Independent Expert Scientific Committee
on Coal Seam Gas and Large Coal Mining Development

10 May 2013

The Hon Tony Burke MP
Minister for Sustainability, Environment, Water, Population and Communities
Parliament House
Canberra ACT 2600

Dear Minister

Thank you for your letter of 12 March 2013 seeking advice from the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the Committee) on several matters relating to the implementation of proposed amendments to the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Committee has considered each of the three points outlined in your letter and offers the following advice.

a) Defining significant impact: Advice on the relevant considerations that you might take into account in determining whether a proposed action will have a significant impact on water resources is provided at Appendix A. This is broad level advice. The Committee understands the need for the development of detailed policy guideline/s from the Department to explain the definition of 'significant impact' with respect to water resources and would be happy to provide comment on these guidelines if you consider it appropriate.

   The Committee has proposed a description of 'significant impact' that differs slightly to the definition contained in the *National Partnership Agreement for Coal Seam Gas and Large Coal Mining Development* (the NPA) agreed between the Commonwealth and the States. Nevertheless, the underlying concepts are the same. The Committee's advice on the considerations, as provided in Appendix A, has been developed to improve consistency and group together similar geomorphic and ecological concepts.

b) Providing necessary information: Advice on the elements that could be included in Terms of Reference for the assessment of controlled actions is provided at Appendix B. These Terms of Reference must provide a strong direction for the information needed to understand:

- the impact of a proposed coal seam gas or large coal mine action;
- the effectiveness of the proposed development's mitigation measures; and
- if appropriate, the necessary offset measures.

The proposed elements presented at Appendix B are drawn from Committee's expert deliberations and the published and available *Independent Expert Scientific Committee Information Guidelines for proposals relating to the development of coal seam gas and large coal mines where there is a significant impact on water resources* (available at www.environment.gov.au/coal-seam-gas-mining/project-advice/pubs/iesc-information-guidelines.pdf).

c) Mitigation Action: Advice on the elements that could be usefully considered by the regulator for setting conditions of approval for coal seam gas or large coal mining projects where water impacts are likely to be significant is provided at Appendix C. These elements are predicated on the assumption that conditions should specify:

- the activities required to reduce and/or mitigate the impacts;
- the actions needed to offset any residual impacts; and
- the activities required for ongoing management of the proposal.

The Committee considers that, when determining how a proposed development can be undertaken in a manner that is acceptable, it is important to reference the relevant significant impact guidelines and examine the key responses contained in the environment assessment documentation (which will be specified by the Terms of Reference for the assessment of controlled actions). An important element of condition setting is to examine the risks inherent in proposed actions and ensure that the establishment, coverage and details of the proposed conditions address those risks.

One of the major changes resulting from the proposed legislative amendments will bring about a focus on information relating to cumulative impacts. These potential impacts will need to be considered at a number of stages when determining whether a coal seam gas or coal mining development is likely to have a significant impact on water resources during the assessment of the proposal.

The Committee's advice has been developed to assist in the implementation of the proposed amendments to the EPBC Act, if passed. The provision of scientific advice is intended to provide transparency and increased scientific rigour in regulatory decision making. On behalf of the Committee, I express our appreciation for your request to contribute advice to assist in the implementation of actions that may arise from this legislative amendment.

Yours sincerely

Ms Lisa Corbyn

Chair

Appendices:

Appendix A – Relevant considerations that might be taken into account in determining whether a proposed action will have a significant impact on water resources

Appendix B – Elements that could be included in Terms of Reference for the assessment of controlled actions so as to best ensure necessary information is provided for assessment

Appendix C - Elements that could usefully be considered by the regulator for setting conditions of approval for coal seam gas or large coal mining projects where water impacts are found to be significant

Appendix A

Relevant considerations that might be taken into account in determining whether a proposed action will have a significant impact on water resources

A significant impact on water resources may be caused by an action relating to a coal seam gas or large coal mine development, or the cumulative impact of such actions.

A significant impact, as defined in the *Matters of National Environmental Significance (MNES) – Significant Impact Guidelines 1.1*, as available on the Department's website, is one which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. This description is applicable for coal seam gas and large coal mine developments, which are likely to have a significant impact on a water resource.

A water resource, as defined by the *Commonwealth Water Act (2007)*, means, a) surface water or groundwater, or b) a watercourse, lake, wetland or aquifer (whether or not it currently has water in it), and includes all aspects of the water resource (including water, organisms and other components and ecosystems that contribute to the physical state and environmental value of the water resource).

The Committee considers that factors which may directly or indirectly have a significant impact on water resources could include, but not be limited to, those that:

1. alter groundwater and surface water characteristics and processes, including:
   a. water quantity;
   b. water quality;
   c. groundwater pressure, water table levels, and/or groundwater and surface water interactions;
   d. surface water and/or groundwater flow regimes;
   e. river/flood plain connectivity;
   f. watercourse diversions or impoundments; and
   g. landscape modifications, such as large voids and spoil piles.

2. alter the ecological characteristics and processes of a wetland, watercourse, or groundwater dependent ecosystem, including:
   a. biological diversity, species composition and/or ecosystem function; and
   b. the availability of water for the environment.

