Water quality protection note no. 15

July 2019

(Plain English version, February 2021)

Basic raw materials extraction

Scope

This note applies to extractive industries[1] that remove basic raw materials (BRM) from the ground. BRM includes sand (including silica sand), clay, hard rock, limestone (including metallurgic limestone), gravel, gypsum and other construction and road building materials[2].

Extractive industries usually have an active point of extraction (e.g. a pit) that may be mobile, following the resource through the landscape (sometimes in-stream), and a processing site (i.e. for stockpiling, lay-down areas, washing, crushing and screening). This note covers both.

In most cases BRM operations need roads, offices, workshops and staff amenities. This note also applies to these facilities, although more detailed guidance is available in other Department of Water and Environmental Regulation (DWER) water quality protection notes (WQPNs – see our website).

In this note we advise you, as BRM operators, how to limit your impacts on the environment and water resources. It applies to new proposals and the expansion of existing operations. We encourage the operators of existing BRM operations to adopt the recommendations in this note. This note replaces:

- Statewide policy no. 1: Policy and guidelines for construction and silica sand mining in public drinking water source areas (Water and Rivers Commission 1999)
- WQPN no. 15: *Extractive industries near sensitive water resources* (Department of Water 2003)

[1] *Industry – extractive* is defined in the model scheme template as 'premises, other than premises used for mining operations, that are used for the extraction of basic raw materials including by means of ripping, blasting or dredging and may include facilities for any of the following purposes:
(a) the processing of raw materials including crushing, screening, washing, blending or grading
(b) activities associated with the extraction of basic raw materials including wastewater treatment, storage, rehabilitation, loading, transportation, maintenance and administration' (Government of Western Australia 2015). For *industry – mining*, see our *Water quality protection guidelines for mining and mineral processing*, available on our website.

[2] As defined in *Draft state planning policy (SPP) 2.4: Basic raw materials* (Western Australian Planning Commission 2018).

- South West Region guideline: *Water resource considerations for extractive industries* (Department of Water 2014).

It supports the water resource protection aspects in the *Guideline for mining proposals in Western Australia* (Department of Mines and Petroleum 2016).

Please see our WQPN no. 3: *Using water quality protection notes* (Department of Water 2016c) for standard information to be read in conjunction with this note.

Water quality contamination risks

BRM extraction can cause problems to water resources through:

- dramatic changes in hydrological regimes such as groundwater levels, flooding and waterway channel migration – sometimes well beyond the extraction site or many years later
- exposure of the groundwater table, leading to evaporation and providing a pathway for contamination to enter the aquifer
- possible exposure of acid sulfate soils (see our website)
- erosion, with the eroded soil running off into surface water sources, reducing water clarity, transporting other contaminants, clogging infrastructure such as culverts, pipes and drains, degrading waterways and wetlands and their ecological values, and acting as a 'mask' to drinking water treatment processes
- hydrocarbon and chemical pollution from fuel, oil and chemical leaks and spills, affecting surface water and groundwater quality
- pathogen spread from septic tanks and staff amenities, posing a risk to water quality and public health.

For general information about protecting water quality, see WQPN no. 8: *Further reading* (Department of Water 2016d).

Approvals required

On crown and reserved land, the Department of Mines, Industry Regulation and Safety (DMIRS) is responsible for issuing approvals for BRM extraction. On privately owned land, local governments have this responsibility under the *Planning and Development Act 2005*. See the *BRM applicants manual* (Western Australian Planning Commission 2009) for more information.

DMIRS and DWER have made an administrative agreement to streamline our interactions for water resource management in mining (Department of Water & Department of Mines and Petroleum 2016). The agreement sets out processes and protocols, including schedules of standard endorsements for regulating mining activities under the *Mining Act 1978*. When water resource management areas are affected, DMIRS applies these standard endorsements when it grants mining tenements.

