LANDFORM REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
LAN1	Erosion	Baseline	LAN1. Determining baseline erosion and sediment transport characteristics in areas surrounding the RPA	LAN1A. What are the baseline rates of gully formation for areas surrounding the RPA?
				LAN1B. What are the baseline rates of sediment transport and deposition in creeks and billabongs?
LAN2	Erosion	Baseline	LAN2. Understanding the landscape-scale processes and extreme events affecting landform stability	LAN2A. What major landscape-scale processes could impact the stability of the rehabilitated landform (e.g. fire, extreme events, climate)?
				LAN2B. How will these landscape-scale processes impact the stability of the rehabilitated landform (e.g. mass failure, subsidence)?
LAN3	Erosion	Predicting	LAN3. Predicting erosion of the rehabilitated landform	LAN3A. What is the optimal landform shape and surface (e.g. riplines, substrate characteristics) that will minimise erosion?
				LAN3B. Where, when and how much consolidation will occur on the landform?
				LAN3C. How can we optimise the landform evolution model to predict the erosion characteristics of the final landform (e.g. refining parameters, validation using bedload, suspended sediment and erosion measurements, quantification of uncertainty and modelling scenarios)?
				LAN3D. What are the erosion characteristics of the final landform under a range of modelling scenarios (e.g. location, extent, timeframe, groundwater expression and effectiveness of mitigations)?
				LAN3E. How much suspended sediment will be transported from the rehabilitated site (including land application areas) by surface water?
LAN4	Erosion	Monitoring	LAN4. Development of remote sensing methods for monitoring erosion	LAN4A. How do we optimise methods to measure gully formation on the rehabilitated landform?
				LAN4B. What monitoring data are required for ongoing LEM validation?
LAN5	Erosion	Monitoring	LAN5. Development of water quality monitoring methods for assessing landform erosion	LAN5A. How can we use suspended sediment in surface water (or turbidity as a surrogate) as an indicator for erosion on the final landform?

WATER AND SEDIMENT REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
WS1	Biodiversity and ecosystem health	Source	WS1. Characterising contaminant sources on the RPA	WS1A. What contaminants (including nutrients) are present on the rehabilitated site (e.g. contaminated soils, sediments and groundwater; tailings and waste rock)?
				WS1B. What factors are likely to be present that influence the mobilisation of contaminants from their source(s)?
WS2	Biodiversity and ecosystem health	Pathway	WS2. Predicting transport of contaminants in groundwater	WS2A. What is the nature and extent of groundwater movement, now and over the long-term?
				WS2B. What factors are likely to be present that influence contaminant (including nutrients) transport in the groundwater pathway?
				WS2C. What are predicted contaminant (including nutrients) concentrations in groundwater over time?

WATER AND SEDIMENT REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
WS3	Biodiversity and ecosystem health	Pathway	WS3. Predicting transport of contaminants in surface water	WS3A. What is the nature and extent of surface water movement, now and over the long-term?
				WS3B. What concentrations of contaminants from the rehabilitated site will aquatic (surface and ground-water dependent) ecosystems be exposed to?
				WS3C. What factors are likely to be present that influence contaminant (including nutrients) transport in the surface water pathway?
				WS3D. Where and when does groundwater discharge to surface water?
				WS3E. What factors are likely to be present that influence contaminant transport (including nutrients) between groundwater and surface water?
				WS3F. What are the predicted concentrations of suspended sediment and contaminants (including nutrients) bound to suspended sediments in surface waters over time?
				WS3G. To what extent will the interaction of contaminants between sediment and surface water affect their respective qualities?
				WS3H. Where and when will suspended sediments and associated contaminants accumulate downstream?
WS4	Biodiversity and ecosystem health	Receptor	WS4. Characterising baseline aquatic biodiversity and ecosystem health	WS4A. What are the nature and extent of baseline surface water, hyporheic and stygofauna communities, as well as other groundwater dependent ecosystems, and their associated environmental conditions?
WS5	Biodiversity and ecosystem health	Receptor	WS5. Determining the impact of contaminated sediments on aquatic biodiversity and ecosystem health	WS5A. Will contaminants in sediments result in biological impacts, including the effects of acid sulfate sediments?
				WS5B. What are the factors that influence the toxicity of contaminants in sediment?
				WS5C. What would be the impact of contaminated sediments to surface aquatic ecosystems?
WS6	Biodiversity and ecosystem health	Receptor	WS6. Determining the impact of nutrients in surface water on aquatic biodiversity and ecosystem health	WS6A. What is the toxicity of ammonia to local aquatic species, considering varying local conditions (e.g. pH and temperature)?
				WS6B. Can Annual Additional Load Limits (AALL) be used to inform ammonia closure criteria?
				WS6C. Will the total loads of nutrients (N and P) to surface waters cause eutrophication?
WS7	Biodiversity and ecosystem health	Receptor	WS7. Determining the impact of contaminants in surface and ground-water on aquatic biodiversity and ecosystem health	WS7A. Are current guideline values appropriate given the potential for variability in toxicity due to mixtures, modifying factors and different exposure scenarios?
				WS7B. What is the risk associated with emerging contaminants?
				WS7C. Are current guideline values appropriate to protect the key groups of aquatic organisms that have not been represented in laboratory and field toxicity assessments (e.g. flow-dependent insects, hyporheic biota and stygofauna)?
				WS7D. How do acidification events impact upon, or influence the toxicity of contaminants to, aquatic biota?
				WS7E. How will Mg:Ca ratios influence Mg toxicity?
				WS7F. Can a contaminant plume in creek channels form a barrier that inhibits organism migration and connectivity (e.g. fish migration, invertebrate drift, gene flow)?
				WS7G. What concentrations of contaminants will be detrimental to the health of (non-riparian) aquatic vegetation?
				WS7H. What concentrations of contaminants will be detrimental to the health of riparian vegetation?