3. result in persistent organic pollutants, heavy metals, salt or other potentially harmful chemicals accumulating in the environment.
4. alter ecological, physical or chemical aspects of coastal processes.
5. increase demand for, or reduce the quality or availability of, water for human consumption.

For the purposes of the above factors, consideration of significant impacts on water resources from a coal seam gas or large coal mining development should be considered together with cumulative impacts of other existing and likely developments on water resources. *The Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) definitions of coal seam gas development and large coal mining development includes references to the significance of impacts of a particular development on water resources when considered with other developments, whether past, present or likely to occur in the reasonably foreseeable future. This is an 'upfront' requirement and is distinctive for the test of significance for this particular matter of national environmental significance.

Appendix B

Elements that could be included in Terms of Reference for the assessment of controlled actions so as to best ensure necessary information is provided for assessment

The aim of the Terms of Reference for the assessment documentation is to ensure that an appropriate level of information is available to adequately confirm the nature of the impacts. In determining the nature and extent of the impact, it is important to understand: direct and indirect impacts; the possible response from the impacted environment; the duration of the impact; whether it is localised or broad scale; and whether it is preventable, avoidable and/or reversible. A key element to any assessment documentation is the availability of baseline information so that the impact can be assessed against the current state of the environment. Key baseline information requirements are outlined below and include the 'description of the proposal', 'background data and modelling' and 'water balance'. A 'water balance' is considered fundamental baseline information on which to assess any change to store or flow of water in the system arising from the development.

The Committee recognises that baseline data may not always be present or easily accessible. However, any difficulties in obtaining data should not preclude the proponent from endeavouring to provide baseline information to enable a comprehensive assessment of the likely impacts of the proposed development.

The Terms of Reference to the assessment documentation should also ensure that information is provided to confirm the effectiveness of any proposed mitigation measures and, if appropriate, the effectiveness of any offset measures to address residual impacts. The Terms of Reference therefore need to, as outlined below, provide clear guidance to enable assessment of likely significant impacts on water resources and water related assets, risk, cumulative impacts, and ongoing management and monitoring activities.

The key elements of the Terms of Reference that would be relevant to this process are drawn from the Committee's expert deliberations and the *Information Guidelines for Proposals Relating to the Development of Coal Seam Gas and Large Coal mines where there is a Significant Impact on Water Resources* developed by the Committee. The Information Guidelines have recently been made publicly available on the Committee's website to ensure adequate information is contained in development proposals that the Committee considers.

Suggested elements of Terms of Reference - Information needs for Committee advice

A. A description of the proposal

An overall description of the proposal that will give insight into its purpose, character, scale and the means by which it is likely to have a significant impact on water resources.

B. Background data and modelling

Provide a detailed description of baseline water resources, including critical water dependent values of concern that are supported by those resources. This description should include, but not be limited to:

1. Identification of water related assets (aquatic ecosystems, terrestrial ecosystems, drinking water supply and human health, irrigation water supply, surface infrastructure, industry, regional communities, aquifers), including:
    - fauna, flora and species habitat surveys as they relate to dependence on water resources;
    - location of springs and other groundwater dependent ecosystems;
    - identification of the geological formation/ aquifer to which springs and groundwater dependent ecosystems are connected; and
    - an estimation of the ecological water requirements of identified springs and groundwater dependent ecosystems.
2. A description of the water resources of the site and region, including maps of all surface water and groundwater resources, relevant to the project.
3. Descriptions of geology and hydrogeology at an appropriate level of spatial and vertical resolution (i.e. at both site and regional scale). Definition of the geological sequence in the area with names and descriptions of the formations from youngest to oldest, with accompanying surface geology and cross sections.
4. Descriptions of hydraulic characteristics (for example, hydraulic conductivity and storage characteristics) for each aquifer. The map and map legend should use appropriate symbols and names, describe all formations and structures according to geological convention and clearly indicate the bore holes from which data are derived. Definitions of any geological structures (for example, faults) in the area and evidence for the influence of the structures on groundwater, in particular groundwater flow or recharge.
5. Presentation of data to demonstrate the varying depths to the aquifers and associated standing water levels or potentiometric heads and hydraulic characteristics.

6. Definition of the likely recharge sources for each aquifer, details of discharge from the aquifers, direction of groundwater flow and contours of groundwater elevations for all aquifers likely to be impacted by the proposed development.
7. Assessments of the extent of hydrological interactions between water sources including surface water/ groundwater connectivity, inter-aquifer connectivity and connectivity with sea water.
8. Surface hydrology resources including hydrographs, raw data and any records of seasonal and historic annual variations in level, quality and date of measurement, along with elevations of the reference points from which water levels were measured.
9. Surface water and groundwater hydrochemical data assessments and modelling, including water quality parameters (such as relevant organic chemicals, heavy metals, radionuclides and other potentially harmful chemicals).
10. A numerical groundwater model that is calibrated to baseline conditions and enables a probabilistic evaluation of potential future scenarios. The groundwater modelling should:
    a) outline the model conceptualisation of the aquifer system or systems, including key assumptions and model limitations;
    b) represent each aquifer, storage and flow characteristics of each aquifer, linkages between aquifers, if any, and the existing recharge/discharge pathways of the aquifers and the changes that are predicted to occur upon commencement of the development activities;
    c) incorporate the various stages of the proposed development and provide predictions of water level/pressure declines in each aquifer for the life of the project and beyond;
    d) provide information on the time to maximum drawdown and the time for drawdown equilibrium to be reached;
    e) identify the volumes predicted to be dewatered on an annual basis with an indication of the proportion supplied from each aquifer;
    f) provide information on potential water level recovery rates and timeframes in each aquifer for the life of the project and until equilibrium is expected to be achieved; and
    g) include recommendations, a program for review and an update of the model as more data and information become available.