You must gain all the relevant approvals from us. The type and number of approvals depends on the work you intend to do and the project's location. One or more of the following may apply:

- If you use a mechanical plant to screen, wash, crush, grind, mill, size or separate more than 5,000 tonnes of extracted material a year, you must have a works approval and licence[3] under Part V the *Environmental Protection Act 1986*.
- If you are a mechanical plant operator (regardless of the amount of extracted material processed), you must comply with the Environmental Protection (Noise) Regulations 1997 and Environmental Protection (Unauthorised Discharge) Regulations 2004.
- You may need a permit to clear native vegetation under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004.
- If you are in a proclaimed *Rights in Water and Irrigation Act 1914* area, you may need a licence to construct a bore and take groundwater or surface water (including dewatering), or a permit to divert surface water or to interfere with beds and banks of a watercourse. All artesian bores and the water taken from them also require a licence.
- You must have a licence to clear land within a clearing controlled catchment (Denmark, Harris, Kent, Mundaring, Warren and Wellington) under the *Country Areas Water Supply Act 1947*. Please email cawsa@dwer.wa.gov.au
- You need to seek our advice about special requirements if you are proposing to extract BRM in a waterway management area proclaimed under the *Waterways Conservation Act 1976* (Department of Water & Department of Mines and Petroleum 2016).
- Seek our advice about any proposed BRM extraction near sensitive water resources[4]. The decision-making authority should refer these applications to us for our advice.

The Environmental Protection Authority (EPA) may need to assess your proposal if it involves a significant impact on the environment.

Go to www.data.wa.gov.au for maps of the above areas. To find out what information we may need to assess your proposal, see WQPN no. 18: *Information the department requires to assess a proposed development or activity*. For more information about these approvals and assessments, visit our website or contact us.

[3] Industrial premises with potential to cause emissions and discharges to air, land or water are known as 'prescribed premises' and trigger regulation under the *Environmental Protection Act 1986*. See Schedule 1 of the Environmental Protection Regulations 1987 for prescribed premises categories. See also *Guideline: Industry Regulation Guide to Licensing*.

[4] For a definition of 'sensitive water resources', see WQPN no. 4: *Sensitive water resources.*

Recommendations

Location

Public drinking water source areas

Public drinking water source areas (PDWSAs) are surface water catchments and groundwater areas that provide drinking water to cities, towns and communities throughout the state. PDWSAs are proclaimed under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909* or the *Country Areas Water Supply Act 1947*. Find their locations at www.data.wa.gov.au. For more information, see our Strategic policy: *Protecting public drinking water sources in WA* (Department of Water 2016a) and our WQPN no. 25: *Land use compatibility tables for public drinking water source areas* (Department of Water 2016b).

The following applies to BRM extraction within PDWSAs:

- BRM extraction is 'compatible with conditions' in priority 1 (P1), priority 2 (P2) and priority 3 (P3) areas (Department of Water 2016b). We outline the conditions in this note.
- To find out if incidental land uses and activities are appropriate within PDWSAs, see our WQPN no. 25*: Land use compatibility tables for public drinking water source areas* (Department of Water 2016b).
- In P1 areas, maintain a minimum of 3 m undisturbed profile[5] to the highest groundwater level[6]. In P2 and P3 areas[6], this minimum is 2 m.
- Avoid wellhead protection zones (WHPZs) and reservoir protection zones (RPZs) (unless we approve otherwise, in writing). By-laws may apply in these areas. Additionally, *Schedule 2: Public drinking water source areas* in the administrative agreement (Department of Water & Department of Mines and Petroleum 2016) may prevent BRM extraction in these areas.
- You should stage extraction so that operations start at the furthest distance away from protection zones. This enables best management practices to become well-established before mining occurs closer to these water supply abstraction points.
- You need to liaise with the water service provider to ensure you are protecting drinking water supply infrastructure.

[5] See Appendix A for further information about how we determined separation distances.

[6] The highest level of the saturated zone in the soil. Where measurement is required, this is represented by the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero (Watts & Hurt 1991). Highest groundwater level should take into account the range of seasonal groundwater conditions in the context of long-term variability and possible groundwater rise following extraction of BRM. The scale of investigation and analysis will depend on the presence of local water resources, the availability of existing data, the proposed BRM operation and any associated risks. Our *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013) tells you what to consider when assessing the groundwater regime and groundwater levels. The principles in this publication are relevant to groundwater investigations for BRM operations. Groundwater information is available via *Water information reporting* on our website. You should ask us for advice about the level of investigations required.

