. However, some bulk samples are managed separately.

Contaminated plant and equipment is disposed to the contaminated waste storage facility and is managed according to the contaminated waste management plan. Off - site laboratory waste and PPE has EPA approval to be temporarily stored at the Pilot Plant prior to being disposed to the TSF.

2.7.2 Purpose

- Provide data to assist in the management of **LLRW** from the Olympic Dam Operation.

2.7.3 Deliverable(s)

- Records of the categories, quantities, radiation levels and location of **LLRW** disposed of within the SML.

2.7.4 Method

Olympic Dam maintains systems to record categories, quantities and locations of **LLRW** disposed of or stored within the SML. The waste management contractor is responsible for maintaining such records, which are entered into an electronic register.

The location, type and quantity of material and its disposal is recorded.

3 COMMITMENTS

3.1 Reporting

The results and a discussion of the results are presented in the annual EPMP report as outlined in the **Environmental Management Manual** (EMM).

3.2 Summary of commitments

Table 3-1: Summary of commitments

Action	Parameter	Frequency
Monitor	EP liquor levels	Daily
Monitor	Sewage ponds to identify potential for adverse **environmental impact**	Weekly
Monitor	Minimum pond depth for operational EPs	Monthly
Monitor	Overall (solids and liquor) inventory in EPs	Monthly
Monitor	Size and location of the supernatant liquor pond in each TSF cell	Monthly

Action	Parameter	Frequency
Monitor	Tailings pore pressures	Monthly
Monitor	Sewage Pond sampling to ensure effective operation	Quarterly
Monitor	Rate of rise of tailings in each TSF cell	Annually
Calculate	Liquor balance for each evaporation cell	Monthly
Calculate	Water balance for the TSF	Annually
Conduct	Independent audit of the TSF	Annually
Conduct	Landfill audit detailing composition of waste	As Required.
Maintain	Register of industrial and general waste disposal and recovery	Continuous
Maintain	Register of hazardous waste disposal (for wastes disposed of within the SML)	Continuous
Maintain	Register of **LLRW /Contaminated Waste** for disposal (for wastes disposed of within the SML)	Continuous
Report	Monitoring results in the annual EPMP report to the Indenture Minister	Annually
Review	The Waste MP and modify as appropriate	Annually

4 DEFINITIONS AND REFERENCES

4.1 Definitions

Throughout the EPMP some terms are taken to have specific meaning. These are indicated in bold text in the documentation and are defined in the glossary in section 5 of the EMM. Defined terms have the same meaning wherever they appear in bold text. Some other terms and acronyms are also defined in the glossary, but do not appear in bold text.

4.2 References

BHP Billiton, 2013, Site Water Control Management Plan, Document No. 19245.

BHP Billiton, 2015, Tailings Retention System Management Plan FY16–FY17, Document No. 80791.

BHP Billiton, 2014, TRS Operation, Maintenance and Surveillance Manual, Document No. 83204.

4.3 Bibliography

ARPANSA, 2005, Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing, Canberra: ARPANSA.