SOILANDWATER

EROSION CONTROL PLAN

Jumping Creek QUEANBEYAN

Version 3

29 January 2019

FRANKLIN CONSULTING AUSTRALIA PTY LIMITED

abn 59 611 394 953

www.soilandwater.net.au

SOIL AND WATER

OUR COMPANY

Franklin Consulting Australia Pty Limited, trading as Soil and Water, offers expert advice and services to the agriculture, development and environmental conservation sectors. We provide soil and water management advice, undertake land capability and soil assessment, erosion and sediment control, and soil conservation, catchment and property management planning. We have extensive experience in both government and private sectors in senior management and consulting roles.

We provide our services to individual land holders, sub-division developers, surveyors, commercial business owners, and land development and regulatory agencies.

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EXECUTIVE SUMMARY

Soil and Water (Franklin Consulting Australia Pty Limited) was engaged by Peet Limited to develop an Erosion Control Plan to support a housing development at Lonergan Drive, Greenleigh, New South Wales (known as Jumping Creek). The development involves residential and a dedicated Public Reserve which will be managed for conservation purposes with provision for recreation by residents and the public.

The Jumping Creek site is approximately 96.43 ha in area and is located near the locality of Greenleigh, approximately 3km south-east of the Queanbeyan CBD. The site is described as Lot 5 DP 1199045 (Figure 1). The site is a combination of undulating and flatter land, bounded by Greenleigh Estate (zoned E4 Environmental Living) to the north-west, the Queanbeyan River to the west, and steep escarpments to the north, east and south east (parts of which lie within the Cuumbeun Nature Reserve). Most of the surrounding escarpment land is zoned E2 Environmental Conservation.

Figure 1: Lot 5 DP1199045

This Erosion Control Plan is one of three reports being prepared by Franklin Consulting Australia, the others being a Vegetation Management Plan (delivered) and Trail Management Plan.

The site has significant areas of active erosion, many of which are related to active and historical vehicle tracks. There are also some areas of erosion related to the historical mining activities on the lot.

Erosion located in the area to be developed for housing is not addressed in this report as these sites will be rehabilitated as part of the construction program. Erosion areas associated with active or historical trails are addressed separately in the Trail Management Plan.

The remediation/rehabilitation program prioritises activity recognising the timeframes associated with the various stages of development and the different priorities for work based on severity and impact of erosion in different areas.

Site inspections identified 12 areas of erosion across the development site that lay outside the area to be developed for housing. Six of these areas are erosion generated by run-off in minor drainage depressions. One site is related to historical mining operations on the site, and another is the product of quarrying on the site. The remaining five sites are the result of uncontrolled access to the site and the impact of vehicular traffic on the site.

Erosion the site is contributing sediment at a rate of 34-95 tonnes per hectare of eroded area. This compares with the sediment generation rate from non-eroded areas of approximately 0.03 tonnes per hectare. The proximity of erosion sites to watercourse means most of the sediment mobilised is directly contributing to declining downstream water quality in the Queanbeyan River.

Rehabilitation strategies for each of the erosion sites comprise a range of interventions including revegetation and construction of erosion control earthworks. The staged erosion control works program will progressively reduce the sediment being mobilised on the site commensurate with the size of the development.

CONTENTS

1. INTRODUCTION

1.1 SCOPE

This Erosion Control Plan will:

- identify all areas of erosion on the site
- identify erosion as active or historical
- assess the significance of the erosion areas
- prioritise erosion site for remediation
- provide a staged remedial works program for priority erosion sites (2-3 years)
- provide a long-term erosion monitoring, management and maintenance program.

Areas of erosion located within the footprint of housing or associated infrastructure are not addressed in this plan. These sites will be rehabilitated as part of the construction phase. Erosion associated with the trail network, is addressed in the separate Trail Management Plan. Erosion control associated with the construction phase of the development is not addressed in this plan.

1.2 REFERENCES

Vegetation Management Plan, Jumping Creek, Queanbeyan, Soil and Water (2018)

Trail Management Plan, Jumping Creek, Queanbeyan, Soil and Water (2018)

Planning for Bush Fire Protection, NSW Rural Fire Service, August 2018

Soils and Construction: Managing Urban Stormwater, NSW Government, 2004

Soil Landscapes of the Canberra 1:100,000 Sheet, Department of Land and Water Conservation, B.R.Jenkins, 2000

1.3 METHODOLOGY

The following methodology was used to develop the Erosion Control Plan:

1. Desk top analysis of aerial and satellite imagery to identity areas of erosion for investigation
2. Final lot layout reviewed to identify erosion areas which are located within the area proposed for housing and associated infrastructure and which will therefore be remediated as part of the construction phase
3. Site investigation to assess:
    a. Spatial extent and severity of erosion
    b. Status of erosion (i.e. active or stable [historical])

   c. Priority for remediation/rehabilitation

   d. Options for remediation/rehabilitation.

4. Staged remediation/rehabilitation work program developed.

5. Monitoring and Maintenance Program developed to support rehabilitation program.

2. BIOPHYSICAL LANDSCAPE

2.1 LOCALITY AND LANDSCAPE

The site is located between the western slope of the escarpment and the Queanbeyan River south-east of Queanbeyan. Access will be provided by the Ellerton Drive Extension (under construction).

The areas of the development proposed for housing and associated infrastructure are described as the Burra Soil Landscape[1] This landscape consists of undulating to rolling hills and alluvial fans with gently to moderately inclined slopes. Local relief is less than 90 metres between 650 and 900 metres elevation.

The hilly area along the northern boundary of the development is described as the Macanally Mountain Soil Landscape. This landscape consists of rolling to steep low hills with moderately to steeply inclined slopes of 10-30% grade. Local relief is up to 200 metres at 600-1,000 metre elevation.

The steep west-facing slopes paralleling the eastern boundary of the development correspond to the Foxlow Soil Landscape. This consists of cobble strewn rolling to rugged steep hills and mountains with moderately to steeply inclined slopes greater than 20% in grade. Local relief is up to 300 metres between elevations of 600-1,150 metres.

The area is drained by overland flow and a network of minor drainage depressions and major streams draining towards the Queanbeyan River which borders the property along the south-western boundary.

2.2 CLIMATE

The climate is typically a cool and moderately dry climate. Average rainfall for the area is 600 – 800 mm. Warm summers with large evaporative deficit, cool winters with small evaporative deficit; median summer monthly rainfall for Canberra airport 49 mm; median monthly winter rainfall 38 mm; mean monthly summer evaporation is 177 mm, mean monthly winter evaporation is 60 mm.

2.3 GEOLOGY

The areas proposed for housing and associated infrastructure overlies Silurian volcanics including Colinton volcanics and the Cappanana Formation. This includes tuffs with minor siltstone, shale, sandstone and limestone.

The steeper slopes in the north and east of the proposed development are underlain by Ordovician metasediments of the Pittman Formation which have been subject to low grade metamorphism, folding and faulting. Beds are often near vertical dipping and include greywacke, shale, slates and chert. Bedrock is highly fractured and variable.

[1] *Soil Landscapes of the Canberra 1:100,000 Sheet,* B.R.Jenkins, 2000

2.4 SOILS

The soils in the areas proposed for housing and the majority of related infrastructure, range from shallow well-drained Tenosols and Rudosols on crests and upper slopes, moderately dep and moderately drained Red Kurosols and Red Kandosols on mid and lower slopes. These soils are moderately to highly susceptible to erosion from non-concentrated and concentrated water flows.

The soil on the steeper slopes along the eastern boundary of the development range from shallow Rudosols to Yellow Kandosols to Brown Kurosols. These soils are moderately to highly susceptible to erosion from non-concentrated water flows and very highly susceptible to erosion from concentrated water flows. As these soils are located on steeper slopes, the erosion risk along drainage depressions and tracks which concentrate water flows is significant.

The soil on the steeper slopes along the northern boundary of the development range from shallow Rudosols on crests and sideslopes to Red and Brown Kurosols on sideslopes. These soils are moderately susceptible to erosion from non-concentrated water flows and highly susceptible to erosion from concentrated water flows. As these soils are located on steeper slopes, the erosion risk along drainage depressions and tracks which concentrate water flows is significant however not as high a risk as along the slopes on the eastern boundary.