- You should use dry methods of extraction.
- You should manage fuel and chemical storage using WQPN no. 65 *Toxic and hazardous substances* and WQPN no. 56: *Tanks for fuel and chemical storage near sensitive water resources*. Additionally, schedules 2.1 and 2.2 of the administrative agreement (Department of Water & Department of Mines and Petroleum 2016) prohibit the handling, storage, transport and use of toxic and hazardous substances (including human wastes) within PDWSAs (unless we approve in writing).
- In the absence of a water management plan or fuel management plan we have approved, conduct any refuelling, mechanical servicing and washdown outside of P1 and P2 areas.
- You should train employees and use signs to remind them about the potential risks to drinking water quality in a PDWSA. See our brochure *Living and working in PDWSAs* (Department of Water 2011).

Gnangara public drinking water source area

The Gnangara PDWSA is legally constituted as the Gnangara Underground Water Pollution Control Area under the *Metropolitan Water Supply, Sewerage, and Drainage Act 1909*. It provides a significant source of drinking water for Perth. See www.data.wa.gov.au for its location.

Most BRM in the Gnangara PDWSA lies under current or past pine plantations. We recognise the strategic importance of BRM extraction, and the importance of protecting PDWSAs to ensure good-quality, reliable, low-cost drinking water is available to the public, now and in the future.

Recent modelling using our Perth Region Aquifer Modelling System (PRAMS) shows that groundwater levels in the Gnangara PDWSA are changing. This is because of climate change, planned increases in urban land uses, proposed reductions in groundwater abstraction and the management of pine plantations. Therefore, we need the regional model to predict the highest groundwater level to determine vertical separation distances for BRM extraction.

We conducted investigations in 2017 to address this, which resulted in the following special condition:

- The highest groundwater level for the Gnangara PDWSA, from which to determine separation distances for BRM extraction, is the **highest groundwater levels from the year 2000**.

This level:

- approximates the PRAMS analysis
- reflects the last time that water levels at most Gnangara groundwater-dependent ecosystems met the criteria in *Ministerial statement no. 819* (Office of the Appeals Convenor 2009)
- is definable using existing, readily available data (see *Water information reporting* on our website).

Clearing control catchments (Country Areas Water Supply Act 1947)

- We will need to assess BRM activities within clearing control catchments for potential salinity impacts. Please email cawsa@dwer.wa.gov.au

Near waterways

- BRM extraction should be above the 1 in 100 (1%) annual exceedance probability flood level. To find out flood information, visit www.data.wa.gov.au.
- You should avoid areas prone to seasonal inundation or waterlogging.
- Maintain adequate buffers between waterways and their foreshore areas. See *Operational policy 4.3: Identifying and establishing waterways foreshore areas* and *Determining foreshore reserves* (Department of Water 2012).
- For any land- or water-based developments or activities near the Swan, Canning, Helena or Southern rivers, please contact the Department of Biodiversity, Conservation and Attractions (DBCA) for special requirements.

BRM extraction within waterways (in-stream mining)

In-stream mining is when BRM is extracted from riverbeds or from pits in floodplains. This occurs mostly in the state's north-west in seasonal and ephemeral waterways (i.e. waterways that do not flow all year round). Alluvial deposits are easily extracted from the surface, require little processing and are periodically replenished with new material from upstream when water flow is high.

Waterways are complex and dynamic systems that vary in their sensitivity and response to disturbances such as in-stream mining. In-stream mining can cause beds and banks to erode, the river channel to widen (which poses a risk to infrastructure such as bridge piers and pipelines), sedimentation, surface and groundwater quality to decline, and damage to aquatic and riparian habitats, flora and fauna.

- Appendix B has specific information for in-stream mining proposals that you should apply in addition to the other recommendations in this note.
- If you are proposing in-stream mining that is also within a PDWSA, please contact us for advice, as you may need to take site-specific management measures.

Wetlands

To find out the locations of wetlands, and any separation distances or special measures you may need to apply, please contact DBCA.

Groundwater

- Assess acid sulfate soil risks and mitigate if required. Go to our website or contact us for more information.