WATER AND SEDIMENT REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
WS8	Biodiversity and ecosystem health	Receptor	WS8. Determining the impact of suspended sediment on aquatic biodiversity and ecosystem health	WS8A. What are the physical effects of suspended sediment on aquatic biodiversity, including impacts from sedimentation and variation in sediment characteristics (e.g. particle size and shape)?
				WS8B. To what extent does salinity affect suspended particulates, and what are the ecological impacts of this?
WS9	Biodiversity and ecosystem health	Monitoring	WS9. Optimisation of water quality monitoring programs and assessment methods	WS9A. How do we optimise methods to monitor and assess ecosystem health and surface and groundwater quality?

HEALTH IMPACTS OF RADIATION AND CONTAMINANTS REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
RAD1	Human and ecosystem health	Source	RAD1. Radionuclides in the rehabilitated site	RAD1A. What are the activity concentrations of uranium and actinium series radionuclides in the rehabilitated site, including waste rock, tailings and land application areas?
RAD2	Human and ecosystem health	Pathway	RAD2. Radionuclides in aquatic ecosystems	RAD2A. What are the above-background activity concentrations of uranium and actinium series radionuclides in surface water and sediment?
RAD3	Human and ecosystem health	Pathway	RAD3. Radon progeny in air	RAD3A. What is the above-background concentration of radon and radon progeny in air from the rehabilitated site?
				RAD3B. If an assessment using conservative values shows a potential issue with meeting closure criteria (3A and 7A): What is the equilibrium factor between radon progeny and radon in air?
				RAD3C. If an assessment using conservative values shows a potential issue with meeting closure criteria (3A and 7A): What is the unattached fraction of radon progeny in air?
RAD4	Human and ecosystem health	Pathway	RAD4. Radionuclides in dust	RAD4A. If an assessment using conservative values shows a potential issue with meeting closure criteria (4B and 7A): What is the resuspension factor (or emission rate) of dust emitted from the final landform?
				RAD4B. What is the above-background activity concentration in air of long-lived alpha-emitting radionuclides in dust emitted from the final landform?
				RAD4C. If an assessment using conservative values shows a potential issue with meeting closure criteria (4B and 7A): What is the activity median aerodynamic diameter of long-lived alpha-emitting radionuclides in dust emitted from the final landform?
RAD5	Human and ecosystem health	Pathway	RAD5. Radionuclides in bushfoods	RAD5A. What are the concentration ratios of actinium-227 and protactinium-231 in bush foods?
RAD6	Human and ecosystem health	Receptor	RAD6. Radiation dose to wildlife	RAD6A. What are the representative organism groups that should be used in wildlife dose assessments for the rehabilitated site?
				RAD6B. What are the whole-organism concentration ratios of uranium and actinium series radionuclides in wildlife represented by the representative organism groups?
				RAD6C. What are the tissue to whole organism conversion factors for uranium and actinium series radionuclides for wildlife represented by the representative organism groups?
				RAD6D. What are the dose-effect relationships for wildlife represented by the representative organism groups?
				RAD6E. What is the sensitivity of model parameters on the assessed radiation doses to wildlife?
RAD7		Receptor	RAD7. Radiation dose to the public	RAD7A. What is the above-background radiation dose to the public from all exposure pathways traceable to the rehabilitated site?