2.5 EROSION RISK

The erosion rates (amount of sediment mobilised) on these types of soil can be estimated using the Universal Soil Loss Equation Model (USLE). For shale soil (such as those across most of the development site), on 5% and 10% grades (where most of the areas of erosion occurs), the estimated soil loss at the surface and at 15cm depth (for sites where topsoil has been lost already) is estimated below:

shale soil, gentle slope

Site condition	R	L	S	K	C	Erosion rate (t/ha/yr)
Natural	1300	80	5%	.022	.001	0.03
Bare surface	1300	80	5%	.022	1	34.0
Bare 15cm	1300	80	5%	.026	1	40.2
Bare 15cm	1300	80	10%	.026	1	94.9

Therefore, the areas of active erosion on the site are contributing sediment at a rate of 34-95 tonnes per hectare. Soil loss from areas of the development which are not eroding are in the order of 0.03 tonnes per hectare. It is also important to consider that the property is drained by two major creeks and the Queanbeyan River which means that sediment mobilised on the property through erosion generally drains directly to a watercourse contributing to downstream water quality issues and sedimentation problems.

2.6 VEGETATION & GROUNDCOVER

The range of species and vegetation communities that occur on the development site are discussed in detail in the Vegetation Management Plan. The area proposed for housing development and associated infrastructure is extensively cleared woodland with scattered remnant native trees and shrubs remaining. There is a significant range of exotic tree species including poplars and willows which tend to concentrate in the riparian zone along with dense thickets of blackberries. Groundcover across the site is comprised of a mix of native species and exotic pasture and weed species. Level of groundcover is generally adequate to minimise the erosion risk except for areas of existing erosion and trails.

The lower sideslopes of the steeper areas to the north and east of the proposed housing areas, are partially cleared and vegetation comprises of native and exotic groundcover species and dense patches of ti-tree. Mid to upper slopes and crest are generally vegetated with remnant native open Eucalypt forest. The extensive canopy cover with scattered shrubs and limited groundcover species, is generally adequate to minimise the erosion risk except for cleared areas associated with tracks and trails, and areas where run-off concentrates such as drainage depressions and creeks.

3. AREAS OF EROSION

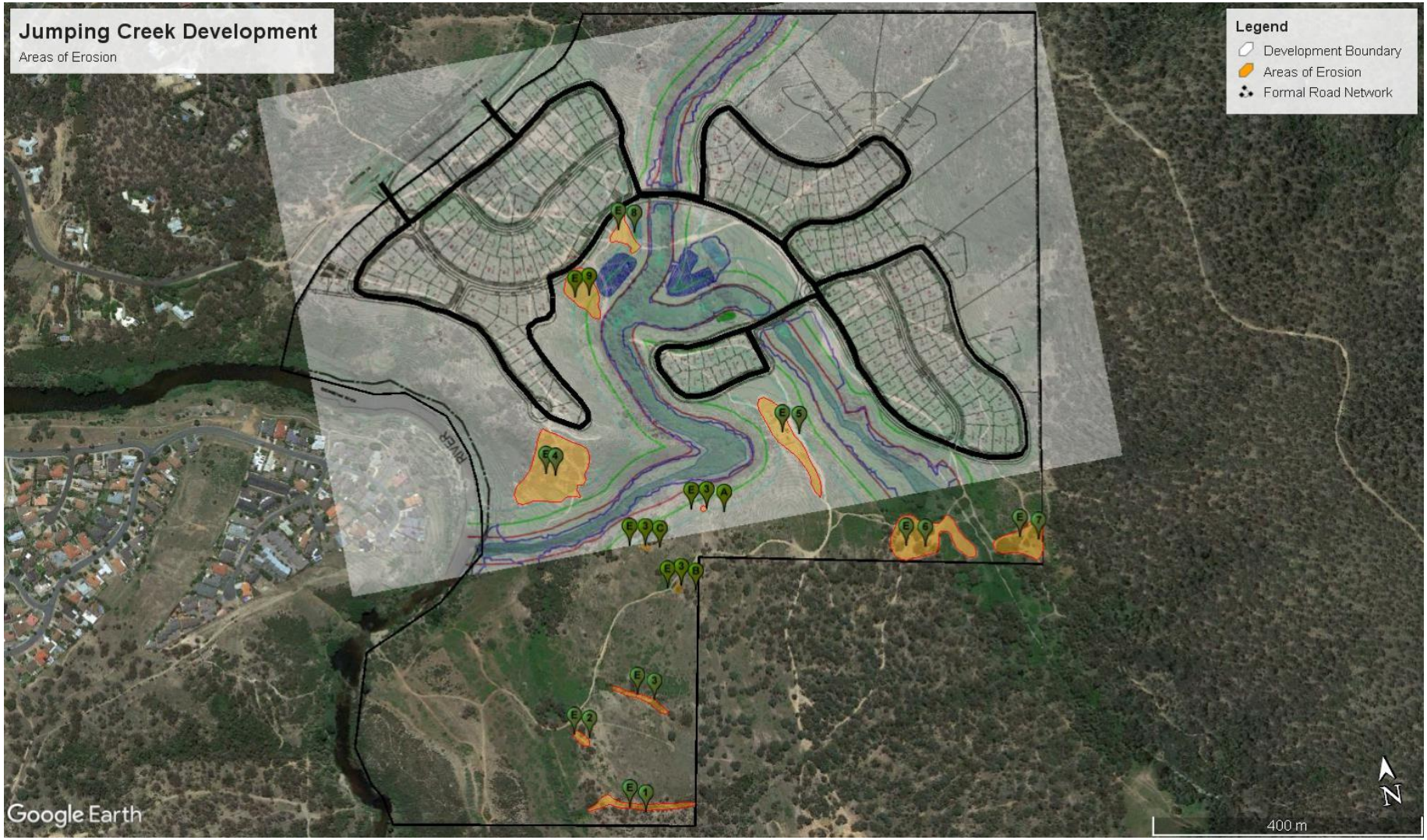


Figure 1: Areas of Erosion

3.1 AREAS OF EROSION

There are 12 areas of erosion identified across the development site that lay outside the area to be developed for housing or associated infrastructure, refer **Figure 1**. Six of these areas are erosion generated by rainfall run-off and associated with minor drainage depressions, refer sites E1, E2, E3, E3A, E3B & E3C. One site is related to historical mining operations on the site (E9), and another is the product of quarrying on the site (E5). The remaining five sites (E4, E6-E9) are the result of uncontrolled access to the site and the impact of four-wheel drive and other vehicular traffic on the site.

3.2 SIGNIFICANCE OF EROSION

The main significance of erosion on the site is that it is contributing sediment at a rate of 34-95 tonnes per hectare of eroded area. This compares with the sediment generation rate from non-eroded areas of approximately 0.03 tonnes per hectare. Most of the erosion sites are also located close the major creeks and river that drain the site. This means that the once sediment is mobilised (erosion) there is little chance that the material will be redeposited in the landscape before reaching the watercourse. Therefore, erosion on the site is having a direct and significant impact on water quality in the Queanbeyan River.

The impact of erosion directly on the landscape is also significant. Erosion reduces the trafficability of trails and tracks and can compromise the integrity of built infrastructure particularly roads, pipes and culverts. In addition, erosion reduces the visual amenity of landscapes which will impact the area significantly as the numbers of people interacting with the local environment increases.

3.3 REHABILITATION OPTIONS

The rehabilitation of erosion generally requires that sediment mobilisation (erosion) is minimised on the site. Interventions focus on:

- increasing the resilience of the soil surface to particle dislodgement, generally by increasing groundcover with vegetation and may include temporary measures such as mulching or erosion mats or fabrics
- reducing the pressure being applied to the soil surface from run-off (or wind in some case) by diverting runoff away from the site and/or reducing the velocity of flows across the surface by surface roughening
- intercepting sediment once it has been mobilised by filtering with vegetation and/or reducing velocity until sediment drops from suspension.

The rehabilitation options proposed in this report generally use a combination of measures depending on site specific issues such as catchment size, slope, topography, proximity to watercourses, degree of existing erosion, presence of existing vegetation and proximity to infrastructure.

4. SITE EROSION AUDIT

Figure 2: E1, E2 and E3 Erosion Works

E1 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E1  Lat -35.380413° Lon 149.253317°	Minor gully and bank erosion associated with a minor drainage depression. Site has reasonable vegetation cover of native trees and shrubs. Small active gully heads and small areas of bare eroding bank.	Moderate erosion	Low – Moderate (potential for natural regeneration)	Seed and mulch areas of bare bank where this is actively eroding. Where run-on water Is not a problem light cultivation (hand cultivation or small scarifier) may assist in providing a seed bed for revegetation. Species selection should reflect species list in Vegetation Management Plan.

DSC 3806: Small areas of bare eroding bank

DSC 3807: Small active gully heads in gully line

DSC 3808: Actively eroding vertical creekbank

DSC 3809: Extensive native vegetation in the riparian zone

DSC 3810: Areas of eroding bank collapsing into creek bed

DSC 3811: Small active gully head

Figure 3: E1, E2 and E3 Erosion Works

E2 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E2  Lat -35.378787° Lon 149.252293°	Eroding gully head in small drainage depression.	Moderately active gully head.	Low to medium priority (small depth of gully may naturally regenerate overtime)	Construct a small earth diversion bank upslope of the gully head to divert runoff in the drainage depression around the active gully head. Lightly rip the area around the gully head below the diversion bank, then seed and mulch the area with suitable species mix, consistent with the Vegetation Management Plan.