Where dewatering is not required:

- Maintain an adequate vertical separation distance between the base of extraction and the highest groundwater level[7] to protect water quality and ensure evaporation does not occur, both during and after extraction. You should determine both of these separation distances during planning approvals processes, before activities begin. Consider the following points when determining these distances:
  - During extraction, this distance depends on site-specific factors. Please contact us for more information.
  - The post-mining separation distance must be appropriate for the future land use (i.e. according to the relevant local planning scheme). If the land use will be urban, see *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013) for more information.
  - We encourage development approval conditions that stipulate maximum pit floor depths.
- If any groundwater interception occurs during extraction (that breaches the extractive industry licence conditions), cease work and provide an advice notice to the relevant approval authority within 24 hours (see *Approvals required* section), followed by agreed remedial action.

If dewatering is required:

- If the proposal is within a proclaimed groundwater area under the *Rights in Water and Irrigation Act 1914*, you may need a licence. Please contact us to determine what additional information you must submit for approvals (see *Approvals required* section), such as a hydrogeological report. See WQPN no. 13: *Dewatering of soils at construction sites* for more information about requirements for dewatering.

Landscape

- Ideally, you should select land that is gently sloping (between 1 in 20 and 1 in 50) so you can manage runoff and wastes, but avoid erosion.
- Avoid rocky and steep slopes, and land prone to erosion.

[7] The highest level of the saturated zone in the soil. Where measurement is required, this is represented by the shallowest depth to free water that stands in an unlined borehole or where the soil moisture tension is zero (Watts & Hurt 1991). Highest groundwater level should take into account the range of seasonal groundwater conditions in the context of long-term variability and possible groundwater rise following extraction of BRM. The scale of investigation and analysis will depend on the presence of local water resources, the availability of existing data, the proposed BRM operation and any associated risks. Our *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013) tells you what to consider when assessing the groundwater regime and groundwater levels. The principles in this publication are relevant to groundwater investigations for BRM operations. Groundwater information is available via *Water information reporting* on our website. You should ask us for advice about the level of investigations required.

- Post-mining landscapes need to be identified and agreed upon through consultation before the approval of new projects (see *Closure, rehabilitation and subsequent land uses*).

Other land uses

- Separation distances between BRM extraction and sensitive land uses – such as urban areas – may apply, as stated in Guidance statement no. 3: *Separation distances between industrial and sensitive land uses* (Environmental Protection Authority 2005).
- Avoid infrastructure and maintain adequate separation distances to ensure its operation is not compromised. Please consult with the relevant operator/owner of the infrastructure.

Construction

- Use existing roads and tracks to access the site where possible. You should not create new access ways onto major roads.
- Restrict access routes to the excavation area to the minimum necessary (i.e. the least possible creek crossings) and select these for the least impact (i.e. areas with minimum vegetation).
- Construct creek crossings in accordance with *Building creek crossings* (Department of Water 2010). If the creek is within a proclaimed surface water area under the *Rights in Water and Irrigation Act 1914*, you may require a permit to interfere with the beds and banks (please contact us).
- Construct roads in accordance with WQPN no. 44: *Roads near sensitive water resources*.

Operation and management

- You should stage extraction so that at any one time the active area of extraction is in accordance with the relevant approvals (i.e. local government's extractive industry licence conditions, Part V *Environmental Protection Act 1986* works approval or licence conditions or DMIRS approval conditions).

Solid waste

- It is an offence under the Environmental Protection (Unauthorised Discharges) Regulations 2004 to cause or allow scheduled items to be discharged to the environment. Scheduled items include (but are not limited to) acids, hydrocarbons and sediment.
- Any wastes you cannot reuse or recycle in the operation should be stored appropriately and disposed of at an approved facility offsite.

Water supply

- If your operation is within a proclaimed surface water or groundwater area under the *Rights in Water and Irrigation Act 1914*, you may need a licence to construct a bore, and abstract groundwater or surface water. All artesian bores and the water

taken from them are licensed under the Act. Go to our website or contact us for more information.