11. Relevant information generated by a bioregional assessment that can indicate the baseline conditions of the proposed development area. Where a bioregional assessment has not yet been completed, best available information should be used in describing the existing state of water-related ecosystems and processes at the regional scale. This information can include publicly available information from nearby or adjacent developments (for example, information from Environmental Impact Statements).
12. An assessment of the quality of, and risks inherent in, the data used in the background data and modelling.

C. Water and salt balances

A site specific water balance and a site specific salt balance, complemented by regional balances for both water and salt covering the larger area of potential impact, should be developed and applied based on the results of numerical modelling.

Information is required about the water and salt balances for the whole system, the set of water and salt stores within the system boundary and the flow of water and salts between those stores. The proposal needs to assess the change to any store or flow of water and salts in the system arising from the development.

Specific flows and changes that need to be identified include:

1. Any changes that occur to the salt loads of the ground water and surface water systems as a result of the proposed operation.
2. Aquifer storage properties and groundwater flows and pressures resulting from the depressurisation of target coal measures.
3. Water infiltration from surface stores.
4. An estimation of the flow/exchange of water between overlying and/or underlying aquifers and the target coal measure for all major aquifers over the project area.
5. Waste water from the operation, including brine treatment processes, disposal methods and volumes.
6. All volumes and quality of water intended for injection.
7. Volumes and quality of water used during mining, including within the mine itself (for example, coal washing, dust suppression) and for other associated activities (for example, cooling or other industrial processes).
8. Any water that is not available from within the extraction and treatment loops that must be imported from elsewhere. This water may be from surface, underground, or from another activity external to the system boundary.

9. All interactions and flows that exist that are part of the background (baseline) water flows of any given system. For example, each recharge and discharge for each aquifer/aquitard and seepage/recharge for each surface water store, rainfall interception and evaporation, and there is a shallow subsurface transition zone (hyporheic) where water may either pass through and recharge the underlying aquifers, or may be discharged directly to the surface water system.

D. Significant impacts on water resources and water related assets

The proponent should provide an assessment of the likely significant impacts on water resources and water related assets. The assessment should include but not be limited to:

1. An assessment of how the proposed development will change both local and regional water and salt balances.
2. In the case of underground mines, predictions of subsidence and effects from dewatering and depressurisation (including lateral effects) on surface topography, groundwater and movement of water across the landscape and possible fracturing of confining layers.
3. The aquifers that will be directly impacted by mining operations, including the aquifers that will be exposed/partially removed by open cut mining and/or underground mining.
4. The aquifers that will be dewatered or indirectly impacted by dewatering in connected aquifers.
5. The extent of impact on hydrological interactions between water sources including surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water.
6. For open cut mines, predictions of the extent of the cone of depression and consequential impacts on water resources.
7. Impacts associated with surface water diversions.
8. Direct and indirect impacts on water related assets (groundwater and surface water aquatic ecosystems, terrestrial ecosystems, drinking water supply and human health, irrigation water supply, surface infrastructure, industry, regional communities and aquifers) with reference to the *Australian Guidelines for Water Quality Monitoring and Reporting* (www.environment.gov.au/water/publications/quality/nwqms-monitoringreporting.html)
9. Impacts on hydraulic properties of aquifer geology including potential for physical transmission of water within and between formations, effects of depressurisation due to gas extraction and estimates of likelihood of leakage of contaminants from coal beds through geological formations.

10. Estimates of the quality and quantity of operational discharges of water (particularly saline water) including potential emergency discharges due to unusual events, and the likely impacts on water related assets.
11. Indication of the vulnerability to contamination (for example, from salt production and salinity) and the likely impacts on the identified water assets.
12. Identification and consideration of landscape modifications, for example, voids, onsite earthworks, roadway and pipeline networks through effects on surface water flow including erosion and fragmentation of habitat of water dependent species and communities.
13. The cumulative impact of the proposal when all relevant developments (past, present and/or reasonably foreseeable) are considered in combination (see section on 'cumulative impacts' below).
14. Proposed mitigation actions for each identified impact.

E. Risk

The proponent should provide an assessment of risk that could be expected to address, but not be limited to, the following elements:

1. An identification of regional water related assets in the area of the proposal and changes to the regional water balance that might be vulnerable to the development proposal.
2. Identification of impacts on those assets likely to arise from activities associated with the proposal.
3. An assessment of the likelihood and consequence of identified impacts occurring and the consequential effect on water balance, water quality and water related assets.
4. An assessment of the magnitude or severity of impact in the event that the impact was to occur.
5. An assessment of the overall level of risk to those assets that might combine probability of occurrence with consequence or severity of impact.
6. An assessment of residual risk following the application of proposed mitigation measures.

