Department of
Environment and Conservation

Western Australian guidelines for biosolids management

December 2012

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The first biosolids guidelines were produced in 2002, by the former Biosolids Working Group. The Working Group originally included representatives from the Department of Environmental Protection and the Water and Rivers Commission (which later amalgamated to become Department of Environment in 2001), as well as a representative from the Department of Health. These guidelines were released as a working draft so they could be easily updated as new information became available from stakeholders or from ongoing research into the beneficial use of biosolids. A working draft also enabled currency with the National Guidelines on Biosolids Management (National Resource Management Ministerial Council 2004).

In 2006, the Biosolids Working Group was restructured to include a representative from the Department of Environment and Conservation, the Department of Water, the Department of Health and the Water Corporation. The working group commenced a formal review of the guidelines, as well as including stakeholder input on how the guidelines could be improved. As a result of this review process, the guidelines have now been updated.

If you have any comments regarding the guidelines, please forward them to:

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This document is available in alternative formats on request.

Cover photo: Application of biosolids (Photo courtesy of the Water Corporation).

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1.0 DEFINITIONS

ABBREVIATIONS AND ACRONYMS

Acronym	Term	Definition
BCC	biosolids contaminant concentration	Concentration of contaminant levels in the biosolids. First step in calculating the contaminant grading system for biosolids.
BACC	biosolids adjusted contaminant concentration	A statistically modified measure of contaminant concentration based on current and historical data.
CACT	contaminant acceptance concentration threshold	Upper limit of metal concentrations for contaminant classification of biosolids.
CEC	cation exchange capacity	A measure of the soil's ability to hold positively charged ions. It is a very important soil property influencing soil structure, stability, nutrient availability, soil pH and the soil's reaction to fertilisers and other ameliorants.
CFU	colony forming unit	Individual colonies of bacteria of the same organism.
CLBAR	contaminant limited biosolids application rate	The limiting rate at which biosolids can be applied without exceeding the maximum allowable concentration of any one component.
DAFWA	Department of Agriculture and Food WA	DAFWA's primary function is to assist the state's agriculture, food and fibre sectors to be sustainable and profitable.
DEC	Department of Environment and Conservation	The department that is the primary agency responsible for protecting the environment under the *Environmental Protection Act 1986*.
DoH	Department of Health	The department responsible for the implementation of the Health Act and protection of public health.
DoW	Department of Water	The department responsible for the protection and management of the state's water resources (including public drinking water source areas).
EAR	Environmental Assessment Report	Report compiled by DEC that documents the assessment of the application and supports the determination of the licence and conditions of that licence.
LGA	local government authority	The administrative body for a specific geographic area. Local governments may have specific restrictions on biosolids application.
LAB	lime amended biosolids	Biosolids with sufficient added lime to destroy or inhibit regrowth of microorganisms (including pathogens).
MASCC	maximum allowable soil contaminant concentrations	The total contaminants found when soil and applied biosolids are combined should not exceed the maximum allowable soil contaminant concentrations. MASCC are measured in mg/kg dry weight of soil and are mean concentration values.

Acronym	Term	Definition
MPC	maximum permissible concentration	The maximum level of contaminate concentrate to reduce excessive uptake of metals by crops or ingestion by humans or animals or deleterious effects on the environment.
MPN	most probable number	As exact numbers of microbial organisms are difficult to obtain, MPN is a technique used to estimate microbial populations existing in soils, water and agricultural products.
MR	mineralisation rate	The mineralisation rate for organic nitrogen is included as organic nitrogen is not immediately available and may be released over a number of years. The rate of release is assumed to be dependent on the biosolids treatment process.
NATA	National Association of Testing Authorities	Australia's national laboratory accreditation authority. NATA accreditation recognises and promotes facilities competent in specific types of testing, measurement, inspection and calibration.
NBRP	National Biosolids Research Program	A national research program coordinated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) that aims to aid revision of guidelines to maximise the benefits and minimise the risks of applying biosolids and other organic wastes to land.
NLBAR	nitrogen limited biosolids application rate	The rate at which biosolids can be applied without exceeding the crop or soil nitrogen requirements, thereby protecting groundwater from nutrient leaching.
PBI	phosphorus buffering index	A measure of the capacity of soils to buffer excess phosphorus which is then released over subsequent growing seasons.
PDWSA	public drinking water source areas	PDWSAs include all underground water pollution control areas, catchment areas and water reserves constituted under the *Metropolitan Water Supply, Sewerage, and Drainage (MWSSD) Act 1909* and the *Country Areas Water Supply (CAWS) Act 1947.*
PFU	plaque forming units	Concentration of viruses in a solution capable of lysing host cells and forming a colony, or plaque, in the culture.
PLBAR	phosphorus limited biosolids application rate	The rate at which biosolids can be applied without exceeding the crop or soil phosphorus requirements, thereby protecting groundwater from nutrient leaching.
PRI	phosphorus retention index	A measure of the capacity of soils to retain and immobilise excess phosphorus, which is then released over subsequent growing seasons.
pH		A measure of the hydrogen-ion concentration in a solution. On the pH scale of 0–14, a value of 7 represents a neutral condition; decreasing values below 7 indicate increasing acidity, and increasing values above 7 indicate increasing alkalinity.

Acronym	Term	Definition
QA/QC	quality assurance/quality control	Quality assurance is the process or set of processes used to measure and assure the quality of a product. Quality control is the process of meeting products and services to consumer expectations.
REF	review of environmental factors	A report accompanying a third party independent auditor's certification.
RSCL	receiving soil contaminant limits	Limit based on the most conservative assessment end point (from human health, environment and food safety).
SOUR	specific oxygen uptake rate	Also known as the oxygen consumption or respiration rate. SOUR is defined as the milligrams of oxygen consumed per gram of volatile suspended solids per hour.
VAR	vector attraction reduction	Treatment methods for biosolids that reduce the nuisance through attraction of pests such as insects and rodents.
VSR	volatile solids reduction	Reducing the portion of total solids present in sludge that contain calorific value.
VSS	volatile suspended solids	Solids lost on ignition (heating to 550°C). Gives an approximation of the amount of organic matter present in the solid fraction of wastewater and activated sludge.
WC	Water Corporation	The Water Corporation is the principal supplier of water, wastewater and drainage services in Western Australia to hundreds of thousands of homes, businesses and farms, as well as providing bulk water to farms for irrigation.

GLOSSARY

Aerobic digestion	A sludge stabilisation process using bacteria in an aerobic (oxygen containing) environment to digest organic matter in raw sludge thereby stabilising the sludge.
Aerobic thermophilic digestion	A sludge digestion process carried out in an aerobic (oxygen containing) environment using micro-organisms tolerant to elevated temperatures up to 55–60°C, to increase the rate of biological activity.
Anaerobic digestion	A sludge stabilisation process using bacteria in an anaerobic (without free oxygen) environment to digest organic matter in raw sludge thereby stabilising the sludge.
Anaerobic mesophilic digestion	A sludge digestion process carried out in an anaerobic (without free oxygen) environment using microorganisms tolerant to temperatures between 32–38°C, to increase the rate of biological activity.
Biosolids	Sludge from a wastewater treatment plant that has undergone further treatment to reduce disease causing pathogens and volatile organic matter significantly, resulting in a stabilised material suitable for beneficial use. Does not include industrial and food processing sludges.
Biosolids cake	Stabilised biosolids that have been dewatered by mechanical or solar means to usually greater than 15 per cent total solids.
Biosolids product	Composted or blended materials that include biosolids as a component.
Blends	A mix or dilution of biosolids with other materials without further treatment.
Bunds	A wall structure designed to retain or exclude run-off.
Coliphage	A type of virus that infects *E. coli*. Coliphages are considered representative of faecally derived viruses.
Compost	A blended mix which may contain biosolids and other products to produce heat from microbiological stabilisation in the presence of air for a specific period while monitoring time and temperature. This is done primarily to break down organic matter into a more bioavailable form, and also has the effect of reducing pathogens. Also; the end

	product of the composting process.
Contaminants	Substance or object in contact or mixed with a material that poses a risk of harm to human health or the environment.
Contaminant grade	A grading based on the concentration of chemical contaminants in biosolids or biosolids products.
Dry tonnes	Term used to describe the mass of biosolids, excluding any moisture that is present within the biosolids, as determined by moisture content analysis, for example, 100 wet tonnes at 75 per cent moisture is equivalent to 25 dry tonnes.
Electrical conductivity	A measure of salinity. In soil analysis it is used to measure the quantity of water soluble salts in the soil.
Endotoxin	A toxin produced by certain bacteria and released upon destruction of the bacterial cell.
Escherichia coli (*E. coli*)	The most common thermotolerant-coliform present in the lower intestine of warm-blooded organisms and used as indicator of faecal contamination.
Eutrophication	A process of accumulation of nutrients in surface waters. Human activities contributing fertilisers and other high nutrient wastes can speed up the process, leading to algal blooms and deterioration in water quality.
Groundwater	All waters occurring below the land surface.
Helminths	Parasitic worms that cause disease and illness in humans such as tapeworm, pinworm and trichinosis. They are usually transmitted via contaminated food, water, soil or other objects. Adult worms live in the intestines and other organs.
Landcare programs	Community-based programs, or stewardship, which implements management practices which protect or restore soil, water and biological resources. Programs may include soil conservation, managing erosion and salinity, sustainable farming practices and revegetation etc.
Leachate	Water discharged from stockpiled biosolids, either by surface run-off or groundwater infiltration, which has been in contact with the biosolids and therefore has the potential to be contaminated.
Lime amended biosolids (LAB)	Biosolids that have had sufficient lime added to destroy or inhibit regrowth of microorganisms (including pathogens).

Pathogen	Microorganism which can cause disease in humans or animals.
Pathogen grade	A grading based on the level of treatment undertaken to achieve desired microbial limits and a reduction in odour and vector attraction for biosolids and biosolids products.
Pellets	Small compressed balls or granular-like product dried to greater than 90 per cent total solids.
Product tonne	Actual tonnes produced. Typically this is wet tonnes.
Septage	Wet sludge taken from a septic tank for the purposes of disposal or reuse.
Sludge	Unstabilised concentrated organic solids produced during a wastewater treatment process. Sludge cannot be beneficially used without further treatment and stabilisation to produce biosolids.
Stabilisation	The treatment of sludge to reduce the volume, pathogen concentrations and volatility. Methods of stabilisation include anaerobic digestion, aerobic digestion, addition of chemicals and addition of heat.
Stockpile	A secure pile of biosolids that can be identified. Stockpiling can be part of the stabilisation process.
Vectors	Animals such as flies, mosquitoes and rodents which are attracted to putrescible organic matter and which may spread pathogens. In WA flies are particular vectors of concern.
Vector attraction	Ability for the biosolids to attract insects such as flies and mosquitoes.
Waterway	Includes wetlands, lakes, creeks, streams, rivers and areas that may not have running water in them at the time, such as drains and ditches that discharge into other waterways.
Wetland	Wetlands are areas that are permanently, seasonally or intermittently waterlogged or inundated with water, which may be fresh, saline, flowing or static, including areas of marine water, the depth of which does not exceed six metres. In WA the term is commonly used to describe that sub-group of non-marine wetlands that are in basin or flat form (such as lakes, sumplands, damplands and palusplain).
Wet tonnes	Term commonly used to describe the ‘as is’ mass of biosolids, that is, total dry tonnes plus moisture.

2.0 GENERAL INFORMATION

Biosolids are stabilised organic solid residues generated from municipal treatment of domestic and industrial wastewater.

In WA, biosolids are used as organic humus and as a fertiliser substitute on selected agricultural properties or are disposed to landfill. Biosolids are used in forestry applications, landcare programs and mine site rehabilitation, and are incorporated into commercial composts.

2.1 Purpose of document

In accordance with the State government's commitment to reduce the amount of waste going to landfill, the application of biosolids to land is encouraged, provided this process is managed appropriately to minimise potential risks to the environment and public health.

These guidelines provide information and guidance on appropriate management practices for the careful use of biosolids for land application on agricultural, forestry, mine-site rehabilitation and landcare programs. The guidelines:

- promote responsible use of biosolids in accordance with sustainable management practices to provide benefit to the land
- protect public health and the environment by ensuring adequate controls are in place
- provide a set of easy-to-follow instructions and management controls which can be implemented by stakeholders to outline the statutory obligations of those who deal with biosolids to meet relevant legislation and follow approval pathways
- promote consistent practices to define and classify various grades of biosolids and options for their use
- protect the interests of biosolids suppliers and recipients through a clear outline of their obligations and responsibilities
- consider local conditions and requirements.

Although this document is a set of guidelines, it is not a design or operations manual. Nevertheless, offences under existing environmental and health legislation may be committed if appropriate management practices are not implemented and harm to the environment, public or worker health occurs. Offenders may be prosecuted and penalties for such offences may be substantial.

Other guidelines and publications that assist in the management of biosolids were referred to in the development of these Western Australian guidelines.

2.2 Scope

These guidelines address the beneficial use of biosolids through land application on agricultural and forestry land, mine site rehabilitation and landcare programs. These guidelines are restricted to biosolids produced from municipal wastewater plants treating domestic and industrial wastes.

The guidelines do not cover the use or management of untreated wastewater, septage, sludge, or concentrated solids from specific industries such as piggeries or tanneries.

In addition, the guidelines are not directly applicable to other organic material or animal manures.

These guidelines also do not specifically apply to the use of biosolids in compost or other blended soil products other than in land applications on agricultural and forestry land, mine site rehabilitation and landcare programs. However, many concepts within this document are relevant to such products. For guidance, please contact the Department of Environment and Conservation (DEC) for information relating to the protocols and the calculator for contaminants within these products.

The term 'biosolids' used within these guidelines refers to the stablised sludge material produced from the treatment of domestic and industrial wastewater. However, where these biosolids have been blended with other materials for use in land applications on agricultural and forestry land, mine site rehabilitation and landcare programs, the blended product is included within the definition of 'biosolids' and is to be treated as such in accordance with these guidelines.

Note the Department of Health (DoH) has a mandate to regulate human pathogens in biosolids and in all products containing biosolids regardless of the application of the final product. As such, the sections within these guidelines relevant to human pathogens are applicable to both biosolids and all products containing biosolids.

Similarly, Department of Water (DoW) has a mandate to protect the drinking water supply for the West Australian community and the use and application of biosolids is not supported in the state's public drinking water source areas (PDWSAs).

This guideline has been developed for use by regulators, producers and recipients of biosolids.

2.3 Transitional period

Given that current projects are in various stages of trialling guidelines, treatment and performance criteria, a transitional phase for these guidelines becoming effective is six months from date of publication.

2.4 Biosolids research

Biosolids use has been extensively researched in Australia and overseas through field trials and laboratory analysis. The research has been used to determine appropriate standards to protect the environment, public health and agricultural produce.

An Australia-wide, national research program coordinated by CSIRO reviewed the use of biosolids under different conditions. For more information on this program, please see www.csiro.au/science/National-Biosolids-Research-Program.html.

In WA, the Water Corporation has completed a number of research projects specific to the needs of the state to ensure that the land application of biosolids is of minimum risk to the public and the environment. These projects examined but were not limited to:

- the availability of phosphorus in biosolids and its effects on the environment
- the attraction of insects to biosolids, particularly flies
- nutrient availability and bioavailability of copper, zinc and cadmium in biosolids
- the presence and die-off of pathogens following the direct land application of biosolids
- risk assessment of organic contaminants in biosolids.