- You should reuse uncontaminated stormwater in the operations where possible.
- If the operation is not connected to a scheme supply, and you need a potable water source, see our WQPN no. 9: *Community drinking water sources – protection and management* for more information.
- Use low-volume, high-pressure water hoses for washdown to minimise the amount of water used. This will reduce the cost and volume of wastewater you need to manage.

Wastewater

- You should connect your facilities to deep sewerage, if available. If not, you should install onsite wastewater treatment systems in accordance with the *Government sewerage policy* (Western Australian Planning Commission draft 2016, or as updated).
- Small-scale facilities may not need permanent toilet facilities, so for these sites, you should provide portable toilets according to *Health Act 1911* requirements. Contact your local government for advice.

Stormwater

- You should direct stormwater from 'clean' areas such as roofs, clean paved areas and areas outside of the work site away from operational areas.
- Stormwater that originates from outside or adjacent to the works area needs to be diverted around the works area.
- If appropriate, treat and reuse contaminated stormwater in the operations.
- You should manage stormwater flowing from disturbed areas, including areas for stockpiles, to prevent turbidity (e.g. via settling pits). Design settling pits to handle up to a two-hour, 1 in 10 (10%) annual exceedance probability event.
- The following coefficients of runoff are appropriate for BRM excavation pits with a slope of 5% or less, during the two-hour, 1 in 10 (10%) annual exceedance probability event and for the pit floor only (you should not use them for any other land uses). We derived the values using the ranges of recommended losses from *Australian rainfall and runoff* (Ball et al. 2019).

Material	**Coefficient of runoff**
Sand	0.1
Limestone	0.5
Gravel	0.8
Rock	1.0

- You should ensure overflow systems are engineered to manage stormwater runoff resulting from greater than two-hour, 1 in 10 (10%) annual exceedance probability events, and up to the critical 1 in 100 (1%) annual exceedance probability event. The overflow system and pathway should be designed to mitigate erosion and flood risks.
- See our *Stormwater management manual for Western Australia* (Department of Water 2004–08) for more advice.

Dust

- For prescribed premises under the *Environmental Protection Act 1986*, we may consider that dust from processing and stockpiling activities is a 'specified emission' and impose controls via licence conditions. We do not consider that dust from BRM extraction, including blasting and free digging, is a component of the prescribed activity. This is subject to the general provisions of the Act. Penalties apply for causing pollution or environmental harm.
- We issues licences under the *Rights in Water and Irrigation Act 1914* we issue licences for water abstraction to manage dust on a temporary basis with a reduced tenure. These licences are not transferable to other users and we will not renew them past the life of the mine. You need to demonstrate how you will implement best practice to minimise the volume of water used. Go to our website or contact us for more information.
- See *A guideline for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities* (Department of Environment and Conservation 2011) to find out more about managing dust.

Toxic and hazardous substances

- You should store and use any chemicals, fuels, pesticides and fertilisers in accordance with WQPN no. 65: *Toxic and hazardous substances* and WQPN 56: *Tanks for fuel and chemical storage near sensitive water resources*.
- Limit the herbicides used in PDWSAs to those specified in the Department of Health's PSC 88: *Use of herbicides in water catchment areas*.
- Contact the Department of Health for advice on the use of pesticides where these may contact people, food or water supplies.
- Ensure refuelling occurs within bunded compounds to allow effective recovery of spills. The bunded area must be designed to hold a 1 in 20 (5%) annual exceedance probability, 72-hour storm event and 110% of tank contents. Bunding should be high enough to contain wave action and jetting from leaks, but the size minimised to reduce the footprint of the containment area.
- You should store and handle dangerous goods in accordance with the Dangerous Goods Safety (Storage and Handling of Non-Explosives) Regulations 2007. Similarly, you should store and handle explosives in accordance with the Dangerous Goods Safety (Explosives) Regulations 2007. Contact DMIRS for more information.

Vehicles

- You must ensure all machinery and vehicles are regularly serviced and maintained, clean and free of oil, fuel, hydraulic or any other fluid leaks before they enter the excavation area.
- Conduct the washdown of vehicles and any mechanical equipment as outlined in WQPN no. 68: *Mechanical equipment wash down*.
- Direct all contaminated washdown water to the wastewater treatment system.
- Conduct vehicle or machinery servicing and repairs in accordance with WQPN no. 28: *Mechanical servicing and workshops*.