DSC 3803: Small active gully head in base of drainage depression

Figure 4: E1, E2 and E3 Erosion Works

E3 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E3  Lat -35.378787° Lon 149.252293°	Gully and bank erosion in minor drainage depression	Moderately active	Medium priority (significant length of eroding bank and active gully head)	Construct a small earth diversion bank upslope of the active gully head and divert runoff around the active gully head site. Lightly scarify areas of bare and eroding bank and seed and mulch the area with suitable species from the Vegetation Management Plan.

DSC 3801: Long section of active bank erosion

DSC 3802: Active gully head at the top of the gully line

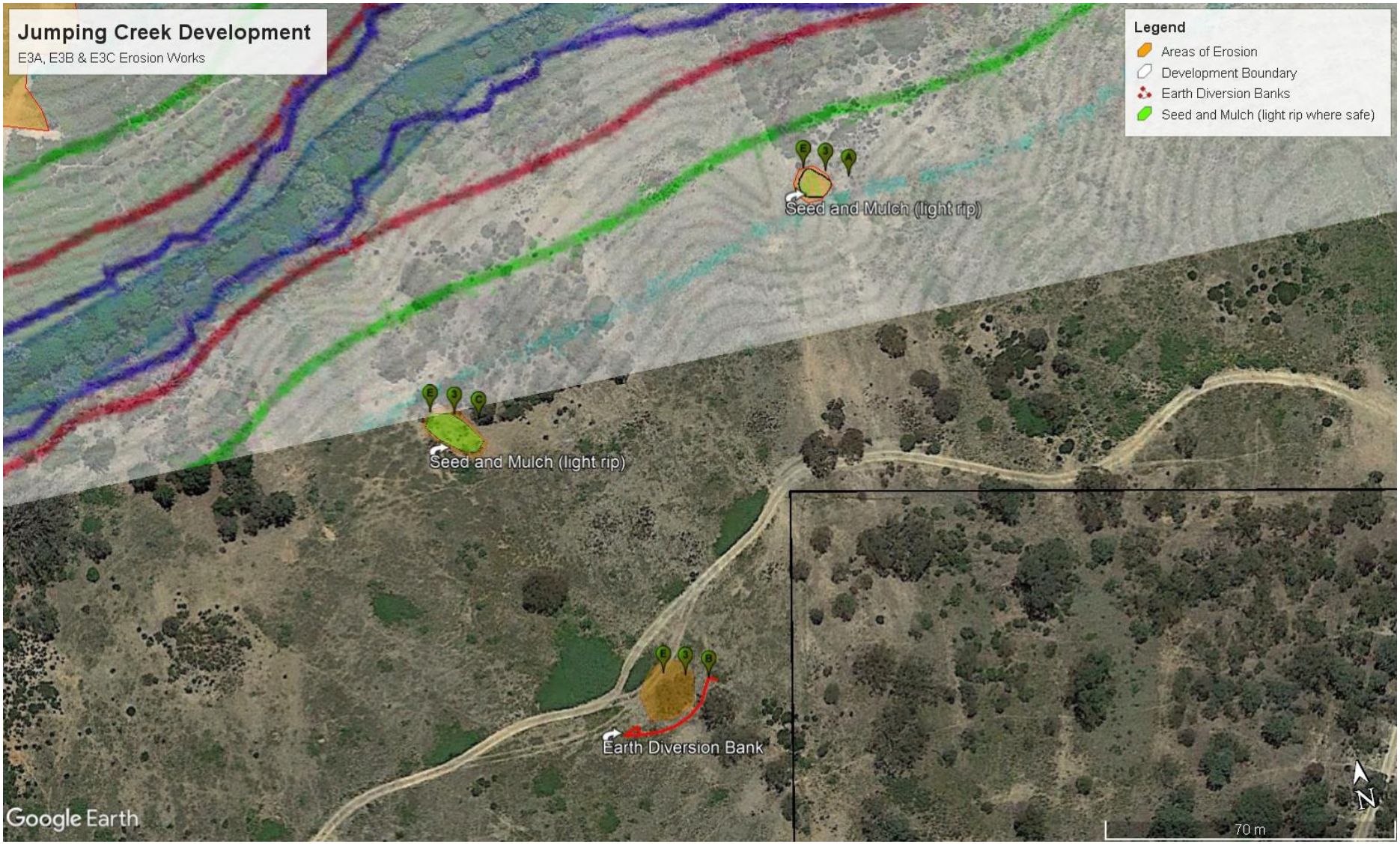


Figure 5: E3A, E3B & E3C Erosion Works

E3A, B & C – Erosion Areas				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E3A Lat -35.376405 Lon 149.254887	Small area of gully erosion in minor drainge depression  **E3A: Stable gully head**	Stable	Low	Lightly scarify the surface then seed and mulch areas of bare gully and bank
E3B Lat -35.377410 Lon 149.254253	Small area of gully erosion in minor drainge depression  **E3B: Active minor gully head**	Minor active gully erosion	Low to medium	Construct small earth diversion bank upslope of gully head. Lightly scarify the area below the diversion bank then seed and mulch areas of bare earth

E3C Lat -35.376763 Lon 149.253822	Small area of gully and bank erosion in minor drainge depression  **E3C: Active gully head and banks**	Minor active gully and bank erosion	Medium	Lightly scarify the area below the gully head and along the areas of bare bank, then seed and mulch areas

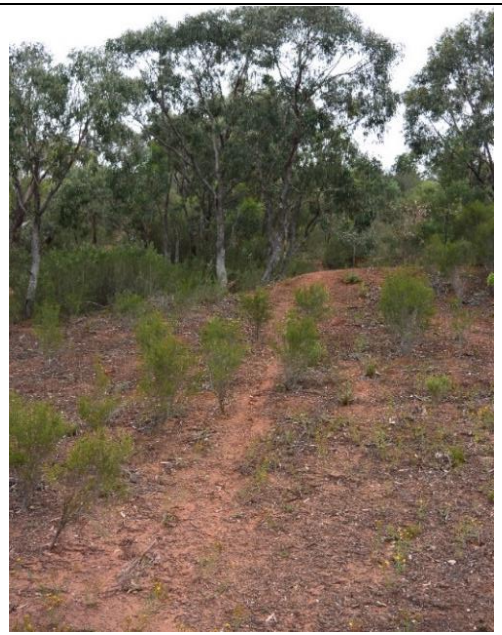
Figure 6: E4 Erosion Works

E4 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E4 Lat -°35.376043 Lon °149.251654	Extensive area of steep slope with historical erosion and soil erosion earthworks in place. Erosion created by four-wheel driving tracks up and down the steep slopes.	Small localised areas of active erosion however mostly stable.	Medium (due to high erosion risk and damage to expensive erosion control infrastructure if minor maintenance is not undertaken.	Maintain existing erosion control infrastructure by cleaning sediment out of channels and building up freeboard (height) of banks where these have been degraded. Fill areas of minor rill erosion with loose rock and topsoil. Seed and mulch bare areas to reduce sheet and rill erosion