2.5 Guideline review

These guidelines were updated in 2010 and again in 2011 and 2012, and should be updated regularly at no more than five-year intervals, or earlier if changes are required based on further research and as knowledge of best management practices evolve.

Biosolids suppliers and recipients should remain informed about emerging information and research.

2.6 Benefits of biosolids use

Biosolids are rich in nutrients and organic matter and a good source of natural fertiliser as well as a carbon-rich soil amendment to enhance soil characteristics. The nutrients—including nitrogen and phosphorus, two elements essential for crop growth, and micronutrients such as copper, zinc and iron—release slowly and assist in plant growth.

Programs for the beneficial use of biosolids are in place in all Australian states and internationally. In WA, biosolids are currently used as organic humus and as an inorganic fertiliser substitute on selected agricultural and forestry properties, and as a source of nutrients and organic matter in compost production. Some of the benefits derived from the use of biosolids include:

- improved soil characteristics and enhanced soil moisture and nutrient retention properties
- improved crop production
- improved tree growth in tree plantations
- improved economic returns
- conservation of landfill space
- the provision of topsoil for land used for recreation and agriculture.

2.7 Potential risks of biosolids use

Due to the diverse sources of wastewater, biosolids may contain chemical contaminants including human and veterinary pharmaceuticals, and metals and pesticides from domestic and industrial sources. Biosolids which are not appropriately treated may contain significant levels of microorganisms including bacteria, viruses and helminths (parasitic worms), some of which may cause disease (known as pathogens).

These guidelines have been developed to facilitate responsible, beneficial use and to minimise the risk of any adverse effects on public health, animal health and the

environment. Appendix 1 has specific information on methods for safe handling of biosolids to minimise these risks.

It is important that biosolids suppliers and recipients work together to assess the potential risks, which generally fall into the following categories:

- environmental risk to land, water and air
- human and animal health risk
- food safety risks
- legal risks.

The risks posed will vary, dependent upon the end use of the biosolids (for example, application for forestry versus application to land used for growing human food crops) and the location (for example, relative to houses or water resources), land capability (for example, climate, soil types, slopes) and scheme size.

For the use of 'restricted grade biosolids' (see Table 6 for definition), details of risk identification and assessment should be provided in the Review of Environmental Factors (REF) (Appendix 2).

2.7.1 Environmental risk

As a minimum, biosolids use must meet the following environmental performance objectives:

- Protect the soil, groundwater and surface waters.
- Avoid soil contamination or structural changes that reduce productivity.
- Avoid adverse ecological impacts.
- Avoid adverse impacts on the air environment.

To assess whether these objectives can be met, the risks to groundwater, soils and surface water need to be assessed for the organic and inorganic contaminants, nutrients and pathogens potentially present in biosolids.

Sections 3 to 8 of these guidelines outline suggested treatment, biosolids quality, site control, monitoring and record-keeping measures for managing and minimising risks to the environment. However, where risk assessment indicates additional measures are necessary, appropriate extra precautions should be implemented.

There is debate in the scientific literature regarding acceptable limits for contaminants in biosolids and soils. These guidelines have adopted a scientific approach to ensure that environmental or public health problems associated with biosolids use are prevented. This approach is aimed at gaining public confidence and ensuring agricultural markets and food safety are not compromised.

While the contaminant limits are scientifically justified, risk management means that biosolids producers should implement waste management programs that reduce contaminants to sewer to the lowest practical levels. Risk management also means that suppliers should diversify land application programs, rather than focusing on a single site with long-term regular biosolids applications.

Biosolids may contain significant concentrations of phosphorus and nitrogen. While these nutrients are generally less available in biosolids than in inorganic fertilisers, if applied to land in amounts exceeding agronomic demand, pollution of surface and/or groundwaters may result.

To minimise this risk, biosolids application rates should be limited to the annual crop nutrient (agronomic rate) requirements.

2.7.2 Human and animal health risk

Raw sewage sludge may contain high levels of pathogens, and human or animal contact with untreated or inadequately treated wastewater products, including sludges, poses a risk of infection by microorganisms. Further processing or treatment of sewage sludge produces the stabilised material known as biosolids. While biosolids are treated to a level to significantly reduce pathogens and microorganisms, they may continue to pose a risk to public health through the potential transmission of microorganisms such as:

- bacteria (for example, salmonella and campylobacter)
- protozoa (for example, cryptosporidium and giardia)
- viruses (for example, adenoviruses, hepatitis)
- helminths (for example, intestinal nematodes, hookworm).

There are a number of recognised exposure pathways including inhalation, ingestion and contact with broken skin. To manage these risks, appropriate treatment processes to reduce pathogen levels have been developed, as well as practices for the safe handling, storage and application of biosolids.

The degree of risk from the above pathogen groups when found in biosolids depends on the extent of treatment (Table 2) and the end use (Table 6). The risk also depends on the population served by the treatment plant. As an example, some pathogen groups, such as helminths, typically have low incidence rates in Australia compared to some overseas populations and are endemic in only certain parts of Australia.

Biosolids end-use schemes must not pose an unacceptable risk to the general public, on-site workers, animal health or food safety. The potential offsite impacts of disease transmission by way of vectors such as insects, birds and other animals must be evaluated and controls provided if deemed necessary. Potential impacts through direct contact with biosolids at application sites, and indirect impacts through food contact or impacts on drinking water must also be addressed.

2.7.3 Food safety risks

Biosolids potentially contain chemical contaminants, including metals and pesticides, due to the diverse sources and variable composition of wastewater. Biosolids must be appropriately tested prior to use to determine their concentrations of chemicals. This will identify any risk of applying unwanted chemicals to the soil. These chemicals may leach and move through the soil, contaminating the environment or entering the food chain, potentially resulting in health and economic implications.

To minimise this risk, biosolids and proposed sites are sampled to determine contaminant limited biosolids application rates (CLBAR). Appendix 3 includes a guide to determining CLBAR.

For further advice regarding produce (food safety) risk management associated with the use of biosolids, codes, regulations or approved quality assurance / quality control (QA/QC) systems, contact the appropriate agencies listed in Section 9.1.

Regardless of scientific evidence that demonstrates the safety of using biosolids and products containing biosolids, some markets for agricultural produce (for example, salad or vegetable production) may hold negative views on the use of biosolids and may not wish to source produce grown on land treated with biosolids. Proposed biosolids land application programs based on agricultural applications should investigate market acceptance of the practice.

2.7.4 Legal risks

Wastewater treatment plant owners, operators and end recipients may be liable under common law for the use of biosolids or products containing biosolids that cause harm.

Recipients of biosolids should make themselves aware of the documents (legislation, policies, codes of practice, Australian Standards and guidelines) relevant to the use of biosolids.

To minimise the legal risks associated with biosolids end-use schemes, suppliers in particular should ensure their potential legal risks and liabilities are addressed. This should include:

- establishing due diligence procedures and systems such as an environmental management system
- adherence to these guidelines and other relevant documents.

3.0 ROLES AND RESPONSIBILITIES

These guidelines provide direction on appropriate management practices and considerations for biosolids management but they are not legally enforceable.

However, it is very important for recipients of biosolids and the wider community to understand that there are existing laws in place which protect the environment, public health and worker health and safety. The inappropriate management of biosolids can result in breaches of these laws and the initiation of enforcement action against the offender.

These guidelines document best-practice management of biosolids to be used by regulators, suppliers, transporters, appliers/end recipients. Meeting the requirements and recommendations of these guidelines will deliver the maximum beneficial outcomes from the fertilising and soil conditioning properties of the biosolids and minimise the potential for adverse effects.

In all cases, application of biosolids should be conducted in accordance with the recommendations in these guidelines, unless they conflict with site-specific requirements imposed by any regulatory agency.

3.1 Biosolids suppliers and recipients

Biosolids end-use schemes typically involve a distinct supplier (for example, the water utility) and end recipient (for example, farmer, land application practitioner). In some cases the supplier and recipient may be the same entity. The responsibilities outlined in these guidelines reflect the shared obligation between supplier and recipient to ensure that biosolids are appropriately used and that this obligation continues after the physical transfer of biosolids from supplier to recipient.

The supplier is responsible for:

- ensuring that biosolids have been appropriately treated and sampled, and the classification is suitable for the use that they are being supplied for. A laboratory analysis of the biosolids for each load or batch of biosolids (as is relevant) including concentrations, must be provided to the recipient.
- ensuring biosolids are provided for purposes in keeping with the recommendations of these guidelines and appropriate to the use for that classification of biosolids
- ensuring that each scheme supplied with ‘restricted use biosolids’ (Table 6) has approvals in place and licences, where required
- ensuring correct location details of land intended for biosolids application are obtained from potential recipient to ensure suitability under these guidelines
- ensuring there are appropriate mechanisms in place (for example, contractual arrangements, audit schedule) for recipients to meet their obligations as outlined in these guidelines, the REF and the conditions of approval and/or licence, where required
- ensuring recipients are provided with sufficient information to conduct the biosolids application in a way that minimises risks to public health and the environment.

- maintaining records (for at least five years) of all schemes supplied with biosolids, including recipient, location, quality and quantity of biosolids
- ensuring biosolids recipient obtains all necessary approvals (local government authority [LGA] and regulatory)

The recipient is responsible for:

- ensuring that required approvals are held
- ensuring that use of restricted use biosolids (Table 6) (including: storage, application, signage, monitoring) is in accordance with these guidelines, the REF and approvals and/or licence conditions
- maintaining clear pathways for communication with the community such as signage, and notification of adjacent landholders of storage and application of biosolids on site
- protecting the health of any workers exposed to the use of biosolids
- maintaining records of the use of restricted use biosolids, including the source of biosolids, location, quality and quantity of biosolids applied, biosolids application rates and site assessment details. These records should be retained for a minimum of five years.
- maintaining clear pathways for communication with the community such as through signage, telephone line and proactive contact with local government and nearby residents.

3.2 Department of Environment and Conservation

DEC is the primary agency responsible for protecting the environment under the *Environmental Protection Act 1986*. DEC may license premises where prescribed activities are undertaken.

Where 1,000 or more wet tonnes of biosolids are proposed to be applied to a property via land application in any 12-month period, that property is defined as a solid waste facility (category 61A, Schedule 1,) under the Environmental Protection Regulations 1987, and requires a works approval and licence from the DEC. These may contain conditions related to the location of the activities, storage and application of biosolids.

It is a requirement of these guidelines that an application for a licence using the industry licensing system (ILS) is accompanied by a REF that has been certified by a third party independent auditor. This information is used by the DEC to complete an environmental assessment report (EAR). At times, the biosolids supplier may assist DEC by submitting a draft EAR with their REF.

DEC will review applications and, if approved, may issue a licence which may contain specific conditions, sometimes different to those outlined in these guidelines. The licence is a legally binding document and where they differ from the guidelines, their specific conditions prevail. Failure to hold or comply with the conditions of a licence is an offence with substantial penalties. DEC is the responsible agency and will respond to any licence queries, environmental harm or pollution issues (see contact details in Section 9.1).

Application packages, including information required for such an application, are available from DEC.

Where biosolids are provided to the composting and soil blending industries, for use in applications other than land applications on agricultural and forestry land, mine site rehabilitation and landcare programs, please contact DEC for information relating to the protocols and the calculator to assist industry to meet appropriate contaminant levels in their products.

3.3 Department of Health

DoH is responsible for the implementation of the Health Act and protection of public health. The Environmental Health Directorate of DoH specifically deals with applications for use of biosolids and products containing biosolids and is primarily focused on pathogen concentration, transmission of disease, protection of public health and the management of flies and other vectors. Application proposals in accordance with the guidelines enable DoH to be satisfied that the wastewater treatment by-product has been properly treated to biosolids level, and that the concerns listed above have been addressed. DoH does not have a minimum trigger volume, so all proposals for biosolids use, other than P1C1 material (see section 4), are to be submitted to DoH by the third party. Applications triggering DEC licence requirements will be responded to via that process.

More information about the required information for a REF and approval is provided in Appendix 2.

3.4 Department of Water

DoW is responsible for managing the state's water resources, including the protection of PDWSAs. This department prepares drinking water source protection reports on water quality hazards and risk levels within a PDWSA that includes recommendations to avoid, minimise, or manage those risks for the protection of the water supply in the provision of safe drinking water supply.

Priority areas are assigned to guide land-use planning decisions within PDWSAs. Three priority (priority 1, 2 and 3) areas and two protection zones (reservoir and wellhead protection zones) are used, as described in the Department of Planning's *State Planning Policy 2.7 Public drinking water source policy*, 2003.

The use and application of biosolids is not supported in the state's PDWSAs. However, the use and application of soil conditioners containing unrestricted use biosolids (P1C1 material) is considered acceptable in a priority 3 PDWSA where the soil conditioner also complies with the relevant pathogen destruction levels and contaminant criteria according to the current Australian Standard 4454: *Composts, soil conditioners and mulches* (2012).

The location of PDWSAs can be viewed on DoW's *Geographic Data Atlas*, available at the department's website (Section 10). This interactive web mapping tool is subject to change.

Specific information on the boundary of PDWSAs, priority areas, protection zones, and bore locations (subject to change) is provided in DoW's drinking water source protection (DWSP) reports (these include DWSP assessments, DWSP plans and DWSP reviews,

and the Western Australian Planning Commission's land use and water management strategies (Section 10).

3.5 Local government

Local government may have specific local restrictions on biosolids application and should be notified of intent 30 days prior to biosolids application. It is advisable, and good practice, to provide the local government with information of proposed biosolids applications and transport routes 12 months in advance to assist with road maintenance and other local issues.

3.6 Other agencies

WorkSafe is a division of the Department of Commerce, the Western Australian government agency responsible for the administration of the *Occupational Safety and Health Act 1984,* and is responsible for the protection of workers. If workers are spreading the biosolids or being exposed to them without an understanding of the appropriate protection, WorkSafe is the agency which should be contacted. It is the responsibility of the person in control of the workplace or site, in most cases the landowner, to ensure a safe work environment.

The Department of Agriculture and Food WA (DAFWA) may make recommendations relating to plant nutrient uptake rates and the use of biosolids on sensitive crops.

4.0 CLASSIFICATION OF BIOSOLIDS

Prior to leaving the wastewater treatment facility or the re-processing facility, biosolids should be classified to determine if they are suitable for a specific end use.

Biosolids are classified according to two factors:

1. Contaminant grade: based on the concentration of chemical contaminants in the biosolids and the product containing biosolids.

2. Pathogen grade: based on the level of treatment undertaken to achieve desired microbial limits and a reduction in odour and vector attraction for biosolids and biosolids products.

4.1 Biosolids sampling

The first step in biosolids classification is to establish a sampling regime. The sampling program should reflect the relative risks of the biosolids, considering inputs into the treatment system, historical variability in biosolids quality, homogeneity of the material and the risk exposure through the end use. Default sampling regimes are provided in these guidelines (section 4.5). However, alternative approaches that provide equivalent statistical confidence in the classification result may be adopted, provided that the approach is endorsed by DEC or an approved auditor.

Wastewater treatment processes may change from time to time, or not have a regular biosolids monitoring program (>48 samples per year) and require a broader suite of analytes. An example of wastewater treatment process changes might include:

- introduction of a new wastewater treatment process
- irregular biosolids production such as produced from oxidation ponds
- changes in the quality of inflow, or changes which could lead to reduced quality of biosolids.

Appendix 5 provides more detail on determining when sampling and monitoring might need to be increased.

In addition, biosolids should be free from physical contaminants, such as plastics, that could potentially compromise their intended beneficial use. Physical removal can be achieved through effective screening and grit removal during the pre-treatment process.