F. Cumulative impacts

The proponent should provide an assessment of cumulative impacts taking into account all relevant developments (past, present and/or reasonably foreseeable) to determine the risks and impacts posed by a single new proposal, in combination with other developments.

A cumulative impacts assessment may require a qualitative or semi-quantitative approach, particularly for ecological risk assessment, if data is lacking. A cumulative impact assessment may also require consideration of interactive or synergistic impacts, as well as a more simple summation of individual proposals or impacts. Information should include but not be limited to:

1. Catchment and regional scale information provided through any available bioregional assessments (Geographic Information System (GIS) based water related assets, geophysical, hydrological, ecological information).
2. Total existing and planned licensed and extracted water for consumptive, industry and agricultural purposes in the surface catchment and groundwater basin within which the proposal is based.
3. Existing water quality guidelines, targets (i.e. salinity), environmental flow objectives and requirements for the ecosystems of the surface catchment and groundwater basin within which the proposal is based.
4. The proportional increase in water resource use and impacts as a consequence of the proposal.
5. The overall level of risk to water related assets that combine probability of occurrence with severity of impact of multiple actions.

G. Ongoing management and monitoring

The proponent should provide management and monitoring plans which focus in particular on mitigating, managing and monitoring risks and assets identified in the assessment of the project, and be capable of tracking changes against pre-development conditions.

Management and monitoring plans should address all impacts identified through the assessment where a management regime or intervention is required to mitigate the risk of a significant impact on water resources and ecological assets.

A groundwater monitoring network should be established such that there is sufficient data to assess background conditions, seasonal variations and recharge /discharge behaviours. The monitoring program should consist of dedicated groundwater monitoring bores and should not include uncased test holes or bore holes where there is no data on aquifers or a drilling log.

The groundwater monitoring program could be expected to satisfy the following criteria:

1. Clearly defined monitoring objectives are stated.
2. Maps to demonstrate location of bores, their purpose and screened hydrostratigraphic unit are provided.
3. Variables such as water level, electrical conductivity (salinity) and pH, are measured at monthly intervals or daily by data logger, to allow for the assessment of seasonal variations in storage and quality.
4. The methodology for the number, location and placement of monitoring bores and the outcomes the groundwater monitoring network can accurately describe for water quality and water levels over time.
5. The monitoring network should have adequate sites and spatial distribution to provide an understanding of groundwater gradients, flow directions, recharge processes, quality and water levels in each aquifer in both the project area and the surrounding areas where impacts to groundwater from project operations are likely to occur. The network should include shallow alluvial aquifers.
6. The monitoring network should extend beyond the predicted impact areas to demonstrate/confirm that impacts are not occurring beyond these areas.
7. A full chemical analysis covering all major ions should be undertaken at an appropriate periodicity. Parameters should be monitored that are relevant to ecotoxicology, human and animal health. Where the monitoring bore is located in an area vulnerable to groundwater contamination from mine impacts, additional parameters such as heavy metals should be monitored.
8. Drilling logs of all monitoring bores and accurate co-ordinates should be provided. Where vibrating wire piezometers are installed, depths of each piezometer should be provided.
9. All data supplied should be linked to the aquifer it is representing.
10. A proposed reporting program should be provided, which includes triggers for the review of the program, current and additional data, assessment, analysis and reporting requirements. Water quality monitoring should be managed in accordance with the relevant National Water Quality Management Strategy (NWQMS) guideline: *Australian Guidelines for Water Quality Monitoring and Reporting* (www.environment.gov.au/water/publications/quality/nwqms-monitoring-reporting.html)

Appendix C

Elements that could usefully be considered by the regulator for setting conditions of approval for coal seam gas or large coal mining projects where water impacts are found to be significant

Setting conditions should reduce the level of impact a coal seam gas or large coal mining development is likely to have on the environment and provide data to determine whether ongoing management is effective. There is a specific need for conditions of approval to address the risks and uncertainties of impacts from coal seam gas and large coal mining developments. The conditions need to reflect the scale of the projects and the uncertainties about the location of infrastructure and tenements. As conditions are usually developed in response to particular identified risks, it is difficult to apply a standard approach. There needs to be flexibility in condition setting that has regard to regional and project-specific characteristics of proposals, and different legislative approaches of jurisdictions.

The response below identifies some of the key elements and approaches (to manage risk and uncertainties) which should be considered by the regulator when setting conditions of approval. However, it is understood that these considerations will need to be customised for the project under assessment. The response is provided under the five key themes that are common to the response on the significant impact at Appendix A (and in part, to the response on the Terms of Reference at Appendix B).