Accidents and emergency response

- Clean up any spills immediately, disposing of the solids in sealed containers for disposal offsite to a licensed facility, and draining the residue to a sealed collection sump, not into the environment.
- Report immediately any chemical spill or contaminated water that escapes containment to our Pollution Watch Hotline, phone 1300 784 782. If the spill is within a PDWSA, you should also advise the Water Corporation immediately, phone 13 13 75.
- You should have a contingency plan for emergency situations such as accidents, fires, chemical spills and vandalism that could affect water resources. See WQPN no. 10: *Contaminant spills – emergency response* for more information.

Monitoring

- Design and conduct a monitoring program under advice from the relevant approval authorities to check for impacts and changes. Consider using baseline monitoring, photo monitoring, aerial imagery, topographic surveys and soil, surface water and groundwater monitoring.
- See WQPN no. 30: *Groundwater monitoring bores* to find out more.

Closure, rehabilitation and subsequent land uses

- Consider the post-BRM extraction land use before starting extraction. This will help determine what the finished landscape needs to look like, how much BRM can be extracted and what the final separation to groundwater needs to be.
- The landscape should preferably be restored to conditions that are similar to the surrounding environment, including physical and biological processes. As a guide, consider whether the final landform is safe, stable, non-polluting and self-sustaining. Ongoing earthworks should not be needed to maintain the site.
- Ensure that an appropriate vertical separation distance to groundwater is achieved, considering the protection of groundwater and consistency with future land uses that fall under the relevant local planning scheme.
- We do not support the creation of new water bodies by leaving open pits and voids. If you propose an open water body for future recreation or conservation purposes, you will need to demonstrate that issues such as water resource

management, water quality protection and mosquitoes/midges can be successfully managed in the long-term. See our *Interim position statement: Constructed lakes* for more information (Department of Water 2007).

- Prepare a mine closure plan that:
  - considers the timing of the project; you may need a staged closure plan, with rehabilitation occurring as areas are closed off rather than waiting for the entire operation to cease
  - considers zoning and future use of the land and appropriate finished ground levels as predetermined in a mining plan
  - specifies details of the final landform
  - specifies finished depth to groundwater levels, appropriate for the future land use
  - considers recontouring, stability and erosion risk
  - specifies appropriate material for backfilling if required
  - discusses proper removal of infrastructure (such as ramps)
  - addresses public and animal safety
  - outlines revegetation plans (if appropriate)
  - ensures any natural elements are replaced where required (i.e. large woody debris in streams)
  - refers to *Guidelines for preparing mine closure plans* (Department of Mines and Petroleum & Environmental Protection Authority 2015).
- If your site is within a PDWSA, please also see WQPN 84: *Rehabilitation of disturbed land in public drinking water source areas*.

Appendix A: Statewide policy no. 1

The following is an extract from Statewide policy no. 1: *Policy and guidelines for construction and silica sand mining in public drinking water source areas (Water and Rivers Commission 1999)*. It outlines the important history and scientific information behind the 3 m (for P1 areas) and 2 m (for P2 and P3 areas) separation distances recommended for PDWSAs. Note that Department of Water and Environmental Regulation has since replaced the functions of the Water and Rivers Commission.

Environmental impacts arising from sand mining activities include impacts on local and regional groundwater flow regime and the possible risk of groundwater pollution. An adequate clearance between the finished surface level and the highest known groundwater levels is of critical importance in ensuring impacts on water resources are minimised.

In determining an appropriate clearance the following issues were considered:

- sufficient clearance to allow accidental fuel spills to be contained in the unsaturated zone for a reasonable period of time
- sufficient clearance to ensure evaporation losses during mining are minimised
- sufficient clearance to ensure evapotranspiration losses from the rehabilitated minesite do not unacceptably reduce aquifer recharge.

Sufficient clearance to allow fuel spills to be contained in the unsaturated zone

Fuel spills and leaks from onsite storage facilities pose a threat of groundwater contamination. The most important element in the reduction of any groundwater hydrocarbon contamination is the extent to which the unsaturated zone above the watertable can contain the volume of fuel spilled.