DSC 3766: Well vegetated erosion control earthworks

DSC 3767: Erosion control earthworks

DSC 3770: Deposition in erosion bank channels



DSC 3775: Tracks eroding bank freeboard

DSC 3777: Minor erosion on back batter of erosion control bank

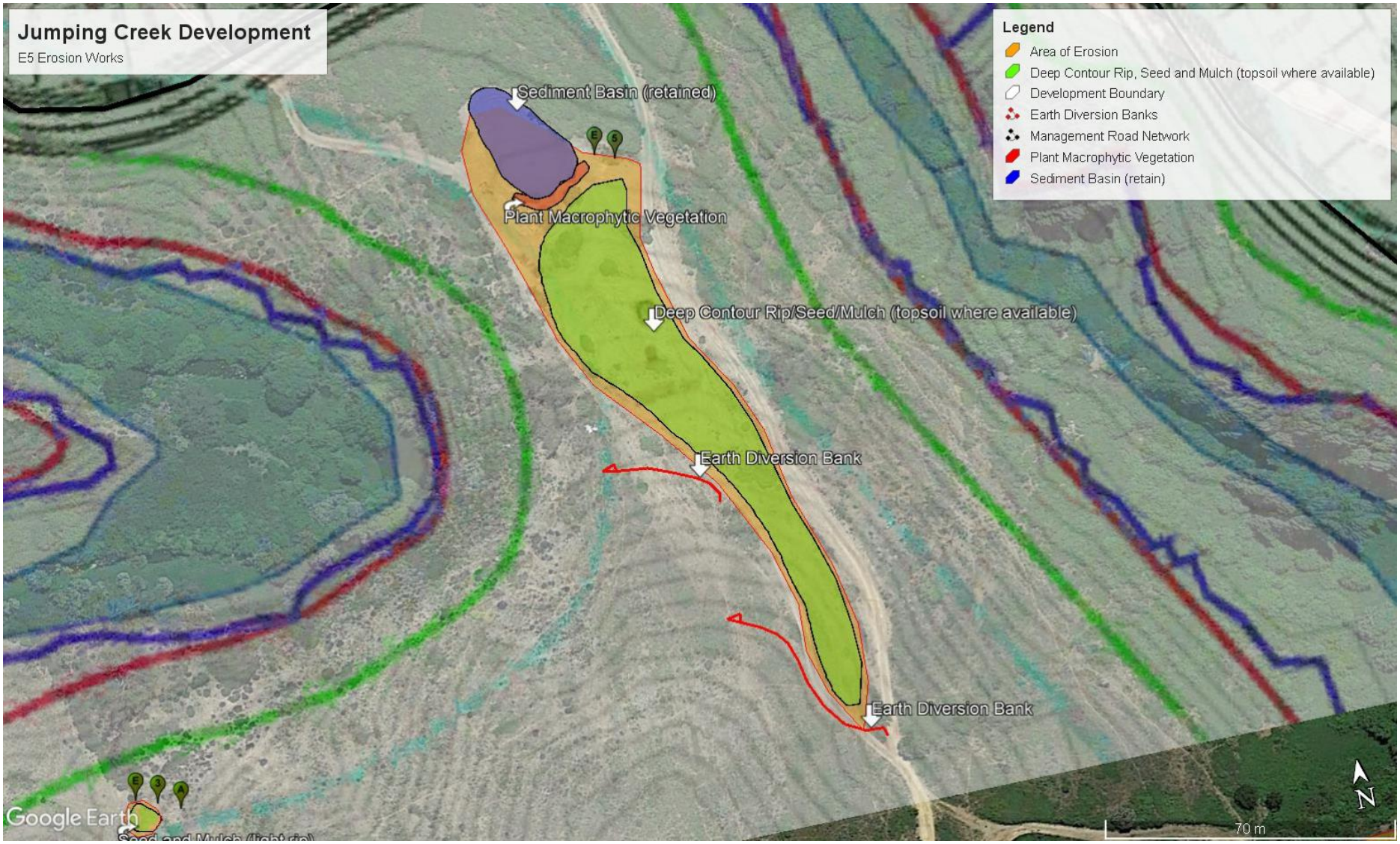


Figure 7: E5 Erosion Works

E5 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E5 Lat –35.375649° Lon 149.256613°	Gravel quarry with erosion emanating from the large area of bare subsoil and degraded bedrock material.	Moderately active sheet and rill erosion across most of the site	Medium (site drains internally to a small sediment basin reducing immediate impact on nearby watercourse)	Construct small earth diversion banks upslope of the gravel quarry to divert clean runoff away from the site and reduce erosion potential. Deep rip the bed of the quarry on the contour to reduce runoff and retain sediment. Where available topsoil the base of the quarry to promote revegetation. Seed and mulch the area with suitable groundcover and shrub species, refer Vegetation Management Plan. Retain the sediment detention basin and enhance the filtering capacity by planting macrophytes in the shallow backwater of the storage.

DSC 3789: Quarry site ponding water in the base

DSC 3781: Eroding trails leading into the quarry site

DSC 3790: Sheet and rill erosion across the quarry site

DSC 3792: Diversion of upslope runoff will prevent clean water entering the site and exacerbating erosion and sediment mobilisation

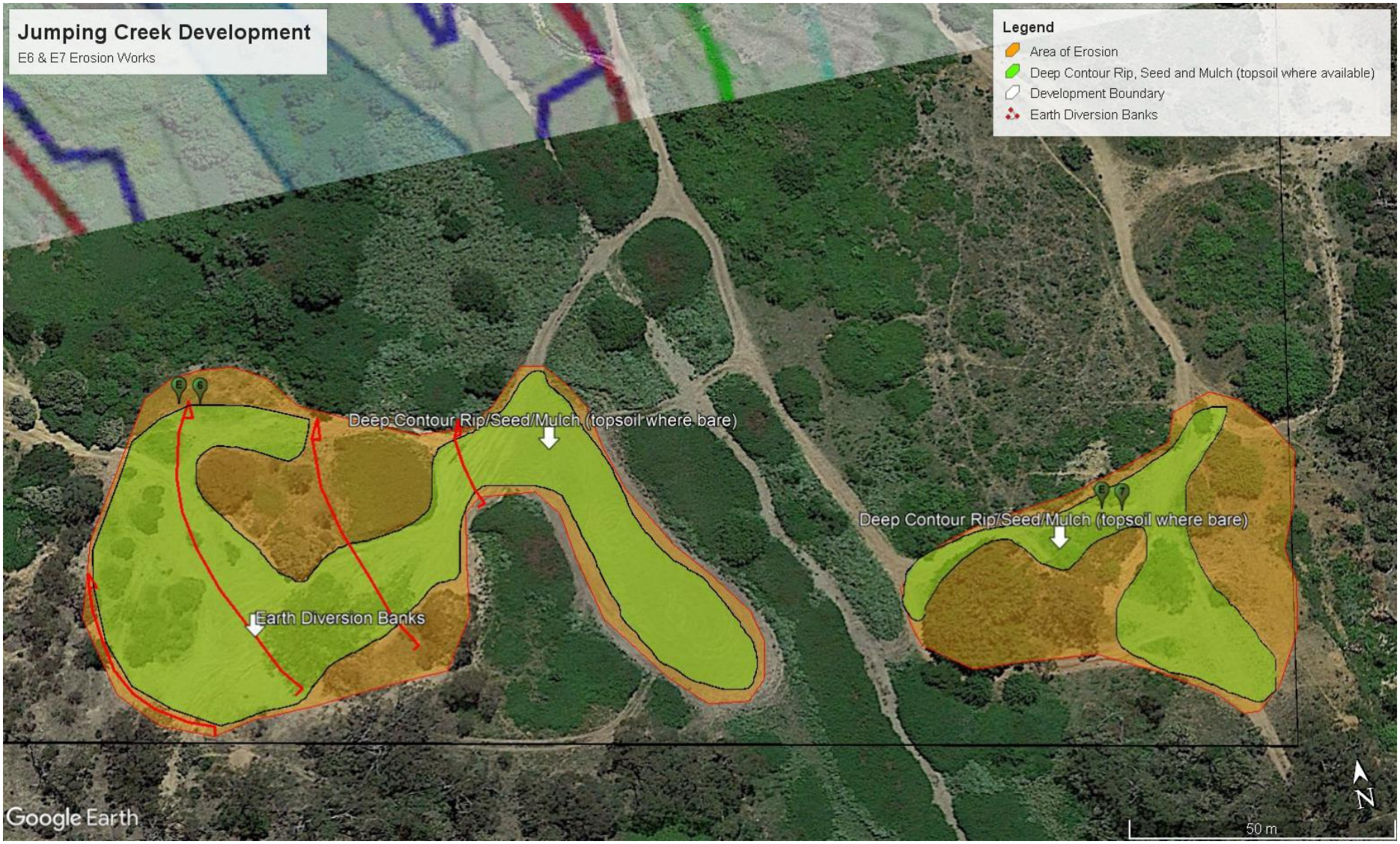


Figure 8: E6 & E7 Erosion Works

E6 – Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E6 Lat -35.376894° Lon 149.258879°	Extensive area of sheet and rill erosion formed by the concentration of track and trails and vehicle traffic on steep slopes. Includes an extensive area of bare creek flats below flood level	Active moderate to severe erosion.  **DSC 3830: Extensive bare area with sheet and rill erosion**	High (large extent of erosion and proximity to creek resulting in direct mobilisation of sediment to watercourse)	Construct an earth diversion bank to direct upslope runoff away from the site. Construct multiple graded banks across the site to control local water and convey this to a safe disposal area. Shape and deep contour rip the site below and between banks. Where possible import topsoil and spread on areas which have eroded to the subsoil level. Seed the area with suitable species, refer Vegetation Management Plan. Mulch all bare seeded areas to reduce erosion and promote germination.