Potential considerations when drafting conditions

1. *Alterations to groundwater and surface water characteristics and processes, including :*
   a. *water quantity;*
   b. *water quality;*
   c. *groundwater pressure, water table levels, and/or groundwater and surface water interactions;*
   d. *surface water and/or groundwater flow regimes;*

In order to determine appropriate conditions for acceptable impacts on groundwater and surface water characteristics and processes, it is considered useful to address and focus on: the project scheduling, the proposed groundwater and surface water monitoring programs; assessment and monitoring of cumulative impacts; ongoing data availability and revision of modelling (and subsequent amendments to monitoring programs); and the utilisation of thresholds/trigger levels (which incorporate a risk approach and mitigation measures that can be implemented through management plans).

Specific conditions should also be developed for the delivery of appropriate water management and if applicable any reinjection regimes, as well as appropriate controls for interconnectivity issues, hydraulic fracturing, well integrity, flooding and erosion. Ongoing monitoring and evaluation is an important aspect for delivery of adequate controls and management regimes for the life of the project.

Project scheduling: Depending on the project's scale and locality, may be required to schedule the project's development phases/stages in order to manage environmental impacts.

Groundwater monitoring program: A groundwater monitoring program is essential to determine potential impacts from proposals, such as cumulative impacts; predicted impacts to the regional and site water balance; drawdown; interconnectivity; subsidence and toxicant movement; and risks to assets and receptors. The proposed groundwater monitoring program should include a field-based investigation of the spatial distribution of strata and structure within the project area and the role of faulting and its influence on migration of groundwater and/or gas into surface water systems as part of the environmental impact assessment documentation.

The groundwater monitoring program should contain, at a minimum, the identification of background reference conditions for each formation potentially affected by the proposal (and the rationale for selection) including: the number and location of monitoring bores and their flow, pressure, head, and water quality characteristics. Water level data and electrical conductivity (EC) can be expected to include at least one reading every 12 hours, using electronic data loggers, and an appropriate auditing program to ensure accuracy. The water quality sampling strategy will depend on the interconnectivity of the system, which may be established using published literature and appropriate background sampling. For example, in highly connected systems, daily monitoring may be required until a suitable baseline is established. In moderately connected systems, sampling quarterly may be more appropriate. Water quality sampling should include sampling of: pH; EC; total dissolved solids (TDS); temperature; turbidity; cations; anions; dissolved metals (such as those specified in the ANZECC 2000 guidelines); nutrients; pesticides; and methane and other hydrocarbon concentrations.

The approach to be taken, including the methods to determine trends to indicate potential impacts, should be provided to an appropriate authority for approval. If groundwater monitoring triggers are reached, planned escalating management and mitigation measures should be implemented and, within an appropriate timeframe, the appropriate authority should be notified of all relevant data, mitigation measures being conducted and assessment of the extent of potential impacts. The scale in which triggers are exceeded along with the scale of risk to groundwater systems may involve stopping production.

Surface water monitoring program: An agreed surface water monitoring program is also essential to determine potential impacts from proposals, such as cumulative impacts; predicted impacts to the regional and site water balance; changes to hydrology; water quality; toxicant movement; and risks to ecological assets and receptors. The surface water monitoring program proposed as part of the environmental impact assessment documentation, should include: identification of the surface and aquatic systems to be monitored and their environmental values; water quality parameters (such as that discussed for groundwater monitoring); environmental characteristics; ecological characteristics; and the rationale for selection; the frequency of the monitoring and rationale for the frequency; and baseline data for each monitoring site for comparison of monitoring results over the life of the project. The program could be expected to include clearly identified triggers for mitigation actions, including stopping production, if necessary.

Cumulative impacts: A cumulative impact assessment should acknowledge potential impacts from a proposal that will, to some degree, contribute to cumulative impacts regardless of whether the proposal is regionally significant in comparison to other developments. Mitigation measures would be expected to minimise this contribution. A collaborative approach between proponents that already have mining operations within the area, for ongoing modelling and monitoring of quality and quantity of both surface and groundwater should be undertaken to validate surface and groundwater monitoring and to provide an indication of critical cumulative impacts on threatened species and ecological communities. This approach can then provide a better understanding of the cumulative impacts which could aid further regulatory development as needed.

Monitoring data and predictive models should be provided to relevant Commonwealth and state / territory authorities, to help them determine cumulative impacts prior to commencing project activities. Monitoring data collected throughout the life of the project and post project life could also be considered for public dissemination.

Proponents should also secure offsets for potential impacts, including cumulative impacts. Offsets may include securing an appropriate parcel of land which includes relevant species assemblages, or that contributes to research on relevant conservation issues. The offset plan must include all details of the offset area including the timing and arrangements for securing properties; maps and site descriptions; environmental values relevant to matters of national environmental significance; connectivity with other habitats and biodiversity corridors; and a rehabilitation plan and other mechanisms for long-term protection, conservation and management (including covenanting and reserving). The offset plan and results of the monitoring of the offset plan should be made publically available within a timely fashion.

Predictive Model revisions: All conceptual, analytical and numerical models should be regularly reviewed and updated as new data becomes available to provide a more accurate estimate of potential impacts. Models should also be independently reviewed at appropriate periods (for example, the first model review within 18 months, second within three years, and then at appropriate intervals). Review findings could be expected to be made publicly available.