Sampling needs to be carried out by suitably qualified persons using approved sample collection and preservation methods. Further information on sampling requirements including sampling frequency is provided in Appendix 5. All analyses should be conducted by a competent body with appropriate certification (for example, National Association of Testing Authorities [NATA] accreditation).

Note that any biosolids sample returning <LOD (lower than the limit of detection), the value of 0.5 x LOD is to be used for statistical analysis.

4.2 Contaminant grading

The contaminant grade of biosolids is determined by identifying the 'biosolids adjusted contaminant concentration' (BACC) for each contaminant in the batch, and comparing these with the 'contaminant acceptance concentration thresholds' (CACT) listed in Table 1 (page 25).

The BACC is calculated as:

$$BACC = m + s.d.$$

Where: m = mean concentration of a given contaminant calculated from all samples (including historical data).

s.d. = standard deviation of the mean concentration of a given contaminant calculated from all samples (including historical data).

4.2.1 Contaminant grade sampling

For approved wastewater treatment process (those that have undergone a verification process, see section 4.4) the default sampling requirement to calculate the BACC is one sample per 100 dry tonnes with a minimum of seven samples to be included in the calculation of the mean and standard deviation. Sampling must be conducted 92 per cent of the time for a continuous sampling regime (such as 48 of 52 weekly samples).

Where biosolids are sourced from a treatment plant undergoing process verification, such as a new 'wastewater treatment plant' (WWTP) or changes to an existing WWTP, a minimum of seven samples over a three-month period should be included in the calculation of the mean and standard deviation.

A contaminant grade for each analyte is determined by the mean + 1 standard deviation and is further described in Appendix 5 Calculating contaminant grade.

For both established and approved processes, once the BACC for each contaminant has been determined it is compared against the CACT outlined in Table 1.

When a new treatment process is introduced or there is a change in an existing treatment process, the biosolids contaminant grade must be reassessed. Use Table A9 in Appendix 3 to determine the contaminant grade for each regulated contaminant.

There are three CACT levels for each contaminant, representing the upper contaminant limit for the three grades of biosolids. Grade C1 is for the highest quality of biosolids (lowest contaminant level) and Grade C3 represents the lowest quality (highest contaminant level) and typically remains sludge.

The producers and re-processors of biosolids must undertake the required sampling and analysis and provide sufficient information about the concentration of contaminants in biosolids before they are removed from the treatment plant or reprocessing site.

Contamination grading of biosolids involves the following steps:

- sampling (refer to Appendix 5)
- accredited laboratory (for example, NATA) testing of contaminant levels
- statistical examination of the results and presentation of summary data
- calculation of the BACC for comparison with the chemical contaminant thresholds (refer to Table 1 and Table A9 in Appendix 5).

Following the identification of the contaminant grade for each contaminant, the overall contaminant grade for the batch is determined. This corresponds to the lowest quality grade determined for any contaminant. For example, if most of the contaminant concentrations in biosolids passed Grade C1, but one contaminant was Grade C2, the entire batch would be classified as Grade C2.

All sludge is assumed to be Grade C3 until proven otherwise. If the sludge is not sampled, it is considered Grade C3 and not suitable for application to land.

A contaminant grade may be improved by blending or treating with other acceptable materials, such as composted green waste, lime or other by-products. The blended product must be re-sampled, analysed and re-graded to determine its new contaminant grade.

Table 1**: Contaminant acceptance concentration thresholds for biosolids**

Contaminant	Grade C1 (mg/kg)*	Grade C2 (mg/kg)*	Grade C3
Cadmium	1	20	untested or greater than grade C2
Chromium (VI) **	1	1	untested or greater than grade C2
Copper	100	2,500	untested or greater than grade C2
Zinc	200	2,500	untested or greater than grade C2
Dieldrin	0.02	0.5	untested or greater than grade C2
Chlordane	0.02	0.5	untested or greater than grade C2

* All values in mg/kg dry weight

** National Environment Protection (Assessment of Site Contamination) Measure 1999, National Environment Protection Council Service Corporation. Note that chromium (VI) is a strong oxidising agent and is unlikely to be present in biosolids. However, given its toxicity and the industrial feedstock into biosolids, some chromium (VI) could still remain in an unreduced form if process parameters are not optimal for complete reduction to occur, and so testing for this contaminant remains.

It is worth noting that the receiving soil contaminant limits (Table 1, Grade C1) may be lower than background soil levels. This becomes problematic as biosolids applications would be prohibited if the relevant contaminants in biosolids exceeded the C1 limit. However, it is acknowledged that background concentrations may have a low bioavailability fraction and therefore biosolids applications pose a low risk. DEC will consider, on a case-by-case basis, endorsing the use of biosolids in these situations.

Other chemicals apart from those listed in Table 1 may be present in biosolids, including dioxins, pharmaceuticals and personal care products. Research to date has not demonstrated that these contaminants need to be regulated with respect to biosolids application in accordance with best management practices.

In line with the intention of these guidelines to be a living document, they will be updated as required if evidence emerges that these contaminants are of concern to the environment or health.

4.2.2 Contaminants not included in the grading

The following information is from the *Draft South Australian Biosolids Guidelines for the Safe Handling and Reuse of Biosolids* (EPA 2009).

Based on significant research conducted by the National Biosolids Research Program (NBRP) certain compounds were excluded from the contamination grading for various reasons outlined below. Data from the WA component of the NBRP project supports similar results to that of South Australia and therefore these exclusions are considered valid for WA.

Arsenic

The average arsenic concentration in biosolids used in the National Biosolids Research Program was 5mg/kg (which is below the previous Grade A limit of 20mg/kg) and the minimum recorded ambient background of arsenic in Australian agricultural soil is 1mg/kg (Sorvari et al. 2008). Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of arsenic in the biosolids is unlikely to significantly impact on the background concentration. Therefore, arsenic was removed from the list of contaminants to be monitored.

Chromium (III)

The average chromium (III) concentration in biosolids used in the National Biosolids Research Program was 92mg/kg and the average recorded ambient background of chromium in Australian agricultural soil is 47.8mg/kg. Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of chromium (III) in the biosolids is unlikely to significantly impact on the background concentration. Therefore, chromium (III) was not included in the list of contaminants to be monitored.

Lead

The average lead concentration in biosolids used in the National Biosolids Research Program was 64mg/kg (which is below the previous Grade A limit of 200mg/kg) and the average recorded ambient background of lead in Australian agricultural soil is 19.88mg/kg. Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of lead in the biosolids is unlikely to significantly impact on the background concentration. Therefore, lead was removed from the list of contaminants to be monitored.

Mercury and cadmium

The average mercury concentration in biosolids used in the National Biosolids Research Program was 3mg/kg and the lowest background concentration is 0.01mg/kg. Although

mercury bioaccumulates and is therefore hazardous to organisms higher up the food chain, research has shown that it is only half as hazardous to public health (via food) as cadmium. As cadmium levels found in South Australian biosolids are typically less than or equal to that of mercury levels, cadmium poses the greater risk and becomes the limiting factor. Therefore, cadmium is included in the list of contaminants to be monitored and mercury is not.

Molybdenum

Soil concentrations of molybdenum can vary from 0.5 to 40mg/kg, with an average value of 2mg/kg. Concentrations in South Australian biosolids vary between 5 and 17mg/kg. Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of molybdenum in the biosolids is unlikely to significantly impact on the background concentration. Thus, molybdenum was not included in the list of contaminants to be monitored. Even with some potential in the long term for molybdenum concentrations to increase in soils, these potential increases are not large, especially when compared to the potential increases that may arise due to the addition of fertilisers containing molybdenum. For example, pasture fertilisers are often supplemented with molybdenum at a concentration of between 0.1 and 0.05% (w/w basis).

Nickel

The average nickel concentration in biosolids used in the National Biosolids Research Program was 32mg/kg (which is below the previous Grade A limit of 60mg/kg) and the average recorded ambient background of nickel in Australian agricultural soil is 21.9mg/kg. Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of nickel in the biosolids is unlikely to significantly impact on the background concentration. Therefore, nickel was removed from the list of contaminants to be monitored.

Selenium

The average selenium concentration in biosolids used in the National Biosolids Research Program was 4mg/kg. The lowest recorded ambient background concentration for an Australian agricultural soil is 0.5mg/kg (Sorvari et al. 2008). Given the typical agronomic application rate of 10 tonnes/ha, and assuming the biosolids are incorporated into the top 10cm of soil, the concentration of selenium in the biosolids is unlikely to significantly impact on the background concentration. Therefore, selenium was not included in the list of contaminants to be monitored.

A full list of the contaminant acceptance concentration thresholds for biosolids is provided in Appendix 5, page 75 For those contaminants currently not included in Table 1, but in Table A9 (p.77), these may need to included in a grading process, if required by a government agency.

4.3 Pathogen grading

Four pathogen grades are used: P1, P2, P3 and P4. All sludges are assumed to be pathogen grade P4 unless proven otherwise (Table 2).

Pathogen grading is required for biosolids and all products containing biosolids. Pathogen grading is dependent upon meeting:

- a treatment process that is known to reliably reduce pathogen levels
- microbiological limits that demonstrate the effectiveness of the treatment process, and
- a vector attraction reduction control.

There are a number of treatment processes that are known to reliably reduce pathogens and these are listed in Table 2. It should be noted that the types of treatment processes listed are not intended to be an exhaustive list. If biosolids are produced using different methods than those listed, the supplier must demonstrate through process verification and routine monitoring that any proposed treatment method meets an equivalent pathogen standard.

Suppliers of biosolids must implement a QA/QC system to ensure that the pathogen grade can be reliably demonstrated. The system will include measurement of process parameters and microbiological indicators.

The reliability of sludge treatment processes in reducing pathogens is essential for public health protection. Ideally, validation of a treatment and assurance of the microbiological quality of biosolids should be done with all pathogens, but this is not practicable at this time. Consequently, microbial indicators are used for routine evaluation of treatment performance and final biosolids quality. Indicator organisms are organisms believed to indicate the presence of a larger set of pathogens. *Escherichia coli* (*E. coli*) and coliphages are considered suitable microbial indicators of faecally derived bacteria and viruses respectively.

Because of the different extents of inactivation exhibited by various microorganisms after biosolids treatments, monitoring at least one indicator for bacteria (*E. coli*) and one indicator for viruses (coliphages) is required. Monitoring of microbial indicators for public health protection, as mentioned above, has two purposes: the first is to verify the microbial quality of the final biosolids, and the second is to validate the efficacy of the treatment used to achieve the biosolids maximum pathogen levels in Table 2.

The pathogen standards in Table 2 are technologically based requirements aimed at reducing the presence of pathogens and potential exposures to them. This is achieved through treatment or a combination of treatments, and use restrictions. Treatment performance involves measurement of the microbial indicator in the sludge during the treatment train, and in the final biosolids, to determine the capacity of the treatment to reduce pathogens. The calculation of pathogen log removals, following treatment with a quality assurance/quality control program, is considered a better approach for microbial risk management rather than only end-point quality monitoring for microbial indicators.

At present, only end product quality is included in Table 2 because there are insufficient data to determine the log removals that can be achieved for each one of the approved treatment methods. However, projects are required to monitor for microbial treatment performance.

E. coli is a bacteria from the thermo-tolerant coliforms group. *E. coli* monitoring can be used alone for pathogen grade P2 and P3 applications (that is, biosolids applications with low likelihood of human contact).

Coliphages are viruses that infect coliform bacteria. There are many types of coliphages, and the choice of which to monitor depends on the situation. However, usually one or both of two groups, somatic coliphages and F-RNA coliphages (or MS2), are monitored. The somatic coliphages are usually more numerous in sludge and are more resistant to thermal inactivation than F-RNA coliphages. F-RNA coliphages are less prevalent in human faeces than somatic coliphages but they can be cultivated and enumerated to perform challenge test to demonstrate the log removals a treatment can achieve.

Helminths are parasitic worms that are transmitted to humans through contact with contaminated soil containing faeces. Helminths monitoring is required for biosolids applications in endemic areas of the Kimberley region, north of the 26th parallel. Biosolids grade P1 shall comply with Strongyloides & Hookworm (viable Ova) <1 per 50 grams of dry final biosolids.

Please note that values for *E. coli* <100 **cfu or MPN** per gram of dry final biosolids (in Table 2) are the same. For coliphage it should be <10 **pfu** per 10 grams of dry final biosolids (required only for P1). No salmonella testing is required.

Note that testing for coliphages is a new parameter for routine evaluation of treatment performance and final P1 biosolids quality and, as such, laboratories in WA are yet to validate analytical technique and obtain NATA accreditation for this testing. Sampling for coliphages will continue to be undertaken during the transitional period of validation and NATA accreditation, but an exemption period for reporting coliphages and NATA quality assurance of the sample results will apply during this transitional period. It is envisaged that achieving NATA accreditation can be achieved within 12 months.

Table 2**: Approved treatment methods**

Pathogen grade	Approved treatment methods *[1]	Maximum pathogen levels [Ω]	Other conditions
Grade P1 Low pathogen levels with minimum regrowth potential	Composting: The industry standard AS 4454 may be referred to for composting processes Note that, use of re-processed biosolids are required to demonstrate microbial treatment performance that achieves a product containing biosolids that is suitable for unrestricted use (P1)	Coliphages <10 **pfu** per 10 grams of dry final biosolids **AND** *E. coli* less than 100 counts per gram of dry final biosolids Strongyloides & Hookworm (viable Ova) <1 per 50 grams of dry final biosolids (only required north of the 26th parallel)	Final biosolids do not generate offensive odours Weed seed controls may be needed in agricultural or landscape applications 30 days maturation of product required before use Certified QA to AS/NZS ISO 9001:2008 or equivalent process
	Addition of lime so that pH is maintained at pH >12 for 72 hours including heated at >52°C for 12 hours; following the 72 hours then, air dried to >50% solids.		Final biosolids do not generate offensive odours Certified QA to AS/NZS ISO 9001:2008 or equivalent process Undigested sludge: either aerated in a windrow for 15 days with a minimum of 5 turnings; or demonstrate minimum regrowth potential by assay
	Heated to >80°C, dried to >90% solids and kept dry until used.		Final biosolids do not generate offensive odours Certified QA to AS/NZS ISO 9001:2008 or equivalent process Product from undigested sludge shall demonstrate minimum regrowth potential by an approved assay method
	Digested and dried to solids >10% and stored for >3 years.		Final biosolids do not generate offensive odours Final biosolids stored in a manner that ensures no contamination

Pathogen grade	Approved treatment methods *[1]	Maximum pathogen levels Ω	Other conditions
	Other accepted processes		Process verification requirements
Grade P2 Low pathogen levels with some regrowth potential	Composted at >53°C for 5 days or >55°C for 3 days	*E. coli*[2] – less than 1,000 counts per gram of dry final biosolids Strongyloides & Hookworm (viable Ova) <1 per 50 grams of dry final biosolids (only required north of the 26th parallel)	Final biosolids do not generate offensive odours when coupled with management controls Weed seed controls may be needed in agricultural or landscape applications Compost may need to be matured to ensure toxic organic compounds do not subsequently affect plant growth
	Heated to 70°C for 1 hour and then dried to >90% solids		Final biosolids do not generate offensive odours when coupled with management controls Final product to be kept dry until applied
	Digested, heated to 70°C for 1 hour and then dried to >75% solids		
	Aerobic thermophilic digestion (55-60°C for 10 continuous days), and a total solids reduction of >50%		Final biosolids do not generate offensive odours when coupled with management controls, and with a volatile solids reduction of >38%
	Other accepted processes, e.g. storage where safety can be demonstrated		Process verification requirements
Grade P3 Low- Medium pathogen levels with some regrowth potential	Anaerobic digestion ≥15°C for ≥60 days	*E. coli*[2] – less than 2,000,000 counts per gram of dry final biosolids Strongyloides & Hookworm (viable Ova) <1 per 50 grams of dry final biosolids (only required north of the 26th parallel)	Final biosolids do not generate offensive odours when coupled with management controls, and with a volatile solids reduction of >38% Lime amended biosolid (LAB) product is applied within 7 days
	Aerobic digestion at ≥20°C for ≥40 days or at ≥15°C for ≥60 days		
	Addition of lime so that pH is maintained at >12 for >3 hours		
	Aerobic composting at >40°C for ≥5 days, including at least 4 hours at >55°C. Process control as per AS 4454–2003		Final biosolids do not generate offensive odours when coupled with management controls Weed seed controls may be needed in agricultural or landscape applications

Pathogen grade	Approved treatment methods *[1]	Maximum pathogen levels Ω	Other conditions
	Mesophilic anaerobic digestion at 35°C ± 3°C for ≥15 days	Minimum pathogen reduction of 1.5 log reduction through digestion (pathogen count reduced by 1.5 orders of magnitude from start to finish of sludge treatment process)	Trigger value *E. coli* – less than 2,000,000 counts per gram of dry final biosolids, with a volatile solids reduction of >38%
	Other accepted processes		1.5 log reduction (pathogen count reduced by 1.5 orders of magnitude from start to finish of sludge treatment process) and >38% Volatile Solids Reduction
Medium – high or unknown pathogen levels with minimum pathogen reduction. All biosolids are considered P4 until proven otherwise.	Untreated or inadequately treated sludge	*E. coli*[2] – greater than 2,000,000 counts per gram of dry final biosolids	N/A

* 'Approved treatment methods' should be "established processes that achieve significant pathogen reduction".