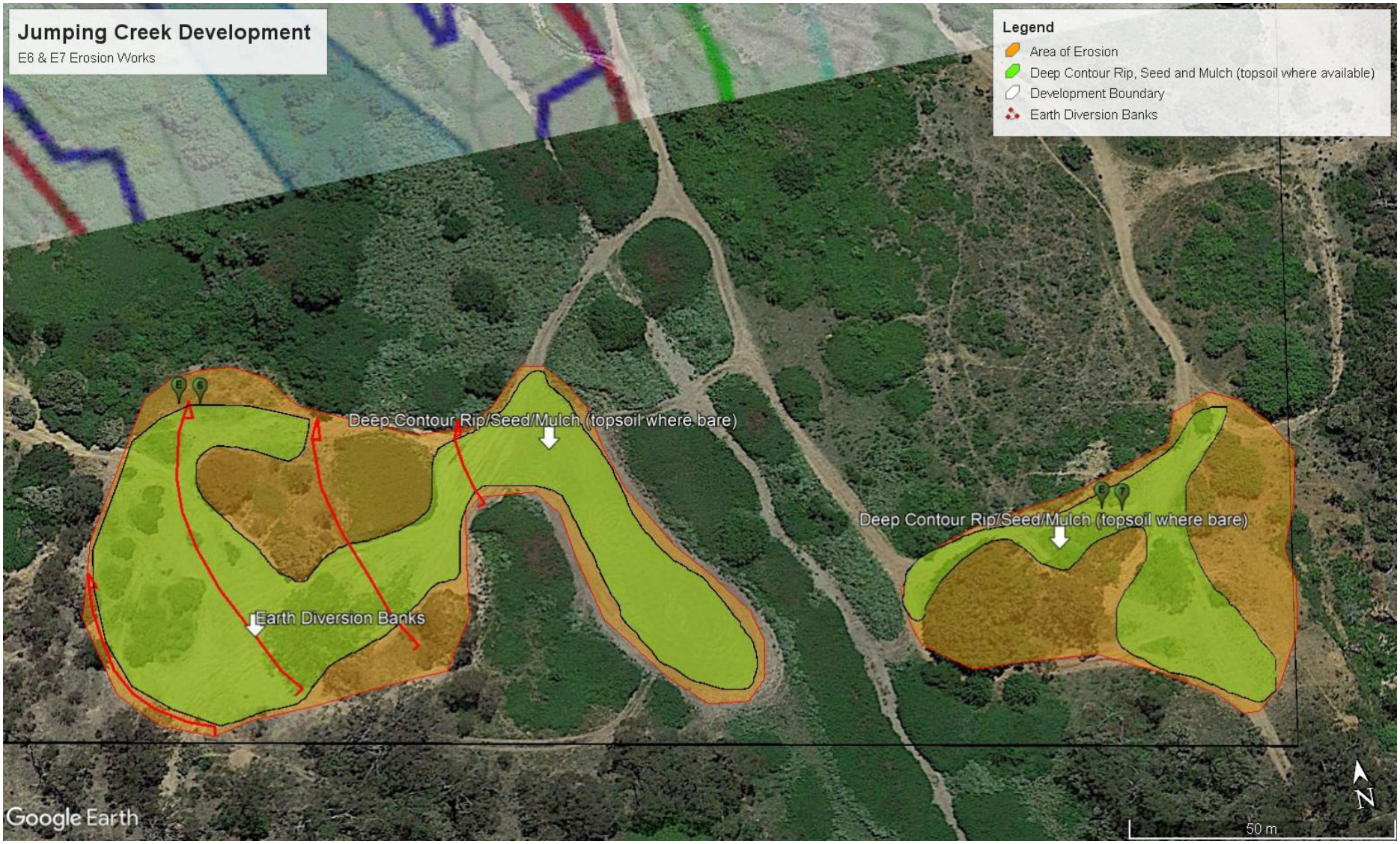


Figure 9: E6 & E7 Erosion Works

E7: Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E7  Lat -35.377149° Lon 149.259884°	Moderate to steep sloping site with a concentration of trails and old mine/quarry site creating bare areas of sheet and rill erosion.	Active areas of minor to moderate erosion	Medium (localised sites requiring intervention to stabilise)	Decommission redundant trails and divert runoff away from these sites with minor trail crossover banks. Deep contour rip the site and where possible import topsoil and spread on areas which have eroded to the subsoil level. Seed the area with suitable species, refer Vegetation Management Plan. Mulch all bare seeded areas to reduce erosion and promote germination.

DSC 3831: Erosion of steep redundant trails

DSC 3832: Concentration of trails causing erosion

DSC 3833: Sheet and rill erosion across the site

DSC 3834: Mine/quarry site adjacent to the eastern boundary

DSC 3835: Eroding vertical edges on old mine site.

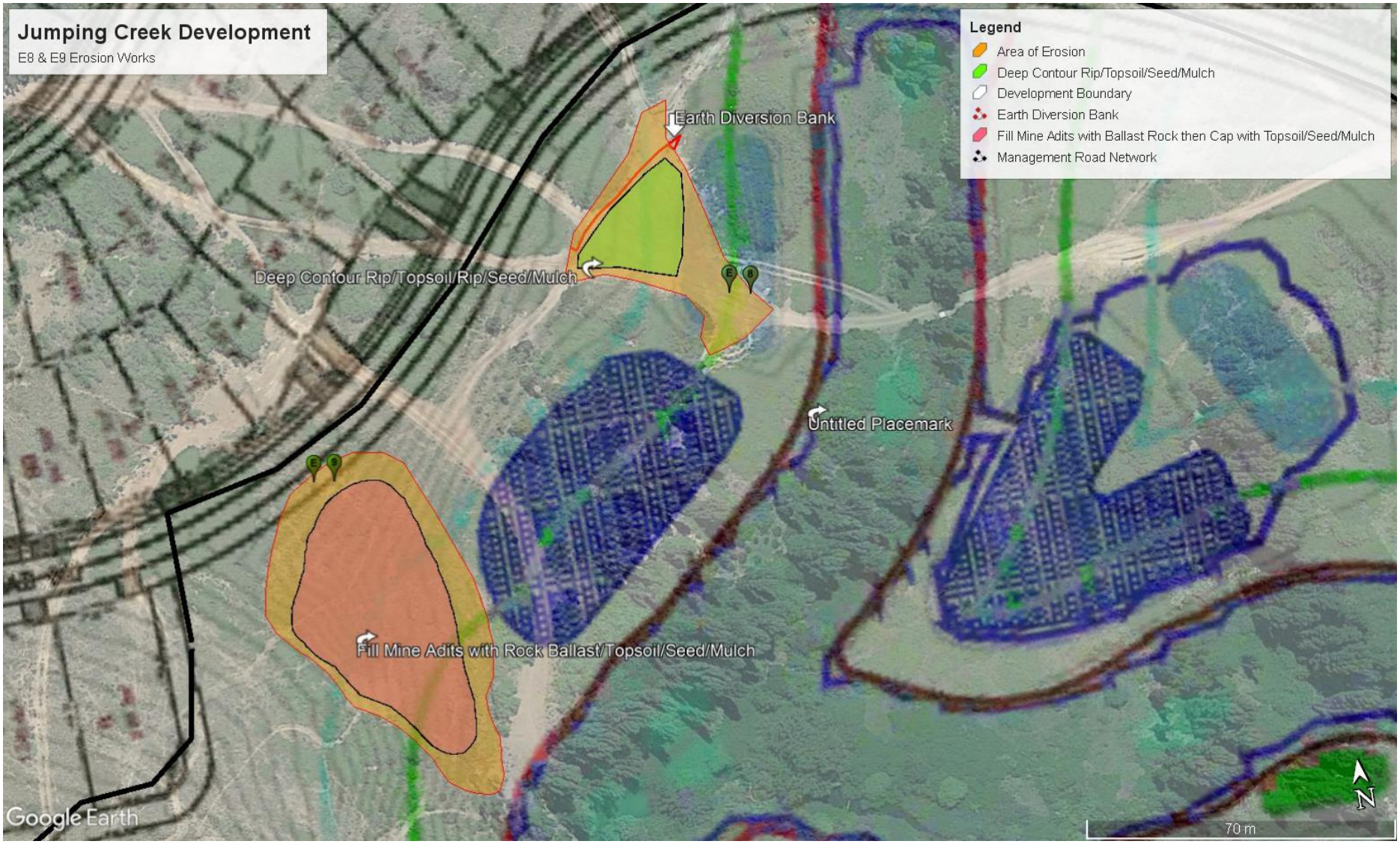


Figure 10: E8 & E9 Erosion Works

E8: Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E8  Lat -35.372430° Lon 149.254476°	Extensive area of sheet and rill erosion formed by the concentration of track and trails and vehicle traffic on moderate slopes.	Active moderate erosion  **DSC 3844: Large area of bare sheet erosion**  **DSC 3845: Sedimentation from upslope track erosion**	Medium (active sheet and rill erosion with close proximity to the creek)	Construct an earth diversion bank to direct upslope runoff away from the site. Shape and deep contour rip the site below the bank. Where possible import topsoil and spread on areas which have eroded to the subsoil level. Seed the area with suitable species, refer Landscape Plan. Mulch all bare seeded areas to reduce erosion and promote germination. **NB:The eastern portion of this area will become a sediment basin in Phase 2 of the development and therefore erosion control works should be concentrated upslope of this area and completed in conjunction with the construction of the basin.**