HEALTH IMPACTS OF RADIATION AND CONTAMINANTS REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
	Human and ecosystem health			RAD7B. What is the sensitivity of model parameters on the assessed doses to the public?
RAD8	Ecosystem health	Receptor	RAD8. Impacts of contaminants on wildlife	RAD8A. Will contaminant concentrations in surface water (including creeks, billabongs and seeps) pose a risk of chronic or acute impacts to terrestrial wildlife?
RAD9	Human health	Receptor	RAD9. Impacts of contaminants on human health	RAD9A. What are the contaminants of potential concern to human health from the rehabilitated site?
				RAD9B. What are the concentration factors for contaminants in bush foods?
				RAD9C. What are the concentrations of contaminants in drinking water sources?
				RAD9D. What is the dietary exposure of, and toxicity risk to, a member of the public associated with all contaminant sources, and is this within relevant Australian and/or international guidelines?
RAD10	Human and ecosystem health	Monitoring	RAD10. Optimisation of radionuclide monitoring and assessment methods	RAD10A. How do we optimise methods to monitor and assess radionuclides?

ECOSYSTEM RESTORATION REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
ESR1	Ecosystem similarity	Ecosystem similarity	ESR1. Determining the characteristics of terrestrial vegetation in the areas surrounding the RPA.	ESR1A. What are the compositional and structural characteristics of the terrestrial vegetation (including seasonally-inundated savanna) surrounding the RPA, and how do they vary spatially and temporally?
				ESR1B. Which indicators of similarity should be used to assess revegetation success?
				ESR1C. What values should be prescribed to each indicator of similarity to demonstrate revegetation success?
ESR2	Ecosystem similarity	Ecosystem similarity	ESR2. Determining the requirements to support a terrestrial faunal community similar to areas surrounding the RPA.	ESR2A. What faunal community structure (composition, relative abundance, functional groups) is present in the areas surrounding the RPA?
				ESR2B. What habitat, including enhancements, should be provided on the rehabilitated site to ensure the colonisation of fauna, including threatened species?
				ESR2C. What is the risk of feral animals (e.g. cats and dogs) to faunal colonisation and long-term sustainability?
ESR3	Ecosystem similarity	Ecosystem similarity	ESR3. Understanding how to establish native terrestrial vegetation, including understory species.	ESR3A. How do we successfully establish terrestrial vegetation, including understory (e.g. seed supply, seed treatment and timing of planting)?
ESR4	Ecosystem similarity	Ecosystem similarity	ESR4. Determine density of introduced species in areas surrounding the RPA.	ESR4A. What is the composition and abundance of feral animals and weeds in areas surrounding the RPA?
ESR5	Long term viability	Ecosystem Sustainability	ESR5. Develop a restoration trajectory for Ranger mine	ESR5A. What are the key sustainability indicators that should be used to measure restoration success?
				ESR5B. How can we develop restoration trajectories (flora and fauna) to predict when the rehabilitated site will move to a sustainable ecosystem without further management intervention (e.g. different fire and weed scenarios)?

ECOSYSTEM RESTORATION REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
ESR6	Long term viability	Ecosystem Sustainability	ESR6. Understanding the impact of contaminants on vegetation establishment and sustainability	ESR6A. What concentrations of contaminants from the rehabilitated site may be available for uptake by terrestrial plants?
				ESR6B. Based on the structure and health of vegetation on the Land Application Areas, what species appear tolerant to the cumulative impacts of contaminants and other stressors over time?
ESR7	Long term viability	Ecosystem sustainability	ESR7. Understanding the effect of waste rock properties on ecosystem establishment and sustainability	ESR7A. What is the potential for plant available nutrients (e.g. nitrogen and phosphorus) to be a limiting factor for sustainable nutrient cycling in waste rock?
				ESR7B. Will sufficient plant available water be available in the final landform to support a mature vegetation community?
				ESR7C. Will ecological processes required for vegetation sustainability (e.g. soil formation, reproduction and nutrient cycling) occur on the rehabilitated landform?
				ESR7D. Are there any other properties of the rehabilitated site that could be attributed to any observed impairment of ecosystem establishment and sustainability, including vegetation and key functional groups of soil fauna?
ESR8	Long term viability	Ecosystem Sustainability	ESR8. Understanding fire resilience and management in ecosystem restoration	ESR8A. What is the most appropriate fire management regime to ensure a fire resilient ecosystem on the rehabilitated site?
ESR9	Ecosystem similarity and sustainability	Monitoring	ESR9. Developing best-practice monitoring methods for ecosystem restoration	ESR9A. How do we optimise methods to measure revegetation and faunal community structure and sustainability on the rehabilitated site, at a range of spatial/temporal scales and relative to the areas surrounding the RPA?

CROSS-THEME REHABILITATION THEME				
KKN No.	**ER Link**	**Category**	**Title**	**Questions**
CT1	Biodiversity and Ecosystem Health	Risk	CT1. Assessing the cumulative risks to the success of rehabilitation on-site and to the protection of the off-site environment.	CT1A. What are the cumulative risks to the success of rehabilitation on-site and to the off-site environment?
CT2	World Heritage values	Heritage Values	CT2. Characterising World Heritage values of the Ranger Project Area	CT2A. What World Heritage Values are found on the Ranger Project Area, and how might these influence the incorporation of the site into Kakadu National Park and World Heritage Area?