[1] With advances in treatment processes, any new treatment process will be required to show the capacity to achieve the quality of biosolids according to the guidelines.

Ω Pathogen levels refer to Biosolids and all products containing biosolids. Note that any biosolids or product containing biosolids samples returning <LOD (lower than the limit of detection) the value of 0.5 x LOD is to be given.

[2] *E. coli* – counts per gram of final biosolids and product containing biosolids is based on geometric mean of seven samples.

4.4 Process verification

Process verification will be required to demonstrate that the treatment process is working effectively in the following circumstances:

- any treatment plant producing pathogen grade P1 or P2 biosolids
- any new treatment plant
- whenever there is a significant change to treatment plant inputs, such as changes to the treatment process, a major increase in plant loadings that could reduce the effectiveness of the existing treatment process, changes to industrial inputs or any non-approved treatment process.

Process verification requirements depend on the target pathogen grade of the treatment process and whether the treatment process is an approved treatment method.

Table 3**: Process verification requirements for pathogen grading**

Pathogen grade	Verification requirements for Biosolids [β]
P1 (approved process)	Maximum pathogen levels for P1 Achieves Vector Attraction Reduction (VAR) (Table 5) Does not generate offensive odours Tested for pathogen regrowth potential Measurement of process criteria (for example, time, temperature) to ensure compliance with designated process. Viable helminth ova[3] OR Batch testing to show <1 enteric virus present in 100g (dry weight) of final biosolids and <1 helminth ova/10g (90th per centile compliance) (dry weight)
P1 (other process)	Maximum pathogen levels for P1 Achieves VAR (Table 5) Does not generate offensive odours Tested for pathogen regrowth potential Viable helminth ova[3] OR Batch testing to show <1 enteric virus present in 100g (dry weight) of final biosolids and <1 helminth ova/10 g (90th per centile compliance) (dry weight)
P2 (approved process)	Maximum pathogen levels for P2 Achieves VAR (Table 5) Tested for pathogen regrowth potential Measurement of process criteria (for example time, temperature) to ensure compliance with designated process. Viable helminth ova[3] OR Batch testing to show <2 enteric virus present in 10g (dry weight) of final biosolids and <1 helminth ova/10 g (90th per centile compliance) (dry weight)
P2 (other process)	Maximum pathogen levels for P2 Achieves VAR (Table 5) Tested for pathogen regrowth potential Viable helminth ova[3] OR

Pathogen grade	Verification requirements for Biosolids [β]
	Batch testing to show <2 enteric viruses plaque forming units/10g and <1 helminth ova/10g (90th per centile compliance) (dry weight)
P3 (approved process)	Maximum pathogen levels for P3 Achieves VAR (Table 5) Measurement of process criteria (for example, time, temperature) to ensure compliance with designated process. Viable helminth ova[3] OR Batch testing to show <2 enteric virus present in 10g (dry weight) of final biosolids and <1 helminth ova/10 g (90th per centile compliance) (dry weight)
P3 mesophilic anaerobic digestion	Minimum 2 log reduction for enteric viruses Achieves VAR (Table 5) Minimum solids retention is >15 days Digester temperature maintained at 35ºC± 3ºC Observe an enteric virus trigger value of <2,000,000g/dry product Viable helminth ova[3] OR Batch testing to show <2 enteric virus present in 10g (dry weight) of final biosolids and <1 helminth ova/10g (90th per centile compliance) (dry weight)
P3 (other process)	Maximum pathogen levels for P3 Achieves VAR (Table 5) Measurement of process criteria (for example, time, temperature) to ensure compliance with designated process. Viable helminth ova[3] OR Batch testing to show <2 enteric virus present in 10g (dry weight) of final biosolids and <1 helminth ova/10g (90th per centile compliance) (dry weight)

[3] Helminth ova monitoring is required only for wastewater treatment processes above the 26th parallel.

βVerification requirements are required for biosolids and all products containing biosolids.

4.5 Routine monitoring

Once process verification is demonstrated, routine monitoring must be implemented to demonstrate continued compliance with treatment grade standards. Suppliers should implement a monitoring system that verifies both that the process parameters are being met and that pathogen reduction is being achieved. For pathogen and volatile solids reduction monitoring, the default routine sampling regime is one sample per 300 dry tonnes or as approved by the DEC and DoH. For pathogen regrowth, the default sampling regime is three samples tested annually. As noted previously, any biosolids sample returning <LOD (lower than the limit of detection), is to be given the value of 0.5 x LOD.

For mesophilic anaerobic digestion, the default routine process monitoring for digester temperature and solids retention time should be collected monthly and reported annually and in each REF to demonstrate compliance. Other wastewater treatment processes will have different monitoring requirements. The processor must determine a reasonable monitoring frequency to provide certainty that the processing conditions are being met. Table 4 is a guide for determining sampling frequency.

Table 4**: Frequency of biosolids monitoring** [4]

Amount of sewage sludge (tonne per 365 day period)	Frequency
Greater than zero but less than 290	Once per year
Equal to or greater than 290 but less than 1,500	Once per quarter (4 times per year)
Equal to or greater than 1,500 but less than 15,000	Once per 60 days (6 times per year)
Equal to or greater than 15,000	Once per month (12 times per year)

[4] Source – US EPA Environmental Regulations and Technology 503, 2003

4.6 Pathogen regrowth

Bacteria present in the biosolids or products containing biosolids have the potential to regrow after treatment. For biosolids or products containing biosolids of P1 and P2 grade, regrowth testing for *E. coli* and coliphages is required in order to demonstrate that the treatment process is working effectively and that, in combination with normal end-use management controls, regrowth has not occurred. Regrowth testing should be conducted annually, using three samples.

4.7 Vector attraction reduction

Vectors are living organisms that are capable of transmitting pathogens from one organism to another, either:

- mechanically, by transporting the pathogen
- biologically, by playing a role in the life cycle of the pathogen.

Vectors include flies, mosquitoes or other insects, birds, rats and other vermin.

The transport of pathogens by vectors can be controlled by any of the following:

- application of approved biological treatment processes (that is, anaerobic or aerobic digestion), which breaks down volatile solids, reducing the available food substrate for continued microbial activities and odour producing potential
- chemical or physical conditions (for example, heat, increasing the pH, and drying) which can significantly reduce or stop microbial activity
- physical barriers between vectors and volatile solids in biosolids.

Vector attraction reduction (VAR) is an outcome expected to be met from the processing and treatment of biosolids and products containing biosolids as indicated in Table 5. For other non-prescribed treatment processes, options for reducing vector attraction are shown in Table 5 (page 38). The VAR option is dependent on the biosolids or products containing biosolids treatment method. Vector controls are discussed further in Section 6.6 of these guidelines.

Table 5**: Vector attraction reduction measures** [5, 6]

Suggested vector attraction reduction measures	Biosolids and products containing biosolids suited to these measures
Volatile solids reduced by ≥38% in the digester	Anaerobically or aerobically digested sludge
Drying to ≥75% solids	Stabilised, anaerobically or aerobically digested sludge
Drying to ≥90% solids	Heat dried unstabilised sludge
Aerobic treatment for ≥14 days at average temperature >45^{o}C and temperature never <40^{o}C	Composted product
pH raised to ≥12, and without further addition of alkali maintained at ≥12 for 2 hours and ≥11.5 for an additional 22 hours	Alkali amended product (LAB)
Specific Oxygen Uptake Rate (SOUR) at 20^{o}C ≤ 1.5mg O_2/hr/g total solids	Liquid sludges from aerobic processes operating at 10 to 30^{o}C
Injection or incorporation of biosolids into soil within 6 hours of surface application	Partially stabilised or unstabilised sludges

[5] Adapted from US EPA Environmental Regulations and Technology 503, 2003 and

[6] Draft SA EPA Biosolids Guideline, 2009

4.8 Suitable use of options for biosolids

The contaminant and pathogen grading of biosolids determines their suitability for different end uses. The minimum contaminant and pathogen grades required for different end uses are detailed in Table 6 on page 39. Generally, the highest quality, or 'unrestricted use', biosolids are suitable for any use and are not subject to the suggested and required management requirements presented in these guidelines (See Appendix 6 on page 81 for a flowchart of this process). Other biosolids are suitable for restricted uses only, with mid-quality (P2 or P3 and C2) biosolids suitable for agriculture, forestry and land rehabilitation; and non-compliant low quality biosolids or sludges only suitable for disposal to landfill, thermal processing or further processing.

Table 6: **End uses of biosolids according to classification**

Biosolids end use	Pathogen grade	Contaminant grade*
Unrestricted use[7]		
Unrestricted use	P1	C1
Restricted use		
Agricultural direct land application (crops that may be consumed raw and in contact with biosolids)	P1	C2
Urban landscaping* (not household use)	P2	C2
Horticulture*	P2	C2
Agricultural direct land application (crops that may be consumed raw but not in contact with biosolids)[8]	P2	C2
Agricultural direct land application (pasture and crops that are processed before being consumed, but not root crops)[9]	P3	C2
Forestry direct land application	P3	C2
Rehabilitation (for example, mine sites, contaminated or degraded sites, within the wastewater treatment plant boundary)	P3	C2
Not suitable for direct use		
Composting	P4	C3
Class II (Putrescible) landfill[10]	P4	C3
Class III (Putrescible) landfill[10]	P4	C3

Biosolids end use	Pathogen grade	Contaminant grade*
Class IV (Secure) landfill[10]	P4	C3
Thermal processing (incineration, oil extraction, metal smelting or use in building products)	P4	C3

Note that DoH require the pathogen grade to be determined for biosolids and all products containing biosolids. While the contaminant grade and end use only applies to biosolids for the purposes of these guidelines, these classifications are also referred to in the protocols and calculator developed by DEC for biosolids products used in applications other than land applications.

* Although these uses are outside the scope of the Guidelines, the Guidelines would be of assistance in the consideration of any such proposals by relevant regulatory authorities on a case by case basis.

[7] Unrestricted use biosolids may still be subject to regulatory control, such as through labelling laws for fertilisers or Unauthorised Discharges Regulations 2004 where environmental harm may be caused by inappropriate use (i.e. over application causing nutrient issues)

[8] Includes fruit trees, grapes

[9] Includes cereal crops. May also include a soil improvement application such as shelter belts, revegetation of firebreaks, fodder crops, deep rooted plants for long-term cropping

[10] Biosolids being disposed to landfill need to meet the relevant requirements of the *Landfill Waste Classification and Waste Definitions* (1996), as amended and may be subject to DEC licence conditions.

5.0 SITE SUITABILITY FOR LAND APPLICATION

The land application of biosolids is not appropriate at some sites even if the biosolids are of a grade suitable for that purpose. This is because the characteristics of some sites mean they pose an unacceptable risk to the environment or public health. As such it is important to determine the physico-chemical characteristics of the site prior to the acceptance of biosolids and assess the suitability for land application of biosolids.

5.1 Soil

Assessment of soil physical and chemical characteristics helps to pre-determine the fate of nutrients and metals that are applied in the biosolids. Note that a sample returning <LOD (lower than the limit of detection) is to be given the value of 0.5 x LOD for statistical analysis.

5.1.1 Metal concentrations in soils

An assessment of existing metal concentrations in soil prior to the application of all grades of biosolids, except for unrestricted biosolids, is required to ensure any biosolids application will not exceed acceptable contaminant levels in the soil. The total contaminants from the combined soil and applied biosolids should not exceed the maximum allowable soil contaminant concentrations listed in Table 7.

Table 7: Maximum allowable soil contaminant concentrations (MASSC)

Contaminant	Maximum allowable soil contaminant concentration (mg/kg)[11]
Cadmium	1
Chromium (VI)	1
Copper	100
Zinc	200

[11] Maximum allowable soil contaminant concentrations are measured in mg/kg dry weight of soil and are mean concentration values.

Variation to MASCC limits

Research into plant uptake of cadmium, copper and zinc, has been carried out by the National Biosolids Research Program (NBRP). Under certain soil conditions, the mobility and rate of uptake of these metals is increased, resulting in greater risk of phytotoxicity, soil health and food quality (plant cadmium concentrations above recommended health limits). Soil conditions that influence these outcomes are pH, clay content, organic carbon and cation exchange capacity. Refer to Appendix 3 on page 66 for determining biosolids application rates.

In certain circumstances, it may be possible to apply biosolids when background soil concentrations exceed the MASCC. For example, some soils may have naturally occurring high metal concentrations with a low bioavailable fraction. Additionally, if the intended end use of the land is not agriculture then soil limits based on protection of food quality may not be applicable. Justification for increases to MASCC must be provided and will be considered on a case-by-case basis. Assessment of increased MASCC should be based on the principles of the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 1999).

5.1.2 Soil type

Research in WA and nationally has provided a great deal of information about soil types that have the capacity to assimilate nutrients and immobilise metals.

Biosolids should not be applied to sites where soil characteristics are assessed as ‘typically unsuitable’ as shown in Table 8.