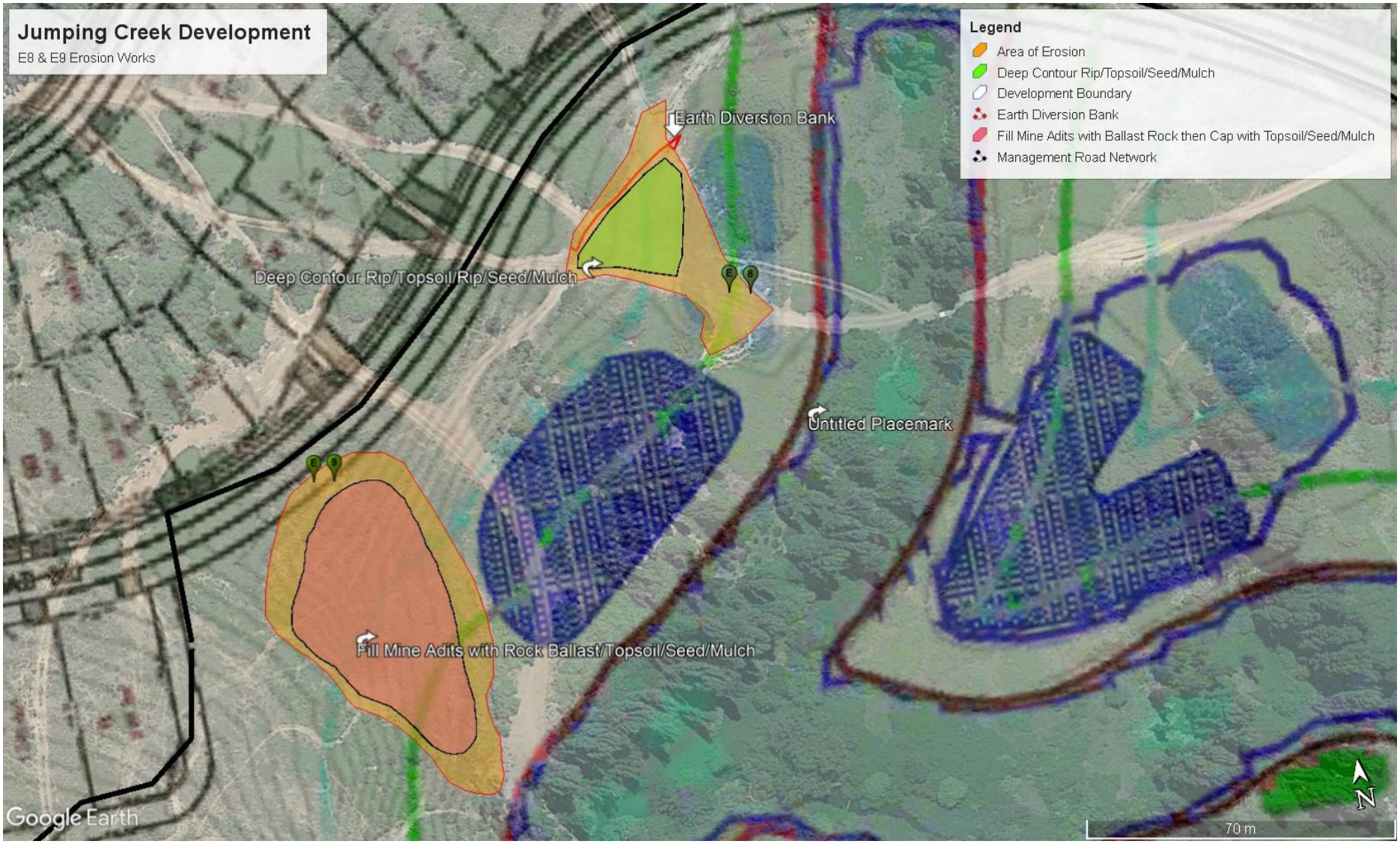


Figure 11: E8 & E9 Erosion Works

E9: Erosion Area				
SITE REF & LOCATION Lat/Long	**DESCRIPTION**	**STATUS Active (Severe, Moderate, Minor) or Stable**	**REMEDIATION PRIORITY High/Medium/Low**	**REMEDIATION OPTION**
E9  Lat -35.375432° Lon 149.252395°	Historical mine site with small areas of bare ground and various mine adits. Largely vegetated however still presents a safety hazard	Stable (minor erosion risk but active safety risk)  **DSC 3010: Mine adits revegetated with blackberries**	High (safety risk and potential risk with surface water accessions into mine adits creating potential groundwater issues)	Mine adits should back filled with coarse ballast material then capped with topsoil and revegetated with appropriate species, refer Landscape Plan. Any bare areas associated with the previous mining activity should be capped with coarse ballast rock (to create a hydraulic break and prevent capillary rise in soils) then topsoiled and seeded. Seeded areas should be mulched to reduce erosion and promote germination.

DSC 3011: Areas of mine spoil material stockpiled on surface

DSC 3012: Partially obscured mine adit creating safety hazard

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5. STAGED WORKS PROGRAM

The soil and water management plan will be implemented across the development in four distinct phases as presented in **Figures 12-15** below. The Erosion control works (referred to in this Erosion Control Plan) are staged to be consistent with the soil and water management phases. For example, Stage 1 of the erosion works will be undertaken during Phase 1 of the soil and water management works, and so on.