In the event of a fuel spill, the unsaturated zone can minimise the possible lateral spread of the hydrocarbon plume, provide the opportunity for remediation and lessen the risk of contaminant interaction with the groundwater.

The vulnerability of water resources to contamination from fuel leaks depends on the retention capacity of the soils, depth to the watertable, seasonal watertable variations and quantity of fuel spilt.

Previously, a minimum 2 m clearance between the lowest mined profile and the highest known watertable was required. The Commission has reviewed this requirement and commissioned the Centre for Groundwater Studies (CGS) to conduct a study (Johnson, 1997). This study analysed the extent of diesel infiltration for likely fuel spill scenarios and also tested whether the depth of 2 m of unsaturated zone is sufficient to protect groundwater supplies from hydrocarbon contamination.

The simulated diesel spill scenarios modelled a range of situations, from large and extensive spills to smaller instantaneous releases over a longer period of

time. The study assumed that the unsaturated zone consists of Bassendean Sands, which are typical of those being mined in underground water pollution control areas near Perth.

The study demonstrated that for slow leaks (5000 L, 400 L and 200 L of fuel leaking over 12 hours), the maximum depth of hydrocarbon infiltration would be contained in the range 0.64 m to 1.28 m. The time taken to reach these depths would range from 2.5 days to 50 days.

Hydrocarbon infiltration is sensitive to changes in soil characteristics, increasing in porous sandy soils.

For rapid spills (400 L of fuel spilled in 1 minute), the maximum depth of hydrocarbon infiltration would be contained in the 1.03 to 2.05 m zone. The time taken to reach these depths would range from 1.6 days to 12 days.

Considering the results of the CGS's study, the Commission considers that the 2 m buffer zone of undisturbed sand profile is appropriate. This buffer minimises the risk of contamination of groundwater from hydrocarbons and allows time for remediation to take place.

Sufficient clearance to ensure evaporation losses during mining are acceptable

Direct evaporation of groundwater can take place when the watertable is close to the surface, usually within 0.5 to 2 m (Bouwer, 1996). Evaporation losses were found to be inversely proportional to the depth of the watertable. The relationship between the evaporation rate and watertable depth for sandy sediments, shows that with a watertable at a depth of 2 m the evaporation rate is approximately 1 mm/day (Bouwer, 1996).

Capillary rise also contributes to the process of evaporation. Empirical field data on sediments and other materials underlying the Swan Coastal Plain provides evidence that the watertable in these sediments can create a zone of capillary rise of 1.5 to 2 m (Davidson, 1995).

Existing data provide reasonable indication that a minimum thickness of 2 m of unsaturated zone is necessary to prohibit the loss of significant quantities of water through evaporation.

Sufficient clearance to ensure evapotranspiration losses from the rehabilitated minesites do not unacceptably reduce aquifer recharge

Transpiration is the loss of water vapour from vegetation. Where the depth to the groundwater table is small (typically less than 3 m) the vegetation will often establish roots which draw water directly from the watertable to meet their requirements. These plants are known as phreatophytes (Bouwer, 1996).

Bestow (1976) has demonstrated that in the Perth region, the amount of transpiration decreases as the depth to the watertable increases by approximately 400 mm per metre. For example where the depth to watertable is 2 m, Bestow predicts transpiration losses will be about 700 mm; however,

for a depth of 3 m the predicted transpiration loss will be around 300 mm and for 4 m transpiration losses will be negligible.

Farrington et al. (1988) found that within the range 4 to 12 m of the watertable depth over Gnangara Mound, the evapotranspiration rate is not correlated to depth of watertable.

Perth area receives around 870 mm of rain per year, not all of which infiltrates into the soil. In Priority 1 areas the depth to watertable should be maintained such that transpiration losses are small relative to rainfall. The minimum clearance in these areas is recommended to be 3 m (roughly equating to the minimum clearance for phreatophytic vegetation). This recognises that these sites will be revegetated following mining.