Table 8: **Soil characteristics and associated restrictions**

Soil characteristic	Soil limitations			
	Slight	Moderate	Severe	Typically unsuitable
Depth to seasonal high water table[12]	>90cm	60–90cm	45–60cm	<45cm
Depth to most restrictive layer[13]	>90cm	60–90cm	45–60cm	<45cm
Electrical conductivity of saturated extract (ECe) (dS/m) at 0–45cm depth[14]	ECe <2	ECe 2 – <4	ECe 4 – <8	ECe ≥ 8
pH at 0–10cm depth[15]	>6.5	5.5–6.5	4.5–<5.5	<4.5
pH at 10–30cm depth[15]	>6.0	5.0–6.0	4.0–<5.0	<4.0

[12] Depth to seasonal high watertable: Perched water tables may cause waterlogging and make biosolids application impractical. Presence of a shallow watertable may also indicate soil conditions which favour movement of nutrients and contaminants into the groundwater.
[13] Depth to most restrictive layer: This criterion is based on bedrock or hardpans. The risk of run-off following rainfall increases with a shallow restrictive layer. If underlying bedrock is fractured there is a risk of movement of nutrients and contaminants into the groundwater.
[14] Electrical conductivity: Biosolids application may increase salinity. At ECe levels >4dS/m many plant species will not grow. At ECe >8dS/m most plant species will not grow.
[15] pH: In general, a site is too acidic if pH <4.5 (0–10cm depth) or pH <4.0 (10–45cm depth). Consideration should also be given to changes to the MASCC from lower pH levels. Liming of soils may be used to buffer acidic soils. This limitation does not apply to limed biosolids.

An important consideration of site selection is the ability of the soil to immobilise phosphorus. Phosphorus is typically deficient in the highly weathered WA soils and the application of biosolids can redress this deficiency. However, phosphorus in excess of plant requirements has the potential to leach from the site and enter water resources, contributing to eutrophication. When biosolids are applied at rates designed to provide plants with nitrogen requirements, a relatively high amount of phosphorus is also applied. As with other organic and inorganic fertilisers, biosolids recipients should design beneficial use programs as part of a holistic nutrient management strategy to minimise the potential for phosphorus leaching.

Many soils have the capacity to retain and immobilise excess phosphorus which can then be released over subsequent growing seasons. Soil properties that influence the phosphorus retention capacity include texture (for example, clay, laterite) and organic matter. Generally speaking, the less clay and organic matter present in the soil, the lower the ability of the soil to immobilise phosphorus. The phosphorus retention index (PRI) or the phosphorus buffering index (PBI) are measures of these various factors.[16]

Biosolids application should be targeted towards areas where the risks of phosphorus losses are minimal. Table 9 provides a soil ranking system that can be used to identify suitable soil types for biosolids application when the intended application rate is based

upon the plant's nitrogen uptake rate (see Section 8.1). Biosolids application where the soil category is one to four may be conducted on the basis of the nitrogen requirement of the plants.

Table 9: Soil ranking system based on the phosphorus retention index[16,17]

PRI (mL/g)	Bicarbonate extractable P (Colwell) (mg P/kg)	Agronomic demand for P	Risk of P leaching given reactive Fe >200 mg /kg	Category**
>70	<15	High	Negligible	1
	>15	Moderate	Negligible	1
15-70	<15	High	Low	1
	15-25	Moderate	Low	2
	>25	Low	Low	3
2-15	<10	High	Low	1
	10-20	Moderate	Low	2
	>20	Low	Low	3
<2	<15	Moderate	Moderate	4
	>15	Low	High if <200 mg Fe/kg	5

****Soils ranked in order of preference from highest (1) to lowest (5).**

Categories preferred for land application are 1>2>3, with category 4 least suitable and category 5 not recommended.

[16] Source – Bolland and Windsor, 2007
[17] Source – Pritchard, 2005

Soil types with a category of 5 should not be used for biosolids application unless the application rate is limited to the phosphorus uptake of the plant or the recipient can demonstrate that phosphorus losses will not occur.

5.1.3 Soil type and depth to groundwater

Leaching of nitrogen and phosphorus is a major concern relating to water resource contamination. The potential risk of contamination to groundwater depends on a number of factors, including the geology of the soil and the depth to the watertable. To protect water quality, biosolids should not be applied to areas listed as 'typically unsuitable' in Table 10. Groundwater suitability ratings are based on soil type, permeability and porosity.

Table 10 should be interpreted such that for mixed soils the predominant soil type is the determinant, and for duplex soils, the surface strata is the determinant.

For the purpose of this document, depth to groundwater shall be determined using the method described in the Australian/New Zealand Standard 5667.11:1998: Water quality–Sampling Part 11: Guidance on sampling of groundwater (A/NZ 5667.11.1998).

Table 10: **Depth to groundwater[18] restrictions**

Strata	Depth to groundwater		
	Typically unsuitable	Acceptable	Desirable
Clay	<1.5 metres	>1.5 metres	>2 metres
Sand	<2 metres	>2 metres	>5 metres
Laterite	<3 metres	>3 metres	>5 metres
Sandy limestone	<5 metres	>5 metres	>10 metres
Gravel and hard rock[19]	Unsuitable		
Karstic limestone	Unsuitable		

[18] Groundwater other than seasonal watertables (see Table 8 for criteria for seasonal watertables)
[19] Gravel refers to unconsolidated gravel material where little or no soil forming processes have occurred.

5.2: Proximity to sensitive land areas and water resources

Sensitive areas where application of restricted use biosolids will not be permitted include:

- areas of environmental significance such as
  - environmental protection policy (EPP) areas
  - conservation category wetlands
  - Ramsar wetlands
  - national parks and conservation reserves.

The location of these areas can be obtained from contacting the Office of the Environmental Protection Authority www.epa.wa.gov.au or by contacting DEC at www.dec.wa.gov.au

- areas subject to water logging
- areas within the significant recorded flood line
- public drinking water source areas.

For the location of these areas, and guidance on the use of products containing biosolids within these areas, information can be obtained from DoW at www.water.wa.gov.au or by contacting the department's relevant regional office.

- areas prone to endemic diseases (for example, hookworm) typically above the 26th parallel
- areas subject to issues of public health concern may be subject to certain restrictions and additional conditions of approval. Restrictions would be determined on a case-by-case basis by DoH.

5.3 Buffer distances

Buffers are used to reduce the potential impact of activities which pose an environmental and health risk. Buffers are required for biosolids applications to land to reduce odour impacts and protect sensitive water resources from contamination. Buffers are more effective if they are permanent, stable and covered with grasses and natural vegetation to limit the transfer of biosolids from the application area to neighbouring protected areas. Recommended buffer distances are provided in Table 11.

Table 11: **Minimum buffer distances**

Description	Buffer distance (m)
Boundary of wetland vegetation around estuaries and lakes	400
Conservation wetlands (for example, Ramsar)	200[20]
Private drinking water supply bores	100
Agricultural, stock and domestic non-drinking water supply bores	50
High water mark for agricultural dams	100
Permanent creeks, streams, rivers and other wetlands	100[20]
Banks of intermittent flow water courses	50
Farm driveways, access roads and fence lines	5
Animal enclosures	50
Occupied dwellings on properties with biosolids applications	100
Occupied dwellings on other properties	1,000[21]

[20] Seek DEC advice for each specific case.

[21] With the written agreement of the respective affected occupiers, this buffer may be reduced. This agreement and supporting documentation from the affected parties must be included in the REF.

5.4 Timing of application

The application of biosolids should not occur during rainfall events or when heavy rains are forecast. To avoid nutrient losses, biosolids should be applied to fallow land as close to the time of sowing as possible. Biosolids should not be applied when strong winds will carry dust and/or odours beyond the buffer area or property boundary. Applications to permanent pasture can only occur during renovation or establishment.

5.5 Slope of land

Run-off and seepage of nutrients can be a problem when applying biosolids to land. Surface run-off increases with greater slope and may cause soil erosion. Slope recommendations are provided in Table 12.

Table 12: **Slope limitations**

Slope gradient (%)	Slope gradient (ratio)	Comments
0–3%	<1:33	Ideal – no concern for run-off or erosion
>3–6%	1:33–1:16	Suitable – slight risk of erosion
>6–12%	1:16–1:8	Suitable if soil conservation practices are used to minimise erosion (for example, contour banking)
>12–15%	1:8–1:7	Typically unsuitable unless the site is maintained with at least 80% vegetative ground cover or engineered drainage controls
>15%	>1:7	Unsuitable

5.6 Reapplication

Repeat applications of biosolids can lead to the accumulation of nutrients, metals and pesticide residues. It is important to test the soil to determine the level of nutrients and contaminants in the soil prior to initial or repeat applications, and reduce the application rate if required. The soil sampling procedure is outlined in Appendix 7 on page 82.

6.0 BIOSOLIDS STORAGE

Many of the potential environmental and health risks associated with the land application of biosolids are related to storage prior to spreading. These potential risks include:

- flystrike in stockpiles <8 weeks aged
- ground and surface water contamination
- leaching of contaminants during heavy rainfall events and floods
- public and occupational health risks from uncontrolled access and/or inappropriate storage, transport or handling.

The following factors can influence the severity of these risks:

- stockpile size
- biosolids quality
- length of time biosolids will be stored
- time of the year (that is, effects of moisture, temperature and wind gradients)
- stockpile design (capacity, run-off and leachate controls)
- stockpile location.

Minimum in-field storage is encouraged, to reduce these issues and nuisance potential.

If more than 30 days storage is expected, biosolids must be located within a specifically designed and built storage structure called a 'bund' (section 6.4). If the initial short-term storage period becomes a long-term storage period (that is, more than 30 days), interim measures are needed, and a more permanent and specifically designed structure may need to be constructed to hold this stockpile.

The biosolids supplier and end recipient are both responsible for ensuring that the risks associated with stockpiling biosolids within a facility or application area are managed.

6.1 Siting of stockpiles

It is important that an appropriate location is selected when biosolids are stockpiled. The following criteria describe the most appropriate site for the biosolids stockpile:

- flat (slope gradient ≤3 per cent); raised land set well back from waterways and flood prone land
- protected from unauthorised access
- stockpiles should not be situated in an area deemed unsuitable for biosolids application, for example, due to soil type, proximity to dwellings or sensitive areas or groundwater depth (Section 5).
- DoW does not support stockpiles of biosolids on any land located within a public drinking water source area, other than at wastewater treatment plants licensed by DEC.

6.2 Fencing and signage

Biosolids should not be stored for any period of time in areas where the public has ready access. The property owner must ensure that the location selected for the storage of biosolids is:

- fenced to prevent unauthorised access. If the premises cannot be economically fenced such as a large tree plantation, other measures such as road closures should be considered
- sign-posted at all entrances to the property, from the time of delivery of the biosolids to the property until the biosolids have been incorporated and stock exclusion periods are completed. Signs must be:
  - weatherproof (for example, metal or sturdy plastic)
  - in compliance with AS 1319–1994, Safety signs for the occupational environment
  - worded, at a minimum or as approved by DoH, to include the following information:

BIOSOLIDS ARE BEING STORED AND USED IN THIS AREA. CONTACT WITH BIOSOLIDS MAY AFFECT HUMAN HEALTH. THEREFORE, UNAUTHORISED ACCESS IS PROHIBITED.

6.3 Drainage

Biosolids stockpiles, regardless of the length of storage, should be located on flat (slope gradient of ≤3 per cent), raised land so that stormwater from other areas does not run through the stockpile, which may cause leaching of contaminants and nutrients into the environment.

If a flat, raised storage area is not possible, a drainage channel should be constructed to divert stormwater away from the stockpile and minimise the potential for contaminant and nutrient leaching. Any leachate collected inside the storage area should be used within the biosolids application area.

6.4 Bunding

Bunds should be constructed around biosolids stockpiles if the material has been approved for storage for longer than 30 days or the stockpile is located on a slight slope (slope gradient of >3 per cent).

Bunds serve a number of purposes. They ensure that the biosolids are contained within a specific area; they assist in keeping stormwater away from the stockpiles; and they provide a physical barrier to help restrict access.

Bunds may, in most cases, be constructed from earth from the application site. Run-off diversion drains may be required around the upslope side of the bund.

6.5 Covering

Biosolids stockpiles are not required to be covered provided that the storage period and monitoring requirements are met. Should biosolids stockpiles be covered or otherwise enclosed to exclude vectors and prevent wind-blown material, the stockpiling period may be extended beyond the recommended period. See sections 6.6 and 6.7 for further information on fly control, monitoring and storage times. Any monitoring or sampling should be conducted prior to use or when the covers are removed if stockpiling for >30 days.

6.6 Vector control

A vector is an animal that could potentially play a role in transmitting pathogens from biosolids to humans. Vectors could include flies, mosquitoes, fleas, rodents, birds or domestic animals.

Risks from vectors can be controlled by reducing the potential for physical contact (for example, minimising the storage time; covering biosolids stockpiles). Methods to manage vectors may vary between sites depending upon the vectors to control, seasonal conditions and the type of biosolids used.

6.7 Fly control

Stockpiling of biosolids may also provide the substrate in which vectors can breed, creating nuisance as well as enhancing the potential for pathogen transfer from biosolids to humans or animals. Prevention of flies breeding is of primary concern in terms of health risk and nuisance factor. To avoid this:

- Primarily, biosolids should be incorporated quickly into the soil sub-surface. Dried biosolids and rotary cultivation are considered the best control methods for all nuisance flies.
- The storage period should be limited to seven days during warmer months (October to May) and 30 days during the remainder of the year.
- Where biosolids are stockpiled for more than seven days they should be monitored for flystrike on a fortnightly basis by an entomologist during the warmer months (October to May) and monthly during the remainder of the year unless a more frequent monitoring schedule is recommended by an entomologist.
- If the planned storage period will exceed seven days (during warmer months) the recipient must demonstrate in the REF that this will not give rise to fly breeding.
- The visual inspection of biosolids for fly breeding is to be carried out by the recipient on a weekly basis.
- A contingency plan should be developed to deal with flystrike. This plan should be available on site and may include (but is not limited to):
    - if flystrike is detected in a biosolids stockpile, provisions should be in place to enable the spreading of that stockpile within one day of detection

- stockpile can be treated with insecticide if fly strike is detected and spreading is not possible. It is important to note that insecticides have a very limited lifespan against flies. Therefore treatment is only advised if spreading is not possible
- DoH and local government must be advised in the event of flystrike.

Research has shown that typically lime amended biosolids (LAB) do not attract flies or encourage breeding due to the elevated pH levels and heavy texture of the LAB. Therefore routine monitoring of LAB is not required.

6.8 Monitoring

Biosolids stockpiles should be visually inspected by the recipient or their representative each week, to ensure the integrity of the stockpile, and/or bunds, drainage channels and potential fly breeding. If the integrity of the stockpile, bunds or drainage channels is found to be compromised, action to rectify the situation needs to be implemented as soon as possible. More frequent monitoring may be required in the event of heavy rainfall.

6.9 Contingency planning

These guidelines adopt a risk management approach to biosolids storage and application. This means that risks are assessed and measures are taken to minimise them where appropriate.

It is possible that circumstances that influence management of the stockpile may change during the course of storage on site, particularly for periods longer than 30 days. The plan for management of the stockpile, incorporating the control measures above, should be flexible enough to account for these changing circumstances. For example, despite the implementation of appropriate vector control measures, flystrike still may be detected in a stockpile. In this case it may be necessary to spread the biosolids immediately.

In all cases, contingency planning needs to be conducted prior to receipt of biosolids from the supplier. A documented plan must be prepared which should include provisions to spread biosolids, treat flystrike through insecticides, or remove biosolids from the property altogether, at short notice in an emergency situation. The plan should also incorporate a response to unexpected storage incidents such as flooding of a stockpile area.

Details of parties requiring notification should be included in the contingency plan, including, but not limited to:

- DEC
- DoH
- local government.