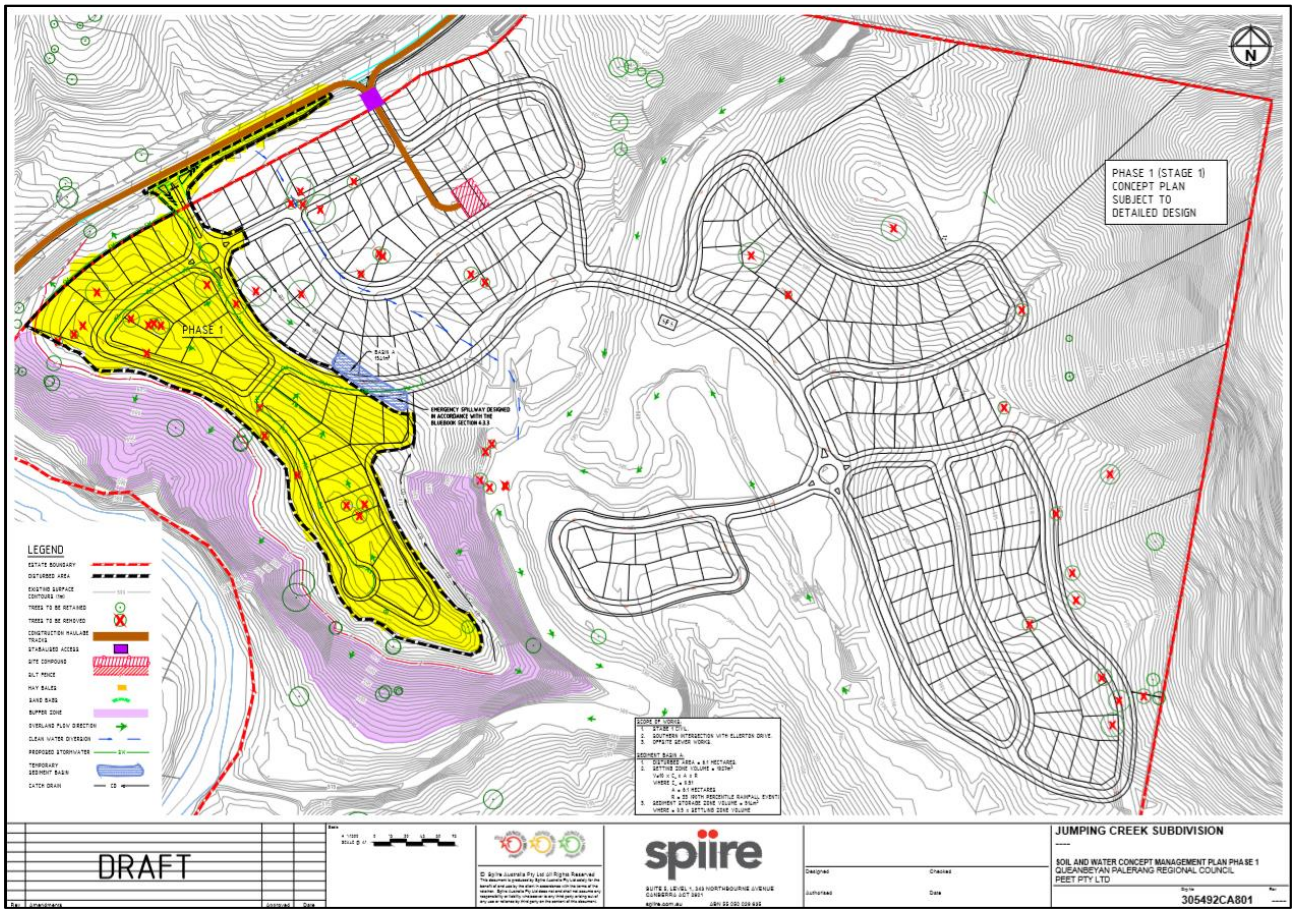

Figure 12: Soil & Water Management - Phase 1

Indicative layout only - please refer to engineering set for latest layout

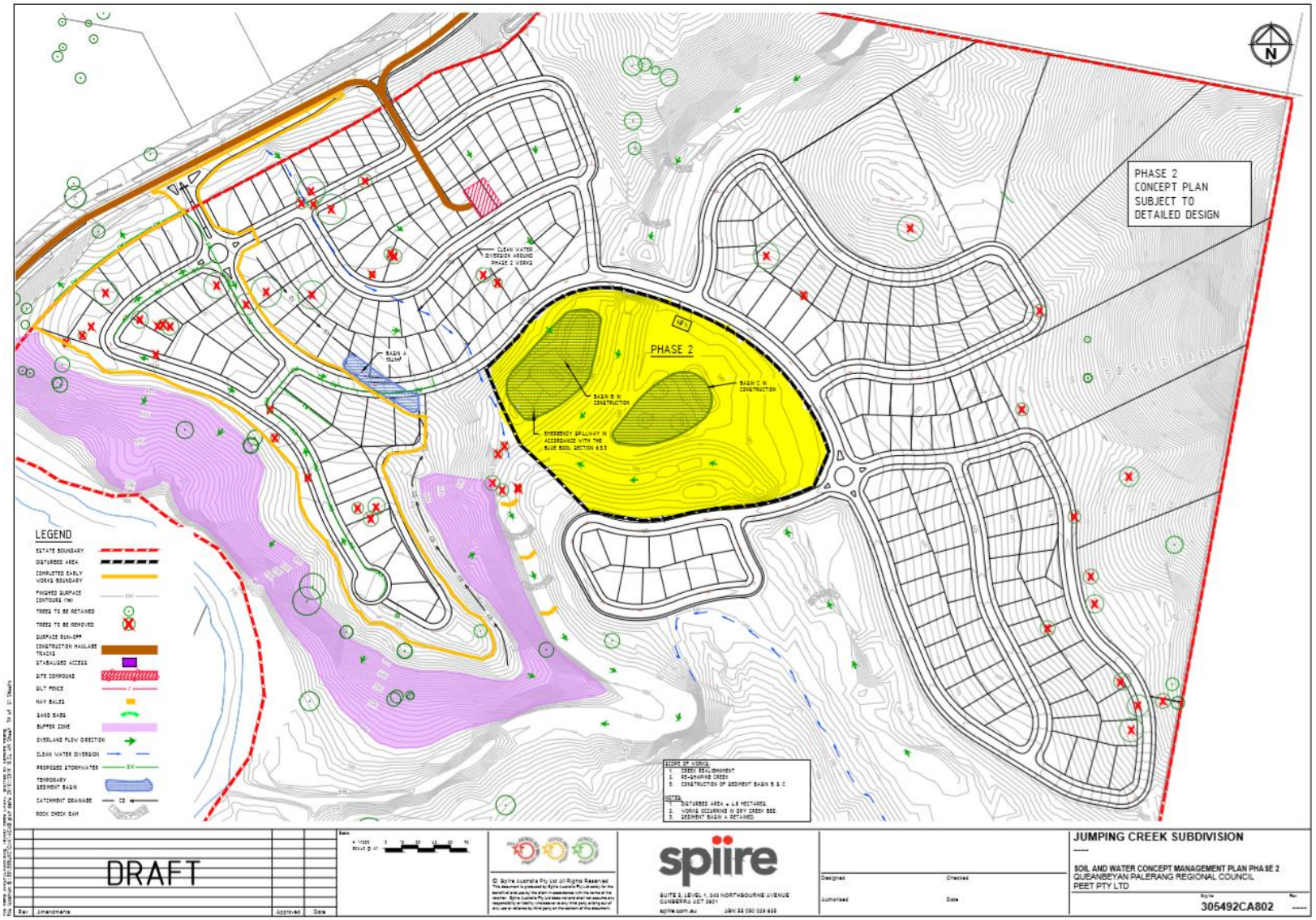

Figure 13: Soil & Water Management - Phase 2

Indicative layout only - please refer to engineering set for latest layout

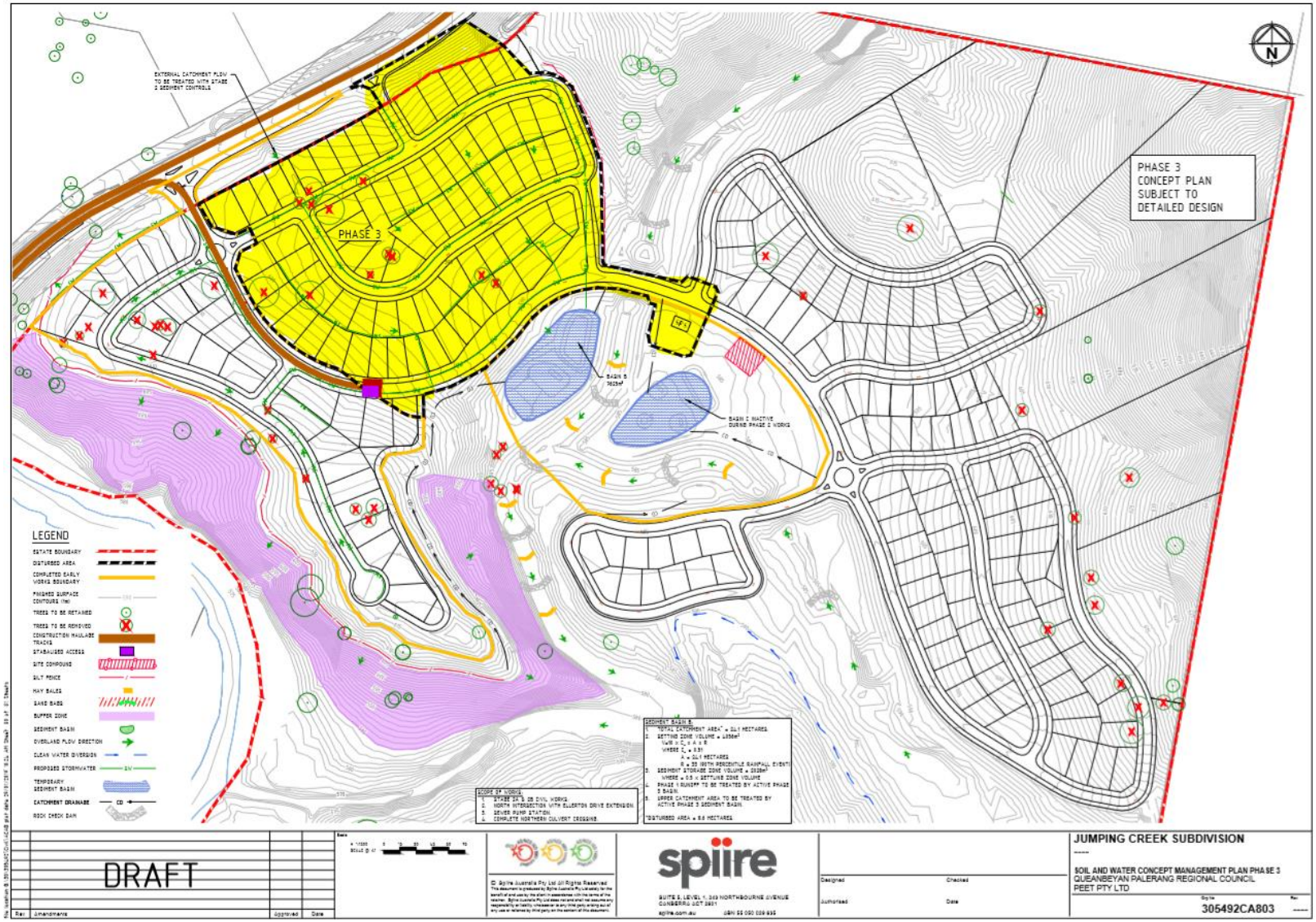

Figure 14: Soil & Water Management - Phase 3

Indicative layout only - please refer to engineering set for latest layout

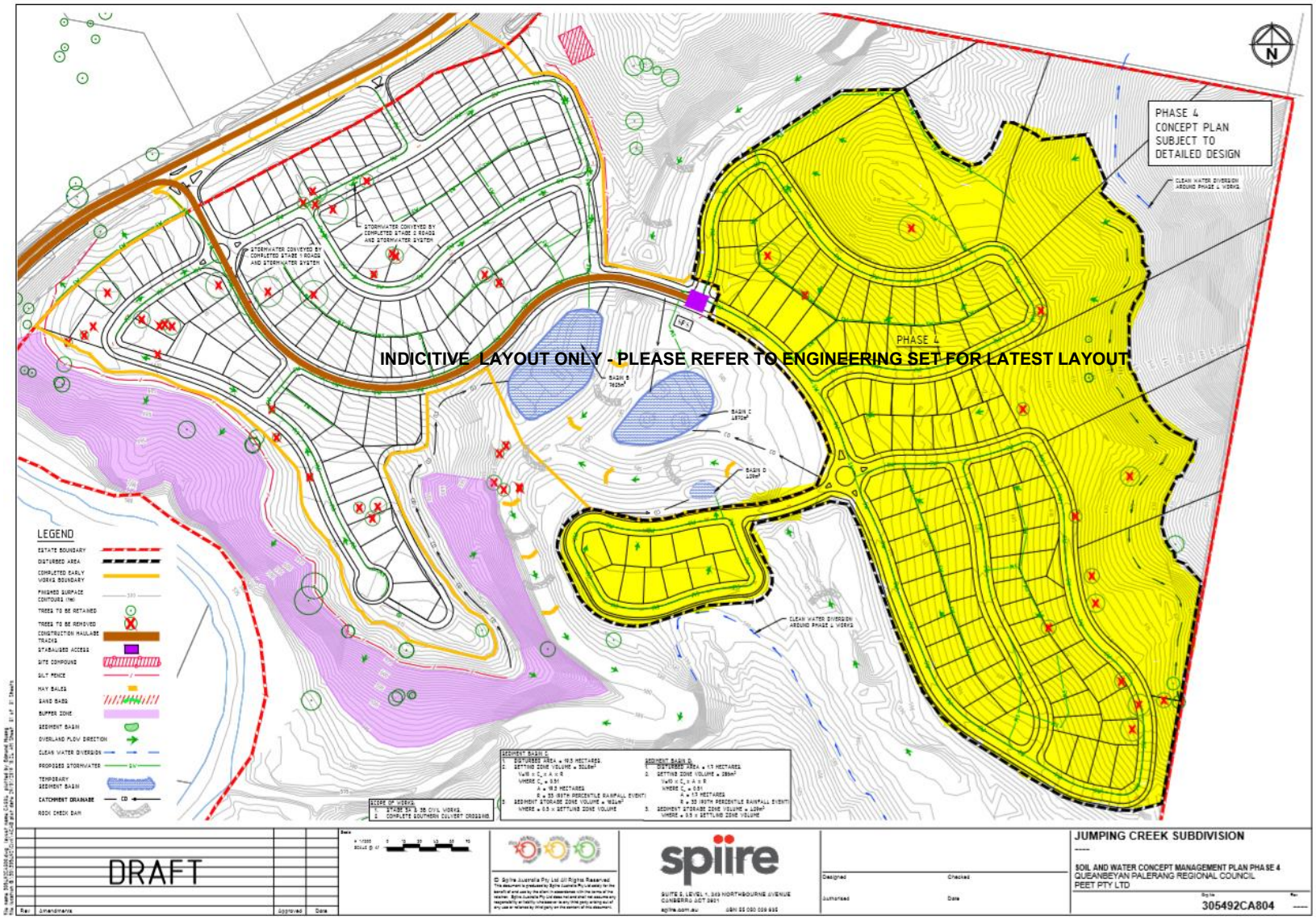

Figure 15: Soil & Water Management - Phase 4

Indicative layout only - please refer to engineering set for latest layout

The erosion control work proposed will be staged to recognise both the priority of the works and phases of the development. Works will be undertaken in conjunction with the construction activities and provision of access associated with each phase of soil and water management activities. The appropriate scheduling of works within each Stage will be undertaken by the developer prior to commencement of works.

5.1 STAGE 1 EROSION CONTROL WORKS (SOIL & WATER MANAGEMENT PHASE 1)

SITE REF	EROSION WORKS
E4	Maintain the existing erosion control earthworks by cleaning out bank channels and topping up bank freeboard.

5.2 STAGE 2 EROSION CONTROL WORKS (SOIL & WATER MANAGEMENT PHASE 2)

SITE REF	EROSION WORKS
E8	Construct an earth diversion bank upslope of the eroded area. Deep rip the area on the contour and spread imported topsoil where erosion has reached subsoil. Revegetate by seeding and mulching. **NB:The eastern portion of this area will become a sediment basin in Phase 2 of the development and therefore erosion control works should be concentrated upslope of this area and completed in conjunction with the construction of the basin.**
E9	Fill and vegetate mine adits and any other bare areas by capping with coarse ballast rock then topsoiling, seeding and mulching.

5.3 STAGE 3 EROSION CONTROL WORKS (SOIL & WATER MANAGEMENT PHASE 3)

SITE REF	REMEDIATION WORKS REQUIRED
No Work Proposed	

5.4 STAGE 4 EROSION CONTROL WORKS (SOIL & WATER MANAGEMENT PHASE 4)

SITE REF	REMEDIATION WORKS REQUIRED
E1	Lightly rip on the contour (where there is no run-on water), then seed and mulch bare eroding banks.
E2	Construct earth diversion bank upslope of gully head to divert flows around the site. Lightly rip on the contour below the diversion bank, then seed and mulch.
E3	Construct earth diversion bank upslope of gully head to divert flows around the site. Lightly rip on the contour below the diversion bank, then seed and mulch.
E3 A,B,C	**A-** Lightly rip on the contour (where there is no run-on water), then seed and mulch bare eroding banks. **B-** Construct earth diversion bank upslope of gully head to divert flows around the site. Lightly rip on the contour below the diversion bank, then seed and mulch. **C-** Lightly rip on the contour (where there is no run-on water), then seed and mulch bare eroding banks.