Trigger/Threshold levels: Trigger levels should be developed for all watercourses and formations potentially affected by the proposal, including consideration of whether proposed trigger levels will be adequate to protect ecological assets. For example, drawdown triggers related to assets and receptors should be developed as a precautionary measure to identify whether the proposal is having a greater impact than predicted.

Trigger levels should incorporate a risk based approach and mitigation measures. The risk based approach should also include early warning indicators where drawdown thresholds are being approached, and an assessment of the reversibility of impacts. A management plan for drawdown should be approved by a relevant authority prior to the commencement of the action. The plan should include options of stopping production until mitigation measures are implemented.

Water management: Water management strategies are required to determine potential impacts / beneficial re-use options of the proposal. Preferred water management strategies should be agreed to prior to production. This includes water treatment methods and standards; water storage locations; and volumes, including any storage and volumes required to pilot or implement reinjection if applicable or other groundwater re-pressurisation techniques; water use or disposal options and methods (for example, frequency, volumes, quality and environmental values documented for each receiving environment, brine storage locations and volumes and brine crystal waste management strategies).

Interconnectivity: Monitoring of water fluxes associated with connectivity between surface and groundwater systems, and between formations, is required to determine appropriate trigger levels to protect water assets and associated receptors. This is directly relevant to contaminant migration, such as from hydraulic fracturing or managed reinjection of concentrated brines into deep underlying formations. For example, the proponent should monitor and record water levels within all formations potentially impacted by the project. Where drawdown is experienced below the appropriate trigger level during background monitoring, that is not the result of the pumping of licensed bores, the proponent should undertake an assessment of the potential for induced flow between formations. The proponent should then notify the appropriate authority within an appropriate timeframe, and report on the effectiveness of mitigation measures.

Well integrity: Well failure during construction, operation and decommissioning phases of the project has the potential to cause aquifer interconnectivity. However, well failure rates and water fluxes associated with the potential failure or degradation of well integrity are currently poorly understood. Proponents should therefore monitor, as a minimum, a significant proportion of bores to determine well failure rates and substantiate impacts to water assets and related receptors. Monitoring data should also be made publicly available. Ideally, an independent audit could be expected to be undertaken annually with findings made publicly available. As bores (well cement / grouting / casing / headworks) may need to be replaced following decommissioning and abandonment, appropriate financial resources could be expected to be provided by the proponent to minimise future liabilities. The regulator may need to ensure that there are appropriate measures to deal with issues associated with legacy bores, a matter most relevant for coal seam gas proposals given the quantum of wells across industry.

Hydraulic fracturing: Details of the estimated number, location, height with respect to the Australian Height Datum, and mapped spatial distribution of boreholes where hydraulic fracturing may be necessary, should ideally be submitted annually to the appropriate authority. This information is useful to determine the potential distribution and migration of contaminants within affected aquifers. In addition, details of the hydraulic fracturing compounds used; their suppliers; the constituent components of any hydraulic fracturing agents and any other reinjected fluid(s); their scientific names and Chemical Abstract Service (CAS) numbers; their toxicity as individual substances and as total effluent toxicity and ecotoxicity (based on methods outlined in the National Water Quality Management Strategy); details of their registration for use in Australia as industrial chemicals; and the proponent's current associated Material Safety Data Sheets could be expected to be made publicly available. Further, the extent of hydraulic fractures should be recorded through micro-seismic monitoring program, and a 3D representation developed to confirm that such fractures have been confined within the coal seam.

Managed aquifer recharge: Coal seam gas proponents should be required to investigate whether reinjection is a viable option for water management, including an assessment of potential benefits compared to other water disposal options within a particular region cogniscent of any risks posed by re-injection. Any proposed program and schedule for field piloting of aquifer reinjection of treated coal seam gas water and other groundwater repressurisation techniques should be approved prior to publication.

An ongoing coal seam gas water treatment program is required to ensure that any water to be used for reinjection, or used for other groundwater repressurisation options, is at least equal to the water quality of the receiving groundwater system.

Managed reinjection of concentrated brines into deep underlying formations: Coal seam gas proponents should be required to investigate options to dispose of concentrated brines. Any proposed program and schedule for field piloting of reinjection of concentrated brines, and an associated seismicity monitoring program, should be approved prior to publication.

Flooding: All modelling should be updated and periodically reviewed as data becomes available. In addition, all infrastructure should be located at an appropriate level above, or protected from, the maximum predicted flood levels, as described in the current '*Australian Rainfall & Runoff*' guidelines published by Engineers Australia. This is required to prevent water from decanting into watercourses, for example, contributing significant quantities to a catchments existing salt load (noting end of valley targets are specified for particular catchments), or causing sedimentation effects or altering the flow regime of the surface water ecosystem.

Erosion: An Erosion and Sediment Control Plan is required to minimise erosion and the release of sediment to receiving waters and contamination of stormwater. An Erosion and Sediment Control Plan should be developed by an appropriately qualified person and implemented for all stages of the mining activities on the site.

Performance measures: Proponents should be required to undertake annual reporting against specified conditions to report monitoring data and potential impacts to water assets and associated receptors. Annual reporting and publication of reports on the internet may also be appropriate. Where appropriate, independent audits should be undertaken and the results be made publicly available.

e. river/flood plain connectivity

For this impact, it is important to focus on discharge regimes and receiving environments.