7.0 TRANSPORT OF BIOSOLIDS

Liquid biosolids may trigger permitting requirements under the Environmental Protection (Controlled Waste) Regulations 2004. These regulations provide a licensing system for the transport of designated controlled wastes. Further information about controlled waste permit requirements can be obtained from DEC. A basic guide for biosolids that may trigger the requirement for permitting is provided below in Table 13:

Table 13: **Allowable solids content for controlled waste regulations** [22]

Total solids	Environmental Protection (Controlled Waste) Regulations 2004
Not spadeable	Permit required
Spadeable	Permit not required

[22] The spadeability may be increased by the addition of polymers.

Biosolids shall be transported and applied to land in ways that avoid public nuisance, particularly with respect to dust and odour. This requires careful selection of transport routes, timing and site access. The local government must be advised of a minimum of transport dates, expected number of truck movements and proposed routes. Restrictions on vehicle types and load size may apply to certain roads, and permits may be required from Main Roads WA.

To minimise the risk of spillage, biosolids should have a solids content of 15 per cent or greater. Vehicles used to transport biosolids must:

- be fitted with grain locks
- have water-tight seals on rear tailgates
- have the load covered with a waterproof cover.

Transport vehicles should not be used for back-loading foodstuffs for animal or human consumption.

Truck tailgates and tyres should be cleaned prior to leaving the wastewater treatment plant and the delivery site to ensure that biosolids are not spilt on roadways. All transport vehicles should be thoroughly cleaned before being used for any other purpose.

Transport operators should be provided with training in correct transport procedures and incident management.

7.1 Incident management plans

An incident management plan for application of biosolids should be developed to ensure rapid clean-up of spills both en route and at the end-use site. The local government, DoH and DEC are to be informed in the event of a spill. DoW is to be informed of spills in a PDWSA. Dry clean-up for spills is recommended.

8.0 BIOSOLIDS APPLICATION

With the exception of biosolids application to forestry or mine site rehabilitation, the application of biosolids is considered beneficial use when the application rate of nutrients in the biosolids is compatible with the nutrient requirements of the vegetation, crops or pasture growing on the land. Whenever biosolids application rates greatly exceed the nutrient requirement, the application is not considered beneficial and may be considered pollution under the *Environmental Protection Act 1986*. The regulatory consequences of causing pollution are not covered in these guidelines. See the DEC website (www.dec.wa.gov.au) for further information.

For biosolids applications to forestry and site rehabilitation see Appendix 8.

The suitability of land for the application of biosolids is determined by the biosolids classification and the site characteristics, in particular, the site land use (for example, agricultural or non-agricultural) and proximity to sensitive water resources.

The soil must be sampled prior to biosolids application. The results of the soil analysis, including contaminant and nutrient concentrations, are used to assess the soil suitability receiving the biosolids.

8.1 Calculating biosolids application rate

Biosolids application rates are calculated to meet the nutrient demand for the proposed crop without providing excess nutrients or other contaminants that may otherwise be leached into the environment.

The quantity of biosolids per hectare that can be applied directly to land is restricted by the nitrogen limited biosolids application rate (NLBAR) and the contaminant limited biosolids application rate (CLBAR) and the phosphorus limited biosolids application rate (PLBAR) if required. Details of how to calculate these values can be found in Appendix 3.

8.2 Biosolids spreading

All biosolids applied to land in a rural setting should be spread evenly and then incorporated into the topsoil within 36 hours. Incorporation reduces odour problems, vector attraction, nitrogen loss through volatilisation and surface losses due to erosion, and improves the availability of phosphorus. The best method of incorporation will depend on soil conditions (moisture, soil type). Disc ploughing is considered to be one of several effective methods.

Soil incorporation may not be compatible with all farming systems (for example, no till agriculture) and certain soil and weather conditions can cause significant environmental harm (for example, soil compaction, dust and erosion). Agricultural application of biosolids without the requirement for incorporation within 36 hours will only be

considered for times of year where soil conditions are not suitable for incorporation at the time of conducting the biosolids application.

In this instance incorporation of the biosolids may be delayed until soil conditions improve (for example, increase soil moisture).

Even spreading ensures maximum agronomic benefit, and reduces the risk of excess contaminants and nutrients being applied to sections of the land. Purpose-built spreaders which give a predictable application rate should be used. Application equipment should be calibrated to apply biosolids at the calculated application rate. Application equipment should be cleaned before moving from the application site to prevent biosolids falling onto roads.

Stock exclusion and withholding periods commence from first delivery of biosolids through to final incorporation including throughout the spreading process. This stock exclusion includes time where biosolids may be land applied but not incorporated. If biosolids are stockpiled for >30 days fencing may be used around the stockpile to exclude stock. Refer to Table 14 for more detailed information.

Biosolids applications in forests and timber plantations are the only applications exempt from incorporation. However, public access to the forestry biosolids application area should be restricted for a minimum period of 12 months after surface application.

8.3 Health and safety aspects of biosolids handling

As restricted use biosolids and products containing biosolids may contain pathogens and chemical contaminants, routine occupational health and safety precautions should be practiced, including:

- education of on-site workers as to the risks associated with exposure to biosolids (ingestion or inhalation of biosolids dusts)
- worker immunisations where appropriate
- provision of wash facilities and use of personal protective equipment
- no food or drink consumption while directly working with biosolids and washing hands before meals or smoking
- not allowing children access to biosolids, either during storage or application
- adopting techniques that minimise the generation of mists and airborne dust
- for biosolids >40 per cent total solids, minimising worker access to the site during biosolids application, keeping workers upwind during application and using protective equipment, for example eye protection and masks should be worn if dusts/aerosols are generated.

Employers should make themselves aware of their occupational health and safety responsibilities and duties under the *Occupational Health and Safety Act 1984*. An OH&S plan should be prepared, staff trained, and safe practices integrated into day-to-day work procedures. Refer to Appendix 1.

8.4 Record keeping and monitoring

The supplier of biosolids is expected to maintain accurate records of the quality and quantity of biosolids supplied, the application rate, the date of supply, the location of properties supplied and area where biosolids have been applied (that is, paddock name) (for sample Biosolids Application Checklist see Appendix 9).

The end-recipient of biosolids is expected to maintain accurate records of the dates of spreading and of subsequent uses of land for a period of five years after spreading. The end-recipient should also note any difficulties with the application, and inform the supplier as soon as practicable. Use of devices such as GPS will assist in accurate record keeping.

Depending upon the location of the application site, regulatory agencies may request monitoring at the site by the supplier for a specified period. Monitoring after application is to ensure that there are no adverse effects on public health or the local environment. Such monitoring may be included in DEC licence conditions or DoH approval conditions for the premises.

8.5 Activity constraint following direct land application

Specified activities may not take place on land treated with biosolids of pathogen grade P2 or P3 for a specified period of time after the application (Table 14 on page 56).

Table 14**: Withholding periods**

Activity	Withholding period for pathogen grade P2 and P3
Food crops that may be consumed raw but not in contact with biosolids	No fallen fruit is to be collected for human use.
All other food crops	Must not be harvested for 30 days after biosolids incorporation.
Animal feed and fibre crops	Must not be harvested for 30 days after biosolids application/incorporation.
Animal withholding periods	Animals must not be grazed on the site for 30 days after biosolids application/incorporation.[23] Lactating (including milk for human consumption) and newborn animals should not be allowed to graze the site for 45 days after biosolids application. Poultry and pigs must not be grazed for at least one year on land subject to previous biosolids application; their feeding habits result in high levels of ingested soil.
Turf	Turf grown on land to which biosolids have been directly applied must not be harvested for at least one year after biosolids application/incorporation.
Forestry and timber plantations	Public access to forestry and timber plantation biosolids application areas should be restricted for 12 months.

[23] Source – NSW EPA Environmental Guidelines, 1997

9.0 MORE INFORMATION

9.1 Contacts

For more information regarding biosolids land application licences and approvals, direct land application of biosolids, or to make comments about these guidelines, contact:

Department of Environment and Conservation
Environmental Regulation Division
Phone: (08) 6467 5000
Fax: (08) 6467 6520
Email: environmental.regulation@dec.wa.gov.au

Department of Health WA
Environmental Health Directorate
Phone: (08) 9388 4999
Fax: (08) 9388 4910

Department of Water
Water Source Protection Planning Branch
Phone: (08) 6364 7600
Fax: (08) 6364 7601
Email: waterquality@water.wa.gov.au

Water Corporation
Wastewater Treatment Branch
Water Technologies Division
Phone: 13 13 75
www.watercorporation.com.au

Department of Agriculture and Food WA
Regional Operations Manager, Moora
Phone: (08) 9651 0555
Fax: (08) 9651 1008
Email: enquiries@agric.wa.gov.au

National Biosolids Research Program (NRBP)
C/o CSIRO
Land and Water Division
Phone: (08) 8303 8533
www.csiro.au

9.2 Complaints and specific requests

Most of the biosolids land application trials have used biosolids from a Water Corporation wastewater treatment plant. If you have a query about a particular site where biosolids are being applied, a concern on the methodology of application or any other issue associated with biosolids use, please contact the Water Corporation on 13 13 75. The Water Corporation has an agreed process that is followed and notifies the relevant agency immediately, and includes the query and outcome in the annual reporting.

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11.0 APPENDICES

Appendix 1: Occupational hygiene and safe handling of biosolids

Appendix 2: Review of environmental factors (REF)

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APPENDIX 1: OCCUPATIONAL HYGIENE AND SAFE HANDLING OF BIOSOLIDS AND PRODUCTS CONTAINING BIOSOLIDS

This appendix is derived from a Water Corporation document, titled 'Occupational hygiene and safe handling of biosolids' (Water Corporation 2005).

Health hazard information

Acute effects

- Eyes: biosolids contact with eyes may cause infection
- Skin: breaks in the skin will increase the risk of infection
- Inhaling: workers handling and applying dry biosolids to land may risk infection from inhaled dust
- Swallowing: ingestion is generally the major route of infection. Touching the mouth with the hands after handling biosolids will increase the possibility of infection. Eating or smoking before washing hands will increase the risk of infection.

Chronic effects

- Infectious diseases are generally of short duration and successfully treated with antibiotics.

Safe handling information

- Storage and transport: keep biosolids moist to prevent dust formation. Transport in covered trucks with grainlocks and tailgate seals. Drivers should be trained on safe handling procedures.
- Reactivity data: no data.
- Fire/explosion hazard: burning biosolids may produce carbon monoxide and ammonia gas.

Precautions for use

- Exposure standards: biosolids are complex mixtures. Health issues may exist for specific components.
- Engineering controls: biosolids should not be turned more than is necessary during the land application process to minimise the potential for release of odour, air-borne particles and return to surface of biosolids material.
- Flammability: biosolids can release both toxic and flammable gases. Ventilation is required to prevent build-up of vapours and gases. Avoid ignition sources where flammable gas concentrations could reach hazardous levels.
- Personal protection: appropriate workplace and personal hygiene practices should be adopted.
- Hands should be washed and nails scrubbed well with soap after contact with biosolids before eating, drinking, smoking, going to the toilet, and at the end of work.
- Cuts and abrasions should be covered with waterproof dressings.
- A suitable change of clothes should be worn during work. Footwear and gloves are required to protect against injury from sharp objects. Discard torn gloves. Eye protection should be worn to protect against dust.

- Wear appropriate dust masks if biosolids are extremely dry. Workers should be upwind of the application process.
- Wherever possible, separately launder and store work clothes.
- Clean soiled work tools after use.

APPENDIX 2: REVIEW OF ENVIRONMENTAL FACTORS (REF)

The REF is the report accompanying a third party independent auditor's certification. The third party auditor is to provide a certification that the REF has met with these guidelines (Appendix 4). All applications require a REF, and submission to DoH.

The REF document must contain all the relevant information and supporting documentation so the auditor and agencies do not have to seek further information from the recipient which may cause significant time delays. The REF cannot be prepared until all sampling, investigations of the site and LGA consultation, have been completed. Where approved, a simplified REF may be assessed by the auditor and agencies with the provision that a REF with all relevant information and supporting documentation related to the property is available or known to the auditor and agencies. For all new proposed biosolids land applications the REF must contain all the relevant information.

A checklist is provided below:

- type of biosolids use proposed. If a trial is proposed, provide details of monitoring program to be established and research methodology.
- details of the use site, including location, local government authority, brief history of biosolids use on site, list of paddocks.
- relevant previous REFs or licences issued for the same properties or paddocks as outlined in the new REF.
- name, address and contact details of the user and land owner/manager.
- source of the biosolids, type of biosolids.
- the quantity of biosolids to be used, including wet tonnes and dry tonnes.
- contaminant and pathogen grade, data and method used to classify biosolids.
- site assessment details, including slope, buffer distances, soil type, soil quality, proximity to sensitive receptors, depth to groundwater, location of any water bores on/in proximity to the site and proximity to PDWSAs. If the REF covers a number of sites, then representative sampling is to be done for each site.
- biosolids transport systems, including transport vehicle type, route, vehicle wash down.
- evidence that the local government authority has been consulted.
- biosolids storage systems including location, duration, run-off controls.
- roles and responsibilities for day-to-day management and compliance issues.
- biosolids application, timeframe and soil incorporation method.
- a scaled locality plan of the end-use site, showing all important features, sensitive land uses and receptors (for example, waterways), site boundaries, locations of fences, prominent warning signs and storage locations (if on site).
- contaminant and nutrient application rate calculation methods and resultant application rates. Comparison (%) of proposed application rates to NLBAR and PLBAR with discrepancies to be fully justified (for example, P immobilisation in soil).
- for land management practices (for example, cropping, forestry, pastoral) details of plant/species type, plant/crop density, nutrient utilisation, and full calculations demonstrating the sufficient utilisation of biosolids nutrients.
- justification of the crop nutrient requirements by consulting local agronomist or DAFWA.

- controls, if relevant, for drainage, stormwater run-on and run-off, and groundwater protection.
- access controls – public and/or stock, including withholding periods (if relevant).
- contingency plan.
- incident management plans, including spillage management and flystrike.
- monitoring procedures for flystrike.
- monitoring procedures for soil, biosolids, groundwater and agricultural produce, if relevant.
- participation agreement between supplier and user.
- occupational health and safety controls.
- recordkeeping and reporting programs.
- notification required to DEC and DoH at least four weeks prior to application.

APPENDIX 3: PROCEDURE FOR DETERMINING BIOSOLIDS APPLICATION RATE

A maximum annual biosolids application rate is set for two reasons:

1. To ensure that the amount of contaminant supplied to the site does not exceed the maximum contaminant load.
2. To ensure that the addition of nutrients from biosolids does not exceed agronomic rates (NLBAR).

The application rate is set to minimise the risk of high concentrations of available metals being present in the soil at any time and taken up by crops. The maximum biosolids application rate will be determined by the lower of the CLBAR and the NLBAR.

Calculation of maximum permissible concentration

Biosolids are given a contamination grading to prevent the risk of excessive uptake of metals by crops, ingestion of contaminants by humans or animals, or deleterious effects on the environment. A large single application to a site or repeated applications to a site could lead to such outcomes.

A maximum permissible annual contaminant load has been set for cadmium (Table A1).

It should be noted that the maximum permissible contaminant load for cadmium has been set across a period of five years. Therefore, it is possible to apply biosolids at an application rate of 0.15kg/ha cadmium in a single application. However, no subsequent biosolids applications containing cadmium may be made for the next five years. Alternatively, annual applications can be made providing that the total cadmium loading does not exceed 0.15kg/ha over five years.

Maximum permissible concentrations (MPCs) have been set for the contaminants in soils used for the production of food crops for human and animal consumption (Table A2).