E5	Construct earth diversion bank upslope of the old quarry site to divert run-on water away from site. Deep rip the area on the contour and spread imported topsoil where erosion has reached subsoil. Revegetate by seeding and mulching. Plant macrophytes in the backwater of the sediment detention basin at the downslope end of the quarry.
E6	Construct earth diversion bank upslope of the eroded area to divert run-on water away from site. Construct graded banks (three) across the eroded area to intercept local run-off water and convey to a safe disposal area. Deep rip the area on the contour and spread imported topsoil where erosion has reached subsoil. Revegetate by seeding and mulching.
E7	Deep rip the area on the contour and spread imported topsoil where erosion has reached subsoil. Revegetate by seeding and mulching.

6. MONITORING, MAINTENANCE AND MANAGEMENT PROGRAM

Monitoring, maintenance and management should commence as soon as works have been undertaken and continue into the long term. It is expected that the roles and responsibilities for these activities will change overtime as the development is progressively completed and sections of public land revert to Council for ongoing management. The role of community groups, associations and/or local Landcare groups should also be considered in developing long term plans. Refer **Table 2** below.

Monitoring, maintenance and management should include a scheduled program of activities plus event-based triggers requiring additional activity. For some sites the frequency and event-based triggers will change over time in response the changing vulnerability of sites resulting from the construction of drainage and revegetation outcomes.

Table 2: Monitoring Program

Erosion Monitoring Site	Frequency of monitoring inspections	Additional Inspections Triggered by Specific Events	Responsibilities	Management Response
Revegetation (with light ripping)	Every **3 months** for the first 12 months following sowing Then **annually** at the end of summer when groundcover is at lowest	During the first **12 months** - after major rainfall runoff events Then after >1 in 1-year rainfall events	Developer, community groups, contractors	Identify re-seeding and/or more intensive erosion control work to ensure stability of the site
Revegetation with deep ripping	Every **3 months** for the first 18 months following sowing Then **annually** at the end of summer when groundcover is at lowest	During the first **12 months** - after major rainfall runoff events Then after >1 in 1-year rainfall events	Developer, community groups, contractors	Identify re-seeding and/or more intensive erosion control work to ensure stability of the site
Revegetation with ripping and diversion earthworks	Every **3 months** for the first 24 months following sowing Then **annually** at the end of summer when groundcover is at lowest	During the first **24 months** - after major rainfall runoff events Then after >1 in 1-year rainfall events	Developer, community group, contractors	Identify re-seeding or earthworks repair or upgrades required to ensure stability of the site

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