Discharges: Water that has, or will have, the potential to cause environmental harm should not be released directly or indirectly to any waters except as permitted under the conditions of the environmental authority. The discharge strategy should include both chemical and biological assessments of water quality. Median levels for water quality parameters for stressors should not exceed the relevant 80th percentile values of reference data for the appropriate discharge regime (for example, in terms of timing: no, low, medium, high flow events). The median release water quality for toxicants should be sufficient to protect 95 per cent of species, consistent with ANZECC 2000 guidelines, or if matters of national environmental significance are present or likely to occur, then 98 per cent of species. If water quality parameters are unable to be met, water should be retained on site, such as in proposed dams or temporarily stored in open-cut pits, and treated to levels that allow discharge with no or minimal environmental risks. Ideally, baseline monitoring should also be undertaken daily after an event, for a minimum of the first seven days, to help determine water quality parameters of first flush events.

The proponent should notify the administering authority as soon as practicable, before commencing to release water to the receiving environment. Notification should include the following information: release commencement date / time; expected release timings and durations; expected release cessation date / time; release point/s; release volume and quality (estimated); receiving water/s including the natural flow rate and quality upstream and downstream of the release point; total estimated salt and heavy metal concentrations and loads of the discharge event; and details (including available data) regarding likely impacts on the receiving water/s. Adaptive management strategies should also be developed for investigating and responding to exceedances prior to discharge events.

If quality characteristics of the receiving water at the downstream monitoring points exceed any of the specified trigger levels during a release event, the proponent should compare the downstream results to the upstream and reference site results in the receiving waters and:

i. where the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action is to be taken; or

ii. where the downstream results exceed the upstream results, complete an investigation in accordance with the ANZECC and ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within an appropriate timeframe, including:

    a. details of the investigation carried out; and

    b. actions to prevent environmental harm.

f. watercourse diversions and impoundments

For this impact, it is important to focus on creek diversion proposals (including construction and rehabilitation) as well as the management of voids, tailings and subsidence.

Watercourse diversions: Proposed surface water diversion channels should mimic the existing stream characteristics as closely as possible to minimise potential adverse impacts. For example, this includes achieving similar or better levels of:

- stream roughness and meander wavelength to the existing creek;
- channel stability, where there is no worsening of channel conditions upstream, around and downstream of the project; and

- hydraulic parameters, including bank-full flow size, velocity, sheer stress and stream power are similar, or if appropriate, better than the current values in the existing creeks in the area.

As far as possible, natural materials and geometry should also be used for the construction and stabilisation of the diversion. A rehabilitation plan should also be developed, which includes species composition (for example, fish, aquatic invertebrates, and riparian vegetation) that reflects the species composition within the existing reference sites and upstream reaches of the area. Ideally, the watercourse alignment should be independently audited at five yearly intervals until the watercourse is determined to be fully rehabilitated, and should consider state and industry guidelines, as appropriate (for example, the *Australian Coal Association Research Program Guidelines*).

g. enduring landscape modifications, such as large voids and spoil piles

For this impact, it is important to focus on the management of voids, tailings and subsidence.

Final voids: Open cut coal mining creates voids in the landscape, below the water table. Voids can range in size. An example of the size of a large void, from a project recently considered by the Committee, is approximately 65 ha (area) and 140 m deep. On cessation of dewatering from open cut mines, the water level recovers, potentially drawing water from nearby aquifers even though mining has ceased, and creating a 'pit lake' within the mine void. The final void may take centuries or longer to reach hydraulic and chemical equilibrium. Final voids may display acute acidity, salinity, sodicity, or high concentrations of heavy metals and consequently have high toxicity and very low productivity. Discharge of this water through seepage or overtopping is an environmental concern and ongoing management of final voids is required long after mine closure.

Backfilling of voids is considered best environmental practice. The site should then be rehabilitated, with an appropriate monitoring regime implemented until it is determined that the site is considered to be either in as good, or better, condition than prior to the commencement of mining activities. Site condition should include the monitoring of species ranges, abundances and assemblage composition, compared to baseline monitoring undertaken prior to mining commencement and reference conditions of at least three other sites in close proximity of the project.

Site specific technical issues should be considered in determining whether final voids should be backfilled. For example, there may be projects in arid and semi-arid areas where final voids prevent tailings leachate from migrating offsite, and the risk of void decant is negligible.

Tailings management: Water quality has the potential to be impacted by seepage from the tailings storage. Contaminants that will have, or have the potential, to cause serious or material environmental harm should not be released directly or indirectly to any waters except as permitted by the approval conditions (for example, discharge limits). The proponent should also ensure that proper and effective measures are taken to avoid or otherwise minimise the generation and / or release of acidic and saline drainage.