Critical soil concentrations of metal contaminants can adversely affect microbial processes and plant productivity (for example, Cu, Zn) or exceed levels permitted by food standards for human consumption (for example, Cd). These critical values are affected by soil properties such as pH, clay content, organic carbon content and cation exchange capacity. A set of soil-specific maximum limits for copper, zinc and cadmium are shown in Table A3, Table A4 and Table A5 respectively, and are dependent on the soil properties at a site.

Table A1: **Maximum permissible cadmium contaminant load**

Contaminant	Limiting value (kg/ha)
Cadmium	0.03 (or 0.15kg/ha over 5 years)

The total permissible concentration for copper and zinc equates to the sum of the appropriate maximum permitted added biosolids copper and zinc concentrations from Table A3 and Table A4 respectively, and the appropriate background soil concentration taken from Table A2. For example, if a selected site intended for biosolids application has a pH 7.5, an organic carbon content of 1%, an iron content of 0.5% and a cation exchange capacity of 10cmolc/kg, the total permissible concentration for copper and zinc would be:

Copper = 102.8mg/kg Cu (Table A3) + 10mg/kg Cu (Table A6) = 112.8mg/kg Cu

Zinc = 305.8mg/kg Zn (Table A4) + 25mg/kg Zn (Table A6) = 330.8mg/kg Zn

Biosolids should not be applied to sites where existing contaminant concentrations are in excess of the maximum allowable soil contaminant concentration contained in Table A3, Table A4, Table A5 and Table A6 unless approved by DEC.

Table A2: **Maximum permissible concentrations in soil**

Contaminant	Soils used for food production (mg/kg dry weight)
Arsenic	20
Lead	200
Mercury	1
Nickel	60

Table A3**: Maximum permitted added biosolids copper (Cu) concentrations in soil at varying pH and organic carbon content**

	Organic carbon content (%)							
	Ratio	0.5	1.0	2.0	3.0	4.0	5.0	6.0
pH	OC	0.5	1.0	2.0	3.0	4.0	5.0	6.0
	mg added biosolids Cu/kg soil							
4.0		4.1	8.5	17.7	27.1	36.7	46.4	56.2
4.5		5.9	12.2	25.2	38.7	52.3	66.2	80.2
5.0		8.4	17.4	36.0	55.2	74.7	94.5	114.5
5.5		11.9	24.8	51.4	78.7	106.6	134.8	163.4
6.0		17.0	35.3	73.3	112.4	152.2	192.5	233.2
6.5		24.3	50.4	104.7	160.4	217.2	274.7	332.8
7.0		34.7	72.0	149.4	228.9	309.9	392.0	475.0
7.5		49.5	102.8	213.2	326.8	442.4	559.5	678.0
8.0		70.7	146.7	304.3	466.4	631.4	798.6	967.6

Table A4: **Maximum permitted added biosolids zinc (Zn) concentrations in soils**

	Cation exchange capacity (cmolc/kg)							
	CEC correction factor	0.3	0.5	1.0	2.0	3.0	4.0	6.0
pH	CEC	3.0	5.0	10.0	20.0	30.0	40.0	60.0
	mg added biosolids Zn/kg soil							
4.0		14.8	21.2	34.4	56.0	74.5	91.1	121.1
4.5		20.2	28.9	47.0	76.5	101.7	124.5	165.5
5.0		27.6	39.5	65.3	104.5	139.0	170.1	226.0
5.5		37.7	54.0	87.8	142.8	189.8	232.3	308.8
6.0		51.5	73.7	199.9	195.1	259.3	317.4	421.9
6.5		70.4	100.7	163.8	226.5	354.3	433.6	576.4
7.0		96.1	137.6	223.8	354.1	484.0	592.4	787.4
7.5		131.3	188.0	305.8	497.5	661.3	809.3	1,075.7
8.0		179.4	256.8	417.8	679.6	903.4	1105.6	1469.9

Table A5: **Maximum permitted total cadmium (Cd) concentrations in soils**

	Clay content (%)		
	5	25	50
pH			mg Cd/kg soil
4.5	0.54	1.17	1.96
5.5	0.68	1.31	2.10
6.5	0.82	1.45	2.24
7.5	0.96	1.59	2.38
8.5	1.10	1.73	2.52

This limit is to ensure food products for human consumption do not exceed Australian Cadmium Food Standards.

Table A6: **Expected background concentrations of copper and zinc in soils at different levels of soil iron**

Soil Fe (%)	Cu (mg/kg)	Zn (mg/kg)
0.1	<4	<4
0.5	<10	<25
1	<15	<35
5	<45	<85
10	<70	<130
15	<90	<165
20	<105	<195
25	<120	<225

The CLBAR is the rate, in dry solid tonnes per hectare, which will cause the concentration of the limiting contaminant to reach the maximum allowable soil contaminant concentration (MASCC) (Table A2) after application is completed.

The CLBAR for a biosolids batch at a particular site is determined by calculating the CLBAR for each contaminant using the following equation:

$$CLBAR = \frac{(MASCC - ASCC)}{BACC} \times SM$$

where:

CLBAR = Contaminant limited biosolids application rate (dry tonnes/ha)

MASCC = Maximum allowable soil contaminant concentration (mg/kg) (Table A2)

ASCC = Actual soil contaminant concentration (mg/kg) obtained from soil samples

BACC = Biosolids adjusted contaminant concentration (Section 4.2)

SM = Incorporated soil mass per hectare (dry tonnes/ha)

The CLBAR for each individual contaminant can be compared by undertaking calculations in a tabulated format. The contaminant with the lowest CLBAR is the limiting contaminant, and its CLBAR is the maximum application rate permitted.

In WA it would be unusual for typical wastewater treatment plant biosolids to be limited by contaminants other than nutrients. In most instances the limiting factor will be the NLBAR or PLBAR (where required).

Nitrogen limited biosolids application rate

Because part of the nitrogen in biosolids is in organic form, it is not readily available for plant use immediately after application. The available nitrogen content of the biosolids includes the inorganic nitrogen forms of ammonia, nitrate and nitrite, plus a fraction of the organic nitrogen content. The fraction of the organic nitrogen content available will depend on the nitrogen mineralisation rate (MR) in the year following application.

The available biosolids nitrogen is calculated using the following formula:

Available biosolids nitrogen (year 1) = [Ammonia N x (1-VR)] + [(Total Kjeldahl N – Ammonia N) x MR] + Oxidised N

Where: VR = ammonia N volatilisation rate (%) from Table A7, divided by 100
MR = organic N mineralisation rates (%) from Table A8, divided by 100
Oxidised N = the sum of nitrate plus nitrite N

Table A7 provides estimated biosolids ammonia volatilisation rates per year.

The nitrogen mineralisation rate depends on several parameters such as the type of biosolids, climate, rainfall and soil. Suggested values are provided in Table A8 (from NSW EPA 1997). Nitrogen mineralisation is being investigated in WA and consideration should be given to any findings applicable to the proposed application site.

Table A7: **Biosolids ammonia volatilisation**

Biosolids *	Volatilisation rate per year (%)
Dewatered biosolids cake <30% total solids	50
Dewatered biosolids cake >30% total solids	0–10
Lime amended biosolids	10

* assumes application rate occurs within 14 days of production

Table A8: **Biosolids type and nitrogen mineralisation rate**

Biosolids type	Nitrogen MR per year (%)
Anaerobically digested	15
Aerobically digested	25
Composted	10

For agricultural applications the nitrogen limited biosolids application rate (NLBAR), in dry solid tonnes per hectare, is based on the crop requirements and the available nitrogen content of the biosolids.

NLBAR (t/ha) = Crop requirement (kg/ha) / Available biosolids nitrogen (kg/t)

Phosphorus limited biosolids application rate

If required, the phosphorus limited biosolids application rate (PLBAR) is calculated according to the following formula:

Available biosolids P = Total P / reactive rate (21%)

PLBAR (t/ha) = Crop requirement (kg/ha) / Available biosolids P (kg/t)

APPENDIX 4: INDEPENDENT THIRD PARTY AUDITOR

Appointment of auditor

An independent third party auditor is to be selected using the selection criteria below:

- certify that the REF has met with these guidelines
- provide certification to accompany the REF when submitted by the supplier to DoH, DEC (if >1,000 product tonnes applied per year) and the supplier at the same time
- conduct an audit every three years of the application process as outlined in the REF on a random basis and unannounced
- provide the audit report directly to DoH, DEC (if >1,000 product tonnes applied per year) and the supplier at the same time.

The certification is to be posted on the DEC website (if >1,000 product tonnes applied per year), or made publicly available by other means after DEC and DoH have given approval to the application.

The independent review of a REF against these guidelines by an independent third party auditor achieves objectives that include:

- provides greater certainty to interested persons that the application of the biosolids to land is in compliance with the guidelines
- reduces time required by DEC and DoH for assessment and licence issue
- allows greater accountability and transparency of the process to the public.

The engagement of an auditor to independently review the REF and undertake an audit of the land application process will always be at the expense of the person or organisation who is submitting the REF for approval.

Selection criteria for auditor

The appointment of an auditor is to be in agreement with DEC and DoH prior to the auditor commencing the audit process.

The auditor is to have demonstrated and have relevant auditor knowledge, skills and experience. Knowledge of biosolids applications and issues would be an advantage, as would understanding Western Australian legislation.

DEC, DoH and the Water Corporation may develop a joint selection process for developing a panel of approved auditors which will enable the audit process to proceed for each REF without any time delays.

APPENDIX 5: BIOSOLIDS SAMPLING PROCEDURES

This appendix sets out the procedure for sampling biosolids, and is a modified version of Section 5 of the Tasmanian Biosolids Reuse Guidelines (Department of Primary Industries, Water and Environment 1999) and also refers to Schedule 1-Biosolids Sampling and Analysis Procedures, Environmental Guidelines – Use and Disposal of Biosolids Products (NSW EPA 1997).

Biosolids must be sampled and analysed in order to undertake grading and classification. Laboratory tests are required to determine:

- contaminant concentrations
- nutrient status
- microbiological status.

When to sample

Biosolids should be sampled when they are in the condition intended for final use. Normally this will be at the end of processing and as close as possible to the time of use.

Depending on the end use, biosolids may be sampled as either liquids or solids. Liquid biosolids are defined as any biosolids with the capacity to flow and be conveyed via a pump. All other products are treated as solids.

Sampling requirements – contaminant grading

New wastewater treatment plants and wastewater treatment plants that sample irregularly are required to monitor for the total of 11 contaminants (Table A9) at the frequency shown in Table 4

Very few wastewater treatment plants ever show unacceptable levels for more than a few of the contaminants.

An initial screening analysis prior to the implementation of beneficial use operations can reduce the ongoing costs of chemical analyses.

Treatment processes producing biosolids regularly (that is, all except lagoon systems), samples should be taken monthly for three months. Analysis should include the full list of contaminants (Table A9) as part of a screening analysis. Any contaminant which is present at less than 50 per cent of the contaminant acceptance concentration threshold (Table 1, Section 4.2) for the target end use of the biosolids can be dropped from future sampling procedures, with the proviso that a full screening is repeated:

- at annual intervals
- whenever there is reason to suspect a change in the composition of the influent to the wastewater treatment plant, such as might occur with the connection of new industries to the sewer.

Having established if there is opportunity to reduce the analysis requirements for contaminants, the frequency of sampling for contaminant grading depends on the production rate.

For plants producing biosolids continuously (such as large metropolitan plants) one sample should be collected for each 100 dry tonnes produced. There are three exceptions to this rule (see dot points below) when one sample should be collected for each 50 dry tonnes produced.

- At the start of a sampling program, when at least 12 analyses are required to prove the confidence of the initial contaminant grading and to provide baseline data for future comparisons. The first three screening samples can be used as the start of this database. All analytical data should be added to the database, as this improves the reliability of the contaminant grading and also helps to identify changes in contaminant concentrations over time.
- When the actual concentration of any of the monitored contaminants in a sample is greater than 80 per cent of the contaminant acceptance concentration thresholds (CACT) (Table A9). In this case, the higher sampling frequency of one sample per 50 dry tonnes should be used until there are at least three consecutive samples in which the actual concentrations of all monitored contaminants are less than 80 per cent of the contaminant acceptable concentration thresholds.
- When there is reason to believe that the contaminant concentrations in the biosolids are variable during a particular period of time.

For biosolids sourced from lagoon-based wastewater treatment plants, one sample per 100 dry tonnes should be collected. This sample should be composed of a minimum of two sub-samples, and combined to form two composite samples. Samples may be collected at any time prior to application.

Table A9: **Contaminant acceptance concentration thresholds for new or changed processes**

Contaminant	Grade C1 (mg/kg)*	Grade C2 (mg/kg)*	Grade C3
Arsenic	20	60	untested or greater than grade C2
Cadmium	1	20	untested or greater than grade C2
Chromium (VI)***	1	1	untested or greater than grade C2
Copper	100 (150)**	2,500	untested or greater than grade C2
Lead	200	420	untested or greater than grade C2
Mercury	1	15	untested or greater than grade C2
Nickel	60	270	untested or greater than grade C2
Selenium	3	50	untested or greater than grade C2
Zinc	200 (300)**	2,500	untested or greater than grade C2
Dieldrin	0.02	0.5	untested or greater than grade C2
Chlordane	0.02	0.5	untested or greater than grade C2

* all values in mg/kg dry weight
** denotes values for composted products used for general domestic purposes, not for soil replacement
*** National Environment Protection (Assessment of Site Contamination) Measure 1999, National Environment Protection Council Service Corporation. Note that chromium (VI) is a strong oxidising agent and is unlikely to be present in biosolids. However, given its toxicity and the industrial feedstock into biosolids, some chromium (VI) could still remain in an unreduced form if process parameters are not optimal for complete reduction to occur, and so testing for this contaminant remains.

Calculating contaminant grade – an example

In order to calculate the contaminant grade of a biosolids batch the following procedure should be followed:

- Sample the biosolids. Analyse sample for contaminant levels by an accredited laboratory (for example, NATA).
- Statistically examine the results and prepare summary data as outlined below.
- Calculate the biosolids adjusted contaminant concentration (BACC) for comparison with the chemical contaminant thresholds as outlined below (refer to Table 1, Section 4.2).

Examples of steps 3 and 4 of the contaminant grade procedure are provided below.

Step 3: Statistical examination of the results and preparation of summary data

For each contaminant, calculate the mean and standard deviation of the results.

Table A10: **Example of calculation of the mean and standard deviation**

Sample	Cadmium (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)
1	0.87	432.3	185.1
2	1.83	529.9	208.4
3	0.58	430.0	139.4
4	0.49	582.1	120.0
5	1.43	454.7	286.2
6	2.01	396.3	66.8
7	0.56	510.4	197.0
Mean	1.11	476.5	171.8
Standard deviation	0.64	66.0	70.7

Note: Although calculations are shown only for cadmium, copper and zinc, this example shows the method to be used for any element.

Step 4: Calculation of BACC

Calculate the BACC using the equations provided in Section 4.2.

Table A11: **Example of the calculation of the biosolids adjusted contaminant concentration**

	Cadmium (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)
Mean	1.11	476.5	171.8
Standard deviation	0.64	66.0	70.7
Batch BACC (mean and standard deviation)	1.75	542.5	242.5

Determining the contaminant grade

For each contaminant, compare the BACC with the relevant chemical contaminant threshold to determine the contaminant grade. The lowest individual concentration grade determines the biosolids classification. In the example below, the biosolids classification is C2.