Appendix B: Recommendations for BRM extraction in waterways (in-stream mining)

Lower-risk locations

- BRM resources can sometimes be sourced from the floodplain area or abandoned stream channels such as on terraces and outer areas of floodplains. These can be easier to access and have lower environmental risk than mining within the waterway channel.
- Braided waterway systems are preferred over other types of river systems for BRM extraction, because they carry a lot of coarse sediment and are more dynamic, so they are less sensitive to disturbance.
- Larger waterways are preferred to smaller creeks and streams for BRM extraction, because large rivers have more sediment and the disturbance is proportionally smaller.

Floodplain mining

- Mining pits must be situated at least 30 m away from the top of the waterway banks. For larger waterways, a bigger buffer may be appropriate. Contact us for further advice, if required.
- Do not excavate floodplains below the thalweg in the adjacent channel. The thalweg is the lowest point of the bed along an entire reach of a waterway.

In-stream mining locations

- In-stream BRM excavation areas should:
  - not be within 1 km of a bridge, water supply facilities or pipelines
  - exclude in-stream islands with established riparian vegetation
  - avoid eroding sections of waterways
  - identify permanent river pools and avoid impacts by providing an adequate buffer
  - minimise impacts to the waterway banks and riparian vegetation.
- Roads, processing sites, stockpiles and other infrastructure should be away from the riparian zone, or at least 30 m away from the top of the waterway bank.
- Access ramps into the waterway should be less than 10 m wide, limited to the minimum number and have locations selected for the lowest risk to the channel banks and riparian vegetation. Where possible, select locations with minimal vegetation, gently sloping banks, located on straight sections of channels, and avoiding eroding areas.

Resource estimation and replenishment

- Extraction should only occur in aggrading areas, where the natural deposition and accumulation of sediments occurs, forming sand and gravel bars.
- Excavation should remove loose sediments only, not consolidated or calcreted sediments that form the channel bed or banks.
- An appropriate amount of sediment needs to remain in the system to maintain sediment transport processes, particularly for large, episodic floods.
- Test pits are recommended before mining to indicate the depth of loose aggrading material.
- Resource estimation should more accurately map the locations and depth of available resource taking into account the exclusion areas and buffers required (e.g. from bridges and pipelines, around permanent pools and in-stream vegetated islands, and from banks and low-flow channels).

Management measures

- Extraction should commence when dry season river flow declines and a sufficient portion of the channel bed is exposed. Extraction should cease before the wet season, before the risk of inundation of the mined area increases.
- Shallow extraction over a wider area of the river bed may be more sustainable and have lower environmental risk than extraction from a deeper pit.
- Extraction sites must be a sufficient distance from the base of the dominant channel banks. The recommended buffer is 10% of the dominant channel width or 3 m (whichever is greater), measured from the base (toe) of the bank.
- If the river is not completely dry, excavation can occur in elevated dry parts of the channel, but must not occur below the depth of the water level in the low flow channel; and buffers should protect the low-flow channel and the channel bank on either side of the excavation area.
- Do not excavate within 0.5 m of the current watertable. If the watertable is accidentally exposed, extraction should immediately cease in that location and the area should be backfilled with original material to at least 0.5 m above the watertable.
- Refuelling should occur outside of the waterway and buffer.
- Significant vegetation in the waterway (e.g. large mature trees) should be protected by a 2 m buffer from the drip line (outer edge) of the foliage or canopy to protect essential root systems.
- Avoid disturbing roughness elements (such as large woody debris) in the waterway where possible. Those that are disturbed should be retained for later replacement.
- Stockpiles within the channel should be removed before the start of the wet season.

- Deeper mining pits should be recontoured for stability (to prevent erosion) before the start of the wet season.

Monitoring

- Monitoring may be required to evaluate the upstream and downstream effects and any potential long-term channel changes as a result of in-stream mining.
- It may be necessary to monitor the sediment replenishment after major river flows to demonstrate the sustainability of the extraction rate.
- When extraction is undertaken near permanent pools, monitoring may be required to identify and minimise detrimental impacts.

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Disclaimer

Department of Water and Environmental Regulation
Prime House
8 Davidson Terrace
Joondalup WA 6027
dwer.wa.gov.au

Phone: +61 8 6364 7000
Fax: +61 8 6364 7001
Email: water.quality@dwer.wa.gov.au
National Relay Service 13 36 77