Subsidence: Depending on the scale of subsidence predictions, subsidence has the potential to increase surface and groundwater connectivity, and may be greater than predicted. For example, subsidence from longwall mining could cause fracturing over significant portions of proposed mine sites. Should changes to the subsidence predictions occur, a review should be conducted to determine the causes. Appropriate measures should be implemented to ensure that subsidence is not greater than the original predictions. A subsidence management plan, including both near and far field monitoring, should also be provided, and monitoring results made publicly available. The monitoring program should include (as a minimum) baseline and ongoing geodetic monitoring programs to quantify deformation at the land surface and underground within the proponent's tenements. This should link from the tenement scale to the wider region across which groundwater extraction activities are occurring and any relevant regional program of monitoring. Modelling should be made publicly available, which estimates the potential hydrological implications of predicted surface and subsurface deformation, and measures for linking surface and sub-surface deformation form activities.

An exceedence response plan should be developed in relation to the monitoring program. The exceedence response plan should include (as a minimum) mechanisms to avoid, minimise and manage the risk of adverse impacts of the exceedence and response actions and timeframes that can be taken by the proponent if subsidence or surface deformation occurs which impacts on surface or groundwater hydrology and any associated aquatic ecology or surface geomorphology.

In addition, a buffer may be applied to protect assets, such as peat swamps. However, conditions relating to buffer zone requirements could be revised if the proponent is able to demonstrate that a proven technology or engineering methodology can be used that prevents the risk of subsidence in the listed ecological community, or that would allow any subsidence related impacts to be remediated.

2. *alter the ecological characteristics and processes of a wetland, watercourse, or groundwater dependent ecosystem, including:*

    a. *biological diversity, species composition or ecosystem function;*

For this impact it is important to consider species thresholds, monitoring requirements and development of appropriate mitigation measures specific to species' requirements.

Species thresholds: Threshold values are required to protect key species (such as reporting or control line values for additional investigation, more intensive management action, make good, and cease operations) at which management actions will be initiated to respond to escalating levels of risk and designed to protect water quality and the associated environmental values and surface and aquatic systems. Threshold values should be reported against previously discussed surface and groundwater monitoring requirements.

Ecological monitoring: Ecological monitoring is required to provide important baseline information that could be used to measure any resulting changes and also assist with assessing the potential impacts of any proposed expansion of coal seam gas and coal mining exploration or production in the area. The ecological monitoring program proposed as part of the environmental impact assessment documentation, should include: identification of the surface and aquatic systems to be monitored and their environmental values; water quality (such as that discussed for groundwater monitoring), and environmental and ecological characteristics, and the rationale for selection; the frequency of the monitoring and rationale for the frequency; and baseline data for each monitoring site for comparison of monitoring results over the life of the project. The ecological monitoring program should quantify risks to receptors, and enable conclusions regarding the absence / presence of aquatic species to be based on an assessment over a longer time-period.

Appropriate mitigation measures: A range of avoidance and mitigation measures based on the ecological characteristics of the project area needs to be developed and implemented to manage those impacts to an acceptable level and compensate for residual impacts. These measures could include having a suitably qualified expert on site during construction of infrastructure to advise on ways to minimise impacts to ecological communities; removing any superfluous mine affected water from the catchment area for disposal at an appropriate site; creating compensatory habitat, such as riffles, waterholes and riparian corridors, within the stream diversion areas; minimising discharges and using site specific data to develop discharge guidelines; and establishing buffer zones to potentially reduce the risk of unacceptable impacts on endangered ecological communities, particularly if buffers that reflect local geological characteristics are incorporated between mining proposals and high quality sites.

b. the availability of water for the environment;

Any changes to surface or groundwater availability may impact on the existing environment. Particular consideration should be given to temporal and spatial changes on water availability and the capacity of ecosystems impacted by these changes to adapt. Such adaptations should not result in changes to the structure, function and biological composition of those ecosystems.

Other relevant considerations for this impact are referred to in the response to 1 and 2(a) above.

3. result in persistent organic pollutants, heavy metals, salt or other potentially harmful chemicals accumulating in the environment;

Dewatering activities from both coal seam gas and coal mining production bring groundwater containing heavy metals and other chemicals to the surface which, *in situ*, would have no impact on the environment. Any disposal of this water, including discharge to surface water systems, re-injection, or disposal to registered landfill, must ensure that accumulation of the metals, chemicals or pollutants will not impact on ecosystems or the environment.

Other considerations for this impact are referred to in the response to 1(a) – well integrity and hydraulic fracturing, 1(e) and 1(g) above.

4. *alter ecological, physical or chemical aspects of coastal processes;*

Lowering of groundwater should not have an impact on groundwater outflow to the sea which will cause significant impact to the near shore environment, for example on sea grasses, or result in sea water intrusion and subsequent impacts on coastal ecosystems. Surface water flows need to be maintained so that there is no change to the tidal limit within an estuarine environment. The quality of surface water also needs to be maintained so that there are no chemical changes resulting in degradation of local ecosystems.

Other considerations for this impact are referred to in 1 and 2 above.

5. *increase demand for, or reduce the quality or availability of, water for human consumption.*

Activities, particularly in remote areas, should ensure that there will be no impact on communities dependent on groundwater for their water supply. These impacts include lowering of groundwater levels or any resultant changes in water quality that may be caused by changes in groundwater level. Any disposal of untreated water back into the groundwater system should ensure that there is no impact on the potable supply.

Other relevant considerations for this impact are referred to in 1 and 2 above.