Table A12: **Example of the determination of the contaminant grade**

Compound	BACC (mg/kg)	Grade C1	Grade C2	Grade C3	Contamination grade
Cadmium	1.75	1	20	>20	C2
Chromium (VI)	0.8	1	1	>1	C1
Copper	542.5	100	2,500	>2,500	C2
Zinc	242.5	200	2,500	>2,500	C2
Dieldrin	0.013	0.02	0.5	>0.5	C1
Chlordane	0.007	0.02	0.5	>0.5	C1
Lowest contamination grade of contaminant equates to					C2

Sampling requirements – pathogen grading

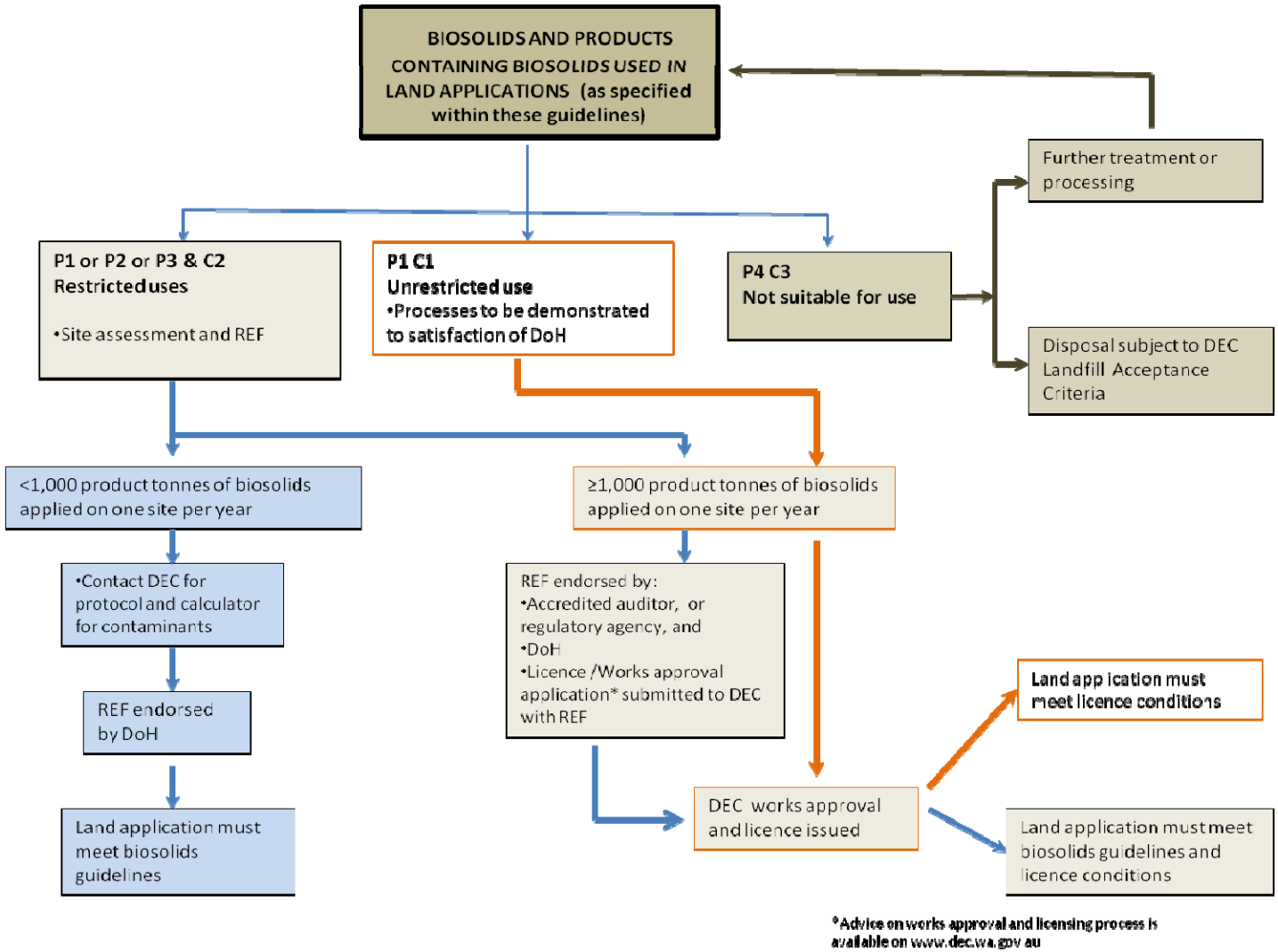
Initial pathogen grading of biosolids can be estimated based upon the method of treatment. However, for P1 and P2 biosolids which have been stockpiled for >30 days, re-sampling of the biosolids will be required to ensure there has been no pathogen regrowth.

Sampling should be conducted by the biosolids supplier and analysed according to Section 4. All records must be maintained by the biosolids supplier and biosolids recipient as described in Section 3.1.

Sampling

- Place one 250g sample taken using dedicated 'clean scoop' into a sterilised container. It is important to minimise the exposure to the air as this limits regrowth under aerobic conditions.
- Cool for a minimum of two hours at <4ºC prior to shipping.
- Label and place composite samples in a mini cooler with three to four ice bricks. Transfer to the laboratory via chain of custody procedures; ensure the sample is tested within 24 hours.
- Test for microbiological requirements for coliphages and *E. coli* (see Table A14).
- Ensure that microbiological testing is performed in accordance with Australian Standards.

APPENDIX 6: PROCESS LOW CHART – APPROVALS FOR BIOSOLIDS APPLIED TO LAND



APPENDIX 7: SAMPLING INFORMATION

Soil sampling

This appendix sets out the procedure of sampling land for direct biosolids applications, and is adapted from Appendix D of the *Guidelines for Environmental Management–Biosolids Land Application* (EPA Victoria 2004), Appendix C of the *Tasmanian Biosolids Reuse Guidelines* (DPIWE 1999) and Appendix 1 from the *Draft South Australian Biosolids Guideline for the Safe Handling and Reuse of Biosolids* (EPA 2009).

Soil sampling and analysis is required to establish the physical and chemical characteristics of the soil at a site proposed for biosolids application. Soil nutrient and contaminant concentrations are used to calculate application rates. Electrical conductivity, pH, phosphorus and soil depth are measures of the soil suitability for biosolids application. The soil sampling should be carried out under the direction of a person experienced in soil survey design.

Soil sampling information is to be included in the submitted REF. The soil sampling design should incorporate the following elements:

- Avoid sampling excessive amounts of plant material with soil.
- Separate samples should be taken for different soil unit areas, based on soil type, land form and/or farming history.
- Topsoil samples should be comprised of a composite of at least 30 to 40 cores taken in an even distribution across the sample area.
- Topsoil sampling depth for pasture, turf field and fodder crops should be 0–10cm. For woody perennial crops the sampling depth should be 0–15cm. For areas that have previously received biosolids sub-surface soil sampling of 15–30cm must also be conducted.
- Sampling should avoid unrepresentative locations, such as patches of very good growth, stock camps, old or present fence lines, dam and trough surrounds, recently fertilised areas, places where fertilisers have been stacked or spilled and soil near roads or buildings.
- Samples should be collected as close as possible to the time of application.
- Collect sufficient quantity of each sample for laboratory analysis, usually between 0.5 and 1.0kg.

Analysis of soil and biosolids samples

All samples are to be tested and analysed by laboratories registered by the NATA or other recognised quality assurance accreditation organisation for specific tests as recommended in the *National Water Quality Management Strategy Guidelines for Sewerage Systems – Biosolids Management* (NRMMC 2004).

DEC recommends that samples be analysed for the parameters listed in Table A13, Table A14 and Table A15 below. Tables A13 and A15 have been adapted from the Draft South

Australian Biosolids Guideline for the Safe Handling, Reuse or Disposal of Biosolids (Environment Protection Authority 1996). Units are mg/kg dry weight unless otherwise specified.

Table A13: **Biosolids and soils contaminant and nutrient sampling requirements**

Contaminant grades: (C1 to C3)	
Analyte	Suitable test method
pH (pH units)	NEPC Method 103
Moisture content (%)	-
Total cadmium	NEPC Methods 201, 202, 203
Chromium (VI)	NEPC Methods 201, 202, 203
Total copper	NEPC Methods 201, 202, 203
Total zinc	NEPC Methods 201, 202, 203
Dieldren	NEPC Method 504
Chlordane	NEPC Method 504
Ammonia	EPA Methods 1689, 1690
Nitrate/nitrite (Oxidised N)	EPA Methods 1685, 1686
Total Kjeldahl nitrogen	EPA Methods 1687, 1688
Total nitrogen	-
Total phosphorus	-

Table A14: **Pathogen sampling requirements**

Parameter	Suitable test method	Method	Units
Pathogen grade P1			
[20] *E. coli*	EPA 1680 EPA, 1681 AS 4276.6 AS 4276.7 AS 4276.21	Membrane filtration or Most probable number (MPN)	*E. coli* (cfu per 1g total solids dry weight) or *E. coli* (MPN per 1g total solids dry weight)
[18] Helminths	World Health Organization	[19] Log reduction Concentration and microscopy	Number of larvae and ova / 50g (dry weight)
Coliphages	APHA. 2005 9224	Single agar layer (plaque forming units – pfu)	pfu per 10g (dry weight)
Pathogen grades (P2 and P3)			
[18] Helminths	World Health Organization	[19] Log reduction Concentration and microscopy	Number of larvae and ova / 50g (dry weight)
[20] *E. coli*	EPA 1680 EPA, 1681 AS 4276.6 AS 4276.7 AS 4276.21	Membrane filtration Most probable number (MPN)	*E. coli* (cfu per 1g total solids dry weight) or *E. coli* (MPN per 1g total solids dry weight)

[18] Helminth analysis is required only above the 26th parallel.

[19] Mesophilic anaerobic digestion

[20] *E. coli* is the geometric mean of 7 samples.

Table A15: **Soil sampling requirements**

Soil	
Analyte	Suitable test method
pH (CaCl)	NEPC Method 103
Cation exchange capacity (cmolc/kg)	NEPC Method 301
Clay content (%)	-
Organic carbon content (%)	NEPC Method 105
Iron (%)	
Total arsenic	NEPC Methods 202, 203
Total cadmium	NEPC Method 203
Chromium (VI)	NEPC Method 203
Total copper	NEPC Method 201
Total lead	NEPC Method 201
Total mercury	NEPC Method 204
Total nickel	NEPC Method 201
Total zinc	NEPC Method 203
Phosphorus retention index (PRI)	TBA
Soil bulk density	-

APPENDIX 8: DETERMINATION OF APPLICATION RATES

Limitations to application rate

The nitrogen, phosphorus and contaminant analysis data of the biosolids and the soil are used to calculate the maximum allowable biosolids application rate for a given site. The maximum allowable application rate is the lower rate of the NLBAR, the PLBAR and the CLBAR. When the soil type is shown to have a soil category of 1 to 4 (Table 9, Section 5.1.2), the PLBAR may be excluded from application rate calculations providing that the application rate does not exceed the NLBAR or the CLBAR. Application at NLBAR in these soil types has been demonstrated to not result in phosphorus leaching.

The NLBAR and PLBAR are the rates at which biosolids can be applied without exceeding the annual nutrient requirements of the crop or vegetation grown on the land. The CLBAR is the rate at which biosolids can be applied without exceeding the maximum allowable concentration of contaminants in the soil.

Typical agricultural crop nutrient requirements

For agricultural applications the NLBAR and PLBAR will vary depending on the crop and site history. Table A16 below contains indicative nitrogen and phosphorus requirements for various crops, but should be used only as a guide. Consultation with a local district agronomist or DAFWA should be sought prior to the commencement of each application season and to determine the specific requirements for a given site. The nutrient requirements of a crop or pasture depend on management practices, soil and climate.

Table A16: **Nitrogen and phosphorus requirements for different crop types**

Crop or pasture	Nitrogen (kg/ha)	Phosphorus (kg/ha)
Wheat, barley, oats	80	9
Canola	125	12
Dairy pasture	0	18
Extensive grazing pasture	0	5

Non-agricultural applications

Nutrient requirements for forestry and land rehabilitation applications should be considered on a site-specific risk management basis.

Forestry

Research into biosolids application in forests indicates that application rates of up to 350 kg/ha of available N results in significant growth responses without adverse environmental impacts. In WA extensive monitoring of forestry sites where biosolids were applied at 356.56kg $N_{available}$ and 88kg $P_{available}$ per tonnes of dried biosolids (34 dry tonnes per hectare) showed that P and N leaching has not occurred, even on highly permeable soils. Application timing is essential for well developed root systems that can use all the applied nutrients. Typically in WA, biosolids are applied to trees while they are not water limited and their canopies are expanding. Table A17 (below) shows N and P requirements for pine from one to 30 years.

Table A17: **Nitrogen and phosphorus requirements for pine trees**

Age of trees (years)	Nutrient uptake (kg ha^{-1} yr^{-1})
0–2	Very little while trees are still establishing roots in the first 2 to 3 months; however, no reliable data for this age. An informed estimate (based on one experiment planted on an infertile ex-native forest site in which the trees did not receive N fertiliser): N 15 to 20kg ha^{-1} yr^{-1} P 3kg ha^{-1} yr^{-1}
2–12 (and 12–30 in thinned trees)	While canopies are expanding rapidly and the trees are not water limited: N 90 to 100kg ha^{-1} yr^{-1} P 15kg ha^{-1} yr^{-1}
12–30 (unthinned or closed canopies after thinning)	While canopies are not expanding rapidly and trees are irrigated and not water limited: N 60kg ha^{-1} yr^{-1} P 5kg ha^{-1} yr^{-1}

Land rehabilitation

Biosolids used for land rehabilitation are typically applied as a single application and may provide more nutrients than the plants can take up within one year.

The maximum total nitrogen application rate allowed on land rehabilitation sites is 1,200kg N/ha as a once-only application. This is based on total Kjeldahl nitrogen. If repeated applications are intended, the application rate should be determined on the basis of annual nutrient requirements.

APPENDIX 9: SAMPLE BIOSOLIDS APPLICATION CHECKLIST

This sample checklist has been derived from an example of the Water Corporation document *Biosolids Application Checklist.* It may provide the basis of a contract between the supplier and user of biosolids to demonstrate that the supplier has taken all reasonable care to ensure that the user is aware of the nature of biosolids, hazards associated with biosolids, and the precautions required to ensure that the application does not result in unacceptable risks to either public health or the environment. The document should be signed by both parties and a copy presented in the REF submitted to DEC and DoH for assessment.

SAMPLE CHECKLIST ONLY

1. I am aware of the nature of biosolids, in accordance with the definition provided in the *Western Australian guidelines for biosolids management*.

2. I possess a copy of the *Western Australian guidelines for biosolids management* 2012 and I will follow the application requirements contained within that document.

3. Biosolids supplied to me will not be used for any purpose other than that which has been approved by the relevant regulatory agencies.

4. I am aware that all biosolids contain some levels of pathogens.

5. I am aware of the personal protection requirements described in the *Western Australian guidelines for biosolids management 2012*, 'Occupational hygiene and safe handling of biosolids' (Appendix 1).

6. I will follow all application requirements that are relevant to my site as set by the relevant regulatory agencies.

7. I am aware that the use and application of biosolids are not supported in the state's public drinking water source areas (Section 3.4)

8. I will not allow stock in areas where biosolids are stockpiled unless the stockpile has been fenced off or protected by stock-proof barriers.

9. I am aware that stock are not permitted to enter areas where biosolids have been applied for a period of one month (45 days for lactating and newborn animals).

10. I am aware that the withholding period for crop harvesting is one month from completion of the biosolids application.

11. I will keep a copy of all relevant records for a minimum of five years.